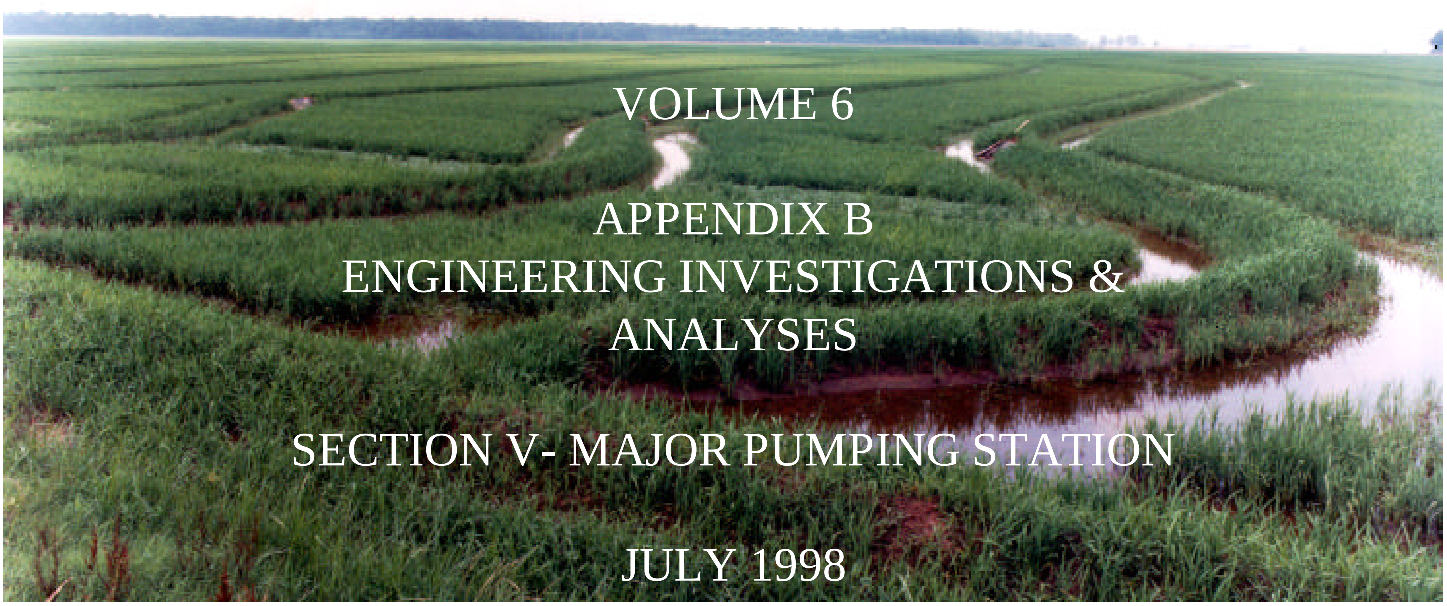
US Army Corps
of Engineers
Memphis District
Mississippi River Comission

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY

GRAND PRAIRIE REGION AND BAYOU METO BASIN, ARKANSAS PROJECT

GRAND PRAIRIE AREA DEMONSTRATION PROJECT

GENERAL REEVALUATION REPORT



VOLUME 6

APPENDIX B
ENGINEERING INVESTIGATIONS & ANALYSES

SECTION V- MAJOR PUMPING STATION

JULY 1998

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SECTION V - MAJOR PUMPING STATION

PART A - GENERAL

5-A-01. PURPOSE.

The purpose of this engineering support document is to etablish essential data, assumptions, and criteria for provideing a basis for the mechanical, electrical, and structural design requirements of the Major Pumping Staion. This appendix, as approved, will form the basis upon which the design documents for final design of the pumping station will be prepared.

5-A-02. PROJECT AREA.

The Eastern Arkansas Region Comprehensive Study Area includes all or part of 24 counties in eastern Arkansas, a 13,400 square mile area which represents 25 percent of the land area of the state. The primary emphasis of the study is agricultural water supply and conservation and fish and wildlife restoration/enhancement. Depletion of the groundwater reserves caused by heavy agricultural use is the primary problem. Depletion of the alluvial aquifer is threatening the future of agriculture as it is presently practiced in the region. This valuable resource has been exhausted to only the perennial yields in parts of the area; and, if current trends continue, this natural resource could be completely lost, resulting in catastrophic economic losses to the area. The Grand Prairie Area Demonstration Project area includes portions of Arkansas, Prairie, Lonoke, and Monroe counties in eastern Arkansas. This project area covers approximately 362,662 acres which includes approximately 254,406 acres of cropland. The Grand Prairie Demonstration project will provide a supplemental agricultural water supply while preserving the groundwater resource. The project provides significant oppportunity for fish and wildlife restoration and environmental enhancement.

5-A-03. PROJECT DESCRIPTION.

The primary plan of improvement for the Grand Prairie area consists of a major pumping station and a network of new canals, existing channels, pipelines, and associated channel structures to provide interbasin transfer of surface water to the water depleted areas. Included as an integral part of the plan are; conservation measures, groundwater management strategies, retrofit of farms, on-farm storage resrvoirs, and fish and wildlife restoration and management features. A pumping station located on the White River just north of DeValls Bluff will be utilitzed to deliver excess surface water from the White River throughout the project area during peak use periods and for filling storage resirevoirs during off-season periods. The overall views for the major pumping station are shown in Appendix V-E, GRAND PRAIRIE PUMPING STATION, MECHANICAL DESIGN DEVELOPMENT, STATION LAYOUT AND PUMP CURVES.

5-A-04. GENERAL REEVALUATION.

The first phase of the general reevaluation was to determine if a feasible plan of improvement exists and to identify the plan which best meets the needs of the area. Once identified, detailed engineering and design studies would be conducted. Hydraulics Branch determined, based on optimization of groundwater use, conservation measures, and on-farm storage, that a pumping station with a capacity of 1800 cfs would meet the demand requirements of the area farmers. The pumping station will be located on the White River on the southern edge of the Wattensaw State Game Area. An inlet channel from the White River will carry water to the pumping station. Pumps in the station will discharge into two 10'-6" steel pipes which will carry the water for over a mile to the outlet structure. Here the water will begin its journey through hundreds of miles of open channels, check structures, turnouts, auxiliary pump stations and inverted syphons to finally end up in rice fields or storage ponds. This pumping station design was later used as Alternate Number 1 in a series of alternative designs considered in an attempt to optimize material and energy cost. Alternate Number 1 consisted of 6 identical centrifugal split case pumps with horizontal electric motors. This design is covered in **Appendix V-A** of this report.

5-A-05. LIFE CYCLE COST ANALYSIS.

In order to optimize the pumping station design, a life cycle cost analysis was performed. Three pumping station designs were considered. The life cycle first cost, operation cost, and maintenance cost of the pumping station developed during the feasibility study (Alternate 1) were compared to two other designs. The analysis is described in Part B.

5-A-06. CONCLUSIONS.

The pumping station design with the lowest life cycle cost was Alternate 2. This pumping station incorporates four 400 cfs vertical, mixed-flow, single-stage pumps and two 100 cfs vertical, mixed-flow, single-stage pumps. During the course of the study and after optimization of most project features and plan selected, farmers in the lower portion of the Grand Prairie Region decided to drop out of the Irrigation District. This resulted in a lower demand of 1640 cubic feet per second. This new flow rate was used in the development of the concept design as described in Part C. The four large pumps were reduced in size to 360 cfs while leaving the two smaller pumps at 100 cfs.

PART B - LIFE CYCLE COST ANALYSIS

5-B-01. INTRODUCTION.

In an attempt to reduce costs below those formulated in the baseline design performed for feasibility determinations of this project, several alternate proposals were analyzed. Comparative cost estimates were made for all station configurations, with the lowest first cost station being selected for further development and enhanced design. All designs were based on the initial premise that the station be capable of pumping 1800 cfs from an average sump elevation of 158.0 feet up to the canal at an elevation of 233.3 feet. In addition to the 8 pump station with horizontal split-case centrifugal pumps and horizontal direct-drive motors, as proposed in the feasibility phase of this study (See **Appendix V-A**), two additional layouts were also analyzed.

5-B-02. ALTERNATE NUMBER 2.

The second configuration considered was a station containing 6 vertical, 2-stage, mixed-flow pumps driven by vertical, direct-drive motors. In order to provide for low flow conditions during the winter months, and to better match demand requirements during summer months, two of the pumps were rated at a lower capacity than the others. It was decided that the larger pumps be sized at 400 cubic feet per second each and the smaller pumps be sized at 100 cubic feet per second each. This would allow the station operator to vary flow in no greater that 200 cfs increments. Each of the larger 400 cfs pumps would be a 68" by 84" mixed-flow pump. The motors driving these pumps wound be rated at not less than 6000 HP turning at 260 RPM. Each of the two smaller 100 cfs pumps would be a 33" by 42" two stage mixed flow pump with a 530 RPM, 1500 HP motor. All pumps would be fed through a formed suction inlet in order to reduce vortex formation and cavitation. Further details on this configuration are contained in **Appendix V-B.**

5-B-03. ALTERNATE NUMBER 3.

The third configuration considered was a station containing 8 vertical dry pit centrifugal pumps driven by vertical, direct-drive motors. Six of the pumps would be rated at 266.7 cubic feet per second and two of the pumps would be rated at 100 cubic feet per second. This arrangement would provide the needed flexibility necessary to best match demand requirements. The six larger pumps would be 54" centrifugal pumps with 3500 horsepower induction motors. Each of the two smaller pumps would be a 42" centrifugal pump with a 2000 horsepower, direct-drive, induction motor. All pumps would be fed through a formed suction inlet in order to reduce vortex formation and cavitation. Further details on this configuration are contained in **Appendix V-C**.

5-B-04. RESULTS.

In order to determine the most economical and feasible configuration, the costs for all three alternatives were tabulated and compared. It was apparent from the results, that alternate 2 with vertical mixed-flow pumps was a clear winner among the three choices. Alternate 2 was lower in first cost, total life cycle cost, and in annual cost. Total first cost for this pumping station configuration, including inlet channel and discharge pipe was $34,104,276. Cost comparisons and resulting bar charts are displayed in **Appendix V-D**.

PART C - MECHANICAL DESIGN DEVELOPMENT

5-C-01. INTRODUCTION.

Now that the general station configuration has been determined by a life cycle cost analysis, our goal has become more fully focused on development of this concept into a workable and functional station. Operation and maintenance features also play heavily in the fine tuning of the concept plan. The end product should have good architectural appeal, be easy to maintain, and have operational features that will allow the Watermaster to control pumps, valves, and accessories from a central operation control room.

5-C-02. GENERAL.

The pumping station required for pumping water between the White River and the canal network of the Grand Prairie Demonstration Project was downsized after removal of the southern most area from the project area (31,813 acres). Based on the latest available information from Hydraulics Branch, the pumping station will now need to pump a minimum of 1640 cubic feet per second against a static head of 75.3 feet. The pumping station selected for further development, will have 6 pumps total. Each pump will be driven by a vertical electric motor attached to the pump above the pump elbow. The pumping station substructure will be a multi-level concrete monolith measuring 120 feet long by 106 feet wide. The station control room will be on the inlet side of the pump house and will be located at elevation 190.0. Adjacent to the control room on one side will be a women's restroom and men's restroom. Adjacent to the control room on the other side will be a break room equipped with sink, stove, and refrigerator. A roll-up door will allow truck access to the pump room at elevation 190.0 so trucks can unload pump parts for assembly. Beneath the control room floor level at elevation 174.0 will be the mechanical rooms where the electrical switchgear, air compressors, elevator equipment, sewage treatment equipment, and potable water tank are located. Also located at elevation 174.0 is the pump room floor where the pump motors and discharge valves are situated. See **Appendix V-E** for details.

<u>Basic Data</u>

Sump Floor Elevation	144.0 feet NGVD
Operating Floor Elevation	190.0 feet NGVD
Pump Floor Elevation	174.0 feet NGVD
Pump Discharge Centerline	181.0 feet NGVD
Historical High River Water Elevation	187.6 feet NGVD
100 Year Flood River Elevation	188.0 feet NGVD
Average River Water Elevation (Design)	158.0 feet NGVD
Historical Low River Water Elevation	153.3 feet NGVD
Design Main Canal Water Elevation	233.3 feet NGVD
Station Design Flow Rate	1640 CFS
Large Pump Flow Rate (4 Pumps)	360 CFS
Small Pump Flow Rate (2 Pumps)	100 CFS

5-C-03. MAIN PUMPS.

a. General. There will be a total of 6 vertical mixed-flow pumps located in the pumping station. Since the life cycle cost analysis, Alternate 2, where 2-stage pumps were specified, the pumps have evolved into single-stage, lower specific speed pumps with Francis type impellers. These impellers have a larger radial velocity than their two stage counterparts, but will be less expensive since one stage has been eliminated. Four of the pumps will be 60" by 84" rated at 360 cfs each. The other two pumps will be 30" by 42" mixed flow rated at 100 cfs each. The Watermaster will have the flexibility of using the two different sizes in combination to best match the required flow demand of the canal network.

b. Design Conditions. The pump design was based on a total station capacity of 1640 cubic feet per second, an average low river elevation of 158.0 feet, and a discharge canal water surface elevation of 233.3 feet. The pumps will be operating against a static head varying between 80 feet at historic low river and 45.7 at project record flood.

c. Materials. The pump column and discharge pipe will be ASTM A-36 steel plate. Pump bowls will be cast from close grain cast iron ASTM A48. Impellers will be single piece bronze castings keyed to a stainless steel bowl shaft such that the impeller can be torqued in either direction. Guide bearings shall be sleeve type with bronze linings. Line shafts will have stainless steel bearing journals and stainless steel couplings. Bearings will be grease lubricated with Farval automatic lubricators.

d. Pump Valves. There will be a motorized butterfly valve for shutoff in the discharge pipe of each pump. These valves are for maintenance and emergency purposes only and are normally left in the open position. There is also a pneumatic operated, butterfly or cone type, pump control valve in the discharge of each pump. During pump starting, this control valve will open as the pump comes up to speed and will close gradually as the pump starts to wind down. During power loss or during an emergency situation the station's compressed air storage will be sufficient to return all valves to their closed position.

e. Formed Suction Inlet. Each pump will be fed through a Corps of Engineers low profile type 10 formed suction inlet. The dimensions of the formed suction inlet are dictated by the impeller bowl opening size. The formed suction inlet will severely reduce problems from vortex formation and subsequent induced cavitation. It will also eliminate the need for a sump model study. A converging concrete inlet section will funnel water from the inlet bay into the formed suction inlet.

5-C-04. MAIN MOTORS.

The four 360 cfs pumps will be driven by 5300 hp, 4160 volt, three phase motors with soft start capability. The two 100 cfs pumps will be driven by 1650 horsepower motors. All pump motors will be air cooled and will have oil lubricated bearings. A maintenance platform with access steps will be provided around the motor if needed. Motors will be controlled manually from console in master control room. Motors will be started and stopped, as required, to best match the demand of the system. If finer regulation is required than can be achieved by started/stop control, then the pump control valves can be regulated to adjust flow rate.

5-C-05. DISCHARGE PIPE.

Pumps will be manifolded into two main discharge barrels that will carry the flow in excess of a mile to the discharge structure at the head of the irrigation canal system. These main pipes will be 120 inches in diameter with 1/2 inch thick walls, and welded joints. Pipes shall have a minimum of 4 foot cover to overcome hydraulic uplift. Air and vacuum relief valves will be located along the pipe, approximately every 1/2 mile, to provide for the removal of trapped air and to prevent excessive vacuum during draining.

5-C-06. ROLLER GATES.

Roller gates will be installed at the entrance of each of the pump inlet conduits. A motor operated hoist will be used to open each of the roller gates when needed. The gate hoist will have a position limit switch and a torque limiting device to prevent damage to the gate and gate stem. The larger roller gates will have a tandem operator with two hoists and one motor operator. The smaller roller gates will have only a single motor operated hoist.

5-C-07. STATION OVERHEAD CRANE.

A 30-ton, double girder bridge type crane, with top running trolley will be provided in the station. The crane bridge will have a span of 48 feet and shall be provided with a walkway. The hoist shall have a total lift of 60 feet. The bridge, trolley, and hoist will be motorized and will have infrared remote controls for easy operation. The bridge will have a variable speed drive capable of traveling a maximum of 160 feet per minute. The trolley will also have a variable speed drive with a maximum travel speed of 80 feet per minute. The hoist will have a variable speed of between 21 feet per minute and a creep speed of 1.6 feet per minute. An auxiliary 10 ton monorail hoist will be mounted on the trolley for light lifting operations.

5-C-08. SUMP UNWATERING SYSTEM.

The sump unwatering system for this pumping station will consist of mud valves, concrete embedded gravity drain pipes, and a submersible pump located in a drain pit beside the station. Mud valves will be of the rising stem type and will be controlled by a hand-wheel operated floor stands located at elevation 189.6. Each floor stand shall have an indicator to show the relative position of each mud valve. The stem shall be stainless steel and of the manufacture's recommended diameter for the application. Stem guides will be placed at intervals along the stem, to keep the L/R ratio below 200. Each sump bay will be equipped with one 6" mud valve. Mud valves will be connected to a 12" cast iron header which will carry sump water to the pump pit. The pump pit will contain a removable submersible pump.

A 20 HP, 1750 RPM, single-stage, vertical, submersible, non-clog, 8 inch pump with check valve will be installed in the chamber and will discharge the effluent into the inlet channel through the pumping station wing walls. Access to the pumping pit will be through a hinged hatch at the top of the pit. The pump will be capable of delivering 1000 GPM against a 42 foot head, thus giving a sump unwatering time of approximately 70 minutes. See **Appendix V-F** for calculations. The discharge pipe will exit the pit, travel through the ground, and discharge into the inlet channel. The end of the discharge pipe will have a flap valve, as an added measure, to prevent backflow of river water into the station when the unwatering pump is not being used. The pump will operate automatically via float control switches and will be capable of removal by sliding up guide rails and without using tools to disconnect the pump from the discharge piping. The pump will also have manual override controls to allow the pump to be started and stopped at any time as station personnel see fit.

5-C-09. FLOOR DRAINAGE SYSTEM.

The pumping station will have floor drains or trench drains located on each level, as required, to capture water leaking from the pumps, leaching through the walls, or resulting from washdown operations. Water will be carried by cast iron drainage pipes to a drain pit located on the opposite side of the pumping station from the sump unwatering pump pit. A submersible pump similar to that used in the unwatering system will be used to discharge this water into the inlet channel. Piping will be routed from the pit, through the ground, to the inlet wing wall. The pump will be sized to handle a total influx of 100 GPM. The pump will be a 3", single-stage, vertical, non-clog, submersible with 5 HP, 1750 RPM drive motor. The pump will be automatically controlled by floats in the pit.

5-C-10. VENTILATION SYSTEM.

