WEST BANK OF THE MISSISSIPPI RIVER
IN THE VICINITY OF NEW ORLEANS, LA

EAST OF HARVEY CANAL HURRICANE PROTECTION PROJECT

DESIGN MEMORANDUM NO. 3

COUSINS PUMPING STATION COMPLEX

IN TWO VOLUMES

VOLUME I

DEPARTMENT OF THE ARMY

NEW ORLEANS DISTRICT, CORPS OF ENGINEERS

NEW ORLEANS, LOUISISANA

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WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LA EAST OF HARVEY CANAL HURRICANE PROTECTION DESIGN MEMORANDUM NO. 3

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PROJECT AUTHORIZATION

1. Authority. The West Bank of the Mississippi River in the Vicinity of New Orleans (East of Harvey Canal), Louisiana project was authorized by Section 101(a)(17) of the Water Resources Development Act of 1996 (Public Law 104-303).

2. Purpose and Scope. The purpose of this Design Memorandum (DM) is to present the assumptions, criteria, and computations for developing the plan, design and cost estimates for constructing the Cousins Pumping Station Complex portion of the East of Harvey Canal Hurricane Protection features of the West Bank of the Mississippi River in the Vicinity of New Orleans, Louisiana Project. The recommended designs contained in this DM reflect the least costly method of providing the authorized standard project hurricane (SPH) protection. The basis for the recommended project is detailed in the West Bank of the Mississippi River in the Vicinity of New Orleans, LA (East of the Harvey Canal) Feasibility Report and Environmental Impact Statement dated August, 1994. The plan detailed in this DM consists of modifications to the Cousins Pumping Station to accommodate an additional 2,000 cfs. The outfall canal will be enlarged and diverted to discharge adjacent to navigable floodgate. A U-Frame Culvert will be constructed under Lapalco Bridge through which the outfall discharge will be routed. Parallel protection along the outfall canal will be provided. The connecting canal (First Avenue Canal) between the Harvey and Cousins Pumping Stations will be enlarged. The Destrehan Avenue Bridge will be extended by one span (60 feet) to accommodate the enlargement of Cousins outfall canal. Roller gates will be constructed on either side of the Destrehan Avenue Bridge to facilitate closing the bridge during flood conditions.

3. Other Pertinent Projects.

   A. Mississippi River Levees. The Mississippi River levees below New Orleans, Louisiana are included in the comprehensive plan for the protection of the alluvial valley of the river between the Head of Passes, Louisiana and Cape Girardeau, Missouri, as authorized by the Flood Control Act of 15 May 1928 and subsequent acts.

   B. Algiers Lock and Canal. The Algiers Lock and Canal Project was authorized by the River and Harbor Act of 2 March 1945, Public Law No. 14, 79th Congress, 1st Session. The project recommended modification of the existing project for the Gulf

Intracoastal Waterway between Apalachee Bay, Florida and the Mexican Border to provide an alternate waterway connection with the Mississippi River in the vicinity of Algiers, La.

C. Westwego to Harvey. The Westwego to Harvey project provides for SPH hurricane protection to the West Bank of the Mississippi River in Jefferson Parish between Westwego and the Harvey Canal. The project was authorized by the Water Resources Development Act of 1986 (Public Law 99-662). East of Harvey Canal was authorized as a modification to this project.

D. Southeast Louisiana. The Southeast Louisiana Project was authorized by Section 10 of the Fiscal Year 1996 Appropriations Act. The purpose of this project is to reduce flood damage on Jefferson, Orleans and St. Tammany Parishes.

4. Local Cooperation. In accordance with the cost sharing and financing concepts reflected in the Water Resources Development Act of 1986 (Public Law 99-662), and the authorizing documents, the non-Federal Sponsor must comply with the following requirements.

A. Provide lands, easements, and rights-of-way, and borrow and excavated material disposal area.

B. Accomplish all alterations and relocations to utilities and facilities (other than railroad bridges) necessary for construction of the project.

C. Pay 34.75 percent of the first cost allocated to hurricane protection. Funds provided by non-Federal interests for the interim hurricane protection may be considered beneficial expenditures and may be credited as part of the non-Federal contribution of the project pursuant to the Water Resources Development Act of 1986.

D. Bear all costs of operation, maintenance and replacement of all features of hurricane protection facilities.

5. Status of Local Cooperation. The Louisiana Department of Transportation and Development is the non-Federal Sponsor for construction of this project. A Project Cooperation Agreement (PCA) is being developed and will be signed before initiation of project construction.

6. Project Document Investigations.

A. General. A Feasibility Report entitled "West Bank of the Mississippi River in the Vicinity of New Orleans, LA. (East of the Harvey Canal)" dealing with providing hurricane protection for the West Bank of the Mississippi River in the vicinity of New Orleans for the area east of Harvey Canal was completed in August 1994. This study recommended SPH level protection consisting of a navigable floodgate in the Harvey Canal, a 1,000 cfs increase in capacity at the Cousins Pumping Station, a combination of levees and floodwalls on the east side of Harvey Canal from the floodgate to Hero Pumping Station and raising the existing protection along the east and west sides of Algiers Canal and Hero Canal. Studies, investigations and planning made for this DM include the following:

(1) surveys,

(2) soils investigations including general and undisturbed type borings,

(3) detail design studies for construction of the pumping station, fronting protection and floodwalls,

(4) determination of real estate requirements and costs,

(5) determination of required relocations and coordination with affected facility owners; determination of relocation costs,

(6) cost estimates for the pumping station, fronting protection, floodwalls and levees.

B. Future investigations required. Future investigations to be performed include field surveys and soil borings in connection with the Plans and Specifications for the project.

LOCATION OF PROJECT AND TRIBUTARY AREA

7. Project Location. The Cousins Pumping Station Complex portion of the East of Harvey Hurricane Protection features of the West Bank of the Mississippi River in the Vicinity of New Orleans, Louisiana Project is located in southeast Louisiana in Jefferson Parish, on the west bank of the Mississippi River (Plate G-1).

PROJECT PLAN

8. General. The project work will consist of raising the flood protection along the Cousins Outfall Canal to the SPH level. Both the First Avenue Canal and the Cousins Pumping Station will be enlarged to accommodate an additional 2,000 cfs. A frontal protection T-wall will be provided on the discharge side of the Cousins Pumping Station. The outfall canal will be enlarged, and parallel protection I-walls will be provided. The Destrehan Avenue Bridge will be lengthened by one (1) sixty-foot span, and floodgates will be constructed at each end of the bridge. A required closure wall in the existing outfall canal will route the outfall discharge through required flume under the Lapalco Bridge into the Harvey Canal.

The authorized plan called for the addition of 1,000 cfs pumping capacity at the Cousins Pumping Station and modification of First Avenue Canal to accommodate an additional 1,000 cfs. Addition of another 1,000 cfs of pumping capacity was authorized under the Southeast Louisiana Project. This document contains designs for the addition of 2,000 cfs to the Cousins Pumping Station. Separate cost estimates are provided for the 1,000 and 2,000 cfs additions. The Ease of Harvey Project will pay for the addition of the first 1,000 cfs and the Southeast Louisiana Project will pay for the addition of the second 1,000 cfs.

HYDROLOGY AND HYDRAULICS

9. Hydrology.

A. General. The hydrology and hydraulic analysis for the East of Harvey Hurricane Protection features of the West Bank of the Mississippi River in the vicinity of New Orleans, Louisiana Project was presented in the Feasibility Report entitled West Bank of the Mississippi River in the Vicinity of New Orleans, La. (East of the Harvey Canal), August 1994. This document presented detailed descriptions and analyses of the hydrologic regime of the area and detailed descriptions and analyses of the hydraulic methods and procedures used in design of the features of this plan. Also included were essential data, assumptions and criteria used and results of studies that provide the basis for determining surges, routings, wind tides, wave runup and overtopping and frequencies. All basic hydraulic information required for design of the East and West of Algiers feature of the East of Harvey HPP project is included in this report.

B. Design Hurricane. The design hurricane is the SPH. The SPH represents the most severe combination of hurricane parameters that is reasonable characteristic of the area, excluding extremely rare combinations. The hurricane would approach each individual site at such a rate of movement as to produce the maximum hurricane surge at each location of interest. The SPH has a central pressure index of 27.4 inches of mercury, a maximum 5 minute average wind velocity offshore (in the Gulf of Mexico) of 100 knots 30 feet above the surface at a radius of 30 nautical miles, and a forward speed of 11 knots along a path critical to each location of interest.

C. Design Heights of Protected Structures. Predicted hurricane surge height for existing conditions along Harvey Canal is +7.5 NGVD and design elevation for protective structures is +9.5 NGVD. Historical evidence of sea level rise and subsidence indicates the need for a projection of storm surge stages and their effect on this project's effectiveness. Sea level rise of 0.5 foot per century along the Gulf Coast is recommended by the latest Corp's guidance. Estimates of subsidence in coastal Louisiana were developed by COE geologists from radio carbon dating of buried marsh deposits. Using the projected sea level rise of 0.25 foot in the next 50 years and the appropriate subsidence rate in the coastal zones bordering the project area, hurricane surge heights, which could be expected in the year 2040, were computed.

Predicted surge height for 50-yr. future conditions is +9.3 NGVD and elevation for protected structures is +11.5 NGVD.

10. Hydraulics.

A. General. Water from Cousins Canal and First Avenue Canal will be pumped to Cousins Discharge Channel, which will flow into Harvey Canal. The existing and design flow in Cousins Canal is 2,000 cfs. Existing flow in First Avenue Canal is 1,000 cfs. Two alternate design flows are considered for First Avenue Canal. Alternate 1 involves an additional 1,000 cfs flow in First Avenue Canal (total 2,000 cfs). Alternate 2 involves an additional 2,000 cfs discharge in First Avenue Canal (Total 3,000 cfs).

The existing flow in Cousins Discharge Channel is 3,000 cfs. The design flow in Cousins Discharge Channel will be 4,000 cfs according to Alternate 1 and 5,000 cfs according to Alternate 2.

HEC-2 Model runs were performed to determine water surface elevations and velocities in First Avenue Canal and Cousins Discharge Channel. Detailed HEC –2 model results are presented in Appendix B.

In addition, a physical model was built by Alden Research Laboratories, Massachusetts, for the Cousins Canal, First Avenue Canal and Cousins Discharge Channel. The results of the physical model are incorporated in the design. Description and results of physical model are presented in Appendix D.

B. Design Criteria. The design criteria for the First Avenue Canal and Cousins Discharge Channel are described in the following subsections.

1) Design Criteria for First Avenue Canal. The design criteria for the First Avenue Canal as per the Jefferson Parish Master Drainage Plan is to flow 2,100 or 3,100 cfs. The desired water surface elevation at the downstream side of First Avenue Canal (near Cousins Pump Station forebay) is -6.7 NGVD and on the upstream side of the First Avenue Canal (near Harvey Pump station) is -6.3 NGVD.

2) Design Criteria for Cousins Discharge Channel. HEC-2 Model run was performed to determine the water surface profiles in Cousins Discharge Channel for the following discharges that were based on the Jefferson Parish Master Drainage Plan:

TABLE 1
Design Criteria for Cousins Discharge Channel

DISCHARGE*	SCENARIO
1) 3,000 cfs	Existing discharge of 2,000 cfs through Cousins Canal and existing discharge of 1,000 cfs through First Avenue Canal
2) 4,000 cfs	Existing discharge of 2,000 cfs Through Cousins Canal and proposed discharge of 2,000 cfs through First Avenue Canal
3) 5,000 cfs	Existing discharge of 2,000 cfs through Cousins Canal + proposed discharge of 2,000 cfs through First Avenue Canal + an additional 1,000 cfs capacity in Cousins Pump Station

*Rounded to nearest thousand

The following down stream elevations are considered at Harvey Canal, which were based on the previous HEC-2 model runs performed by the Corps of Engineers:

TABLE 2
Down Stream Elevations at Harvey Canal Considered for HEC-2 Model

Number	Elevation in feet NGVD	Description
1.	-1.0	Maximum Drawdown Stage from the Standard Project Hurricane not on critical path
2.	0.0	99 % Duration Stage
3.	1.0	Approximate Low Mean Stage
4.	2.0	Approximate Normal Water Level
5.	3.0	Max. Elevation at which the Sector Gate would be operated
6.	4.0	0.1% Duration Stage
7.	5.0	Highest Stage of Record
8.	7.5	Hurricane Stage

C. Improvements to First Avenue Canal. The First Avenue Canal will be widened from the Harvey Pumping Station to the Cousins Pumping Station to accommodate an additional 2,000 cfs. The additional 2,000 cfs is required to bypass the Harvey Pumping Station when the proposed sector gate is closed during storm events. The current capacity of the Harvey Pumping Station is 1,000 cfs and an additional 1,000 cfs is added to First Avenue Canal as a result of improvements made under the Southeast Louisiana Project.

1) General. HEC-2 model runs were performed for First Avenue Canal for the following cases:

TABLE 3
Description of HEC-2 Model Runs for First Avenue Canal

Case No.	Channel Description	Elevation at Cousins P/S (ft. NGVD)	Discharge First Ave. (cfs)
Case 1	Existing channel cross sections and profile	-6.7	1,000, 2,100 and 3,100
Case 2	Design channel cross-section: bottom width 68' with 1V to 3H slope for approximately 1,000 ft from the Cousins P/S and bottom width 50' and 1V to 6H side slope for the remaining part of the Canal	-6.7	1,000, 2,100 and 3,100
Case 3	Design channel cross-section: bottom width 108' with 1V to 3H slope for approximately 1,000 ft from the Cousins P/S and bottom width 91' and 1V to 6H side slope for the remaining part of the canal	-6.7	1,000, 2,100 and 3,100

2) Results and Discussion for Case 1. The HEC-2 results for Case 1 indicated that the First Avenue Canal is capable of delivering a discharge of up to 3,000 cfs without overtopping the banks. However, it will not meet the Jefferson Parish Master Drainage Plan criteria of -6.3 NGVD (+14.13 C.D.) elevation at the upstream (near Harvey Pump Station). Therefore the First Avenue Canal needs to be improved.

3) Results and Discussion for Case 2. The results for Case 2 indicated that the First Avenue Canal, with the proposed cross-section, will deliver the 2,100 cfs discharge close to the Master Drainage Plan criteria. However, it will fail to meet the criteria with 3,100 cfs.

4) Results and Discussion for Case 3. The results for Case 3 indicated that the proposed cross section will deliver a discharge of 3,100 cfs with a water surface elevation at the upstream of the First Avenue Canal of -6.2 NGVD, which is close to the Master Drainage Plan criteria and is acceptable to Jefferson Parish.

D. Improvements to Cousins Canal. Improvements to the Cousins Canal are being done under a separate project included in the Southeast Louisiana Project.

E. Improvements to Cousins Discharge Channel. HEC-2 model runs were performed for Cousins Discharge Channel for the following cases:

TABLE 4
Description of HEC-2 Model Runs for Cousins Discharge Channel

Case Number	Channel Description	Elevations at Harvey Canal (ft. NGVD)	Discharge (Cousins Discharge Channel) (cfs)
Case 1	Existing channel cross sections and profile	-1 to +7.5	3,000, 4,000 and 5,000
Case 2	Design channel cross-section and profile (channel bottom -8 NGVD and -9 NGVD)	-1 to +7.5	4,000 and 5,000
Case 3	Sensitivity analysis. i.e., by varying Manning's 'n' and contraction and expansion coefficients using design channel cross-section and profile (channel bottom -9 NGVD)	-1 to +7.5	5,000
Case 4	Corps of Engineer's design of channel and culvert	-1 to +7.5	5,000

1) Results and Discussion for Case 1. The results of these runs indicated that, in some cases, the downstream elevations considered at Harvey Canal are higher than the existing bank elevations of the Cousins Discharge Channel. Therefore, the computed water surface elevations show overtopping of the banks. The water surface profiles for lower elevations (-1.0, 0.0, and 1.0 NGVD) at Harvey Canal showed unsteady flow pattern in sections close to Harvey Canal. It was observed

that the discharge channel bottom at those sections exhibit reverse slope with significant reduction in the channel cross-section. Hence, it is recommended that the channel cross-section be modified to reduce the velocity of water and turbulence as it meets the Harvey Canal. It was also observed that the computed water velocities in these sections are significantly higher than the previous sections. This may be attributed to the fact that the existing channel cross-sections at these sections are significantly constricted because of reduced depth of the channel. The Destrehan Avenue Bridge crosses the discharge channel between the pump station and the Harvey Canal was considered in these model runs for possible flow restrictions in the channel. It was determined that the flow in the Cousins Discharge Channel would be impeded by the bottom girder when the elevations at Harvey Canal are higher and/or the discharges through the channel are higher.

2) Results and Discussion for Case 2. Since the existing Cousins Discharge Channel showed very high velocities and water surface elevations for certain cases, it was determined that the Cousins Discharge Channel must be improved. Therefore, two alternate designs were proposed for channel improvement by considering the depth to -8 and -9 NGVD. The results indicated that, compared to both existing conditions and design with a channel bottom of -8 NGVD, a design channel bottom of -9 NGVD will significantly reduce the water surface elevations and velocities all along the Cousins Discharge Channel and in particular, near the Destrehan Avenue Bridge and the proposed culvert.

3) Results and Discussion for Case 3. Sensitivity Analyses was performed by running additional HEC-2 model runs by varying the Manning's coefficient and the contraction and expansion coefficients. Additional cross-sections were also incorporated at the proposed Cousins Discharge Channel bend. The results of these runs indicated a head loss of less than 6 inches between the discharge basin and the proposed culvert, except for some extreme instances where the Manning's coefficient and/or the contraction and expansion coefficients were higher than normal and the water surface elevations in the Harvey Canal were lower than normal conditions.

4) Results and Discussion for Case 4. HEC-2 model runs were performed for using the preliminary design shown in the West Bank of the Mississippi River in the Vicinity of New Orleans, La. (East of the Harvey Canal) - Feasibility Report. The Feasibility Report design has shorter reach of the Cousins Discharge Channel by pass and uses two box culverts between Lapalco Bridge piers. Due to this reason the estimated velocities at the culvert location are significantly higher as compared to the velocities at the location of the culvert proposed in this Design Memorandum for a 5,000 cfs discharge.

F. Improvements to Cousins Pump Station. The proposed project consists of an addition to Cousins Pumping Station. The addition consists of two (2) 1,000 cfs horizontal pumps which will be constructed on the north side of the existing station. The additional 2,000 cfs is required to bypass the Harvey Pumping Station when the proposed sector gate is closed during storm events. The current capacity of the Harvey Pumping Station is 1,000 cfs with an additional 1,000 cfs called for in the Jefferson Parish Master Drainage Plan. Based on the results of the Alden Research Laboratory report, modifications will be made to the existing intake basin to smooth flow into the pump station.

GEOLOGY

11. General. The Geotechnical Investigation included drilling undisturbed borings, soil mechanics laboratory tests, and engineering analyses. Engineering analyses, based on the soil borings and laboratory test results, were made to determine recommendations regarding allowable pile load capacities, estimates of settlement, wall pressures, levee stability analyses, I-wall and T-wall analyses, overall pump station stability, canal stability, and construction recommendations. The results of the soil borings, laboratory tests, and analyses, together with appropriate recommendations, are included in the report of the Geotechnical Investigation (See Geotechnical Appendix Volume II).

SOILS AND FOUNDATIONS INVESTIGATION AND DESIGN

12. General. Soils and foundation investigation included drilling undisturbed borings, soil mechanics laboratory tests, and engineering analyses. Engineering analyses, based on the soil borings and laboratory test results, were made to determine recommendations regarding allowable pile load capacities, estimates of settlement, wall pressures, levee stability analyses, I-wall and T-wall analyses, overall pump station stability, canal stability, and construction recommendations. The results of the soil borings, laboratory tests, and analyses, together with appropriate recommendations, are included in Volume II.

DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

13. Pump Station and Appurtenances.

A. Cousins Pump Station. This design memorandum covers two (2) alternates for the modifications to Cousins Pumping Station. Alternate No. 1 is the addition of one (1) 1,050 cfs horizontal pump into the existing Cousins Complex. The additional 1,000 cfs is needed to replace the current capacity of the Harvey Pumping Station when the sector gate in the Harvey Canal is closed. The Harvey Pumping Station currently discharges 1,000 cfs into the Harvey Canal north of the proposed sector gate. Alternate No. 2 is the addition of two (2) 1,050 cfs horizontal pumps into the existing Cousins Complex. The additional 2,100 cfs is for the existing 1,000 cfs at the Harvey Pumping Station and proposed 1,000 cfs addition to the Harvey Pumping Station which is authorized under the Southeast Louisiana Project.

1) <u>Alternate No. 1 - 1,050 cfs addition</u>

Scope: Under this alternate a single horizontal pump with associate drive equipment shall be installed in a new pump station addition to the north of the original Cousins Station. The station will house all the accessories that are needed to support a single one (1) 1,050 cfs horizontal pump.* The Accessories shall include:

(a) One (1) Parallel Reduction Gear*
(b) One (1) 3400 BHP (Continuous) @ 900 rpm Diesel Engine*
(c) One (1) Air Cooled Engine Radiator*
(d) One (1) 1,000 gallon Elevated Fuel Oil Storage Tank
(e) One (1) Electric Motor driven Air Compressor
(f) One (1) Diesel Engine driven Air Compressor
(g) One (1) 2100 cfm Elect. Motor Driven Vacuum Pump
(h) One (1) 2100 cfm Diesel Engine Driven Vacuum Pump
(i) One (1) 750 gallon (100 ft^3) Elevated starting Air Storage Tank
(j) One (1) 750 gallon waste Lube Oil Tank
(k) One (1) waste Lube Oil Transfer Pump
(l) One (1) 350 cubic Feet Barometric Tank
(m) One (1) Engine Control Panel*
(n) One (1) Exhaust Silencer*
(o) One (1) Air Intake Filler & Silencer*
(p) Three (3) 20,000 gallon Fuel Oil Storage Tank
(q) One (1) Duplex Fuel Oil Transfer Pump w/ Separator & Strainers
(r) One (1) 30 feet Wide Trash Screen w/ Climber Type Rake
(s) Four (4) Electric Exhaust Fans
(t) Three (3) 250 gallon Elevated Fuel Oil Day Tank (Cousins No. 1)

* Denotes equipment to be supplied by Pump Manufacturer/Supplier under a separate contract. Regardless of which alternate is chosen, the description of the equipment for the installation of a single 1,050 cfs pump is identical to that of two (2) 1,050 cfs horizontal pumps.

2) <u>Alternate No. 2 - 2,100 cfs addition</u>

Scope: Under this alternate Two 1,050 cfs horizontal pumps with all associated drive equipment shall be installed in a new pump station addition constructed to the north of the original Cousins Station. The new station will house all accessories that are needed to support two (2) 1,050 cfs horizontal pumps.* These Accessories shall include:

(a) Two (2) Parallel Reduction Gears*
(b) Two (2) 3400 BHP (Continuous) @ 900 rpm Diesel Engine*

(c) Two (2) Air Cooled Engine Radiator
(d) Two(2) 1,000 gallon Elevated Fuel Oil Storage Tank
(e) One (1) Electric Motor driven Air Compressor
(f) One (1) Diesel Engine driven Air Compressor
(g) One (1) 2100 cfm Elect. Motor Driven Vacuum Pump
(h) One (1) 2100 cfm Diesel Engine Driven Vacuum Pump
(i) Two (2) 750 gallon (100 ft^3) Elevated Starting Air Storage Tank
(j) One (1) 750 gallon waste Lube Oil Tank
(k) One (1) waste Lube Oil Transfer Pump
(l) Two (2) 350 cubic feet Barometric Tank
(m) Three (3) 20,000 gallon Fuel Oil Storage Tank
(n) One (1) Duplex Fuel Oil Transfer Pump w/ Separator & Strainers
(o) Two (2) 30 feet Wide Trash Screen w/ Climber Type Rake
(p) Six (6) Electric Exhaust Fans
(q) Two (2) Engine Control Panels*
(r) Two (2) Exhaust Silencers*
(s) Two (2) Air Intake Fillers & Silencers*
(t) Three (3) 250 gallon Elevated Fuel Oil Day Tank (Cousins No. 1)

* Denotes equipment to be supplied by Pump Manufacturer/Supplier under a separate contract. Regardless of which alternate is chosen, the description of the equipment for the installation of a single 1,050 cfs pump is identical to that of two (2) 1,050 cfs horizontal pumps.

3) Pump Operation. It is the intent of this document to propose equipment that when designed and constructed operates to meet the requirements set forth and follows the guidelines of operation for the similar pumps in the adjoining station. The horizontal pump shall provide a minimum pump capacity of 1,050 cfs at nominal intake and tidal head conditions. This pumping equipment selection will be capable of continuous pumping at both the current +7.50 NGVD storm surge requirements as well as the future projected storm surge of +9.50 NGVD.

4) Pump Tidal Protection. The discharge tube(s) proposed for the station addition will have a high invert of +9.50 NGVD for protection against the current and projected prediction of tidal surge events. The existing horizontal pumps have a discharge high invert of +5.07 NGVD. Based on this current protection, an intake tube ceiling elevation at its lowest invert of -16.50 and a 0.5 foot buffer or safety factor, the intake canal can be at elevation -11.57 NGVD or higher and continue to be protected against a +9.50 surge by using air suppression. The original Cousins Station that houses the three (3) 72 inch diameter and one (1) 36 inch diameter verticals have discharge pipe high inverts of +5.39 NGVD. At this elevation and the fact that the intake bells are below El. -20.00, air suppression could be considered for tidal protection on the verticals. Suppression would be a valid method of protection to intake elevations in excess of -15.00 when considering a +9.50 surge and a 0.50 foot buffer. However, since the discharge tubes of these pumps must be extended approximately 35 feet to accommodate the

new flood wall construction, it is more practical to install butterfly valves in both 72 inch and 36 inch discharges when the pipe is extended. To extend each of these discharges the existing discharge bells must be relocated to the flood side of the discharge flood wall. This will require the relocation of the vacuum breaker system and construction of an access catwalk to the protected side of the new flood wall. The 72 inch diameter discharge tubes should be fitted with a 24 inch diameter air release check valve and the 36 inch tubes with a 12 inch air release valve. These valves should be placed at the high point of the discharge just upstream of the discharge bell mitered elbow.

5) Pumping Equipment. The pumping equipment package which is composed of a 1,000 cfs, 132 inch diameter horizontal pump, a parallel reduction gear, diesel drive engine, engine control panel, exhaust silencer, intake air filler and silencer are all part of an equipment package to be supplied by others outside the scope of this contract. The equipment selected is described in the technical specifications in Appendix C, Mechanical Machinery. This equipment will be purchased under separate contract but installed under the construction contract for this station. The selection of the equipment type reflects the philosophies and desires by Jefferson Parish Department of Public Works as well as the design requirements set forth by the U.S. Corps of Engineers. The selection of remote mounted air cooled radiators versus Keel Coolers was one request made by the Parish. It was their feeling that remote radiators could be more easily maintained than the submerged Keel Coolers especially since there will be a 25 ton crane installed to service the pump rotating element regardless.

6) Overhead Cranes. The pumping station will be equipped with two overhead bridge type traveling cranes. A crane with 25 tons capacity will be installed inside the building to handle the engines, gears, vacuum pumps and other equipment located in the building. A crane with a capacity of 25 tons will be installed outside the building, over the 1,050 cfs pumps and will be used to handle these and other miscellaneous equipment in the area. The cranes will be controlled by pendant from the trolley with weatherproof controls.

B. Bar Screen and Mechanical Trash Rake

1) Bar Screen. Bar screens constructed of 0.5 inch x 9 inch galvanized steel flat bars on 4 inch centers and located at the inlet to the pump station preventing trash and debris from entering and damaging the pump or getting into the outfall canal.

2) Mechanical Trash Rake. Trash rakes will be provided to remove debris that accumulates on the bar screen. This trash rake will be of the climber type and will consist of a continuous unit. The unit will consist of vertical raking members mounted between two steel side frames.

A pin rack designed to mesh with two (2) cog wheels will be installed in each side frame. Debris will be removed from the 9 inch bar screen by a stainless steel rake assembly that is designed to mesh with the bar screen and span the entire channel.

The rake shall be driven by two (2) 10.0 horsepower, totally enclosed severe duty motors and shall be controlled by both local and remote control panels which shall be capable of either manual or automatic activation.

C. Fuel Oil Systems

1) General. The fuel oil systems for each pumping plant will include fuel oil storage tanks, transfer pumps, day tanks, piping control and alarms.

The new station will require the replacement of the four existing 10,000 gallon ground storage tanks to construct the new station. The existing fuel tanks will be replaced with three (3) new 20,000 gallon horizontal tanks to obtain a total fuel capacity of 60,000 gallons. This will include providing new elevated day tanks for the existing station to match the fuel delivery system proposed for the new station. Currently, the existing stations use exterior transfer pumps to pump to a floor mounted day tank which supplies fuel to and returns fuel back from the pump, compressor, generator and vacuum pump diesel engines. To circulate fuel back to the main storage tanks, a fuel pump out pump must be used. Under the new arrangement a new duplex transfer pump will be installed near the new and relocated storage tanks. Each pump will have its own dedicated discharge that can supply fuel to each day tank at each station. The new day tanks will be elevated to provide a positive head of fuel to the engines and gravity return or overflow back to the storage tanks. To provide uniformity in the method of operation, the existing original and station addition shall be equally reconfigured. This will require elevating the day tanks and repiping the fuel system to achieve the same operations as the proposed station.

2) Fuel Oil Storage Tanks. An additional 10,000 gallon fuel tank for each 1,000 cfs pump will be installed adjacent to the area proposed for relocation of the existing 10,000 gallon tanks. This capacity will provide sufficient fuel for all pumping operations for no less than three (3) days operation without refueling.

3) Fuel Oil Day Tanks. The pump engine will have a 1,000 gallon capacity fuel oil day tank. The day tank will be constructed of carbon steel in accordance with the National Fire Protection Association and have fill, overflow, drain, vent and outlet connections, level indicating gauge, and float switch to automatically control the fuel inlet solenoid valve and fuel oil transfer pump which fills all of the day tanks from the storage tanks. High and low level alarms will also be provided. In addition to the 1,000 gallon day tanks at the new station addition, three (3) 250 gallon elevated day tanks will be installed at Cousins No. 1 and two (2) 1,000 gallon elevated day tanks will be installed at Cousins No. 2 so that the

entire fuel system will operate by pumped fuel to the day tanks and return fuel to the supply tanks by means of gravity.

4) Fuel Oil Transfer Pumps. The existing Fuel Oil Transfer Pumps will be relocated and re-piped to provide fuel transfer from the fuel oil storage tanks to the station Day Tanks (including the existing stations).

D. Vacuum Priming Systems.

1) General. The vacuum priming system will provide vacuum priming for the 1,050 cfs pump, vacuum breaker valves to prevent back siphoning when a pump is stopped, and low pressure compressed air to depress the water level in all existing horizontal pump discharge tubes or lines under emergency conditions. The vacuum priming system for the 1,050 cfs pump will consist of one electric motor driven vacuum pump complete with barometric tanks, piping valves and controls. The vacuum breaker valves which will be located at the high point of the discharge tubes, will be pneumatically operated with a spring to open/air to close diaphragm valves and capable of automatic or manual operation.

2) Vacuum Pumps. An electric motor driven vacuum pump will be the primary vacuum pump to prime the 1,050 cfs pump system in the station. The pump will be a complete integral unit with the pump and motor mounted on a skid base. The pump will have a continuous rating of 2,100 cfm at 20 inches of mercury and will be driven by a 125 H.P. electric motor. The pump will be of the centrifugal water displacement type, single stage, capable of handling slugs of water without damaging the pump. The pumps will be Nash Engineering Co. Model CL-2002 or equal. The standby or emergency vacuum pump will be the same model and capacity as the electric driven pumps, but will be driven by a diesel engine through a reduction gear and clutch. The diesel engine will have a 175 continuous horsepower rating and will be radiator cooled. The pump, engine and reduction gear will be a complete integral unit mounted on a skid.

3) Vacuum Breaker Valves. One pneumatically operated and one manually operated (for emergency) vacuum breaker valves and associated piping will be located at the high point of all pump discharge tubes. The automatic operation of the vacuum breaker value will be initiated by a RPM sensor on the pump input shaft.

4) Air Suppression System. The primary source of suppression air to depress the water level in the existing horizontal pump discharge tubes under emergency conditions will be the two 2,100 cfm vacuum pumps acting as low pressure air compressors. This reversal of air flow is accomplished by manually operated valves in the vacuum piping system. The suppression air pressure is 3.5 to 4.0 psig. The entire system is protected against excessive vacuum or pressure by a combination vacuum and pressure relief valve.

Connection to existing system although the new 1,000 cfs pump will have its own dedicated primary and backup vacuum pumps for priming and air suppression purposes, it shall also be connected to the existing vacuum pumps to create redundancy and increased capacity. Because of its proximity, the addition of air suppression to the proposed pumps can simply be accomplished by connecting to the vacuum prime system. Therefore, the new pumps will have suppression capability also.

E. Compressed Air System

1) General. The compressed air system will provide air to three pressure levels. Air will be compressed and stored at 250 psig. The highest pressure system will be used for starting the diesel engines driving the 1,000 cfs pump. Pressure reducing stations will be provided to reduce pressure from the highest level to 160 psig for general plant use, to 30 psi for instrument air. Two air compressors, one electric motor driven and one diesel engine driven, will provide air for all systems. As with the vacuum breaker system, the new compressed air system will provide redundancy and increased air capacity when connected to the compressed air system of the existing station. Compressed air, reduced to 3.5 psig will also serve as a back up to the air suppression system supplied by the vacuum pumps.

2) Air Compressors. The two air compressors will be two-stage, air-cooled, reciprocating type with air-cooled intercoolers. The capacity of each compressor will be 600 cfm at a minimum continuous discharge pressure of 250 psig. The electric drive unit will be driven by a 20 H.P., 1,800 RPM 480 volt, 3-phase, 60 hertz ball bearing induction motor.

The diesel drive unit will be driven by a 25 H.P., 2,000 RPM diesel engine. Each unit will be skid mounted and a complete package completely pre-wired with all required controls which will be the dual type combination of automatic start-stop or constant speed pressure unloader with manual selection switch.

3) Air Storage Tanks and Piping. Two (2) 750 gallon (100 ft^3) storage tanks will be provided at the new station. Tanks will be designed for and ASME and National Board Stamped for an operating pressure of 300 psig. Piping will be Scheduled 80 galvanized steel pipe with socket welded fittings. Air tanks will be elevated to provide additional floor space for pump operation and floor space efficiency.

F. Ventilation System. Forced ventilation will be required in order to prevent temperatures within the building from reaching critical levels. Six (6) 42 inch direct drive panel fans will be required to provide exhaust functions. The fans shall have a capacity of 23,200 cfm at 0.25 inch static pressure standard air. The drive shall be a three horsepower, 1160 RPM, NEMA Design B direct drive electric motor. This motor shall be a heavy duty, industrial continuous duty motor suitable for operation on 230/460 volts, 3 phase, 60 hertz.

Two hundred seventy five (275) square feet (gross area) of intake louvers will be provided on the East face of the buildings. This will provide approximately 138 square feet of free intake area. With the six exhaust fans operating at full capacity, this will provide a louver air velocity within the station of 1,000 feet per minute. The intake louvers shall be designed to be self draining and sized for free air velocity to be at least 200 fpm below the point of beginning water penetration of 2 oz. of water per square foot of free area. The intake louvers shall be manually operated.

G. Site Utilities.

To complete the station addition, several utilities must be relocated due to its current location being near the proposed station location. These utilities are as follows:

1) Emergency Well Water. The existing water well is located just adjacent to the fuel tank farm. Its location may require the well to be abandoned to facilitate construction. If relocation is required as established by final design, a new well of equal size will be located adjacent to the new fuel farm location. The submersible pump will be re-used in the well and the existing well will be plugged and abandoned.

2) Mechanical Sewer Treatment Plant. The location of the existing mechanical sewer treatment plant requires it to be relocated prior to construction of the new station. The plant will be up sized to handle the additional sewer flow attributed to the new bathroom facility required for the new station addition.

3) Propane Tanks. The propane tanks located north of Cousins No. 1 must be likewise abandoned and relocated to provide the area needed for construction of the station addition.

H. Electrical Distribution System. Cousins Pumping Station is presently served by an 800A, 480V, 3∅, 3W underground service. The service pole is located on Lapalco Boulevard side with a bank of 3-167.5 kVA transformers. The underground service is terminated in the Motor Control Center in a metal building. This service feeds both the original pumping station (1973) and the addition (1983). The total connected load is 475kVA. The existing emergency generator is located inside the metal building (1983) and rated at 420kW, 480V, 3∅, 3W.

Both the normal and emergency services are loaded to their maximums. Major alterations to existing normal service would be required if the new pumping station were to be fed from the present service. A more economical approach would be to feed the new pumping station from a separate pole located as indicated on the site plan. New emergency generator proposed is 400kW, 480V, 3Ø, 3W located as indicated on site plan. The One-Line diagram on Sheet E-2 indicated the proposed distribution system.

14. Culvert. The HEC-2 model runs performed using the preliminary design shown in the West Bank of the Mississippi River in the Vicinity of New Orleans, LA. (East of the Harvey Canal) – Feasibility Report show high velocities at the culvert location. The Feasibility report called for two (2) Box culverts between piers of the Lapalco Bridge. From the perspective of hydraulics, this design will increase the velocities not only due to the obstruction caused by the pier but also due to the shorter reach of the modified Cousins Discharge Channel. Therefore, the culvert location is proposed to be moved closer to the Harvey Canal, adding approximately 150 feet to the Cousins Discharge Channel reach. The site is located directly below the Lapalco Boulevard Bridge on the west side of the main bridge piers, as shown on PLATE C-1.

    Two construction methodologies were considered for the culvert (flume) structure: conventional cofferdam, pile-supported, cast in place, concrete structure and a float-in, pile-supported, concrete-gravity structure. The cost of the cast in place structure was estimated at $3,123,679.00 (see Appendix E sheet S-12). The cost estimate of the pile-supported, float-in, concrete-gravity structure was considerably less at $2,448,732.00 (see Appendix A Detail Estimate of Incremental Cost page A-9).

    Therefore the design discharge flume included in this Design Memorandum consists of a pile-supported, float-in type, concrete-gravity-structure; whose function is to provide proper hydraulic flow from the Cousins Pump Station while providing anti-scour protection to the West piers of the Lapalco Bridge.

    The float-in culvert is simply an "open-culvert" when installed, and due to the "flow-through" design, the Load Case scenario of dewatering was eliminated from consideration and not considered for cost projections.

    The culvert will have a clear opening of 107.67 feet with a sill elevation of –9.00 NGVD. The seven and one half foot deep hull is installed at elevation - 16.50 NGVD, allowing a sill elevation of - 9.00 NGVD. The wing walls are 8 feet wide and 111 feet long, and extend to an elevation of +9.50 NGVD with a design elevation of +11.50 to allow for the 50 year subsidence, as shown on PLATE C-2.

15. Destrehan Bridge Extension. Destrehan Avenue Bridge will be lengthened by the addition of one sixty-foot span to accommodate the widening of the Cousins Pumping Station discharge channel. A bottom roller floodgate will be provided at each end of the bridge. For bridge details, see Plates B-1 and B-2.

16. Roller Gates. Bottom roller type floodgates will be provided at each end of the Destrehan Avenue Bridge at the following stations:

Gate Number	Centerline Station	Gate Opening Width
1	2+46.63 North Wall Line	40 feet
2	3+03.19 South Wall Line	40 feet

*See Plates R-1 to R-5 for details.

17. Floodwalls.

A. I-type Floodwalls.
The project includes 1123 feet of I-type floodwall protection along the banks of the Cousins Pumping Station discharge channel. The I-walls include two (2) bottom roller floodgates and ties into the pump station frontal protection on the west end of the discharge channel and the closure wall/cantilevered sheet pile wall on the east end of the discharge channel. The detailed alignment of the proposed I-wall is shown on Plate G-4. Typical I-wall design sections are shown on Plates F-7 through F-10.

B. Cantilevered Sheet Pile Wall.
The project includes 184 feet of cantilevered sheet pile wall protection along the Cousins Pumping Station discharge channel. The cantilevered sheet pile wall is located on the south side of the discharge channel and ties into the I-wall on the west end and the concrete culvert on the west end. The detailed alignment of the proposed I-wall is shown on Plate G-4. The typical cantilevered steel sheet pile wall design section is shown on Plates F-7.

STRUCTURAL DESIGN

18. Criteria for Structural Design. The structural design presented herein complies with standard engineering practice and criteria set forth in Engineering Manuals and Engineering Technical Letters for Civil Works Construction published by the Office of the Chief of Engineers, subject to modifications indicated by engineering judgement and experience to meet local conditions.

19. Basic Data. Basic data relevant to the design of the protective works are described in the following table:

TABLE 5
RELEVANT STRUCTURAL DESIGN DATA

Water Elevations

	Elevations (Feet N.G.V.D.)
Still Water Level (Harvey Canal)	7.5
Still Water Level + 2 feet Freeboard (Harvey Canal)	9.5
Low Water Level (Harvey Canal)	0.0
Cousins Pumping Station Intake	-8.5

Levee and Floodwall Net Grades

I-Walls, Cantilevered. Sheet Pile Wall, Bottom Roller Floodgates*	11.5
Pumping Station Frontal Protection T-Wall	11.5
Culvert	11.5
Discharge Channel Closure Wall	11.5

* Note: Structural design for the foundations of I-walls, cantilevered. sheet pile wall and bottom roller floodgates have been analyzed to an elevation of 11.50 NGVD with a still water elevation of 9.50 NGVD to accommodate future sea-level rise. Proposed construction of these items provide protection to an elevation of 9.50 NGVD, which is the current Standard Project Hurricane.

20. Design Methods:

A. Reinforced Concrete. The design of reinforced concrete structures is in accordance with the requirements of the strength design method of the current ACI Building Code, as modified by the guidelines of EM 1110-2-2104 "Strength Design Criteria for Reinforced Concrete Hydraulic Structures", dated January 1990. The basic minimum compressive strength of concrete will be 3,000 psi, except for prestressed concrete piling, where the minimum will be 5,000 psi, and for the culvert structure, where the minimum will be 6,000 psi. For convenient reference, pertinent stresses are tabulated below:

TABLE 6
Pertinent Stresses for Reinforced Concrete Design

Reinforced Concrete

fc' (bridge and gate substructure)	3,000 psi
fc' (bridge and superstructure)	3,200 psi
fc' (pump station and floodwalls)	4,000 psi
fc' (prestressed piles and culvert)	6,000 psi
fy (Grade 60)	60,000 psi
Maximum Flexural Reinforcement Ratio	0.25x balance ratio
Minimum Flexural Reinforcement Ratio	200/fy
fu (Prestressing Strands, Grade 250)	250,000 psi
fu (Prestressing Strands, Grade 270)	270,000 psi

B. Prestressed Concrete. (Panels)

P/S Tendons 0.50 inch diameter 270 KSI steel stress relieved strand, tensioned to 28.9 kips, init. 0.60 inch diameter 270 KSI, as spec.

C. Post Tension.

P/T Conduit - 1.66 x .072 diameter steel tubing
P/T Tendons (Same as above)
P/T Grout 10 KSI.

21. Pumping Station. The proposed pumping station will consist of a reinforced concrete structure on a pile supported foundation. The superstructure will consist of rigid structural steel frames and steel framing. Typical sections are shown on Plates P-1 to P-7.

Brief general construction specifications for the structure items are as follows:

A. Foundation Piling. All piling shall be Class B timber piles of Southern Yellow Pine or Douglas Fir conforming to American Society for Testing and Materials Standard Specifications for Round Timber Piles Designation D-25, latest revision thereof. For pile length of 54 feet and less, minimum tip diameter shall be 7 inches and minimum butt diameter shall be 12 inches. For pile lengths 55 feet to 74 feet, inclusive, minimum tip diameter shall be 7 inches and minimum butt diameter shall be 13 inches.

B. Steel Sheet Piling. All steel sheet piling for the temporary cofferdams and permanent steel sheet pile walls shall meet the requirements of the Standard

Specification for Steel Sheet Piling of the American Society of Testing and Materials, ASTM Designation A 328, latest revision thereof.

C. Concrete. In advance of any concrete operations, all materials proposed for use in concrete will be sampled and tested to determine their compliance with specifications. All concrete shall be designed, proportioned, mixed, placed and cured in accordance with the American Concrete Institute Specification ACE 301 and the Portland Cement Association's Bulletin A Design and Control of Concrete Mixture.

All concrete for the pump station shall have a minimum 28-day compressive strength of 4,000 psi.

D. Reinforcing Steel. All reinforcing steel shall be ASTM A615, Grade 60, New Billet Steel Bars with deformations conforming to ASTM A305 and shall be detailed, fabricated, installed and accessories provided in accordance with the latest revisions of ACI 318 and ACI 301.

E. Structural Steel And Miscellaneous Iron. Standards for the erection of steel and the furnishing of material for the work shall conform to the following American Institute of Steel Construction Publications:

1) Code of Standard Practice for Steel Buildings and Bridges

2) Specification for the Design, Fabrication and Erection of Structural Steel for Buildings

3) American Society for Testing and Materials:

- Structural Steel shall conform to ASTM A-36
- Hot dip galvanizing shall conform to ASTM A-123.

22. Culvert and Sheet Pile Cut Off Wall.

A. Culvert.

1) General. The proposed culvert consists of a pile-supported, "float-in" type concrete gravity structure. Appendix "E" includes all of the spread sheet calculations for the culvert design S-1 through S-7. Spreadsheet S-1 calculates the weight and draft of the seven and a half-foot deep hull with the design elevation of +11.50 NGVD.

Calculations for determining the hogging moment at launch are shown on S-2 and S-3. Determination of hogging moment is necessary because of the eccentric load caused by the weight and center of gravity of the upper wing walls, which are located at the extreme ends of the hull. The hogging moment calculated, without ballast, is -14, 402 feet (kips). The equivalent hogging moment stress is 240 psi. The prestress in the sill of the hull is 520 psi, as shown on S-3, therefore, final prestress due to hogging moment, without ballast is 280 psi.

The transverse moment of inertia is calculated for use in the hogging moment stress calculations in spreadsheet S-3. Sheet S-4 and S-6 calculates the various load cases analyzed, and Sheet S-5 and S-7 calculates the Floatation Factor of Safety.

2) Load Cases. Three load cases were analyzed, as follows:

a. Load Case I: The launching scenario wherein the completed 7 feet deep hull with the 18.5 feet wing walls above the hull deck, or "sill", is floated out of a graving dock.

b. Load Case II: Develops the hull stresses and soil bearing values at water elevation of - 1.00 NGVD. The hull is installed with full ballast in the seven-foot section, and a minimum of 8 feet of water will exist in the wing walls due to the free-flooding feature of the hull wing walls. In this condition, a hogging moment of - 11,505 feet kips is developed, causing a tension in the sill at - 9.00 feet elevation of 188 psi, or approximately 50 psi less tension than the floating hull prior to installation. The soil bearing is 184 psf.

c. Load Case III: Calculates similar values for a flood tide of +9.50 feet and +11.5 NGVD.

(i) Design Elevation +9.50 NGVD: The hogging moment at the center of the hull is reduced to -5,103 feet kips in this condition, while another-6,489 feet kips of hogging moment is caused by the internal channel head against the wing walls, resulting in a final hogging moment of -14,191 feet kips. This results in a sill tension of 288 psf versus the original 520 psf prestress, so that the hull or sill does not have any tension in any of its components during a flood tide. The soil bearing stress is reduced to 163 psf, with only 2 feet of wing wall exposed above the flood tide.

(ii) Elevation +11.50 NGVD: The hogging moment at the center of the hull is reduced to 5,187 feet kips in this condition, while another 9,187 feet kips of hogging moment is caused by the internal channel head against the wing walls, resulting in a final hogging moment of 16,165 feet kips. This results in a sill tension of 257 psf versus the original 520 psf prestress, so that the hull or sill does not have any tension in any of its components during a flood tide. The soil bearing stress is reduced to 159 psf, with only 2 feet of wing wall exposed above the flood tide.

(iii) Factor of Safety. The factor of safety against floatation SFF is calculated on Sheet S-5, and S-7 for 9.5 and 11.5 design flood elevations respectfully in accordance with the USACOE Engineer Technical Letter No. 1110 2-307 for external pressure loading as well as for buoyancy of the submerged hull. In all load cases the factor of safety against floatation exceeded the recommended minimum value of 1.30.

3) Pile & Soil Bearing Analysis.

a. Soil Bearing Analysis, Sheet S-5, Piling Required: none.

b. Pile Supported Alternate – No Dewatering, Sheet S-6, Piling Required: 24-24 inch piles x 80 feet in 30 inch sleeves.

c. Pile Supported Alternate, With Dewatering and With Water Ballast, Sheet S-7, Piling Required: 24-36 inch piles x 115 feet in 42 inch sleeves.

d. Pile Supported Alternate, With Dewatering and With Concrete Ballast, Sheet S-8, Piling Required: 24-36 inch piles x 140 feet in 42 inch sleeves.

B. Connector Piles. Review of the proceeding three Load Cases indicates that the worse case scenario for the structure is Load Case II. To eliminate soil bearing, without dewatering, the analysis of this case showed that due to the soil bearing pressure of 184 to 200 psf the structure would require 24-24 inch diameter piles of 60 ton capacity, installed in and grouted to 30 inch diameter connector sleeves. These connector sleeves are cast into the hull grid. The analysis of this case is shown on Sheet S-6. Sheets S-7 and S-8 are based on a dewatering scenario, which, has been eliminated as a design scenario due to the open culvert design.

The sleeves are 30 inche diameter pipe of a minimum 0.5 inch wall thickness, and are anchored to the basic hull with welded studs on the outside of the sleeve, which are fully encased by the concrete pour in the appropriate cells, as shown on plate C-3.

The 30 inch sleeves are 6.5 feet long, having welded studs on the outside to transmit the 60 ton shear to the basic hull, with 0.75 inch x 2 inche flat bars vertically installed on 120 degree spacing to act as "spiders" to center the 36 inch pile.

The top of the 30 inch sleeves are equipped with a 1 inch thick flange equipped with 16 – 1 inch round bolts, with the head of the bolt on the bottom of the flange and the threaded portion extending up 4 inches. This flange is cast level with the hull "sill" of the barge.

Then a 30 inch diameter sleeve is bolted to the installed bolts, and these sleeves extend up to an elevation + 2.00 NGVD, with the hull sill at 9 feet below the specified water line. These upper sleeves are equipped with a rubber gasket to seal the flanges together. Twelve of these units are shipped, installed on the sill deck of the barge hull before installation. The 12–36 inch connector piles are then driven, and fully grouted by pumping out the water in the 3 inch interstice and casting a non-shrink tremy concrete in between.

The 12 upper sleeves are then unbolted by divers, and installed on the other side of the hull, (and bridge) for the driving of the remaining 12 connector piles.

Once the float-in structure is installed, the entire hull will be free-flooded, so that all compartments, including the wing walls, will always be filled with water.

C. Sheet Pile Cut Off Wall.

1) General. Steel sheet piles will be driven on either side of the proposed location of the float-in structure in the discharge channel to an Elevation of –39.0 NGVD, as shown in plate C-8.

Also, the sheet piling is driven only on the parallel sides of the channel section and the area of excavation is not closed off by sheet piling across the proposed channel.

2) Loading Cases. Analysis shown on sheet S-4.

23. Destrehan Avenue Bridge Extension.

A. General. Destrehan Avenue Bridge will be lengthened by the addition of one sixty-foot span. Modifications to the bridge will include a new north abutment, and the addition of two 16 inche prestressed concrete piles to the existing north abutment. New bearing seats will be constructed on the existing north abutment to support the required superstructure. The superstructure consists of 5 – 60 feet Type III precast prestressed concrete girders supporting a 7 inch deck. Required barrier railing will match the existing.

B. Loading Cases. The lengthening of Destrehan Avenue Bridge was designed in accordance with AASHTO requirements for HS-20 loading. The following load cases were considered:

Group 1: Dead Load+Live Load+Impact
100% of Allowable Stress Used

Group 3: Dead Load+Live Load+Impact+Wind+Longitudinal Force
125% of Allowable Stressed Used

24. Bottom Roller Gates and Gate Monoliths.

A. General. Bottom Roller Gates will be constructed at locations described in Paragraph 19. The gate monoliths for the bottom roller gates will consist of a reinforced concrete stem on a monolithic concrete base supported on prestressed concrete piles. A continuous steel sheet pile seepage cutoff wall will be provided beneath the base slab for seepage cutoff purposes.

B. Loading Cases. The pile designs for the bottom roller gate monoliths, based on the use of a pile test, are designed with a factor of safety = 2.0. The following load cases were used for preliminary design of the bottom roller gate monoliths:

(1) Case I: Gate closed, static water pressure to SWL, no wind, impervious sheet pile cutoff, no dynamic wave force (100% forces used).

(2) Case II: Gate closed, static water pressure to SWL, no wind, pervious sheet pile cutoff, no dynamic wave force (100% forces used).

(3) Case III: Gate closed, static water pressure to SWL +2 feet, no wind, impervious sheet pile cutoff, no dynamic wave force (75% forces used).

(4) Case IV: Gate closed, static water pressure to SWL +2 feet, no wind, pervious sheet pile cutoff, no dynamic wave force (75% forces used).

(5) Case V: Gate closed, wind from protected side (75% forces used).

(6) Case VI: Gate closed, winds from flood side (75% forces used).

(7) Case VII: Gate open, no wind, and truck on protected side edge of base slab (100% forces used).

(8) Case VIII: Gate open, no wind, and truck on flood side edge of base slab (100% forces used).

(9) Case IX: Gate open, wind from protected side, and truck on flood side edge of base slab (75% forces used).

(10) Case X: Gate open, wind from flood side, and truck on protected side edge of base slab (75% forces used).

25. I-Type Floodwall.

A. General. The I-walls consist of steel sheet piling driven into the existing earthen embankment. The upper portion of the sheet piling will be capped with concrete. The sheet piling will be driven to the required depth with 9 inches of the sheet piling extending above the finished ground elevation. The concrete portion of the floodwall will extend from 2 feet below the finished ground elevation to the required protection height. A typical I-wall section is shown on Plate F-7.

B. Loading Cases. In the design of the I-walls, the following loading cases were considered:

(1) Case I: Water SWL, Q-Case, F.S. = 1.5
(2) Case II: Water to SWL + 2 feet, Q-Case, F.S. = 1.0
(3) Case III: Water to SWL, S-Case, F.S. = 1.2
(4) Case IV: Water to LPL with lateral earth pressure

C. Joints. Expansion joints in the I-walls will be spaced at approximately 32.5 feet apart, adjusted to fall at the steel sheet pile interlocks. To compensate for expansion, contraction, or displacement, three-bulb waterstops and premolded expansion joint fillers will be provided. Where the I-wall joins the T-wall, the deflection of the I-wall will produce a lateral displacement. To compensate for this displacement, a special sheet pile connection detail and a waterstop seal located in a notch in the I-wall have been designed to prevent water from flowing through this joint.

26. Cantilevered Sheet Pile Floodwall.

A. General. The cantilevered sheet pile wall consists of steel sheet piling driven into the existing earthen embankment to an elevation of 9.5 NGVD. The sheet piling will be capped with a 2 feet x 2 feet concrete cap to an elevation of 10.00 NGVD. A typical cantilevered sheet pile wall section is shown on Plate F-7.

B. Loading Cases. In the design of the cantilevered sheet pile wall, the following loading cases were considered:

1) Case I: Water to SWL, Q-Case, F.S. = 1.5
2) Case II: Water to SWL + 2 feet, Q-Case, F.S. = 1.0
3) Case III: Water to SWL, S-Case, F.S. = 1.2
4) Case IV: Water to LPL with lateral earth pressure

27. Pumping Station Frontal Protection.

A. General. Pumping Station Frontal Protection will be provided by a T-wall. The T-wall will consist of a reinforced concrete stem on a monolithic concrete base of varying width supported on prestressed concrete piles. The base of the T-wall will be constructed on a four-inch concrete stabilization slab. A continuous steel sheet pile wall will be provided beneath the base for seepage cutoff purposes.

B. Loading Cases. The T-walls were designed for the following load conditions:

1) Case I: Static water pressure to SWL, no wind, impervious sheet pile cutoff (100% of forces used)

2) Case II: Static water pressure to SWL, no wind, pervious sheet pile cutoff (100%of forces used)

3) Case III: Static water pressure to SWL +2 feet, no wind, impervious sheet pile cutoff (75% of forces used)

4) Case IV: Static water pressure to SWL +2 feet, no wind, pervious sheet pile cutoff (75% of forces used)

5) Case V: Water at low water level, no wind (100% of forces used)

6) Case VI: Water at low water level, wind from protected side (75% of forces used)

C. Joints. Expansion joints in the T-wall will be spaced not more than 40 feet apart. To compensate for expansion, contraction, or displacement, three-bulb waterstops and premolded expansion joint fillers will be provided.

28. Closure Wall.

A. General. The closure wall will consist of two rows of 84 inch Ø cylinder piles filled with sand. The floodside of the wall will be lined with steel sheet pile. An 18 feet by 4 feet cast-in-place concrete cap will connect the cylinder piles to the sheet piles.

B. Loading Cases. In the design of the closure wall, the following loading cases were considered:

1) Case I: Water to SWL, Q-Case, F.S. = 1.5

2) Case II: Water to SWL + 2 feet, Q-Case, F.S. = 1.0

C. Joints. Expansion joints in the concrete cap will be spaced approximately 33 feet apart, adjusted to fall at the steel sheet pile interlocks. To compensate for expansion, contraction, or displacement, three-bulb waterstops and premolded expansion joint fillers will be provided.

29. Cathodic Protection and Corrosion Control.

A. Cathodic Protection for Steel Sheet Piling. All steel sheet piling will be bonded together to obtain electrical continuity and no corrosion protection measures will be provided. Cathodic protection can be installed in the future if the need arises. The sheet piles will be bonded together with a No. 6 reinforcing bar welded to the top of each pile. Flexible jumpers insulated with cross-linked polyethylene will be welded or brazed to adjacent sheet piles at the monolith joints, 2 to 3 inches below the bottom of the concrete.

B. Corrosion Control. All exposed ferrous metal components will be either galvanized or stainless steel to provide for corrosion control.

METHOD OF CONSTRUCTION

30. General

A. Cousins Pumping Station. Prior to beginning construction on the addition to Cousins Pumping Station, the existing fuel tanks shall be relocated. A bypass fuel system shall be maintained at all times during relocation so that the existing pumps remain operational. The addition to the pumping station shall be constructed prior to modifications to the existing station. The intent of the construction schedule shall be to keep the existing station operational during the construction of the proposed pump(s). Once the new pump(s) are operational, the original station can be taken out of service and all needed modifications made. Upon completion of work on the original station, the existing station addition can be taken out of service for needed modifications. At no time shall the original station and existing station addition be out of service at the same time.

B. Culvert. The connector pile supported, float-in concrete structure will consist of a concrete hull with an integral concrete wingwall superstructure that extends 18.5 feet above the sill deck. The overall dimensions of the float-in structure are 111 feet width by 127 feet length by 26 feet overall height of side, including wingwalls, with a hull depth of 7.5 feet. The wingwalls are 8.0 feet thick and extend 18.5 feet above the sill. When this structure is in position and ballasted, the bottom of the float-in structure will rest beneath the canal bottom at –16.50 NGVD elevation. The sill will be continuous with the canal bottom at –9 NGVD elevation.

After installation of the cutoff/retaining sheet pile walls, walers, and tie rods the area will be excavated to -18 NGVD, with slopes as shown on Plate C-6. Eighteen inches of limestone will be added as a leveling bed prior to the float-in culvert installation, as shown on plate C-7. The float-in culvert has a hull depth of 7.5 feet and a draft of approximately 5.44 feet. The wing walls are 8 feet thick and extend 18.5 feet above the sill which will be approximately +1.5 elevation while being towed to the site.

1) Basic Construction. The hull will be constructed with 20 watertight compartments (see Plate C-2). All of the compartments will be accessible from the top of the wingwall structure. Each of the compartments can be emptied of ballast water individually by integrated piping and venting system for the purpose of internal hull inspection. Watertight doors will allow

passage between compartments on grid lines 2 and 12. The hull and wingwalls will have 3 structural levels: the bottom at Level 1, the sill at Level 2, and the wingwall upper deck at Level 3. The ballast manifolds will be located on Level 3.

a) A structural, sanded-mix, semi-lightweight concrete will be used for construction of all of the bottom, top sill, and vertical panels, and columns.

The construction process will begin with the bottom (see Plate C-4). The bottom slab will be cast with a formed perimeter lip or chine. Precast concrete wall panels (see PlateC-5) will be erected on the bottom slab at all exterior wall and interior compartment wall locations. The panels will be spaced apart at their nodal junctions to accept poured-in-place octagonal concrete columns (see Plate C-4). After the columns forms are placed in position, a second layer of concrete will be poured on the bottom slab to bring the bottom to full design thickness, and to bond the wall panels to the hull. The columns will be cast before the bottom has set. Wall panels and columns will be topped with pre-cast concrete wafer panels at levels 2 and 3. The wafers will not butt together tightly but are spaced to allow wall and column reinforcing dowels to pass through the joints. The joints will be filled when a second layer of concrete is poured over the wafer panels to form a finished level. Horizontal diaphragm panels will be provided in wingwalls at Level 2.

Typical concrete design specifications are listed below:

Bottom slab 1st pour – 4-1/2" - 6500 PSI
Bottom slab 2nd pour – 3-1/2" - Semi-lightweight sanded mix - 6500 PSI
Wall panel:
  Exterior - 6"- Semi-lightweight sanded mix - 6500 PSI
  Interior - 5"- Semi-lightweight sanded mix - 6500 PSI
Sill Wafer - 3"- Semi-lightweight sanded mix - 6500 PSI
Sill top pour - 5"- Semi-lightweight sanded mix - 6500 PSI
Column thickness, varies ~24" - Semi-lightweight sanded mix – 6500 PSI

(b) Reinforcement: The structure will embody an integrated system of bonded reinforcing, bonded pre-tensioning, and bonded post-tensioning which will tie the pre-cast and cast-in-place concrete components into a unified whole. Bonded reinforcement will be provided by standard dowel, column, and spiral matrix components. Bonded pre-tensioning will be provided by embedded seven-wire strand and applied at a design schedule determined for the particular assembly.

Bonded post-tensioning will be provided by seven wire strand tendons encased in conduit. During fabrication of the hull, pipe conduit will be routed through both the pre-cast panels and through the poured columns and horizontal components to accept post-tensioning cable. The cable will be threaded through the conduit and tensioned to a design schedule determined for the particular assembly. After tensioning, grout will be pumped under pressure into the conduit to bond the matrix permanently. Details and location of reinforcing, pre-stressing, and post-tensioning are shown in Plates C-4 and C-5.

2) Installation. Prior to the installation of the float-in concrete gravity structure, a cutoff/retaining wall with forty 40 feet long steel sheet piles will be driven to -39.0 NGVD, as shown on plate C-8. After the installation of the cutoff/retaining steel sheet pile wall, walers and tie-rods, the area will be excavated to –18 NGVD, with slope as shown on plate C-6. Eighteen inches of limestone will be added as a leveling bed prior to the float-in culvert installation as shown on plate C-7.

After proper alignment positioning the culvert structure will then be ballasted with water, being kept level at all times by manipulation of the pumps and manifolding, so that the floating is uniform.

The culvert will be fully ballasted to a -9.00 feet elevation, allowed to stabilize on the bottom, then sealed in place with 12 feet of tremie concrete between the 24 inch space between the 40 feet sheet pile wall and the wing-wall hull sides. The hull has a 13 inch "lip" at the hull bottom that will provide uplift gravitational reaction to the structure, resulting in a factor of safety against floatation of 1.32 when fully free-flooded under a +11.50 NGVD flood tide in the discharge channel of the Cousins Pump Station.

3) Flood Wall and Culvert Tie-in. The floodwalls are constructed as specified in prior sections. The floodwall culvert tie-in will consist of a vertical concrete abutment column cast integral with the hull wingwall at either side of the structure. The column is grooved vertically with a dovetail sectioned slot containing an embedded sheet pile. The abutting sheet pile of the floodwall will be driven into this slot interlocked with the embedded sheet pile and the joint will be filled with grout (see Plate C-2).

C. Destrehan Bridge Extension. The Destrehan Avenue Bridge lengthening shall be constructed prior to the widening of the Cousins Discharge Channel.

D. Roller Gates. The bottom roller gates shall be constructed concurrently with the Destrehan Avenue Bridge lengthening to minimize closure of Destrehan Avenue.

E. Floodwalls. The closure wall shall be constructed after the installation of the culverts and the construction of the South Floodwall.

ACCESS ROAD

31. General: Vehicular access to the Cousins Pump Station, Destrehan Avenue Bridge, First Avenue Canal, Cousins Canal and Cousins Outfall Canal is possible via Lapalco Blvd. and West Bank Expressway via Destrehan Ave. Also, from Peters Rd. via Lapalco Blvd. Site for the culverts must be accessed by Harvey Canal. The Contractor will be required to comply with all local ordinances regarding hauling over public roads. Additionally, the Contractor will be responsible for maintenance to the roads utilized in the hauling operations.

RELOCATIONS

32. General. Under the authorizing law, local interest are responsible for the accomplishment "...of all necessary alterations and relocations to roads, railroads, pipelines, cables, wharves, drainage structures and other facilities made necessary by the construction work,...". For the area covered in this memorandum, there are no residences required. A summary of the existing utilities requiring relocation is shown in Table 7.

TABLE 7

Utility Relocation Schedule

Station	Item/Description	Disposition
7+43.70 South Wall Line	16 inch H.P. Gas Line	Raise/relocate over floodwall
7+89.37 South Wall Line	16 inch H.P. Gas Line	Raise/relocate over floodwall
6+58 South Wall Line	Electrical Power Lines	Raise/relocate over floodwall

The above list of pipelines will be relocated by the local interests in accordance with criteria set forth for hurricane protection levee and floodwall crossings. These criteria will be furnished to local interests.

ENVIRONMENTAL EFFECTS

33. General.

A. Environmental Assessment. Resources described as significant in the West Bank of the Mississippi River in the Vicinity of New Orleans, LA (East of the Harvey Canal) Feasibility Report and Environmental Impact Statement included bottomland hardwoods; swamps; aquatic resources; wildlife; endangered species; recreation; National Register of Historic Places; hazardous, toxic, and radiological wastes (HTRW); and socio-economic resources. Because of concern for aquatic resources and contaminants that may be released during construction of the sector gate, the top two feet of material that is excavated from the Harvey Canal would be hauled to an industrial landfill. Bottomland hardwoods and wooded swamp would be impacted by construction of the project. The project, as originally designed, would impact 233 acres of bottomland hardwoods and 46 acres of wooded swamp. Changes are currently underway in design of the project on the west side of the proposed sector gate in the Harvey Canal that would result in significant reduction of impacts to wooded lands. Subsequent to the anticipated official approval of the design change, project impacts would change to approximately 69.5 acres of bottomland hardwoods and 46 acres of wooded swamp.

B. Mitigation. The approved habitat mitigation feature I the authorized plan consists of the acquisition of 312 acres of bottomland hardwood forest in the Bayou Piquant finger ridge area of St. Charles Parish. Mitigation would include habitat development to develop the required habitat value and would include operation and maintenance of that area to maintain the required habitat value. Changes are underway to relocate the mitigation area to within the guide levees of the Davis Pond Freshwater Diversion Project area that is currently under construction. The mitigation for the East of Harvey project would be accomplished in the same general area as the mitigation for the Westwego to Harvey Hurricane Protection Project.

C. Hazardous, Toxic, and Radioactive Wastes. An initial assessment for HTRW was completed on 9 August 1994. The assessment concluded that the risk of encountering HTRW sites along the Harvey Canal, Algiers Canal, and Hero canal levee segments is minimal. The 1994 report recommends that upon final selection of an alignment, a meeting should be arranged with appropriate offices of the Louisiana Department of Environmental Quality (LDEQ) to evaluate the selected alignment and construction methods, to insure implementation of a safe project. Current 1998 protocol would first subject the final selected alignment and construction methods, to insure implementation of a safe project. Current 1998 protocol would first subject the final selected alignment to a contract Certified Industrial Hygienist investigation after which the necessity of any additional coordination with LDEQ and other agencies will be determined.

COMPLIANCE WITH ENVIRONMENTAL LAWS

34. General.

A. National Environmental Policy Act. The final Environmental Impact Statement was filed on 30 September 1994. Proposed project changes reflecting a reduction of project impacts and the relocation of the mitigation area, will be documented in an Environmental Assessment and an expected Finding of No Significant Impact, as well as related documents.

B. Clean Water Act. A Section 404(b)(1) evaluation was completed on 19 August 1994. Section 401, State Water Quality Certification, was granted by letter, dated 30 August 1994,from the State of Louisiana Department of Environmental Quality.

C. Coastal Zone Management Act. A letter from the Louisiana Department of Natural Resources, dated 1 August 1994, granted consistency with the State of Louisiana's approved Coastal Resources Program.

D. National Historic Preservation Act. Cultural resources investigations were completed as part of the feasibility study. The results of the investigations were included in the report entitled West Bank of the Mississippi River in the Vicinity of New Orleans, LA (East of the Harvey Canal) Feasibility Report and Environmental Impact Statement, dated August 1994. Cultural resources investigations for the 312-acre Bayou Bois Piquant mitigation area were completed during 1994 as part of the Davis Pond Freshwater Diversion Project, St. Charles Parish, Louisiana. Cultural resources efforts were coordinated with Louisiana's State Historic Preservation Officer (SHPO). Construction of the project will not impact National Register of Historic Places properties or significant cultural resources and no further cultural resources investigations are warranted. The SHPO has concurred with these recommendations.

E. Recreation. The land use of the area within the project boundaries is largely urban and industrial. Very little water oriented recreation exists within the project zone of influence. Recreation activities within the area can be categorized as non-consumptive or passive: walking, driving, sightseeing. Pedestrian access to the levee in the vicinity of the Gulf Intracoastal Waterway and Hero Canal is limited due to its isolation from roadways and areas of public access. Minimal recreational sport fishing and boating occur in the GIWW due to the presence of large vessel traffic and more desirable fishing and boating areas in the vicinity.

In the rural environment west of the Harvey Canal, recreational fishing and hunting are popular activities. Hiking, bird watching, camping, and many nature-oriented activities also occur. Contributing to recreational success in the area are three major recreation areas. The Lake Salvador Wildlife Management Area, Jean Lafitte

National Historic Park, and Bayou Segnette State Park provide quality recreation experiences to residents of the area.

COORDINATION WITH OTHER AGENCIES

35. General.

Coordination with other agencies shall be provided by the West Jefferson Levee District.

REAL ESTATE REQUIREMENTS

36. General. Appurtenances follow the existing 1st Avenue Canal and drainage canal. All proposed work falls within the existing right-of-way, and no additional right-of-way will need to be acquired. In the event that right-of-way or construction easements would need to be acquired, the West Jefferson Levee District would acquire said right-of-ways and construction easements without cost to the United States. Right-of-way limits are shown on Plate G-5. Local interest are required to assume cost of relocation assistance to persons and business displaced by such acquisitions pursuant to the requirement of Public Law 91-646. However, no relocations of this type are contemplated for the recommended plan.

OPERATION AND MAINTENANCE

37. General. The Cousins Pumping Station Complex Hurricane Protection will be maintained and operated at the expense of local interests (Jefferson Parish and West Jefferson Levee District) as a feature of local cooperation for the project. The estimate of the annual operation and maintenance costs for the protection features, which are detailed in this Design Memorandum, are as follows:

A. Bottom Roller Floodgate $18,000/year

(Involves operating rollergates 4 times/year, spot painting 2 times/year, miscellaneous routine maintenance 4 times/year, and complete repainting of both floodgates every 10 years)

B. Destrehan Avenue Bridge Extension $22,500/year

C. Cousins Pumping Station Addition $1,633,000/year

D. Floodwall Maintenance $6,000/year

E. Culvert $3,780/year

F. Mitigation Feature. Operation and maintenance of the habitat mitigation would consist of maintenance of existing forested wetland habitat, continued development of forested wetland habitat quality goals not achieved in the initial habitat development period, and protection of the area from any activity not described in the jointly approved habitat development plan. The jointly approved plan would consist of a plan approved by representatives of the Louisiana Department of Wildlife and Fisheries, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers.

F. Mitigation Feature. Operation and maintenance of the habitat mitigation would consist of maintenance of existing forested wetland habitat, continued development of forested wetland habitat quality goals not achieved in the initial habitat development period, and protection of the area from any activity not described in the jointly approved habitat development plan. The jointly approved plan would consist of a plan approved by representatives of the Louisiana Department of Wildlife and Fisheries, the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers.

SCHEDULE FOR DESIGN AND CONSTRUCTION

38. Schedule for Design and Construction. The sequence of contracts and Schedule for Design and Construction for the recommended plan are shown in Table 8 below.

TABLE 8

Schedule for Design for Construction East of Harvey Hurricane Protection Project Cousins Pumping Station Complex 2000 cfs

Contracts	Plans & Specs Start	Plans & Specs Complete	Advert.	Construction Award	Construction Complete	Const/Cost
Cousins Pumping Station Contract 1	Jan-99	Jul-00	Nov-00	Feb-01	Feb-03	$14,214,472
Destrehan Bridge Contract 2	Jan-99	Oct-99	Jan-00	Apr-00	Jan-01	$1,140,000
Canals & Channels Contract 3	Feb-99	Oct-99	Jan-00	Jul-00	Jul-01	$3,416,935
Floodwalls Contract 4	Feb-99	Jun-00	Sept-00	Dec-00	Dec-01	$2,202,924
Culvert Structure Contract 5	Jan-99	Sept-99	Jan-00	Apr-00	Feb-01	$2,448,732
Closure Wall/ Relocation/ Floodwall Contract 6	Apr-99	Apr-00	Sept-00	Dec-00	Dec-01	$5,822,688

ESTIMATE OF INCREMENTAL COSTS

39. General. Based on May 1998 price levels, the estimated first cost for construction of the Cousins Pumping Station Complex Project is $36,616,000. Of this cost $14,214,472 is for the modification and renovation of the Cousins Pumping Station, $1,140,000 is for the modification of the Destrehan Bridge which includes two Bottom Roller Floodgates, $3,416,935 is for the improvements of the First Avenue canal and Pump Station discharge channel, $2,202, 924 is for floodwalls and frontal protection, $2,448,732 is for a U-Frame Culvert, $5,522,688 is for a closure wall on the existing discharge channel, $300,000 is for relocations, $350,949.01 is for Construction Engineering and Design, $3,509,490.10 is for Plans and Specifications, and $3,509,490.10 is for Construction Administration.

Table 9

Breakdown of Cost Between East of Harvey Project and SELA Projects

Item	Description	Flood Protection East of Harvey	Drainage SELA	2000 CFS Total Cost
1	Pump Station	$8,267,256.00	$5,947,216.00	$14,214,472.00
2	Destrehan Ave. Bridge	$1,140,000.00		$ 1,140,000.00
3	Canals & Channels	$3,416,935.00		$ 3,416,935.00
4	Floodwalls	$2,202,924.00		$ 2,202,924.00
5	Culvert Structure	$2,448,732.00		$ 2,448,732.00
6	Closure Wall	$5,312,688.00	$ 210,000.00	$ 5,522,688.00
7	Relocations	$ 300,000.00		$ 300,000.00
	Construction First Cost Total	**$23,088,535.00**	**$6,157,216.00**	**$29,245,751.00**
		Project Cost for SELA		
1	Constr. Cost			$6,157,216.00
2	Const. E&D	$61,572.16	$12,314.43	$ 73,886.60
3	P&S	$615,721.60	$123,144.32	$ 738,865.92
4	Constr. Admin.	$615,721.60	$123,144.32	$ 738,865.92
	Total			**$7,708,834.40**
		Project Cost for WJLD		
1	Constr. Cost			$23,088,535.00
2	Const. E&D	$230,885.35	$46,177.07	$277,062.42
3	P&S	$2,308,853.50	$461,770.70	$2,770,624.20
4	Constr. Admin.	$2,308,853.50	$461,770.70	$2,770,624.20
	Total			**$28,906,845.00**

Summation of SELA & WJLD's Costs

1	Constr. Cost			$29,245,751.00
2	Const. E&D	$292,457.51	$58,491.50	$ 350,949.01
3	P&S	$2,924,575.10	$584,915.02	$ 3,509,490.10
4	Constr. Admin.	$2,924,575.10	$584,915.02	$ 3,509,490.10
	Total			**$36,615,680.00**
	Total (rounded)			**$36,616,000.00**

A detailed cost estimate is shown in Appendix A.

40. Funds Required by Fiscal Year. To maintain the schedule for design and construction for the Cousins Pumping Station Complex of the East of Harvey Hurricane Protection Project as shown in Table 8 above, Federal and Non-Federal funds will be required by Fiscal Year as follows:

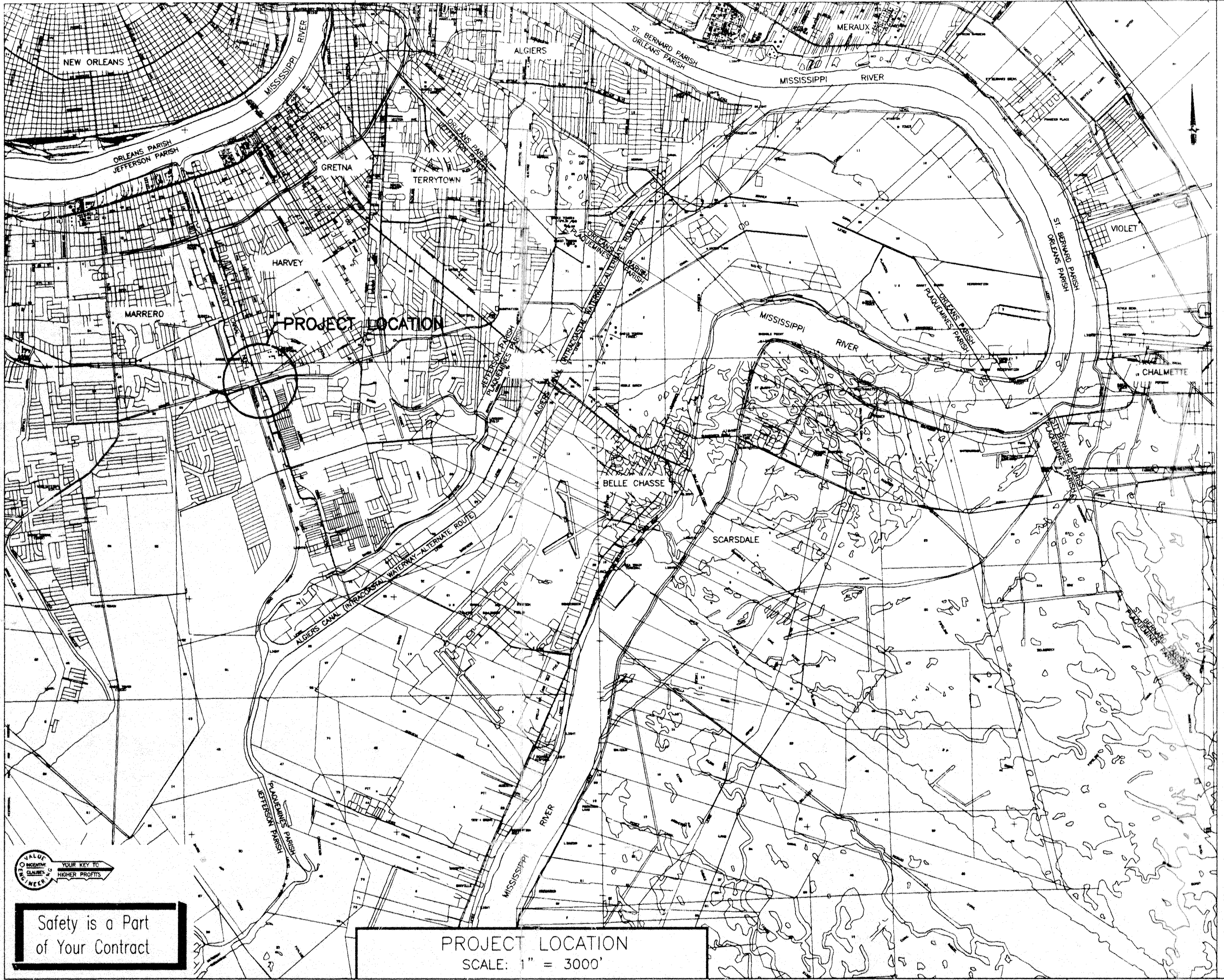
TABLE 10

Federal and Non-Federal Funding by Fiscal Year

Funds Required	FY 99/00	$4,334,457
Funds Required	FY 00/01	$16,140,611
Funds Required	FY 01/02	$11,298,428
Funds Required	FY 02/03	$4,842,184
	TOTAL *(rounded)*	$36,616,000

RECOMMENDATIONS

41. Recommendations. The plan of improvement presented herein is the least costly plan that provides the authorized level of protection, uses the minimum acquisition of right-of-way and achieves a high degree of flood protection and pumping capacity, early on, for the developed area of the Harvey Canal. It is recommended that the 2000 CFS Plan be approved as the basis of preparing plans and specifications for this project.



PROJECT LOCATION
SCALE: 1" = 3000'

VICINITY MAP
SCALE OF MILES
40 0 40 80 120 160 200

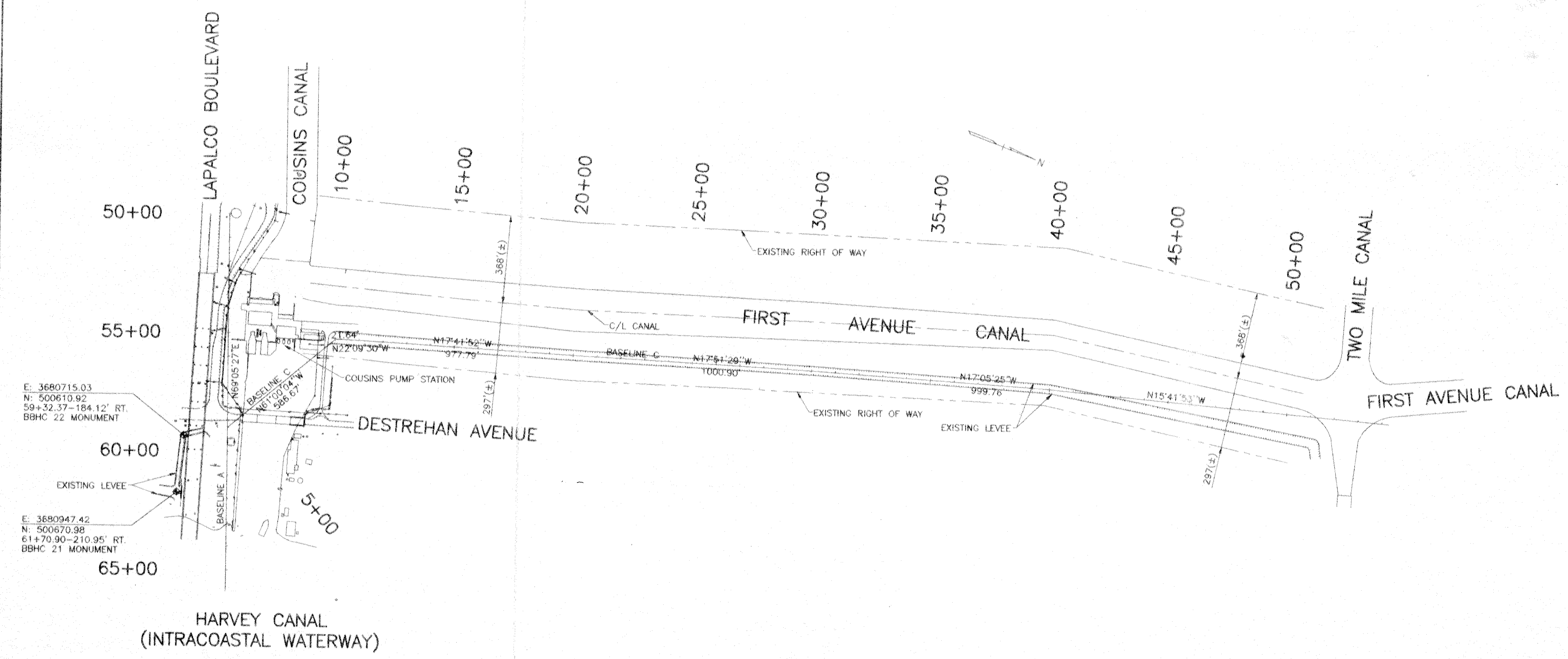
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

PROJECT LOCATION MAP–VICINITY MAP

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE: 12	PLOT DATE: PLOT DAT	CADD FILE: TITLE-A.DWG
	DRAWN BY: G.A.D.	CHECKED BY: A.A.R.	FILE NO. H-2-44070
	DATE:	DATE:	

PLATE G-1



SITE PLAN
SCALE: 1" = 200'

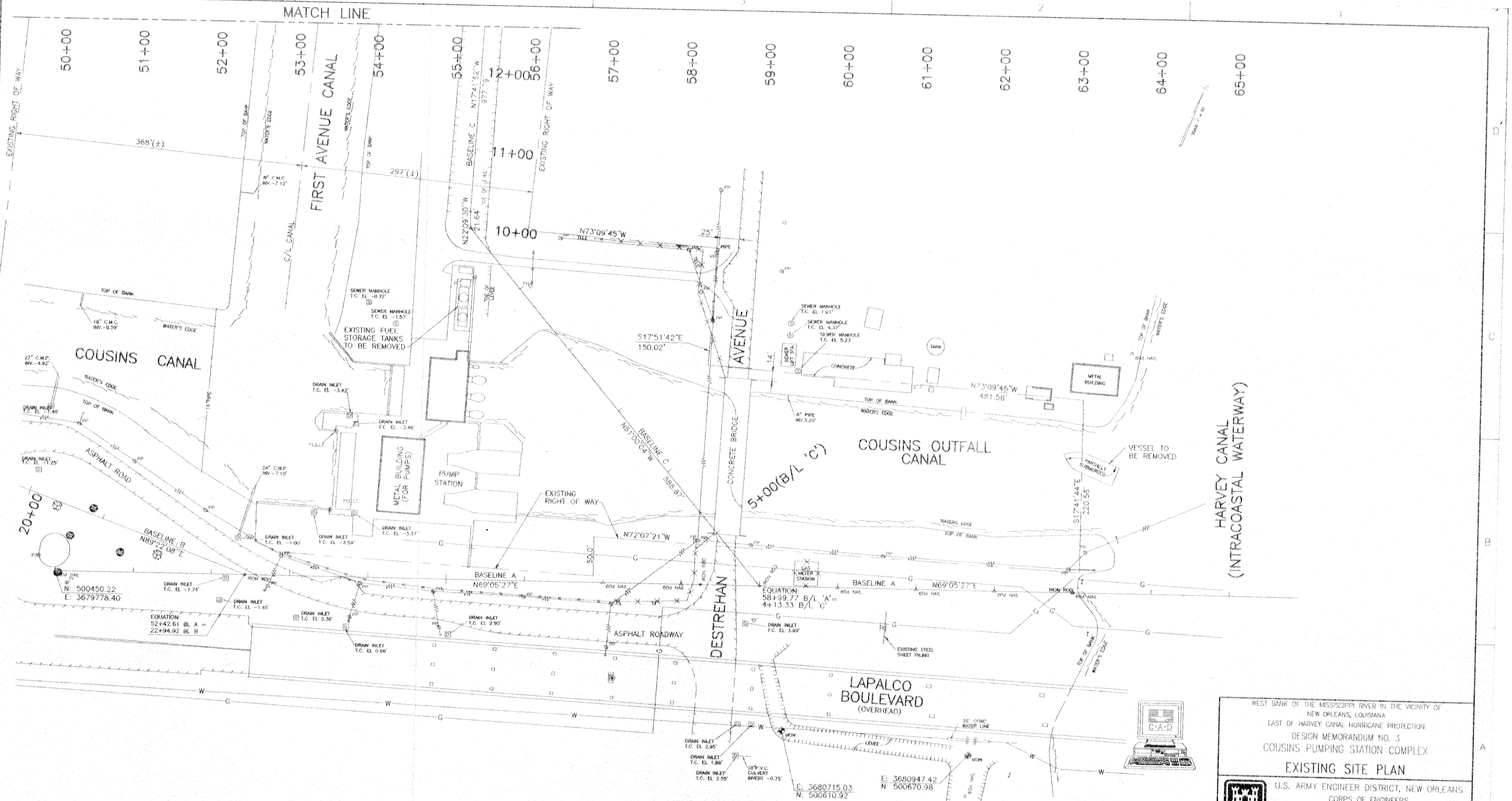
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

OVERALL SITE PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
PLOT SCALE: 1 = 400
PLOT DATE: 1/96
DRAWN BY: M.Z.
CHECKED BY: A.R.
DATE: JANUARY 1996
CADD FILE:
FILE NO. H-2-44970

PLATE C-2



EXISTING SITE PLAN

SCALE: 1" = 50'

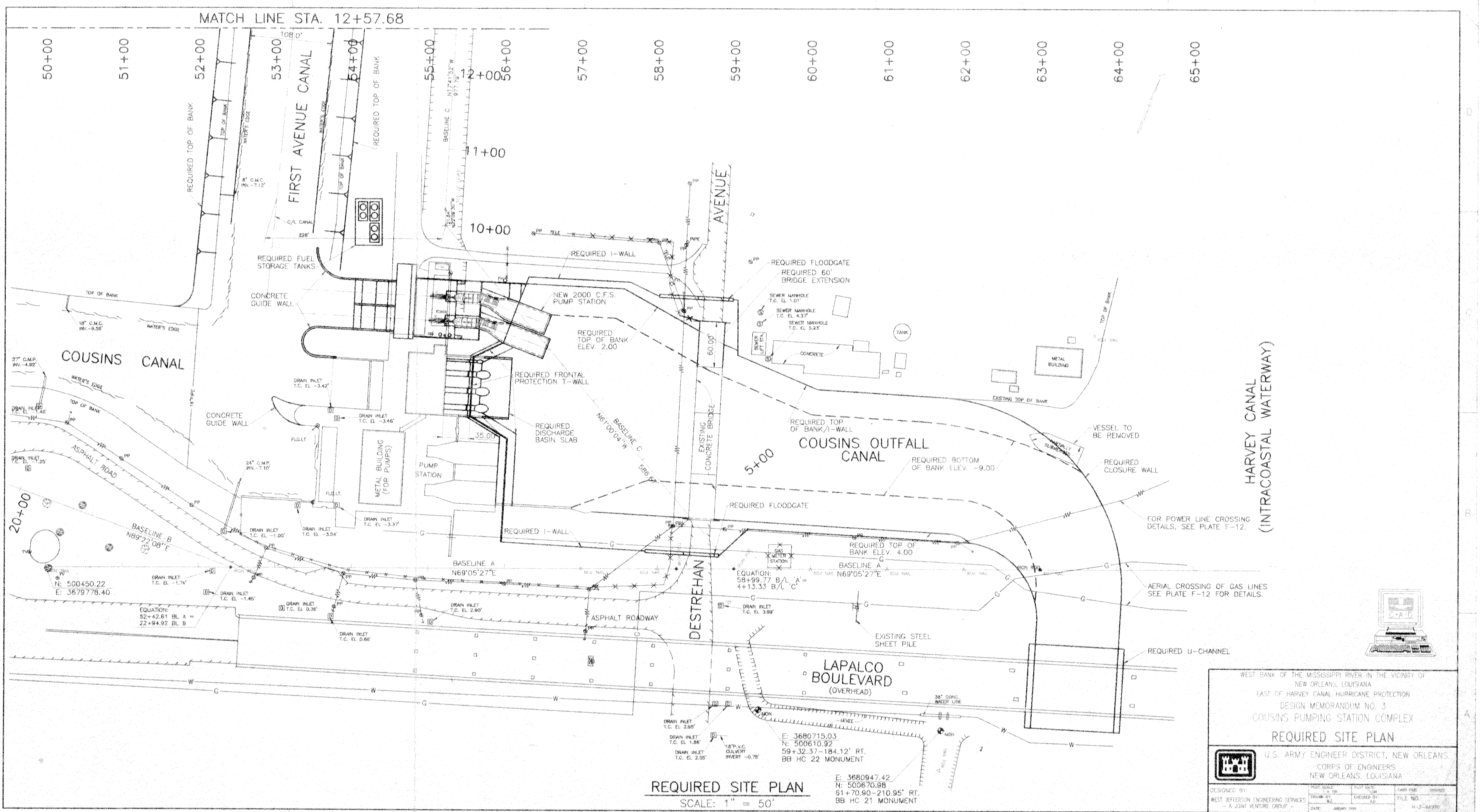
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

EXISTING SITE PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO. H-2-44970



REQUIRED SITE PLAN

SCALE: 1" = 50'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

REQUIRED SITE PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

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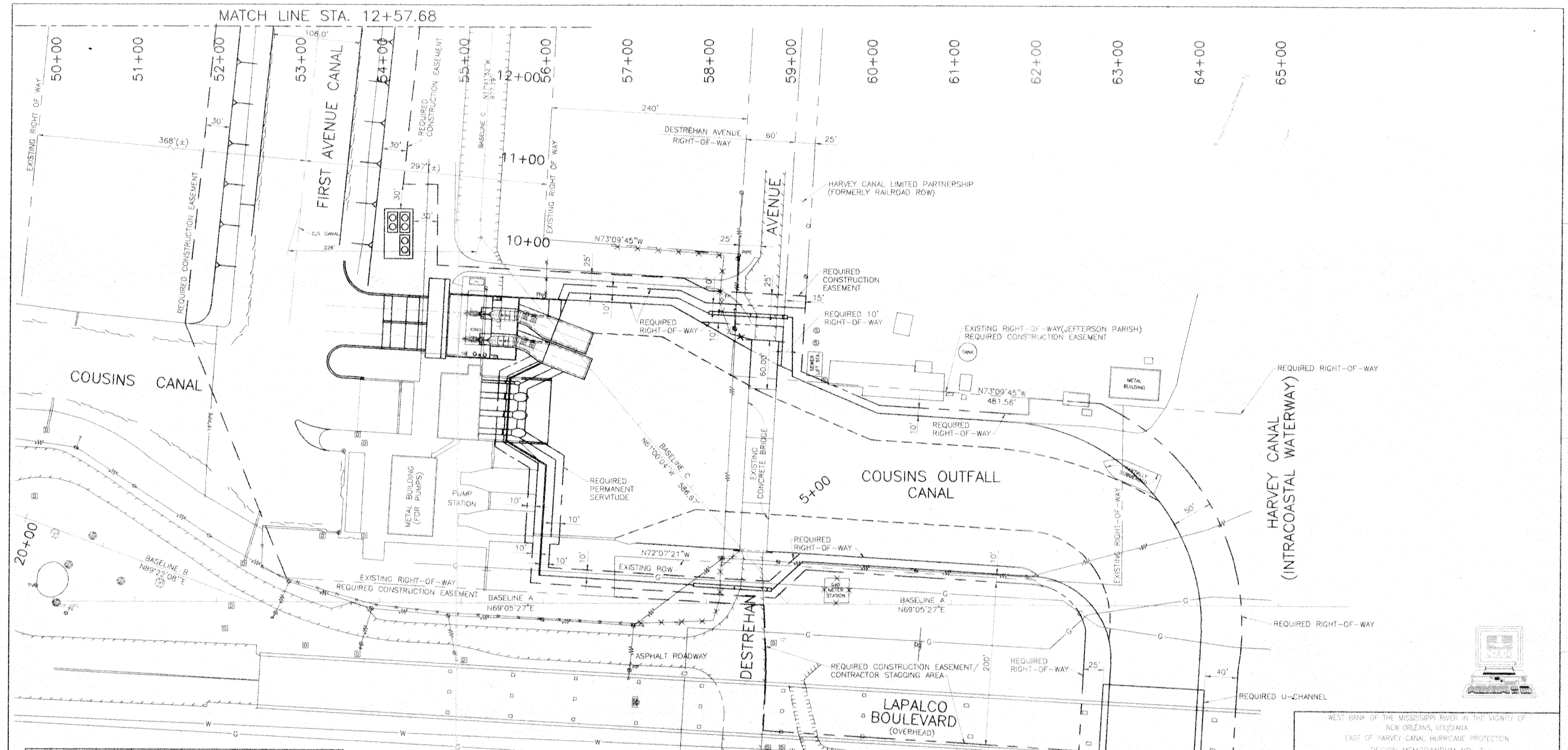
PLATE G-4



DESCRIPTION	LEGEND	AREA (ACRES)
REQUIRED RIGHT-OF-WAY		2.65
REQUIRED PERMANENT SERVITUDE		0.26
REQUIRED CONSTRUCTION EASEMENT		43.95

RIGHT-OF-WAY PLAN
SCALE: 1" = 50'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

RIGHT-OF-WAY PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

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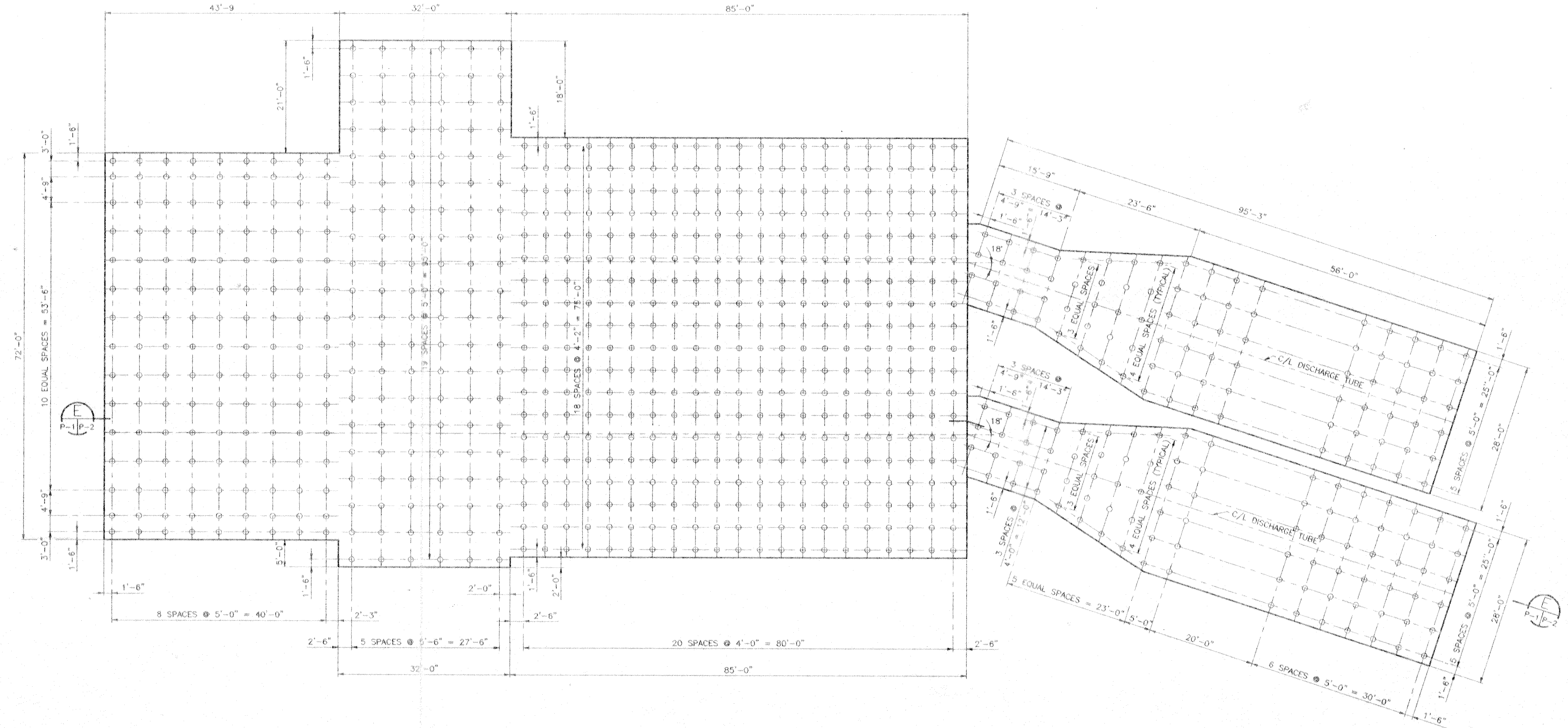
FILE NO. H-2-44970



PUMP STATION PILING PLAN

SCALE: 1/8" = 1'-0"

NOTE:

ALL PILES ARE CLASS B ASTM D25 TREATED TIMBER PILES

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA

EAST OF HARVEY CANAL HURRICANE PROTECTION

DESIGN MEMORANDUM NO. 3

COUSINS PUMPING STATION COMPLEX

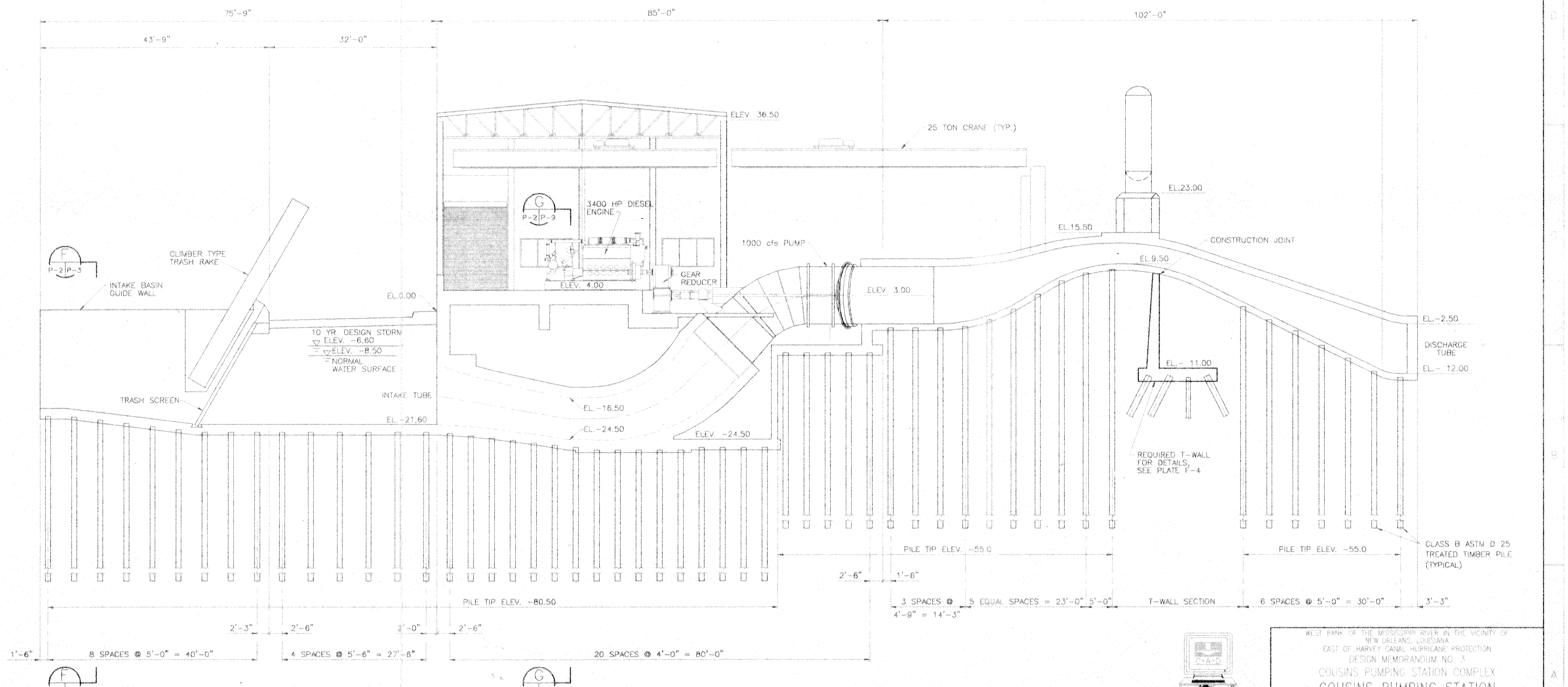
COUSINS PUMPING STATION PILING PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –	PLOT SCALE: 1 = 16	PLOT DATE: 1/99	CADD FILE: 3003-069
	DRAWN BY: MZ	CHECKED BY: AJL	FILE NO. H-2-44970
	DATE: JANUARY 1999		



SECTION E P-1 P-2
SCALE: 1/8" = 1'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

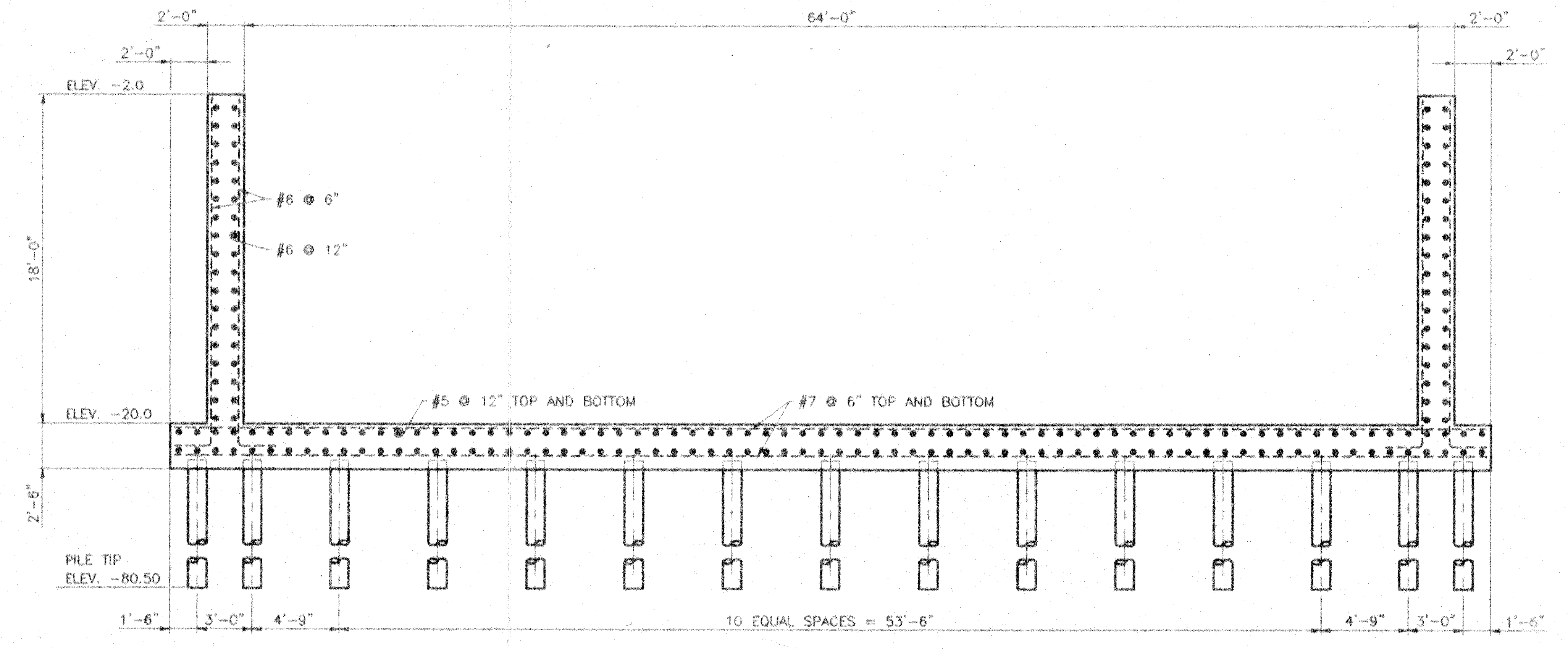
COUSINS PUMPING STATION
SECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

DATE: JANUARY 1996

FILE NO. H-2-44970



SECTION F P-2 P-3
SCALE: 1/4" = 1'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
COUSINS PUMPING STATION
INTAKE BASIN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE: 1 = 8	PLOT DATE: 1/88	CADD FILE:
	DRAWN BY: S.Z.	CHECKED BY: A.R.	FILE NO. H-2-44970
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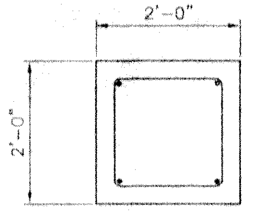
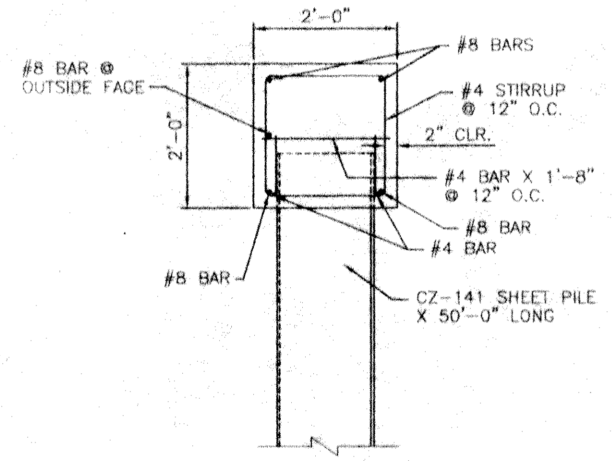
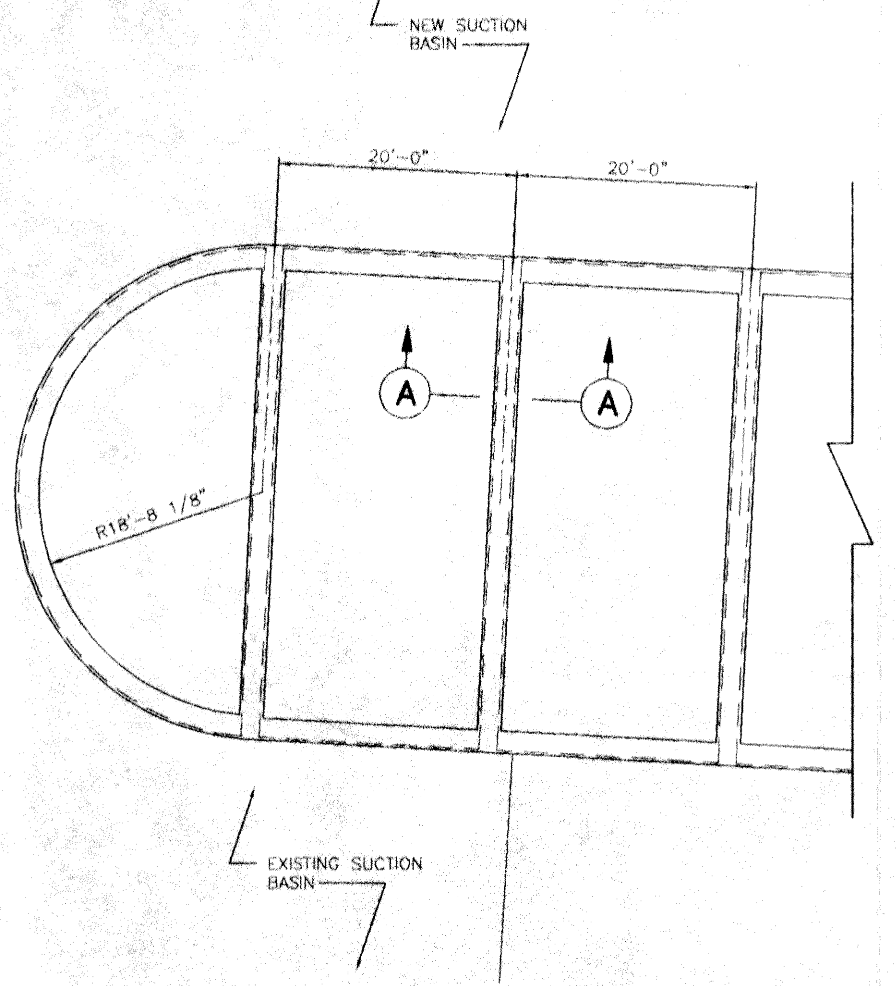


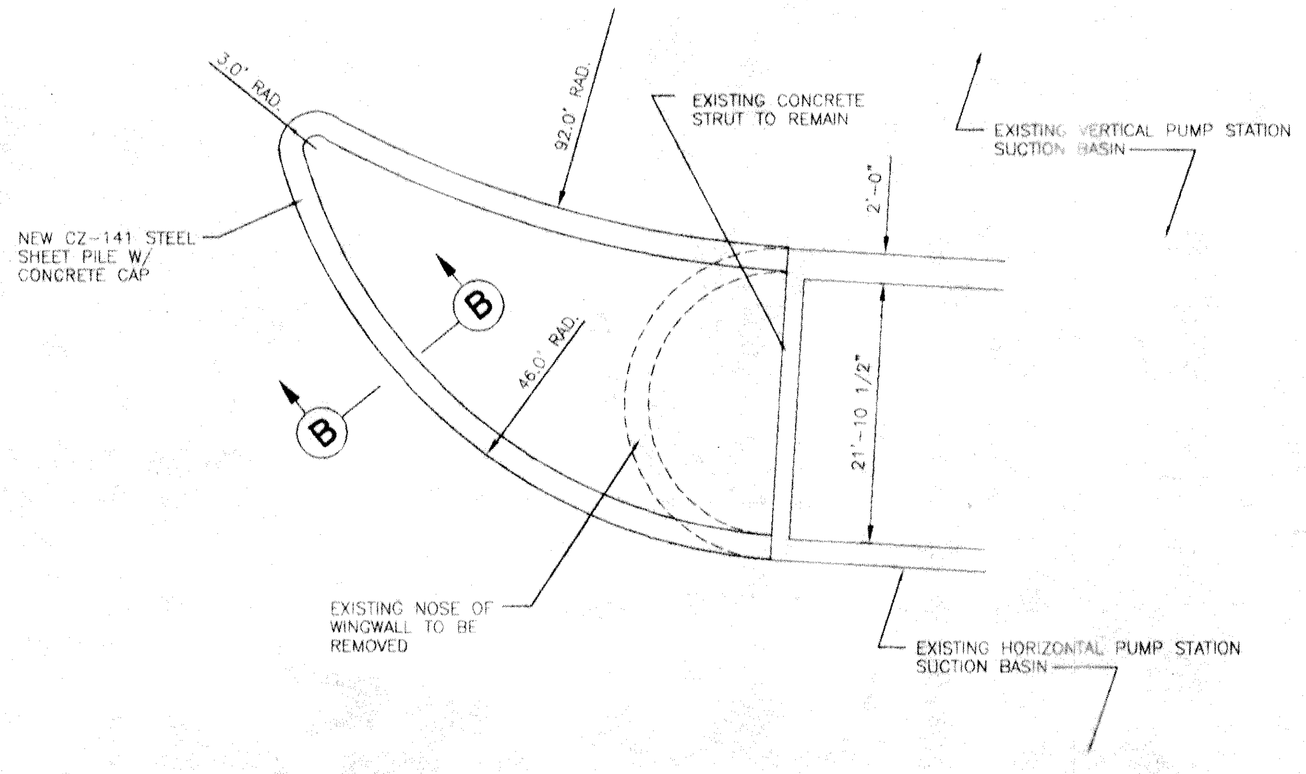
SECTION (A)
SCALE: 3/4 " = 1'- 0"



SECTION (B)
SCALE: 3/4 " = 1'- 0"



AREA BETWEEN STRUCTURES AT NOSE OF PROPOSED WINGWALL
SCALE: 3/16" = 1'- 0"



MODIFICATIONS TO EXISTING NOSE OF WINGWALL
SCALE: 3/16" = 1'- 0"

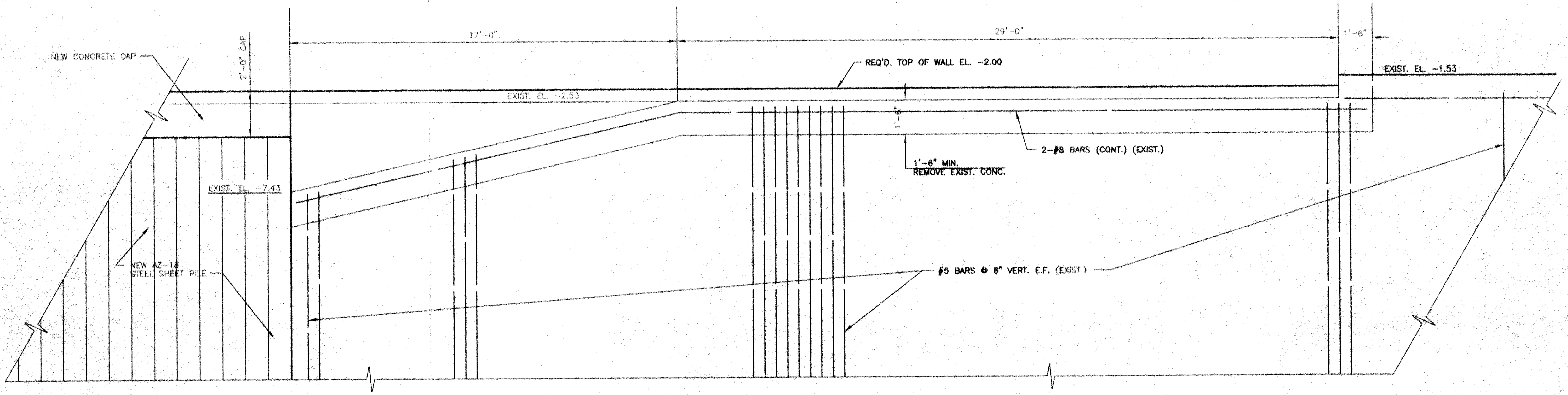
C•A•D

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA
PUMPING STATION WINGWALLS

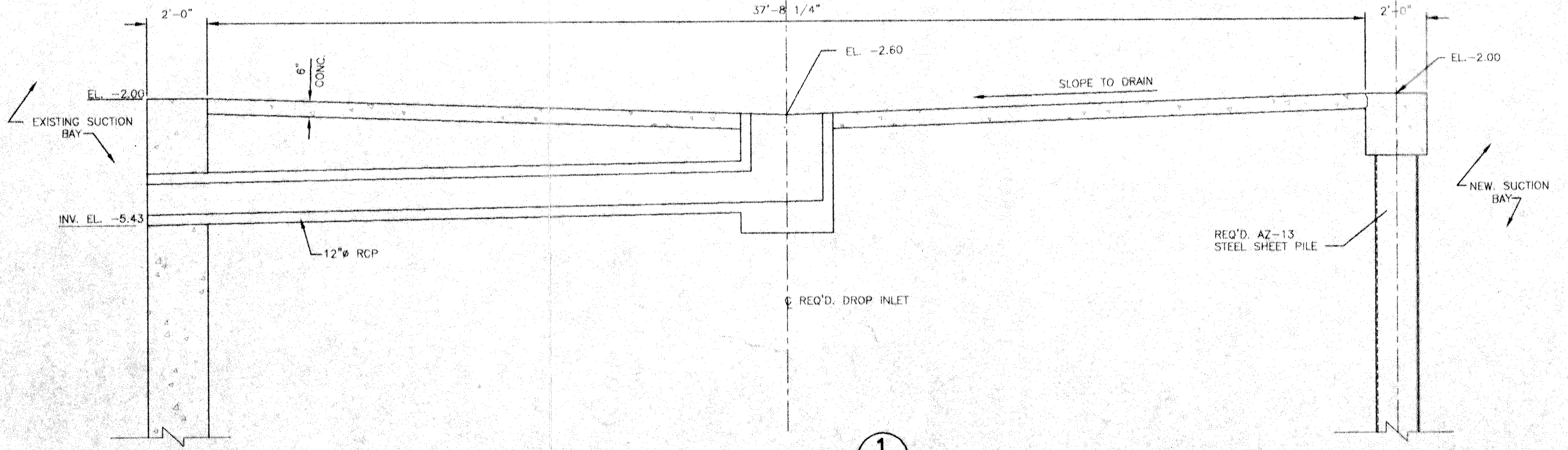
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44970



ELEVATION
SOUTH WALL EXIST. SUCTION BASIN
SCALE: 1/2" = 1'- 0"



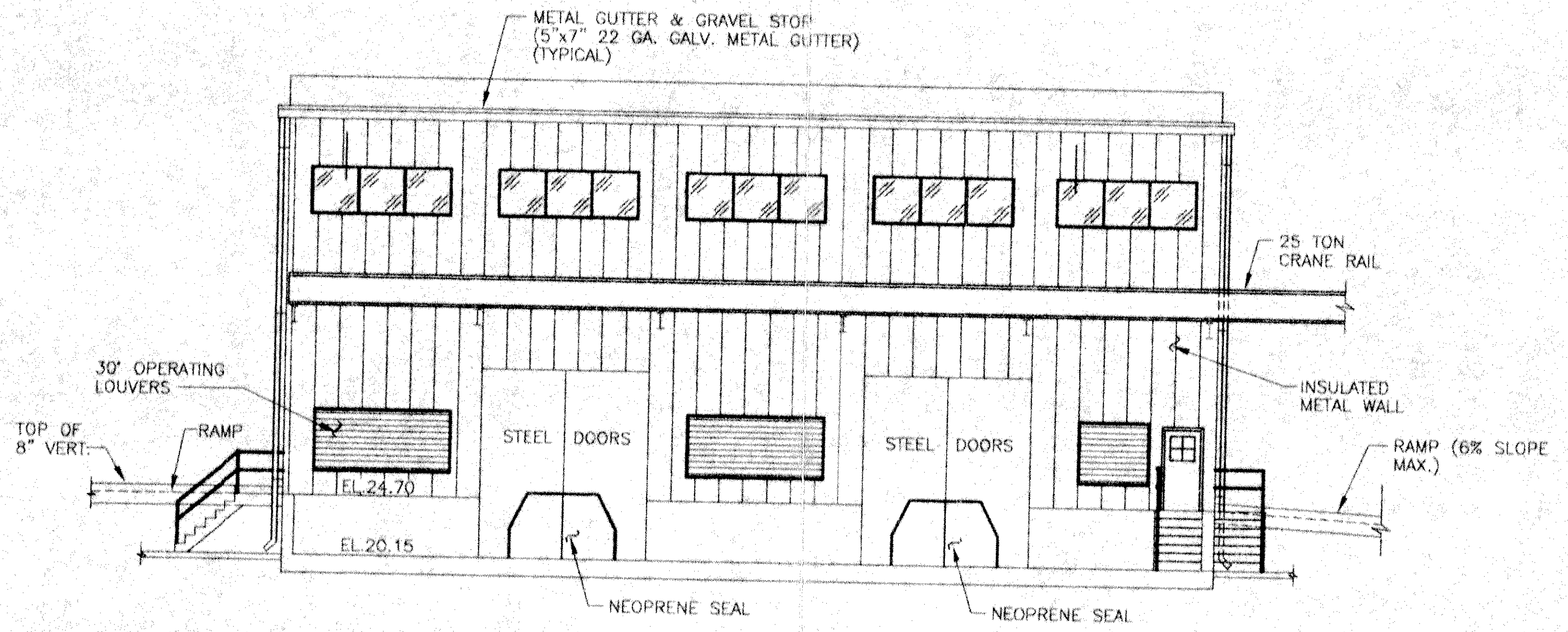
SECTION 1
SCALE: 1/2" = 1'- 0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA
PUMPING STATION WINGWALLS

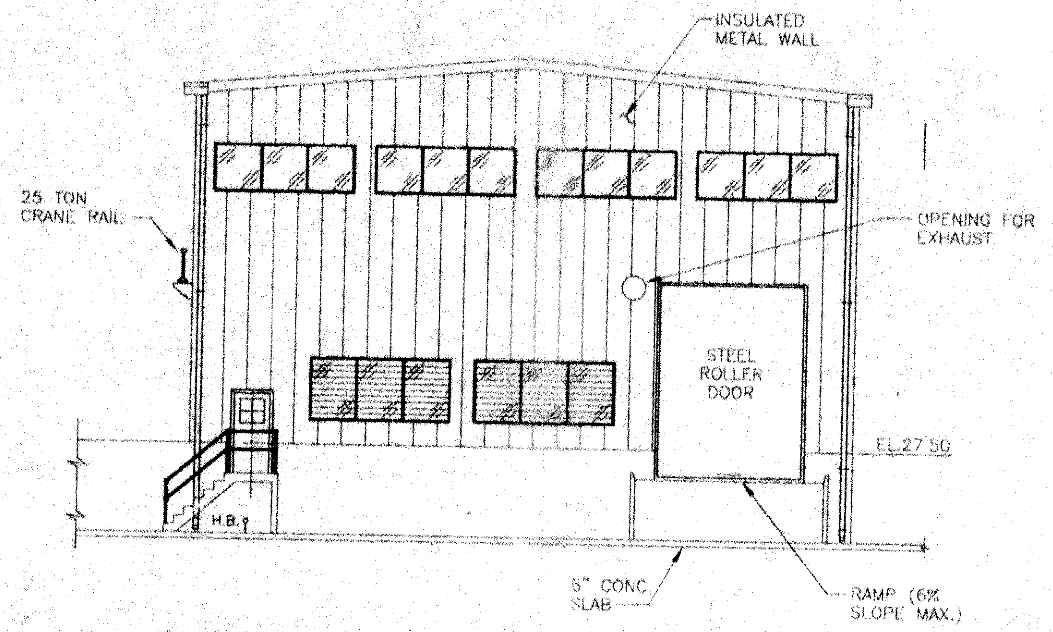
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

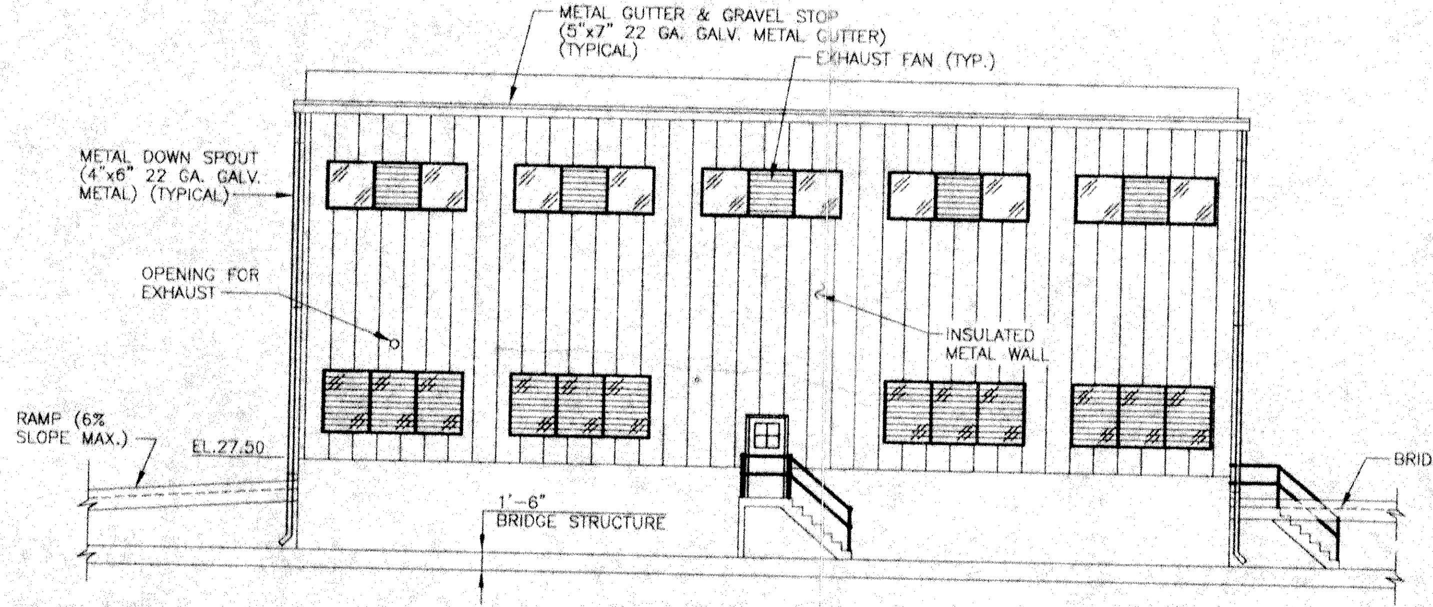
FILE NO.
H-2-44970



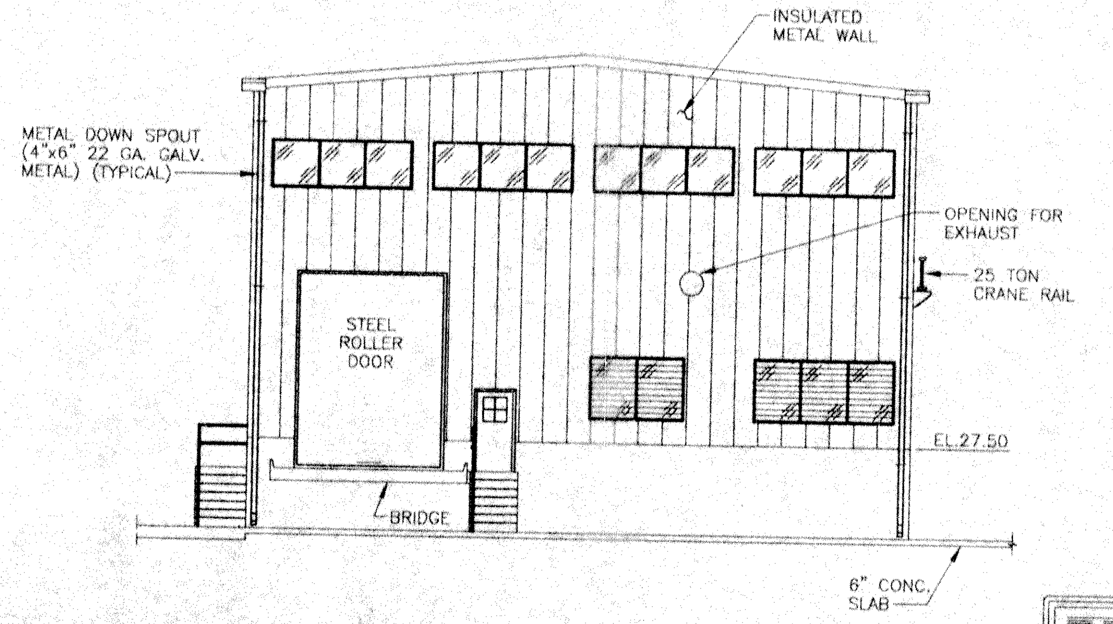
EAST ELEVATION
SCALE : 1/8" = 1'-0"



NORTH ELEVATION
SCALE : 1/8" = 1'-0"



WEST ELEVATION
SCALE : 1/8" = 1'-0"



SOUTH ELEVATION
SCALE : 1/8" = 1'-0"

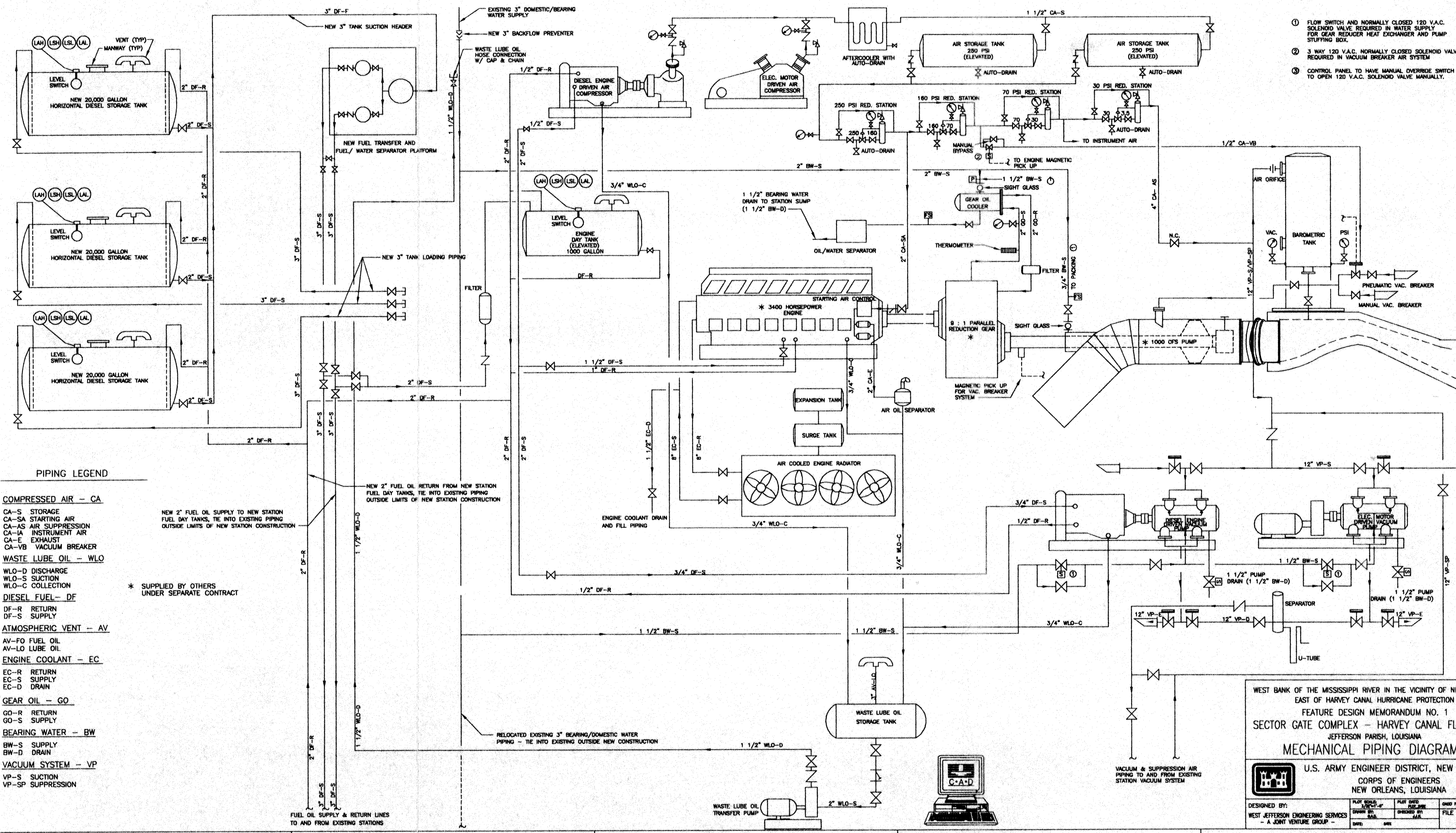
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

2000 CFS BUILDING ELEVATIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44970



① FLOW SWITCH AND NORMALLY CLOSED 120 V.A.C. SOLENOID VALVE REQUIRED IN WATER SUPPLY FOR GEAR REDUCER HEAT EXCHANGER AND PUMP STUFFING BOX.

② 3 WAY 120 V.A.C. NORMALLY CLOSED SOLENOID VALVE REQUIRED IN VACUUM BREAKER AIR SYSTEM

③ CONTROL PANEL TO HAVE MANUAL OVERRIDE SWITCH TO OPEN 120 V.A.C. SOLENOID VALVE MANUALLY.