The pump room will be ventilated via 12 motor-driven roof mounted ventilators. Motorized air intake louvers will be provided along the north, south, and east walls of the station. The ventilators will have a 5 HP NEMA standard motor, which will be permanently sealed and prelubricated with ball bearings and of the open drip-proof type, and a 48 inch fan with a capacity of 26,084 CFM each at 1/4 inch static pressure. See **Appendix V-G** for calculations. The ventilator hoods shall be aluminum with a wire mesh bird screen to prevent entrance of foreign matter, and the fan assembly shall be all steel.

There will be eight operable louvers, 144 inches by 96 inches, and eight stationary louvers of the same size mounted in series. The damper blades of the operable louvers shall have a width of at least 6 inches and provide at least 50 percent free area when in the open operating position. The dampers shall be made of 16 gauge galvanized steel with stainless steel adjusting linkages and ball bearings. The blades shall be at four to six inch centers. The inside of the dampers will have an insect screen. The stationary louvers shall be constructed of 16 gauge galvanized steel. The louvers will be constructed with at least 50 percent free area and of the drainable type. Velocity through the intake louver/dampers will be approximately 1200 feet per minute.

The toilet area will be ventilated using a small single speed direct-drive centrifugal ventilator. The fan shall be capable of exhausting at least 300 cubic feet per minute at a 1/4 inch static pressure.

5-C-11. OFFICE HEATING AND AIR CONDITIONING.

The office shall have a nominal 7 1/2 ton heat pump with auxiliary strip heating. See **Appendix V-H** for calculations. The heat pump will be a commercial roof-top mounted unit. The heat pump shall have an outside air intake for bringing in fresh air. The condenser section shall have direct drive propeller type fans with permanently lubed bearings and resiliently mounted to reduce vibration; a hermetically sealed reciprocating compressor with low and high pressure protection, charged with R-22 refrigerant; and copper refrigerant coils with mechanically bonded smooth plate fins.

The evaporator section shall have horizontal discharge provided by permanently lubricated forward curved fan(s), copper refrigerant coils with mechanically bonded smooth plate fins, a thermal expansion valve, and condensate drain with pan. The heat pump will be controlled by a remote mounted thermostat located in the office space. The thermostat shall have controls for on/off, temperature, airflow, and heating/cooling mode. The unit shall operate on 480 volts, 3 phase, 60 hertz.

During the winter months should additional heat be needed on the operating floor and/or lower levels while doing maintenance, plug-in infrared heaters will be used. The water pipe located throughout the station will use pipe heated cable, and the pipe will also be insulated to prevent freezing. The pipe heating cable will be sized to pass no more than 6 watts/ft. at 40^0F for the pipe size pipe being heated.

5-C-12. WELL WATER SYSTEM.

A well will be drilled near the pumping station to provide water for all pumping station needs. The well will be located approximately 250 feet north of the pumping station. The piping will run to the station underground. The pump will be made for well water pump applications and constructed of corrosion resistant metals to ensure a long life. A submersible pump will be provided to deliver water at a rate of not less than 15 gallons per minute against a pressure of 50 PSI. The pumping level will depend upon how deep the well must be drilled. Since there is a great variance in the potable drinking water level throughout the area, the depth of the well will not be known for certain until the well is actually drilled. The well will be drilled deep enough so that all water needs can be supplied by one well. The water will be filtered and/or cleaned as necessary before being used. The water will be stored in a 150 gallon diaphragm type hydro-pneumatic storage tank located in the mechanical room at elevation 174.0.

5-C-13. PLUMBING.

The plumbing system will consist of a water supply system, plumbing fixtures, and a sewage disposal system.

a. Water Supply System. The water supply system shall consist of supply piping, a 150 gallon hydro-pneumatic storage tank, chlorinator and a water heater. The storage tank shall be of the diaphragm type operating between 30 and 50 PSI. The water heater shall be a 40 gallon, 9000 watt, 240 volt tank with an adjustable thermostat.

b. Plumbing Fixtures. The plumbing fixtures in the men's latrine shall consist of one water closet with flush valve, one urinal with flush valve, and two lavatories with hot and cold water available. The plumbing fixtures in the women's latrine shall consist of two water closets with flush valves and two lavatories. The sewage discharge from the latrines will be piped into a small Coast Guard approved sewage treatment plant. The sewage treatment plant will have a treatment capacity of 240 gallons of waste water per day. The system shall be self contained and the effluent, after treatment, shall be free from all bacteria ,colorless, and odorless and will be discharged into the inlet.

c. Sewage Disposal System. The sewage treatment plant will be a Coast Guard certified Type II Marine Sanitation Device consisting of two treatment tanks and a chlorine contact chamber. The first treatment tank will be an aeration tank where sewage mixes with aerated liquid. The second tank will be a biological filter tank where sludge in the liquid settles out in the bottom of the tank and the remaining liquid passes through the biological filter to the top. After passing through the biological filter, the liquid will pass into a chlorine contact chamber where disease-carrying bacteria are killed. The effluent will be discharged into the pump station sump.

5-C-14. FIRE EXTINGUISHERS.

One portable fire extinguisher will be located in the office area and three portable fire extinguishers will be installed on each of the lower levels, and eight portable fire extinguishers will be installed on the operating floor. All fire extinguishers will be Underwriter's laboratory tested. The fire extinguishers shall be all purpose A-B-C dry chemical type. They shall have a pressure gauge showing proper operating pressures, a discharge nozzle, use either air or nitrogen as an expeller, and use non-toxic dry chemical. The fire extinguisher shall have a capacity of 20 lbs and UL. rating of 10A : 40B : C.

5-C-15. COMPRESSED AIR SYSTEM.

Air compressors will be located in the mechanical room on the operating floor. Air will be needed for operating tools, for cleaning equipment, and for operating the pneumatic pump control valves. The compressed air system will consist of two 5 horsepower, single phase, 208 volt, 3 phase, 60 Hz, 1096 RPM motorized compressors and enough storage tanks to operate all pump control valves in a power loss situation. The system will operate between 110 PSI and 140 PSI. Dryers will be used to reduce the moisture content of the air stored in the air tanks.

5-C-16. HYDRAULIC ELEVATOR.

One hydraulic elevator will be located in an elevator shaft on the west side of the station. The elevator will have inside dimensions of 80 inches wide and 65 inches in depth. The elevator will have a 3'-6" by 7 foot door. The hydraulic equipment will be housed in a machine room located on the operating floor. The hydraulic pump will be driven by a 30 hp motor operating on 480 volts, 3 phase. The elevator equipment room will be cooled by an A/C duct running down through the closest in the break room.

5-C-17. DISCHARGE PIPE.

Two of the large pumps and one of the small pumps will discharge into one of two 120" discharge pipes that will carry the water in excess of a mile to the discharge structure. The 120" pipe will have welded joints if placed in stable soil. Where placed in backfill, an analysis will be necessary to determine if flexible couplings will be required. The discharge pipes leaving the pumps will have dresser couplings to allow for differential settlement of the structure and to provide earthquake protection.

5-C-18. TRASH BARRIER.

Located in the inlet channel, at the end of the finger levees extending from the station, will be a trash barrier to strain the incoming water of large foreign objects and debris. The trash barrier will have a walkway across the top so personnel can access the face of the barrier for cleaning. The trash barrier will be angled parallel to flow during high stages such that the current in the river will tend to sweep the accumulated trash downstream. Any trash attached to the barrier can be manually dislodged and shoved into the main flow of the river.

PART D - ELECTRICAL DESIGN DEVELOPMENT

5-D-01. GENERAL

a. Scope. The design of the electrical system for servicing the pumping plant located on the White River just north of DeValls Bluff, Arkansas, as part of the Grand Prairie Area Demonstration Project will include provisions for power, control, lighting, ventilation, lightning protection and grounding.

b. Design Criteria. The design of the various sub-systems will be based on the use of equipment and materials that are available as standard products of the electrical industry. In the selection of materials and equipment, special consideration will be given to ease of operation, reliability and ease of maintenance. The Standards of the National Electrical Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE) and the American National Standards Institute (ANSI) will be used as guides in the selection of motors, switchgear and other electrical equipment. The design of circuits, conduit systems and the grounding system will conform to the National Electrical Code, the National Electrical Safety Code and Corps of Engineers Guide Specifications. The electrical design of the pumping station will be generally in accordance with EM 1110-2-3105 dated 30 March 1994, Engineering and Design, "Mechanical and Electrical Design of Pumping Stations" as this manual contains criteria pertinent to the design and selection of mechanical and electrical systems for flood control structures and not irrigation water supply.

5-D-O2. POWER SOURCES.

a. Commercial. All commercial electrical power for the pumping plant will be supplied by Entergy Services, Inc., with headquarters in Little Rock, Arkansas. The 4160-volt three phase power needed for the pump motors (a total of 24,500 HP) and the 480-volt three phase power needed for all the ancillary systems will be furnished from a transformer station located adjacent to the pumping station and fed from a 115kV transmission line. The transmission line will be fed from a power company substation located on the north side of the city of DeValls Bluff, Arkansas approximately one mile from the pumping plant. The power company will provide power to the pumping plant with this new service and does not intend to add to, or alter the transmission line for possible future customers (due to the remoteness of the area). Therefore, all construction costs for the electrical service must be paid by the ultimate end user. The power company will supply the 4.16kV from their transformer to a termination point where two separate feeders (each sized for half the pumping station load) will be brought into the pumping station (as recommended in EM 1110-2-3105). These two feeders will be connected inside the medium voltage switchgear by a tie breaker for service continuity. The power company has requested that no pump motor be started at full voltage across the line and that not more than one pump motor be started at one time. This will be accomplished by using autotransformer reduced voltage motor starting with microprocessor logic control on the solid state motor starters.

b. Operating Costs. The power company has furnished a cost for operating the pumping station both on a firm power and a interruptible power basis (and which rates incorporate their construction costs). The power company has also agreed to reduce the **minimum** monthly rates if the Government contributes to the initial cost of the transmission line and substation. In addition, should the end user not consume energy (i.e. not pump) for any one month of the year, a minimum monthly bill provision per month will be charged for that month (an amount based on a 2 ½ % factor of the total construction cost **or** the rate schedule minimum). In this stage of the project, Entergy Services, Inc. estimates a total construction cost of approximately $2 million dollars and would in all probability ask for a minimum contract period of at least 5 years. The power company has stated that any reduction in their construction costs for the substation and the transmission line may reduce the amount of minimum monthly fees that will be passed on to the customer. The minimum monthly bill charged by the power company will be the **higher** amount of either approximately 2.5% of total power company construction costs **or** the rate schedule minimum. With construction costs of about $2 million dollars, the minimum monthly bill would be about $50,000 (2.5% X $2 million) or the rate schedule minimum. The rate schedule monthly minimum charge is composed of two items, the normal energy usage plus $2.57 per Kilowatt of the highest demand established during the 12 months ending with the current month. The estimated highest electrical monthly demand for the pumping station is expected to be approximately 15,000 Kilowatts. During any one month, if the pumping station did not run at all, the lowest monthly minimum rate schedule bill would therefore be 15,000 Kilowatts X $2.57 per Kilowatt or approximately $38,550. This would be the absolute lowest monthly electric bill for the pumping station.

The Government may contribute to the power company costs of building the substation and transmission line for the Major Pumping Station which will lower the minimum monthly cost of $50,000. Since the minimum rate schedule bill will be $38,550 (even if the pumping station does not run the demand charges must be paid), it is possible to lower the capital construction costs for the substation and transmission line. The construction cost can be reduced to a amount where 2.5% of construction costs decreases the $50,000 to $38,550, i.e., reduce the $2 million dollars construction costs to approximately $1.5 million dollars (where 2.5% of $1.5 million dollars would equal the $38,550 rate minimum). This reduction of power company construction costs would require a Government contribution of approximately $500,000 on the front end but would only affect the power charges for one month (December is considered a low or no operation month due to low water demand, low river and/or pumping station maintenance; all other months have pumping station operations and would raise those monthly bills above the $38,550 absolute lowest monthly bill). The total savings for that one month would only be $50,000 minus $38,550 or $11,450. Continued discussions with the power company may improve these figures and this is being investigated.
Based on the estimated monthly horsepower loads furnished to them and assuming no Government contribution for the initial costs of transmission lines and substation, they have estimated a rate schedule. The estimated charges for electrical energy are as follows:

YEAR	1995	1996	1997	1998	1999
FIRM POWER $	3,397,119	3,423,999	3,545,810	3,470,214	3,254,739
FIRM POWER $/kWH	.0470	.0473	.0491	.0480	.0450
INTERRUPTIBLE $	2,601,474	2,628,354	2,750,166	2,674,569	2,459,094
INTERRUPTIBLE $/kWH	.0360	.0364	.0380	.0370	.0340

The interruptible power rate is based on the pumping station reducing its load to 1,000kW when called upon to do so. In all probability, the actual energy charges will fall somewhere between the Firm Power rate and the Interruptible Power rate. In addition, any Government contribution to the cost of installing a transmission line and substation would subsequently lower the minimum monthly charges for energy and/or demand, and because of recent power company de-regulating rules and planned power company decreases in power rates in 1998 and 1999, these rates can be expected to be even lower.

The interruptible power rates, if chosen, would require installation of pumping plant generators to provide some measure of reliability for the station. The generators can be self contained units located next to the electric substation on concrete pads and would allow the pumping plant to operate during peak power company electrical demand to provide the necessary irrigation water to the canal system. A cost analysis comparing the total cost of using firm power vs. interruptible power plus generators would be required. At the present time Memphis District is unable to do this cost study due to manpower and time constraints, however, HDC will be requested to complete the study before Plans and Specifications are developed. There is one condition that may restrict the use of diesel generators. The use of diesel driven pumps was considered at the beginning of this project and this approach was questioned by the Arkansas Game and Fish Commission because of the pumping plant's location next to the Wattensaw State Game Area. The Commission expressed concern about the noise, diesel smoke and possible contamination of the area by diesel fuel (as a leak or oil spill), however, if the cost analysis is found to be economically justified, further discussions with the Commission will be held.

5-D-03. POWER DISTRIBUTION.

a. General. All electric power to the pumping units and all auxiliary systems will be distributed through medium voltage metal clad motor control centers and motor controller line-ups. The medium voltage switchgear and motor controller line-ups will be supplied with 4,160 volt three phase power and will be furnished with space heaters with thermostat control to prevent condensation. Additionally, a programmable microprocessor logic-controller-based Supervisory Control and Data Acquisition (SCADA) system will be used which will allow starting of one motor at a time as required by the power company. A feeder from the medium voltage switchgear will supply power to the low voltage distribution system.

b. Loads. Utilization equipment controlled from the switchboard and motor control centers will be as follows:

4,160-volt, three-phase equipment:
4 - 5,300 HP vertical induction electric pump motors.
2 - 1,650 HP vertical induction electric pump motors.

480-volt, three-phase equipment:
1 - 30 ton bridge crane
1 - well pump
2 - dewatering pumps
12 - roof vents
6 - sluice gates
2 - air compressor
1 - vacuum pump
1 - elevator
1 - office air conditioning system

208-volt, single phase equipment:
6 - gate motor heaters
1 - office heater
1 - electric range
1 - water heater
6 - motorized shut-off valves
6 - Farval lubricating units
2 - infrared radiant heaters
1 - sewage treatment pump
Interior and exterior lighting

120-volt, single phase equipment:
Motor and switchgear heaters
Motor starter control power for testing
Office and control room lighting
Dewatering pump and well motor heaters
Receptacles
Emergency lights
Sanitation device
Chlorinator
Annunciator
Refrigerator

c. Voltage Drop Requirements. Conductors for feeders will be sized to prevent a voltage drop from exceeding three percent at the farthest outlet on the feeder. Where feeders are in series with branch circuits, conductors will be sized to prevent a total voltage drop on both feeders and branch circuits from exceeding five percent at the farthest outlet on the branch circuit.

5-D-04. PUMP MOTOR CONTROL SYSTEM.

a. General. The pump motor control system will conform to the requirements of EM 1110-2-3105. Each of the two motor controller line-ups will be powered from a main service disconnecting device which will be a power circuit breaker of the vacuum type. Transition sections will allow the metal-clad switchgear (containing the vacuum circuit breakers) to be integrated with the motor controller line-ups. The medium voltage motor controller line-ups will comply with ANSI/NEMA ICS 2-324, "A-C General Purpose High Voltage Class E Controllers" and UL Standard 347 (Underwriters Laboratories, Inc. 1985). Each motor controller will include a high and low voltage section, motor starters and motor protection.

b. High and low voltage sections. The high voltage section will contain a line isolation switch, current limiting power fuses, and magnetic vacuum contactor. The low voltage section shall be isolated and barriered from the high voltage section and shall contain the controls and protective relaying.

c. Motor starters. Motor starters shall contain all components necessary for non-reversing, reduced voltage, autotransformer start, induction motors.

d. Motor protection. Motor protection will be provided by a microprocessor based protective system which will combine control, monitoring, and protection functions in one assembly. The protective system will monitor the motor's three phase AC current, the temperatures of the motor windings, and the temperatures of the motor and/or pump bearings. The microprocessor based protective system will use the positive and negative (unbalance) sequence current algorithm method to determine the motor protection curve; protective features will include motor overload, instantaneous overcurrent, ground fault, phase loss and phase unbalance, jam trip, number of motor starts per time period, motor bearing temperature, and incomplete sequence.

5-D-05. LOW VOLTAGE DISTRIBUTION SYSTEM.

a. General. The low voltage distribution system will provide power to all low voltage utilization equipment, including the lighting system, gate operators, overhead crane, air conditioning system, air compressors, SCADA equipment, and all small motors. The low voltage distribution system will include a 480Y/277 volt and a 208Y/120 volt system.

b. 480Y/277 volt system. The 480Y/277 volt system will be supplied by a three phase feeder from a vacuum type power circuit breaker located in the station's metal-clad switchgear. The feeder will supply power to a 4,160 - 480Y/277 volt, floor mounted transformer; the transformer will distribute power through a two section, wall mounted distribution panel.

c. 208Y/120 volt system. The 208Y/120 volt system will be supplied by a three phase feeder from a molded case circuit breaker located in the 480Y/277 volt distribution panel. The feeder will supply power to a 480 - 208Y/120 volt, floor mounted transformer; the transformer will distribute power through a wall mounted distribution panel.

5-D-06. PUMP LOW WATER CUTOFF CONTROL.

The pump low water cutoff control will consist of a strain gage or vibrating wire technology sensor in each pump bay (one for each pump motor). The sensors will be sealed and be made of an abrasion and corrosion resistant material. The sensor will be supported by a corrosion and abrasion resistant jacketed cable which will be capable of holding the switch in a vertical position, resisting any drift during pump operation. The sensors will be installed in a PVC type pipe for physical protection.