PIPING LEGEND

COMPRESSED AIR – CA
- CA-S STORAGE
- CA-SA STARTING AIR
- CA-AS AIR SUPPRESSION
- CA-IA INSTRUMENT AIR
- CA-E EXHAUST
- CA-VB VACUUM BREAKER

WASTE LUBE OIL – WLO
- WLO-D DISCHARGE
- WLO-S SUCTION
- WLO-C COLLECTION

DIESEL FUEL– DF
- DF-R RETURN
- DF-S SUPPLY

ATMOSPHERIC VENT – AV
- AV-FO FUEL OIL
- AV-LO LUBE OIL

ENGINE COOLANT – EC
- EC-R RETURN
- EC-S SUPPLY
- EC-D DRAIN

GEAR OIL – GO
- GO-R RETURN
- GO-S SUPPLY

BEARING WATER – BW
- BW-S SUPPLY
- BW-D DRAIN

VACUUM SYSTEM – VP
- VP-S SUCTION
- VP-SP SUPPRESSION

* SUPPLIED BY OTHERS UNDER SEPARATE CONTRACT

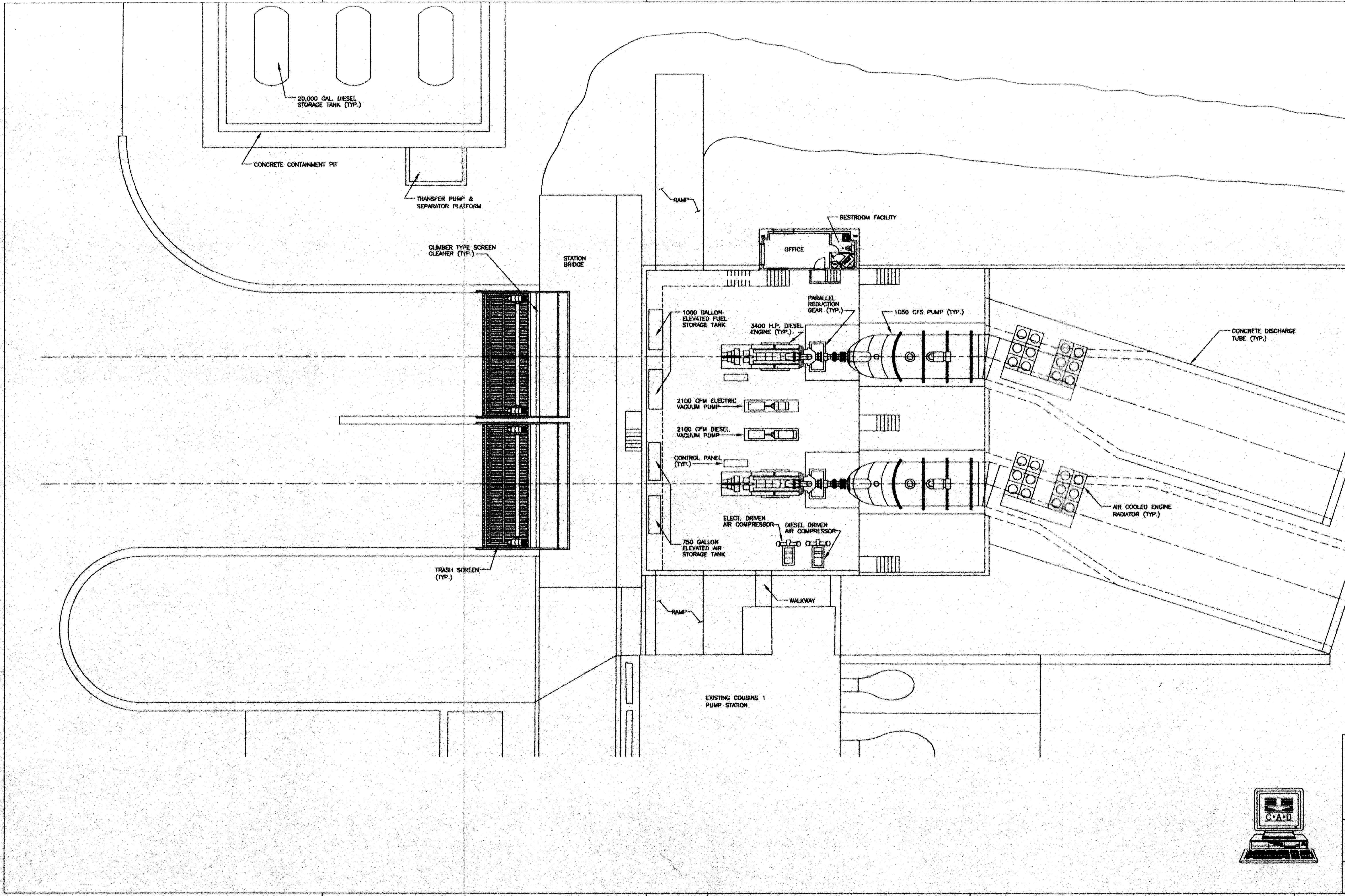
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
SECTOR GATE COMPLEX – HARVEY CANAL FLOODGATE
JEFFERSON PARISH, LOUISIANA

MECHANICAL PIPING DIAGRAM

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
– A JOINT VENTURE GROUP –

FILE NO. H-2-44920

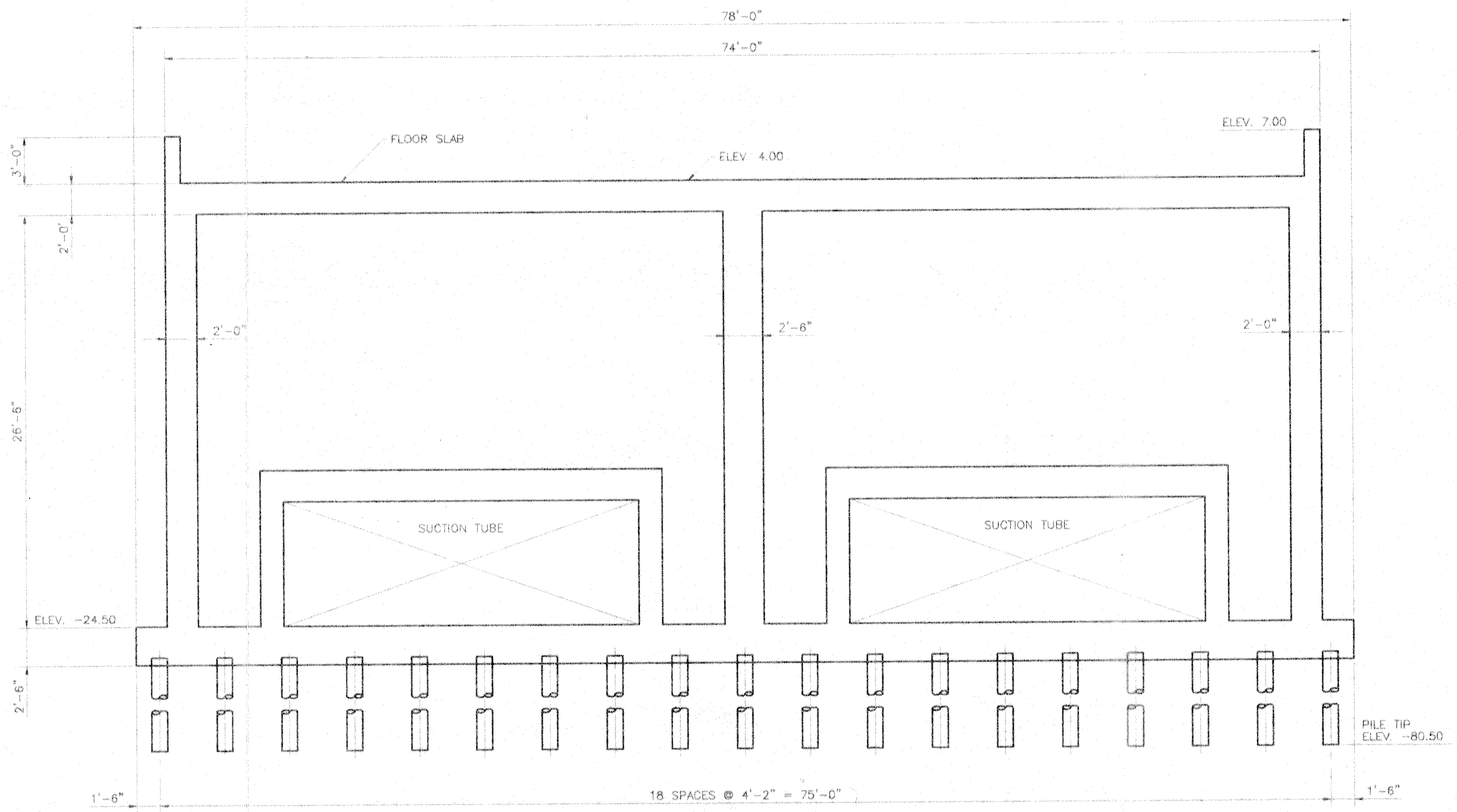


WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

MECHANICAL EQUIPMENT LAYOUT

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE: 3/32"=1'-0"	PLOT DATE: PLOT_DATE	CADD FILE: DWG_FILE
	DRAWN BY: S.A.D.	CHECKED BY: J.J.R.	FILE NO. H-2-44920
	DATE: DATE		



SECTION G P-2 P-9
SCALE: 1/4" = 1'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

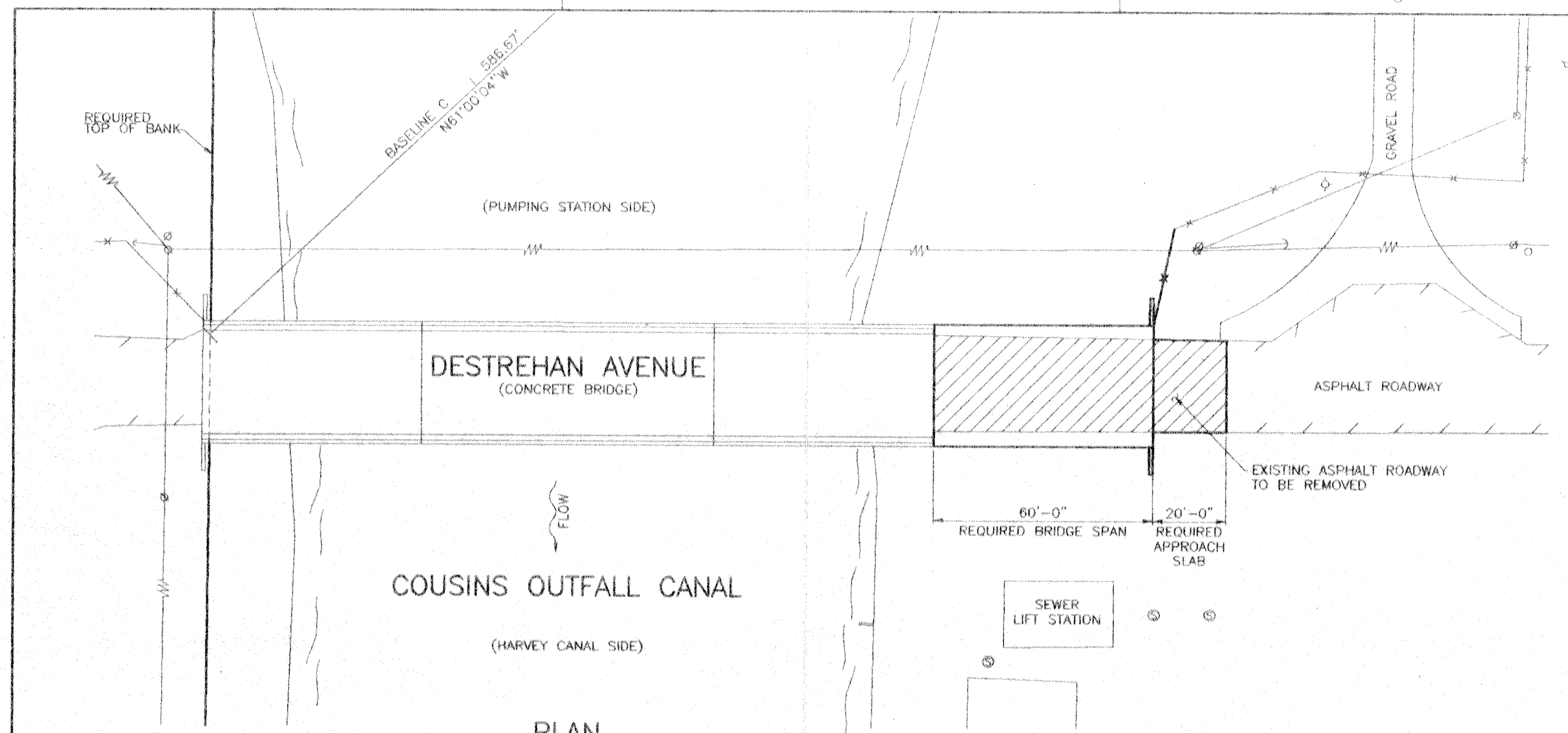
PUMPING STATION SECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

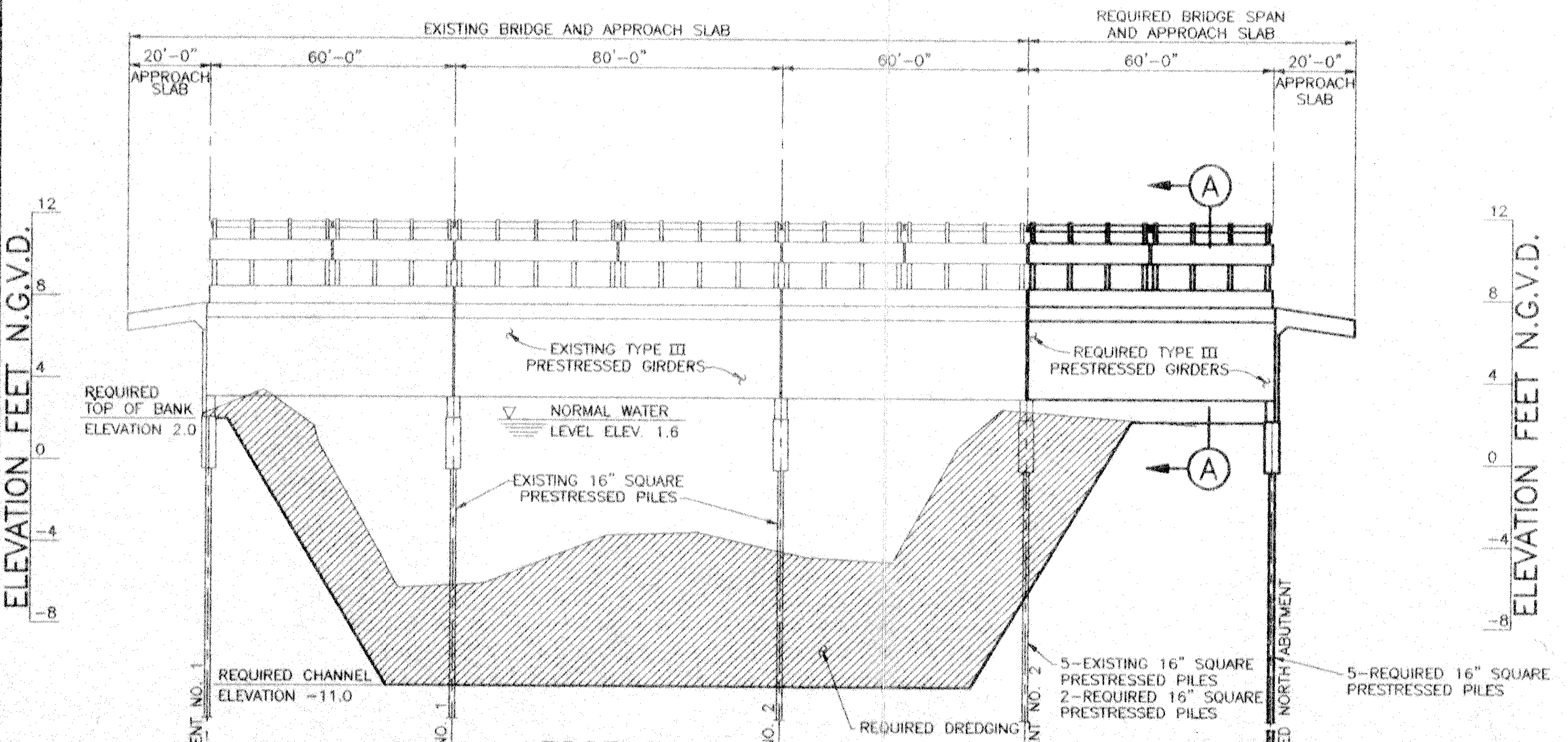
DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44070

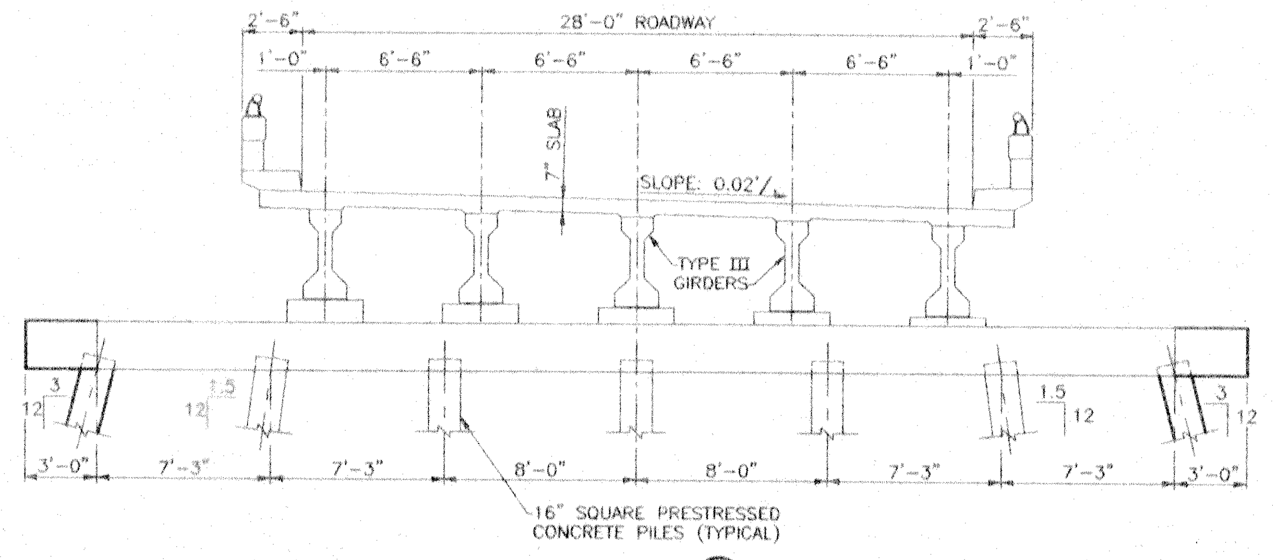
PLATE P-9



PLAN
SCALE: 1" = 20'



PROFILE
SCALE: HORIZ. 1" = 20'
VERT. 1" = 4'



SECTION (A)
SCALE: 1/4" = 1'-0"

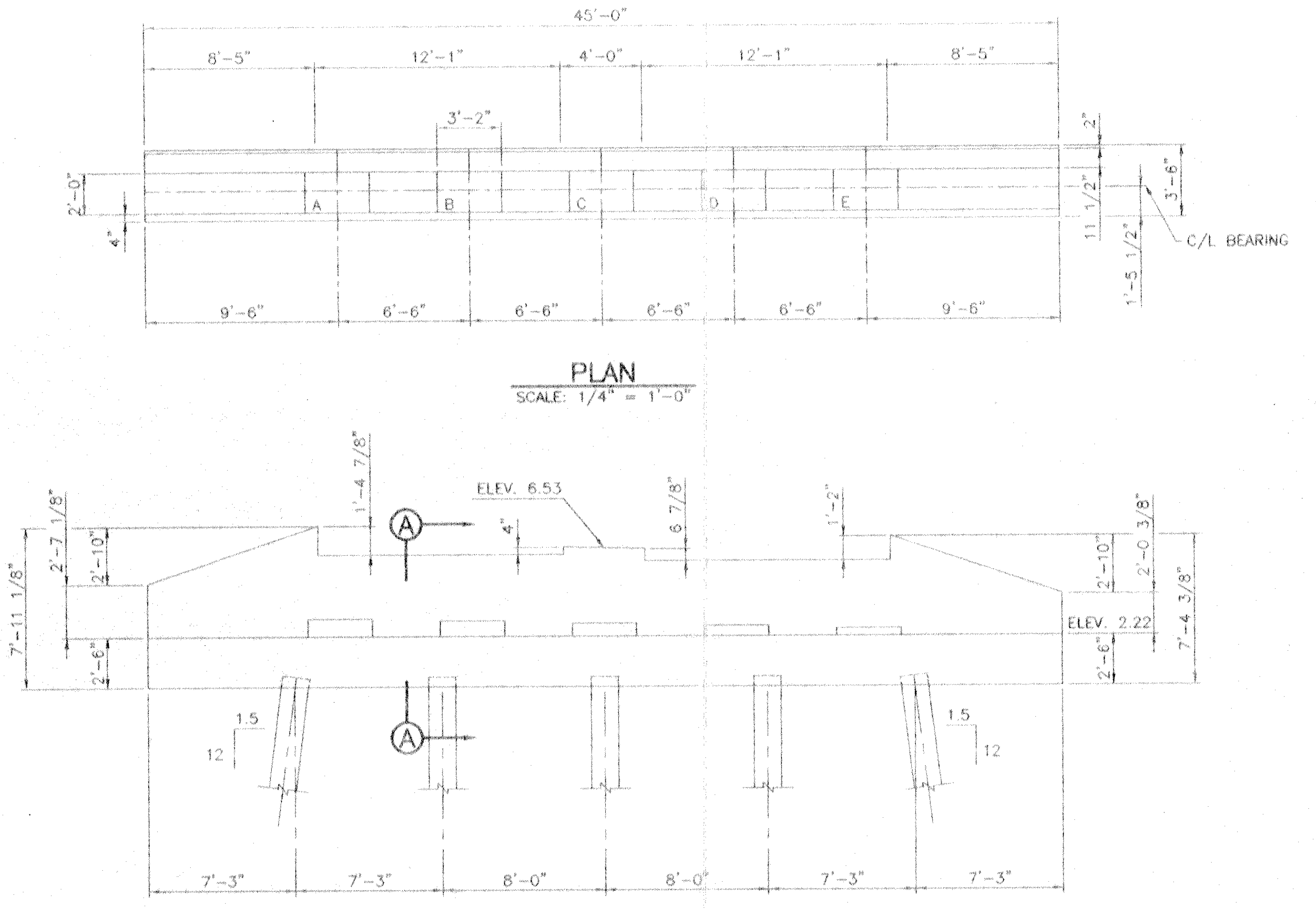
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

DESTREHAN AVENUE BRIDGE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
DATE: JANUARY 1998
FILE NO. H-2-44970

PLATE B-1

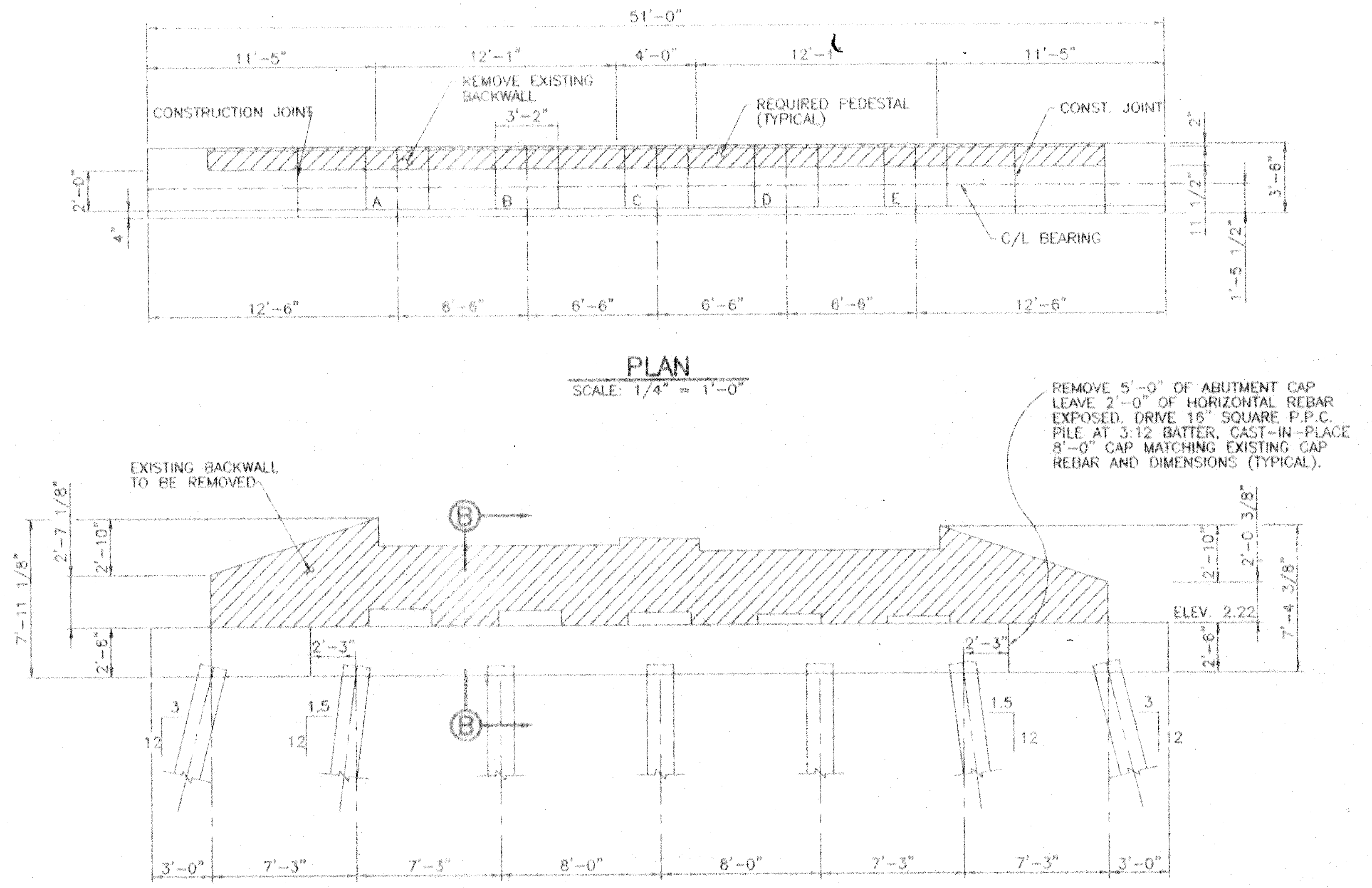


PLAN
SCALE: 1/4" = 1'-0"

REQUIRED NORTH ABUTMENT
SCALE: 1/4" = 1'-0"

TABLE OF ELEVATIONS	
LOCATION	ELEVATION
A	3.11
B	2.98
C	2.85
D	2.72
E	2.59

REQUIRED PILE TIP ELEVATION: (-)81.73

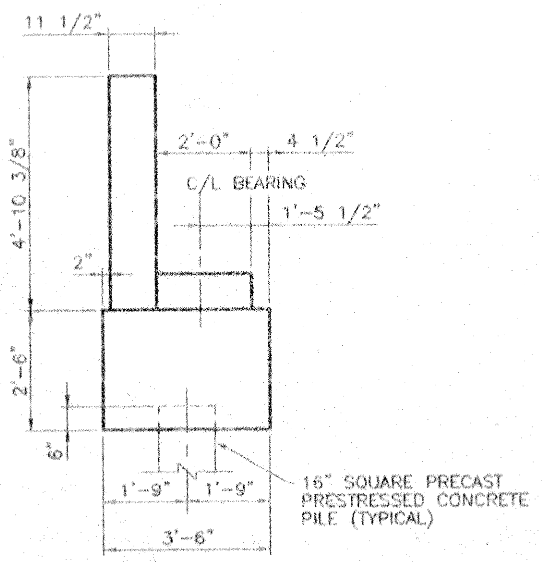


PLAN
SCALE: 1/4" = 1'-0"

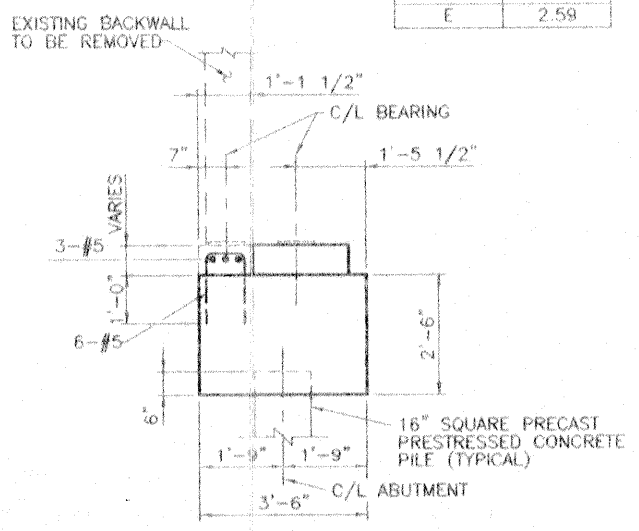
ABUTMENT NO. 2
SCALE: 1/4" = 1'-0"

TABLE OF ELEVATIONS	
LOCATION	ELEVATION
A	3.11
B	2.98
C	2.85
D	2.72
E	2.59

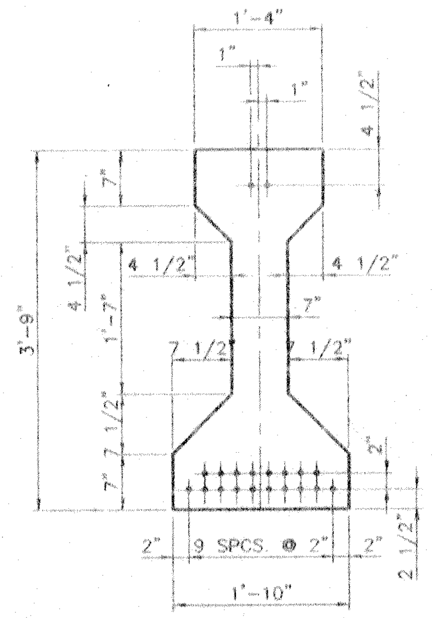
REQUIRED PILE TIP ELEVATION: (-)81.73



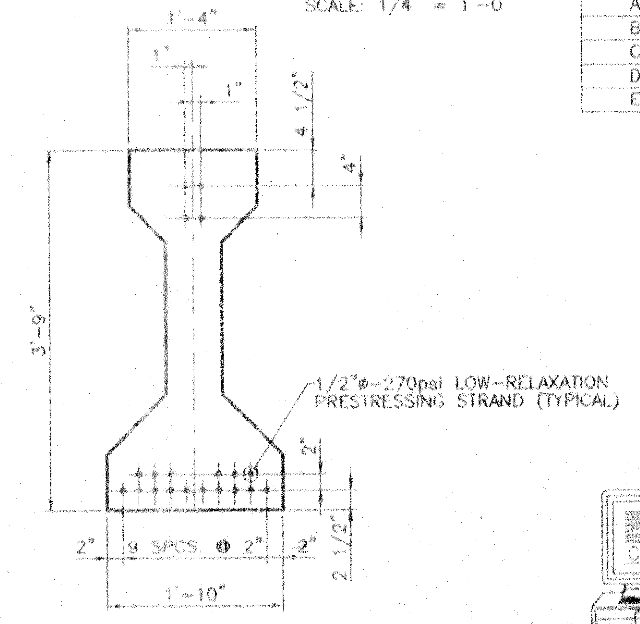
SECTION (A)
SCALE: 1/2" = 1'-0"



SECTION (B)
SCALE: 1/2" = 1'-0"



SECTION AT C/L SPAN
SCALE: 1" = 1'-0"



SECTION AT END OF SPAN
SCALE: 1" = 1'-0"

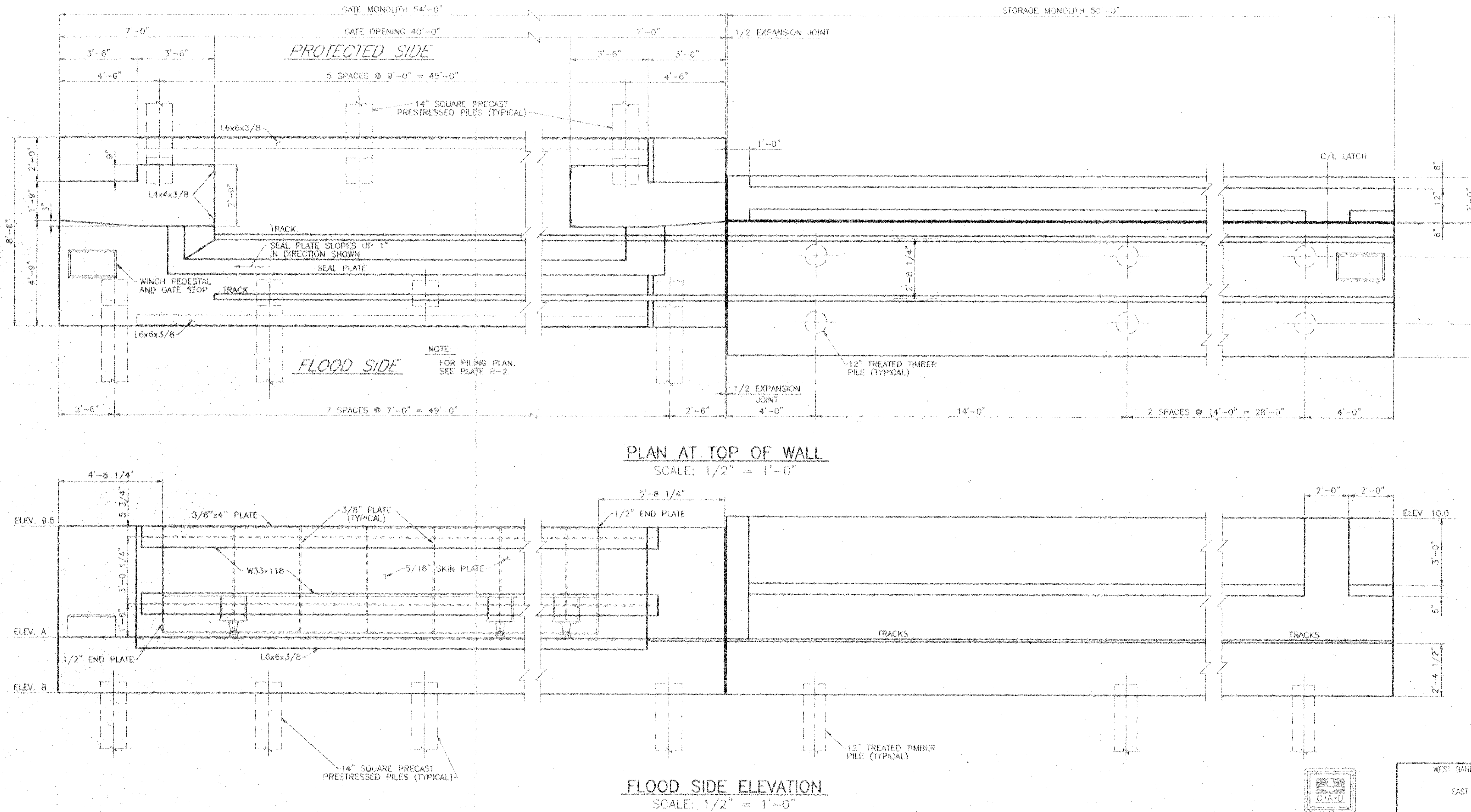
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

DESTREHAN AVENUE BRIDGE DETAILS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO. H-2-44970



SCHEDULE OF ELEVATIONS		
LOCATION	ELEV. A	ELEV. B
NORTH GATE	4.50	2.00
SOUTH GATE	5.00	2.50

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

BOTTOM ROLLER GATE

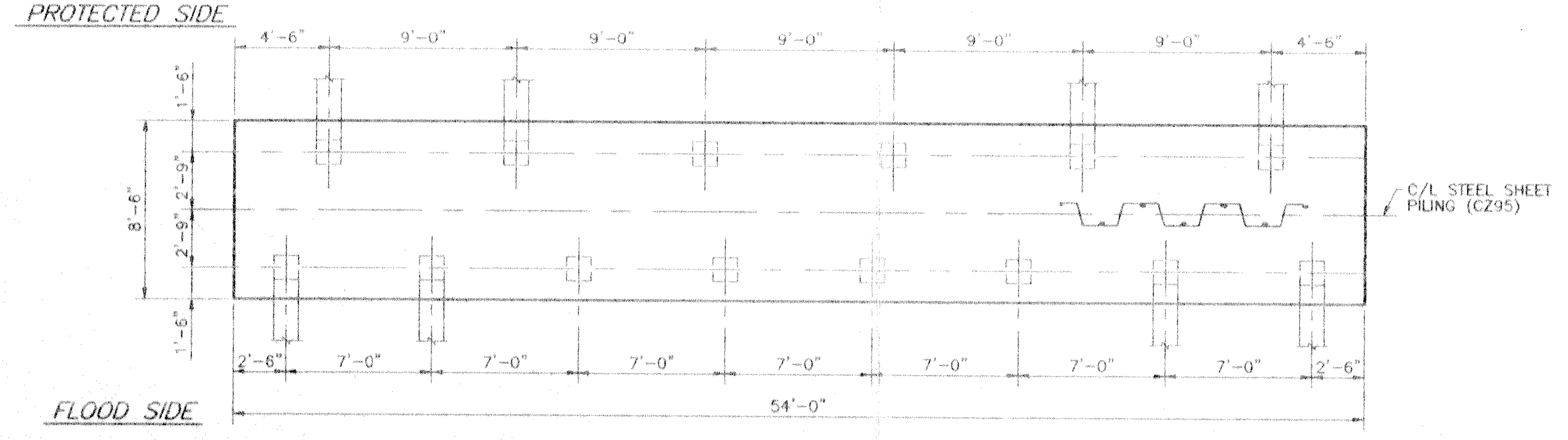
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

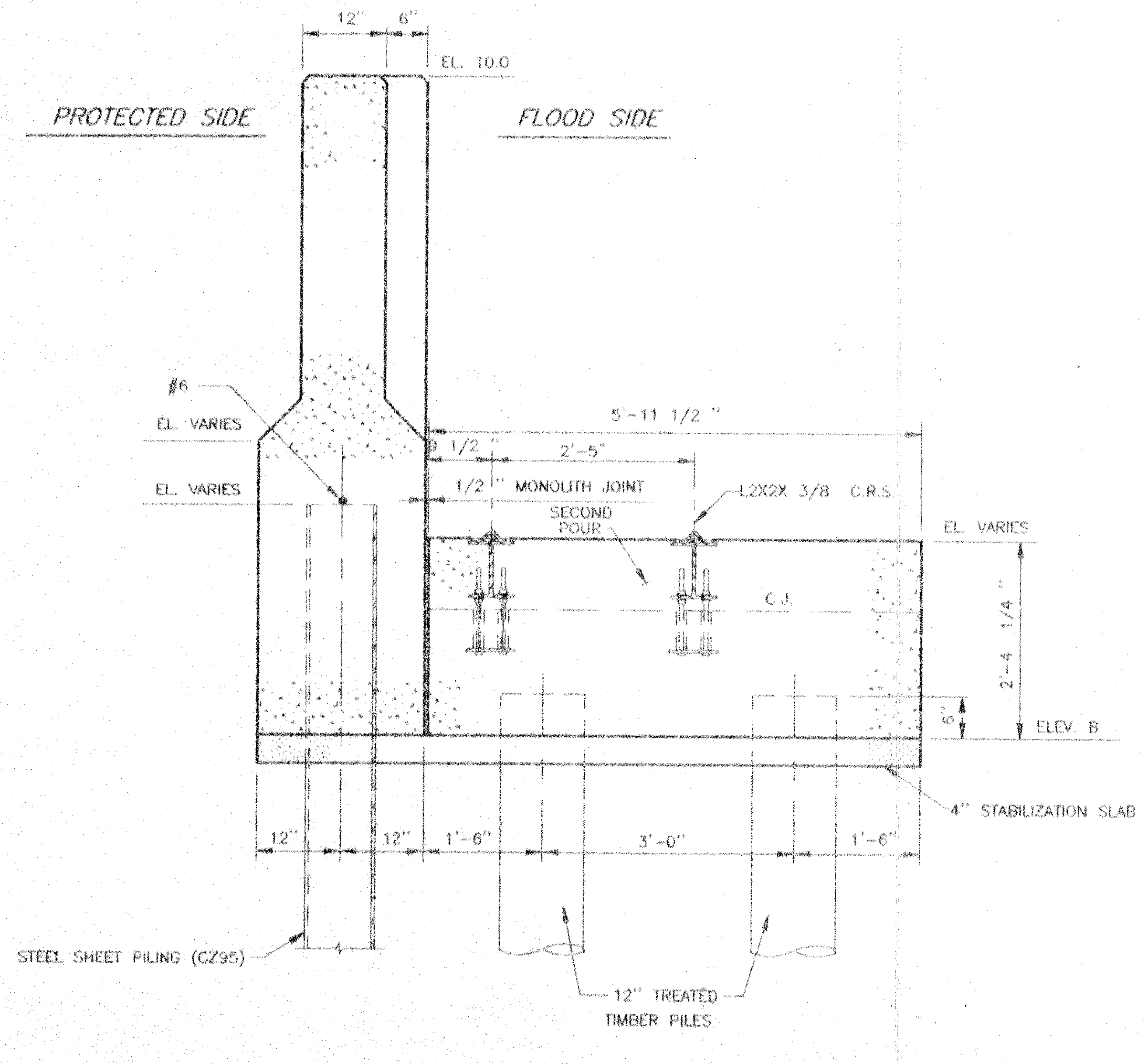
DATE: JANUARY 1999

FILE NO. H-2-44970

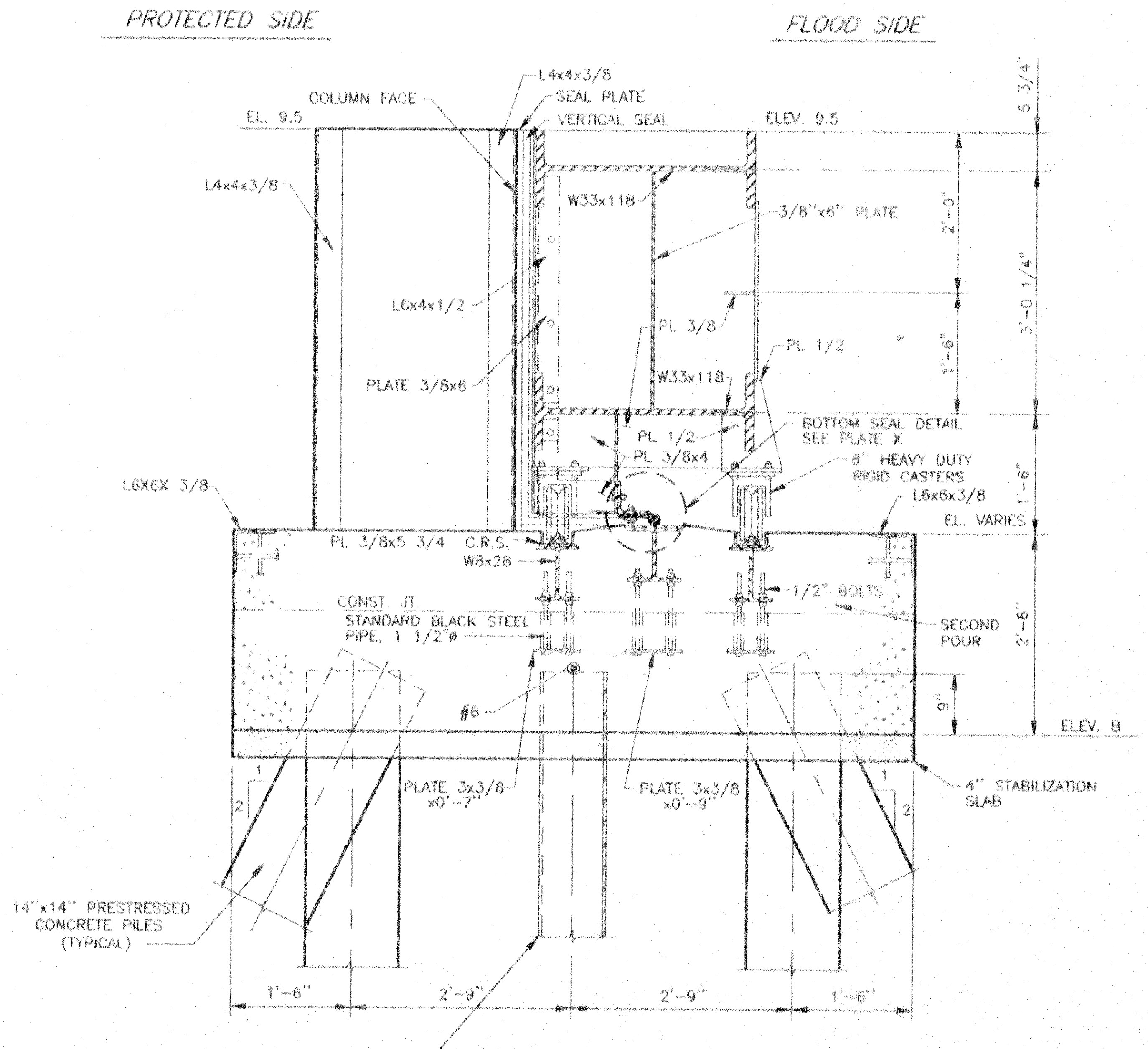
PLATE R-1



GATE MONOLITH PILING PLAN
SCALE: 1/4" = 1'-0"



STORAGE MONOLITH
SCALE: 1" = 1'-0"



GATE MONOLITH
SCALE: 1" = 1'-0"

NOTE:
FOR SCHEDULE OF ELEVATIONS, SEE PLATE NO. R-1.

SCALE: 1" = 1'- 0"
12" 0 1' 2' 3' 4' 5'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

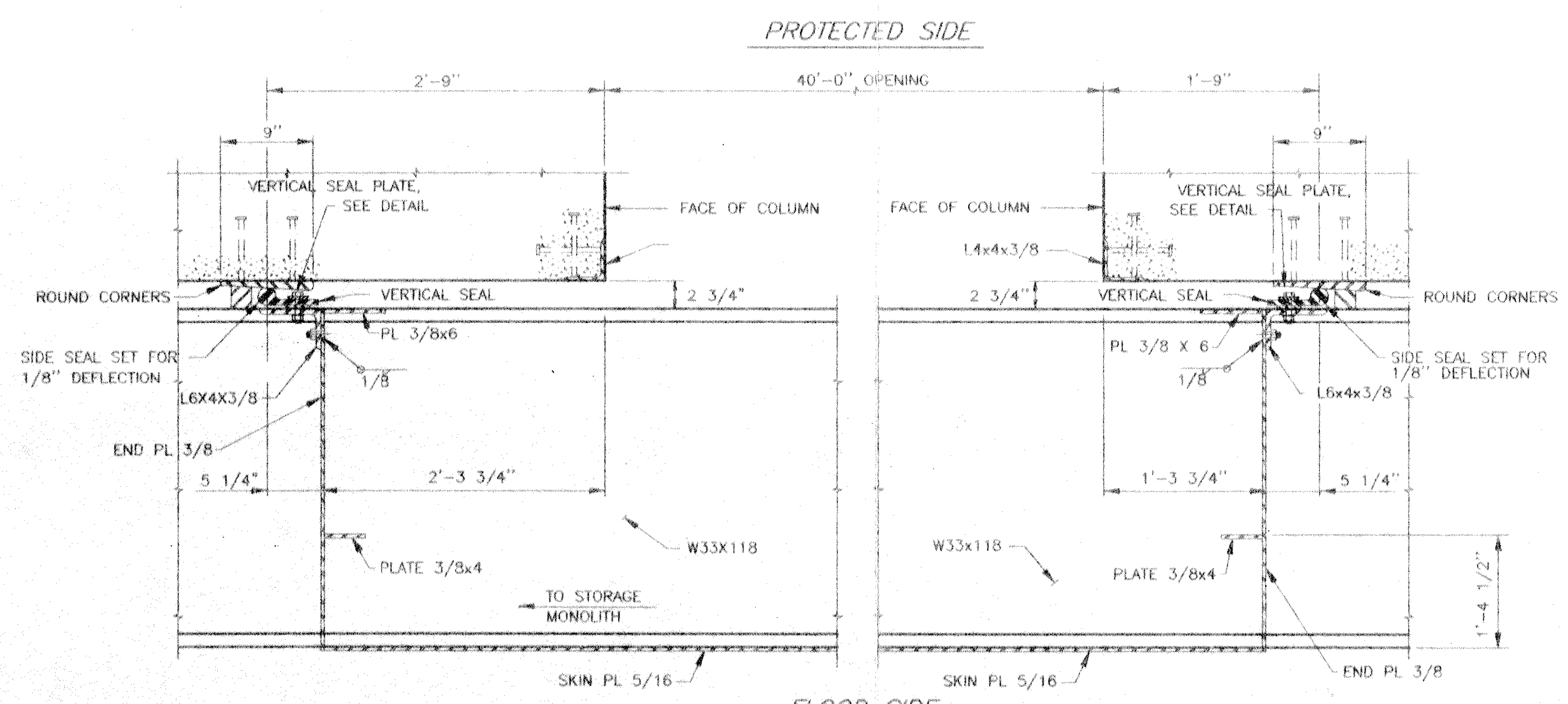
BOTTOM ROLLER GATE SECTIONS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

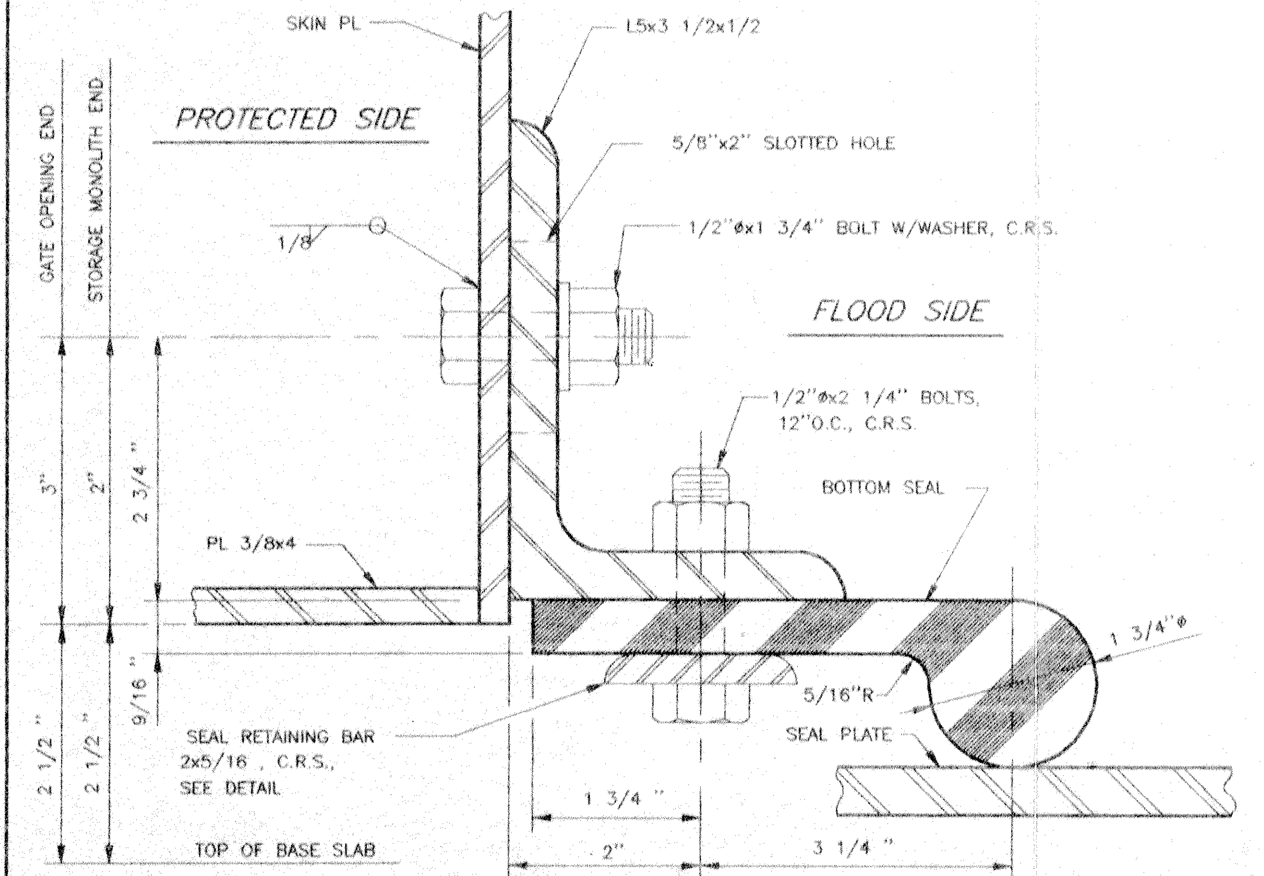
H-2-44970

PLATE R-2



SECTION THRU ROLLER GATE

SCALE: 1 1/2" = 1' - 0"



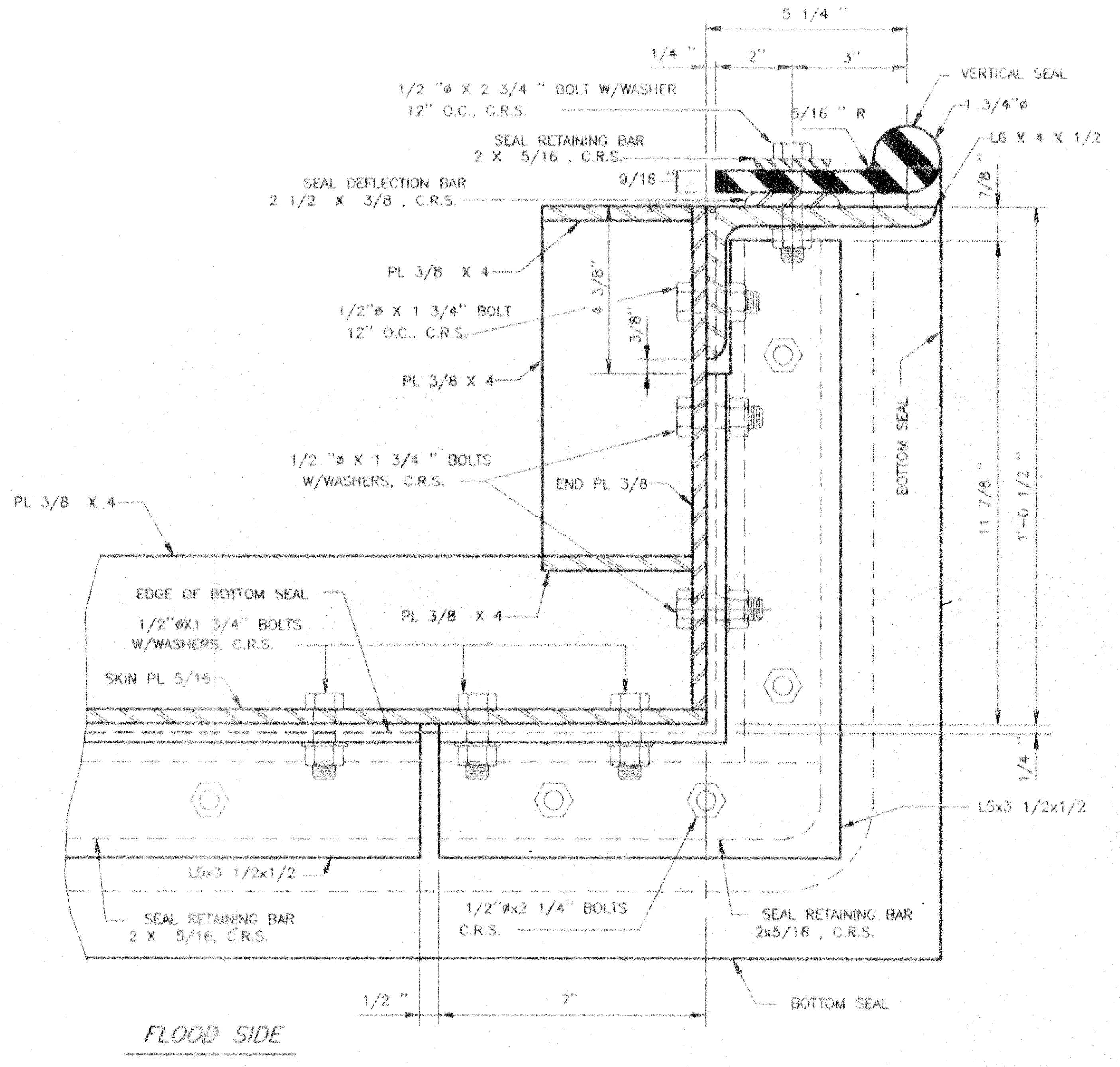
TYPICAL SECTION THRU BOTTOM SEAL

SCALE: 12" = 1' - 0"

SCALE: 1 1/2" = 1'-0"

SCALE: 6" = 1'-0"

SCALE: 12" = 1'-0"



VERTICAL SEAL

PLAN AT END OF GATE BELOW W

SCALE: 6" = 1" - 0"

C·A·D

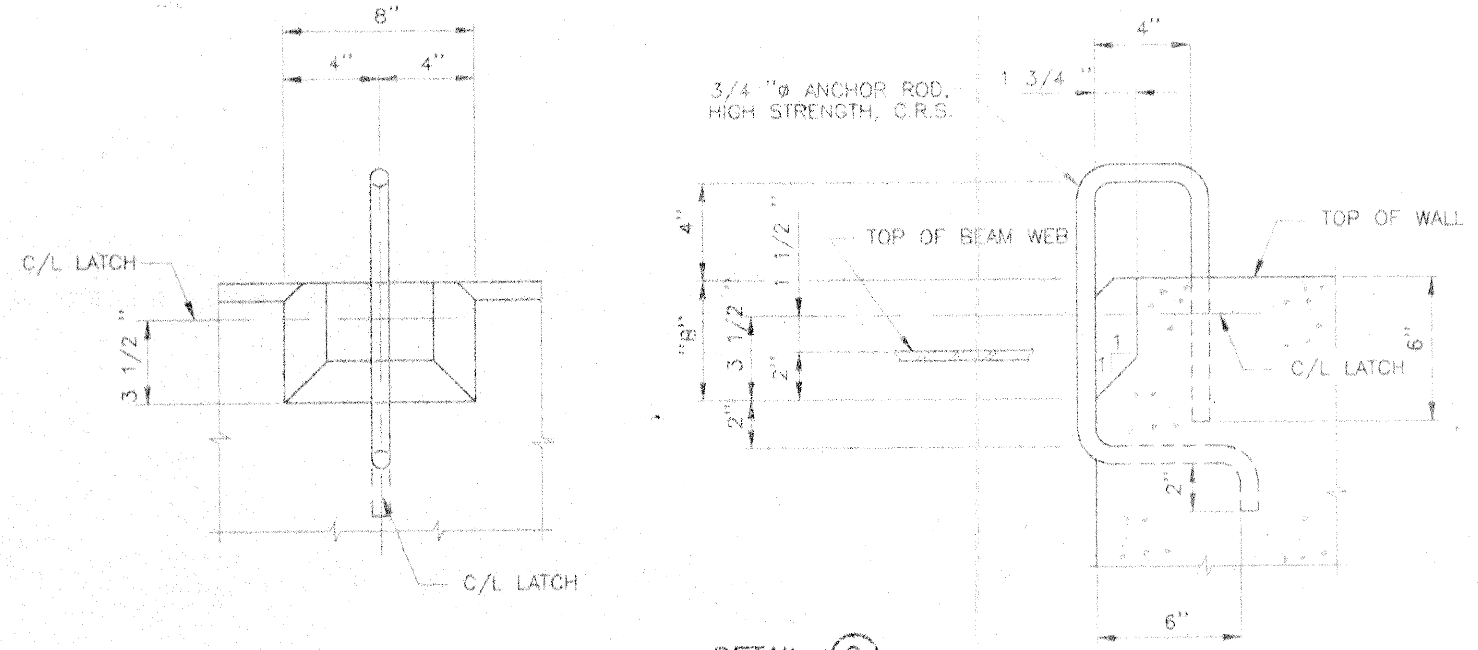
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

BOTTOM ROLLER GATE SEAL DETAILS

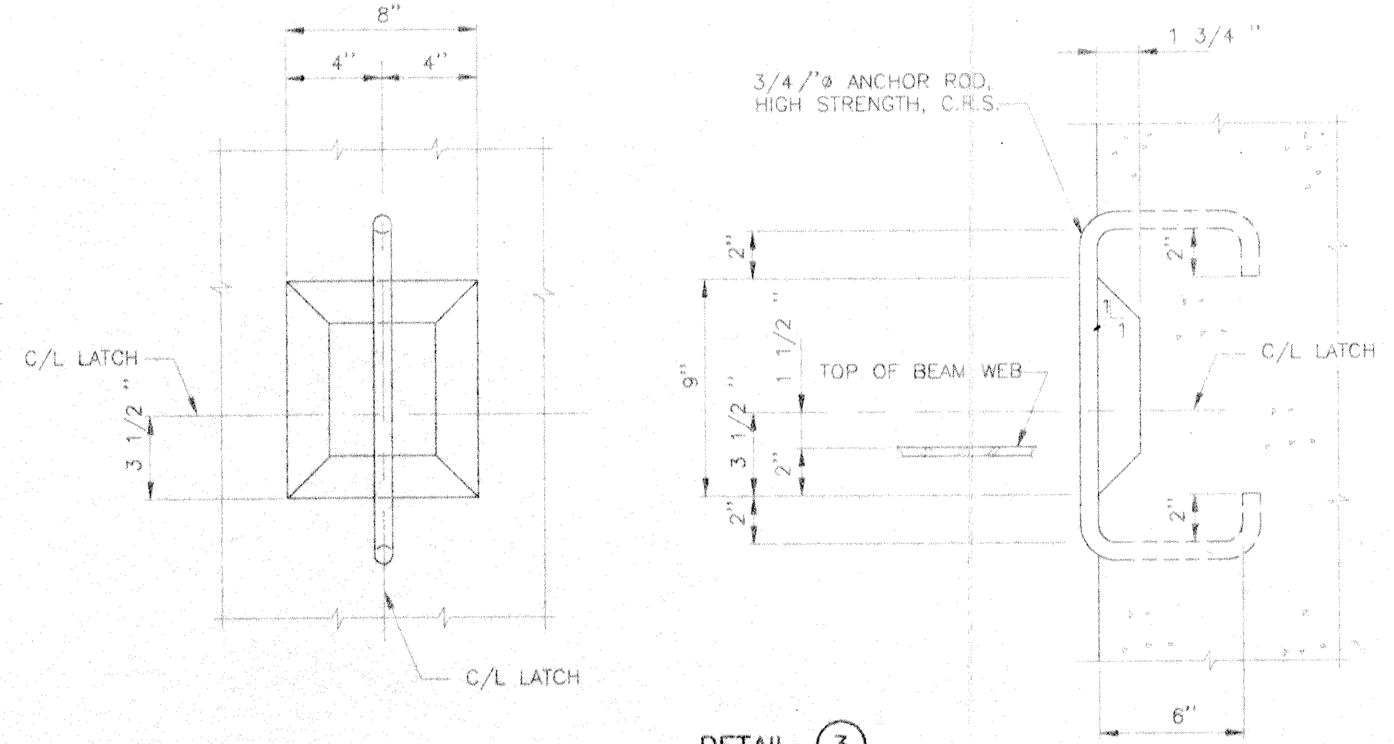
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO. H-2-44970



DETAIL (2)
SCALE: 3" = 1' - 0"



DETAIL (3)
SCALE: 3" = 1' - 0"

SCALE: 3" = 1'-0"

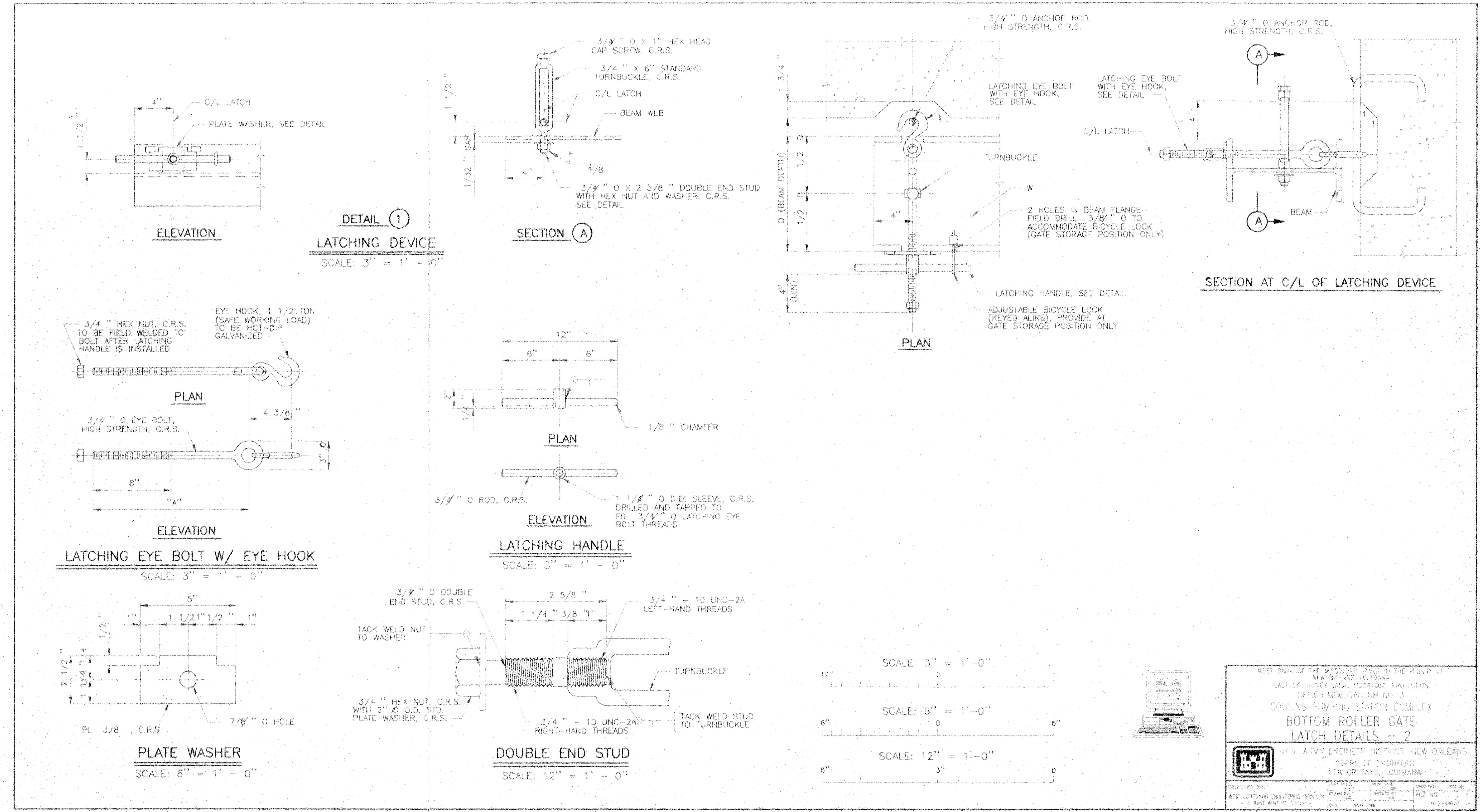
12" 0 1'

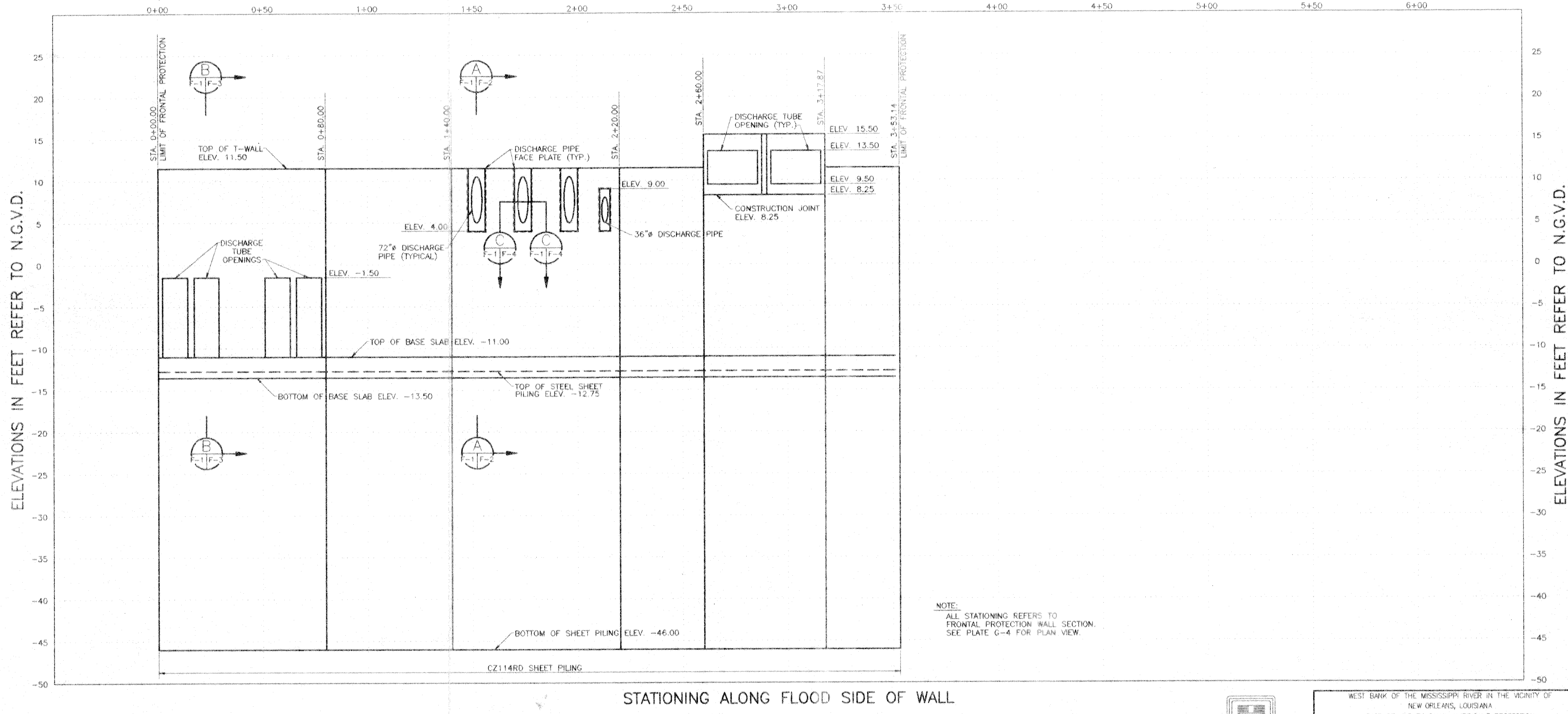
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

BOTTOM ROLLER GATE
LATCH DETAILS – 1

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:	PLOT SCALE:	PLOT DATE:	CADD FILE:
WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –	DRAWN BY: M.Z.	CHECKED BY: A.R.	FILE NO. H-2-44970
	DATE: JANUARY 1996		


4"
C/L LATCH
PLATE WASHER, SEE DETAIL
1 1/2"
ELEVATION
DETAIL 1
LATCHING DEVICE
SCALE: 3" = 1' - 0"
3/4" Ø X 1" HEX HEAD CAP SCREW, C.R.S.
3/4" X 6" STANDARD TURNBUCKLE, C.R.S.
C/L LATCH
BEAM WEB
1 1/2"
1/32" GAP
4"
1/8
3/4" Ø X 2 5/8" DOUBLE END STUD WITH HEX NUT AND WASHER, C.R.S. SEE DETAIL
SECTION A
3/4" Ø ANCHOR ROD, HIGH STRENGTH, C.R.S.
1 3/4"
LATCHING EYE BOLT WITH EYE HOOK, SEE DETAIL
TURNBUCKLE
W
2 HOLES IN BEAM FLANGE-FIELD DRILL 3/8" Ø TO ACCOMMODATE BICYCLE LOCK (GATE STORAGE POSITION ONLY)
D (BEAM DEPTH)
1/2 D
1/2 D
4"
4" (MIN)
LATCHING HANDLE, SEE DETAIL
ADJUSTABLE BICYCLE LOCK (KEYED ALIKE), PROVIDE AT GATE STORAGE POSITION ONLY
PLAN
3/4" Ø ANCHOR ROD, HIGH STRENGTH, C.R.S.
LATCHING EYE BOLT WITH EYE HOOK, SEE DETAIL
C/L LATCH
BEAM
A
SECTION AT C/L OF LATCHING DEVICE
3/4" HEX NUT, C.R.S. TO BE FIELD WELDED TO BOLT AFTER LATCHING HANDLE IS INSTALLED
EYE HOOK, 1 1/2 TON (SAFE WORKING LOAD) TO BE HOT-DIP GALVANIZED
PLAN
4 3/8"
3/4" Ø EYE BOLT, HIGH STRENGTH, C.R.S.
3" Ø
8"
"A"
ELEVATION
LATCHING EYE BOLT W/ EYE HOOK
SCALE: 3" = 1' - 0"
12"
6"
6"
2"
1/4"
1/8" CHAMFER
PLAN
3/4" Ø ROD, C.R.S.
1 1/4" Ø O.D. SLEEVE, C.R.S. DRILLED AND TAPPED TO FIT 3/4" Ø LATCHING EYE BOLT THREADS
ELEVATION
LATCHING HANDLE
SCALE: 3" = 1' - 0"
5"
1"
1 1/2
1"
1/2"
1"
1/2"
2 1/2"
1 1/4
1/4
7/8" Ø HOLE
PL 3/8, C.R.S.
PLATE WASHER
SCALE: 6" = 1' - 0"
3/4" Ø DOUBLE END STUD, C.R.S.
TACK WELD NUT TO WASHER
2 5/8"
1 1/4"
3/8"
1"
3/4" - 10 UNC-2A LEFT-HAND THREADS
TURNBUCKLE
3/4" HEX NUT, C.R.S. WITH 2" Ø O.D. STD. PLATE WASHER, C.R.S.
3/4" - 10 UNC-2A RIGHT-HAND THREADS
TACK WELD STUD TO TURNBUCKLE
DOUBLE END STUD
SCALE: 12" = 1' - 0"
SCALE: 3" = 1'-0"
12" 0 1'
SCALE: 6" = 1'-0"
6" 0 6"
SCALE: 12" = 1'-0"
8" 3" 0
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
BOTTOM ROLLER GATE
LATCH DETAILS - 2
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
H-2-44970
PLATE R-5



COUSINS PUMP STATION
FRONTAL PROTECTION PROFILE

SCALE: HORIZ. 1" = 20'
VERT. 1" = 5'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

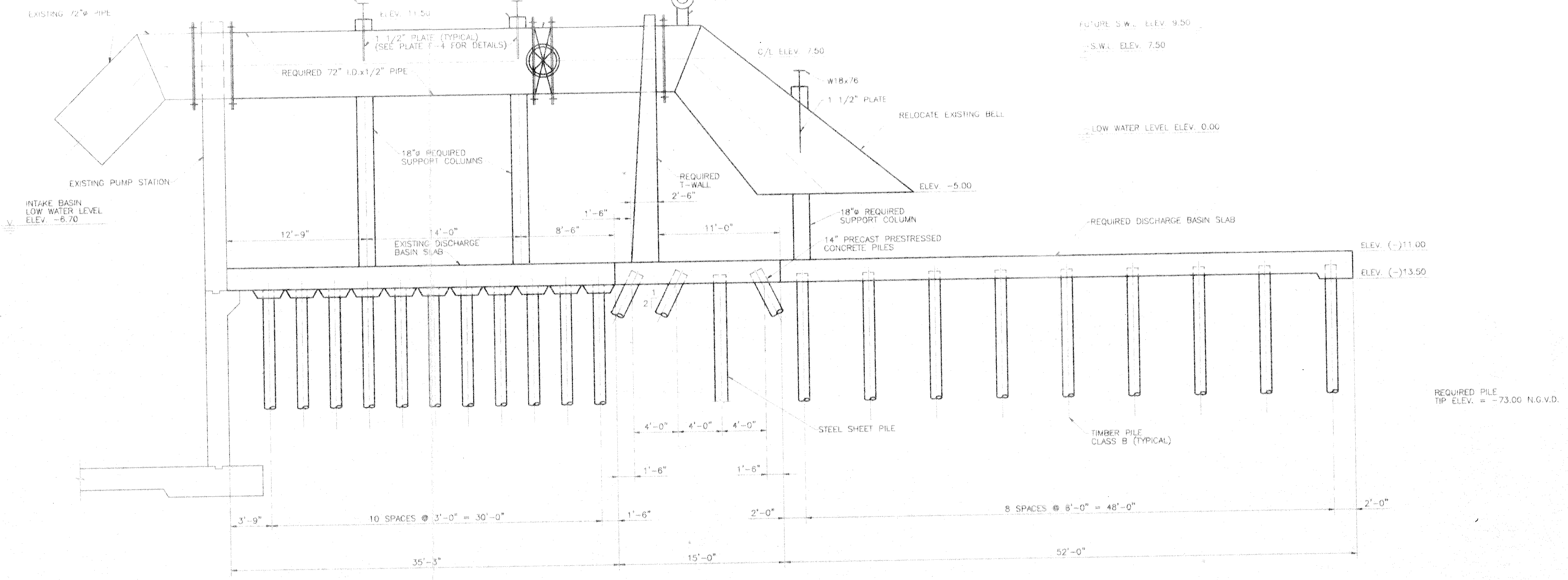
FRONTAL PROTECTION PROFILE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

DATE: JANUARY 1998

FILE NO. H-2-44970



72"ø VERTICAL PUMP (A / F-1 F-2)
SCALE: 1/4"=1'-0"

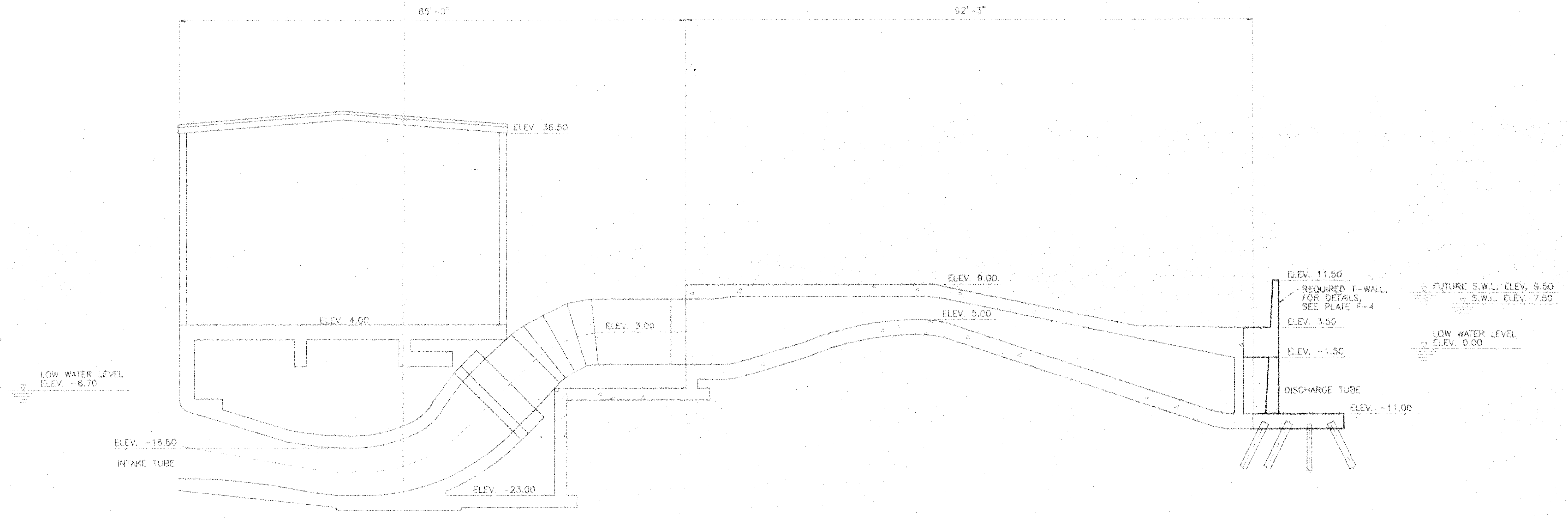
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

EXISTING COUSINS PUMP STATION
SECTION - 1

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44970



EXISTING COUSINS PUMPING STATION (B F-1 F-3)
SCALE: 1/8" = 1'-0"

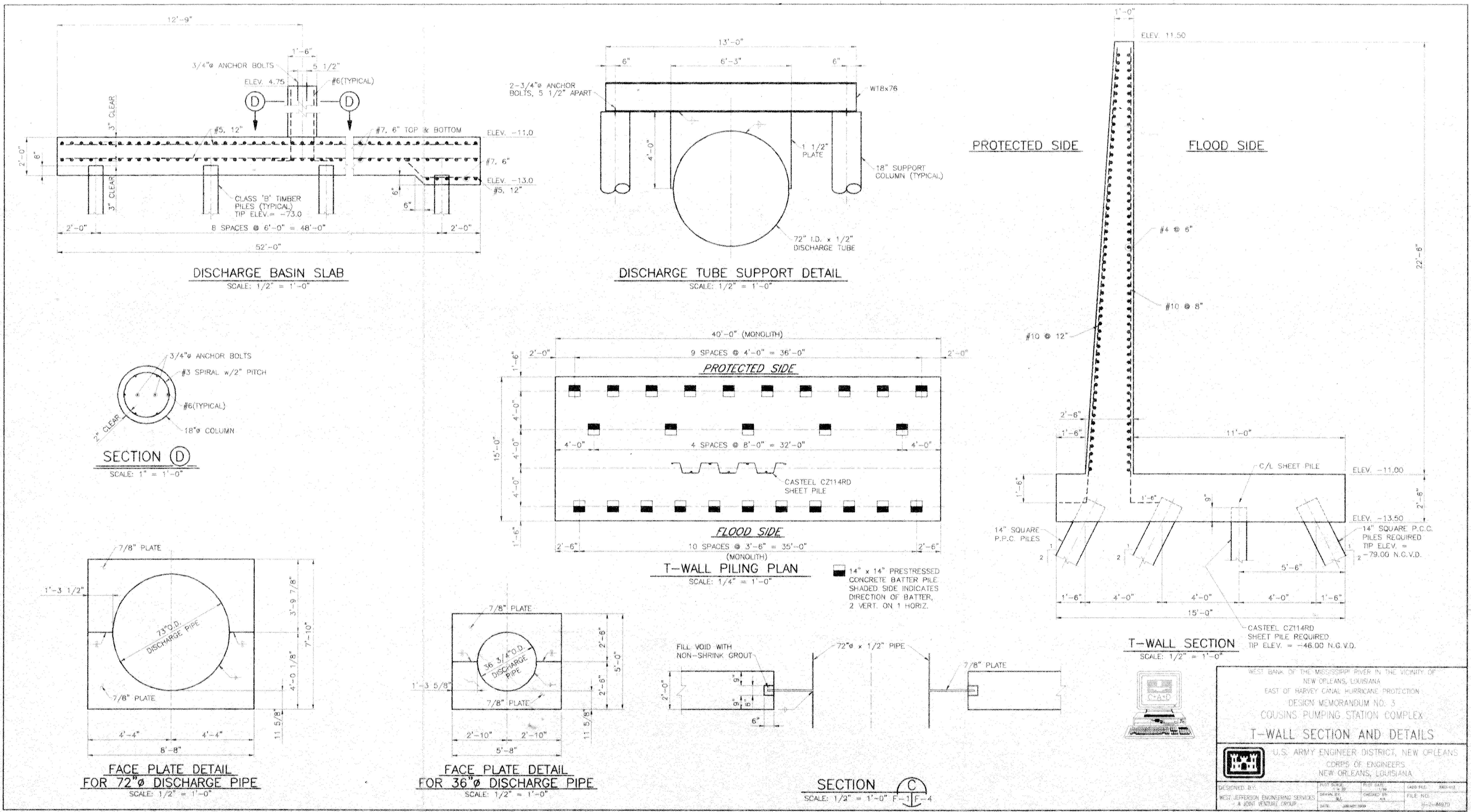
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

EXISTING COUSINS PUMPING STATION SECTION - 2

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

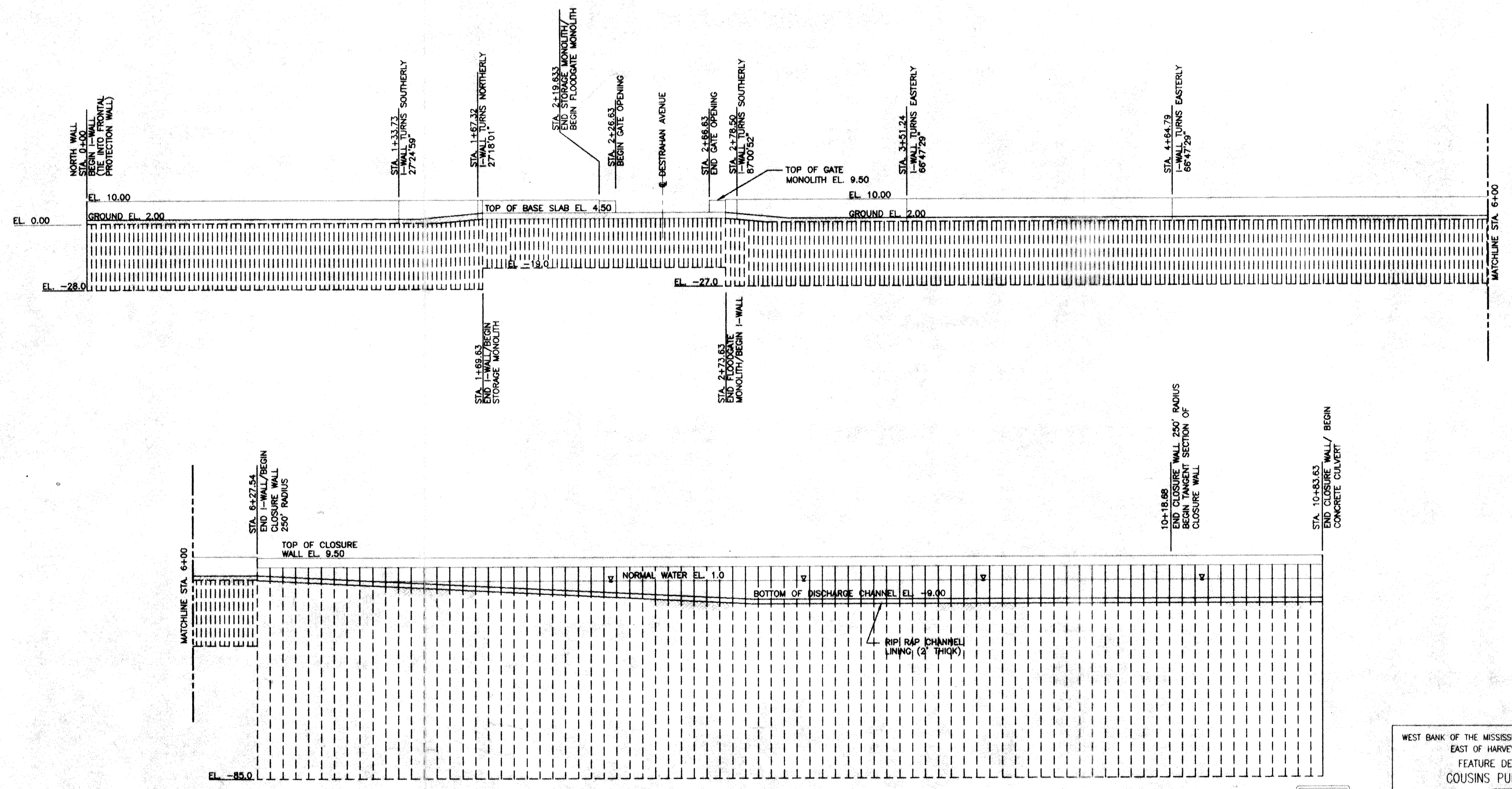
DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44970



DISCHARGE BASIN SLAB
SCALE: 1/2" = 1'-0"
12'-9"
1'-6"
3/4"ø ANCHOR BOLTS
5 1/2"
ELEV. 4.75
#6(TYPICAL)
3" CLEAR
#5, 12"
#7, 6" TOP & BOTTOM
ELEV. -11.0
#7, 6"
ELEV. -13.0
#5, 12"
CLASS 'B' TIMBER PILES (TYPICAL) TIP ELEV.= -73.0
8 SPACES @ 6'-0" = 48'-0"
52'-0"
DISCHARGE TUBE SUPPORT DETAIL
SCALE: 1/2" = 1'-0"
13'-0"
6'-3"
2-3/4"ø ANCHOR BOLTS, 5 1/2" APART
W18x76
1 1/2" PLATE
18" SUPPORT COLUMN (TYPICAL)
72" I.D. x 1/2" DISCHARGE TUBE
SECTION D
SCALE: 1" = 1'-0"
3/4"ø ANCHOR BOLTS
#3 SPIRAL w/2" PITCH
#6(TYPICAL)
2" CLEAR
18"ø COLUMN
T-WALL PILING PLAN
SCALE: 1/4" = 1'-0"
40'-0" (MONOLITH)
9 SPACES @ 4'-0" = 36'-0"
PROTECTED SIDE
4 SPACES @ 8'-0" = 32'-0"
CASTEEL CZ114RD SHEET PILE
FLOOD SIDE
10 SPACES @ 3'-6" = 35'-0" (MONOLITH)
14" x 14" PRESTRESSED CONCRETE BATTER PILE SHADED SIDE INDICATES DIRECTION OF BATTER, 2 VERT. ON 1 HORIZ.
T-WALL SECTION
SCALE: 1/2" = 1'-0"
PROTECTED SIDE
FLOOD SIDE
ELEV. 11.50
#4 @ 6"
#10 @ 8"
#10 @ 12"
22'-6"
11'-0"
C/L SHEET PILE
ELEV. -11.00
ELEV. -13.50
14" SQUARE P.P.C. PILES
14" SQUARE P.C.C. PILES REQUIRED TIP ELEV. = -79.00 N.G.V.D.
15'-0"
CASTEEL CZ114RD SHEET PILE REQUIRED TIP ELEV. = -46.00 N.G.V.D.
FACE PLATE DETAIL FOR 72"ø DISCHARGE PIPE
SCALE: 1/2" = 1'-0"
7/8" PLATE
73"O.D. DISCHARGE PIPE
8'-8"
FACE PLATE DETAIL FOR 36"ø DISCHARGE PIPE
SCALE: 1/2" = 1'-0"
36 3/4"O.D. DISCHARGE PIPE
5'-8"
SECTION C
SCALE: 1/2" = 1'-0" F-1 F-4
FILL VOID WITH NON-SHRINK GROUT
72"ø x 1/2" PIPE
7/8" PLATE
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
T-WALL SECTION AND DETAILS
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA
DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
PLATE F-4

NOTE: ALL STATIONING REFERS TO NORTH WALL STATION. SEE PLATE G-4 FOR PLAN VIEW.



NORTH FLOODWALL PROFILE

SCALE: 1" = 20'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

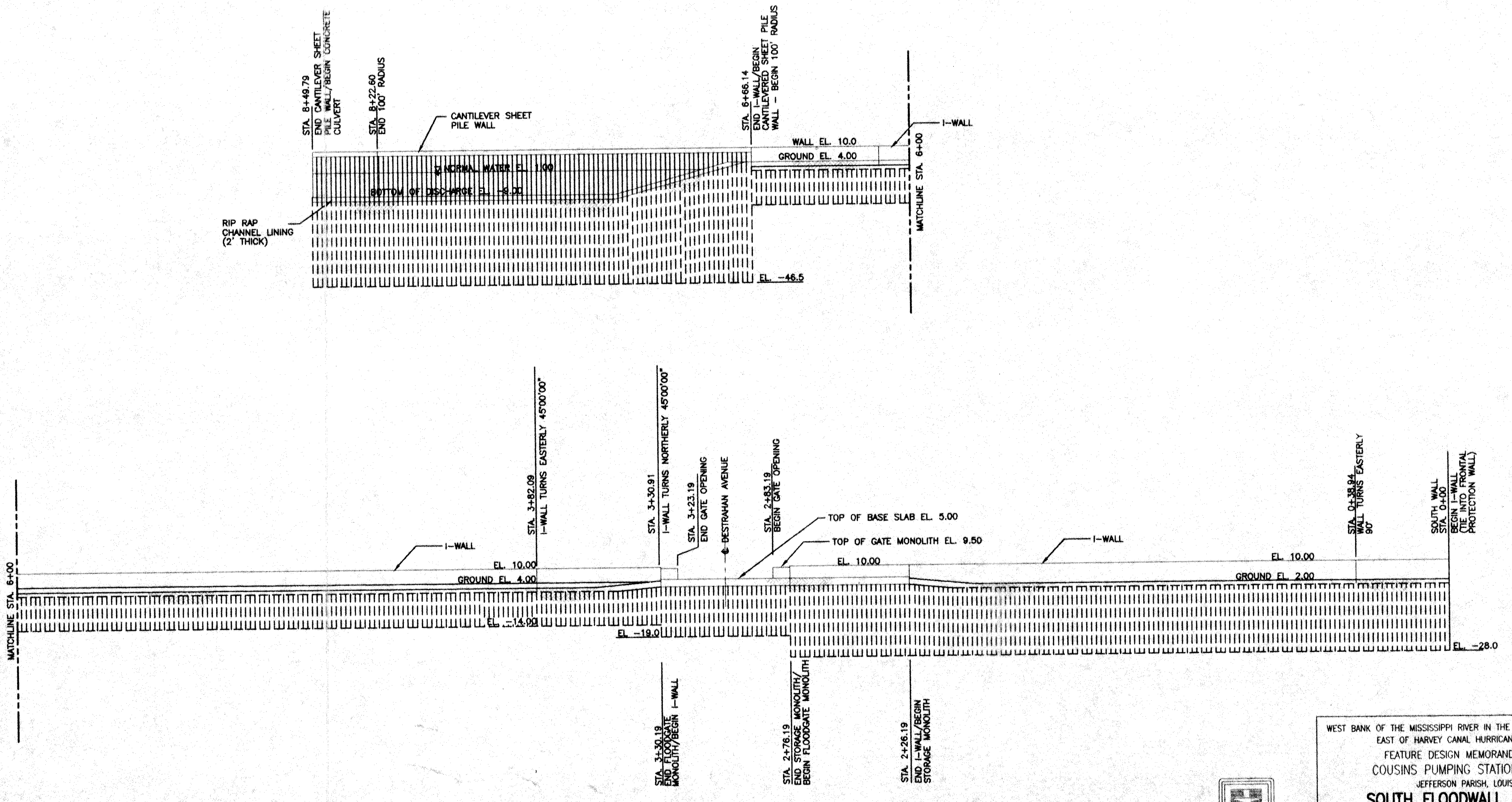
NORTH FLOODWALL PROFILE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO. H-2-44970

NOTE: ALL STATIONING REFERS TO SOUTH WALL STATIONS. SEE PLATE G-4 FOR PLAN VIEW.



SOUTH FLOODWALL PROFILE
SCALE: 1" = 20'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

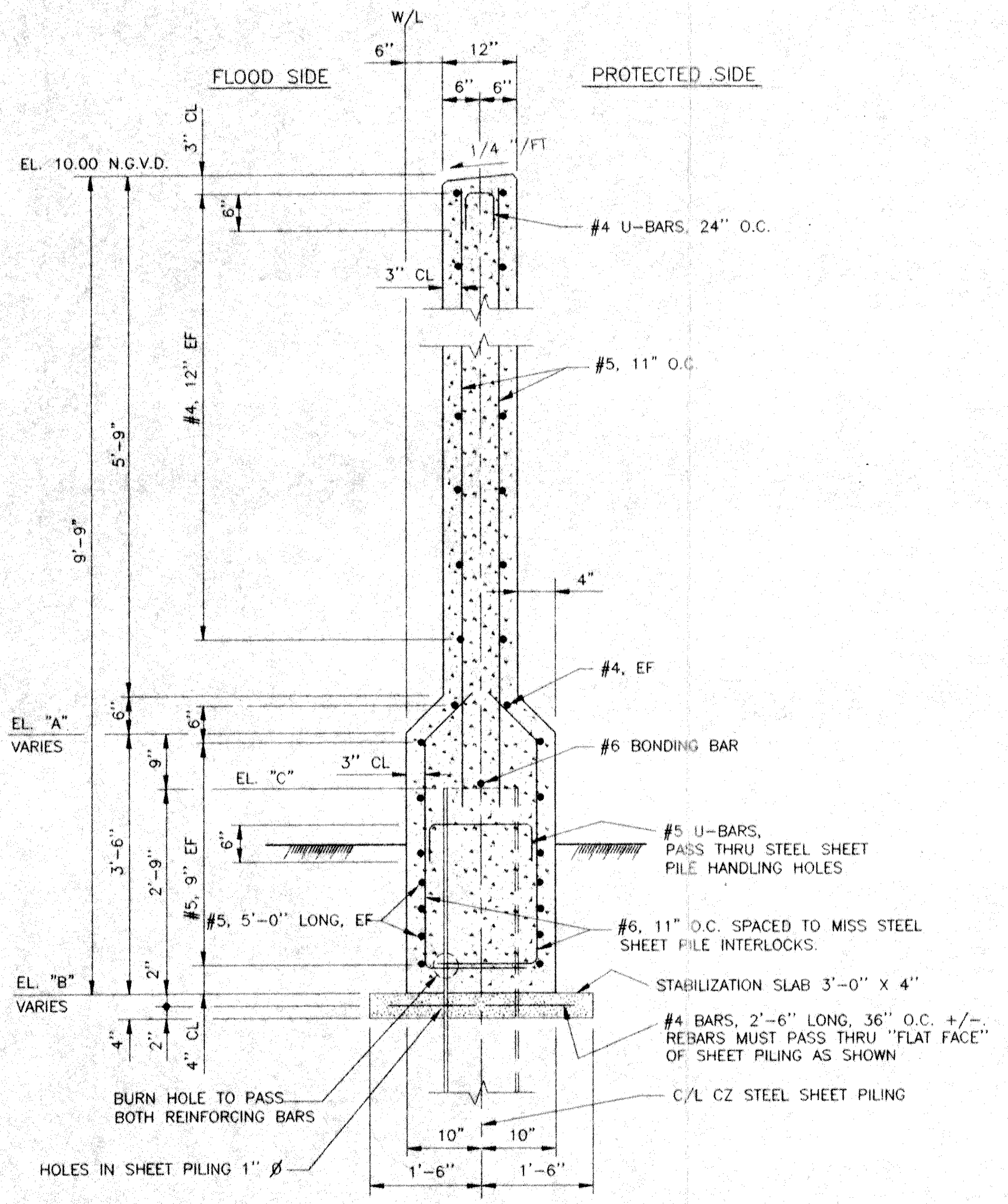
SOUTH FLOODWALL PROFILE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO. H-2-44970

PLATE F-6

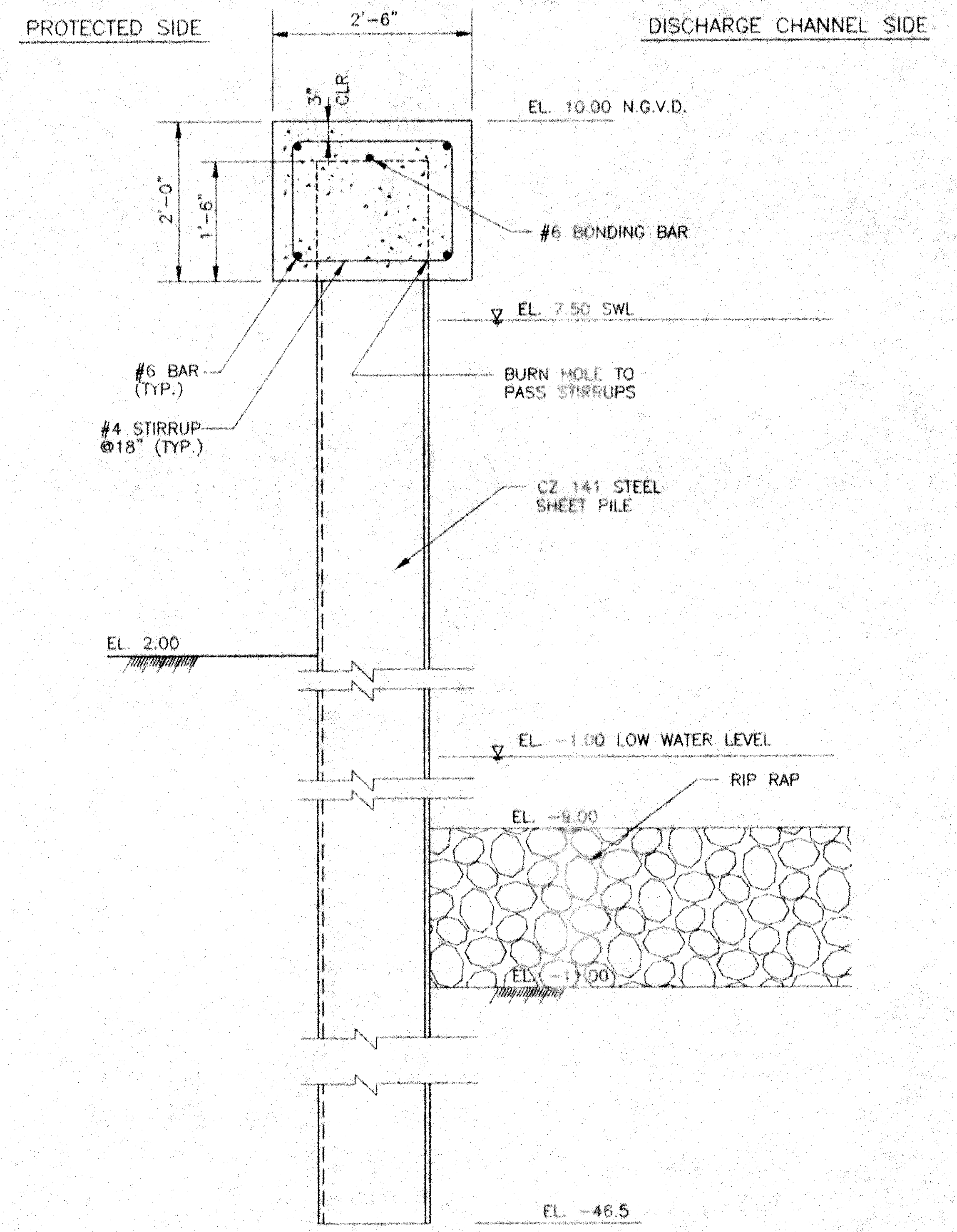


TYPICAL I-WALL SECTION

SCALE: 1" = 1'- 0"

SCHEDULE OF ELEVATIONS

PROPOSED GROUND EL.	EL. "A"	EL. "B"	EL. "C"
EL. 2.00	3.75	0.25	3.00
EL. 4.00	5.75	2.25	5.00



TYPICAL CANTILEVER SHEET PILE WALL

SCALE: 1 " = 1'- 0"

SCALE: 3/4 " = 1'- 0"

SCALE: 1" = 1'- 0"

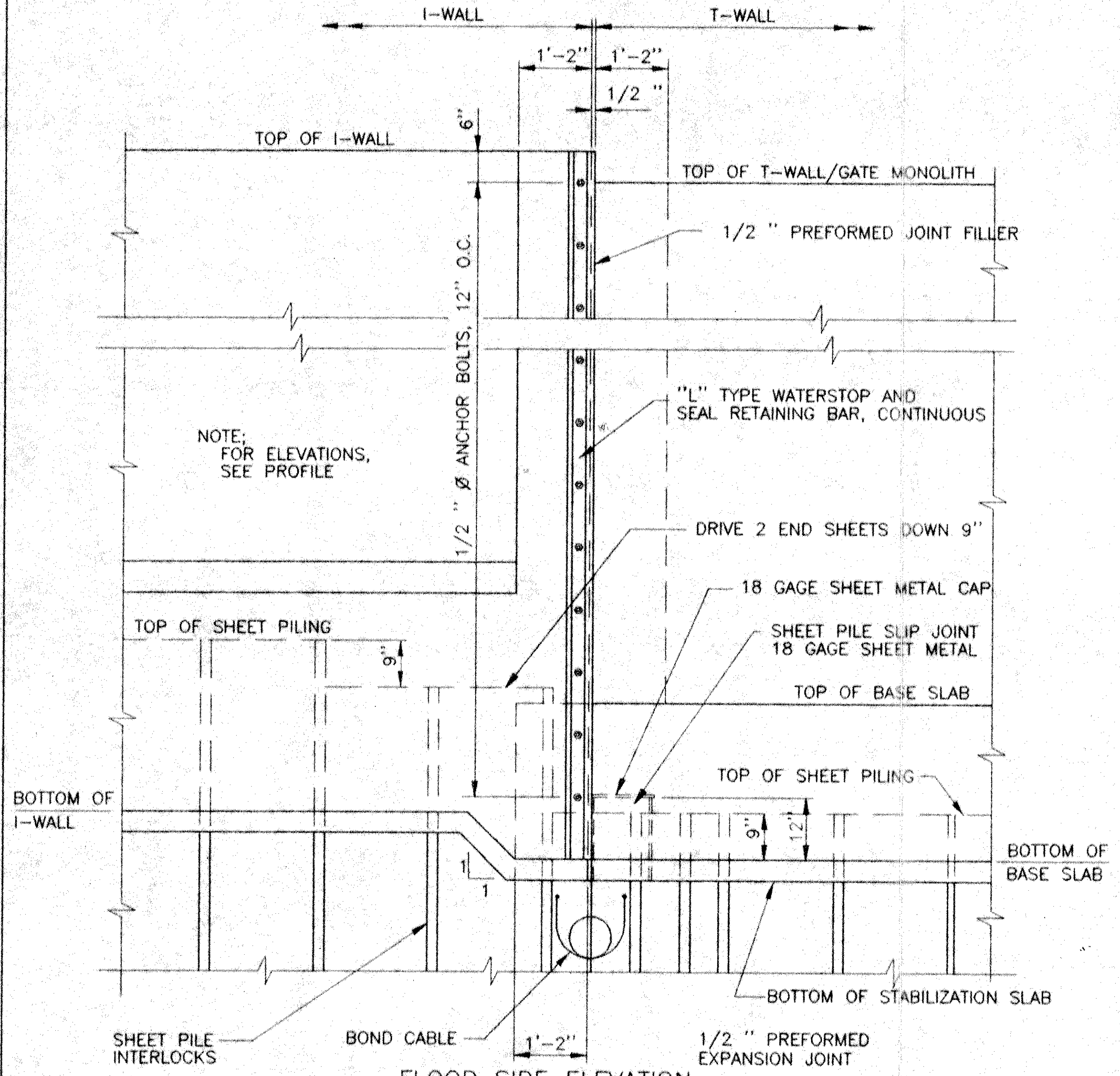
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

TYP. I-WALL & CANT. SHT. PILE WALL

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

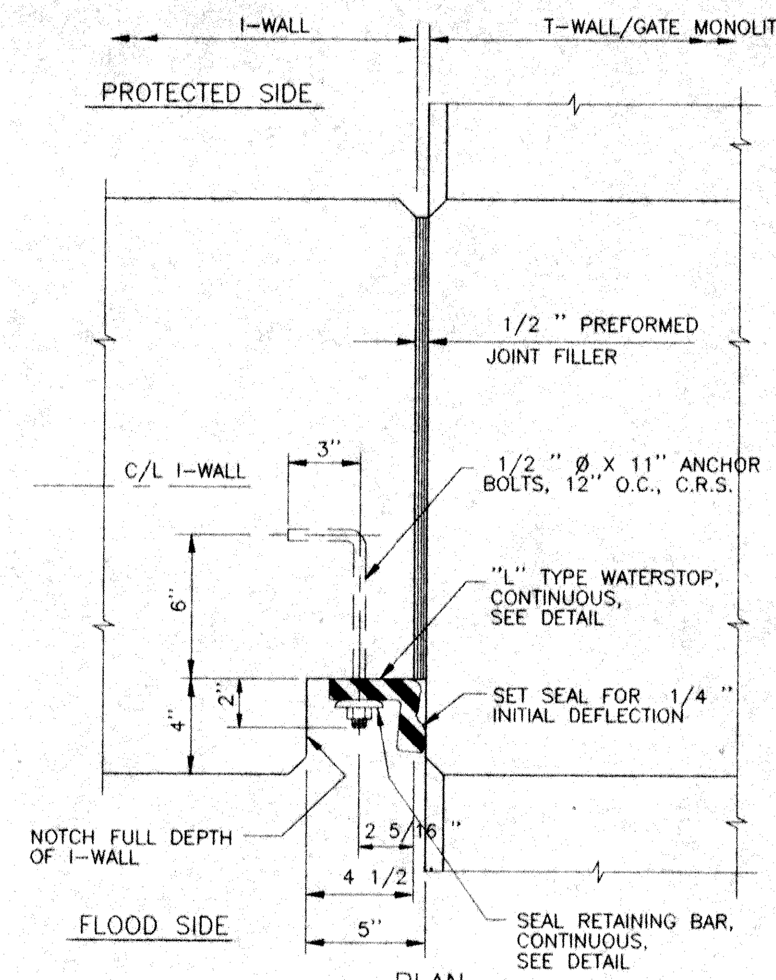
FILE NO. H-2-44970



FLOOD SIDE ELEVATION

I-WALL TO GATE MONOLITH

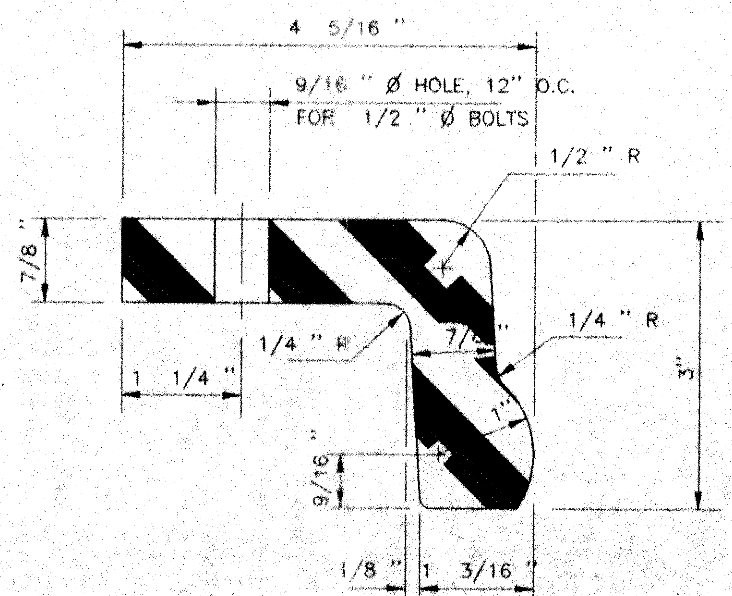
SCALE: 3/4 " = 1'- 0"



PLAN

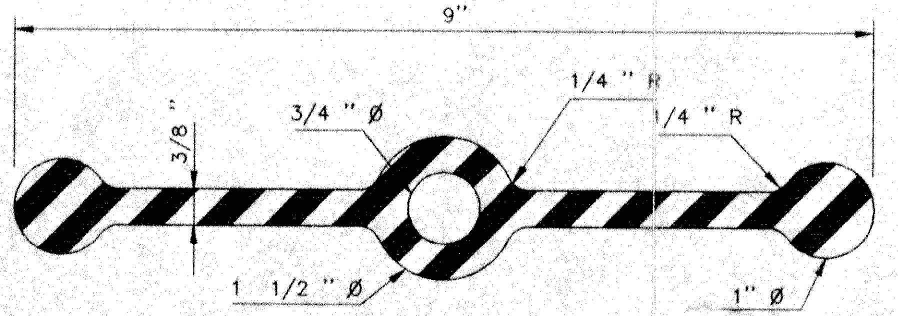
I-WALL TO GATE MONOLITH

SCALE: 3" = 1' - 0"



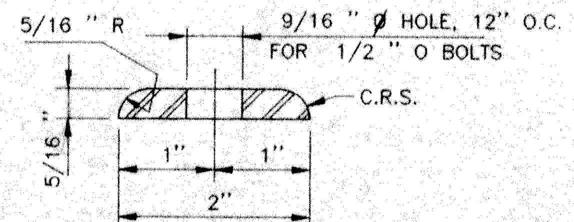
" L " TYPE WATERSTOP

SCALE: 12" = 1' - 0"



THREE BULB WATERSTOP

SCALE: 12" = 1' - 0"



SEAL RETAINING BAR

SCALE: 12" = 1' - 0"

SCALE: 3/4 " = 1'- 0"

SCALE: 3" = 1' - 0"

SCALE: 12" = 1' - 0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

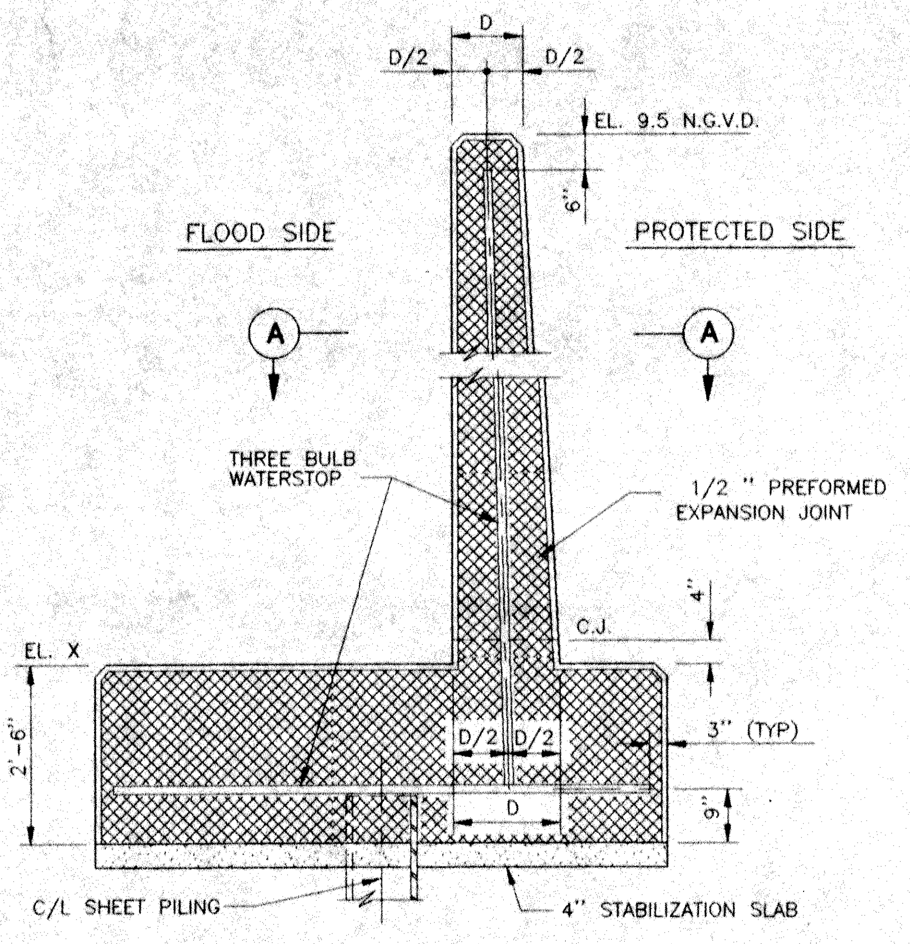
TYPICAL WALL JOINT (1 OF 2)

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
– A JOINT VENTURE GROUP –

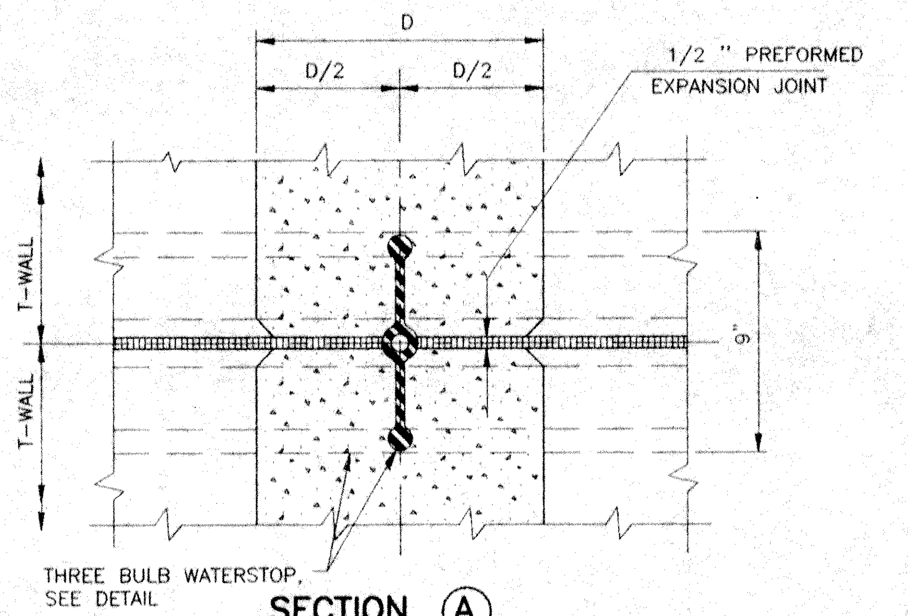
FILE NO.
H-2-44970

PLATE F-8



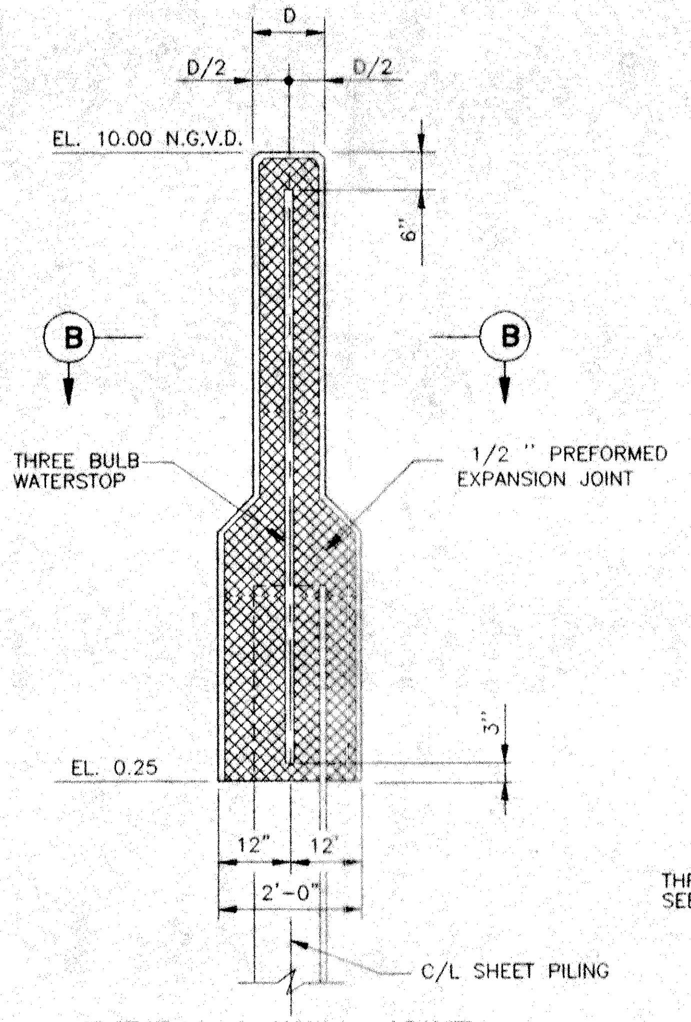
TYPICAL T-WALL JOINT

SCALE: 3/4 " = 1'- 0"



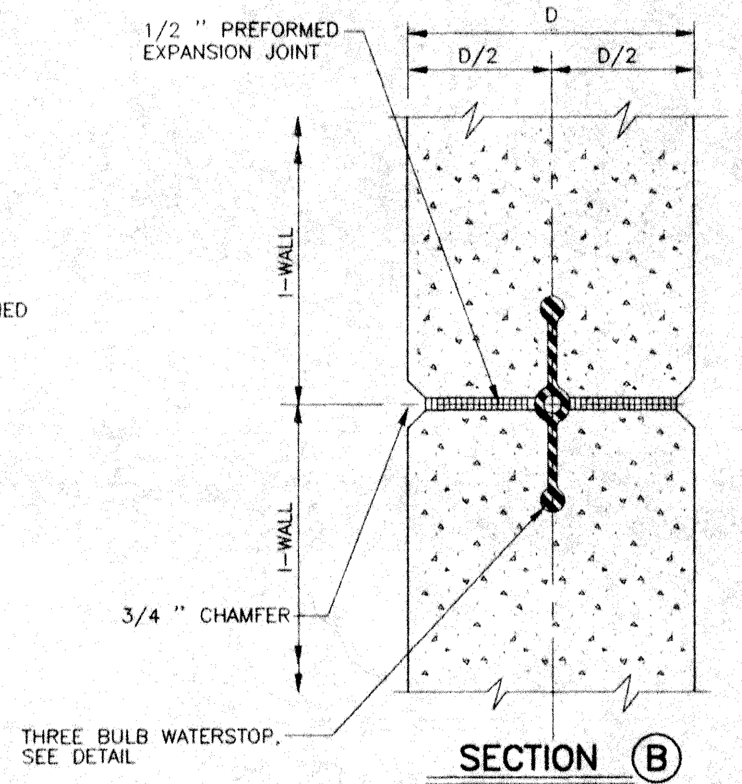
SECTION (A)

SCALE: 3" = 1' - 0"



TYPICAL I-WALL JOINT

SCALE: 3/4 " = 1'- 0"



SECTION (B)

SCALE: 3" = 1' - 0"

SCALE: 3/4 " = 1'- 0"

12" 0 1' 2' 3' 4' 5'

SCALE: 3" = 1' - 0"

12" 0 1'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

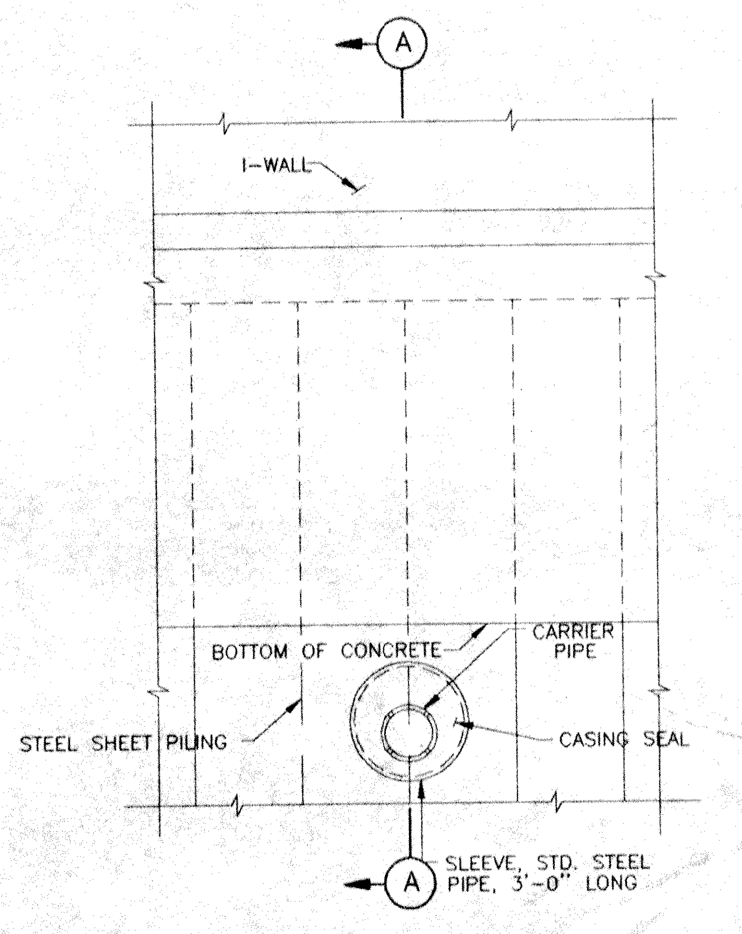
TYPICAL WALL JOINT (2 OF 2)

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

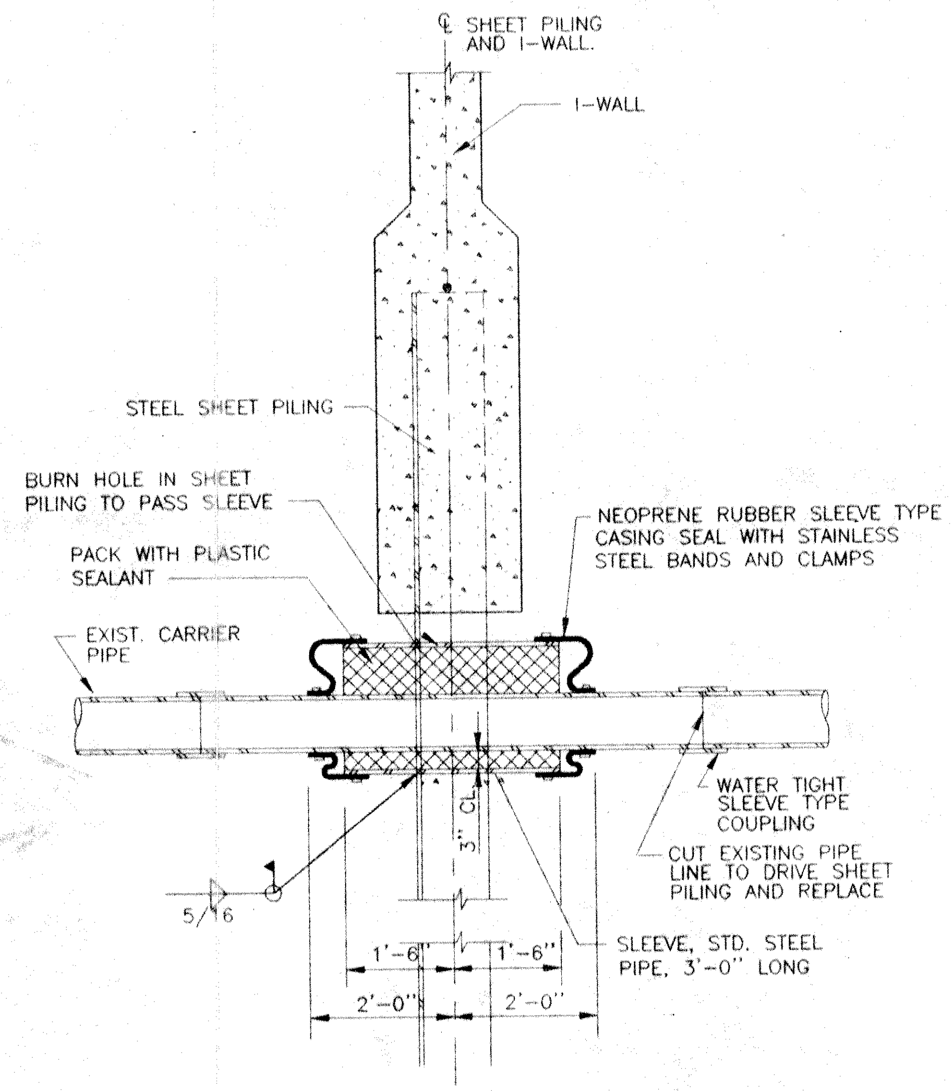
FILE NO. H-2-44970

PLATE F-9

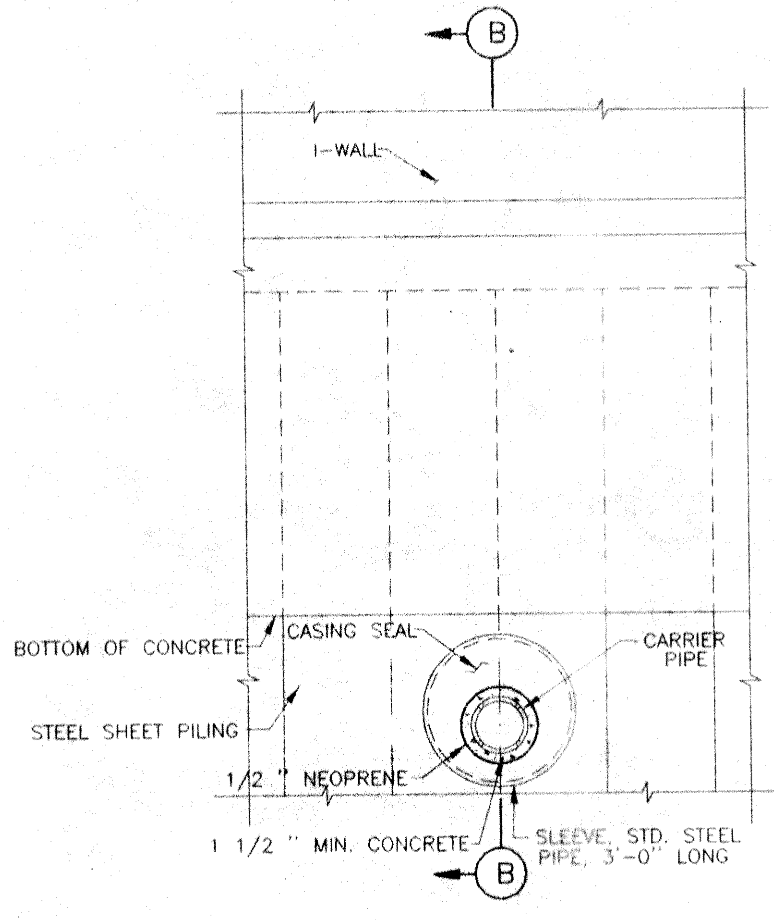


ELEVATION

TYPICAL PIPE THRU I-WALL

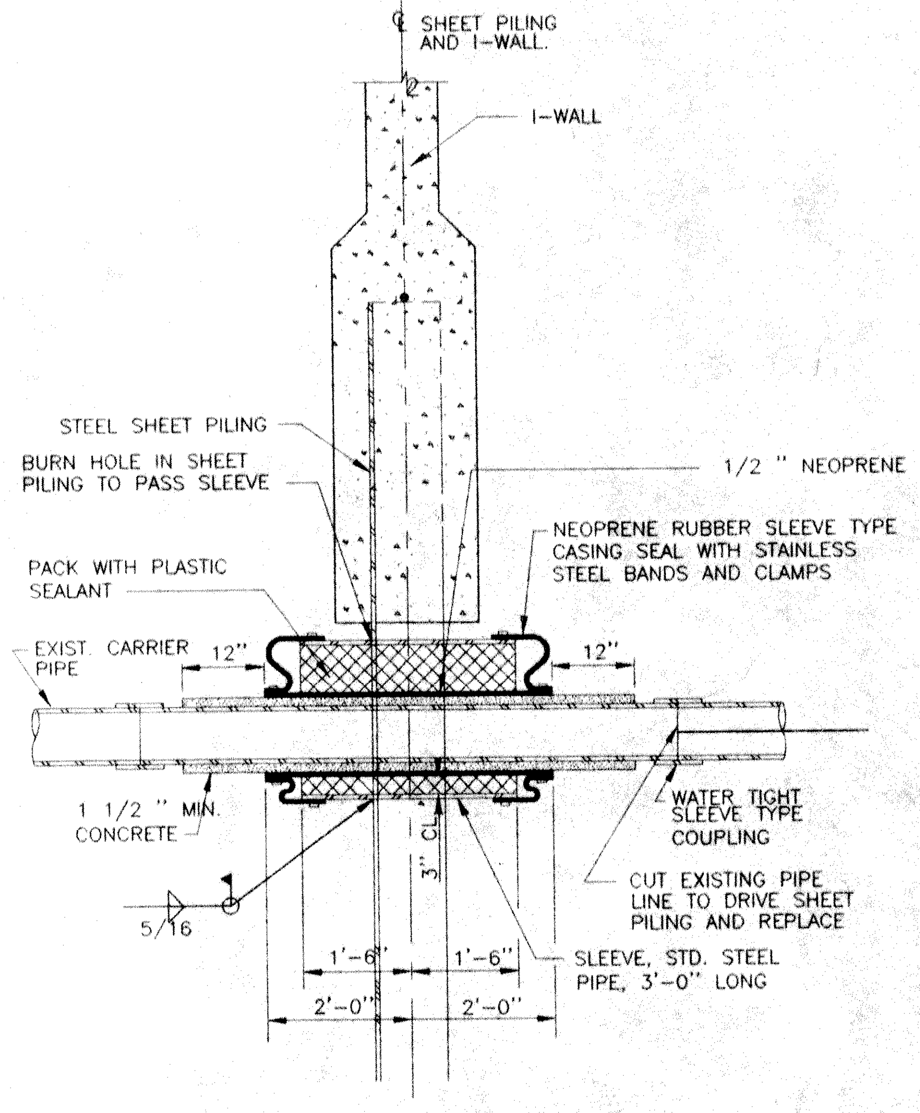


SECTION A



ELEVATION

TYPICAL GAS PIPE THRU I-WALL



SECTION B

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

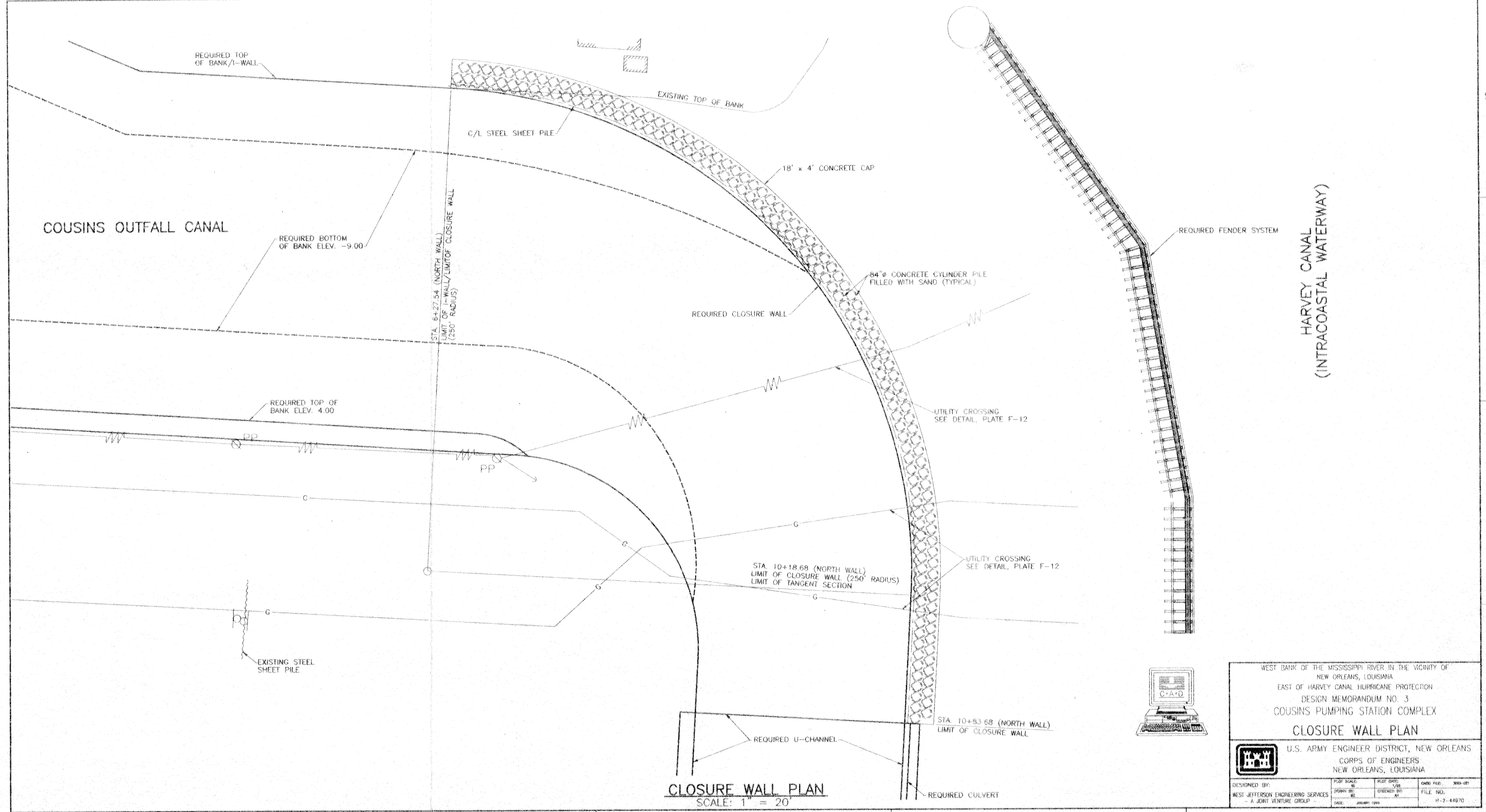
UTILITY CROSSING DETAILS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO. H-2-44970

PLATE F-10



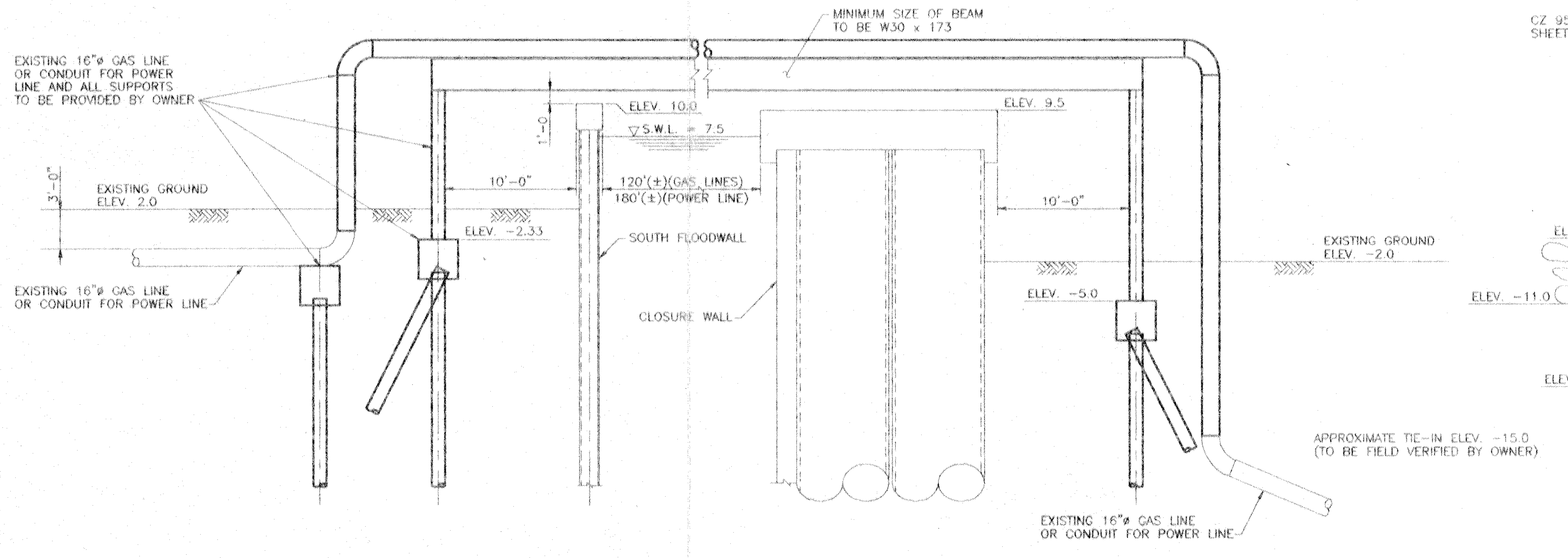
CLOSURE WALL PLAN
SCALE: 1" = 20'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

CLOSURE WALL PLAN

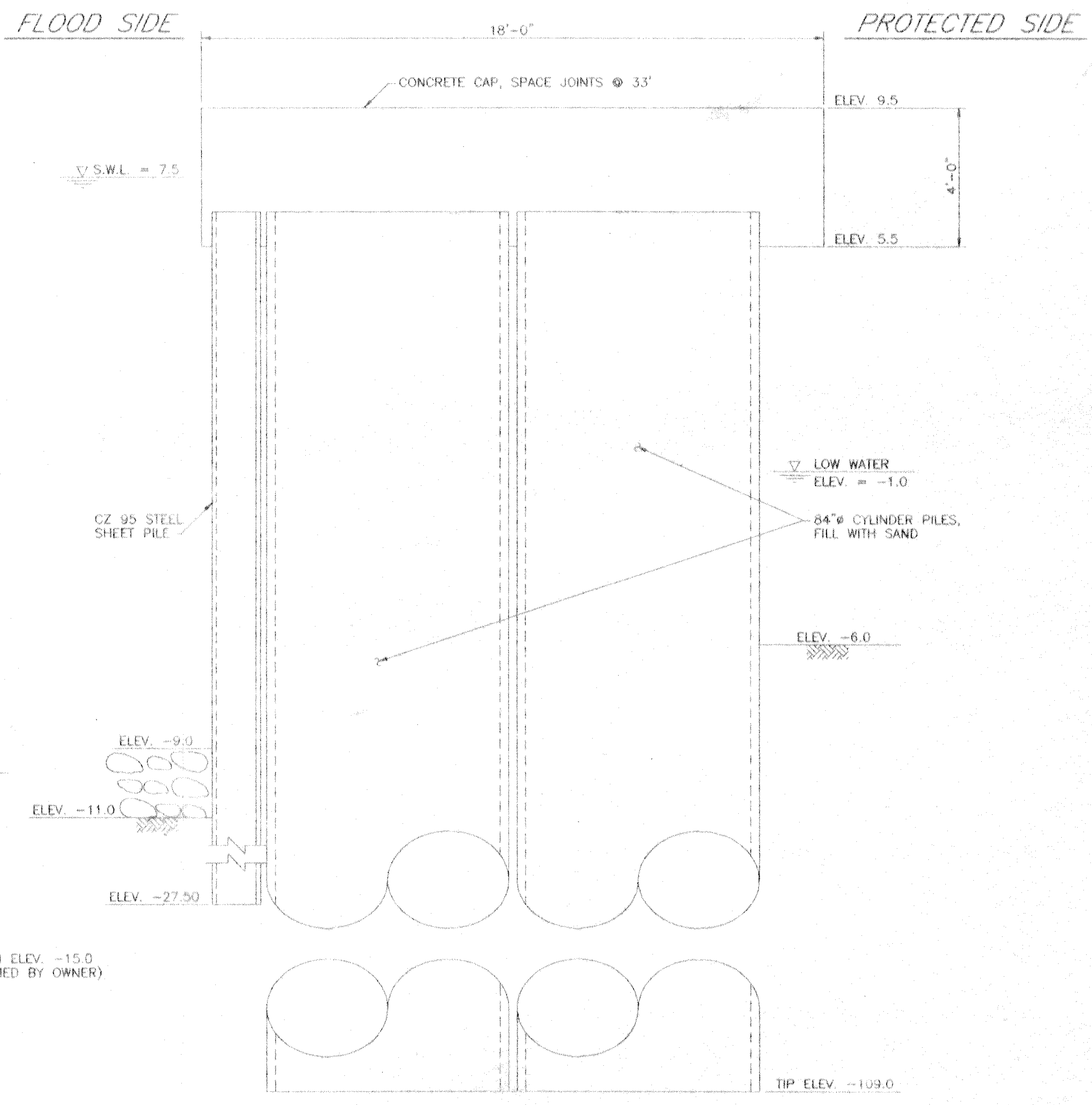
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:	PLOT SCALE: 40	PLOT DATE: 1/99	CADD FILE: 3003-021
WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –	DRAWN BY: MZ	CHECKED BY: AH	FILE NO.
	DATE: JANUARY 1999		H-2-44970



DIVERSION CHANNEL TYPICAL UTILITY CROSSING

SCALE: 1 = 5'



CLOSURE WALL SECTION

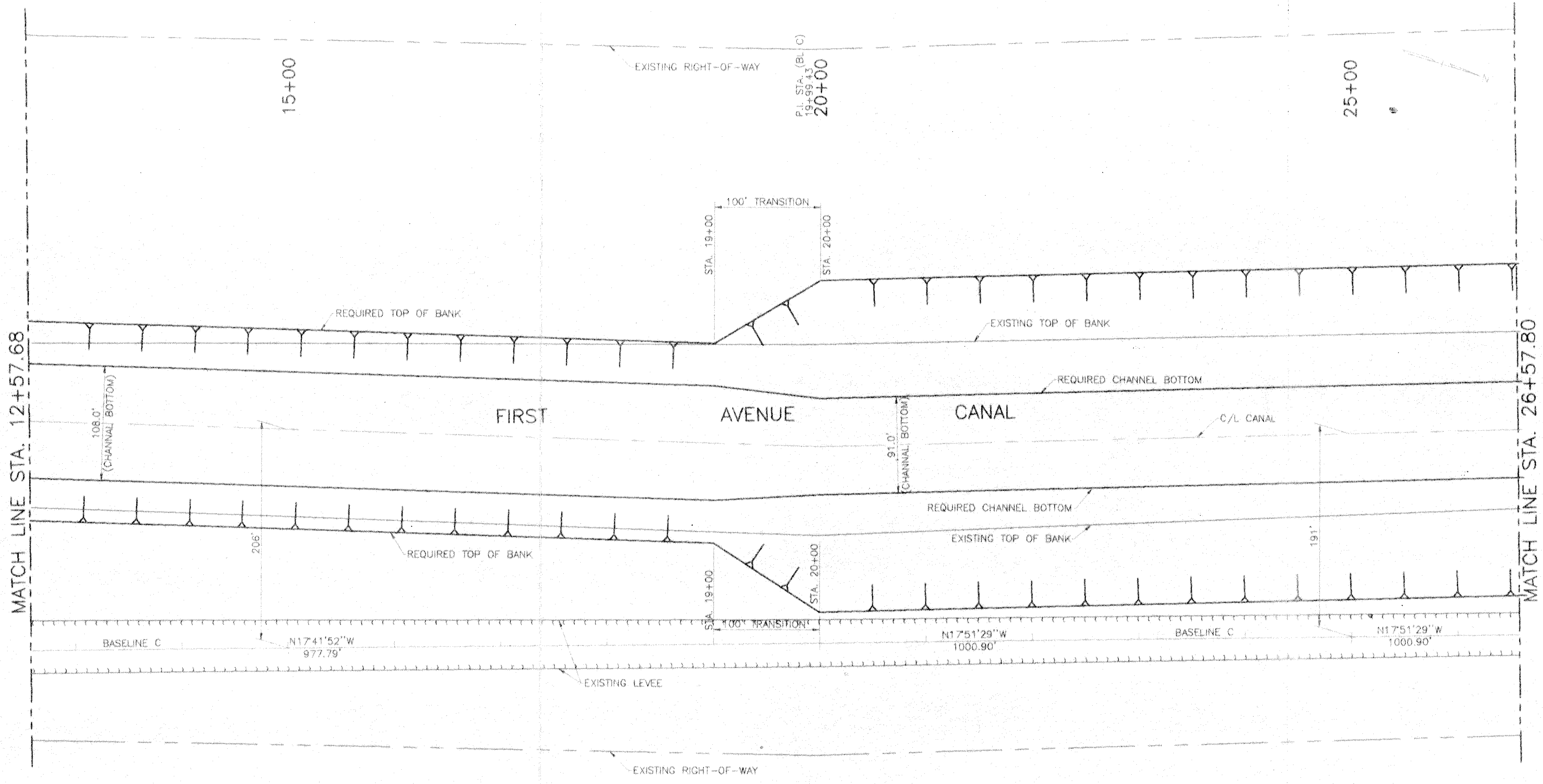
SCALE: 1/2" = 1'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

CLOSURE WALL SECTION AND UTILITY CROSSING

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:	PLOT SCALE: 1 = 10	PLOT DATE: 1/99	CADD FILE: 3003-020
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	DRAWN BY: M.Z.	CHECKED BY: A.R.	FILE NO. H-2-44970
	DATE: JANUARY 1999		



FIRST AVENUE CANAL

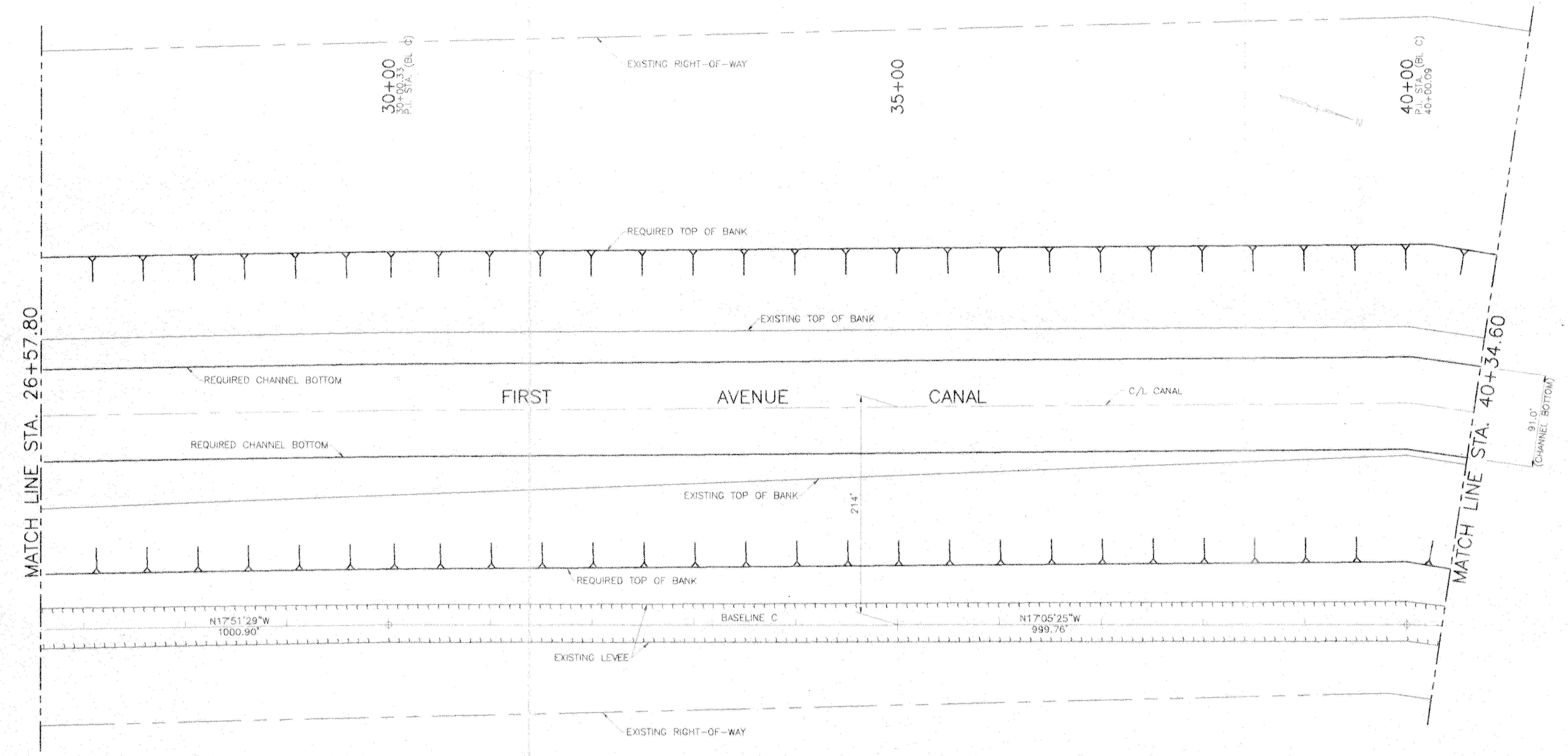
SCALE: 1" = 50'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

FIRST AVENUE CANAL
PLAN - 1

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE: 1 = 100	PLOT DATE: 1/99	CADD FILE: [illegible]
	DRAWN BY: M.L.	CHECKED BY: A.M.	FILE NO. H-2-44070
	DATE: JANUARY 1999		



FIRST AVENUE CANAL

SCALE: 1" = 50'

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA

EAST OF HARVEY CANAL HURRICANE PROTECTION

DESIGN MEMORANDUM NO. 3

COUSINS PUMPING STATION COMPLEX

FIRST AVENUE CANAL

PLAN – 2

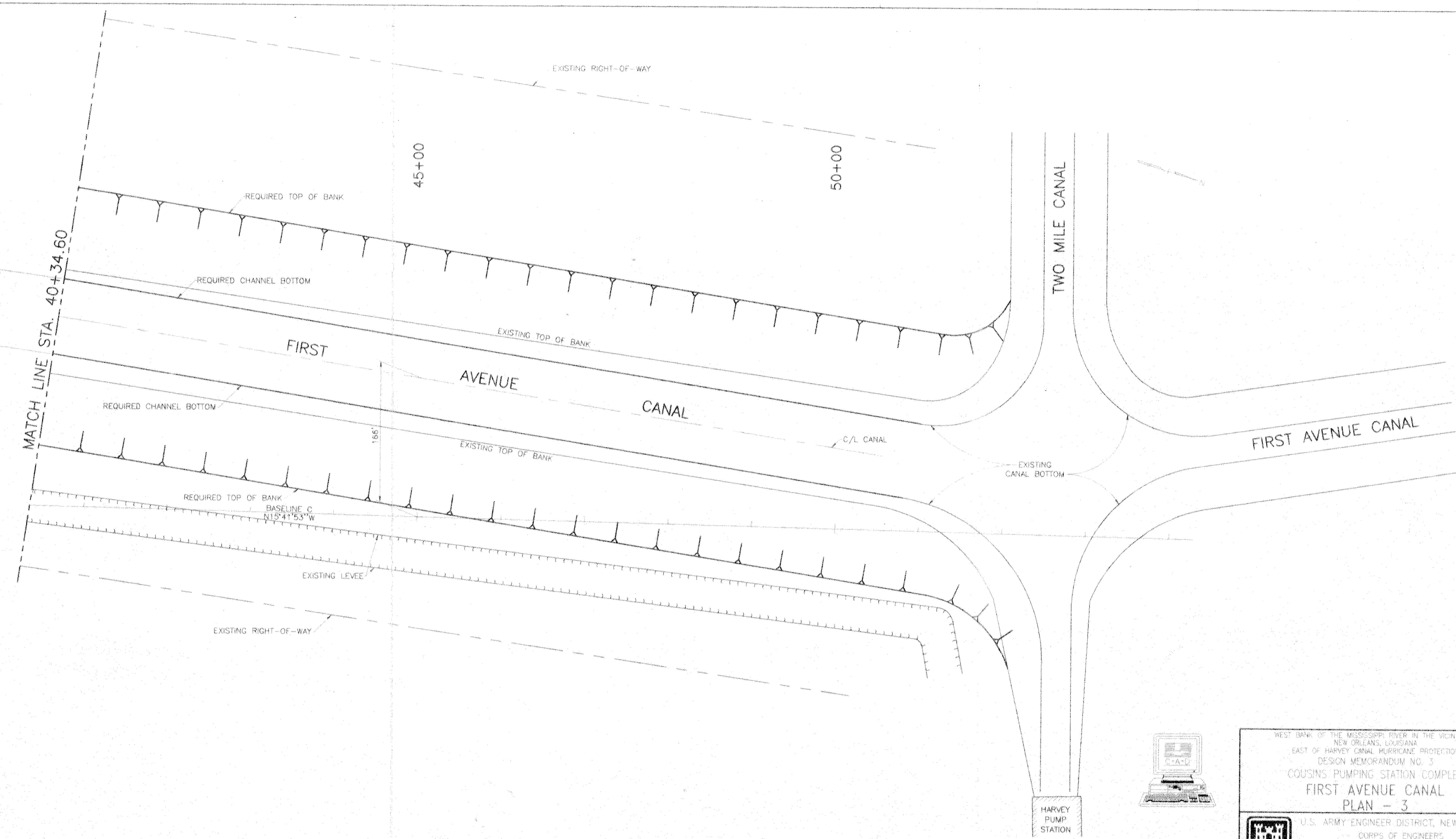
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS

CORPS OF ENGINEERS

NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –	PLOT SCALE:	PLOT DATE:	CADD FILE:
	DRAWN BY:	CHECKED BY:	FILE NO. H-2-44970
	DATE:		

PLATE CH-2



FIRST AVENUE CANAL

SCALE: 1" = 50'

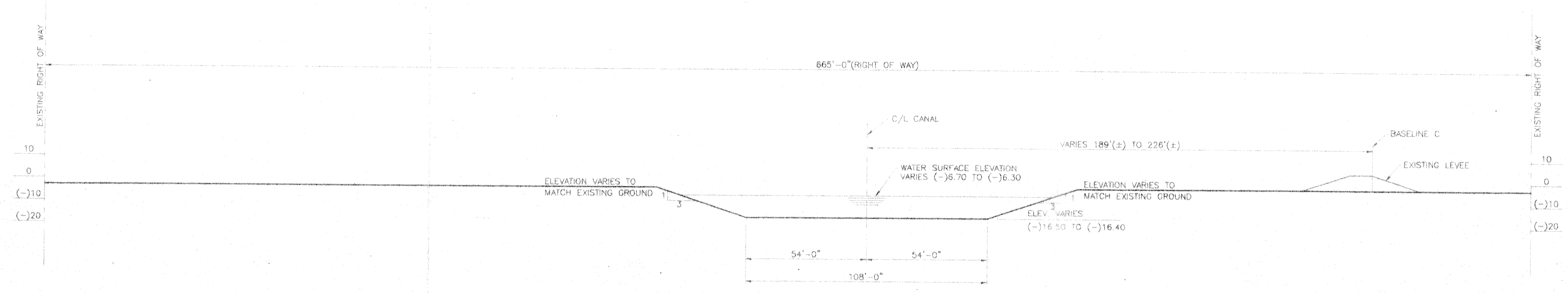
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

FIRST AVENUE CANAL
PLAN – 3

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

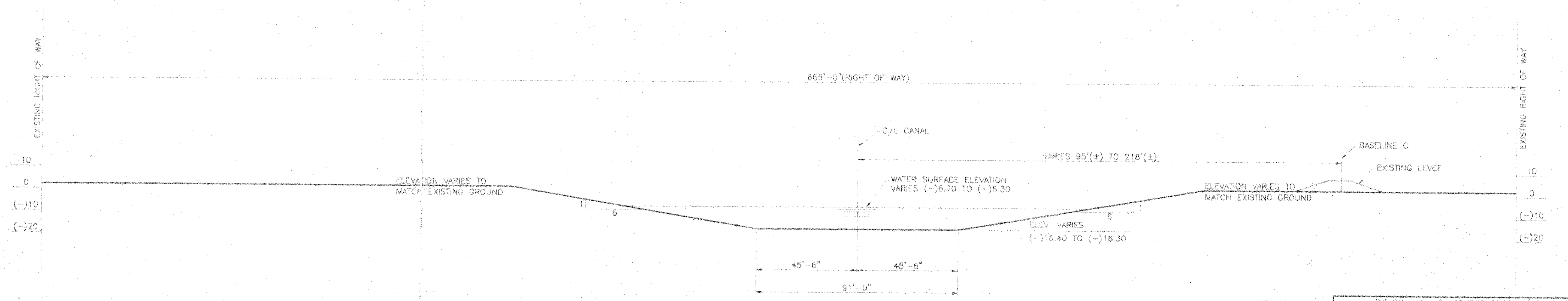
DESIGNED BY:	PLOT SCALE: 1 = 100	PLOT DATE: 1/99	CADD FILE: 1093-004
WEST JEFFERSON ENGINEERING SERVICES — A JOINT VENTURE GROUP —	DRAWN BY: MJ	CHECKED BY: AH	FILE NO.
	DATE: JANUARY 1999		H-2-44970

PLATE CH-3



FIRST AVENUE CANAL TYPICAL SECTION

STA. 9+00.00 TO STA. 19+00.00
(SECTION TAKEN AT STA. 9+69.77)
SCALE: 1" = 20'-0"



FIRST AVENUE CANAL TYPICAL SECTION

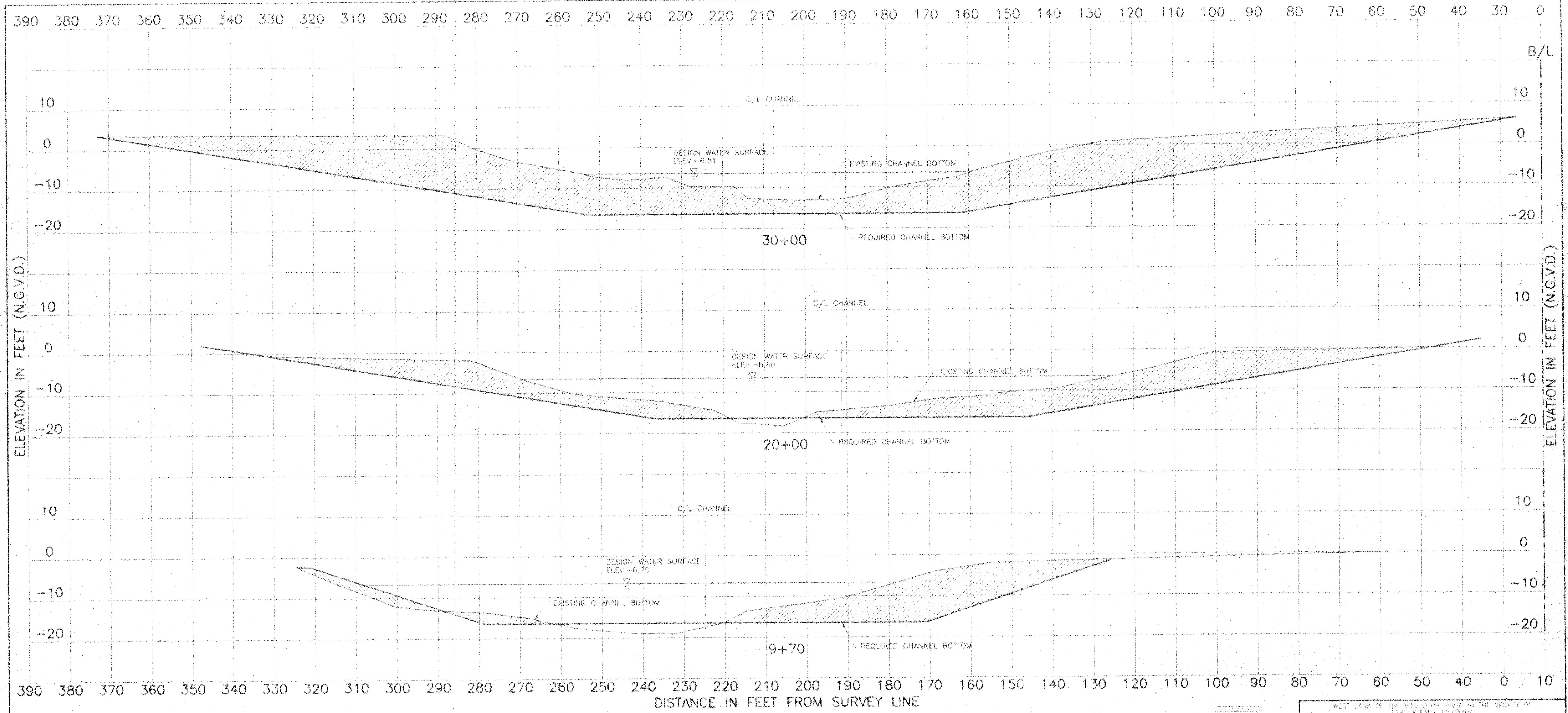
STA. 20+00.00 TO STA. 51+00.00
(SECTION TAKEN AT STA. 30+00.44)
SCALE: 1" = 20'-0"

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

FIRST AVENUE CANAL TYPICAL SECTION

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE: 1 = 40	PLOT DATE: 1/99	CADD FILE: 3001-01F
	DRAWN BY: M.Z.	CHECKED BY: A.H.	FILE NO. H-2-44070
	DATE: JANUARY 1999		



LEGEND

REQUIRED DREDGING

REQUIRED FILL

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

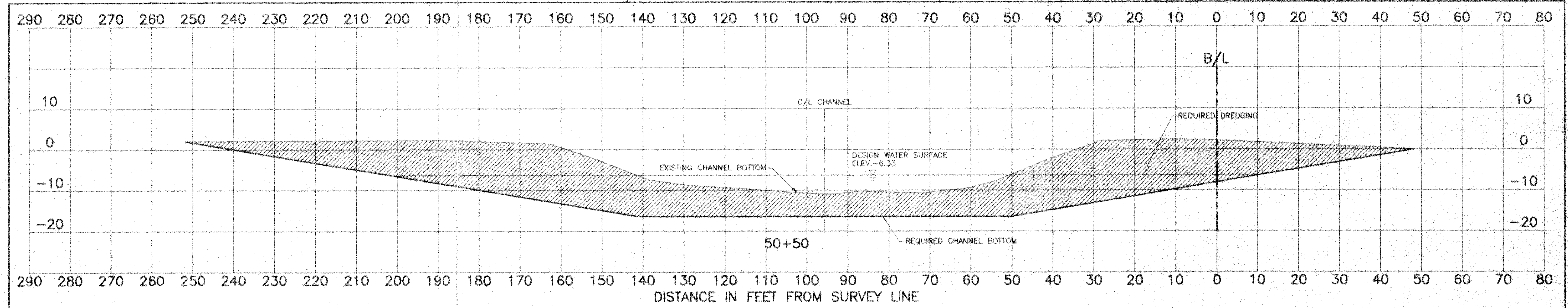
FIRST AVENUE CANAL
EXISTING SECTON - 1

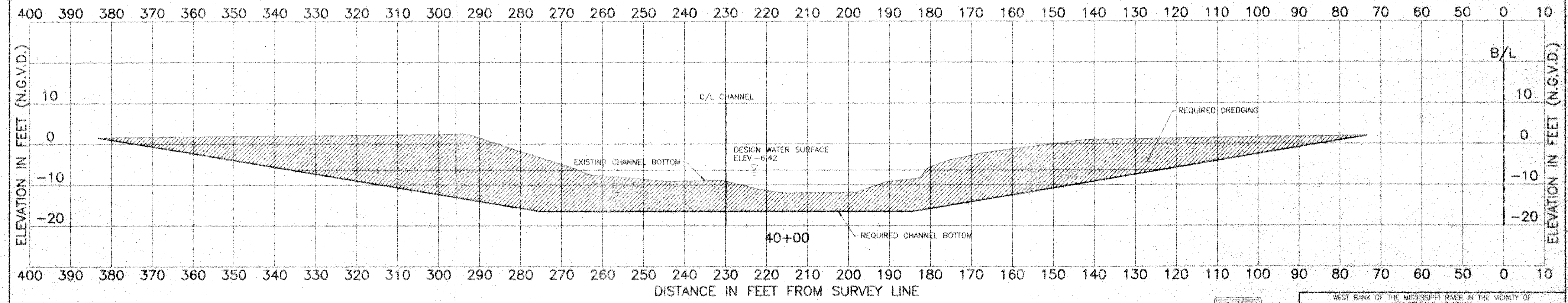
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

FILE NO.
H-2-44970

PLATE CH-5





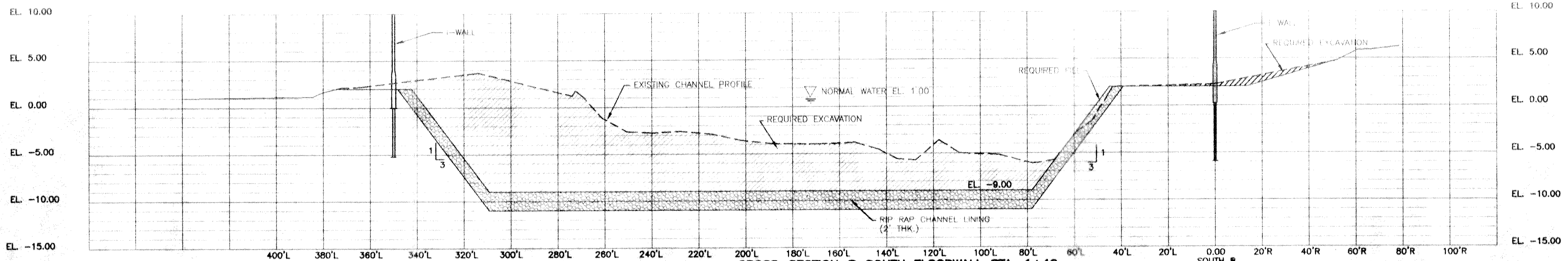
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX

FIRST AVENUE CANAL EXISTING SECTION - 2

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

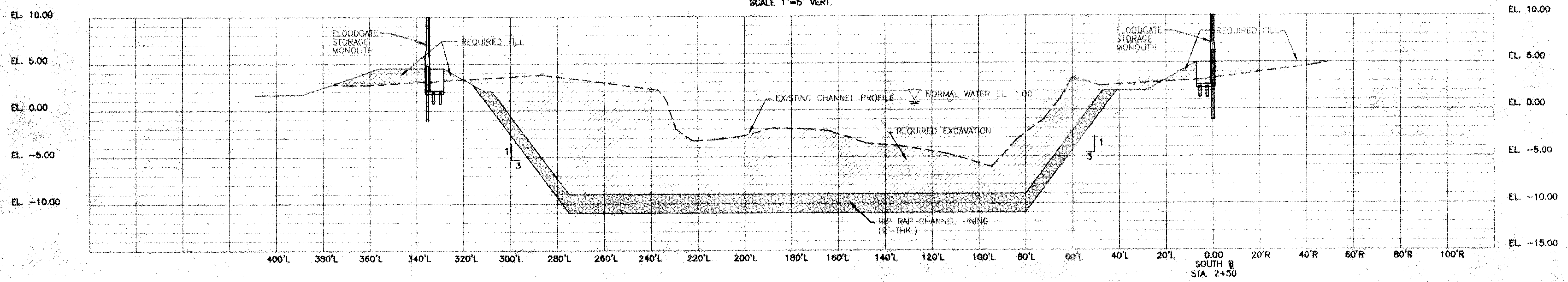
DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

PLOT SCALE: 1 = 20	PLOT DATE: 1/98	CADD FILE: [illegible]
DRAWN BY: MJ.	CHECKED BY: A.K.	FILE NO. H-2-44970
DATE: JANUARY 1998		



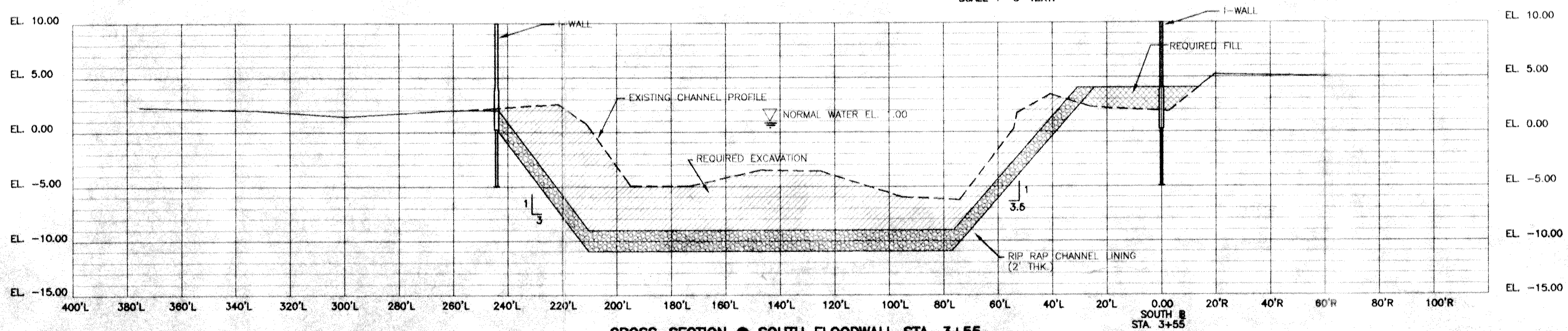
CROSS-SECTION @ SOUTH FLOODWALL STA. 1+40

SCALE 1"=20' HORIZ.
SCALE 1"=5' VERT.