5-D-07. CONDUIT AND BOXES.

a. General. All wiring will be installed in rigid metal conduit except that motors and other electrical equipment subject to vibration will be connected with liquid-tight flexible metal conduit. All conduit will be embedded unless otherwise specified. All conduit runs will avoid pockets or traps which retain moisture, and the specifications will emphasize provisions necessary to drain all conduits.

b. Pull and Junction Boxes. All embedded pull boxes and junction boxes will be of cast metal of sufficient thickness, or provided with bosses, to accommodate the required threads for conduit connections of the sizes specified. Drain pipe and screen will be provided in the bottom of the boxes.

c. Outlet boxes. All outlet boxes for receptacles, switches, and lighting fixtures will be of cast metal with bosses drilled and tapped or with threaded hubs of the size specified. The edges will be designed to take a heavy cover gasket with four or more screws for attaching covers or fixtures.

5-D-08. MOTORS.

a. Main Pump Motors. The main pump motors will be 4 - 5,300 HP, 4.16kV, three-phase, 60 Hz., 1.1 Service Factor, vertical shaft, 360 RPM induction motors and 2 - 1,650 HP, 4.16kV, three phase, 60 HZ, 1.1 Service Factor, vertical shaft, 450 RPM induction motors each with stator and bearing RTD's and with an approximate power factor at full load of 94% or better. The horsepower of each motor meets the requirements of EM 1110-2-3105 (used only as a guide since this pumping plant will not be used for flood control and is therefore not covered under the EM).

b. Ancillary Motors. The motors used for operating the pumping station auxiliaries and station service equipment will be single speed, 480-volt, three-phase, 60 Hz. The horsepower ratings for all 480-volt motors will be determined by the machinery requirements and duty cycle. Motors one HP and larger will be provided with space heaters to prevent condensation while idle.

5-D-09. LIGHTING AND RECEPTACLES.

a. Lighting.

(1.) Interior Lighting. The following shows the interior lighting area locations, type of luminaires and footcandle intensities:

AREA	TYPE	FOOTCANDLES
Operating Room	HPS	30
Pump Bays	LPS	5
Office and Control Room	Fluorescent	50
Toilet	Incandescent	15
Stairs	Vaportight Incandescent	15
Equipment Room	Fluorescent	30

The lighting loads will be determined by using the following formula:

$$\text{Watts} = \frac{\text{Footcandle intensity x total area of room x watts per lamp}}{\text{Lumens per lamp x coefficient of utilization x maint. factor}}$$

(2.) Exterior Lighting. All exterior lighting will be provided with vandal-proof polycarbonate refractor or shields. The following shows the exterior lighting locations, types of luminaires and footcandle intensities:

AREA	TYPE	FOOTCANDLES
Entrance	High Pressure Sodium	5
Building Perimeter	High Pressure Sodium	5

The lighting loads will be determined by using the following formula:

$$\text{Watts} = \frac{\text{Footcandle intensity x total area of room x watts per lamp}}{\text{Lumens per lamp x coefficient of utilization x maint. factor}}$$

(3.) Emergency Lighting. Each floor of the pumping station will be provided with fifty watt emergency lighting units operated from a 12-volt DC battery which will remain fully charged at all times by a battery charger that will "float" on the line and will be fed from a 120-volt lighting panelboard in the motor control center. Separate emergency lighting units are preferable to a central battery station to avoid the extra cost of large battery chargers, an explosion proof room and increased ventilation.

b. Receptacles. Three-pole duplex receptacles will be provided at appropriate points in the walls of the operating floor, office, and equipment room. Receptacles will be 120-volt AC, 20-ampere two wire with grounding pole. All circuits from the lighting panelboard in the switchboard supplying power to the receptacles will have ground fault interrupter circuit breakers. No exterior convenience receptacles will be provided as experience has shown increasing vandalism to these types of structures and in addition no future exterior repairs to the structure are anticipated.

5-D-10. VENTILATION.

Eight roof ventilators will be provided for the proper ventilation of the operating room floor and toilet room. A vent fan (smaller than the roof ventilators) will be furnished for the toilet room.

5-D-11. COMMUNICATIONS.

An outlet box will be provided in the office wall for future telephone connections. A conduit from the outlet box will be stubbed outside of the pumping station and capped. Several empty conduits will also be installed in the office to allow for communication cables and equipment associated with the SCADA control system for the entire canal network and controlled by the Watermaster.

5-D-12. ANNUNCIATOR.

Motor control centers number 1 and number 2 will be furnished with a SCADA system containing annunciator alarm panels and alarm horns to alert the pumping station operator whenever a problem occurs with the pumps , pump motors or power system. The annunciator panel will light a window or other similar device and energize an alarm horn. The first fault to be monitored will be locked in to the respective alarm panel for easy operator identification. Each pumping unit will be monitored and will have separate alarm panels. The annunciator will monitor pump motor bearing and winding temperatures, pump bearing temperatures, pump and pump motor vibration and loss of power. Additionally, a identical remote alarm panel will be located in the control room and will contain individual windows and lights for each pumping unit, and one common horn. The horn, windows and lights will be interconnected to each pumping unit alarm circuit so that during normal operation the green indicating light(s) will be illuminated. If a problem occurs with any of the pumping units alarm circuits, the horn will sound and the red indicating light(s) will illuminate. The operator can then check the proper window on the alarm panel or at the motor control center for the problem. Each annunciator and the remote alarm panel will be supplied with battery backup for operation during loss of power.

5-D-13. GROUNDING SYSTEM.

The pumping plant electrical system will be grounded in accordance with the National Electrical Code. The grounding electrode system will consist of all metal underground water pipe and a concrete encased electrode conforming to NEC 250-81(c) (covering the steel reinforcing bars in the concrete foundation) bonded together with bonding jumpers as specified in NEC 250-81. All jumpers and grounding electrode conductor connections will be done by exothermic weld. The step down 4.16kV/480 and the 480/208Y/120 volt, three-phase dry type transformers located in the switchboard and motor control center feeding the distribution panels are considered separately derived systems and will be grounded as per NEC 250-26. All electrical equipment, machinery and exposed metal will be bonded to the grounding electrode system.

5-D-14. LIGHTNING PROTECTION SYSTEM.

The lightning protection system that will be provided for the pumping station will be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and will conform to NFPA Nos. 70 and 78, UL 96 and UL 96A. The system will consist of air terminals, roof conductors, down conductors, ground connections and grounds, electrically interconnected to form the shortest possible distance to ground without passing through any nonconducting parts of the structure. All conductors on the structure will be exposed except where conductors are in protective sleeves exposed on the outside wall. Secondary conductors will interconnect with grounded metallic parts within the building. The entire lightning protection system will be designed in accordance with procedures outlined in TM 5-811-3.

5-D-15. SHORT CIRCUIT ANALYSIS.

The short circuit or fault current calculations for the 4160-volt and 480-volt, three-phase systems in the pumping plant will be done using a short circuit analysis computer program. Each segment of the one line diagram will be defined by a pair of unique nodes or point numbers. The short circuit program will contain system data, default X and R components table filenames, component summary, short circuit input data and short circuit output data. The short circuit calculations will reflect the actual magnitude of a potential fault current at a particular point on the one line diagram. The magnitude of the fault current at any given point will depend upon how much short-circuit current is available from the sources (the utility service and all operating motors and/or generators) and the characteristics of the components in the circuit. These calculations will insure that proper sized protection devices are installed at appropriate places in the system to prevent possible damage to the system and potential harm to human life.

PART E - STRUCTURAL DESIGN DEVELOPMENT

5-E-01. GENERAL.

This section presents the basic criteria, assumptions, methods of analysis, and results of the computations for the design of the main pumping station structure selected in the Life Cycle Cost Analysis (Part B). Sufficient engineering and design was performed to enable refinement of project features, prepare the cost estimate, develop a design and construction schedule to allow detailed design to begin immediately following receipt of preconstruction engineering and design (PED) funds.

5-E-02. PUMPING STATION DESIGN.

Corps of Engineer design criteria was applied to simple beam moments and shears in order to size structural members. Two past pumping station projects (W. G. Huxtable and Cypress Creek) where also used to assist in sizing members. Once structural members were sized, Microstation 3D models were developed. The 3D models were used to calculate quantities and the center of gravity of the structures. The 3D models included preliminary site design. The site work for the 1640 cfs station included a 9000 foot gravel access road along the discharge pipe, a 30' x 30' x 14' discharge structure, a 1000 foot asphalt access road to a proposed highway, a 1800 foot long inlet channel with a 104' bottom width and 1V:3.5H side slopes, a 150' x 150' electrical substation site, and miscellaneous culverts, fencing, retaining walls, etc.. The training walls for the pumping station will be reinforced earth and are covered in the Geotechnical section. See **Appendix V-I** for calculations.

5-E-03. COST ESTIMATE.

The cost for construction of the 1640 cfs Major Pumping Station is estimated at $28,966,970. See **Appendix V-J** for cost breakdown.

Grand Prairie Area Demonstration Project

Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-A

GRAND PRAIRIE PUMPING STATION

GENERAL REEVALUATION

U.S. Army Corps of Engineers
Memphis District

SECTION V - MAJOR PUMPING STATION

PART A - GENERAL

5-A-01. PURPOSE.

The purpose of this engineering support document is to establish essential data, assumptions, and criteria for providing a basis for the mechanical, electrical, and structural design requirements of the Major Pumping Station. This appendix, as approved, will form the basis upon which the design documents for final design of the pumping station will be prepared.

5-A-02. PROJECT AREA.

The Eastern Arkansas Region Comprehensive Study Area includes all or part of 24 counties in eastern Arkansas, a 13,400 square mile area which represents 25 percent of the land area of the state. The primary emphasis of the study is agricultural water supply and conservation and fish and wildlife restoration/enhancement. Depletion of the groundwater reserves caused by heavy agricultural use is the primary problem. Depletion of the alluvial aquifer is threatening the future of agriculture as it is presently practiced in the region. This valuable resource has been exhausted to only the perennial yields in parts of the area; and, if current trends continue, this natural resource could be completely lost, resulting in catastrophic economic losses to the area. The Grand Prairie Area Demonstration Project area includes portions of Arkansas, Prairie, Lonoke, and Monroe counties in eastern Arkansas. This project area covers approximately 362,662 acres which includes approximately 254,406 acres of cropland. The Grand Prairie Demonstration project will provide a supplemental agricultural water supply while preserving the groundwater resource. The project provides significant opportunity for fish and wildlife restoration and environmental enhancement.

5-A-03. PROJECT DESCRIPTION.

The primary plan of improvement for the Grand Prairie area consists of a major pumping station and a network of new canals, existing channels, pipelines, and associated channel structures to provide interbasin transfer of surface water to the water depleted areas. Included as an integral part of the plan are: conservation measures, groundwater management strategies, retrofit of farms, on-farm storage reservoirs, and fish and wildlife restoration and management features. A pumping station located on the White River just north of DeValls Bluff will be utilized to deliver excess surface water from the White River throughout the project area during peak use periods and for filling storage reservoirs during off-season periods.

5-A-02. MAIN PUMPS.

a. The eight irrigation pumps will be horizontal double suction split case centrifugal pumps with bottom suction and side discharge. Each pump will come with a 60 inch diameter flanged suction connection and a 48 inch flanged discharge connection.

b. Double suction pumps are designed to move water at moderate heads more economically than other types of pumps. They provide mechanical dependability, efficient operation, and low cost maintenance. Impellers are dynamically balanced and constructed with double inlets which practically eliminates end thrust. The pumps will have split casing to allow easy access to all rotating parts. The pumps selected were the largest, most practical size available. These pumps can be fabricated at the factory, shipped to the site assembled, and installed as a unit.

c. The pump design was based on a total station capacity of 1800 cubic feet per second (cfs), an average low river elevation of 158.0 feet, and a discharge canal elevation of 233.3 feet. The pumps will be operating against a design static head of 75.3 feet. The total dynamic head, as used in the calculations, is the sum of the static head, discharge pipe losses, inlet conduit losses, fitting losses, sluice gate losses, and discharge velocity head. Maximum power requirements for each pump is 2997 horsepower (hp) at an operating speed of 355 revolutions per minute (RPM). With a service factor of 1.1, the motor should be rated at not less than 3300 horsepower.

d. The pump casing will be closed grain cast iron. Impellers will be bronze, keyed to a stainless steel shaft and securely held in axial position by bronze sleeves passing through the packing glands. Each pump will have anti-fiction oil lubricated ball bearings. Each pump and motor will be mounted on a common fabricated steel baseplate. The coupling between the pump and motor will be of the gear type designed to transmit the total output power of the motor with a 1.5 service factor.

e. There will be a motorized double disc gate valve for shutoff in the inlet and outlet of each pump. These valves are for maintenance and emergency purposes only and are normally left in the open position. There is also a motorized combination throttling, check and drain valve in the discharge pipe of each pump. This valve is normally used to check the flow of water when the pump shuts off. When checking, the valve is hydraulically damped to prevent the check disc from closing too quickly or causing excessive water hammer. With the motor, the operator can either force the valve towards a closed condition in a flow situation (thereby throttling), or force the valve towards an open condition in a checked situation (thereby draining).

5-A-03. MAIN MOTORS.

The eight pump motors will be 3300 hp, 4160 volt, three phase, 60 hertz, 20 pole, 360 RPM, horizontal induction motors with soft start capability. The motors will be air cooled and will have oil lubricated bearings.

5-A-04. VACUUM PRIMING SYSTEM.

A vacuum priming system will be needed to establish prime in the pumps on initial start-up and whenever the discharge pipes are drained. There will be two 50 CFM vacuum pumps mounted on a horizontal tank in the mechanical room located at elevation 141.0. A 1-1/4 inch priming valve will be installed a the top of each pump. The system will prime one pump in 9.68 minutes. Air release valves will be piped thru a solenoid valve to the common vacuum header running the length of the station. When starting a pump, the controls will automatically activate the solenoid valve, detect when the water has reached the proper level in the pump, start the pump, and deactivate the solenoid valve. If the pump is already primed, the controls will sense the existing water level and start the pumps without delay.

5-A-05. SLUICE GATES.

A 9 foot by 8 foot sluice gate will be installed at the entrance of each of the pump inlet conduits. A motor operated gate hoist will be used to open each of the sluice gates. The gate hoist will have a position limit switch and a torque limiting device to prevent damage to the gate and gate stem. The sluice gates will be rated for a minimum seating head of 50 feet of water and an unseating head of 10 feet of water.

5-A-06. TRASH BARRIER.

Located in the inlet channel, at the end of finger levees extending from the station will be a trash barrier to strain the incoming water of foreign objects and debris. The trash barrier will have a walkway across the top so personnel can access the face of the barrier for cleaning.

5-A-07 STATION OVERHEAD CRANE.

A 30-ton, double girder bridge type crane, with top running trolley shall be provided in the station. The crane bridge shall have a span of 65 feet and shall be provided with a walkway. The hoist shall have a total lift of 69 feet. The bridge, trolley, and hoist will be motorized and will have infrared remote controls for easy operation..

5-A-08. SUMP UNWATERING SYSTEM.

A sump unwatering system will be installed so that individual pump bays can be unwatered for inspection and maintenance. Each pump bay conduit will have a 12" floor drain with a 12" cast iron gravity drain pipe terminating at a collection chamber. At the end of each drain pipe will be a shut-off valve. Shut-off valves will have operating stems which will extend above the historical high water level of El. 187.6. A 14 HP, 1750 RPM, single stage, vertical, submersible, non clog, eight inch sewage pump with check valve will be installed in the chamber and will discharge the effluent into the inlet channel thru an 8" ductile iron pipe. Access to the chamber will be provided via a manhole and ladder. The pump will be capable of delivering 500 GPM against a 50 FT. head, thus giving a sump unwatering time of approximately 45 minutes.

5-A-09. OPERATING FLOOR DRAINAGE SYSTEM.

The operating floor of the station will have a grated trench running the length of the station to catch any water leakage or spillage that might occur during routine operation and/or maintenance procedures. The trench will empty into a pit where the water can be pumped out using a 4" submersible pump. The water will be discharged through a 4" cast iron pipe into the inlet channel.

5-A-10. VENTILATION SYSTEM.

The operating floor will be ventilated via eight motor-driven roof mounted ventilators. Motorized air intake louvers will be provided along the north and south walls of the station. The ventilators will have a 3 HP NEMA standard motor, which will be permanently sealed and prelubed with ball bearings and of the open drip-proof type, and a 54 inch fan with a capacity of 9,094 CFM each at 1/4 inch static pressure. This will allow for approximately 9 air changes per hour on the operating floor. The hoods shall be aluminum with a wire mesh bird screen to prevent entrance of foreign matter and the fan assembly shall be all steel. See Appendix C for ventilation system design calculations.

There will be eight operable louvers, 72 inches by 48 inches located in the north and south walls of the operating floor, and eight stationary louvers, 60 inches by 54 inches, located in the north and south external walls of the station. The dampers shall be movable and have a width of at least six inches and provide at least 50 percent free area when in the open operating position. The dampers shall be made of 16 gauge galvanized steel with stainless steel adjusting linkages and ball bearings. The blades shall be at four to six inch centers. The inside of the dampers will have an insect screen so as to prevent insects from entering the pump station. The stationary louvers shall be constructed of 16 gauge galvanized steel. The louvers will be constructed with at least 50 percent free area and of the drainable type. Velocity through the intake louver/dampers will be approximately 800 feet per minute.

5-A-11. OFFICE HEATING AND AIR CONDITIONING.

The office shall have a nominal five ton heat pump with strip heating. The heat pump will be a commercial split system. The condensing unit will be mounted above the office inside of the pump station and the indoor air handler with evaporator will be mounted above the ceiling of the office. By mounting the condensing unit inside of the pump house it will be protected from vandalism. Locating the condenser unit inside of the pump station will allow for easier maintenance and will protect the unit from the weather, therefore increasing the life of the unit. The evaporator unit will have fresh air ducts extending outside so that fresh air can be pulled into the building.

During the winter months should additional heat be needed on the operating floor and/or lower levels while doing maintenance, plug-in infrared heaters will be used. The water pipe located throughout the station will use pipe heated cable and the pipe will also be insulated to prevent freezing. The pipe heating cable will be sized to pass no more than 6 watts/ft. at 40 degrees F for the pipe size pipe being heated. A immersion heater will be supplied for the water storage tank. The water heater will be sized to prevent the water from freezing when the ambient temperature is 20 ^{0}F.

5-A-12. WELL WATER SYSTEM.

A well will be drilled near the pumping station to provide water for all pumping station needs. The well will be located approximately 250 feet north of the pumping station. The piping will run to the station underground. The pump will be made for well water pump applications and constructed of corrosion resistant metals to ensure a long life. A submersible pump will be provided to deliver water at a rate of not less than 50 gallons per minute against a pressure of 50 PSI. The pumping level will depend upon how deep the well must be drilled. Since there is a great variance in the potable drinking water level throughout the area, the depth of the well will not be known for certain until the well is actually drilled. The well will be drilled deep enough so that all water needs can be supplied by one well. The water will be filtered and/or cleaned as necessary before being used. The water will be stored in a 525 gallon hydro-pneumatic storage tank located in the pump station.

5-A-13. PLUMBING.

The plumbing system will consist of a water supply system, bathroom fixtures, kitchen fixtures, and a sewage disposal system.

a. The water supply system shall consist of supply piping, a 525-gallon hydro-pneumatic storage tank, and a water heater. The 525-gallon storage tank shall have an operating range between 30 and 50 PSI. The water heater shall be a 20 gallon, 1650 watt, 120 volt tank with an adjustable thermostat and 7.5 gallons per hour of recovery with a 90 degree F temperature rise.

b. The pumping station will have two bathrooms, one for men and one for women. A break room with kitchen sink, garbage disposal and refrigerator will also be included for the convenience of the pumping station staff. The men's restroom will have one water closet with a flush valve, one urinal with flush valve, and one lavatory with hot and cold water available. The women's restroom will have two water closets with flush valves and one lavatory with hot and cold water available.

c. Discharge from the restrooms and break room will be piped to a small Coast Guard approved sewage treatment plant located in the lower level of the pumping station. The sewage treatment plant will have a treatment capacity of 240 gallons of waste water per day. The system shall be self contained and the effluent, after treatment , shall be free from all bacteria, colorless, and odorless and will be discharged into the intake.

d. Sewage Treatment System. The sewage treatment plant will be a Coast Guard certified Type II Marine Sanitation Device consisting of two treatment tanks and a chlorine contact chamber. The first treatment tank will be an aeration tank where sewage mixes with aerated liquid. The second tank will be a biological filter tank where sludge in the liquid settles out in the bottom of the tank and the remaining liquid passes through the biological filter to the top. After passing through the biological filter, the liquid will pass into a chlorine contact chamber where disease-carrying bacteria area killed. The effluent will be discharged into the pump station sump. The sewage treatment plant will be sized to accommodate a crew of four.

5-A-14. COMPRESSED AIR SYSTEM.

An air compressor will be located in the mechanical room on the operating floor to be used for operating tools, cleaning equipment, etc. The compressed air system will consist of one 5 horsepower, single phase, 230 volt, 60 Hz, 1096 RPM motor mounted on a horizontal 60 gallon tank. The system will operate between 110 PSI and 140 PSI.

5-A-15. HYDRAULIC ELEVATOR.

One hydraulic elevator will be located in the interior wall on the west side of the station. The elevator will have inside dimensions of 68 inches wide and 51 inches in depth. The elevator will have a 3 foot by 7 foot door. The hydraulic equipment will be housed in a machine room located on the operating floor.

PART B - ELECTRICAL

5-B-01. GENERAL.

The design of the electrical system for servicing the pumping plant located on the White River just north of DeValls Bluff, Arkansas, as part of the Grand Prairie Area Demonstration Project will include provisions for power, control, lighting, ventilation, lightning protection and grounding.

5-B-02. DESIGN CRITERIA.

The design of the various sub-systems will be based on the use of equipment and materials that are available as standard products of the electrical industry. In the selection of materials and equipment, special consideration will be given to ease of operation, reliability and ease of maintenance. The Standards of the National Electrical Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE) and the American National Standards Institute (ANSI) will be used as guides in the selection of motors, switchgear and other electrical equipment. The design of circuits, conduit systems and the grounding system will conform to the National Electrical Code, the National Electrical Safety Code and Corps of Engineers Guide Specifications. The electrical design of the pumping station will be generally in accordance with EM 1110-2-3105 dated 30 March 1994, Engineering and Design, "Mechanical and Electrical Design of Pumping Stations" as this manual contains criteria pertinent to the design and selection of mechanical and electrical systems for flood control structures and not irrigation water supply.

5-B-03. POWER SOURCES.

All commercial electrical power for the pumping plant will be supplied by Entergy Services, Inc., with headquarters in Little Rock, Arkansas. The 4160-volt three phase power needed for the pump motors (a total of 26,400 hp) and the 480-volt three phase power needed for all the ancillary systems will be furnished from a transformer station located adjacent to the pumping station and fed from a 115kV transmission line. The transmission line will be fed from a power company substation located on the north side of the city of DeValls Bluff, Arkansas approximately one mile from the pumping plant. The power company will provide power to the pumping plant with this new service and does not intend to add to, or alter the transmission line for possible future customers (due to the remoteness of the area). Therefore, all construction costs for the electrical service must be paid by the ultimate end user. The power company has furnished a cost for operating the pumping station both on a firm power and a interruptible power basis (and which rates incorporate their construction costs). In addition, should the end user not consume energy (i.e. not pump) for any one month of the year, a minimum bill provision of approximately $60,000 per month will be charged for that month (an amount based on a 2-3% factor of the total construction cost). In this early concept stage of the project, Entergy Services, Inc. estimates a total construction cost of approximately 2 million dollars and would in all probability ask for a minimum contract period of 10 years. If the end user does not pump as indicated, and after the power company has recouped the construction cost of the service (either by payment of energy costs per month while pumping for a determined period of years or with a minimum monthly bill of $60,000 per month for a determined period of years), a minimum monthly maintenance fee will be charged to the end user for continuance of the service. The pumping station will be serviced via two separate power sources from the transformer station so that the 4160-volt, three-phase service will not be required to be energized continuously. The power company has requested that no pump motor be started at full voltage across the line and that not more than one pump motor be started at one time. This will be accomplished by using some type of permissive switch or logic control on the solid state controllers.

The power company has estimated that the total construction cost of substations and transmission lines will be approximately 2 million dollars (in 1994 dollars and using the extreme cost estimates on both ends). Based on the estimated monthly horsepower loads furnished to them, they have estimated a rate schedule. The estimated charges for electrical energy are shown below:

YEAR	1995	1996	1997	1998	1999
FIRM POWER $	3,397,119	3,423,999	3,545,810	3,470,214	3,254,739
FIRM POWER $/kWH	.0470	.0473	.0491	.0480	.0450
INTERRUPTIBLE $	2,601,474	2,628,354	2,750,166	2,674,569	2,459,094
INTERRUPTIBLE $/kWH	.0360	.0364	.0380	.0370	.0340

The interruptible power rate is based on the pumping station reducing its load to 1000kW when called upon to do so. In all probability, the actual energy charges will fall somewhere between the Firm Power rate and the Interruptible Power rate.

5-B-04. SECONDARY DISTRIBUTION.

a. General. All electric power to the pumping units and all auxiliary systems will be distributed through medium voltage metal clad motor control centers and a low voltage switchboard and motor control center. The switchboard and low voltage motor control center will be furnished as one complete unit, with a separate 480-volt, three-phase service feed. Each section of the switchboard and motor control center will have space heaters with thermostat control to prevent condensation. The medium voltage motor control centers will be supplied with 4,160-volt, three-phase power and will also be furnished with space heaters and thermostat control. Additionally, a programmable logic-controller-based Supervisory Control and Data Acquisition (SCADA) system will be used which will allow starting of one motor at a time as required by the power company.

b. Loads. Utilization equipment controlled from the switchboard and motor control centers will be as follows:

4,160-volt, three-phase equipment:

8 - 3,300 HP horizontal induction electric pump motors.

480-volt, three-phase equipment:

1 - overhead crane
1 - well pump
2 - dewatering pumps
8 - roof vents
8 - sluice gates
1 - air compressor
1 - vacuum pump
1 - elevator

208-volt, single phase equipment:

8 - gate motor heaters
1 - office heater
1 - office air conditioner
2 - infrared radiant heaters
1 - sewage treatment pump
Interior and exterior lighting

120-volt, single phase equipment:

Motor and switchgear heaters
Motor starter control power for testing
Office and control room lighting
Office water heater
Dewatering pump and well motor heaters
Receptacles
Emergency lights
Sanitation device
Chlorinator
Annunciator

c. Voltage Drop Requirements. Conductors for feeders will be sized to prevent a voltage drop from exceeding three percent at the farthest outlet on the feeder. Where feeders are in series with branch circuits, conductors will be sized to prevent a total voltage drop on both feeders and branch circuits from exceeding five percent at the farthest outlet on the branch circuit.

5-B-05. PUMP MOTOR CONTROL SYSTEM.

The medium voltage metal clad motor control centers will consist of the following:

a. A 4.16kV three-pole motor operated fused load break switch will be furnished for each motor control center. Each load side terminal will be equipped with a station type lightning arrestor and each switch will be properly grounded,

b. A metering compartment with fused drawout potential transformers (having a ratio of 6kV/150-volts), current transformers, a control power transformer, a three-phase monitor, and a capacitor trip device which will shunt trip the main circuit breaker in the event of any loss of phase or phases, phase overcurrent relays, instantaneous overcurrent relays, ground fault (ground overcurrent) relay and indicating lights. Additionally, phase selector switches for voltage and current measurements as well as switchboard type taut-band, 240 degree arc meters - one for voltage and one for amperage - will be provided. Switch positions will indicate "Phase A", "Phase B", "Phase C" and "Off" for current readings and "Phases A-B", "Phases B-C", "Phases C-A" and "Off" for voltage readings. A manual permissive switch (69) that will allow the starting of only one motor at a time, as requested by the power company, will also be incorporated into the final design.

c. Four 4.16kV, three-phase, 60 Hz. motor controllers consisting of two major components - a solid state starter and a programmable motor protector. Additionally, each motor controller will contain a non-load break mechanical isolating switch, current limiting power fuses and a vacuum contactor.

Each solid state starter will use power thyristors to provide continuously-smooth controlled acceleration (soft start) and deceleration (soft stop). The soft start feature will provide reduced voltage starting to limit inrush current, thus minimizing the effects of starting the motors on the transmission and distribution system, meeting power company requirements. The soft stop feature will prevent damage to the structure's discharge gates by gradually reducing the speed of the motor and pump. A bypass contactor with voltage surge protection will short around the power electronics after the motor starts, connecting the motor directly to the supply lines. This feature will provide increased controller reliability and line spike protection for the SCR section during the pump motor run mode.

Each programmable motor protector will be a microprocessor based unit designed to prevent or minimize damage to the motor under a fault condition. The motor protector will allow the operator to program an operating envelop for the motor in terms of voltage, current, ground fault limits, temperature, overload and line integrity limits. The motor protector will continuously monitor the motor/motor circuit and protect against abnormal operating conditions including overload, short circuit, phase loss/phase unbalance, phase reversal, undervoltage, ground fault, long acceleration/stall, jam, underload, bearing overtemperature and repeat starts. The motor protector will give an indication when any operating parameter reaches a programmable alarm point, and will cause the solid state starter to deenergize the motor when any parameter reaches a programmable trip point. The motor protector will include an annunciator panel that will indicate the specific cause of an alarm and/or trip signal. Each motor controller will be provided with an incomplete sequence timer that will receive inputs from the pump bearing cooling water system, the pump low water cutoff control and the lubricating oil system of any gear reducer that is used. The timer will prevent the motor from starting unless all input parameters to it are in an acceptable mode. The pump motors will automatically deenergize whenever a failure occurs in the pump bearing cooling water system, the lubricating oil system of the gear reducer, or from low water cutoff. A "Hand-Auto" selector switch in the pump low water control circuit will allow the motor to start in a low water condition for the purpose of testing and/or inspecting the pump. Additionally, the motor controllers will be furnished with a SCADA system that will allow only one pump motor to start at a time, satisfying the requirements of the power company. A separate low voltage control circuit power input will also be provided that will allow for maintenance and/or testing of the motor starters without energizing the main 4.16kV power supply. In addition, each monitor protection control module will be fitted with a separate RTD module that will monitor the pump motor stator temperature, the motor bearing temperatures and the pump bearing temperatures. Should any of these temperatures exceed preset values, the appropriate annunciator window and the alarm system will be energized. The medium voltage metal clad motor control centers will be solidly grounded.

5-B-06. SWITCHBOARD AND 480-VOLT MOTOR CONTROL CENTER.

The 480-volt, three-phase switchboard and motor control center will be supplied by a separate 480-volt three-phase service from the power company and will contain the following:

a. A drawout main circuit breaker and a metering compartment containing potential transformers and current transformers. The main circuit breaker will feed 480-volt, three-phase power to combination motor starters and a transformer. The switchboard and motor control center may also contain a annunciator panel and alarm horn.

b. An ammeter and ammeter switch for measuring phase current, and a voltmeter and voltmeter switch for measuring phase-to-phase voltage.

c. A ground overcurrent relay (ground fault), a reverse phase relay, a phase overcurrent relay, a instantaneous overcurrent relay, an undervoltage relay and a three-phase monitor with a capacitor trip device which will shunt trip the main breaker.

5-B-07. PUMP LOW WATER CUTOFF CONTROL.

The pump low water cutoff control will consist of float switches in each pump bay (one for each pump motor). The float switches will be liquid level type, hermetically sealed and be made of an abrasion- and corrosion-resistant material. The switch will be supported by a corrosion- and abrasion-resistant sheathed cable which will be capable of holding the switch in a vertical position, resisting any drift during pump operation.

5-B-08. CONDUIT AND BOXES.

a. Conduit. All wiring will be installed in rigid metal conduit except that motors and other electrical equipment subject to vibration will be connected with liquid-tight flexible metal conduit. All conduit will be embedded unless otherwise specified. All conduit runs will avoid pockets or traps which retain moisture, and the specifications will emphasize provisions necessary to drain all conduits.

b. Pull and junction boxes. All embedded pull boxes and junction boxes will be of cast metal of sufficient thickness, or provided with bosses, to accommodate the required threads for conduit connections of the sizes specified. Drain pipe and screen will be provided in the bottom of the boxes.

c. Outlet boxes. All outlet boxes for receptacles, switches, and lighting fixtures will be of cast metal with bosses drilled and tapped or with threaded hubs of the size specified. The edges will be designed to take a heavy cover gasket with four or more screws for attaching covers or fixtures.

5-B-09. MOTORS.

The eight main pump motors will be 3300 HP, 4.16kV, three-phase, 60 Hz., 1.0 Service Factor, horizontal solid shaft, 360 RPM induction motors with stator and bearing RTD's and with an approximate power factor at full load of 94% or better. The horsepower of each motor meets the requirements of EM 1110-2-3105 (used only as a guide since this pumping plant will not be used for flood control and is therefore not covered under the EM). The motors used for operating the pumping station auxiliaries and station service equipment will be single speed, 480-volt, three-phase, 60 Hz. The horsepower ratings for all 480-volt motors will be determined by the machinery requirements and duty cycle. Motors one HP and larger will be provided with space heaters to prevent condensation while idle.

5-B-10. LIGHTING .

a. Interior Lighting. The following shows the interior lighting area locations, type of luminaires and footcandle intensities:

AREA	TYPE	FOOTCANDLES
Operating Room	HPS	30
Pump Bays	LPS	5
Office and Control Room	Fluorescent	50
Toilet	Incandescent	15
Stairs	Vaportight Incandescent	15
Equipment Room	Fluorescent	30

The lighting loads will be determined by using the following formula:

$$\text{Watts} = \frac{\text{Footcandle intensity x total area of room x watts per lamp}}{\text{Lumens per lamp x coefficient of utilization x maint. factor}}$$

b. Exterior Lighting. All exterior lighting will be provided with vandal-proof polycarbonate refractor or shields. The following shows the exterior lighting locations, types of luminaires and footcandle intensities:

AREA	TYPE	FOOTCANDLES
Entrance	Mercury Vapor	5
Building Perimeter	Mercury Vapor	5

The lighting loads will be determined by using the following formula:

$$\text{Watts} = \frac{\text{Footcandle intensity x total area of room x watts per lamp}}{\text{Lumens per lamp x coefficient of utilization x maint. factor}}$$

c. Emergency Lighting. Each floor of the pumping station will be provided with fifty watt emergency lighting units operated from a 12-volt DC battery which will remain fully charged at all times by a battery charger that will "float" on the line and will be fed from a 120-volt lighting panelboard in the motor control center.

5-B-11. RECEPTACLES.

Three-pole duplex receptacles will be provided at appropriate points in the walls of the operating floor, office, and equipment room. Receptacles will be 120-volt AC, 20-ampere two wire with grounding pole. All circuits from the lighting panelboard in the switchboard supplying power to the receptacles will have ground fault interrupter circuit breakers. No exterior convenience receptacles will be provided.

5-B-12. VENTILATION.

Eight roof ventilators will be provided for the proper ventilation of the operating room floor and toilet room. A vent fan (smaller than the roof ventilators) will be furnished for the toilet room.

5-B-13. COMMUNICATIONS.

An outlet box will be provided in the office wall for future telephone connections. A conduit from the outlet box will be stubbed outside of the pumping station and capped.

5-B-14. ANNUNCIATOR.

Motor control centers number 1 and number 2 will be furnished with a SCADA system containing annunciator alarm panels and alarm horns to alert the pumping station operator whenever a problem occurs with the pumps , pump motors or power system. The annunciator panel will light a window or other similar device and energize an alarm horn. The first fault to be monitored will be locked in to the respective alarm panel for easy operator identification. Each pumping unit will be monitored and will have separate alarm panels. The annunciator will monitor pump motor bearing and winding temperatures, pump bearing temperatures, pump and pump motor vibration and loss of power. Additionally, a remote alarm panel will be located in the control room and will contain individual windows and lights for each pumping unit, and one common horn. The horn, windows and lights will be interconnected to each pumping unit alarm circuit so that during normal operation the green indicating light(s) will be illuminated. If a problem occurs with any of the pumping units alarm circuits, the horn will sound and the red indicating light(s) will illuminate. The operator can then check the proper window on the alarm panel or at the motor control center for the problem. Each annunciator and the remote alarm panel will be supplied with battery backup for operation during loss of power.

5-B-15. GROUNDING SYSTEM.

The pumping plant electrical system will be grounded in accordance with the National Electrical Code. The grounding electrode system will consist of all metal underground water pipe and a concrete encased electrode conforming to NEC 250-81(c) (covering the steel reinforcing bars in the concrete foundation) bonded together with bonding jumpers as specified in NEC 250-81. All jumpers and grounding electrode conductor connections will be done by exothermic weld. The step down 480/208Y/120 volt, three-phase dry type transformer located in the switchboard and motor control center feeding panels P1, P2, P3 and P4 is considered a separately derived system and will be grounded as per NEC 250-26. All electrical equipment, machinery and exposed metal will be bonded to the grounding electrode system.

5-B-16. LIGHTNING PROTECTION SYSTEM.

The lightning protection system that will be provided for the pumping station will be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and will conform to NFPA Nos. 70 and 78, UL 96 and UL 96A. The system will consist of air terminals, roof conductors, down conductors, ground connections and grounds, electrically interconnected to form the shortest possible distance to ground without passing through any nonconducting parts of the structure. All conductors on the structure will be exposed except where conductors are in protective sleeves exposed on the outside wall. Secondary conductors will interconnect with grounded metallic parts within the building. The entire lightning protection system will be designed in accordance with procedures outlined in TM 5-811-3.

*ADDED"

ORRECTED COPY - 8/8/94 = 8/9/94

- PRELIMINARY -

PART LIST		ORDER NO.		REF.	