CROSS-SECTION @ SOUTH FLOODWALL STA. 2+50

SCALE 1"=20' HORIZ.
SCALE 1"=5' VERT.



CROSS-SECTION @ SOUTH FLOODWALL STA. 3+55

SCALE 1"=20' HORIZ.
SCALE 1"=5' VERT.

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE
CHANNEL CROSS-SECTIONS (1 OF 2)

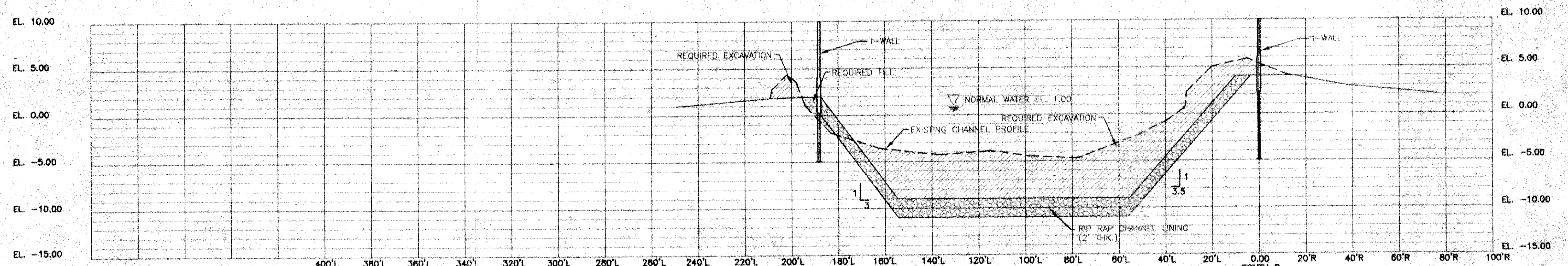
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
– A JOINT VENTURE GROUP –

FILE NO. H-2-44970

5 4 3 2 1

PLATE CH-7



CROSS-SECTION @ SOUTH FLOODWALL STA. 4+65

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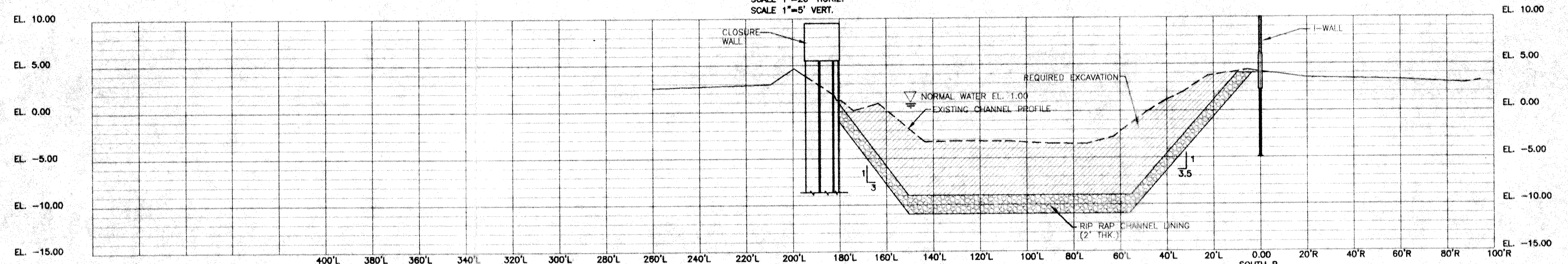
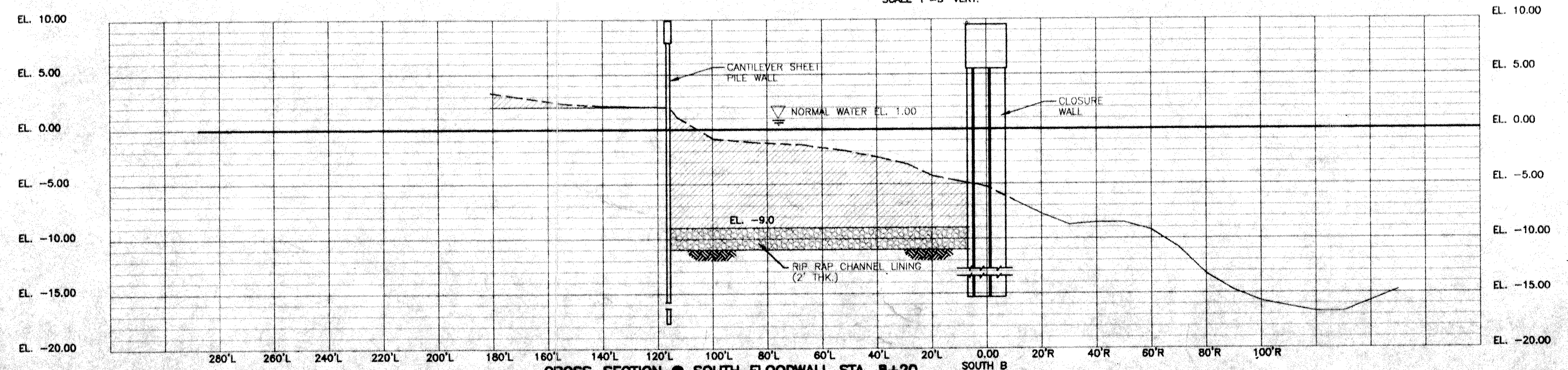


CROSS-SECTION @ SOUTH FLOODWALL STA. 6+55

SCALE 1"=20' HORIZ.
SCALE 1"=5' VERT.



CROSS-SECTION @ SOUTH FLOODWALL STA. 8+20

SCALE 1"=20' HORIZ.
SCALE 1"=5' VERT.

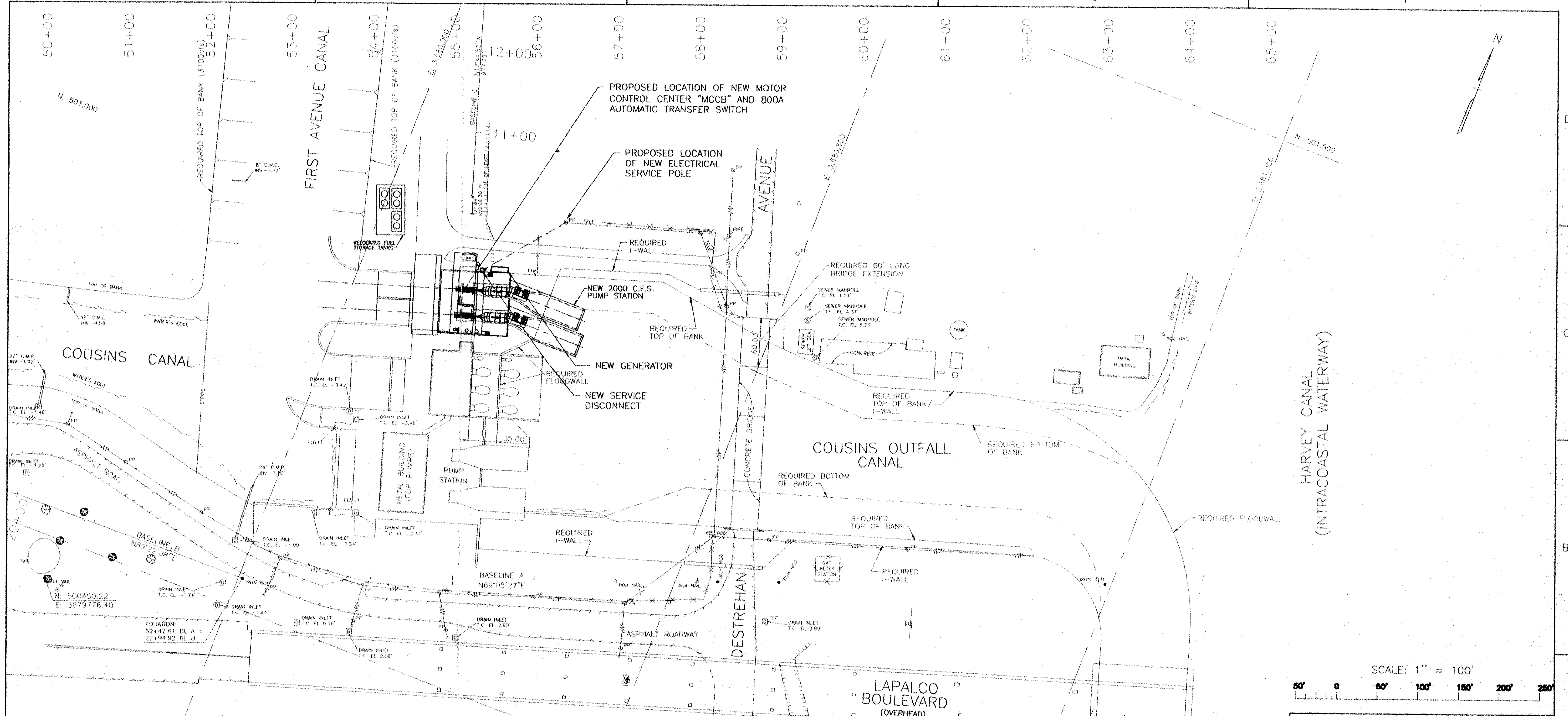
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 3
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE
CHANNEL CROSS-SECTIONS (2 OF 2)

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
– A JOINT VENTURE GROUP –

FILE NO.
H-2-44970



WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA
ELECTRICAL SITE PLAN

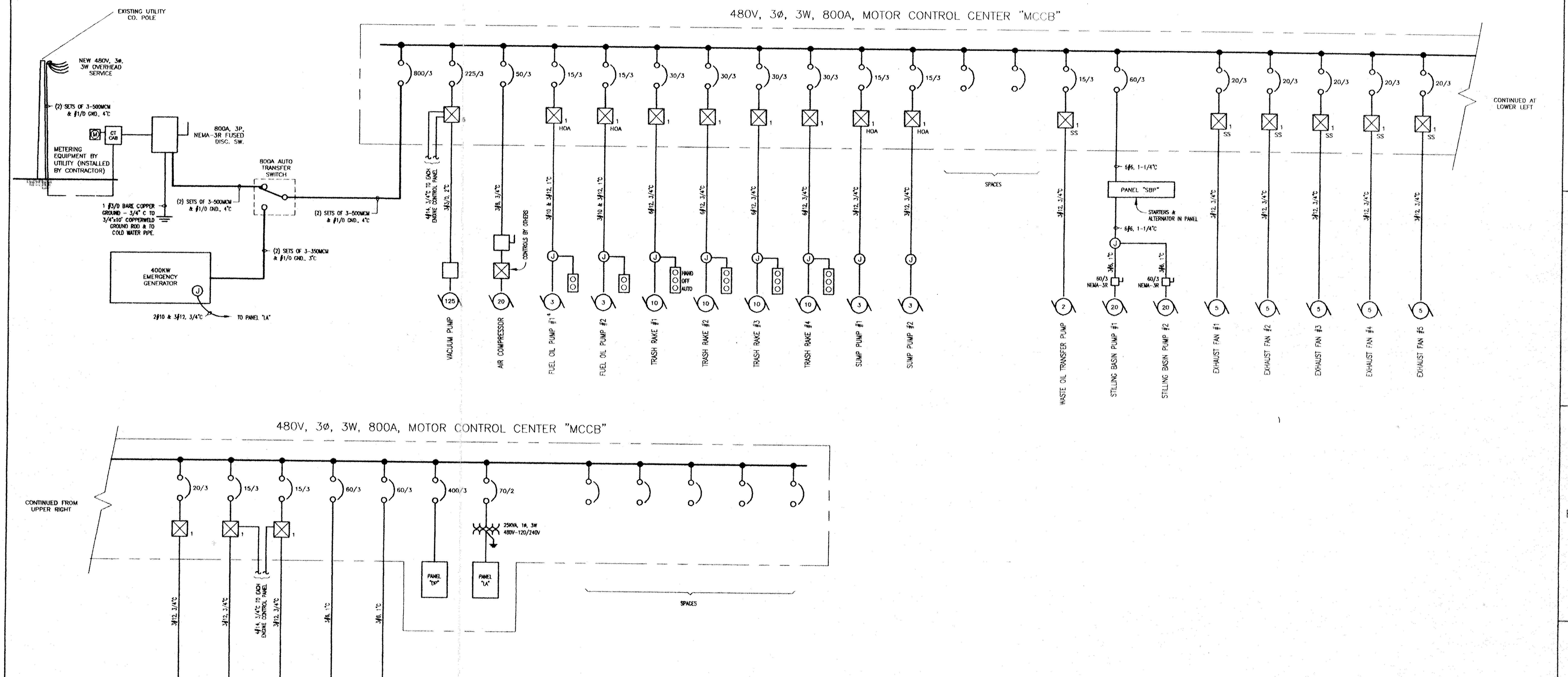
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

[redacted]
PERRIN & CARTER, INC.
ENGINEERS, ARCHITECTS, & PLANNERS
3501 Ridgelake Dr., Metairie, La 70002

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –

FILE NO. E-1

E-1



WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
FEATURE DESIGN MEMORANDUM NO. 1
COUSINS PUMPING STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

PROPOSED ONE LINE DIAGRAM

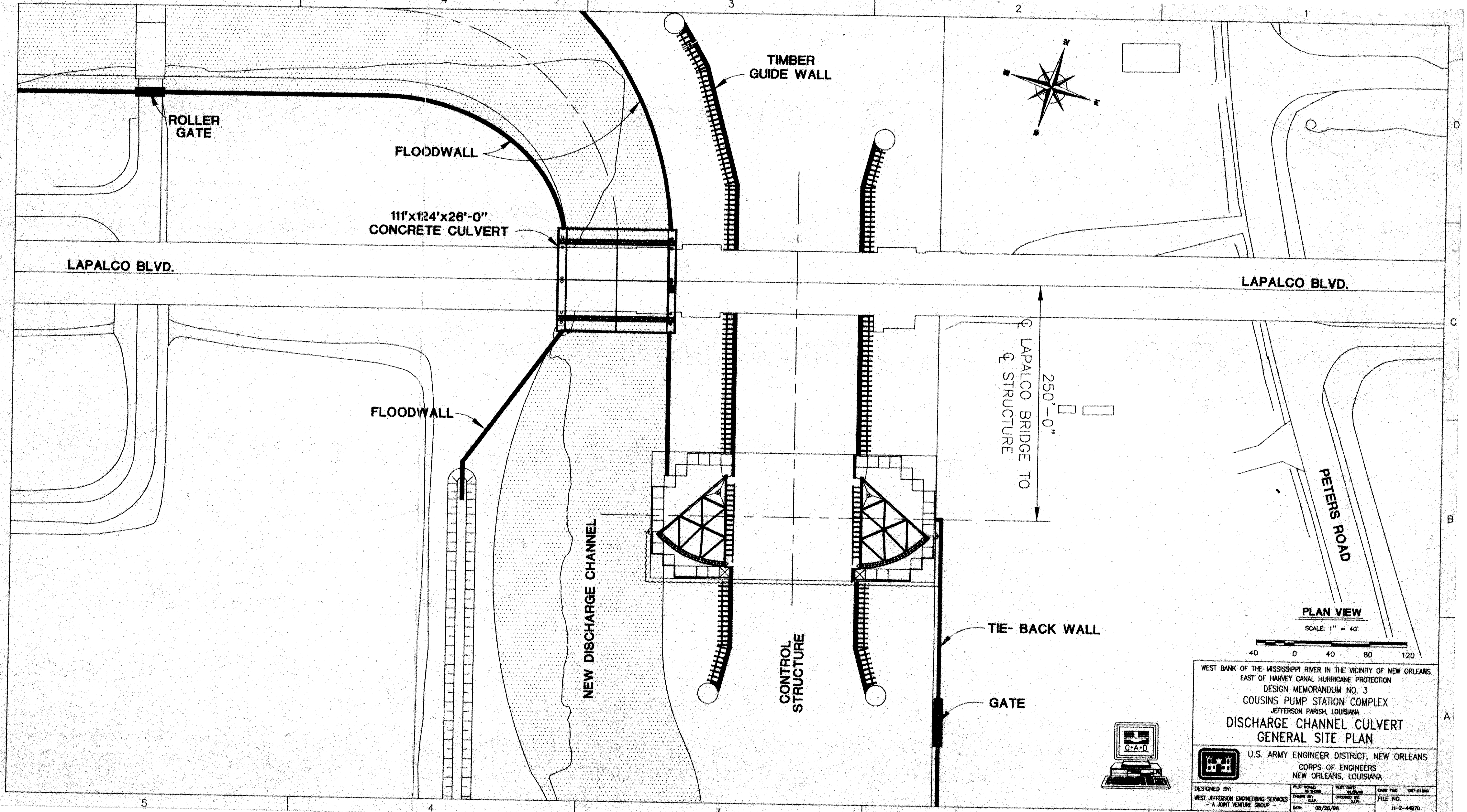
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

PERRIN & CARTER, INC.
ENGINEERS, ARCHITECTS, & PLANNERS
3501 Ridgelake Dr., Metairie, La 70002

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

FILE NO.
E-2

E-2

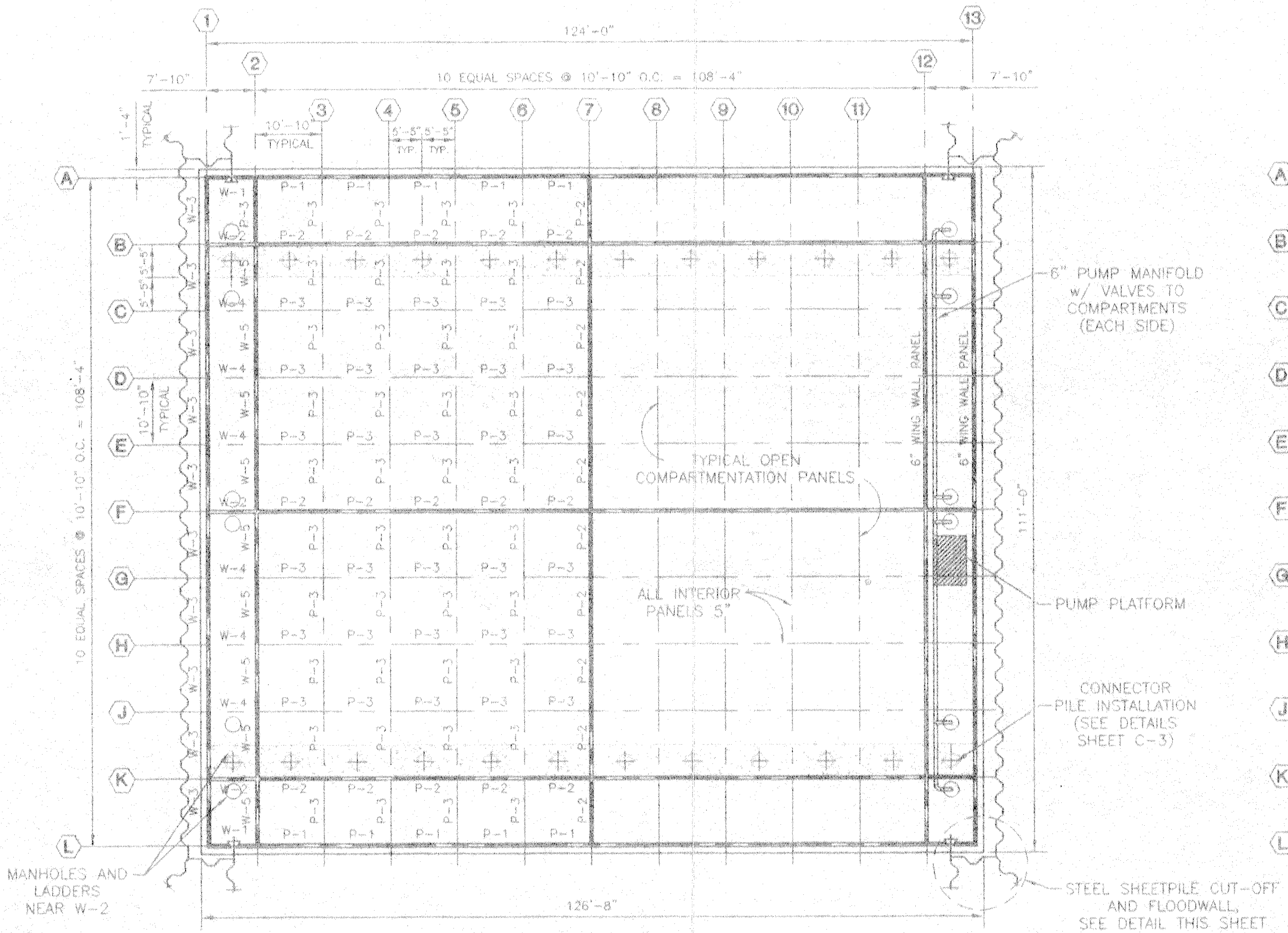


WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT GENERAL SITE PLAN

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

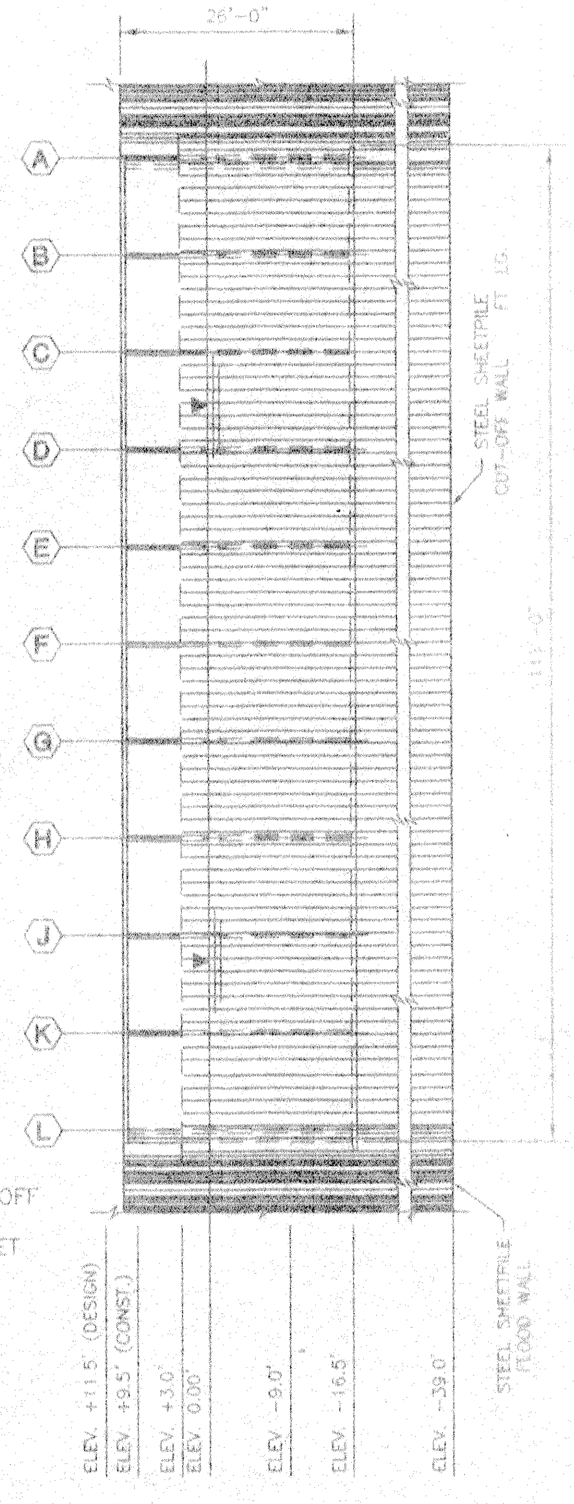
DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
DATE: 08/26/98
FILE NO. H-2-44970



NOTE:
DESIGN ELEV. = +11.5' N.G.V.D.
CONSTRUCTION ELEV. = +9.5' N.G.V.D.

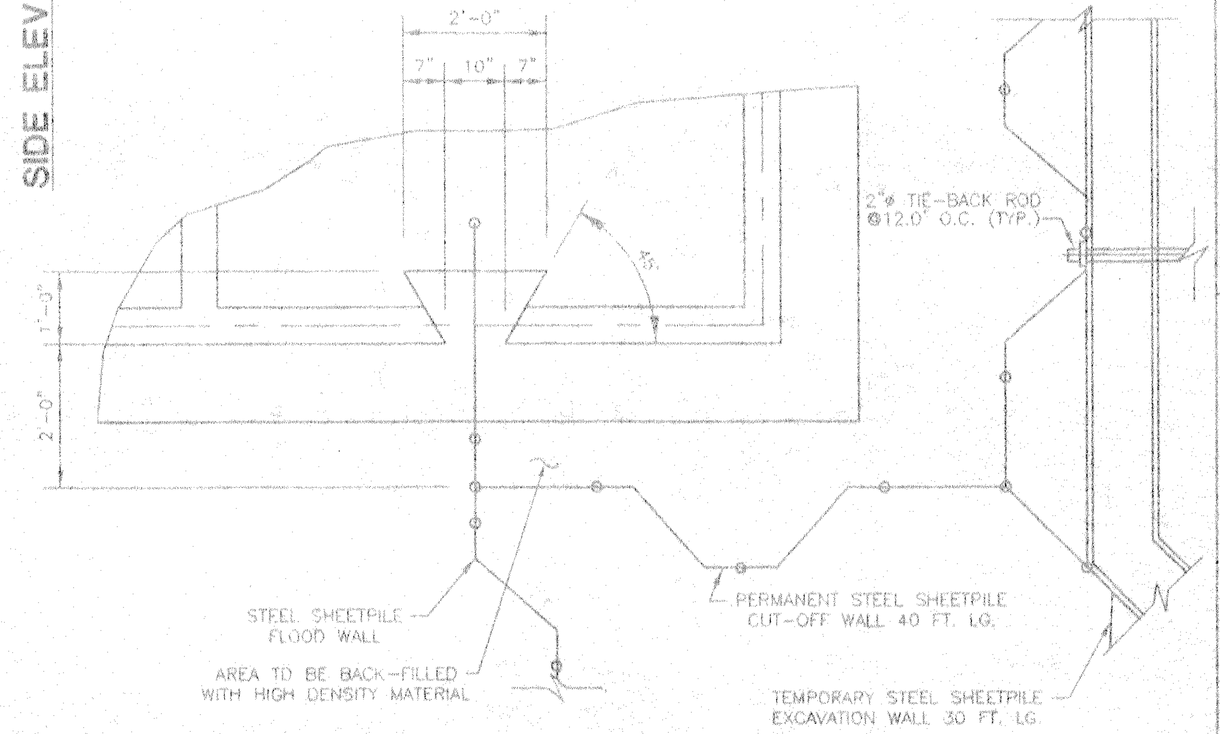
PLAN OF HULL COMPARTMENTATION

NOTE:
ALL COMPARTMENTS 10' BAYS. 4"ø VENT LINES AT TOP AND BOTTOM OF HULL VENTED UP VERTICALLY OUTBOARD OF W-5 PANEL.



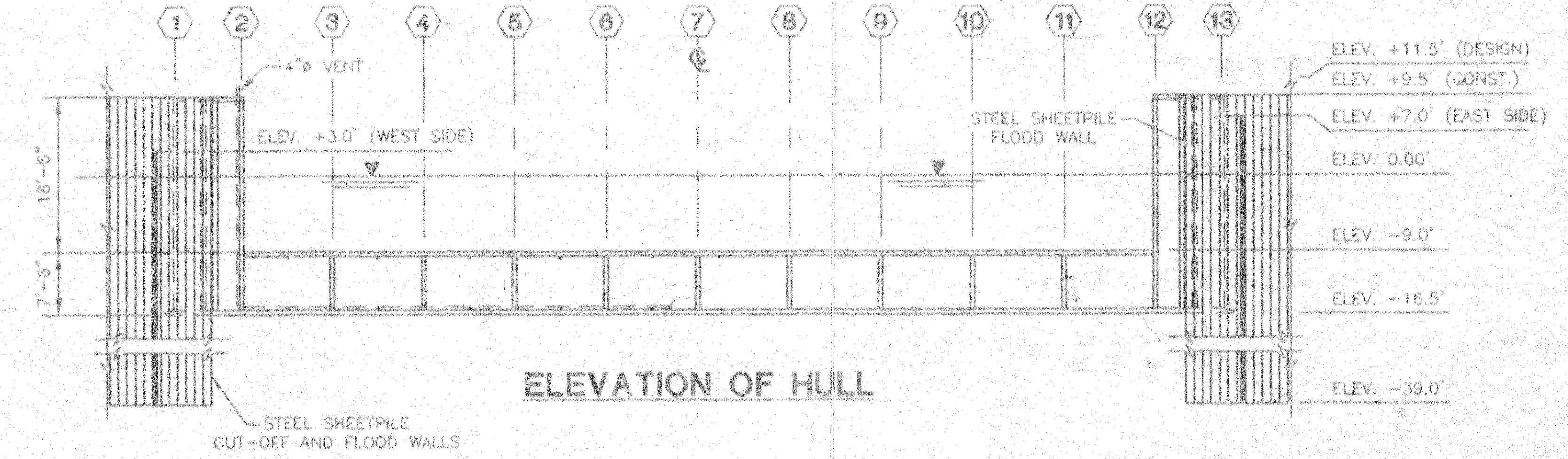
SIDE ELEVATION

PANEL SCHEDULE					
PANEL	t	W	H	No.	PANEL
W-1	6"	6'-10"	24'-5"	4	SOLID
W-2	5"	6'-10"	24'-5"	10	SOLID
W-3	6"	9'-10"	24'-5"	20	SOLID
W-4	6"	9'-10"	24'-5"	8	OPEN
W-5	6"	9'-10"	24'-5"	20	OPEN
P-1	6"	9'-10"	6'	20	SOLID
P-2	5"	9'-10"	6'	60	SOLID
P-3	5"	9'-10"	6'	120	OPEN



STEEL SHEETPILE CUT-OFF AND FLOOD WALLS

NOT TO SCALE



ELEVATION OF HULL

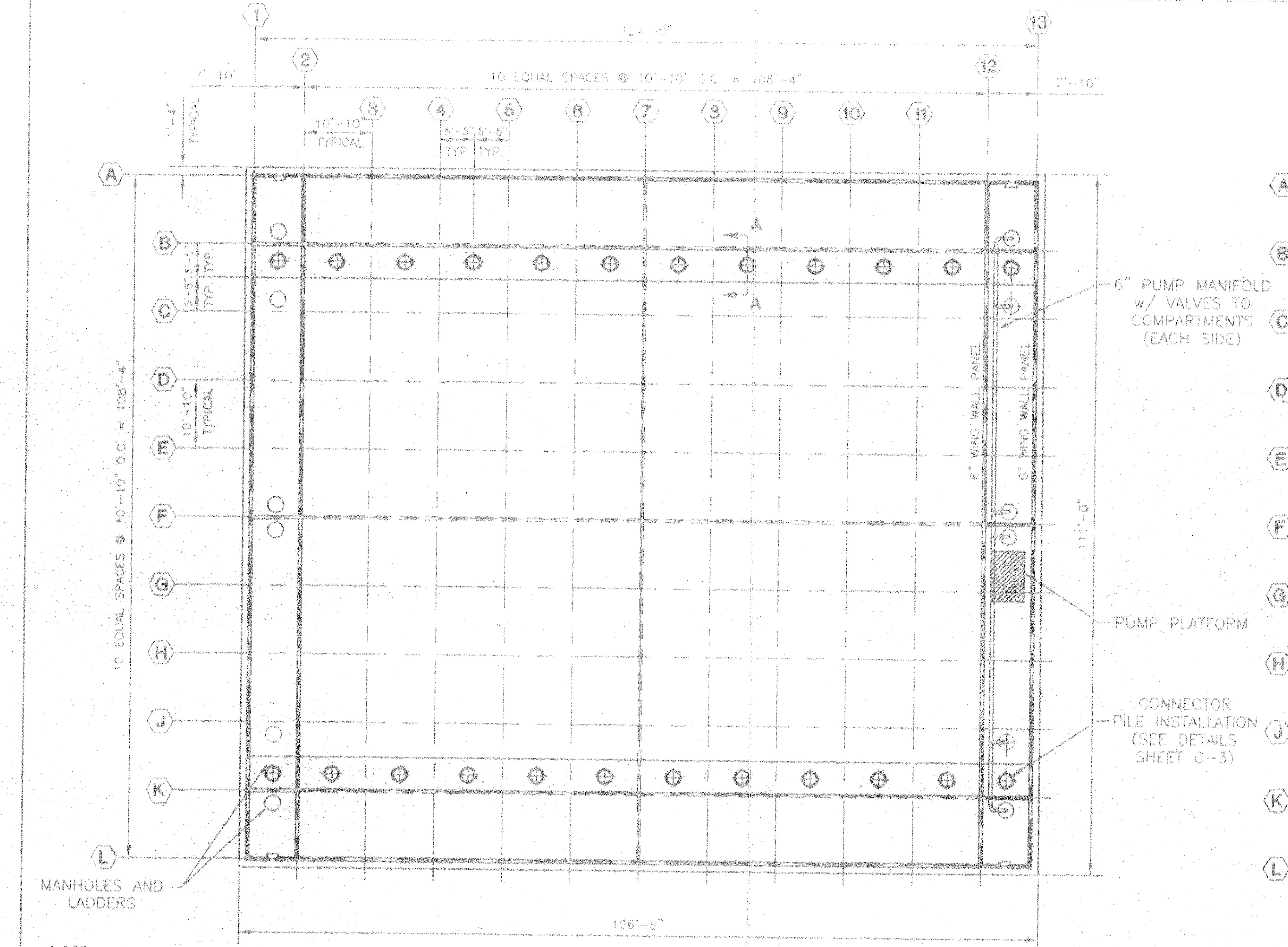
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT PLAN, ELEVATIONS AND DETAILS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -
DATE: 09/28/98
FILE NO.: H-2-44970

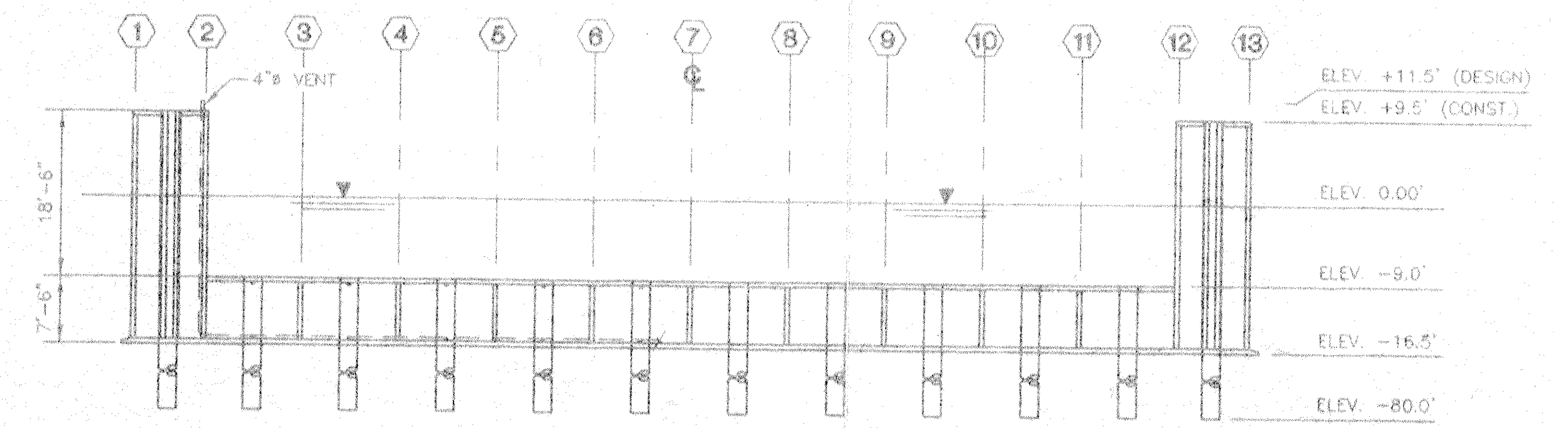
C-2



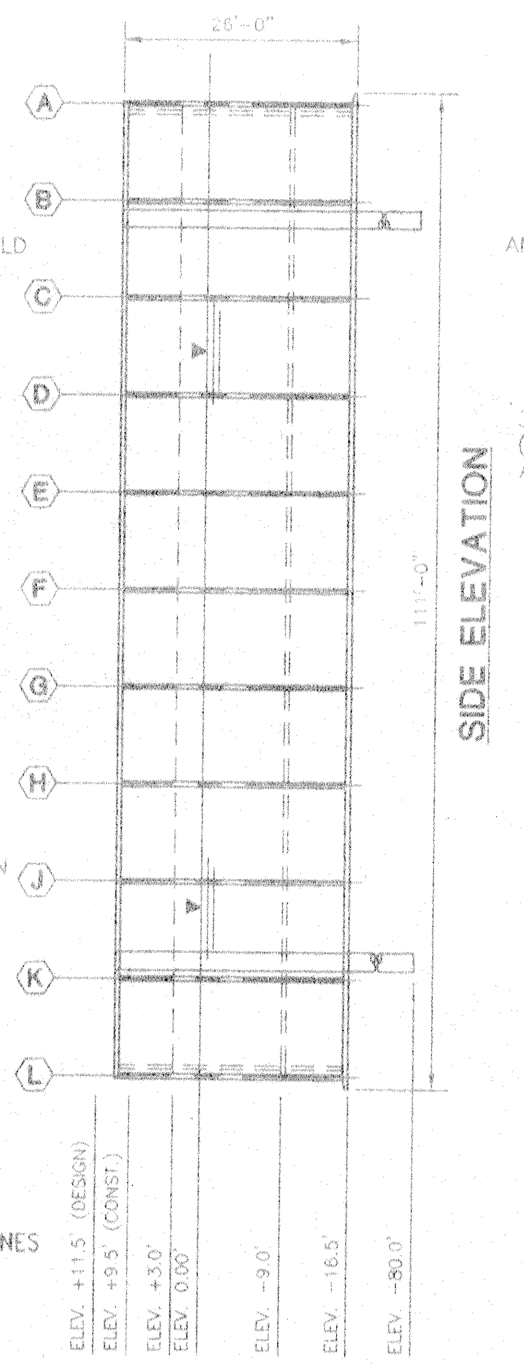
NOTE:
DESIGN ELEV. = +11.5' N.G.V.D.
CONSTRUCTION ELEV. = +9.5' N.G.V.D.

PLAN OF HULL COMPARTMENTATION

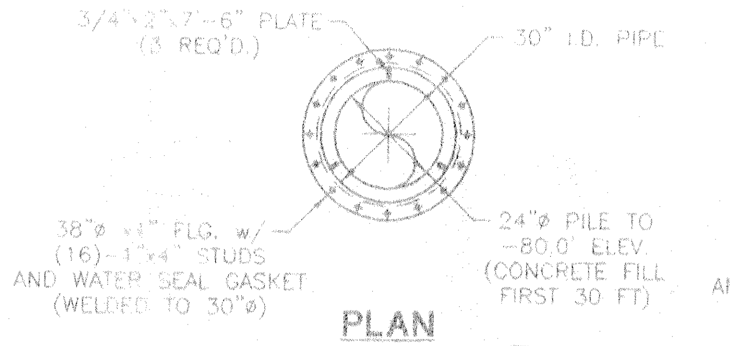
NOTE:
ALL COMPARTMENTS 10' BAYS. 4"ø VENT LINES AT TOP AND BOTTOM OF HULL VENTED UP VERTICALLY OUTBOARD OF W-5 PANEL.



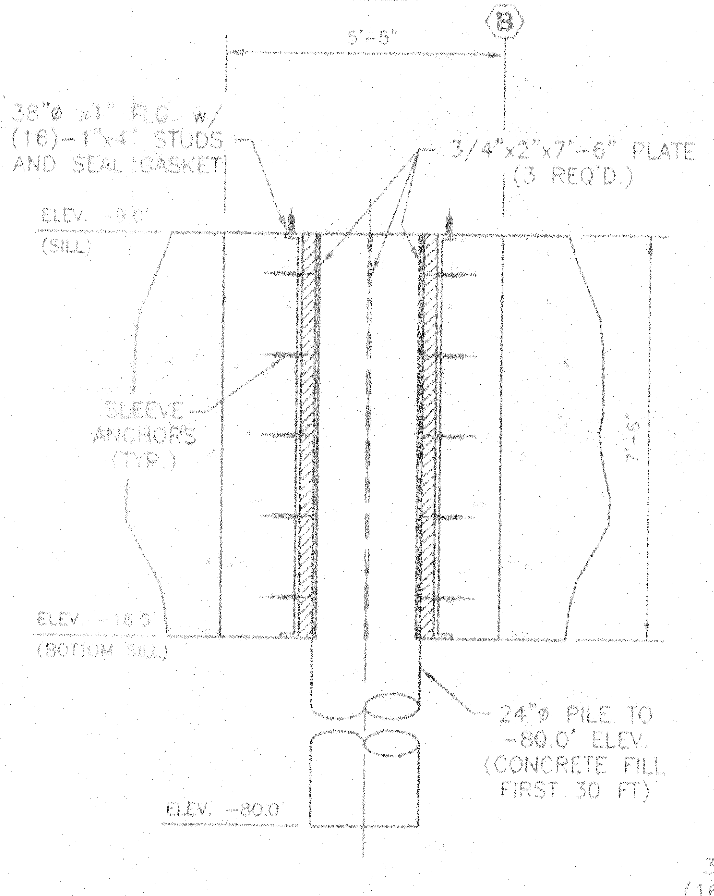
ELEVATION OF HULL



SIDE ELEVATION



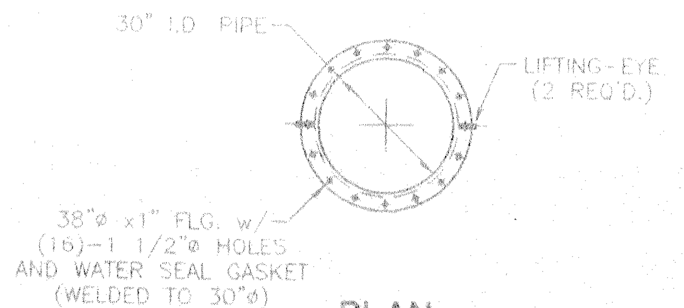
PLAN



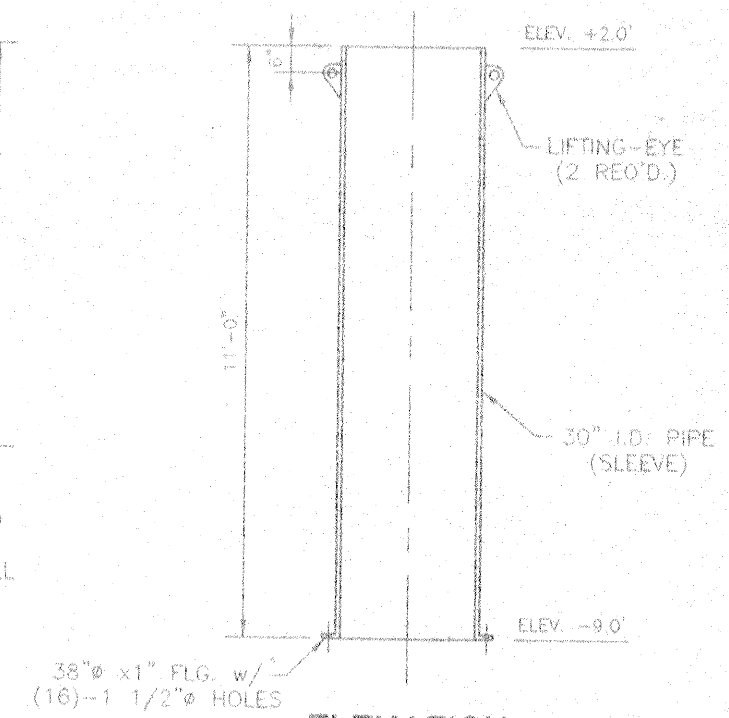
ELEVATION

SECTION A-A
CONNECTOR PILE INSTALLATION

(TYPICAL 24 PLACES)



PLAN



ELEVATION

GROUTING SLEEVE

(20 REQUIRED)

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT
CONNECTOR PILE PLAN AND DETAILS

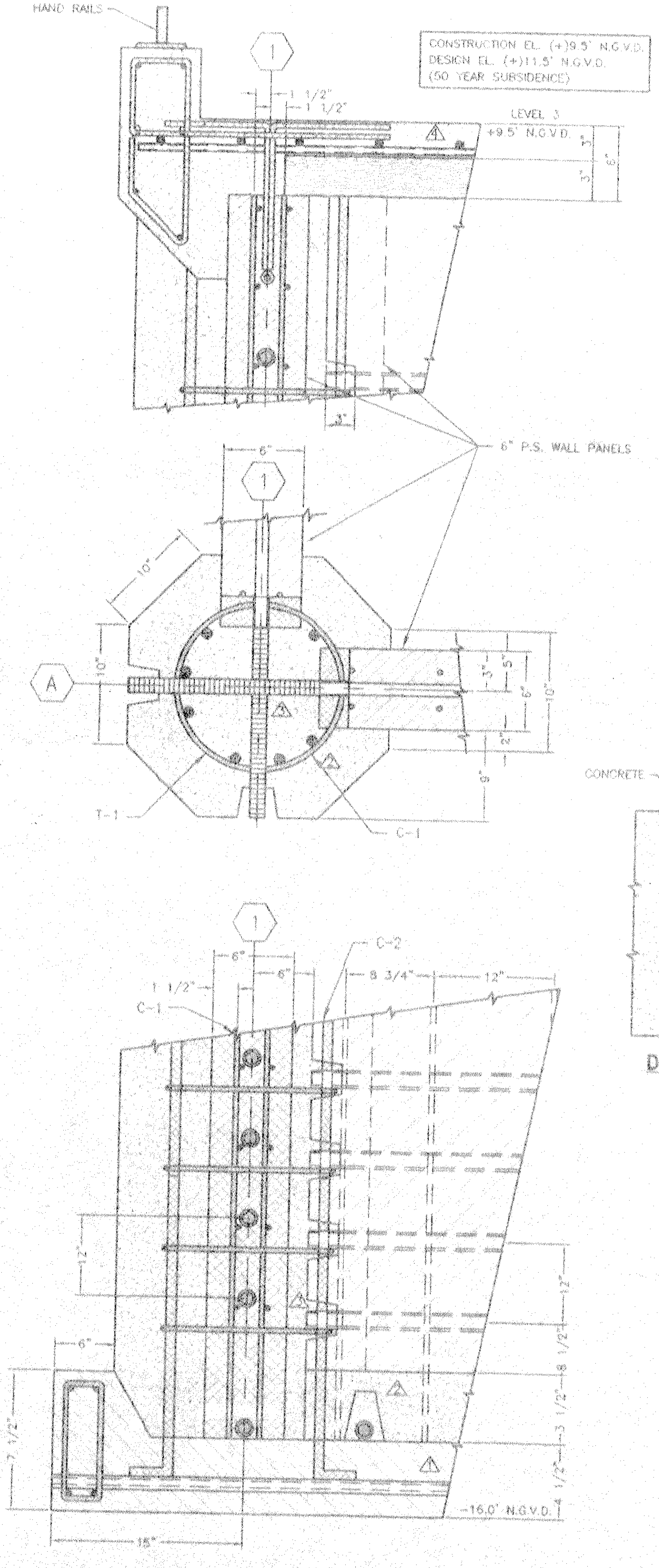
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

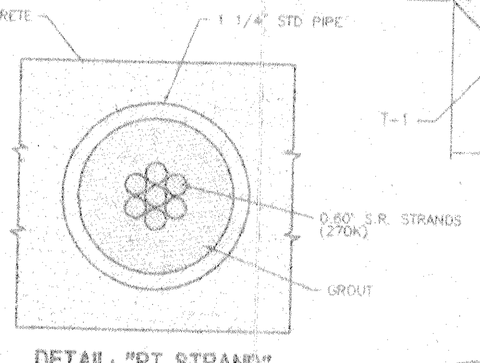
DATE: 08/26/88

FILE NO. H-2-44970

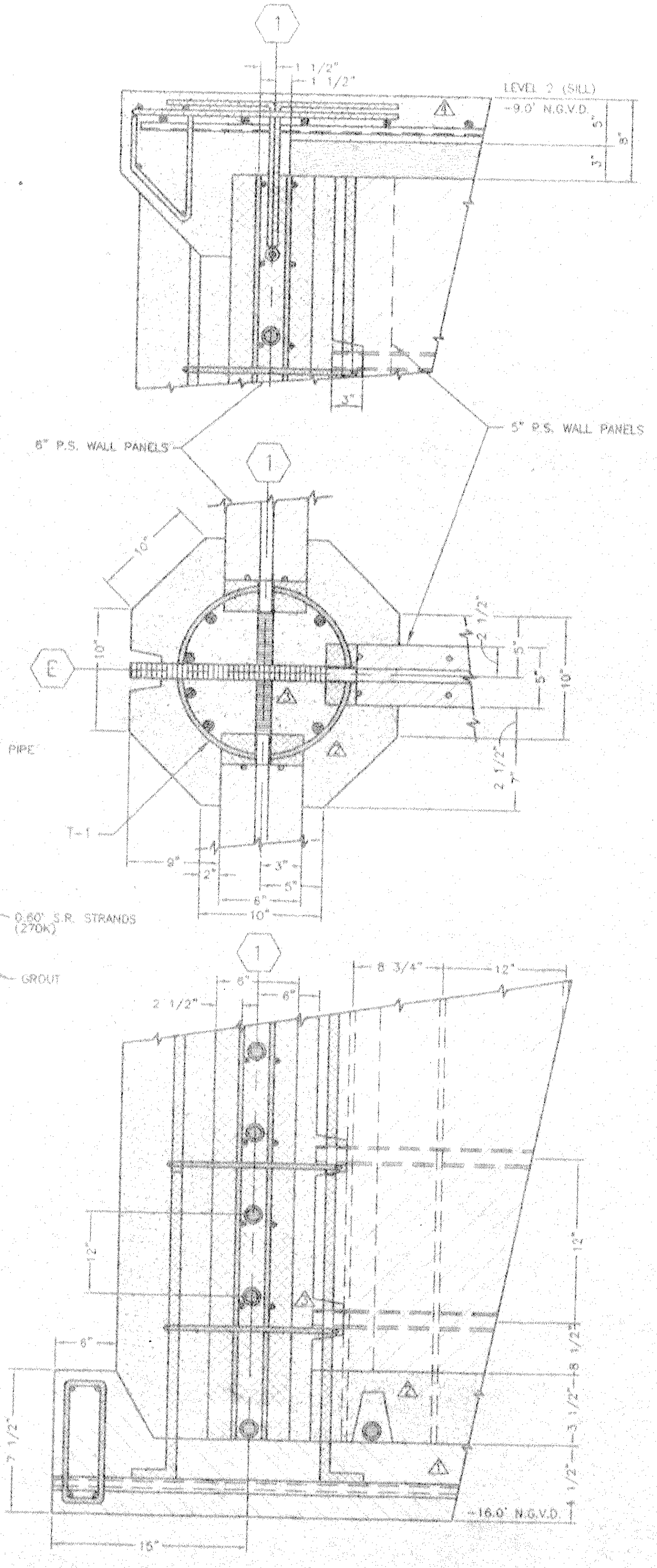
C-3



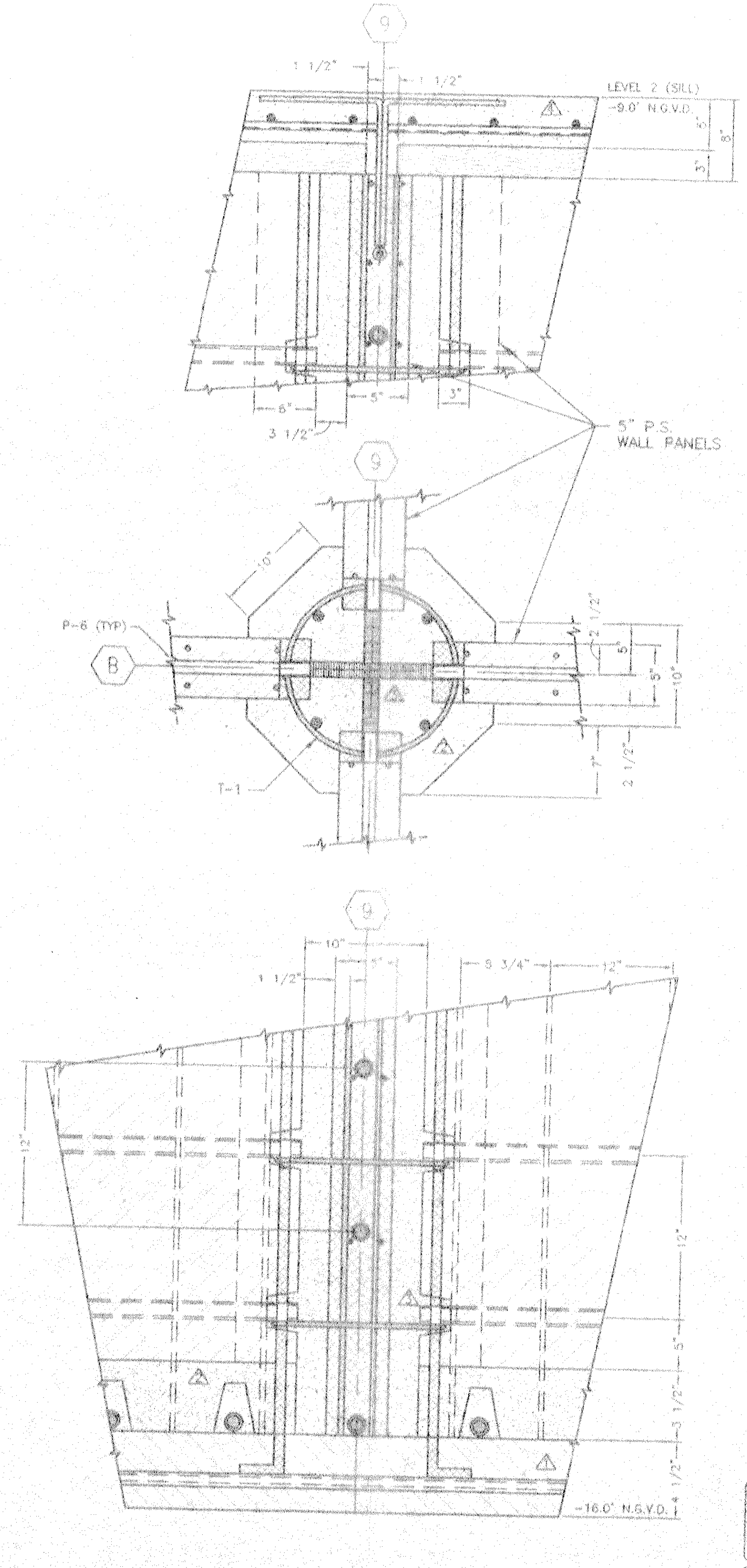
TYPICAL CORNER COL. POUR
NOT TO SCALE



DETAIL "PT STRAND"
N.T.S.



TYPICAL EXTERIOR COL. POUR
NOT TO SCALE



TYPICAL INTERIOR COL. POUR
NOT TO SCALE

C-1 – #9ø COLUMN REINFORCEMENT
C-2 – #9ø DOWEL (BEND 6"x30")
T-1 – #5 GAUGE SPIRAL @ 12" PITCH
P-6 – .60" POST TENSIONED TENDONS IN 1 1/4" STD PIPE CONDUIT STAGGERED WITH NUMBERED PANELS

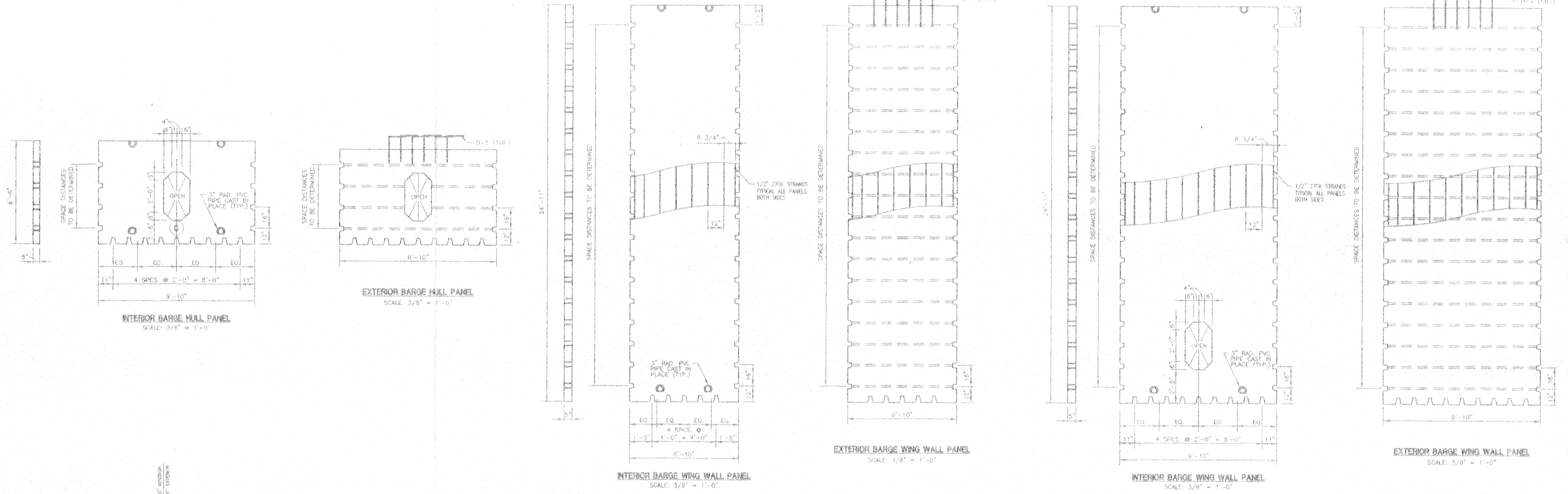
1 : POUR 1 6,500 PSI @ 150 PCF HR
2 : POUR 2 6,500 PSI @ 122 PCF SLWT
3 : POUR 3 6,500 PSI @ 122 PCF SLWT
4 : POUR 4 6,500 PSI @ 150 PCF HR

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT JOINT DETAILS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:	PLOT SCALE: 1 1/2"=1'-0"	PLOT DATE:	CADD FILE:
WEST JEFFERSON ENGINEERING SERVICES – A JOINT VENTURE GROUP –	DRAWN BY:	CHECKED BY:	FILE NO.
	DATE: 08/26/98		H-2-44970



INTERIOR BARGE HULL PANEL
SCALE: 3/8" = 1'-0"

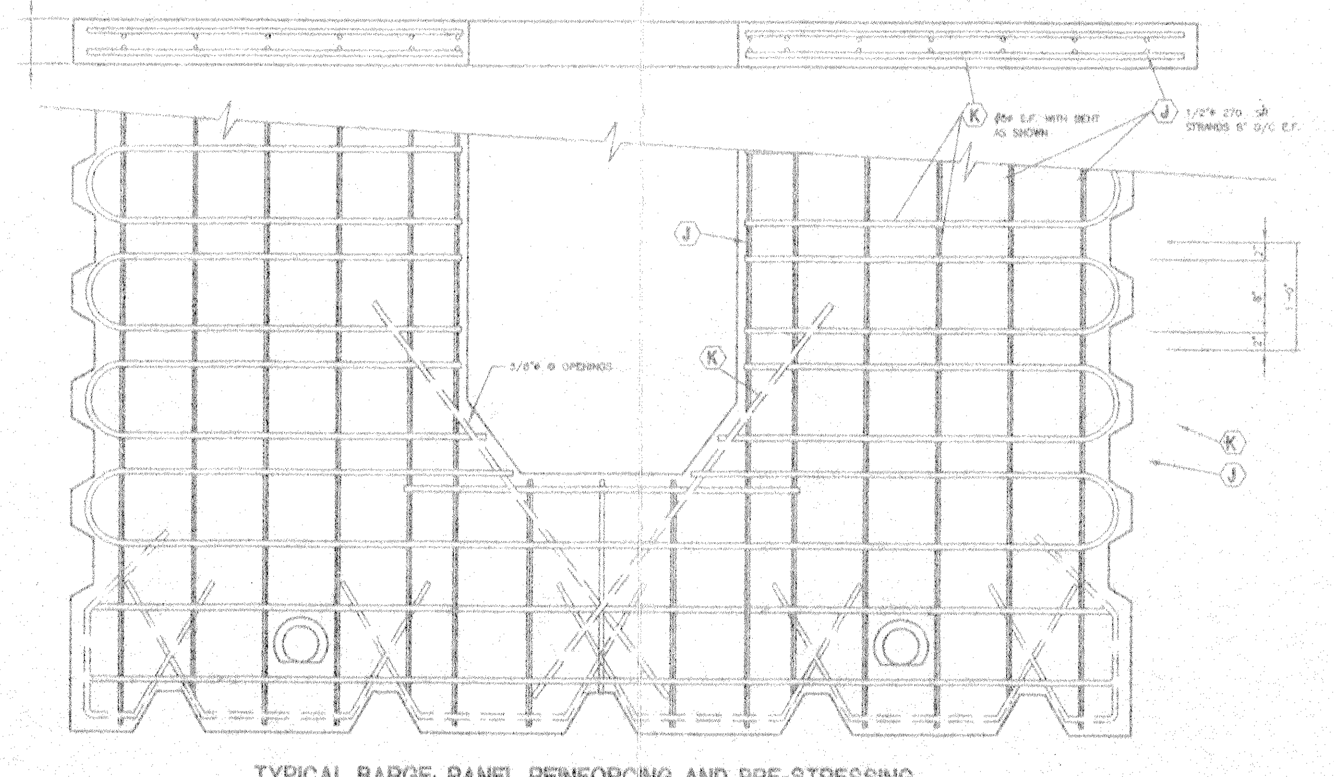
EXTERIOR BARGE HULL PANEL
SCALE: 3/8" = 1'-0"

INTERIOR BARGE WING WALL PANEL
SCALE: 3/8" = 1'-0"

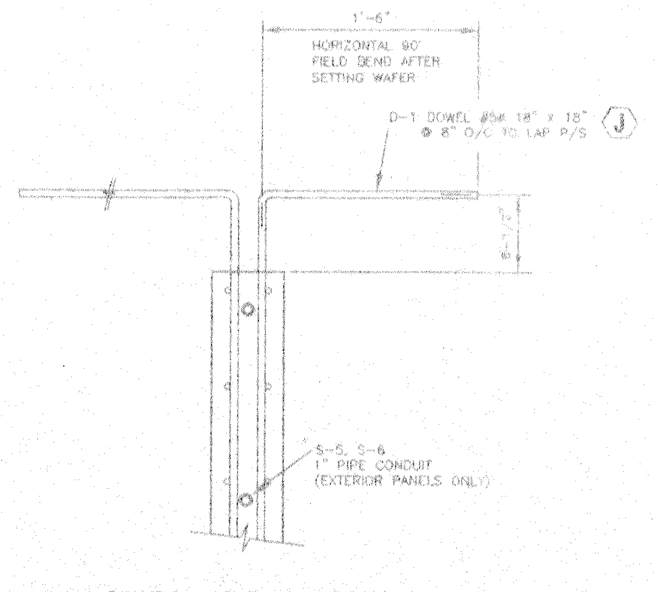
EXTERIOR BARGE WING WALL PANEL
SCALE: 3/8" = 1'-0"

INTERIOR BARGE WING WALL PANEL
SCALE: 3/8" = 1'-0"

EXTERIOR BARGE WING WALL PANEL
SCALE: 3/8" = 1'-0"



TYPICAL BARGE PANEL REINFORCING AND PRE-STRESSING
NOT TO SCALE



SECTION AT PANEL TOP
SCALE: 3/32" = 1'-0"

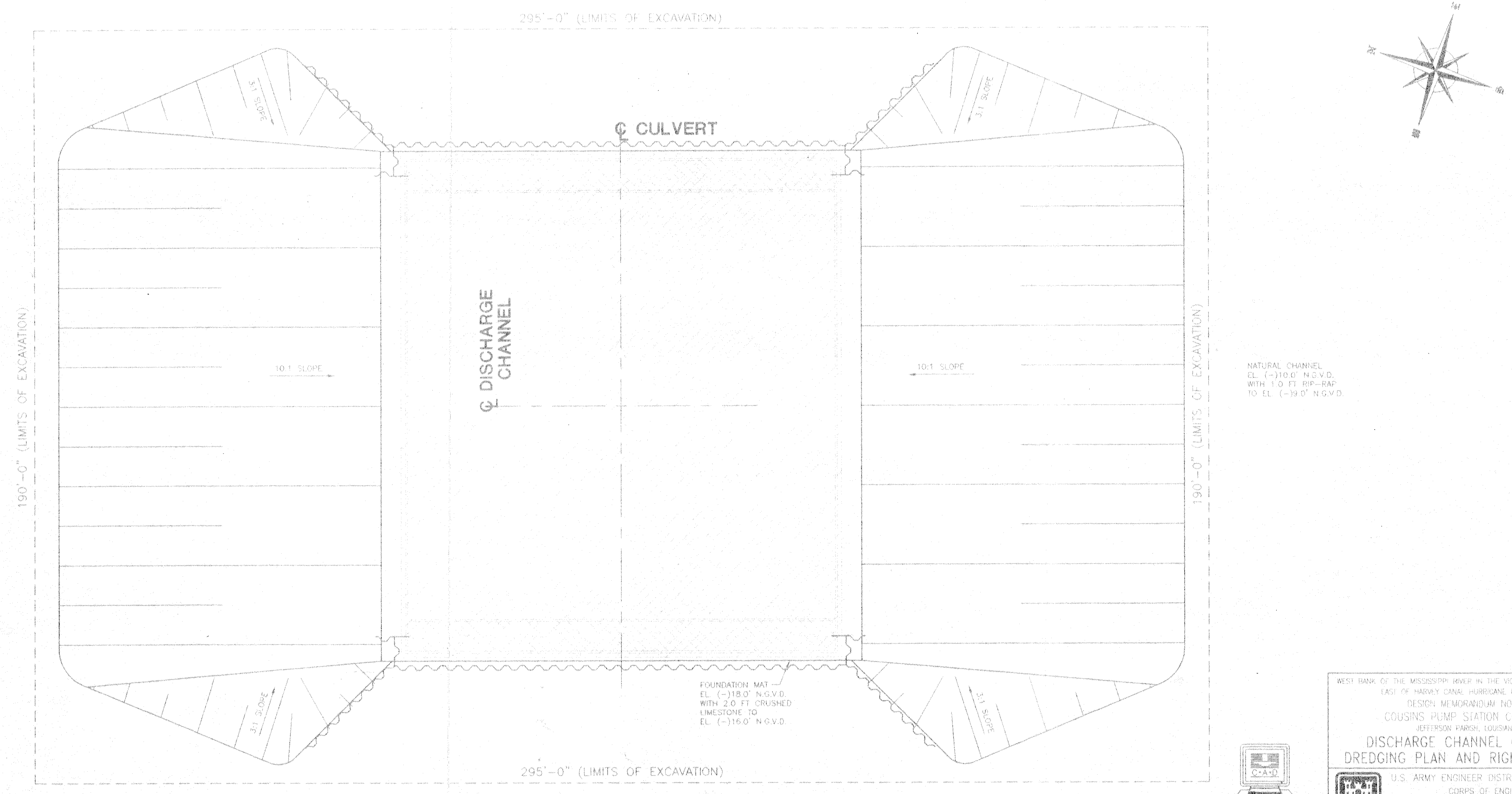
WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT PANEL DETAILS

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:	PLOT SCALE: 3/32"=1'-0"	PLOT DATE:	CADD FILE:
WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP	DRAWN BY:	CHECKED BY:	FILE NO. H-2-44970
	DATE: 08/26/98		

C-5



DREDGING PLAN AND RIGHT-OF-WAY

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

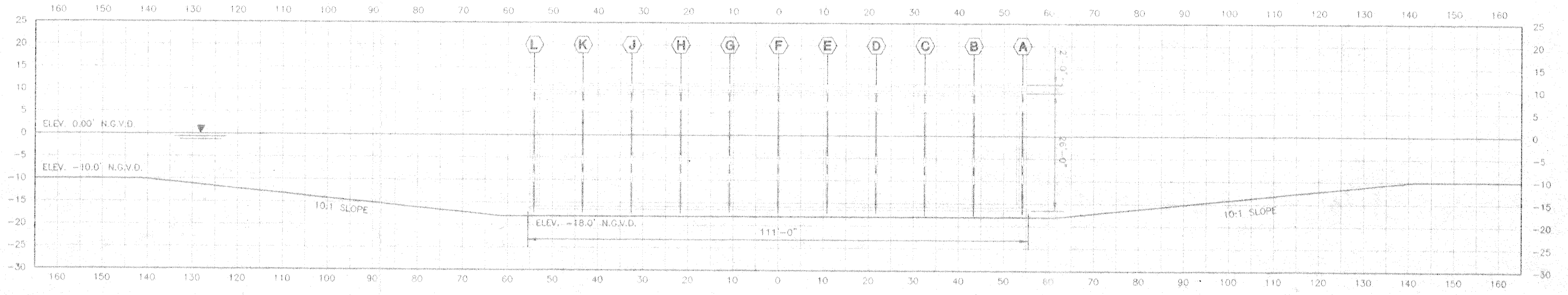
DISCHARGE CHANNEL CULVERT
DREDGING PLAN AND RIGHT-OF-WAY

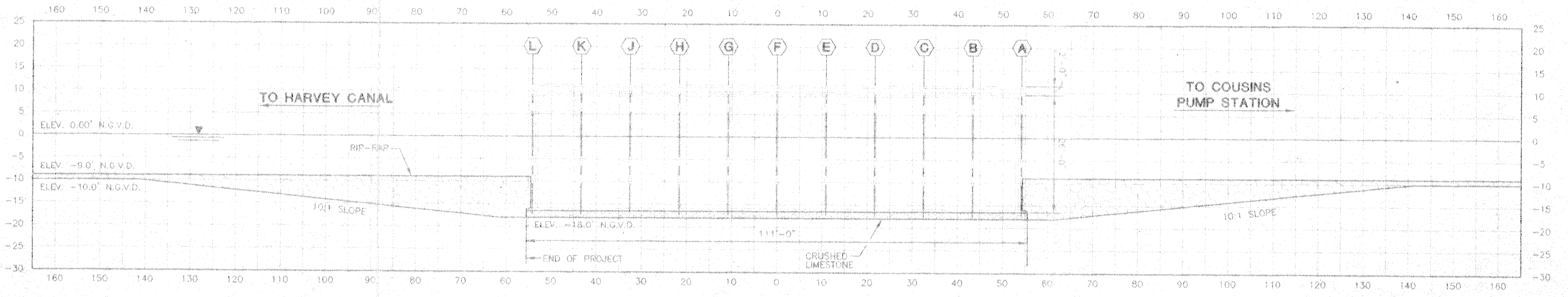
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

DRAWN BY: DAP
CHECKED BY: DFP
DATE: 08/26/98
FILE NO. H-2-44970

C-6





DREDGING PROFILES

VOLUME OF MATERIAL:	
CRUSHED LIMESTONE:	+/-1,750 Tons
RIP-RAP:	+/-5,950 Tons
TOTAL:	+/-7,700 Tons

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

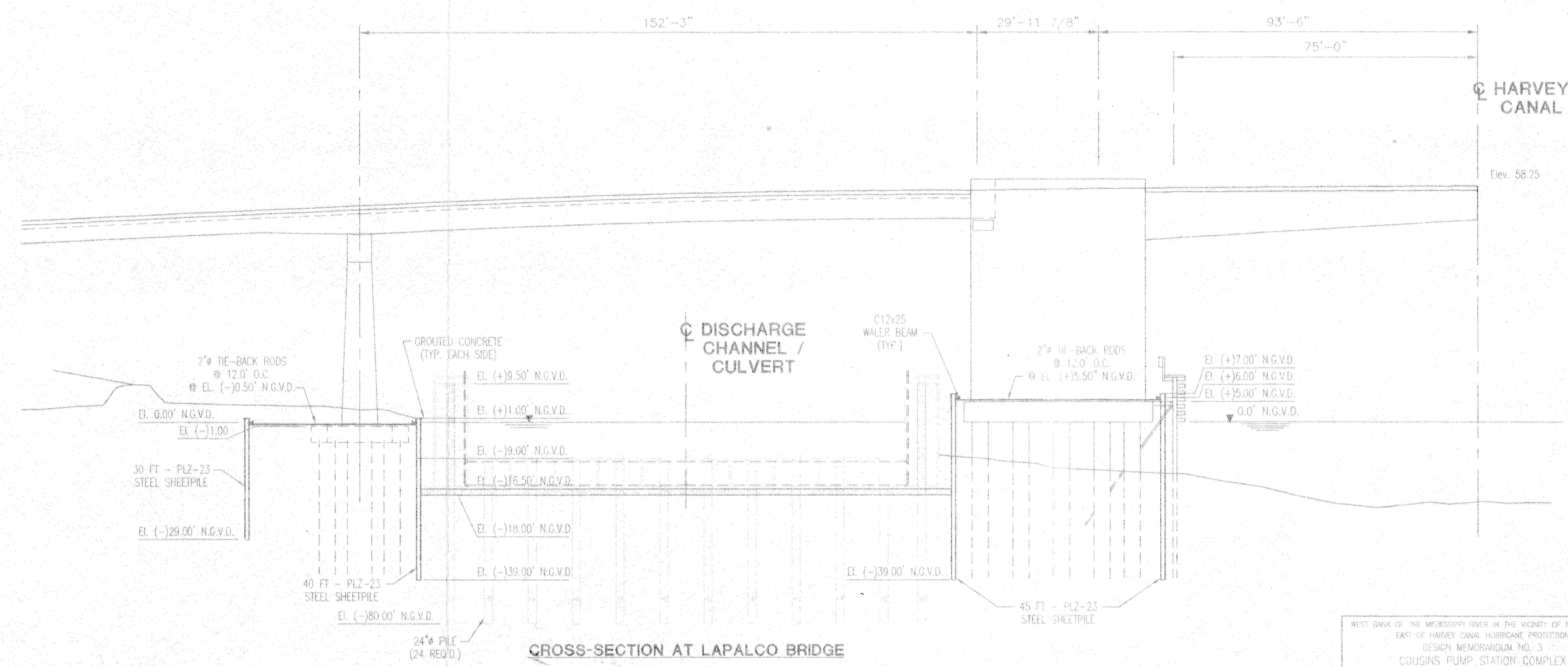
DISCHARGE CHANNEL CULVERT DREDGING PROFILES

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -

DATE: 08/28/89

FILE NO. H-2-44970



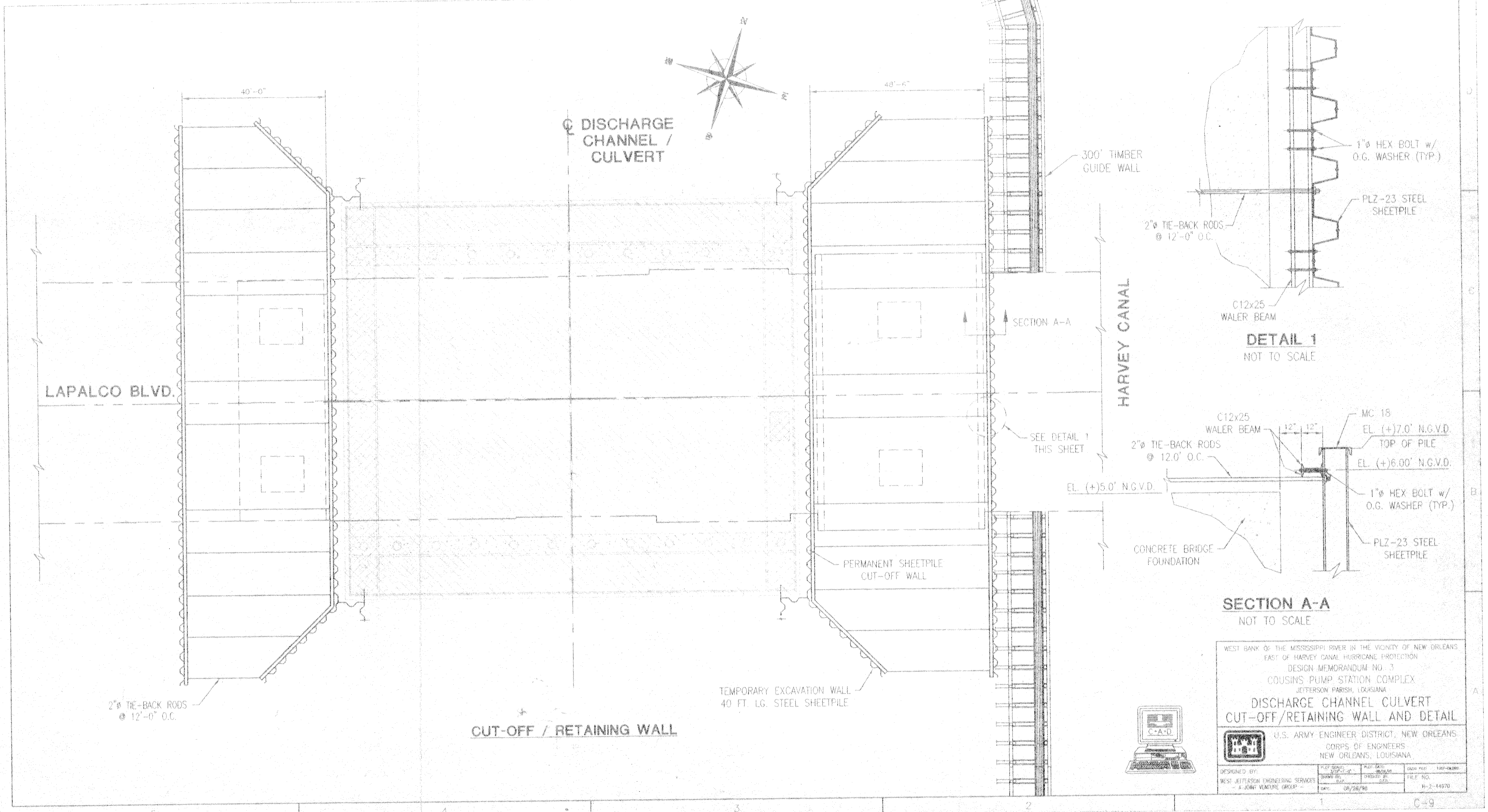
CROSS-SECTION AT LAPALCO BRIDGE

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT
CROSS-SECTION AT LAPALCO BRIDGE

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY: WEST JEFFERSON ENGINEERING SERVICES - A JOINT VENTURE GROUP -	PLOT SCALE:	PLOT DATE:	CADD FILE:
	DRAWN BY:	CHECKED BY:	FILE NO.
	DATE: 08/26/98		H-2-44970



WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS
EAST OF HARVEY CANAL HURRICANE PROTECTION
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION COMPLEX
JEFFERSON PARISH, LOUISIANA

DISCHARGE CHANNEL CULVERT
CUT-OFF/RETAINING WALL AND DETAIL

U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

DESIGNED BY:
WEST JEFFERSON ENGINEERING SERVICES
- A JOINT VENTURE GROUP -

DATE: 08/26/98
FILE NO. H-2-14970

C-9

APPENDIX A

DETAILED ESTIMATE OF INCREMENTAL COST

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF NEW ORLEANS, LOUISIANA

EAST OF HARVEY HURRICANE PROTECTION PROJECT
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION
DETAILED ESTIMATE OF FIRST COST
(MAY 1998 PRICE LEVELS)

1000 CFS

Item	Description	Total	Contingency	Project Cost
1	Pump Station	$ 7,210,130.00	$ 1,057,126.00	$ 8,267,256.00
2	Destrahan Ave. Bridge	$ 950,000.00	$ 190,000.00	$ 1,140,000.00
3	Canals & Channels	$ 2,847,446.00	$ 569,489.00	$ 3,416,935.00
4	Floodwalls	$ 1,835,770.00	$ 367,154.00	$ 2,202,924.00
5	Culvert Structure	$ 2,020,960.00	$ 427,772.00	$ 2,448,732.00
6	Closure Wall	$ 4,427,240.00	$ 885,448.00	$ 5,312,688.00
7	Relocations	$ 250,000.00	$ 50,000.00	$ 300,000.00
	Construction First Cost Total	**$ 19,541,546.00**	**$ 3,546,989.00**	**$23,088,535.00**
	PROJECT COST			
1	Construction Cost	$ 19,541,546.00	$ 3,546,989.00	$23,088,535.00
2	Constr. Engineering and Design	$ 230,885.35	$ 46,177.07	$ 277,062.42
3	Plans and Specifications	$ 2,308,853.50	$ 461,770.70	$ 2,770,624.20
4	Construction Administration	$ 2,308,853.50	$ 461,770.70	$ 2,770,624.20
	Total	**$ 24,390,138.35**	**$ 4,516,707.47**	**$28,906,845.82**
	Total (rounded)			**$28,907,000.00**

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
1,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
1	**Pump Station (1000 CFS)**						
1.1	**Mobilization & Demobilization**						
1.1.1	Mob/demob (for pump station)	LS	LS	$ 200,000.00	$ 200,000	$ 40,000	$ 240,000
1.2	**Earthwork for Structure**						
1.2.1	Structure Excavation	20,000	cy	$ 10.00	$ 200,000	$ 50,000	$ 250,000
1.2.2	Cofferdam	LS	LS	$ 700,000.00	$ 700,000	$ 140,000	$ 840,000
1.3	**Pumping Station Structure**						
1.3.1	Structural Concrete	3,400	cy	$ 375.00	$ 1,275,000	$ 255,000	$ 1,530,000
1.3.2	Concrete Discharge Tube	450	cy	$ 600.00	$ 270,000	$ 54,000	$ 324,000
1.3.3	Timber Piles	35,500	lf	$ 10.00	$ 355,000	$ 71,000	$ 426,000
1.3.4	Pile Test	LS	LS	$ 36,000.00	$ 36,000	$ 7,200	$ 43,200
1.3.5	Building (including Office & Bathroom)	3,150	sf	$ 40.00	$ 126,000	$ 25,200	$ 151,200
1.4	**Pumping Station Mechanical**						
1.4.1	1000 cfs Horizontal Pump	1	ea	$ 891,000.00	$ 891,000	$ -	$ 891,000
1.4.2	Horizontal Reduction Gear	1	ea	$ 283,500.00	$ 283,500	$ -	$ 283,500
1.4.3	3,400 h.p. Diesel Engine	1	ea	$ 747,000.00	$ 747,000	$ -	$ 747,000
1.4.4	Engine Cooling System	1	ea	$ 120,000.00	$ 120,000	$ 24,000	$ 144,000
1.4.5	Vacuum Pump System	LS	LS	$ 110,000.00	$ 110,000	$ 22,000	$ 132,000
1.4.6	Air System	LS	LS	$ 35,000.00	$ 35,000	$ 7,000	$ 42,000
1.4.7	Fuel Oil System	LS	LS	$ 70,000.00	$ 70,000	$ 14,000	$ 84,000
1.4.8	Crane	2,	ea	$ 90,000.00	$ 180,000	$ 36,000	$ 216,000
1.4.9	Mechanical Trash Rakes	1	ea	$ 450,000.00	$ 450,000	$ 90,000	$ 540,000
1.4.10	Mechanical Installation	LS	LS	$ 425,000.00	$ 425,000	$ 85,000	$ 510,000
1.4.11	Waste Oil System	LS	LS	$ 13,000.00	$ 13,000	$ 2,600	$ 15,600
1.4.12	Potable Water System	LS	LS	$ 4,000.00	$ 4,000	$ 800	$ 4,800
1.4.13	Ventillation System	LS	LS	$ 18,000.00	$ 18,000	$ 3,600	$ 21,600
1.4.14	Electrical	LS	LS	$ 300,000.00	$ 300,000	$ 60,000	$ 360,000
1.4.15	Controls	LS	LS	$ 38,000.00	$ 38,000	$ -	$ 38,000
1.4.16	Services of Erecting Engineer	20	Day	$ 1,200.00	$ 24,000	$ -	$ 24,000
1.4.17	Field Services	6	Day	$ 1,200.00	$ 7,200	$ -	$ 7,200
1.5	**Intake Modifications**						
1.5.1	Excavation	2,500	cy	$ 6.75	$ 16,875	$ 4,219	$ 21,094
1.5.2	Steel Sheet Piling	14,373	sf	$ 15.00	$ 215,595	$ 43,119	$ 258,714
1.5.3	Coating	6,020	sf	$ 2.00	$ 12,040	$ 2,408	$ 14,448
1.5.4	Concrete Cap (Including Reinforcing)	50	cy	$ 300.00	$ 15,000	$ 3,000	$ 18,000
1.5.5	Tie-Back System	LS	LS	$ 25,000.00	$ 25,000	$ 5,000	$ 30,000
1.5.6	Sand Back Fill	735	cy	$ 12.00	$ 8,820	$ 2,205	$ 11,025
1.5.7	Rip Rap	1,700	ton	$ 23.00	$ 39,100	$ 9,775	$ 48,875
	Sub-total Pump Station				$ 7,210,130	$ 1,057,126	$ 8,267,256

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
1,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
2	**DESTRAHAN AVENUE BRIDGE**						
2.1	**Destrahan Ave. Bridge Extension** (Includes Structural Excavation and Backfill, Prestressed Concrete Piles, Class A and Class AA Concrete, Type III Prestressed Girders, and Misc. Items)						
2.1.1	Destrahan Ave. Bridge Extension	1	LS	$ 250,000.00	$250,000	$50,000	$300,000
2.2	**Bottom Roller Floodgates** (Includes Structural Steel, Concrete, Steel Sheet Piling, Prestressed Concrete Piles, Timber Piles, and Misc. Items, Gate Monolith and Storage Monolith)						
2.2.1	40' Wide Opening	2	EA	$ 350,000.00	$700,000	$140,000	$840,000
	Sub-total Destrahan Ave. Bridge				$ 950,000	$ 190,000	$ 1,140,000
3	**CANALS AND CHANNELS**						
3.1	**First Ave. Canal Widening**						
3.1.1	Excavation	310000	CY	$ 6.75	$2,092,500	$418,500	$2,511,000
3.2	**Discharge Channel Modifications**						
3.2.1	Excavation	47,826	cy	$ 6.75	$ 322,826	$ 64,565	$ 387,391
3.2.2	Compacted Fill	912	cy	$ 12.00	$ 10,944	$ 2,189	$ 13,133
3.2.3	Rip Rap	18,312	ton	$ 23.00	$ 421,176	$ 84,235	$ 505,411
	Sub-total Canals				$2,847,446	$569,489	$3,416,935
4	**FLOODWALLS**						
4.1	**I-Type Floodwalls** (Includes Steel Sheet Piling, Concrete Cap and Misc. Items)						
4.1.1	6' High Above Ground	336	lf	$ 400.00	$ 134,400	$ 26,880	$ 161,280
4.1.2	8' High Above Ground	750	lf	$ 600.00	$ 450,000	$ 90,000	$ 540,000
4.2	**Frontal Protection T-Wall** (Includes Structural Excavation and Backfill, Steel Sheet Piling, Prestressed Concrete Piles, Concrete, and Misc. Items)						
4.2.1	22.5' High Above Ground	355	LF	$ 2,500.00	$887,500	$177,500	$1,065,000
4.2.1	Discharge Basin Slab (Includes Structural Excavaton, Concrete, Timber Piles & Misc. Items)	4160	SF	$ 45.00	$187,200	$37,440	$224,640
4.3	**Cantilevered Sheet Pile Wall**						
4.3.1	Steel Sheet Piling	10,330	sf	$ 15.00	$ 154,950	$ 30,990	$ 185,940
4.3.2	Concrete Cap (Including Reinforcing)	28	cy	$ 300.00	$ 8,400	$ 1,680	$ 10,080
4.3.3	Coating	6,660	sf	$ 2.00	$ 13,320	$ 2,664	$ 15,984
	Sub-total Floodwalls				$1,835,770	$367,154	$2,202,924

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
1,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
5	**CULVERT STRUCTURE**						
5.1	**Mobilization & demobilization**						
5.1.1	Mob/demob (for culvert structure)	LS	LS	$ 25,000.00	$ 25,000	$ 5,000	$ 30,000
5.2	**Earth work for structures**						
5.2.1	Structure excavation	3,600	cy	$ 6.75	$ 24,300	$ 4,860	$ 29,160
5.2.2	Geotextile	1,700	sy	$ 4.50	$ 7,650	$ 1,530	$ 9,180
5.2.3	Leveling bed	1,350	tons	$ 25.00	$ 33,750	$ 6,750	$ 40,500
5.3	**Approach channels**						
5.3.1	Excavation	3,200	cy	$ 6.75	$ 21,600	$ 4,320	$ 25,920
5.3.2	Geotextile	2,600	sy	$ 4.50	$ 11,700	$ 2,340	$ 14,040
5.3.3	Bedding	900	cy	$ 28.00	$ 25,200	$ 5,040	$ 30,240
5.3.4	Riprap	7,800	ton	$ 23.00	$ 179,400	$ 35,880	$ 215,280
5.4	**Concrete gravity structure**						
5.4.1	Semi-lightweight concrete	600	cy	$ 375.00	$ 225,000	$ 45,000	$ 270,000
5.4.2	Hardrock concrete	660	cy	$ 250.00	$ 165,000	$ 33,000	$ 198,000
5.4.3	Post-tensioning system	80,000	lf	$ 1.50	$ 120,000	$ 24,000	$ 144,000
5.4.4	Reinforcing	168,000	lb	$ 0.45	$ 75,600	$ 15,120	$ 90,720
5.4.5	6" & 5" Panel PS/PC	450	cy	$ 300.00	$ 135,000	$ 27,000	$ 162,000
5.4.6	30" Connector Pile Sleeves	365	lf	$ 120.00	$ 43,800	$ 8,760	$ 52,560
5.4.7	Installation	LS	LS	$ 75,000.00	$ 75,000	$ 15,000	$ 90,000
5.5	**Foundation work**						
5.5.1	24" Connector Piles	2,160	lf	$ 210.00	$ 453,600	$ 113,400	$ 567,000
5.5.2	Concrete Cap	120	cy	$ 150.00	$ 18,000	$ 4,500	$ 22,500
5.5.3	Sheet pile cut-off wall (Retaining wall)	8,400	sf	$ 15.00	$ 126,000	$ 25,200	$ 151,200
5.5.4	Fabricated channel cap	210	lf	$ 20.00	$ 4,200	$ 840	$ 5,040
5.5.5	High density mix	950	cy	$ 50.00	$ 47,500	$ 9,500	$ 57,000
5.5.6	Pile testing	LS	LS	$ 40,000.00	$ 40,000	$ 8,000	$ 48,000
5.6	**Tie-Back/Retaining Wall**						
5.6.1	Sheet piles	6,000	sf	$ 8.50	$ 51,000	$ 10,200	$ 61,200
5.6.2	Walers	840	lf	$ 24.00	$ 20,160	$ 4,032	$ 24,192
5.6.3	Miscellaneous hardware	LS	LS	$ 5,000.00	$ 5,000	$ 1,000	$ 6,000
5.7	**Special construction**						
5.7.1	Instrumentation	LS	LS	$ 5,000.00	$ 5,000	$ 1,000	$ 6,000
5.8	**Mechanical system**						
5.8.1	Piping and manifolds	LS	LS	$ 35,000.00	$ 35,000	$ 7,000	$ 42,000
5.8.2	Pumps	LS	LS	$ 30,000.00	$ 30,000	$ 6,000	$ 36,000
5.9	**Power and lighting system**						
5.9.1	Electrical services/work	LS	LS	$ 5,000.00	$ 5,000	$ 1,000	$ 6,000
5.9.2	Other electrical work	LS	LS	$ 10,000.00	$ 10,000	$ 2,000	$ 12,000
5.10	**Associated general items**						
5.10.1	Tile gages	LS	LS	$ 2,500.00	$ 2,500	$ 500	$ 3,000
	Sub-total Culvert				$ 2,020,960	$ 427,772	$ 2,448,732

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
1,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
6	**CLOSURE WALL**						
6.1.1	Steel Sheet Piling	16416	SF	$ 15.00	$246,240	$49,248	$295,488
6.1.2	66" Diameter Prestressed Concrete Cylinder Piles	14900	LF	$ 250.00	$3,725,000	$745,000	$4,470,000
6.1.3	Concrete Cap (Includes Reinforcing)	1216	CY	$ 375.00	$456,000	$91,200	$547,200
	Sub-total Closure Wall				$4,427,240	$885,448	$5,312,688
7	**RELOCATION**						
7.1	16" High Pressure Gas Line	2	LS	$ 75,000.00	$ 150,000	$30,000	$180,000
7.1.2	Electircal Power Lines	1	LS	$ 100,000.00	$ 100,000	$20,000	$120,000
	Sub-total Relocation				$ 250,000	$ 50,000	$ 300,000
	Construction Cost Total				$ 19,541,546	$ 3,546,989	$ 23,088,534

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
	PROJECT COST						
1	Construction Cost				$ 19,541,546	$ 3,546,989	$ 23,088,534
2	Constr. Engineering and design				$ 230,885	$ 46,177	$ 277,062
3	Plans and specifications				$ 2,308,853	$ 461,771	$ 2,770,624
4	Construction administration				$ 2,308,853	$ 461,771	$ 2,770,624
	Total				$ 24,390,138	$ 4,516,707	$ 28,906,845
	TOTAL (rounded)						$ 28,907,000

WEST BANK OF THE MISSISSIPPI RIVER IN THE VICINITY OF
NEW ORLEANS, LOUISIANA
EAST OF HARVEY HURRICANE PROTECTION PROJECT
DESIGN MEMORANDUM NO. 3
COUSINS PUMP STATION
DETAILED ESTIMATE OF FIRST COST
(MAY 1998 PRICE LEVELS)
2000 CFS

Item	Description		Total		Contingency	Project Cost
1	Pump Station	$	12,488,785.00	$	1,725,687.00	$14,214,472.00
2	Destrahan Ave. Bridge	$	950,000.00	$	190,000.00	$ 1,140,000.00
3	Canals & Channels	$	2,847,446.00	$	569,489.00	$ 3,416,935.00
4	Floodwalls	$	1,835,770.00	$	367,154.00	$ 2,202,924.00
5	Culvert Structure	$	2,020,960.00	$	427,772.00	$ 2,448,732.00
6	Closure Wall	$	4,602,240.00	$	920,448.00	$ 5,522,688.00
7	Relocations	$	250,000.00	$	50,000.00	$ 300,000.00
	Construction First Cost Total	**$**	**24,995,201.00**	**$**	**4,250,550.00**	**$29,245,751.00**
	PROJECT COST					
1	Construction Cost	$	24,995,201.00	$	4,250,550.00	$29,245,751.00
2	Constr. Engineering and Design	$	292,457.51	$	58,491.50	$ 350,949.01
3	Plans and Specifications	$	2,924,575.10	$	584,915.02	$ 3,509,490.12
4	Construction Administration	$	2,924,575.10	$	584,915.02	$ 3,509,490.12
	Total	**$**	**31,136,808.71**	**$**	**5,478,871.54**	**$36,615,680.25**
	Total (rounded)					**$36,616,000.00**

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
2,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
1	**Pump Station (2000 CFS)**						
1.1	**Mobilization & Demobilization**						
1.1.1	Mob/demob (for pump station)	LS	LS	250,000.00	$ 250,000	$ 50,000	$ 300,000
1.2	**Earthwork for Structure**						
1.2.1	Structure Excavation	33,333	cy	10.00	$ 333,330	$ 83,333	$ 416,663
1.2.2	Cofferdam	LS	LS	891,000.00	$ 891,000	$ 178,200	$ 1,069,200
1.3	**Pumping Station Structure**						
1.3.1	Structural Concrete	5,650	cy	375.00	$ 2,118,750	$ 423,750	$ 2,542,500
1.3.2	Concrete Discharge Tube	900	cy	600.00	$ 540,000	$ 108,000	$ 648,000
1.3.3	Timber Piles	57,680	lf	10.00	$ 576,800	$ 115,360	$ 692,160
1.3.4	Pile Test	LS	LS	36,000.00	$ 36,000	$ 7,200	$ 43,200
1.3.5	Building (including Office & Bathroom)	5,050	sf	40.00	$ 202,000	$ 40,400	$ 242,400
1.4	**Pumping Station Mechanical**						
1.4.1	1000 cfs Horizontal Pump	2	ea	891,000.00	$ 1,782,000	$ -	$ 1,782,000
1.4.2	Horizontal Reduction Gear	2	ea	283,500.00	$ 567,000	$ -	$ 567,000
1.4.3	3400 h.p. Diesel Engine	2	ea	747,000.00	$ 1,494,000	$ -	$ 1,494,000
1.4.4	Engine Cooling System	2	ea	120,000.00	$ 240,000	$ 48,000	$ 288,000
1.4.5	Vacuum Pump System	LS	LS	130,000.00	$ 130,000	$ 26,000	$ 156,000
1.4.6	Air System	LS	LS	45,000.00	$ 45,000	$ 9,000	$ 54,000
1.4.7	Fuel Oil System	LS	LS	90,000.00	$ 90,000	$ 18,000	$ 108,000
1.4.8	Crane	2	ea	105,000.00	$ 210,000	$ 42,000	$ 252,000
1.4.9	Mechanical Trash Rakes	3	ea	375,000.00	$ 1,125,000	$ 225,000	$ 1,350,000
1.4.10	Mechanical Installation	2	ea	425,000.00	$ 850,000	$ 170,000	$ 1,020,000
1.4.11	Waste Oil System	LS	LS	15,000.00	$ 15,000	$ 3,000	$ 18,000
1.4.12	Potable Water System	LS	LS	5,000.00	$ 5,000	$ 1,000	$ 6,000
1.4.13	Ventillation System	2	ea	18,000.00	$ 36,000	$ 7,200	$ 43,200
1.4.14	Relocate Water Well	LS	LS	95,000.00	$ 95,000	$ 19,000	$ 114,000
1.4.15	Electrical	LS	LS	375,000.00	$ 375,000	$ 75,000	$ 450,000
1.4.16	Controls	LS	LS	76,000.00	$ 76,000	$ -	$ 76,000
1.4.17	Services of Erecting Engineer	32	Day	1,200.00	$ 37,800	$ -	$ 37,800
1.4.18	Field Services	8	Day	1,200.00	$ 9,600	$ -	$ 9,600
1.5	**Intake Modifications**						
1.5.1	Excavation	5,000	cy	6.75	$ 33,750	$ 8,438	$ 42,188
1.5.2	Steel Sheet Piling	14,373	sf	15.00	$ 215,595	$ 43,119	$ 258,714
1.5.3	Coating	6,020	sf	2.00	$ 12,040	$ 2,408	$ 14,448
1.5.4	Concrete Cap (Including Reinforcing)	50	cy	300.00	$ 15,000	$ 3,000	$ 18,000
1.5.5	Tie-Back System	LS	LS	25,000.00	$ 25,000	$ 5,000	$ 30,000
1.5.6	Sand Back Fill	735	cy	12.00	$ 8,820	$ 2,205	$ 11,025
1.5.7	Rip Rap	2,100	ton	23.00	$ 48,300	$ 12,075	$ 60,375
	Sub-total Pump Station				$ 12,488,785	$ 1,725,687	$ 14,214,472

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
2,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
2	**DESTRAHAN AVENUE BRIDGE**						
2.1	**Destrahan Ave. Bridge Extension** (Includes Structural Excavation and Backfill, Prestressed Concrete Piles, Class A and Class AA Concrete, Type III Prestressed Girders, and Misc. Items)						
2.1.1	Destrahan Ave. Bridge Extension	1	LS	250,000.00	$250,000	$50,000	$300,000
2.2	**Bottom Roller Floodgates** (Includes Structural Steel, Concrete, Steel Sheet Piling, Prestressed Concrete Piles, Timber Piles, and Misc. Items, Gate Monolith and Storage Monolith)						
2.2.1	40' Wide Opening	2	EA	350,000.00	$700,000	$140,000	$840,000
	Sub-total Destrahan Ave. Bridge				**$ 950,000**	**$ 190,000**	**$ 1,140,000**
3	**CANALS AND CHANNELS**						
3.1	**First Ave. Canal Widening**						
3.1.1	Excavation	310000	CY	6.75	$2,092,500	$418,500	$2,511,000
3.2	**Discharge Channel Modifications**						
3.2.1	Excavation	47,826	cy	6.75	$ 322,826	$ 64,565	$ 387,391
3.2.2	Compacted Fill	912	cy	12.00	$ 10,944	$ 2,189	$ 13,133
3.2.3	Rip Rap	18,312	ton	23.00	$ 421,176	$ 84,235	$ 505,411
	Sub-total Canals				**$2,847,446**	**$569,489**	**$3,416,935**
4	**FLOODWALLS**						
4.1	**I-Type Floodwalls** (Includes Steel Sheet Piling, Concrete Cap and Misc. Items)						
4.1.1	6' High Above Ground	336	lf	400.00	$ 134,400	$ 26,880	$ 161,280
4.1.2	8' High Above Ground	750	lf	600.00	$ 450,000	$ 90,000	$ 540,000
4.2	**Frontal Protection T-Wall** (Includes Structural Excavation and Backfill, Steel Sheet Piling, Prestressed Concrete Piles, Concrete, and Misc. Items)						
4.2.1	22.5' High Above Ground	355	LF	2,500.00	$887,500	$177,500	$1,065,000
4.2.1	Discharge Basin Slab (Includes Structural Excavaton, Concrete, Timber Piles & Misc. Items)	4160	SF	45.00	$187,200	$37,440	$224,640
4.3	**Cantilevered Sheet Pile Wall**						
4.3.1	Steel Sheet Piling	10,330	sf	15.00	$ 154,950	$ 30,990	$ 185,940

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
2,000 CFS

Item	Description	Quantity	Unit	Unit cost		Total		Contingency		Project cost
4.3.2	Concrete Cap (Including Reinforcing)	28	cy	300.00	$	8,400	$	1,680	$	10,080
4.3.3	Coating	6,660	sf	2.00	$	13,320	$	2,664	$	15,984
	Sub-total Floodwalls					**$1,835,770**		**$367,154**		**$2,202,924**
5	**CULVERT STRUCTURE**									
5.1	**Mobilization & demobilization**									
5.1.1	Mob/demob (for culvert structure)	LS	LS	25,000.00	$	25,000	$	5,000	$	30,000
5.2	**Earth work for structures**									
5.2.1	Structure excavation	3,600	cy	6.75	$	24,300	$	4,860	$	29,160
5.2.2	Geotextile	1,700	sy	4.50	$	7,650	$	1,530	$	9,180
5.2.3	Leveling bed	1,350	tons	25.00	$	33,750	$	6,750	$	40,500
5.3	**Approach channels**									
5.3.1	Excavation	3,200	cy	6.75	$	21,600	$	4,320	$	25,920
5.3.2	Geotextile	2,600	sy	4.50	$	11,700	$	2,340	$	14,040
5.3.3	Bedding	900	cy	28.00	$	25,200	$	5,040	$	30,240
5.3.4	Riprap	7,800	ton	23.00	$	179,400	$	35,880	$	215,280
5.4	**Concrete gravity structure**									
5.4.1	Semi-lightweight concrete	600	cy	375.00	$	225,000	$	45,000	$	270,000
5.4.2	Hardrock concrete	660	cy	250.00	$	165,000	$	33,000	$	198,000
5.4.3	Post-tensioning system	80,000	lf	1.50	$	120,000	$	24,000	$	144,000
5.4.4	Reinforcing	168,000	lb	0.45	$	75,600	$	15,120	$	90,720
5.4.5	6" & 5" Panel PS/PC	450	cy	300.00	$	135,000	$	27,000	$	162,000
5.4.6	30" Connector Pile Sleeves	365	lf	120.00	$	43,800	$	8,760	$	52,560
5.4.7	Installation	LS	LS	75,000.00	$	75,000	$	15,000	$	90,000
5.5	**Foundation work**									
5.5.1	24" Connector Piles	2,160	lf	210.00	$	453,600	$	113,400	$	567,000
5.5.2	Concrete Cap	120	cy	150.00	$	18,000	$	4,500	$	22,500
5.5.3	Sheet pile cut-off wall (Retaining wall)	8,400	sf	15.00	$	126,000	$	25,200	$	151,200
5.5.4	Fabricated channel cap	210	lf	20.00	$	4,200	$	840	$	5,040
5.5.5	High density mix	950	cy	50.00	$	47,500	$	9,500	$	57,000
5.5.6	Pile testing	LS	LS	40,000.00	$	40,000	$	8,000	$	48,000
5.6	**Tie-Back/Retaining Wall**									
5.6.1	Sheet piles	6,000	sf	8.50	$	51,000	$	10,200	$	61,200
5.6.2	Walers	840	lf	24.00	$	20,160	$	4,032	$	24,192
5.6.3	Miscellaneous hardware	LS	LS	5,000.00	$	5,000	$	1,000	$	6,000
5.7	**Special construction**									
5.7.1	Instrumentation	LS	LS	5,000.00	$	5,000	$	1,000	$	6,000
5.8	**Mechanical system**									
5.8.1	Piping and manifolds	LS	LS	35,000.00	$	35,000	$	7,000	$	42,000
5.8.2	Pumps	LS	LS	30,000.00	$	30,000	$	6,000	$	36,000
5.9	**Power and lighting system**									

DETAILED ESTIMATE OF INCREMENTAL COST
COUSINS PUMPING STATION COMPLEX
2,000 CFS

Item	Description	Quantity	Unit	Unit cost	Total	Contingency	Project cost
5.9.1	Electrical services/work	LS	LS	5,000.00	$ 5,000	$ 1,000	$ 6,000
5.9.2	Other electrical work	LS	LS	10,000.00	$ 10,000	$ 2,000	$ 12,000
5.10	**Associated general items**						
5.10.1	Tile gages	LS	LS	2,500.00	$ 2,500	$ 500	$ 3,000
	Sub-total Culvert				**$ 2,020,960**	**$ 427,772**	**$ 2,448,732**
6	**CLOSURE WALL**						
6.1.1	Steel Sheet Piling	16416	SF	15.00	$246,240	$49,248	$295,488
6.1.2	84" Diameter Prestressed Concrete Cylinder Piles	15600	LF	250.00	$3,900,000	$780,000	$4,680,000
6.1.3	Concrete Cap (Includes Reinforcing)	1216	CY	375.00	$456,000	$91,200	$547,200
	Sub-total Closure Wall				**$4,602,240**	**$920,448**	**$5,522,688**
7	**RELOCATION**						
7.1	16" High Pressure Gas Line	2	LS	75,000.00	$ 150,000	$30,000	$180,000
7.1.2	Electircal Power Lines	1	LS	100,000.00	$ 100,000	$20,000	$120,000
	Sub-total Relocation				**$ 250,000**	**$ 50,000**	**$ 300,000**
	Construction Cost Total				**$ 24,995,201**	**$ 4,250,550**	**$ 29,245,751**
	PROJECT COST						
1	Construction Cost				**$ 24,995,201**	**$ 4,250,550**	**$ 29,245,751**
2	Constr. Engineering and Design				$ 292,458	$ 58,492	$ 350,949
3	Plans and Specifications				$ 2,924,575	$ 584,915	$ 3,509,490
4	Construction Administration				$ 2,924,575	$ 584,915	$ 3,509,490
	Total				**$ 31,136,808**	**$ 5,478,872**	**$ 36,615,680**
	TOTAL (rounded)						**$ 36,616,000**

APPENDIX B

HEC-2 MODEL RESULTS

TABLE OF CONTENTS

1. First Avenue Canal: Summary Output Tables of HEC-2 Model runs are enclosed for the First Avenue Canal for the following cases:

Case Number	Channel Description	Elevation at Cousins P/S (ft. NGVD)	Discharge (cfs)
Case 1	Existing channel cross-sections and profile	-6.7	1,000; 2,100 and 3,100
Case 2	Design channel cross-section: bottom width 68' with 1V to 3H slope for approximately 1,000 ft from the Cousins P/S and bottom width 50' and 1V to 6H side slope for the remaining part of the Canal.	-6.7	1,000; 2,100 and 3,100
Case 3	Design channel cross-section: bottom width 108' with 1V to 3H slope for approximately 1,000 ft from the Cousins P/S and bottom width 91' and 1V to 6H side slope for the remaining part of the Canal.	-6.7	1,000; 2,100 and 3,100

2. Cousins Discharge Channel: Summary Output Tables of HEC-2 Model runs are enclosed for the Cousins Discharge Channel for the following cases:

Case Number	Channel Description	El. at Harvey Canal, ft. (NGVD)	Discharge (cfs)
Case 1	Existing channel cross-sections and profile	-1 to +7.5	3,000; 4,000 and 5,000
Case 2	Design channel cross-section and profile (channel bottom -8' NGVD and -9' NGVD)	-1 to +7.5	4,000 and 5,000
Case 3	Sensitivity analysis. i.e., by varying Manning's 'n' and contraction and expansion coefficients using design channel cross-secion and profile (channel bottom -9' NGVD)	-1 to +7.5	5,000
Case 4	Corps of Engineer's design of channel and culvert	-1 to +7.5	5,000

3. Cousins Canal: Summary Output Tables of HEC-2 Model runs for the Cousins Canal are enclosed for the existing conditions.

ABBREVIATIONS

SECNO	Cross-section number
QCH	Discharge in the channel
AREA	Area of flow
XLCH	Length of the channel between cross-sections
TOPWID	Top width of water in the channel
ELMIN	Lowest point of the channel in the cross-section
XLBL	Left bank elevation
RLBL	Right bank elevation
DEPTH	Water depth in the channel
CWSEL	Water surface elevation in the channel
VCH	Velocity of the water in the channel

FIRST AVENUE CANAL

CASE 1

FIRAVE

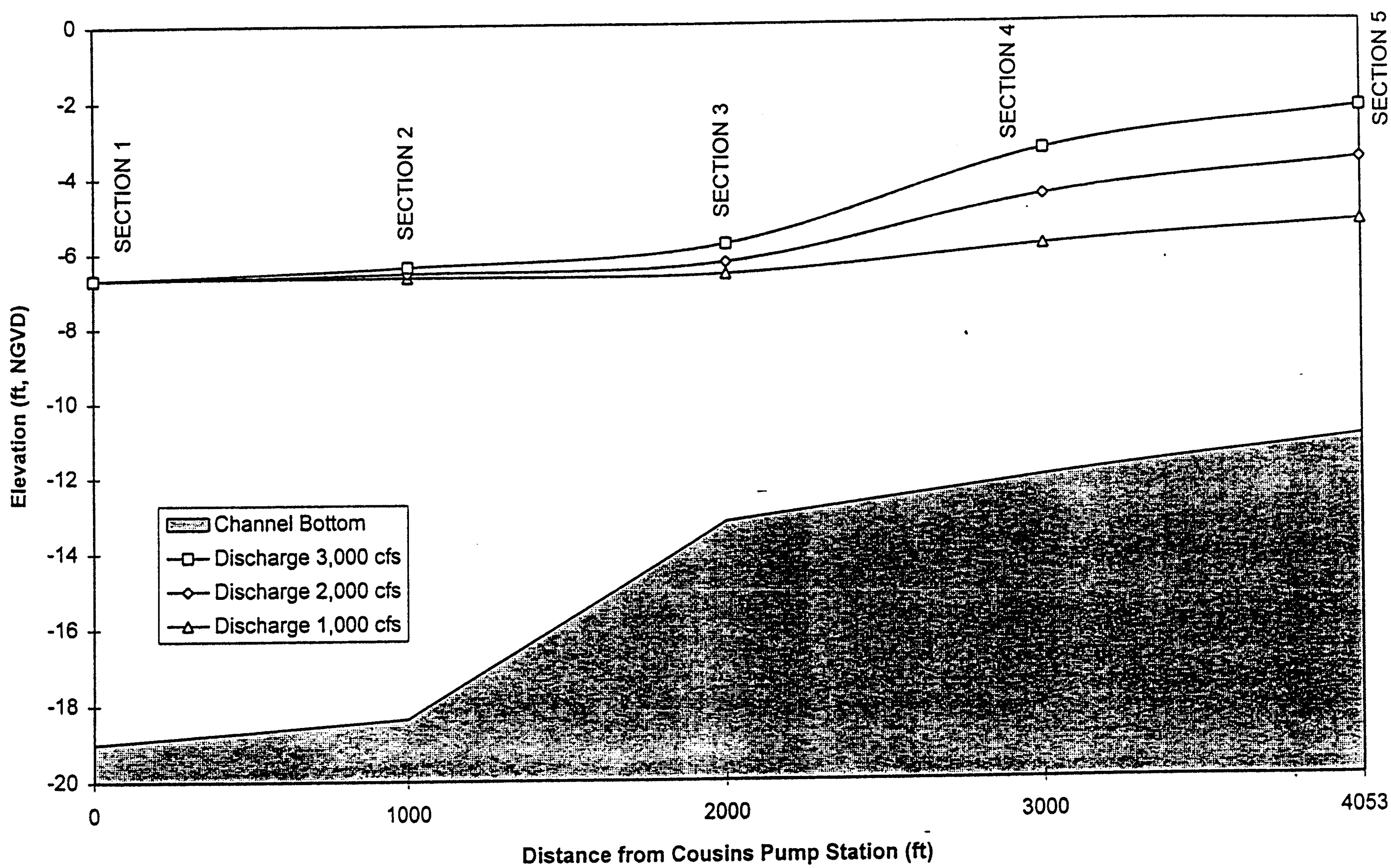
INPUT FILE: FIRAVE.DAT

SUMMARY PRINTOUT

DATE: 10-08-97

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	1000	996.82	0	138.05	-19.01	-3.93	-2.31	12.31	-6.7	1
	1	2000	996.82	0	138.05	-19.01	-3.93	-2.31	12.31	-6.7	2.01
	1	3000	996.82	0	138.05	-19.01	-3.93	-2.31	12.31	-6.7	3.01
*	2	1000	813.85	1000	144.45	-18.37	-0.97	-2.07	11.71	-6.66	1.23
	2	2000	830.55	1000	145.31	-18.37	-0.97	-2.07	11.82	-6.55	2.41
	2	3000	856.33	1000	146.64	-18.37	-0.97	-2.07	11.99	-6.38	3.5
*	3	1000	321.84	1000	94.25	-13.2	0.82	3.2	6.6	-6.6	3.11
*	3	2000	352.04	1000	96.58	-13.2	0.82	3.2	6.91	-6.29	5.68
*	3	3000	400.47	1000	100.21	-13.2	0.82	3.2	7.4	-5.8	7.49
	4	1000	331.2	1000	86.66	-12.04	-2.09	2.49	6.16	-5.88	3.02
*	4	2000	450.46	1000	94.35	-12.04	-2.09	2.49	7.48	-4.56	4.44
*	4	3000	568.62	1000	102.71	-12.04	-2.09	2.49	8.68	-3.36	5.28
	5	1000	392.74	1053	94.68	-11.02	2.04	1.42	5.72	-5.3	2.55
	5	2000	554.61	1053	102.2	-11.02	2.04	1.42	7.37	-3.65	3.61
	5	3000	699.03	1053	108.6	-11.02	2.04	1.42	8.73	-2.29	4.29

Water Surface Profiles in First Avenue Canal (Elevation at Pump Station fixed at -6.7 NGVD)



FIRST AVENUE CANAL

CASE 2

FIRST AVENUE CANAL

INPUT FILE: FAM2100.DAT
SUMMARY OUTPUT
DISCHARGE: 2100 CFS
(1000 & 3100 CFS ARE INCLUDED FOR COMPARISON PURPOSES)

CROSS SECTIONS TAKEN FROM DEI'S 50% SUBMITTAL
BOTTOM WIDTH 68' WITH 1V TO 3H SLOPE FOR SECTIONS 1 AND 2
BOTTOM WIDTH 50' WITH 1V TO 6H SLOPE FOR REST OF THE SECTIONS
TRANSITION BETWEEN SECTIONS 2 AND 3
SECTION 1 NEAR PUMP STATION

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
1	2100	954.52	0	126.8	-16.5	-3.12	-3.12	9.8	-6.7	2.2
2	2100	970.33	900	127.55	-16.5	-3.12	-3.12	9.92	-6.58	2.16
3	2100	1090.84	100	169.35	-16.5	1.96	1.96	9.95	-6.55	1.93
4	2100	1114.26	1000	171.01	-16.5	1.96	1.96	10.08	-6.42	1.88
5	2100	1135.03	1000	172.46	-16.5	1.96	1.96	10.2	-6.3	1.85
6	2100	1155.7	1053	173.89	-16.5	1.96	1.96	10.32	-6.18	1.82
1	1000	954.52	0	126.8	-16.5	-3.12	-3.12	9.8	-6.7	1.05
2	1000	958.1	900	126.97	-16.5	-3.12	-3.12	9.83	-6.67	1.04
3	1000	1071.52	100	167.98	-16.5	1.96	1.96	9.83	-6.67	0.93
4	1000	1077.29	1000	168.39	-16.5	1.96	1.96	9.87	-6.63	0.93
5	1000	1082.31	1000	168.75	-16.5	1.96	1.96	9.9	-6.6	0.92
6	1000	1087.56	1053	169.12	-16.5	1.96	1.96	9.93	-6.57	0.92
1	3100	954.52	0	126.8	-16.5	-3.12	-3.12	9.8	-6.7	3.25
2	3100	989.1	900	128.43	-16.5	-3.12	-3.12	10.07	-6.43	3.13
3	3100	1122.88	100	171.61	-16.5	1.96	1.96	10.13	-6.37	2.76
4	3100	1167.73	1000	174.72	-16.5	1.96	1.96	10.39	-6.11	2.65
5	3100	1208.35	1000	177.48	-16.5	1.96	1.96	10.62	-5.88	2.57
6	3100	1247.34	1053	180.1	-16.5	1.96	1.96	10.84	-5.66	2.49

FIRST AVENUE CANAL

CASE 3

FIRST AVENUE CANAL

INPUT FILE: FAM3100.DAT
SUMMARY OUTPUT
DISCHARGE: 3100 CFS
(1000 & 2100 CFS ARE INCLUDED FOR COMPARISON PURPOSES)

CROSS SECTIONS TAKEN FROM DEI'S 50% SUBMITTAL
BOTTOM WIDTH 108' WITH 1V TO 3H SLOPE FOR SECTIONS 1 AND 2
BOTTOM WIDTH 91' WITH 1V TO 6H SLOPE FOR REST OF THE SECTIONS
TRANSITION BETWEEN SECTIONS 2 AND 3
SECTION 1 NEAR PUMP STATION

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
1	3100	1346.52	0	166.8	-16.5	-3.13	-3.13	9.8	-6.7	2.3
2	3100	1367.1	900	167.54	-16.5	-3.13	-3.13	9.92	-6.58	2.27
3	3100	1498.17	100	210.33	-16.5	1.96	1.96	9.95	-6.55	2.07
4	3100	1527.03	1000	211.97	-16.5	1.96	1.96	10.08	-6.42	2.03
5	3100	1553.31	1000	213.45	-16.5	1.96	1.96	10.2	-6.3	2
6	3100	1579.36	1053	214.91	-16.5	1.96	1.96	10.32	-6.18	1.96
1	1000	1346.52	0	166.8	-16.5	-3.13	-3.13	9.8	-6.7	0.74
2	1000	1348.66	900	166.88	-16.5	-3.13	-3.13	9.81	-6.69	0.74
3	1000	1471.03	100	208.77	-16.5	1.96	1.96	9.82	-6.68	0.68
4	1000	1474.28	1000	208.96	-16.5	1.96	1.96	9.83	-6.67	0.68
5	1000	1477.21	1000	209.13	-16.5	1.96	1.96	9.84	-6.66	0.68
6	1000	1480.27	1053	209.3	-16.5	1.96	1.96	9.86	-6.64	0.68
1	2100	1346.52	0	166.8	-16.5	-3.13	-3.13	9.8	-6.7	1.56
2	2100	1355.95	900	167.14	-16.5	-3.13	-3.13	9.86	-6.64	1.55
3	2100	1481.21	100	209.36	-16.5	1.96	1.96	9.87	-6.63	1.42
4	2100	1495.37	1000	210.17	-16.5	1.96	1.96	9.93	-6.57	1.4
5	2100	1507.94	1000	210.88	-16.5	1.96	1.96	9.99	-6.51	1.39
6	2100	1520.79	1053	211.61	-16.5	1.96	1.96	10.05	-6.45	1.38

COUSINS DISCHARGE CHANNEL

CASE 1

INPUT FILE: COUDIS5.DAT

SUMMARY PRINTOUT

DATE: 10-2-97

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	3000	409.26	0	115.98	-6.32	4.31	2.78	5.32	-1	7.33
•	1	3000	528.82	0	124.44	-6.32	4.31	2.78	6.32	0	5.67
	1	3000	660.33	0	138.57	-6.32	4.31	2.78	7.32	1	4.54
	1	3000	800.11	0	140.99	-6.32	4.31	2.78	8.32	2	3.75
	1	3000	942.29	0	143.14	-6.32	4.31	2.78	9.32	3	3.18
	1	3000	1086	0	144.33	-6.32	4.31	2.78	10.32	4	2.76
	1	3000	1230.7	0	144.7	-6.32	4.31	2.78	11.32	5	2.44
•	2	3000	327.5	100	127.94	-3.51	4.85	2.03	3.15	-0.36	9.16
•	2	3000	371.82	100	133.85	-3.51	4.85	2.03	3.48	-0.03	8.07
•	2	3000	517.51	100	142.41	-3.51	4.85	2.03	4.52	1.01	5.8
	2	3000	662.99	100	151.17	-3.51	4.85	2.03	5.52	2.01	4.52
	2	3000	815.32	100	154.07	-3.51	4.85	2.03	6.52	3.01	3.68
	2	3000	971.78	100	158.85	-3.51	4.85	2.03	7.52	4.01	3.09
	2	3000	1130	100	159.15	-3.51	4.85	2.03	8.52	5.01	2.65
•	3	3000	585.25	100	150.22	-3.74	2	1.63	4.71	0.97	5.13
•	3	3000	582.28	100	150.13	-3.74	2	1.63	4.68	0.94	5.15
	3	3000	649.9	100	152.67	-3.74	2	1.63	5.14	1.4	4.62
	3	3000	772.97	100	155.57	-3.74	2	1.63	5.93	2.19	3.88
	3	3000	914.76	100	155.57	-3.74	2	1.63	6.85	3.11	3.28
	3	3000	1063.7	100	155.57	-3.74	2	1.63	7.8	4.06	2.82
	3	3000	1214.4	100	155.57	-3.74	2	1.63	8.78	5.04	2.47
	4	3000	729.97	100	163.57	-4.71	1.05	2.34	5.97	1.26	4.11
	4	3000	726.09	100	163.56	-4.71	1.05	2.34	5.94	1.23	4.13
	4	3000	787.4	100	163.73	-4.71	1.05	2.34	6.32	1.61	3.81
	4	3000	904.32	100	164.05	-4.71	1.05	2.34	7.03	2.32	3.32
	4	3000	1045.8	100	164.06	-4.71	1.05	2.34	7.89	3.18	2.87
	4	3000	1198.4	100	164.06	-4.71	1.05	2.34	8.83	4.12	2.5
	4	3000	1354.9	100	164.06	-4.71	1.05	2.34	9.79	5.08	2.21
	5	3000	879.16	100	158.44	-6.24	0.76	1.67	7.65	1.41	3.41
	5	3000	875.95	100	158.42	-6.24	0.76	1.67	7.63	1.39	3.42
	5	3000	929.93	100	158.7	-6.24	0.76	1.67	7.97	1.73	3.23
	5	3000	1036.3	100	158.7	-6.24	0.76	1.67	8.64	2.4	2.89
	5	3000	1167.2	100	158.7	-6.24	0.76	1.67	9.48	3.24	2.57
	5	3000	1312.4	100	158.7	-6.24	0.76	1.67	10.39	4.15	2.29
	5	3000	1462.9	100	158.7	-6.24	0.76	1.67	11.34	5.1	2.05
	6	3000	882.48	29	158.46	-6.24	0.76	1.67	7.67	1.43	3.4
	6	3000	879.32	29	158.44	-6.24	0.76	1.67	7.65	1.41	3.41
	6	3000	932.58	29	158.7	-6.24	0.76	1.67	7.99	1.75	3.22
	6	3000	1038.1	29	158.7	-6.24	0.76	1.67	8.65	2.41	2.89
	6	3000	1169.6	29	158.7	-6.24	0.76	1.67	9.48	3.24	2.56
	6	3000	1314	29	158.7	-6.24	0.76	1.67	10.39	4.15	2.28
	6	3000	1464.6	29	158.7	-6.24	0.76	1.67	11.34	5.1	2.05
	7	3000	883.91	33	158.47	-6.24	0.76	1.67	7.68	1.44	3.39
	7	3000	880.76	33	158.45	-6.24	0.76	1.67	7.66	1.42	3.41
	7	3000	933.93	33	158.7	-6.24	0.76	1.67	8	1.76	3.21
	7	3000	1039.2	33	158.7	-6.24	0.76	1.67	8.66	2.42	2.89
	7	3000	1173.2	33	158.7	-6.24	0.76	1.67	9.51	3.27	2.56
	7	3000	1321.1	33	158.7	-6.24	0.76	1.67	10.44	4.2	2.27
	7	3000	1474.3	33	158.7	-6.24	0.76	1.67	11.4	5.16	2.03
	8	3000	773.17	38	170.21	-6.12	2.21	1.09	7.55	1.43	3.88
	8	3000	769.74	38	170.13	-6.12	2.21	1.09	7.53	1.41	3.9
	8	3000	827.63	38	171.39	-6.12	2.21	1.09	7.87	1.75	3.62
	8	3000	944.46	38	173.11	-6.12	2.21	1.09	8.54	2.42	3.18
	8	3000	1091.4	38	173.11	-6.12	2.21	1.09	9.38	3.26	2.75
	8	3000	1252.3	38	173.11	-6.12	2.21	1.09	10.32	4.2	2.4
	8	3000	1419.2	38	173.11	-6.12	2.21	1.09	11.28	5.16	2.11
•	9	3000	1199.8	100	224.14	-6.11	1.14	1.04	7.73	1.62	2.5
•	9	3000	1195.8	100	224.14	-6.11	1.14	1.04	7.72	1.61	2.51
•	9	3000	1264.6	100	224.14	-6.11	1.14	1.04	8.02	1.91	2.37
•	9	3000	1404.3	100	224.14	-6.11	1.14	1.04	8.65	2.54	2.14
•	9	3000	1586.4	100	224.14	-6.11	1.14	1.04	9.46	3.35	1.89
•	9	3000	1790.4	100	224.14	-6.11	1.14	1.04	10.37	4.26	1.68
•	9	3000	2003.5	100	224.14	-6.11	1.14	1.04	11.32	5.21	1.5
•	10	3000	2037.6	100	223.04	-13	2	2.07	14.7	1.7	1.47
•	10	3000	2033.7	100	222.87	-13	2	2.07	14.69	1.69	1.48
•	10	3000	2100.4	100	225.76	-13	2	2.07	14.98	1.98	1.43
•	10	3000	2237.6	100	225.94	-13	2	2.07	15.59	2.59	1.34
•	10	3000	2417.9	100	225.94	-13	2	2.07	16.39	3.39	1.24
•	10	3000	2619.3	100	225.94	-13	2	2.07	17.29	4.29	1.15
•	10	3000	2832.6	100	225.94	-13	2	2.07	18.23	5.23	1.06

INPUT FILE: COUDIS4.DAT

SUMMARY PRINTOUT

DATE: 10/2/97

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	4000	409.28	0	115.98	-6.32	4.31	2.78	5.32	-1	9.77
•	1	4000	528.82	0	124.44	-6.32	4.31	2.78	6.32	0	7.56
	1	4000	660.33	0	138.57	-6.32	4.31	2.78	7.32	1	6.06
	1	4000	800.11	0	140.99	-6.32	4.31	2.78	8.32	2	5
	1	4000	942.29	0	143.14	-6.32	4.31	2.78	9.32	3	4.24
	1	4000	1086	0	144.33	-6.32	4.31	2.78	10.32	4	3.68
	1	4000	1230.7	0	144.7	-6.32	4.31	2.78	11.32	5	3.25
•	2	4000	409.93	100	140.63	-3.51	4.85	2.03	3.77	0.26	9.76
•	2	4000	409.94	100	140.63	-3.51	4.85	2.03	3.77	0.26	9.76
•	2	4000	519.98	100	142.44	-3.51	4.85	2.03	4.54	1.03	7.69
	2	4000	664.44	100	151.27	-3.51	4.85	2.03	5.53	2.02	6.02
	2	4000	816.38	100	154.09	-3.51	4.85	2.03	6.52	3.01	4.9
	2	4000	971.4	100	156.84	-3.51	4.85	2.03	7.52	4.01	4.12
	2	4000	1130.6	100	159.15	-3.51	4.85	2.03	8.52	5.01	3.54
•	3	4000	692.04	100	154.2	-3.74	2	1.63	5.41	1.67	5.78
•	3	4000	692.03	100	154.2	-3.74	2	1.63	5.41	1.67	5.78
•	3	4000	705.61	100	154.57	-3.74	2	1.63	5.49	1.75	5.67
	3	4000	799.49	100	155.57	-3.74	2	1.63	6.1	2.36	5
	3	4000	928.69	100	155.57	-3.74	2	1.63	6.94	3.2	4.31
	3	4000	1072	100	155.57	-3.74	2	1.63	7.86	4.12	3.73
	3	4000	1221	100	155.57	-3.74	2	1.63	8.82	5.08	3.28
	4	4000	850.9	100	163.9	-4.71	1.05	2.34	6.71	2	4.7
	4	4000	850.9	100	163.9	-4.71	1.05	2.34	6.71	2	4.7
	4	4000	861.26	100	163.93	-4.71	1.05	2.34	6.77	2.06	4.64
	4	4000	946.24	100	164.06	-4.71	1.05	2.34	7.29	2.58	4.23
	4	4000	1070.1	100	164.06	-4.71	1.05	2.34	8.04	3.33	3.74
	4	4000	1213.6	100	164.06	-4.71	1.05	2.34	8.92	4.21	3.3
	4	4000	1366.2	100	164.06	-4.71	1.05	2.34	9.85	5.14	2.93
	5	4000	1000.1	100	158.7	-6.24	0.76	1.67	8.42	2.18	4
	5	4000	1000.1	100	158.7	-6.24	0.76	1.67	8.42	2.18	4
	5	4000	1009.9	100	158.7	-6.24	0.76	1.67	8.48	2.24	3.96
	5	4000	1084.4	100	158.7	-6.24	0.76	1.67	8.95	2.71	3.69
	5	4000	1197.6	100	158.7	-6.24	0.76	1.67	9.66	3.42	3.34
	5	4000	1330.3	100	158.7	-6.24	0.76	1.67	10.51	4.27	3.01
	5	4000	1475.4	100	158.7	-6.24	0.76	1.67	11.42	5.18	2.71
	6	4000	1003.8	29	158.7	-6.24	0.76	1.67	8.43	2.19	3.98
	6	4000	1003.8	29	158.7	-6.24	0.76	1.67	8.43	2.19	3.98
	6	4000	1013.5	29	158.7	-6.24	0.76	1.67	8.5	2.26	3.95
	6	4000	1087.1	29	158.7	-6.24	0.76	1.67	8.96	2.72	3.68
	6	4000	1199.5	29	158.7	-6.24	0.76	1.67	9.67	3.43	3.33
	6	4000	1333.1	29	158.7	-6.24	0.76	1.67	10.51	4.27	3
	6	4000	1477.4	29	158.7	-6.24	0.76	1.67	11.42	5.18	2.71
	7	4000	1006.4	33	158.7	-6.24	0.76	1.67	8.46	2.22	3.97
	7	4000	1006.4	33	158.7	-6.24	0.76	1.67	8.46	2.22	3.97
	7	4000	1016	33	158.7	-6.24	0.76	1.67	8.52	2.28	3.94
	7	4000	1089.3	33	158.7	-6.24	0.76	1.67	8.98	2.74	3.67
	7	4000	1207.5	33	158.7	-6.24	0.76	1.67	9.72	3.48	3.31
	7	4000	1346.6	33	158.7	-6.24	0.76	1.67	10.6	4.36	2.97
	7	4000	1495	33	158.7	-6.24	0.76	1.67	11.53	5.29	2.68
	8	4000	905.87	38	173.08	-6.12	2.21	1.09	8.32	2.2	4.42
	8	4000	905.87	38	173.08	-6.12	2.21	1.09	8.32	2.2	4.42
	8	4000	916.47	38	173.11	-6.12	2.21	1.09	8.38	2.26	4.36
	8	4000	997.23	38	173.11	-6.12	2.21	1.09	8.85	2.73	4.01
	8	4000	1128.4	38	173.11	-6.12	2.21	1.09	9.6	3.48	3.55
	8	4000	1280.7	38	173.11	-6.12	2.21	1.09	10.48	4.36	3.12
	8	4000	1442.2	38	173.11	-6.12	2.21	1.09	11.42	5.3	2.77
•	9	4000	1383.1	100	224.14	-6.11	1.14	1.04	8.55	2.44	2.89
•	9	4000	1383.1	100	224.14	-6.11	1.14	1.04	8.55	2.44	2.89
•	9	4000	1395.3	100	224.14	-6.11	1.14	1.04	8.61	2.5	2.87
•	9	4000	1490.1	100	224.14	-6.11	1.14	1.04	9.03	2.92	2.68
•	9	4000	1647.1	100	224.14	-6.11	1.14	1.04	9.73	3.62	2.43
•	9	4000	1835.9	100	224.14	-6.11	1.14	1.04	10.57	4.46	2.18
•	9	4000	2040.3	100	224.14	-6.11	1.14	1.04	11.48	5.37	1.96
•	10	4000	2226.6	100	225.94	-13	2	2.07	15.54	2.54	1.8
•	10	4000	2226.6	100	225.94	-13	2	2.07	15.54	2.54	1.8
•	10	4000	2238.4	100	225.94	-13	2	2.07	15.59	2.59	1.79
•	10	4000	2330.7	100	225.94	-13	2	2.07	16	3	1.72
•	10	4000	2484.7	100	225.94	-13	2	2.07	16.68	3.68	1.61
•	10	4000	2671.5	100	225.94	-13	2	2.07	17.51	4.51	1.5
•	10	4000	2874.8	100	225.94	-13	2	2.07	18.41	5.41	1.39