SCALE	CHK'D.	PATTERSON PUMP COMPANY	DWG. NO. 07284-1 VK
DATE	APPR'VD.	OUTLINE DIMENSIONS FOR 60X48 TYPE MAD PUMP	
DRAWN	MAT.		PATT. NO. / PART

L No. ______ MODEL No. 60 x 48 MAD

C.O.E. - GRAND PRAIRIE IRRIGATION PROJECT

CUST. ORD. No. ______

51778 CAPACITY 100,000 GPM AT 100 FT. HD. AT 355 R.P.M.

UTE POSITION ______ ROTATION ______

OR WP-I; 1.0 SF - INDUCTION MAKE MFG's CHOICE

RPM 1120 H.P. 3000 PHASE 3 CYCLE 60 VOLTS 4160

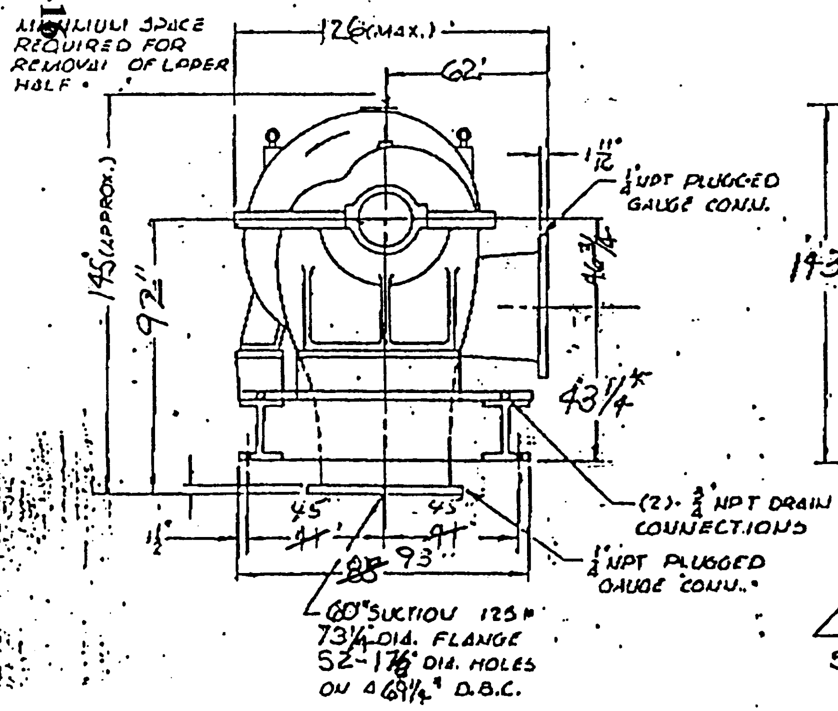
TIFIED BY ______ DATE ______

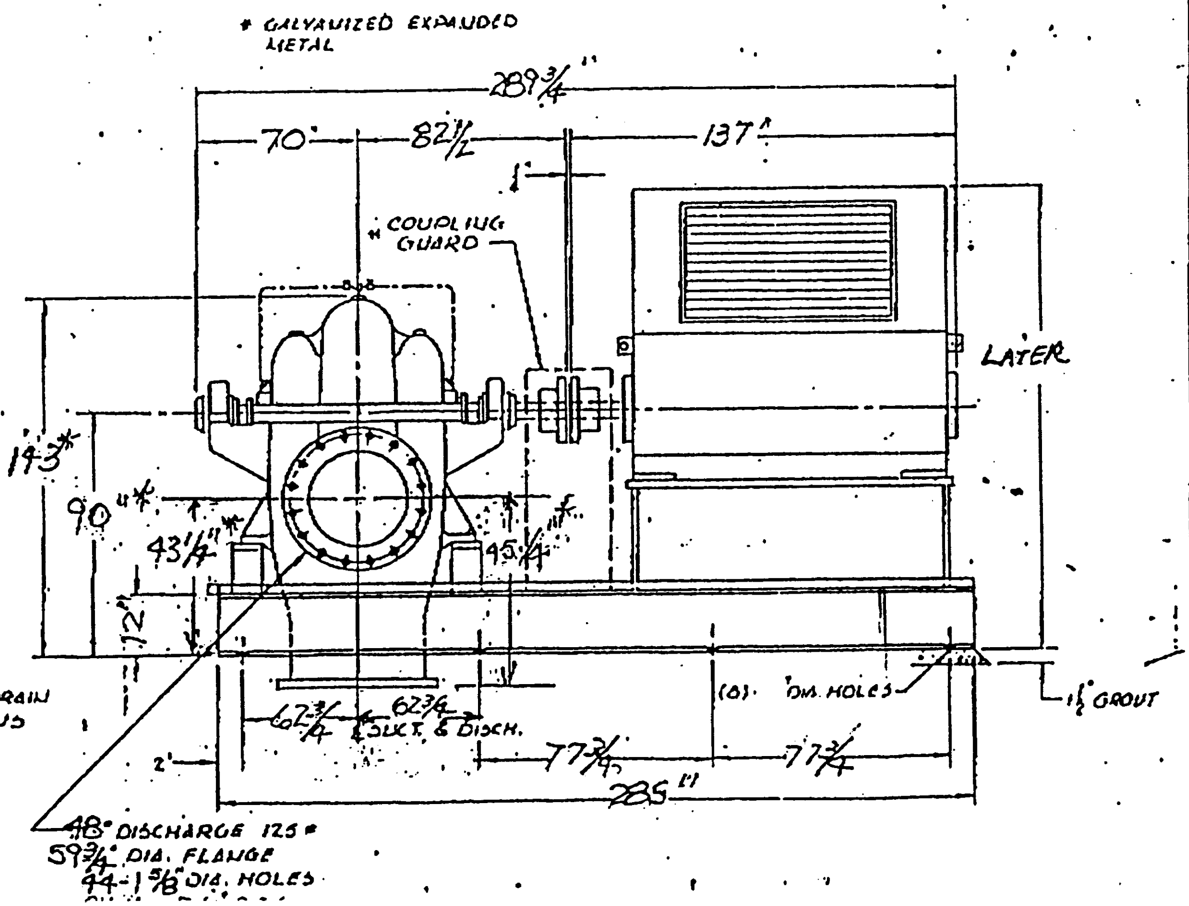
PRELIMINARY · DO NOT USE FOR CONSTRUCTION

2250 CFS

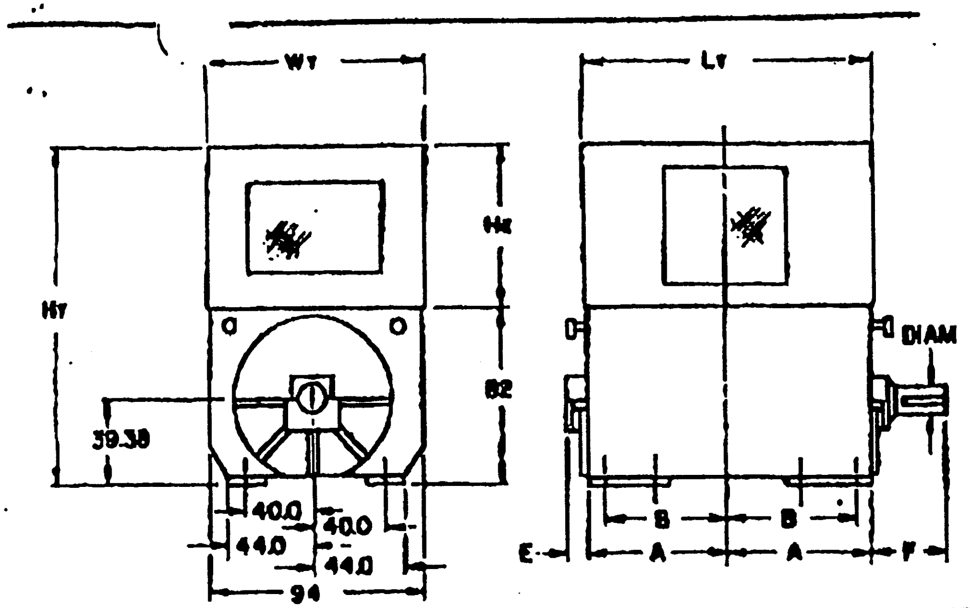
92800#/UNIT

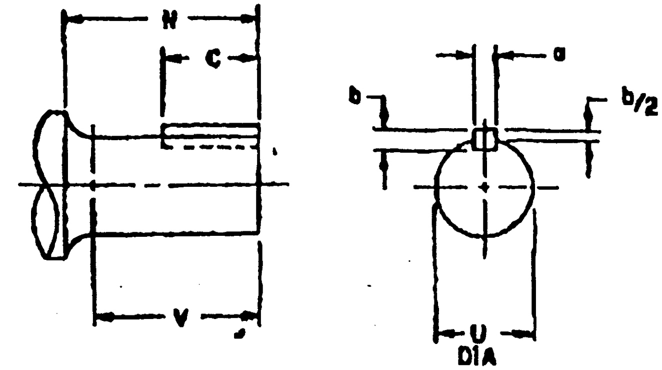
CLOCKWISE PUMP SHOWN





DWG. SUB.





SHAFT DETAIL

DESCRIPTION	HT	WT	HK	LT	A	B
6207	127	96	45	58	28	24
6208	127	96	45	68	33	29
6209	127	96	45	78	38	34
6210	127	96	45	88	43	39
6211	127	96	45	99	48.5	44.5
→ 6212	127	96	45	110	54	50

DIAM	N	V	a	b	c	U	E	F
5	8.75	8.50	1.25	1.25	6.12	5.0030/5.0020	5.69	16.13
5.5	9.75	9.50	1.25	1.25	7.50	5.5030/5.5020	5.69	17.13
6	10.25	10.00	1.50	1.50	7.50	6.0035/6.0025	6.19	18.13
6.5	11.75	11.50	1.50	1.50	9.25	6.5040/6.5030	6.19	19.63
7	11.75	11.50	1.75	1.50	9.25	7.0040/7.0030	6.19	19.63
8	15.25	15.00	2.00	1.50	12.50	8.0045/8.0035	7.19	24.13

FRAME DESIGNATION EXAMPLE B6209S60

B	62	09	S60
BRACKET TYPE	FRAME TYPE	FRAME LENGTH	SHAFT DIAMETER

Westinghouse Electric Corporation

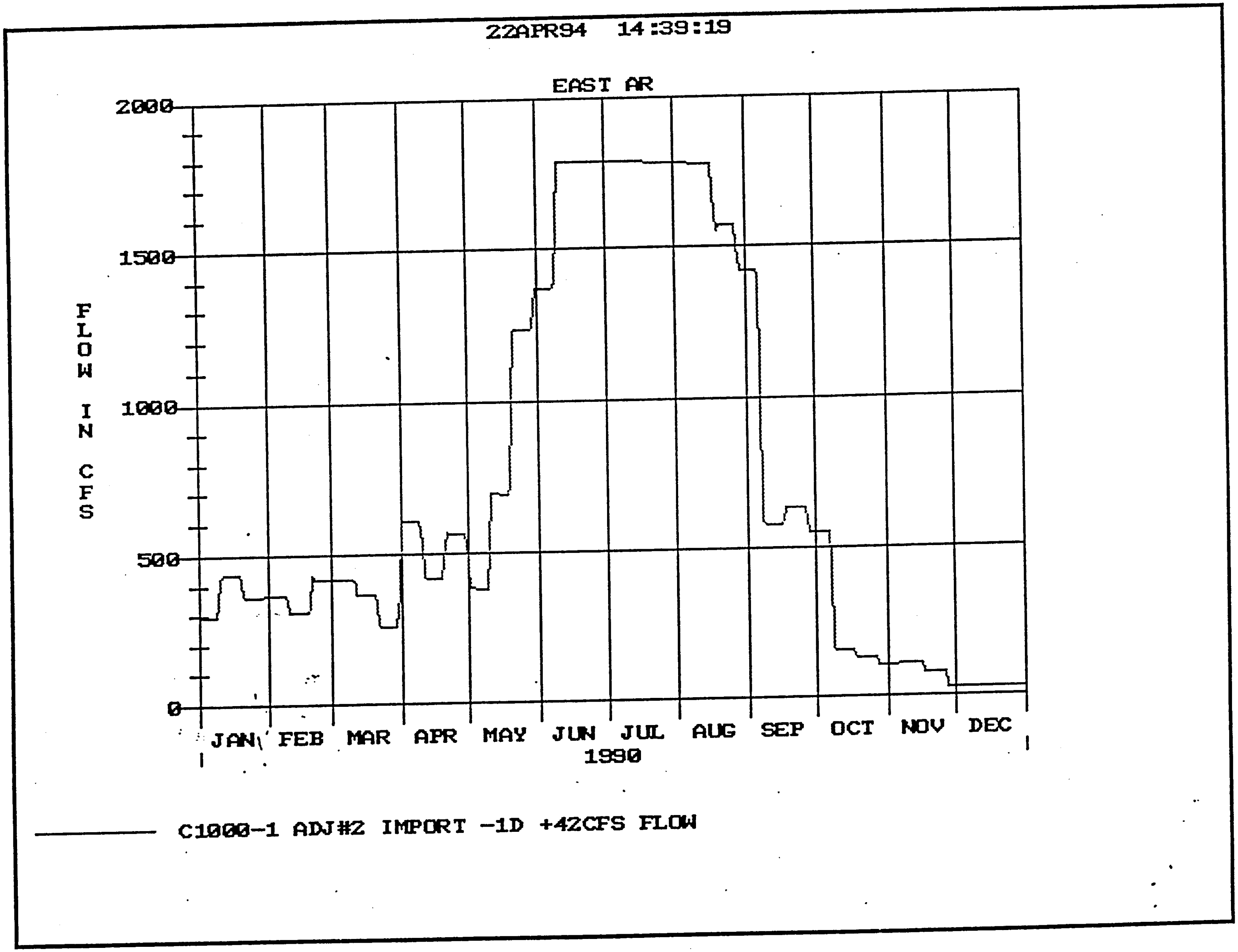
TITLE TYPE LLD-CS B62 FRAME WP I INDUCTION MOTOR

DIMENSION IN INCHES · SCALE NTS

DFTM. | APPD | APPD | APPD

1866B5

HEAVY INDUSTRY MOTOR DIV. ROUND ROCK TX. USA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FLOW IN CFS
JAN
FEB
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APR
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JUN
JUL
AUG
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OCT
NOV
DEC
1990
C1000-1 ADJ#2 IMPORT -1D +42CFS FLOW

PATTERSON PUMP COMPANY

SPEED CHANGE PROGRAM FOR C.O.E. - MEMPHIS
FOR: WAYNE QUARLES - GRAND PRAIRIE IRR. PROJECT
60 x 48 MAD - BOTTOM SUCTION — PRELIMINARY CURVE
DESIGN: 101,000 GPM @ 104ft TDH @ 355 RPM

PROGRAM FOR CALCULATING SMALL CHANGES IN RPM. THIS IS BASED ON THE AFFINITY LAWS. TYPE IN THE RPM, THE KNOWN FLOW CONDITIONS, THE DESIRED RPMS AND THE

BASED UPON PUMP CURVE 072794TLVK — 8/04/94 - VON KEARNS

INITIAL RPM	355	FLOW - GPM
RPM #1 =	355	HEAD - FT.
RPM #2 =	355	EFF. - %
		BHP - H.P.
POOLE 12-15-87	REV. 5-2-94	NPSH - FT.

355 RPM INITIAL - EXISTING PUMPS — NOTE:

DATA PT.	FLOW		HEAD	EFF.	BHP	NPSHR
S.O. 1)	0	@	164.0	0	—	0
2)	30,000	@	154.0	0.57	2046.8	6
3)	55,000	@	144.0	0.78	2564.1	10
4)	70,000	@	134.0	0.84	2819.9	13
5)	82,000	@	124.0	0.875	2934.5	17
6)	92,000	@	114.0	0.89	2975.8	20
7)	101,000	@	104.0	0.885	2997.2	22
8)	110,000	@	90.0	0.86	2907.0	26
9)	115,000	@	74.0	0.8	2686.2	30

355 RPM #1 — NOTE:

DATA PT.	FLOW		HEAD	EFF	BHP	NPSHR
S.O. 1)	0	@	164.0	0	—	0
2)	30,000	@	154.0	0.57	2046.8	6
3)	55,000	@	144.0	0.78	2564.1	10
4)	70,000	@	134.0	0.84	2819.9	13
5)	82,000	@	124.0	0.875	2934.5	17
6)	92,000	@	114.0	0.89	2975.8	20
7)	101,000	@	104.0	0.885	2997.2	22
8)	110,000	@	90.0	0.86	2907.0	26
9)	115,000	@	74.0	0.8	2686.2	30

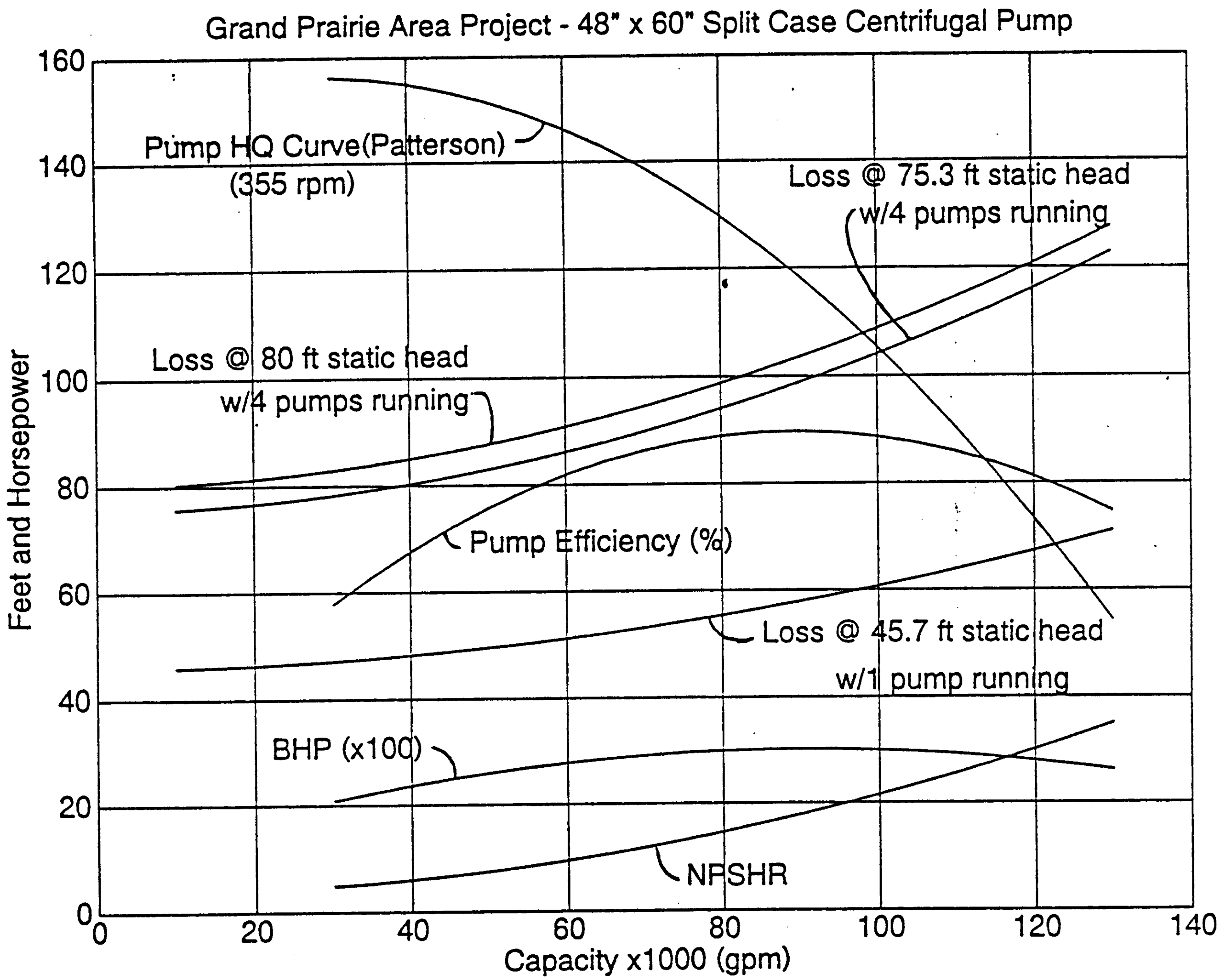
355 RPM #2 - DESIGN MAX SPEED — NOTE:

DATA PT.	FLOW		HEAD	EFF	BHP	NPSHR
S.O. 1)	0	@	164.0	0	—	0
2)	30,000	@	154.0	0.57	2046.8	6
3)	55,000	@	144.0	0.78	2564.1	10
4)	70,000	@	134.0	0.84	2819.9	13
5)	82,000	@	124.0	0.875	2934.5	17
6)	92,000	@	114.0	0.89	2975.8	20
7)	101,000	@	104.0	0.885	2997.2	22
8)	110,000	@	90.0	0.86	2907.0	26
9)	115,000	@	74.0	0.8	2686.2	30

subsidiary of THE GORMAN-RUPP COMPANY

FLOW GPM	INLET CONDUIT	SLUICE GATES	PUMP PIPE	60" GATE VALVE	48" GATE VALVE	48" VAL[illegible]	48" X 120" TEE	120" PIPE 4 PUMPS	120" PIPE 1 PUMP	EXIT LOSSES	LOSSES 4 PUMPS	LOSSES 1 PUMP	[illegible]D [illegible]PS	HEAD 1 PUMP
10,000	.003	.000	.002	.001	.001	.098	.017	.218	.017	.020	.36	.159	75.66	75.46
15,000	.006	.001	.004	.001	.003	.220	.038	.459	.036	.045	.78	.355	76.08	75.66
20,000	.009	.001	.007	.002	.006	.391	.068	.777	.061	.080	1.34	.627	76.64	75.93
25,000	.014	.002	.011	.004	.009	.611	.107	1.168	.092	.125	2.05	.976	77.35	76.28
30,000	.020	.003	.016	.005	.013	.879	.154	1.631	.129	.180	2.90	1.400	78.20	76.70
35,000	.026	.004	.021	.007	.018	1.197	.209	2.163	.171	.245	3.89	1.899	79.19	77.20
40,000	.033	.006	.027	.010	.023	1.563	.274	2.761	.218	.320	5.02	2.474	80.32	77.77
45,000	.041	.007	.033	.012	.030	1.979	.346	3.426	.271	.405	6.28	3.124	81.58	78.42
50,000	.050	.009	.040	.015	.037	2.443	.427	4.154	.329	.500	7.68	3.850	82.98	79.15
55,000	.059	.011	.048	.018	.044	2.956	.517	4.946	.391	.605	9.20	4.650	84.50	79.95
60,000	.070	.013	.056	.022	.053	3.518	.616	5.800	.459	.720	10.87	5.525	86.17	80.83
65,000	.081	.015	.065	.025	.062	4.128	.722	6.714	.531	.845	12.66	6.475	87.96	81.78
70,000	.092	.017	.074	.029	.072	4.788	.838	7.690	.608	.981	14.58	7.500	89.88	82.80
75,000	.105	.020	.084	.034	.082	5.496	.962	8.724	.690	1.126	16.63	8.599	91.93	83.90
80,000	.118	.023	.095	.038	.094	6.253	1.094	9.818	.777	1.281	18.81	9.773	94.11	85.07
85,000	.132	.026	.106	.043	.106	7.060	1.235	10.970	.868	1.446	21.12	11.021	96.42	86.32
90,000	.146	.029	.117	.049	.119	7.915	1.385	12.180	.964	1.621	23.56	12.344	98.86	87.64
95,000	.161	.032	.130	.054	.132	8.818	1.543	13.446	1.064	1.806	26.12	13.741	101.42	89.04
100,000	.177	.036	.142	.060	.147	9.771	1.710	14.770	1.168	2.001	28.81	15.213	104.11	90.51
101,000	.181	.036	.145	.061	.150	9.967	1.744	15.041	1.190	2.041	29.37	15.516	104.67	90.82
105,000	.194	.039	.156	.066	.162	10.773	1.885	16.149	1.278	2.206	31.63	16.758	106.93	92.06
110,000	.211	.043	.170	.073	.177	11.823	2.069	17.584	1.391	2.421	34.57	18.378	109.87	93.68
115,000	.229	.047	.184	.079	.194	12.922	2.261	19.074	1.509	2.646	37.64	20.072	112.94	95.37
120,000	.248	.051	.199	.086	.211	14.070	2.462	20.619	1.631	2.882	40.83	21.841	116.13	97.14
125,000	.267	.056	.214	.094	.229	15.267	2.672	22.219	1.758	3.127	44.14	23.683	119.44	98.98
130,000	.287	.060	.230	.101	.248	16.513	2.890	23.872	1.889	3.382	47.58	25.600	122.88	100.90
140,000	.328	.070	.264	.118	.287	19.151	3.351	27.339	2.163	3.922	54.83	29.655	130.13	104.95
150,000	.372	.080	.299	.135	.330	21.985	3.847	31.019	2.454	4.503	62.57	34.005	137.87	109.31
160,000	.419	.091	.337	.154	.375	25.014	4.377	34.907	2.761	5.123	70.80	38.652	146.10	113.95
170,000	.468	.103	.376	.173	.424	28.238	4.942	39.003	3.086	5.783	79.51	43.594	154.81	118.89
180,000	.520	.116	.418	.195	.475	31.658	5.540	43.304	3.426	6.484	88.71	48.830	164.01	124.13
190,000	.574	.129	.461	.217	.529	35.274	6.173	47.807	3.782	7.224	98.39	54.362	173.69	129.66
200,000	.630	.143	.506	.240	.586	39.084	6.840	52.512	4.154	8.004	108.55	60.189	183.85	135.49

RADIUS OF PUMP DISCHARGE PIPE (FT.)= 2.000
RADIUS OF DISCHARGE HEADER (FT)= 5.000
AREA OF PUMP DISCHARGE PIPE (SQ. FT)= 12.560
DIAMETER OF HEADER (FT.)= 10.000
AREA OF HEADER (SQ. FT)= 78.500
RADIUS OF PUMP INLET (FT)= 2.500
AREA OF PUMP INLET PIPE (SQ. FT)= 19.625
AREA OF CONDUIT (SQ. FT.)= 60.000
AREA OF SLUICE GATE (SQ. FT.)= 72.000
STATIC HEAD (FT.)= 75.300

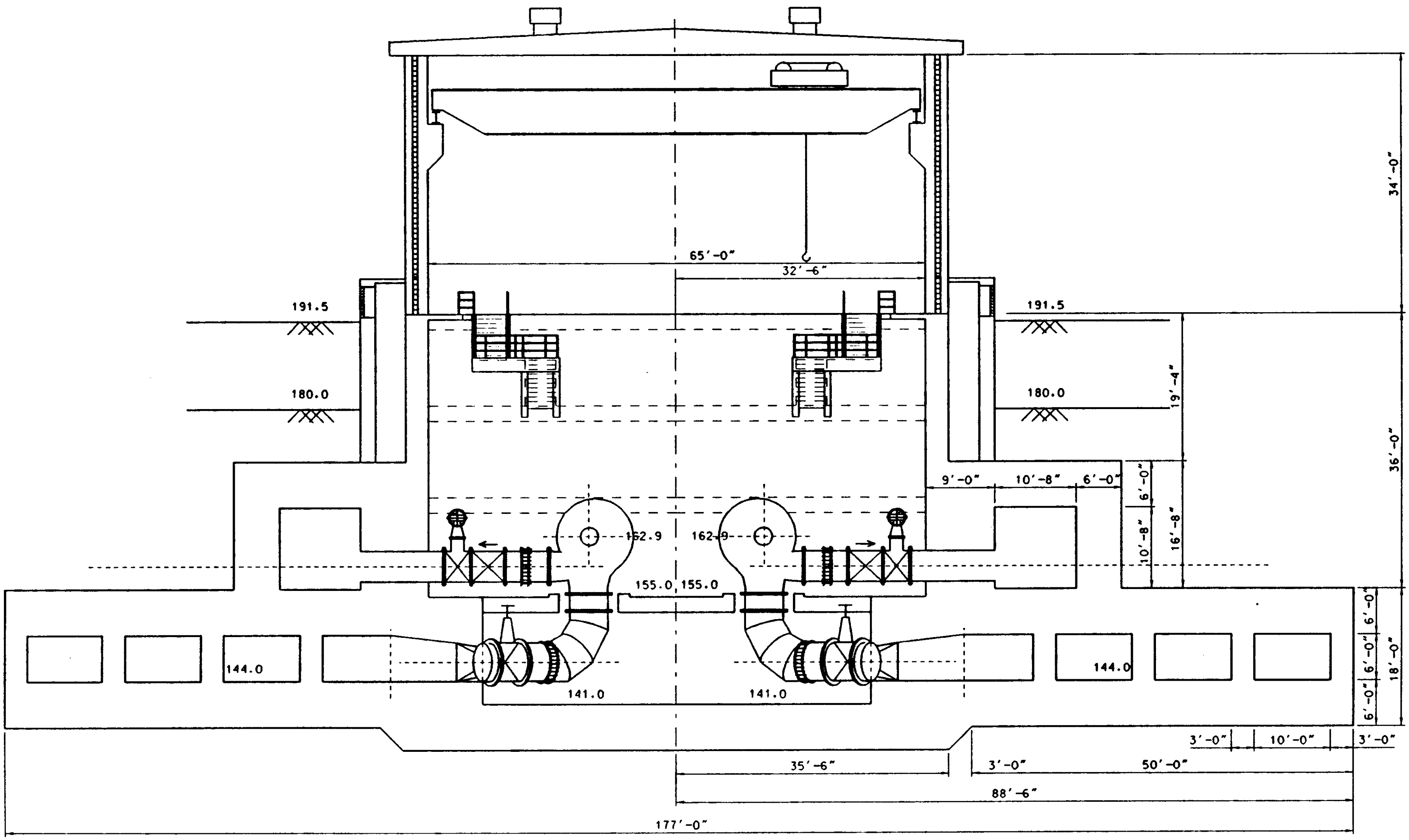

Grand Prairie Area Project - 48" x 60" Split Case Centrifugal Pump
Pump HQ Curve(Patterson)
(355 rpm)
Loss @ 75.3 ft static head
w/4 pumps running
Loss @ 80 ft static head
w/4 pumps running
Pump Efficiency (%)
Loss @ 45.7 ft static head
w/1 pump running
BHP (x100)
NPSHR
Feet and Horsepower
Capacity x1000 (gpm)
0
20
40
60
80
100
120
140
160

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

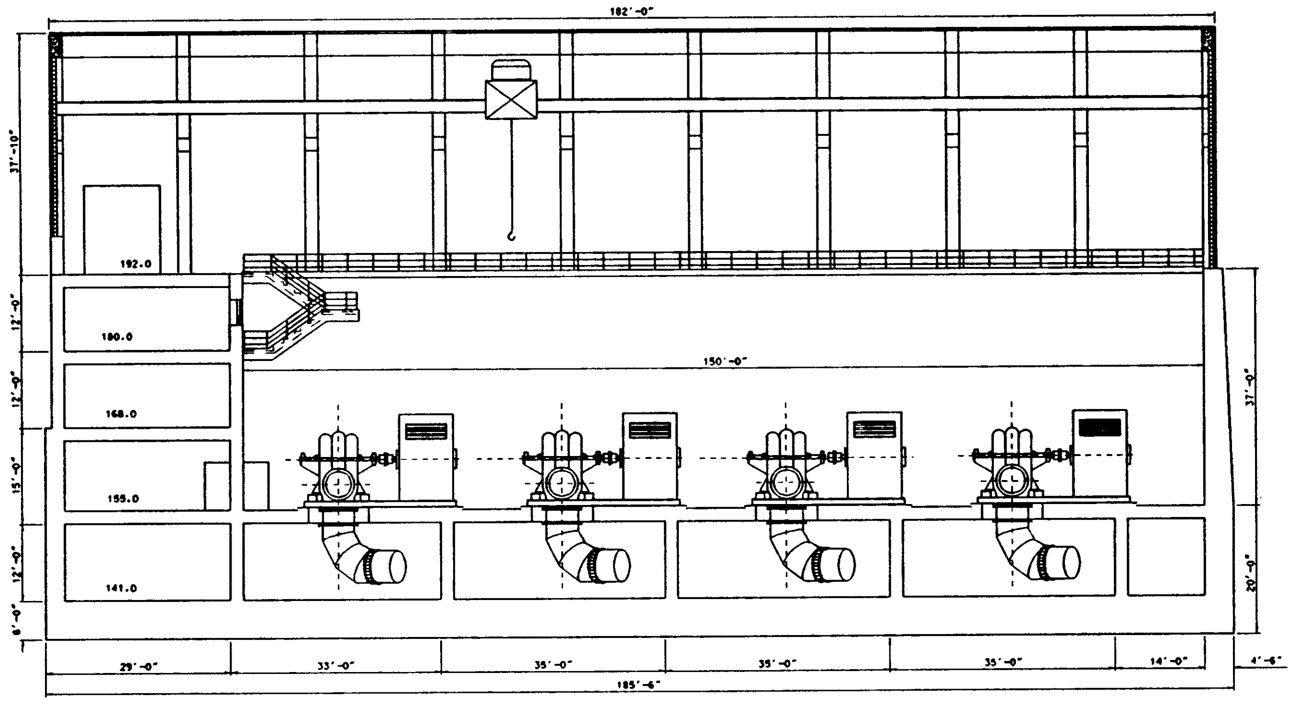
EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

TRANSVERSE ELEVATION



TRANSVERSE ELEVATION
SCALE 1" = 20'-0"

PLATE
V-A-1



LONGITUDINAL ELEVATION
SCALE 1" = 30'-0"

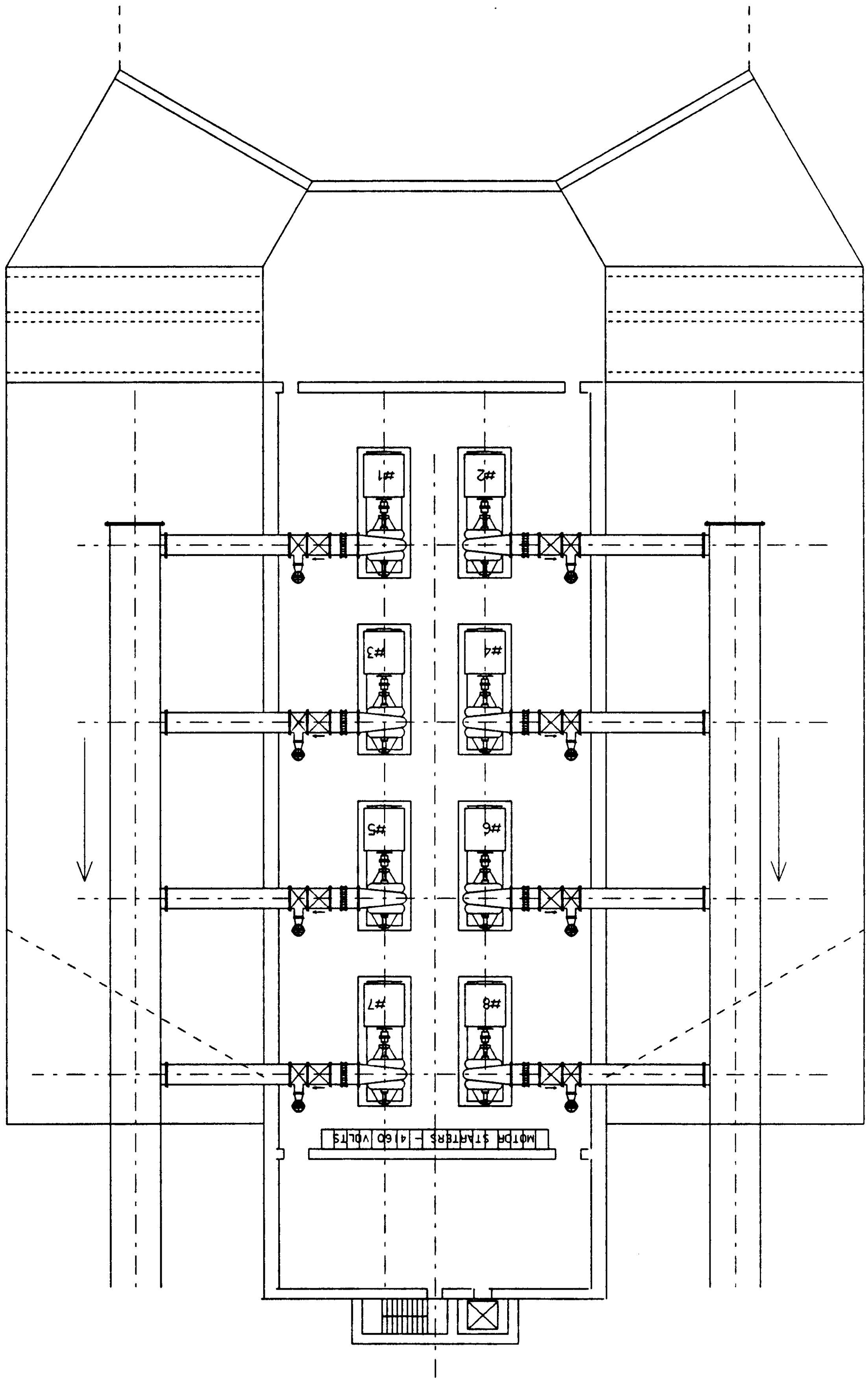
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