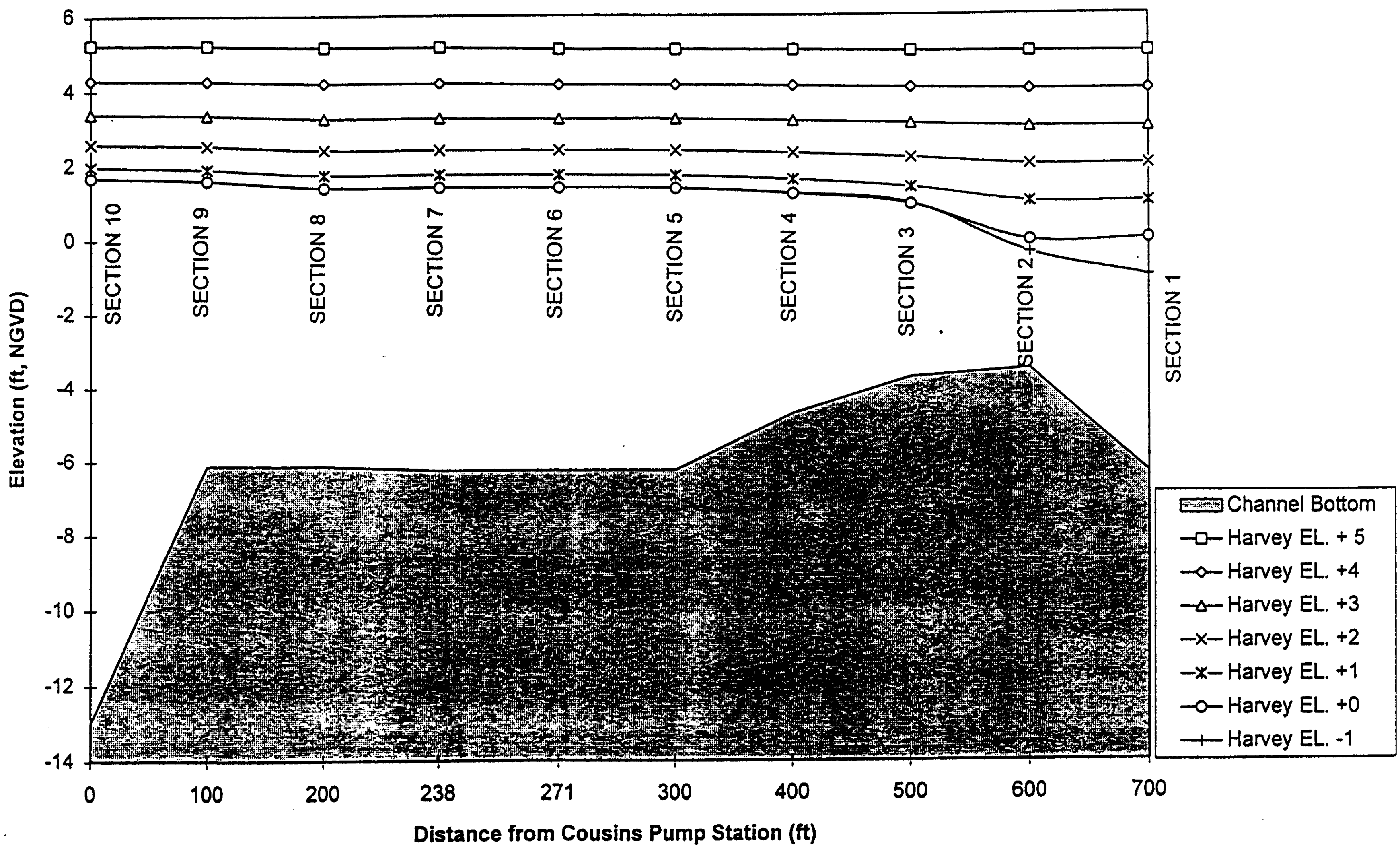
INPUT FILE: COUDIS3.DAT

SUMMARY PRINTOUT

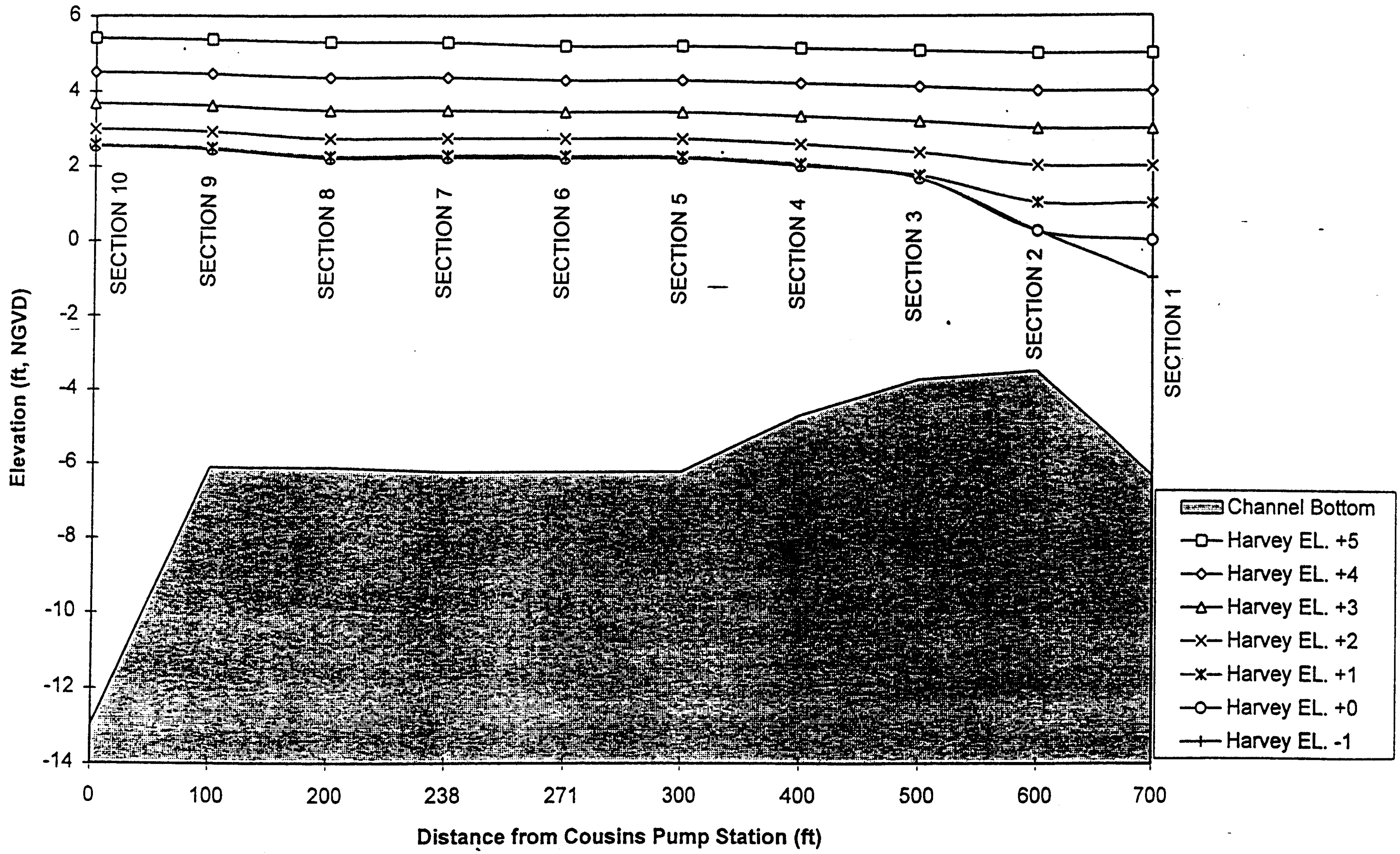
DATE: 10-02-97

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
•	1	5000	447.18	0	118.06	-6.32	4.31	2.78	5.64	-0.68	11.18
•	1	5000	528.82	0	124.44	-6.32	4.31	2.78	6.32	0	9.46
	1	5000	660.33	0	138.57	-6.32	4.31	2.78	7.32	1	7.57
	1	5000	800.11	0	140.99	-6.32	4.31	2.78	8.32	2	6.25
	1	5000	942.29	0	143.14	-6.32	4.31	2.78	9.32	3	5.31
	1	5000	1086	0	144.33	-6.32	4.31	2.78	10.32	4	4.6
	1	5000	1230.7	0	144.7	-6.32	4.31	2.78	11.32	5	4.06
•	2	5000	477.71	100	141.86	-3.51	4.85	2.03	4.25	0.74	10.47
•	2	5000	477.12	100	141.85	-3.51	4.85	2.03	4.24	0.73	10.48
•	2	5000	524.62	100	142.51	-3.51	4.85	2.03	4.57	1.06	9.53
	2	5000	666.68	100	151.39	-3.51	4.85	2.03	5.54	2.03	7.5
	2	5000	817.87	100	154.12	-3.51	4.85	2.03	6.53	3.02	6.11
	2	5000	972.55	100	156.86	-3.51	4.85	2.03	7.53	4.02	5.14
	2	5000	1130.3	100	159.15	-3.51	4.85	2.03	8.53	5.02	4.42
•	3	5000	785.5	100	155.57	-3.74	2	1.63	6.02	2.28	6.37
•	3	5000	785.67	100	155.57	-3.74	2	1.63	6.02	2.28	6.36
•	3	5000	780.21	100	155.57	-3.74	2	1.63	5.98	2.24	6.41
•	3	5000	837.23	100	155.57	-3.74	2	1.63	6.34	2.6	5.97
	3	5000	947.99	100	155.57	-3.74	2	1.63	7.06	3.32	5.27
	3	5000	1083.1	100	155.57	-3.74	2	1.63	7.93	4.19	4.62
	3	5000	1228	100	155.57	-3.74	2	1.63	8.86	5.12	4.07
	4	5000	957.26	100	164.06	-4.71	1.05	2.34	7.35	2.64	5.22
	4	5000	957.39	100	164.06	-4.71	1.05	2.34	7.36	2.65	5.22
	4	5000	952.94	100	164.06	-4.71	1.05	2.34	7.33	2.62	5.25
	4	5000	1000.3	100	164.06	-4.71	1.05	2.34	7.62	2.91	5
	4	5000	1102.1	100	164.06	-4.71	1.05	2.34	8.24	3.53	4.54
	4	5000	1233.5	100	164.06	-4.71	1.05	2.34	9.04	4.33	4.05
	4	5000	1379.4	100	164.06	-4.71	1.05	2.34	9.93	5.22	3.62
	5	5000	1106.3	100	158.7	-6.24	0.76	1.67	9.09	2.85	4.52
	5	5000	1106.5	100	158.7	-6.24	0.76	1.67	9.09	2.85	4.52
	5	5000	1102.7	100	158.7	-6.24	0.76	1.67	9.06	2.82	4.53
	5	5000	1143.8	100	158.7	-6.24	0.76	1.67	9.32	3.08	4.37
	5	5000	1234.9	100	158.7	-6.24	0.76	1.67	9.9	3.66	4.05
	5	5000	1355.9	100	158.7	-6.24	0.76	1.67	10.66	4.42	3.69
	5	5000	1492.7	100	158.7	-6.24	0.76	1.67	11.52	5.28	3.35
	6	5000	1110.4	29	158.7	-6.24	0.76	1.67	9.11	2.87	4.5
	6	5000	1110.5	29	158.7	-6.24	0.76	1.67	9.11	2.87	4.5
	6	5000	1106.8	29	158.7	-6.24	0.76	1.67	9.08	2.84	4.52
	6	5000	1147.4	29	158.7	-6.24	0.76	1.67	9.34	3.1	4.36
	6	5000	1237.6	29	158.7	-6.24	0.76	1.67	9.91	3.67	4.04
	6	5000	1357.8	29	158.7	-6.24	0.76	1.67	10.67	4.43	3.68
	6	5000	1494.1	29	158.7	-6.24	0.76	1.67	11.53	5.29	3.35
	7	5000	1115.5	33	158.7	-6.24	0.76	1.67	9.14	2.9	4.48
	7	5000	1115.7	33	158.7	-6.24	0.76	1.67	9.14	2.9	4.48
	7	5000	1111.6	33	158.7	-6.24	0.76	1.67	9.12	2.88	4.5
	7	5000	1156	33	158.7	-6.24	0.76	1.67	9.4	3.16	4.33
	7	5000	1253.2	33	158.7	-6.24	0.76	1.67	10.01	3.77	3.99
	7	5000	1380.4	33	158.7	-6.24	0.76	1.67	10.81	4.57	3.62
	7	5000	1522.5	33	158.7	-6.24	0.76	1.67	11.71	5.47	3.28
	8	5000	1025.2	38	173.11	-6.12	2.21	1.09	9.01	2.89	4.88
	8	5000	1025.3	38	173.11	-6.12	2.21	1.09	9.01	2.89	4.88
	8	5000	1020.8	38	173.11	-6.12	2.21	1.09	8.99	2.87	4.9
	8	5000	1069.9	38	173.11	-6.12	2.21	1.09	9.27	3.15	4.67
	8	5000	1176.7	38	173.11	-6.12	2.21	1.09	9.89	3.77	4.25
	8	5000	1317.2	38	173.11	-6.12	2.21	1.09	10.69	4.57	3.8
	8	5000	1472.8	38	173.11	-6.12	2.21	1.09	11.59	5.47	3.39
•	9	5000	1546.8	100	224.14	-6.11	1.14	1.04	9.28	3.17	3.23
•	9	5000	1546.9	100	224.14	-6.11	1.14	1.04	9.28	3.17	3.23
•	9	5000	1541.8	100	224.14	-6.11	1.14	1.04	9.26	3.15	3.24
•	9	5000	1598.4	100	224.14	-6.11	1.14	1.04	9.51	3.4	3.13
•	9	5000	1725	100	224.14	-6.11	1.14	1.04	10.08	3.97	2.9
•	9	5000	1894.8	100	224.14	-6.11	1.14	1.04	10.83	4.72	2.64
•	9	5000	2088	100	224.14	-6.11	1.14	1.04	11.7	5.59	2.39
•	10	5000	2395.8	100	225.94	-13	2	2.07	16.29	3.29	2.09
•	10	5000	2396	100	225.94	-13	2	2.07	16.29	3.29	2.09
•	10	5000	2391	100	225.94	-13	2	2.07	16.27	3.27	2.09
•	10	5000	2445.7	100	225.94	-13	2	2.07	16.51	3.51	2.04
•	10	5000	2569	100	225.94	-13	2	2.07	17.06	4.06	1.95
•	10	5000	2735.8	100	225.94	-13	2	2.07	17.8	4.8	1.83
•	10	5000	2927	100	225.94	-13	2	2.07	18.64	5.64	1.71

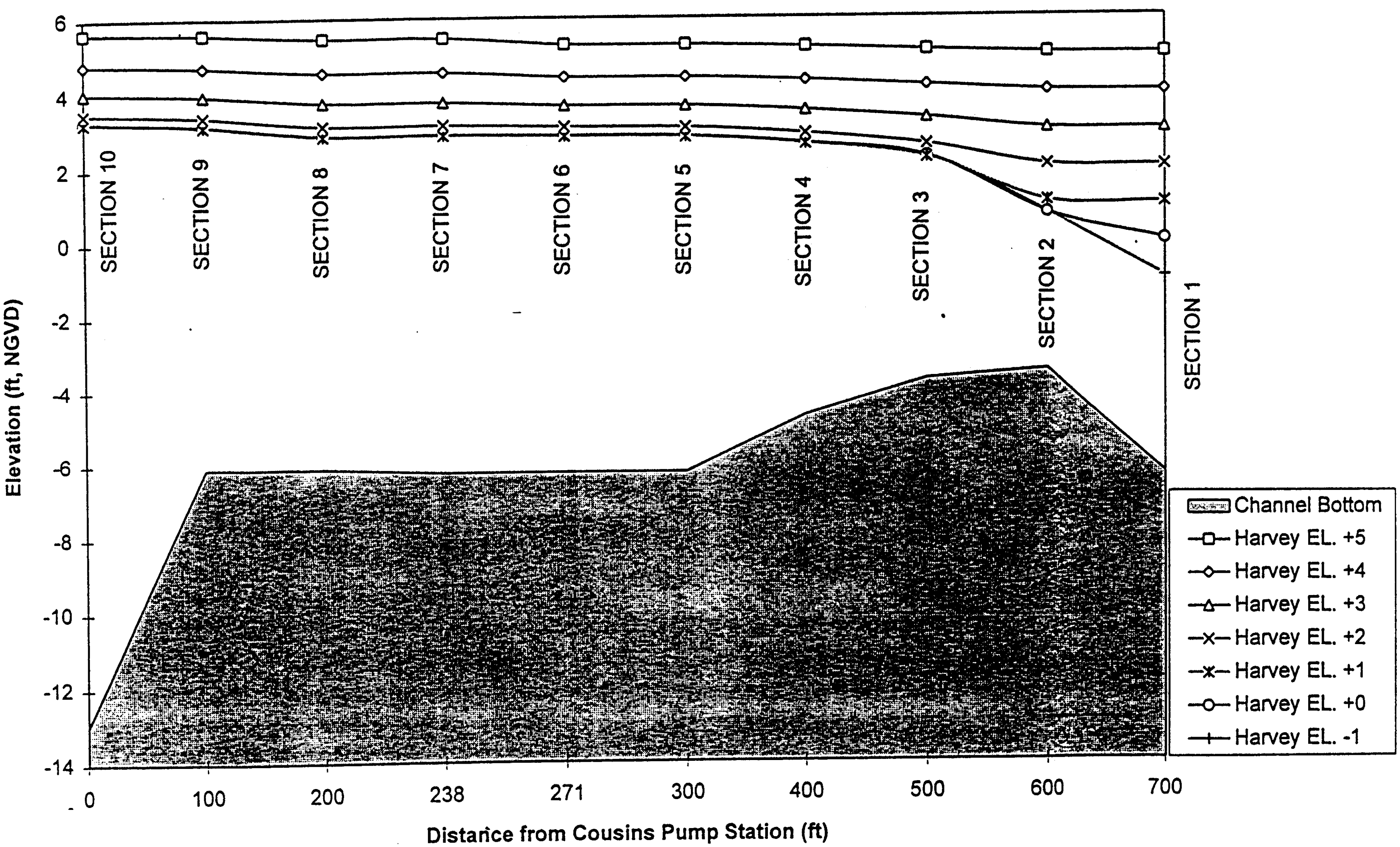
Water Surface Profiles in Cousins Discharge Channel (Discharge 3,000 cfs)



Water Surface Profiles in Cousins Discharge Channel (Discharge 4,000 cfs)



Water Surface Profiles in Cousins Discharge Channel (Discharge 5,000 cfs)



COUSINS DISCHARGE CHANNEL

CASE 2

COUSINS DISCHARGE CHANNEL

SUMMARY OUTPUT
INPUT FILE: DIS5K-9.DAT
DISCHARGE: 5000 CFS
CHANNEL BOTTOM AT -9.0

P.S. TO DSTRHN BRIDGE: TOP WIDTH OF CHANNEL TAKEN FROM DEI'S 50% SUBMITTAL
DSTRHN BRIDGE TO HARVEY CANAL: TOP WIDTH OF CHANNEL TAKEN FROM CEEC'S LAYOUT
ALL CROSS SECTIONS HAVE 15' BERM AT +2.0 ON THE LAPALCO BLVD SIDE
SIDE SLOPE 1 VERTICAL TO 3 HORIZONTAL FROM +2.0 TO BOTTOM
VERTICAL WALL CONSIDERED FROM +2.0 TO +9.5
CULVERT (BETWEEN SECTIONS 2 AND 3) UNDER LAPALCO BRIDGE CONSIDERED 108' WIDE
DESTRAHAN BRIDGE BETWEEN SECTIONS 6 AND 7
SECTION 10 NEAR PUMP STATION

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	5000	984	0	147	-9	9.5	9.5	8	-1	5.08
*	2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-1.04	5.82
*	3	5000	865.17	100	108	-9	9.5	9.5	8.01	-0.99	5.78
	4	5000	1062.03	395.08	150.15	-9	9.5	9.5	8.52	-0.48	4.71
	5	5000	1075.14	103	150.67	-9	9.5	9.5	8.6	-0.4	4.65
	6	5000	1087.55	137	151.17	-9	9.5	9.5	8.7	-0.3	4.6
	7	5000	1093.62	33	151.41	-9	9.5	9.5	8.73	-0.27	4.57
*	8	5000	1778.79	26.48	225.29	-9	9.5	9.5	8.97	-0.03	2.81
	9	5000	2129.03	75	263.11	-9	9.5	9.5	9.02	0.02	2.35
	10	5000	2132.24	70	263.19	-9	9.5	9.5	9.03	0.03	2.34
*	1	5000	1134	0	153	-9	9.5	9.5	9	0	4.41
*	2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	-0.05	5.17
*	3	5000	970.53	100	108	-9	9.5	9.5	8.98	-0.02	5.15
	4	5000	1190.39	395.08	155.2	-9	9.5	9.5	9.37	0.37	4.2
	5	5000	1199.95	103	155.56	-9	9.5	9.5	9.42	0.42	4.17
	6	5000	1209.1	137	155.92	-9	9.5	9.5	9.49	0.49	4.14
	7	5000	1213.5	33	156.09	-9	9.5	9.5	9.51	0.51	4.12
*	8	5000	1945.44	26.48	229.69	-9	9.5	9.5	9.7	0.7	2.57
	9	5000	2318.14	75	267.39	-9	9.5	9.5	9.74	0.74	2.16
	10	5000	2323.13	70	267.5	-9	9.5	9.5	9.75	0.75	2.15
	1	5000	1290	0	159	-9	9.5	9.5	10	1	3.88
*	2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	0.95	4.65
*	3	5000	1077.19	100	108	-9	9.5	9.5	9.97	0.97	4.64
	4	5000	1332.43	395.08	160.59	-9	9.5	9.5	10.27	1.27	3.75
	5	5000	1339.57	103	160.86	-9	9.5	9.5	10.3	1.3	3.73
	6	5000	1346.28	137	161.11	-9	9.5	9.5	10.35	1.35	3.71
	7	5000	1349.52	33	161.23	-9	9.5	9.5	10.37	1.37	3.71
*	8	5000	2135.63	26.48	234.61	-9	9.5	9.5	10.52	1.52	2.34
	9	5000	2537.21	75	272.26	-9	9.5	9.5	10.55	1.55	1.97
	10	5000	2541.4	70	272.36	-9	9.5	9.5	10.56	1.56	1.97

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	5000	1452	0	165	-9	9.5	9.5	11	2	3.44
*	2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	1.95	4.23
*	3	5000	1184.53	100	108	-9	9.5	9.5	10.97	1.97	4.22
	4	5000	1489.33	395.08	180	-9	9.5	9.5	11.21	2.21	3.36
	5	5000	1495.47	103	180	-9	9.5	9.5	11.24	2.24	3.34
	6	5000	1501.73	137	180	-9	9.5	9.5	11.28	2.28	3.33
	7	5000	1504.39	33	180	-9	9.5	9.5	11.29	2.29	3.32
*	8	5000	2352.16	26.48	252.5	-9	9.5	9.5	11.41	2.41	2.13
	9	5000	2786.09	75	290	-9	9.5	9.5	11.43	2.43	1.79
	10	5000	2789.69	70	290	-9	9.5	9.5	11.44	2.44	1.79
	1	5000	1632	0	180	-9	9.5	9.5	12	3	3.06
*	2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	2.95	3.87
*	3	5000	1292.16	100	108	-9	9.5	9.5	11.96	2.96	3.87
	4	5000	1660.51	395.08	180	-9	9.5	9.5	12.16	3.16	3.01
	5	5000	1665.05	103	180	-9	9.5	9.5	12.18	3.18	3
	6	5000	1669.23	137	180	-9	9.5	9.5	12.21	3.21	3
	7	5000	1671.33	33	180	-9	9.5	9.5	12.22	3.22	2.99
*	8	5000	2580.31	26.48	252.5	-9	9.5	9.5	12.31	3.31	1.94
	9	5000	3046.73	75	290	-9	9.5	9.5	12.33	3.33	1.64
	10	5000	3049.69	70	290	-9	9.5	9.5	12.34	3.34	1.64
	1	5000	1812	0	180	-9	9.5	9.5	13	4	2.76
*	2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	3.95	3.57
*	3	5000	1399.99	100	108	-9	9.5	9.5	12.96	3.96	3.57
	4	5000	1834.36	395.08	180	-9	9.5	9.5	13.12	4.12	2.73
	5	5000	1837.81	103	180	-9	9.5	9.5	13.14	4.14	2.72
	6	5000	1840.69	137	180	-9	9.5	9.5	13.16	4.16	2.72
	7	5000	1847.28	33	180	-9	9.5	9.5	13.2	4.2	2.71
*	8	5000	2822.6	26.48	252.5	-9	9.5	9.5	13.27	4.27	1.77
	9	5000	3323.97	75	290	-9	9.5	9.5	13.29	4.29	1.5
	10	5000	3326.42	70	290	-9	9.5	9.5	13.29	4.29	1.5
	1	5000	1992	0	180	-9	9.5	9.5	14	5	2.51
*	2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	4.96	3.32
*	3	5000	1508.04	100	108	-9	9.5	9.5	13.96	4.96	3.32
	4	5000	2009.98	395.08	180	-9	9.5	9.5	14.1	5.1	2.49
	5	5000	2012.66	103	180	-9	9.5	9.5	14.11	5.11	2.48
	6	5000	2014.7	137	180	-9	9.5	9.5	14.13	5.13	2.48
	7	5000	2024.69	33	180	-9	9.5	9.5	14.18	5.18	2.47
*	8	5000	3068.12	26.48	252.5	-9	9.5	9.5	14.24	5.24	1.63
	9	5000	3603.89	75	290	-9	9.5	9.5	14.26	5.26	1.39
	10	5000	3607.26	70	290	-9	9.5	9.5	14.26	5.26	1.39
	1	5000	2442	0	180	-9	9.5	9.5	16.5	7.5	2.05
*	2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.46	2.81
*	3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.47	2.81
	4	5000	2453.3	395.08	180	-9	9.5	9.5	16.56	7.56	2.04
	5	5000	2454.85	103	180	-9	9.5	9.5	16.57	7.57	2.04
	6	5000	2455.81	137	180	-9	9.5	9.5	16.58	7.58	2.04
	7	5000	2470.77	33	180	-9	9.5	9.5	16.66	7.66	2.02
*	8	5000	3688.57	26.48	252.5	-9	9.5	9.5	16.7	7.7	1.36
	9	5000	4315.7	75	290	-9	9.5	9.5	16.71	7.71	1.16
	10	5000	4318.04	70	290	-9	9.5	9.5	16.71	7.71	1.16

COUSINS DISCHARGE CHANNEL

SUMMARY OUTPUT
INPUT FILE: DIS5K-8.DAT
DISCHARGE: 5000 CFS
CHANNEL BOTTOM AT -8.0

P.S. TO DSTRHN BRIDGE: TOP WIDTH OF CHANNEL TAKEN FROM DEI'S 50% SUBMITTAL
DSTRHN BRIDGE TO HARVEY CANAL: TOP WIDTH OF CHANNEL TAKEN FROM CEEC'S LAYOUT
ALL CROSS SECTIONS HAVE 15' BERM AT +2.0 ON THE LAPALCO BLVD SIDE
SIDE SLOPE 1 VERTICAL TO 3 HORIZONTAL FROM +2.0 TO BOTTOM
VERTICAL WALL CONSIDERED FROM +2.0 TO +9.5
CULVERT (BETWEEN SECTIONS 2 AND 3) UNDER LAPALCO BRIDGE CONSIDERED 108' WIDE
DESTRAHAN BRIDGE BETWEEN SECTIONS 6 AND 7
SECTION 10 NEAR PUMP STATION

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	5000	882	0	147	-8	9.5	9.5	7	-1	5.67
*	2	5000	748.62	111.61	108	-8	9.5	9.5	6.93	-1.07	6.68
*	3	5000	757.07	100	108	-8	9.5	9.5	7.01	-0.99	6.6
	4	5000	997.54	395.08	151.64	-8	9.5	9.5	7.77	-0.23	5.01
	5	5000	1012.28	103	152.22	-8	9.5	9.5	7.87	-0.13	4.94
	6	5000	1029.65	137	152.91	-8	9.5	9.5	7.99	-0.01	4.86
	7	5000	1037.27	33	153.21	-8	9.5	9.5	8.03	0.03	4.82
*	8	5000	1677.8	26.48	227.24	-8	9.5	9.5	8.29	0.29	2.98
	9	5000	2004.82	75	265.11	-8	9.5	9.5	8.35	0.35	2.49
	10	5000	2008.8	70	265.2	-8	9.5	9.5	8.36	0.36	2.49
*	1	5000	1032	0	153	-8	9.5	9.5	8	0	4.84
*	2	5000	856.17	111.61	108	-8	9.5	9.5	7.93	-0.07	5.84
*	3	5000	861.54	100	108	-8	9.5	9.5	7.98	-0.02	5.8
	4	5000	1111.97	395.08	156.1	-8	9.5	9.5	8.52	0.52	4.5
	5	5000	1124.04	103	156.57	-8	9.5	9.5	8.59	0.59	4.45
	6	5000	1135.81	137	157.02	-8	9.5	9.5	8.67	0.67	4.4
	7	5000	1141.23	33	157.23	-8	9.5	9.5	8.7	0.7	4.38
*	8	5000	1820.06	26.48	230.97	-8	9.5	9.5	8.91	0.91	2.75
	9	5000	2165.02	75	268.71	-8	9.5	9.5	8.96	0.96	2.31
	10	5000	2170.83	70	268.84	-8	9.5	9.5	8.97	0.97	2.3
	1	5000	1188	0	159	-8	9.5	9.5	9	1	4.21
*	2	5000	964.38	111.61	108	-8	9.5	9.5	8.93	0.93	5.18
*	3	5000	967.96	100	108	-8	9.5	9.5	8.96	0.96	5.17
	4	5000	1245.88	395.08	161.17	-8	9.5	9.5	9.36	1.36	4.01
	5	5000	1254.61	103	161.49	-8	9.5	9.5	9.41	1.41	3.99
	6	5000	1263.35	137	161.82	-8	9.5	9.5	9.47	1.47	3.96
	7	5000	1267.29	33	161.96	-8	9.5	9.5	9.49	1.49	3.95
*	8	5000	1994.34	26.48	235.45	-8	9.5	9.5	9.66	1.66	2.51
	9	5000	2365.11	75	273.14	-8	9.5	9.5	9.7	1.7	2.11
	10	5000	2369.99	70	273.25	-8	9.5	9.5	9.71	1.71	2.11

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	5000	1350	0	165	-8	9.5	9.5	10	2	3.7
*	2	5000	1072.82	111.61	108	-8	9.5	9.5	9.93	1.93	4.66
*	3	5000	1075.31	100	108	-8	9.5	9.5	9.96	1.96	4.65
	4	5000	1399.15	395.08	180	-8	9.5	9.5	10.27	2.27	3.57
	5	5000	1407.13	103	180	-8	9.5	9.5	10.31	2.31	3.55
	6	5000	1414.45	137	180	-8	9.5	9.5	10.36	2.36	3.53
	7	5000	1417.55	33	180	-8	9.5	9.5	10.38	2.38	3.53
*	8	5000	2202.45	26.48	252.5	-8	9.5	9.5	10.5	2.5	2.27
	9	5000	2603.66	75	290	-8	9.5	9.5	10.54	2.54	1.92
	10	5000	2607.82	70	290	-8	9.5	9.5	10.54	2.54	1.92
	1	5000	1530	0	180	-8	9.5	9.5	11	3	3.27
*	2	5000	1181.15	111.61	108	-8	9.5	9.5	10.94	2.94	4.23
*	3	5000	1183.01	100	108	-8	9.5	9.5	10.95	2.95	4.23
	4	5000	1566.5	395.08	180	-8	9.5	9.5	11.2	3.2	3.19
	5	5000	1572.28	103	180	-8	9.5	9.5	11.23	3.23	3.18
	6	5000	1577.1	137	180	-8	9.5	9.5	11.26	3.26	3.17
	7	5000	1580.57	33	180	-8	9.5	9.5	11.28	3.28	3.16
*	8	5000	2424.13	26.48	252.5	-8	9.5	9.5	11.38	3.38	2.06
	9	5000	2856.56	75	290	-8	9.5	9.5	11.41	3.41	1.75
	10	5000	2859.96	70	290	-8	9.5	9.5	11.41	3.41	1.75
	1	5000	1710	0	180	-8	9.5	9.5	12	4	2.92
*	2	5000	1289.61	111.61	108	-8	9.5	9.5	11.94	3.94	3.88
*	3	5000	1290.93	100	108	-8	9.5	9.5	11.95	3.95	3.87
	4	5000	1737.98	395.08	180	-8	9.5	9.5	12.16	4.16	2.88
	5	5000	1742.29	103	180	-8	9.5	9.5	12.17	4.17	2.87
	6	5000	1745.56	137	180	-8	9.5	9.5	12.2	4.2	2.86
	7	5000	1754.21	33	180	-8	9.5	9.5	12.25	4.25	2.85
*	8	5000	2662.5	26.48	252.5	-8	9.5	9.5	12.33	4.33	1.88
	9	5000	3129.08	75	290	-8	9.5	9.5	12.35	4.35	1.6
	10	5000	3131.86	70	290	-8	9.5	9.5	12.35	4.35	1.6
	1	5000	1890	0	180	-8	9.5	9.5	13	5	2.65
*	2	5000	1398.13	111.61	108	-8	9.5	9.5	12.95	4.95	3.58
*	3	5000	1399.11	100	108	-8	9.5	9.5	12.96	4.96	3.57
	4	5000	1912.06	395.08	180	-8	9.5	9.5	13.12	5.12	2.61
	5	5000	1915.35	103	180	-8	9.5	9.5	13.14	5.14	2.61
	6	5000	1917.63	137	180	-8	9.5	9.5	13.15	5.15	2.61
	7	5000	1930.21	33	180	-8	9.5	9.5	13.22	5.22	2.59
*	8	5000	2905.56	26.48	252.5	-8	9.5	9.5	13.29	5.29	1.72
	9	5000	3405.9	75	290	-8	9.5	9.5	13.31	5.31	1.47
	10	5000	3409.63	70	290	-8	9.5	9.5	13.31	5.31	1.47
	1	5000	2340	0	180	-8	9.5	9.5	15.5	7.5	2.14
*	2	5000	1669.34	111.61	108	-8	9.5	9.5	15.46	7.46	3
*	3	5000	1669.86	100	108	-8	9.5	9.5	15.46	7.46	2.99
*	4	5000	2353.37	395.08	180	-8	9.5	9.5	15.57	7.57	2.12
	5	5000	2355.21	103	180	-8	9.5	9.5	15.58	7.58	2.12
	6	5000	2356.24	137	180	-8	9.5	9.5	15.59	7.59	2.12
	7	5000	2374.21	33	180	-8	9.5	9.5	15.69	7.69	2.11
*	8	5000	3522.44	26.48	252.5	-8	9.5	9.5	15.73	7.73	1.42
	9	5000	4113.45	75	290	-8	9.5	9.5	15.74	7.74	1.22
	10	5000	4116.01	70	290	-8	9.5	9.5	15.74	7.74	1.21

COUSINS DISCHARGE CHANNEL

SUMMARY OUTPUT
INPUT FILE DIS4K-8.DAT
DISCHARGE: 4000 CFS
CHANNEL BOTTOM AT -8.0

P.S. TO DSTRHN BRIDGE: TOP WIDTH OF CHANNEL TAKEN FROM DEI'S 50% SUBMITTAL
DSTRHN BRIDGE TO HARVEY CANAL: TOP WIDTH OF CHANNEL TAKEN FROM CEEC'S LAYOUT
ALL CROSS SECTIONS HAVE 15' BERM AT +2.0 ON THE LAPALCO BLVD SIDE
SIDE SLOPE 1 VERTICAL TO 3 HORIZONTAL FROM +2.0 TO BOTTOM
VERTICAL WALL CONSIDERED FROM +2.0 TO +9.5
CULVERT (BETWEEN SECTIONS 2 AND 3) UNDER LAPALCO BRIDGE CONSIDERED 108' WIDE

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	4000	882	0	147	-8	9.5	9.5	7	-1	4.54
*	2	4000	751.47	111.61	108	-8	9.5	9.5	6.96	-1.04	5.32
*	3	4000	756.89	100	108	-8	9.5	9.5	7.01	-0.99	5.28
	4	4000	954.7	395.08	149.94	-8	9.5	9.5	7.49	-0.51	4.19
	5	4000	966.19	103	150.4	-8	9.5	9.5	7.56	-0.44	4.14
	6	4000	977.68	137	150.85	-8	9.5	9.5	7.65	-0.35	4.09
	7	4000	982.24	33	151.04	-8	9.5	9.5	7.67	-0.33	4.07
	8	4000	1579.3	26.48	224.63	-8	9.5	9.5	7.85	-0.15	2.53
	9	4000	1883.65	75	262.35	-8	9.5	9.5	7.9	-0.1	2.12
	10	4000	1888.58	70	262.47	-8	9.5	9.5	7.91	-0.09	2.12
*	1	4000	1032	0	153	-8	9.5	9.5	8	0	3.88
*	2	4000	859.14	111.61	108	-8	9.5	9.5	7.95	-0.05	4.66
*	3	4000	862.57	100	108	-8	9.5	9.5	7.98	-0.02	4.64
	4	4000	1082.21	395.08	154.96	-8	9.5	9.5	8.33	0.33	3.7
	5	4000	1090.87	103	155.29	-8	9.5	9.5	8.37	0.37	3.67
	6	4000	1098.48	137	155.59	-8	9.5	9.5	8.43	0.43	3.64
	7	4000	1101.66	33	155.71	-8	9.5	9.5	8.45	0.45	3.63
*	8	4000	1746.77	26.48	229.06	-8	9.5	9.5	8.59	0.59	2.29
	9	4000	2076.57	75	266.73	-8	9.5	9.5	8.63	0.63	1.93
	10	4000	2080.63	70	266.82	-8	9.5	9.5	8.64	0.64	1.92
	1	4000	1188	0	159	-8	9.5	9.5	9	1	3.37
*	2	4000	967.23	111.61	108	-8	9.5	9.5	8.96	0.96	4.14
*	3	4000	969.52	100	108	-8	9.5	9.5	8.98	0.98	4.13
	4	4000	1224.4	395.08	160.37	-8	9.5	9.5	9.23	1.23	3.27
	5	4000	1230.61	103	160.6	-8	9.5	9.5	9.26	1.26	3.25
	6	4000	1236.02	137	160.8	-8	9.5	9.5	9.3	1.3	3.24
	7	4000	1238.33	33	160.89	-8	9.5	9.5	9.31	1.31	3.23
*	8	4000	1939.33	26.48	234.05	-8	9.5	9.5	9.42	1.42	2.06
	9	4000	2298.57	75	271.68	-8	9.5	9.5	9.45	1.45	1.74
	10	4000	2301.89	70	271.75	-8	9.5	9.5	9.46	1.46	1.74

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	4000	1350	0	165	-8	9.5	9.5	10	2	2.96
*	2	4000	1075.48	111.61	108	-8	9.5	9.5	9.96	1.96	3.72
*	3	4000	1077.07	100	108	-8	9.5	9.5	9.97	1.97	3.71
	4	4000	1381.08	395.08	180	-8	9.5	9.5	10.17	2.17	2.9
	5	4000	1386.26	103	180	-8	9.5	9.5	10.2	2.2	2.89
	6	4000	1391.22	137	180	-8	9.5	9.5	10.23	2.23	2.88
	7	4000	1393.09	33	180	-8	9.5	9.5	10.24	2.24	2.87
*	8	4000	2157.03	26.48	252.5	-8	9.5	9.5	10.32	2.32	1.85
	9	4000	2547.75	75	290	-8	9.5	9.5	10.35	2.35	1.57
	10	4000	2551.9	70	290	-8	9.5	9.5	10.35	2.35	1.57
	1	4000	1530	0	180	-8	9.5	9.5	11	3	2.61
*	2	4000	1183.67	111.61	108	-8	9.5	9.5	10.96	2.96	3.38
*	3	4000	1184.85	100	108	-8	9.5	9.5	10.97	2.97	3.38
	4	4000	1553.12	395.08	180	-8	9.5	9.5	11.13	3.13	2.58
	5	4000	1556.85	103	180	-8	9.5	9.5	11.15	3.15	2.57
	6	4000	1560.06	137	180	-8	9.5	9.5	11.17	3.17	2.56
	7	4000	1561.81	33	180	-8	9.5	9.5	11.18	3.18	2.56
*	8	4000	2388.92	26.48	252.5	-8	9.5	9.5	11.24	3.24	1.67
	9	4000	2813.02	75	290	-8	9.5	9.5	11.26	3.26	1.42
	10	4000	2816.48	70	290	-8	9.5	9.5	11.26	3.26	1.42
	1	4000	1710	0	180	-8	9.5	9.5	12	4	2.34
*	2	4000	1291.95	111.61	108	-8	9.5	9.5	11.96	3.96	3.1
*	3	4000	1292.8	100	108	-8	9.5	9.5	11.97	3.97	3.09
	4	4000	1727.75	395.08	180	-8	9.5	9.5	12.1	4.1	2.32
	5	4000	1730.52	103	180	-8	9.5	9.5	12.11	4.11	2.31
	6	4000	1732.67	137	180	-8	9.5	9.5	12.13	4.13	2.31
	7	4000	1737.92	33	180	-8	9.5	9.5	12.16	4.16	2.3
*	8	4000	2632.49	26.48	252.5	-8	9.5	9.5	12.21	4.21	1.52
	9	4000	3092.06	75	290	-8	9.5	9.5	12.22	4.22	1.29
	10	4000	3094.95	70	290	-8	9.5	9.5	12.22	4.22	1.29
	1	4000	1890	0	180	-8	9.5	9.5	13	5	2.12
*	2	4000	1400.27	111.61	108	-8	9.5	9.5	12.97	4.97	2.86
*	3	4000	1400.9	100	108	-8	9.5	9.5	12.97	4.97	2.86
	4	4000	1904.01	395.08	180	-8	9.5	9.5	13.08	5.08	2.1
	5	4000	1906.12	103	180	-8	9.5	9.5	13.09	5.09	2.1
	6	4000	1907.61	137	180	-8	9.5	9.5	13.1	5.1	2.1
	7	4000	1915.47	33	180	-8	9.5	9.5	13.14	5.14	2.09
*	8	4000	2879.03	26.48	252.5	-8	9.5	9.5	13.18	5.18	1.39
	9	4000	3374.75	75	290	-8	9.5	9.5	13.2	5.2	1.19
	10	4000	3377.19	70	290	-8	9.5	9.5	13.2	5.2	1.18
	1	4000	2340	0	180	-8	9.5	9.5	15.5	7.5	1.71
*	2	4000	1671.03	111.61	108	-8	9.5	9.5	15.47	7.47	2.39
*	3	4000	1671.36	100	108	-8	9.5	9.5	15.48	7.48	2.39
*	4	4000	2348.51	395.08	180	-8	9.5	9.5	15.55	7.55	1.7
	5	4000	2349.69	103	180	-8	9.5	9.5	15.55	7.55	1.7
	6	4000	2350.36	137	180	-8	9.5	9.5	15.56	7.56	1.7
	7	4000	2362.34	33	180	-8	9.5	9.5	15.62	7.62	1.69
*	8	4000	3502	26.48	252.5	-8	9.5	9.5	15.65	7.65	1.14
	9	4000	4089.61	75	290	-8	9.5	9.5	15.66	7.66	0.98
	10	4000	4091.27	70	290	-8	9.5	9.5	15.66	7.66	0.98

COUSINS DISCHARGE CHANNEL

SUMMARY OUTPUT
INPUT FILE DIS4K-9.DAT
DISCHARGE: 4000 CFS
CHANNEL BOTTOM AT -9.0

P.S. TO DSTRHN BRIDGE: TOP WIDTH OF CHANNEL TAKEN FROM DEI'S 50% SUBMITTAL
DSTRHN BRIDGE TO HARVEY CANAL: TOP WIDTH OF CHANNEL TAKEN FROM CEEC'S LAYOUT
ALL CROSS SECTIONS HAVE 15' BERM AT +2.0 ON THE LAPALCO BLVD SIDE
SIDE SLOPE 1 VERTICAL TO 3 HORIZONTAL FROM +2.0 TO BOTTOM
VERTICAL WALL CONSIDERED FROM +2.0 TO +9.5
CULVERT (BETWEEN SECTIONS 2 AND 3) UNDER LAPALÇO BRIDGE CONSIDERED 108' WIDE

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	4000	984	0	147	-9	9.5	9.5	8	-1	4.07
*	2	4000	861.11	111.61	108	-9	9.5	9.5	7.97	-1.03	4.65
*	3	4000	864.84	100	108	-9	9.5	9.5	8	-1	4.63
	4	4000	1032.98	395.08	148.99	-9	9.5	9.5	8.33	-0.67	3.87
	5	4000	1041.62	103	149.33	-9	9.5	9.5	8.38	-0.62	3.84
	6	4000	1050.35	137	149.68	-9	9.5	9.5	8.45	-0.55	3.81
	7	4000	1053.96	33	149.83	-9	9.5	9.5	8.47	-0.53	3.8
	8	4000	1703.41	26.48	223.28	-9	9.5	9.5	8.63	-0.37	2.35
	9	4000	2034.99	75	260.96	-9	9.5	9.5	8.67	-0.33	1.97
	10	4000	2039.13	70	261.06	-9	9.5	9.5	8.67	-0.33	1.96
*	1	4000	1134	0	153	-9	9.5	9.5	9	0	3.53
*	2	4000	968.65	111.61	108	-9	9.5	9.5	8.97	-0.03	4.13
*	3	4000	971.13	100	108	-9	9.5	9.5	8.99	-0.01	4.12
	4	4000	1169.45	395.08	154.38	-9	9.5	9.5	9.23	0.23	3.42
	5	4000	1175.67	103	154.63	-9	9.5	9.5	9.27	0.27	3.4
	6	4000	1181.87	137	154.87	-9	9.5	9.5	9.31	0.31	3.38
	7	4000	1184.46	33	154.97	-9	9.5	9.5	9.33	0.33	3.38
*	8	4000	1888.71	26.48	228.2	-9	9.5	9.5	9.45	0.45	2.12
	9	4000	2249.26	75	265.84	-9	9.5	9.5	9.48	0.48	1.78
	10	4000	2252.66	70	265.92	-9	9.5	9.5	9.49	0.49	1.78
	1	4000	1290	0	159	-9	9.5	9.5	10	1	3.1
*	2	4000	1076.54	111.61	108	-9	9.5	9.5	9.97	0.97	3.72
*	3	4000	1078.26	100	108	-9	9.5	9.5	9.98	0.98	3.71
	4	4000	1316.74	395.08	160.01	-9	9.5	9.5	10.17	1.17	3.04
	5	4000	1321.35	103	160.18	-9	9.5	9.5	10.19	1.19	3.03
	6	4000	1325.81	137	160.35	-9	9.5	9.5	10.22	1.22	3.02
	7	4000	1327.73	33	160.42	-9	9.5	9.5	10.24	1.24	3.01
*	8	4000	2092.24	26.48	233.49	-9	9.5	9.5	10.33	1.33	1.91
	9	4000	2484.49	75	271.1	-9	9.5	9.5	10.36	1.36	1.61
	10	4000	2487.28	70	271.16	-9	9.5	9.5	10.36	1.36	1.61

	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	4000	1452	0	165	-9	9.5	9.5	11	2	2.75
*	2	4000	1184.59	111.61	108	-9	9.5	9.5	10.97	1.97	3.38
*	3	4000	1185.82	100	108	-9	9.5	9.5	10.98	1.98	3.37
	4	4000	1475.63	395.08	180	-9	9.5	9.5	11.13	2.13	2.71
	5	4000	1479.61	103	180	-9	9.5	9.5	11.15	2.15	2.7
	6	4000	1483.76	137	180	-9	9.5	9.5	11.18	2.18	2.7
	7	4000	1485.36	33	180	-9	9.5	9.5	11.19	2.19	2.69
*	8	4000	2315.39	26.48	252.5	-9	9.5	9.5	11.26	2.26	1.73
	9	4000	2740.52	75	290	-9	9.5	9.5	11.28	2.28	1.46
	10	4000	2744.16	70	290	-9	9.5	9.5	11.28	2.28	1.46
	1	4000	1632	0	180	-9	9.5	9.5	12	3	2.45
*	2	4000	1292.63	111.61	108	-9	9.5	9.5	11.97	2.97	3.09
*	3	4000	1293.57	100	108	-9	9.5	9.5	11.98	2.98	3.09
	4	4000	1650.08	395.08	180	-9	9.5	9.5	12.1	3.1	2.42
	5	4000	1653.01	103	180	-9	9.5	9.5	12.11	3.11	2.42
	6	4000	1655.75	137	180	-9	9.5	9.5	12.13	3.13	2.42
	7	4000	1656.95	33	180	-9	9.5	9.5	12.14	3.14	2.41
*	8	4000	2552.03	26.48	252.5	-9	9.5	9.5	12.2	3.2	1.57
	9	4000	3011.48	75	290	-9	9.5	9.5	12.21	3.21	1.33
	10	4000	3014.54	70	290	-9	9.5	9.5	12.22	3.22	1.33
	1	4000	1812	0	180	-9	9.5	9.5	13	4	2.21
*	2	4000	1400.77	111.61	108	-9	9.5	9.5	12.97	3.97	2.86
*	3	4000	1401.46	100	108	-9	9.5	9.5	12.98	3.98	2.85
	4	4000	1826.2	395.08	180	-9	9.5	9.5	13.08	4.08	2.19
	5	4000	1828.42	103	180	-9	9.5	9.5	13.09	4.09	2.19
	6	4000	1830.3	137	180	-9	9.5	9.5	13.1	4.1	2.19
	7	4000	1834.31	33	180	-9	9.5	9.5	13.12	4.12	2.18
*	8	4000	2797.85	26.48	252.5	-9	9.5	9.5	13.17	4.17	1.43
	9	4000	3293.27	75	290	-9	9.5	9.5	13.18	4.18	1.21
	10	4000	3295.85	70	290	-9	9.5	9.5	13.19	4.19	1.21
	1	4000	1992	0	180	-9	9.5	9.5	14	5	2.01
*	2	4000	1508.96	111.61	108	-9	9.5	9.5	13.97	4.97	2.65
*	3	4000	1509.48	100	108	-9	9.5	9.5	13.98	4.98	2.65
	4	4000	2003.43	395.08	180	-9	9.5	9.5	14.06	5.06	2
	5	4000	2005.15	103	180	-9	9.5	9.5	14.07	5.07	1.99
	6	4000	2006.48	137	180	-9	9.5	9.5	14.08	5.08	1.99
	7	4000	2012.73	33	180	-9	9.5	9.5	14.12	5.12	1.99
*	8	4000	3045.95	26.48	252.5	-9	9.5	9.5	14.15	5.15	1.31
	9	4000	3577.84	75	290	-9	9.5	9.5	14.16	5.16	1.12
	10	4000	3580.03	70	290	-9	9.5	9.5	14.17	5.17	1.12
	1	4000	2442	0	180	-9	9.5	9.5	16.5	7.5	1.64
*	2	4000	1779.49	111.61	108	-9	9.5	9.5	16.48	7.48	2.25
*	3	4000	1779.78	100	108	-9	9.5	9.5	16.48	7.48	2.25
	4	4000	2449.2	395.08	180	-9	9.5	9.5	16.54	7.54	1.63
	5	4000	2450.2	103	180	-9	9.5	9.5	16.54	7.54	1.63
	6	4000	2450.81	137	180	-9	9.5	9.5	16.55	7.55	1.63
	7	4000	2460.46	33	180	-9	9.5	9.5	16.6	7.6	1.63
*	8	4000	3670.57	26.48	252.5	-9	9.5	9.5	16.63	7.63	1.09
	9	4000	4294.71	75	290	-9	9.5	9.5	16.63	7.63	0.93
	10	4000	4296.23	70	290	-9	9.5	9.5	16.64	7.64	0.93

COUSINS DISCHARGE CHANNEL

CASE 3

East of Harvey Canal Hurricane Protection - Design Memorandum No. 3 - Cousins Pumping Station Complex
Summary Table of Sensitivity Analyses
Additional HEC-2 Model Runs for the Discharge Channel from the Discharge Basin through 100' D/S of Proposed Culvert Under Lapalco
For Q of 5,000 cfs, Channel Bottom of -9' NGVD, with Varying Contraction and Expansion Coefficients, and Channel Mannings 'n'

Water Surface Elevation at Harvey Canal, ft. NGVD	Run 1		Run 2		Run 3		Run 4		Run 5		Run 6		Run 7		Run 8		Run 9	
	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S	EG D/S	EG U/S
-1.00	-0.60	0.07	-0.60	0.28	-0.60	0.76	-0.60	0.13	-0.60	0.34	-0.60	0.81	-0.60	0.23	-0.60	0.43	-0.60	0.90
0.00	0.30	0.30	0.30	0.95	0.30	1.33	0.30	0.85	0.30	1.00	0.30	1.38	0.30	0.93	0.30	1.08	0.30	1.45
1.00	1.23	1.60	1.23	1.72	1.23	2.02	1.23	1.65	1.23	1.77	1.23	2.06	1.23	1.71	1.23	1.83	1.23	2.12
2.00	2.18	2.47	2.18	2.57	2.18	2.80	2.18	2.51	2.18	2.60	2.18	2.84	2.18	2.56	2.18	2.66	2.18	2.89
3.00	3.15	3.37	3.15	3.44	3.15	3.63	3.15	3.40	3.15	3.47	3.15	3.66	3.15	3.45	3.15	3.52	3.15	3.71
4.00	4.12	4.32	4.12	4.38	4.12	4.53	4.12	4.35	4.12	4.41	4.12	4.55	4.12	4.39	4.12	4.44	4.12	4.59
5.00	5.10	5.29	5.10	5.33	5.10	5.45	5.10	5.31	5.10	5.35	5.10	5.47	5.10	5.34	5.10	5.39	5.10	5.50
7.50	7.57	7.73	7.57	7.76	7.57	7.83	7.57	7.75	7.57	7.77	7.57	7.84	7.57	7.77	7.57	7.80	7.57	7.86

Legend:

	Mannings 'n'	Contraction coeff.	Expansion coeff.
Run 1	0.03	0.10	0.30
Run 2	0.04	0.10	0.30
Run 3	0.06	0.10	0.30
Run 4	0.03	0.30	0.50
Run 5	0.04	0.30	0.50
Run 6	0.06	0.30	0.50
Run 7	0.03	0.60	0.80
Run 8	0.04	0.60	0.80
Run 9	0.06	0.60	0.80

EG — Energy Gradient
D/S — Down Stream (100' South of the proposed culvert under Lapalco Bridge)
U/S — Up Stream (Apporximtely 100' feet from the Cousins Pump Station)

Head loss (difference in EG between U/S and D/S) less than 6" (0.5')
Head loss (difference in EG between U/S and D/S) between 6" and 9"(0.5' to 0.75')
Head loss (difference in EG between U/S and D/S) between 9" and 1"(0.75' to 1')
Head loss (difference in EG between U/S and D/S) over 12" (1')

RUN 1 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.03 0.1 0.3
INPUT FILE NAME: DI5K-9M1.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.01	-0.47	-0.99	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.98	0.4	-0.02	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.97	1.31	0.97	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.24	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.96	3.2	2.96	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	919.79	33.2	113.5	-9	9.5	9.5	8.1	-0.44	-0.9	5.44
4	5000	1027.66	33.2	113.5	-9	9.5	9.5	9.05	0.42	0.05	4.87
4	5000	1137.96	33.2	113.5	-9	9.5	9.5	10.03	1.33	1.03	4.39
4	5000	1249.55	33.2	113.5	-9	9.5	9.5	11.01	2.26	2.01	4
4	5000	1361.74	33.2	113.5	-9	9.5	9.5	12	3.21	3	3.67
4	5000	1474.48	33.2	113.5	-9	9.5	9.5	12.99	4.17	3.99	3.39
4	5000	1587.56	33.2	113.5	-9	9.5	9.5	13.99	5.14	4.99	3.15
4	5000	1870.18	33.2	113.5	-9	9.5	9.5	16.48	7.6	7.48	2.67

5	5000	994.13	49	121	-9	9.5	9.5	8.22	-0.39	-0.78	5.03
5	5000	1105.61	49	121	-9	9.5	9.5	9.14	0.45	0.14	4.52
5	5000	1220.86	49	121	-9	9.5	9.5	10.09	1.35	1.09	4.1
5	5000	1338.21	49	121	-9	9.5	9.5	11.06	2.28	2.06	3.74
5	5000	1456.65	49	121	-9	9.5	9.5	12.04	3.22	3.04	3.43
5	5000	1575.98	49	121	-9	9.5	9.5	13.02	4.18	4.02	3.17
5	5000	1694.66	49	121	-9	9.5	9.5	14.02	5.15	5.02	2.95
5	5000	1996.09	49	121	-9	9.5	9.5	16.5	7.6	7.5	2.5
6	5000	1099.09	48.7	132	-9	9.5	9.5	8.33	-0.35	-0.67	4.55
6	5000	1217.21	48.7	132	-9	9.5	9.5	9.22	0.48	0.22	4.11
6	5000	1340.52	48.7	132	-9	9.5	9.5	10.16	1.37	1.16	3.73
6	5000	1466.81	48.7	132	-9	9.5	9.5	11.11	2.29	2.11	3.41
6	5000	1594.76	48.7	132	-9	9.5	9.5	12.08	3.23	3.08	3.14
6	5000	1723.99	48.7	132	-9	9.5	9.5	13.06	4.19	4.06	2.9
6	5000	1854.06	48.7	132	-9	9.5	9.5	14.05	5.16	5.05	2.7
6	5000	2180.17	48.7	132	-9	9.5	9.5	16.52	7.61	7.52	2.29
7	5000	1248.29	56.6	148	-9	9.5	9.5	8.43	-0.32	-0.57	4.01
7	5000	1377.16	56.6	148	-9	9.5	9.5	9.31	0.51	0.31	3.63
7	5000	1512.83	56.6	148	-9	9.5	9.5	10.22	1.39	1.22	3.31
7	5000	1652.56	56.6	148	-9	9.5	9.5	11.17	2.31	2.17	3.03
7	5000	1794.61	56.6	148	-9	9.5	9.5	12.13	3.25	3.13	2.79
7	5000	1938.44	56.6	148	-9	9.5	9.5	13.1	4.2	4.1	2.58
7	5000	2083.45	56.6	148	-9	9.5	9.5	14.08	5.17	5.08	2.4
7	5000	2447.61	56.6	148	-9	9.5	9.5	16.55	7.61	7.55	2.04
8	5000	1382.22	53.8	162.5	-9	9.5	9.5	8.51	-0.29	-0.49	3.62
8	5000	1521.19	53.8	162.5	-9	9.5	9.5	9.36	0.53	0.36	3.29
8	5000	1668.3	53.8	162.5	-9	9.5	9.5	10.27	1.41	1.27	3
8	5000	1820.35	53.8	162.5	-9	9.5	9.5	11.2	2.32	2.2	2.75
8	5000	1975.29	53.8	162.5	-9	9.5	9.5	12.16	3.26	3.16	2.53
8	5000	2130.91	53.8	162.5	-9	9.5	9.5	13.12	4.21	4.12	2.35
8	5000	2289.72	53.8	162.5	-9	9.5	9.5	14.1	5.17	5.1	2.18
8	5000	2690.32	53.8	162.5	-9	9.5	9.5	16.56	7.62	7.56	1.86
9	5000	1483.59	47.7	173.5	-9	9.5	9.5	8.55	-0.27	-0.45	3.37
9	5000	1630.28	47.7	173.5	-9	9.5	9.5	9.4	0.54	0.4	3.07
9	5000	1784.52	47.7	173.5	-9	9.5	9.5	10.29	1.42	1.29	2.8
9	5000	1946.19	47.7	173.5	-9	9.5	9.5	11.22	2.33	2.22	2.57
9	5000	2111.13	47.7	173.5	-9	9.5	9.5	12.17	3.26	3.17	2.37
9	5000	2278.51	47.7	173.5	-9	9.5	9.5	13.14	4.21	4.14	2.19
9	5000	2446.75	47.7	173.5	-9	9.5	9.5	14.11	5.18	5.11	2.04
9	5000	2873.83	47.7	173.5	-9	9.5	9.5	16.57	7.62	7.57	1.74

10	5000	1542.72	40.9	180	-9	9.5	9.5	8.58	-0.26	-0.42	3.24
10	5000	1694.08	40.9	180	-9	9.5	9.5	9.42	0.55	0.42	2.95
10	5000	1854.3	40.9	180	-9	9.5	9.5	10.31	1.42	1.31	2.7
10	5000	2021.45	40.9	180	-9	9.5	9.5	11.24	2.33	2.24	2.47
10	5000	2192.14	40.9	180	-9	9.5	9.5	12.19	3.27	3.19	2.28
10	5000	2365.47	40.9	180	-9	9.5	9.5	13.15	4.22	4.15	2.11
10	5000	2540.6	40.9	180	-9	9.5	9.5	14.12	5.18	5.12	1.97
10	5000	2983.03	40.9	180	-9	9.5	9.5	16.58	7.62	7.58	1.68
11	5000	1545.72	35	180	-9	9.5	9.5	8.59	-0.25	-0.41	3.23
11	5000	1696.4	35	180	-9	9.5	9.5	9.42	0.56	0.42	2.95
11	5000	1856.94	35	180	-9	9.5	9.5	10.32	1.43	1.32	2.69
11	5000	2023.58	35	180	-9	9.5	9.5	11.24	2.34	2.24	2.47
11	5000	2193.89	35	180	-9	9.5	9.5	12.19	3.27	3.19	2.28
11	5000	2366.93	35	180	-9	9.5	9.5	13.15	4.22	4.15	2.11
11	5000	2541.85	35	180	-9	9.5	9.5	14.12	5.18	5.12	1.97
11	5000	2983.89	35	180	-9	9.5	9.5	16.58	7.62	7.58	1.68
12	5000	1053.82	33.1	149.82	-9	9.5	9.5	8.47	-0.18	-0.53	4.74
12	5000	1185.7	33.1	155.01	-9	9.5	9.5	9.34	0.61	0.34	4.22
12	5000	1329.76	33.1	160.49	-9	9.5	9.5	10.25	1.47	1.25	3.76
12	5000	1486.42	33.1	180	-9	9.5	9.5	11.19	2.37	2.19	3.36
12	5000	1659.05	33.1	180	-9	9.5	9.5	12.15	3.29	3.15	3.01
12	5000	1833.7	33.1	180	-9	9.5	9.5	13.12	4.24	4.12	2.73
12	5000	2009.76	33.1	180	-9	9.5	9.5	14.1	5.19	5.1	2.49
12	5000	2454.8	33.1	180	-9	9.5	9.5	16.56	7.63	7.56	2.04
13	5000	1065.68	103	150.3	-9	9.5	9.5	8.55	-0.11	-0.45	4.69
13	5000	1192.61	103	155.28	-9	9.5	9.5	9.39	0.66	0.39	4.19
13	5000	1334.88	103	160.68	-9	9.5	9.5	10.29	1.5	1.29	3.75
13	5000	1490.13	103	180	-9	9.5	9.5	11.22	2.4	2.22	3.36
13	5000	1661.73	103	180	-9	9.5	9.5	12.17	3.31	3.17	3.01
13	5000	1835.7	103	180	-9	9.5	9.5	13.14	4.25	4.14	2.72
13	5000	2011.28	103	180	-9	9.5	9.5	14.11	5.21	5.11	2.49
13	5000	2454.37	103	180	-9	9.5	9.5	16.57	7.63	7.57	2.04
14	5000	1079.84	137	150.86	-9	9.5	9.5	8.65	-0.02	-0.35	4.63
14	5000	1204.48	137	155.74	-9	9.5	9.5	9.46	0.73	0.46	4.15
14	5000	1343.61	137	161.01	-9	9.5	9.5	10.34	1.55	1.34	3.72
14	5000	1498.83	137	180	-9	9.5	9.5	11.26	2.43	2.26	3.34
14	5000	1667.75	137	180	-9	9.5	9.5	12.2	3.34	3.2	3
14	5000	1840.01	137	180	-9	9.5	9.5	13.16	4.27	4.16	2.72
14	5000	2014.47	137	180	-9	9.5	9.5	14.13	5.22	5.13	2.48
14	5000	2456.01	137	180	-9	9.5	9.5	16.58	7.64	7.58	2.04

15	5000	1086.21	33	151.11	-9	9.5	9.5	8.69	0.01	-0.31	4.6
15	5000	1209.14	33	155.92	-9	9.5	9.5	9.49	0.75	0.49	4.14
15	5000	1346.99	33	161.14	-9	9.5	9.5	10.36	1.57	1.36	3.71
15	5000	1501.62	33	180	-9	9.5	9.5	11.28	2.45	2.28	3.33
15	5000	1669.87	33	180	-9	9.5	9.5	12.21	3.35	3.21	2.99
15	5000	1846.62	33	180	-9	9.5	9.5	13.19	4.31	4.19	2.71
15	5000	2024.48	33	180	-9	9.5	9.5	14.18	5.28	5.18	2.47
15	5000	2470.97	33	180	-9	9.5	9.5	16.66	7.72	7.66	2.02
16	5000	1768.54	26.48	225.02	-9	9.5	9.5	8.92	0.04	-0.08	2.83
16	5000	1939.35	26.48	229.53	-9	9.5	9.5	9.67	0.77	0.67	2.58
16	5000	2132.08	26.48	234.51	-9	9.5	9.5	10.5	1.59	1.5	2.35
16	5000	2348.39	26.48	252.5	-9	9.5	9.5	11.39	2.46	2.39	2.13
16	5000	2578.3	26.48	252.5	-9	9.5	9.5	12.3	3.36	3.3	1.94
16	5000	2821.68	26.48	252.5	-9	9.5	9.5	13.27	4.31	4.27	1.77
16	5000	3067.82	26.48	252.5	-9	9.5	9.5	14.24	5.28	5.24	1.63
16	5000	3688.85	26.48	252.5	-9	9.5	9.5	16.7	7.73	7.7	1.36
17	5000	2117.25	75	262.85	-9	9.5	9.5	8.97	0.06	-0.03	2.36
17	5000	2311.13	75	267.23	-9	9.5	9.5	9.72	0.79	0.72	2.16
17	5000	2533.12	75	272.17	-9	9.5	9.5	10.54	1.6	1.54	1.97
17	5000	2781.79	75	290	-9	9.5	9.5	11.42	2.47	2.42	1.8
17	5000	3044.43	75	290	-9	9.5	9.5	12.32	3.37	3.32	1.64
17	5000	3322.93	75	290	-9	9.5	9.5	13.28	4.32	4.28	1.5
17	5000	3603.55	75	290	-9	9.5	9.5	14.26	5.29	5.26	1.39
17	5000	4316.03	75	290	-9	9.5	9.5	16.71	7.73	7.71	1.16
18	5000	2120.51	70	262.92	-9	9.5	9.5	8.98	0.07	-0.02	2.36
18	5000	2316.15	70	267.35	-9	9.5	9.5	9.72	0.8	0.72	2.16
18	5000	2537.31	70	272.27	-9	9.5	9.5	10.54	1.6	1.54	1.97
18	5000	2785.4	70	290	-9	9.5	9.5	11.42	2.47	2.42	1.8
18	5000	3047.4	70	290	-9	9.5	9.5	12.33	3.37	3.33	1.64
18	5000	3325.37	70	290	-9	9.5	9.5	13.29	4.32	4.29	1.5
18	5000	3606.92	70	290	-9	9.5	9.5	14.26	5.29	5.26	1.39
18	5000	4318.37	70	290	-9	9.5	9.5	16.71	7.73	7.71	1.16

RUN 2 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.04 0.1 0.3
INPUT FILE NAME: DI5K-9M2.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.01	-0.47	-0.99	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.99	0.4	-0.01	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.31	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.14	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	923.9	33.2	113.5	-9	9.5	9.5	8.14	-0.41	-0.86	5.41
4	5000	1030.43	33.2	113.5	-9	9.5	9.5	9.08	0.44	0.08	4.85
4	5000	1139.92	33.2	113.5	-9	9.5	9.5	10.04	1.34	1.04	4.39
4	5000	1250.99	33.2	113.5	-9	9.5	9.5	11.02	2.27	2.02	4
4	5000	1362.82	33.2	113.5	-9	9.5	9.5	12.01	3.22	3.01	3.67
4	5000	1475.32	33.2	113.5	-9	9.5	9.5	13	4.18	4	3.39
4	5000	1588.23	33.2	113.5	-9	9.5	9.5	13.99	5.15	4.99	3.15
4	5000	1870.5	33.2	113.5	-9	9.5	9.5	16.49	7.6	7.49	2.67

5	5000	1002.36	49	121	-9	9.5	9.5	8.28	-0.33	-0.72	4.99
5	5000	1111.29	49	121	-9	9.5	9.5	9.18	0.5	0.18	4.5
5	5000	1224.92	49	121	-9	9.5	9.5	10.12	1.38	1.12	4.08
5	5000	1341.21	49	121	-9	9.5	9.5	11.08	2.3	2.08	3.73
5	5000	1458.93	49	121	-9	9.5	9.5	12.06	3.24	3.06	3.43
5	5000	1577.75	49	121	-9	9.5	9.5	13.04	4.2	4.04	3.17
5	5000	1696.11	49	121	-9	9.5	9.5	14.03	5.16	5.03	2.95
5	5000	1996.96	49	121	-9	9.5	9.5	16.51	7.61	7.51	2.5
6	5000	1111.19	48.7	132	-9	9.5	9.5	8.42	-0.27	-0.58	4.5
6	5000	1225.72	48.7	132	-9	9.5	9.5	9.29	0.54	0.29	4.08
6	5000	1346.67	48.7	132	-9	9.5	9.5	10.2	1.42	1.2	3.71
6	5000	1471.39	48.7	132	-9	9.5	9.5	11.15	2.33	2.15	3.4
6	5000	1598.25	48.7	132	-9	9.5	9.5	12.11	3.26	3.11	3.13
6	5000	1726.7	48.7	132	-9	9.5	9.5	13.08	4.21	4.08	2.9
6	5000	1856.22	48.7	132	-9	9.5	9.5	14.06	5.17	5.06	2.69
6	5000	2181.51	48.7	132	-9	9.5	9.5	16.53	7.62	7.53	2.29
7	5000	1264.79	56.6	148	-9	9.5	9.5	8.55	-0.21	-0.45	3.95
7	5000	1388.93	56.6	148	-9	9.5	9.5	9.38	0.59	0.38	3.6
7	5000	1521.42	56.6	148	-9	9.5	9.5	10.28	1.45	1.28	3.29
7	5000	1658.98	56.6	148	-9	9.5	9.5	11.21	2.35	2.21	3.01
7	5000	1799.53	56.6	148	-9	9.5	9.5	12.16	3.28	3.16	2.78
7	5000	1942.28	56.6	148	-9	9.5	9.5	13.12	4.23	4.12	2.57
7	5000	2086.51	56.6	148	-9	9.5	9.5	14.1	5.19	5.1	2.4
7	5000	2449.51	56.6	148	-9	9.5	9.5	16.56	7.62	7.56	2.04
8	5000	1402.63	53.8	162.5	-9	9.5	9.5	8.63	-0.17	-0.37	3.56
8	5000	1535.89	53.8	162.5	-9	9.5	9.5	9.45	0.62	0.45	3.26
8	5000	1679.1	53.8	162.5	-9	9.5	9.5	10.33	1.47	1.33	2.98
8	5000	1828.45	53.8	162.5	-9	9.5	9.5	11.25	2.37	2.25	2.73
8	5000	1979.88	53.8	162.5	-9	9.5	9.5	12.19	3.29	3.19	2.53
8	5000	2135.88	53.8	162.5	-9	9.5	9.5	13.15	4.24	4.15	2.34
8	5000	2293.68	53.8	162.5	-9	9.5	9.5	14.12	5.2	5.12	2.18
8	5000	2692.71	53.8	162.5	-9	9.5	9.5	16.58	7.63	7.58	1.86
9	5000	1507.16	47.7	173.5	-9	9.5	9.5	8.69	-0.14	-0.31	3.32
9	5000	1645.64	47.7	173.5	-9	9.5	9.5	9.49	0.64	0.49	3.04
9	5000	1797.26	47.7	173.5	-9	9.5	9.5	10.37	1.49	1.37	2.78
9	5000	1955.78	47.7	173.5	-9	9.5	9.5	11.28	2.38	2.28	2.56
9	5000	2118.49	47.7	173.5	-9	9.5	9.5	12.22	3.3	3.22	2.36
9	5000	2284.28	47.7	173.5	-9	9.5	9.5	13.17	4.25	4.17	2.19
9	5000	2451.4	47.7	173.5	-9	9.5	9.5	14.14	5.2	5.14	2.04
9	5000	2876.65	47.7	173.5	-9	9.5	9.5	16.59	7.63	7.59	1.74

10	5000	1568.72	40.9	180	-9	9.5	9.5	8.72	-0.12	-0.28	3.19
10	5000	1712.99	40.9	180	-9	9.5	9.5	9.52	0.65	0.52	2.92
10	5000	1868.36	40.9	180	-9	9.5	9.5	10.39	1.5	1.39	2.68
10	5000	2032.05	40.9	180	-9	9.5	9.5	11.3	2.39	2.3	2.46
10	5000	2200.3	40.9	180	-9	9.5	9.5	12.23	3.31	3.23	2.27
10	5000	2371.87	40.9	180	-9	9.5	9.5	13.18	4.25	4.18	2.11
10	5000	2545.71	40.9	180	-9	9.5	9.5	14.15	5.21	5.15	1.96
10	5000	2986.13	40.9	180	-9	9.5	9.5	16.59	7.64	7.59	1.67
11	5000	1572.85	35	180	-9	9.5	9.5	8.74	-0.1	-0.26	3.18
11	5000	1716.22	35	180	-9	9.5	9.5	9.53	0.67	0.53	2.91
11	5000	1871.61	35	180	-9	9.5	9.5	10.4	1.51	1.4	2.67
11	5000	2034.66	35	180	-9	9.5	9.5	11.3	2.4	2.3	2.46
11	5000	2202.43	35	180	-9	9.5	9.5	12.24	3.32	3.24	2.27
11	5000	2373.63	35	180	-9	9.5	9.5	13.19	4.26	4.19	2.11
11	5000	2547.19	35	180	-9	9.5	9.5	14.15	5.21	5.15	1.96
11	5000	2987.13	35	180	-9	9.5	9.5	16.6	7.64	7.6	1.67
12	5000	1078.94	33.1	150.83	-9	9.5	9.5	8.64	-0.03	-0.36	4.63
12	5000	1204.47	33.1	155.74	-9	9.5	9.5	9.46	0.72	0.46	4.15
12	5000	1344.04	33.1	161.03	-9	9.5	9.5	10.34	1.55	1.34	3.72
12	5000	1498.47	33.1	180	-9	9.5	9.5	11.26	2.43	2.26	3.34
12	5000	1668.27	33.1	180	-9	9.5	9.5	12.2	3.34	3.2	3
12	5000	1840.89	33.1	180	-9	9.5	9.5	13.16	4.28	4.16	2.72
12	5000	2015.48	33.1	180	-9	9.5	9.5	14.13	5.23	5.13	2.48
12	5000	2458.21	33.1	180	-9	9.5	9.5	16.58	7.65	7.58	2.03
13	5000	1098.43	103	151.6	-9	9.5	9.5	8.77	0.09	-0.23	4.55
13	5000	1218.77	103	156.29	-9	9.5	9.5	9.55	0.81	0.55	4.1
13	5000	1354.62	103	161.42	-9	9.5	9.5	10.4	1.61	1.4	3.69
13	5000	1506.37	103	180	-9	9.5	9.5	11.31	2.48	2.31	3.32
13	5000	1673.91	103	180	-9	9.5	9.5	12.24	3.38	3.24	2.99
13	5000	1844.4	103	180	-9	9.5	9.5	13.19	4.3	4.19	2.71
13	5000	2018.17	103	180	-9	9.5	9.5	14.15	5.25	5.15	2.48
13	5000	2458.47	103	180	-9	9.5	9.5	16.59	7.66	7.59	2.03
14	5000	1116.49	137	152.31	-9	9.5	9.5	8.89	0.2	-0.11	4.48
14	5000	1232.27	137	156.81	-9	9.5	9.5	9.63	0.89	0.63	4.06
14	5000	1366.41	137	161.86	-9	9.5	9.5	10.47	1.67	1.47	3.66
14	5000	1518.53	137	180	-9	9.5	9.5	11.36	2.53	2.36	3.29
14	5000	1682.42	137	180	-9	9.5	9.5	12.27	3.41	3.27	2.97
14	5000	1851.96	137	180	-9	9.5	9.5	13.21	4.33	4.21	2.7
14	5000	2023.76	137	180	-9	9.5	9.5	14.17	5.26	5.17	2.47
14	5000	2461.37	137	180	-9	9.5	9.5	16.6	7.67	7.6	2.03

15	5000	1121.39	33	152.5	-9	9.5	9.5	8.92	0.23	-0.08	4.46
15	5000	1236.02	33	156.95	-9	9.5	9.5	9.66	0.91	0.66	4.05
15	5000	1367.68	33	161.9	-9	9.5	9.5	10.48	1.69	1.48	3.66
15	5000	1519.47	33	180	-9	9.5	9.5	11.37	2.54	2.37	3.29
15	5000	1683.74	33	180	-9	9.5	9.5	12.29	3.42	3.29	2.97
15	5000	1857.18	33	180	-9	9.5	9.5	13.25	4.36	4.25	2.69
15	5000	2032.69	33	180	-9	9.5	9.5	14.23	5.32	5.23	2.46
15	5000	2475.6	33	180	-9	9.5	9.5	16.69	7.75	7.69	2.02
16	5000	1817.25	26.48	226.32	-9	9.5	9.5	9.14	0.25	0.14	2.75
16	5000	1976.87	26.48	230.51	-9	9.5	9.5	9.83	0.93	0.83	2.53
16	5000	2161.05	26.48	235.25	-9	9.5	9.5	10.63	1.71	1.63	2.31
16	5000	2372.68	26.48	252.5	-9	9.5	9.5	11.49	2.56	2.49	2.11
16	5000	2597.34	26.48	252.5	-9	9.5	9.5	12.38	3.44	3.38	1.93
16	5000	2836.27	26.48	252.5	-9	9.5	9.5	13.32	4.37	4.32	1.76
16	5000	3079.22	26.48	252.5	-9	9.5	9.5	14.29	5.33	5.29	1.62
16	5000	3695.31	26.48	252.5	-9	9.5	9.5	16.73	7.75	7.73	1.35
17	5000	2170.55	75	264.06	-9	9.5	9.5	9.19	0.27	0.19	2.3
17	5000	2354.34	75	268.2	-9	9.5	9.5	9.88	0.95	0.88	2.12
17	5000	2566.48	75	272.91	-9	9.5	9.5	10.66	1.72	1.66	1.95
17	5000	2809.51	75	290	-9	9.5	9.5	11.52	2.56	2.52	1.78
17	5000	3066.21	75	290	-9	9.5	9.5	12.4	3.44	3.4	1.63
17	5000	3339.63	75	290	-9	9.5	9.5	13.34	4.38	4.34	1.5
17	5000	3616.61	75	290	-9	9.5	9.5	14.3	5.33	5.3	1.38
17	5000	4323.44	75	290	-9	9.5	9.5	16.74	7.76	7.74	1.16
18	5000	2176.21	70	264.19	-9	9.5	9.5	9.2	0.28	0.2	2.3
18	5000	2359.18	70	268.31	-9	9.5	9.5	9.88	0.95	0.88	2.12
18	5000	2570.57	70	273	-9	9.5	9.5	10.67	1.72	1.67	1.95
18	5000	2813.04	70	290	-9	9.5	9.5	11.52	2.57	2.52	1.78
18	5000	3069.13	70	290	-9	9.5	9.5	12.4	3.44	3.4	1.63
18	5000	3342.05	70	290	-9	9.5	9.5	13.34	4.38	4.34	1.5
18	5000	3619.96	70	290	-9	9.5	9.5	14.3	5.33	5.3	1.38
18	5000	4325.77	70	290	-9	9.5	9.5	16.74	7.76	7.74	1.16

RUN 3 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.06 0.1 0.3
INPUT FILE NAME: DI5K-9M3.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.89	100	108	-9	9.5	9.5	8.02	-0.46	-0.98	5.77
3	5000	970.53	100	108	-9	9.5	9.5	9	0.41	0	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.32	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.97	4.16	3.97	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.97	5.14	4.97	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	933.85	33.2	113.5	-9	9.5	9.5	8.23	-0.33	-0.77	5.35
4	5000	1037.24	33.2	113.5	-9	9.5	9.5	9.14	0.5	0.14	4.82
4	5000	1144.75	33.2	113.5	-9	9.5	9.5	10.09	1.38	1.09	4.37
4	5000	1254.55	33.2	113.5	-9	9.5	9.5	11.05	2.3	2.05	3.99
4	5000	1365.52	33.2	113.5	-9	9.5	9.5	12.03	3.24	3.03	3.66
4	5000	1477.41	33.2	113.5	-9	9.5	9.5	13.02	4.19	4.02	3.38
4	5000	1589.89	33.2	113.5	-9	9.5	9.5	14.01	5.16	5.01	3.14
4	5000	1871.29	33.2	113.5	-9	9.5	9.5	16.5	7.61	7.5	2.67

5	5000	1023.23	49	121	-9	9.5	9.5	8.46	-0.17	-0.54	4.89
5	5000	1126.02	49	121	-9	9.5	9.5	9.31	0.61	0.31	4.44
5	5000	1235.58	49	121	-9	9.5	9.5	10.21	1.47	1.21	4.05
5	5000	1349.14	49	121	-9	9.5	9.5	11.15	2.36	2.15	3.71
5	5000	1464.98	49	121	-9	9.5	9.5	12.11	3.29	3.11	3.41
5	5000	1581.26	49	121	-9	9.5	9.5	13.08	4.23	4.08	3.16
5	5000	1699.99	49	121	-9	9.5	9.5	14.06	5.19	5.06	2.94
5	5000	1999.31	49	121	-9	9.5	9.5	16.53	7.63	7.53	2.5
6	5000	1141.99	48.7	132	-9	9.5	9.5	8.65	-0.05	-0.35	4.38
6	5000	1247.94	48.7	132	-9	9.5	9.5	9.45	0.7	0.45	4.01
6	5000	1362.98	48.7	132	-9	9.5	9.5	10.33	1.53	1.33	3.67
6	5000	1483.63	48.7	132	-9	9.5	9.5	11.24	2.42	2.24	3.37
6	5000	1607.64	48.7	132	-9	9.5	9.5	12.18	3.33	3.18	3.11
6	5000	1734.06	48.7	132	-9	9.5	9.5	13.14	4.27	4.14	2.88
6	5000	1860.76	48.7	132	-9	9.5	9.5	14.11	5.22	5.11	2.69
6	5000	2185.17	48.7	132	-9	9.5	9.5	16.56	7.64	7.56	2.29
7	5000	1306.63	56.6	148	-9	9.5	9.5	8.83	0.06	-0.17	3.83
7	5000	1419.69	56.6	148	-9	9.5	9.5	9.59	0.79	0.59	3.52
7	5000	1544.28	56.6	148	-9	9.5	9.5	10.43	1.6	1.43	3.24
7	5000	1676.27	56.6	148	-9	9.5	9.5	11.33	2.46	2.33	2.98
7	5000	1812.87	56.6	148	-9	9.5	9.5	12.25	3.37	3.25	2.76
7	5000	1952.76	56.6	148	-9	9.5	9.5	13.19	4.3	4.19	2.56
7	5000	2093.4	56.6	148	-9	9.5	9.5	14.15	5.24	5.15	2.39
7	5000	2454.75	56.6	148	-9	9.5	9.5	16.59	7.66	7.59	2.04
8	5000	1454.21	53.8	162.5	-9	9.5	9.5	8.95	0.13	-0.05	3.44
8	5000	1574.26	53.8	162.5	-9	9.5	9.5	9.69	0.84	0.69	3.18
8	5000	1706.23	53.8	162.5	-9	9.5	9.5	10.51	1.64	1.51	2.93
8	5000	1848.88	53.8	162.5	-9	9.5	9.5	11.39	2.5	2.39	2.7
8	5000	1997.16	53.8	162.5	-9	9.5	9.5	12.3	3.4	3.3	2.5
8	5000	2149.49	53.8	162.5	-9	9.5	9.5	13.23	4.32	4.23	2.33
8	5000	2304.56	53.8	162.5	-9	9.5	9.5	14.19	5.26	5.19	2.17
8	5000	2698.57	53.8	162.5	-9	9.5	9.5	16.62	7.67	7.62	1.85
9	5000	1565.18	47.7	173.5	-9	9.5	9.5	9.03	0.19	0.03	3.19
9	5000	1690.67	47.7	173.5	-9	9.5	9.5	9.75	0.89	0.75	2.96
9	5000	1831.15	47.7	173.5	-9	9.5	9.5	10.56	1.68	1.56	2.73
9	5000	1981.64	47.7	173.5	-9	9.5	9.5	11.43	2.53	2.43	2.52
9	5000	2137.72	47.7	173.5	-9	9.5	9.5	12.33	3.42	3.33	2.34
9	5000	2299.38	47.7	173.5	-9	9.5	9.5	13.26	4.33	4.26	2.17
9	5000	2464.2	47.7	173.5	-9	9.5	9.5	14.21	5.27	5.21	2.03
9	5000	2884.43	47.7	173.5	-9	9.5	9.5	16.63	7.68	7.63	1.73

10	5000	1633.31	40.9	180	-9	9.5	9.5	9.08	0.23	0.08	3.06
10	5000	1761.57	40.9	180	-9	9.5	9.5	9.79	0.92	0.79	2.84
10	5000	1905.78	40.9	180	-9	9.5	9.5	10.59	1.7	1.59	2.62
10	5000	2060.67	40.9	180	-9	9.5	9.5	11.45	2.55	2.45	2.43
10	5000	2222.51	40.9	180	-9	9.5	9.5	12.35	3.43	3.35	2.25
10	5000	2389.41	40.9	180	-9	9.5	9.5	13.28	4.35	4.28	2.09
10	5000	2559.77	40.9	180	-9	9.5	9.5	14.22	5.28	5.22	1.95
10	5000	2994.69	40.9	180	-9	9.5	9.5	16.64	7.68	7.64	1.67
11	5000	1640.91	35	180	-9	9.5	9.5	9.12	0.26	0.12	3.05
11	5000	1767.67	35	180	-9	9.5	9.5	9.82	0.94	0.82	2.83
11	5000	1910.64	35	180	-9	9.5	9.5	10.61	1.72	1.61	2.62
11	5000	2064.57	35	180	-9	9.5	9.5	11.47	2.56	2.47	2.42
11	5000	2225.69	35	180	-9	9.5	9.5	12.36	3.44	3.36	2.25
11	5000	2392.01	35	180	-9	9.5	9.5	13.29	4.36	4.29	2.09
11	5000	2561.93	35	180	-9	9.5	9.5	14.23	5.29	5.23	1.95
11	5000	2996.1	35	180	-9	9.5	9.5	16.64	7.69	7.64	1.67
12	5000	1142.1	33.1	153.32	-9	9.5	9.5	9.05	0.35	0.05	4.38
12	5000	1253.36	33.1	157.61	-9	9.5	9.5	9.77	1.02	0.77	3.99
12	5000	1382.1	33.1	162.44	-9	9.5	9.5	10.57	1.78	1.57	3.62
12	5000	1530.92	33.1	180	-9	9.5	9.5	11.44	2.6	2.44	3.27
12	5000	1693.35	33.1	180	-9	9.5	9.5	12.34	3.48	3.34	2.95
12	5000	1860.62	33.1	180	-9	9.5	9.5	13.27	4.38	4.27	2.69
12	5000	2031.24	33.1	180	-9	9.5	9.5	14.22	5.31	5.22	2.46
12	5000	2467.67	33.1	180	-9	9.5	9.5	16.64	7.7	7.64	2.03
13	5000	1178.52	103	154.74	-9	9.5	9.5	9.29	0.57	0.29	4.24
13	5000	1281.69	103	158.69	-9	9.5	9.5	9.95	1.18	0.95	3.9
13	5000	1403.92	103	163.24	-9	9.5	9.5	10.71	1.9	1.71	3.56
13	5000	1550.53	103	180	-9	9.5	9.5	11.55	2.71	2.55	3.22
13	5000	1707.49	103	180	-9	9.5	9.5	12.42	3.55	3.42	2.93
13	5000	1869.65	103	180	-9	9.5	9.5	13.33	4.44	4.33	2.67
13	5000	2038.12	103	180	-9	9.5	9.5	14.26	5.36	5.26	2.45
13	5000	2469.85	103	180	-9	9.5	9.5	16.66	7.72	7.66	2.02
14	5000	1198.47	137	155.51	-9	9.5	9.5	9.42	0.69	0.42	4.17
14	5000	1297.57	137	159.29	-9	9.5	9.5	10.05	1.28	1.05	3.85
14	5000	1416.36	137	163.7	-9	9.5	9.5	10.78	1.98	1.78	3.53
14	5000	1561.71	137	180	-9	9.5	9.5	11.61	2.77	2.61	3.2
14	5000	1715.65	137	180	-9	9.5	9.5	12.46	3.6	3.46	2.91
14	5000	1877.14	137	180	-9	9.5	9.5	13.36	4.47	4.36	2.66
14	5000	2043.72	137	180	-9	9.5	9.5	14.29	5.38	5.29	2.45
14	5000	2474.79	137	180	-9	9.5	9.5	16.67	7.74	7.67	2.02

15	5000	1202.49	33	155.66	-9	9.5	9.5	9.44	0.71	0.44	4.16
15	5000	1300.83	33	159.41	-9	9.5	9.5	10.07	1.3	1.07	3.84
15	5000	1418.98	33	163.79	-9	9.5	9.5	10.8	1.99	1.8	3.52
15	5000	1563.93	33	180	-9	9.5	9.5	11.62	2.78	2.62	3.2
15	5000	1719.02	33	180	-9	9.5	9.5	12.48	3.61	3.48	2.91
15	5000	1884.48	33	180	-9	9.5	9.5	13.4	4.51	4.4	2.65
15	5000	2054.17	33	180	-9	9.5	9.5	14.35	5.44	5.35	2.43
15	5000	2487.89	33	180	-9	9.5	9.5	16.75	7.82	7.75	2.01
16	5000	1930.07	26.48	229.29	-9	9.5	9.5	9.63	0.74	0.63	2.59
16	5000	2067.48	26.48	232.86	-9	9.5	9.5	10.23	1.32	1.23	2.42
16	5000	2232.88	26.48	237.08	-9	9.5	9.5	10.93	2.01	1.93	2.24
16	5000	2433.3	26.48	252.5	-9	9.5	9.5	11.73	2.79	2.73	2.05
16	5000	2645.83	26.48	252.5	-9	9.5	9.5	12.57	3.63	3.57	1.89
16	5000	2873.99	26.48	252.5	-9	9.5	9.5	13.47	4.52	4.47	1.74
16	5000	3109.01	26.48	252.5	-9	9.5	9.5	14.4	5.44	5.4	1.61
16	5000	3712.44	26.48	252.5	-9	9.5	9.5	16.79	7.82	7.79	1.35
17	5000	2300.44	75	266.99	-9	9.5	9.5	9.68	0.75	0.68	2.17
17	5000	2458.72	75	270.53	-9	9.5	9.5	10.26	1.33	1.26	2.03
17	5000	2649.19	75	274.72	-9	9.5	9.5	10.96	2.02	1.96	1.89
17	5000	2878.72	75	290	-9	9.5	9.5	11.75	2.8	2.75	1.74
17	5000	3121.67	75	290	-9	9.5	9.5	12.59	3.63	3.59	1.6
17	5000	3382.82	75	290	-9	9.5	9.5	13.49	4.52	4.49	1.48
17	5000	3650.77	75	290	-9	9.5	9.5	14.42	5.45	5.42	1.37
17	5000	4343.1	75	290	-9	9.5	9.5	16.8	7.82	7.8	1.15
18	5000	2305.5	70	267.11	-9	9.5	9.5	9.68	0.76	0.68	2.17
18	5000	2463.17	70	270.63	-9	9.5	9.5	10.27	1.33	1.27	2.03
18	5000	2653.03	70	274.8	-9	9.5	9.5	10.97	2.02	1.97	1.88
18	5000	2882.07	70	290	-9	9.5	9.5	11.76	2.8	2.76	1.73
18	5000	3124.47	70	290	-9	9.5	9.5	12.59	3.63	3.59	1.6
18	5000	3385.18	70	290	-9	9.5	9.5	13.49	4.53	4.49	1.48
18	5000	3654.06	70	290	-9	9.5	9.5	14.42	5.45	5.42	1.37
18	5000	4345.41	70	290	-9	9.5	9.5	16.8	7.83	7.8	1.15

RUN 4 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.03 0.3 0.5
INPUT FILE NAME: DI5K-9M4.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.01	-0.47	-0.99	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.98	0.4	-0.02	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.97	1.31	0.97	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.24	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.96	3.2	2.96	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	921.56	33.2	113.5	-9	9.5	9.5	8.12	-0.42	-0.88	5.43
4	5000	1028.87	33.2	113.5	-9	9.5	9.5	9.06	0.43	0.06	4.86
4	5000	1138.85	33.2	113.5	-9	9.5	9.5	10.03	1.33	1.03	4.39
4	5000	1250.25	33.2	113.5	-9	9.5	9.5	11.02	2.26	2.02	4
4	5000	1362.3	33.2	113.5	-9	9.5	9.5	12	3.21	3	3.67
4	5000	1474.94	33.2	113.5	-9	9.5	9.5	13	4.17	4	3.39
4	5000	1587.96	33.2	113.5	-9	9.5	9.5	13.99	5.14	4.99	3.15
4	5000	1870.31	33.2	113.5	-9	9.5	9.5	16.49	7.6	7.49	2.67

5	5000	997.74	49	121	-9	9.5	9.5	8.25	-0.36	-0.75	5.01
5	5000	1108.18	49	121	-9	9.5	9.5	9.16	0.47	0.16	4.51
5	5000	1222.81	49	121	-9	9.5	9.5	10.11	1.37	1.11	4.09
5	5000	1339.76	49	121	-9	9.5	9.5	11.07	2.29	2.07	3.73
5	5000	1457.91	49	121	-9	9.5	9.5	12.05	3.23	3.05	3.43
5	5000	1577.03	49	121	-9	9.5	9.5	13.03	4.19	4.03	3.17
5	5000	1696.78	49	121	-9	9.5	9.5	14.02	5.16	5.02	2.95
5	5000	1996.54	49	121	-9	9.5	9.5	16.51	7.61	7.51	2.5
6	5000	1104.95	48.7	132	-9	9.5	9.5	8.37	-0.31	-0.63	4.53
6	5000	1221.53	48.7	132	-9	9.5	9.5	9.25	0.51	0.25	4.09
6	5000	1343.85	48.7	132	-9	9.5	9.5	10.18	1.4	1.18	3.72
6	5000	1469.48	48.7	132	-9	9.5	9.5	11.13	2.31	2.13	3.4
6	5000	1596.95	48.7	132	-9	9.5	9.5	12.1	3.25	3.1	3.13
6	5000	1725.82	48.7	132	-9	9.5	9.5	13.07	4.2	4.07	2.9
6	5000	1855.62	48.7	132	-9	9.5	9.5	14.06	5.17	5.06	2.69
6	5000	2181.06	48.7	132	-9	9.5	9.5	16.53	7.61	7.53	2.29
7	5000	1256.92	56.6	148	-9	9.5	9.5	8.49	-0.26	-0.51	3.98
7	5000	1383.67	56.6	148	-9	9.5	9.5	9.35	0.55	0.35	3.61
7	5000	1517.93	56.6	148	-9	9.5	9.5	10.26	1.42	1.26	3.29
7	5000	1656.68	56.6	148	-9	9.5	9.5	11.19	2.34	2.19	3.02
7	5000	1798.02	56.6	148	-9	9.5	9.5	12.15	3.27	3.15	2.78
7	5000	1941.3	56.6	148	-9	9.5	9.5	13.12	4.22	4.12	2.58
7	5000	2085.9	56.6	148	-9	9.5	9.5	14.09	5.18	5.09	2.4
7	5000	2450.67	56.6	148	-9	9.5	9.5	16.56	7.62	7.56	2.04
8	5000	1393.05	53.8	162.5	-9	9.5	9.5	8.57	-0.23	-0.43	3.59
8	5000	1529.47	53.8	162.5	-9	9.5	9.5	9.41	0.58	0.41	3.27
8	5000	1674.85	53.8	162.5	-9	9.5	9.5	10.31	1.45	1.31	2.99
8	5000	1825.66	53.8	162.5	-9	9.5	9.5	11.23	2.35	2.23	2.74
8	5000	1979.7	53.8	162.5	-9	9.5	9.5	12.18	3.28	3.18	2.53
8	5000	2136.13	53.8	162.5	-9	9.5	9.5	13.15	4.23	4.15	2.34
8	5000	2292.65	53.8	162.5	-9	9.5	9.5	14.12	5.19	5.12	2.18
8	5000	2692.4	53.8	162.5	-9	9.5	9.5	16.58	7.63	7.58	1.86
9	5000	1495.96	47.7	173.5	-9	9.5	9.5	8.62	-0.2	-0.38	3.34
9	5000	1639.82	47.7	173.5	-9	9.5	9.5	9.45	0.6	0.45	3.05
9	5000	1793.68	47.7	173.5	-9	9.5	9.5	10.34	1.46	1.34	2.79
9	5000	1952.1	47.7	173.5	-9	9.5	9.5	11.26	2.36	2.26	2.56
9	5000	2116.04	47.7	173.5	-9	9.5	9.5	12.2	3.29	3.2	2.36
9	5000	2282.66	47.7	173.5	-9	9.5	9.5	13.16	4.24	4.16	2.19
9	5000	2451.11	47.7	173.5	-9	9.5	9.5	14.13	5.2	5.13	2.04
9	5000	2876.24	47.7	173.5	-9	9.5	9.5	16.59	7.63	7.59	1.74

10	5000	1555.7	40.9	180	-9	9.5	9.5	8.65	-0.19	-0.35	3.21
10	5000	1704.12	40.9	180	-9	9.5	9.5	9.47	0.61	0.47	2.93
10	5000	1863.12	40.9	180	-9	9.5	9.5	10.36	1.47	1.36	2.68
10	5000	2027.83	40.9	180	-9	9.5	9.5	11.27	2.37	2.27	2.47
10	5000	2197.44	40.9	180	-9	9.5	9.5	12.22	3.3	3.22	2.28
10	5000	2369.96	40.9	180	-9	9.5	9.5	13.17	4.24	4.17	2.11
10	5000	2544.46	40.9	180	-9	9.5	9.5	14.14	5.2	5.14	1.97
10	5000	2985.77	40.9	180	-9	9.5	9.5	16.59	7.64	7.59	1.67
11	5000	1558.88	35	180	-9	9.5	9.5	8.66	-0.18	-0.34	3.21
11	5000	1706.6	35	180	-9	9.5	9.5	9.48	0.61	0.48	2.93
11	5000	1865.08	35	180	-9	9.5	9.5	10.36	1.47	1.36	2.68
11	5000	2030.22	35	180	-9	9.5	9.5	11.28	2.37	2.28	2.46
11	5000	2199.42	35	180	-9	9.5	9.5	12.22	3.3	3.22	2.27
11	5000	2371.61	35	180	-9	9.5	9.5	13.18	4.24	4.18	2.11
11	5000	2545.86	35	180	-9	9.5	9.5	14.14	5.2	5.14	1.96
11	5000	2986.75	35	180	-9	9.5	9.5	16.59	7.64	7.59	1.67
12	5000	1065.25	33.1	150.28	-9	9.5	9.5	8.55	-0.11	-0.45	4.69
12	5000	1194.76	33.1	155.36	-9	9.5	9.5	9.39	0.67	0.39	4.18
12	5000	1337.17	33.1	160.77	-9	9.5	9.5	10.3	1.51	1.3	3.74
12	5000	1493.18	33.1	180	-9	9.5	9.5	11.23	2.4	2.23	3.35
12	5000	1664.65	33.1	180	-9	9.5	9.5	12.18	3.32	3.18	3
12	5000	1838.42	33.1	180	-9	9.5	9.5	13.15	4.26	4.15	2.72
12	5000	2013.79	33.1	180	-9	9.5	9.5	14.12	5.22	5.12	2.48
12	5000	2457.67	33.1	180	-9	9.5	9.5	16.58	7.64	7.58	2.03
13	5000	1076.75	103	150.74	-9	9.5	9.5	8.62	-0.04	-0.38	4.64
13	5000	1201.53	103	155.63	-9	9.5	9.5	9.45	0.72	0.45	4.16
13	5000	1342.21	103	160.96	-9	9.5	9.5	10.33	1.55	1.33	3.73
13	5000	1496.84	103	180	-9	9.5	9.5	11.26	2.43	2.26	3.34
13	5000	1667.3	103	180	-9	9.5	9.5	12.2	3.34	3.2	3
13	5000	1840.4	103	180	-9	9.5	9.5	13.16	4.28	4.16	2.72
13	5000	2015.31	103	180	-9	9.5	9.5	14.13	5.23	5.13	2.48
13	5000	2457.24	103	180	-9	9.5	9.5	16.59	7.65	7.59	2.03
14	5000	1090.51	137	151.28	-9	9.5	9.5	8.72	0.05	-0.28	4.59
14	5000	1213.16	137	156.07	-9	9.5	9.5	9.52	0.78	0.52	4.12
14	5000	1350.81	137	161.28	-9	9.5	9.5	10.38	1.6	1.38	3.7
14	5000	1505.41	137	180	-9	9.5	9.5	11.3	2.47	2.3	3.32
14	5000	1673.25	137	180	-9	9.5	9.5	12.23	3.37	3.23	2.99
14	5000	1844.68	137	180	-9	9.5	9.5	13.18	4.3	4.18	2.71
14	5000	2018.47	137	180	-9	9.5	9.5	14.15	5.24	5.15	2.48
14	5000	2458.87	137	180	-9	9.5	9.5	16.59	7.66	7.59	2.03

15	5000	1096.93	33	151.54	-9	9.5	9.5	8.76	0.08	-0.24	4.56
15	5000	1217.88	33	156.25	-9	9.5	9.5	9.54	0.8	0.54	4.11
15	5000	1354.23	33	161.41	-9	9.5	9.5	10.4	1.61	1.4	3.69
15	5000	1508.23	33	180	-9	9.5	9.5	11.31	2.48	2.31	3.32
15	5000	1675.57	33	180	-9	9.5	9.5	12.24	3.38	3.24	2.98
15	5000	1851.41	33	180	-9	9.5	9.5	13.22	4.33	4.22	2.7
15	5000	2028.56	33	180	-9	9.5	9.5	14.2	5.3	5.2	2.46
15	5000	2473.79	33	180	-9	9.5	9.5	16.68	7.74	7.68	2.02
16	5000	1783.37	26.48	225.42	-9	9.5	9.5	8.99	0.11	-0.01	2.8
16	5000	1951.54	26.48	229.85	-9	9.5	9.5	9.72	0.83	0.72	2.56
16	5000	2142.22	26.48	234.77	-9	9.5	9.5	10.55	1.63	1.55	2.33
16	5000	2357.39	26.48	252.5	-9	9.5	9.5	11.43	2.5	2.43	2.12
16	5000	2586.13	26.48	252.5	-9	9.5	9.5	12.33	3.39	3.33	1.93
16	5000	2828.3	26.48	252.5	-9	9.5	9.5	13.29	4.34	4.29	1.77
16	5000	3073.49	26.48	252.5	-9	9.5	9.5	14.26	5.3	5.26	1.63
16	5000	3692.79	26.48	252.5	-9	9.5	9.5	16.72	7.74	7.72	1.35
17	5000	2134.29	75	263.23	-9	9.5	9.5	9.04	0.12	0.04	2.34
17	5000	2325.17	75	267.55	-9	9.5	9.5	9.77	0.84	0.77	2.15
17	5000	2544.8	75	272.43	-9	9.5	9.5	10.58	1.64	1.58	1.96
17	5000	2792.06	75	290	-9	9.5	9.5	11.46	2.5	2.46	1.79
17	5000	3053.39	75	290	-9	9.5	9.5	12.36	3.4	3.36	1.64
17	5000	3330.5	75	290	-9	9.5	9.5	13.31	4.35	4.31	1.5
17	5000	3610.04	75	290	-9	9.5	9.5	14.28	5.31	5.28	1.39
17	5000	4320.54	75	290	-9	9.5	9.5	16.73	7.75	7.73	1.16
18	5000	2137.48	70	263.31	-9	9.5	9.5	9.05	0.13	0.05	2.34
18	5000	2330.13	70	267.66	-9	9.5	9.5	9.78	0.85	0.78	2.15
18	5000	2548.96	70	272.52	-9	9.5	9.5	10.59	1.65	1.59	1.96
18	5000	2795.63	70	290	-9	9.5	9.5	11.46	2.51	2.46	1.79
18	5000	3056.34	70	290	-9	9.5	9.5	12.36	3.4	3.36	1.64
18	5000	3332.94	70	290	-9	9.5	9.5	13.31	4.35	4.31	1.5
18	5000	3613.4	70	290	-9	9.5	9.5	14.28	5.31	5.28	1.38
18	5000	4322.88	70	290	-9	9.5	9.5	16.73	7.75	7.73	1.16

RUN 5 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.04 0.3 0.5
INPUT FILE NAME: DI5K-9M5.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.02	-0.47	-0.98	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.99	0.4	-0.01	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.31	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.14	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	925.76	33.2	113.5	-9	9.5	9.5	8.16	-0.39	-0.84	5.4
4	5000	1031.69	33.2	113.5	-9	9.5	9.5	9.09	0.45	0.09	4.85
4	5000	1140.83	33.2	113.5	-9	9.5	9.5	10.05	1.35	1.05	4.38
4	5000	1251.7	33.2	113.5	-9	9.5	9.5	11.03	2.28	2.03	3.99
4	5000	1363.39	33.2	113.5	-9	9.5	9.5	12.01	3.22	3.01	3.67
4	5000	1475.79	33.2	113.5	-9	9.5	9.5	13	4.18	4	3.39
4	5000	1588.62	33.2	113.5	-9	9.5	9.5	14	5.15	5	3.15
4	5000	1870.63	33.2	113.5	-9	9.5	9.5	16.49	7.6	7.49	2.67

5	5000	1006.09	49	121	-9	9.5	9.5	8.31	-0.3	-0.69	4.97
5	5000	1113.93	49	121	-9	9.5	9.5	9.21	0.52	0.21	4.49
5	5000	1226.91	49	121	-9	9.5	9.5	10.14	1.4	1.14	4.08
5	5000	1342.78	49	121	-9	9.5	9.5	11.1	2.31	2.1	3.72
5	5000	1460.2	49	121	-9	9.5	9.5	12.07	3.25	3.07	3.42
5	5000	1578.81	49	121	-9	9.5	9.5	13.05	4.2	4.05	3.17
5	5000	1698.19	49	121	-9	9.5	9.5	14.03	5.17	5.03	2.94
5	5000	1997.42	49	121	-9	9.5	9.5	16.52	7.61	7.52	2.5
6	5000	1117.13	48.7	132	-9	9.5	9.5	8.46	-0.23	-0.54	4.48
6	5000	1230.08	48.7	132	-9	9.5	9.5	9.32	0.58	0.32	4.06
6	5000	1350.03	48.7	132	-9	9.5	9.5	10.23	1.44	1.23	3.7
6	5000	1474.07	48.7	132	-9	9.5	9.5	11.17	2,35	2.17	3.39
6	5000	1600.44	48.7	132	-9	9.5	9.5	12.12	3.28	3.12	3.12
6	5000	1728.54	48.7	132	-9	9.5	9.5	13.1	4.22	4.1	2.89
6	5000	1857.78	48.7	132	-9	9.5	9.5	14.07	5.19	5.07	2.69
6	5000	2182.4	48.7	132	-9	9.5	9.5	16.54	7.62	7.54	2.29
7	5000	1273.42	56.6	148	-9	9.5	9.5	8.6	-0.16	-0.4	3.93
7	5000	1395.45	56.6	148	-9	9.5	9.5	9.43	0.63	0.43	3.58
7	5000	1526.53	56.6	148	-9	9.5	9.5	10.31	1.48	1.31	3.28
7	5000	1663.11	56.6	148	-9	9.5	9.5	11.24	2.38	2.24	3.01
7	5000	1802.94	56.6	148	-9	9.5	9.5	12.18	3.3	3.18	2.77
7	5000	1945.15	56.6	148	-9	9.5	9.5	13.14	4.25	4.14	2.57
7	5000	2088.96	56.6	148	-9	9.5	9.5	14.11	5.2	5.11	2.39
7	5000	2452.52	56.6	148	-9	9.5	9.5	16.57	7.64	7.57	2.04
8	5000	1413.39	53.8	162.5	-9	9.5	9.5	8.7	-0.11	-0.3	3.54
8	5000	1544.15	53.8	162.5	-9	9.5	9.5	9.5	0.67	0.5	3.24
8	5000	1685.64	53.8	162.5	-9	9.5	9.5	10.37	1.51	1.37	2.97
8	5000	1833.77	53.8	162.5	-9	9.5	9.5	11.28	2.4	2.28	2.73
8	5000	1985.92	53.8	162.5	-9	9.5	9.5	12.22	3.32	3.22	2.52
8	5000	2141.01	53.8	162.5	-9	9.5	9.5	13.18	4.26	4.18	2.34
8	5000	2296.61	53.8	162.5	-9	9.5	9.5	14.14	5.22	5.14	2.18
8	5000	2694.8	53.8	162.5	-9	9.5	9.5	16.59	7.64	7.59	1.86
9	5000	1519.39	47.7	173.5	-9	9.5	9.5	8.76	-0.07	-0.24	3.29
9	5000	1656.85	47.7	173.5	-9	9.5	9.5	9.55	0.69	0.55	3.02
9	5000	1804.49	47.7	173.5	-9	9.5	9.5	10.41	1.53	1.41	2.77
9	5000	1961.67	47.7	173.5	-9	9.5	9.5	11.31	2.42	2.31	2.55
9	5000	2123.4	47.7	173.5	-9	9.5	9.5	12.25	3.33	3.25	2.35
9	5000	2288.44	47.7	173.5	-9	9.5	9.5	13.2	4.27	4.2	2.18
9	5000	2455.72	47.7	173.5	-9	9.5	9.5	14.16	5.22	5.16	2.04
9	5000	2879.06	47.7	173.5	-9	9.5	9.5	16.6	7.65	7.6	1.74

10	5000	1581.52	40.9	180	-9	9.5	9.5	8.79	-0.05	-0.21	3.16
10	5000	1722.96	40.9	180	-9	9.5	9.5	9.58	0.71	0.58	2.9
10	5000	1877.06	40.9	180	-9	9.5	9.5	10.43	1.54	1.43	2.66
10	5000	2038.41	40.9	180	-9	9.5	9.5	11.33	2.43	2.33	2.45
10	5000	2205.59	40.9	180	-9	9.5	9.5	12.26	3.34	3.26	2.27
10	5000	2376.35	40.9	180	-9	9.5	9.5	13.21	4.28	4.21	2.1
10	5000	2549.56	40.9	180	-9	9.5	9.5	14.17	5.23	5.17	1.96
10	5000	2988.87	40.9	180	-9	9.5	9.5	16.61	7.65	7.61	1.67
11	5000	1585.8	35	180	-9	9.5	9.5	8.81	-0.04	-0.19	3.15
11	5000	1726.31	35	180	-9	9.5	9.5	9.59	0.72	0.59	2.9
11	5000	1879.72	35	180	-9	9.5	9.5	10.44	1.55	1.44	2.66
11	5000	2041.28	35	180	-9	9.5	9.5	11.34	2.43	2.34	2.45
11	5000	2207.94	35	180	-9	9.5	9.5	12.27	3.35	3.27	2.26
11	5000	2378.3	35	180	-9	9.5	9.5	13.21	4.28	4.21	2.1
11	5000	2551.2	35	180	-9	9.5	9.5	14.17	5.23	5.17	1.96
11	5000	2989.99	35	180	-9	9.5	9.5	16.61	7.65	7.61	1.67
12	5000	1090.19	33.1	151.27	-9	9.5	9.5	8.71	0.04	-0.29	4.59
12	5000	1213.44	33.1	156.08	-9	9.5	9.5	9.51	0.78	0.51	4.12
12	5000	1351.41	33.1	161.3	-9	9.5	9.5	10.38	1.6	1.38	3.7
12	5000	1505.2	33.1	180	-9	9.5	9.5	11.3	2.47	2.3	3.32
12	5000	1673.84	33.1	180	-9	9.5	9.5	12.23	3.37	3.23	2.99
12	5000	1845.6	33.1	180	-9	9.5	9.5	13.19	4.3	4.19	2.71
12	5000	2019.5	33.1	180	-9	9.5	9.5	14.15	5.25	5.15	2.48
12	5000	2461.08	33.1	180	-9	9.5	9.5	16.6	7.66	7.6	2.03
13	5000	1109.11	103	152.02	-9	9.5	9.5	8.84	0.15	-0.16	4.51
13	5000	1227.45	103	156.62	-9	9.5	9.5	9.6	0.86	0.6	4.07
13	5000	1361.84	103	161.69	-9	9.5	9.5	10.45	1.66	1.45	3.67
13	5000	1512.99	103	180	-9	9.5	9.5	11.35	2.52	2.35	3.3
13	5000	1679.43	103	180	-9	9.5	9.5	12.27	3.41	3.27	2.98
13	5000	1849.08	103	180	-9	9.5	9.5	13.21	4.33	4.21	2.7
13	5000	2022.18	103	180	-9	9.5	9.5	14.17	5.27	5.17	2.47
13	5000	2461.33	103	180	-9	9.5	9.5	16.61	7.67	7.61	2.03
14	5000	1127.01	137	152.73	-9	9.5	9.5	8.95	0.26	-0.05	4.44
14	5000	1240.87	137	157.14	-9	9.5	9.5	9.69	0.94	0.69	4.03
14	5000	1373.53	137	162.12	-9	9.5	9.5	10.51	1.72	1.51	3.64
14	5000	1525.01	137	180	-9	9.5	9.5	11.4	2.56	2.4	3.28
14	5000	1687.87	137	180	-9	9.5	9.5	12.3	3.44	3.3	2.96
14	5000	1856.57	137	180	-9	9.5	9.5	13.24	4.35	4.24	2.69
14	5000	2027.74	137	180	-9	9.5	9.5	14.19	5.29	5.19	2.47
14	5000	2464.23	137	180	-9	9.5	9.5	16.62	7.68	7.62	2.03

15	5000	1131.78	33	152.91	-9	9.5	9.5	8.99	0.29	-0.01	4.42
15	5000	1244.55	33	157.28	-9	9.5	9.5	9.71	0.96	0.71	4.02
15	5000	1374.84	33	162.17	-9	9.5	9.5	10.53	1.73	1.53	3.64
15	5000	1525.99	33	180	-9	9.5	9.5	11.41	2.58	2.41	3.28
15	5000	1689.38	33	180	-9	9.5	9.5	12.32	3.45	3.32	2.96
15	5000	1861.95	33	180	-9	9.5	9.5	13.28	4.39	4.28	2.69
15	5000	2036.76	33	180	-9	9.5	9.5	14.25	5.34	5.25	2.45
15	5000	2478.41	33	180	-9	9.5	9.5	16.7	7.77	7.7	2.02
16	5000	1831.67	26.48	226.7	-9	9.5	9.5	9.2	0.32	0.2	2.73
16	5000	1988.79	26.48	230.82	-9	9.5	9.5	9.89	0.98	0.89	2.51
16	5000	2171.07	26.48	235.51	-9	9.5	9.5	10.67	1.75	1.67	2.3
16	5000	2381.56	26.48	252.5	-9	9.5	9.5	11.52	2.59	2.52	2.1
16	5000	2605.09	26.48	252.5	-9	9.5	9.5	12.41	3.47	3.41	1.92
16	5000	2842.85	26.48	252.5	-9	9.5	9.5	13.35	4.4	4.35	1.76
16	5000	3084.86	26.48	252.5	-9	9.5	9.5	14.31	5.35	5.31	1.62
16	5000	3699.23	26.48	252.5	-9	9.5	9.5	16.74	7.77	7.74	1.35
17	5000	2187.14	75	264.44	-9	9.5	9.5	9.25	0.33	0.25	2.29
17	5000	2368.07	75	268.51	-9	9.5	9.5	9.93	1	0.93	2.11
17	5000	2578.02	75	273.16	-9	9.5	9.5	10.7	1.76	1.7	1.94
17	5000	2819.65	75	290	-9	9.5	9.5	11.55	2.6	2.55	1.77
17	5000	3075.08	75	290	-9	9.5	9.5	12.43	3.47	3.43	1.63
17	5000	3347.17	75	290	-9	9.5	9.5	13.37	4.4	4.37	1.49
17	5000	3623.08	75	290	-9	9.5	9.5	14.32	5.35	5.32	1.38
17	5000	4327.94	75	290	-9	9.5	9.5	16.75	7.77	7.75	1.16
18	5000	2192.73	70	264.56	-9	9.5	9.5	9.26	0.34	0.26	2.28
18	5000	2372.86	70	268.62	-9	9.5	9.5	9.93	1	0.93	2.11
18	5000	2582.07	70	273.25	-9	9.5	9.5	10.71	1.77	1.71	1.94
18	5000	2823.15	70	290	-9	9.5	9.5	11.55	2.6	2.55	1.77
18	5000	3077.98	70	290	-9	9.5	9.5	12.43	3.47	3.43	1.62
18	5000	3349.58	70	290	-9	9.5	9.5	13.37	4.41	4.37	1.49
18	5000	3626.41	70	290	-9	9.5	9.5	14.33	5.35	5.33	1.38
18	5000	4330.27	70	290	-9	9.5	9.5	16.75	7.77	7.75	1.15

RUN 6 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.06 0.3 0.5
INPUT FILE NAME: DI5K-9M6.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.96	100	108	-9	9.5	9.5	8.03	-0.46	-0.97	5.77
3	5000	970.53	100	108	-9	9.5	9.5	9	0.41	0	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.32	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.97	4.16	3.97	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.97	5.14	4.97	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	935.93	33.2	113.5	-9	9.5	9.5	8.25	-0.31	-0.75	5.34
4	5000	1038.6	33.2	113.5	-9	9.5	9.5	9.15	0.51	0.15	4.81
4	5000	1145.73	33.2	113.5	-9	9.5	9.5	10.09	1.39	1.09	4.36
4	5000	1255.29	33.2	113.5	-9	9.5	9.5	11.06	2.31	2.06	3.98
4	5000	1366.11	33.2	113.5	-9	9.5	9.5	12.04	3.24	3.04	3.66
4	5000	1477.89	33.2	113.5	-9	9.5	9.5	13.02	4.2	4.02	3.38
4	5000	1590.29	33.2	113.5	-9	9.5	9.5	14.01	5.16	5.01	3.14
4	5000	1872.67	33.2	113.5	-9	9.5	9.5	16.5	7.61	7.5	2.67

5	5000	1027.2	49	121	-9	9.5	9.5	8.49	-0.14	-0.51	4.87
5	5000	1128.8	49	121	-9	9.5	9.5	9.33	0.63	0.33	4.43
5	5000	1237.65	49	121	-9	9.5	9.5	10.23	1.48	1.23	4.04
5	5000	1350.75	49	121	-9	9.5	9.5	11.16	2.38	2.16	3.7
5	5000	1466.28	49	121	-9	9.5	9.5	12.12	3.3	3.12	3.41
5	5000	1583.54	49	121	-9	9.5	9.5	13.09	4.24	4.09	3.16
5	5000	1701.94	49	121	-9	9.5	9.5	14.07	5.2	5.07	2.94
5	5000	1999.77	49	121	-9	9.5	9.5	16.53	7.63	7.53	2.5
6	5000	1148.07	48.7	132	-9	9.5	9.5	8.7	-0.01	-0.3	4.36
6	5000	1252.41	48.7	132	-9	9.5	9.5	9.49	0.74	0.49	3.99
6	5000	1366.41	48.7	132	-9	9.5	9.5	10.35	1.56	1.35	3.66
6	5000	1486.35	48.7	132	-9	9.5	9.5	11.26	2.44	2.26	3.36
6	5000	1609.86	48.7	132	-9	9.5	9.5	12.2	3.35	3.2	3.11
6	5000	1735.91	48.7	132	-9	9.5	9.5	13.15	4.28	4.15	2.88
6	5000	1863.65	48.7	132	-9	9.5	9.5	14.12	5.23	5.12	2.68
6	5000	2186.05	48.7	132	-9	9.5	9.5	16.57	7.65	7.57	2.29
7	5000	1315.23	56.6	148	-9	9.5	9.5	8.89	0.11	-0.11	3.8
7	5000	1426.23	56.6	148	-9	9.5	9.5	9.64	0.83	0.64	3.51
7	5000	1549.42	56.6	148	-9	9.5	9.5	10.47	1.63	1.47	3.23
7	5000	1680.42	56.6	148	-9	9.5	9.5	11.35	2.49	2.35	2.98
7	5000	1816.29	56.6	148	-9	9.5	9.5	12.27	3.39	3.27	2.75
7	5000	1955.63	56.6	148	-9	9.5	9.5	13.21	4.32	4.21	2.56
7	5000	2097.32	56.6	148	-9	9.5	9.5	14.17	5.26	5.17	2.38
7	5000	2456.22	56.6	148	-9	9.5	9.5	16.61	7.67	7.61	2.04
8	5000	1464.74	53.8	162.5	-9	9.5	9.5	9.01	0.19	0.01	3.41
8	5000	1582.44	53.8	162.5	-9	9.5	9.5	9.74	0.89	0.74	3.16
8	5000	1714.36	53.8	162.5	-9	9.5	9.5	10.55	1.68	1.55	2.92
8	5000	1855.62	53.8	162.5	-9	9.5	9.5	11.42	2.53	2.42	2.69
8	5000	2001.22	53.8	162.5	-9	9.5	9.5	12.32	3.42	3.32	2.5
8	5000	2152.9	53.8	162.5	-9	9.5	9.5	13.26	4.34	4.26	2.32
8	5000	2307.48	53.8	162.5	-9	9.5	9.5	14.21	5.28	5.21	2.17
8	5000	2701.4	53.8	162.5	-9	9.5	9.5	16.63	7.68	7.63	1.85
9	5000	1578.4	47.7	173.5	-9	9.5	9.5	9.1	0.25	0.1	3.17
9	5000	1699.61	47.7	173.5	-9	9.5	9.5	9.8	0.94	0.8	2.94
9	5000	1838.33	47.7	173.5	-9	9.5	9.5	10.6	1.72	1.6	2.72
9	5000	1987.51	47.7	173.5	-9	9.5	9.5	11.46	2.56	2.46	2.52
9	5000	2143.44	47.7	173.5	-9	9.5	9.5	12.36	3.44	3.36	2.33
9	5000	2304.23	47.7	173.5	-9	9.5	9.5	13.29	4.36	4.29	2.17
9	5000	2467.56	47.7	173.5	-9	9.5	9.5	14.23	5.3	5.23	2.03
9	5000	2886.84	47.7	173.5	-9	9.5	9.5	16.65	7.69	7.65	1.73

10	5000	1646.4	40.9	180	-9	9.5	9.5	9.15	0.3	0.15	3.04
10	5000	1771.11	40.9	180	-9	9.5	9.5	9.85	0.97	0.85	2.82
10	5000	1913.43	40.9	180	-9	9.5	9.5	10.64	1.74	1.64	2.61
10	5000	2066.96	40.9	180	-9	9.5	9.5	11.49	2.58	2.49	2.42
10	5000	2227.8	40.9	180	-9	9.5	9.5	12.38	3.46	3.38	2.24
10	5000	2393.87	40.9	180	-9	9.5	9.5	13.3	4.37	4.3	2.09
10	5000	2563.58	40.9	180	-9	9.5	9.5	14.25	5.31	5.25	1.95
10	5000	2997.42	40.9	180	-9	9.5	9.5	16.66	7.7	7.66	1.67
11	5000	1653.3	35	180	-9	9.5	9.5	9.18	0.33	0.18	3.02
11	5000	1777.51	35	180	-9	9.5	9.5	9.87	1	0.87	2.81
11	5000	1918.57	35	180	-9	9.5	9.5	10.66	1.76	1.66	2.61
11	5000	2071.1	35	180	-9	9.5	9.5	11.51	2.6	2.51	2.41
11	5000	2231.16	35	180	-9	9.5	9.5	12.4	3.47	3.4	2.24
11	5000	2396.64	35	180	-9	9.5	9.5	13.31	4.38	4.31	2.09
11	5000	2565.9	35	180	-9	9.5	9.5	14.25	5.31	5.25	1.95
11	5000	2998.96	35	180	-9	9.5	9.5	16.66	7.7	7.66	1.67
12	5000	1152.88	33.1	153.74	-9	9.5	9.5	9.12	0.42	0.12	4.34
12	5000	1262.15	33.1	157.95	-9	9.5	9.5	9.82	1.07	0.82	3.96
12	5000	1389.37	33.1	162.71	-9	9.5	9.5	10.62	1.82	1.62	3.6
12	5000	1537.53	33.1	180	-9	9.5	9.5	11.48	2.64	2.48	3.25
12	5000	1698.87	33.1	180	-9	9.5	9.5	12.37	3.51	3.37	2.94
12	5000	1865.28	33.1	180	-9	9.5	9.5	13.3	4.41	4.3	2.68
12	5000	2035.23	33.1	180	-9	9.5	9.5	14.24	5.33	5.24	2.46
12	5000	2470.53	33.1	180	-9	9.5	9.5	16.65	7.72	7.65	2.02
13	5000	1188.38	103	155.12	-9	9.5	9.5	9.35	0.63	0.35	4.21
13	5000	1289.95	103	159	-9	9.5	9.5	10	1.23	1	3.88
13	5000	1410.89	103	163.5	-9	9.5	9.5	10.75	1.94	1.75	3.54
13	5000	1556.87	103	180	-9	9.5	9.5	11.58	2.74	2.58	3.21
13	5000	1712.87	103	180	-9	9.5	9.5	12.45	3.58	3.45	2.92
13	5000	1874.24	103	180	-9	9.5	9.5	13.35	4.46	4.35	2.67
13	5000	2042.07	103	180	-9	9.5	9.5	14.28	5.38	5.28	2.45
13	5000	2472.7	103	180	-9	9.5	9.5	16.68	7.74	7.68	2.02
14	5000	1208.18	137	155.88	-9	9.5	9.5	9.48	0.75	0.48	4.14
14	5000	1305.74	137	159.59	-9	9.5	9.5	10.1	1.33	1.1	3.83
14	5000	1423.28	137	163.95	-9	9.5	9.5	10.83	2.02	1.83	3.51
14	5000	1567.99	137	180	-9	9.5	9.5	11.64	2.8	2.64	3.19
14	5000	1720.99	137	180	-9	9.5	9.5	12.49	3.63	3.49	2.91
14	5000	1881.71	137	180	-9	9.5	9.5	13.39	4.5	4.39	2.66
14	5000	2047.65	137	180	-9	9.5	9.5	14.31	5.4	5.31	2.44
14	5000	2477.62	137	180	-9	9.5	9.5	16.69	7.75	7.69	2.02

15	5000	1212.1	33	156.03	-9	9.5	9.5	9.51	0.77	0.51	4.13
15	5000	1308.95	33	159.71	-9	9.5	9.5	10.12	1.35	1.12	3.82
15	5000	1425.87	33	164.05	-9	9.5	9.5	10.84	2.03	1.84	3.51
15	5000	1570.19	33	180	-9	9.5	9.5	11.66	2.81	2.66	3.18
15	5000	1724.51	33	180	-9	9.5	9.5	12.51	3.64	3.51	2.9
15	5000	1889.14	33	180	-9	9.5	9.5	13.43	4.54	4.43	2.65
15	5000	2058.17	33	180	-9	9.5	9.5	14.37	5.46	5.37	2.43
15	5000	2490.67	33	180	-9	9.5	9.5	16.77	7.83	7.77	2.01
16	5000	1943.49	26.48	229.64	-9	9.5	9.5	9.69	0.79	0.69	2.57
16	5000	2078.84	26.48	233.15	-9	9.5	9.5	10.27	1.36	1.27	2.41
16	5000	2242.52	26.48	237.32	-9	9.5	9.5	10.97	2.05	1.97	2.23
16	5000	2441.83	26.48	252.5	-9	9.5	9.5	11.76	2.83	2.76	2.05
16	5000	2653.38	26.48	252.5	-9	9.5	9.5	12.6	3.65	3.6	1.88
16	5000	2880.43	26.48	252.5	-9	9.5	9.5	13.5	4.55	4.5	1.74
16	5000	3114.55	26.48	252.5	-9	9.5	9.5	14.43	5.47	5.43	1.61
16	5000	3716.32	26.48	252.5	-9	9.5	9.5	16.81	7.84	7.81	1.35
17	5000	2315.89	75	267.34	-9	9.5	9.5	9.73	0.81	0.73	2.16
17	5000	2471.8	75	270.82	-9	9.5	9.5	10.31	1.38	1.31	2.02
17	5000	2660.29	75	274.96	-9	9.5	9.5	11	2.06	2	1.88
17	5000	2888.47	75	290	-9	9.5	9.5	11.79	2.83	2.79	1.73
17	5000	3130.3	75	290	-9	9.5	9.5	12.62	3.66	3.62	1.6
17	5000	3390.2	75	290	-9	9.5	9.5	13.52	4.55	4.52	1.47
17	5000	3657.13	75	290	-9	9.5	9.5	14.44	5.47	5.44	1.37
17	5000	4347.56	75	290	-9	9.5	9.5	16.82	7.84	7.82	1.15
18	5000	2320.89	70	267.45	-9	9.5	9.5	9.74	0.81	0.74	2.15
18	5000	2476.21	70	270.92	-9	9.5	9.5	10.32	1.38	1.32	2.02
18	5000	2664.21	70	290	-9	9.5	9.5	11.01	2.06	2.01	1.88
18	5000	2891.8	70	290	-9	9.5	9.5	11.79	2.84	2.79	1.73
18	5000	3133.09	70	290	-9	9.5	9.5	12.62	3.66	3.62	1.6
18	5000	3392.54	70	290	-9	9.5	9.5	13.52	4.55	4.52	1.47
18	5000	3660.4	70	290	-9	9.5	9.5	14.44	5.47	5.44	1.37
18	5000	4349.87	70	290	-9	9.5	9.5	16.82	7.84	7.82	1.15

RUN 7 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.03 0.6 0.8
INPUT FILE NAME: DI5K-9M7.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.01	-0.47	-0.99	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.98	0.4	-0.02	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.97	1.31	0.97	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.24	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.96	3.2	2.96	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	924.4	33.2	113.5	-9	9.5	9.5	8.14	-0.4	-0.86	5.41
4	5000	1030.77	33.2	113.5	-9	9.5	9.5	9.08	0.45	0.08	4.85
4	5000	1140.24	33.2	113.5	-9	9.5	9.5	10.05	1.34	1.05	4.39
4	5000	1251.32	33.2	113.5	-9	9.5	9.5	11.02	2.27	2.02	4
4	5000	1363.16	33.2	113.5	-9	9.5	9.5	12.01	3.22	3.01	3.67
4	5000	1475.65	33.2	113.5	-9	9.5	9.5	13	4.18	4	3.39
4	5000	1588.55	33.2	113.5	-9	9.5	9.5	14	5.15	5	3.15
4	5000	1871.69	33.2	113.5	-9	9.5	9.5	16.49	7.6	7.49	2.67

5	5000	1003.45	49	121	-9	9.5	9.5	8.29	-0.32	-0.71	4.98
5	5000	1112.2	49	121	-9	9.5	9.5	9.19	0.51	0.19	4.5
5	5000	1225.82	49	121	-9	9.5	9.5	10.13	1.39	1.13	4.08
5	5000	1342.12	49	121	-9	9.5	9.5	11.09	2.31	2.09	3.73
5	5000	1459.83	49	121	-9	9.5	9.5	12.06	3.25	3.06	3.43
5	5000	1578.62	49	121	-9	9.5	9.5	13.05	4.2	4.05	3.17
5	5000	1698.12	49	121	-9	9.5	9.5	14.03	5.17	5.03	2.94
5	5000	1998.54	49	121	-9	9.5	9.5	16.52	7.61	7.52	2.5
6	5000	1114.09	48.7	132	-9	9.5	9.5	8.44	-0.25	-0.56	4.49
6	5000	1228.19	48.7	132	-9	9.5	9.5	9.3	0.56	0.3	4.07
6	5000	1348.95	48.7	132	-9	9.5	9.5	10.22	1.43	1.22	3.71
6	5000	1473.54	48.7	132	-9	9.5	9.5	11.16	2.34	2.16	3.39
6	5000	1600.27	48.7	132	-9	9.5	9.5	12.12	3.27	3.12	3.12
6	5000	1728.59	48.7	132	-9	9.5	9.5	13.1	4.23	4.1	2.89
6	5000	1857.98	48.7	132	-9	9.5	9.5	14.08	5.19	5.08	2.69
6	5000	2184.04	48.7	132	-9	9.5	9.5	16.55	7.63	7.55	2.29
7	5000	1270.24	56.6	148	-9	9.5	9.5	8.58	-0.18	-0.42	3.94
7	5000	1393.64	56.6	148	-9	9.5	9.5	9.42	0.62	0.42	3.59
7	5000	1525.71	56.6	148	-9	9.5	9.5	10.31	1.48	1.31	3.28
7	5000	1662.93	56.6	148	-9	9.5	9.5	11.24	2.38	2.24	3.01
7	5000	1803.17	56.6	148	-9	9.5	9.5	12.18	3.3	3.18	2.77
7	5000	1945.63	56.6	148	-9	9.5	9.5	13.15	4.25	4.15	2.57
7	5000	2089.59	56.6	148	-9	9.5	9.5	14.12	5.21	5.12	2.39
7	5000	2453.27	56.6	148	-9	9.5	9.5	16.58	7.64	7.58	2.04
8	5000	1409.67	53.8	162.5	-9	9.5	9.5	8.67	-0.13	-0.33	3.55
8	5000	1542.11	53.8	162.5	-9	9.5	9.5	9.49	0.65	0.49	3.24
8	5000	1684.8	53.8	162.5	-9	9.5	9.5	10.37	1.5	1.37	2.97
8	5000	1833.71	53.8	162.5	-9	9.5	9.5	11.28	2.4	2.28	2.73
8	5000	1986.36	53.8	162.5	-9	9.5	9.5	12.22	3.32	3.22	2.52
8	5000	2141.75	53.8	162.5	-9	9.5	9.5	13.18	4.26	4.18	2.33
8	5000	2299.01	53.8	162.5	-9	9.5	9.5	14.15	5.22	5.15	2.17
8	5000	2695.53	53.8	162.5	-9	9.5	9.5	16.6	7.65	7.6	1.85
9	5000	1514.87	47.7	173.5	-9	9.5	9.5	8.73	-0.1	-0.27	3.3
9	5000	1654.33	47.7	173.5	-9	9.5	9.5	9.54	0.68	0.54	3.02
9	5000	1805.17	47.7	173.5	-9	9.5	9.5	10.4	1.52	1.4	2.77
9	5000	1963.02	47.7	173.5	-9	9.5	9.5	11.31	2.41	2.31	2.55
9	5000	2123.45	47.7	173.5	-9	9.5	9.5	12.25	3.33	3.25	2.35
9	5000	2288.92	47.7	173.5	-9	9.5	9.5	13.2	4.27	4.2	2.18
9	5000	2456.48	47.7	173.5	-9	9.5	9.5	14.17	5.23	5.17	2.04
9	5000	2880.76	47.7	173.5	-9	9.5	9.5	16.61	7.66	7.61	1.74

10	5000	1575.53	40.9	180	-9	9.5	9.5	8.76	-0.08	-0.24	3.17
10	5000	1719.38	40.9	180	-9	9.5	9.5	9.56	0.69	0.56	2.91
10	5000	1875.24	40.9	180	-9	9.5	9.5	10.42	1.54	1.42	2.67
10	5000	2038.52	40.9	180	-9	9.5	9.5	11.33	2.42	2.33	2.45
10	5000	2205.46	40.9	180	-9	9.5	9.5	12.26	3.34	3.26	2.27
10	5000	2376.73	40.9	180	-9	9.5	9.5	13.21	4.28	4.21	2.1
10	5000	2550.25	40.9	180	-9	9.5	9.5	14.18	5.23	5.18	1.96
10	5000	2989.9	40.9	180	-9	9.5	9.5	16.62	7.66	7.62	1.67
11	5000	1578.97	35	180	-9	9.5	9.5	8.77	-0.07	-0.23	3.17
11	5000	1722.11	35	180	-9	9.5	9.5	9.57	0.7	0.57	2.9
11	5000	1877.41	35	180	-9	9.5	9.5	10.43	1.54	1.43	2.66
11	5000	2040.28	35	180	-9	9.5	9.5	11.33	2.43	2.33	2.45
11	5000	2207.76	35	180	-9	9.5	9.5	12.27	3.35	3.27	2.26
11	5000	2378.66	35	180	-9	9.5	9.5	13.21	4.28	4.21	2.1
11	5000	2551.9	35	180	-9	9.5	9.5	14.18	5.24	5.18	1.96
11	5000	2991.05	35	180	-9	9.5	9.5	16.62	7.66	7.62	1.67
12	5000	1082.74	33.1	150.98	-9	9.5	9.5	8.66	-0.01	-0.34	4.62
12	5000	1208.56	33.1	155.9	-9	9.5	9.5	9.48	0.75	0.48	4.14
12	5000	1348.43	33.1	161.19	-9	9.5	9.5	10.36	1.58	1.36	3.71
12	5000	1503.4	33.1	180	-9	9.5	9.5	11.29	2.46	2.29	3.33
12	5000	1673.1	33.1	180	-9	9.5	9.5	12.23	3.37	3.23	2.99
12	5000	1845.53	33.1	180	-9	9.5	9.5	13.19	4.3	4.19	2.71
12	5000	2019.87	33.1	180	-9	9.5	9.5	14.15	5.25	5.15	2.48
12	5000	2461.98	33.1	180	-9	9.5	9.5	16.6	7.67	7.6	2.03
13	5000	1093.71	103	151.41	-9	9.5	9.5	8.74	0.06	-0.26	4.57
13	5000	1215.13	103	156.15	-9	9.5	9.5	9.53	0.8	0.53	4.11
13	5000	1353.36	103	161.37	-9	9.5	9.5	10.4	1.61	1.4	3.69
13	5000	1506.98	103	180	-9	9.5	9.5	11.31	2.49	2.31	3.32
13	5000	1675.71	103	180	-9	9.5	9.5	12.25	3.39	3.25	2.98
13	5000	1847.49	103	180	-9	9.5	9.5	13.2	4.31	4.2	2.71
13	5000	2021.38	103	180	-9	9.5	9.5	14.17	5.26	5.17	2.47
13	5000	2461.55	103	180	-9	9.5	9.5	16.61	7.67	7.61	2.03
14	5000	1106.9	137	151.93	-9	9.5	9.5	8.83	0.15	-0.17	4.52
14	5000	1226.4	137	156.58	-9	9.5	9.5	9.6	0.86	0.6	4.08
14	5000	1361.77	137	161.69	-9	9.5	9.5	10.45	1.66	1.45	3.67
14	5000	1515.36	137	180	-9	9.5	9.5	11.35	2.52	2.35	3.3
14	5000	1681.57	137	180	-9	9.5	9.5	12.28	3.41	3.28	2.97
14	5000	1851.72	137	180	-9	9.5	9.5	13.22	4.33	4.22	2.7
14	5000	2024.51	137	180	-9	9.5	9.5	14.18	5.28	5.18	2.47
14	5000	2463.17	137	180	-9	9.5	9.5	16.62	7.68	7.62	2.03

15	5000	1113.37	33	152.19	-9	9.5	9.5	8.86	0.18	-0.14	4.49
15	5000	1231.19	33	156.76	-9	9.5	9.5	9.63	0.88	0.63	4.06
15	5000	1365.24	33	161.81	-9	9.5	9.5	10.47	1.68	1.47	3.66
15	5000	1518.22	33	180	-9	9.5	9.5	11.37	2.54	2.37	3.29
15	5000	1684.19	33	180	-9	9.5	9.5	12.29	3.43	3.29	2.97
15	5000	1858.63	33	180	-9	9.5	9.5	13.26	4.37	4.26	2.69
15	5000	2034.71	33	180	-9	9.5	9.5	14.24	5.33	5.24	2.46
15	5000	2478.03	33	180	-9	9.5	9.5	16.7	7.76	7.7	2.02
16	5000	1806.13	26.48	226.02	-9	9.5	9.5	9.09	0.21	0.09	2.77
16	5000	1970.12	26.48	230.33	-9	9.5	9.5	9.81	0.91	0.81	2.54
16	5000	2157.64	26.48	235.17	-9	9.5	9.5	10.61	1.69	1.61	2.32
16	5000	2370.99	26.48	252.5	-9	9.5	9.5	11.48	2.55	2.48	2.11
16	5000	2597.96	26.48	252.5	-9	9.5	9.5	12.38	3.44	3.38	1.92
16	5000	2838.27	26.48	252.5	-9	9.5	9.5	13.33	4.38	4.33	1.76
16	5000	3082.02	26.48	252.5	-9	9.5	9.5	14.3	5.34	5.3	1.62
16	5000	3698.69	26.48	252.5	-9	9.5	9.5	16.74	7.77	7.74	1.35
17	5000	2160.45	75	263.83	-9	9.5	9.5	9.14	0.22	0.14	2.31
17	5000	2346.57	75	268.03	-9	9.5	9.5	9.85	0.92	0.85	2.13
17	5000	2562.55	75	272.82	-9	9.5	9.5	10.65	1.7	1.65	1.95
17	5000	2807.58	75	290	-9	9.5	9.5	11.51	2.56	2.51	1.78
17	5000	3066.91	75	290	-9	9.5	9.5	12.4	3.44	3.4	1.63
17	5000	3341.93	75	290	-9	9.5	9.5	13.35	4.38	4.35	1.5
17	5000	3619.82	75	290	-9	9.5	9.5	14.31	5.34	5.31	1.38
17	5000	4327.32	75	290	-9	9.5	9.5	16.75	7.77	7.75	1.16
18	5000	2163.53	70	263.9	-9	9.5	9.5	9.15	0.23	0.15	2.31
18	5000	2351.44	70	268.14	-9	9.5	9.5	9.86	0.93	0.86	2.13
18	5000	2566.65	70	272.91	-9	9.5	9.5	10.65	1.71	1.65	1.95
18	5000	2811.11	70	290	-9	9.5	9.5	11.51	2.56	2.51	1.78
18	5000	3069.83	70	290	-9	9.5	9.5	12.41	3.45	3.41	1.63
18	5000	3344.34	70	290	-9	9.5	9.5	13.35	4.39	4.35	1.5
18	5000	3623.17	70	290	-9	9.5	9.5	14.31	5.34	5.31	1.38
18	5000	4329.65	70	290	-9	9.5	9.5	16.75	7.77	7.75	1.15

RUN 8 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.04 0.6 0.8
INPUT FILE NAME: DI5K-9M8.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	865.17	100	108	-9	9.5	9.5	8.02	-0.46	-0.98	5.78
3	5000	970.53	100	108	-9	9.5	9.5	8.99	0.4	-0.01	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.31	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.96	4.16	3.96	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.96	5.14	4.96	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	928.75	33.2	113.5	-9	9.5	9.5	8.18	-0.37	-0.82	5.38
4	5000	1033.66	33.2	113.5	-9	9.5	9.5	9.11	0.47	0.11	4.84
4	5000	1142.26	33.2	113.5	-9	9.5	9.5	10.06	1.36	1.06	4.38
4	5000	1252.79	33.2	113.5	-9	9.5	9.5	11.04	2.29	2.04	3.99
4	5000	1364.27	33.2	113.5	-9	9.5	9.5	12.02	3.23	3.02	3.66
4	5000	1476.5	33.2	113.5	-9	9.5	9.5	13.01	4.19	4.01	3.39
4	5000	1589.23	33.2	113.5	-9	9.5	9.5	14	5.16	5	3.15
4	5000	1872.09	33.2	113.5	-9	9.5	9.5	16.49	7.6	7.49	2.67

5	5000	1011.96	49	121	-9	9.5	9.5	8.36	-0.26	-0.64	4.94
5	5000	1118.03	49	121	-9	9.5	9.5	9.24	0.55	0.24	4.47
5	5000	1229.97	49	121	-9	9.5	9.5	10.17	1.42	1.17	4.07
5	5000	1345.17	49	121	-9	9.5	9.5	11.12	2.33	2.12	3.72
5	5000	1462.14	49	121	-9	9.5	9.5	12.08	3.27	3.08	3.42
5	5000	1580.41	49	121	-9	9.5	9.5	13.06	4.22	4.06	3.16
5	5000	1699.54	49	121	-9	9.5	9.5	14.05	5.18	5.05	2.94
5	5000	1999.39	49	121	-9	9.5	9.5	16.52	7.62	7.52	2.5
6	5000	1126.39	48.7	132	-9	9.5	9.5	8.53	-0.16	-0.47	4.44
6	5000	1236.82	48.7	132	-9	9.5	9.5	9.37	0.62	0.37	4.04
6	5000	1355.17	48.7	132	-9	9.5	9.5	10.27	1.48	1.27	3.69
6	5000	1478.15	48.7	132	-9	9.5	9.5	11.2	2.38	2.2	3.38
6	5000	1603.78	48.7	132	-9	9.5	9.5	12.15	3.3	3.15	3.12
6	5000	1731.33	48.7	132	-9	9.5	9.5	13.12	4.25	4.12	2.89
6	5000	1860.15	48.7	132	-9	9.5	9.5	14.09	5.2	5.09	2.69
6	5000	2185.35	48.7	132	-9	9.5	9.5	16.56	7.64	7.56	2.29
7	5000	1286.73	56.6	148	-9	9.5	9.5	8.69	-0.07	-0.31	3.89
7	5000	1405.44	56.6	148	-9	9.5	9.5	9.5	0.69	0.5	3.56
7	5000	1534.33	56.6	148	-9	9.5	9.5	10.37	1.53	1.37	3.26
7	5000	1669.37	56.6	148	-9	9.5	9.5	11.28	2.42	2.28	3
7	5000	1808.1	56.6	148	-9	9.5	9.5	12.22	3.34	3.22	2.77
7	5000	1949.48	56.6	148	-9	9.5	9.5	13.17	4.27	4.17	2.56
7	5000	2092.65	56.6	148	-9	9.5	9.5	14.14	5.23	5.14	2.39
7	5000	2455.12	56.6	148	-9	9.5	9.5	16.59	7.65	7.59	2.04
8	5000	1429.87	53.8	162.5	-9	9.5	9.5	8.8	-0.01	-0.2	3.5
8	5000	1556.75	53.8	162.5	-9	9.5	9.5	9.58	0.74	0.58	3.21
8	5000	1695.58	53.8	162.5	-9	9.5	9.5	10.43	1.57	1.43	2.95
8	5000	1841.82	53.8	162.5	-9	9.5	9.5	11.33	2.45	2.33	2.71
8	5000	1992.59	53.8	162.5	-9	9.5	9.5	12.26	3.36	3.26	2.51
8	5000	2146.62	53.8	162.5	-9	9.5	9.5	13.21	4.29	4.21	2.33
8	5000	2302.89	53.8	162.5	-9	9.5	9.5	14.17	5.24	5.17	2.17
8	5000	2697.93	53.8	162.5	-9	9.5	9.5	16.61	7.66	7.61	1.85
9	5000	1538.07	47.7	173.5	-9	9.5	9.5	8.86	0.03	-0.14	3.25
9	5000	1671.27	47.7	173.5	-9	9.5	9.5	9.63	0.77	0.63	2.99
9	5000	1817.71	47.7	173.5	-9	9.5	9.5	10.48	1.59	1.48	2.75
9	5000	1972.48	47.7	173.5	-9	9.5	9.5	11.37	2.47	2.37	2.53
9	5000	2130.81	47.7	173.5	-9	9.5	9.5	12.29	3.38	3.29	2.35
9	5000	2294.69	47.7	173.5	-9	9.5	9.5	13.23	4.31	4.23	2.18
9	5000	2461.08	47.7	173.5	-9	9.5	9.5	14.19	5.26	5.19	2.03
9	5000	2882.69	47.7	173.5	-9	9.5	9.5	16.62	7.67	7.62	1.73

10	5000	1601.05	40.9	180	-9	9.5	9.5	8.9	0.06	-0.1	3.12
10	5000	1738.1	40.9	180	-9	9.5	9.5	9.66	0.79	0.66	2.88
10	5000	1889.14	40.9	180	-9	9.5	9.5	10.5	1.61	1.5	2.65
10	5000	2049.03	40.9	180	-9	9.5	9.5	11.39	2.48	2.39	2.44
10	5000	2213.59	40.9	180	-9	9.5	9.5	12.31	3.39	3.31	2.26
10	5000	2383.11	40.9	180	-9	9.5	9.5	13.25	4.32	4.25	2.1
10	5000	2555.34	40.9	180	-9	9.5	9.5	14.2	5.26	5.2	1.96
10	5000	2992.98	40.9	180	-9	9.5	9.5	16.63	7.68	7.63	1.67
11	5000	1605.55	35	180	-9	9.5	9.5	8.92	0.07	-0.08	3.11
11	5000	1741.66	35	180	-9	9.5	9.5	9.68	0.8	0.68	2.87
11	5000	1891.96	35	180	-9	9.5	9.5	10.51	1.62	1.51	2.64
11	5000	2051.29	35	180	-9	9.5	9.5	11.4	2.49	2.4	2.44
11	5000	2216.27	35	180	-9	9.5	9.5	12.31	3.39	3.31	2.26
11	5000	2385.34	35	180	-9	9.5	9.5	13.25	4.32	4.25	2.1
11	5000	2557.23	35	180	-9	9.5	9.5	14.21	5.27	5.21	1.96
11	5000	2994.29	35	180	-9	9.5	9.5	16.63	7.68	7.63	1.67
12	5000	1107.4	33.1	151.95	-9	9.5	9.5	8.83	0.14	-0.17	4.52
12	5000	1227.12	33.1	156.61	-9	9.5	9.5	9.6	0.86	0.6	4.07
12	5000	1362.61	33.1	161.72	-9	9.5	9.5	10.45	1.66	1.45	3.67
12	5000	1515.36	33.1	180	-9	9.5	9.5	11.35	2.52	2.35	3.3
12	5000	1682.26	33.1	180	-9	9.5	9.5	12.28	3.42	3.28	2.97
12	5000	1852.7	33.1	180	-9	9.5	9.5	13.23	4.34	4.23	2.7
12	5000	2025.57	33.1	180	-9	9.5	9.5	14.19	5.28	5.19	2.47
12	5000	2465.38	33.1	180	-9	9.5	9.5	16.62	7.69	7.62	2.03
13	5000	1125.5	103	152.67	-9	9.5	9.5	8.94	0.25	-0.06	4.44
13	5000	1240.7	103	157.13	-9	9.5	9.5	9.69	0.94	0.69	4.03
13	5000	1371.14	103	162.03	-9	9.5	9.5	10.52	1.72	1.52	3.65
13	5000	1522.98	103	180	-9	9.5	9.5	11.4	2.57	2.4	3.28
13	5000	1687.76	103	180	-9	9.5	9.5	12.32	3.45	3.32	2.96
13	5000	1856.14	103	180	-9	9.5	9.5	13.25	4.36	4.25	2.69
13	5000	2028.22	103	180	-9	9.5	9.5	14.21	5.3	5.21	2.47
13	5000	2465.63	103	180	-9	9.5	9.5	16.63	7.7	7.63	2.03
14	5000	1143.12	137	153.36	-9	9.5	9.5	9.06	0.36	0.06	4.37
14	5000	1254	137	157.64	-9	9.5	9.5	9.77	1.02	0.77	3.99
14	5000	1384.35	137	162.52	-9	9.5	9.5	10.58	1.78	1.58	3.61
14	5000	1534.82	137	180	-9	9.5	9.5	11.45	2.62	2.45	3.26
14	5000	1696.11	137	180	-9	9.5	9.5	12.35	3.49	3.35	2.95
14	5000	1863.54	137	180	-9	9.5	9.5	13.28	4.39	4.28	2.68
14	5000	2033.73	137	180	-9	9.5	9.5	14.23	5.32	5.23	2.46
14	5000	2468.51	137	180	-9	9.5	9.5	16.64	7.71	7.64	2.03

15	5000	1147.71	33	153.54	-9	9.5	9.5	9.09	0.38	0.09	4.36
15	5000	1257.57	33	157.77	-9	9.5	9.5	9.8	1.04	0.8	3.98
15	5000	1385.77	33	162.57	-9	9.5	9.5	10.6	1.8	1.6	3.61
15	5000	1535.85	33	180	-9	9.5	9.5	11.47	2.63	2.47	3.26
15	5000	1697.91	33	180	-9	9.5	9.5	12.37	3.5	3.37	2.94
15	5000	1869.13	33	180	-9	9.5	9.5	13.32	4.43	4.32	2.68
15	5000	2042.89	33	180	-9	9.5	9.5	14.28	5.38	5.28	2.45
15	5000	2482.63	33	180	-9	9.5	9.5	16.73	7.79	7.73	2.01
16	5000	1853.8	26.48	227.28	-9	9.5	9.5	9.3	0.41	0.3	2.7
16	5000	2006.98	26.48	231.29	-9	9.5	9.5	9.97	1.06	0.97	2.49
16	5000	2186.38	26.48	235.9	-9	9.5	9.5	10.73	1.81	1.73	2.29
16	5000	2394.99	26.48	252.5	-9	9.5	9.5	11.58	2.64	2.58	2.09
16	5000	2616.81	26.48	252.5	-9	9.5	9.5	12.45	3.51	3.45	1.91
16	5000	2852.78	26.48	252.5	-9	9.5	9.5	13.39	4.44	4.39	1.75
16	5000	3093.36	26.48	252.5	-9	9.5	9.5	14.34	5.38	5.34	1.62
16	5000	3705.11	26.48	252.5	-9	9.5	9.5	16.76	7.79	7.76	1.35
17	5000	2212.61	75	265.01	-9	9.5	9.5	9.35	0.42	0.35	2.26
17	5000	2389.03	75	268.98	-9	9.5	9.5	10.01	1.07	1.01	2.09
17	5000	2595.66	75	273.55	-9	9.5	9.5	10.77	1.82	1.77	1.93
17	5000	2834.98	75	290	-9	9.5	9.5	11.6	2.65	2.6	1.76
17	5000	3088.48	75	290	-9	9.5	9.5	12.48	3.52	3.48	1.62
17	5000	3358.54	75	290	-9	9.5	9.5	13.41	4.44	4.41	1.49
17	5000	3632.83	75	290	-9	9.5	9.5	14.36	5.39	5.36	1.38
17	5000	4334.69	75	290	-9	9.5	9.5	16.77	7.8	7.77	1.15
18	5000	2218.07	70	265.14	-9	9.5	9.5	9.35	0.43	0.35	2.25
18	5000	2393.73	70	269.08	-9	9.5	9.5	10.01	1.08	1.01	2.09
18	5000	2599.65	70	273.64	-9	9.5	9.5	10.77	1.83	1.77	1.92
18	5000	2838.44	70	290	-9	9.5	9.5	11.61	2.66	2.61	1.76
18	5000	3091.35	70	290	-9	9.5	9.5	12.48	3.52	3.48	1.62
18	5000	3360.93	70	290	-9	9.5	9.5	13.41	4.44	4.41	1.49
18	5000	3636.15	70	290	-9	9.5	9.5	14.36	5.39	5.36	1.38
18	5000	4337.01	70	290	-9	9.5	9.5	16.78	7.8	7.78	1.15

RUN 9 - SUMMARY OUTPUT
Date: 3/2/98
COUSINS DISCHARGE CHANNEL
SENSITIVITY ANALYSIS
NC RECORD BEFORE BEND AND BRIDGE 0.08 0.08 0.06 0.6 0.8
INPUT FILE NAME: DI5K-9M9.DAT

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH
1	5000	984	0	147	-9	9.5	9.5	8	-0.6	-1	5.08
1	5000	1134	0	153	-9	9.5	9.5	9	0.3	0	4.41
1	5000	1290	0	159	-9	9.5	9.5	10	1.23	1	3.88
1	5000	1452	0	165	-9	9.5	9.5	11	2.18	2	3.44
1	5000	1632	0	180	-9	9.5	9.5	12	3.15	3	3.06
1	5000	1812	0	180	-9	9.5	9.5	13	4.12	4	2.76
1	5000	1992	0	180	-9	9.5	9.5	14	5.1	5	2.51
1	5000	2442	0	180	-9	9.5	9.5	16.5	7.57	7.5	2.05
2	5000	859.35	111.61	108	-9	9.5	9.5	7.96	-0.52	-1.04	5.82
2	5000	966.66	111.61	108	-9	9.5	9.5	8.95	0.37	-0.05	5.17
2	5000	1074.51	111.61	108	-9	9.5	9.5	9.95	1.29	0.95	4.65
2	5000	1182.61	111.61	108	-9	9.5	9.5	10.95	2.23	1.95	4.23
2	5000	1290.68	111.61	108	-9	9.5	9.5	11.95	3.18	2.95	3.87
2	5000	1398.91	111.61	108	-9	9.5	9.5	12.95	4.15	3.95	3.57
2	5000	1507.23	111.61	108	-9	9.5	9.5	13.96	5.13	4.96	3.32
2	5000	1778.07	111.61	108	-9	9.5	9.5	16.46	7.59	7.46	2.81
3	5000	867.44	100	108	-9	9.5	9.5	8.03	-0.45	-0.97	5.76
3	5000	971.1	100	108	-9	9.5	9.5	9	0.41	0	5.15
3	5000	1077.19	100	108	-9	9.5	9.5	9.98	1.32	0.98	4.64
3	5000	1184.53	100	108	-9	9.5	9.5	10.97	2.25	1.97	4.22
3	5000	1292.16	100	108	-9	9.5	9.5	11.97	3.2	2.97	3.87
3	5000	1399.99	100	108	-9	9.5	9.5	12.97	4.16	3.97	3.57
3	5000	1508.04	100	108	-9	9.5	9.5	13.97	5.14	4.97	3.32
3	5000	1778.51	100	108	-9	9.5	9.5	16.47	7.59	7.47	2.81
4	5000	939.2	33.2	113.5	-9	9.5	9.5	8.27	-0.29	-0.73	5.32
4	5000	1040.72	33.2	113.5	-9	9.5	9.5	9.17	0.53	0.17	4.8
4	5000	1147.23	33.2	113.5	-9	9.5	9.5	10.11	1.4	1.11	4.36
4	5000	1256.43	33.2	113.5	-9	9.5	9.5	11.07	2.32	2.07	3.98
4	5000	1367.01	33.2	113.5	-9	9.5	9.5	12.04	3.25	3.04	3.66
4	5000	1478.62	33.2	113.5	-9	9.5	9.5	13.03	4.21	4.03	3.38
4	5000	1590.9	33.2	113.5	-9	9.5	9.5	14.02	5.17	5.02	3.14
4	5000	1873.09	33.2	113.5	-9	9.5	9.5	16.5	7.61	7.5	2.67

5	5000	1033.39	49	121	-9	9.5	9.5	8.54	-0.1	-0.46	4.84
5	5000	1133.1	49	121	-9	9.5	9.5	9.36	0.67	0.36	4.41
5	5000	1240.83	49	121	-9	9.5	9.5	10.25	1.51	1.25	4.03
5	5000	1353.21	49	121	-9	9.5	9.5	11.18	2.4	2.18	3.69
5	5000	1468.25	49	121	-9	9.5	9.5	12.13	3.31	3.13	3.41
5	5000	1585.17	49	121	-9	9.5	9.5	13.1	4.26	4.1	3.15
5	5000	1703.32	49	121	-9	9.5	9.5	14.08	5.21	5.08	2.94
5	5000	2000.46	49	121	-9	9.5	9.5	16.54	7.64	7.54	2.5
6	5000	1157.47	48.7	132	-9	9.5	9.5	8.77	0.06	-0.23	4.32
6	5000	1259.29	48.7	132	-9	9.5	9.5	9.54	0.78	0.54	3.97
6	5000	1371.66	48.7	132	-9	9.5	9.5	10.39	1.6	1.39	3.65
6	5000	1490.5	48.7	132	-9	9.5	9.5	11.29	2.47	2.29	3.35
6	5000	1613.24	48.7	132	-9	9.5	9.5	12.22	3.37	3.22	3.1
6	5000	1738.72	48.7	132	-9	9.5	9.5	13.17	4.3	4.17	2.88
6	5000	1866.03	48.7	132	-9	9.5	9.5	14.14	5.25	5.14	2.68
6	5000	2188.91	48.7	132	-9	9.5	9.5	16.58	7.66	7.58	2.28
7	5000	1328.38	56.6	148	-9	9.5	9.5	8.98	0.2	-0.02	3.76
7	5000	1436.22	56.6	148	-9	9.5	9.5	9.7	0.89	0.7	3.48
7	5000	1557.25	56.6	148	-9	9.5	9.5	10.52	1.68	1.52	3.21
7	5000	1686.71	56.6	148	-9	9.5	9.5	11.4	2.53	2.4	2.96
7	5000	1821.47	56.6	148	-9	9.5	9.5	12.31	3.42	3.31	2.75
7	5000	1959.97	56.6	148	-9	9.5	9.5	13.24	4.34	4.24	2.55
7	5000	2101.03	56.6	148	-9	9.5	9.5	14.2	5.28	5.2	2.38
7	5000	2460.21	56.6	148	-9	9.5	9.5	16.62	7.69	7.62	2.03
8	5000	1480.78	53.8	162.5	-9	9.5	9.5	9.11	0.29	0.11	3.38
8	5000	1594.89	53.8	162.5	-9	9.5	9.5	9.81	0.97	0.81	3.14
8	5000	1724.25	53.8	162.5	-9	9.5	9.5	10.61	1.74	1.61	2.9
8	5000	1863.65	53.8	162.5	-9	9.5	9.5	11.47	2.58	2.47	2.68
8	5000	2009.5	53.8	162.5	-9	9.5	9.5	12.37	3.46	3.37	2.49
8	5000	2159.94	53.8	162.5	-9	9.5	9.5	13.29	4.38	4.29	2.31
8	5000	2311.89	53.8	162.5	-9	9.5	9.5	14.24	5.31	5.24	2.16
8	5000	2704.54	53.8	162.5	-9	9.5	9.5	16.65	7.7	7.65	1.85
9	5000	1596.41	47.7	173.5	-9	9.5	9.5	9.2	0.35	0.2	3.13
9	5000	1715.35	47.7	173.5	-9	9.5	9.5	9.89	1.02	0.89	2.91
9	5000	1851.05	47.7	173.5	-9	9.5	9.5	10.67	1.78	1.67	2.7
9	5000	1996.38	47.7	173.5	-9	9.5	9.5	11.52	2.61	2.52	2.5
9	5000	2150.83	47.7	173.5	-9	9.5	9.5	12.4	3.49	3.4	2.32
9	5000	2310.47	47.7	173.5	-9	9.5	9.5	13.32	4.4	4.32	2.16
9	5000	2473.71	47.7	173.5	-9	9.5	9.5	14.26	5.33	5.26	2.02
9	5000	2890.46	47.7	173.5	-9	9.5	9.5	16.67	7.72	7.67	1.73

10	5000	1665.11	40.9	180	-9	9.5	9.5	9.26	0.4	0.26	3
10	5000	1786.76	40.9	180	-9	9.5	9.5	9.93	1.05	0.93	2.8
10	5000	1926.08	40.9	180	-9	9.5	9.5	10.71	1.81	1.71	2.6
10	5000	2076.5	40.9	180	-9	9.5	9.5	11.55	2.64	2.55	2.41
10	5000	2235.74	40.9	180	-9	9.5	9.5	12.43	3.51	3.43	2.24
10	5000	2400.6	40.9	180	-9	9.5	9.5	13.34	4.41	4.34	2.08
10	5000	2569.37	40.9	180	-9	9.5	9.5	14.28	5.34	5.28	1.95
10	5000	3001.53	40.9	180	-9	9.5	9.5	16.68	7.72	7.68	1.67
11	5000	1672.12	35	180	-9	9.5	9.5	9.29	0.43	0.29	2.99
11	5000	1792.43	35	180	-9	9.5	9.5	9.96	1.08	0.96	2.79
11	5000	1930.62	35	180	-9	9.5	9.5	10.73	1.83	1.73	2.59
11	5000	2080.99	35	180	-9	9.5	9.5	11.56	2.65	2.56	2.4
11	5000	2239.42	35	180	-9	9.5	9.5	12.44	3.52	3.44	2.23
11	5000	2403.64	35	180	-9	9.5	9.5	13.35	4.42	4.35	2.08
11	5000	2571.91	35	180	-9	9.5	9.5	14.29	5.35	5.29	1.94
11	5000	3003.24	35	180	-9	9.5	9.5	16.68	7.73	7.68	1.66
12	5000	1169.34	33.1	154.38	-9	9.5	9.5	9.23	0.51	0.23	4.28
12	5000	1275.47	33.1	158.45	-9	9.5	9.5	9.91	1.15	0.91	3.92
12	5000	1400.41	33.1	163.11	-9	9.5	9.5	10.69	1.88	1.69	3.57
12	5000	1547.54	33.1	180	-9	9.5	9.5	11.53	2.69	2.53	3.23
12	5000	1707.2	33.1	180	-9	9.5	9.5	12.42	3.55	3.42	2.93
12	5000	1872.33	33.1	180	-9	9.5	9.5	13.34	4.45	4.34	2.67
12	5000	2041.28	33.1	180	-9	9.5	9.5	14.27	5.37	5.27	2.45
12	5000	2474.82	33.1	180	-9	9.5	9.5	16.68	7.74	7.68	2.02
13	5000	1203.5	103	155.7	-9	9.5	9.5	9.45	0.72	0.45	4.15
13	5000	1302.5	103	159.47	-9	9.5	9.5	10.08	1.31	1.08	3.84
13	5000	1421.48	103	163.89	-9	9.5	9.5	10.81	2.01	1.81	3.52
13	5000	1566.48	103	180	-9	9.5	9.5	11.64	2.79	2.64	3.19
13	5000	1720.98	103	180	-9	9.5	9.5	12.49	3.63	3.49	2.91
13	5000	1881.18	103	180	-9	9.5	9.5	13.39	4.5	4.39	2.66
13	5000	2048.05	103	180	-9	9.5	9.5	14.32	5.41	5.32	2.44
13	5000	2476.99	103	180	-9	9.5	9.5	16.7	7.76	7.7	2.02
14	5000	1223.05	137	156.45	-9	9.5	9.5	9.58	0.83	0.58	4.09
14	5000	1318.15	137	160.06	-9	9.5	9.5	10.18	1.4	1.18	3.79
14	5000	1433.79	137	164.34	-9	9.5	9.5	10.89	2.08	1.89	3.49
14	5000	1577.5	137	180	-9	9.5	9.5	11.7	2.85	2.7	3.17
14	5000	1729.05	137	180	-9	9.5	9.5	12.54	3.67	3.54	2.89
14	5000	1888.6	137	180	-9	9.5	9.5	13.43	4.53	4.43	2.65
14	5000	2053.61	137	180	-9	9.5	9.5	14.34	5.43	5.34	2.43
14	5000	2481.89	137	180	-9	9.5	9.5	16.71	7.78	7.71	2.01

15	5000	1226.84	33	156.6	-9	9.5	9.5	9.6	0.86	0.6	4.08
15	5000	1321.29	33	160.18	-9	9.5	9.5	10.2	1.42	1.2	3.78
15	5000	1436.34	33	164.43	-9	9.5	9.5	10.9	2.09	1.9	3.48
15	5000	1579.66	33	180	-9	9.5	9.5	11.71	2.86	2.71	3.17
15	5000	1732.79	33	180	-9	9.5	9.5	12.56	3.69	3.56	2.89
15	5000	1896.18	33	180	-9	9.5	9.5	13.47	4.58	4.47	2.64
15	5000	2064.22	33	180	-9	9.5	9.5	14.4	5.49	5.4	2.42
15	5000	2494.86	33	180	-9	9.5	9.5	16.79	7.86	7.79	2
16	5000	1964.05	26.48	230.18	-9	9.5	9.5	9.78	0.88	0.78	2.55
16	5000	2096.11	26.48	233.59	-9	9.5	9.5	10.35	1.44	1.35	2.39
16	5000	2257.66	26.48	252.5	-9	9.5	9.5	11.03	2.11	2.03	2.21
16	5000	2454.78	26.48	252.5	-9	9.5	9.5	11.81	2.88	2.81	2.04
16	5000	2664.76	26.48	252.5	-9	9.5	9.5	12.64	3.7	3.64	1.88
16	5000	2890.17	26.48	252.5	-9	9.5	9.5	13.54	4.58	4.54	1.73
16	5000	3122.95	26.48	252.5	-9	9.5	9.5	14.46	5.5	5.46	1.6
16	5000	3722.16	26.48	252.5	-9	9.5	9.5	16.83	7.86	7.83	1.34
17	5000	2339.58	75	267.87	-9	9.5	9.5	9.82	0.89	0.82	2.14
17	5000	2491.69	75	271.26	-9	9.5	9.5	10.38	1.45	1.38	2.01
17	5000	2678.17	75	290	-9	9.5	9.5	11.06	2.12	2.06	1.87
17	5000	2903.26	75	290	-9	9.5	9.5	11.84	2.88	2.84	1.72
17	5000	3143.33	75	290	-9	9.5	9.5	12.67	3.7	3.67	1.59
17	5000	3401.35	75	290	-9	9.5	9.5	13.55	4.59	4.55	1.47
17	5000	3666.76	75	290	-9	9.5	9.5	14.47	5.5	5.47	1.36
17	5000	4354.26	75	290	-9	9.5	9.5	16.84	7.86	7.84	1.15
18	5000	2344.48	70	267.98	-9	9.5	9.5	9.83	0.9	0.83	2.13
18	5000	2496.02	70	271.35	-9	9.5	9.5	10.39	1.45	1.39	2
18	5000	2682.29	70	290	-9	9.5	9.5	11.07	2.12	2.07	1.86
18	5000	2906.55	70	290	-9	9.5	9.5	11.84	2.89	2.84	1.72
18	5000	3146.09	70	290	-9	9.5	9.5	12.67	3.71	3.67	1.59
18	5000	3403.68	70	290	-9	9.5	9.5	13.56	4.59	4.56	1.47
18	5000	3670.01	70	290	-9	9.5	9.5	14.48	5.5	5.48	1.36
18	5000	4356.56	70	290	-9	9.5	9.5	16.84	7.86	7.84	1.15

COUSINS DISCHARGE CHANNEL

CASE 4

SUMMARY OUTPUT
Date: 4/13/98
COUSINS DISCHARGE CHANNEL
CULVERT AS PER COE DESIGN
INPUT FILE NAME: DICOE.DAT
DISCHARGE 5,000 cfs

SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	EG	CWSEL	VCH	
1	5000	1243	0	226	-6.5	9.5	9.5	5.5	-0.75	-1	4.02	
1	5000	1469	0	226	-6.5	9.5	9.5	6.5	0.18	0	3.4	
1	5000	1695	0	226	-6.5	9.5	9.5	7.5	1.14	1	2.95	
1	5000	1921	0	226	-6.5	9.5	9.5	8.5	2.11	2	2.6	
1	5000	2147	0	226	-6.5	9.5	9.5	9.5	3.08	3	2.33	
1	5000	2373	0	226	-6.5	9.5	9.5	10.5	4.07	4	2.11	
1	5000	2599	0	226	-6.5	9.5	9.5	11.5	5.06	5	1.92	
1	5000	3164	0	226	-6.5	9.5	9.5	14	7.54	7.5	1.58	
2	5000	1259.35	100	226	-6.5	9.5	9.5	5.58	-0.68	-0.92	3.97	
2	5000	1478.48	100	226	-6.5	9.5	9.5	6.54	0.22	0.04	3.38	
2	5000	1700.95	100	226	-6.5	9.5	9.5	7.53	1.16	1.03	2.94	
2	5000	1924.96	100	226	-6.5	9.5	9.5	8.52	2.12	2.02	2.6	
2	5000	2149.76	100	226	-6.5	9.5	9.5	9.51	3.1	3.01	2.33	
2	5000	2375	100	226	-6.5	9.5	9.5	10.51	4.08	4.01	2.11	
2	5000	2600.49	100	226	-6.5	9.5	9.5	11.51	5.06	5.01	1.92	
2	5000	3164.8	100	226	-6.5	9.5	9.5	14	7.54	7.5	1.58	
3	5000	752.45	10	152.52	-6.5	9.5	9.5	5.36	-0.45	-1.14	6.64	CULVERT
3	5000	913.43	10	157.27	-6.5	9.5	9.5	6.4	0.37	-0.1	5.47	BEGINS
3	5000	1077.09	10	161.96	-6.5	9.5	9.5	7.43	1.26	0.93	4.64	
3	5000	1244.2	10	166.61	-6.5	9.5	9.5	8.45	2.2	1.95	4.02	
3	5000	1415.18	10	171.24	-6.5	9.5	9.5	9.46	3.15	2.96	3.53	
3	5000	1590.22	10	175.85	-6.5	9.5	9.5	10.47	4.12	3.97	3.14	
3	5000	1816.84	10	226	-6.5	9.5	9.5	11.48	5.09	4.98	2.75	
3	5000	2386.21	10	226	-6.5	9.5	9.5	13.99	7.56	7.49	2.1	
4	5000	764.69	120	152.89	-6.5	9.5	9.5	5.45	-0.38	-1.05	6.54	CULVERT
4	5000	920.1	120	157.47	-6.5	9.5	9.5	6.45	0.41	-0.05	5.43	ENDS
4	5000	1081.39	120	162.08	-6.5	9.5	9.5	7.45	1.29	0.95	4.62	
4	5000	1247.14	120	166.69	-6.5	9.5	9.5	8.46	2.21	1.96	4.01	
4	5000	1417.27	120	171.29	-6.5	9.5	9.5	9.47	3.16	2.97	3.53	
4	5000	1591.8	120	175.89	-6.5	9.5	9.5	10.47	4.13	3.97	3.14	
4	5000	1818.42	120	226	-6.5	9.5	9.5	11.48	5.1	4.98	2.75	
4	5000	2385.3	120	226	-6.5	9.5	9.5	13.99	7.56	7.49	2.1	

5	5000	1368.59	10	226	-6.5	9.5	9.5	6.05	-0.24	-0.45	3.65	
5	5000	1544.71	10	226	-6.5	9.5	9.5	6.83	0.5	0.33	3.24	
5	5000	1745.04	10	226	-6.5	9.5	9.5	7.72	1.35	1.22	2.87	
5	5000	1956.13	10	226	-6.5	9.5	9.5	8.66	2.26	2.16	2.56	
5	5000	2172.73	10	226	-6.5	9.5	9.5	9.61	3.2	3.11	2.3	
5	5000	2392.45	10	226	-6.5	9.5	9.5	10.59	4.15	4.09	2.09	
5	5000	2613.11	10	226	-6.5	9.5	9.5	11.56	5.12	5.06	1.91	
5	5000	3170.83	10	226	-6.5	9.5	9.5	14.03	7.57	7.53	1.58	
6	5000	1206.39	100	200	-6.5	9.5	9.5	6.03	-0.2	-0.47	4.14	
6	5000	1363.43	100	200	-6.5	9.5	9.5	6.82	0.53	0.32	3.67	
6	5000	1541.29	100	200	-6.5	9.5	9.5	7.71	1.37	1.21	3.24	
6	5000	1728.53	100	200	-6.5	9.5	9.5	8.64	2.27	2.14	2.89	
6	5000	1922.23	100	200	-6.5	9.5	9.5	9.6	3.21	3.1	2.6	
6	5000	2116.66	100	200	-6.5	9.5	9.5	10.58	4.16	4.08	2.36	
6	5000	2311.99	100	200	-6.5	9.5	9.5	11.55	5.13	5.05	2.16	
6	5000	2806.33	100	200	-6.5	9.5	9.5	14.02	7.57	7.52	1.78	
7	5000	1163.9	152	190	-6.5	9.5	9.5	6.13	-0.09	-0.37	4.3	
7	5000	1304.81	152	190	-6.5	9.5	9.5	6.88	0.61	0.38	3.83	
7	5000	1470.46	152	190	-6.5	9.5	9.5	7.74	1.42	1.24	3.4	
7	5000	1645.72	152	190	-6.5	9.5	9.5	8.67	2.31	2.17	3.04	
7	5000	1827.14	152	190	-6.5	9.5	9.5	9.62	3.24	3.12	2.74	
7	5000	2011.45	152	190	-6.5	9.5	9.5	10.59	4.18	4.09	2.49	
7	5000	2196.72	152	190	-6.5	9.5	9.5	11.56	5.14	5.06	2.28	
7	5000	2665.38	152	190	-6.5	9.5	9.5	14.03	7.58	7.53	1.88	
8	5000	1170.64	50	190	-6.5	9.5	9.5	6.17	-0.05	-0.33	4.27	
8	5000	1311.22	50	190	-6.5	9.5	9.5	6.9	0.63	0.4	3.81	
8	5000	1474.59	50	190	-6.5	9.5	9.5	7.76	1.44	1.26	3.39	
8	5000	1648.99	50	190	-6.5	9.5	9.5	8.68	2.32	2.18	3.03	
8	5000	1829.25	50	190	-6.5	9.5	9.5	9.63	3.24	3.13	2.73	
8	5000	2012.86	50	190	-6.5	9.5	9.5	10.59	4.19	4.09	2.48	
8	5000	2197.68	50	190	-6.5	9.5	9.5	11.57	5.15	5.07	2.28	
8	5000	2665.75	50	190	-6.5	9.5	9.5	14.03	7.59	7.53	1.88	
9	5000	1177.92	33	190	-6.5	9.5	9.5	6.2	-0.02	-0.3	4.24	BRIDGE
9	5000	1316.32	33	190	-6.5	9.5	9.5	6.93	0.65	0.43	3.8	BEGINS
9	5000	1478.07	33	190	-6.5	9.5	9.5	7.78	1.46	1.28	3.38	
9	5000	1651.5	33	190	-6.5	9.5	9.5	8.69	2.33	2.19	3.03	
9	5000	1855.12	33	190	-6.5	9.5	9.5	9.76	3.38	3.26	2.7	
9	5000	2042.43	33	190	-6.5	9.5	9.5	10.75	4.34	4.25	2.45	
9	5000	2230.07	33	190	-6.5	9.5	9.5	11.74	5.32	5.24	2.24	
9	5000	2701.61	33	190	-6.5	9.5	9.5	14.22	7.77	7.72	1.85	

10	5000	1221.24	26.48	219.95	-6.5	9.5	9.5	6.24	0	-0.26	4.09	BRIDGE
10	5000	1382.59	26.48	225.57	-6.5	9.5	9.5	6.96	0.67	0.46	3.62	ENDS
10	5000	1576.62	26.48	232.16	-6.5	9.5	9.5	7.81	1.47	1.31	3.17	
10	5000	1794.37	26.48	252.5	-6.5	9.5	9.5	8.72	2.34	2.22	2.79	
10	5000	2064.42	26.48	252.5	-6.5	9.5	9.5	9.79	3.38	3.29	2.42	
10	5000	2312.7	26.48	252.5	-6.5	9.5	9.5	10.78	4.35	4.28	2.16	
10	5000	2561.44	26.48	252.5	-6.5	9.5	9.5	11.76	5.32	5.26	1.95	
10	5000	3184.67	26.48	252.5	-6.5	9.5	9.5	14.24	7.77	7.74	1.57	
11	5000	1490.2	75	258.5	-6.5	9.5	9.5	6.38	0.05	-0.12	3.36	
11	5000	1669.85	75	263.84	-6.5	9.5	9.5	7.06	0.7	0.56	2.99	
11	5000	1888.92	75	270.21	-6.5	9.5	9.5	7.88	1.49	1.38	2.65	
11	5000	2136.94	75	290	-6.5	9.5	9.5	8.78	2.36	2.28	2.34	
11	5000	2442.56	75	290	-6.5	9.5	9.5	9.83	3.39	3.33	2.05	
11	5000	2722.17	75	290	-6.5	9.5	9.5	10.8	4.36	4.3	1.84	
11	5000	3006.63	75	290	-6.5	9.5	9.5	11.78	5.33	5.28	1.66	
11	5000	3723.05	75	290	-6.5	9.5	9.5	14.25	7.78	7.75	1.34	
12	5000	1500.59	70	258.81	-6.5	9.5	9.5	6.41	0.08	-0.09	3.33	
12	5000	1677.19	70	264.06	-6.5	9.5	9.5	7.09	0.72	0.59	2.98	
12	5000	1894	70	270.36	-6.5	9.5	9.5	7.9	1.51	1.4	2.64	
12	5000	2140.92	70	290	-6.5	9.5	9.5	8.79	2.37	2.29	2.34	
12	5000	2445.1	70	290	-6.5	9.5	9.5	9.84	3.4	3.34	2.04	
12	5000	2726.83	70	290	-6.5	9.5	9.5	10.81	4.36	4.31	1.83	
12	5000	3010.23	70	290	-6.5	9.5	9.5	11.79	5.33	5.29	1.66	
12	5000	3725.17	70	290	-6.5	9.5	9.5	14.25	7.78	7.75	1.34	

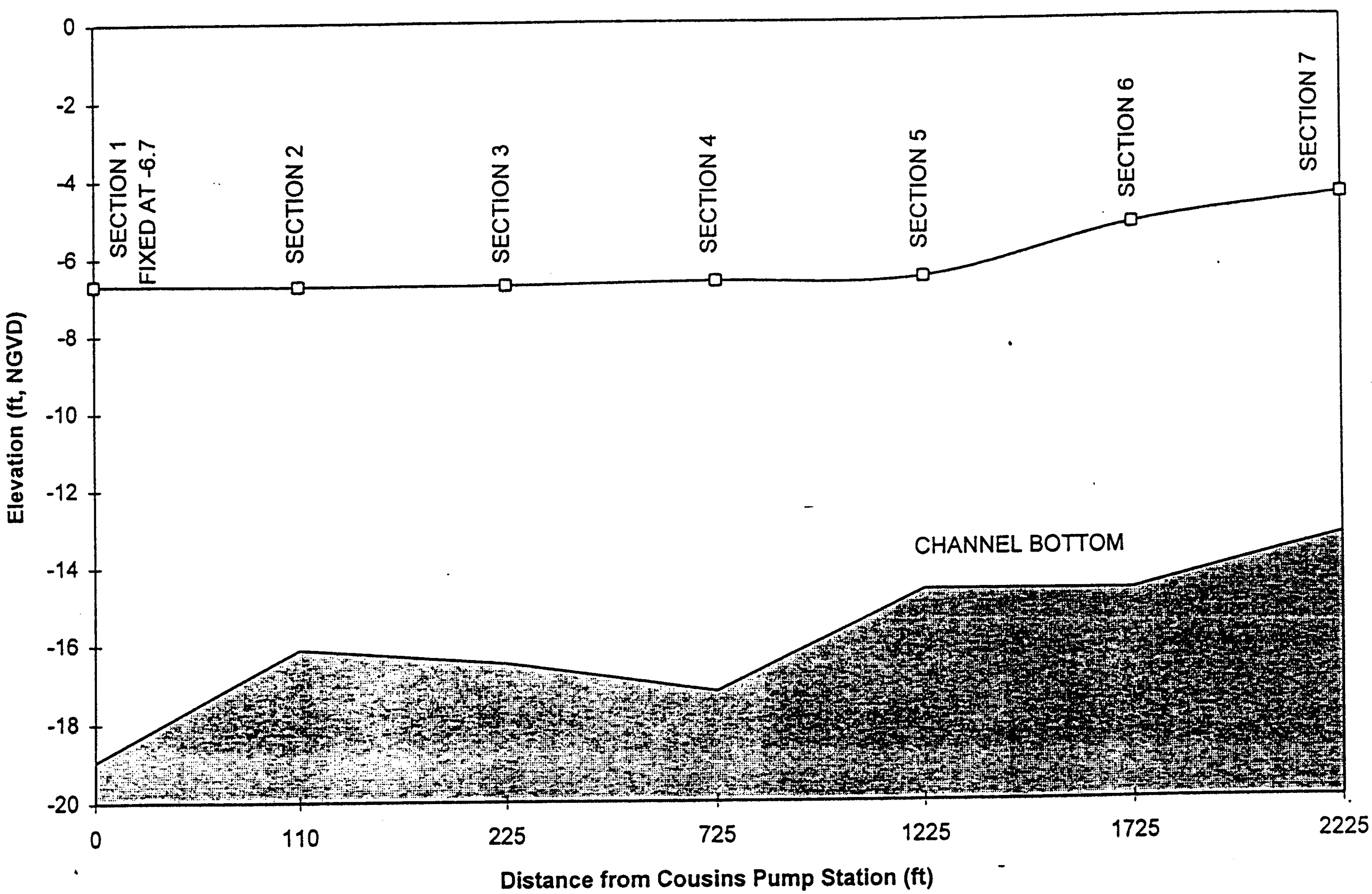
COUSINS CANAL

EXISTING CONDITIONS

COUSCAN

INPUT FILE: COUSCAN.DAT											
SUMMARY PRINTOUT											
DATE: 10-08-97											
	SECNO	QCH	AREA	XLCH	TOPWID	ELMIN	XLBEL	RBEL	DEPTH	CWSEL	VCH
	1	2000	1391.56	0	183.86	-18.96	-1.8	-1.83	12.26	-6.7	1.44
*	2	2000	861.44	110	130.66	-16.12	-3.49	-1.04	9.39	-6.73	2.32
	3	2000	763.19	105	109.6	-16.49	-3.69	-1.8	9.77	-6.72	2.62
*	4	2000	520.46	500	85.05	-17.22	-0.95	0.24	10.58	-6.64	3.84
*	5	2000	267.04	500	52.13	-14.62	2.1	1.15	8.07	-6.55	7.49
*	6	2000	333.22	500	52.06	-14.66	0.96	0.78	9.43	-5.23	6
	7	2000	277.46	500	47.57	-13.3	0.01	-0.11	8.78	-4.52	7.21

Water Surface Profile in Cousins Canal (Discharge 2,000 cfs)



APPENDIX C

MECHANICAL MACHINERY

APPENDIX C
MECHANICAL MACHINERY

SECTION C1 - DIESEL ENGINES

PART 1 - GENERAL

C1-1. SCOPE. The work provided for herein consists of furnishing all plant, labor, equipment and material and performing all operations required to design; manufacture; assemble; factory test; prepare for shipment and storage; deliver; provide instructions and supervision for erection by others under a separate contract; field test with the auxiliaries and accessories as specified; a minimum of one engine to be furnished under this contract for the horizontal pump(s) specified in Section C2. These requirements shall also apply for up to seven identical diesel engines if required.

C1-2. QUALITY CONTROL.

C1-2.1 General. The Contractor shall establish and maintain quality control for all manufacturing, fabrication, factory tests, preparation for shipment, shipment, erection instructions and supervision, and field testing to assure compliance with contract requirements and to maintain records of his/her quality control for all fabrication, erection, and testing operations, including but not limited to the following:

(1) Shop welding, machine work and fabrication, and assembly.

(2) Preparation for shipment and storage.

(3) Factory tests before shipping.

(4) Inspection at the work site for damage to and defects in material and equipment.

C1-2.2 Reporting. Two copies of the records of inspections, shop fabrication and assembly and tests as well as the corrective action taken, shall be furnished the Government as directed by the Contracting Officer.

C1-3. DESCRIPTION OF WORK.

C1-3.1 General. Except for paragraph C1-17, "SPECIAL TOOLS", and paragraph C1-16, "SPARE PARTS", the following paragraphs prescribe the minimum requirements for one engine, but these requirements shall apply for up to seven engines to be furnished under these specifications. Similar parts of the engines shall be of the same materials and workmanship and, insofar as practicable, shall be interchangeable. The engine will be used to drive a pump through a speed reducer. The engine shall be adequately designed and conservatively rated to provide a reliable, efficient and smooth power source under all operating conditions.

C1-3.2 Standard Products. Except as otherwise specified herein, the engine shall be a new, currently manufactured standard production item of a manufacturer regularly engaged in the production of such equipment, as indicated by published information, commercially available prior to the date of advertisement of this solicitation. Information shall be furnished with each bid showing that the exact diesel engine proposed has a proven and satisfactory service record of not less than two (2) years operating at not less than 1200 hours per year, having the same bore and stroke and the same block, camshaft, main and connecting rod bearings, at the same brake horsepower, BMEP, piston speed and rotative speed as the engine offered.

C1-3.2.1 The engine shall be offered only at the speed and rating for which it has been designed, and shall operate on No. 2 diesel fuel. The engine shall conform to the standards set forth by the Diesel Engine Manufacturers Association. An experimental engine, one having a lesser or greater number of cylinders than the standard production engine, or one without a demonstrated satisfactory service record will be rejected.

C1-3.2.2 The manufacturer's representative shall maintain a local parts storage facility located within a 100 mile radius of the pumping station capable of supplying replacement parts and technical factory authorized service at the pumping station within 4 hours of being notified.

C1-3.2.3 The diesel engine with accessories, the engine control panel, the speed reducer, and the horizontal pump shall be supplied together as a complete pumping unit by the pump supplier in order to optimize the compatibility of components.

C1-3.2.4 The engine shall be similar and equal to the applicable models manufactured by Alco Power Inc., Fairbanks-Morse Division of Colt Industries, or General Motors, Electromotive Division, or approved equal.

C1-3.3 Engine Characteristics. A two cycle, turbo charged intercooled engine is preferred, however the engine provided under these specifications may be either a two or four cycle, straight start diesel engine, naturally aspirated or turbo charged, intercooled, with mechanical injection, compressed air start and remote radiator cooling capable of operating on No. 2 diesel fuel The engine shall include all standard equipment and systems and shall be suitable for variable speed/variable load operation at all speeds from idle to maximum.

C1-3.4 Engine Rotation. The direction of rotation of the engine, pump and reduction gear shall be coordinated by the pump supplier. It is intended that the engine deliver power in only one direction. An anti-reverse backstop device shall be installed on the high speed shaft of the speed reducer by the speed reducer manufacturer.

C1-3.5 Engine Skid. The engine shall be mounted on a steel skid type base structure upon which all engine auxiliary equipment and accessories shall be located and completely piped and wired, except for the engine control panel, the air inlet filter and the exhaust silencer. The mating surfaces between the skid and the engine shall be machined only after complete fabrication of the skid and stress relief of all welds. Final machining of mating surfaces on individual components of the skid prior to final assembly and stress relief of welds will be unacceptable. All shim material shall be stainless steel. The skid shall have an appropriately sized opening with a bolted cover plate to permit maintenance personnel to access the underside of the engine after its installation on the operating floor.

C1-3.6 Installation. The engine will be installed by others under a separate contract. It will be directly anchored and grouted to the concrete floor as shown on the drawings without the use of vibration isolators. All stainless steel anchor bolts, nuts, washers, sleeves, shims, wedge plates and other items required for the engine installation shall be supplied by the engine manufacturer.

C1-3.7 Power Takeoff. The engine will normally be started with a dry pump. Flooding or priming of the impeller will take place after the engine has reached operating speed. As a result, no clutch is required. A straight drive through the reduction gear is required for driving the pump. The engine manufacturer shall coordinate his/her flywheel requirements with the pump and speed reducer manufacturers. The reduction gear shall be coupled as close as possible to the engine power take-off through a coupling and shaft supplied by the speed reducer manufacturer as specified in Section C3.

C1-3.8 Emissions. The Contractor shall submit certified test reports which verify that the engine complies with all Federal and local regulations and restrictions regarding the limits of emissions such as carbon monoxide (CO), hydrocarbons (HC) and nitrous oxide (NOx).

C1-3.9 Service Platforms. Service platforms, hand railings and stairs to the main floor shall be provided for access to all engine controls and engine points requiring periodic inspection and maintenance.

C1-3.10 Guards. All exposed rotating and hot parts shall be guarded. All guards shall comply with the standards of the Occupational Safety and Health Administration (OSHA).

C1-3.11 Instruments, Meters, Gauges, Motors, and Heater Connections. The engine shall have the fittings necessary for the connection of instruments, meters, and gauges that will be mounted on the engine control panel. All conduit between the engine and control panel shall be stainless steel.

C1-3.11.1 The engine control panel shall be as specified in Section C4.

C1-3.11.2 A terminal box shall be provided on the engine skid in close proximity to the location of the engine control panel. The terminal box shall be provided with terminal blocks of ample capacity for the electrical conductors from the engine to the engine control panel. Conduits as required for the protection of electrical circuits shall be provided from the junction box on the engine skid to the connection points on the engine.

C1-3.11.3 A shut off valve shall be provided on all pressure lines. This shut off valve shall be conveniently located on the engine as near the source as possible. Tubing for pressure lines shall be provided from this shut off valve to a tubing terminal block located in the same area of the skid as the junction box.

C1-3.11.4 Connection between the engine mounted monitoring points, motors and heaters and their readouts and controls on the engine control panel shall be made at the electrical junction box and the tubing terminal block. Connection for the following instruments, meters, and gauges which will be mounted on the engine control panel shall be provided:

(1) Fuel pressure gauge (downstream of pump).

(2) Fuel differential pressure gauge (across filter).

(3) Engine lubricating oil differential pressure gauge (across filter).

(4) Engine lubricating oil (downstream of pump).

(5) Engine jacket water pressure gauge.

(6) Engine jacket water temperature gauges (inlet and outlet).

(7) Engine lubricating oil temperature gauges (inlet and outlet).

(8) Running time meter.

(9) Electric tachometer.

(10) Engine speed control.

(11) Engine cylinder exhaust temperature pyrometer with a selector switch for each cylinder.

(12) Engine starting air pressure gauge.

(13) Lube oil keep warm system on/off switch.

(14) Lube oil pre-lube pump indicating lights.

(15) Fuel flow meter (gph).

(16) Engine start/stop switch.

(17) Emergency stop button.

C1-3.12 Painting. The engine, skid, its auxiliaries and accessories, except for the intake and exhaust silencers, the stainless steel flexible connectors and other components which will be subjected to high temperatures, and except for those interior surfaces which will be immersed in or otherwise continuously exposed to lubricating oil, shall be cleaned, treated, and primed, in accordance with the manufacturer's standard practice and then given two coats of the manufacturer's standard paint of a battleship gray color with total thickness not less than 3 mils primer and 4 mils enamel. Interior surfaces exposed to lubricating oil shall be cleaned and treated in accordance with the manufacturer's standard practice. Components which will be subject to high temperatures shall be cleaned and treated in accordance with the manufacturer's standard practice and given two coats of heat resistant aluminum paint meeting the applicable requirements of Fed. Spec. TT-P28G "Paint, Aluminum, Heat Resisting (1200 degrees F)." All openings shall be closed with either plastic closures or other lint free material before any priming or painting is done.

C1-3.13 Nameplate. The engine shall be identified by means of a separate nameplate permanently affixed in a conspicuous location. The plate shall bear the manufacturer's name, model designation, serial number, and any other pertinent information such as speed, horsepower, displacement, type, etc. The plate shall be made of stainless steel with raised or depressed lettering and contrasting background.

C1-3.14 Instruction Plates. The engine shall be equipped with suitably located instruction plates, including any warnings and cautions, describing any special and important procedures to be followed in starting, operating and servicing the equipment. Plates shall be made of stainless steel with raised or depressed lettering and contrasting background.

C1-3.15 Torsional Analysis. The entire pumping unit consisting of pump, speed reducer and engine shall operate free from critical speeds or harmful torsional vibrations at all speeds and loads required to obtain the guarantee points and other conditions of head and capacity as listed in paragraph C2-6.3. Before the pump, speed reducer, and engine are released for delivery, the engine supplier shall analyze the system for harmful torsional natural frequencies using mass elastic information supplied by the pump and speed reducer manufacturers. A natural frequency within 25% above or below a normal operating speed will be unacceptable.

C1-4. ENGINE. The engine shall be a complete, factory assembled, naturally aspirated or turbocharged/intercooled unit, with the engine and all auxiliaries, except the intake and exhaust silencers, and the engine control panel, mounted on a fabricated steel common base.

C1-4.1 Connections. All internal connections shall be made, and the only connections required to be made at the site of installation (under a separate contract by others) shall be external connections such as those for fuel, starting air, jacket water cooling, exhaust gases, and engine control. All openings shall be sealed with plastic caps, plugs or films, or by an equivalent lint-free technique.

C1-4.2 The engine shall be of the "V" type. The engine shall have a standard net continuous horsepower rating (prime power service) at the engine coupling, at all altitudes up to 500 feet above sea level, with an ambient temperature of 100 degrees F, with all engine driven accessories and speed reducer attached, of not less than that required to operate the pump at the speeds, capacities, and heads specified under paragraph C2-6.3. The net rating of the engine shall be the published long term continuous rating as defined by the Diesel Manufacturers Association Standards including all parasitic and gear losses. The engine shall be able to meet the maximum power requirements of the pumping unit at a maximum engine speed of 900 RPM and a maximum piston speed of 1600 FPM. The maximum Brake Mean Effective Pressure (BMEP) under maximum continuous horsepower ratings shall not exceed the following values:

a. Two cycle, naturally aspirated........................90 psi

b. Two cycle, turbocharged/intercooled.............150 psi

c. Four cycle, naturally aspirated........................95 psi

d. Four cycle, turbocharged/intercooled.............240 psi

C1-4.2.1 The engine shall be capable of operation at 110 percent of its standard net continuous brake horsepower rating for a period of at least two (2) continuous hours, out of any twenty-four (24) consecutive hours of operation with safe operating temperatures.

C1-5 ENGINE SYSTEMS. All materials shall be new and conform to the standards of The American Society for Testing Materials where such standards are applicable.

C1-5.1 Lubricating System. The engine shall be provided with a full pressure lubricating oil system, consisting of an oil pump, oil strainer, oil filter ,oil cooler, oil level indicator or bayonet gauge, lubricating oil keep warm system, prelubricating pump, and sump all arranged to distribute oil to all moving parts of the engine under a predetermined and constant pressure at rated RPM. The lube oil system shall be completely contained, piped and mounted on the engine skid complete with fill and drain lines.

C1-5.1.1. Lubricating Oil Pump. The engine driven lubricating oil pump or pumps shall be of standard manufacture, shall be easily replaceable as a unit without the necessity of dismantling the engine and shall be conservatively sized to supply the proper amount of oil under pressure to the main bearings, crankpin bearings, pistons, piston pins, timing gears, camshaft bearings, turbocharger bearings, and valve mechanism. The engine driven lubricating oil pump or pumps shall be of the positive displacement type and shall be driven in a positive manner from the engine crankshaft. The pump shall be protected by a relief valve to bypass the oil into the sump with a check valve on the discharge line. A pressure sensor shall be located downstream of the pump to provide signals for low lube oil pressure alarm and shutdown.

C1-5.1.2 Filter. The engine lubricating system shall include a full flow, replaceable cartridge type oil filter(s) with a spring loaded by-pass valve to ensure lubricating oil circulation in the event the filter(s) become clogged. The filter(s) shall have a minimum filtering capability of 10 to 15 microns. The filter(s) shall have the inlet and outlet connections clearly marked. The filter(s) shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. An indicating differential pressure sensor shall be provided across the filter.

C1-5.1.3 Strainer. The engine lubricating system shall include a full flow oil strainer ahead of the engine, which shall be capable of filtering down to 80 micron size, or to a size that will prevent clogging or damage of engine components. Easy drainage of sludge shall be accomplished through a drain plug located near the bottom of the shell. A suitable by-pass relief valve shall also be provided.

C1-5.1.4 Oil Cooler. The engine shall be provided with a water cooled lube oil cooler and a thermostatically controlled bypass valve, to maintain the lube oil temperature within the specified limits. The lubricating oil cooler shall be a horizontal shell and tube heat exchanger with seamless copper-nickel tubes not less than 5/8 in. O.D. and cast iron or steel shell with cast iron water boxes and bronze or brass tube sheets. Velocity through the tubes shall not exceed five (5) fps. The tube bundle shall be removable to facilitate cleaning. Other types of coolers standard with the engine manufacturer and with a proven record of service may also be used. Complete date shall be submitted to the Contracting Officer for approval. The cooler shall be of sufficient capacity to maintain the lubricating oil at 185 degrees F regardless of load or ambient temperature. The heat exchanger shall be furnished complete with the necessary base and/or brackets, mounted on the engine base structure and completely piped into the engine lubricating oil system.

C1-5.1.5 Temperature Control Valve. The engine lubricating system shall include a three-way thermostatic bypass valve of appropriate size and temperature rating to maintain the oil temperature within the engine manufacturer's limits while the engine is operating continuously at either rated or partial loads. The temperature control valve shall have a manual over-ride. Other methods of controlling the lube oil temperature shall be submitted in writing and in adequate detail for approval by the Contracting Officer.

C1-5.1.6 Drain Valve. An easily accessible oil drain valve shall be provided which will permit easy and complete drainage of the engine sump.

C1-5.1.7 Lubricating Oil Keep Warm System. The lubricating system shall include a thermostatically controlled and independently operating lube oil keep warm system complete with pump, immersion heater and all required components to maintain a constant lube oil temperature within the engine of approximately 120 degrees F under a minimum ambient temperature of 20 degrees F when the engine is not operating. The maximum watt density of the immersion heater shall not exceed 13 Watts per square inch of surface area. The immersion heater shall be rated for use in 480 V, 3 ph, 60 hz service. The pump shall be an electric motor driven oil pump with a capacity and head recommended by the engine manufacturer. The pump shall completely fill the oil lines and establish lubricating oil pressure prior to engine start. The pump shall incorporate a built-in relief valve directly connected to the motor and a check valve on the discharge line. The motor-pump assembly shall be mounted on a common cast iron or steel drip lip base, shall be furnished complete with all required controls and shall be suitable for operation on 480 V, 3 ph, 60 hz service. The motor shall be T.E.F.C. conforming to NEMA Standards and shall turn on ball bearings.

C1-5.1.8 Prelubricating Pump. A prelubricating system shall be incorporated to assure proper lubrication when starting and stopping the engine. It shall be interlocked with the engine starting sequence so that it is automatically actuated at each engine start. The pump shall be an electric motor driven oil pump with a capacity and head recommended by the engine manufacturer. The pump shall completely fill the oil lines and establish lubricating oil pressure prior to engine start. The pump shall incorporate a built-in relief valve directly connected to the motor and a check valve on the discharge line. The motor-pump assembly shall be mounted on a common cast iron or steel drip lip base, shall be furnished complete with all required controls and shall be suitable for operation on 480 V, 3 ph, 60 hz service. The motor shall be T.E.F.C. conforming to NEMA Standards and shall turn on ball bearings. If the engine is turbocharged, the turbocharger shall have a separate pump. The engine shall be furnished with the proper amount of clean lube oil in separate containers to match the engine's lube oil capacity.

C1-5.2 Cooling System. The engine cooling system shall be the closed loop, fresh water type, utilizing a 50 per cent ethylene glycol/water solution as coolant with rust inhibiting and water treatment chemicals.

C1-5.2.1 Jacket Water Pump. The engine shall be equipped with an engine driven centrifugal pump or pumps that shall circulate coolant through the engine jacket, cylinder head, intercooler (if used), lube oil cooler, and remote keel cooler (furnished and installed by others). The pump(s) shall be easily replaceable and equipped with shaft seals which will prevent leakage. The shaft seals shall be of a material that is compatible with the coolant solution of ethylene glycol and which will not dry out in intermittent operation. The pump(s) shall be of sufficient head and capacity to match the engine plus the piping and keel cooler friction losses, assumed to be a maximum of 8 psi external to the engine.

C1-5.2.2 Temperature Control Valve. The cooling system shall contain a three-way thermostatic bypass valve with manual override to maintain the proper jacket water temperature, as specified by the engine manufacturer, under all load conditions. These units shall be mounted on the engine base structure and shall be completely piped and tested before shipment.

C1-5.2.3 An expansion tank shall be provided with the engine. Its volume shall be not less than 15% of the coolant volume in the total system. The tank shall be properly fitted for vent, overflow, expansion, and make up line, and shall be equipped with a sight glass with shut off valves on both ends. The tank shall be suitable for an operating temperature of 250 degrees F, and a working pressure of 125 psig. The tank shall be constructed of welded steel, hot-dipped galvanized inside and outside, fabricated, tested, and stamped in accordance with ASME Boiler and Pressure Vessel Code Section VIII Division I and registered with the National Board of Boiler and Pressure Vessel Inspectors. The tank shall be mounted so that the bottom of the tank is above the top of the engine. The tank shall be supported by steel legs or bases for vertical installation, or steel saddles for horizontal installation.

C1-5.2.4 Jacket Water Keep-Warm System. The cooling system shall be supplied with a thermostatically controlled keep-warm system complete with an immersion heater and all controls required to automatically maintain a jacket water temperature within the engine of 120 degrees F under an ambient temperature of 20 degrees F whenever the engine is not operating. Power for the immersion heater shall be 480V, 3ph, 60hz.

C1-5.2.5 Freeze Protection. The engine shall be furnished with the proper amounts of rust inhibiting and water treatment chemicals plus ethylene glycol, in separate containers, that will result in a 50% concentration of the engine's jacket water volume, plus 20% to accommodate the volume of the keel cooler and the supply and return lines.

C1-5.2.6 Additional Cooling Equipment. If the engine is turbo charged, any additional required heat exchanger or cooling equipment for the air intercoolers shall also be furnished complete with all required pumps, expansion tank, controls, water treating system, bleed-off system and heating system.

C1-5.2.7 Data. The engine manufacturer shall make available upon request all information (such as flow, head, heat rejection, maximum operating temperature, etc.) required for sizing the keel cooler.

C1-5.3 Fuel System. The engine shall operate on ASTM D-975 No. 2 diesel fuel with a minimum cetane No. of 40. The fuel system shall conform to the applicable requirements of

NFPA 37, National Fire Protection Association "Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines." Fuel supply shall be from an elevated 1,000 gallon day tank furnished by others, installed at a maximum height of 15 ft. above the station floor and a horizontal distance of 20 ft. It shall be equipped with a mechanical fuel injection system consisting of a fuel pump, strainer, filters, safety bypass valve, and an individual injection pump system with single orifice injection valves or unit injectors.

C1-5.3.1 Fuel Pump. The fuel pump shall be engine driven and of a positive displacement design. It shall have the capacity to transfer fuel from the day tank at a rate and pressure as required by the injectors under maximum load conditions, and to return excess fuel from injector manifold back to the day tank.

C1-5.3.2 Fuel Filter. The engine shall be supplied with a minimum of one duplex filter with transflow change over valve. The filter shall be located on the suction side of the fuel pump and shall have the inlet and outlet connections plainly marked. Indicating pressure gauges with connections to the engine control panel shall be provided on the inlet and discharge sides. The filter shall be capable of filtering particles down to 25 micron size.

C1-5.3.3 Strainer. A full flow strainer of the replaceable cartridge type shall be provided between the engine and the day tank, upstream of the fuel filter. An indicating differential pressure gauge with connections to the engine control panel shall be provided across the strainer. The strainer cartridge shall be capable of filtering out particles down to 125 micron size.

C1-5.3.4 Safety Bypass Valve. A safety bypass valve shall be provided next to the pump isolation valve to prevent buildup of excessive pressures if the discharge line or fuel pump filters become clogged. This bypass shall relieve at a pressure that will protect the fuel piping from over-pressurizing and return the fuel to the day tank.

C1-5.4 Starting System. The engine shall be provided with a compressed air starting system. The system shall consist of one or more air driven motors, a start-stop switch on the engine control panel which provides functions including testing, reset, manual-run/ start, manual stop and adjustable cranking and cooling down operation, and an air filter. Compressed air at 150 psig and 16 SCFM will be available.

C1-5.4.1 Air Driven Motor(s). The air driven motor(s) shall include a lubricator, a quick opening valve, a solenoid valve, a pressure reducing valve, a line strainer with a water trap and an automatic bleed off, and all interconnecting piping. Air starting exhaust piping shall terminate under the engine skid in a properly sized collector with a drain valve, to collect all trapped oil and water. The collector shall be located so as to be easily accessible from the front of the engine.

C1-5.5 Induction System. The engine shall be provided with one or more heavy duty, replaceable element, dry type combination filter- silencer of sufficient capacity to effectively protect the engine from grit and dust. The filter shall be sized to provide the required combustion air under maximum load conditions within acceptable friction losses, while filtering out 95% of AC fine test dust. The filter and silencer shall be designed with a bottom inlet for external installation by others approximately 25 feet from the engine air intake, using 24 inch diameter line and two 90 degree elbows.

C1-5.6 Exhaust System. The engine shall be provided with a vertical exhaust silencer for external installation by others approximately 20 feet from the engine exhaust, using 24 inch diameter line and three 90 degree elbows. It shall be provided with a horizontal flanged inlet, a vertical outlet with a rain cap, and a drain cock. The silencer shall be of all welded construction, of aluminized steel on both internal and external surfaces. Welding electrodes shall be compatible with the silencer material. Any damage to the aluminized finish as a result of welding shall be repaired by wire brushing, cleaning, and protectively covering with a high heat resistant paint matching the aluminized finish. The silencer shall be provided with factory installed brackets for its installation, and a suitable corrugated stainless steel, flanged expansion joint sized to match the engine exhaust port. The pressure drop across the silencer shall not exceed the recommendations of the engine manufacturer under maximum operating conditions. The silencer shall be of the critical "400 level" type with minimum attenuation levels of 40-47 dB(A) under maximum operating conditions.

C1-6. ENGINE COMPONENTS.

C1-6.1 Engine Block. The engine block shall be fabricated of welded structural steel, final machined after all welds have been stress relieved.

C1-6.2 Crankcase. The crankcase shall have inspection covers through which main and connecting rod bearings can be checked and replaced. The engine shall be designed and constructed to withstand crankcase explosions without injury to personnel or damage to the engine. For that purpose several of the inspection covers shall be combination inspection covers and crankcase pressure relief valves. The total free area of the pressure relief valves shall be based on a ratio of not less than 1.5 square inches of relief area per cubic foot of crankcase volume. The combination inspection covers and crankcase pressure relief valves shall be designed to withstand a minimum explosive force of 25 psig. Each combination inspection cover and crankcase pressure relief valve shall incorporate an automatic shutdown device which will automatically shut down the engine when an explosion takes place. A manual reset button shall be provided with each shutdown device. The manual button must be operated on each and every shutdown device before the engine can be started after an explosion.

C1-6.3 Bearings. Main and connecting rod bearings shall be of the precision type with upper and lower removable shells and replaceable tri-metal or aluminum alloy inserts, precision fit with no shimming required.

C1-6.4 Crankshaft. The crankshaft shall be of forged carbon steel or high strength iron alloy of proper design, statically counterweighted and dynamically balanced, with a large thrust bearing and flange for connection to the flywheel at the drive end.

C1-6.5 Pistons. Pistons shall be trunk type made of close grain cast iron, and oil cooled. An aluminum body and skirt with steel cap type is also acceptable.

C1-6.6 Cylinders. The cylinders shall be equipped with full length, fully replaceable cylinder liners, individually cast of high grade cast iron, chrome plated and honed, of the wet type with steel or cast iron cooling jacket.

C1-6.7 Valves. All valves shall be fabricated of alloy steel with hard chrome-cobalt alloy facing, and valve seats (or replaceable inserts) of solid chrome-cobalt alloy. They shall be readily accessible for maintenance and shall be positively rotated each time they lift off the seat.

C1-6.8 Connecting Rods. The connecting rods shall be fabricated of one piece steel forgings with removable, replaceable bearings and bushings.

C1-6.9 Exhaust Manifold. The exhaust manifold shall be liquid cooled unless the engine is turbocharged. If not liquid cooled, the manifold shall be protected by stainless steel heat shields.

C1-6.10 Turbo Charger. If the engine is turbo charged, the turbo charger shall have a single exhaust outlet and replaceable turbine blades. Scavenging and/or turbo chargers shall be driven by the main engine and/or exhaust gasses. Separate electric motors or engine driven blowers and/or superchargers will not be acceptable.

C1-6.11 Barring Device. A hand-operated or pneumatic barring device to turn the engine for inspection or maintenance shall be furnished. If pneumatic, this device shall operate on the starting air pressure system and shall incorporate required safety devices to prevent engagement while the engine is operating.

C1-7. RESERVED.

C1-8. GOVERNOR AND CONTROLS.

C1-8.1 Speed Regulating Governor. An engine driven adjustable mechanical/ hydraulic type speed regulating governor shall be provided to maintain close speed regulation under all load conditions and speed settings from idle to full speed. The speed variation shall not exceed 6% of normal speed when full load is suddenly applied or resumed. The design of the governor shall be such that the engine speed may be changed by governor adjustment during engine operation under load to any speed between 80% and 110% of normal operating speed and the governor shall maintain that speed within 1/2%. The speed fluctuation at any load shall not exceed 2%.

C1-8.2 Overspeed Governor and Load Limit. An emergency governor with overspeed trip shall be provided on the engine to shut down the unit should the speed exceed a pre-determined rpm. The overspeed trip shall also provide an alarm signal for remote indication in the engine control panel. The emergency governor shall be independent of the regulating governor. When the overspeed stop has been tripped, the shutdown mechanism shall be such that the engine fuel or air supply is prevented in the shortest time practicable from entering the engine cylinders. The engine shall have an overload fuel limit set at 110% of full load rating.

C1-8.3 Mechanical Shutdown Device. The engine shall be equipped with a mechanical shutdown device that will, when manually actuated, shut down the engine in the shortest practicable time. This device shall not depend on any electrical device for its operation, and the lever or button used to actuate the mechanical shutdown device shall be mounted on the engine and be easily accessible to the operating personnel. The lever or button shall be clearly marked and identified.

C1-9. NORMAL AND EMERGENCY SHUTDOWN.

C1-9.1 General. Using the controls furnished with the engine control panel and the governors furnished with the engine, the engine shall be capable of automatic shutdown. There shall be two types of shutdown using the controls and governors: normal shutdown and emergency shutdown.

C1-9.2 Normal Shutdown. In the normal shutdown mode, the engine shall slow down to an idle speed setting, idle at this speed for a predetermined period of time, and then automatically shut down. Manually operating the "STOP" pushbutton in the engine control panel shall stop the engine in the normal shutdown mode.

C1-9.3 Emergency Shutdown. In the emergency shutdown mode, the engine's fuel supply shall be shut off to the cylinders and the engine shall come to a stop due to lack of fuel. Conditions that shall stop the engine using the emergency shutdown mode are: low reducer lubricating oil pressure, low engine lubricating oil pressure, high engine jacket water temperature, high engine crankcase pressure, engine overspeed, depressing the "EMERGENCY STOP" button on the engine control panel, and actuating the mechanical shutdown device on the engine. Concurrent with any emergency shutdown shall be visual and audible alarms.

PART 3 - EXECUTION

C1-10. FACTORY TESTS.

C1-10.1 General. One engine of each size supplied shall be subjected to a load test and a fuel consumption test. All engines shall be subjected to start and stop test, emergency shut down tests, governor test, and instrument test.

C1-10.1.1 The engine shall be tested essentially as hereinafter specified, in the manufacturer's or manufacturer's supplier's plant at his/her expense, and in the presence of a representative of the Contracting Officer. A minimum of two weeks notice prior to the test shall be given to the Contracting Officer to arrange for his/her representative to witness the tests.

C1-10.1.2 Major engine failure or repeated minor engine failures during the test will be cause for rejection of the engine. Components which fail or indicate inherent weakness during the test shall be replaced, and the test repeated.

C1-10.1.3 All test apparatus shall be inspected, tested, calibrated and the calibration certified in writing by a competent person or testing agency regularly engaged in that business. The tests shall be run using fuel as specified in paragraph C1-5.3 and using the same lubricating oil and at the pressure which will be used in service. All test results shall be recorded on printed forms standard with the engine manufacturer and which have been submitted to the Contracting Officer for approval prior to commencing the tests. Six bound and certified copies of the test results shall be provided to the Contracting Officer for his/her approval within one week of completion of the tests.

C1-10.1.4 Prior to completion of the first engine, the manufacturer, or manufacturer's supplier, shall submit for approval a description of the various test setups, sample calculation and test procedures he/she proposes to use to test all of the engines and shall include drawings of the test setups showing the test instruments and equipment. Each instrument shall be described in detail, giving all data pertinent or applicable, including but not limited to: Manufacturer's name, type, model number, its degree of accuracy, and certification.

C1-10.2 Load Test. The engine, complete with all attached auxiliaries and including the engine control panel, shall be connected to a calibrated load absorbing device such as a dynamometer, which can simulate accurately the load imposed by the reducer and pump over the full range of heads and capacities. For these tests, full load is interpreted to mean 100% of the power required to operate the pump and speed reducer at its normal rated speed and maximum power requirements.

C1-10.2.1 Exhaust back pressure and intake air friction shall be not less than 80% of the back pressure and friction which will exist after installation at the pumping station site. A mercury barometer, correct to within plus or minimum 0.05 inches of mercury, and subsequently further corrected for temperature, shall be used to obtain the barometric pressure at the test site. Wet and dry bulb temperatures shall be taken at a point near the engine air intake for determination of the true relative humidity of the entering air.

C1-10.2.2 Prior to running the load test, a check test shall be performed to determine that the engine is in suitable condition for tests and to allow a complete check of all instrumentation. Upon satisfactory completion of the check test, the engine shall be run in accordance with the following table.

RUN	FRACTION OF RATED ENGINE LOAD	DURATION HOURS	ENGINE SPEED
1	0	1/4	Min. recommended
2	0	1/4	3/4 x rated
3	1/4	2	3/4 x rated
4	2/4	4	Rated
5	3/4	5	Rated
6	4/4	6	Rated
7	0	1/2	Rated

During the load test the engine shall be closely attended and observed for evidence of excessive temperatures or unusual conditions which may cause damage. Upon satisfactory completion of the load test, the tests described in the following paragraphs shall be performed.

C1-10.3 Fuel Consumption Test. Fuel consumption tests shall be conducted at 2/4 engine load, 3/4 engine load, and 4/4 engine load. Duration of the test at each load condition shall be not less than one hour and may be conducted concurrently with the load test. Tests shall not commence until the engine temperatures and pressures have stabilized. Either the time-weight or the flowmeter technique may be used for this test. If the specified fuel consumption rates are exceeded, the engine shall be rejected, but may be retested after minor adjustment, injector replacement or fuel pump replacement.

C1-10.4 Governor Test. Start the engine, warm it up and while it is operating at rated speed, load it to the full load which it must carry in actual service. The load shall then be entirely removed, without touching the governor adjustment, and the speed measured at no load. Regulation shall be calculated by the formula:

$$R= ((NLS - RLS) \times 100)/RLS$$

where R = regulation in percent, NLS = no load speed, RLS = rated load speed. The test shall be repeated until consistent results are obtained, but not less than three times. Speeds shall be determined by a tachometer. If the regulation exceeds two percent, the governor shall be rejected and another governor installed and tested.

C1-10.5 Start and Stop Test. Using the controls provided with the engine, start and stop the engine not less than three times at minimum load. The engine must start easily and come up to normal idling speed under all ambient air temperatures between 20 degrees F and 110 degrees F. When the "STOP" button is actuated, the engine must slow down to idle and then, after a preset time, shut down. When the "EMERGENCY STOP" button is actuated, the engine must stop immediately.

C1-10.6 Overspeed Test. Disconnect, or otherwise render inoperative, the overspeed governor. Start the engine and slowly increase the speed to 110% of rated speed under maximum load. Maintain this overspeed for not less than 15 minutes. Any evidence of excessive noise or vibration during the test period, or any evidence of injury to, noticeable change in, or destruction of any part, shall be considered as failure of this test. Speed shall be determined by a tachometer.

C1-10.7 Overspeed Protection Device Test. With the overspeed governor operative, start the engine and slowly increase the speed under maximum load until the overspeed protection device goes into operation. The overspeed governor shall not permit operation at speeds greater than 110% of the full load rated speed. Otherwise, it shall be rejected and a new device installed and tested as described above. Speed shall be determined by a tachometer.

C1-10.8 Low Oil Pressure Protective Device Test. With the engine shut down, remove the low oil pressure protective device from the engine, but leave it electrically connected. Starting at the pressure tap on the engine for the protective device, connect in series, going away from the engine, 1) A shut-off valve, 2) The low oil pressure protective device, 3) A master oil pressure gauge, and 4) A bleed valve discharging to atmosphere. Start the engine, bring it up to idling speed and allow it to warm up. Open the bleed valve and purge any air from the test arrangement. Close the bleed valve and record the oil pressure. Close the shut-off valve. Gradually open the bleed valve, observing the pressure gauge, and record the pressure at which the protective device shuts down the engine. If this method of test is not applicable to the engine being tested, the procedure may be altered with the approval of the Contracting Officer. The protective device shall function within plus or minus 10% of the minimum operating pressure prescribed by the engine manufacturer. Otherwise it shall be rejected and a new device tested as described above.

C1-10.9 High Water Temperature Protective Test. Install a master thermometer or a master thermocouple/potentiometer type temperature indicating device at the water outlet connection between the engine and the test radiator or heat exchanger. Start the engine, bring it up to rated speed and record the water temperature once it has stabilized. Block or partially block the cooling water passing through the heat exchanger and load the engine as required to raise the coolant temperature. Record the temperature at which the high water temperature protective device functions. The device shall function within plus or minus 10% of the maximum operative water temperature prescribed by the engine manufacturer. Otherwise it shall be rejected and a new device installed and tested as described above.

C1-10.10 High Crankcase Pressure Limiting Device. Start the engine and bring it to operating speed. Manually trip the shut down device on one of the explosion relief valves. The engine shut down circuit must operate satisfactorily, and shut down the engine. The engine shall be incapable of restarting until the reset button on the explosion relief valve is pushed. Repeat this procedure for the remaining explosion relief valves but without the engine operating. The engine shut down circuit shall be actuated each time the shut down device is tripped. The engine starting circuit shall be incapable of being energized until the reset button is pushed. Any explosion relief valve shut down device that does not send the proper signal shall be rejected and a new device installed and tested as described above.

C1-10.11 Instrument Test. Perform this test from a cold start. Connect the master instruments in parallel with the engine control panel instruments. Set the panel instruments to zero or to the ambient conditions registered by the master instruments. Start the engine and bring it up to idle speed. Read both master and panel instruments concurrently in approximate 20% steps, for the full scale, as the engine comes up to normal operative temperatures and pressures. Variations of more than plus or minus 5% between the indication of the master and panel instruments shall be cause for rejection of the panel instruments. The master instruments shall be the calibrated tachometer thermometers, thermocouple/potentiometer, pressure gauges, fuel scales, flowmeters, and similar devices used for the other tests specified herein.

C1-10.12 Test Results. Upon satisfactory completion of the tests, the engine manufacturer shall certify the results and compile them in a bound book. One original and four copies shall be made available to the Government.

C1-11. FIELD TESTS. Refer to Section C5.

C1-12. PREPARATION FOR SHIPMENT AND PROCESSING FOR STORAGE.

C1-12.1 Shipment. All openings shall be sealed with plastic caps, plugs or films. The engines fabricated structural steel base may serve as a skid for loading, shipping and unloading. All auxiliaries and accessories not attached to engine shall be securely mounted on skids of ample size, and all small parts shall be boxed. The skid mounting and boxing shall be done in a manner which will prevent damage to the engine and its auxiliaries and accessories during loading, shipment, unloading, storage and subsequent handling. Weatherproof covers shall be provided to protect the engine and its auxiliaries and accessories during shipment. Any eyebolts, special slings or devices used in loading the equipment at the manufacturer's plant shall be furnished for unloading and handling at destination and shall become the property of the Government.

C1-12.2 Storage. The engine and all auxiliaries and accessories shall be protectively processed for not less than 12 months storage indoors at the destination. The pump machinery supplier through the engine manufacturer shall furnish for approval by the Contracting Officer a complete description of the processing method or methods used. The Contractor shall make provisions for regular inspections and maintenance of the engine by an authorized representative of the manufacturer during the estimated 12-month storage period.

C1-13. INSTALLATION AND ERECTION INSTRUCTIONS.

C1-13.1 General. No later than 30 days prior to the time that the engine is delivered, the Contractor shall furnish the Contracting Officer, for approval, three copies of a typed or printed and bound manual describing the procedure to be followed by the erecting engineer in erecting, assembling and installing the engine. To the extent necessary and/or desirable, the description for the engine shall be coordinated and consolidated with the similar descriptions specified for the pump and speed reducer.

C1-13.2 Description Requirements. The description shall be a complete, orderly and step by step explanation of the various operations required, and shall also include such things as bolt torque values, permissible coupling misalignment, recommended instrument setup, recommended gauges and instruments, bearing clearances, and similar details. The description shall be complemented and supplemented by drawings, sketches, photographs, and similar material to whatever extent necessary or desirable to provide a procedure that will be comprehended by an engineer or mechanic without extensive experience in erecting or installing engines of this type.

C1-13.3 Changes. The Contracting Officer will make such changes and/or modifications in the manual as he/she deems necessary or desirable, and return one copy to the Contractor. Five copies of the corrected manual shall be furnished to Contracting Officer.

C1-14. OPERATION AND MAINTENANCE MANUAL AND PARTS LISTS.

C1-14.1 General. The operation and maintenance manual and parts list shall be bound separately, shall be approximately 8-1/2 inches by 11 inches, printed on good quality paper and bound between flexible, durable covers. Drawings incorporated in the manual and/or parts lists may be reduced to page size provided they are clear and easily legible, or may be folded into the manual to page size. Photographs and/or catalog cuts of components may be included for identification.

C1-14.2 Manual. The Contractor shall furnish for approval ten (10) copies of a detailed shop maintenance manual containing complete information in connection with the operation, lubrication, adjustment, routine and/or special maintenance, disassembly, repair and reassembly of the engine. The manual shall include a step by step procedure outline for starting, running, and stopping the engine. This outline shall incorporate the total machinery package, including the pump, gear, engine, and control panel. Included in the procedure outline shall be pre-start instructions such as oil checks, prelube, etc., starting instructions, stopping instructions, and post-operating instructions. The outline shall contain information on all safety and control devices, their function, set points, and resetting instruction. Instructions for shutting down the engine in case of an emergency shall be included.

C1-14.3 Parts List. The Contractor shall furnish ten (10) copies of the manufacturer's spare parts lists and/or bulletins for the engine. These lists and/or bulletins shall clearly show all details and parts, and all parts shall be adequately described and have proper identification marks.

C1-15. SUBMITTALS.

C1-15.1 General. Within 15 days of receipt of notice of award, the Contractor shall furnish for approval by the Contracting Officer six copies of drawings and other information on the engine and its auxiliaries that he/she proposes to furnish. This information shall be in addition to the information submitted with the bid.

C1-15.2 Drawings. Outline drawings of the engine showing the principal dimensions, the location and size of piping, the location of the tubing terminal block and the electrical junction box on the skid, the size and location of the anchor bolts, the center of gravity of the engine and skid with all mounted accessories and auxiliaries (both dry and wet). A complete set of dimensional drawings, in reproducible form shall be submitted within 60 days of award indicating all above details.

C1-15.2.1 Drawings and descriptive literature of the intake and exhaust silencers, and of the expansion couplings for the exhaust, fuel and other systems, showing dimensions, and materials of construction. The descriptive literature of the exhaust silencer shall indicate the levels of attenuation at different frequencies.

C1-15.3 Descriptive Literature. Descriptive literature, with fully detailed and annotated schematics, describing the operation of all engine systems, including but not limited to the lube oil system, the fuel system, the cooling system, starting system, induction system, exhaust system, monitoring system and emergency shutdown system. The descriptive literature of each system shall include exploded drawings of the system showing and identifying all components.

C1-15.4 Data. The following data shall be submitted:

(1) Make of engine.
(2) Model No.
(3) Number of cylinders.
(4) Continuous horsepower rating.
(5) Intermittent horsepower rating.
(6) Maximum horsepower rating.
(7) RPM
(8) Strokes per cycle.
(9) Turbocharged or naturally aspirated.

(10) Bore and stroke (in.).
(11) Displacement (cu. in.).
(12) Piston speed (fps).
(13) Maximum torque at rated speed (ft. lb.).
(14) Compression ratio.
(15) Brake mean effective pressure (psi).
(16) Minimum idling speed (RPM).
(17) Minimum operating speed (RPM).
(18) Minimum load
(19) Water cooled exhaust manifold (Yes or No).
(20) Total weight, wet and dry (Lbs.).
(21) Lube oil capacity (gallons)
(22) Jacket water capacity (gallons).
(23) Heat rejection of jacket water (BTU/min.).
(24) Heat rejection lube oil cooling water (BTU/min.).
(25) Heat rejection intercooler water (BTU/min.).
(26) Heat rejection exhaust manifold (if water cooled) (BTU/ min.).
(27) Total heat rejection to cooling water (BTU/min.).
(28) Jacket cooling water (GPM) and optimum temperature (°F), in and out.
(29) Lube oil cooler water (GPM) and optimum temperature (°F), in and out.
(30) Intercooler water (GPM) and optimum temperature (°F), in and out.
(31) Maximum safe jacket water temperature from engine (°F).
(32) Required keel cooler in and out temperature (°F).
(33) Allowable pressure drop in remote keel cooler and piping. (psig).
(34) Fuel oil consumption (Lb./BHP/Hr).
(35) Lube oil consumption (Gal./Hr).
(36) Lube oil circulated (GPM) and optimum temperature, to and from engine (°F).
(37) Maximum safe operating temperature of lube oil (°F).
(38) Intake air volume (CFM) and allowable pressure drop (psi).
(39) Exhaust temperature (°F).
(40) Exhaust volume (CFM or Lb/Hr) and allowable pressure drop (psi).
(41) Pressure and volume required for air starting system
(42) Recommended exhaust silencer, critical level, pipe size, diameter.
(43) Recommended Air Intake Filter.
(44) Type of injector and Manufacturer.
(45) Type of governor and Manufacturer.
(46) Engine driven accessories and required horsepower.

C1-16. SPARE PARTS. The engine manufacturer shall provide, at the time the engine is delivered, the following spare parts:

ITEM	QTY	DESCRIPTION
1	3	Cylinder head complete with valves, cages, springs, etc.
2	3	Cylinder liner (w/liner jacket if applicable), or cylinders with all necessary water seal rings.
3	3	Air starter motor, complete
4	6	Sets of replacement oil filter element
5	6	Sets of replacement fuel oil filter element
6	6	Sets of replacement air filter element
7	3	Engine driven lube oil pump assembly
8	3	Engine driven jacket water pump assembly
9	3	Hydraulic governor

The spare parts shall include any other special items which the manufacturer deems necessary for the engine provided. All spare parts shall be duplicates of the original parts furnished and interchangeable therewith. All spare parts shall be enclosed in separate, sealed moisture proof bags with desiccant bags, and packed in containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each container, shall be securely fastened, in a moisture-proof envelope, to the outside of the container. The packing list shall also provide the following information:

(1) Manufacture.

(2) Contract number.

(3) Identification, including the manufacturer's drawing number or part number for each spare part in the container.

C1-17. SPECIAL TOOLS. At the time that the engine is delivered to the job site (or storage area), the engine manufacturer shall furnish all "special" tools required to completely assemble, disassemble or maintain the engine. "Special" tools are defined as any special or conventional wrenches with a dimension across the flats greater than one inch, any grossly oversized or special dimension tools of any kind, any special attachments or fixtures, all lifting devices to be used in conjunction with the station crane, or any other similar item. All special tools shall be clearly identified with their intended purpose and shall remain the property of the

Government.

C1-18. LIFTING CONNECTIONS. The engine, as assembled for installation, shall be provided with lifting connections to facilitate handling during loading, unloading and installation. The connections shall be painted yellow for easy identification and shall be so located as to prevent warping or misalignment of the engine or its components.

C1-19. MEASUREMENT AND PAYMENT. No measurement will be made for the manufacture, assembly, factory testing, preparation for storage, and shipment and unloading of the new diesel engine complete with all auxiliaries, accessories and spare parts. Payment for the manufacture, assembly, factory testing, and preparation for storage of the new diesel engine, complete with all auxiliaries, accessories and spare parts will be made at the contract unit price for "Diesel Engine and Auxiliaries." Price and payment shall constitute full compensation for furnishing all plant, labor, materials, equipment, operation and maintenance manuals, spare parts, parts lists, and performing all necessary operations including factory testing and painting.

C1-19.1 Payment for engineering design work for the diesel engines and auxiliaries will be made at the contract lump sum price for "Engineering and Design Service."

C1-19.2 Payment for shipping the diesel engine and unloading at the storage site, complete with all auxiliaries, accessories and spare parts will be made at the contract unit price for "Shipping and Unloading."

SECTION C2 - HORIZONAL PUMPS

PART 1 - GENERAL

C2-1. SCOPE. Design, model and prototype test, furnish, deliver and unload a minimum of one horizontal axial-flow pump with a nominal capacity of 1000 cfs. Coordinate the suitability for use with the engine, gears and couplings specified in subsequent sections of the contract specifications. Design and furnish pump body and wall sleeve anchorages including threaded bolts and structural steel members for concrete embedment. These requirements shall also apply for up to seven identical horizontal axial-flow pumps.

C2-2. REFERENCES. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

C2-2.1 Acoustical Society of America (ASA).

ASA S2.19	Mechanical Vibrations - Balance Quality Requirements

(1989)	of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance

C2-2.2 American Society for Testing and Materials (ASTM).

ASTM A 27-91	Steel Castings, Carbon, for General Applications
ASTM A 36-91	Structural Steel
ASTM A 48-92	Gray Iron Castings
ASTM A 108-90a	Steel Bars, Carbon, Cold Finished, Standard Quality
ASTM A 123-89a	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 276-92	Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A 285-90	Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength
ASTM A 297-89	Steel Casting, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A 312-92	Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A 516-90	Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 576-90b	Steel Bars, Carbon, Hot-Wrought, Special Quality
ASTM A 668-91	Steel Forgings, Carbon and Alloy, for General Industrial Use
ASTM B 148-92a	Aluminum-Bronze Sand Castings
ASTM B 584-91a	Copper Alloy Sand Castings for General Applications
ASTM D 2000-90	Rubber Products in Automotive Applications
ASTM E 709-91	Magnetic Particle Examination

C2-2.3 American Society of Mechanical Engineers (ASME).

ASME-16	Boiler and Pressure Vessel Code; Section VIII, Pressure (1992)Vessels, Division 1 - Basic Coverage
ASME-17	Boiler and Pressure Vessel Code; Section IX, Welding (1992) and Brazing Qualifications ASME B4.1 (1967; R 1987) Preferred Limits and Fits for Cylindrical Parts
ASME B16.5	Flanges and Flanged Fittings (1988)
ASME B46.1	Surface Texture (Surface Roughness, Waviness, and Lay) (1985)
ASME B106.1M	Design of Transmission Shafting (Second Printing) (1985)

C2-2.4 American Welding Society (AWS).

AWS D1.1	Structural Welding Code - Steel (1992)

C2-2.5 American Water Works Association (AWWA).

AWWA C200	Steel Water Pipe, 6 In. and Larger (1986)
AWWA C203	Coal-Tar Protective Coatings and Linings for Steel Water (1991) Pipelines - Enamel and Tape - Hot-Applied
AWWA C207	Steel Pipe Flanges for Waterworks Service - Sizes 4 In. (1986) Through 144 In.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings (1983; R 1989)

C2-2.6 Hydraulic Institute (HI).

HI-01	Standards for Centrifugal, Rotary & Reciprocating Pumps (1983)

C2-2.7 Instrument Society of America (ISA).

ISA RP2.1	Manometer Tables (1985)

C2-2.8 Steel Structures Painting Council (SSPC).

SSPC Paint 25	Red Iron Oxide, Zinc Oxide, Raw Linseed Oil and Alkyd (1991) Primer (without Lead and Chromate Pigments)

SSPC SP 3	Power Tool Cleaning (1989)
SSPC SP 5	White Metal Blast Cleaning (1991)
SSPC SP 7	Brush-Off Blast Cleaning (1991)

C2-3 SUBMITTALS. Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section H "Submittal Procedures":

C2-3.1 SD-01, Data.

C2-3.1.1 Lists of Materials; (FIO). Furnish two copies of purchase orders, mill orders, shop orders for materials, and work orders, including orders placed or extended by each supplier. Contractor shall at time of submittal of drawings furnish list designating materials to be used for each item.

C2-3.1.2 Materials; (GA). Furnish, within 60 days of notice of award, names of manufacturers of machinery and other equipment which Contractor contemplates incorporating in the work, together with performance capacities and other relevant information pertaining to the equipment.

C2-3.1.3 Parts List; (FIO). Furnish 10 copies of manufacturer's complete parts list showing all parts and spare parts and bulletins for pump. Clearly show all details and parts, and adequately describe parts or have proper identification marks.

C2-3.1.4 Total Head; (GA). Submit computations of total head and losses.

C2-3.1.5 Shipping Bills; (FIO). Copies of certified shipping bills, in duplicate, shall be mailed promptly to Contracting Officer.

C2-3.1.6 Torsional Analysis; (GA). Submit detailed analysis report.

C2-3.2 SD-04, Drawings.

C2-3.2.1 Drawings; (GA). Within 30 days of notice of award of contract, drawing shall be submitted as listed below. Drawings shall be of sufficient size to be easily read. Drawings notes and dimensions shall be in English. Drawings requiring changes as a result of model test should be submitted within 45 days after approval of model test.

a. Outline drawings of pump showing pertinent dimensions and weight of each component of the pump.

b. Drawing showing details and dimensions of pump mounting design or layout including any embedded items.

c. Cross-sectional drawings of pump showing each component. Major or complicated sections of pump shall be shown in detail. Indicate on each drawing an itemized list of components showing type, grade, and class of material used and make and model number of standard component used.

d. Detail and assembly drawings required for manufacturing showing dimensions, tolerances, and clearances of shafts, bearings, couplings, and packing gland, and diameter and tip clearance of impeller.

e. Drawings covering erection and installation, which Contractor intends to furnish to the erecting engineer.

C2-3.3 SD-06. Instructions.

C2-3.3.1 Installation and Erection Instructions Manual; (GA). No later than 30 days prior to the time of pump delivery, three copies of typed or printed, and bound. manuals shall be furnished describing procedures to be followed by erecting engineer for erecting, assembling, installing, and dry-and wet-testing pump. To the extent necessary or desirable the manuals shall coordinate and consolidate description of pump with similar descriptions specified for gear reducer and diesel engine. Description shall be complete, orderly, step-by-step explanation of operations required, and shall also include such things as alignment procedures, bolt torque values, permissible impeller/impeller casing clearances; permissible impeller casing out-of-roundness; permissible shaft misalignment; recommended instrument setups; recommended gages and instruments; shaft clearances; and similar details.

Description shall be complemented and supplemented by drawings, sketches, photos, and similar materials to whatever extent necessary or desirable, and the overall result shall be a description that may be comprehended by an engineer or mechanic without extensive experience in erecting or installing pumps of this type.

C2-3.3.2 Changes In Installation and Erections Manual; (GA). The Contracting Officer will make changes or modifications as deemed necessary or desirable in the manual, and return one copy to the Contractor. Differences of opinion shall be reconciled in a manner mutually agreeable to the Contractor and Government, and five copies of the corrected manual shall be furnished the Government. The erecting engineer shall follow these instructions when erecting or installing the pumps. Deviation shall be permissible only when agreed to in advance by the Contractor and Government.

C2-3.4 SD-08. Statements.

C2-3.4.1 Test Setup and Procedures; (GA). The Contractor shall, prior to proceeding with the construction of the model, but not later than 90 days after the date of notice to proceed, submit to the Contracting Officer for approval a description of the proposed model and test procedure. Included therein shall be dimensioned drawings and cross-sectional views of the model pump showing the location of all instruments and the point of their connection to the model.

C2-3.4.2 Castings and Casting Repairs; (GA). The Contractor shall submit criteria for acceptance of castings and casting repairs, including welding procedure for each material used, to the Contracting Officer for approval within 90 days of date of notice to proceed.

C2-3.5 SD-14, Samples.

C2-3.5.1 Materials; (GA). Samples of materials shall be submitted as directed. Equipment, materials, and articles installed or used without the approval of the Contracting Officer shall be at risk of subsequent rejection.

C2-3.6 SD-19, Operation and Maintenance Manuals.

C2-3.6.1 Operating and Maintenance Instructions; (FIO). Ten 10 copies of manuals containing complete information on operation, lubrication, adjustment, routine and special maintenance, disassembly, repair, reassembly, list of special tools required, and trouble diagnostics of pump and auxiliary units shall be furnished. Operation and maintenance manual and parts lists shall be bound separately, shall be approximately 8-1/2 inches by 11 inches, printed on good quality paper and bound in three ring lose leaf binder. Drawings incorporated in the manual or parts lists, may be reduced to page size provided they are clear and legible, or may be folded into the manual to page size. Photographs or catalog cuts of components may be included for identification. The manuals shall have one complete set of photo reproducible drawings for the pumps and its components. There shall also be one 24 inch by 36 inch longitudinal cross section of the pump detailing the assembly of all parts.

C2-4. QUALIFICATIONS. Welding operators, welders, and tack welders shall be qualified and, as necessary, requalified for the particular type of work. Qualification shall be in accordance with one of the following codes: Part III, Section 5 of AWS D1.1; or Section IX of ASME-17. Contractor shall certify by name to Contracting Officer the welders and welding operators so qualified, including date of qualification, code, and procedures under which each qualified. Prior qualification may be accepted provided the welder has performed satisfactory work under the code for which he/she qualified within the preceding three months. Contractor shall require welder or welding operator to repeat qualifying tests when, in the opinion of the Contracting Officer, work indicates reasonable doubt as to welder's proficiency. In such cases, welder shall be recertified as required above. The welder shall be considered disqualified until successful completion of retest. All expenses in connection with qualification and requalification shall be borne by the Contractor.

C2-5. REGULATORY REQUIREMENTS. The Contractor shall comply with the following requirements:

a. Engineer Manual, EM 385-1-1, "Safety and Health Requirements Manual".

b. Engineer Manual, EM 110-2-3105, "Mechanical and Electrical Design of Pumping Stations" (1962).

c. Federal Acquisition Regulation, FAR 52.246-2, "Inspection of Supplies - Fixed Price".

C2-6. SYSTEM DESCRIPTION. The pump shall be a constant duty cycle, horizontal shaft , single stage, axial-flow propeller type pump with approximately 132 inch diameter impeller casing and with a nominal capacity of 1000 CFS. The pump shall be designed to provide the performance required by paragraph C2-6.3 "Capacities" and shall be designed to fit between and coupled to the concrete intake and discharge tunnels shown on the contract drawings. The pump shall have the following sections: suction piece, suction elbow, impeller casing, diffuser vane and discharge expansion piece. Thrust loads shall be carried by a horizontal, solid shaft to a thrust bearing mounted inside the pump body. Pump designs based on previously modeled and manufactured pumps are preferred.

C2-6.1 Design Requirements.

a. The pump is for the purpose of pumping storm water from collection canals into an outfall canal. Water pumped will not exceed 92 degrees F, will be relatively turbid, and may contain sand, silt, and vegetative trash capable of passing trashracks. Trash-racks will have 3 ½-inch clear openings. The pump shall be designed to operate in the dry without harm to the pump and without time or speed restrictions.

b. The pump shall be a component of a complete system designed to be operated by a horizontal crankshaft diesel engine, as described in Section C1 "Diesel Engines," through a vertical offset horizontal parallel shaft, helical gear speed reducer described in Section C3 "Speed Reducers for Stormwater Pumps." The pump manufacturer shall coordinate the completeness and compatibility of the whole pumping unit including but not limited to; all connections from the pump to the engine, couplings, gears, guards, drive shafts, instrumentation, and controls.

c. The pump shall be designed to geometrically fit as shown on the contract drawings between the discharge and intake tunnels with no major modifications, alterations, or additions to the pumping station or suction bays to accommodate it. However, requests for changes in setting of pump, supports, and accessories, which would involve only minor modifications, will be considered.

d. The pump manufacturer shall calculate pool to pool pump performance. Pool to pool performance shall take into account the head losses associated with the concrete intake and discharge tubes shown on the contract drawings. Entrance and exit head losses shall be included as well as velocity head losses. Head losses associated with trash racks need not be considered for modeling purposes.

e. Pump priming will be accomplished with the assistance of vacuum equipment supplied by others. As such, the pump shall be made air tight from a negative pressure. Vacuum piping connections for priming shall be located on top of the pump elbow section.

f. Pump anchorages and wall sleeve shall be designed for embedment in concrete.

C2-6.2 Performance Requirements.

a. Maximum level of vibration of assembled pumping unit, consisting of pump, gear reducer, and engine, when tested in the dry as specified in Section C5 "FIELD SERVICES", shall not be greater than the value of lower limit of the "good" range of "General Machinery Vibration Severity Chart". Measurements shall be made at 90%, 95%, 100% and 105% of pump rated speed. The General Machinery Vibration Severity Chart may be obtained from IRD Mechanalysis Inc., 6150 Huntly Rd., Columbus, Ohio 43229.

b. Pump shall be capable of operation without instability over the entire range of heads specified in paragraph C2-6.3. Instability is defined, for this specification, as when one or more of the following conditions occur: pump has two or more flow rates at the same total head; head-capacity curve has a dip (region on curve where change in flow rate produces an abnormally low head); when any point in usable range of head-capacity curve cannot be repeated within 5 percent; when a test point deviates from normal curve by 5 percent.

C2-6.3 Capacities. The pumps furnished shall have the minimum characteristics tabulated in the table that follows. Pumps which deliver more flow, than the minimums listed in the table, at rated head and speed will be rated higher in the Bid Evaluation.

Condition	Minimum quantity (CFS)	Pool-to-pool head (ft.)	Min. pump pool-to-pool efficiency (%)	Water level in suction basin El. (ft. NGVD)	Maximum pump speed (%)
1	915	15	72	-12.00	100
2	1010	13	77	-12.00	100
3	1080	11	74	-10.00	100

4	1150	9	75	-10.00	100
5	1250	5.5	64	-3.5	100
6	960	16.5	72	-8.5	105
7	860	18.0	66	-8.5	105

Table Notes:

a. Elevations are based on National Geodetic Vertical Datum (NGVD) in feet. "CFS" is the abbreviation for Cubic feet per second; "ft." is the abbreviation for feet.

b. Condition 3 is defined as the primary design point.

c. Pool to pool heads shown in the table are defined as the vertical distance in feet between the water surface elevation in the suction basin and the water surface elevation in the discharge basin at the pumping station and do not include any pump intake and discharge tube losses, pump losses, or velocity head losses. All intake and discharge tube losses, sudden contraction and expansion losses as well as frictional losses and velocity head losses are chargeable to the pump and shall be considered pump losses.

d. Condition Nos. 1 thru 5 specified above are for the pump operating at normal (100%) speed which shall not exceed 100 RPM. Horsepower load at conditions 6 inclusive of reduction gear losses, should not exceed the maximum continuous rating of the engine drive. Conditions Nos. 6 and 7 are with the pump operating at a maximum speed of +105% of normal speed. Condition 6 is a condition resulting from a current hurricane, and Condition 7 is a rare condition resulting from a major hurricane on a "critical" path with high tides. Increase in speed shall be allowed if recommended by the pump, gear and engine manufacturers. The horsepower load at Condition 7, inclusive of reduction gear losses shall not exceed the maximum published intermittent load rating of the engine. The pump shaft centerline shall be at elevation 3.00 feet NGVD. The suction pool elevations at the various conditions are shown in the table. Conditions 1 thru 4 represent normal tidal fluctuation and condition 5 represents severe rainstorm flooding the intake bay. Reduced speed performance is not required.

e. The design and speed of the prototype pump shall be such that the pump shall operate in the "good" range of the "General Machinery Vibration Severity Chart" at all conditions specified above. Vibration measurements shall be made in horizonal directions 90 degrees apart and in the vertical direction. Location for the measurements shall be as shown on the contract drawings. In addition, the model test of the pump shall demonstrate operation free of cavitation at all conditions. Test shall be conducted in accordance with paragraph C2-14.2.5.

f. The pump machinery supplier shall guarantee that the pump will meet the performance delineated above with the discharge tube arrangement depicted on the contract plans.

C2-7 DELIVERY, STORAGE AND HANDLING. Shipping and handling bills or memorandums of all shipments of finished pieces or members to designated site shall be furnished, giving designation mark and weight of each piece, number of pieces, total weight, and if shipped by rail in carload lots, car initial and number.

C2-7.1 Processing for Storage.

C2-7.1.1 General. All machined contact or running surfaces, bearings, journals and other such parts of the pump shall be prepared for 24 months of outdoors storage. Unless this processing is as described below, the Contractor shall furnish to the Contracting Officer for approval, 60 days prior to shipment, a complete description of processing method to be used, including complete instructions for maintaining protection. After application of preservatives, pump parts, accessories, auxiliaries, and spare parts shall be sealed in bags with a supply of desiccant. "Pump parts" means pump parts, shafting, bearings, seals, accessories, auxiliaries, and spare parts that would be subject to damaging effects of corrosion, such as rust or oxidation. All pump parts shall be place in crates. "Crate," means boxing suitable for export shipping by ocean carrier and as described below:

a. Crates shall have a screwed cover or hatch for access. Screws shall be stainless steel.

b. Crates shall be sealed, moisture tight without ventilation openings.

c. Openings shall be provided with removable covers so that wire ropes or slings can be attached to hoisting or skidding devices to facilitate loading, unloading, and handling. Covers shall be fastened with stainless steel screws.

C2-7.1.2 Shaft Storage. Shafts shall be prepared for shipment and storage to prevent damage such as bending, deforming machined surfaces, and corrosion. Detailed handling instructions for shipment, unpacking, assembly, and disassembly shall be provided.

C2-7.13 Pump Casing. Pump casings shall have exposed flange ends sealed with 1 inch thick marine grade plywood bolted to the flange ends using the flange's bolt holes. Machined surfaces shall be properly protected from damage and corrosion for a minimum of 12 months of exterior exposure. Painted surfaces shall be protected from damage from handling during shipping and storage by means of suitable blocking devises or by crating. If crates are used, they shall be provided with removal covers fasten with stainless steel screws to allow for periodic inspections.

C2-8. PROJECT/SITE CONDITIONS.

C2-8.1 Datum. Elevations shown or referred to in specifications, are Cairo datum.

C2-8.2 Pool-to-Pool Head. Pool-to-pool head is the difference in feet between the water surface elevation in the sump bay and water surface elevation in discharge channel. Pump manufacturer shall determine total head. Total head includes losses from the water surface on suction side of pump to discharge water surface, plus velocity head.

C2-9. MAINTENANCE.

C2-9.1 Special Tools. Three sets of "special tools" required to completely assemble, disassemble, or maintain the pumps shall be furnished. "Special tools" refer to grossly oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. If required, a device shall be provided for temporarily supporting the pump shaft and impeller during assembly, disassembly, and reassembly of pump. Lifting devices other than slings required for use in conjunction with a crane for assembling and disassembling the pump shall be furnished including devices for handling pump components such as the shaft, bearings, bearing houses and impeller. Portable steel cabinets shall be provided large enough to accommodate "special tools" furnished under this paragraph and as required by Sections "C1-Diesel Engines" and "C3- Speed Reducers for Stormwater Pumps." Special tool cabinets shall be mounted on four rubber-tired casters. Drawers shall be provided to accommodate small tools. The front of the cabinet shall be fitted with a hinged door designed to swing horizontally. Doors shall be furnished with necessary stops, catches, and hasps for completely securing cabinet with a padlock. Padlocks shall be furnished complete with three keys. "Special tools," because of their size and weight, do not permit storage in tool cabinet shall be packaged in sturdy wooden crates with covers that are fastened with screws.

C2-10. ERECTING ENGINEER. Refer to Section C5 - "SERVICES OF AN ERECTING ENGINEER".

PART 2 PRODUCTS

C2-11. MATERIALS AND METALWORK FABRICATION. Materials shall conform to requirements of paragraph C2-5 "Regulatory Requirements", subparagraph b., FAR 52.246-2, and to additional specified requirements. Classification and grade of material incorporated in work shall be in accordance with designated specifications.

C2-11.1 Designated Materials. Designated materials shall conform to the following specifications, grades. and classifications.

Material	Grade	Class	Specification
Aluminum-Bronze	Alloy No. C95500	Castings	ASTM B 148
Cast Iron		30A, 30B	ASTM A 48
Cast Steel	65-35 Annealed		ASTM A 27
Cold Tar Protective Coating-Hot Applied			AWWA C203
Cold Roll Steel Bars	Min. Tensile 65KSI		ASTM A 108
Copper Alloy Casting	Alloy No. C93700		ASTM B 584
Corrosion-Resistance	CA15M		ASTM A 487/ A487M
Alloy Casting *	CA6NM CA15M	Class A / C<0.03%	ASTM A 487/A 487M
Dimension for Steel Water Pipe Fittings			AWWA C208
Hot Rolled Stainless	G10200 & G11410		ASTM A 576
Ring Flanges		B	AWWA C207
Rubber Products in Automotive Appl.			ASTM D 2000
Seamless and Welded Aust. Stainless Steel Pipe			ASTM A 312
Stainless Bars and Shapes	S30400 & S41000		ASTM A 276
Steel Forgings		D	ASTM A 668
Steel Pipe, 6 Inches and Larger			AWWA C200
Steel Plates, Pressure Vessel	60 or 70		ASTM A 516
Steel Plates,	B		ASTM A 285

Structural Quality			
Structural Steel			ASTM A 36
Surface Texture (Surface Roughness, Waviness, and Lay)			ASTM B46.1

* Note: If CA6NM is used the contractor shall submit procedure for fabrication and welding for approval by the Contracting Officer.

C2-11.2 Castings.

C2-11.2.1 Cast or Stamp Mark Number. Cast mark number shall be provided on each casting. Heat number shall be cast or stamped on each casting. Warped, distorted, or oversized castings that will interfere with proper fit with other parts of machinery or structures will be rejected. Cracked castings of non-weldable materials (cast iron, etc.) will be rejected. Repairs to castings shall not be made prior to approval by the Contracting Officer. The structure of the metal in castings shall be homogeneous and free from excessive non-metallic inclusions.

C2-11.2.2 Visual Examination. Casting shall be visually examined for defects. Visual defects shall then be further examined by Magnetic Particle Tests. Magnetic particle tests and inspection shall conform to Appendix 6 of ASME-16 and ASTM E 709. Steel castings shall not be used with defects disclosed by magnetic particle test which exceed the degree permitted by Appendix 7 of ASME-16.

C2-11.2.3 Casting Repairs. Castings, except those of cast iron shall have all unsound material or defects removed by chipping, machining, air-arc gouging or grinding, and shall be repaired by welding. Welding repairs shall conform to welding procedures developed and approved for the type of material involved. Stress relief annealing shall be accomplished prior to final machining.

C2-11.2.4 Acceptance Criteria. Criteria for acceptance of castings and casting repairs, including the approved welding procedure for each material used, shall be developed by the Contractor. Standards that are not definitive or that delegate discretionary authority for acceptability of castings or casting repairs to manufacturer's representatives or other individuals are not acceptable. Castings not meeting approved criteria shall be either rejected or repaired as dictated by approved standards. Repairs shall be accomplished in accordance with approved procedure and repaired areas shall be reinspected to insure completed repairs are satisfactory.

C2-11.3 Bolted Connections.

C2-11.3.1 Bolts, Nuts, and Washers. Bolts, nuts, and washers shall conform to requirements of paragraph C2-11.1 "Designated Materials," and paragraph C2-12.11 "Bolts, Nuts and Washers" for types required. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to bolt axis. Plain washer shall conform to the requirements of ANSI B18.22.1 heavy series and lock washers shall conform to the requirements of ANSI B18.21.1 heavy series. All bolts heads and nuts shall be hexagon.

C2-11.3.2 Drill or Subdrill and Ream Holes. Unless otherwise approved holes for bolts shall drilled or subdrill and reamed at the manufacturer's shop. Holes shall be accurately located, smooth, cylindrical and perpendicular to the member. Holes for unfinished bolts shall be no larger than 1/8 inch in diameter than the bolt. Holes for machined bolts shall be not more than 0.020 inches larger than the nominal diameter of the bolt.

C2-11.3.3 Match-ream or Drill Holes. Holes for fitted bolts shall be match-ream or drilled in the shop. Holes shall be smooth, cylindrical, and perpendicular to the member with all burrs removed. Bolt threads shall be entirely outside of holes. Body diameter of bolt shall have tolerances as recommended by ASME B4.1 for class of fit specified. Reamed holes with fitted bolts shall be selectively assembled for an LC-1 fit.

C2-11.3.4 Holes for High-strength Bolts. Holes for high-strength bolts shall be accurately spaced, cylindrical, and perpendicular to the member. Holes in material that is less than the bolt diameter shall be drilled and then reamed to full size. Poor matching of holes will be cause for rejection. Drifting done during assembly shall not distort metal or enlarge holes. For slight mismatching, reaming to a larger diameter for next standard size bolt will be allowed.

C2-11.3.5 Materials Not Specifically Described. Materials not specifically described shall conform to latest ASTM specification or to other listed commercial specifications covering class or kinds of materials to be used.

C2-11.4 Metalwork.

C2-11.4.1 Flame Cutting of Material. Flame cutting of material other than steel shall be subject to approval of the Contracting Officer. Shearing shall be accurately done, and all portions of work neatly finished. Steel may be cut by mechanically guided or hand- guided torches, provided an accurate profile with a smooth surface free from cracks and notches is secured. Surfaces and edges to be welded shall be prepared in accordance with Section 3 of AWS D1.1. Chipping and/or grinding will not be required except where specified and as necessary to remove slag and sharp edges of mechanically guided or hand-guided cuts not exposed to view. Visible or exposed hand-guided cuts shall be chipped, ground, or machined to metal free of voids, discontinuities, and foreign materials.

C2-11.4.2 Stress-Relieving Procedure. After all fabrication welding is completed, and prior to any machining, pump weldments shall be stress-relieved by heat treatment. The contractor shall submit proposed stress-relieving procedure for approval by the Contracting Officer.

C2-11.5 Machine Work.

C2-11.5.1 General. Tolerances for machine-finished surfaces designated by non-decimal dimensions shall be within 1/64 inch. Sufficient machining stock shall be allowed on placing pads to insure true surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal surfaces shall be polished and all surfaces shall be finished with sufficient smoothness and accuracy to insure proper operation when assembled. All like parts shall be interchangeable. All drilled holes for bolts shall be accurately located.

C2-11.5.2 Class of Fit Required. All fits between the various parts described shall be as described in the table below. No alternates to these fits will be allowed without specific approval of the Contracting Officer. Tolerances, allowances, and gages for metal fits between plain, non-threaded cylindrical parts not shown below shall conform to ANSI B4.1, for class of fit required.

Description	Type of fit	Total interference or clearance
Shaft to impeller	Interference Locational Fit	ANSI B4.1 Class LN2
Shaft sleeves (at packing gland)	Interference Locational Fit	ANSI B4.1 Class LN2
Shaft coupling (will be pressed on in field)	Interference Locational Fit	ANSI B4.1 Class LN2
Shaft to bearing, inner race	As recommended for "normal to heavy loads"	Mfg. Recommendation
Shaft to bearing, outer race	As recommended for "normal to heavy loads"	Mfg. Recommendation
Key to keyway, fitted sideways (by others upon erection)	Interference Locational Fit	ANSI B4.1 Class LN1
Key to keyway, top and bottom	Clearance Locational Fit	ANSI B4.1 Class LC1

C2-11.5.3 Surface Finishes. Where surface finishes are indicated, or on Contractor's drawings, or as specified herein, symbols used or finishes specified shall be in accordance with ANSI B46.1. Values of roughness height specified are the arithmetical average deviation expressed in microinches. Roughness specified is the maximum value and any lesser degree will be satisfactory unless otherwise called for on drawings. Compliance with specified surface shall be determined by sense of feel and by visual inspection of work compared to Roughness Comparison Specimens, in accordance with provisions of ANSI B46.1. Values of roughness width and waviness height are not specified, but they shall be consistent with general type of finish produced and specified by roughness height. Finishes shall be 250 rms or better on flange faces, 125 rms on general machine work and 32 rms on bearing journals at anti-friction bearings. Flaws such as scratches, ridges, holes, peaks, cracks or checks which will make the part unsuitable will be cause for rejection.

C2-11.5.4 Unfinished Surfaces. Work shall be laid out to insure matching of adjoining unfinished surfaces. Unfinished surfaces shall be true to lines and dimensions shown on the contract and/or Contractor's drawings and shall be chipped or ground free of all projections and rough spots. Where there is a large discrepancy between adjoining unfinished surfaces, the surfaces shall be ground or machined to proper alignment. Depressions or holes not affecting strength or usefulness of parts shall be filled in a manner approved by the Contracting Officer.

C2-11.5.5 Alignment of Wetted Surfaces. Accurate alignment shall be maintained between wetted surfaces being joined with flanges. Where plates of the water passage change thickness, transition shall occur on the outer surface, leaving inner surface properly aligned. When welding has been completed and welds have been cleaned, but prior to stress relieving, joining of plates shall be carefully checked in the presence of Government inspector for misalignment of adjoining parts. Localized misalignment between inside of wetted surfaces of an adjoining flange connecting sections of pump or tunnels shall not exceed 1/4 inch. Misalignments greater than 1/4 inch shall be corrected by grinding away offending metal, providing the maximum depth to which metal is to be removed does not exceed 1/4 inch and does not introduce excessive stress in the part. Where required correction is greater than 1/4 inch that section of pump shall be rejected for use. Proposed procedure for all corrective work, other than minor grinding, shall be approved by Contracting Officer prior to start of corrective work. Corrective work shall be finished by grinding corrected surface to a smooth taper. Length of the taper along each flow line element shall be 10 times the depth of the offset error at flow line. Wetted surface irregularities that might have existed in an approved model shall not be reason for accepting comparable surface irregularities in prototype pump.

C2-11.5.6 Dowel Holes. Dowel holes shall be bored true to gages, smooth and straight, and at right angles to axis of the member. Boring shall be done after members are securely fastened in position.

C2-11.5.7 Shafting. Shafting of non-uniform diameter shall be made of hot-rolled steel, shall have fillets where changes in section occur, and shall be ground and polished. Plain shafting may be made of cold-finished steel unless specified otherwise.

C2-11.6 Welding.

C2-11.6.1 Welding of Steel. Unless otherwise authorized or specified, welding of steel shall be by electric arc-welding process, using a method that excludes atmosphere from molten metal. Welding of steel, unless specified otherwise, shall conform to applicable provisions of AWS D1.1. All welding operators and machines shall be qualified as required by paragraph C2-4, "QUALIFICATIONS." The Contractor shall certify that welding operators are so qualified. All expenses in connection with qualification and requalification tests for welders and welding machines shall be borne by the Contractor.

C2-11.6.2 Temporary Welds. Temporary welds required for fabrication and erection shall be made under controlled conditions prescribed herein for permanent work. Each temporary weld shall be removed after serving its purpose and ground flush with adjacent surfaces.

C2-11.6.3 Inspection. Welding shall be subject to inspection by the Contracting Officer or his/her representative. The Contracting Officer may require coupons to be cut from any location in any joint for testing. All section of welds found defective shall be chipped or cut out to base metal and properly rewelded. When coupons are cut, the member's cut shall be repaired in a neat and workmanlike manner. Cost of providing the coupons, repairing and testing shall be borne by the manufacturer if found defected. Cost associated with testing parts which are not defected will be borne by the Government.

C2-11.6.4 Welding Procedure. The welding procedure for each structure to be welded shall be in accordance with the best modern welding practice, and shall be such as to minimize residual stresses and distortion of the finished members.

C2-11.6.5 Stress Relieving. Stress relieving shall be by heat treatment. The method used shall be approved by the Contracting Officer. All machining shall be done after stress relieving. In the event the complete bottom half of the suction elbow cannot be positioned for machining, then a section of the suction end may be welded after machining, then the weld stress relieved. Adequate provisions shall be taken to prevent distortion of the machined part.

C2-11.7 Shop Assembly. Unless otherwise specified, each finished pump, shall be assembled in the shop to determine correctness of fabrication and matching of component parts. Tolerances shall not exceed those specified or shown on Contractor's drawings and each assembled unit shall be closely checked to ensure that all necessary clearances and alignments have been provided and that binding does not occur in any moving part. Assembly in shop shall be in the same position as final installation in the field unless otherwise specified. The assembly shall consist of pump casings pieces and sections and shall include mounting the shaft and impeller in the pump casing with both inboard and outboard bearings and seals. Assembly and disassembly shall be preformed in the presence of a Government representative, unless waived in writing by Contracting Officer. Errors encountered shall be immediately remedied. Before disassembly for shipment, each piece of a machine or structure shall be match marked, drilled and doweled, and serial numbered to facilitate erection in the field. The location of match marks shall be shown by circling with a ring of white paint after the shop coat of paint has been applied, or as otherwise directed. Match marks shall be documented on pump assembly drawings and provided with each pump.

C2-12. HORIZONTAL PUMPS.

C2-12.1 Speed. Rotative speed of pump shall be no greater than 100 RPM. The pump manufacturer shall verify that rotative speed of pump at which the NPSH is produced is not more than the required speed required to meet the design requirements of paragraph C2-6.3 "Capacities", as determined by cavitation tests specified in paragraph C2-14.2 "Factory Tests."

C2-12.2 Reverse Flow. Pump manufacturer shall show by computation that the pump is capable of withstanding the full force exerted on it when subjected to reverse flow with activation of the reverse flow backstop. The computations shall use the most severe condition from paragraph C2-6.3 for head and tail water and shall take into account stresses caused from changes in momentum of pumped water and machinery components as well as static heads. Under these conditions stress shall not exceed 2/3 of the yield strength of the materials.

C2-12.3 Efficiency. Pool-to-pool efficiency at head-capacity conditions specified in paragraph C2-6.3 "Capacities" shall not be less than as shown in Table 1 when calculated as follows:

$$\text{Efficiency} = [(Q \times H)/(3960 \times BHP)] \times 100$$

Where: Q = Discharge, gallons per minute
H = Pool-to-pool total head, feet
BHP = Pump brake horsepower

C2-12.4 Design Stresses. Working stresses for structural steel, other than that used for pump parts, shall conform to the requirements of the A.I.S.C. Except for the pump shaft, rotating parts of the pump and other machinery components subject to high stresses or shock shall be so designed that the maximum stress due to the most severe operating condition does not exceed two-thirds of the yield point. Where other parts of the pump assembly are subject to operating stresses, the unit stress in ferrous materials used shall not exceed the values in the following table. For the pump shaft the combined torsional and bending stresses at any point shall not exceed 11 percent of the minimum yield point.

Table 4

Material	Maximum unit stress in pounds per square inch	
	Stress in tension	Stress in compression
Cast Iron	2,000	10,000
Cast Steel	10,000	10,000
Alloy Cast Steel, Alloy Steel, Rolled Shapes and Plates	20 percent of the Ultimate Strength or 33 Percent of the Yield Point	20 percent of the Ultimate Strength or 33 Percent of the Yield Point
Plate Steel, Where Utilized	12,000	12,000
Pump Shaft	Stress in Torsion: 11 percent of the yield point	Stress in Bending: 11 percent of the yield point

C2-12.5 Suction Piece. The suction piece shall be fabricated steel with a minimum shell thickness of 3/4 inch and shall be furnished as shown on the drawings. It shall be of one-piece construction with one end flanged to mate with the suction elbow and the other end prepared for grouting into the concrete intake tube. Its flange thickness, tolerance and pressure rating shall be the same as for the pump impeller and diffuser casings.

C2-12.6 Suction Elbow. The suction elbow shall be fabricated from steel plate having a minimum wall thickness of 3/4 inch. The elbow shall be ribbed where necessary for strength and rigidity and shall be designed for a minimum of 20 inches mercury vacuum. The outboard bearing housing shall be rigidly supported from the elbow. Direct support of the housing on the concrete structure will not be allowed. The exact design of the elbow shall be determined by the pump manufacturer. The suction elbow shall be split horizontally on the shaft centerline. The horizontal split flange shall be faced and drilled, and the back of the flange spot faced. Great care shall be taken in the setting up of this piece for machining so that it is not distorted or sprung by the devices used to hold it. The suction end of the elbow shall be flanged to suit the suction piece. The pump end of this piece shall be flanged to suit the impeller casing flange. Both flanges shall have a minimum thickness of 1-1/2 inches after machining. All welds on the pipes, ribs, etc. shall be continuous, i.e., tack welds will not be allowed. Field welds will not be allowed. A 20 inch diameter manhole and 1-1/2 inch flanged air inlet connection shall be built into the suction elbow where shown on the drawings.

C2-12.7 Impeller Casing. The impeller casing shall be of fabricated steel plate and shall have flanged ends. The shell thickness shall be not less than 1 inch after machining. Welds shall be heat-treated stress-relieved before final machining. The casing shall be designed to withstand a minimum of 20 inches of mercury vacuum. The impeller casing shall be horizontally split and flanged on the shaft centerline and on both ends in order to mate with the elbow and diffuser sections. Concentric and split flanges shall be provided with a registered fit or a minimum of four equally spaced dowels for alinement. Dowels shall be suitable for permanent alinement. Machine finish impeller-swept area in impeller casing shall have a surface finish of at least 125 rms and shall be concentric with the impeller axis. Tolerance for concentricity of impeller with the impeller axis shall not be greater than 20 percent of the operating clearance between impeller and impeller casing.

C2-12.8 Diffuser Vane Section. The diffuser vane section shall be fabricated from steel plate with vanes welded to the inner casing. all welds shall be stressed relieved. The diffuser section shall have a minimum wall thickness of 3/4 inch. The vanes shall be of 1-1/2 inch minimum thickness. The diffuser casing shall be horizontally split and flanged on the shaft centerline with support points provided as indicated on the drawings. The casing shall have flanges on both ends to mate with the impeller casing and the discharge piece. Concentric and split flanges shall be provided with a registered fit or a minimum of four equally spaced dowels for alinement. The lower half of the diffuser section shall be carefully designed to carry the pump inboard bearings within a watertight inner cone. The diffuser section shall be designed for a minimum of 20 inches of mercury vacuum.

C2-12.9 Discharge Piece. The discharge piece shall be fabricated steel with a minimum shell thickness of 3/4 inch and shall be furnished as shown on the drawings. It shall be of one-piece construction with one end flanged to mate with the diffuser vane section and the other end prepared for grouting into the concrete discharge tunnel. The discharge piece shall incorporate an annular convoluted steel expansion ring. The convoluted section shall be steel with a minimum thickness of 3/4 inch and shall be designed to yield due to foundation movement without the section becoming dislodged from the discharge tunnel. Its flange thickness, tolerance and pressure rating shall be the same as for the pump impeller and diffuser casings.

C2-12.10 Flanges. Pump flanges, including horizontal split flanges, shall have a minimum thickness of 1-1/2 inches after machining and shall be faced and drilled. The back face shall be spot faced or ring faced to receive flange bolts and/or nuts. Flanges shall be machined and bolt holes drilled concentric with pump centerline, having tolerance of plus or minus one fourth of the clearance between bolt and bolt hole. Flange thickness after machining shall not vary by more than 10 percent from the maximum flange thickness. Where necessary, flange stiffeners shall be provided. To the maximum extent possible, flanges shall be designed to be through bolted. Flanges which require the use of studs or are not through bolted such that both the nut and bolt are readily accessible shall require written approval from the Contracting Officer. Welded flanges shall be welded with one or more continuous beads on both sides of the flange at the connecting intersection to the pump section. Final design of welds is the responsibility of the manufacturer. Flanges shall have a 250 rms finish or better on the mating surfaces. A minimum of eight jacking bolts shall be provided for separating the horizonal flange.

C2-12.10.1 Flanged Joints. All surfaces of the finished flanges shall be true and straight to within 0.005 inches when restrained. All mating surfaces shall be machined so that when joined without sheet gaskets will form a vacuum tight joint using only "Permatex" or an approved equivalent product. After initial assembly and final alinement at the factory all flange surfaces shall be doweled at a minimum of eight equally spaced locations. The dowels shall be tapered and fitted into tapered holes and shall be designed to aid in reassembling.

C2-12.11 Bolts, Nuts and Washers. Bolts, nuts, screws and other fasteners shall be Type 316 stainless steel.

C2-12.12 Impeller. The pump impeller shall be cast steel with an outside diameter of not less than 10'-6" and not greater than 11'-6". The impeller vanes shall be carefully cast integrally with the hub in one piece to produce smooth vanes without distortion or warping. The nose cone of the impeller shall be a separately cast steel component arranged for bolting to the impeller hub. A minimum 30 inch access opening at the top of the impeller hub shall be provided for inspection of the impeller casing. The impeller shall have its outside diameter machine finished so as to produce a close running fit between the impeller and casing. The impeller shall be bored and key-seated for a press fit to the shaft. The design of the impeller shall be such that mild heating of the casting in order to facilitate placement and removal from the shaft can be used without harming the impeller. The impeller shall have appropriate holes in the hub to for removal from the shaft. The manufacturer shall verify by means of templates or pitchometers that the impeller is geometrically similar to the model impeller. Results of the comparative testing shall be certified and provided to the government for approval.

C2-12.12.1 Inspection of Casting. After removal from mold, and prior to finishing of surface imperfections, castings shall be inspected for cracks using the magnetic particle method in the presents of the Contracting Officer or his representative. Minor surface imperfections shall be filled or ground down as necessary to preserve correct contour and outline of impeller and to restore surface imperfections to the same degree of finish as surrounding surfaces. Surface pits, depressions, projections, or overlaps showing greater than 1/16 inch variation from the general contour for that section shall be corrected. Method and procedure for accomplishing repair shall be as set forth in standards furnished under paragraph C2-11.2 "Castings". Castings that exhibit surface imperfections as defined above which covers an area of more than 10 percent of blade surface will be rejected.

C2-12.12.2 Dynamic Balance. The finished impeller shall be dynamically balanced to within 4000 oz-in of unbalance. Dynamically balance shall be by the two-plane balancing technique. The impeller shall be balanced at 100% and 110% of maximum operating speed. Amount of allowable unbalance shall be quality grade G 6.3 in accordance with ASA S2.19. Weights needed to obtain required level of balance shall be securely welded to the inside cavity of the impeller hub. In no case will portions of the impeller be removed or weights be added to the outside of the hub, vanes, or water passages. Balancing procedure shall be submitted to the Contracting Officer for approval at least four weeks prior to date of balancing. Each finished impeller shall be weighted and weight stamped on the hub. Weight shall be accurate to 0.5 percent of the total weight of impeller. Weighing and balancing shall be witnessed by the Contracting Officer or his representative.

C2-12.13 Pump Shaft. The shaft design shall be in accordance with ASME B106.1M. The shaft shall be designed with a minimum factor of safety of 5 based on ultimate tensile strength of shaft material and rated horsepower of the engine, and not more than 2/3 of the yield strength of the material at maximum horsepower of the engine. The pump shaft shall be in one piece supported by the outboard bearing and the inboard bearing immediately in back of the impeller. It shall be finished and polished all over and shall be of forged steel ASTM A-668 Class D. All machine work shall be accurate, with fits properly maintained. The shaft shall be a minimum of 16 inches in diameter, with slightly reduced diameters allowed at the impeller and bearing fits. Shaft run out at any point when supported on its bearings shall be less than 0.002 inches, and shaft out of round shall be less than 0.0005 inches. A threaded hole, 2-1/2 inch diameter 10 threads per inch, R.H., and 6 inches deep shall be provided in the end of the shaft for installing the impeller.

C2-12.14 Shaft Sleeves. Stainless steel sleeves, with a minimum surface hardness of 450 Brinnell, shall be provided on the shaft for the inboard and outboard packing boxes. The packing box sleeves shall be of the length required by the manufacturer. These sleeves shall be press fitted or shrink fitted to the shaft and then machined. The out of round of the finished sleeve shall be less than 0.0005 inches.

C2-12.15 Pump and Gear Reducer Shafts Coupling. Pump and gear reducer floating shaft and couplings shall be in accordance with Section "C3- Speed Reducers for Storm Water Pumps."

C2-12.16 Pump Bearings.

C2-12.16.1 Inboard Bearing. The pump inboard bearings shall be mounted within the inner cone of the diffuser section which shall be entirely sealed from the flow area. The bearing shall be mounted downstream of the impeller so that the impeller is between the inboard and the outboard bearings. A bulkhead provided with a packing box for the pump shaft shall be installed on the impeller side of this cavity to exclude all water from the inner cone and bearings. The inboard bearing bulkhead and packing box housing shall be horizontally split. The other end of the cavity shall be sealed by a water tight bolted access cover. The housing and access cover shall be large enough to accommodate the removal of the interior bearing and all bearing parts. The pump inboard bearing assembly within the cavity shall be of the anti-friction type designed for oil lubrication and shall incorporate a thrust bearing used in combination with a radial load bearing. The radial bearing shall be a spherical roller bearing used in conjunction with a spherical roller thrust bearing. The thrust bearing shall be designed to carry the full thrust of the impeller calculated by assuming a 20 foot differential head across the full area of a circle the same outside diameter as impeller. The radial bearing shall be designed to carry the calculated design dead load multiplied by 1.3. The pump anti-friction bearings shall be designed for a minimum B-10 life of 100,000 hours. The housing shall incorporate a spring arrangement for eliminating thrust bearing clearance when the bearing is unloaded as during priming. The front and rear covers of the inboard bearing housing shall have male and female fits as will assist in preventing distortion of the housing.

C2-12.16.2 Inner Cone. The inner cone shall be provided with a vent pipe and drain pipe to the exterior of the pump. The vent and drain pipes shall be a minimum of 2 inches nominal diameter. The vent shall terminate with a screened breather above the diffuser section. The drain pipe shall terminate with a 2 inch flange below the diffuser section. Other piping for bearing oil level determination, drain and fill, bearing temperature sensing and lines to the packing gland shall also be provided.

C2-12.16.3 Outboard Bearing. The outboard bearing shall be anti-friction type, self-aligning, spherical roller designed for oil lubrication and shall have a minimum B-10 life of 100,000 hours based on the dead load times a service factor of 1.3. The bearing shall be mounted in a four bolt removal cap cast steel pillow block. The pillow block shall be supported on the suction elbow.

C2-12.16.4 Bearing Lubrication. Oil piping shall be included so that bearing oil level can be checked by site glass, drained and refilled from outside the pump.

C2-12.16.5 Bearing Heat Sensors. Each pump bearing shall be provided with an independent and separate temperature indicator with visual and audible alarms mounted on the diesel engine control panel. Temperature indicators shall be liquid crystal with a minimum 3/4 inch numerical readout in degrees Fahrenheit. Provisions shall be made at the bearings and inside the bearing housings for mounting the temperature sensors. The temperature sensor units shall be an "Alnor" Type N-14 clock pyrotroller or equal. The sensing elements shall be an "Alnor" thermocouples complete for this installation and compatible with the specified indicators. All components of the temperature sensors shall be furnished. Support leads and protect from water and mechanical damage. Terminate leads outside of pump casing in an approved waterproof junction box and cap until final connections are made in the field. Lead protection shall consist of pipes fastened to pump with brackets using bolts and nuts to permit their removal, and shall be constructed with enough unions to be completely disassembled. Leads passing through pump water passage in pump shall either be contained in a guide vane or be protected by schedule-80 pipe.

C2-12.17 Packing Boxes. Grease lubricated stuffing box shall be used at the inboard bearing and a water lubricated stuffing box used where the pump shaft exits the pump housing. The stuffing boxes shall be of suitable design and shall be submitted by the pump manufacturer for approval. These stuffing boxes shall incorporate a bronze gland, bronze lantern ring, and bronze neck ring. The stuffing boxes shall provide for not less than five rings of 1 inch square braided packing. The grease lubricated stuffing box shall be designed to use Lubriplate No. 630-

2, NLGI No. 2 lithium grease or equal for lubrication. The water lubricated packing shall be supplied with potable water for lubrication and cooling.

C2-12.18 Lifting Lugs. Furnish major pump components with lifting lugs or eye bolts to facilitate handling. Design and arrange lugs or bolts to allow safe handling of pump components singly or collectively as required during shipping, installation, and maintenance.

C2-13 PAINTING.

C2-13.1 General. Painting shall be done in a professional manner and in accordance with the paint manufacturer's best recommendations. Five copies of the paint manufacture's application recommendations shall be furnished the government 30 days prior to coating. Coatings shall be applied by spray equipment at the factory with only touch up painting permitted in the field. Whenever possible the complete coating system shall be applied to the disassembled components of the pump to ensure complete coverage and maximum protection against corrosion. All ferrous metal surfaces shall be painted except stainless steel, galvanized, machined mating and contact surfaces, and pump impeller and shaft. Rubber, plastic and nonferrous metals shall not be painted. Non painted surfaces adjacent to painted surfaces shall be neatly taped off to avoid painting. Steel surfaces that are to be embedded in concrete shall be left unpainted except for the first 6" of embedment. Paint coating system shall comply with either paragraphs C2-13.2 or C2-13.3 depending on the surface exposure.

C2-13.2 Paint System No. 1. Paint system no. 1 shall be applied to all parts as delineated above that are not wetted by pumped water. The first coat shall be applied at a rate of not more than 600 square feet per gallon. Subsequent coatings shall be applied at a rate not to exceed 450 square feet per gallon. Total dry film thickness shall not be less than 9 mils as proportioned below.

PAINT SYSTEM NO. 1

Surface preparation	1st Coat	2nd Coat	3rd Coat
Power tool or brush-off blast cleaning as per SSPSP 3 or SSPC SP 7	SSPC Paint 25 (3 mils minimum)	FS TT-P-38 (Aluminum, 3 mils minimum)	FS TT-P-38 (Aluminum, 3 mils minimum)

C2-13.3 Paint System No. 2. Paint system no. 2 shall be applied to all parts as delineated above that are wetted by pumped water. The first coat shall be applied at a rate of not more than 600 square feet per gallon. Subsequent coatings shall be applied at a rate not to exceed 450 square feet per gallon. Total dry film thickness shall not be less than 20 mils as proportioned below.

PAINT SYSTEM NO. 2

Surface preparation	1st Coat	2nd Coat	3rd Coat	4th Coat
Blast cleaning approaching white metal as per SSPC SP 5	Primer if recommended by paint mfg.	Cold-applied coal tar epoxy	Cold-applied coal tar epoxy	Cold-applied coal tar epoxy
		----------------- MS MIL-C-18480 ----------------- Total 20 mils minimum		

C2-13.4 Metallic Coatings.

C2-13.4.1 Zinc Coatings. Zinc coatings shall be applied in a manner, thickness, and quality conforming to ASTM A 123.

C2-13.4.2 Methods to Regalvanize. When zinc coating is destroyed by cutting, welding, or other causes, affected areas shall be regalvanized by the following methods. Coatings 2-ounces or heavier shall be regalvanized with suitable low-melting zinc-base alloy similar to recommendations of American Hot-Dip Galvanizers Association to thickness and quality specified for original zinc coating. Coating less than 2 ounces shall be regalvanized by repair compound conforming to MS DOD-P-21035.

C2-14. TESTS, INSPECTIONS AND VERIFICATION.

C2-14.1 Torsional Vibration and Dynamic Analysis. Assembled pumping unit, consisting of engine, speed reducer and pump shall be free from critical speeds or harmful torsional vibrations at all speeds encountered within the operating range of performance characteristics given in paragraph C2-6.2.

C2-14.1.1 Torsional Analysis. Before pump, gear drive, and engine are released for manufacture, engine supplier shall analyze the system for harmful torsional natural frequencies using mass elastic information provided by pump and gear drive manufacturers. A natural frequency that occurs within 25 percent above or below any of the operating speeds required for pump operating conditions is considered to be unacceptable.

C2-14.1.2 Lateral Frequency Analysis. Before the pump, gear drive, and engine furnished under Sections "C1 - Diesel Engines" and "C3 - Speed Reducers for Stormwater

Pumps" respectively, are released for manufacture, the pump, engine, gear drive, shall be analyzed by the pump manufacturer for harmful natural frequencies in the lateral directions. A natural frequency that occurs within 25 percent above or below any operating speeds required for pump operating conditions is considered to be harmful and not acceptable. The dynamic analysis model shall be constructed using a commercially available program such as Ansys, Cosmos/M, or equivalent that utilizes finite element methods. The analysis shall also include all pump parts such as pipes, shafts, bearings, mass concentrations, and other such features as necessary to accurately model the furnished machinery. The model shall incorporate Reed critical frequency and mass elastic diagram information provided by the gear drive manufacturer. If the gear drive manufacturer cannot demonstrate to the satisfaction of Contracting Officer based on impact tests of similar units that the Reed critical frequency value is accurate, a dynamic analysis using finite element methods as described herein shall be conducted by gear drive manufacturer to determine gear drive Reed critical frequency for use by pump manufacturer. A complete dynamic analysis report including the following information shall be submitted:

a. Computer program used.

b. Schematic diagram of the model depicting nodes and elements.

c. Input data consisting of node coordinates, element types, material properties, element characteristics, element connectivities, and specified displacements.

d. Gear mass elastic and Reed critical information or dynamic analysis, if required.

e. Analysis results including all significant natural frequencies.

f. Interpretation of results.

An impact-test on the gear drive before shipment shall be made to determine the actual Reed critical frequency of the drive. Results of impact tests shall be submitted. Pump manufacturer shall address any discrepancy between calculated and actual gear drive Reed critical frequency values as to whether or not design changes are required to prevent harmful natural frequencies in engine/pump/gear drive. If any design changes are required to meet the requirements of this paragraph they shall be made at no cost to Government.

C2-14.2 Factory Test.

C2-14.2.1 General. The performances and cavitation limits of the prototype pump shall be determined by a series of tests made on a scale model of the pump and water passages. The model test shall be completed within 180 days after date of notice to proceed. The tests results shall require government approval prior to the start of prototype production. Any production started prior to an approved successful model test shall be done at the pump manufacturer's risk.

The final performance model tests shall be conducted in the presence of a Contracting Officer's Representative. The Contracting Officer's Representative shall be given at least 14 days notice prior to final performance tests if the test are performed within United States and 45 days noticed if performed outside of the U.S. Final performance test is defined as the test that is used to generate the data required by the specifications.

C2-14.2.2 Test Setup. The model pump shall be homologous to the proposed prototype pump shown on the contract drawings and as specified herein, and with the shaft mounted in the horizonal position. The intake bay and pump's suction elbow shall be equipped with windows strategically located for viewing those areas where separation is likely to occur. The impeller inlet diameter and the datum for this test specification shall be as indicated on the contract drawings. The model pump shall have a minimum impeller diameter not less than 12 inches. The formed suction intake and discharge shown on the contract drawings shall be included in the model test and shall be geometrically the same as that used for the prototype.

C2-14.2.3 Instrumentation and Procedures. Each instrument shall be described in detail, giving all data applicable, such as the manufacturer's name, type, model number, the certified accuracy, coefficient, ratios, specific gravity of manometer fluid to be used, and smallest scale division. When necessary for clarity, a sketch of the instrument or instrument arrangement shall be included. Also included therein shall be a fully detailed narrative description of each proposed method of instrumentation and of the procedures to be used.

a. Head Measurements. Head measurements shall be made using either a direct-reading water column, a mercury-air or mercury-water manometer, or a pressure transducer. Vacuums shall be measured with either a mercury-air or mercury-water manometer or a pressure transducer. Fluctuations shall be dampened sufficiently to permit the column gages and transducers to be read to either the closest one-hundredth (0.01) of 1 foot of water or one-tenth (0.1) of 1 inch of mercury. When pressure transducers are used, their accuracy shall be checked with a manometer. Model test heads shall be the same as prototype heads.

b. Capacity. Model pump capacity shall be determined by a calibrated venturi or magnetic flowmeter. The venturi or nozzle taps shall be connected to column gages or a differential pressure transducer equipped with dampening devices that will permit the differential head to be determined to either the closest one-hundredth (0.01) of 1 foot of water or one-tenth (0.1) of 1 inch of mercury. Both magnetic and venturi flowmeters shall have been calibrated within 6 months of the model test and shall be accurate to within 0.5% of actual flow.

c. Rotational Speed of Pump. The rotational speed of the model pump shall be measured in accordance with HI-01, except that revolution counters shall not be used. Non-contacting hand-held electronic tachometers are acceptable. Device used shall permit speed to be determined to 1 RPM.

d. Power Input. The power input to the pump shall be measured in accordance with "Power Measurements" in HI-01, except that calibrated electric drives shall not be used. A torque-measuring device measuring the torque of the input shaft of the pump is acceptable, provided it is accurate to 1 percent and has been calibrated within the last 6 months. The method used shall permit horsepower to be determined to 1 horsepower.

e. Cavitation Tests. The instruments to be used for these tests shall be selected by the Manufacturer and shall be of the type suited for cavitation testing. However, in no case shall the instruments used yield results less accurate than those obtained with the performance test.

C2-14.2.4 Pump Test. The model shall be sufficiently extensive and complete to demonstrate that the proposed pump complies with the specified performance. Compliance with the requirements of the specifications will be determined from the curves required by the contract specifications. Test procedures, except as herein specified, shall be in accordance with applicable provisions of Hydraulic Institute Standard HI-01. Temperature of water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

a. Performance of The Prototype Pump. The performance of the prototype pump shall be determined by a series of test points sufficient in number to develop a constant-speed curve over the range of total heads corresponding to the pool-to-pool heads in paragraph C2-6.3 "Capacities". A series of constant speed tests shall be conducted to prove the pump performance characteristics. The tests shall be run at model speeds equivalent to the prototype pump normal (100%) speed and also at 105% and 90% of normal speed. For these tests the model impeller shall be subject to a series of lifts, by varying suction absolute pressure, equivalent to a suction pool elevation of -13.5,-11.5,-9.5,-7.5,-5.5 and -2.0, feet NGVD respectively for the actual pump. The total head for the model test shall be the same as specified for the prototype. Each constant speed tests shall cover the full operating range of the pump as specified (at the equivalent test points), and in addition shall cover the higher and lower heads that are expected near shutoff head and near zero head. There shall be a minimum of fifteen (15) test points for each speed series between maximum and minimum test points. The maximum and minimum and other test points shall be to the satisfaction of the contracting officer. If the plot of the data indicates a possibility of instability or dip in the head-versus-capacity curve, a sufficient number of additional points on either side of instability shall be made to clearly define the head-capacity characteristics. For compliance with the guarantees, the efficiency of the prototype pump shall be considered to be the efficiency of the model. No other computation or upward adjustment of model efficiency to prototype conditions will be permitted.

b. Tests Results. The results of the tests shall be plotted to show total pool to pool head, brake horsepower, and percent efficiency as ordinates; all plotted against the pump discharge in gallons per minute for the model pump and cubic feet per second for the prototype pump as the abscissa. The curves showing prototype performance shall be plotted to a scale that will permit reading head directly to 0.2 foot, capacity to 10 cubic feet per second, efficiency to 1 percent, and power input to 10 horsepower.

C2-14.2.5 Cavitation and Critical Sigma Tests. Cavitation tests shall be conducted to prove that at the various pool-to-pool heads of conditions 1 thru 7 the pump is free of cavitation and consequence loss of performance or objectional vibration at the high suction lift and shall include the determination of the critical cavitation coefficient, sigma. The cavitation tests shall be conducted to include the full operating range of the pump as specified and shall have a minimum of ten points, not necessarily the specified conditions, between maximum and minimum test points. Pool-to-pool head shall be used in determining all values of sigma. The maximum and minimum and other test points shall be to the satisfaction of the Contracting Officer. Method of producing equivalent submergence of the impeller shall be as approved by the Contracting Officer. Critical sigma shall be determined on a constant capacity or constant head and constant speed basis. Suction conditions shall be varied to produce cavitation. Critical sigma shall be the maximum value of sigma at which any one or all of the plotted curves, head or capacity, horsepower and efficiency, show a sudden drop from the overall trend of more than three percent. A sufficient number of points to accurately locate the departure point shall be obtained. Each test point shall be calculated and plotted before proceeding to the next point. The value of sigma obtained shall be less than the corresponding plant sigma. The test results shall be plotted to show pool-to-pool head, brake horsepower and efficiency as ordinates; all plotted against sigma as the abscissa. The relation of plant sigma to the respective critical sigma shall be shown on the curve. "Lift" of the model for the purpose of Sigma testing will be considered the same as the Prototype "lift" when the absolute pressure at the top of the model impeller is identical to the absolute pressure at the top of the impeller of the prototype at the maximum lift. For all other test runs, "lift" shall be to the centerline of the propeller. Model data results shall be adjusted to account for differences between model water temperature and prototype water temperature of 92 degrees Fahrenheit

C2-14.2.7 Reserved.