LONGITUDINAL ELEVATION

PLATE
V-A-II



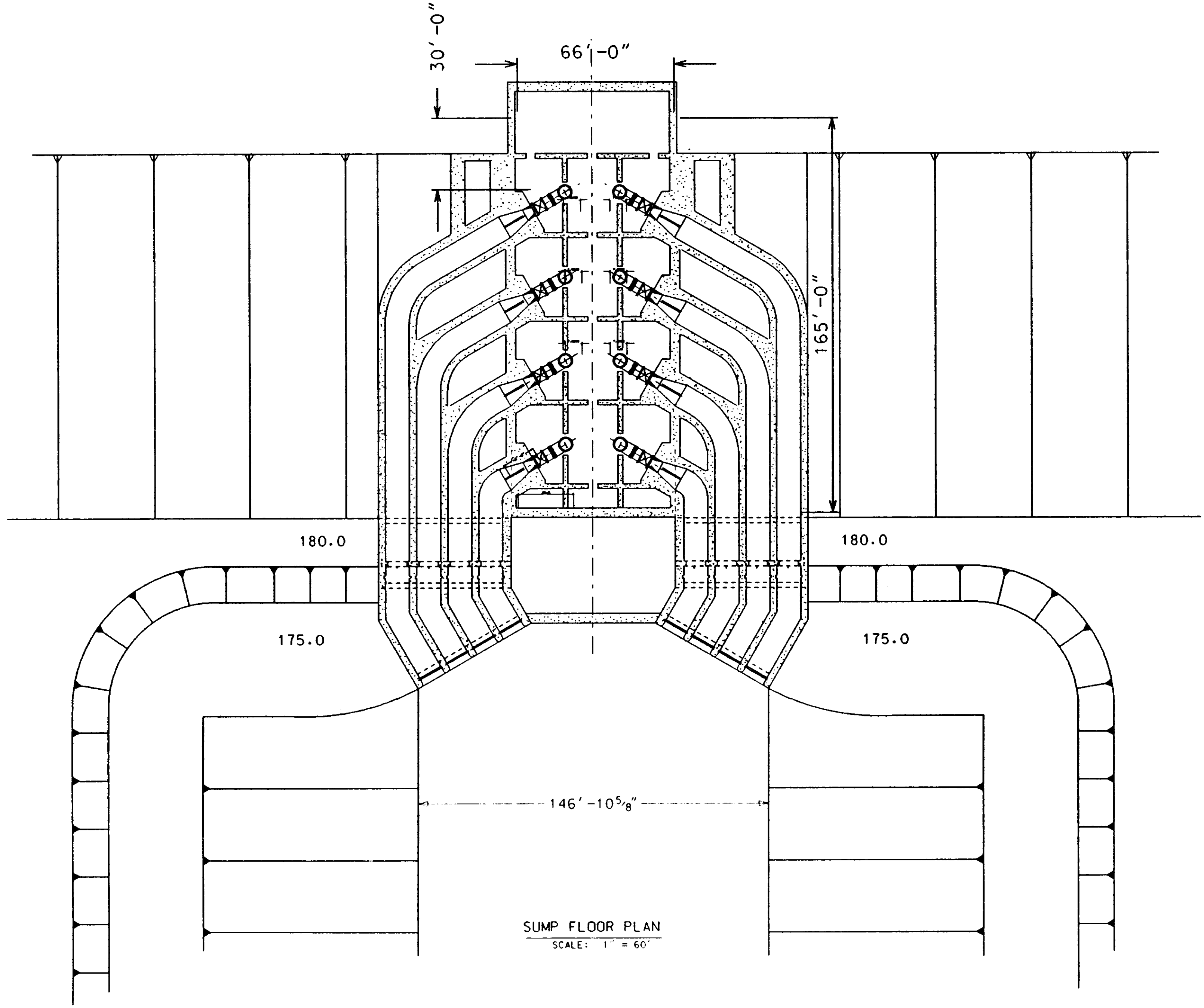
US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

OPERATING FLOOR PLAN

PLATE
V-A-III



SUMP FLOOR PLAN
SCALE: 1" = 60'

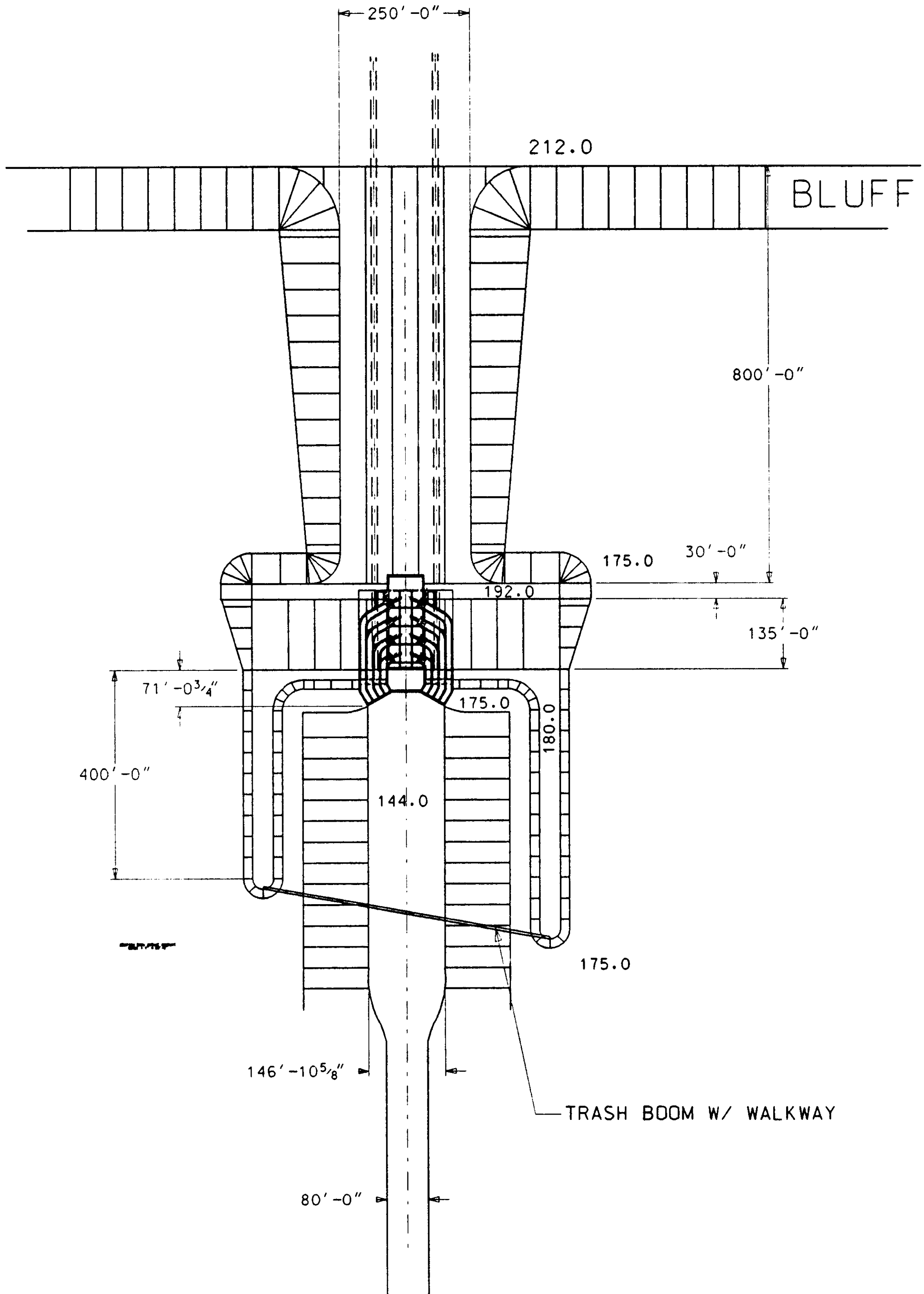
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

SUMP FLOOR PLAN

PLATE
V-A-IV



SITE PLAN

SCALE: 1" = 300'

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

SITE PLAN

PLATE
V-A-V

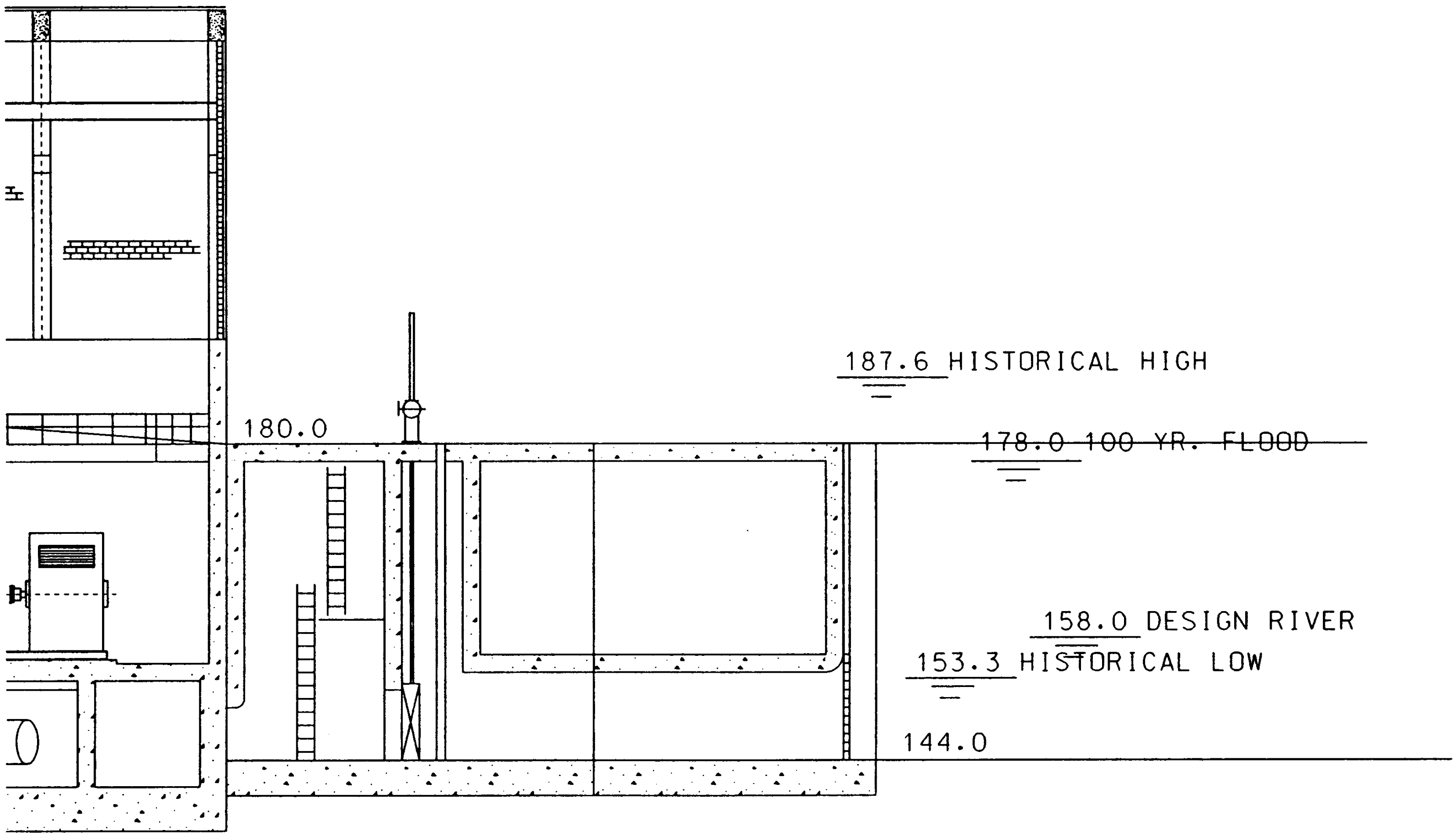
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

STATION INLET

PLATE
V-A-VI



CONDUIT ELEVATION

SCALE: 1" = 20'

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-B

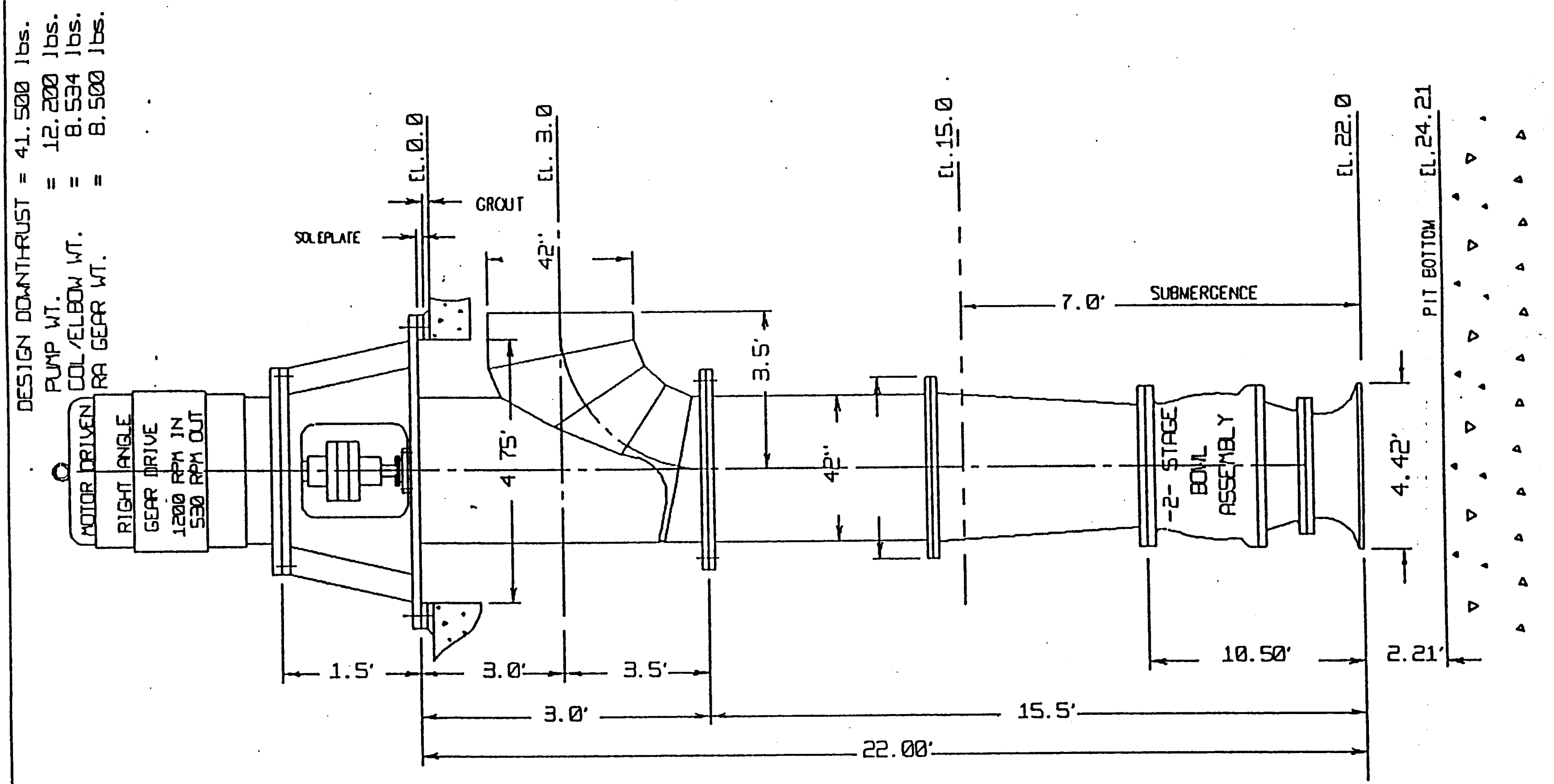
GRAND PRAIRIE PUMPING STATION

ALTERNATE NUMBER 2

STATION LAYOUT AND PUMP CURVES

U.S. Army Corps of Engineers
Memphis District

Appendix V-B-1



MEMPHIS DISTRICT
CORPS OF ENGINEERS
GRAND PRAIRIE IRRIGATION PROJECT
DESIGN: 100 CFS @ 100ft TDH
@ 530 RPM PUMP SPEED

-PRELIMINARY ONLY-

AB-19411

PATTERSON PUMP COMPANY A SUBSIDIARY OF THE GORMAN-RUPP COMPANY	OUTLINE DIMENSIONS for 33 x 42'' SAFV PUMP	DWG. NO. 101195VK-2	
		DRAWN	DATE
		SCALE NONE	APPRVD.