C2-14.2.6 Blade Templates Demonstration. The Contractor shall demonstrate to the Government witness that the blade templates fit the tested pump. The templates shall be sufficiently complete to permit construction of the impeller from the templates. The demonstration shall be done immediately after the performance/cavitation testing is completed. The Contractor shall retain all templates for the accepted pump model and for the prototype, and shall furnish them to the Government upon request of the Contracting Officer, to permit the Government to verify that the prototype pump is in complete geometric similarity with the model. In lieu of providing templates, the Contractor shall furnish dimensioned drawings of the impeller that contain all dimensions needed to manufacture the impeller. The Contractor shall retain the model pump impeller used for the test until final acceptance of the prototype pump. The model impeller shall be stamped with identification marks. The Contractor shall retain all templates for the components of the tested model or prototype pump, or both, and shall furnish them to the Government upon request of the Contracting Officer along with the necessary facilities and instruments needed to permit the Government to verify that the prototype pumps are in complete geometric similarity with the model pump or the tested pump.

C2-14.2.7 Witness Test. When the Contractor is satisfied that the model performs in accordance with the requirements of the specifications and the guaranteed values, the Contractor shall notify the Contracting Officer that the witness tests are ready to be run on the model and shall furnish two copies of the curves required in paragraph C2-14.2.4.b "Tests Results." Two weeks will be required to review this data before the Contracting Officer will be available to visit the Contractor's laboratory for witnessing the test. Should the results of the witness test reveal that the model does not perform in accordance with the requirements of the specification and the guaranteed values, the Contractor shall make such changes to the model as are required to make it acceptable before again notifying the Contracting Officer that the witness tests are ready to be run. Immediately upon completion of each witness test, copies of all data taken during the test shall be delivered to the Contracting Officer witnessing the test. Computations of test results and plotted preliminary curves shall be furnished to the witness.

C2-14.2.8 Test Report. The Contractor shall, within 30 days of receipt of approval of the witness test, furnish to the Contracting Officer seven bound copies of a report covering the model performance and cavitation tests. Each test report shall include, as a minimum, the following:

a. A statement of the purpose of the test. The name of the project, the contract number, and specified pumping conditions. Where the guaranteed values differ from the specified values, they shall also be given.

b. A resume of preliminary studies, if such studies were made.

c. A description of the model pump and motor including serial numbers, if available. The information required under "b" above may be included here.

d. Copies of calibration of instruments used.

e. A description of the test procedure used, including dates, test personnel, any retest events, and witness test data.

f. Sample computations (complete).

g. A discussion of the test results.

h. Conclusions.

I. Photographic evidence in the form of either 24 color photographs of test equipment, the test setup and representative test segments, or a VHS videotape, at least 30 minutes in length, covering the same information as the photographs. All photographic evidence shall be labeled with the Contract number, location, date/time, and test activity. The videotape shall be voice annotated with the same information.

j. Copies of instrument calibration.

k. Copies of all recorded test data.

l. Curves as required in paragraph C2-14.2.4.b "Tests Results."

m. Curves showing the performance of the prototype pump.

n. Drawings, including cross sections of the water passages that should be incorporated in the construction contract.

o. Drawings of the test setup, showing all pertinent dimensions and elevations and a detailed dimensioned cross section of the model pump.

C2-15. ANCHORS AND SUPPORT ITEMS. All anchor bolts for the pump and those accessories of the pump furnished with the pump including any special supports for the pump shall be designed, sized and supplied by the pump machinery supplier as part of this section.

C2-16. RESERVED.

C2-17. RESERVED.

C2-18. NAMEPLATE. The pump shall be identified by means of a separate name-plate permanently affixed in a conspicuous location. The plate shall bear the manufacturer's name, model designation, serial number if applicable, and other pertinent information such as horsepower, speed, capacity, type, direction of rotation, etc. The plate shall be made of corrosion-resisting metal with raised or depressed lettering and contrasting background.

C2-19. INSTRUCTION PLATES. The pump shall be equipped with suitably located instruction plates, including any warnings and cautions, describing any special and important procedures to be followed in starting, operating, and servicing the equipment. Plates shall be made of corrosion-resisting metal with raised or depressed lettering and contrasting background.

C2-20. GUARDS AND COVERS. Safety guards and/or covers shall be provided wherever necessary to protect the operators from accidental contact with moving parts. Guards and covers shall be of sheet steel, expanded metal, or another acceptable material and removable for disassembly of the pump.

C2-21. SPARE PARTS. The Contractor shall furnish the following spare parts:

a. Two complete sets of bearing seals used on two pumps.

b. Sufficient length of packing to allow repacking of all glands.

PART 3 EXECUTION

C2-22. INSTALLATION. The installation of the equipment furnished under this section and related drive machinery furnished under other sections of this specification shall be in accordance with the approved Installation and Erection Instructions Manual required by paragraph C2-3 "SUBMITTALS." The erection engineer, familiar with the equipment to be installed, shall supervise the handling, installation, start-up and testing of the equipment as required by Section "C5-FIELD SERVICES."

C2-23. FIELD TESTS. Field test shall be in accordance with the requirements of Section "C5 - FIELD SERVICES."

C2-25 MEASUREMENT AND PAYMENT. No measurement will be made for work specified in this section. Payment for the fabrication of the pump will be made at the contract unit price for "Pump". Price and payment shall constitute full compensation for furnishing all plant, labor, and equipment to complete the work as specified herein and as shown on the drawings.

C2-25.1. Modeling testing, fabrication, collection and reduction of data and other work associated with model testing shall be paid for at the contract lump sum price for "Model Testing." Payment for all work related to designing the pumps, engineering required for matching and coupling drive components and controls, and dynamic and torsional analysis shall be made at the contract lump sum price for "Engineering and Design Service."

C2-25.2. Payment for special tools, patterns, setups and jigs and/or for modifying standard tools used solely for the production of the pumps shall be paid for at the contract lump sum price for "Tools and Jigs". Price and payment shall constitute full compensation for furnishing all plant, labor, and equipment for special tools, patterns, setups and jigs and/or modifying standard tools and shall be invoiced on the first (1st) delivery order.

SECTION C3 - SPEED REDUCERS FOR STORM WATER PUMPS

PART 1 - GENERAL

C3-1. SCOPE. The work consists of designing and furnishing a minimum of one helical

gear, double reduction speed reducer with coupling and shaft required for connection with the engine and pump specified in Sections C1 and C2 respectively.
These requirements shall also apply for up to seven identical speed reducers if required.

C3-2. REFERENCES. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

C3-2.1 American Gear Manufacturers Association (AGMA).

AGMA 6010-E	Standard for Spur, Helical, Herringbone, and Bevel (1991) Enclosed Drives.
AGMA 6025-C	Sound for Enclosed Helical, Herringbone, and Spiral (1990) Bevel Gear Drives.

C3-2.2 American Society of Mechanical Engineers (ASME).

ASME B31.1	Power Piping. (1992)

C3-2.3 Anti-friction Bearing Manufacturers Association (AFBMA).

AFBMA 9	Load Ratings and Fatigue Life for Ball Bearings. (1990)
AFBMA 11	Load Ratings and Fatigue Life for Roller Bearings. (1990)

C3-2.4 National Electrical Manufacturers Association (NEMA).

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum). (1991)

C3-2.5 National Fire Protection Association (NFPA).

NFPA 70	National Electrical Code. (1993)

C3-2.6 National Fluid Power Association (NFLPA).

NFLPA T3.10.8.8 R1	Hydraulic Filter Fine Element Multi-Pass Test (1990) Hydraulic Fluid Power - Filters - Multi-Pass Method for Evaluating Filtration Performance

C3-3. GENERAL REQUIREMENTS.

C3-3.1 Materials and Equipment. Materials and equipment shall be the standard products of manufacturers regularly engaged in the production of gear reducers and couplings for pump drives and shall essentially duplicate products which have been in prior satisfactory use for at least 2 years prior to bid opening. All products shall be new. The reduction gear and couplings will be used to transmit power from the diesel engine to the pump as indicated on the contract drawings and specified herein. The gear reducers and couplings shall be adequately designed and conservatively rated to provide a reliable, efficient, smooth and quiet running drive under all operating conditions. The gear reducers shall be furnished complete with all auxiliaries ready for operation after installation under another contract.

C3-3.2 Spare Parts. The gear reducer/coupling manufacturer shall provide, at the time of delivery, one set of standard recommended spare parts for each unit and coupling. The spare parts shall include those items customarily furnished plus any other special items which the manufacturers deems necessary for the gear reducer and couplings provided. All spare parts shall be duplicates of the original parts furnished and interchangeable therewith. All spare parts shall be enclosed in separate, sealed moisture proof bags with desiccant bags, and packed in containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each container, shall be securely fastened, in a moisture- proof envelope, to the outside of the container. The packing list shall also provide the following information:

(1) Manufacture.

(2) Contract number.

(3) Identification, including the manufacturer's drawing number or part number for each spare part in the container.

As a minimum the manufacturers of the gear reducers and couplings shall provide the following spare parts:

ITEM	DESCRIPTION	QTY
1	Set of filter elements	7
2	Set of each type of hose used.	7
3	Lubrication pumps	7
4	Coupling seals set	7
5	Bearing seals set	7
6	Gear reducer gasket set	7

7	Engine coupling heat resistant elastomer member set	7

C3-3.3 Delivery and Storage. Material and equipment shall be protected from weather, humidity, temperature variation, dirt, dust, and other contaminants during delivery and storage. The gear reducer and accessories shall be protectively processed for not less than 24 months storage indoors at the destination.

C3-4. SYSTEM DESCRIPTION.

C3-4.1 Design Conditions. The reduction gear unit shall be capable of continuously transmitting not less than the maximum horsepower required by the pump at maximum load, Condition No. 6 of paragraph C2-6.3 "Capacities", multiplied by a minimum service factor of 2.25. The gear reducer shall be capable of operating with ambient temperatures in the range of 32 degrees F to 125 degrees F. Speed reducers with AGMA application factors higher than the minimum will be rated higher in the award evaluation.

C3-4.2 Critical Speeds. Dynamic analysis of the pump, reducer, and engine assembly shall be performed by the pump manufacturer. The reducer manufacturer shall coordinate with the pump manufacturer in performing the dynamic analysis. The reducer manufacturer shall make any design modifications to the reducer or connecting couplings which are necessary to avoid resonances in the system. A torsional natural frequency within 25 percent or lateral natural frequency within 25 percent of normal operating speed of any shaft or gear mesh frequency is unacceptable.

C3-4.3 Arrangement. The speed reducer input and output shaft shall be connected to the engine and pump with flexible steel, self aligning gear type couplings with exposed coupling bolts. The Contractor shall ensure compatibility and fit of the reducer high-speed and low-speed shafts with that of the pump and engine. The speed reducer mounting shall be designed to permit removal of the reducer and reinstallation without requiring realignment of the reducer and shafting or altering pump and/or engine. Before assembly, each gear and shaft assembly shall be statically and dynamically balanced. Reducer vertical shaft centerline distance and arrangement shall be as shown on the contract drawings. There shall be no horizonal offset between the low-speed and high-speed shaft.

C3-5. SUBMITTALS. Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section H "Submittal Procedures":

C3-5.1 SD-01, Data. Provide complete computations, design loads, and catalog data, as follows:

a. System Description; GA.

b. Bearings; GA.

c. Gears; GA.

d. Shafts; GA.

e. Couplings ; GA.

f. Backstop; GA.

g. Housing; GA.

h. Lubrication System; GA.

i. Instrumentation; GA.

j. Speed Reducer and Related Lubricating and Auxiliary Equipment; GA.

C3-5.2 SD-04, Drawings. Within 30 days of notice of award of contract, drawing shall be submitted as listed below. Drawings shall be of sufficient size for easy reading and consisting of a complete list of equipment and materials, including manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; and installation instructions. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of work including clearances for maintenance and operation. Drawings notes and dimensions shall be in English. Drawings shall include the following:

a. Reducer Drawings; GA.

b. Lubrication System; GA.

c. Instrumentation; GA.

C3-5.3 SD-09, Reports. A field test report documenting all data for load and speed measurement, lubrication oil temperature and flow, cooling water temperature and flow, gear contact patterns, adjustment of component settings, and otherwise showing compliance with specified performance criteria, submittals shall include:

a. Shop Testing; GA.

b. Field Testing; GA.

C3-5.4 SD-10 Reducer Quality Control Report. Submittals shall include:

a. Material Chemical Certification; GA

b. Heat Treatment Certification; GA

c. Gear Accuracy Reports (lead and profile charts to confirm with gearing calculations and NDT certificates); GA

C3-5.5 SD-19, Operation and Maintenance Manuals. The Operation and Maintenance Manual shall provide detailed startup and operating procedures, lubrication instructions, installation and alignment procedures, routine maintenance requirements and procedures, complete detailed procedures for disassembly and assembly of the reducer, parts list for all parts detailed, assembly drawings of the reducer showing all parts, suppliers for all parts, settings and adjustment for protective devices, and a list of all tools, handling devices, and spare parts furnished. Submittals shall include:

a. Operation and Maintenance Manual; GA.

PART 2 PRODUCTS

C3-6. GENERAL. The reducer assembly shall be rated in accordance with AGMA 6010-E as applicable. The unit rating shall be equal to or exceed the maximum input power times an application factor. The service factor shall be 2.25 for reducers driven by diesel engines. The speed reducers shall be designed and manufactured by a firm that is regularly engaged in the manufacture of speed reducers of the type utilized for these installations. The reduction gear unit shall be single or double reduction, vertical off-set, parallel horizontal shafts with an anti-reverse backstop and, lube oil pumps. Cooling will be by external keel coolers supplied by others. The gear manufacturer shall provide external connections for coupling to the keel coolers. The manufacturer shall also supply cooling requirements. The units shall be factory assembled and furnished complete in every respect with couplings, supports, and lubrication system. Total gear losses shall not exceed three percent (3%) of the input horsepower. The nameplate shall bear the manufacturer's name, model designation, serial number, unit rating, service factor, reduction ratio, and other applicable information. The gear reducer shall conform to the requirements of AGMA 6010-E. The reducer shall display the certified manufacturer's AGMA insignia as evidence of conformance to AGMA standards.

C3-7. BEARINGS. Bearings shall be the anti-friction type, certified by the manufacturer for the application and shall be rated for an L-10 life of 100,000 hours at the rated operating load of the reducer. Ball bearing load ratings shall conform to AFBMA 9. Roller bearing load ratings shall conform to AFBMA 11. Bearings shall be self-contained within the gear case housing and shall be oil lubricated from the gear unit's pressure lubrication system.

C3-8. GEARS. Gearing shall be of helical design, precision built from alloy steel and shall be gas nitrided or carburized, through hardened and precision machine ground. Gears shall be AGMA Quality No. 12 or higher. The pinion or gear of each helical set shall be crowned to eliminate end loading. Gears shall use standard diametral pitches. In addition to rating the gears according to AGMA 6010-E , gear stresses shall not exceed 80 percent of yield strength for engine peak torque prior to stall. Each gear shall be statistically and dynamically balanced. The maximum pitch line velocity shall not exceed 4,000 feet per minute at 105 percent of pump design speed.

C3-9. SHAFTS. Each shaft shall be heat treated alloy steel with precision ground surfaces for bearings and gears. Input shaft size and configuration shall be compatible with the engine. Output shaft size and configuration shall be compatible with the pump. Welded shafts are not acceptable. Individual shafts shall be statically and dynamically balanced along the axial and radial axes to an amplitude of less than .001 inch at design speed. Suitable oil seals shall be provided where shafting passes through the housing to insure against oil leakage and dirt and water infiltration.

C3-10. COUPLINGS. The speed reducer shall be connected to the engine and pump by flexible steel, self aligning gear type couplings. The couplings shall have a service factor of 2.25 based on maximum rated load. In addition, at peak engine torque prior to stall, stresses shall not exceed 80 percent of yield strength. Engine end- couplings shall feature piloting bushings of bronze and shall transmit torque by means of compression of heat resistant elastomer members which shall effectively absorb shock and engine vibrations. The angle and offset misalinements between coupled shafts shall be less than one half of that allowed by the coupling manufacturer. The couplings shall be dynamically balanced to AGMA balance classification 7 or better. Coupling to shaft fit shall be as shown in the table of fits in paragraph C2-11.5.2 "Class of Fit Required".

C3-11. BACKSTOPS. A backstop shall be provided on the high speed shaft of the reducer to prevent reverse rotation of the pump. The backstop shall be sized for 150% of maximum pump drive torque. A service factor of 2.25 shall be applied to the manufacturer's published ratings. In addition the backstop shall be suitable for continuous operation at engine idle speed. The backstop shall be of a type with cylindrical rollers on inclined cam planes. The backstop shall be mounted with the outer race moving and the inner race fixed. The backstop shall operate at a temperature of less than 160 degrees F under all operating conditions with an ambient temperature of 32 to 125 degrees F. The backstop shall be provided with a circulating oil lubrication system and shall have sufficient flow rate to provide the required cooling. The lubrication system may be part of the gear reducer lubrication system. The recommended gearbox lubricant shall be selected for compatibility with the backstop mechanism.

C3-12. HOUSING.

C3-12.1 General. The housing shall be fabricated from welded steel plates and shapes, stress relieved prior to machining, and reinforced to carry all applied loads and to maintain gear alignment. The housing shall fully enclosed all gearing and bearings and split along the centerline of the shafts. The slit centerline shall be joined by machined flanges. The housing shall be rigidly bolted to the reducer baseplate. It shall have a minimum of four jack bolts to facilitate alignment. The housing bottom shall be machined. The interior of the reducer shall be painted with an oil compatible coating. The exterior shall be painted with the manufacturer's standard coating system. Color shall be light gray. The housing shall have an oil fill connection and a drain connection with a magnetic plug. Lifting lugs shall be provided for lifting the entire reducer assembly and any subassembly or component which cannot be lifted using web slings. The housing shall be water tight up to the invert of the gear output shaft for the pump.

C3-12.2 Seals. Shafts shall have a lip seals to prevent leakage of oil and exclude dirt and water. Lip seals shall utilize hardened steel wear sleeves to preclude shaft repair or replacement if the seal wears the shaft. The seals shall be water tight up to the lowest shaft invert.

C3-12.3 Inspection Covers. The housing shall have inspection holes with cover plates located above the maximum oil level to permit viewing of gear teeth allowing evaluation of the contact patterns of each gear mesh and to allow inspection of internal features of the lubrication system.

C3-13. LUBRICATION SYSTEM.

C3-13.1 General. The speed reducer shall be provided with an oil lubrication system that will provide continuous lubrication to the gears, bearings, and oil lubricated type backstop. The system shall consist of an oil circulating pump, oil-to-water keel coolers (supplied by others), piping, filters, and controls. Each reducer shall be provided with its own system. The lubrication system shall be self - contained and provided with pressure and temperature gauges and with alarms for low oil pressure and high temperature. The oil circulating pump shall be driven directly from the speed reducer shaft. The maximum oil sump temperature at rated speed and load shall not exceed 160 degrees F at an ambient temperature of 125 degrees F. The reducer shall be capable of operating with an ambient temperature in a range of 32 to 125 degree F.

C3-13.2 Oil Pump. The oil pump shall be positive displacement type gear type. The pump shall have a relief valve which discharges to the sump. The pump shall be reversible so it continues to function during a runaway condition. The pump shall be capable of supplying sufficient oil through the keel coolers to cool the speed reducers.

C3-13.3 Oil and Breather Filters. The lubricating system shall have two oil filters on the pump outlet side. One filter shall be for removing particles and the other for water removal. The filter for particles shall have a Beta rating of B6 greater than 75 at 60 psi differential tested in accordance with NFLPA T3.10.8.8 R1. The reducer manufacturer may propose an alternate Beta rating by submitting proof that B6 greater than 75 is unsuitable for the lubricant to be used. Each filter shall incorporate a glycerin filled differential pressure gauge to indicate the pressure drop across the filter. The filter shall have an internal magnetic element. The water removal filter shall maintain a water content in the oil of no greater than 200 ppm. All filter assemblies shall be sized so the pressure drop across the clean filter is no greater than 4 psi. The particle filter shall be sized to avoid bypass at a startup oil temperature of 70 degrees F. Filters shall have a bypass setting of 45 to 60 psi. Element collapse rating shall not be less than 150 psi. The breather filter shall have a Beta rating of B6 greater than 75 and a desiccant chamber to remove water.

C3-13.4 Remote Radiator. The speed reducers shall be cooled by air cooled engine radiators. A pump of sufficient pump capacity in terms of flow rate and pressure and control valves shall be supplied by the speed reducer manufacturer for circulating the speed reducer oil thru the remote radiator. The radiator will be located approximately 70 feet from the speed reducers with ten 90 degree elbows on the supply line and ten 90 degree elbows on the return line. Supply and return line is limited in size to 6 inch, schedule 40 pipe. Minimum air temperature that the line will be exposed is 32 degrees.

a) RADIATOR: A horizontal, remotely located, fan cooled, heat exchanger capable of removing all waste heat generated by the engine shall be provided.

(1) Radiator shall be designed or selected using 100o F ambient temperature at sea level and a coolant composed of 50% water and 50% ethylene glycol. Duty cycle shall be continuous

(2) The radiator shall be designed or selected to maintain the temperature of water/glycol coolant leaving the engine jacket at 165o F to 170o F and the temperature of the lube oil leaving the engine at 185o F. These temperatures and any other cooling requirements shall be maintained at the continuous rating horsepower load of the engine and at 110% of this load. The radiator shall be adequately designed and conservatively rated.

(3) Tubes shall be seamless admiralty brass, not less than 5/8" O.D., and shall have copper or aluminum fins. The core shall have a screen guard.

(4) The vertical discharge fan or fans shall be driven by T.E.F.C., ball bearing 460 volt, 3 phase, 60 Hertz electric motors conforming to NEMA Standards. The number of fans required per radiator, horsepower and speed requirements shall be determined by the radiator manufacturer, multi-v-belt or geared drives with guards shall connect motors to fans. Motors shall be equipped with 120 volt single phase space heaters with built in controls. Space heater terminals shall be brought out to cast iron gasketed motor junction box.

(5) The entire heat exchanger construction shall be in accordance with the ASME Unfired Pressure Vessel Code but need not bear the ASME stamp. All structural members and

steel appurtenances shall be hot dipped galvanized. The radiator shall be designed and adequately braced to withstand a wind velocity of 150 mph.

(6) The radiator shall be furnished complete with all accessories including a galvanized expansion tank if required. The size of all expansion tanks shall be approved by the Engineer.

(7) The radiator shall be factory tested with all of the manufacturer's standard tests.

(8) Those surfaces which cannot be galvanized, excluding aluminum fins, shall be thoroughly cleaned with solvents and made free of grease, weld, scale, etc., and prime coated with two shop coat of Tnemec #90-92 zinc coating.

C3-13.5 Reserve.

C3-13.6 Piping and Tubing. Oil lines up to 2 inches O.D. shall be seamless steel tubing with 37 degree flare or flareless fittings. Where pipe sizes of 2 inches and over are required, steel pipe with welded fittings shall be used. Water piping shall be copper or copper alloy with brazed or 95-5 soldered joints. All piping, tubing, and fittings shall conform to ASME B31.1. Vibration isolating tubing and piping supports shall be used. Oil tubing or ports shall be kept within the gear case where feasible. Dissimilar metals shall be electrically isolated to prevent corrosion.

C3-13.7 Lubricating Oil. Lubricating oil shall be mineral oil or synthetic hydrocarbon as recommended in AGMA 6010-E for a temperature range of 32 to 160 degrees F. The lubricant shall be suitable for the entire temperature range without change of lubricant. Lubricant additives shall be used as recommended by the reducer manufacturer. Lubricant shall also be suitable for use with the backstop. Catalog data of the proposed lubricant shall be submitted for approval.

C3-14. INSTRUMENTATION. Instrumentation for the reducer shall be supplied and installed as a complete working package, coordinated with the pump and engine supplier. All electrical work shall conform to NFPA 70. Electrical enclosures shall be NEMA 250, Type 4. An electrical termination cabinet shall be provided. Available power is 120 V, 1 ph. The speed reducer shall have the following devices as a minimum:

a. High oil temperature switch located in the oil sump and connected to audible and visual alarms. The switch shall be set to activate the alarm for temperatures over 180 degrees F. At temperatures of 200 degrees F and higher the engine shall automatically shutdown. Lower settings may be used if recommended by the reducer manufacturer.

b. An oil pressure gauge shall be located to indicate the oil pump pressure. The gauge shall be clearly visible from the engine room floor. The gauge shall be a 4.5 inch face diameter with a range from 0 to 150 psi and shall be glycerin filled with a snubber and isolation valve.

c. Industrial dial type thermometers shall be located to detect oil sump temperature, oil temperature after leaving the heat exchanger and backstop oil temperature. Thermometers shall have a 4-1/2 inch face and scale range of 0 to 250 degrees F. In addition the sump temperature of the lubricating oil shall be indicated remotely by an "Alnor" type N 14/19 "Pyrotroller" mounted with the temperature indicating instrument specified for the pump bearings. The sensing element shall be an "Alnor" type 3480 stainless steel stem thermocouple and NPT fitting, all compatible with the specified indicator.

d. An oil level sight gauge with a built in reflector shall be provided. The gauge shall be located so that it can be easily read when the reducer is installed.

e. An oil flow switch shall be provided which shall activate an audible and visual alarm to indicate that oil flow is less than 80 percent of design and shall shut down the engine if flow drops below 60 percent of design.

f. A vibration alarm shall be provided with visual and audible alarms when the vibration level exceeds 0.5 inches/sec or at a baseline recommended by the manufacturer.

PART 3 EXECUTION

C3-15. TESTS, INSPECTIONS AND VERIFICATION.

C3-15.1 Shop Testing. In addition to or as part of the Contractor's normal shop testing procedure, the reducer shall be tested at rated speed, no load to check for potential problems which shall be eliminated prior to field testing. Gear contact patterns, sound level, lubrication and cooling, and all other operational characteristics shall be checked. The sound pressure level of the speed reducer shall not exceed 90 dBA measured at a distance of 1 m (3 feet) from the equipment. Sound shall be measured in accordance with AGMA 6025-C. The Contractor shall provide any preventative measures to control background noise. The Contractor shall notify the Contracting Officer 2 weeks prior to performing the shop test.

C3-15.2 Installation. The installation of the equipment furnished under this section and related drive machinery furnished under other sections of these specifications shall be in accordance with the approved "Installation and Erection Instructions Manual" described in paragraph C2-3 "SUBMITTALS." The Erection Engineer, familiar with the equipment to be installed, shall supervise the handling, installation, start-up and testing of the equipment as required by Section "C5 - FIELD SERVICES."

C3-15.3 Field Testing. Field tests shall be in accordance with the requirements of Section "C5 - FIELD SERVICES"

C3-16 MEASUREMENT AND PAYMENT. No measurement will be made for work specified in this section. Payment for the fabrication, and testing of the speed reducer and coupling will be made at the contract unit price for "Speed Reducer." Price and payment shall constitute full compensation for furnishing all plant, labor, and equipment to complete the work as specified herein and as shown on the drawings.

C3-16.1 Payment for engineering design work for the speed reducer will be made at the contract lump sum price for "Engineering and Design."

C3-16.2 Payment for shipping the speed reducer and unloading at the storage site, complete with all accessories and spare parts will be made at the contract unit price for "Shipping and Unloading."

SECTION C4 - CONTROLS

PART 1 - GENERAL

C4-1. SCOPE. The work provided for herein consists of furnishing all plant, labor, equipment and material, and performing all operations required to design, manufacture, assemble, factory test, prepare for shipment and storage, deliver, and provide instructions and supervision for erection by others under a separate contract and field test, a minimum of one control/instrument panel for the diesel engine, pump, speed reducer, and vacuum breaker specified in Sections C1, C2, C3, and elsewhere in this contract. Coordinate the suitability and compatibility of the control/instrument panel for use with the engines, speed reducer, pumps, and vacuum breaker valves specified in the associated contract specifications. These requirements shall also apply for up to seven identical control/instrument panels.

C4-2 QUALITY CONTROL

C4-2.1 General. The Contractor shall establish and maintain quality control for all manufacturing, fabrication, factory tests, preparation for shipment, erection instructions and supervision, and field testing to assure compliance with contract requirements and to maintain records of his quality control for all fabrication, erection, and testing operations, including but not limited to the following:

(1) Shop fabrication and assembly

(2) Preparation for shipment and storage.

(3) Factory tests before shipping.

(4) Inspection at the work site for damage to and defects in material and equipment.

C4-2.2 Reporting. Two copies of the records of inspection, erection and tests, as well as the corrective action taken, shall be furnished to the Government as directed by the Contracting Officer.

C4-3. APPLICABLE PUBLICATIONS.

C4-3.1 National Electrical Manufacturers Association (NEMA).

C4-3.2 NFPA 70 (1996) National Electrical Code.

C4-4 SUBMITTALS. Government approval is required for all submittals with a "GA" designation; submittals having an "FIO" designation are for information purposes only. The following shall be submitted in accordance with Section H "SUBMITTAL PROCEDURES".

C4-4.1 SD-01, Data.

C4-4.1.1 List of Materials; (FIO). Furnish two copies of purchase orders and work orders. Contractor shall, at time of submittal of drawing, furnish a list designating material, and components to be used for the panels.

C4-4.1.2. Materials; (GA). Furnish, within 60 days of notice of award, names of manufacturers of components and other equipment which the Contractor contemplates incorporating in the work, together with other relevant information pertaining to the components and equipment.

C4-4.1.3 Parts List;(GA). Furnish 10 copies of manufacturer's complete parts list showing all parts, components, and equipment along with spare parts for control/ instrument panel. Clearly show all details and components and describe or properly identify each individual component, part, or equipment item.

PART 2 - PRODUCTS

C4-5. CONTROL AND INSTRUMENT PANEL. The engine with accessories, the engine control and instrument panel, speed reducer and the pump shall be supplied together as a complete unit by the pump supplier in order to ensure complete compatibility of the individual components. Each complete unit shall be totally enclosed, free-standing, dead front, floor mounted, provided with a NEMA 12 enclosed, cabinet type control and instrument panelboard which shall be mounted adjacent to the engine in an accessible and readable location within ten

(10) feet of the engine. The instrument and control panelboard shall have an overall dimension of 90 inches high by 20 inches deep and width as necessary, contain not less than the following instruments and controls, the arrangement of which shall be approved by the Contracting Officer. The control and instrument panel shall include all required starters, contacts, relays, etc for the complete control and monitoring of the engine, vacuum pump, pump, speed reducer, siphon breaker valve, vacuum breaker valve, and all auxiliaries. The Contractor shall include any additional equipment or alarms necessary to safeguard the furnished equipment or required for proper and safe operation. The Contractor shall coordinate and ensure compatibility with procedures specified in Section C1. The Contractor shall supply a detailed start-up and operating procedure for the equipment supplied. Electrical supply will be 120 volt, 60 Hertz.

1) Engine running time meter calibrated in hours, minimum indication 9, 999 hours and shall be "non-resettable"

2) Tachometer.

3) Hood light switch.

4) Pressure gauge, fuel, across filter.

5) Pressure gauge, fuel, downstream of filter.

6) Differential Pressure gauge, lubricating oil, across filter.

7) Pressure gauge, lube oil, downstream of filter.

8) Pressure gauge, Gear drive lubricating oil.

9) Pressure gauge, starting air.

10) Pressure gauge, jacket water.

11) Compound pressure vacuum gauge, 30 lbs. pressure 30-inch vacuum. Air intake manifold pressure. Engine manufacturer shall specify exact gauge required.

12) Temperature indicator, pump inboard and outboard bearings.

13) Temperature indicator, jacket water in.

14) Temperature indicator, jacket water out.

15) Temperature indicator, lubricating oil in.

16) Temperature indicator, lubricating oil out.

17) Temperature indicator, gear drive lubricating oil.

18) Fuel flowmeter indicator (Gal/Hr).

19) Engine speed control including starting and stopping.

20) Mode switch (Test-Off-Auto)

21) An illuminated window type visual and audible annunciator, with first out indication to indicate low fuel pressure, low lube oil pressure, low reduction gear lube oil pressure, low cooling water pressure to gear reducer heat exchanger, low water pressure to stuffing boxes, engine over speed trip, high jacket water temperature, high lube oil temperature, high pump inboard and outboard oil bearing temperature, high speed reducer lube oil temperature, low engine jacket cooling water pressure, high crankcase pressure (see paragraph C1-6.2), excessive vibration (see paragraph C3-14), low reducer oil flow (below 80% of design flow) and low starting air pressure.

20) Pyrometer exhaust temperature indicator with selector switch for each cylinder exhaust and "Off" position.

21) Lube Oil Keep Warm On/Off Switch and Indicator Lights

22) Engine Start/Stop Push-buttons.

23) Siphon Breaker Open (Green Illuminated Push-button)

24) Siphon Breaker Closed (Red Illuminated Push-button)

25) Pump Lubricator Switch (Manual-Off-Auto).

26) Jacket Water Keep Warm System On/Off Switch and Indicating Lights.

27) Pre-Lube Pump Indicating Lights.

28) One control power master disconnect switch to disconnect all incoming "hot" circuits. This master switch shall have its own enclosure, shall be mounted on the inside of the panel door with handle extended through panel door, and shall be of the rotary-type with pistol grip handle G.E. Type SB-1, or approved equal, with pilot light.

29) "Start-Stop" Push-buttons to control the vacuum pump, flush mounted in the cabinet door, with red indicating pilot light.

30) Set of fuse blocks and necessary fuses for adequate protection of all control circuits as required by the National Electric Code.

31) Emergency Stop push-button.

32) Switches for the Alarm System: Test, Reset, and Acknowledge Switches.

33) All other necessary "Start-Stop" Push-buttons, indicating lights, contacts, and auxiliary relays to perform the manual and automatic functions listed under the Start-Up and Automatic Engine Stopping procedures.

34) All terminals for connection to devices outside the cabinet shall be wired to a terminal strip in the cabinet with terminals and wires identified, and shall be internally wired according to the cabinet wiring diagram provided with the cabinet.

35) Push-buttons to test all pilot lights.

36) Alarm Horn.

37) Alarm horn silencer.

38) General alarm contact to actuate alarm and light for pump unit on monitoring, console in central office.

39) Other interlocks as required for safety and proper operation, start-up and shut-down of engine and pump shall be supplied.

PART 3 - EXECUTION

C4-4.6. INSTRUMENT AND CONTROL PANEL CONSTRUCTION. The instrument board shall be constructed on an angle iron frame with the top, back and side panels of not less than No. 12 gage bonderized steel, with panels removable and held in place by stainless steel screws. All equipment within the panel shall be readily accessible by removal of one or more panels. The back panel shall be provided with a bronze insert screened louver in line with the alarm speaker. A hooded light fixture shall be provided on the top face of the board. It shall protrude about 12 inches from the face of the board and house two fluorescent lamps of sufficient wattage to light the entire front of the board. The bottom leg of the base angle shall be drilled all around for cap screws for fastening to the floor or engine base structure, through shock-absorbing mounts. All wiring for the instrument board shall conform to the latest issue of the National Electrical Code and shall be a minimum No. 14 A.W.G. Groups of exposed wires shall be run straight horizontally or vertically on the back of the board with short radius right angle bends, properly cleated, and shall terminate at terminal blocks near the bottom of the board. All terminal blocks shall provide a minimum of four (4) spare terminals. Wiring and tubing between control panel and engine shall be included. Provision shall be made for easy field connection to external devices on pump and other equipment. The temperature indicators may be combined into one or more multiple position selector switch type. All instruments and controls shall be properly and neatly labeled with engraved laminated plastic nameplates with black letters on white background. The instrument boards shall be finished both sides with a light grey machinery enamel.

C4-4.7. START-UP SEQUENCE. The pumping unit shall be manually put into service by one person from the instrument panel as follows:

1) Energize panel by turning "Master Switch" on. Green light shall indicate the panel is on.

2) Start diesel engine through momentary contact "Engine Start" switch. The "Engine Start" switch shall be electrically interlocked so that the air start solenoid valve will not open until the following actions have been accomplished:

a. The pre-lube pump has been energized and normal lube oil pressure has been attained.

b. A pressure or flow switch in the city water supply line senses water flow to the horizontal pump's stuffing box.

3) After sufficient low speed warm-up, engine shall be brought up to normal operating speed. The pre-lube pump shall be automatically shut-down once the engine has started.

4) Visual and audible alarms shall indicate any malfunction.

C4-4.8 Automatic Engine Stopping.

C4-4.8.1 Delayed Stop. Approved means shall be provided to automatically reduce engine speed to the idle setting and then, after a 10-minute delay for temperature stabilization, to stop the engine.

C4-4.8.2 Immediate Stop. Approved means shall be provided to immediately and automatically stop the engine when any of the following conditions exist:

(1) Reducer lubricating oil pressure decreases below the minimum recommended by the reducer manufacturer.

(2) Reducer lubricating oil flow decreases below 60% of design flow.

(3) Reducer Lubricating oil temperature exceeds 200 degrees F.

(4) Engine lubricating oil pressure decreases below the minimum recommended by the engine manufacturer.

(5) Engine jacket water temperature exceeds the safe operating temperature.

(6) Engine crankcase pressure exceeds a safe limit.

(7) Engine speed exceeds the safe speed recommended by the engine manufacturer. The over speed trip shall require manual resetting. a second over speed trip shall be provided to back up the normal over speed trip in the event it fails to stop the engine.

C4-8. MEASUREMENT AND PAYMENT. No measurement will be made for the assembly, factory testing, and preparation for storage of the new control and instrument panel complete with all auxiliaries, accessories and spare parts. Payment for the manufacture, assembly, factory testing, and preparation for storage of the control and instrument panel will be made at the contract unit price for "Controls". Price and payment shall constitute full compensation for furnishing all plant, labor, materials, equipment, operation and maintenance manuals, parts list, and performing all necessary operations, including factory testing.

C4-8.1 Payment for engineering design work for the control and instrument panels complete with all auxiliaries and accessories shall be included in the contract lump sum price for "Engineering and Design Service."

C4-8.2 Payment for shipping the controls and unloading at the storage site, complete with all auxiliaries, accessories and spare parts will be made at the contract unit price for "Shipping and Unloading."

APPENDIX D

PHYSICAL MODEL

HYDRAULIC MODEL STUDY OF FIRST AVENUE AND COUSINS CANAL INTERSECTION, THE COUSINS PUMPING STATION AND THE COUSINS DISCHARGE CANAL

By

Dean K. White

Johannes Larsen

Sponsored by

COASTAL ENGINEERING AND ENVIRONMENTAL CONSULTANTS, INC.

ALDEN RESEARCH LABORATORY, INC.

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Holden, MA 01520

ABSTRACT

The West Jefferson Levee District, working with the U.S. Army Corps of Engineers in the design of the East Harvey Canal Hurricane Protection Project, will upgrade the Cousins Pumping Station and the drainage and discharge canals. The capacity of the pump station expansion will depend on the capacity of the improvements to the First Avenue Canal. The canal base width will either be 68 ft to carry a maximum flow of 2,000 cfs or 108 ft to carry a maximum flow of 3,000 cfs. The Cousins Canal also serviced by the Cousins Pump Station will not be improved and will have a maximum capacity of 2,000 cfs. The discharge basin and the discharge canal will be expanded to carry the additional flows. Widening of the discharge canal will require increasing the length of the Destrehan Avenue Bridge one span. Coastal Engineering and Environmental Consultants, Inc., under contract to the West Jefferson Levee District to design the proposed expansion, requested the Alden Research Laboratory, Inc. (ARL) to construct a section of both the Cousins Canal and The First Avenue Canal, the existing and proposed pump stations, and the Cousins Discharge Canal immediately downstream of the discharge basin to study flow conditions and losses entering and exiting the pump station.

Modifications were made to the intake walls to minimize flow separation and loss from the drainage canals to the pump station. Velocity measurements made at the entrance to the suction tubes of the 1,000 cfs pumps indicated satisfactory flow distribution. Energy losses in the suction basin were minimized. The discharge basin operated free of major flow disturbances and head losses were acceptable.

INTERSECTION, THE COUSINS PUMPING STATION AND THE COUSINS DISCHARGE CANAL

INTRODUCTION

The West Jefferson Levee District is working with the U.S. Army Corps of Engineers in the design of the East Harvey Canal Hurricane Protection Project. As part of this project, the Cousins Pumping Station will be upgraded, and the inflow and discharge canal transitions improved. The present station consists of two stations; the older, constructed in 1973, containing four pumps with a total capacity of 1,100 cfs and the newer, constructed in 1987, containing two pumps with a total capacity of 2,000 cfs. The proposed pumping station will be constructed similar to the 1987 station and will contain either one or two 1,000 cfs pumps. The capacity of the proposed station will depend on the capacity of the proposed improvements to the First Avenue Canal. The canal base width was tested at 68 ft to carry a 2,000 cfs flow and at 108 ft to carry a 3,000 cfs flow. The existing Cousins Canal will not be improved and will carry up to 2,000 cfs. The discharge basin and discharge canal will also be improved to carry the increased flows. As part of the discharge basin improvement, an additional span is proposed for the Destrehan Avenue Bridge.

The Alden Research Laboratory, Inc. (ARL) was contracted by Coastal Engineering and Environmental Consultants, Inc. to construct and test a 1:25 scale model of the suction and discharge basins to include sections of the canals leading to and from the basins and the existing and proposed pumping stations. Two designs of the First Avenue Canal and the associated increase in pumping capacity were evaluated.

Flow conditions in both the suction basin and the discharge basin were evaluated and velocity distributions were measured at the entrance to the proposed pumping station. Energy losses were measured from the drainage canals to the suction basin and from the discharge basin to the discharge canal. Minor modifications were made to improve flow conditions and minimize losses.

The proposed pump station will use 1,000 cfs pumps similar to the existing 1,000 cfs pumps. The intake and discharge of the proposed pump station are similar to the newer existing station with the exception of the space between pumps in the proposed two pump design. The two pump design will have a wall dividing the intake bay containing the trash racks. Unlike the existing station, the proposed station intake bay will be only as wide as the rectangular entrance to the pump intake tubes.

The discharge basin will be widened on the north side to accommodate the proposed pumps and the Cousins discharge canal modified at Lapalco Boulevard to provide increased flood protection. The Destrahan Avenue Bridge will have an additional span added at the north end. The bottom of the discharge basin and the canal will be flat at elevation -9.0 ft NGVD and deepen to elevation -11 ft NGVD at the pump discharges. The canal sides will be at a 1 on 3 slope. The discharge basin water level will vary form elevation +5 to -1 ft NGVD. The discharge basin excavation will be made to accommodate the two proposed pumps even if only one pump is initially installed. The present Destrahan Avenue Bridge is supported on two pile bents positioned in the canal. Each bent is 51 ft long and utilizes seven 16 in square concrete piles. The superstructure of the bridge is above elevation +5 ft NGVD.

MODEL SIMILITUDE AND SCALING CONSIDERATIONS

To properly simulate the kinematics and dynamics of the flow phenomena to be investigated, an undistorted geometric model was required. Since the model had free surface flow, inertial and gravitational forces were dominant. A necessary condition of similitude is for the model Froude number to be equal to the prototype value. In addition, consideration must also be given to the model Reynolds number, such that viscous forces would not significantly affect the model results.

The Froude number represents the ratio of fluid inertial to gravitational forces, and is given by

Substituting Equation (1) into Equation (2) and defining the length ratio as Equation (4) results in the velocity scale ratio given in Equation (5).

$$y_p/y_m = L_r \tag{4}$$

where L_r is the length scale ratio,

$$V_r = (L_r)^{0.5} \tag{5}$$

The flow ratio, Q_r, may be written as

$$Q_r = A_r V_r \tag{6}$$

where

Q	=	flow, ft^3
A	=	area, ft^2

Substituting Equation (5) into Equation (6), and noting that A can be dimensionally expressed as L^2, yields

$$Q_r = L_r^{5/2} \tag{7}$$

model scale ratio of 1:25 resulted in a Reynolds number of 47,000, well into the turbulent flow range for the First Avenue Canal at design flow. The numerical scale ratios for various parameters of the 1:25 scale model are shown in Table 1.

TABLE 1

NUMERICAL SCALE RATIOS

1:25 MODEL

Parameter	Scale Ratio
Length, L	1/25
Velocity, V	1/5.0
Flow Rate, Q	1/3125
Time, T	1/5.0

MODEL DESCRIPTION AND INSTRUMENTATION

The model was constructed to a scale of 1:25, and located in an ARL building with the necessary flow capacity. The First Avenue Canal was modeled upstream from the suction basin a distance of 500 ft using plastic coated plywood to represent the canal surface. The Cousins Canal was modeled for a distance of 400 ft upstream of the suction basin using a cement and sand mortar finish applied to a crushed stone base. The canal geometry was controlled with templates positioned using control baselines and set to elevation with a laser leveling system. The suction basin elevation was determined by the elevation of the pump stations and the canal bottoms, see Figures 1, 2, and 3.

The intake and discharge of each pump station was constructed from the same plastic coated plywood and only features of the pump station that effected flow conditions in the suction and discharge basins were modeled. At the intake of each pump station, the model was constructed to represent the prototype from the upstream end of the structure to the point where the flow entered the vertical

Flow Measurement

Water supplied to the canals and drawn through and discharged from each of the pumps was pumped through orifice meters constructed according to ASME standards. These meters are accurate to approximately 2 percent of the indicated flow.

Water Surface Measurements

The piezometers were connected to stilling wells and read using a point gauge. Water surface elevations were measured to 0.05 ft prototype.

Point Velocity Measurements

Point velocity measurements were made with a propeller type current meter capable of reading to as low as 0.5 fps prototype.

TEST PROCEDURE

For each test condition, flow was introduced into the canals and the pumps were adjusted to the proper discharge. The drainage canal flows were then adjusted to provide the proper inflow and the suction basin water level gradually adjusted to the proper level. The discharge canal water level was adjusted with the tailgate. After setting a test condition in the model, a point gauge and stilling wells were used to measure the water surface elevations in the canal system at 12 locations, using the piezometric pressure taps installed in the bottom of the model, see Figure 4.

Raw data was entered into a spreadsheet program and plotted as a graph of canal water surface gradeline and energy gradeline versus location. Energy gradeline is defined as:

TEST PROGRAM

The First Avenue canal, with the 108 ft wide bottom width and the proposed pump station with two 1,000 cfs pumps, was installed and tested initially. The discharge basin was configured to accommodate the proposed two 1,000 cfs pumps and remained in that configuration, except for a small section of wall added where the additional pump could be installed, for the testing of the proposed single 1,000 cfs pump. Finally, the First Avenue Canal bottom width was modified to 68 ft and the suction basin changed to accommodate the proposed single 1,000 cfs pump.

TEST RESULTS

Suction Basin

First Avenue Canal with 108 ft Base and Proposed 2,000 cfs Pump Station

The suction basin flow conditions were evaluated under six combinations of canal flow at canal water surface elevation -6.7 ft NGVD, see Table 2. Operating under Initial Condition 1, at the full capacity of 5,100 cfs, there was significant separation and back flow in front of the proposed Pump 2 initiated by the geometry of the excavation through the side slope of the First Avenue Canal, see Figure 5. There was also a large area of back flow in front of Pump 1 of the newer existing station as can be seen in Figure 5. At both of the effected pumps, the back flow forced the flow to enter the suction conduit through only a fraction of the conduit entrance width. The model operating under Initial Conditions 2 and 3 continued to exhibit similar flow problems particularly when two pumps were operating in the proposed or newer existing stations, see Figures 6 and 7. Initial Conditions 4 and 5 also produced separation at the proposed Pump 2 because the flow separated off the dividing wall between the proposed Pumps 1 and 2 under these conditions, see Figures 8 and 9. The proposed pumps were not operated under Initial Condition 6 and only older existing Pumps 2 and 3 and the

Condition 1 (same as Initial Condition 1), conditions in the suction basin leading to the pump intakes were improved, see Figure 13, and the separation at Pump 2 of the proposed pump station has been eliminated by the redesign of the north intake wall. The separation at the newer existing pump station in front of Pump 1 has been reduced by the modification to the wall between the two existing pump stations. Velocity traverses taken at each of the intakes to both the proposed and existing 1,000 cfs pumps are shown on Figures 14 and 15, respectively. The flow entering the proposed pumps is relatively well distributed at the entrance to the suction tubes of each of the pumps with an average velocity entering the intakes of 2.82 fps. The figures provide the normalized velocity and point values can be multiplied by the average velocity to determine the absolute velocity. The velocity distribution at the newer existing Pump 1 is low at the left side of the opening due to the remaining separation, see Figure 15, while the flow at Pump 2 is well distributed. The average velocity entering the suction tubes of the newer existing pumps is 2.57 fps.

TABLE 3

FINAL TEST CONDITIONS 108' CANAL

	1st Ave	Cousins	Pumps Operating							
	Flow	Flow	Old Exist				New Exist		Proposed	
Test	cfs	cfs	1	2	3	4	1	2	1	2
1	3,000	2,100	x	x	x	x	x	x	x	x
2	0	2,000							x	x
3	0	2,000					x	x		
4	3,000	0					x	x		x
5	3,000	0					x	x	x	

With no flow from the First Avenue Canal and 2,000 cfs from the Cousins Canal, the entire flow was drawn through the two proposed pumps, Test Condition 2. There was a region of separation along the south wall of the proposed station, see Figure 16, that reduced flow into the south side of the Pump 1 suction tube, see Figure 17. Flow into the proposed Pump 2 was not effected by the separation, see Figure 17. When the 2,000 cfs from the Cousins Canal was pumped using the newer

First Avenue Canal With 68 ft Base and Proposed 1,000 cfs Pump Station

The 68 ft base First Avenue Canal was installed in the 108 ft canal using the same canal centerline and bottom elevation. The modifications developed during the study of the wider canal and shown as report Figures 11 and 12, were installed during the construction of the 68 ft base width canal, see Figures 25 and 26. The single proposed pump utilized Pump 1 of the two pump station. The maximum capacity of the pumping station was 4,100 cfs and the suction basin was operated at water surface elevation -6.7 ft NGVD.

The suction basin flow conditions were evaluated under four test conditions by recording flow patterns and measuring suction tube entrance velocity distributions, see Table 4. The station was initially evaluated at the full capacity of 4,100 cfs, Test 1. Flow entered the proposed pump station free of separation, see Figure 27, and the velocity distribution at the entrance to the suction tube, shown in Figure 28, is acceptable and similar to the distribution obtained with the 108 ft canal. The flow patterns in the suction basin at the newer existing station, as well as the velocity distribution at the entrances to the suction tubes, see Figure 29, are very similar to the conditions recorded with the wider canal and higher flow. As before, the back flow in front of Pump 1 of the newer existing station causes a poor flow distribution.

TABLE 4

FINAL TEST CONDITIONS 68 FOOT CANAL

Test	1st Ave Flow cfs	Cousins Flow cfs	Pumps Operating: Old Exist 1	Old Exist 2	Old Exist 3	Old Exist 4	New Exist 1	New Exist 2	Proposed 1
1	2,500	1,600	x	x	x	x	x	x	x
2	1,600	0		x	x				x
3	0	2,500		x	x			x	x
4	0	2,500		x	x		x		x

Flow at the north pile bent was parallel to the canal banking and passed between the piles. The piles are on the canal bank and the shallow depth and the small quantity of flow do not make it necessary to align the pile bent with the direction of flow.

The discharge basin was operated with the two proposed pumps off at the three basin levels tested at full flow, see Figures 38, 39, and 40. The flow from the newer existing station moved rapidly along the south side of the discharge basin entering smoothly into the canal while the smaller quantity of water from the older existing station moved slowly through the discharge basin and into the canal. An area of no flow was present downstream of the proposed pumps. Flow was well aligned with the three pile bents supporting the Destrehan Avenue Bridge.

The two existing 1,000 cfs pumps were not operated and the two proposed 1,000 cfs pumps, as well as the older existing station, were operated at a total discharge of 3,100 cfs and flow conditions observed at the three discharge basin water elevations, see Figures 41, 42, and 43. The flow from the two proposed pumps moved rapidly down the north side of the discharge basin with only minor separation at the entrance to the discharge canal. The flow from the older existing station moved more slowly parallel to the flow from the two proposed pumps expanding to the south canal wall at the end of the discharge basin. Flow was not parallel to any of the three pile bents of the Destrahan Avenue Bridge and an area of back flow was present downstream of the newer existing station. The flow turned once into the discharge canal and moved parallel to the canal centerline.

The velocity traverse and the water surface and energy profiles were measured at a discharge of 5,100 cfs and a discharge basin water level of -1 ft NGVD, see Figures 44 and 45, respectively. The velocity traverse indicates an area of low velocity toward the center of the discharge basin. The flow from the newer existing station and the proposed station is higher per foot of canal width than the flow from the older existing station causing the variation in velocity across the width of the basin. The energy loss from the discharge basin to the canal over a distance of approximately 400 ft, with the basin at elevation -1 ft and a pump station flow of 5,100 cfs, was 0.16 ft.

CONCLUSIONS AND RECOMMENDATIONS

1. As initially designed, the intake of the proposed two 1,000 cfs pump expansion of the Cousins Pump Station on the 108 ft wide First Avenue Canal produced unacceptably large areas of separation and back flow at the entrance to the suction tubes of the proposed pumps. In addition, there was a large area of separation at one of the existing 1,000 cfs pumps.

2. The addition of a curved vertical wall at the north side of the proposed two pump expansion eliminated the separation and back flow at the proposed pumps. The wall between the two existing stations was modified and the separation at the existing pump was substantially reduced in size.

3. Velocity traverses at the intake of the suction tubes of the proposed pumps indicated a satisfactory distribution. The presence of the back flow at the newer existing station resulted in a non-uniform velocity distribution at the entrance to the pump suction tube downstream of the separation. The suction tubes for the two proposed and two existing 1,000 cfs pumps decrease in area by a factor of three from the suction tube entrance to the pump impeller. This reduction in area will improve the uniformity of the flow field at the impeller.

4. The loss in energy between the two drainage canals and the suction basin was 0.05 ft and 0.17 ft for the First Avenue Canal and the Cousins Canal, respectively, when the total station flow was 5,100 cfs and the suction basin was at elevation -6.7 ft NGVD.

5. The drainage canals and the pumping station were modified to represent the 68 ft base width First Avenue Canal and a pump station expansion of one 1,000 cfs pump. The resulting total station capacity would be 4,100 cfs. The modifications developed during the two pump expansion were installed in the one pump expansion and functioned satisfactorily.

FIGURES

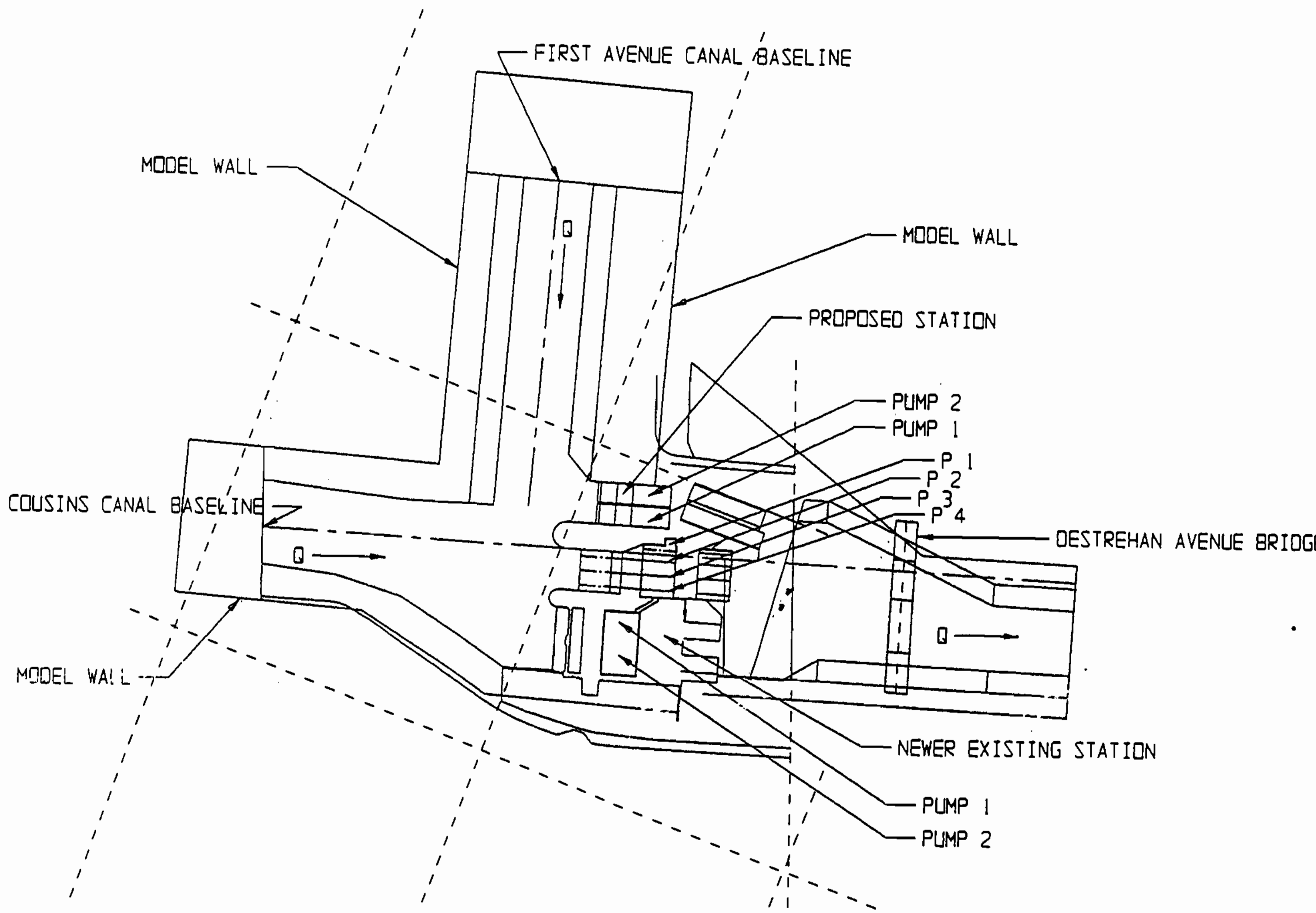

FIGURE 1 CPS CANALS MODEL LAYOUT

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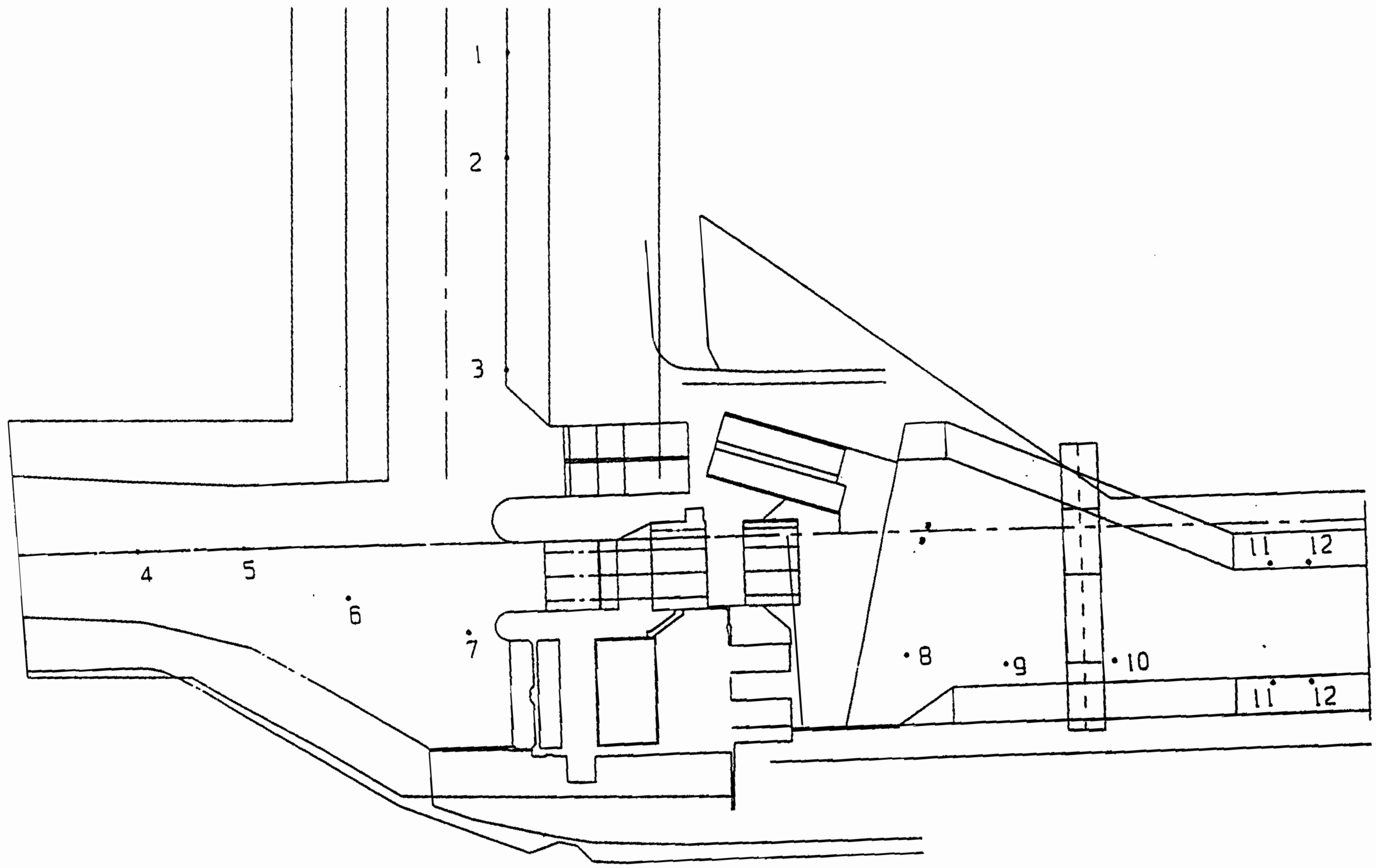


FIGURE 4 PRESSURE TAP LOCATIONS

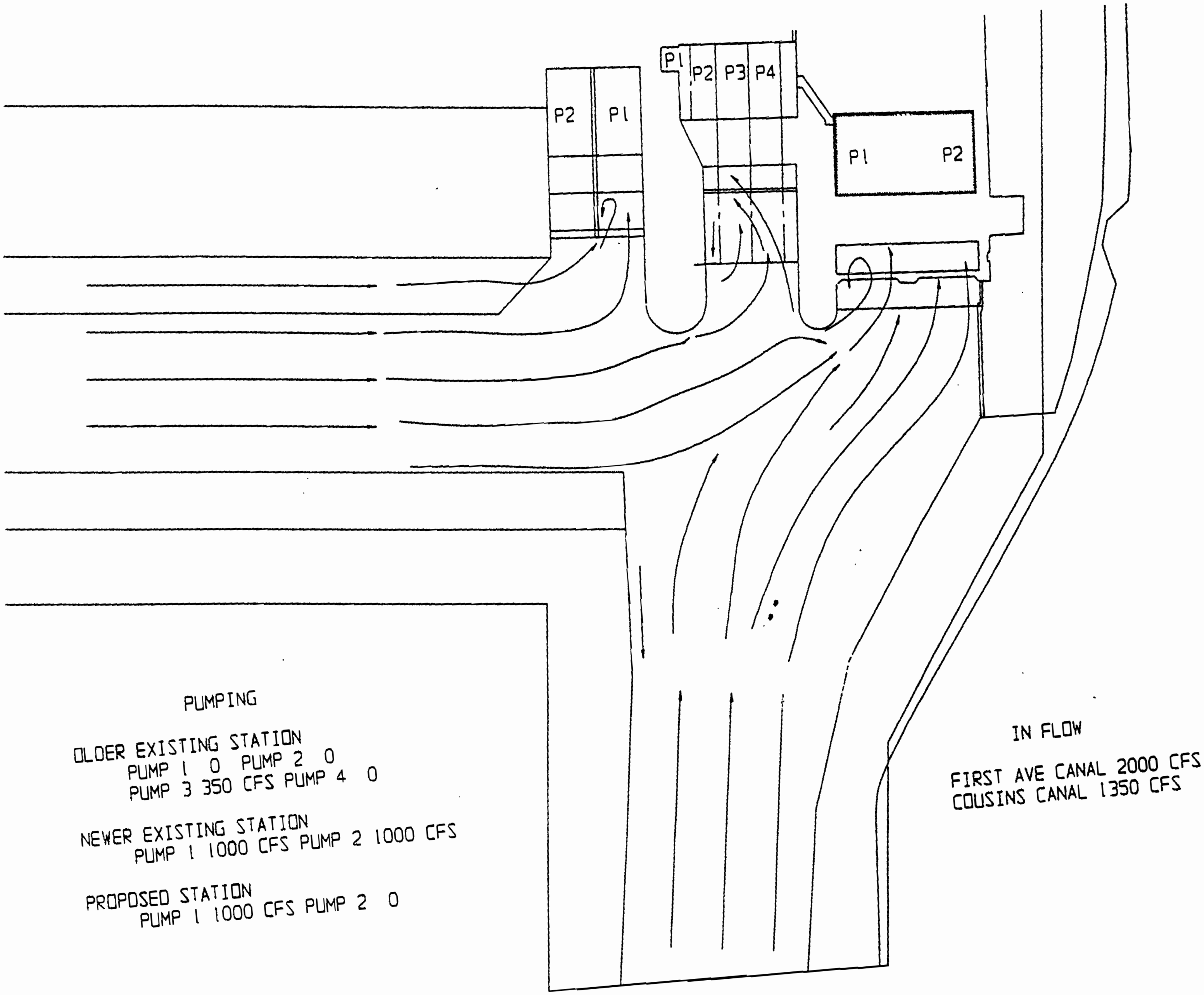


FIGURE 6 FLOW PATTERNS AT 3350 CFS

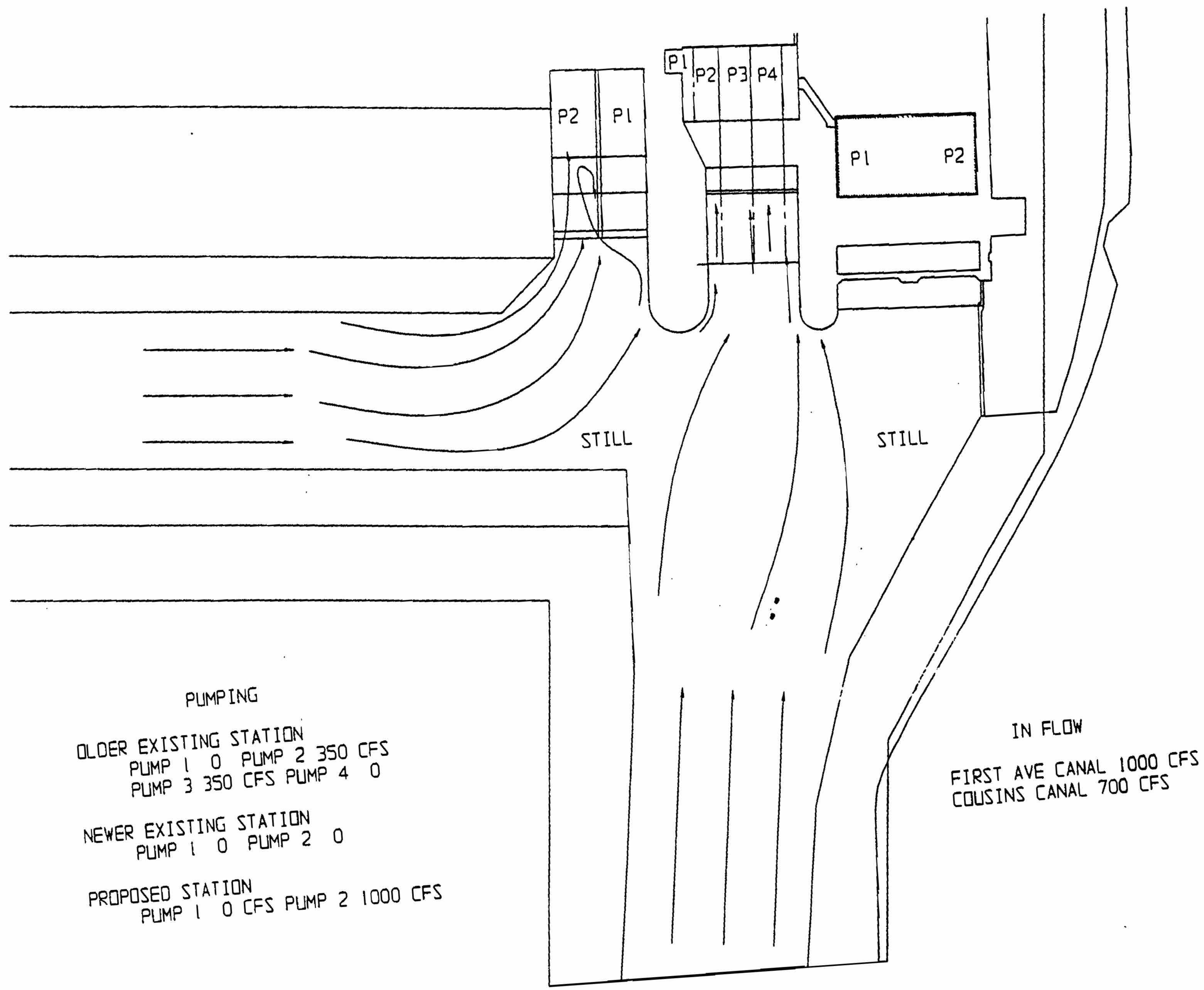


FIGURE 8 FLOW PATTERNS AT 1700 CFS

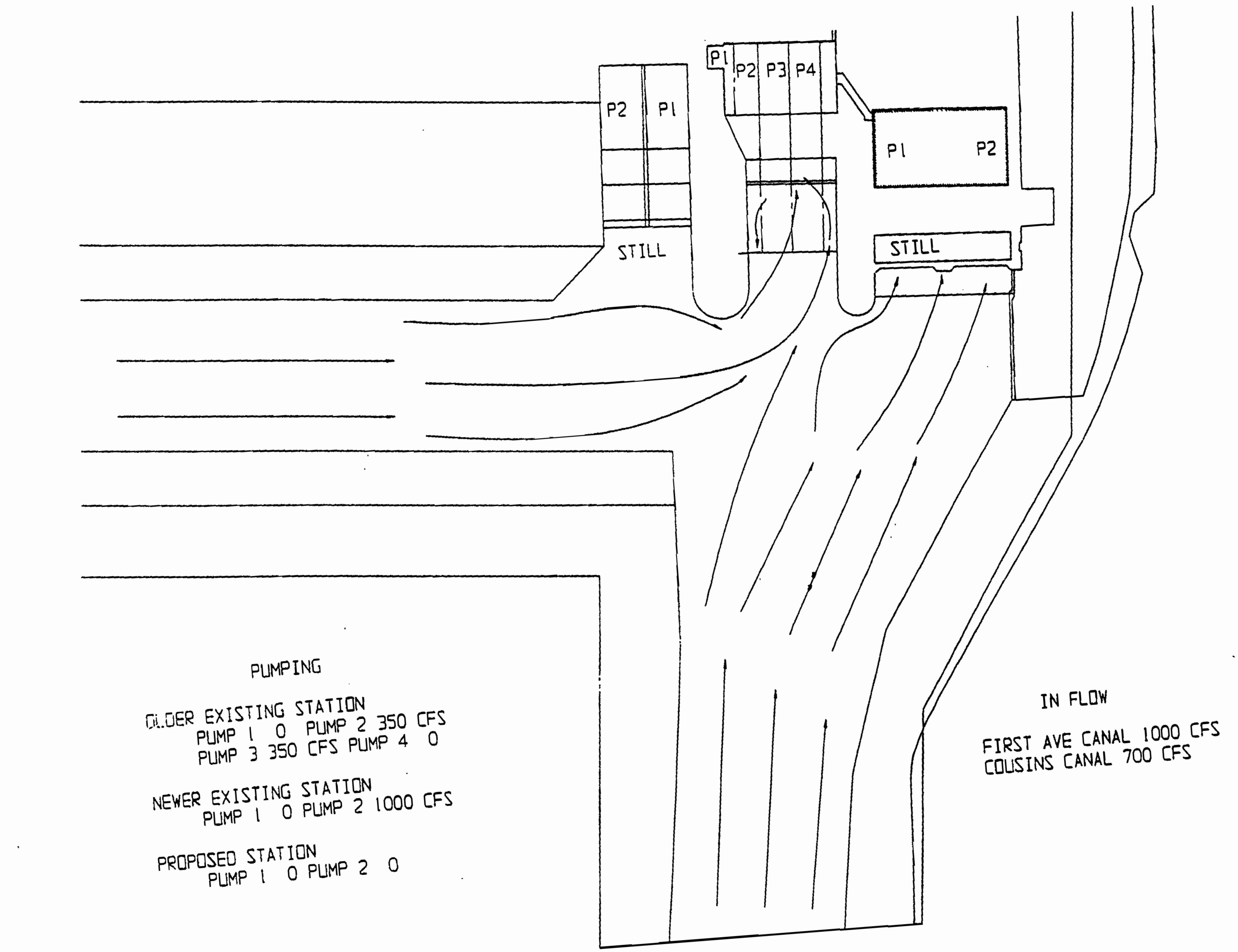


FIGURE 10 FLOW PATTERNS AT 1700 CFS

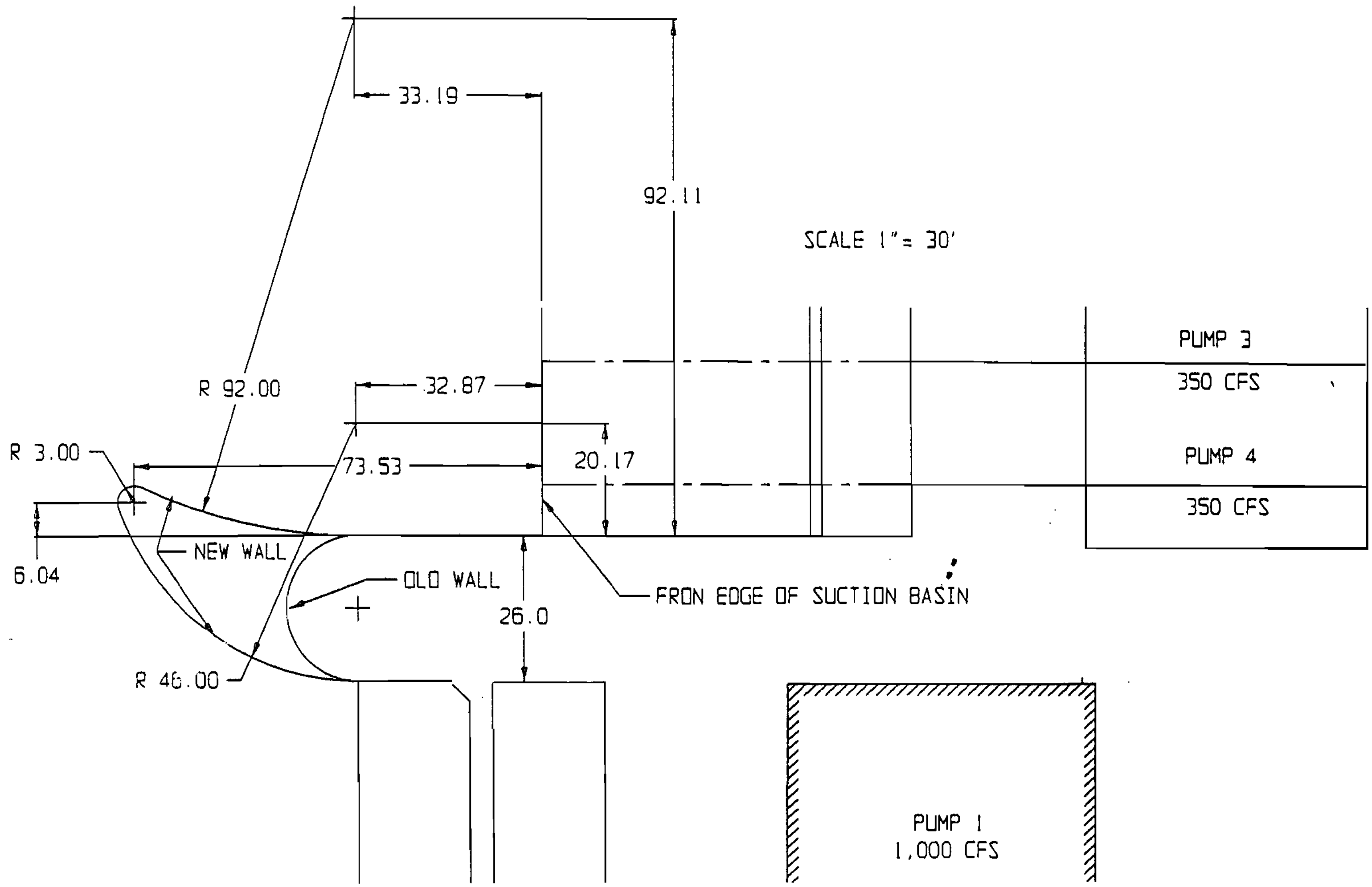
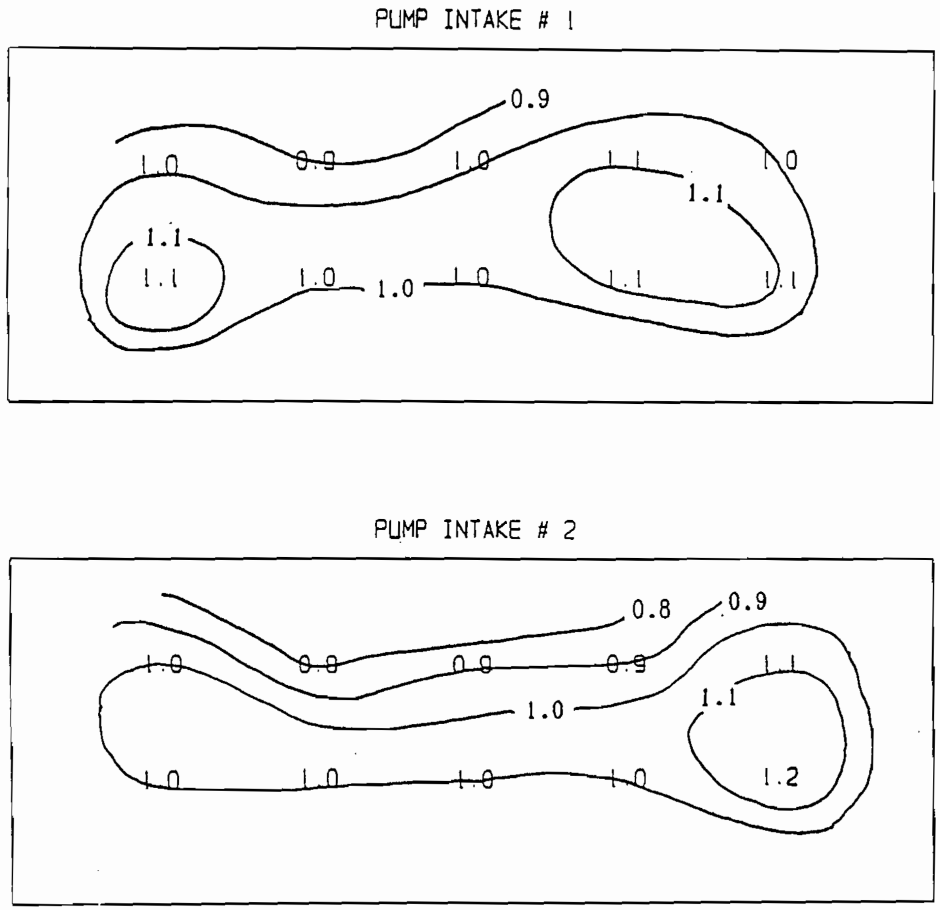


FIGURE 12 RECOMENDED CURVED WALL BETWEEN EXISTING STATIONS



PUMP OPERATION

EXISTING STATION
TWO PUMPS AT 1,000 cfs
THREE PUMPS AT 350 cfs
ONE PUMP AT 50 cfs

PROPOSED STATION
TWO PUMPS AT 1,000 cfs

CANAL CONDITIONS
FIRST AVENUE CANAL 3,000 cfs
COUSINS CANAL 2,100 cfs
SUCTION BASIN EL. -6.7 ft

SHOWING PUMP INTAKES #1 AND #2
LOOKING DOWNSTREAM

NORMALIZED VELOCITY USING
AVERAGE VELOCITY OF 2.82 FPS

FIGURE 14 PROPOSED PUMP STATION NORMALIZED INLET VELOCITY DISTRIBUTION TOTAL STATION FLOW 5100 CFS 108 FT CANAL

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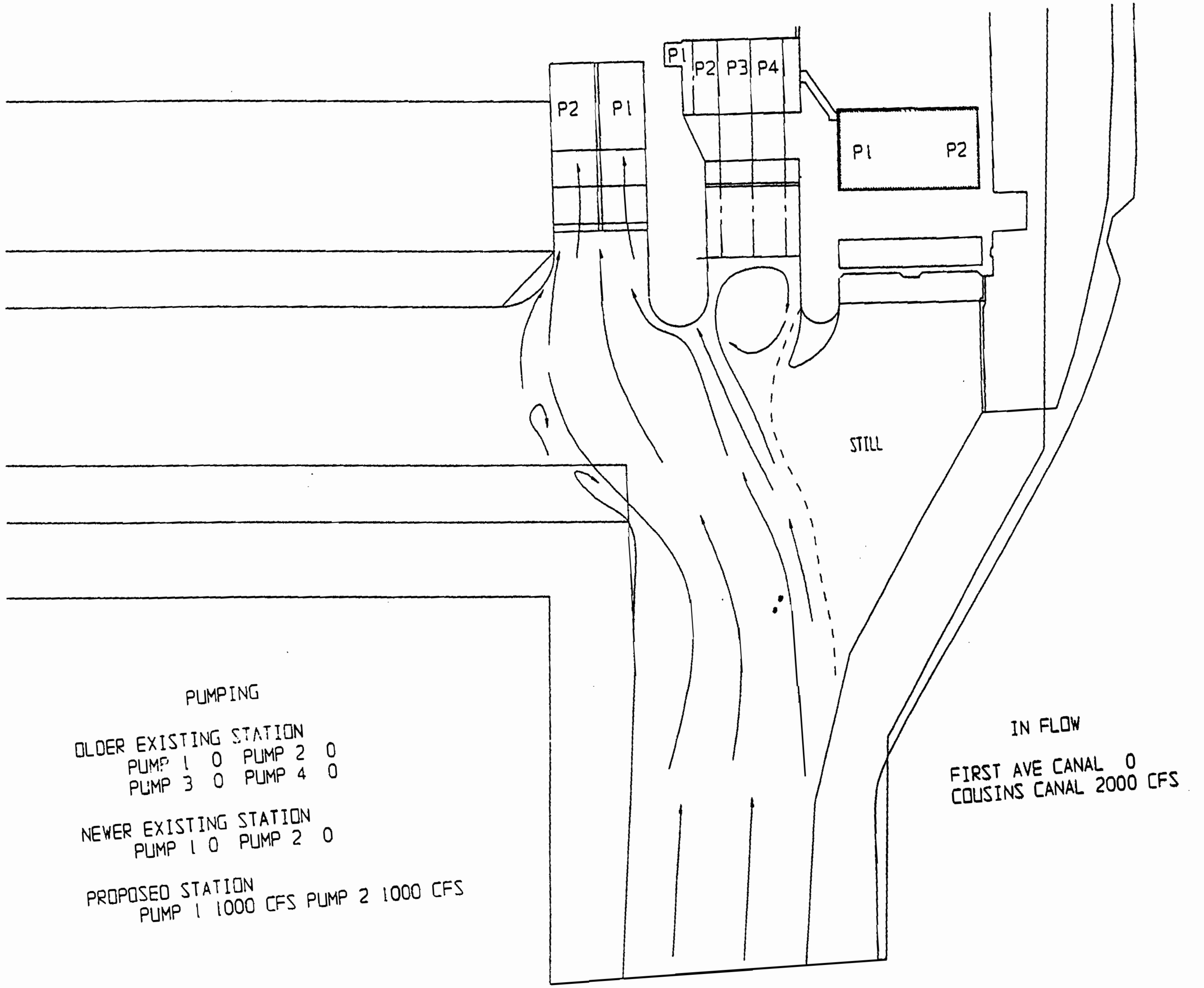


FIGURE 16 FLOW PATTERNS AT CONDITION 2

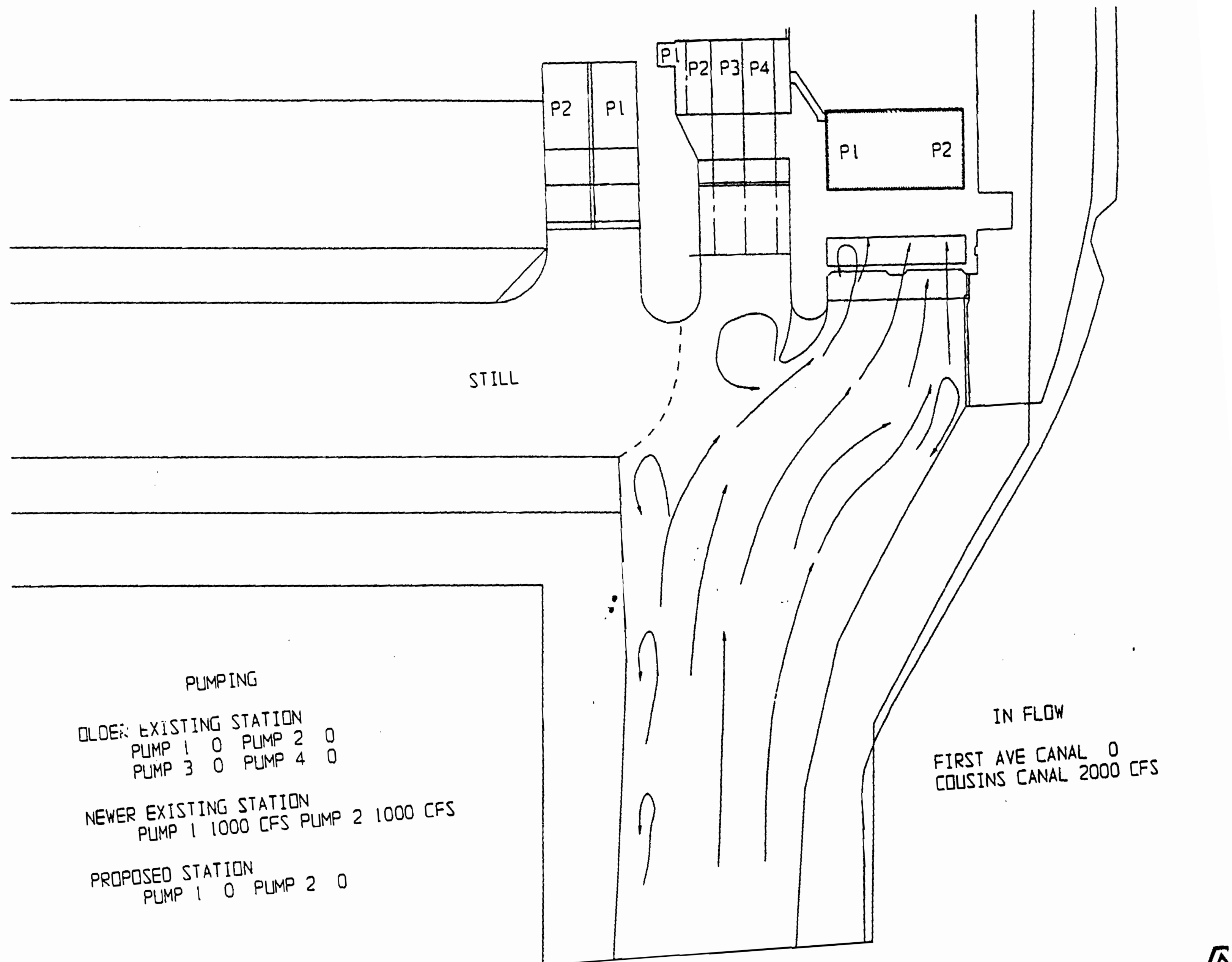
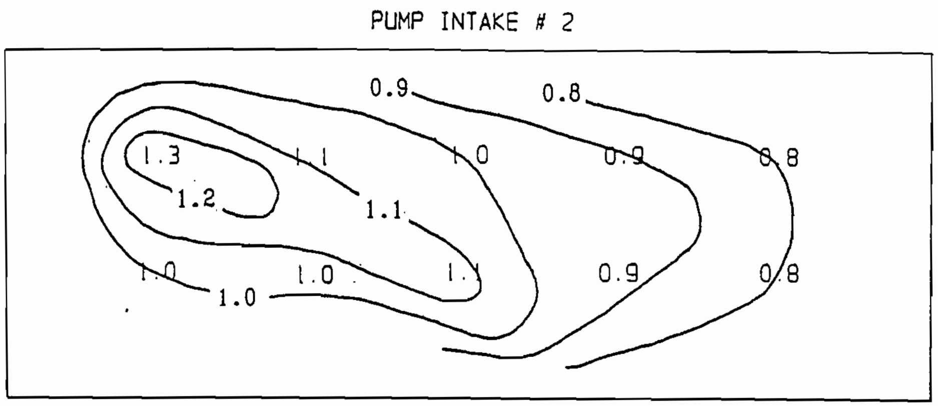


FIGURE 18 FLOW PATTERNS AT CONDITION 3



PUMP OPERATION

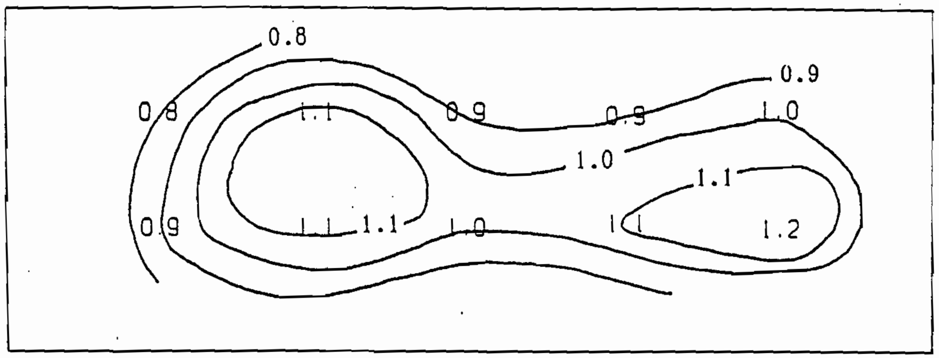
EXISTING STATION
TWO PUMPS AT 1,000 cfs
THREE PUMPS AT 0 cfs
ONE PUMP AT 0 cfs

PROPOSED STATION
PUMP # 2 AT 1,000 cfs
PUMP # 1 AT 0 cfs

CANAL CONDITIONS
FIRST AVENUE CANAL 3,000 cfs
COUSINS CANAL 0 cfs
SUCTION BASIN EL. -6.7 ft

NORMALIZED VELOCITY USING
AVERAGE VELOCITY OF 2.82 FPS

FIGURE 20 PROPOSED PUMP STATION NORMALIZED INLET VELOCITY DISTRIBUTION TOTAL STATION FLOW 3000 CFS 108 FT CANAL



PUMP OPERATION

EXISTING STATION
TWO PUMPS AT 1,000 cfs
THREE PUMPS AT 0 cfs
ONE PUMP AT 0 cfs

PROPOSED STATION
PUMP # 1 AT 1,000 cfs
PUMP # 2 AT 0 cfs

CANAL CONDITIONS
FIRST AVENUE CANAL 3,000 cfs
COUSINS CANAL 0 cfs
SUCTION BASIN EL. -6.7 ft

NORMALIZED VELOCITY USING
AVERAGE VELOCITY OF 2.82 FPS

FIGURE 22 PROPOSED PUMP STATION NORMALIZED INLET VELOCITY DISTRIBUTION TOTAL STATION FLOW 3000 CFS 108 FT CANAL

ARL

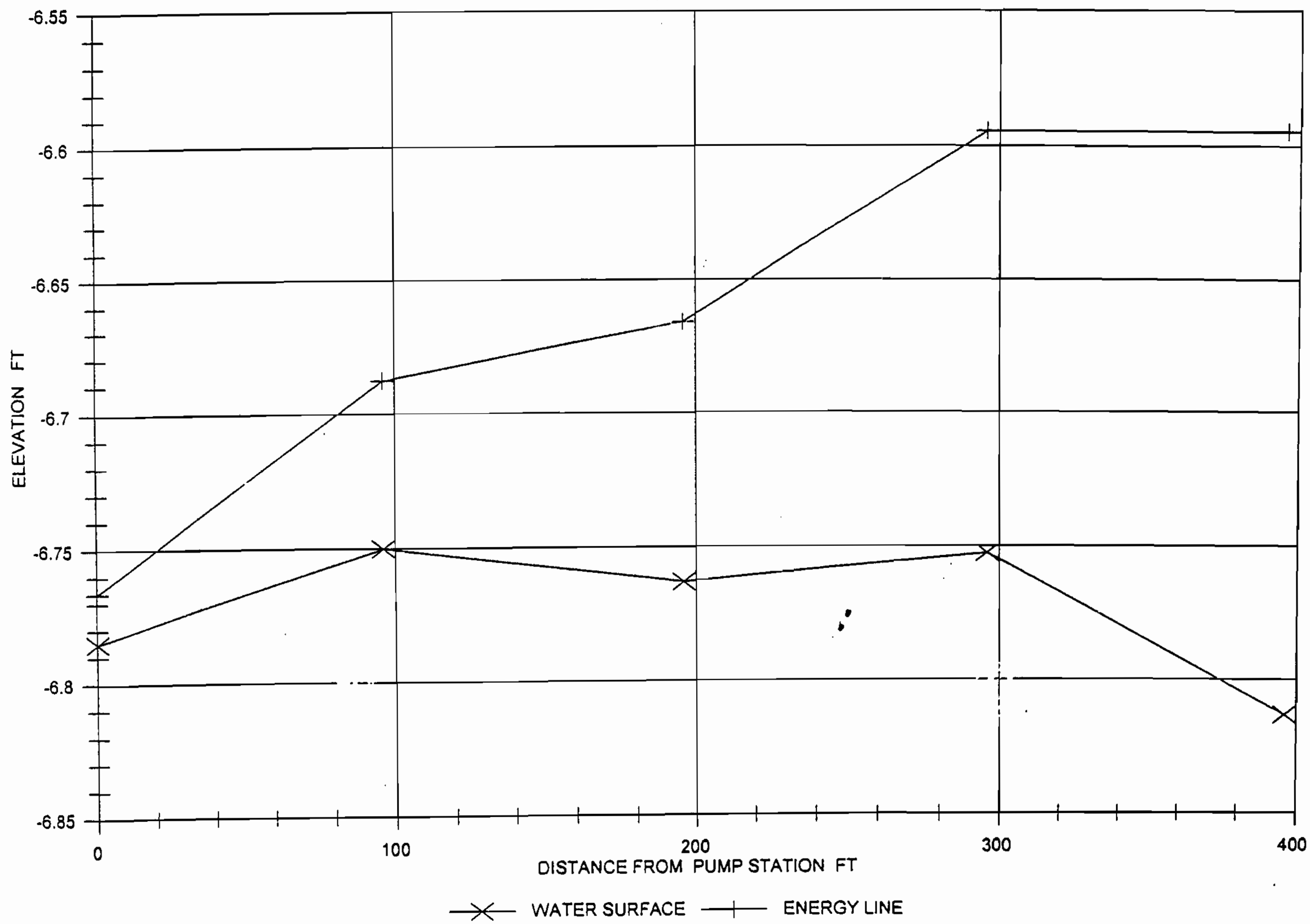


FIGURE 24 COUSINS GRADELINE 5,100 CFS

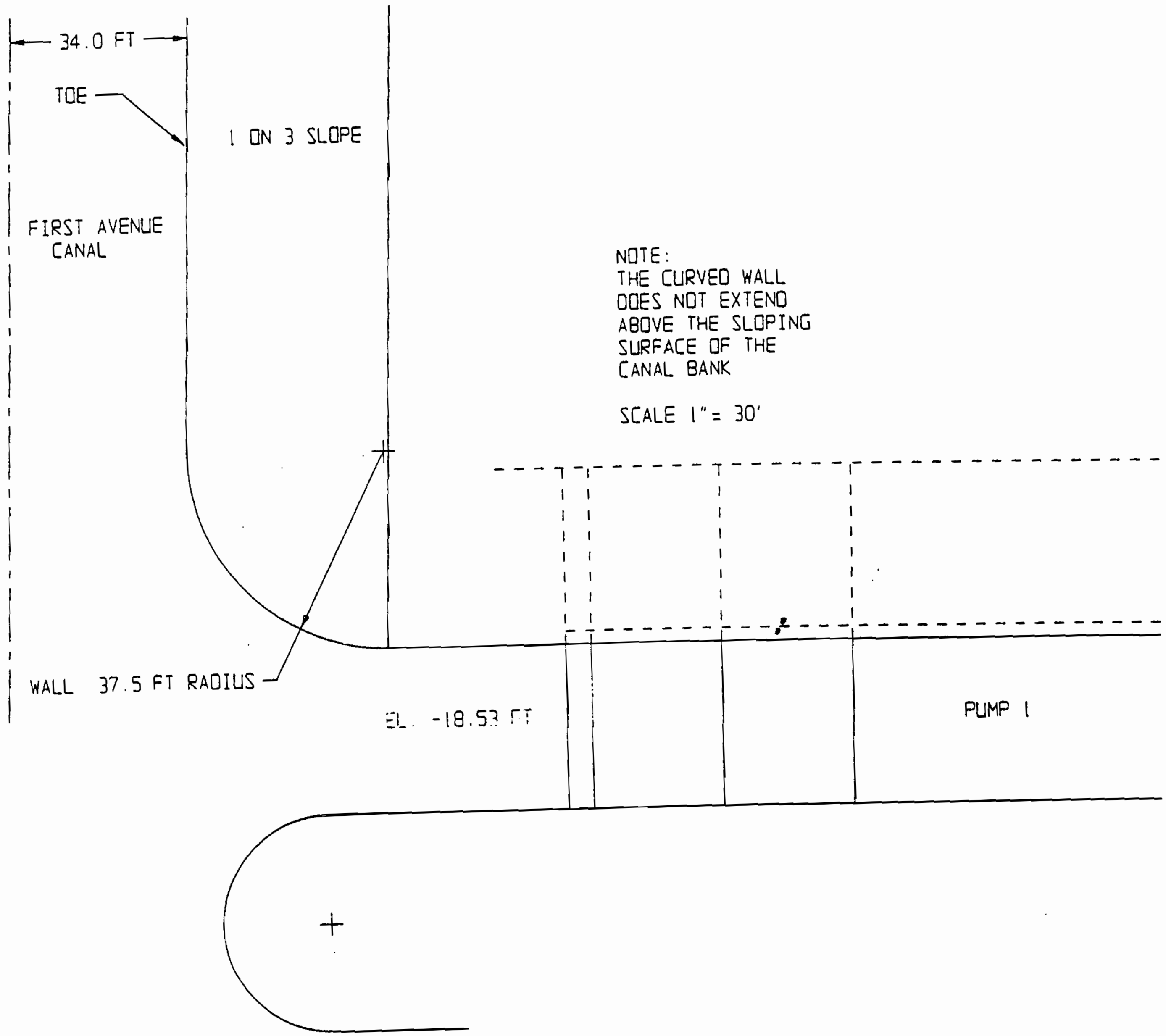
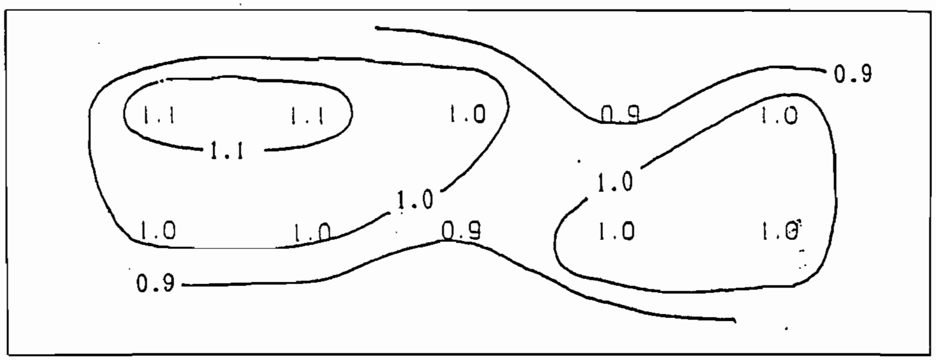


FIGURE 26 RECOMMENDED CURVED WALL ENTERING NEW PUMP STATION 68 FT CANAL

PUMP INTAKE # 1



PUMP OPERATION

EXISTING STATION
TWO PUMPS AT 1,000 cfs
THREE PUMPS AT 350 cfs
ONE PUMP AT 50 cfs

PROPOSED STATION
PUMP # 1 AT 1,000 cfs

CANAL CONDITIONS
FIRST AVENUE CANAL 2,500 cfs
COUSINS CANAL 1,600 cfs
SUCTION BASIN EL. -6.7 ft

NORMALIZED VELOCITY USING
AVERAGE VELOCITY OF 2.82 FPS
LOOKING DOWNSTREAM

FIGURE 28 PROPOSED PUMP STATION NORMALIZED INLET VELOCITY
DISTRIBUTION TOTAL STATION FLOW 4100 CFS 68 FT CANAL

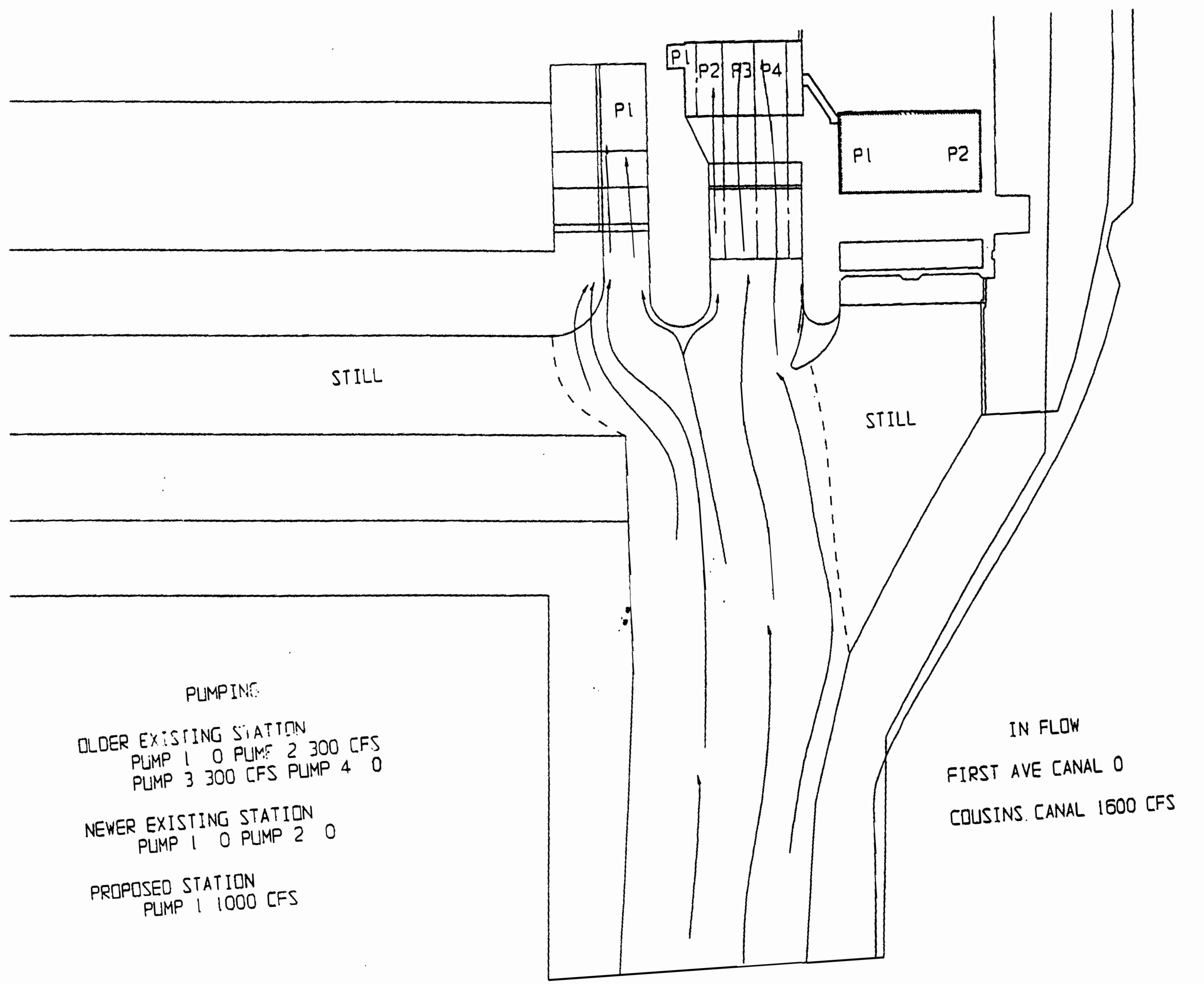


FIGURE 30 FLOW PATTERNS TEST2

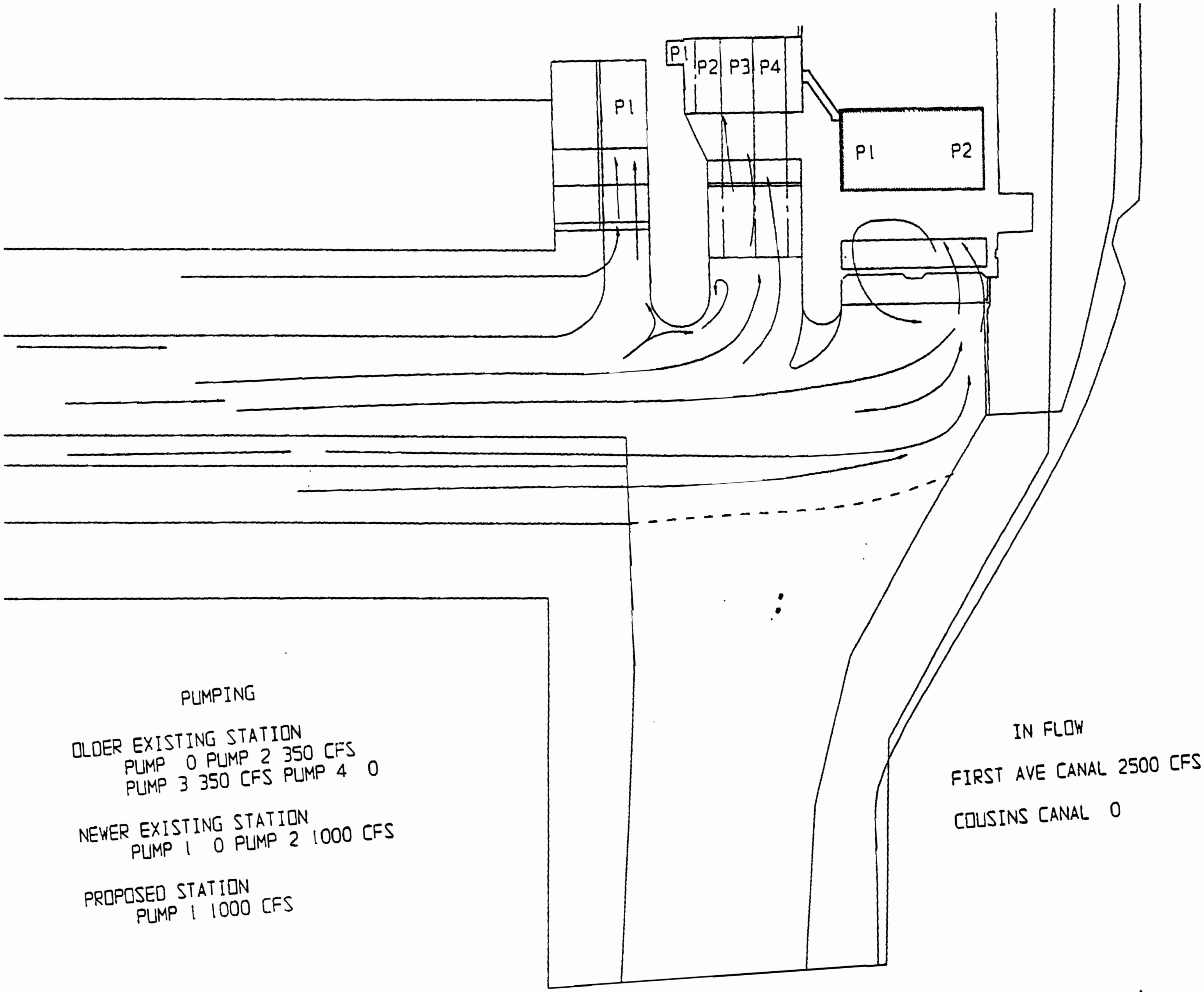
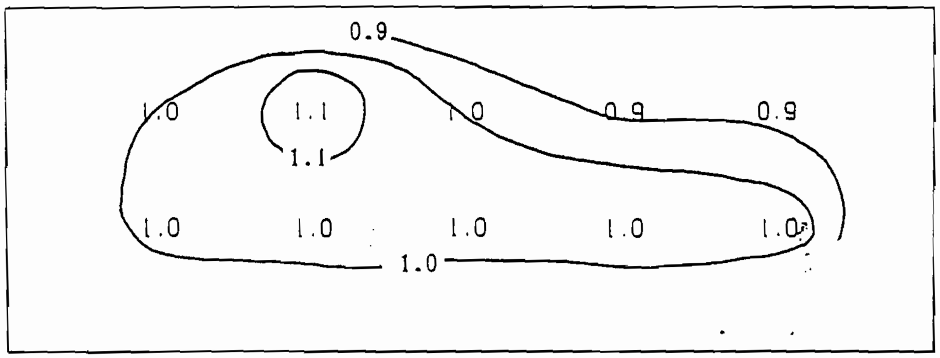


FIGURE 32 FLOW PATTERNS TEST3



PUMP OPERATION

EXISTING STATION
ONE PUMP AT 1,000 cfs
TWO PUMPS AT 250 cfs

PROPOSED STATION
PUMP # 1 AT 1,000 cfs

CANAL CONDITIONS
FIRST AVENUE CANAL 2,500 cfs
COUSINS CANAL 0 cfs
SUCTION BASIN EL. -6.7 ft

NORMALIZED VELOCITY USING
AVERAGE VELOCITY OF 2.82 FPS
LOOKING DOWNSTREAM

FIGURE 34 PROPOSED PUMP STATION NORMALIZED INLET VELOCITY DISTRIBUTION TOTAL STATION FLOW 2500 CFS 68 FT CANAL

ARL

TOTAL FLOW 5100 CFS

PUMPING

OLDER EXISTING STATION
PUMP 1 50 PUMP 2 350 CFS
PUMP 3 350 CFS PUMP 4 350 CFS

NEWER EXISTING STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

PROPOSED STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

WATER ELEVATION + 2 FT

SLOW MOVING FLOW

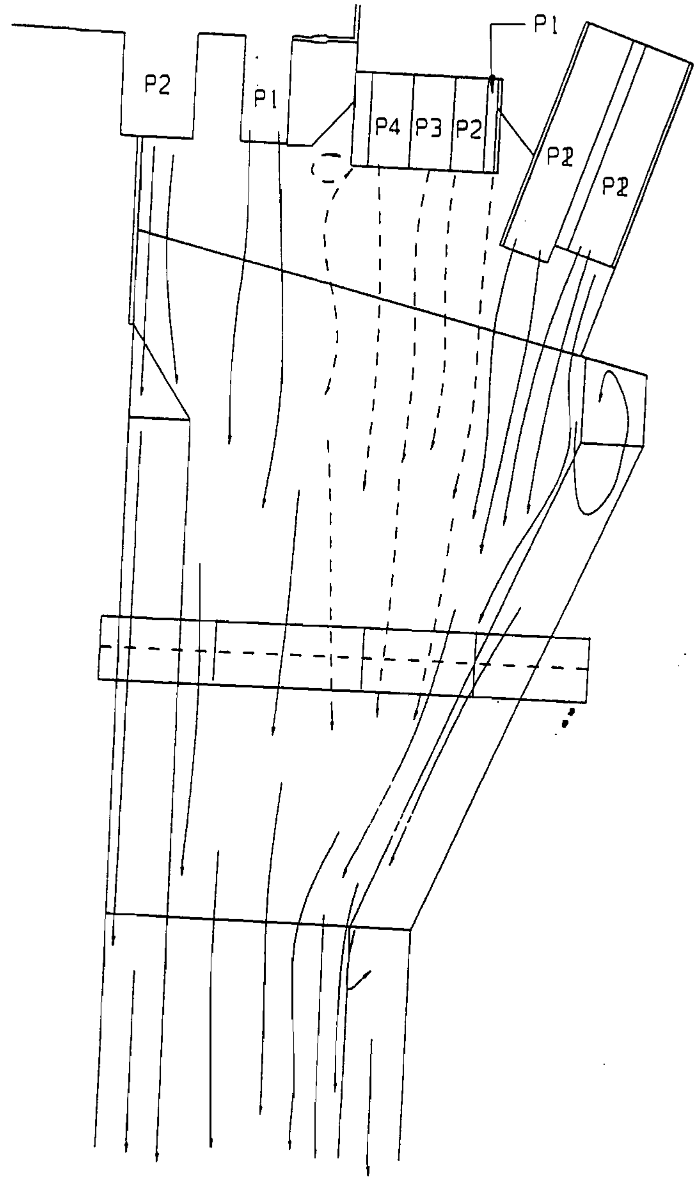


FIGURE 36 DOWNSTREAM FLOW PATTERNS AT 5100 CFS

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TOTAL FLOW 3100 CFS

PUMPING

OLDER EXISTING STATION
PUMP 1 50 PUMP 2 350 CFS
PUMP 3 350 CFS PUMP 4 350 CFS

NEWER EXISTING STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

PROPOSED STATION
PUMP 1 0 PUMP 2 0

WATER ELEVATION - 1 FT

SLOW MOVING FLOW - - - - - - →

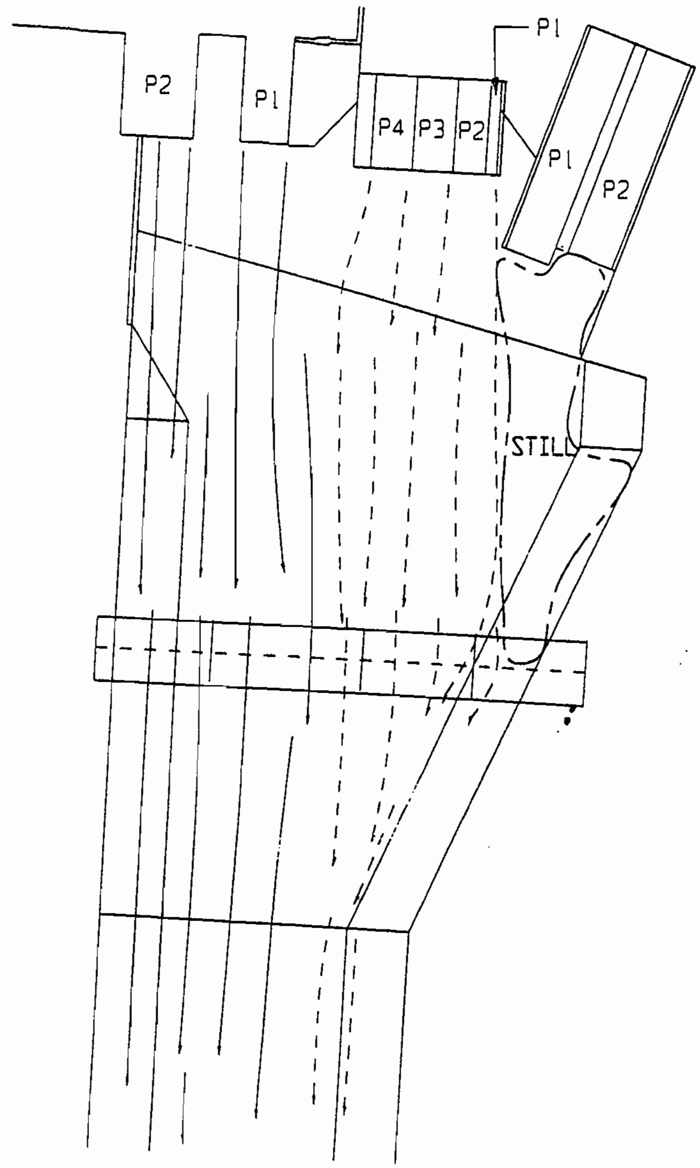

FIGURE 38 DOWNSTREAM FLOW PATTERNS AT 3100 CFS

TOTAL FLOW 3100 CFS

PUMPING

OLDER EXISTING STATION
PUMP 1 50 PUMP 2 350 CFS
PUMP 3 350 CFS PUMP 4 350 CFS

NEWER EXISTING STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

PROPOSED STATION
PUMP 1 0 PUMP 2 0

WATER ELEVATION + 5 FT

SLOW MOVING FLOW - - - - - - ➞

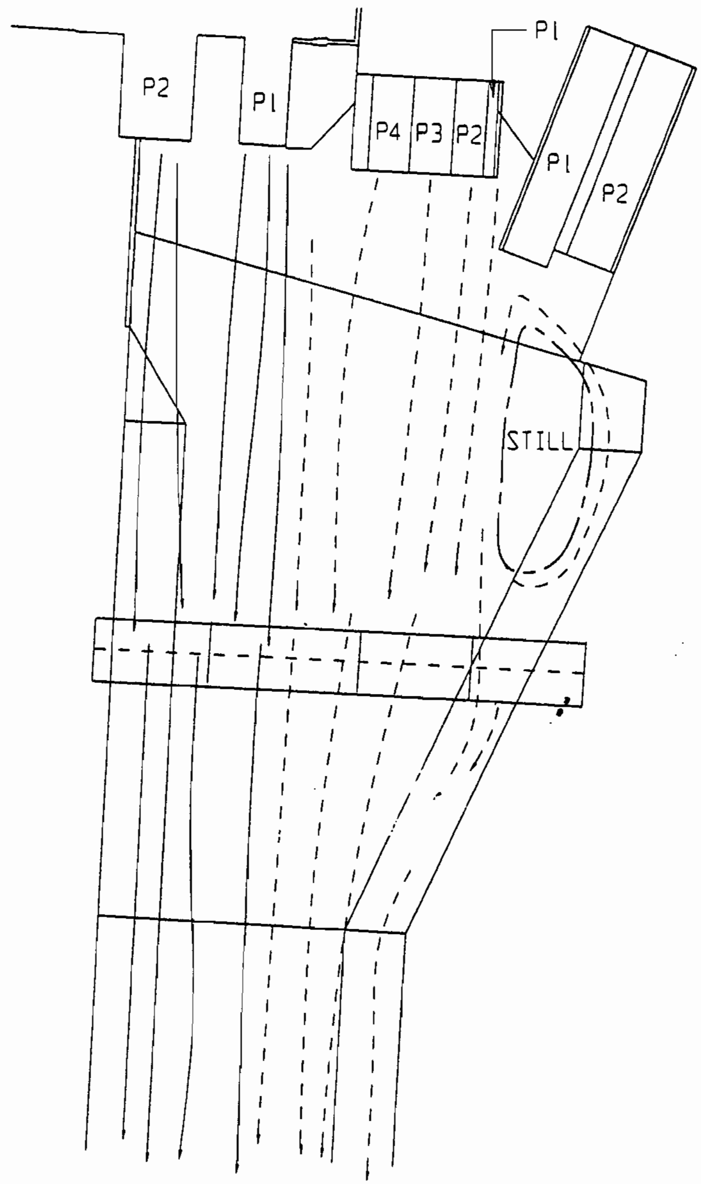

FIGURE 40 DOWNSTREAM FLOW PATTERNS AT 3100 CFS

TOTAL FLOW 3100 CFS

PUMPING

OLDER EXISTING STATION
PUMP 1 50 PUMP 2 350 CFS
PUMP 3 350 CFS PUMP 4 350 CFS

NEWER EXISTING STATION
PUMP 1 0 PUMP 2 0

PROPOSED STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

WATER ELEVATION + 2 FT

SLOW MOVING FLOW ------→

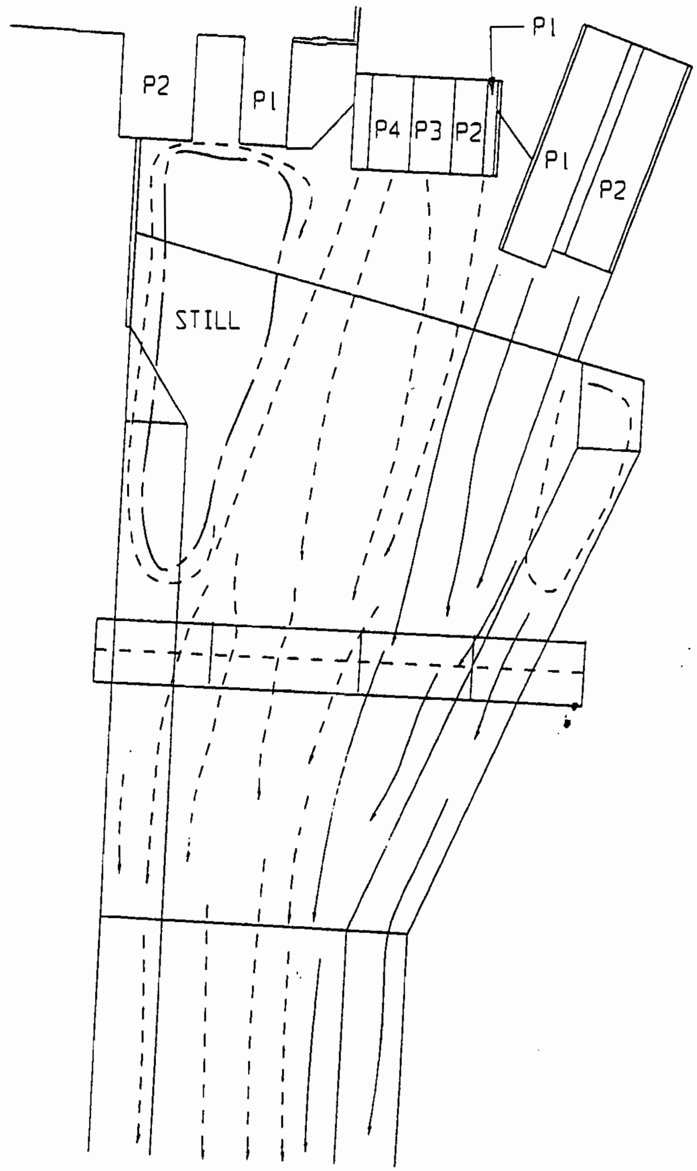

FIGURE 42 DOWNSTREAM FLOW PATTERNS AT 3100 CFS

LOCATIONS OF VELOCITIES (ft/s)

	1	2	3	4	5	6	7	8
A	2.7	3.6	4.0	2.6	2.5	3.3	3.8	4.3
B	2.3	3.0	3.8	2.6	2.3	3.0	3.4	3.6

PUMP OPERATION

EXISTING STATION
TWO PUMPS AT 1,000 cfs
THREE PUMPS AT 350 cfs
ONE PUMP AT 50 cfs

PROPOSED STATION
TWO PUMPS AT 1,000 cfs

CANAL CONDITIONS
TOTAL FLOW 5,100 cfs
WSEL = -1.0 ft

VELOCITY TRAVERSE IS 37 ft UPSTREAM FROM CENTER LINE OF BRIDGE, AT DEPTHS OF 1.5 ft AND 6.5 ft. (LOOKING DOWNSTREAM)

FIGURE 44 DOWNSTREAM VELOCITY DISTRIBUTION TOTAL CANAL FLOW 5100 CFS, 2 NEW PUMPS

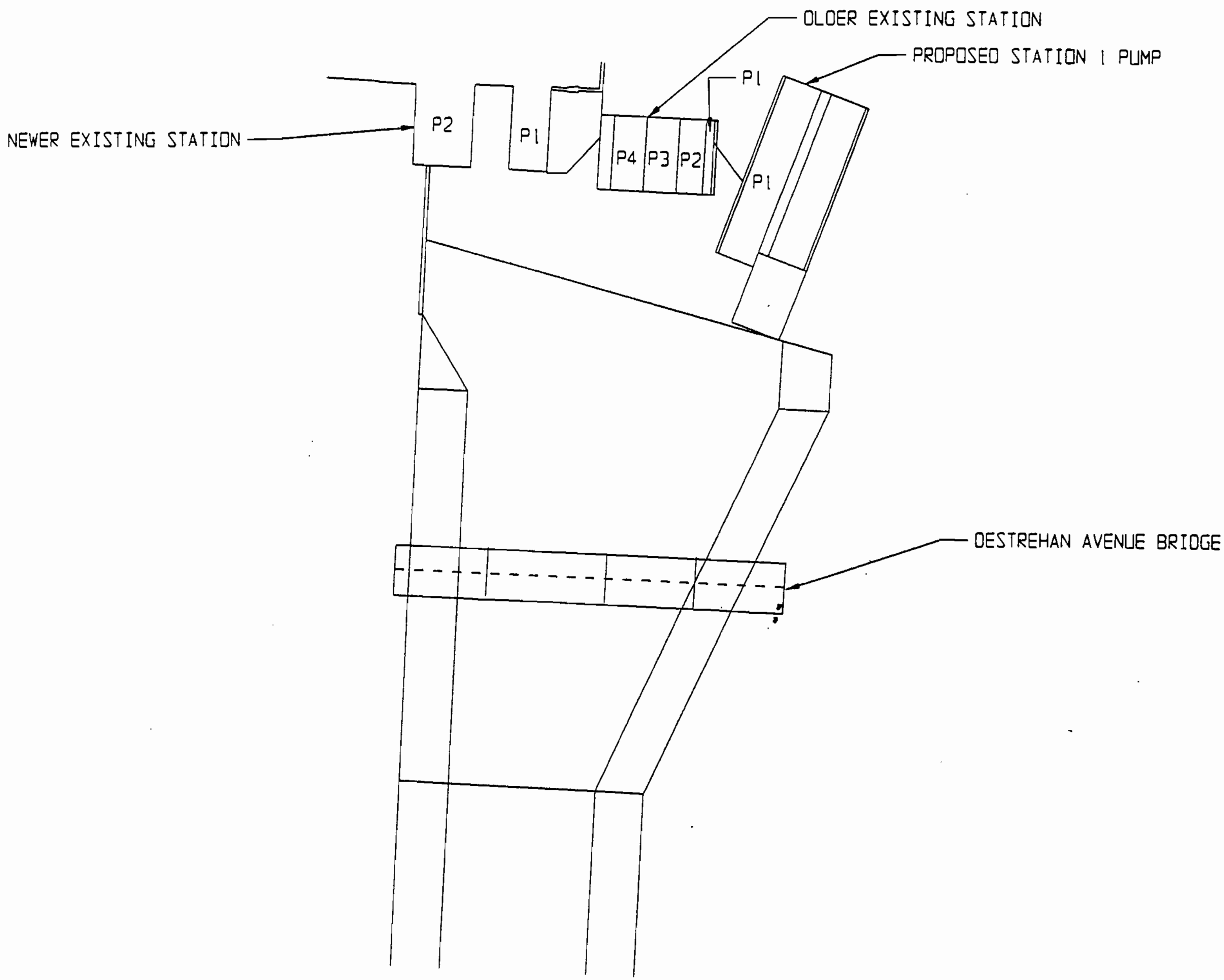

FIGURE 46 DOWNSTREAM BASIN 1 PROPOSED PUMP

TOTAL FLOW 4100 CFS

PUMPING

OLDER EXISTING STATION
PUMP 1 50 PUMP 2 350 CFS
PUMP 3 350 CFS PUMP 4 350 CFS

NEWER EXISTING STATION
PUMP 1 1000 CFS PUMP 2 1000 CFS

PROPOSED STATION
PUMP 1 1000 CFS

WATER ELEVATION + 2 FT

SLOW MOVING FLOW ------→

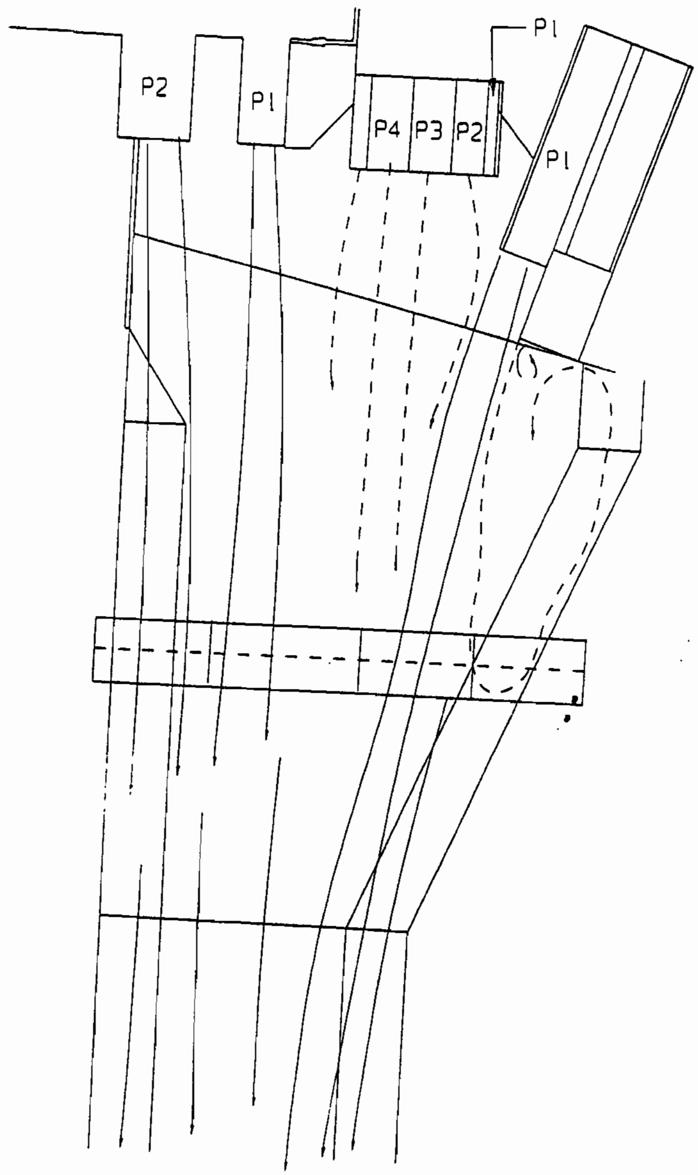

FIGURE 48 DOWNSTREAM FLOW PATTERNS AT 4100 CFS

ARL

APPENDIX E

DESIGN CALCULATIONS

DESIGN CALCULATIONS

I-WALL

CANTILEVER

COUSINS PUMP STA. COMPLEX	BURK-KLEINPETER, INC. ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL			
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I-WALL

MAX MOMENT IN SHEET PILE = 41.6 K-FT
FROM EUSTIS REPORT DATED FEB 1998

$$S_{REQ'D} = \frac{M_{MAX}}{0.65 f_y} = \frac{41{,}600 \text{ lb ft} \times 12}{0.65\,(50{,}000)}$$

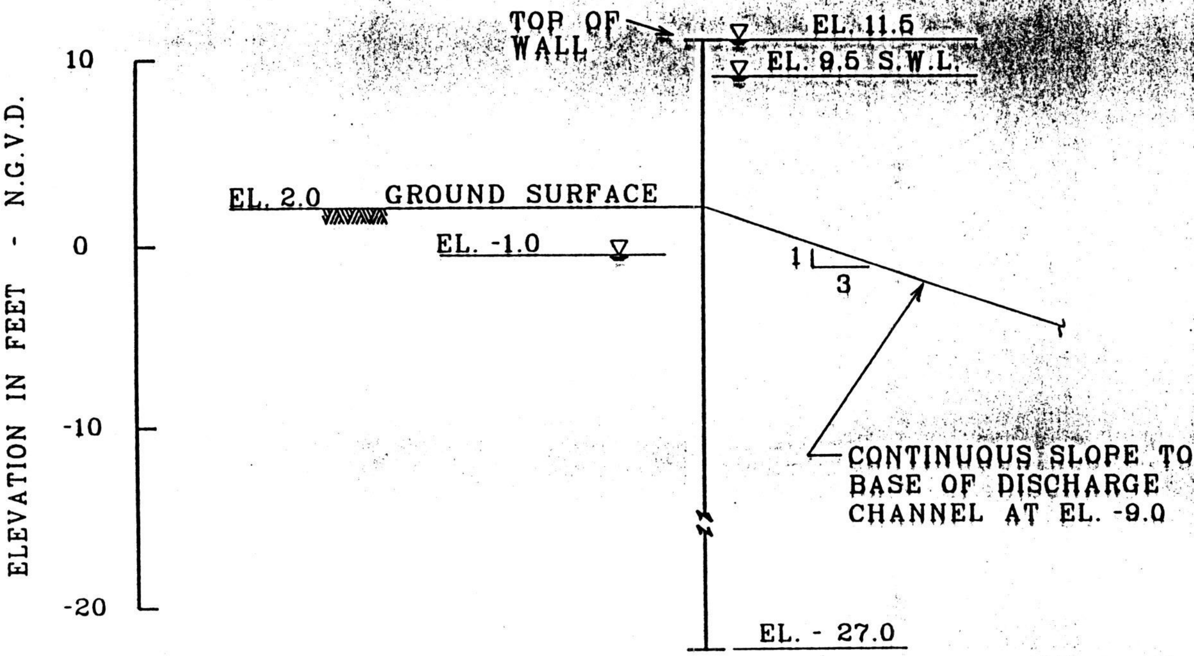
$$S_{REQ'D} = 15.36 \text{ in}^3/\text{FT.}$$

USE CASTEEL CZ95 SHEETPILE   WITH S = 15.53

I WALLS & TIE BACK WALL
DUE TO COE ON 4/15

Computation Sheet

I-WALLS & TIE-BACK WALL
DUE TO COE 4/15



DESIGN SUMMARY					
FLOOD SIDE WATER ELEVATION	PROTECTED SIDE WATER ELEVATION	FACTOR OF SAFETY	MAX. MOMENT FT-KIPS	WALL BOTTOM ELEVATION	SCALED DEFLECTION LB-IN^3 AT EL. 11.5
9.5	-1.0	1.5	25.1	-26.0	7.8×10^{10}
11.5	-1.0	1.0	41.6	-27.0	3.2×10^{10}

NOTE : 1) DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN INCHES TO 4th POWER TO OBTAIN DEFLECTION IN INCHES.

2) BASED ON HARR'S ANALYSIS,SHEETPILE TIPS AT EL. -27.0 PROVIDE A FACTOR OF SAFETY OF 5 OR MORE AGAINST PIPING.

3) SOIL PARAMETERS ARE TAKEN FROM FIGURE 8 OF 7 OCTOBER 1997 REPORT EXCEPT ABOVE EL. -10.0 WHERE PARAMETERS ARE TAKEN FROM FIGURE 6.

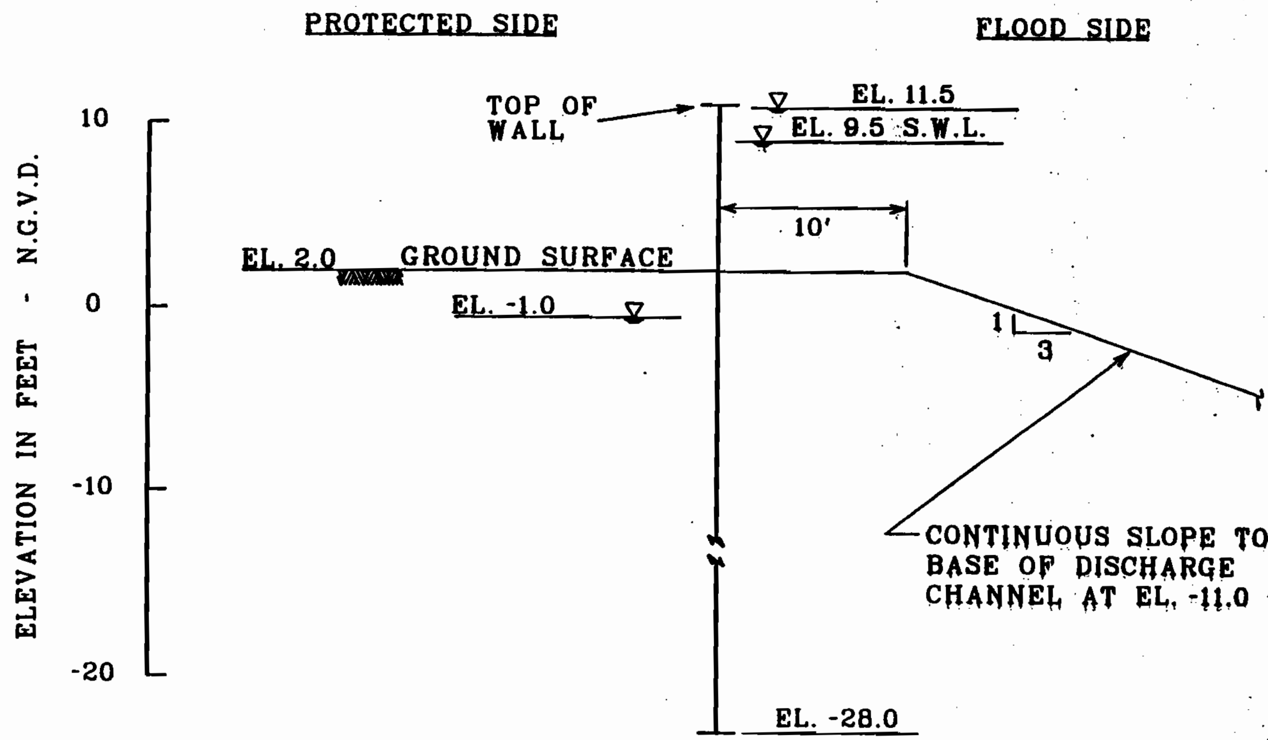
4) SEE APPENDIX FOR COMPUTER ANALYSES OF GOVERNING SHEETPILE DESIGN GIVEN ABOVE.

I-WALL DESIGN
NORTH BANK OF DISCHARGE CANAL
EAST OF DESTREHAN AVENUE BRIDGE

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

EUSTIS ENGINEERING COMPANY, INC.

ENCLOSURE 2
(REVISED FIGURE 35)



DESIGN SUMMARY					
FLOOD SIDE WATER ELEVATION	PROTECTED SIDE WATER ELEVATION	FACTOR OF SAFETY	MAX. MOMENT FT-KIPS	WALL BOTTOM ELEVATION	SCALED DEFLECTION LB-IN^3 AT EL. 11.5
9.5	-1.0	1.5	21.3	-25.5	7.4×10^{10}
11.5	-1.0	1.0	36.1	-28.0	2.9×10^{10}

NOTE : 1) DIVIDE SCALED DEFLECTION BY MODULUS OF ELASTICITY IN PSI TIMES PILE MOMENT OF INERTIA IN INCHES TO 4th POWER TO OBTAIN DEFLECTION IN INCHES.

2) BASED ON HARR'S ANALYSIS,SHEETPILE TIPS PENETRATING TO EL. -28.0 PROVIDE A FACTOR OF SAFETY OF 5 OR MORE AGAINST PIPING.

3) SOIL PARAMETERS ARE TAKEN FROM FIGURE 6 OF 7 OCTOBER 1997 REPORT.

4) SEE APPENDIX FOR COMPUTER ANALYSES OF GOVERNING SHEETPILE DESIGN GIVEN ABOVE.

I-WALL DESIGN
COUSINS PUMP STATION
DISCHARGE TO DESTREHAN AVENUE BRIDGE

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

EUSTIS ENGINEERING COMPANY, INC.

ENCLOSURE 1
(REVISED FIGURE 34)

DESIGN REQUIREMENTS BASED ON
US ARMY CORPS OF ENGINEERS
EM 1110-2-2104 30 JUNE 1993
"STRENGTH DESIGN FOR REINFORCED - CONCRETE HYDRAULIC STRUCTURES"

GENERAL REQUIREMENTS:
CONCRETE DESIGN WITH THE STRENGTH DESIGN METHOD IN ACCORDANCE WITH THE CURRENT ACI 318, EXCEPT AS HEREINAFTER SPECIFIED.

REINFORCEMENT GRADE 60 (ASTM A 615 (BILLET STEEL))

ANCHORAGE, DEVELOPMENT, AND SPLICES CONFORM TO ACI 318

NOTE: DESIGNER MUST INDICATE THE LENGTH OF EMBEDMENT REQUIRED FOR BAR DEVELOPMENT, SPLICE LENGTHS, AND SPECIAL REQUIREMENTS SUCH AS STAGGERING OF SPLICES, ETC. ON THE CONTRACT DRAWINGS.

HOOKS + BENDS IN ACCORDANCE TO ACI 318

BAR SPACING

MINIMUM - CLEAR DISTANCE BETWEEN BARS 1½ TIMES THE NOMINAL DIA. OF THE BAR NOR LESS THAN 1½ TIMES THE MAXIMUM SIZE OF COARSE AGGREGATE.

NO. 14 6 INCHES CENTER TO CENTER
NO. 18 8 INCHES CENTER TO CENTER

PARALLEL REINFORCEMENT - PLACED IN 2 OR MORE LAYERS CLEAR DIST. BETWEEN LAYERS SHOULD NOT BE LESS THAN 6". IN MASSIVE STRUCTURES LAYERS SHOULD BE PLACED 12" CENTER TO CENTER WHEREVER POSSIBLE.

MAXIMUM - 18" CENTER TO CENTER FOR BOTH PRIMARY AND SECONDARY REINFORCEMENT

MINIMUM COVER:

UNFORMED SURFACES IN CONTACT WITH FOUNDATION	4"
FORMED OR SCREEDED SURFACES SUBJECT TO CAVITATION OR ABRASION, SUCH AS BAFFLE BLOCKS AND STILLING BASIN SLABS	6"

FORMED AND SCREEDED SURFACES SUCH AS STILLING BASIN WALLS, CHUTE SPILLWAY SLABS, AND CHANNEL LINING SLABS ON GRADE:

$t \geq 24"$ THICK	4"
$12" < t > 24"$	3"
$t \leq 12"$	ACI 318

NOTE: IN NO CASE SHALL THE COVER BE LESS THAN:

1.5 × MAXIMUM SIZE OF AGGREGATE
OR
2.5 × MAXIMUM DIA. OF BAR

SPLICING: (ACI 318)
BARS LARGER THAN No. 11 SHALL NOT BE LAP-SPLICED.

TEMPERATURE + SHRINKAGE REINFORCEMENT:

$A_{S_{TEMP}}$ = 0.0028 × GROSS CROSS-SECTIONAL AREA
HALF IN EACH FACE, WITH A MAXIMUM AREA EQUIVALENT TO No. 9 BARS AT 12 INCHES IN EACH FACE.

IN THIN SECTIONS WILL BE NO LESS THAN No. 4 BARS AT 12" IN EACH FACE.

Burk-Kleinpeter, Inc. Engineers, Architects, Planners, Environmental Scientists 4176 Canal Street, New Orleans, LA 70119	Cousins Pumping Station Complex				
	Job No. 9388	Design By: R. Chopin	Date: 4/11/98	Checked By:	Page 3 of 4

CONCRETE DESIGN:

NOTE: FOR CONCRETE DESIGN USE THE FOLLOWING LOAD COMBINATIONS

$$U = 1.7\,(D+L) \quad \text{(NO HYDRAULIC LOADING)}$$

$$U_h = 1.7\,H_f\,(D+L) \quad \text{(HYDRAULIC LOADING)}$$

$$U_h = 0.75\left[1.7\,H_f\,(D+L)\right] \quad \text{(WIND LOADING ALSO)}$$

WHERE:

$H_f = 1.3$ FOR HYDRAULIC STRUCTURES, EXCEPT MEMBERS IN DIRECT TENSION

$H_f = 1.65$ FOR MEMBERS IN DIRECT TENSION.

FOR SHEAR DESIGN OF HYDRAULIC STRUCTURES USE:

$$\phi V_s \geq 1.3\,(V_u - \phi V_c)$$

WHERE: V_u = FACTORED SHEAR FORCE AT THE SECTION
ϕV_c = SHEAR STRENGTH PROVIDED BY CONCRETE
ϕV_s = DESIGN CAPACITY OF THE SHEAR REINFORCEMENT

MAXIMUM TENSION REINFORCEMENT:

RECOMMENDED LIMIT = $0.25\,\rho_b$

MAXIMUM PERMITTED UPPER LIMIT = $0.375\,\rho_b$

USE OF COMPRESSION REINFORCEMENT SHALL BE IN ACCORDANCE WITH ACI 318.

CONTROL OF DEFLECTIONS AND CRACKING:

DEFLECTIONS DUE TO SERVICE LOADS NEED NOT BE INVESTIGATED IF THE LIMITS ON THE DESIGN STRENGTH RATIO OF REINFORCEMENT SPECIFIED ABOVE ARE NOT EXCEEDED.

MINIMUM THICKNESS OF WALLS:

WALL HT. $\geq$ 10' SHALL BE A MINIMUM OF 12" THICK WITH REINFORCEMENT IN BOTH FACES.

Computation Sheet

USE: $f'_c = 4{,}000$ PSI

$f_y = 60{,}000$ PSI

$\rho_{MAX} = 0.25 \times \rho_b$

$\rho_{MIN} = 200/f_y$ OR 1/3 INCREASE OVER REQUIRED BY DESIGN ACI 10.5

COUSINS PUMPING STATION COMPLEX I-WALL DESIGN	BURK-KLEINPETER, INC. ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
	Job No. 9388	Designed By: R. CHOPIN	Date: 4/11/98	Checked By:	Page 1 of 6

TOP OF I-WALL ELEVATION = 11.50

BOTTOM OF CONCRETE CAP ELEVATION = 0.00

HT. OF CONCRETE CAP = 11.5'

FOR THE DESIGN OF THE CONCRETE CAP ON THE I-WALL THE FOLLOWING LOAD CASES WILL BE CONSIDERED:

I - STATIC WATER PRESSURE TO SWL, NO WIND, NO DYNAMIC WAVE FORCE (100% FORCES USED)

II - STATIC WATER PRESSURE WITH WATER LEVEL 2 FEET ABOVE SWL (TOP OF THE WALL), NO WIND, NO DYNAMIC WAVE FORCE (75% FORCES USED)

III - WIND LOAD, NO WATER (75% FORCES USED)

IV - WIND LOAD FROM FLOOD SIDE WITH WATER SURFACE AT SWL (75% FORCES USED)

CONSERVATIVELY SUM MOMENTS ABOUT THE BOTTOM OF THE CAP.

ALSO, CHECK AT BOTTOM OF 12" THICK WALL SECTION

TOP OF WALL 1'-0" THICK

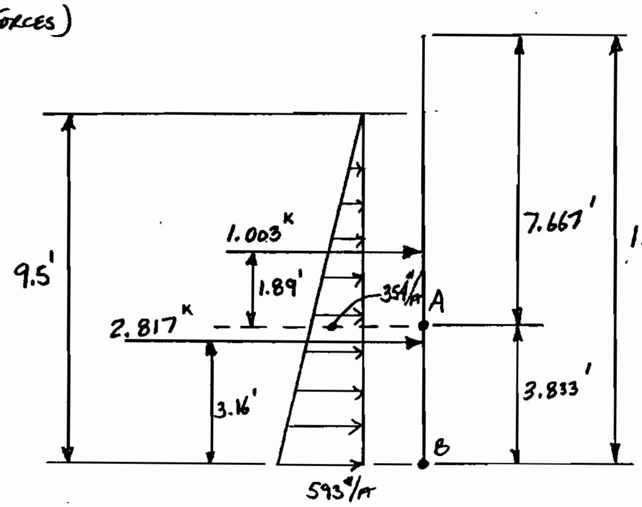
BOTTOM OF WALL 1'-8" THICK → CAP ON TOP OF CASTEEL CZ 95 SHEET PILING

Computation Sheet

Cousins Pumping Station Complex I-Wall Design	**BURK-KLEINPETER, INC.** ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
	Job No. 9388	**Designed By:** R. Chapin	**Date:** 4/11/98	**Checked By:**	**Page** 2 **of** 6

Case I : (Loading per 1' strip of wall)
(100 % Forces)

Point A = 12" wall point



At Point A :

Service Loads :

$V = \underline{1.003^K}$

$M = 1.003^K \times 1.89' = \underline{1.896 \text{ ft}\cdot\text{K}}$

Factored Loads :

$V_u = (1.7)(1.3)(1.003^K) = \underline{2.22^K}$

$M_u = (1.7)(1.3)(1.896 \text{ ft}\cdot\text{K}) = \underline{4.19 \text{ ft}\cdot\text{K}}$

At Point B:

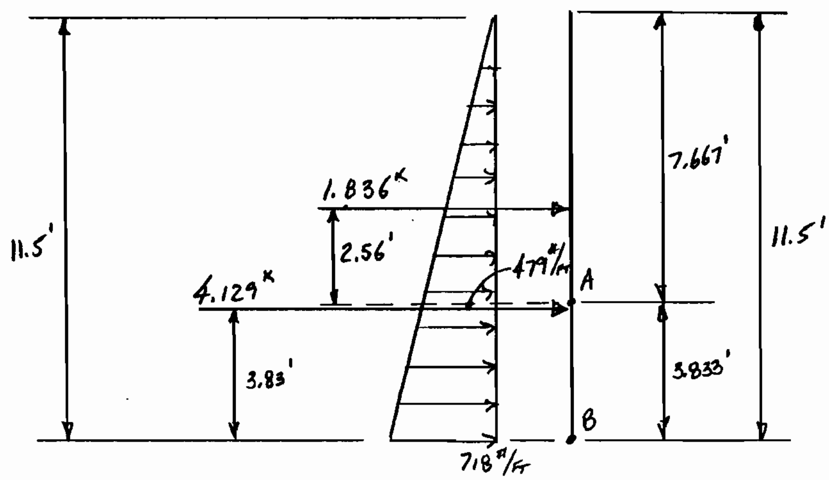
Factored Loads :

$V_u = (1.7)(1.3)(2.817^K) = \underline{6.23^K}$

$M_u = (1.7)(1.3)(2.817^K \times 3.16') = \underline{19.68 \text{ ft}\cdot\text{K}}$

Cousins Pumping Station Complex I-Wall Design	**BURK-KLEINPETER, INC.** ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
	Job No. 93BB	Designed By: R. Chopin	Date: 4/11/98	Checked By:	Page 3 of 6

Case II: (Loading per 1' strip of wall)
(75% Forces)



At Point A:

Factored Loads: $V_u = (0.75)(1.7)(1.3)(1.836^K) = \underline{3.04^K}$

$M_u = (0.75)(1.7)(1.3)(1.836^K \times 2.56') = \underline{7.79 \text{ ft}\cdot\text{K}}$

At Point B:

Factored Loads: $V_u = (0.75)(1.7)(1.3)(4.129^K) = \underline{6.84^K}$

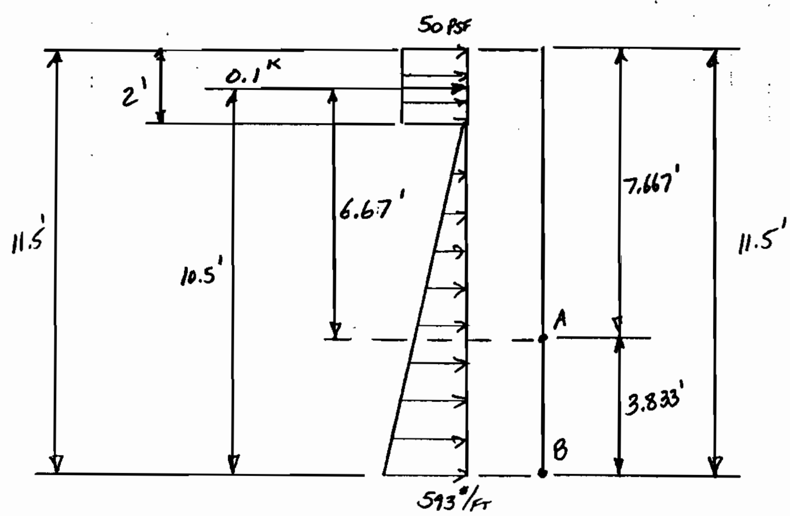
$M_u = (0.75)(1.7)(1.3)(4.129^K \times 3.83') = \underline{26.21 \text{ ft}\cdot\text{K}}$

Case III:

Note: By inspection this case will not govern design

Computation Sheet

CASE IV: (LOADING PER 1' STRIP OF WALL)
(75 % FORCES)



NOTE: FOR LOADS DUE TO WATER SEE CASE I LOADING

AT POINT A:

FACTORED LOADS: $V_u = (0.75)\left(2.22^K + (1.7)(1.3)(0.1^K)\right) = \underline{1.83^K}$

$M_u = (0.75)\left(4.19\,FT\cdot K + (1.7)(1.3)(0.1^K \times 6.67')\right) = \underline{4.25\,FT\cdot K}$

AT POINT B:

FACTORED LOADS:

$V_u = (0.75)\left(6.23^K + (1.7)(1.3)(0.1^K)\right) = \underline{4.84^K}$

$M_u = (0.75)\left(19.68\,FT\cdot K + (1.7)(1.3)(0.1^K \times 10.5')\right) = \underline{16.50\,FT\cdot K}$

COUSINS PUMPING STATION COMPLEX I-WALL DESIGN	BURK-KLEINPETER, INC. ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
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CASE II LOADING GOVERNS DESIGN

DESIGN LOADS AT POINT A: $V_U = 3.04^K$ $M_U = 7.79$ FT·K AT POINT B: $V_U = 6.84^K$ $M_U = 26.21$ FT·K

MINIMUM COVER AT POINTS A & B = 3" CLEAR

$d_A = 12'' - (3'' + \frac{1}{2}(5/8'')) = 8.6875''$ ASSUMING #5 BARS

$d_B = 20'' - (3'' + \frac{1}{2}(3/4'')) = 16.625''$ ASSUMING #6 BARS

FLEXURE DESIGN: $f'_c = 4{,}000$ PSI $f_y = 60{,}000$ PSI

$\rho_b = 0.0285$

$\rho_{max} = 0.25 \times 0.0285 = 0.0071$

$\rho_{min} = 0.0033$

$$R_n = \frac{M_U}{\phi b d^2} \qquad \rho = \frac{0.85 f'_c}{f_y}\left(1 - \sqrt{1 - \frac{4R_n}{1.7f'_c}}\right)$$

SECTION A

$$R_n = \frac{(7.79 \text{ FT·K})(12''/')(1{,}000 \text{ \#/K})}{(0.9)(12'')(8.6875'')^2} = 114.7$$

$\rho = 0.0019 < \rho_{min} = 0.0033$ ACI 10.5.2. $1.33 \times 0.0019 = 0.0026$

$A_{S_{REQ'D.}} = (0.0026)(12'')(8.6875'') = 0.271$ IN²/FT OF WALL

REQ'D. No. 5 BARS @ 13½" O.C.

SECTION B

$$R_n = \frac{(26.21 \text{ FT·K})(12''/')(1{,}000 \text{ \#/K})}{(0.9)(12'')(16.625'')^2} = 105.4$$

$\rho = 0.0018 < \rho_{min} = 0.0033$ $1.33 \times 0.0018 = 0.0024$

$A_{S_{REQ'D.}} = (0.0024)(12'')(16.625'') = 0.479$ IN²/FT OF WALL

REQ'D. No. 6 BARS @ 11" O.C.

MATCH #5 + #6 BARS ∴ $\boxed{\text{USE \#5 @ 11'' TOP E.F. / \#6 @ 11'' BOTTOM E.F.}}$

COUSINS PUMPING STATION COMPLEX	BURK-KLEINPETER, INC. ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
I-WALL DESIGN	Job No. 9388	Designed By: R. CHOPIN	Date: 4/11/98	Checked By:	Page 6 of 6

SHEAR DESIGN :

SECTION A $\quad V_u = 3.04^k$

$$\phi V_c = \phi 2 \sqrt{f'_c}\, bd = (0.85)(2)\sqrt{4{,}000}\,(12)(8.6875) = 11{,}208^{\#}$$

$$\phi V_c = 11.2^k > 3.04^k \quad \underline{\underline{O.K.}}$$

SECTION B $\quad V_u = 6.84^k$

BY INSPECTION $\quad \phi V_c > V_u \quad \underline{\underline{O.K.}}$

TEMPERATURE & SHRINKAGE REINFORCEMENT :

TOP 12" THICK WALL $\quad A_{s_{TEMP}} = 0.0028 \times 12'' \times 92'' = 3.09 \text{ in}^2$

BOTTOM 1'-8" THICK WALL $\quad A_{s_{TEMP}} = 0.0028 \times 20'' \times 46'' = 2.58 \text{ in}^2$

$A_{s_{E.F.}}$ TOP $= \dfrac{3.09 \text{ in}^2}{2} = \underline{\underline{1.55 \text{ in}^2}}$

$A_{s_{E.F.}}$ BOTTOM $= \dfrac{2.58 \text{ in}^2}{2} = \underline{\underline{1.29 \text{ in}^2}}$

VERTICAL STEEL $\quad$ #5 @ 11" TOP E.F.
#6 @ 11" BOT. E.F.

HORIZONTAL STEEL $\quad$ #4 @ 12" TOP E.F.
#5 @ 9" BOT. E.F.

$f'_c = 4{,}000$ psi
$f_y = 60{,}000$ psi

WALL: 1'-0" TOP
1'-8" BOTTOM

Computation Sheet

COUSINS PUMPING STATION COMPLEX	BURK-KLEINPETER, INC. ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL				
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CANTILEVER SHEET PILE WALL

MAX MOMENT = 102.3 ^{KFT} FROM EUSTIS REPORT

$$S_{REQ'D} = \frac{102{,}300 \text{ \# FT } (12)}{0.65\,(50{,}000)}$$

$$S_{REQ'D} = 37.8 \text{ in}^3$$

DUE TO THE FACT THAT THIS WALL IS CANTILEVERED WITH SOIL ON ONE SIDE TO EL. 2.0 AND OPEN CANNEL ON THE OTHER TO EL. -9.0, WE WILL USE HOT-FORMED SHEET PILE RATHER THAN COLD ROLLED SHEETING DUE TO THE TIGHTER INTERLOCK.

USE ARBED AZ 26 w/ $S = 48.4 \text{ in}^3$

OR CZ 141 w/ $S = 39.1 \text{ in}^3$

AZ 26 HAS A WIDTH OF 16.81" → SHEET PILE WALL WILL BE CAPPED W/ CONCRETE. TO GET 6" CLEAR ON EACH SIDE OF CONCRETE, CAP SIZE WILL BE 2'-6" WIDE BY 2'-0" DEEP.

SHEET PILE WILL TAKE ALL LOADS - TEMP. + SHRINKAGE STEEL REQUIRED IN CAP

$$A_{S\,\text{TEMP+SHRINK}} = 0.002\,(24)(30) = 1.44 \text{ in}^2$$

USE 4 - #6 BARS $A_S = 1.77 \text{ in}^2$

Computation Sheet

BURK-KLEINPETER, INC.
ENGINEERS, ARCHITECTS, PLANNERS, ENVIRONMENTAL SCIENTISTS
NEW ORLEANS, LA BATON ROUGE, LA TUSCALOOSA, AL

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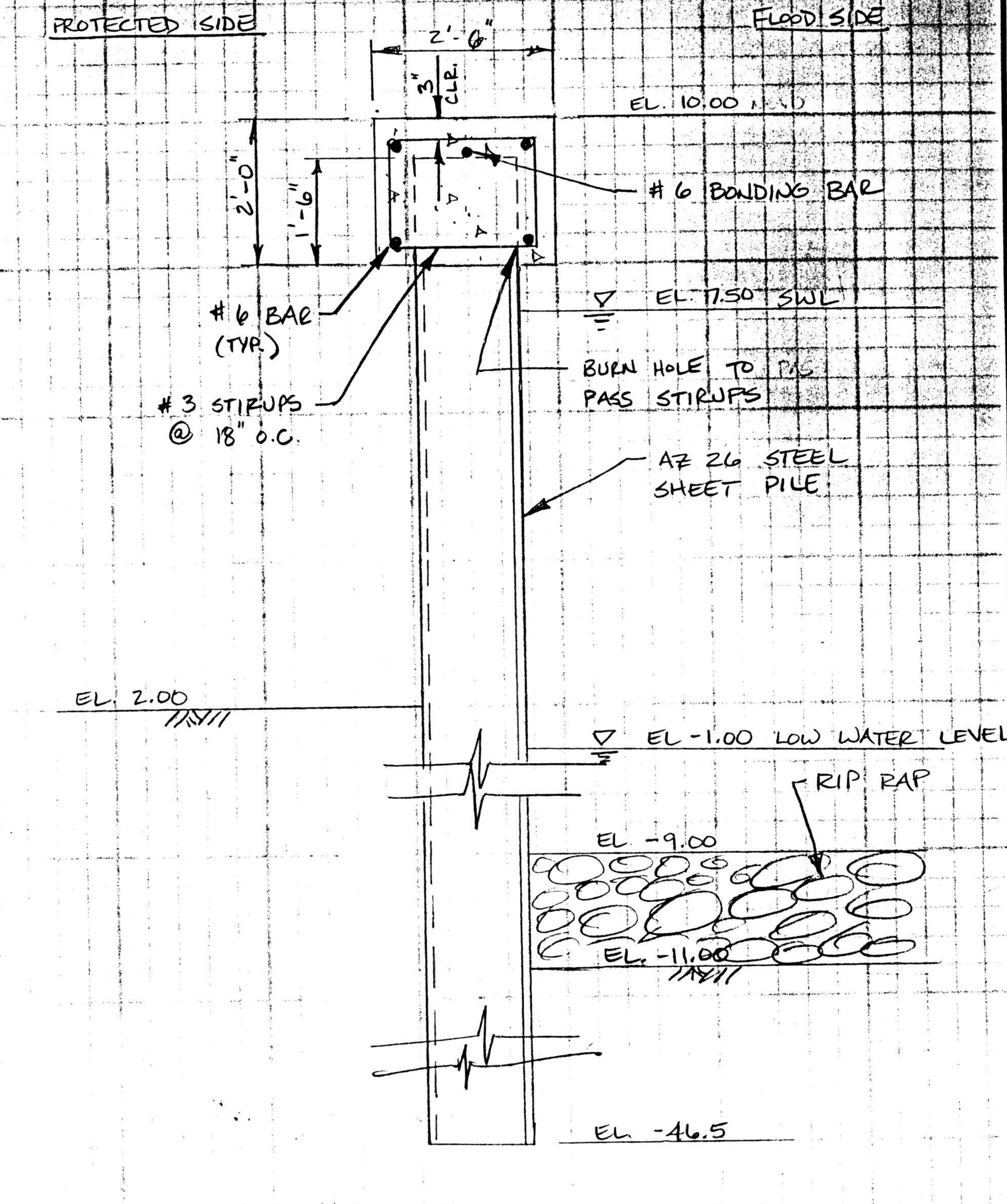


TYPICAL CANTILEVER SHEET PILE WALL
SCALE: 1" = 1'-0"

Computation Sheet

DESIGN CALCULATIONS

CULVERT

CUT OFF WALL

	A	B	C	D	E	F	G	H	I	J	K
1	COUSINS PUMP STATION DISCHARGE CULVERT										CEEC
2	S-1		7.5 FOOT HULL		(UNDER THE LAPALCO BRIDGE)					C.E.E.C.	W J MOUTON
3	CLEAR CHANNEL OPENING:			107.00	FEET	WIDTH		WING WL.	WING WL.:	REVISED:	17 NOV. 97
4	CRITERIA:	LENGTH	W/CHAN	HULL	BAY 1-2	BAYS 2-12	BAY12-13	HULL	HEIGHT	HT OF UNIT	17 MR 98
5	CL DIMENSIONS	108.33	123.50	DEPTH	(1 BAY)	(10 BAYS)	(1 BAY)	DEPTH	AB. SILL		26 AU 98
6	O.T.O. WALLS	108.83	124.00	7.50	7.58	10.83	7.58	7.50	20.50	28.00	
7	O.T.O. BASE	111.00	126.67	7.50	123.50		BUOY/FT:	AT.063 KCF	850.21		
8	HULL BOTTOM:		SILL	7.50		53.67	SILL/2		BUOY/FT.		
9	PANEL AND WEIGHT TAKE - OFF: HULL ONLY							10'-10" Bays		TRANSVERSE	
10	ITEM	LENGTH	WIDTH	THICKNESS	CU. FT.	NUMBER	UNIT WT.	WEIGHT	DRAFT	MOM ARM	MOMENT
11	(Hull is separated from Wing Walls for Calculation Purposes)						KCF	KIPS	FEET	FEET	FT. KIPS
12	BOTTOM	111.00	126.67	8.00	9,373.36	1	0.122	1,144	1.35		
13	TOP: SILL	111.00	110.67	8.00	8,189.36	1	0.122	999	1.18		
14	PANELS (Vertical)	Width	Height	Thickness	Cubic Feet	Number	Unit Wt.	Weight			
15	1,2,12,13 /A to L	9.83	7.208	6.00	35.44	40	0.122	173	0.20		
16	3 to11: A to L	9.83	7.208	5.00	29.53	90	0.122	324	0.38		
17	(Horizontal to page))										
18	A & L: 1-2, 12-13	6.58	7.208	6.00	23.73	4	0.122	22	0.03		
19	A & L: 2 THRU 12	6.58	7.208	6.00	23.73	20	0.122	58	0.07		
20											
21	B THRU K: 2 to 12:	9.83	7.208	6.00	35.44	90	0.122	389	0.46		
22	B Thru K:1-2,12-13	9.83	7.208	5.00	29.53	18	0.122	65	0.08		
23	Check Σ Panels:	(10 x13)+(11 x12) =			262.00	262				C.G.	WT/2 X
24	Column Joints	1.67	7.21	22.00	22.07	143	0.122	385	0.45	FROM CL	C.G. ARM
25							SUM:	3,559		-31.00	-55,162
26								Σ DRAFT:	4.19	FEET	FT. KIPS
27	20.5 FT WING WALL:		WING WALLS:				cy:	1,080	cu yds		
28	PANELS:	Width	Height	Thickness	Cubic Feet	Number	Unit Wt.	Weight			
29	1-2,11-12: A to L	9.83	20.00	6.00	98.33	40.00	0.122	479.87			
30	A and L: 1-2 12-13	6.58	20.00	6.00	65.83	4.00	0.122	32.13			
31	B thru K: 1-2, 12-13	6.58	20.00	5.00	54.86	18.00	0.122	120.47			
32			SUM OF WING WALL PANELS:			62.00				C.G.	WT/2 X
33	TOP OF WING WALL	108.83	8.08	6.00	439.87	2.00	0.122	107.33		FROM CL	C.G. ARM
34	WING WALL JTS	1.67	20.00	22.00	61.23	44.00	0.122	328.70	1.26	-57.96	-30,964
35		VOLUME CY:		Concrete:	Cubic Yds			1,068.50	DRAFT	NEW C.G.	SUM MOM
36	HULL	3,748.70		cy ww:	324				5.44	-37.22	-86,126
37	WING WALLS	1,335.90		cy hull	1,080			4,627.30	CL BUOY:	31.00	
38	SUM	5,084.60		sum cy	1,405		ECCENTRICITY:			-6.22	
39							HOGGING MOMENT: NO BALLAST:				-14,402

	A	B	C	D	E	F	G	H	I	J	K
40	S-2	HOGGING MOMENT AND SOIL BEARING VALUES								WJM	26 AU 98
41						U N I T	WEIGHT	WT / 2	DRAFT	MOM ARM	MOMENT
42						HULL	3,558.81	1,779.40	4.19	-31.00	-55,162
43						WING WALL	1,068.50	534.25	1.26	-57.96	-30,964
44						SUMS:	4,627	2,313.65	5.44	-37.22	-86,126
45						BUOY:	4,627	2,313.65		31.00	71,723
46					LAUNCHED HOGGING MOMENT : IN FT. KIPS:						-14,402
47						(Section Modulus, on Page 3): Ft ^3 =					6,340
48		MOMENT DUE TO EXPOSED WING WALLS				LOW TIDE			FLOATING:	f top:	-0.19
49		WEIGHT	534	1.00	534	-57.96	-30,964				Ksi
50		BUOYANCY	1,136	0.39	443	57.96	25,687			LAUNCHED:	
51							SUM M	-5,277	FT.KIPS	f top:	-0.07
52			NO BALLAST WATER								Ksi
53			HOGGING MOMENT =		-14,402	LAUNCHED		FREEBOARD:	1.56	FEET	
54				FT. KIPS		INSTALLED			RECHECK: SOIL BEARING		
55							DRAFT:	5.23 x .063 = K/SQ.FT =			
56							1,207	cy x27 at .063 =		2,053	Kips
57			WT IN AIR:		4,627	KIPS			WEIGHT	4,627	KIPS/AIR
58	CUBIC YDS CONCRETE: HULL ONLY:				1,080	CY. YDS			DISP-WT	2,574	KIPS
59	CU. YDS IN WW -9 TO -1.00 FT:				127	CY YDS			AREA	14,060	
60				SUM C.Y.	1,207	CY YDS					
61	SUBMERGED WEIGHT OF 1026 CY:				1,923	KIPS	AT				
62	WEIGHT OF EXPOSED WING WALLS:				450	KIPS	-1.00 LOW TIDE				
63	TOTAL LOAD ON SOIL				2,373	KIPS					
64		BOTTOM HULL AREA:			14,060	SQ. FEET					
65			LOAD ON SOIL:		0.169	KSF	ADDITIONAL CHECK ON SOIL BEARING:				LBS:
66					169	PSF	WT/SF OF DISPLACEMENT:			5.25 x 63	342.88
67					Equivalent thickness of SLWT Concrete: Feet:					330/122	2.81
68					Submerged weight of 1 Cu Ft. SLWT:				(Pounds)	122-63	59.00
69						SUBMERGED WT OF 2.71 FT OF SLWT CONCRETE:					165.82
70					AT - 1.00 LOW TIDE:						PSF
71					PLUS ADD WEIGHT OF WING WALLS ABOVE - 1.00 LEVEL						
72					(20.5-8)/20.5 X		1,068	x63/122=	336.44	/AREA =KSF	0.024
73		S U M M A R Y							SOIL BEARING IN PSF:		189.75
74			SOIL BEARING VARIES FROM 163 TO 184 PSF								
75											

	A	B	C	D	E	F	G	H	I	J	K
76	S-3	TRANSVERSE MOMENT OF INERTIA AND SECTION MODULUS OF HULL SECTION									26 AU 98
77	SECTION	LENGTH	WIDTH	THICK	NUMBER	AREA	CG.	A x CG	I	A d^2	Sum I
78		FEET	FEET	INCHES		SQ. FT.	BASE		bd^3/12		
79	BOTTOM	126.67	111.00	8.00	1.00	888.00	0.33	296.00	2.74	8,736.8	8,740
80	S I L L	124.67	109.00	8.00	1.00	872.00	7.17	6,249.35	2.69	11,916.2	11,919
81											
82	WALLS - 6 IN	1.00	7.21	6.00	2.00	7.21	3.67	26.43	31.21	0.0	31
83	WALLS - 5 INCH	1.00	7.21	5.00	9.00	27.03	3.67	99.11	117.05	1.0	118
84					SUM AREA:	1,794	SUM	6,670.90		Sum I	20,808
85							Y' =	3.72		S top	6,340
86										S bottom	5,597
87								8 In Slab:	S = 128 in^3		
88	TENSION STRESS IN HULL AT LAUNCHING:				AT SILL:		∑ Stresses	M Hogging	w Hyd.	- M	-Mx12 /S
89		HOGGING MOMENT:		-14402	/ St =	-2.27	-0.19	-189	1.29	-5.00	-468.93
90				FT KIPS		KIPS/SF	KSI	PSI	20.5ft Hd	.033wL^2	Psi
91	STRESS HULL TO + 650 PSI										
92		AT LAUNCHING			MAXIMUM TENSION IN SILL:			-189	+	0	-189
93		INSTALLED:			MAXIMUM TENSION IN SILL:						-469
94	COMPRESSION STRESS IN HULL AT BOTTOM:								23 ft Hd	.025wL^2	
95		HOGGING MOMENT:		-14402	/ Sb =	2.57	0.21	214	1.44		134.77
96				FT KIPS		KIPS/SF	KSI	PSI			Psi
97											
98						BOTTOM:	_ .=.	214	+	135	349
99											PSI
100	PRE STRESSING IN HULL BOTTOM :										
101	1/2" Ø 270 K STRAND AT 12 INCHES ON CENTERS AT BOTTOM POURS 1 AND 2:								PRESTRESS =		0.52
102											KSI
103	PRESTRESSING IN SILL:										
104	1/2" Ø 270 K STRAND AT 6 IN. LW IN TOPPING								PRESTRESS =		0.52
105	AND AT 12 IN. SW IN TOPPING OVER PRESTRESSED PLANKS								PRESTRESS =		0.26
106								PSI			KSI
107	MINIMUM COMPRESSION IN SILL DURING LAUNCHING & FLOATING:							520.83	PSI P/S		
108								-468.93	PSI TENSION		
109	MINIMUM COMPRESSION			HOGGING	AT SILL:			PSI COMPRESSION			
110	IN HULL WHEN INSTALLED:			MOMENT	f top	P/s	Residual				
111				-5,277	-0.069	0.521	0.451	451	PRE-STRESS		
112				(INSTALLED)			KSI	PSI			
113											
114											
115											

	L	M	N	O	P	Q	R	S	T	U	V	W
1	S-4	COUSINS PUMP STATION DISCHARGE CULVERT									26 AU 98	CEEC
2	7.50' HULL+20.5' WW	LOAD CASE I				LOAD CASE II				LOAD CASE III		
3	LOAD CASE :	LAUNCHIN	∑ Moment CL Hull			-1.0 ELEV	LOW TIDE			+11.5 ELEV	F L O O D	T I D E
4	WATER ON SILL	0.00				8.00	8.00			20.50	20.50	
5	WATER TABLE	0.00				0.00	0.00			0.00	0.00	
6	HULL WEIGHT/2	1,779.40				1,779.40	0.00			1,779.40	1,779.40	
7	VOLUME CY/2	1,874.35				1,874.35	120.56			1,874.35	1,874.35	
8	CONC VOLUME/2	540.20				540.20	540.20			540.20	540.20	
9	WW WEIGHT 1 SIDE	534.25				534.25	534.25			534.25	534.25	
10	VOLUME W W CY/2	667.95				667.95	37.11			667.95	667.95	
11	CONCRETE WW CY/FT	162.19				162.19	7.91			162.19	162.19	
12	HULL MOM ARM	-31.00				-31.00	-31.00			-31.00	-31.00	
13	WW MOMENT ARM	-57.96				-57.96	-57.96			-57.96	-57.96	
14	SUM MOMENTS CL	WEIGHTS	MOM ARM	MOMENTS		WEIGHTS	MOM ARM	MOMENTS		WEIGHTS	MOM ARM	MOMENTS
15	HULL	1,779.40	-31.00	-55,162		1,779	-31.00	-55,162		1,779	-31.00	-55,162
16	WING WALL	534.25	-57.96	-30,964		534	-57.96	-30,964		534	-57.96	-30,964
17	HULL BALLAST	0.00		0		2,269	-31.00	-70,351		2,269	-31.00	-70,351
18	W W BALLAST + Hd	0.00		0		336	-57.96	-19,458		860	-57.96	-49,861
19	SUM HOGG SUM V:	-2,314	HOG M:	-86,126		-4,919	HOG M:	-175,935		-5,443		-206,338
20												
21	HULL BUOYANCY/2	2,314	31.00	71,723		3,188	31.00	98,836		3,188	31.00	98,836
22	WW BUOY AT + HD	0.00		0		443	57.96	25,687		1,136	57.96	65,824
23	SUM: SAGG SUM V:	0.00	SAG. M:	71,723		3,631	SAG. M:	124,524		4,324	SAG M.:	164,660
24	REMAINING SOIL BEAR	0.00				1,287	31.00	39,906		1,119	31	34,700
25	TOTALS	0.00	HOG M:	-14,402			SAG. M:	164,430				199,361
26	DRAFT: FEET:	5.44										
27	SUMS: V =		HOG M:	-14,402		1,287	TENSION	-11,505		1,119	TENSION	-6,978
28	SOIL BEARING			P/A SOIL:		0.191		Ft. Kips		0.166		Ft. Kips
29	SECTION MODULUS		St FT^3	6,340			St FT^3	5,597			St FT^3	5,597
30	TENSION AT SILL		TENSION	-0.189	KSI		TENSION	-0.171	KSI		TENSION	-0.104
31				SILL				SILL				SILL
32	SOIL BEARING ∑ V:					1,287	∑ V			1,119	∑ V	
33											P Horizontal on Wing Wall:	1,166.15
34											Moment Arm above Sill:	7.75
35											Added Hogging Moment/CL Sill:	-9,186.70
36											Added Tension In Sill:	-0.150
37											Total Tension In Sill:	-0.263
38											Remaining P/S of 520 Psi:	0.257
39	FINAL SOIL BEARING:		0.00	Floating		191	Soil Bearing Psf			166	Soil Bearing Psf	

S-5 **FLOATATION FACTOR OF SAFETY**

CEEC
WJM
26 AU 98

SFf = Ws + Wc +S /(U- Wg)

SF f BASED ON HYDRAULIC PRESSURES

			LOAD CASE I			LOAD CASE II	
Ws	Weight of Structure, Complete		4,627	Kips	Flood Tide	4,627	Kips
	(+ Wt. of Conc. & Soil Above Hull Extension)		475	Kips		475	Kips
Wc	Ballast Water (Low Tide)	Elev-1.00	5,210	Kips	El.+ 11.5	6,259	Kips
S	Surcharge Loads		0			0	
U	Uplift Forces acting on Base of Structure		12,753	Kips	(27.5'Hd)	23,381	Kips
Wg	Weight of Water above Top surface		5,997	Kips	(20.5'Hd)	15,368	Kips
	(Totally controlled by Gravity Flow)						
	Floatation Factor of Safety SFf =	S F f:	1.53		S F f:	1.42	

SF f BASED ON BUOYANCY

			LOAD CASE I			LOAD CASE II	
Ws	Weight of Structure, Complete		4,627	Kips	Flood Tide	4,627	Kips
	(+ Wt. of Conc. & Soil Above Hull Extension)		475	Kips		475	Kips
Wc	Ballast Water (Low Tide)	Elev-1.00	5,210	Kips	El.+ 11.5	6,259	Kips
S	Surcharge Loads		0			0	
U	Uplift Forces HULL + WW BUOYANCY:		7,263	Kips	(27.5'Hd)	8,648	Kips
Wg	Weight of Water above Top surface		0	Kips	(20.5'Hd)	0	Kips
	(Controlled by Gravity Flow)		(Equalized Pressure)			(Equalized Pressure)	
	Floatation Factor of Safety SFf =	S F f:	1.42	> 1.30	S F f:	1.31	> 1.30

HULL & WING WALLS
COMPLETELY SUBMERGED

LAPALCO CULVERT: PILE SUPPORTED ALTERNATE:

C.E.E.C. S-6

WJM

21 JLY 98

4 AUG 98

26 AU 98

PRELIMINARY ANALYSIS:

LENGTH OF CULVERT PARALLEL TO CHANNEL:	108.33	FEET
WIDTH OF LAPALCO BRIDGE OVERHEAD:	68.00	FEET
DIFFERENCE:	40.33	FEET
CLEARANCE BELOW EACH SIDE:	20.16	FEET
PILE CAISSON LOCATION FROM CENTERLINE:	40.50	FEET
CLEARANCE BELOW EACH SIDE:	6.50	FEET

CULVERT LOADING ON SOIL:

MAX P/A: SOIL BEARING:	-0.20	KSF	
CONTRIBUTORY WIDTH OF ONE PILE/SPACING:	10.83	FEET	
UNIT LOAD BETWEEN CAISSONS:	2.17	K/ FT	
CENTERLINE SPAN BETWEEN CAISSONS:	81.00	FEET	
POSITIVE MOMENT AT CENTER OF SPAN: WL^2/8:	1,776.94	FT. KIPS	
NEGATIVE MOMENT OF 13.67 FT. CANTILEVERS:	-192.52	FT. KIPS	
MAXIMIMUM MOMENT AT CL SPAN	1,584.42	FT. KIPS	(PER 10.833 FOOT BAY)

PROPERTIES OF ONE-CELL WIDE SECTION 7.50 FT. DEPTH

UNIT	THICKNESS	WIDTH/HT.	AREA	M OFINERTIA	Ad^2	∑ M+Ad^2
TOP	8.00	130.00	1,040.00	5,547	1,748,240	1,753,787
BOTTOM	8.00	130.00	1,040.00	5,547	1,748,240	1,753,787
WALL	6.00	74.00	444.00	202,612	0	202,612
					∑ I:	3,710,185
					Sect. Mod:	82,449 In ^3

STRESS IN HULL AT CENTERLINE:

f = Mx12/S 1,584.42 x 12.00 / 82,449 = 0.231 KSI

(STRESS HULL TO 500 PSI: 1/2" Ø 270 K SR STRANDS AT 6 INCHES ON CENTERS

LOAD ON 24 INCH DIAMETER CAISSONS IN 30 INCH SLEEVES:

2.17 x 108.33/2 = 117.36 Kips

58.68 Tons

USE: 24 INCH Ø CAISSONS, CONCRETE FILLED X 30 FT. LENGTH 80 FEET

24 REQUIRED: DESIGN LOAD: 60 TONS

(NO DEWATERING REQUIRED)

X	Y	Z	AA	AB	AC	AD	AE	AF
	LAPALCO CULVERT: PILE SUPPORTED ALTERNATE:							S-7
	DEWATERING SCENARIO WATER BALLAST							WJM
	WITH WATER BALLAST:							4 AUG 98
	LOAD ON SOIL WITH HULL FULLY BALLASTED:				184.00	PSF		26 AU 98
		UPLIFT HEAD:	11.50	UPLIFT:	-724.50	PSF	AT 63 PCF	
				SUM UPLIFT:	-540.50	PSF		
AREA AFFECTED BY DEWATERING/UPLIFT:					11,456.80	SQ. FEET		
		SUM OF UPLIFT FORCE:			-6,192.40	KIPS		
		DIVIDED BY 24 PILES:			-258.02	KIPS		
					-129.01	TONS		
	PILE REQUIREMENT: 24 - 36 INCH DIAMETER PILES X					115.00		
	UPLIFT UNIT FORCE ON 10 FT. SEGMENT:				-540.50			
				C. WIDTH	10.83		MOMENT:	
			UNIT LOAD:	UPLIFT:	-5.86	KIPS/FT.	MOMENTS:	
		EQUIVALENT SPAN:			81.00	FEET	-4,802.17	
			CANTILEVER:		13.67	FEET	1,846.07	
						Σ MOMENT:	-2,956.10	
		1-CELL		SECTION MODULUS		AE-27 :	82,448.56	
					MAX STRESS:		-0.430	KSI
					SHEAR:		-237.14	
				SHEARING STRESS IN WEB::			-0.44	KSI 6 IN
							-0.33	KSI 8 IN.
		SUMMARY:	HULL DEPTH: 7.50 FEET					
		1	PROVIDE 24 - 36" Ø PILES x 115 FEET IN 42 INCH SLEEVES					
		2	PRESTRESS HULL AND WEBS TO 750 PSI					
		3	INCREASE VERTICAL WALL PANELS LW TO 8 INCH THICKNESS					

	X	Y	Z	AA	AB	AC	AD	AE	AF
76		LAPALCO CULVERT: PILE SUPPORTED ALTERNATE:							S-8
77		DEWATERING SCENARIO: CONCRETE BALLAST							WJM
78		WITH CONCRETE BALLAST:							4 AUG 98
79		LOAD ON SOIL WITH WATER BALLAST:				184.00	PSF		26 AU 98
80		ADDED LOAD DUE TO CONCRETE BALLAST:				461.74	PSF		
81			SUM: SOIL BEARING:			645.74			
82			UPLIFT HEAD:	11.50	UPLIFT:	-724.50	PSF	AT 63 PCF	
83					SUM UPLIFT:	-78.76	PSF		
84	AREA AFFECTED BY DEWATERING/UPLIFT:					11,456.80	SQ. FEET		
85			SUM OF UPLIFT FORCE:			-902.35	KIPS		
86			DIVIDED BY 24 PILES:			-37.60	KIPS		
87						-18.80	TONS		
88		UPLIFT UNIT FORCE ON 10 FT. SEGMENT:				-78.76			
89					C. WIDTH	10.83		MOMENT:	
90				UNIT LOAD:	UPLIFT:	-0.85	KIPS/FT.	MOMENTS:	
91			EQUIVALENT SPAN:			81.00	FEET	-699.77	
92				CANTILEVER:		13.67	FEET	269.01	
93							∑ MOMENT:	-430.76	
94			1-CELL		SECTION MODULUS		AE-28	82,448.56	
95						MAX STRESS:		-0.063	KSI
96						SHEAR:		-34.56	
97					SHEARING STRESS IN WEB::			-0.06	KSI 6 IN
98								-0.05	KSI 8 IN.
99			SUMMARY: UPLIFT FORCES DOES NOT GOVERN THE DESIGN						
100			UNIT LOAD ON SOIL WITH CONCRETE BALLAST:				645.74	(NORMAL OPERATING)	
101		UPLIFT UNIT FORCE ON 10 FT. SEGMENT:				645.74	PSF		
102					C. WIDTH	10.83	FEET	MOMENT:	
103	PILE LOAD:	378.95	KIPS	UNIT LOAD:	UPLIFT:	7.00	KIPS/FT.	MOMENTS:	
104		189.47	TONS	EQUIVALENT SPAN:		81.00	FEET	5,737.19	
105	36"Ø LENGTH:	140.00	FEET	CANTILEVER:		13.67	FEET	-2,205.51	
106		ESTIMATED)					∑ MOMENT:	3,531.67	
107			1-CELL		SECTION MODULUS		AE-28	82,448.56	
108						MAX STRESS:		0.514	KSI
109						SHEAR:		283.32	
110					SHEARING STRESS IN WEB::			0.52	KSI 6 IN
111			S U M M A R Y :		HULL DEPTH: 7.50 FEET			0.39	KSI 8 IN.
112			1	PROVIDE 24 - 36" Ø PILES x 140 FEET IN 42 INCH SLEEVES					
113			2	PRESTRESS HULL AND WEBS TO 800 PSI				USE 8 IN. VERT. WEBS.	
114			3	REPLACE WATER BALLAST WITH CONCRETE					
115									

[illegible] PUMP STATION DISCHARGE CULVERT

C.E.E.C
W J M
14 JULY 98

CALCULATE HORIZONTAL FORCE DUE TO 6.0 FPS FLOW-FRICTION:

COEFFICIENT OF DRAG: TROWELED CONCRETE SURFACE:
REYONOLDS No. Re = 111 x 6 x 1.935/(.01/479) = 6.17e+7
Cd Steel: 0.036 (Fundamentals of Fluid Mechanics, Streeter, 4th Edition
Cd Concrete: Cd Steel x 1.20 = 0.043

A R E A:			A R E A:	
BOTTOM: 111.00	X	126.67	14,060	
SIDES: 2 x 111.00	X	18.00	3,996	
		∑ AREA :	18,056	Sq. Feet

DRAG: Cd x p/2 x A x V^2:
0.043   1.935/2   18,056   6^2   . = .   27,169   POUNDS

R E S I S T A N C E:

BOTTOM FRICTION:
178 PSF Bearing Pressure x Cf 0.5 = PSF: 89.00
111 x 126.67 x 89.00** psf Cohesion: 1,251,373 POUNDS   ** Geotechnical Recommendation

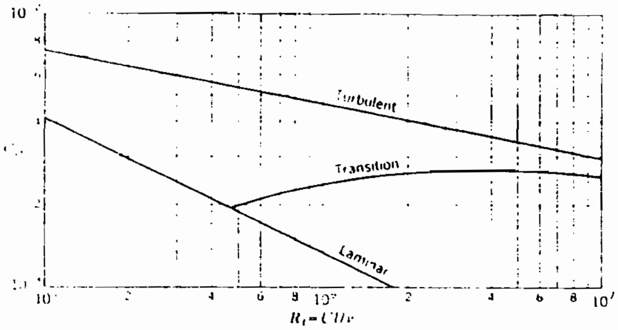
SIDE FRICTION: LAND SIDE:
111 x 16 x 125 PSF   222,000

SIDE FRICTION: CANAL SIDE:
111 x 7 x 60 PSF: 4,620

PASSIVE PRESSURE, ONE SIDE:
126.67 x 7 x 332** PSF Average: 294,381

SUM OF RESISTANCE: 1,772,374

FACTOR OF SAFETY AGAINST HORIZONTAL MOVEMENT: F. S.:
1,772,374 / 27,169   65.24
RESISTANCE / H. FORCE



Laminar $C_D = \frac{1.328}{\sqrt{R_l}}$ transition $C_D = \frac{0.074}{R_l^{1/5}} - \frac{1700}{R_l}$, turbulent $C_D = \frac{0.074}{R_l^{1/5}}$

Fig. 5.17 The drag law for smooth plates.

is valid for a range

$$5 \times 10^5 < \mathbf{R}_l < 10^7$$

Experiment shows that the drag is slightly higher than is predicted by Eq. (5.6.16),

$$C_D = 0.074\mathbf{R}_l^{-1/5} \tag{5.6.17}$$

The boundary layer is actually laminar along the upstream part of the plate. Prandtl[1] has subtracted the laminar portion, producing the equation

$$C_D = 0.074\mathbf{R}_l^{-1/5} - \frac{1700}{\mathbf{R}_l} \qquad 5 \times 10^5 < \mathbf{R}_l < 10^7 \tag{5.6.18}$$

In Fig. 5.17 a log-log plot of C_D vs. $\mathbf{R}_l$ shows the trend of the drag coefficients.

Use of the logarithmic velocity distribution for pipes produces

$$C_D = \frac{0.455}{(\log_{10} R_l)^{2.58}} \qquad 10^6 < \mathbf{R}_l < 10^9 \tag{5.6.19}$$

in which the constant term has been selected for best agreement with experimental results.

Example 5.6 **A smooth, flat plate 10 ft wide and 100 ft long is towed through still water at 68°F with a speed of 20 ft/sec. Determine the drag on one side of the plate and the drag on the first 10 ft of the plate.**

[1] L. Prandtl, Über den Reibungswiderstand stromender Luft, *Results Aerodynamic Test Inst., Gottingen*, III Lieferung, 1927.

For the whole plate

$$\mathbf{R}_l = \frac{100 \times 20 \times 1.935}{0.01/479} = 1.85 \times 10^8$$

From Eq. (5.6.19)

$$C_D = \frac{0.455}{[\log_{10}(1.85 \times 10^8)]^{2.58}} = \frac{0.455}{(8.2675)^{2.58}} = 0.00196$$

The drag on one side is

$$\text{Drag} = C_D bl \frac{\rho U^2}{2} = 0.00196 \times 10 \times 100 \times \frac{1.935}{2} \times (20)^2 = 760 \text{ lb}$$

in which b is the plate width. If the critical Reynolds number occurs at 5 the length l_0 to the transition is

$$\frac{l_0 \times 20 \times 1.935}{0.01/479} = 5 \times 10^5 \qquad l_0 = 0.27 \text{ ft}$$

For the first 10 ft of the plate, $\mathbf{R}_l = 1.85 \times 10^7$, $C_D = 0.00274$, and

$$\text{Drag} = 0.00274 \times 10 \times 10 \times \frac{1.935}{2} \times (20)^2 = 106 \text{ lb}$$

Calculation of the turbulent boundary layer over rough plates pr in similar fashion, starting with the rough-pipe tests using sand roughn At the upstream end of the flat plate, the flow may be laminar; th the turbulent boundary layer where the boundary layer is still thi the ratio of roughness height to boundary-layer thickness ϵ/δ is signi the region of fully developed roughness occurs, and the drag is propor to the square of the velocity. For long plates, this region is followe transition region where ϵ/δ becomes increasingly smaller, and even the plate becomes hydraulically smooth, i.e., the loss would not be re by reducing the roughness. Prandtl and Schlichting[1] have carried th these calculations, which are too complicated for reproduction here.

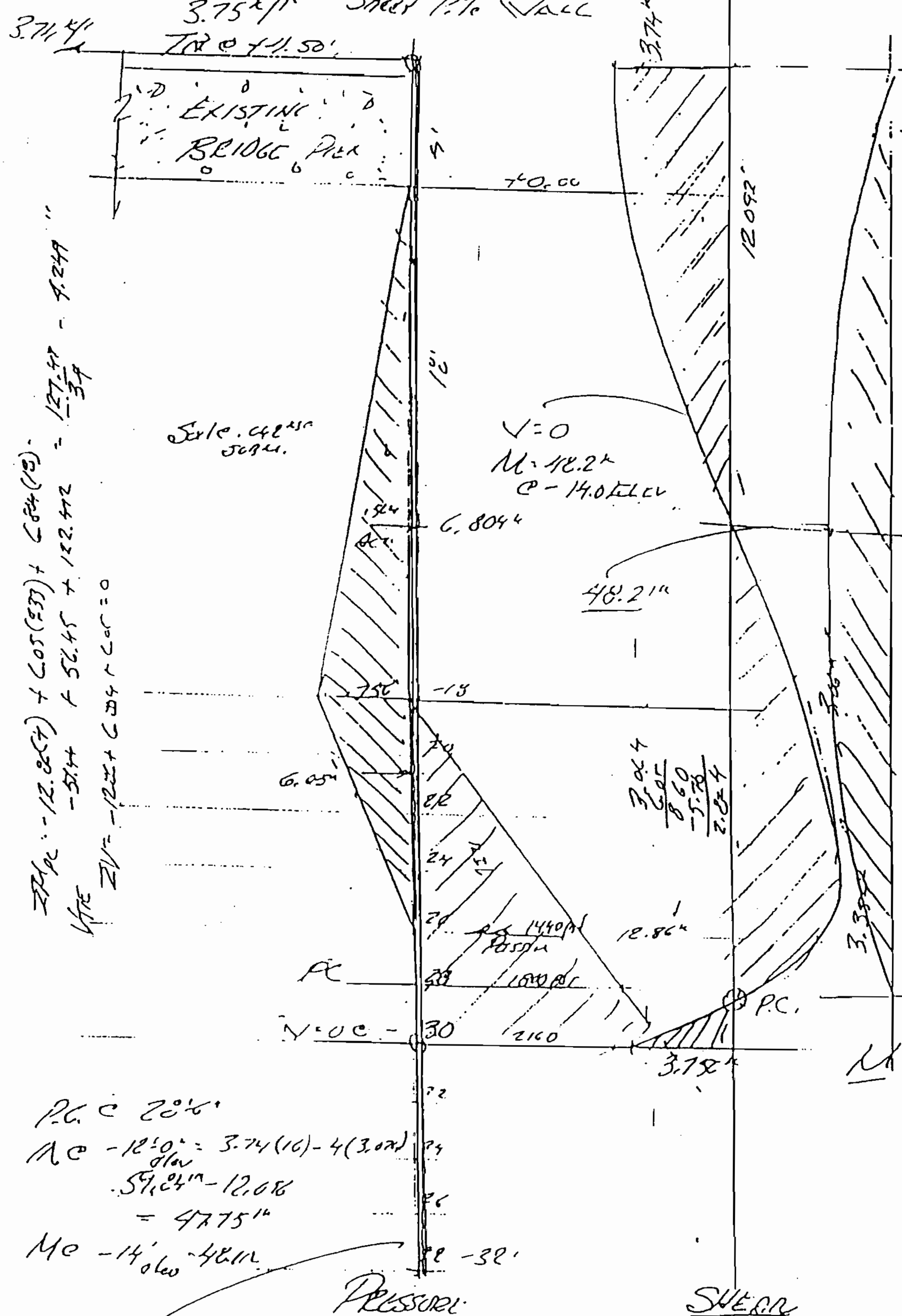
Separation.

Along a flat plate the boundary layer continues to grow in the downs direction, regardless of the length of the plate, when the pressure gr remains zero. With the pressure decreasing in the downstream dire as in a conical reducing section, the boundary layer tends to be redu thickness.

[1] L. Prandtl and H. Schlichting, Das Widerstandsgesetz rauher Platten, *Reederei, Hafen*, p. 1, 1934. See also *NACA Tech. Mem.* 1218, part II.

 COUSINS PUMP STA. DISC. CHANNEL

T3AP98



Tie Rods

Tension
= 3.78(12)'
= 45^k

2"φ DIAM
GR. 40

T allowable =
2.5(24)(5/6)
= 50^k ok

Waler Beam
2-12 Channel
@ 20.7#/'

$M \approx 3.75(12)^2/10$
= 54'k

Sreq'd =
$\frac{54(12)}{24(2)} = 13.5\ in^3$

Sactual
$= 21.5\ in^3 > 13.5\ in^3$

P.C. @ 28'6"
M @ -12'0" elev = 3.74(16) - 4(3.02)
54.84'k - 12.08
= 47.75'k
M @ -14' elev 48'k

Piles ≈ 40' Shorts

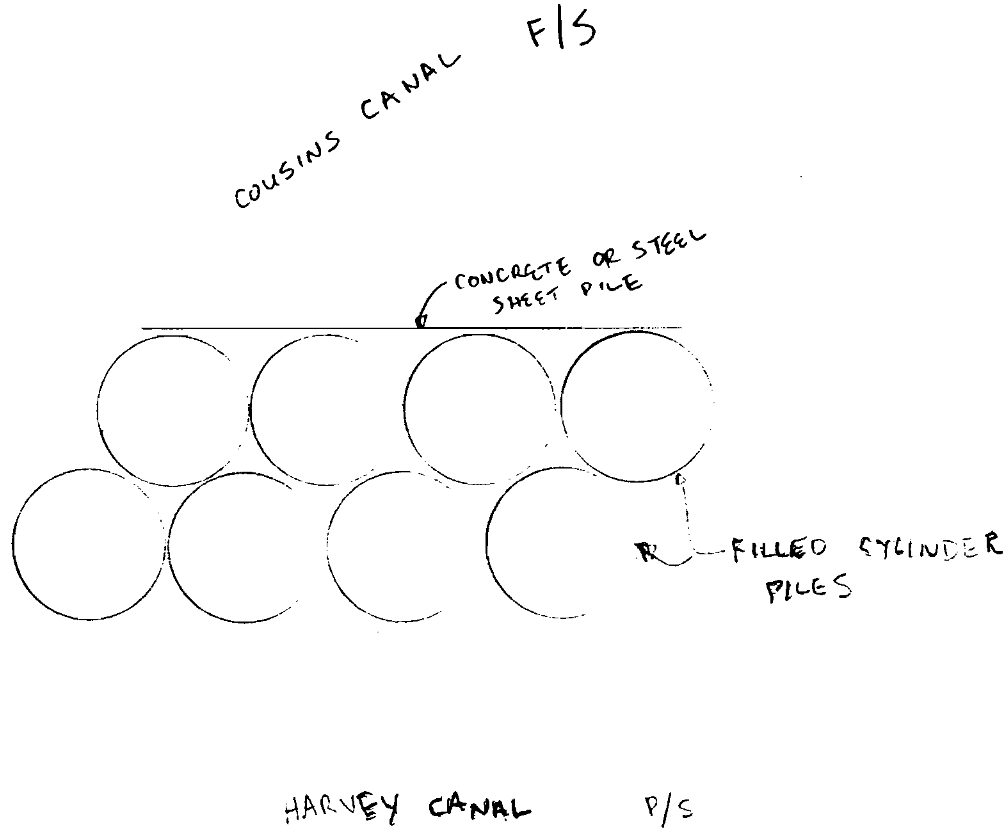
Sr = 24 in³/LF USE: PZ-22 S = 30.2 in³/LF
× 40'-0"

DESIGN CALCULATIONS

CLOSURE WALL

JN 3003	COUSINS COMPLEX CLOSURE WALL	AAH	3-20-98

- USE SAND/CONCRETE FILLED CYLINDER PILES W/SHEET PILE FACE:



MAX MOMENT = 836'K

SCALED DEFLECTION = 5.44×10^{12}

TRY w/ 66"φ PILE:

DEFLECTION : $\Delta = (\text{SCALED DEFLECTION})/EI$

$E = 4,415,200$ psi

$I = 93,454$ in^4/FT WALL

$\Delta = (5.44 \times 10^{12})/(4415200)(93454)$

$\Delta = 13.18''$ N.G.

TRY 72"φ PILE

$I = 683,000 \text{ in}^4/6.0 = \cancel{147,166}\ 113,833 \text{ in}^4$/FT. WALL

$\Delta = (5.44 \times 10^{12})/(4415200)(\cancel{147166}\ 113,833)$

$\Delta = \cancel{8.37''}\ 10.82''$ N.G.

TRY 78"φ PILE

$I = 940,700/6.5 = 144,723 \text{ in}^4$/FT WALL

$\Delta = 5.44 \times 10^{12}/4415200(144723)$

$\Delta = 8.51''$

TRY 84"φ PILE

$I = 1,265,300/7.0 = 180,757 \text{ in}^4$/FT WALL

$\Delta = 5.44 \times 10^{12}/4415200(180757)$

$\Delta = 6.82''$ OK

ALLOWABLE STRESS DESIGN: TRY w/ 84"ϕ

MAX MOMENT = $836'^{K}$
- DIVIDE OVER 2 ROWS OF PILES = $418'^{K}$

ALLOWABLES: $f_a + f_b + f_{pc} \leq 0.9 * .45 f_c'$
$\leq 2430\ psi$ C

$f_a - f_b + f_{pc} \geq 0$ T

AXIAL LOAD DUE TO CAP:

wt per ft wall = $(15)(4)(.150) = 9^{K}/FT\ WALL$

over 2 piles: $4.5^{K}/FT\ WALL \cdot PILE$

FOR 7': $P = (4.5^{K})(7') = 31.5^{K}$

$$f_a = \frac{P}{A} = \frac{31.5}{1693\ in^2} = 0.0186\ ksi$$

$$f_b = \frac{M}{S} = \frac{(418)(12)(7)}{30{,}130} = 1.165\ ksi$$

$$f_{pc} = \frac{F_{pc}}{A_c}$$ - solve for F_{pc} req'd

C: $0.019 + 1.17 + f_{pc} \leq 2.43$

$1.189 + f_{pc} \leq 2.43$

$f_{pc} \leq 1.241\ ksi$

T: $0.019 - 1.17 + f_{pc} \geq 0$

$-1.151 + f_{pc} \geq 0$

$f_{pc} \geq 1.15\ ksi$

$1.15 \leq f_{pc} \leq 1.24$ $\qquad f_{pc} = \frac{F_{pc}}{A}$ $\quad A = 1693\ in^2$

$1.15 \leq \frac{F_{pc}}{1693} \leq 1.24$

$1947^{K} \leq F_{pc} \leq 2099^{K}$

-using prestressing cable consisting of 2 - ½"Ø 270 ksi 7-wire strands of initial tension of 57820 lbs and effective tension of

49,150 lbs :

-each cable gives $F_{pc} = 49^k$

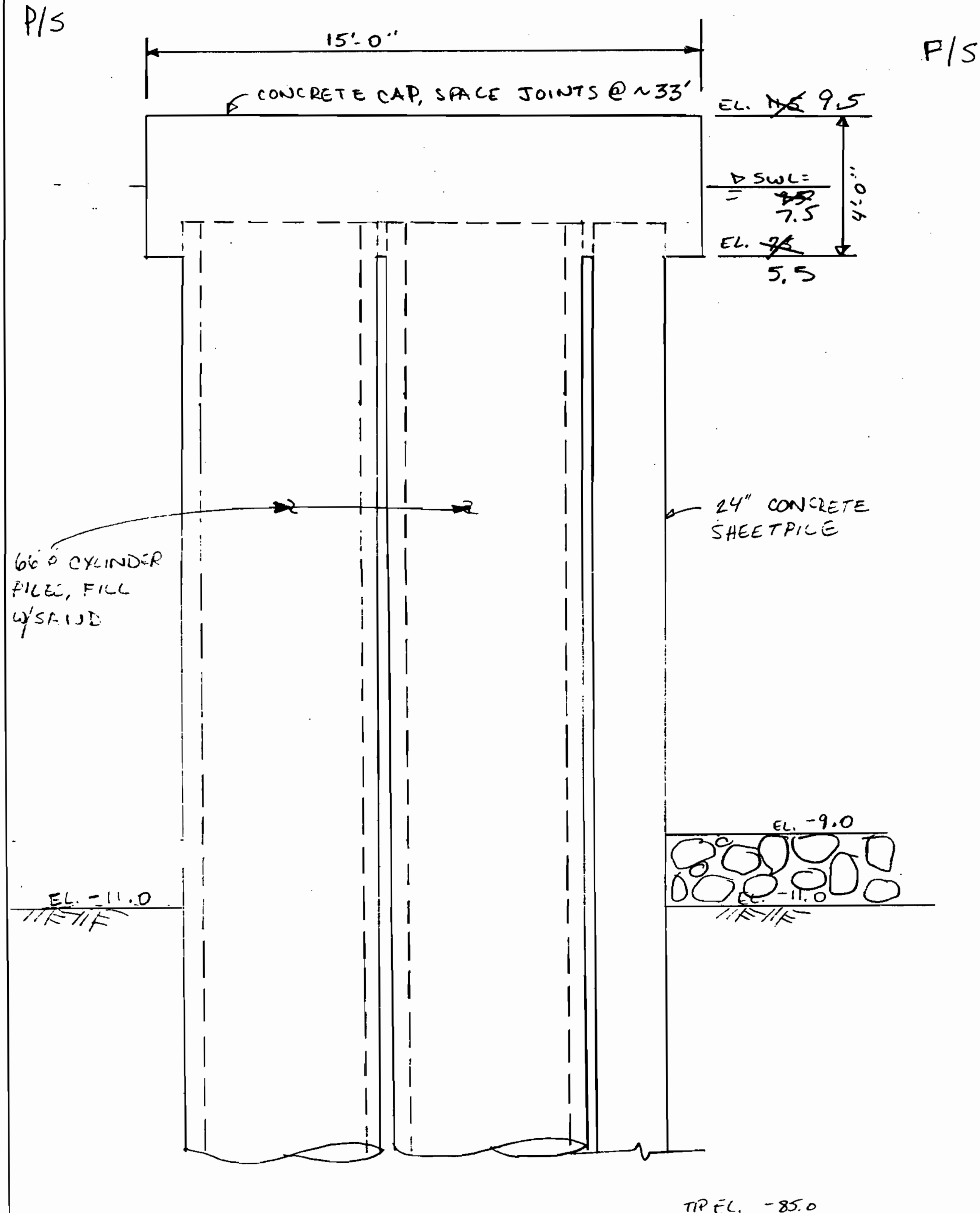
-need $\frac{1947}{49} \le \#\text{cables} \le \frac{2099}{49}$

$39.7 \le \#\text{cables} \le 42.84$

- use 41 cables

— use 84"Ø PILES

JN 3003 | COUSINS COMPLEX CLOSURE WALL | AAH | 3-24-98



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GEOTECHNICAL ENGINEERS
CONSTRUCTION QUALITY CONTROL AND MATERIALS TESTING
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From: Tom Stremlau

Fax Number: (504) 834-0354

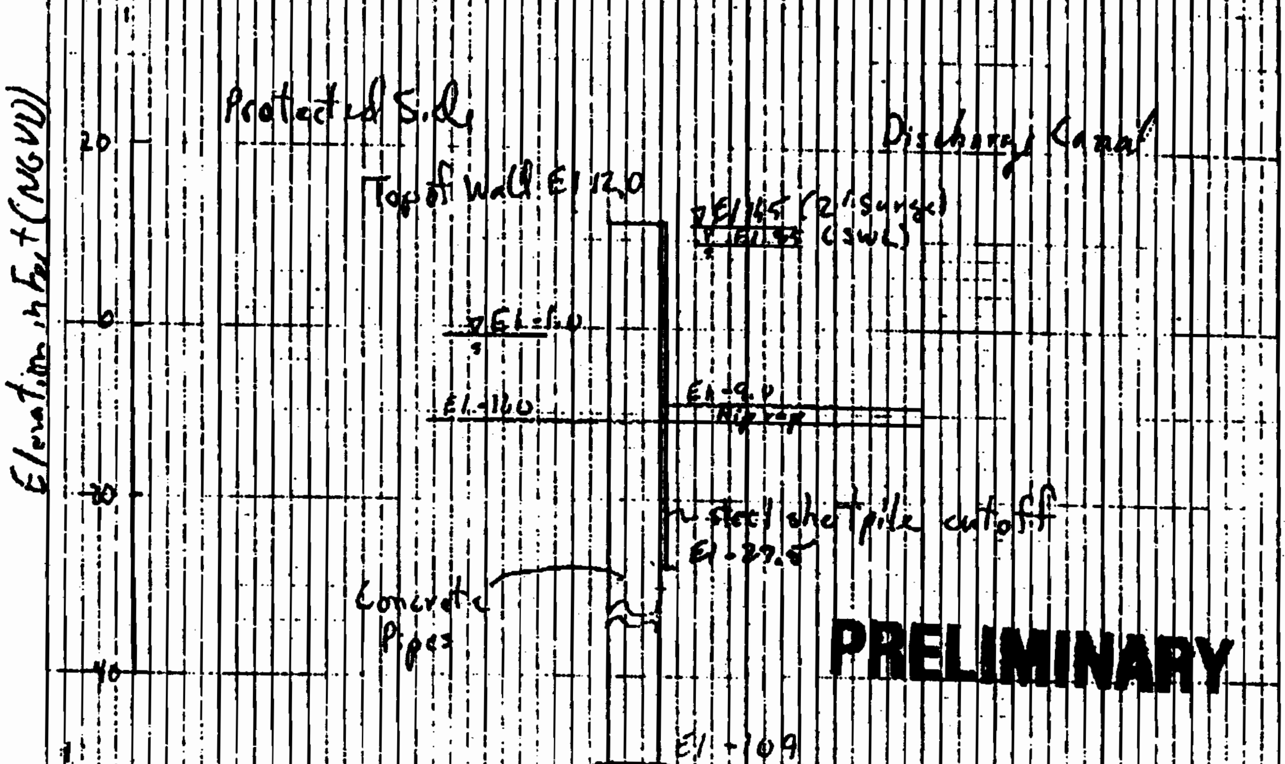
Total Number of Pages Transmitted (Excluding Cover Sheet): 2

Comments: Preliminary Reevaluation of Cantilevered Diversion Wall

AH

MEMO
TO: DESIGN ENGINEERING
ATTENTION: MS APRIL HURRY
FROM: TOM STREMLAU
EUSTIS ENGINEERING
SUBJECT: CANTILEVERED DIVERSION WALL
WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVE CANAL
HARVEY, LA.

I HAVE REEVALUATED THE DIVERION WALL ASSUMING NO ADHESION TO THE WALL WHICH IS THE BASIC CURRENT DIRECTION BY THE CORPS OF ENG. THE PRELIMINARY RESULTS ARE ENCLOSED. REQUIRED PENTRATION FOR THE CUTOFF SHEETPILES IS ALSO GIVEN ON THE ENCLUSURE.



PRELIMINARY

Flood Side Water Elevation	Protected side Water Elevation	Safety Factor	Maximum Moment ft. Kips	Wall Bottom Elevation	Scaled Deflection lb. in³ at El 12
9.5	-1.0	1.5	836	-109	5.44×10^{12}
11.5	-1.0	1.0	772	-85	3.7×10^{12}

Note: 1) Divide scaled deflection by modulus of elasticity in psi times concrete pipe wall moment of inertia to obtain deflection in inches.

2) Boring 3 soil parameters were used for these analyses except all the sand from elevation -61.5 to -86.5 was assumed to have an angle of internal friction of 30°.

3) The steel sheetpiles will provide seepage cutoff. They should extend to elevation -27.5 to provide a factor of safety of 4 against piping using the Harr Method.

4) Adhesion has been assumed to be zero.

Cantilevered Discharge Canal Wall
West Jefferson Levee District
Cousins Pumping Station to First Ave Canal
Harvey, La.

DIETZGEN CORPORATION
MADE IN U.S.A.

EE14149 TKS 1.0W SWL

TOTAL P.03

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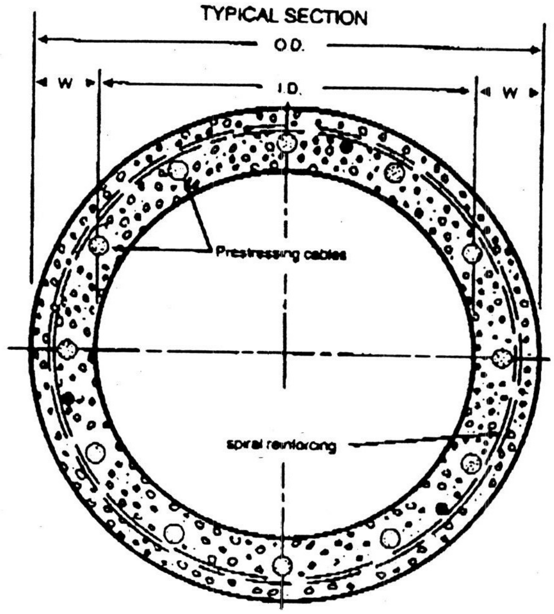
MEMBER pci

ENGINEERING DESIGN DATA

The structural design of a Raymond Cylinder Pile is governed by the external loads acting on the pile and the desired factor of safety.

Generally Cylinder Piles are used for marine structures or dry-land trestles. The piles therefore extend above ground — sometimes to considerable heights and are designed to resist a combination of axial loads and bending moments.

These engineering data provide the basic principles and procedures for a satisfactory structural design. It should be noted that the actual pile bearing capacity generally depends upon the subsoil conditions.



CYLINDER PILE DESIGN PROPERTIES

	SIZE			A_c	I	S		CIRCUM-FERENCE	POINT AREA	WEIGHT PER FOOT Ⓐ	STRESS ON CONCRETE DUE TO EFFECTIVE STRESS PER CABLE Ⓑ	
	O.D.	I.D.	W								Wire Ⓒ	½" Strand Ⓓ
	in.	in.	in.	$in.^2$	$in.^4$	$in.^3$	in.	ft	ft^2	lb	lb/in.²	lb/in.²
	36	27	4½	445	56,360	3,130	11.3	9.43	7.07	479	116.[illegible]	110.5
*	36	26	5	487	60,000	3,330	11.1	9.43	7.07	524	106.[illegible]	100.9
	42	32	5	581	101,300	4,820	13.2	11.00	9.61	625	89.0	84.6
	48	38	5	675	158,200	6,590	15.3	12.57	12.57	726	76.6	72.8
*	54	44	5	770	233,400	8,640	17.4	14.14	15.90	829	67.[illegible]	63.8
	54	42	6	905	264,600	9,800	17.1	14.14	15.90	973	57.[illegible]	54.3
	60	49	5½	942	353,200	11,770	19.4	15.71	19.63	1014	54.9	52.2
*	66	54	6	1131	514,000	15,580	21.3	17.28	23.76	1217	45.7	43.5
	72	60	6	1244	683,000	18,970	23.4	18.85	28.27	1339	41.5	39.5
	78	65	6½	1460	940,700	24,120	25.4	20.42	33.18	1572	35.4	33.7
	84	70	7	1693	1,265,300	30,130	27.3	21.99	38.48	1823	30.5	29.0
	90	76	7	1825	1,582,900	35,180	29.5	23.56	44.18	1964	28.3	26.9

*STANDARD SIZES

NOTES:

Ⓐ The tabulated weights, intended for design purposes, are based on a unit weight of concrete of 155 lbs/ft³ and the nominal wall thicknesses. For handling purposes, allowance should be made for manufacturing tolerance in extra wall thickness with corresponding increase in weight per foot.

Ⓑ Number of prestressing cables ranges from 8 to 16 for 36" piles, 12 to 24 for 54" piles, and 16 to 32 for 66" piles.

Ⓒ Each prestressing cable consists of twelve 0.192"-diameter stess-relieved wires with initial stress of 175,000 psi (60,801 lbs) and effective stress of 148,750 psi (51,681 lbs).

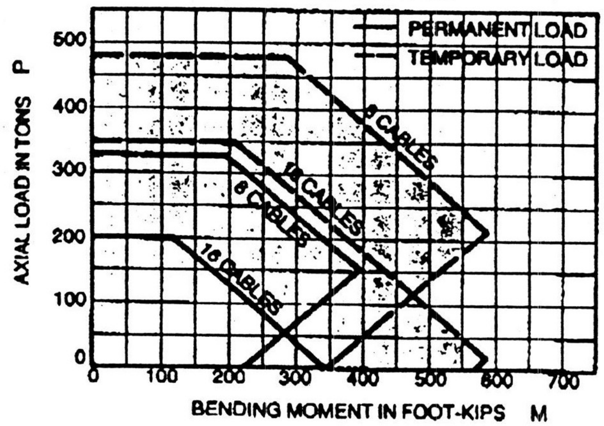
Ⓓ Each prestressing cable consists of two ½"-diameter 270 ksi 7-wire strands with initial tension of 57,820 lbs and effective tensionof 49,150 lbs.

INTERACTION DIAGRAMS FOR RAYMOND PRESTRESSED CONCRETE CYLINDER PILES STRESS DESIGN

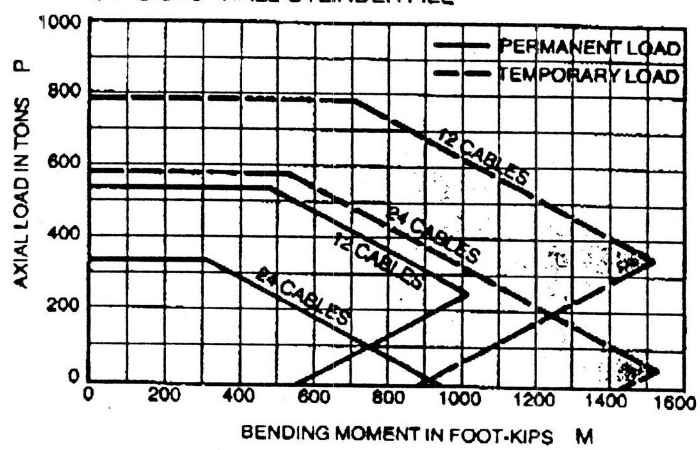
The interaction diagrams are based on the following design criteria:

1. For permanent loading:
   compression:
   $f_a + f_b + f_{pc} \leq 0.9^* \times 0.45 f'_c$
   tension:
   $f_a - f_b + f_{pc} \geq 0$
   *Reflects a 10% reduction for marine structures
2. For temporary loading:
   compression:
   $f_a + f_b + f_{pc} \leq 0.9^* \times 0.60\, f'_c$
   tension:
   $f_a - f_b + f_{pc} \leq 0.9^* \times 6\sqrt{f'_c}$
   *Reflects a 10% reduction for marine structures
3. Eccentricity factor of ten percent for axial load.
   $M_a = 0.10\, D \times P$
4. $f'_c = 7000$ psi
5. Prestressing cables = two ½" diameter 270^k 7-wire strands each. (Note diagrams slightly conservative but applicable for 12-wire cables).
6. Prestressing force = force resulting from effective tension of 49,150 lbs per cable.

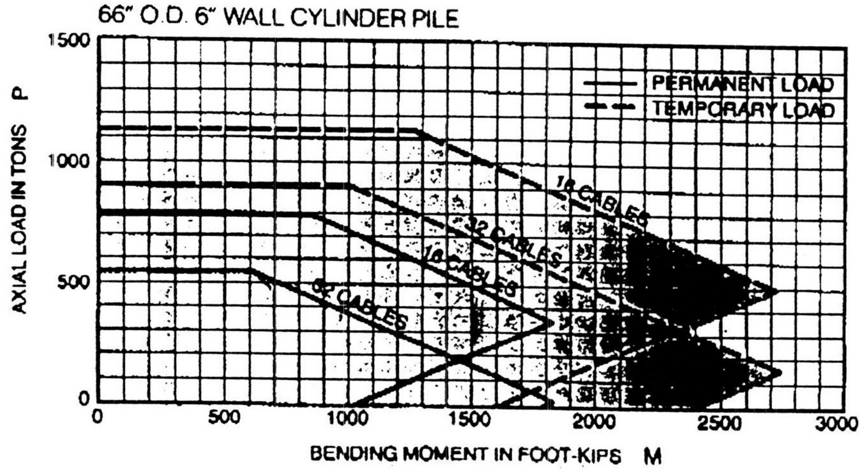
36" O.D. 5" WALL CYLINDER PILE



54" O.D. 5" WALL CYLINDER PILE



66" O.D. 6" WALL CYLINDER PILE



NOTE: Permanent load is load of relatively prolonged duration. Temporary load is permanent load plus loads of short or intermittent duration such as wind, wave, and ship impact.

GENERAL DESIGN NOTES

1. Most cylinder piles are designed for combined axial load and bending.

2. For routine loadings, the pile can generally be designed using stress design (see interaction diagrams page 25). However under extreme loading conditions such as those resulting from a 100-year probability storm (wind, wave and current) or seismic action, strength design analysis must be used to determine the adequacy of the structural strength under such forces. For checking ultimate bending capacities, the following table gives the ultimate bending strengths for various size cylinder piles. Interaction diagrams of ultimate axial load vs ultimate bending moment can be developed using any recognized method of analysis.

CALCULATED ULTIMATE BENDING STRENGTHS

PILE SIZE O.D. in	PILE SIZE WALL in	NUMBER OF CABLES (a)	ULTIMATE BENDING STRENGTH (b) ft k
36	5	16	1400
54	5	24	3400
66	6	32	5500

(a) Each cable consists of two ½" diameter 7-wire strands.
(b) For lesser number of cables adjust ultimate bending strength proportionally

3. The interaction diagrams (page 25) show that the combined axial and bending load capacity of the pile is generally reduced as the number of prestressing cables is increased.

4. If the strength design method requires a greater number of cables than that required by the stress design method for a given size pile, that size pile with the greater number of cables can be used by stressing each cable to less than the normal tension of 49,150 lbs. so that the total prestressing force is equal to that which would be produced by the lesser number of cables (required by the stress method) stressed to the normal tension. In this way the required minimum safety factor for ultimate loads can be achieved without exceeding the maximum allowable stress.

5. The allowable stress resulting from the external loads is:

$$F_a + F_b = 0.9^* \times 0.45\, f'_c - f_{pe}$$

*Reflects 10% reduction for marine structures

6. For slenderness ratios ℓ/r greater than 30 and up to 120, apply a reduction factor R to the allowable stress resulting from the external loads.

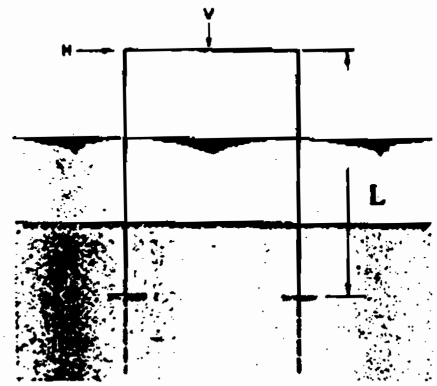
$$R = 1.24 - 0.008\, \ell/r$$

The effective pile length is related to the unsupported length (between points of fixity or hinges) depending upon head and end conditions.

For slenderness ratios exceeding 120, the pile should be investigated for elastic stability using a recognized method of analysis.

7. For cases where $\dfrac{f_b}{f_a + f_b} \le 0.1$ the reduction factor R is applied to F_a only:

$$F_a = R\,(0.9 \times 0.45\, f'_c - f_{pe} - f_b)$$



NOTATION

A_c = area of concrete (including prestressing steel)
D = outside diameter of pile
F_a = allowable stress due to axial external load
F_b = allowable stress due to bending moment
F_{pe} = total force resulting from effective prestress
$f_a = \dfrac{P}{A_c}$ = actual stress due to axial external load
$f_b = \dfrac{M}{S}$ = actual stress due to bending moment
$f_{pe} = \dfrac{F_{pe}}{A_c}$ = effective prestress
f'_c = specified 28-day compressive strength of concrete
I = moment of inertia
L = unsupported pile length
ℓ = effective pile length
M = total bending moment
M_e = bending moment due to eccentric axial load
P = axial external load
R = reduction factor
r = radius of gyration
S = section modulus

DESIGN EXAMPLE

Consider a trestle bent consisting of two vertical Cylinder Piles rigidly connected a pile cap (see sketch)

Given:

The vertical and horizontal forces acting on the bent produce the following axial load and bending moment on each pile:

P = 200 tons
M = 700 kip-feet

Solution:

An examination of the interaction diagrams (page 25) indicates that a 12-cable 54" O.D. × 5" wall pile would satisfy the combined loading requirements.

Pile properties: (page 24)

A_c = 770 in.²
S = 8640 in.³
r = 17.4 in.
f_{pe} = 12 × 63.8 = 766 psi
f'_c = 7000 psi

CASE I: Assume ℓ = 0.5L = 40 ft

$$\frac{\ell}{r} = \frac{40 \times 12}{17.4} = 27.6$$

No reduction required: $\ell/r \le 30$

Allowable compression stress due to external loading without reduction:

$$F_a + F_b = 0.9 \times .45\, f'_c - f_{pe} = 2835 - 766 = 2069 \text{ psi}$$

Actual compression stress due to external loading:

$$f_a + f_b = \frac{P}{A_c} + \frac{M}{S} = \frac{200 \times 2000}{770} + \frac{700 \times 12{,}000}{8640} = 519 + 972$$

= 1491 psi ≤ 2069 psi OK

Case II: Assume ℓ = 0.7L = 56 ft

$$\frac{\ell}{r} = \frac{56 \times 12}{17.4} = 38.6$$

Reduction required: $\dfrac{\ell}{r} > 30$

Reduction factor:

$$R = 1.24 - 0.008\, \ell/r = 1.24 - 0.008 \times 38.6 = 0.93$$

Allowable compression stress due to external loading with reduction:

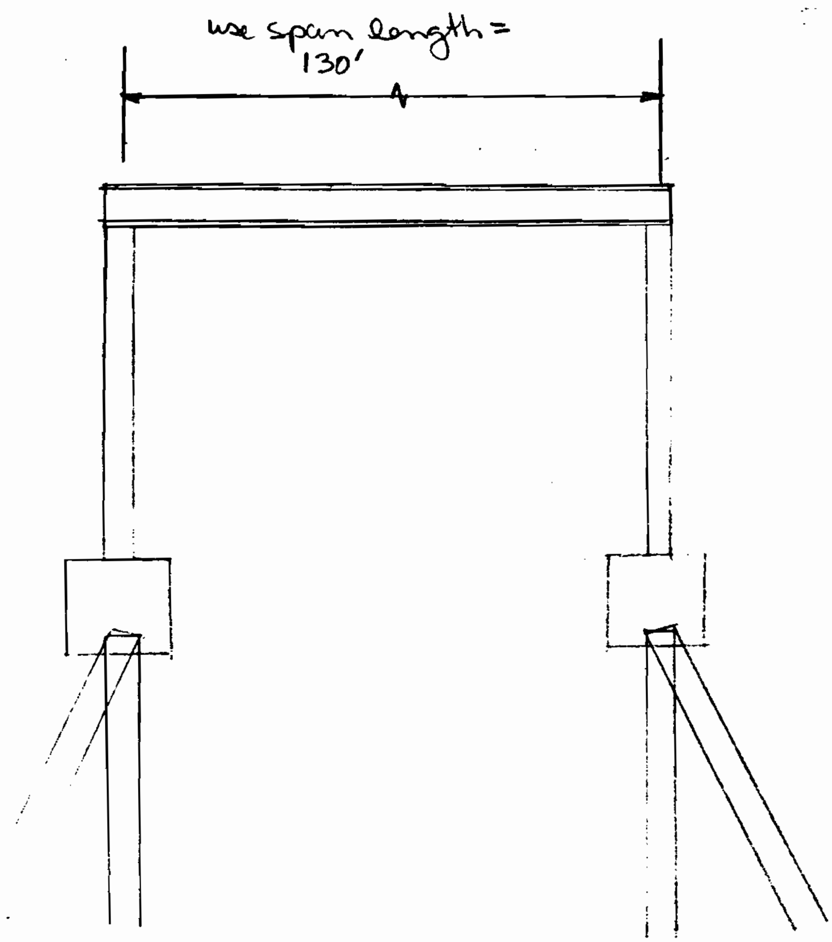
$$F_a + F_b = R\,(0.9 \times 0.45\, f'_c - f_{pe}) = 0.93\,(2835 - 766) = 1924 \text{ psi}$$

Actual compression stress due to external loading:

$f_a + f_b$ = 1491 psi ≤ 1924 psi OK

PIPELINE CROSSING:

- DO PRELIMINARY DESIGN FOR PIPELINE SUPPORT BEAM:



assume beam wt of 300#/ft

pipeline - 18"ϕ GAS LINE - use wt of 200#/FT

wt = 500#/FT

$M = \frac{1}{8}(.5)(130)^2 = 1056'^k$

$S_{reqd} = (1056)(12)/19.8 = 640 \text{ in}^3$ - try W33x201

- check w/ $w = 400\ \#/ft$

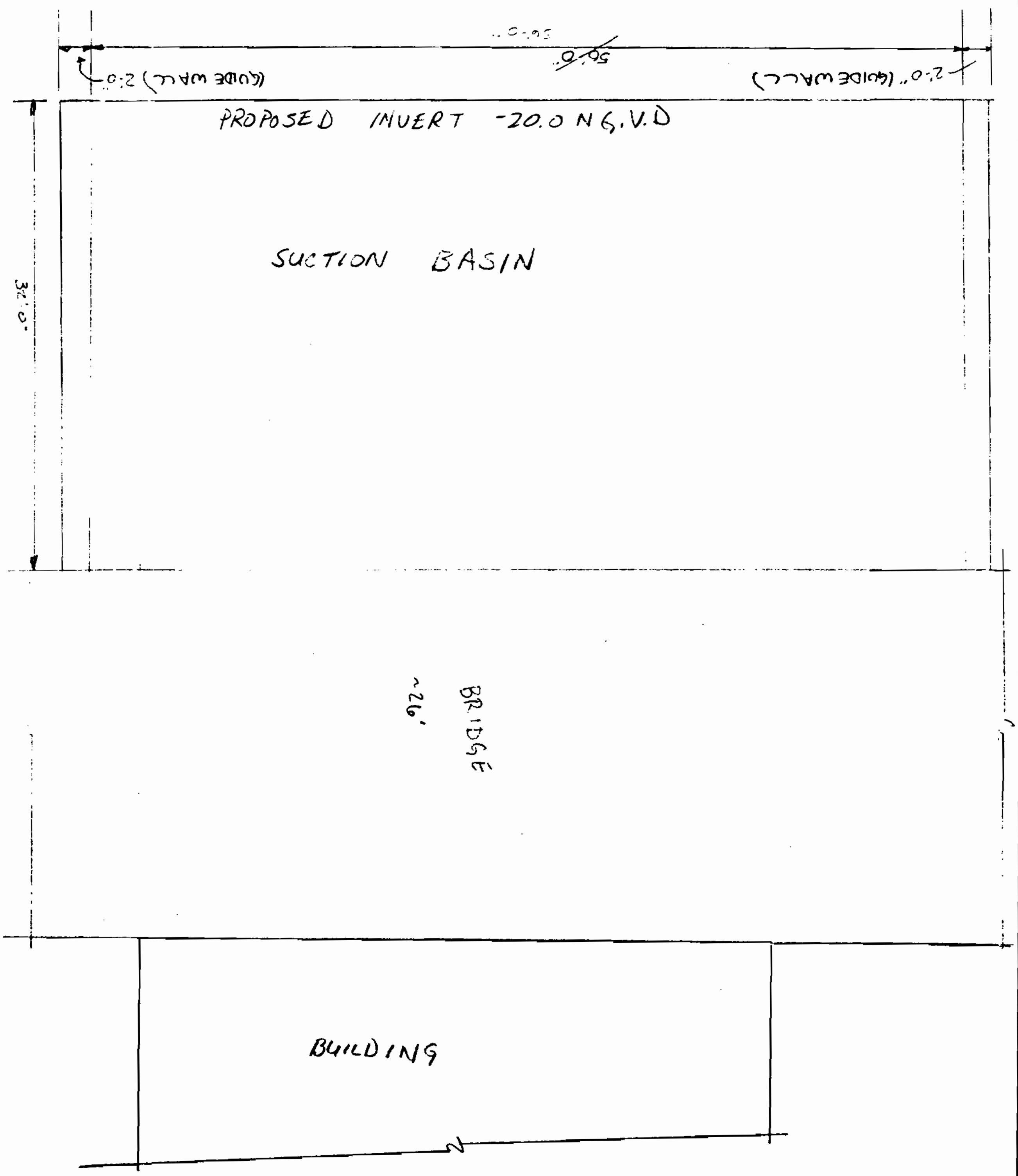
$M = (\frac{1}{8})(.4)(130)^2 = 845'k$

$S_{req'd} = 845(12)/19.8 = 512\ in^3$

- use W30x173

PUMP STATION CALCULATIONS

EXISTING FOUNDATION



JN 3003	SUCTION BASIN COUSINS PUMP STATION	AAH	6-10-97

SUCTION BASIN COMPRESSIVE LOADS:

PILE CAPACITY: (FROM EUSTIS PRELIM. REPORT)

MUDLINE ~~Pile Tip~~ @ -20.5 NGVD

60' TREATED ASTM D 25
QUALITY TIMBER PILE
7" TIP, 13" BUTT → 26 TONS in COMPRESSION
16 TONS IN TENSION

EL. WATER SURFACE = -6.7 NGVD
EL. INVERT = -20.0 NGVD

HEIGHT OF WATER = 13.3'

$wt(water) = (13.3')(.0624\ k/ft^3) = 0.83\ ksf$

$wt(slab) = (2')(.150\ k/ft^3) = 0.30\ ksf$ $\quad 3(.150) = .45$

$wt = 1.13\ ksf$ $\quad 1.28$

$AREA/PILE = \frac{26*2}{1.13} = 46.02\ sf/pile$ $\quad \frac{26*2}{1.28} =$ [illegible]

$\sqrt{46} = 6.78$ - use ~~6.2'~~ GRID $\quad \sqrt{40.625} =$ [illegible] ok

TENSION:

GROUND WATER @ 0.0 , BASIN DRY

$UPLIFT = (20')(.0624) = 1.25\ ksf \uparrow$

$SLAB = (2')(.15-.0624) = -0.18\ ksf \downarrow$

$1.07\ ksf$ tension

$AREA/PILE = \frac{16 \times 2}{1.07} = 29.9\ sf/pile$

$\sqrt{29.9} = 5.47'$ - use 5' GRID ← CONTROLS

- try 60' 12"Ø PPC PILES:

CAPACITY = 50 TONS C
30 TONS T

COMPRESSION: AREA/PILE = $\frac{50 \times 2}{1.13}$ = 88.50 sf

TENSION: AREA/PILE = $\frac{30 \times 2}{1.07}$ = 56.07 sf

$\sqrt{56.07}$ = 7.49' – 7' GRID

- try 60' - 14"Ø PPC PILES:

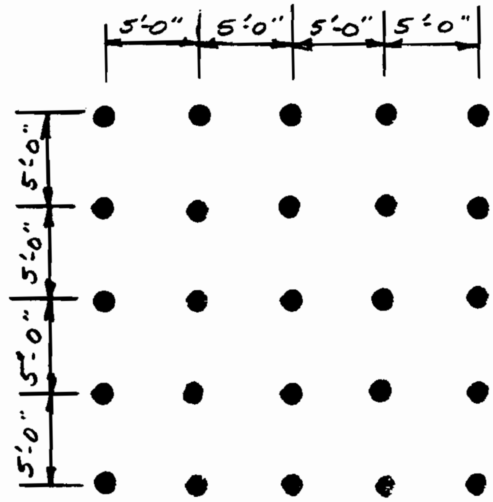
CAPACITY: 60 TONS C
35 TONS T

comp: AREA/PILE = $60 \times 2/1.13$ = 106.2 sf

TENS: AREA/PILE = $\frac{35 \times 2}{1.07}$ = 65.42 sf

$\sqrt{65.42}$ = 8.08 – 8' GRID

SLAB: (DESIGN SLAB FOR TIMBER PILES)



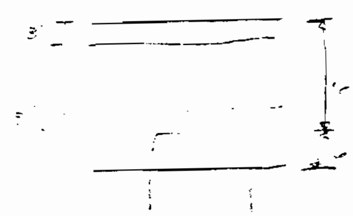
- USE FLAT SLAB.

$w_u = 1.13(1.2) = 1.36$ ksf

$M_o = \frac{w l_2 l_n^2}{8} = \frac{(1.38)(5)(5)^2}{8} = 21.56'^k$

Max NEG $M = 0.65 M_o = 0.65(21.56) = 14.01'^k$

- try 24" SLAB: $d = 21''$ (-M)
$d = 15''$ (+M)



$A_s(+M) = \frac{M}{f_y z}$, $z = 0.9d$

$= \frac{(21.56)(12)}{60(.9)(15)} = 0.32$ in^2

$\frac{(21.56)(12)}{48(.9)(15)} = 0.399$

$A_s(-M) = \frac{(14.01)(12)}{60(.9)(21)} = 0.15$ in^2

$\frac{(14.01)(12)}{48(.9)(21)} = 0.185$

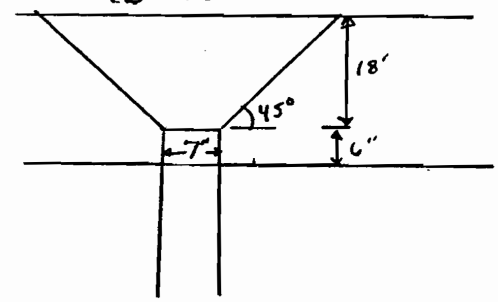
Bottom MAT: -

Top MAT: -

SHEAR:

$$v_u = \frac{V_u}{\phi b_o d}$$, ϕ : 0.85, d = 15'', b_o : 43''(π) = 135.1''

l_b = 2(18)+7 = 43''



V_u = (26 TONS)(2)(1.7) = 88.4^k

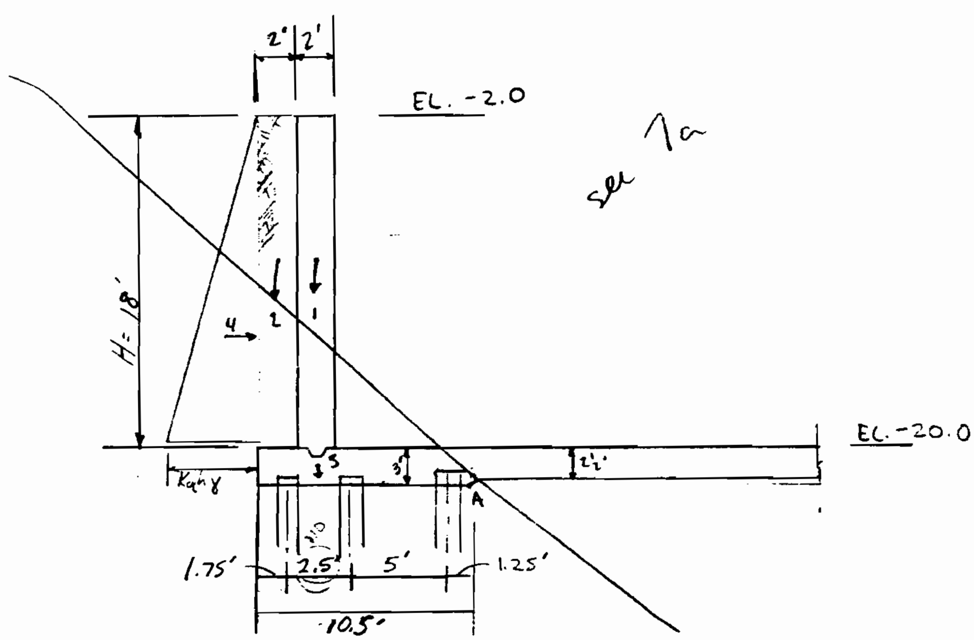
v_u = 88.4/.85(135.1)(15) : 0.051 ksi = 51 psi

v_c (allow) : $4\sqrt{f'_c}$ = $4\sqrt{3000}$: 219 psi ; $4\sqrt{4000}$ = 252 psi

∴ 24'' SLAB IS <u>OK</u>

– use 24'' + 6'' SLAB TO MATCH EXISTING

SUCTION BASIN GUIDE WALL:



see 1a

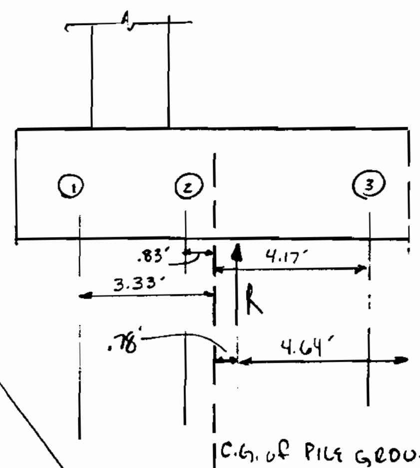
GUIDE WALL (CONT.)

(for 1' STRIP:)

#	LOAD (k)	MOMENT ARM	↺+ MOMENT
1	$(18')(2')(.15\,kcf) = 5.4^k$	7.5'	-40.5
2	$(18')(2')(.12\,kcf) = 4.32^k$	9.5'	-41.04
3	$(8.75')(3')(.15\,kcf) = 3.94^k$	5.25'	-20.68
4	$(\frac{1}{2})(K_a \gamma H)(H) = \frac{1}{2}(.333)(.12)(18)^2 = 6.47^k$	6'	38.82
			63.40

$M = \Sigma V * e \qquad \Sigma V = 13.66^k$

$e = 63.40/13.66 = 4.64$ Left of "A" (w/in center ⅓ ∴ ok)



See 7a

C.G. of PILE GROUP: $\frac{(1.25)+(6.25)+(8.75)}{3} = 5.42'$ from "A"

$e = 5.42 - 4.64 = 0.78'$

for 5' STRIP: $\Sigma V = 13.66 * 5 = 68.3^k$

$M_{(PILE\ GROUP)} = \Sigma V * e$
$= 13.66(5')(.78')$
$= 53.27'^k$

Σd^2 & SECTION MODULUS:

Σd^2: $(1)(3.33)^2 + (1)(.83)^2 + (1)(4.17)^2 = 29.17\ FT^2 \cdot PILE$

SECTION MODULUS:

① $29.17/3.33 = 8.76$ FT PILE

② $29.17/.83 = 35.14$ FT. PILE

③ $29.17/4.17 = 7.00$ FT. PILE

see 7a

PILE REACTIONS:

① $\frac{68.3}{3} - \frac{53.27}{8.76} = 16.7^k\ (c) < 26^T$ ok

② $\frac{68.3}{3} - \frac{53.27}{35.14} = 21.25^k\ (c) < 26^T$ ok

③ $\frac{68.3}{3} + \frac{53.27}{7.00} = 30.38^k\ (c) < 26^T$ ok

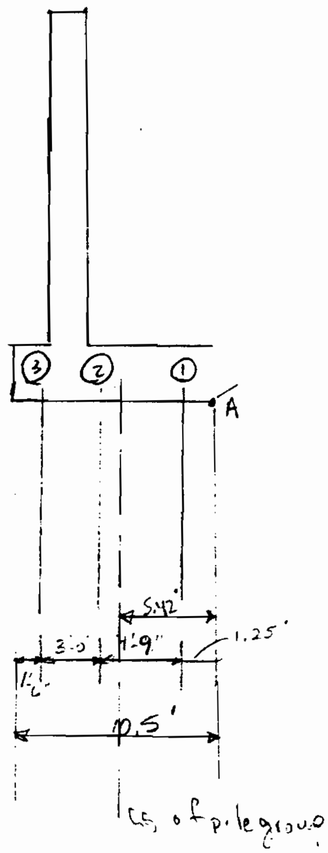
M@ BASE OF WALL:

$P_u = 6.467^k(1.7) = 10.99^k$

$M_u = 10.99(6') = 65.94'^k$

$A_s = \frac{65.94(12)}{60(21'')} = 0.628\ in^2/ft$ — use #6@6" · .88 in^2/ft

SUCTION BASIN GUIDE WALL:



$\Sigma M = 63.40'^{k}$
$\Sigma V = 13.66^{k}$

$e = 63.40/13.66 = 4.64$ left of "A"

within center $\frac{1}{3}$ - ok

(from calcs. dated 6-11-97 p. 6)

C.G. of Pile group: $\frac{(1.25)+(6)+(9.0)}{3} = 5.42'$ from "A"

$e = 5.42 - 4.64 = 0.78$

for 5' strip: $\Sigma V = 13.66 \times 5 = 68.3^{k}$

$M_{pilegroup} = \Sigma V \cdot e$
$= 68.3(.78)$
$= 53.27'^{k}$

$\Sigma d^2 = (4.17)^2 + (.58)^2 + (3.58)^2 = 30.54$ FT²·PILE

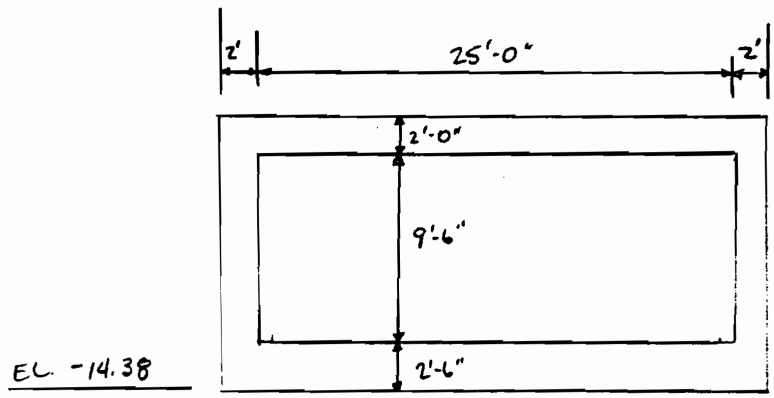
Section Modulus:

$S_1 = 30.54/4.17 = 7.32$ FT PILE
$S_2 = 30.54/.58 = 52.66$
$S_3 = 30.54/3.58 = 8.53$

Pile Reactions:
① $\frac{68.3}{3} + \frac{53.27}{7.32} = 30.0^{K}$ (c) < $26^{T} = 52^{K}$ OK
② $68.3/3 - 53.27/52.66 = 21.8^{K}$ (c) OK
③ $68.3/3 - 53.27/8.53 = 16.5^{K}$ (c) OK

DISCHARGE TUBE:

SECTION 1



section @ end of discharge tube (maximum size)

$wt_{(conc.)} = [(2.5')(29') + (2')(29') + (2')(9.5')(2)](.150\ ^k/cf) = 25.3\ ^k/FT$

$wt(water) = (9.5')(25')(.0624\ ^k/cf) = 14.82\ ^k/FT$

$total = 25.3 + 14.82 = 40.1\ ^k/FT = \frac{40.1}{29} = 1.38\ ^k/SF$

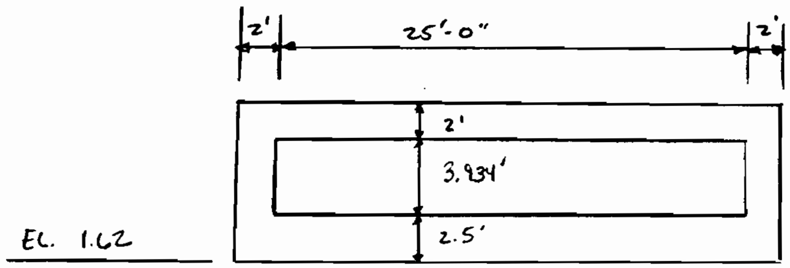
- 60' ASTM D25 TIMBER PILE
  CAPACITY - C - 20 TONS
  T - 13 TONS (MUDLINE ~~[illegible]~~ -13)

$AREA/PILE = \frac{20(2)}{1.38} = 28.98\ sf/PILE$

$\sqrt{28.98} = 5.38$ - use 5' GRID

DISCHARGE TUBE (CONT.)

SECTION 2 :



section @ high point (minimum size)

$wt_{(conc)} = [(2.5)(29) + (2.0)(29) + (4.0)(2)(2)](.150 \text{ k/cf}) = 22.0 \text{ k/ft}$

$wt_{(water)} = (4')(25')(.0624) = 6.24 \text{ k/ft}$

$total = 22.0 + 6.24 = 28.24 \text{ k/ft} = 28.24/29 = 0.97 \text{ ksf}$

-60' ASTM D 25 TIMBER PILES
CAPACITY - C - 14 TONS
T - 9 TONS

$AREA/PILE = 14(2)/.97 = 27.16$

- use 5' GRID

PUMP STATION FOUNDATION SLAB:

$wt_{(conc)} = [2530^k + 1020^k + 500^k] / 51.5(53.33) = 1.47 ksf$

$wt_{(water)} = (8')(21')(.0624) / 51.5' = 0.20 ksf$

$wt_{(shell)} = 0.30 ksf$

$wt_{(equip)} = 150^k / 51.5(53.33) = 0.06 ksf$

$wt_{(live load)} = 1.00 ksf$

3.03 ksf

- ASTM D25 Timber Pile

MUDLINE ~~TIP EL~~ : -26.5

	C	T
50'	20 TONS	12 TONS
57'	26 TONS	16 TONS

50': AREA/PILE : $\frac{20 \times 2}{3.03}$ = 13.20 sf/pile $\sqrt{13.20}$ = 3.63
- $3\frac{1}{2}$ ' GRID

57': AREA/PILE : $\frac{26 \times 2}{3.03}$ = 17.16 sf/pile $\sqrt{17.16}$ 4.14
- 4' GRID

DRAWINGS REQ'D: (FROM DEI)

SECTION THROUGH SUCTION BASIN

PUMPING STATION PROFILE (THROUGH & DISCHARGE TUBE)

GENERAL FLOOR PLAN (BLDG)

SECTION (SHOWING METAL BLDG.) (N/S)

SECTION (SHOWING METAL BLDG.) (E/W)

PLAN (DISCHARGE)

SECTION - DISCHARGE BASIN

PILE LAYOUT

FLOODWALL

FRONTAL PROTECTION CALCULATIONS

EXISTING PUMP STATION

EXISTING SOUTH PUMP STATION (HORIZONTAL PUMPS)
EVALUATION FOR SWL = 9.5 NGVD

(1) FOR FAILURE SURFACE (A)(2), REQ'D PRESSURE = 552 psf.
FAILURE SURFACE @ EL -23 N.G.V.D.

BASE SLAB THICKNESS = 2'-0"

$wt = (150 - 90) = 60$ psf
$\times 2$ / 120 psf

walls: 2 walls @ 15" × 7.35'
4 walls @ 2' × 7'

Rear Wall of Pump Pit: $\frac{(5.15')(2')(150)}{16'}$

$wt = [(2)(1.25)(7.35) + 4(2)(7)](150)/96.25$
$= 116$ psf

$= 96.6$ psf

total wt $= 120 + 116 + 96.6 = 332.6$ psf

PRESSURE TO BE TAKEN BY TENSION PILES = 552 - 332.6
= 219.4 psf

PASSIVE WEDGE AREA = (96.25')(16')
= 1540 sf

TOTAL LOAD TO BE TAKEN BY TENSION PILES = $\frac{(1540)(219.4)}{1000}$
= 337.9 K

PILES = 24

REQ'D LOAD PER PILE = 337.9/24 = 14.1^{K}/PILE
= 7 T/PILE

NOTE: NO TENSION CONNECTORS ON PILES,
∴ NEED T-WALL

(2) FOR FAILURE SURFACE (C) (4), REQ'D PRESSURE = 853 psf
FAILURE SURFACE @ -45 N.G.V.D.

BASE SLAB THICKNESS = 2'

wt = (150 - 107) = 43 psf

43 x 2 = 86 psf

FLOOR SLAB = 2'

wt = (2)(150) = 300 psf

WALLS: 2@ 2' x 27'
1@ 2'-6" x 27'

wt = [(2)(2)(27) + (2.5)(27)](150) / 96.25

= 273.5 psf

total wt = 86 + 300 + 273.5
= 659.5 psf

REQ'D PRESSURE TO BE TAKEN BY TENSION IN
PILES = 853 - 659.5
= 193.5 psf

PASSIVE WEDGE AREA = 20' (96.25')
= 1925 sf

TOTAL LOAD TO BE TAKEN BY TENSION PILES = $\frac{(193.5\,psf)(1925\,sf)}{1000}$

= 372.5^K

PILES = 113

LOAD / PILE = $372.5/113$ = 3.29^K/PILE

NO TENSION CONNECTORS ON PILES,
∴ NEED T-WALL

EXISTING SOUTH PUMP STATION (HORIZONTAL PUMPS)
EVALUATION FOR SWL = 7.5 NGVD.

FOR FAILURE SURFACE A2, REQ'D PRESSURE = 327 psf.

FROM p.1, AVAILABLE PRESSURE = 332.6 psf <u>OK</u>

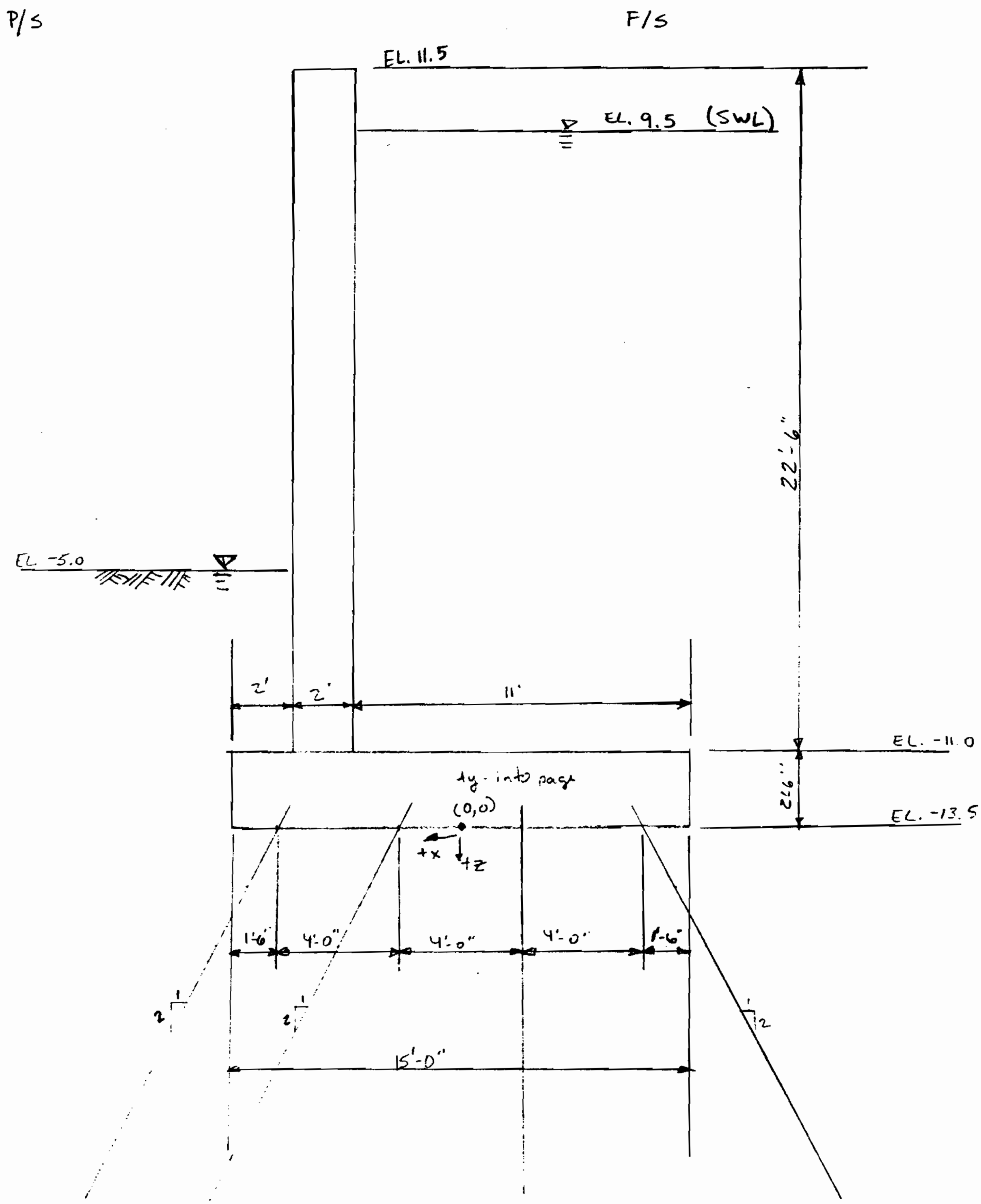
FOR FAILURE SURFACE C4, REQ'D PRESSURE = 555 psf

FROM p.2, AVAILABLE PRESSURE = 659.5 psf <u>OK</u>

∴ PUMP STATION IS STABLE FOR SWL = 7.5 N.G.V.D.

T-WALL IN FRONT OF EXISTING VERTICAL PUMP STATION

* REVISION DUE TO CHANGE IN SWL TO 9.5 N.G.V.D.



T-WALL LOADING CASES:

Case I: Static water pressure to SWL, no wind, impervious sheet pile cut-off (100% forces)

Case II: Static water pressure to SWL, no wind, pervious sheet pile cut off (100% forces)

Case III: Static water pressure to SWL+2', no wind, impervious sheet pile (75% forces)

Case IV: Static water pressure to SWL+2', no wind, pervious sheet pile (75% forces)

Case V: water at low water level, no wind, (100% forces)

Case VI. Water at low water level, wind from flood side (75%)

DEAD LOADS: (per linear foot)

stem: (22.5)(2)(.150 k/CF) = 6.75 k/LF

base: (15)(2.5)(.150) = 5.63

WATER OVER BASE:

@SWL: (11')(20.5')(.064) = 14.43

@SWL+2': (11')(22.5)(.064) = 15.84

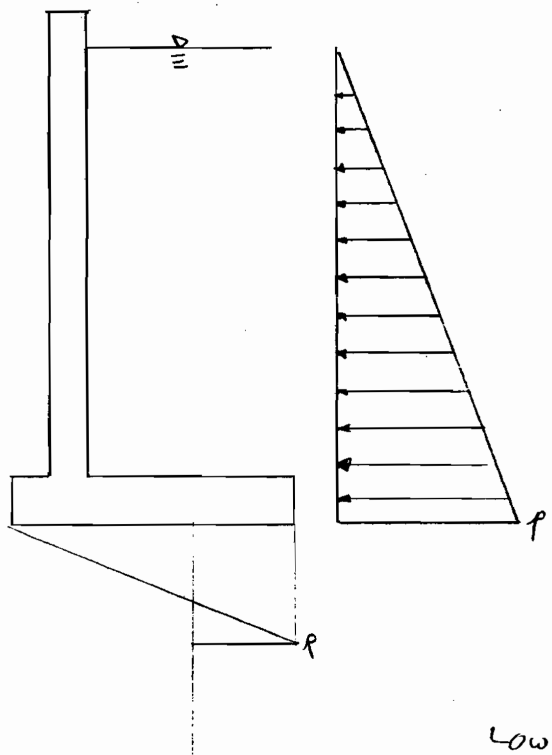
@Low Water: (11')(11')(.064) = 7.74

SOIL ON P/S:

(6')(2')(.120) = 1.44 k/LF

WATER LOADS:

SWL = 9.5



@ SWL:

$p = (23)(.064)$
$= 1.47\ ^{K}/_{FT \cdot FT}$

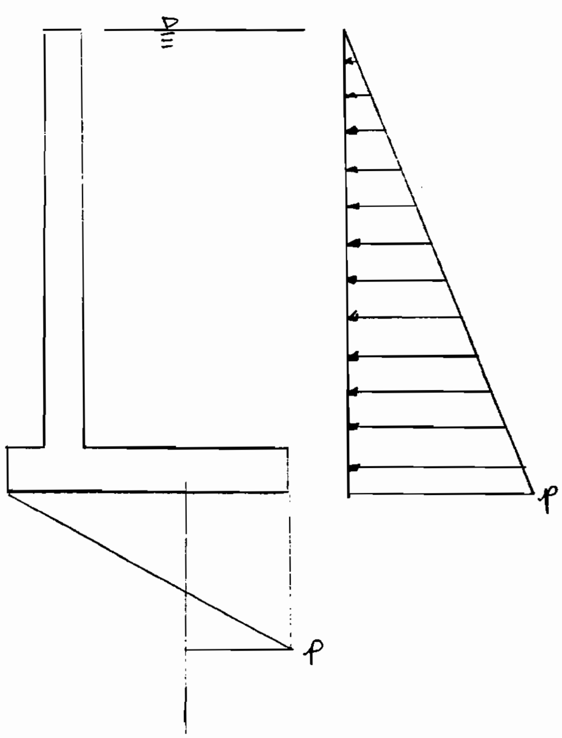
@ SWL + 2':

$p = (25)(.064)$
$= 1.60\ ^{K}/_{FT \cdot FT}$

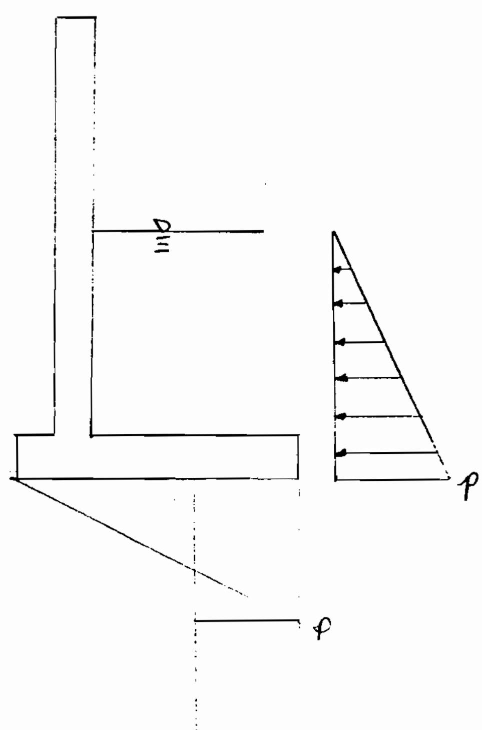
@ low Water

$p = (13.5)(.064)$
$= 0.864\ ^{K}/_{FT \cdot FT}$

SWL + 2'



LOW WATER:



WIND LOADS: ON PROTECTED SIDE:

$(50\,psf)(11.5) = 575\ plf$

ANCHOR FORCE:

7.1^{K}/FT of wall @ $-13.0'$

(ANCHOR FORCE IS $-x$,
LOAD IS $+x$

$7.1 \times 80 = 568^{K}\ +x$ ← ADD TO ALL LOAD GROUPS

Lever arm: $-0.5'$

$M = 7.1(.5) = 3.55 \times 80' = 284$ ↶ $-M_y$ ←

FLOODWALL FORCE TABULATION

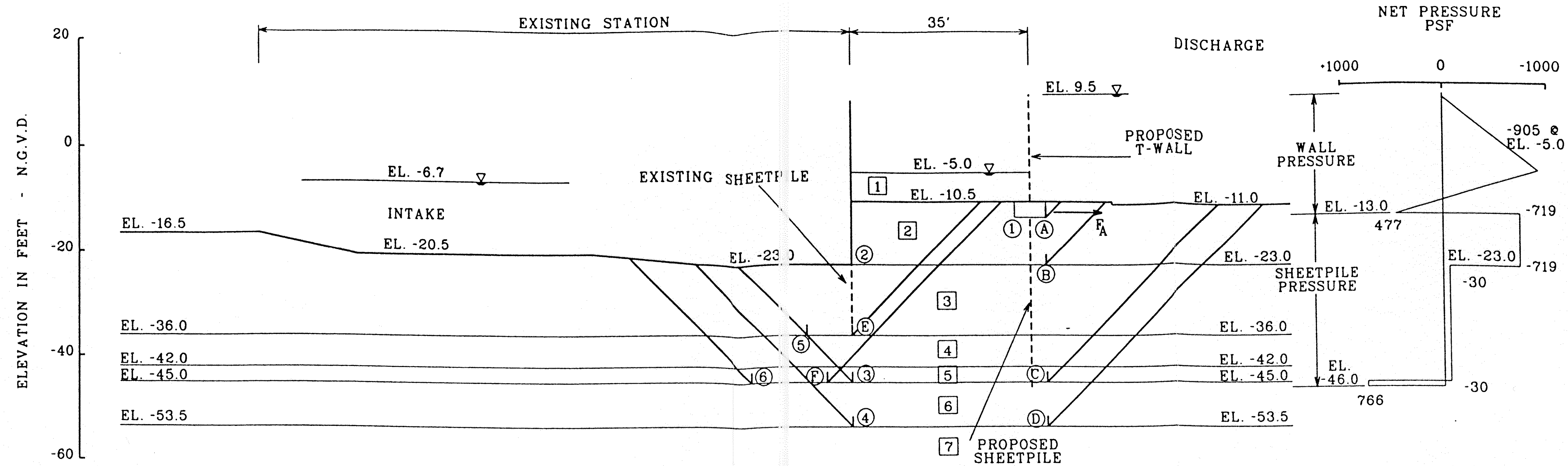
NO.	DESCRIPTION	FORCES (KIPS) F_x	F_y	F_z	LEVER ARM (FT) x	y	z	MOMENTS (FT.K) M_{x-x}	M_{y-y}	M_{z-z}
I	DEAD LOADS									
	(a) STEM			6.75	+4.5				-30.38	
	(b) BASE			5.63	0				0	
	(c) SWL			14.43	-2.0				+28.86	
	(d) SWL+2'			15.84	-2.0				+31.68	
	(e) LOW WATER			7.74	-2.0				+15.48	
	(f) SOIL ON P/S			1.44	+6.5				-9.36	
II	WATER LOADS									
	(a) SWL									
	(½)(1.47)(23)	16.91					-7.67		-129.70	
	buoyancy									
	imp (1.47)(5.5)			-8.09	-4.75				-38.43	
	per (½)(1.47)(15)			-11.03	-2.5				-27.58	
	(b) SWL+2'									
	(½)(1.60)(25)	20.0					-8.33		-166.60	
	buoyancy									
	imp (1.60)(5.5)			-8.80	-4.75				-41.80	
	per (½)(1.60)(15)			-12.00	-2.5				-30.00	
	(c) LOW WATER									
	½(.864)(13.5)	5.83					-4.5		-26.24	
	buoyancy									
	imp (.864)(5.5)			-4.75	-4.75				-22.56	
	per ½(.864)(15)			-6.48	-2.5				-16.20	
III	WIND									
	FROM P/S	0.58					-19.25		-11.17	

JN 3003 | COUSINS PUMP STATION FLOODWALL | AAH | 1-16-98 | 7

LOAD COMBINATIONS

LOADING CASE	DESCRIPTION		FORCES F_x	FORCES F_z	MOMENTS M_{y-y}
I	DL, SWL, IMP. S/P	DL		28.25	-10.88
	100% FORCES	SWL	16.91		-129.70
		IMP		-8.09	-38.43
		TOTAL	16.91	20.16	-179.01
		FOR 80'	1352.80	1612.80	-14,320.8
		+ ANCHOR FORCE	1920.8		-14,036.8
II	DL, SWL, PER. S/P	DL		28.25	-10.88
	100% FORCES	SWL	16.91		-129.70
		PER		-11.03	-27.58
		TOTAL	16.91	17.22	-168.16
		FOR 80'	1352.8	1377.6	-13,452.8
		+ ANCHOR FORCE	1920.8		-13,736.8
III	DL, SWL+2', IMP. S/P	DL		29.66	-8.06
	75% FORCES	SWL+2'	20.0		-166.60
		IMP		-8.80	-41.80
		TOTAL	20.0	20.86	-216.46
		75%	15.0	15.64	-162.34
		FOR 80'	1200.0	1251.6	-12987.6
		+ 75% ANCHOR FORCE	1626.0		-13,200.6
IV	DL, SWL+2', PER. S/P	DL		29.66	-8.06
	75% FORCES	SWL+2'	20.00		-166.60
		PER		-12.00	-30.00
		TOTAL	20.0	17.66	-204.66
		75% TOTAL	15.0	13.24	-153.49
		FOR 80'	1200.0	1059.6	-12,279.6
		+ 75% ANCHOR FORCE	1626.0		-12,492.6
V A	DL, LOW WATER,	DL		21.56	-24.26
	IMP S/P	LOW WATER	5.83		-26.24
	100% FORCES	IMP		-4.75	-22.56
		TOTAL	5.83	16.81	-73.06
		FOR 80'	466.4	1344.8	-5844.8
		+ ANCHOR FORCE	1034.4		-5560.8
V B	DL, LOW WATER,	DL		21.56	-24.26
	PER S/P	LOW WATER	5.83		-26.24
	100% FORCES	PER		-6.48	-16.20
		TOTAL	5.83	15.08	-66.7
		FOR 80'	466.4	1206.4	-5336.0
		+ ANCHOR FORCE	1034.4		-5620
VI	DL, LOW WATER,	DL		21.56	-24.26
	IMP S/P, WIND	LOW WATER	5.83		-26.24
	75% FORCES	IMP		-4.75	-22.56
		WIND	0.58		-11.17
		TOTAL	6.41	16.81	-84.23
		75%	4.81	12.61	-63.17
		FOR 80'	384.6	1008.6	-5053.8

+75% ANCHOR FORCE
F_x: 810.0
M_y: -5266.8



STRATA NO.	SOIL TYPE	UNIT WEIGHT PCF	UNFACTORED			SAFETY FACTOR OF 1.3		
			FRICTION ANGLE DEGREES	COHESION - PSF		FRICTION ANGLE DEGREES	COHESION - PSF	
				AVERAGE	BOTTOM		AVERAGE	BOTTOM
1	SAND	120	30	0	0	24	0	0
2	CLAY	94	0	220	220	0	169	169
3	CLAY CLAYEY SILT	107	0	310	400	0	238	308
4	CLAY	102	0	400	400	0	308	308
5	CLAY	97.5	0	400	400	0	308	308
6	CLAY	97.5	0	485	570	0	373	438
7	CLAY	97.5	0	655	740	0	504	569

T - WALL ANALYSIS					
SUMMATION OF FORCES (USING FACTORED SHEAR STRENGTHS)					
FAILURE SURFACE	ΣR RESISTANCE LBS/FT	ΣD DRIVING LBS/FT	ΣR - ΣD	CHANGE IN NET FORCE	EQUIVALENT PRESSURE PSF
A 1	3734	10455	-6721	-	-
B 2	10586	24499	-13913	-7192	-719
C 3	39230	53798	-14568	-655	-30
D 4	57127	65184	-8057	6511	766

STABILITY OF PUMP STATION			
FAILURE SURFACE	SUMMATION OF FORCES		FACTOR OF * SAFETY
	RESISTING	DRIVING	
E 5	25801	19615	1.32
F 6	43575	22636	1.93

* USING UNFACTORED SOIL PARAMETERS

NOTE :
1) TO SATISFY MOMENT EQUILIBRIUM, SUMMING MOMENTS ABOUT BASE OF FOOTING AT EL. -13.0, REQUIRES SHEET PENETRATION TO EL. -46.0.
2) MAXIMUM MOMENT OCCURS AT EL. -23.0 AND IS 34.9 FT. KIPS/FT OF WALL.
3) CALCULATED ANCHOR FORCE, F_A, IS 7.1 KIPS/FT OF WALL AT EL. -13.0.
4) THE ANCHOR LOAD AND INDICATED T-WALL PRESSURE MUST BE SUPPORTED BY DRIVEN BATTER PILES. AXIAL CAPACITY OF THESE BATTER PILES MUST IGNORE CAPACITY CONTRIBUTION ABOVE EL. -46.0
5) USING THE HARR METHOD OF SEEPAGE ANALYSIS, FACTOR OF SAFETY AGAINST PIPING FAILURE IS 4.5 OR MORE IF THE T-WALL CUTOFF SHEETPILE IS DRIVEN TO EL-. -46.0.
6) SOIL PARAMETERS ARE TAKEN FROM FIGURE 6 OF EUSTIS ENGINEERING REPORT DATED 7 OCTOBER 1997 FOR SUBJECT PROJECT.

20' 0 20'
SCALE

SLOPE STABILITY ANALYSIS AND PROPOSED T-WALL ANALYSES EXISTING NORTH PUMP STATION

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

EUSTIS ENGINEERING COMPANY, INC.

REVISED FIGURE 20

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

PRELIMINARY

MODULUS OF HORIZONTAL SUBGRADE REACTION
COUSINS PUMP STATION TO DESTREHAN AVENUE BRIDGE

ELEVATION IN FEET	K_h x B
0 to -6	114
-6 to -10	103
-10 to -23	97
-23 to -36	136
-36 to -45	176
-45 to -62	251
-62 to -69	11,790
-69 to -75	418
-75 to -86	24,150

Where: K_h = Modulus of horizontal subgrade reaction (lbs/in.^{3})

B = Diameter of pile (inches)

C = Reduction factor for cyclic loading

C = 0.5 for cyclic loading
C = 1.0 for initial loading

D = Reduction factor for effect of group action

D	PILE SPACING IN DIRECTION OF LOADING
1.0	8B
0.85	7B
0.7	6B
0.55	5B
0.40	4B
0.25	3B

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

ALLOWABLE PILE LOAD CAPACITIES
NEW T-WALL FOUNDATION AT EXISTING NORTH PUMP STATION

PILE DESCRIPTION	PILE TIP EMBEDMENT BELOW FOOTING TOP AT EL -11 IN FEET	ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITY IN TONS FACTOR OF SAFETY = 2	
		COMPRESSION	TENSION
12-In. Square Precast, Prestressed Concrete Pile	65.5 72.5	36* 50*	18 27
14-In. Square Precast, Prestressed Concrete Pile	65.5 72.5	44* 61*	21 31
16-In. Square Precast, Prestressed Concrete Pile	65.5 72.5	53* 73*	24 36

* Pile tips assumed to be bearing in sand

Note:

1. Capacity contribution above el -46 has been ignored.
2. Used soil parameters on Figure 6 of Eustis Engineering's report dated 7 October 1997 for the subject project.

AXIAL AND HORIZONTAL RESISTANCE OF BATTER PILES

ESTIMATED FROM ALLOWABLE VERTICAL LOAD CAPACITY

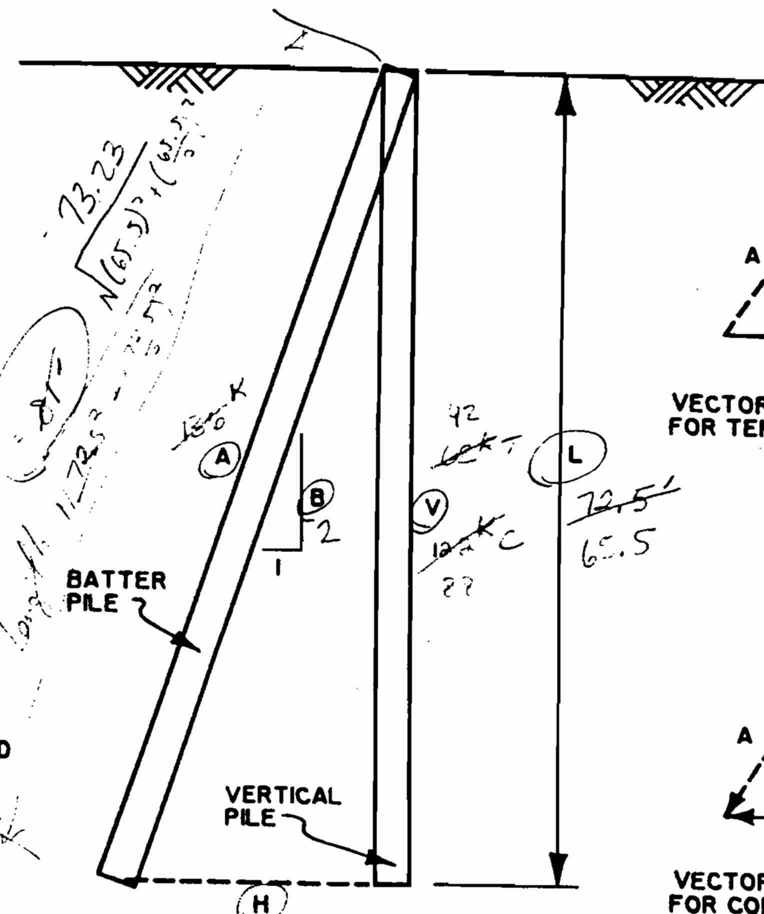
L = VERTICAL COMPONENT OF BATTER PILE EMBEDMENT LENGTH.

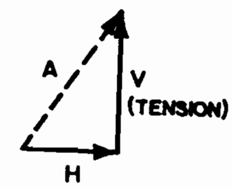
V = ESTIMATED ALLOWABLE SINGLE PILE LOAD CAPACITY OF A PILE DRIVEN VERTICALLY WITH EMBEDMENT LENGTH, L.

B = BATTER OF PILE EXPRESSED AS A RATIO OF VERTICAL DISTANCE TO ONE FOOT HORIZONTAL DISTANCE.

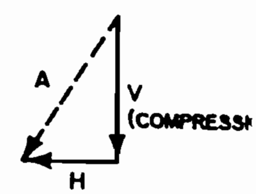
H = HORIZONTAL RESISTANCE OF BATTER PILE ESTIMATED AS FOLLOWS:

$$H = \frac{V}{B}$$





VECTOR DIAGRAM FOR TENSION PILE



VECTOR DIAGRAM FOR COMPRESSION PILE

A = ALLOWABLE AXIAL PILE LOAD CAPACITY OF A SINGLE BATTER PILE ESTIMATED AS FOLLOWS:

$$A = \sqrt{V^2 \left(1 + \frac{1}{B^2}\right)}$$

$H = \frac{V}{2} = 44$ = 61C = $\frac{62}{2}$ = 31 T

= 136.4^K C

= 98.38 C

NOTE: THE AXIAL LOAD RESISTANCE OF A VERTICAL PILE, V, IS DEPENDENT ON THE TYPE OF LOADING--TENSION OR COMPRESSION. CAUTION SHOULD BE EXERCISED TO INSURE THAT THE CORRECT VERTICAL CAPACITY IS USED.

$A_T = \sqrt{(62)^2\left(1+\frac{1}{2^2}\right)}$ = 69.3^K T

= 46.96 T

SOIL CONSTANT:

- PILE CAPACITY ABOVE EL. -46 HAS BEEN IGNORED. SEE EUSTIS REPORT FOR DETAILS.

- CALCULATE ES USING WEIGHTED AVERAGE BELOW EL. -46:

$Kh^* B = [(251)(16') + (1790)(7') + 418(6') + 24150(11)](1/40')$
$= 8867.6$

~~C = 1.0~~
~~D = .44 (14" PILES)~~

~~ES = 8867.6(.44) = 3902 ksi (14" PILES)~~

D = .46 (16" PILES)

ES = 8867.6(.46) = 4079 ksi (16" PILES)

C = 73 * 2 = 146
T = 36 * 2 = 72 } 16' PILES

~~C = 61 * 2 = 122~~
~~T = 31 * 2 = 62~~ } 14' PILES

C = 1.0
D = 0.31 (14" PILES)

ES = 8867.6(.31)
= 2748.9 psi
= 2.75 ksi

C = 61 * 2 122
T = 31 * 2 = 62 (72.5' * 14' PILES)

5' SPACING

~~AB = 5', B = 14"~~

~~A = 5(12)/14~~
~~= 4.29~~

SPACING	D
4B	0.4
5B	0.55
4.29B	0.44

4' SPACING AB = 4' B = 14'
A = 4(12)/14
= 3.43

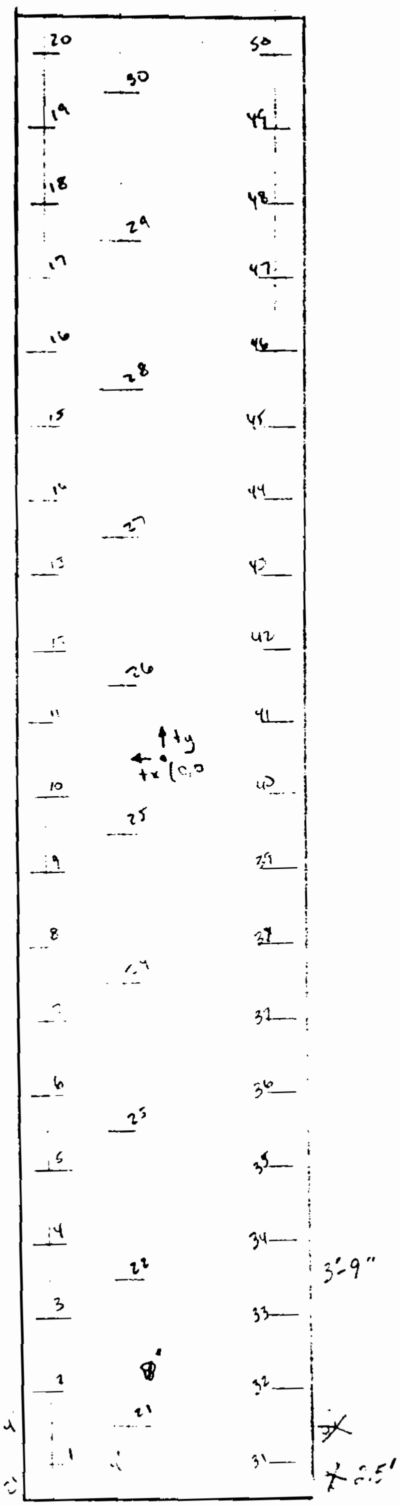
spacing	D
4B	0.4
3B	0.25
3.43B	0.31

JN 3003 | [illegible] PUMP STATION FLOODWALL | AAH | 1-19-98 | 9

PILE LAYOUT:

BATTER 2 ANGLE 0 ← ← BATTER 2 ANGLE 180 →

P/S F/S



#	x	y
1	+6	-38
2		-34
3		-30
4		-26
5		-22
6		-18
7		-14
8		-10
9		-6
10		-2
11		+2
12		+6
13		+10
14		+14
15		+18
16		+22
17		[illegible]
18		[illegible]
19		[illegible]
20	+6	[illegible]
21	+2	-36
22		[illegible]
23		[illegible]
24		[illegible]
25		[illegible]
26		+4
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]		+28
30	+2	+56
31	-6	-38
32		-34
33		-30
34		-26
35		-22
36		-18
37		-14
38		-10
39		-6
40		-2
[illegible]		[illegible]
42		[illegible]
43		+10
44		[illegible]
45		+18

#	x	y
46		+22
47		+26
48		+30
49		+34
50	-6	+38

20 10 ~~30~~ ~~29~~ 21

```
1010 COUS..S PUMP STATION FRONTAL PROTECTION TWALL
1020 PROP 4030 3201 3201 196 2 0 ALL
1030 SOIL ES 2.75 LEN 73 0 ALL
1040 PIN ALL
1050 DLS S 98 47 600.2 223.1 132.6 1510 1166.8 H 14 ALL
1060 ASC S 196 457 0.816 0.856 2 0 ALL
1070 BATTER 2 ALL
1080 ANGLE 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1085 ANGLE 0 16 17 18 19 20
1090 ANGLE 0 21 22 23 24 25 26 27 28 29 30
1100 ANGLE 180 31 32 33 34 35 36 37 38 39 40
1105 ANGLE 180 41 42 43 44 45 46 47 48 49 50 51 52
1110 PILE 1 6 -38 0
1111 PILE 2 6 -34 0
1112 PILE 3 6 -30 0
1113 PILE 4 6 -26 0
1114 PILE 5 6 -22 0
1120 PILE 6 6 -18 0
1121 PILE 7 6 -14 0
1122 PILE 8 6 -10 0
1123 PILE 9 6 -6 0
1124 PILE 10 6 -2 0
1130 PILE 11 6 2 0
1131 PILE 12 6 6 0
1132 PILE 13 6 10 0
1133 PILE 14 6 14 0
1134 PILE 15 6 18 0
1140 PILE 16 6 22 0
1141 PILE 17 6 26 0
1142 PILE 18 6 30 0
1143 PILE 19 6 34 0
1144 PILE 20 6 38 0
1150 PILE 21 2 -36 0
1151 PILE 22 2 -28 0
1152 PILE 23 2 -20 0
1153 PILE 24 2 -12 0
1154 PILE 25 2 -4 0
1160 PILE 26 2 4 0
1161 PILE 27 2 12 0
1162 PILE 28 2 20 0
1163 PILE 29 2 28 0
1164 PILE 30 2 36 0
1170 PILE 31 -6 -36.75 0
1171 PILE 32 -6 -33.25 0
1172 PILE 33 -6 -29.75 0
1173 PILE 34 -6 -26.25 0
1174 PILE 35 -6 -22.75 0
1180 PILE 36 -6 -19.25 0
1181 PILE 37 -6 -15.75 0
1182 PILE 38 -6 -12.25 0
1183 PILE 39 -6 -8.75 0
1184 PILE 40 -6 -5.25 0
1190 PILE 41 -6 -1.75 0
1191 PILE 42 -6 1.75 0
1192 PILE 43 -6 5.25 0
1193 PILE 44 -6 8.75 0
1194 PILE 45 -6 12.25 0
1200 PILE 46 -6 15.75 0
1201 PILE 47 -6 19.25 0
1202 PILE 48 -6 22.75 0
```

```
1203 PILE 49 -6 26.25 0
1204 PILE 50 -6 29.75 0
1205 PILE 51 -6 33.25 0
1206 PILE 52 -6 36.75 0
1210 LOAD 1 1920.8 0 1612.8 0 -14036.8 0
1220 LOAD 2 1920.8 0 1377.6 0 -13736.8 0
1230 LOAD 3 1626.0 0 1251.6 0 -13200.6 0
1240 LOAD 4 1626.0 0 1059.6 0 -12492.6 0
1250 LOAD 5 1034.4 0 1344.8 0 -5560.8 0
1260 LOAD 6 1034.4 0 1206.4 0 -5620.0 0
1270 LOAD 7 810.6 0 1008.6 0 -5266.8 0
1280 FOUT 1 2 3 4 5 6 7 CPSOUT1
1290 PFO ALL
1300 FPL CPSOUT2
```

```
********************************
* CORPS PROGRAM  #  X0080      *   CPGA - CASE PILE GROUP ANALYSIS PROGRAM
* VERSION NUMBER # 86/09/02-A *   RUN DATE 01-19-98     RUN TIME 15:43:00
********************************
```

COUSINS PUMP STATION FRONTAL PROTECTION TWALL

```
THERE ARE  52 PILES AND
            7 LOAD CASES IN THIS RUN.

ALL PILE COORDINATES ARE CONTAINED WITHIN A BOX
                                            X          Y          Z
                                          -----      -----      -----
WITH DIAGONAL COORDINATES = (          -6.00 ,    -38.00 ,       .00 )
                            (           6.00 ,     38.00 ,       .00 )
```

****

PILE PROPERTIES AS INPUT

E KSI	I1 IN**4	I2 IN**4	A IN**2	C33	B66
.40300E+04	.32010E+04	.32010E+04	.19600E+03	.20000E+01	.00000E+00

THESE PILE PROPERTIES APPLY TO THE FOLLOWING PILES -

ALL

****

SOIL DESCRIPTIONS AS INPUT

ES	ESOIL K/IN**2	LENGTH	L FT	LU FT
	.27500E+01	L	.73000E+02	.00000E+00

THIS SOIL DESCRIPTION APPLIES TO THE FOLLOWING PILES -

ALL

****

PILE GEOMETRY AS INPUT AND/OR GENERATED

NUM	X FT	Y FT	Z FT	BATTER	ANGLE	LENGTH FT	FIXITY
1	6.00	-38.00	.00	2.00	.00	73.00	P
2	6.00	-34.00	.00	2.00	.00	73.00	P
3	6.00	-30.00	.00	2.00	.00	73.00	P
4	6.00	-26.00	.00	2.00	.00	73.00	P
5	6.00	-22.00	.00	2.00	.00	73.00	P
6	6.00	-18.00	.00	2.00	.00	73.00	P

7	6.00	-14.00	.00	2.00	.00	73.00	P
8	6.00	-10.00	.00	2.00	.00	73.00	P
9	6.00	-6.00	.00	2.00	.00	73.00	P
10	6.00	-2.00	.00	2.00	.00	73.00	P
11	6.00	2.00	.00	2.00	.00	73.00	P
12	6.00	6.00	.00	2.00	.00	73.00	P
13	6.00	10.00	.00	2.00	.00	73.00	P
14	6.00	14.00	.00	2.00	.00	73.00	P
15	6.00	18.00	.00	2.00	.00	73.00	P
16	6.00	22.00	.00	2.00	.00	73.00	P
17	6.00	26.00	.00	2.00	.00	73.00	P
18	6.00	30.00	.00	2.00	.00	73.00	P
19	6.00	34.00	.00	2.00	.00	73.00	P
20	6.00	38.00	.00	2.00	.00	73.00	P
21	2.00	-36.00	.00	2.00	.00	73.00	P
22	2.00	-28.00	.00	2.00	.00	73.00	P
23	2.00	-20.00	.00	2.00	.00	73.00	P
24	2.00	-12.00	.00	2.00	.00	73.00	P
25	2.00	-4.00	.00	2.00	.00	73.00	P
26	2.00	4.00	.00	2.00	.00	73.00	P
27	2.00	12.00	.00	2.00	.00	73.00	P
28	2.00	20.00	.00	2.00	.00	73.00	P
29	2.00	28.00	.00	2.00	.00	73.00	P
30	2.00	36.00	.00	2.00	.00	73.00	P
31	-6.00	-36.75	.00	2.00	180.00	73.00	P
32	-6.00	-33.25	.00	2.00	180.00	73.00	P
33	-6.00	-29.75	.00	2.00	180.00	73.00	P
34	-6.00	-26.25	.00	2.00	180.00	73.00	P
35	-6.00	-22.75	.00	2.00	180.00	73.00	P
36	-6.00	-19.25	.00	2.00	180.00	73.00	P
37	-6.00	-15.75	.00	2.00	180.00	73.00	P
38	-6.00	-12.25	.00	2.00	180.00	73.00	P
39	-6.00	-8.75	.00	2.00	180.00	73.00	P
40	-6.00	-5.25	.00	2.00	180.00	73.00	P
41	-6.00	-1.75	.00	2.00	180.00	73.00	P
42	-6.00	1.75	.00	2.00	180.00	73.00	P
43	-6.00	5.25	.00	2.00	180.00	73.00	P
44	-6.00	8.75	.00	2.00	180.00	73.00	P
45	-6.00	12.25	.00	2.00	180.00	73.00	P
46	-6.00	15.75	.00	2.00	180.00	73.00	P
47	-6.00	19.25	.00	2.00	180.00	73.00	P
48	-6.00	22.75	.00	2.00	180.00	73.00	P
49	-6.00	26.25	.00	2.00	180.00	73.00	P
50	-6.00	29.75	.00	2.00	180.00	73.00	P
51	-6.00	33.25	.00	2.00	180.00	73.00	P
52	-6.00	36.75	.00	2.00	180.00	73.00	P

						3796.00	

****

APPLIED LOADS

LOAD CASE	PX K	PY K	PZ K	MX FT-K	MY FT-K	MZ FT-K
1	1920.8	.0	1612.8	.0	-14036.8	.0
2	1920.8	.0	1377.6	.0	-13736.8	.0
3	1626.0	.0	1251.6	.0	-13200.6	.0

4	1626.0	.0	1059.6	.0	-12492.6	.0
5	1034.4	.0	1344.8	.0	-5560.8	.0
6	1034.4	.0	1206.4	.0	-5620.0	.0
7	810.6	.0	1008.6	.0	-5266.8	.0

****

ORIGINAL PILE GROUP STIFFNESS MATRIX

.22520E+05	.65888E-03	.54812E+04	.21875E+00	-.22363E+07	.10938E+00
.65888E-03	.47058E+04	-.13178E-02	.00000E+00	-.94878E-01	.86877E+04
.54812E+04	-.13178E-02	.75962E+05	-.18750E+00	-.14024E+06	.31250E-01
.18750E+00	.00000E+00	-.18750E+00	.56307E+10	-.80000E+01	-.50048E+09
-.22363E+07	-.94878E-01	-.14024E+06	-.28000E+02	.32647E+09	.10000E+02
-.31250E-01	.86877E+04	-.62500E-01	-.50048E+09	.14000E+02	.16895E+10

LOAD CASE 1. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 2. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 3. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 4. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 5. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 6. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

LOAD CASE 7. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 22.

****

PILE CAP DISPLACEMENTS

LOAD CASE	DX IN	DY IN	DZ IN	RX RAD	RY RAD	RZ RAD
1	.9741E-01	-.6404E-08	.1449E-01	-.2509E-11	.1576E-03	.3221E-12
2	.1030E+00	-.7176E-08	.1108E-01	-.2784E-11	.2052E-03	-.1737E-12
3	.6787E-01	-.6580E-08	.1155E-01	-.1780E-11	-.1537E-04	.1316E-11
4	.7788E-01	-.6961E-08	.8473E-02	-.2156E-11	.7793E-04	.5054E-12
5	.7198E-01	-.4877E-09	.1305E-01	-.1643E-11	.2943E-03	-.1108E-11
6	.7247E-01	-.1068E-08	.1120E-01	-.1728E-11	.2946E-03	-.1193E-11
7	.4605E-01	-.1050E-08	.1019E-01	-.1025E-11	.1262E-03	-.1157E-12

****

PILE FORCES IN LOCAL GEOMETRY

M1 & M2 NOT AT PILE HEAD FOR PINNED PILES
* INDICATES PILE FAILURE
# INDICATES CBF BASED ON MOMENTS DUE TO
(F3*EMIN) FOR CONCRETE PILES
B INDICATES BUCKLING CONTROLS

LOAD CASE - 1

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
2	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
3	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
4	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
5	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
6	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
7	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
8	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
9	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
10	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
11	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
12	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
13	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
14	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
15	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
16	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
17	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
18	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
19	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
20	7.8	.0	83.6	.0	-164.4	.0	.85	.49	1.64	.88
21	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
22	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
23	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
24	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
25	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
26	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
27	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
28	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
29	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
30	7.5	.0	95.8	.0	-157.9	.0	.98	.55	1.69	.96
31	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
32	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
33	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
34	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
35	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
36	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
37	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
38	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
39	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
40	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
41	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
42	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
43	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
44	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
45	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
46	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
47	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
48	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
49	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
50	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
51	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21
52	-8.9	.0	-36.9	.0	189.3	.0	.78	.88	1.08	.21

LOAD CASE - 2

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
2	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
3	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
4	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
5	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
6	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
7	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
8	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
9	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
10	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
11	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
12	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
13	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
14	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
15	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
16	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
17	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
18	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
19	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
20	8.5	.0	77.1	.0	-179.8	.0	.79	.48	1.64	.82
21	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
22	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
23	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
24	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
25	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
26	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
27	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
28	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
29	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
30	8.1	.0	93.0	.0	-171.4	.0	.95	.56	1.71	.92
31	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
32	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
33	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
34	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
35	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
36	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
37	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
38	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
39	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
40	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
41	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
42	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
43	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
44	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
45	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
46	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
47	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
48	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
49	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
50	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
51	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17
52	-9.4	.0	-41.3	.0	198.8	.0	.88	.96	1.08	.17

LOAD CASE - 3

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
2	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
3	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
4	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
5	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
6	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
7	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
8	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
9	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
10	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
11	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
12	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
13	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
14	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
15	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
16	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
17	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
18	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
19	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
20	5.0	.0	75.2	.0	-105.6	.0	.77	.34	1.47	.97
21	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
22	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
23	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
24	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
25	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
26	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
27	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
28	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
29	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
30	5.0	.0	74.0	.0	-106.2	.0	.75	.33	1.47	.96
31	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
32	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
33	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
34	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
35	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
36	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
37	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
38	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
39	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
40	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
41	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
42	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
43	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
44	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
45	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
46	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
47	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
48	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
49	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
50	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
51	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35
52	-5.9	.0	-37.9	.0	125.4	.0	.81	.75	.94	.35

LOAD CASE - 4

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
2	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
3	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
4	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
5	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
6	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
7	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
8	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
9	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
10	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
11	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
12	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
13	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
14	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
15	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
16	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
17	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
18	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
19	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
20	6.2	.0	67.4	.0	-131.1	.0	.69	.34	1.49	.87
21	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
22	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
23	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
24	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
25	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
26	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
27	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
28	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
29	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
30	6.0	.0	73.5	.0	-127.9	.0	.75	.37	1.51	.91
31	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
32	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
33	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
34	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
35	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
36	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
37	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
38	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
39	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
40	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
41	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
42	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
43	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
44	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
45	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
46	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
47	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
48	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
49	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
50	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
51	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29
52	-6.9	.0	-40.1	.0	145.7	.0	.85	.82	.97	.29

LOAD CASE - 5

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
2	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
3	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
4	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
5	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
6	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
7	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
8	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
9	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
10	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
11	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
12	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
13	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
14	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
15	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
16	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
17	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
18	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
19	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
20	6.2	.0	44.9	.0	-130.4	.0	.46	.25	1.37	.76
21	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
22	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
23	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
24	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
25	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
26	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
27	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
28	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
29	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
30	5.6	.0	67.7	.0	-118.3	.0	.69	.32	1.46	.90
31	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
32	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
33	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
34	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
35	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
36	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
37	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
38	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
39	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
40	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
41	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
42	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
43	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
44	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
45	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
46	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
47	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
48	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
49	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
50	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
51	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47
52	-7.2	.0	-2.8	.0	152.8	.0	.06	.39	1.18	.47

LOAD CASE - 6

PILE	F1	F2	F3	M1	M2	M3	ALF	CBF	ASC	AST

	K	K	K	IN-K	IN-K	IN-K			KSI	KSI
1	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
2	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
3	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
4	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
5	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
6	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
7	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
8	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
9	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
10	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
11	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
12	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
13	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
14	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
15	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
16	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
17	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
18	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
19	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
20	6.3	.0	42.3	.0	-132.9	.0	.43	.27	1.36	.74
21	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
22	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
23	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
24	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
25	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
26	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
27	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
28	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
29	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
30	5.7	.0	65.1	.0	-120.8	.0	.66	.31	1.45	.88
31	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
32	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
33	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
34	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
35	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
36	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
37	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
38	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
39	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
40	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
41	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
42	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
43	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
44	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
45	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
46	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
47	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
48	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
49	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
50	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
51	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45
52	-7.2	.0	-6.2	.0	152.1	.0	.13	.43	1.16	.45

LOAD CASE - 7

PILE	F1	F2	F3	M1	M2	M3	ALF	CBF	ASC	AST
	K	K	K	IN-K	IN-K	IN-K			KSI	KSI

1	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
2	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
3	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
4	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
5	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
6	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
7	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
8	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
9	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
10	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
11	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
12	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
13	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
14	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
15	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
16	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
17	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
18	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
19	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
20	3.7	.0	38.9	.0	-78.1	.0	.40	.19	1.23	.84
21	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
22	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
23	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
24	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
25	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
26	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
27	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
28	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
29	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
30	3.4	.0	48.7	.0	-72.9	.0	.50	.13	1.26	.90
31	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
32	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
33	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
34	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
35	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
36	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
37	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
38	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
39	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
40	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
41	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
42	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
43	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
44	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
45	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
46	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
47	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
48	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
49	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
50	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
51	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58
52	-4.5	.0	-6.0	.0	95.5	.0	.13	.29	1.03	.58

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PILE FORCES IN GLOBAL GEOMETRY

LOAD CASE - 1

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	44.3	.0	71.3	.0	.0	.0
2	44.3	.0	71.3	.0	.0	.0
3	44.3	.0	71.3	.0	.0	.0
4	44.3	.0	71.3	.0	.0	.0
5	44.3	.0	71.3	.0	.0	.0
6	44.3	.0	71.3	.0	.0	.0
7	44.3	.0	71.3	.0	.0	.0
8	44.3	.0	71.3	.0	.0	.0
9	44.3	.0	71.3	.0	.0	.0
10	44.3	.0	71.3	.0	.0	.0
11	44.3	.0	71.3	.0	.0	.0
12	44.3	.0	71.3	.0	.0	.0
13	44.3	.0	71.3	.0	.0	.0
14	44.3	.0	71.3	.0	.0	.0
15	44.3	.0	71.3	.0	.0	.0
16	44.3	.0	71.3	.0	.0	.0
17	44.3	.0	71.3	.0	.0	.0
18	44.3	.0	71.3	.0	.0	.0
19	44.3	.0	71.3	.0	.0	.0
20	44.3	.0	71.3	.0	.0	.0
21	49.5	.0	82.4	.0	.0	.0
22	49.5	.0	82.4	.0	.0	.0
23	49.5	.0	82.4	.0	.0	.0
24	49.5	.0	82.4	.0	.0	.0
25	49.5	.0	82.4	.0	.0	.0
26	49.5	.0	82.4	.0	.0	.0
27	49.5	.0	82.4	.0	.0	.0
28	49.5	.0	82.4	.0	.0	.0
29	49.5	.0	82.4	.0	.0	.0
30	49.5	.0	82.4	.0	.0	.0
31	24.5	.0	-29.0	.0	.0	.0
32	24.5	.0	-29.0	.0	.0	.0
33	24.5	.0	-29.0	.0	.0	.0
34	24.5	.0	-29.0	.0	.0	.0
35	24.5	.0	-29.0	.0	.0	.0
36	24.5	.0	-29.0	.0	.0	.0
37	24.5	.0	-29.0	.0	.0	.0
38	24.5	.0	-29.0	.0	.0	.0
39	24.5	.0	-29.0	.0	.0	.0
40	24.5	.0	-29.0	.0	.0	.0
41	24.5	.0	-29.0	.0	.0	.0
42	24.5	.0	-29.0	.0	.0	.0
43	24.5	.0	-29.0	.0	.0	.0
44	24.5	.0	-29.0	.0	.0	.0
45	24.5	.0	-29.0	.0	.0	.0
46	24.5	.0	-29.0	.0	.0	.0
47	24.5	.0	-29.0	.0	.0	.0
48	24.5	.0	-29.0	.0	.0	.0
49	24.5	.0	-29.0	.0	.0	.0
50	24.5	.0	-29.0	.0	.0	.0
51	24.5	.0	-29.0	.0	.0	.0
52	24.5	.0	-29.0	.0	.0	.0

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LOAD CASE - 2

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	42.1	.0	65.2	.0	.0	.0
2	42.1	.0	65.2	.0	.0	.0
3	42.1	.0	65.2	.0	.0	.0
4	42.1	.0	65.2	.0	.0	.0
5	42.1	.0	65.2	.0	.0	.0
6	42.1	.0	65.2	.0	.0	.0
7	42.1	.0	65.2	.0	.0	.0
8	42.1	.0	65.2	.0	.0	.0
9	42.1	.0	65.2	.0	.0	.0
10	42.1	.0	65.2	.0	.0	.0
11	42.1	.0	65.2	.0	.0	.0
12	42.1	.0	65.2	.0	.0	.0
13	42.1	.0	65.2	.0	.0	.0
14	42.1	.0	65.2	.0	.0	.0
15	42.1	.0	65.2	.0	.0	.0
16	42.1	.0	65.2	.0	.0	.0
17	42.1	.0	65.2	.0	.0	.0
18	42.1	.0	65.2	.0	.0	.0
19	42.1	.0	65.2	.0	.0	.0
20	42.1	.0	65.2	.0	.0	.0
21	48.8	.0	79.6	.0	.0	.0
22	48.8	.0	79.6	.0	.0	.0
23	48.8	.0	79.6	.0	.0	.0
24	48.8	.0	79.6	.0	.0	.0
25	48.8	.0	79.6	.0	.0	.0
26	48.8	.0	79.6	.0	.0	.0
27	48.8	.0	79.6	.0	.0	.0
28	48.8	.0	79.6	.0	.0	.0
29	48.8	.0	79.6	.0	.0	.0
30	48.8	.0	79.6	.0	.0	.0
31	26.9	.0	-32.8	.0	.0	.0
32	26.9	.0	-32.8	.0	.0	.0
33	26.9	.0	-32.8	.0	.0	.0
34	26.9	.0	-32.8	.0	.0	.0
35	26.9	.0	-32.8	.0	.0	.0
36	26.9	.0	-32.8	.0	.0	.0
37	26.9	.0	-32.8	.0	.0	.0
38	26.9	.0	-32.8	.0	.0	.0
39	26.9	.0	-32.8	.0	.0	.0
40	26.9	.0	-32.8	.0	.0	.0
41	26.9	.0	-32.8	.0	.0	.0
42	26.9	.0	-32.8	.0	.0	.0
43	26.9	.0	-32.8	.0	.0	.0
44	26.9	.0	-32.8	.0	.0	.0
45	26.9	.0	-32.8	.0	.0	.0
46	26.9	.0	-32.8	.0	.0	.0
47	26.9	.0	-32.8	.0	.0	.0
48	26.9	.0	-32.8	.0	.0	.0
49	26.9	.0	-32.8	.0	.0	.0
50	26.9	.0	-32.8	.0	.0	.0
51	26.9	.0	-32.8	.0	.0	.0
52	26.9	.0	-32.8	.0	.0	.0

LOAD CASE - 3

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	38.1	.0	65.0	.0	.0	.0
2	38.1	.0	65.0	.0	.0	.0
3	38.1	.0	65.0	.0	.0	.0
4	38.1	.0	65.0	.0	.0	.0
5	38.1	.0	65.0	.0	.0	.0
6	38.1	.0	65.0	.0	.0	.0
7	38.1	.0	65.0	.0	.0	.0
8	38.1	.0	65.0	.0	.0	.0
9	38.1	.0	65.0	.0	.0	.0
10	38.1	.0	65.0	.0	.0	.0
11	38.1	.0	65.0	.0	.0	.0
12	38.1	.0	65.0	.0	.0	.0
13	38.1	.0	65.0	.0	.0	.0
14	38.1	.0	65.0	.0	.0	.0
15	38.1	.0	65.0	.0	.0	.0
16	38.1	.0	65.0	.0	.0	.0
17	38.1	.0	65.0	.0	.0	.0
18	38.1	.0	65.0	.0	.0	.0
19	38.1	.0	65.0	.0	.0	.0
20	38.1	.0	65.0	.0	.0	.0
21	37.6	.0	63.9	.0	.0	.0
22	37.6	.0	63.9	.0	.0	.0
23	37.6	.0	63.9	.0	.0	.0
24	37.6	.0	63.9	.0	.0	.0
25	37.6	.0	63.9	.0	.0	.0
26	37.6	.0	63.9	.0	.0	.0
27	37.6	.0	63.9	.0	.0	.0
28	37.6	.0	63.9	.0	.0	.0
29	37.6	.0	63.9	.0	.0	.0
30	37.6	.0	63.9	.0	.0	.0
31	22.2	.0	-31.2	.0	.0	.0
32	22.2	.0	-31.2	.0	.0	.0
33	22.2	.0	-31.2	.0	.0	.0
34	22.2	.0	-31.2	.0	.0	.0
35	22.2	.0	-31.2	.0	.0	.0
36	22.2	.0	-31.2	.0	.0	.0
37	22.2	.0	-31.2	.0	.0	.0
38	22.2	.0	-31.2	.0	.0	.0
39	22.2	.0	-31.2	.0	.0	.0
40	22.2	.0	-31.2	.0	.0	.0
41	22.2	.0	-31.2	.0	.0	.0
42	22.2	.0	-31.2	.0	.0	.0
43	22.2	.0	-31.2	.0	.0	.0
44	22.2	.0	-31.2	.0	.0	.0
45	22.2	.0	-31.2	.0	.0	.0
46	22.2	.0	-31.2	.0	.0	.0
47	22.2	.0	-31.2	.0	.0	.0
48	22.2	.0	-31.2	.0	.0	.0
49	22.2	.0	-31.2	.0	.0	.0
50	22.2	.0	-31.2	.0	.0	.0
51	22.2	.0	-31.2	.0	.0	.0
52	22.2	.0	-31.2	.0	.0	.0

LOAD CASE - 4

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	35.7	.0	57.5	.0	.0	.0
2	35.7	.0	57.5	.0	.0	.0
3	35.7	.0	57.5	.0	.0	.0
4	35.7	.0	57.5	.0	.0	.0
5	35.7	.0	57.5	.0	.0	.0
6	35.7	.0	57.5	.0	.0	.0
7	35.7	.0	57.5	.0	.0	.0
8	35.7	.0	57.5	.0	.0	.0
9	35.7	.0	57.5	.0	.0	.0
10	35.7	.0	57.5	.0	.0	.0
11	35.7	.0	57.5	.0	.0	.0
12	35.7	.0	57.5	.0	.0	.0
13	35.7	.0	57.5	.0	.0	.0
14	35.7	.0	57.5	.0	.0	.0
15	35.7	.0	57.5	.0	.0	.0
16	35.7	.0	57.5	.0	.0	.0
17	35.7	.0	57.5	.0	.0	.0
18	35.7	.0	57.5	.0	.0	.0
19	35.7	.0	57.5	.0	.0	.0
20	35.7	.0	57.5	.0	.0	.0
21	38.3	.0	63.0	.0	.0	.0
22	38.3	.0	63.0	.0	.0	.0
23	38.3	.0	63.0	.0	.0	.0
24	38.3	.0	63.0	.0	.0	.0
25	38.3	.0	63.0	.0	.0	.0
26	38.3	.0	63.0	.0	.0	.0
27	38.3	.0	63.0	.0	.0	.0
28	38.3	.0	63.0	.0	.0	.0
29	38.3	.0	63.0	.0	.0	.0
30	38.3	.0	63.0	.0	.0	.0
31	24.1	.0	-32.8	.0	.0	.0
32	24.1	.0	-32.8	.0	.0	.0
33	24.1	.0	-32.8	.0	.0	.0
34	24.1	.0	-32.8	.0	.0	.0
35	24.1	.0	-32.8	.0	.0	.0
36	24.1	.0	-32.8	.0	.0	.0
37	24.1	.0	-32.8	.0	.0	.0
38	24.1	.0	-32.8	.0	.0	.0
39	24.1	.0	-32.8	.0	.0	.0
40	24.1	.0	-32.8	.0	.0	.0
41	24.1	.0	-32.8	.0	.0	.0
42	24.1	.0	-32.8	.0	.0	.0
43	24.1	.0	-32.8	.0	.0	.0
44	24.1	.0	-32.8	.0	.0	.0
45	24.1	.0	-32.8	.0	.0	.0
46	24.1	.0	-32.8	.0	.0	.0
47	24.1	.0	-32.8	.0	.0	.0
48	24.1	.0	-32.8	.0	.0	.0
49	24.1	.0	-32.8	.0	.0	.0
50	24.1	.0	-32.8	.0	.0	.0
51	24.1	.0	-32.8	.0	.0	.0
52	24.1	.0	-32.8	.0	.0	.0

LOAD CASE - 5

PILE	PX	PY	PZ	MX	MY	MZ

	K	K	K	IN-K	IN-K	IN-K
1	25.6	.0	37.4	.0	.0	.0
2	25.6	.0	37.4	.0	.0	.0
3	25.6	.0	37.4	.0	.0	.0
4	25.6	.0	37.4	.0	.0	.0
5	25.6	.0	37.4	.0	.0	.0
6	25.6	.0	37.4	.0	.0	.0
7	25.6	.0	37.4	.0	.0	.0
8	25.6	.0	37.4	.0	.0	.0
9	25.6	.0	37.4	.0	.0	.0
10	25.6	.0	37.4	.0	.0	.0
11	25.6	.0	37.4	.0	.0	.0
12	25.6	.0	37.4	.0	.0	.0
13	25.6	.0	37.4	.0	.0	.0
14	25.6	.0	37.4	.0	.0	.0
15	25.6	.0	37.4	.0	.0	.0
16	25.6	.0	37.4	.0	.0	.0
17	25.6	.0	37.4	.0	.0	.0
18	25.6	.0	37.4	.0	.0	.0
19	25.6	.0	37.4	.0	.0	.0
20	25.6	.0	37.4	.0	.0	.0
21	35.3	.0	58.1	.0	.0	.0
22	35.3	.0	58.1	.0	.0	.0
23	35.3	.0	58.1	.0	.0	.0
24	35.3	.0	58.1	.0	.0	.0
25	35.3	.0	58.1	.0	.0	.0
26	35.3	.0	58.1	.0	.0	.0
27	35.3	.0	58.1	.0	.0	.0
28	35.3	.0	58.1	.0	.0	.0
29	35.3	.0	58.1	.0	.0	.0
30	35.3	.0	58.1	.0	.0	.0
31	7.7	.0	.7	.0	.0	.0
32	7.7	.0	.7	.0	.0	.0
33	7.7	.0	.7	.0	.0	.0
34	7.7	.0	.7	.0	.0	.0
35	7.7	.0	.7	.0	.0	.0
36	7.7	.0	.7	.0	.0	.0
37	7.7	.0	.7	.0	.0	.0
38	7.7	.0	.7	.0	.0	.0
39	7.7	.0	.7	.0	.0	.0
40	7.7	.0	.7	.0	.0	.0
41	7.7	.0	.7	.0	.0	.0
42	7.7	.0	.7	.0	.0	.0
43	7.7	.0	.7	.0	.0	.0
44	7.7	.0	.7	.0	.0	.0
45	7.7	.0	.7	.0	.0	.0
46	7.7	.0	.7	.0	.0	.0
47	7.7	.0	.7	.0	.0	.0
48	7.7	.0	.7	.0	.0	.0
49	7.7	.0	.7	.0	.0	.0
50	7.7	.0	.7	.0	.0	.0
51	7.7	.0	.7	.0	.0	.0
52	7.7	.0	.7	.0	.0	.0

LOAD CASE - 6

PILE	PX	PY	PZ	MX	MY	MZ
	K	K	K	IN-K	IN-K	IN-K

1	24.5	.0	35.0	.0	.0	.0
2	24.5	.0	35.0	.0	.0	.0
3	24.5	.0	35.0	.0	.0	.0
4	24.5	.0	35.0	.0	.0	.0
5	24.5	.0	35.0	.0	.0	.0
6	24.5	.0	35.0	.0	.0	.0
7	24.5	.0	35.0	.0	.0	.0
8	24.5	.0	35.0	.0	.0	.0
9	24.5	.0	35.0	.0	.0	.0
10	24.5	.0	35.0	.0	.0	.0
11	24.5	.0	35.0	.0	.0	.0
12	24.5	.0	35.0	.0	.0	.0
13	24.5	.0	35.0	.0	.0	.0
14	24.5	.0	35.0	.0	.0	.0
15	24.5	.0	35.0	.0	.0	.0
16	24.5	.0	35.0	.0	.0	.0
17	24.5	.0	35.0	.0	.0	.0
18	24.5	.0	35.0	.0	.0	.0
19	24.5	.0	35.0	.0	.0	.0
20	24.5	.0	35.0	.0	.0	.0
21	34.2	.0	55.7	.0	.0	.0
22	34.2	.0	55.7	.0	.0	.0
23	34.2	.0	55.7	.0	.0	.0
24	34.2	.0	55.7	.0	.0	.0
25	34.2	.0	55.7	.0	.0	.0
26	34.2	.0	55.7	.0	.0	.0
27	34.2	.0	55.7	.0	.0	.0
28	34.2	.0	55.7	.0	.0	.0
29	34.2	.0	55.7	.0	.0	.0
30	34.2	.0	55.7	.0	.0	.0
31	9.2	.0	-2.3	.0	.0	.0
32	9.2	.0	-2.3	.0	.0	.0
33	9.2	.0	-2.3	.0	.0	.0
34	9.2	.0	-2.3	.0	.0	.0
35	9.2	.0	-2.3	.0	.0	.0
36	9.2	.0	-2.3	.0	.0	.0
37	9.2	.0	-2.3	.0	.0	.0
38	9.2	.0	-2.3	.0	.0	.0
39	9.2	.0	-2.3	.0	.0	.0
40	9.2	.0	-2.3	.0	.0	.0
41	9.2	.0	-2.3	.0	.0	.0
42	9.2	.0	-2.3	.0	.0	.0
43	9.2	.0	-2.3	.0	.0	.0
44	9.2	.0	-2.3	.0	.0	.0
45	9.2	.0	-2.3	.0	.0	.0
46	9.2	.0	-2.3	.0	.0	.0
47	9.2	.0	-2.3	.0	.0	.0
48	9.2	.0	-2.3	.0	.0	.0
49	9.2	.0	-2.3	.0	.0	.0
50	9.2	.0	-2.3	.0	.0	.0
51	9.2	.0	-2.3	.0	.0	.0
52	9.2	.0	-2.3	.0	.0	.0

LOAD CASE - 7

PILE	PX	PY	PZ	MX	MY	MZ
	K	K	K	IN-K	IN-K	IN-K

1	20.7	.0	33.2	.0	.0	.0
2	20.7	.0	33.2	.0	.0	.0
3	20.7	.0	33.2	.0	.0	.0
4	20.7	.0	33.2	.0	.0	.0
5	20.7	.0	33.2	.0	.0	.0
6	20.7	.0	33.2	.0	.0	.0
7	20.7	.0	33.2	.0	.0	.0
8	20.7	.0	33.2	.0	.0	.0
9	20.7	.0	33.2	.0	.0	.0
10	20.7	.0	33.2	.0	.0	.0
11	20.7	.0	33.2	.0	.0	.0
12	20.7	.0	33.2	.0	.0	.0
13	20.7	.0	33.2	.0	.0	.0
14	20.7	.0	33.2	.0	.0	.0
15	20.7	.0	33.2	.0	.0	.0
16	20.7	.0	33.2	.0	.0	.0
17	20.7	.0	33.2	.0	.0	.0
18	20.7	.0	33.2	.0	.0	.0
19	20.7	.0	33.2	.0	.0	.0
20	20.7	.0	33.2	.0	.0	.0
21	24.8	.0	42.0	.0	.0	.0
22	24.8	.0	42.0	.0	.0	.0
23	24.8	.0	42.0	.0	.0	.0
24	24.8	.0	42.0	.0	.0	.0
25	24.8	.0	42.0	.0	.0	.0
26	24.8	.0	42.0	.0	.0	.0
27	24.8	.0	42.0	.0	.0	.0
28	24.8	.0	42.0	.0	.0	.0
29	24.8	.0	42.0	.0	.0	.0
30	24.8	.0	42.0	.0	.0	.0
31	6.7	.0	-3.4	.0	.0	.0
32	6.7	.0	-3.4	.0	.0	.0
33	6.7	.0	-3.4	.0	.0	.0
34	6.7	.0	-3.4	.0	.0	.0
35	6.7	.0	-3.4	.0	.0	.0
36	6.7	.0	-3.4	.0	.0	.0
37	6.7	.0	-3.4	.0	.0	.0
38	6.7	.0	-3.4	.0	.0	.0
39	6.7	.0	-3.4	.0	.0	.0
40	6.7	.0	-3.4	.0	.0	.0
41	6.7	.0	-3.4	.0	.0	.0
42	6.7	.0	-3.4	.0	.0	.0
43	6.7	.0	-3.4	.0	.0	.0
44	6.7	.0	-3.4	.0	.0	.0
45	6.7	.0	-3.4	.0	.0	.0
46	6.7	.0	-3.4	.0	.0	.0
47	6.7	.0	-3.4	.0	.0	.0
48	6.7	.0	-3.4	.0	.0	.0
49	6.7	.0	-3.4	.0	.0	.0
50	6.7	.0	-3.4	.0	.0	.0
51	6.7	.0	-3.4	.0	.0	.0
52	6.7	.0	-3.4	.0	.0	.0

MAX LOAD = 95.8^K C (Load Case 1) = 48^T C
-41.3^K T (Load Case 2) = 21^T T

ALLOWABLES: C = 98^K

T = 47^K

T-WALL MAX. MOMENT = 34.9 FT·K/FT OF WALL @ EL. -23.0

ALLOWABLE STRESS = $.55 f_Y$

f_Y = 38400 psi (ASTM 328)

Allowable Stress = .55(38.4)
= 21.12 ksi

Req'd Section Modulus = $\frac{(34.9)(12)}{21}$

= 19.9 in^3/ft wall

∴ use Casteel Steel Dil. ng CZ 114RD

S = 29.76 in^3/ft. wall

VERTICAL PUMP STATION - DISCHARGE BASIN

PILE CAPACITY - (FROM EUSTIS PRELIM. REPORT)

PILE CUTOFF @ -13 N.G.V.D.

F.S. = 2.0

TREATED ASTM D25 Timber PILE	Length	Compression (TONS)	Tension (TONS)
7" Tip, 12" Butt	50'	14	9
	55'	17	11
	60'	20	13 ← use

EL. Water Surface = +2 N.G.V.D. (TOP OF DISCHARGE BASIN RET WALL)
EL. INVERT = -11 N.G.V.D.

HEIGHT OF WATER = 13.0'

$wt(water) = (13.0)(.0624) = 0.81$ ksf
$wt(slab) = (2.0')(.150) = \underline{0.30}$ ksf
1.11 ksf

for 60' piles: F.S. = 2.0

$AREA/PILE = \frac{20 * 2}{1.11} = 36.04$ sf/pile

$\sqrt{36.04} = 6.00$ - 6' GRID

for 60' piles, F.S. = 3.0 : Comp Cap = $20(2/3) = 13.33$ TONS

$AREA/PILE = \frac{13.33 * 2}{1.11} = 24.02$ sf/pile

$\sqrt{24.02} = 4.9$ - 4'-9" GRID

TENSION :

GROUND WATER @ 0.0, BASIN DRY

UPLIFT = (11')(.0624) = 0.6864 ksf ↑
SLAB = (2')(.15-.0624) = 0.1752 ksf ↓

0.5112 ksf tension

AREA/PILE = $\frac{13*2}{.5112}$ = 50.86 sf/pile (F.S. = 2)

6' GRID CONTROLS

F.S. = 3, capacity = 13 * 2/3 = 8.67 TONS

AREA/PILE = $\frac{8.67*2}{.5112}$ = 33.92

4'9" GRID CONTROLS

SLAB: (DESIGN FOR 6' GRID)

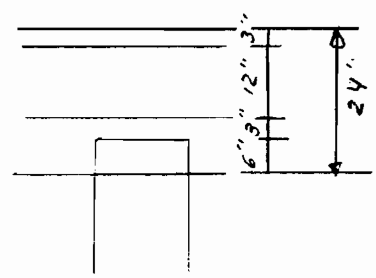
-USE FLAT SLAB :

$w_u = 1.11(1.2) = 1.33$ ksf

$M_0 = \frac{w l_2 l_n^2}{8} = \frac{1.33(6)(6)^2}{8} = 35.91'^k$

M_{max} Neg M = $0.65 M_0$ = .65(35.91) = 23.34'K

try 24" SLAB : d = 21" (-M)
d = 15" (+M)

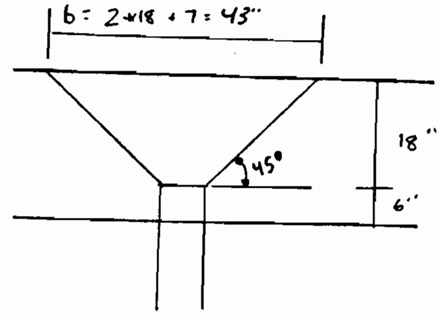


$A_s(+m) = M/f_y z$, z = 0.9d

= (35.91)(12)/48(.9)(15) = 0.665 in^2

$A_s(-m)$ = (23.34)(12)/48(.9)(21) = 0.309 in^2

Shear:



$v_u = \frac{V_u}{\phi b_o d}$

$\phi = 0.85$
$d = 15"$
$b_o = 43" (\pi)$
$= 135.1"$

$V_u = (20 \text{ TONS})(2)(1.7)$
$= 68^k$

$v_u = 68/.85(135.1)(15)$

$v_u = 0.039 ksi = 39 psi$

$v_u(\text{allow}) = 4\sqrt{f'_c} = 4\sqrt{3000} = 219$ psi

∴ 24" SLAB IS OK

- use 24" SLAB, #8 bars @ 12", btm (As = .79 > .665 ok)
#6 bars @ 12", top (As = .44 > .305 ok)

or - #5 @ 6" As = .88 > .665 ok
#4 @ 6" As = .40 > .305 ok

- MATCH EXISTING : #7 @ 6" TOP & BTM // TO PUMP STATION

#5 @ 12" T & B ⊥ TO PUMP STATION

VERTICAL PUMP DISCHARGE TUBE SUPPORTS:

72" TUBES: Q: 330 cfs

$A = \frac{72^2}{4}(\pi) = 4071.5 \text{ in}^2 = 28.27 \text{ ft}^2$

$v = Q/A = \frac{330 \text{ cf}}{s(28.27 \text{ ft}^2)} = 11.67 \text{ ft/s}$

$F = \rho Q (v_2 - v_1)$ $\rho = 1.93 \frac{\text{slugs}}{\text{ft}^3} = \frac{\text{lb} \cdot s^2}{\text{ft}^4}$ $v_2 = 0$

$F = (1.93)(330)(11.67)$
$= 7433 \# = 7.4 \text{ k}$

- Design support to take 7.4^k horizontal load

Loads:

- Design for 25' length of pipe

Pipe: 72" I.D, ½" THICK, 73' O.D.

$A = \pi\left(\frac{73^2 - 72^2}{4}\right) = 113.88 \text{ in}^2/\text{ft}$

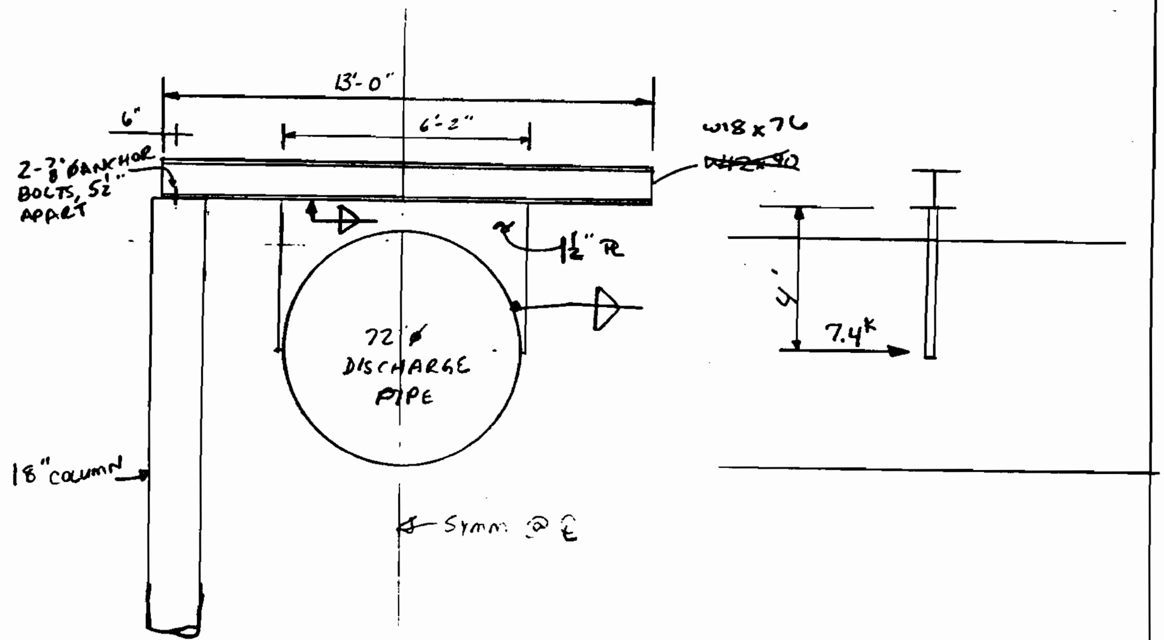
$Vol = (25')\left(\frac{113.88}{144}\right) = 19.77 \text{ cf}$

$wt = 19.77 \text{cf} (.490 \text{ kcf}) = 9.69^k$

water: $A = (\pi/4)(72)^2/144 = 28.27 \text{sf}$

$Vol = (28.27)(25') = 706.75 \text{ cf}$

$wt = 0.0624 \text{ kcf} (706.75) = 44.1^k$



$A_{plate} = (74")(1\tfrac{1}{2}") = 111.0\ in^2$

$P = 44.1 + 9.7 = 53.8^k$

$f_t = 53.8/111.0 = 0.48\ ksi$ ok

$M = 7.4^k(4') = 29.6'^k$

$S = \tfrac{1}{6}bh^2 = \tfrac{1}{6}(74)(\tfrac{1}{2})^2 = 3.08\ in^3$ N.G.

$f_b = 29.6(12)/3.08 = 115.32\ ksi$ N.G.

$S_{reqd} = \frac{M}{F_b} = 29.6(12)/20 = 17.76\ in^3$

$S = \tfrac{1}{6}bh^2 = 17.76 = \tfrac{1}{6}(74)(h^2)$

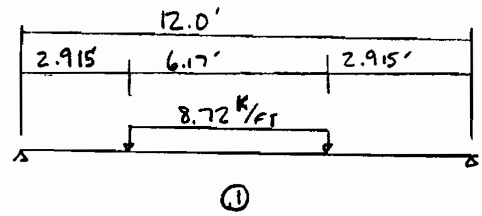
$1.44 = h^2$

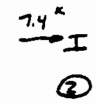
$1.2 = h$

– use $1\tfrac{1}{2}$" R $\quad S = \tfrac{1}{6}(74)(1.5)^2 = 27.75\ in^3$

$f_b = 29.6(12)/27.75 = 12.8\ ksi$ ok

- SUPPORT BEAM





$R_1 = \frac{8.72(6.17)}{2}$

$= 26.90$

$M_1 = 26.90\left(2.915 + \frac{26.9}{2(8.72)}\right)$

$= 119.9^{'K}$

$M_2 = \frac{Pl}{4} = 7.4(12)/4 = 22.2^{'K}$

$F_b = 20\ ksi$

$S_{req'd}$ (for M_1) $= (119.9)(12)/20 = 71.94\ in^3$

W12x79 $S_1 = 107$ $S_2 = 35.8$
W18x76 $S_1 = 146$ $S_2 = 27.6$

W12x79

$M_{DL} = \frac{1}{8}(.079)(12)^2$
$= 1.42^{'K}$

$M_1 = 119.9 + 1.4 = 121.3^{'K}$

$f_{b1} = 121.3(12)/107 = 13.60\ ksi$

$f_{b2} = 22.2(12)/35.8 = 7.44\ ksi$

$\frac{f_1}{F_1} + \frac{f_2}{F_2} \le 1.0$

$\frac{13.60}{20} + \frac{7.44}{20} = 1.05$
5% over N.G.

W18x76

$M_{DL} = \frac{1}{8}(.076)(12)^2$
$= 1.37^{'K}$

$M_1 = 119.9 + 1.4 = 121.3^{'K}$

$f_{b1} = 121.3(12)/146 = 9.97\ ksi$

$f_{b2} = 22.2(12)/27.6 = 9.65\ ksi$

$\frac{9.97}{20} + \frac{9.65}{20} = 0.98$ ok

- use W18x76

Reaction = $\frac{1}{2}(11.7)(12) + \frac{1}{2}(6.17)(8.72)$
$= 27.6^k$

Column - 18" ϕ

$A = \frac{18^2}{4}(\pi) = 254.47 \text{ in}^2$

$f'_c = 3000$ psi

$\phi P_n = \phi(.85)[.85 f'_c (A_g - A_{st}) + f_y A_{st}]$

A_{st} = 6-#6 bars
w/ #3 spiral @ 2"
$A_{st} = 6 \times .44 = 2.64 \text{ in}^2$

$A_n = 254.47 - 2.64 = 251.83 \text{ in}^2$

$f_y = 48$ ksi (for G60 steel)

$\phi = 0.75$ for spiral columns

$\phi P_n = 0.75(.85)[(.85)(3)(251.83) + (48)(2.64)]$

$\phi P_n = 490^k$

Factored Reaction = $1.9 \times 27.6 = 52.44 < 490$ OK

36" PIPE:

$Q = 50\,cfs$

$A = \frac{36^2}{4}(\pi) = 1017.88\,in^2 = 7.07\,ft^2$

$v = Q/A = 50/7.07 = 7.07\,ft/s$

$F = \rho Q v$

$= 1.93(50)(7.07)$

$= 682\# = 0.7^K$

LOADS FOR 25' LENGTH OF PIPE:

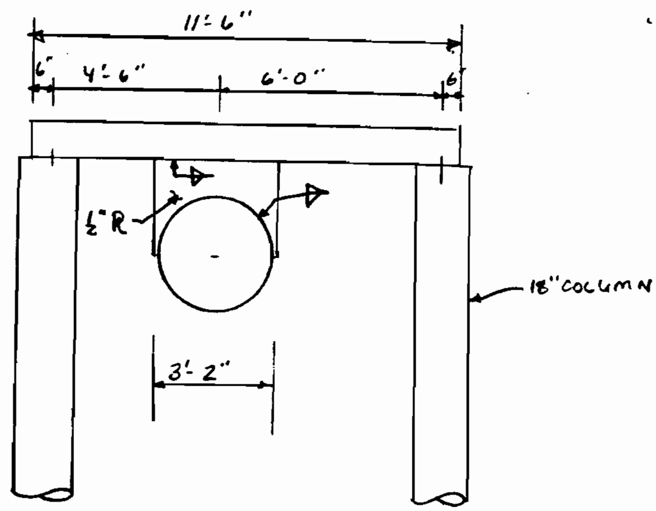
PIPE: 36" I.D., $\frac{3}{8}$" THICK PIPE, $36\frac{3}{4}$" O.D.

$A = \frac{\pi}{4}(36\frac{3}{4}^2 - 36^2) = 42.85\,in^2/ft$

$wt = (25')(\frac{42.85}{144})(.490\,kcf) = 3.65^k$

water: $A = \frac{\pi}{4}(36)^2/144 = 7.07\,ft^2$

$wt = (7.07\,ft^2)(25')(.0624) = 11.03^K$



$P = 11.03^k + 3.65^k = 14.68^k$

$M = 0.7^k(2.5') = 1.75'^k$

$S_{req'd} = M/F_b = 1.75(12)/20 = 1.05 \text{ in}^3$

$S = \frac{1}{6}bh^2 = 1.05$

$h^2 = 1.05(6)/38$

$h^2 = 0.166$

$h = 0.407$

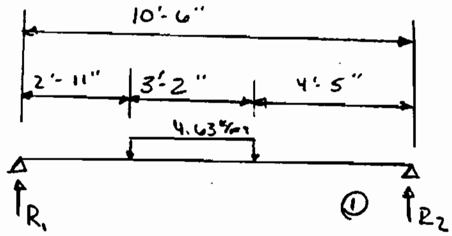
-use $\frac{1}{2}$" PL , $S = \frac{1}{6}(38)(\frac{1}{2})^2 = 1.583$

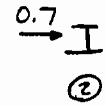
$A = (\frac{1}{2})(38) = 19 \text{ in}^2$

$f_t = 14.68/19 = 0.77 \text{ ksi} < 20$ ok

$f_b = 1.75(12)/1.583 = 13.26 < 20$ ok

SUPPORT BEAM:





$w = 14.68/3.17 = 4.63^{k}/_{FT}$

$M_{DL} = \frac{1}{8}(.075)(10.5)^2$ (ASSUMED $75^{\#}/_{FT}$)
$= 1.03'^{k}$

$M_1 = R_1\left(a + \frac{R_1}{2w}\right)$

$= 8.39\left(2.91 + \frac{8.39}{2(4.63)}\right)$

$= 32.02'^{k} + 1.03 = \underline{33.05'^{k}}$

$R_1 = \frac{wb}{2l}(2c + b)$

$= \frac{(4.63)(3.17)}{2(10.5)}(2(4.417) + 3.17)$

$= 0.699(12)$

$= 8.39$

$M_2 = Pl/4 = 0.7(10.5)/4 = \underline{1.84'^{k}}$

$S_{REQ'D} = 33.05(12)/20 = 19.83\,in^3$

W12x40 $S_1 = 51.9$ $S_2 = 11.0$

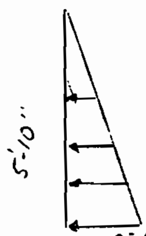
$f_{b_1} = 33.05(12)/51.9 = 7.64$ ksi

$f_{b_2} = 1.84(12)/11 = 2.01$ ksi

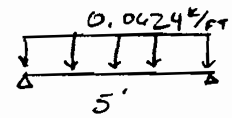
$\frac{7.64}{20} + \frac{2.01}{20} = 0.48 < 1.0$ $\underline{\underline{ok}}$

Check $\frac{1}{2}''$ PL FOR T-WALL/DISCHARGE PIPE CONNECTION:

- use $\frac{7}{8}''$ PL



$p = 5.83(.0624)$
$= 0.364 \ ^k/_{ft}$



$M = \frac{1}{8}(.0624)(5)^2$
$= 0.195'^k < 2.06 \ '^k$

$P = \frac{1}{2}ph$
$= \frac{1}{2}(.364)(5.83)$
$= 1.06^k$ @ 1.943' from btm

$M = (1.06)(1.943)$
$= 2.06^{ft\cdot k}$

A36 steel. $F_y = 20$ ksi

Req'd $S = (2.06)(12)/20$
$= 1.236 \text{ in}^3$

$S = \frac{1}{6}bh^2$

$h^2 = \frac{6S}{b}$

Req'd $h = \sqrt{\frac{6S}{b}}$
$= \sqrt{\frac{6(1.236)}{12}}$

$= 0.786$

$\frac{1}{2}''$ PL N.G. - use $\frac{7}{8}''$ PL

DESIGN CALCULATIONS

DESTRAHAN BRIDGE EXTENSION

- LENGTHEN BRIDGE BY 1 - 60' SPAN:
- USE 5 TYPE III GIRDERS
- ASSUME 7" SLAB TO CHECK GIRDERS, VERIFY LATER.

DEAD LOAD: (GIRDER) : $\left(\frac{559.5}{144}\right)(.150)$ = 0.58 k/FT

DEAD LOAD : (SUPERIMPOSED)

INTERIOR GIRDER:

SLAB: $\left(\frac{7}{12}\right)(6.5')(.150)$ = 0.569

HAUNCH: $\left(\frac{1.5}{12}\right)(1.33)(.150)$ = 0.025

0.594

+10% 0.059

$+\frac{1}{5}$ RAILINGS = $\frac{1}{5}(.64+.26+.05)$ = 0.19 0.653 k/FT

+ 0.19

0.843

EXTERIOR GIRDER:

SLAB: $\left(\frac{7}{12}\right)\left(\frac{6.5}{2}+2.5\right)(.150)$ = 0.503

HAUNCH: $\left(\frac{1.5}{12}\right)(3.417)(.150)$ = 0.064

0.567

+10% 0.057

0.624 k/FT

$+\frac{1}{5}$ RAILINGS : 0.19

0.814

LIVE LOAD: (HS 20-44)

INTERIOR GIRDER:

WHEEL FACTOR: S/5.5 , S = 6.5

$= 6.5/5.5 = 1.18$ wheels/girder

$= 0.59$ lanes/girder

MOMENTS & SHEARS:

DEAD LOAD: (SUPERIMPOSED)
INTERIOR GIRDER:

$M_{DL} = \frac{1}{8}(.843)(60)^2 = 379.35'^{K}$

$V_{DL} = \frac{1}{2}(.843)(60) = 25.29^{K}$

EXTERIOR GIRDER:

$M_{DL} = \frac{1}{8}(.814)(60)^2 = 366.3'^{K}$

$V_{DL} = \frac{1}{2}(.814)(60) = 24.42^{K}$

SELF WT: $M_{DL} = \frac{1}{8}(.58)(60)^2 = 261'^{K}$
$V_{DL} = \frac{1}{2}(.58)(60) = 17.4^{K}$

LIVE LOAD:

MAX MOMENT & SHEAR, 60' SPAN, ONE LANE

$M_{MAX} = 806.5'^{K}$
$V_{MAX} = 60.8^{K}$

INTERIOR GIRDER:

$M_{LL} = (806.5)(.59) = 475.84'^{K}$

$V_{LL} = (60.8)(.59) = 35.87^{K}$

EXTERIOR GIRDER:
TRAFFIC:
$M_{LL} = (806.5)(.423) = 341.15'^{K}$

$V_{LL} = (60.8)(.423) = 25.72^{K}$

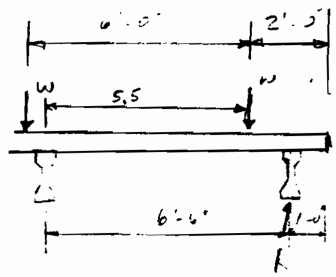
WALKWAY:

$M_{LL} = \frac{1}{8}(.09)(60)^2 = 40.5'^{K}$

$V_{LL} = \frac{1}{2}(.09)(60) = 2.7^{K}$

EXTERIOR GIRDER:

LANE FACTOR: (ASSUME SLAB ACTS AS SIMPLE SPAN BETWEEN GIRDERS)



wheel factor = $5.5/6.5$ = 0.846 wheels/girder
= 0.423 lanes/girder

SIDEWALK LL: (ALLOWABLE STRESS IN GIRDER MAY BE INCREASED BY 25% FOR COMBINATION OF DL, SIDEWALK LL, TRAFFIC LL, + IMPACT, PROVIDING THE BEAM IS OF NO LESS CARRYING CAPACITY THAN WOULD BE REQ'D IF THERE WERE NO SIDEWALKS.)

$(1.5')(.060^{k}/SF) =$ $0.09^{k}/FT$

IMPACT: $I = 50/L+125$

$I = 50/60+125 = 0.270$

IMPACT:

INTERIOR:

$M_I = 0.27(475.84) = 128.48'^{K}$

$V_I = 0.27(35.87) = 9.68^{K}$

EXTERIOR:

TRAFFIC:

$M_I = 0.27(341.15) = 92.11'^{K}$

$V_I = 0.27(25.72) = 6.94^{K}$

WALKWAY

$M_I = 0.27(40.5) = 10.94'^{K}$

$V_I = 0.27(2.7) = 0.73^{K}$

TOTALS:

INTERIOR

$M_{DL+LL+I} = {}^{261+}379.35 + 475.84 + 128.48 = 1244.67'^{K}$

$V_{DL+LL+I} = {}^{17.4+}25.29 + 35.87 + 9.68 = 88.24^{K}$

EXTERIOR (TRAFFIC ONLY)

$M_{DL+LL+I} = {}^{261+}366.3 + 341.15 + 92.11 = 1060.56'^{K}$

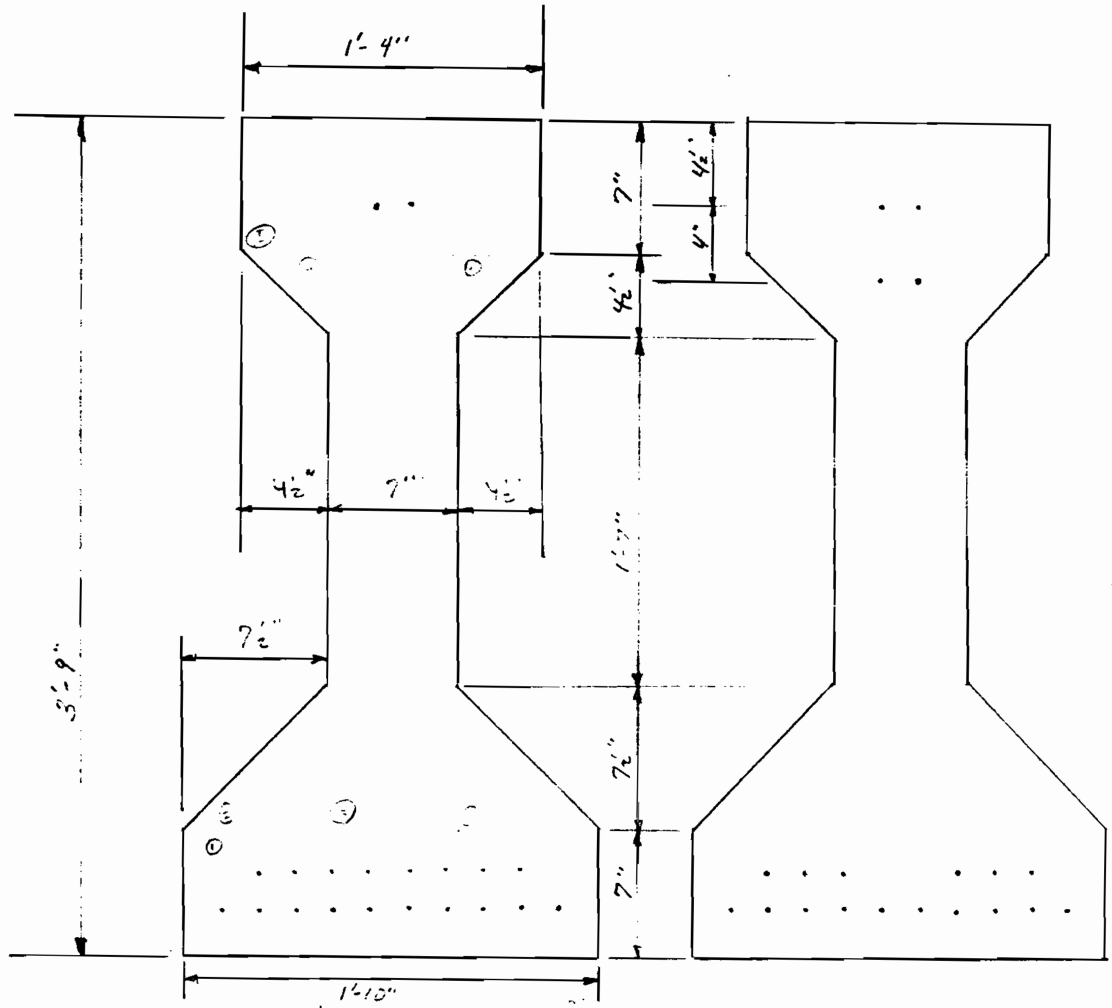
$V_{DL+LL+I} = {}^{17.4+}24.42 + 25.72 + 6.94 = 74.48^{K}$

EXTERIOR (TRAFFIC + WALKWAY, 25% OVERSTRESS)

$M_{DL+LL+I} = 0.8({}^{261+}366.3 + 341.15 + 40.5 + 92.11 + 10.94) = 889.$[illegible]$'^{K}$

$V_{DL+LL+I} = 0.8({}^{17.4+}24.42 + 25.72 + 2.7 + 6.94 + .73) = 62.33^{K}$

∴ INTERIOR GIRDER CONTROLS



section @ ℄ span | section @ end

f'c = 6000 psi
½"ϕ - 270 ksi low-relaxation strands

	A	y	Ay	Ay²	I_o
①	154	3.5	539	1886.5	628.83
②	56.25	9.5	534.375	5076.5625	175.78
③	217	23.5	5099.5	119838.25	17378.08
④	20.25	36.5	739.125	26978.0625	22.78
⑤	112	29.5	3304	97486	457.33
	559.5 in²		10216.0	251 265.375	18662.80

$\bar{y} = 10216.0/559.5 = 18.26"$

$I = 18662.80 + 251265.375 - (18.26)(10216.0)$
$= 83{,}384 \text{ in}^4$

c.g. of strands:

$$\text{℄}: \quad \frac{10(2.5) + 8(4.5) + 2(40.5)}{20} = 7.1$$

$$e = 18.26 - 7.1 = 11.16$$

$$\text{END}: \quad \frac{10(2.5) + 6(4.5) + 2(36.5) + 2(40.5)}{20} = 10.3$$

$$e = 18.26 - 10.3 = 7.96$$

GIRDER:

$$I = 83,384 \text{ in}^4$$

$$S_{TOP} = 83,384/(45 - 18.26) = 3118.3 \text{ in}^3$$

$$S_{BTM} = 83,384/18.26 = 4566.5 \text{ in}^3$$

Allowable Stresses:

Concrete:

f'_c: 6000 psi
f'_{ci}: 0.75(6000) = 4500 psi

INITIAL:

TENSION: $3\sqrt{f'_{ci}} \leq 200$ psi $= 3\sqrt{4500} = 201$ psi - use 200 psi
COMPRESSION: $0.60 f'_{ci} = 0.6(4500) =$ 2700 psi

FINAL:

TENSION 0 psi
COMPRESSION: PRESTRESS + DL - $0.4f'_c$ = [illegible] 2400 psi
LL + ½ (PRESTRESS + DL) - $0.4f'_c$ = 2400 psi
ALL LOAD COMBINATIONS - $0.6f'_c$ = 3600 psi

PRESTRESSING STEEL

½" LOW-RELAXATION STRANDS

INITIAL STRESS: $(.75) f'_s = 0.75(270) =$ 202.5 ksi
FORCE: $20(.1531)(202.5) =$ 620.05^K

FINAL STRESS: $202.5 - 45 = 157.5$ ksi
FORCE: $20(.1531)(157.5) =$ 482.26^K

INITIAL STRESSES:

END:

TOP: $\frac{-620.05}{559.5} + \frac{620.05 * 7.96}{3118.3} = 0.47$ >0.2 N.G.
<0.5 ok

- ADD BONDED REINFORCEMENT, ALLOWABLE INCREASES to $7.5\sqrt{f'_{ci}}$
$= 7.5\sqrt{4500}$
$= 503$ psi

BTM: $\frac{-620.05}{559.5} - \frac{620.05 * 7.96}{4566.5} = -2.19 < -2.7$ ok

@ ℄:

TOP: $\frac{-620.05}{559.5} + \frac{620.05 * 11.16}{3118.3} - \frac{261.0 * 12}{3118.3} = 0.11 < 0.5$ ok

BTM: $\frac{-620.05}{559.5} - \frac{620.05 * 11.16}{4566.5} + \frac{261.0 * 12}{4566.5} = -1.93 < -2.7$ ok

FINAL STRESSES: (PRESTRESS + DL)

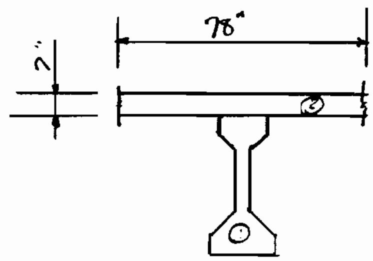
$M_{DL} = 261 + 379.35 = 640.35$

TOP: $\frac{-482.26}{559.5} + \frac{482.26 * 11.16}{3118.3} - \frac{640.35 * 12}{3118.3} = -1.60 < -2.4$ ok

BTM: $\frac{-482.26}{559.5} - \frac{482.26 * 11.16}{4566.5} + \frac{640.35 * 12}{4566.5} = -0.36 < -2.4$ ok

LL + ½(PRESTRESS + DL) $\quad M(LL+I) = 604.32$

- FOR LL, COMPOSITE SECTION MODULUS SHOULD BE USED.



	A	y	Ay	Ay^2	I_o
1	559.5	18.26	10216.47	186552.74	83384
2	546	48.5	26481	1284328.5	2229.5
	1105.5		36697.47	1470881.24	85613.5

$\bar{y} = 36697.47/1105.5 = 33.19$

$I = 85613.5 + 1470881.24 - 33.19(36697.47)$
$= 338506 \ in^4$

$S_{SLAB} = 338506/(52-33.19) = 17996 \ in^3$

$S_{TOP\,GIRDER} = 338506/(45-33.19) = 28663 \ in^3$

$S_{BTM} = 338506/33.19 = 10199 \ in^3$

$e(℄) = 33.19 - 7.1 = 26.09$

FINAL STRESSES (CONT.)

$LL + \frac{1}{2}(PRESTRESS + DL)$

$TOP: \frac{1}{2}\left(\frac{-482.26}{559.5} + \frac{482.26 * 26.09}{28663} - \frac{640.35 * 12}{28663}\right) - \frac{604.32 * 12}{28663} = -0.60$
< -2.4
$\underline{\underline{OK}}$

$BTM: \frac{1}{2}\left(\frac{-482.26}{559.5} - \frac{482.26 * 26.09}{10199} + \frac{640.35 * 12}{10199}\right) + \frac{604.32 * 12}{10199} = 0.04$

- say ok for preliminary

$DL + LL + I$:

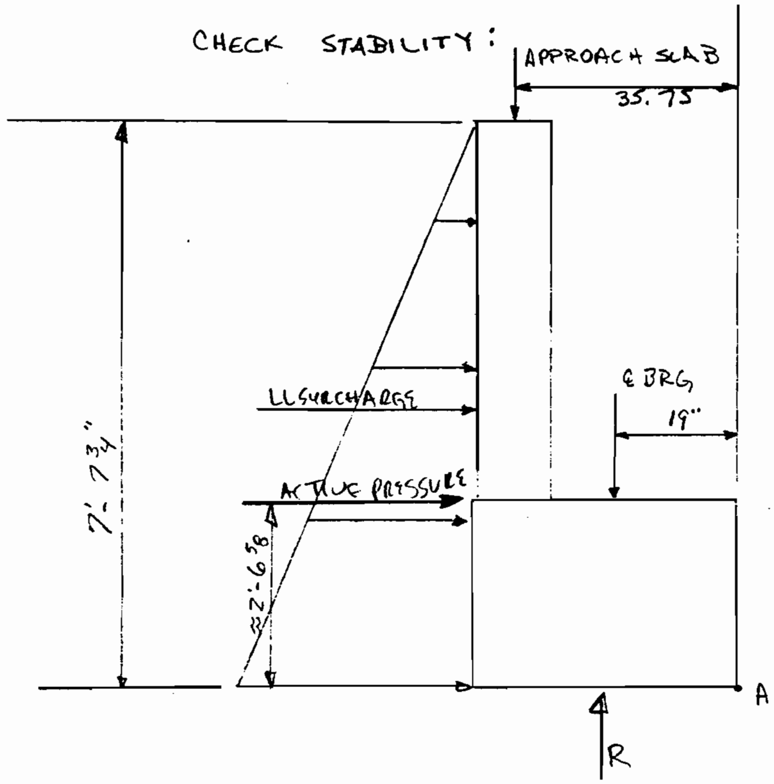
$TOP: \frac{-482.26}{559.5} + \frac{482.26 * 26.09}{28663} - \frac{(640.35 + 604.32)(12)}{28663} = -0.94 < -3.6 \ \underline{\underline{OK}}$

$Btm: \frac{-482.26}{559.5} - \frac{482.26 * 26.09}{10199} + \frac{(640.35 + 604.32)(12)}{10199} = -0.63 < -3.6 \ \underline{\underline{OK}}$

Substructure:

REQ'D ABUTMENT:

CHECK STABILITY:



60' SPAN DL = $225^k/45'$ = $5^k/FT$

60' SPAN LL = $121.6^k/45'$ = $2.70^k/FT$

APPROACH SLAB DL = $35/28'$ = $1.25^k/FT$

ACTIVE PRESSURE: $\frac{1}{2}\gamma H^2 K_o$

$K_o = 1-\sin\phi$, use $33° = \phi$

$K_o = 1 - \sin 33$

$= 0.455$

$= \frac{1}{2}(.120)(7.646)^2(.455)$

$= 1.60\ ^k/FT$

LL SURCHARGE = $H_s \gamma' K_o$

$= (2')(.12)(.455)$

$= 0.11\ ^k/FT$

MOMENTS ABOUT A: (↶ +)

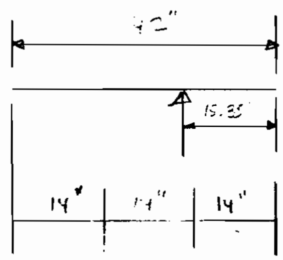
$$R(x) = (5^k/_{FT})(\tfrac{12}{12}) + (2.7^k/_{FT})(\tfrac{14}{12}) + (1.25^k/_{FT})(\tfrac{35.75}{12}) - (1.6^k/_{FT})(2.55) - (0.11)(3.82)$$

$$R(x) = 11.41$$

$$R = 5 + 2.7 + 1.25 = 8.95\ ^k/_{FT}$$

$$x = 11.41/8.92 = 1.28' = 15.35''$$

-should fall into middle 1/3 of [illegible]. ok



-ASSUME 5 PILES

LOAD/PILE: $255 + 121.6 + 35 = 411.6 = 82.32^k/_{PILE}$

-use [illegible] pile tip elev. [illegible] existing bridge = -81.73 NGVD

-pile ≈ 81'

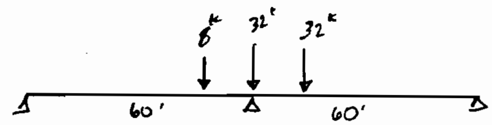
16" ⌀PPC – capacity = ~~50~~ 100 TONS = ~~100~~^{k} 200 > 82.32 ok

MODIFY EXISTING ABUTMENT TO BECOME INTERIOR BENT

- ADD 2 PILES to BRING TOTAL TO 7

DL – 2-60' SPANS · $2(225) = 450^k$

LL –



PIER REACTION $= (32) + (32)\left(\frac{46'}{60}\right) + (8)\left(\frac{46'}{60}\right)$
$= 62.67^k$ PER LANE

TOTAL $= 2(62.67) = 125.34^k$

LOAD/PILE $= (450 + 125.34)/7 = 82.19^k$/PILE

- NECESSITY OF ADDING PILES TO BE DETERMINED BY SOILS REPORT.

Capacity of existing piles = 87 TONS
$= 174^k$

if use only 5 piles: $(450 + 125.34)/5$

$= 115.1^k < 174$

BRIDGE ELEVATIONS:

SURVEY TOP OF SLAB (HIGH SIDE) = 7.65
(LOW SIDE) = 7.09

BRIDGE DWGS TOP OF SLAB (HIGH SIDE) = 7.52
(LOW SIDE) = 6.96

DIFFERENCES: 7.65 - 7.52 : 0.13'
7.09 - 6.96 : 0.13'

∴ ADD 0.13' to ELEVS. ON PLANS.

		PLANS	+.13
ABUTMENT PEDESTALS:	A	2.98	3.11
	B	2.85	2.98
	C	2.72	2.85
	D	2.59	2.72
	E	2.46	2.59

DESTRAHAN AVE. BRIDGE

DEAD LOADS:

60' SPANS:

SLAB: $(\frac{7''}{12})(31.5')(.150\,^k/_{ft^3})$ = $2.76\,^k/_{ft}$

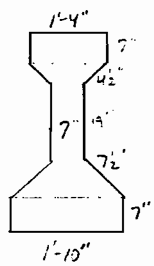
HAUNCHES: $[(\frac{1.5}{12})(3.417')(2) + (\frac{1.5}{12})(1.333')(3)](.150)$ = $0.20\,^k/_{ft}$

BARRIERS: $[(\frac{10}{12})(1.5) + (\frac{6}{12})(1) + \frac{1}{2}(\frac{6}{12})(1)](2)(.15)$ = $0.6\,^k/_{ft}$

$(2)(1.0')(1.0')(.15)$ = $0.3\,^k/_{ft}$

$(2)(1.25)(1.0)(\frac{11}{12})(8)(.15)(\frac{1}{60})$ = $0.05\,^k/_{ft}$

GIRDERS: $(5)(3.88)(.15)$ = $2.91\,^k/_{ft}$



$A = (1.33)(.583) + (.83)(.583) + (.583)(2.583) + (.375)(.375) + (.625)(.625) = 3.88\ ft^2$

$6.82\,^k/_{ft}$

+10% misc (diaphragms, handrails, end dams, ...) 0.68

TOTAL (SUPERSTRUCTURE): $7.5\,^k/_{ft}$

END REACTION = $(7.5)(60)(\frac{1}{2})$ = $\underline{225^k}$

80' SPAN:

- DL/FOOT SAME AS 60' SPAN

END REACTION = $(7.5)(80)/2 = 300^k$

SUBSTRUCTURE:

INTERIOR BENT CAPS:

$(2.5')(3.5')(33')(.15) = \quad 43.31^k$

PEDESTALS: use avg 8 C & C'

$(5)(3.167)(3')(2.71-2.09)(.15) = \underline{4.42^k}$

47.73^k

ABUTMENTS:

$[(2.5)(3.5)+(2.03)(0.958)](45)(.15) = \quad 72.19^k$

$(2)(8.417)(\frac{1}{2})(2.833)(.958)(.15) = \quad 3.43^k$

$(29')(1.67')(.958)(.15) = \quad 6.86^k$

PEDESTALS: $\underline{4.42^k}$

87.0^k

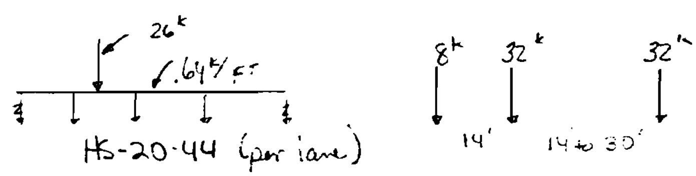
LIVE LOADS:
(use HS 20-44) (per lane)

$60'$ end shear $= 60.8^k$

$28'$ roadway gives 2 lanes

LL Reaction $= 2(60.8) = 121.6^k$ @ abutment

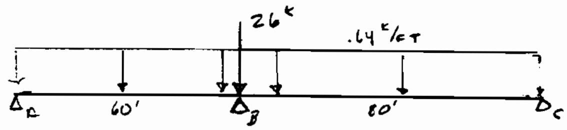
PIER REACTION @ Bent: 60's span - 80's span



HS-20-44 (per lane)

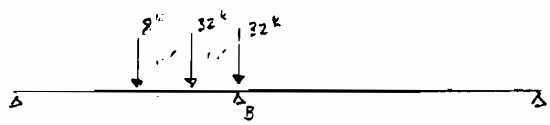
PIER REACTION: (cont.)

Lane Loading:

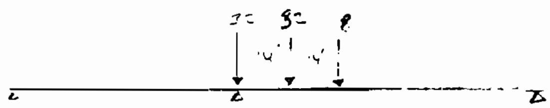


$R_B = (.64)(30+40) + 26$
$= 70.8^k$

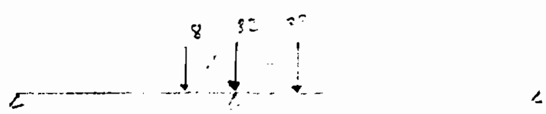
truck loading:



$R_B = 32 + 32\left(\frac{46}{60}\right) + 8\left(\frac{32}{60}\right) = 60.8^k$



$R_B = 32 + 32\left(\frac{66}{80}\right) + 8\left(\frac{52}{80}\right) = 63.6^k$



$R_B = 32 + 8\left(\frac{46}{60}\right) + 32\left(\frac{64}{80}\right) = 64.5^k$

LL PIER REACTION FOR 2 LANES = 129.0^k

APPROACH SLABS:

20' APPROACH SLABS:

$\left(\frac{10''}{12}\right)(28')(.15) = \quad 3.5^k/FT$

DL Reaction : $(20)(3.5)(\tfrac{1}{2}) = 35^k$

EXISTING PILE LOADS:

ABUTMENTS: $225^k + 35^k + 87^k + 121.6^k = \frac{468.6^k}{5\ PILES} = 93.72\ ^k/PILE$

BENTS: $300^k + 225 + 47.73 + 129.0 = \frac{701.73^k}{7\ PILES} = 100.25\ ^k/PILE$

- ALL PILES ARE 16" ϕ
- MAX DESIGN LOAD = 54^T = $10?^k$

DESTRAHAN AVE BRIDGE :

EL. TOP OF BENTS & ABUTS. = 2.09 (ALL SAME)

MIN. PEDESTAL ELEV. = 2.44'

BEARING PAD = 3/4" (60' GIRDERS)
= 1" (80' GIRDERS) ←

GIRDER HEIGHT = 3'-9"

HAUNCH = 1/2"

SLAB = 7"

HEIGHT OF WALKWAY
+HANDRAIL = 10" + 1'3" + 1'0"
+9".5"
= 4'-0

AS BUILT ELEV OF SLAB = $2.44 + \frac{1}{12} + 3.75 + \frac{8.5}{12}$

= 6.98 (MIN. ELEV.)

SURVEY ELEV OF SLAB = 7.09' (MIN. ELEV.)

DIFFERENCE = 7.09 − 6.98 = +0.11'

EQ. SURVEY ELEV OF BTM GIRDER = $2.44 + \frac{1}{12} + 0.11$
= 2.63

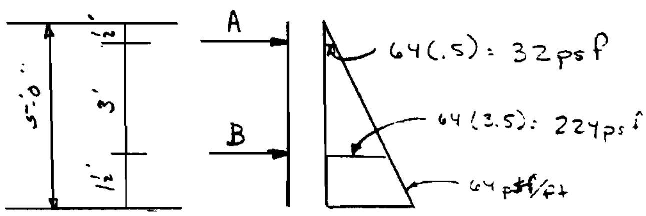
PEDESTAL HT

EQ. SURVEY ELEV BTM BENT CAP = $2.63 - \frac{1}{12} - 2.5 - 0.35$
= −0.30

DESIGN CALCULATIONS

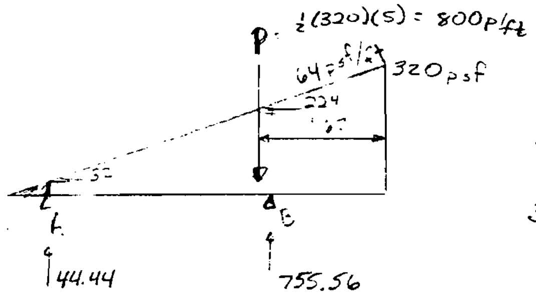
FLOOD GATE

BEAM DESIGN:



$p = 8H$
$= 64\#/cf\,(5')$
$= 320\text{ psf}$

SWL+2':



Reactions: (... A) (↺+)

$0 = -3B - (\tfrac{1}{2})(32)(.5)^2/3 + 32(4.5)^2/2 + (320-32)(\tfrac{1}{2})(4.5)^2(\ldots)$

$3B = -1.33 + 324 + 1?44$

$B = 755.56$

$A = 800 - 755.56 = 44.44$

CANTILEVER MOMENTS

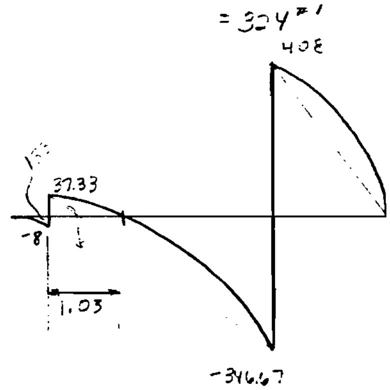
$M_A = \tfrac{1}{2}(32)(.5)^2/3 = 1.33\,\#'$

$M_B = (224)(1.5)^2/2 + \ldots$

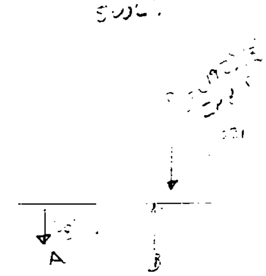
$= 252 + 72$

$= 324\,\#'$

V



SWL:



$M_B = (5)(288) - 3A = 0$

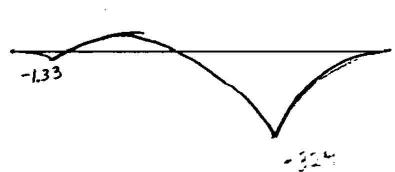
$\ldots = 3A$

$48\ldots A$

$\ldots 288 - 48 = \ldots$

∴ SWL+2' CONTROLS

M



BEAM B:

span length: 40' + 3.5' = 43.5'

$M = \frac{1}{8}(754.67)(43.5)^2/1000$
$= 178.5'^K$

-use A36 steel, $F_b = 20$ ksi

$F = M/S$

$20ksi = 178.5(12)/S_{REQ'D}$

$S_{REQD} = 107.1 in^3$

-use W18 x 71
$S_{xx} = 127 in^3$
$I_{xx} = 1170 in^4$

$f_b = 178.5(12)/127$
$= 16.86 < 20$ ok

-Check deflection

12-15-97

$\Delta = \left(\frac{5}{384}\right)\frac{wl^4}{EI}$

$\Delta = \left(\frac{5}{384}\right)(.754)(43.5*12)^4/29000(1170)$

$\Delta = \frac{21.48''}{12}$ ~~N.G.~~
$= 1.79''$

- try W24x94
$S = 222$
$I = 2700$

$f_b = 178.5(12)/222$
$= 9.65 < 20$ ok

$\Delta = \left(\frac{5}{384}\right)(.754)(43.5*12)^4/29000(2700)$

$= 9.3''$ N.G.

keep $\Delta < l/400$ $(43.5)(12)/400 = 1.31''$

$1.31 = \left(\frac{5}{384}\right)\left(\frac{.754}{12}\right)(43.5*12)^4/29000(I_{REQ'D})$

$I_{REQ'D} = $ ~~1798~~ in^4
$1599 in^4$

12-15-97

$I_{REQ'D} = 1599 in^4$

- use W33x—, W33 req'd for wheel spacing

W33x118 $I = 5900$ (smallest W33)

Top BEAM "A"

$M = \frac{1}{8}(.044)(43.5)^2$
$= 10.64$ #'

find $I_{REQ'D}$:

$1.31 = \left(\frac{5}{384}\right)\left(\frac{.045}{12}\right)(43.5 \ast 12)^4 / 29000 (I_{REQ'D})$
$I_{REQD} = 95.4$

Revised 12-15-97

– use W ~~36x300~~

$S = 1110 \text{ in}^3$
$I = 20300 \text{ in}^4$

$f_b = 178.5(12)/1110 = 1.93 < 20$ ok

$\Delta = \frac{5}{384}(.754)(43.5*12)^4/29000(20300)$

$= 1.24''$ ok

– use W18x97

$I = 1750 \text{ in}^4$
$S = 188$

$f_b = \frac{(178.5)(12)}{188}$

$= 11.4 < 20$ ok

$\Delta = \frac{\frac{5}{384}\left(\frac{.754}{12}\right)(43.5*12)^4}{29000(1750)}$

$\Delta = 1.20''$ ok

TOP BEAM - "A"

$M = \frac{1}{8}(.045)(43.5)^2$
$= 10.64$

And $I_{REQ'D}$:

$1.31 = (\frac{5}{384})(.045)(43.5*12)^4/29000(I_{REQ'D})$

$= 1145 \text{ in}^4$

~~– use W36x135~~

~~$S = 439 \text{ in}^3$~~
~~$I = 7800 \text{ in}^4$~~

~~$f_b = (10.64)(12)/439$~~
~~$= 0.29$ ksi < 20 ok~~

~~$\Delta = \frac{5}{384}(.045)(43.5*12)^4/29000(7800)$~~
~~$= 0.19'' < 1.31$ ok~~

use W18x71

$S = 127$
$I = 1170$

$f_b = (10.64)(12)/127$
$= 1.0$ ksi < 20 ok

$\Delta = \frac{\frac{5}{384}\left(\frac{.045}{12}\right)(43.5*12)^4}{29000(1170)}$

$\Delta = 0.11''$ ok

SKIN PL:

$M_{max} = .324^{1K}$ (p. 2)

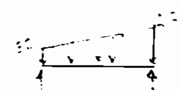
$S_{REQ'D} = .324(12)/20$
$= 0.1944 \, in^3$

try $\frac{5}{16}''$ PL: $S = \frac{1}{6}(12)(\frac{5}{16})^2 = 0.195 \, in^3$ ok

try $\frac{3}{8}''$ PL: $S = \frac{1}{6}(12)(\frac{3}{8})^2 = 0.281 \, in^3$ ← ~~use $\frac{3}{8}''$ PL~~

$f_b = .324(12)/.281$
$= 13.84$ ksi < 20 ok

· try 3' simple span



$M_{max} = .1283 W \ell + \frac{wx}{2}(\ell - x)$

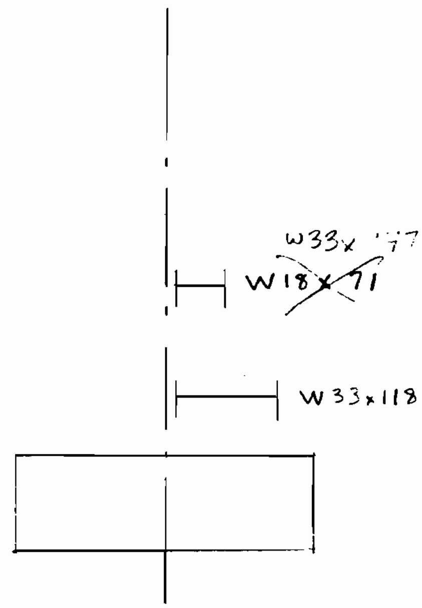
$x = .5774 \ell = .5774(3) = 1.732'$

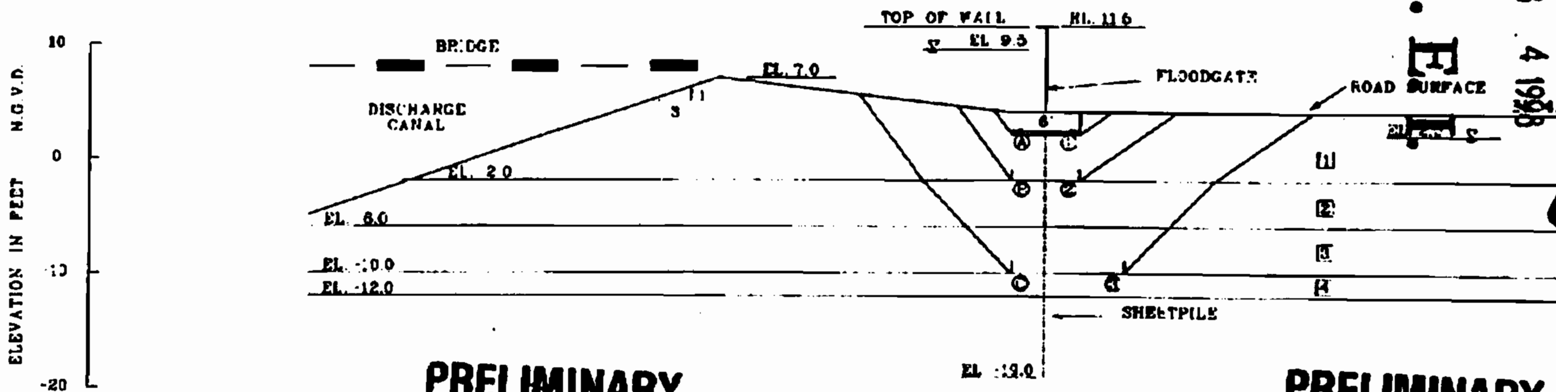
$M_{max} = .1283(\frac{1}{2})(224-32)(3)(3) + \frac{32(1.732)}{2}(3 - 1.732)$

$= 110.85 + 35.14 = 145.$[illegible] $< 324^{\#}$

– DESIGN PILES, FOOTING, WHEN SOILS REPORT IS IN

JN 3003	DESTRAHAN AVE FLOODGATE	AAH	4-9-98





PRELIMINARY

PRELIMINARY

RECEIVED
FEB 4 1998
D.E.

STRATA NO.	SOIL TYPE	UNIT WEIGHT PCF	UNFACTORED FRICTION ANGLE DEGREES	UNFACTORED COHESION - PSF AVERAGE	UNFACTORED COHESION - PSF BOTTOM	SAFETY FACTOR OF 1.3 FRICTION ANGLE DEGREES	SAFETY FACTOR OF 1.3 COHESION - PSF AVERAGE	SAFETY FACTOR OF 1.3 COHESION - PSF BOTTOM
1	FILL-CLAY, SAND & SHELL	120	25	0	0	20	0	0
2	CLAY	95	0	260	260	0	200	200
3	CLAY	90	0	235	220	0	181	169
4	CLAY	90	0	220	220	0	169	169

SUMMATION OF FORCES (USING FACTORED SLOPE STRENGTHS)

FAILURE SURFACE		ΣR RESISTANCE LBS/FT	ΣD DRIVING LBS/FT	ΣR - ΣD	CHANGE IN NET FORCE, LB
A	1	628	1641	-1013	-
B	2	3122	3098	24	1037
C	3	10285	6455	3830	3806

Post-it™ Fax Note 7671	Date 2/5/98 # of pages 1
To DET	From L. Spangler
Co./Dept. April Hurry	Co. Eustis Eng
Phone #	Phone # 834 0157
Fax #	Fax #

NOTE: 1) ANALYSIS INDICATES NO UNBALANCED FORCE BENEATH THE FLOODGATE FOOTING TO MAINTAIN STABILITY WITH RESPECT TO A FACTOR OF SAFETY OF 1.3.

2) SHEETPILE CUT OFF MUST PENETRATE TO EL. -19.0 OR BELOW TO HAVE A FACTOR OF SAFETY OF 2 OR GREATER AGAINST PIPING.

3) SOIL PARAMETERS ARE TAKEN FROM FIGURE 6 OF 7 OCTOBER 1997 REPORT.

4) THIS DRAWING IS A REVISION OF FIGURE 39 OF THE REFERENCED REPORT REFLECTING A RAISED STORM WATER LEVEL.

10' 0 10'

SCALE

FLOODGATE STABILITY ANALYSIS
DESTREHAN AVENUE

WEST JEFFERSON LEVEE DISTRICT
COUSINS PUMP STATION TO FIRST AVENUE CANAL
HARVEY, LOUISIANA

SUBSTRUCTURE:

GATE MONOLITH FORCES:

WT OF ROLLER GATE:

BEAM W33x118 : 118 x 47 = 5546 #
SKIN PL 3/8 x 60' x 47' = 3596 #
9142

+ 15% MISC : 1371
10,513 #

- use 11 K

TRAFFIC LOADS:

- REMAIN THE SAME

WATER LOADS:

water @ SWL + 2' : (64)(7+2.5) = 608 PSF (.75) = 456 PSF
water @ SWL : (64)(5+2.5) = 480 PSF

WIND LOADS: 50 PSF FOR HURRICANE WIND:

AREA = (54')(7') = 378 SF

FORCE = 378(50) = 18900 #

GATE MONOLITH FORCE TABULATIONS

ITEM	COMPUTATIONS	FORCES IN KIPS F_x	F_y	F_z	LEVER ARM, FT x	y	z	MOMENTS IN FT·K $M_{x\text{-}x}$	$M_{y\text{-}y}$	$M_{z\text{-}z}$
I DEAD LOADS										
① COLUMNS (2 EA)	(3.5')(2.75')(7')(.150)(2)			20.21	1.625				-32.84	
	(3.5')(1.75')(7')(.150)(2)			12.86	1.375				-17.68	
	(½)(.25')(3.5')(7')(.150)(2)			0.92	0.42				-0.39	
② FOOTING	(8.5')(2.5')(54.0')(.150)			172.12						
③ GATE OPEN ⅓ wt 1.0' from end	⅓(11) =			3.67	-1.75'	-19.0'		-69.73	6.42	
Ia	Σ LOADING, GATE OPEN			209.78				-69.73	-44.49	
④ GATE CLOSED				11.0	-1.75				19.25	
Ib	Σ LOADING, GATE CLOSED			217.11					-31.66	
II WATER @ 11.5 (SILL+2') HYDROSTATIC [illegible]	(½)(.61)(9.5')(54')	156.47					3.17		-496.0	
WATER WT	(1')(7')(54')(.064)			24.19	-3.75				+90.71	
BUOYANCY IMPERVIOUS (a)	(.61)(4.25)(54)			-140.0	-2.125				-297.50	
PERVIOUS (b)	(.61)(½)(8.5)(54)			-140.0	-1.417				-198.38	

JN 3003

COUSINS PUMP STATION

FLOODGATE

AAH

2-5-98

4

National Brand

GATE MONOLITH FORCE TABULATIONS

ITEM	COMPUTATIONS	FORCES IN KIPS F_x	F_y	F_z	LEVER ARM, FT x	y	z	MOMENTS IN FT-K M_{x-x}	M_{y-y}	M_{z-z}
II (a)	WATER [illegible]	[illegible]		-115.2[illegible]					-702.79	
II (b)	WATER [illegible]	[illegible]		-115.21					-603.67	
III WATER [illegible]										
HYDROSTATIC [illegible]	[illegible]	97.2					2.5		-243.0	
WATER WT	(1')(5')(54')(.064)			17.28	-3.75				+64.8	
BUOYANCY: [illegible]	(1.2)(11.5)(.54)			-110.16	-2.125				-234.09	
[illegible]	[illegible] (.54)			-110.16	-1.417				-156.10	
III (a)	WATER [illegible]	[illegible]		[illegible]					-412.29	
III (b)	WATER [illegible]	[illegible]		[illegible]					-334.3	
IV WIND										
(a) [illegible]	[illegible]	-18.9					3.5		+66.15	
(b) [illegible]	[illegible]	18.9					3.5		-66.15	
V TIMBER [illegible]										
(a) [illegible]	[illegible]			86.4	4.25	-1.0		-86.4	-367.2	
(b) [illegible]	[illegible]			86.4	-4.25	-1.0		-86.4	+367.2	

CU 3003

FLOODGATE

AAF

2-5-98

4/5

LOAD COMBINATIONS

LOADING CASE	DESCRIPTION	FORCES F_x	FORCES F_z	MOMENTS M_y
I	GATE CLOSED, WATER @ SWL, NO WIND, IMPERVIOUS S/P 100% FORCES			
	I (b)		217.11	-31.66
	III (a)	97.2	-92.88	-412.29
	TOTAL	97.2	124.23	-443.95
II	GATE CLOSED, WATER @ SWL, NO WIND, PERVIOUS S/P 100% FORCES			
	I (b)		217.11	-31.66
	III (b)	97.2	-92.88	-334.3
	TOTAL	97.2	124.23	-365.96
III	GATE CLOSED, WATER @ SWL+2', NO WIND, IMPERVIOUS S/P (75% FORCES)			
	I (b)		217.11	-31.66
	II (a)	156.47	-115.81	-702.79
	TOTAL	156.47	101.30	-734.45
	75% TOTAL	117.35	75.98	-550.84
IV	GATE CLOSED, WATER @ SWL-2 NO WIND, PERVIOUS S/P (75% FORCES)			
	I (b)		217.11	-31.66
	II (b)	156.47	-115.81	-603.67
	TOTAL	156.47	101.30	-635.33
	75% TOTAL	117.35	75.98	-476.50
V	GATE CLOSED, WIND FROM P/S (75%)			
	I (b)		217.11	-31.66
	IV (a)	-18.9		+66.15
	TOTAL	-18.9	217.11	34.49
	75% TOTAL	-14.18	162.83	25.87
VI	GATE CLOSED, WIND FROM F/S (75%)			
	I (b)		217.11	-31.66
	IV (b)	18.9		-66.15
	TOTAL	18.9	217.11	-97.81
	75% TOTAL	14.18	162.83	-73.36

JOB NO. [illegible]	FLOOD GATE	AAH	2-5-98

LOAD COMBINATIONS

LOADING CASE	DESCRIPTION	FORCES F_x	F_z	MOMENTS M_y	M_x
VII	GATE OPEN, NO WIND, TRUCKS ON F/S (100% FORCES)				
	I(a)		209.78	-44.49	-69.73
	I(a)		86.4	-367.2	-86.4
	TOTAL		296.18	-411.39	-156.13
VII	GATE OPEN, NO WIND, TRUCKS ON F/S (100% FORCES)				
	I(a)		209.78	[illegible]	-69.73
	V(b)		86.4	[illegible]	-86.4
			296.18	[illegible]	-156.[illegible]

* [illegible] SAME PILE [illegible]
[illegible] NG

ADD 2 PILES
[illegible] side

[illegible] 45' [illegible]

[illegible]

```
1010 DESTREHAN AVENUE FLOODGATE
1020 PROP 4030 3201 3201 196 2 0 ALL
1030 SOIL ES 0.866 LEN 68 0 ALL
1040 PIN ALL
1050 DLS S 78 48 600.2 223.1 132.6 1510.0 1166.8 H 14 ALL
1060 ASC S 196 457 0.816 0.856 2 0 ALL
1070 BATTER 2 1 2 7 8 9 12 13 14
1080 ANGLE 0 1 2 3 4 5 6 7 14
1090 ANGLE 180 8 9 10 11 12 13
1100 PILE 1 -2.75 -24.5 0
1110 PILE 2 -2.75 -17.5 0
1120 PILE 3 -2.75 -10.5 0
1130 PILE 4 -2.75 -3.5 0
1140 PILE 5 -2.75 3.5 0
1150 PILE 6 -2.75 10.5 0
1160 PILE 7 -2.75 17.5 0
1170 PILE 8 2.75 -22.5 0
1180 PILE 9 2.75 -13.5 0
1190 PILE 10 2.75 -4.5 0
1192 PILE 11 2.75 4.5 0
1194 PILE 12 2.75 13.5 0
1196 PILE 13 2.75 22.5 0
1198 PILE 14 -2.75 24.5 0
1200 LOAD 1 97.2 0 124.23 0 -443.95 0
1210 LOAD 2 97.2 0 124.23 0 -365.96 0
1220 LOAD 3 117.35 0 75.98 0 -550.84 0
1230 LOAD 4 117.35 0 75.98 0 -476.5 0
1240 LOAD 5 -14.18 0 162.83 0 25.87 0
1250 LOAD 6 14.18 0 162.83 0 -73.36 0
1260 LOAD 7 0 0 296.18 -156.13 -411.39 0
1270 LOAD 8 0 0 296.18 -156.13 322.71 0
1280 FOUT 1 2 3 4 5 6 7 FGATEOUT
1290 PFO ALL
1300 FPL N
```

```
********  .*********************
* CORPS PROGRAM  #  X0080     *   CPGA - CASE PILE GROUP ANALYSIS PROGRAM
* VERSION NUMBER # 86/09/02-A *   RUN DATE 07-13-98    RUN TIME 16:16:24
********************************

DESTRAHAN AVENUE FLOODGATE

THERE ARE  14 PILES AND
            8 LOAD CASES IN THIS RUN.

ALL PILE COORDINATES ARE CONTAINED WITHIN A BOX
                                             X          Y          Z
                                           -----      -----      -----
WITH DIAGONAL COORDINATES = (              -2.75 ,   -24.50 ,      .00 )
                            (               2.75 ,    24.50 ,      .00 )

********************************************************************************

         PILE PROPERTIES AS INPUT

      E             I1            I2            A            C33           B66
     KSI          IN**4         IN**4        IN**2
  .40300E+04    .32010E+04    .32010E+04    .19600E+03    .20000E+01    .00000E+00

THESE PILE PROPERTIES APPLY TO THE FOLLOWING PILES -

    ALL

********************************************************************************

         SOIL DESCRIPTIONS AS INPUT

   ES      ESOIL       LENGTH         L             LU
         K/IN**2                      FT            FT
         .86600E+00      L        .68000E+02    .00000E+00

THIS SOIL DESCRIPTION APPLIES TO THE FOLLOWING PILES -

    ALL

********************************************************************************

         PILE GEOMETRY AS INPUT AND/OR GENERATED

NUM        X          Y          Z      BATTER    ANGLE    LENGTH  FIXITY
           FT         FT         FT                          FT

  1      -2.75     -24.50       .00      2.00       .00     68.00     P
  2      -2.75     -17.50       .00      2.00       .00     68.00     P
  3      -2.75     -10.50       .00       V         .00     68.00     P
  4      -2.75      -3.50       .00       V         .00     68.00     P
  5      -2.75       3.50       .00       V         .00     68.00     P
  6      -2.75      10.50       .00       V         .00     68.00     P
```

7	-2.75	17.50	.00	2.00	.00	68.00	P
8	2.75	-22.50	.00	2.00	180.00	68.00	P
9	2.75	-13.50	.00	2.00	180.00	68.00	P
10	2.75	-4.50	.00	V	180.00	68.00	P
11	2.75	4.50	.00	V	180.00	68.00	P
12	2.75	13.50	.00	2.00	180.00	68.00	P
13	2.75	22.50	.00	2.00	180.00	68.00	P
14	-2.75	24.50	.00	2.00	.00	68.00	P

						952.00	

****

APPLIED LOADS

LOAD CASE	PX K	PY K	PZ K	MX FT-K	MY FT-K	MZ FT-K
1	97.2	.0	124.2	.0	-444.0	.0
2	97.2	.0	124.2	.0	-366.0	.0
3	117.3	.0	76.0	.0	-550.8	.0
4	117.3	.0	76.0	.0	-476.5	.0
5	-14.2	.0	162.8	.0	25.9	.0
6	14.2	.0	162.8	.0	-73.4	.0
7	.0	.0	296.2	-156.1	-411.4	.0
8	.0	.0	296.2	-156.1	322.7	.0

****

ORIGINAL PILE GROUP STIFFNESS MATRIX

.35693E+04	.13274E-03	.00000E+00	.00000E+00	.20042E+06	.78125E-02
.13274E-03	.53260E+03	-.26548E-03	.00000E+00	.87607E-02	-.25108E+04
.00000E+00	-.26548E-03	.24067E+05	.12500E+00	.12777E+06	.00000E+00
.00000E+00	.00000E+00	.12500E+00	.79454E+09	-.30000E+01	-.47664E+08
.20042E+06	.87607E-02	.12777E+06	-.20000E+01	.26209E+08	.50000E+00
.78125E-02	-.25108E+04	.00000E+00	-.47664E+08	-.15000E+01	.19399E+09

LOAD CASE 1. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 8.

LOAD CASE 2. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 8.

LOAD CASE 3. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 8.

LOAD CASE 4. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 8.

LOAD CASE 5. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

LOAD CASE 6. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

LOAD CASE 7. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 4.

LOAD CASE 8. NUMBER OF FAILURES = 0. NUMBER OF PILES IN TENSION = 0.

****

-ILE CAP DISPLACEMENTS

LOAD CASE	DX IN	DY IN	DZ IN	RX RAD	RY RAD	RZ RAD
1	.7225E-01	-.1739E-09	.9418E-02	-.5131E-11	-.8017E-03	-.1037E-10
2	.6857E-01	-.5048E-09	.9070E-02	-.4784E-11	-.7361E-03	-.9635E-11
3	.8638E-01	-.1818E-08	.8216E-02	-.5625E-11	-.9528E-03	-.1225E-10
4	.8287E-01	-.2133E-08	.7884E-02	-.5295E-11	-.8903E-03	-.1155E-10
5	-.4925E-02	.4277E-08	.6676E-02	-.9775E-12	.1696E-04	.1447E-12
6	.1397E-01	.3279E-08	.7711E-02	-.2029E-11	-.1780E-03	-.2395E-11
7	.2560E-01	-.2764E-05	.1473E-01	-.2393E-05	-.4559E-03	-.5881E-06
8	-.9046E-02	-.2767E-05	.1145E-01	-.2393E-05	.1611E-03	-.5881E-06

****

PILE FORCES IN LOCAL GEOMETRY

M1 & M2 NOT AT PILE HEAD FOR PINNED PILES
* INDICATES PILE FAILURE
# INDICATES CBF BASED ON MOMENTS DUE TO
(F3*EMIN) FOR CONCRETE PILES
B INDICATES BUCKLING CONTROLS

LOAD CASE - 1

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	2.7	.0	33.1	.0	-77.7	.0	.42	.21	1.19	.81	
2	2.7	.0	33.1	.0	-77.7	.0	.42	.21	1.19	.81	
3	2.7	.0	-33.0	.0	-77.8	.0	.69	.58	.86	.48	
4	2.7	.0	-33.0	.0	-77.8	.0	.69	.58	.86	.48	
5	2.7	.0	-33.0	.0	-77.8	.0	.69	.58	.86	.48	
6	2.7	.0	-33.0	.0	-77.8	.0	.69	.58	.86	.48	
7	2.7	.0	33.1	.0	-77.7	.0	.42	.21	1.19	.81	
8	-3.1	.0	-.4	.0	86.8	.0	.01	.21	1.04	.62	
9	-3.1	.0	-.4	.0	86.8	.0	.01	.21	1.04	.62	
10	-2.7	.0	69.4	.0	77.8	.0	.89	.29	1.38	1.00	#
11	-2.7	.0	69.4	.0	77.8	.0	.89	.29	1.38	1.00	#
12	-3.1	.0	-.4	.0	86.8	.0	.01	.21	1.04	.62	
13	-3.1	.0	-.4	.0	86.8	.0	.01	.21	1.04	.62	
14	2.7	.0	33.1	.0	-77.7	.0	.42	.21	1.19	.81	

LOAD CASE - 2

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI
1	2.6	.0	33.0	.0	-73.3	.0	.42	.21	1.18	.82
2	2.6	.0	33.0	.0	-73.3	.0	.42	.21	1.18	.82
3	2.6	.0	-29.5	.0	-73.8	.0	.61	.53	.87	.50
4	2.6	.0	-29.5	.0	-73.8	.0	.61	.53	.87	.50
5	2.6	.0	-29.5	.0	-73.8	.0	.61	.53	.87	.50
6	2.6	.0	-29.5	.0	-73.8	.0	.61	.53	.87	.50

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
7	2.6	.0	33.0	.0	-73.3	.0	.42	.21	1.18	.82	
8	-2.9	.0	-1.6	.0	82.1	.0	.03	.21	1.03	.63	
9	-2.9	.0	-1.6	.0	82.1	.0	.03	.21	1.03	.63	
10	-2.6	.0	64.6	.0	73.8	.0	.83	.25	1.35	.98	#
11	-2.6	.0	64.6	.0	73.8	.0	.83	.25	1.35	.98	#
12	-2.9	.0	-1.6	.0	82.1	.0	.03	.21	1.03	.63	
13	-2.9	.0	-1.6	.0	82.1	.0	.03	.21	1.03	.63	
14	2.6	.0	33.0	.0	-73.3	.0	.42	.21	1.18	.82	

LOAD CASE - 3

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	3.3	.0	34.6	.0	-94.3	.0	.44	.24	1.24	.79	
2	3.3	.0	34.6	.0	-94.3	.0	.44	.24	1.24	.79	
3	3.3	.0	-45.0	.0	-93.0	.0	.94	.76	.83	.38	
4	3.3	.0	-45.0	.0	-93.0	.0	.94	.76	.83	.38	
5	3.3	.0	-45.0	.0	-93.0	.0	.94	.76	.83	.38	
6	3.3	.0	-45.0	.0	-93.0	.0	.94	.76	.83	.38	
7	3.3	.0	34.6	.0	-94.3	.0	.44	.24	1.24	.79	
8	-3.6	.0	-6.1	.0	102.2	.0	.13	.31	1.05	.56	
9	-3.6	.0	-6.1	.0	102.2	.0	.13	.31	1.05	.56	
10	-3.3	.0	76.8	.0	93.0	.0	.98	.35	1.45	1.00	#
11	-3.3	.0	76.8	.0	93.0	.0	.98	.35	1.45	1.00	#
12	-3.6	.0	-6.1	.0	102.2	.0	.13	.31	1.05	.56	
13	-3.6	.0	-6.1	.0	102.2	.0	.13	.31	1.05	.56	
14	3.3	.0	34.6	.0	-94.3	.0	.44	.24	1.24	.79	

LOAD CASE - 4

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	3.2	.0	34.5	.0	-90.1	.0	.44	.23	1.23	.79	
2	3.2	.0	34.5	.0	-90.1	.0	.44	.23	1.23	.79	
3	3.2	.0	-41.6	.0	-89.2	.0	.87	.71	.84	.41	
4	3.2	.0	-41.6	.0	-89.2	.0	.87	.71	.84	.41	
5	3.2	.0	-41.6	.0	-89.2	.0	.87	.71	.84	.41	
6	3.2	.0	-41.6	.0	-89.2	.0	.87	.71	.84	.41	
7	3.2	.0	34.5	.0	-90.1	.0	.44	.23	1.23	.79	
8	-3.5	.0	-7.2	.0	97.7	.0	.15	.31	1.03	.57	
9	-3.5	.0	-7.2	.0	97.7	.0	.15	.31	1.03	.57	
10	-3.2	.0	72.1	.0	89.2	.0	.92	.31	1.42	.99	#
11	-3.2	.0	72.1	.0	89.2	.0	.92	.31	1.42	.99	#
12	-3.5	.0	-7.2	.0	97.7	.0	.15	.31	1.03	.57	
13	-3.5	.0	-7.2	.0	97.7	.0	.15	.31	1.03	.57	
14	3.2	.0	34.5	.0	-90.1	.0	.44	.23	1.23	.79	

LOAD CASE - 5

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	-.3	.0	8.3	.0	8.2	.0	.11	.21	.92	.84	#
2	-.3	.0	8.3	.0	8.2	.0	.11	.21	.92	.84	#
3	-.2	.0	14.0	.0	5.3	.0	.18	.20	.94	.88	#

4	.2	.0	14.0	.0	5.3	.0	.18	.20	.94	.88	#
5	-.2	.0	14.0	.0	5.3	.0	.18	.20	.94	.88	#
6	-.2	.0	14.0	.0	5.3	.0	.18	.20	.94	.88	#
7	-.3	.0	8.3	.0	8.2	.0	.11	.21	.92	.84	#
8	.1	.0	14.9	.0	-1.8	.0	.19	.20	.94	.89	#
9	.1	.0	14.9	.0	-1.8	.0	.19	.20	.94	.89	#
10	.2	.0	11.8	.0	-5.3	.0	.15	.20	.93	.86	#
11	.2	.0	11.8	.0	-5.3	.0	.15	.20	.93	.86	#
12	.1	.0	14.9	.0	-1.8	.0	.19	.20	.94	.89	#
13	.1	.0	14.9	.0	-1.8	.0	.19	.20	.94	.89	#
14	-.3	.0	8.3	.0	8.2	.0	.11	.21	.92	.84	#

LOAD CASE - 6

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	.4	.0	15.3	.0	-12.6	.0	.20	.19	.96	.87	#
2	.4	.0	15.3	.0	-12.6	.0	.20	.19	.96	.87	#
3	.5	.0	3.6	.0	-15.0	.0	.05	.24	.91	.80	
4	.5	.0	3.6	.0	-15.0	.0	.05	.24	.91	.80	
5	.5	.0	3.6	.0	-15.0	.0	.05	.24	.91	.80	
6	.5	.0	3.6	.0	-15.0	.0	.05	.24	.91	.80	
7	.4	.0	15.3	.0	-12.6	.0	.20	.19	.96	.87	#
8	-.7	.0	11.4	.0	20.0	.0	.15	.21	.96	.83	
9	-.7	.0	11.4	.0	20.0	.0	.15	.21	.96	.83	
10	-.5	.0	26.3	.0	15.0	.0	.34	.17	1.02	.92	#
11	-.5	.0	26.3	.0	15.0	.0	.34	.17	1.02	.92	#
12	-.7	.0	11.4	.0	20.0	.0	.15	.21	.96	.83	
13	-.7	.0	11.4	.0	20.0	.0	.15	.21	.96	.83	
14	.4	.0	15.3	.0	-12.6	.0	.20	.19	.96	.87	#

LOAD CASE - 7

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI	
1	.9	.0	22.7	.0	-24.3	.0	.29	.18	1.02	.88	#
2	.9	.0	22.4	.0	-24.4	.0	.29	.18	1.02	.88	#
3	1.0	.0	.0	.0	-27.5	.0	.00	.06	.92	.76	
4	1.0	.0	-.4	.0	-27.5	.0	.01	.07	.91	.75	
5	1.0	.0	-.8	.0	-27.6	.0	.02	.07	.91	.75	
6	1.0	.0	-1.2	.0	-27.6	.0	.03	.08	.91	.75	
7	.9	.0	20.9	.0	-25.2	.0	.27	.18	1.02	.87	#
8	-1.4	.0	30.6	.0	39.1	.0	.39	.16	1.10	.89	#
9	-1.4	.0	30.1	.0	39.1	.0	.39	.16	1.10	.88	#
10	-1.0	.0	57.9	.0	27.5	.0	.74	.20	1.21	1.05	#
11	-1.0	.0	57.4	.0	27.6	.0	.74	.19	1.21	1.05	#
12	-1.4	.0	28.6	.0	38.9	.0	.37	.17	1.09	.88	#
13	-1.4	.0	28.1	.0	38.8	.0	.36	.17	1.08	.87	#
14	.9	.0	20.5	.0	-25.3	.0	.26	.18	1.02	.87	#

LOAD CASE - 8

PILE	F1 K	F2 K	F3 K	M1 IN-K	M2 IN-K	M3 IN-K	ALF	CBF	ASC KSI	AST KSI

1	-.6	.0	22.3	.0	17.3	.0	.29	.18	1.01	.89	#
2	-.6	.0	22.0	.0	17.1	.0	.28	.18	1.01	.89	#
3	-.3	.0	33.0	.0	9.8	.0	.42	.16	1.05	.96	#
4	-.3	.0	32.7	.0	9.8	.0	.42	.16	1.04	.96	#
5	-.3	.0	32.3	.0	9.7	.0	.41	.16	1.04	.96	#
6	-.3	.0	31.9	.0	9.7	.0	.41	.16	1.04	.96	#
7	-.6	.0	20.4	.0	16.4	.0	.26	.18	1.00	.88	#
8	.2	.0	19.7	.0	-5.6	.0	.25	.19	.97	.90	#
9	.2	.0	19.2	.0	-5.7	.0	.25	.19	.97	.90	#
10	.3	.0	12.1	.0	-9.8	.0	.16	.20	.94	.86	#
11	.3	.0	11.6	.0	-9.7	.0	.15	.20	.94	.85	#
12	.2	.0	17.7	.0	-5.9	.0	.23	.19	.96	.89	#
13	.2	.0	17.2	.0	-5.9	.0	.22	.19	.96	.89	#
14	-.6	.0	20.1	.0	16.3	.0	.26	.18	.99	.88	#

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PILE FORCES IN GLOBAL GEOMETRY

LOAD CASE - 1

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	17.2	.0	28.3	.0	.0	.0
2	17.2	.0	28.3	.0	.0	.0
3	2.7	.0	-33.0	.0	.0	.0
4	2.7	.0	-33.0	.0	.0	.0
5	2.7	.0	-33.0	.0	.0	.0
6	2.7	.0	-33.0	.0	.0	.0
7	17.2	.0	28.3	.0	.0	.0
8	2.9	.0	1.0	.0	.0	.0
9	2.9	.0	1.0	.0	.0	.0
10	2.7	.0	69.4	.0	.0	.0
11	2.7	.0	69.4	.0	.0	.0
12	2.9	.0	1.0	.0	.0	.0
13	2.9	.0	1.0	.0	.0	.0
14	17.2	.0	28.3	.0	.0	.0

LOAD CASE - 2

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	17.1	.0	28.4	.0	.0	.0
2	17.1	.0	28.4	.0	.0	.0
3	2.6	.0	-29.5	.0	.0	.0
4	2.6	.0	-29.5	.0	.0	.0
5	2.6	.0	-29.5	.0	.0	.0
6	2.6	.0	-29.5	.0	.0	.0
7	17.1	.0	28.4	.0	.0	.0
8	3.3	.0	-.1	.0	.0	.0
9	3.3	.0	-.1	.0	.0	.0
10	2.6	.0	64.6	.0	.0	.0
11	2.6	.0	64.6	.0	.0	.0
12	3.3	.0	-.1	.0	.0	.0

13	3.3	.0	-.1	.0	.0	.0
14	17.1	.0	28.4	.0	.0	.0

LOAD CASE - 3

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	18.4	.0	29.4	.0	.0	.0
2	18.4	.0	29.4	.0	.0	.0
3	3.3	.0	-45.0	.0	.0	.0
4	3.3	.0	-45.0	.0	.0	.0
5	3.3	.0	-45.0	.0	.0	.0
6	3.3	.0	-45.0	.0	.0	.0
7	18.4	.0	29.4	.0	.0	.0
8	6.0	.0	-3.9	.0	.0	.0
9	6.0	.0	-3.9	.0	.0	.0
10	3.3	.0	76.8	.0	.0	.0
11	3.3	.0	76.8	.0	.0	.0
12	6.0	.0	-3.9	.0	.0	.0
13	6.0	.0	-3.9	.0	.0	.0
14	18.4	.0	29.4	.0	.0	.0

LOAD CASE - 4

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	18.3	.0	29.5	.0	.0	.0
2	18.3	.0	29.5	.0	.0	.0
3	3.2	.0	-41.6	.0	.0	.0
4	3.2	.0	-41.6	.0	.0	.0
5	3.2	.0	-41.6	.0	.0	.0
6	3.2	.0	-41.6	.0	.0	.0
7	18.3	.0	29.5	.0	.0	.0
8	6.3	.0	-4.9	.0	.0	.0
9	6.3	.0	-4.9	.0	.0	.0
10	3.2	.0	72.1	.0	.0	.0
11	3.2	.0	72.1	.0	.0	.0
12	6.3	.0	-4.9	.0	.0	.0
13	6.3	.0	-4.9	.0	.0	.0
14	18.3	.0	29.5	.0	.0	.0

LOAD CASE - 5

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	3.4	.0	7.5	.0	.0	.0
2	3.4	.0	7.5	.0	.0	.0
3	-.2	.0	14.0	.0	.0	.0
4	-.2	.0	14.0	.0	.0	.0
5	-.2	.0	14.0	.0	.0	.0
6	-.2	.0	14.0	.0	.0	.0
7	3.4	.0	7.5	.0	.0	.0
8	-6.7	.0	13.3	.0	.0	.0
9	-6.7	.0	13.3	.0	.0	.0

10	-.2	.0	11.8	.0	.0	.0
11	-.2	.0	11.8	.0	.0	.0
12	-6.7	.0	13.3	.0	.0	.0
13	-6.7	.0	13.3	.0	.0	.0
14	3.4	.0	7.5	.0	.0	.0

LOAD CASE - 6

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	7.2	.0	13.5	.0	.0	.0
2	7.2	.0	13.5	.0	.0	.0
3	.5	.0	3.6	.0	.0	.0
4	.5	.0	3.6	.0	.0	.0
5	.5	.0	3.6	.0	.0	.0
6	.5	.0	3.6	.0	.0	.0
7	7.2	.0	13.5	.0	.0	.0
8	-4.5	.0	10.5	.0	.0	.0
9	-4.5	.0	10.5	.0	.0	.0
10	.5	.0	26.3	.0	.0	.0
11	.5	.0	26.3	.0	.0	.0
12	-4.5	.0	10.5	.0	.0	.0
13	-4.5	.0	10.5	.0	.0	.0
14	7.2	.0	13.5	.0	.0	.0

LOAD CASE - 7

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	10.9	.0	19.9	.0	.0	.0
2	10.8	.0	19.6	.0	.0	.0
3	1.0	.0	.0	.0	.0	.0
4	1.0	.0	-.4	.0	.0	.0
5	1.0	.0	-.8	.0	.0	.0
6	1.0	.0	-1.2	.0	.0	.0
7	10.1	.0	18.3	.0	.0	.0
8	-12.5	.0	28.0	.0	.0	.0
9	-12.2	.0	27.6	.0	.0	.0
10	1.0	.0	57.9	.0	.0	.0
11	1.0	.0	57.4	.0	.0	.0
12	-11.6	.0	26.2	.0	.0	.0
13	-11.4	.0	25.8	.0	.0	.0
14	10.0	.0	18.0	.0	.0	.0

LOAD CASE - 8

PILE	PX K	PY K	PZ K	MX IN-K	MY IN-K	MZ IN-K
1	9.4	.0	20.2	.0	.0	.0
2	9.3	.0	19.9	.0	.0	.0
3	-.3	.0	33.0	.0	.0	.0
4	-.3	.0	32.7	.0	.0	.0
5	-.3	.0	32.3	.0	.0	.0
6	-.3	.0	31.9	.0	.0	.0

7	8.6	.0	18.5	.0	.0	.0	
8	-9.0	.0	17.5	.0	.0	.0	
9	-8.8	.0	17.1	.0	.0	.0	
10	-.3	.0	12.1	.0	.0	.0	
11	-.3	.0	11.6	.0	.0	.0	
12	-8.1	.0	15.7	.0	.0	.0	
13	-7.9	.0	15.3	.0	.0	.0	
14	8.5	.0	18.3	.0	.0	.0	

MAX LOAD = 76.8^{K} ~~40.4^{K}~~ C   LOADCASE ~~1~~ 3

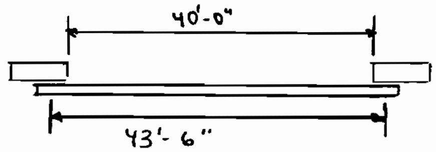
~~-14.0^{K}~~ -45.0^{K} T   LOAD CASE 3 ✓

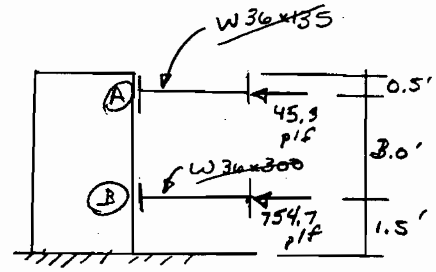
ALLOWABLES : $39^{T} = 78^{K}$ C ok ✓

$24^{T} = 48^{K}$ T ok ✓

CONCRETE DESIGN:

PEDESTALS:





-for reactions, see p. 2

SW(÷2), use 75% for cas

Reaction @ PEDESTAL:

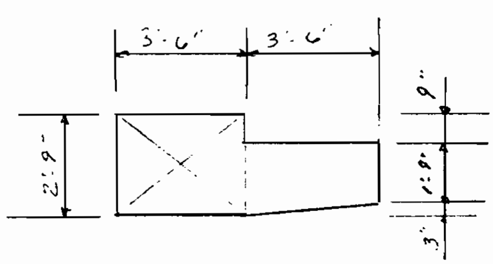
A: $\frac{1}{2}(.045)(43.5) = 0.98^k\ (.75) = 0.74^k$

B: $\frac{1}{2}(.755)(43.5) = 16.4^k(.75) = 12.3^k$

MOMENT @ BASE OF PEDESTAL:

$M = (12.3^k)(1.5') + (.74^k)(4.5')$
$= 21.78'^k$

FACTORED MOMENT $= 1.7 \times 1.3 \times 21.78 = 48.1'^k$



-Assume Moment is resisted by 3'6" x 2'-9" area.

$M_u = \phi[A_s f_y (d - a/2)]$

$A_{s\,req'd} = \frac{M}{\phi f_y (d - a/2)}$

$= 48.1(12) / (.9)(60)(33 - 6 - 1) = 0.41 in^2$

$\rho = .41/42(29.5) = 0.00633$

$\rho_{min} = 200/48000 = 0.0042$

$A_{S\,Req'd} = (0.0042)(42)(29.5) = 5.2\ in^2$ ←

7#8 each face $A_s = 7(.79) = 5.53$
9#7 each face $A_s = 9(.60) = 5.4$

- use 7 #8 each face

- Temp Reinforcement in tapered area

$A_{req'd} = 0.0028 A_g$ (½ in each face)

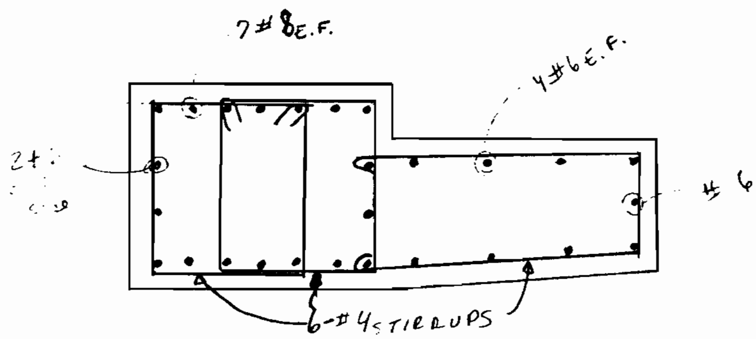
$A_g = (2')(3.5') - \frac{1}{2}(.25')(3.5')$
$= 6.56\ ft^2$
$= 945\ in^2$

$A_s = 0.0028(945)$
$= 2.65\ in^2$

#6 - 7 bars $7(.44) = 3.08\ in^2$

- use 2 #6 bars, 4 in each face

9 #



CHECK SHEAR:

$$V_u = 1.7 * 1.3 (.74 + 12.3)$$
$$= 28.8^k$$

$$V_n = \frac{V_u}{\phi}$$

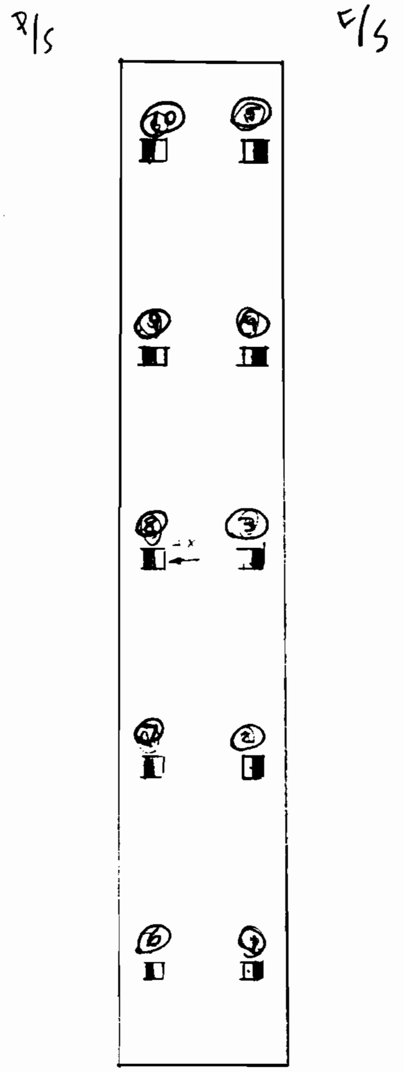
$$= 28.8 / .85$$
$$= 33.9^k$$

$$v_c = 2\sqrt{3000}$$
$$= 109 \text{ psi}$$

$$V_c = (109)[(42)(29.5) + 42(21 - 3.5)]/1000$$
$$= 215^k \quad > 33.9^k$$

- use minimum stirrups

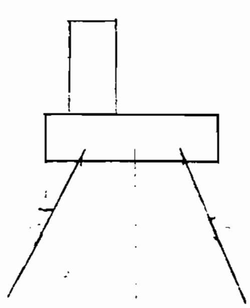
FOUNDATION DESIGN:



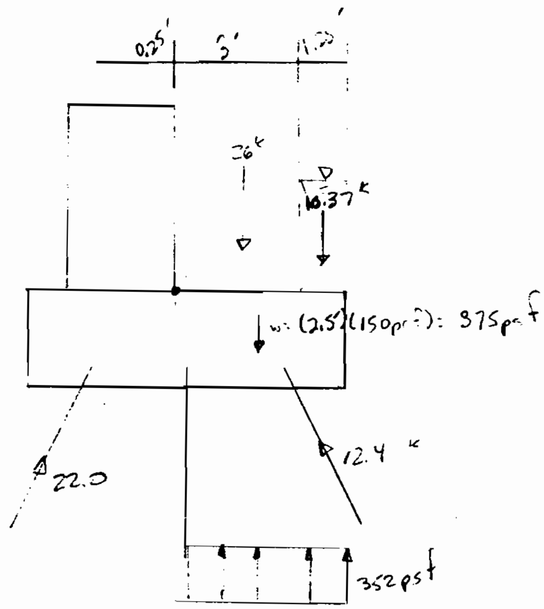
-CHECK CASES 1 & 7

-CASE 1: GATE CLOSED, SWL;
IMPERVIOUS S/P

-CASE 7: GATE OPEN, TRUCK
ON P/S



CASE 1 : GATE CLOSED, SWL, IMP. SP



wt of gate = 26k (p. 7)

wt of water = 10.37k (p. 11)

M @ face of column = GATE * L.A. + WATER * L.A − PILE * L.A.
+ (WT. CONC. − BUOY) L.A.

= (26k)(1.75') + (10.37k)(3.875') − (12.4)(5)(3.0')
+ (375 − 352)(2.375')

= 100.3 'k

FACTORED M = 1.7 * 1.3 * 100.3 = 221.7 'k

M = 221.7/54 = 4.1 'k/FT

CASE 7: GATE OPEN, TRUCK ON P.. TRUCK : 86.4 @ 4.25'
PILE : 19.8

M = 19.8(5)(−2.375)
= 231.56 'k

FACTORED $M = 1.7 \times 1.3 \times 231.56$
$= 511.7^{\prime K}$

$M_u = 511.7/11.0 = 46.5^{\prime K}/FT$

$A_{s\,temp} = 0.0018(A_g)$
$= .0018(12'')(26'')$
$= 0.562\ in^2/ft$

$d = 30'' - 3'' - \frac{1}{2}'' - \frac{1}{2}'' = 26''$

$\rho_{min} = 200/48000 = 0.0042$

$a = 1.2 \times 60 / .85 \times 3 \times 12$
$= 2.35$

$A_{s\,min} = 0.0042(12)(26)$
$= 1.31\ in^2/ft$

$M_u = (1.31)(48)(26 - 2.35/2)(.9)/12 = 117.1^{\prime K} > 46.5$ ok

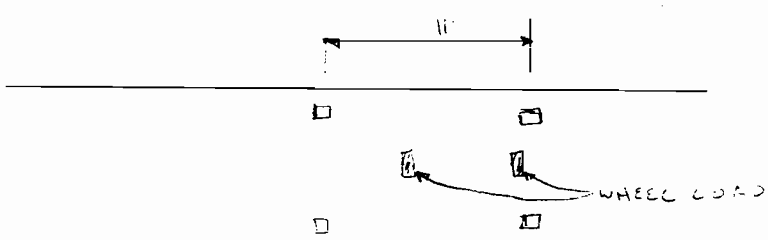
Alt min: $M_u/\phi f'_c b d^2 = 46.5 \times 12 / .9(3.0)(12)(26)^2 = 0.0255$ $\rho = 0.0255(3/48)$
$= 0.0016$

Alt min $= 1.33 \times .0016 = 0.0021$

LONGITUDINAL DIRECTION:

$A_{ST} = 0.0021(12)(26)$
$= 0.66$ - use #8 @12''
$A_{ST\,PROV} = 0.79$

TRUCK LOADS:



Reinforcing perpendicular to traffic direction
(AASHTO 3.24.3)

Moment/foot $= \frac{S+2}{32} \times P_{20}$

$S = 11'$
$P_{20} = 16^K$

$I = 30\%$

L.L. Moment $= \frac{13}{32} \times 16 = 6.5^{\prime K}$

$M_{(LL+I)} = 1.3(6.5) = 8.45^{\prime K}$

for continuity

$M_{DL} = .8(\frac{1}{8} w l^2)$
$= (\frac{1}{8}(.375)(11)^2).8 = 4.5^{\prime K}$

$w = (2.5')(.15\ kcf) = 0.375\ k/ft$

$M_{TOT} = 1.3[(4.5) + (1.7)(8.45)]$
$= 24.5$ (AASHTO)

$M_{TOT} = 1.3(1.7)(4.5 + 8.75)$ (COE)
$= 29.28$

$d = 30' - 3" - \frac{1}{2}" - \frac{1}{2}" = 26"$

$\frac{M_u}{\phi f'_c b d^2} = \frac{29.28 * 12}{.9(3)(12)(26)^2} = 0.016$

$\rho = 0.016(3/48) = 0.001$

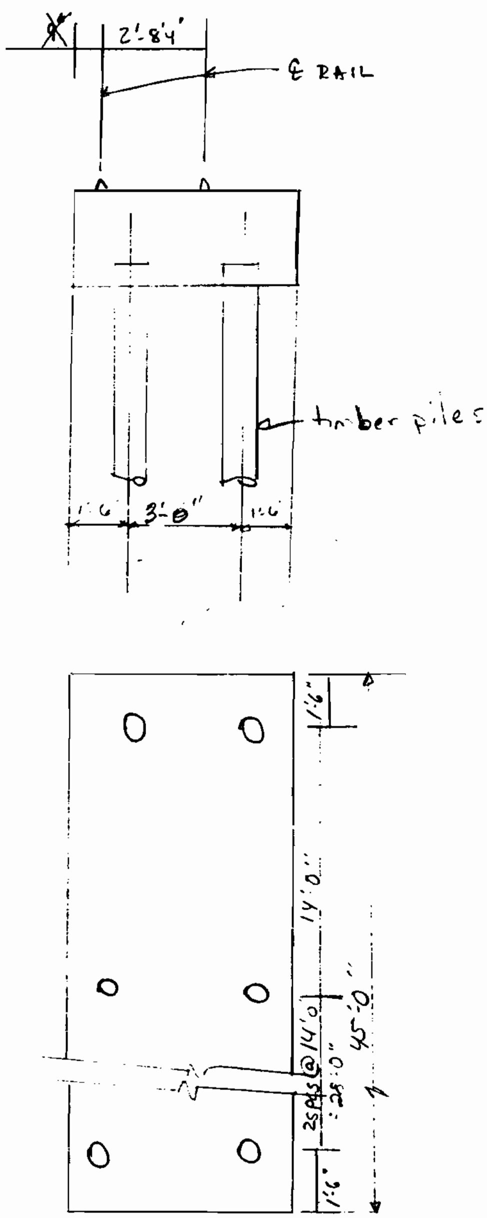
$\rho_{min} = 200/48000 = 0.0042$

alt $\rho_{min} = 1.33 * .001 = 0.0013$

$A_{s\ req'd} = 0.0013(12)(26) = 0.41\ in^2/ft$

use #7 @ 12" - $A_{s\ prov} = 0.60\ in^2/ft$

STORAGE MONOLITH:



LOADING:

GATE : $26^k/45'$

$= 0.58^k/_{FT}$

CONC = $(6')(2.5')(.15)$

$= \cancel{2.25}^k/_{FT}$ $\cancel{2.16}$

TOTAL = 2.83 ~~3.4~~

- use $3.0^k/_{FT}$

ALLOWABLE PILE CAPACITY FOR TIMBER PILE (7" TIP, 13" BUTT)

$C = 13^T$, $T = 9^T$ $(L = 60')$

$= 26^K$

Try 8' spacing:

$$\frac{(3^k/_{FT})(8')}{2} = 12^K$$

Try 14' SPACING

$(3)(14)/2 = 21^k/_{PILE} < 26^k$ OK

$M = (\frac{1}{8})(3.0)(14)^2$
$= 73.5'^k$

Factored M: $1.7 * 1.3 * 73.5$
$= 162.4'^k$
$= 1948.8''^k$

Top of Slab = $4.5 - 1\frac{3}{8}'' = 4.34$
Bottom of Slab = $2.0\frac{1}{3}$

depth = $2'-4\frac{1}{8}''$

$d = 28.125 - 4 = 24.125''$

$\rho_{min} = 200/48000 = 0.0042$

$A_{s\,min} = 0.0042(72'')(24.125'')$
$= 7.30\ in^2$

$\#6 - 17$ $A_s = 17(.44) = 7.48$
$\#7 - 13$ $A_s = 13(.6) = 7.8$
$\#8 - 10$ $A_s = 10(.79) = 7.9$ ←

use 10 #8 TOP & BOTTOM

Shear:

$V = \frac{1}{2} wL$
$= \frac{1}{2}(3)(14)$
$= 21^k$

$V_u = 1.7 * 1.3 * 21$
$= 46.4^k$

$V_n = 46.4/.85 = 54.6^k$

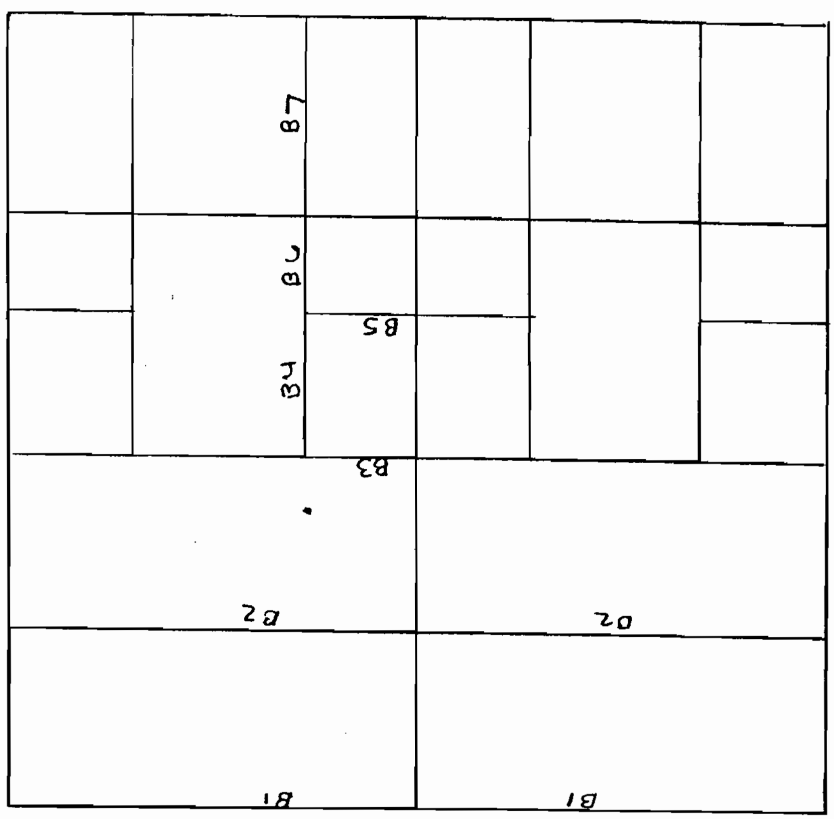
$V_c = 2\sqrt{3000}\,(72)(24.125)/1000 = 190.3^k$

$V_c > 2 V_n$
$190.3 > 2(54.6)$
> 109.2 ✓ - NO STIRRUPS NEEDED

JN 3003 | COUSINS PUMP STATION | AAH | 8-12-97

(2 PUMPS) 87' x 84' 11 1/8"
85'

DISCHARGE SIDE



SUCTION SIDE

JN 3003 | COUSINS PUMP STATION / REQ'D PUMP STATION | AAH | 8-4-97

SLAB: FROM B1 TO B3:

$h = 24"$
$L = 18'-8\frac{1}{2}" = 18.71'$

$DL = (2')(.150\,kcf) = 0.3\,ksf$

MACHINERY LOADS:
- DIESEL ENGINE
- DIESEL TANK
- EMERGENCY GENERATOR
- VACUUM PUMP

BKI

$LL = 100\,psf = 0.1\,ksf$

* FLOOR MUST BE DESIGNED TO SUPPORT HEAVIEST PIECE OF MACHINERY PLACED ANYWHERE : use 300 #/SF - VERIFY w/BKI

HYDRAULIC FACTOR

FACTORED LOAD $= 1.7 * 1.3\,(DL + MACH + LL)$
$= 1.7 * 1.3\,(0.3 + 0.3 + 0.1)$
$= 1.55\,ksf$

$M_{+} = \frac{1}{14} wL^2 = \frac{1}{14}(1.55)(18.71)^2$
$= 38.76'^{K}$ /FOOT WIDTH

(FROM: REINFORCED CONCRETE FUNDAMENTALS BY FERGUSON/BREEN/JIRSA p 350)

$M_{-} = -\frac{1}{9} wL^2$ (@ center support)
$= -\frac{1}{9}(1.55)(18.71)^2$
$= -60.29'^{K}$

$f_c' = 3000\,psi$
$f_y = 48000\,psi$ (Gr 60 - hydraulic structures)

$d = 24" - 4"\,clr - \frac{1}{2}" = 19.5"$

Positive Moment:

$$\frac{M_u}{\phi f'_c b d^2} = \frac{38.74 \times 12}{.9 \times 3 \times 12 \times 19.5^2}$$

$= 0.038$

$\rho = 0.038 \, f'_c/f_y$
$= 0.038(3/48)$
$= 0.0024$

$\rho_{min} = 200/f_y = 200/48000 = 0.0042$

alt $\rho_{min} = 1.33\rho = 1.33(0.0024) = 0.0032$ ←

$A_s = 0.0032(12)(19.5)$
$= 0.75 \text{ in}^2/\text{ft}$

#6 @ 6" → $A_s = 2(.44) = .88 > .75$ ok

Negative Moment:

$$\frac{M_u}{\phi f'_c b d^2} = \frac{60.29(12)}{.9(3)(12)(20.5)^2}$$ $d = 20.5''$

$= 0.053$

$\rho = 0.053 \, f'_c/f_y = 0.053(3/48)$
$= 0.0033$

$\rho_{min} = 0.0042$ ←

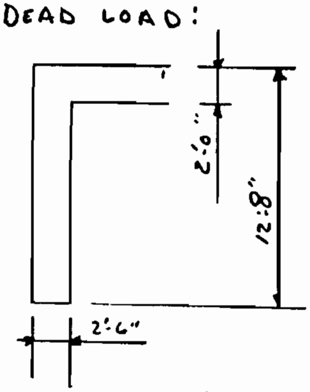
alt $\rho_{min} = 1.33(.0033) = 0.0044$

$A_{sT} = 0.0042(12)(20.5)$
$= 1.03 \text{ in}^2/\text{ft}$

#7 @ 6" = $2(.60) = 1.20 \text{ in}^2/\text{ft}$ over under beam (B2)

BEAM B1:

DEAD LOAD:



BEAM: $(12.67)(2.5)(.150) = 4.75\ ^{k}/_{FT}$

SLAB: $(2')(\frac{16.708}{2})(.15) = 2.51\ ^{k}/_{FT}$

SUPERIMPOSED DL: $(300\ psf)(\frac{16.708}{2}) = 2.61\ ^{k}/_{FT}$

LL = 100 psf = $0.1(\frac{16.708}{2}) = 0.84\ ^{k}/_{FT}$

span length: $43.5' - 4' = 39.5'$

$d = 152" - 3"_{clr} - 3" = 146"$

FACTORED LOAD = $1.7 * 1.3 * (4.75 + 2.51 + 2.51 + .84)$
$= 23.45$

$M_u = \frac{1}{8} w L^2$
$= \frac{1}{8}(23.45)(39.5)^2$
$= 4573'^{k}$

$\frac{M_u}{\phi f'_c b d^2} = \frac{4573 * 12}{.9(3)(30)(146)^2}$

$= 0.032$

$\rho = 0.032(3/48)$
$= 0.002$

$\rho_{min} = 200/48000 = 0.0042$

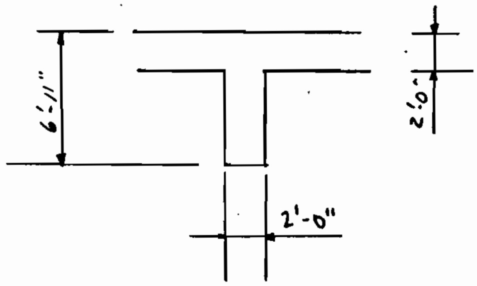
alt $\rho_{min} = 1.33(.002) = 0.0027$ ←

$A_s = 0.0027(30)(146)$
$= 11.83\ in^2$

- 8 - #11 (to match existing)

$A_s = 8(1.56) = 12.48 > 11.83$ ok

BEAM B2:



BEAM: $(6.917')(2')(.15)$ =	2.08
SLAB: $(2')(16.702')(.15)$:	5.01
SUPERIMPOSED DL = $(.3)(16.702)$:	5.01
LL = $(.1)(16.702)$ =	1.67
	13.77

$d = 83 - 3" - 3" = 77"$ spun length = 39.5'

FACTORED LOAD = $1.7 * 1.3 * 13.77$
$= 30.43^{k}/FT$

$$M_u = \frac{1}{8} w L^2$$
$$= \frac{1}{8}(30.43)(39.5)^2$$
$$= 5935'^{k}$$

$$M_u / \phi f'_c b d^2 = 5935(12) / .9(3)(24)(77)^2$$
$$= 0.185$$

$$\rho = 0.185\,(3/48)$$
$$= 0.012 \leftarrow$$

$\rho_{min} = 200/48000 = 0.0042$

$$A_s = 0.012(77)(24)$$
$$= 22.2\,in^2$$ N.G.

TRY 7'-11" x 2'-6" beam:

$d = 77 + 12 = 89"$

DL: BEAM: $(7.917)(2.5)(.15) = 2.97^{k}/FT$

TOTAL $= 2.97 + 5.01 + 5.01 + 1.67 = 14.66^{k}/FT$

FACTORED LOAD = $1.7 * 1.3 * 14.66 = 32.40^{k}/FT$

$$M = \frac{1}{8} w L^2 = \frac{1}{8}(32.4)(39.5)^2$$
$$= 6319'^{k}$$

$M_u/\phi f'_c b d^2 = 6319(12)/.9(3)(30)(89)^2$

$= 0.118$

$\rho = 0.118\ (3/48)$
$= 0.0074$

$A_s = 0.0074(30)(89)$
$= 19.76\ in^2$ N.G.

Try : 8'-6" x 2'-6" Beam
$d = 8\frac{1}{2} \cdot 7 = 96"$

DL: $(8.5)(2.5)(.15) = 3.19$

TOTAL: $3.19 + 5.01 + 5.01 + 1.67 = 14.88\ ^k/FT$

FACTORED LOAD = $1.7 \times 1.3 \times 14.88$
$= 32.88\ ^k/FT$

$M = \frac{1}{8} w L^2$
$= \frac{1}{8}(32.88)(39.5)^2$
$= 6413'^k$

$M_u/\phi f'_c b d^2 = 6413^k(12)/.9(3)(30)(96)^2$

$= 0.103$

$\rho = 0.103\ (3/48)$
$= 0.0064$

$A_s = 0.0064(30)(96)$
$= 18.43$

- use 12 - #11 $A_s = 12(1.56) = 18.72$ ok try original beam as T section:

b_f = Span/4 : 39.5/4 : 9.875×12 : 118.5" ←

$8h_f$: 8×24 : 192"

beam spacing = 18'

→ use $z = d - a/2 = 0.9d$

$z = 0.9(77) = 69.3"$

$d - a/2 = 69.3"$

$77" - a/2 = 69.3"$

$a/2 = 7.7"$

$a = 15.4" < 24$ ∴ $b = 118.5"$

$M_u / \phi f_c' b d^2 = 5935 \times 12 / .9(3)(118.5)(77)^2$

$= 0.038$

$\rho = 0.038(3/48)$

$= 0.0024$

$\rho_{min} = 0.0042$

alt min $= 1.33(.0024) = 0.0032$ ←

$A_s = 0.0032 b_w d$

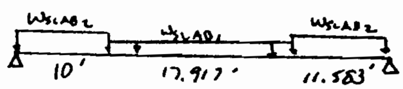
$= 0.0032(24)(77)$

$= 5.92 in^2$

BEAM B3:

$6'\text{-}11'' \times 2'$ 10 - #10 bars $d = 83 - 6'' = 77''$

$w_{BEAM} = (6.917)(2)(.15) = 2.1^{k}/_{FT}$



$\ell = 39.5'$

$w_{SLAB1} = (2')(\frac{16.708}{2})(.15) = 2.51^{k}/_{ft}$

$w_{SLAB2} = w_{SLAB1} + (\frac{15.917}{2})(2')(.15)$
$= 2.51 + 2.39$
$= 4.9^{k}/_{FT}$

superimposed $DL_1 = (.3)(\frac{16.708}{2}) = 2.51$

$DL_2 = Sup.DL_1 + (.3)(\frac{15.917}{2})$
$= 2.51 + 2.39$
$= 4.9$

$LL_1 = (.1)(\frac{16.708}{2}) = 0.84$

$LL_2 = (.1)(\frac{15.917}{2}) + LL_1$
$= 0.80 + 0.84$
$= 1.64$

FACTORED LOADS:

$w_1 = 1.7 * 1.3(2.51 + 2.51 + .84)$
$= 12.95^{k}/_{FT}$

$w_2 = w_1 + 1.7 * 1.3(2.39 + 2.39 + .80)$
$= w_1 + 12.33$
$= 25.28^{k}/_{FT}$

$w_{beam} = 1.7 * 1.3 \times 2.1$
$= 4.64^{k}$

$A_s = (.0081)(24)(77)$
$= 14.97 in^2$

10 - #10 — $A_s = 10(1.27) = 12.7$ N.G.

8 - #11 — $A_s = 8(1.56) = 12.48$ N.G.

10 - #11 — $A_s = 10(1.56) = 15.6$ OK

BEAM B4:

$l = 15'-11''$
$h = 8'-0\frac{5}{8}''$
$b = 24''$

7 - #11 bars $7 \times 1.56 = 10.92$

$d = 96.625 - 6 = 90.625''$

$w_{BEAM} = (8.05)(2)(.15) = 2.4\ ^k/_{FT}$

$w_{SLAB} = (2')(\frac{12.583}{2})(.15) = 1.89\ ^k/_{FT}$

$w_{SUPERIMPOSED} = (.3)(^{12.583}/_2) = 1.89\ ^k/_{FT}$

$w_{LL} = (.1)(^{12.583}/_2) = 0.63\ ^k/_{FT}$

$W_{TOTAL} = 6.81\ ^k/_{FT}$

FACTORED LOAD $= 1.7 \times 1.3 \times 6.81$
$= 15.05$

$M = \frac{1}{8}(15.05)(15.917)^2$
$= 476.62\ ^{1k}$

$M_u/\phi f'_c b d^2 = 476.62(12)/.9(3)(24)(90.625)^2$
$= 0.011$

$\rho = 0.011(^3/_{48}) = 0.00069$

$\rho_{min} = 0.0042$

$A_s = 0.0042(24)(90.625)$
$= 9.135 in^2$ < 10.92 OK

BEAM B5:

$l = 13'7''$ — 5-#9 bars — $5 * 1.00 = 5.0 \, in^2$

$h = 5'6\frac{5}{8}''$

$b_w = 24''$

$$d = 66.625 - 4'' = 62.625''$$

$$w_{BEAM} = (5.55)(2)(.15) = 1.66 \, ^k/_{FT}$$

$$w_{SLAB} = (2')(\tfrac{1}{2})(15.92 + 10.34)(.15) = 3.94 \, ^k/_{FT}$$

$$w_{SUP.DL} = (\tfrac{1}{2})(15.92 + 10.34)(.30) = 3.94 \, ^k/_{FT}$$

$$w_{LL} = (.1)(\tfrac{1}{2})(15.92 + 10.34) = 1.31 \, ^k/_{FT}$$

$$\text{FACTORED LOAD} = 1.7 * 1.3(1.66 + 3.94 + 3.94 + 1.31)$$
$$= 23.98 \, ^k/_{FT}$$

$$M = \tfrac{1}{8} w L^2$$
$$= \tfrac{1}{8}(23.98)(13.58)^2$$
$$= 552.8 \, ^{'k}$$

$$M_u / \phi f'_c b d^2 = 552.8(12) / .9(3)(24)(62.625)^2$$

$$= 0.026$$

$$\rho = 0.026(3/48) = 0.0016$$

$$\rho_{min}(alt) = 1.33(.0016)$$
$$= 0.0021$$

$$A_s = 0.0021(24)(62.625)$$
$$= 3.16 \, in^2 < 5.0 \quad \underline{\underline{ok}}$$

BEAM B6:

$l = 10'-4\frac{1}{8}''$ 7- #11 bars $7 \times 1.56 = 10.92$
$h = 3'-6''$
$b_w = 24''$
$d = 42 - 4 = 38''$

$w_{Beam} = (3.5)(2)(.15) = 1.05\ ^{k}/_{FT}$

$w_{SLAB} = (1')(\frac{1}{2})(15.58)(.15) = 1.17\ ^{k}/_{FT}$

$w_{SUP.DL} = (.3)(^{15.58}/_{2}) = 2.34\ ^{k}/_{FT}$

$w_{LL} = (.1)(^{15.58}/_{2}) = 0.78\ ^{k}/_{FT}$

FACTORED LOAD $= 1.7 + 1.3 + (1.05 + 1.17 + 2.34 + 0.78)$
$= 11.80\ ^{'k}$

$M = \frac{1}{8} w l^2$
$= .125(11.80)(10.34)^2$
$= 157.70\ ^{'k}$

$M_u / \phi f'_c b d^2 = (157.7)(12) / .9(3)(24)(38)^2$

$= 0.020$

$\rho = 0.020(^{3}/_{48}) = 0.00125$

$\rho_{min} = 0.0042$

alt $\rho_{min} = 1.33(.00125) = 0.0017$

$A_s = 0.0017(24)(38)$
≈ 1.55

$A_s = 0.0042(24)(38)$
≈ 3.83 ok

BEAM B7:

$l = 21'\text{-}3''$
$h = 8'\text{-}1\frac{13}{16}''$
$b_w = 24''$

9-#10 bars

$9 * 1.27 = 11.43 in^2$

$d = 97.81 - 6 = 91.81''$

$w_{BEAM} = (8.15)(2)(.15) = 2.44$

$w_{SLAB} = (1')(\frac{1}{2})(15.58)(.15) = 1.17$
$(2')(9.42')(.15) = 2.83$

$w_{SUP.DL} = (.30)[(\frac{1}{2})(15.58) + 9.42] = 5.16$

$w_{LL} = (.1)(\frac{15.58}{2} + 9.42) = 1.72$

FACTORED LOAD = $1.7 * 1.3 * (2.44 + 1.17 + 2.83 + 5.16 + 1.72)$
$= 29.44$

$M = \frac{1}{8} w L^2$
$= \frac{1}{8}(29.44)(21.25)^2$
$= 1661.75^{1k}$

$M_u / \phi f_c' b d^2 = (1661.75)(12) / .9(3)(24)(91.81)^2$

$= 0.036$

$\rho = 0.036(3/48) = 0.00225$

$\rho_{min} = 0.0042$

alt $\rho_{min} = 1.33(0.00225)$
$= 0.0030$

$A_s = 0.0030(24)(91.81)$
$= 6.61$

OK