LOSSES FOR 33" X 42" PUMP - GRAND PRAIRIE PUMPING S[illegible]N ALTERNATE 2 -----ONE PUMP RUNNING -

FLOW GPM	INLET CONDUIT	SLUICE GATES	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 126" TEE	126" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	TOTAL HEAD 1 PUMP	
10,000	.001	.001	.014	.013	.020	.000	.017	.017	.001	.084	75.38	
15,000	.003	.002	.031	.029	.045	.000	.038	.036	.002	.187	75.49	
20,000	.005	.004	.055	.052	.080	.001	.067	.061	.004	.328	75.63	
25,000	.007	.006	.086	.081	.125	.001	.104	.092	.006	.509	75.81	
30,000	.010	.009	.124	.117	.180	.002	.150	.128	.009	.729	76.03	
35,000	.013	.013	.168	.159	.245	.002	.204	.170	.013	.987	76.29	
40,000	.017	.017	.220	.208	.320	.003	.267	.217	.016	1.284	76.58	
44,883	.020	.021	.277	.262	.403	.004	.336	.268	.021	1.611	76.91	***
45,000	.021	.021	.278	.263	.405	.004	.338	.269	.021	1.619	76.92	
50,000	.025	.026	.343	.325	.500	.004	.417	.326	.026	1.993	77.29	
55,000	.030	.031	.416	.393	.605	.005	.504	.389	.031	2.404	77.70	
60,000	.035	.037	.495	.468	.720	.006	.600	.456	.037	2.854	78.15	
65,000	.040	.044	.580	.549	.845	.007	.704	.528	.043	3.341	78.64	
70,000	.046	.051	.673	.637	.980	.008	.817	.604	.050	3.867	79.17	
75,000	.052	.058	.773	.731	1.125	.009	.938	.685	.058	4.430	79.73	
80,000	.059	.066	.879	.832	1.280	.010	1.067	.771	.066	5.031	80.33	
85,000	.066	.075	.993	.939	1.445	.011	1.204	.862	.074	5.670	80.97	
90,000	.073	.084	1.113	1.053	1.620	.013	1.350	.957	.083	6.347	81.65	
95,000	.081	.094	1.240	1.173	1.805	.014	1.504	1.057	.093	7.061	82.36	
100,000	.089	.104	1.374	1.300	2.000	.015	1.667	1.160	.103	7.813	83.11	
105,000	.097	.114	1.515	1.433	2.205	.017	1.838	1.269	.113	8.602	83.90	
110,000	.106	.125	1.662	1.573	2.420	.018	2.017	1.382	.125	9.429	84.73	
115,000	.115	.137	1.817	1.719	2.645	.020	2.204	1.499	.136	10.293	85.59	
120,000	.124	.149	1.978	1.872	2.880	.022	2.400	1.620	.148	11.194	86.49	
125,000	.134	.162	2.147	2.032	3.125	.023	2.605	1.746	.161	12.134	87.43	
130,000	.144	.175	2.322	2.197	3.380	.025	2.817	1.876	.174	13.110	88.41	
140,000	.164	.203	2.693	2.548	3.921	.029	3.267	2.148	.202	15.175	90.47	
150,000	.186	.233	3.091	2.925	4.501	.032	3.751	2.437	.232	17.389	92.69	
160,000	.210	.265	3.517	3.328	5.121	.036	4.267	2.743	.263	19.751	95.05	
170,000	.234	.299	3.971	3.758	5.781	.041	4.817	3.065	.297	22.263	97.56	
180,000	.260	.336	4.451	4.213	6.481	.045	5.401	3.402	.333	24.923	100.22	
190,000	.287	.374	4.960	4.694	7.221	.050	6.018	3.756	.371	27.731	103.03	
200,000	.316	.414	5.496	5.201	8.001	.055	6.668	4.126	.412	30.688	105.99	

RADIUS OF PUMP DISCHARGE PIPE (FT 1.750
RADIUS OF DISCHARGE HEADER (FT)= 5.250
AREA OF PUMP DISCHARGE PIPE (SQ. 9.616
DIAMETER OF HEADER (FT.)= 10.500

AREA OF HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT.)= 22.526
AREA OF SLUICE GATE (SQ. FT.)= 42.250
STATIC HEAD (FT.)= 75.300

Appendix V-B-3

LOSSES FOR 33" X 42" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 2 THREE PUMPS RUNNING

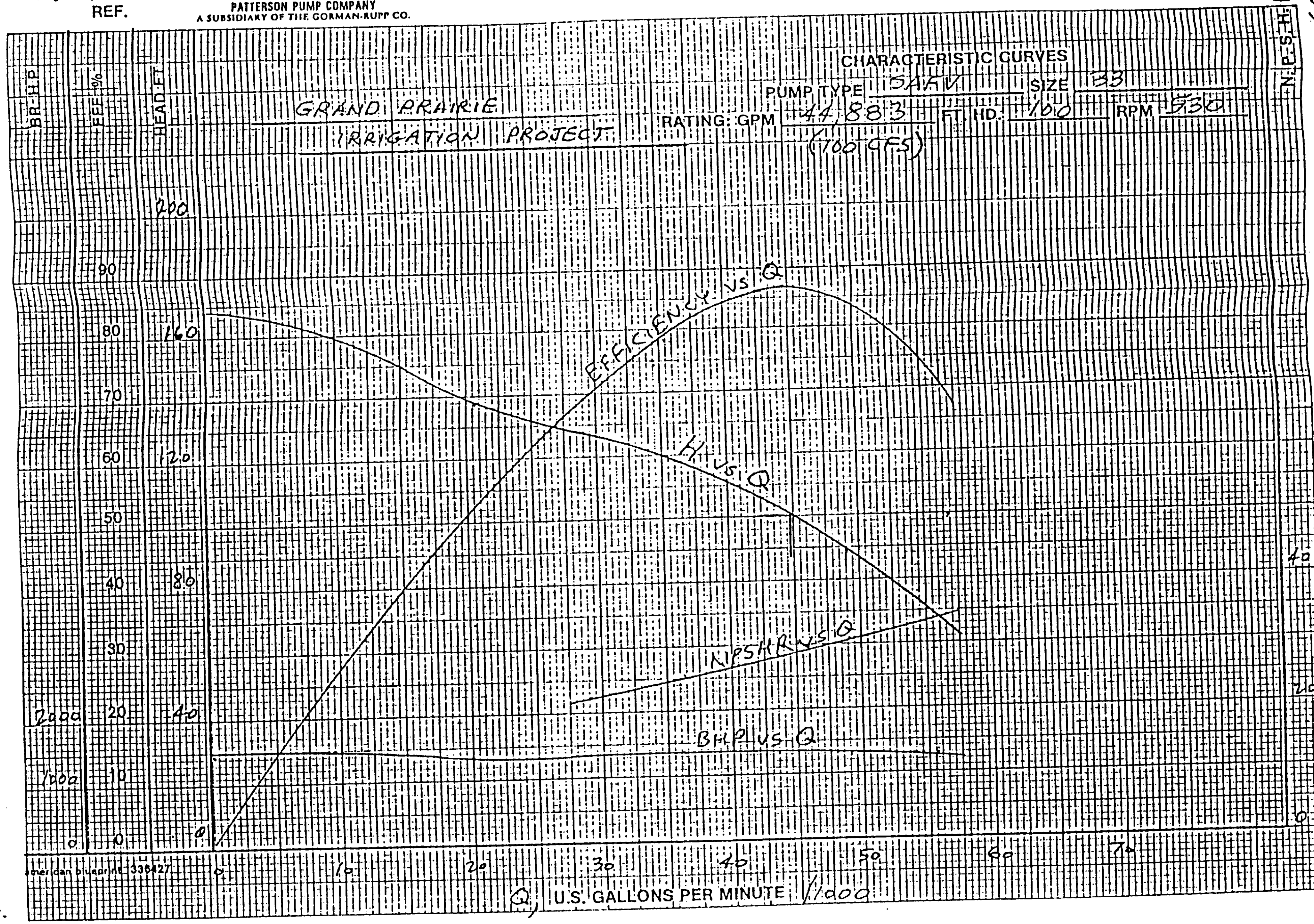
FLOW GPM	INLET CONDUIT	SLUICE GATES	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 126" TEE	126" PIPE 3 PUMP	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP
10,000	.001	.001	.014	.013	.020	.000	.017	12.662	1.402	14.129	89.43
15,000	.003	.002	.031	.029	.045	.000	.038	12.977	1.440	14.566	89.87
20,000	.005	.004	.055	.052	.080	.001	.067	13.297	1.479	15.039	90.34
25,000	.007	.006	.086	.081	.125	.001	.104	13.619	1.518	15.548	90.85
30,000	.010	.009	.124	.117	.180	.002	.150	13.945	1.558	16.095	91.39
35,000	.013	.013	.168	.159	.245	.002	.204	14.275	1.598	16.678	91.98
40,000	.017	.017	.220	.208	.320	.003	.267	14.608	1.639	17.298	92.60
44,883	.020	.021	.277	.262	.403	.004	.336	14.937	1.679	17.939	93.24 ***
45,000	.021	.021	.278	.263	.405	.004	.338	14.945	1.680	17.954	93.25
50,000	.025	.026	.343	.325	.500	.004	.417	15.285	1.722	18.648	93.95
55,000	.030	.031	.416	.393	.605	.005	.504	15.629	1.764	19.378	94.68
60,000	.035	.037	.495	.468	.720	.006	.600	15.976	1.807	20.144	95.44
65,000	.040	.044	.580	.549	.845	.007	.704	16.326	1.851	20.947	96.25
70,000	.046	.051	.673	.637	.980	.008	.817	16.680	1.894	21.787	97.09
75,000	.052	.058	.773	.731	1.125	.009	.938	17.038	1.939	22.663	97.96
80,000	.059	.066	.879	.832	1.280	.010	1.067	17.399	1.984	23.576	98.88
85,000	.066	.075	.993	.939	1.445	.011	1.204	17.763	2.029	24.526	99.83
90,000	.073	.084	1.113	1.053	1.620	.013	1.350	18.131	2.075	25.512	100.81
95,000	.081	.094	1.240	1.173	1.805	.014	1.504	18.502	2.122	26.535	101.83
100,000	.089	.104	1.374	1.300	2.000	.015	1.667	18.876	2.169	27.594	102.89
105,000	.097	.114	1.515	1.433	2.205	.017	1.838	19.254	2.216	28.690	103.99
110,000	.106	.125	1.662	1.573	2.420	.018	2.017	19.635	2.264	29.822	105.12
115,000	.115	.137	1.817	1.719	2.645	.020	2.204	20.020	2.313	30.991	106.29
120,000	.124	.149	1.978	1.872	2.880	.022	2.400	20.408	2.362	32.196	107.50
125,000	.134	.162	2.147	2.032	3.125	.023	2.605	20.800	2.411	33.438	108.74
130,000	.144	.175	2.322	2.197	3.380	.025	2.817	21.195	2.461	34.716	110.02
140,000	.164	.203	2.693	2.548	3.921	.029	3.267	21.994	2.563	37.382	112.68
150,000	.186	.233	3.091	2.925	4.501	.032	3.751	22.807	2.667	40.194	115.49
160,000	.210	.265	3.517	3.328	5.121	.036	4.267	23.634	2.773	43.152	118.45
170,000	.234	.299	3.971	3.758	5.781	.041	4.817	24.474	2.880	46.255	121.56
180,000	.260	.336	4.451	4.213	6.481	.045	5.401	25.327	2.990	49.504	124.80
190,000	.287	.374	4.960	4.694	7.221	.050	6.018	26.193	3.102	52.899	128.20
200,000	.316	.414	5.496	5.201	8.001	.055	6.668	27.073	3.216	56.439	131.74

RADIUS OF PUMP DISCHARGE PIPE (FT	1.750	AREA OF HEADER (SQ. FT)=	86.546
RADIUS OF DISCHARGE HEADER (FT)=	5.250	AREA OF CONDUIT (SQ. FT.)=	22.526
AREA OF PUMP DISCHARGE PIPE (SQ.	9.616	AREA OF SLUICE GATE (SQ. FT.)=	42.250
DIAMETER OF HEADER (FT.)=	10.500	STATIC HEAD (FT.)=	75.300

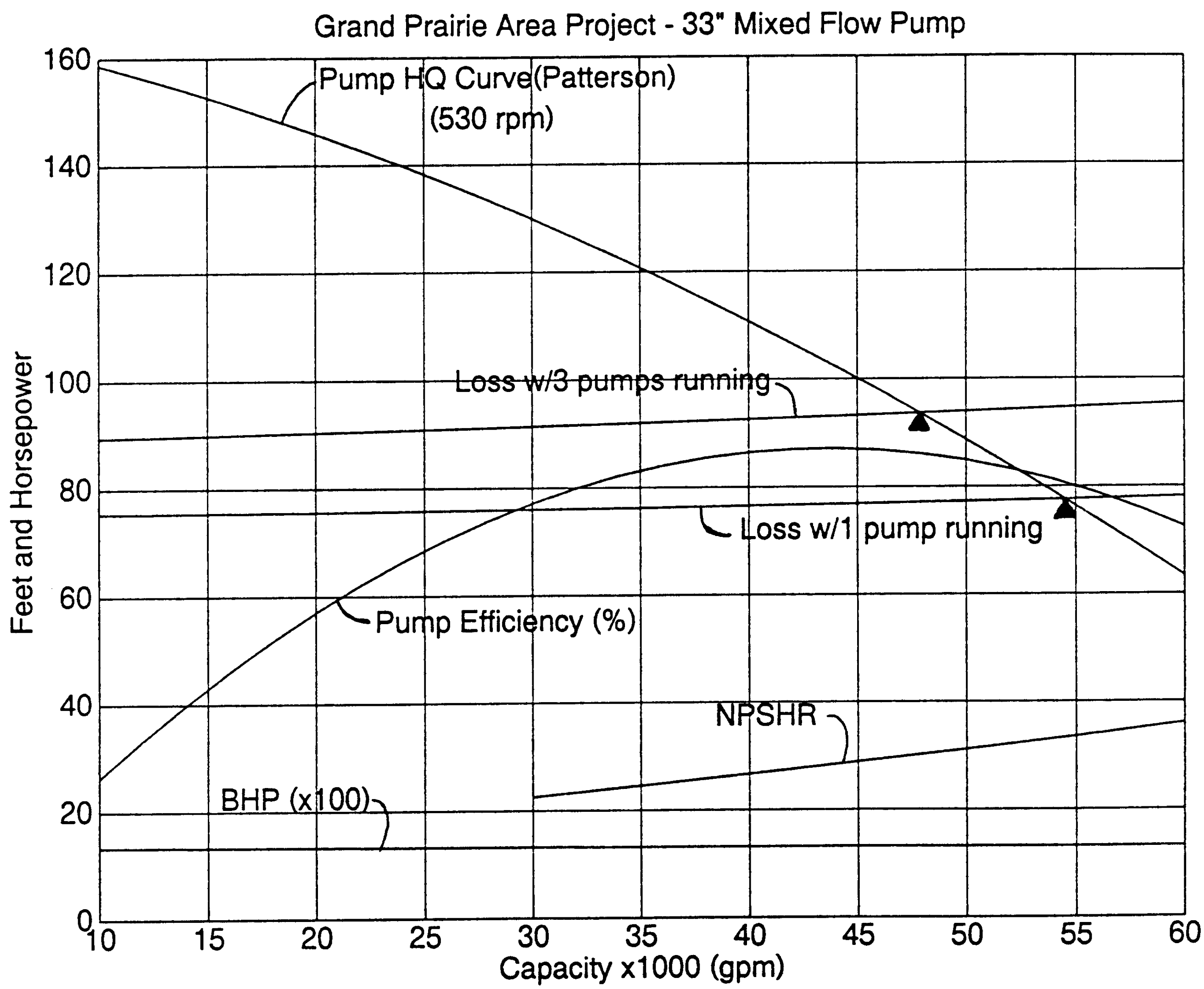
2,207
x D-6756
REF.

PATTERSON PUMP COMPANY
A SUBSIDIARY OF THE GORMAN-RUPP CO.

CURVE NO.

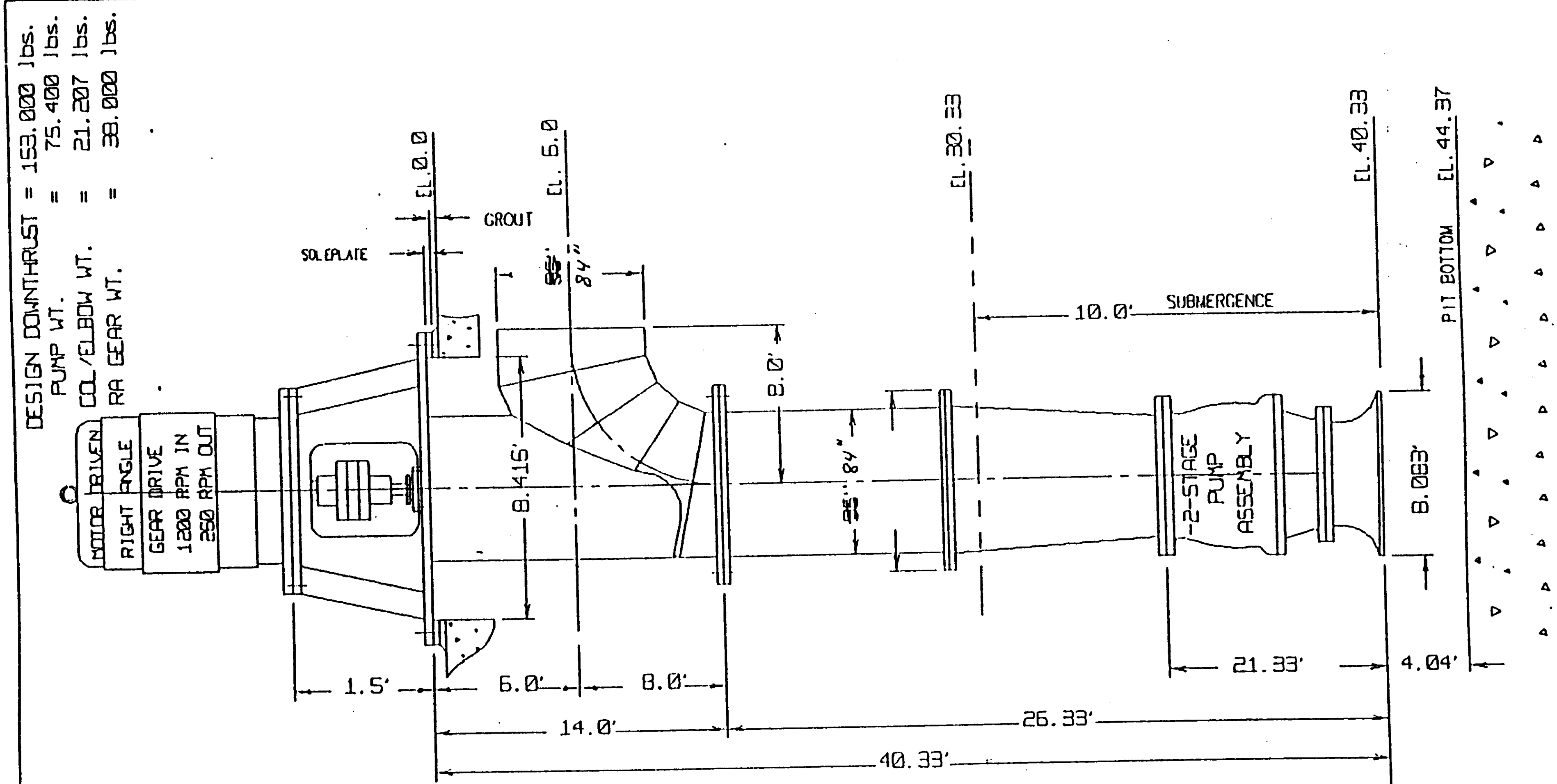


Appendix V-B-4



Appendix V-B-5

Appendix V-B-6



MEMPHIS DISTRICT
CORPS OF ENGINEERS
GRAND PRAIRIE IRRIGATION PROJECT
DESIGN: 400 CFS @ 100ft TDH
@ 260 RPM PUMP SPEED

-PRELIMINARY ONLY-

AB-

PATTERSON PUMP COMPANY A SUBSIDIARY OF THE GORMAN-RUPP COMPANY	OUTLINE DIMENSIONS for 68 x 96'' SAFV PUMP	DWG. NO. 101095VK- DRAWN / DATE SCALE NONE / APPRVD.

LOSSES FOR 84" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 2 ONE PUMP RUNNING -------

FLOW GPM	INLET CONDUIT	FSI	84" PUMP CONTROL VALVE	84" GATE VALVE	30 DEG. BEND	84" PIPE 1 PUMP	84" TO 126" EXPANSION	126" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	TOTAL HEAD 1 PUMP
10,000	.000	.001	.001	.001	.001	.000	.002	.017	.001	.024	75.32
15,000	.000	.002	.002	.003	.001	.000	.005	.036	.002	.050	75.35
20,000	.000	.003	.003	.005	.002	.000	.008	.061	.004	.086	75.39
25,000	.000	.004	.005	.007	.004	.001	.013	.092	.006	.131	75.43
30,000	.000	.006	.007	.010	.005	.001	.018	.128	.009	.185	75.49
35,000	.000	.008	.009	.014	.007	.001	.025	.170	.013	.248	75.55
40,000	.000	.011	.012	.018	.009	.002	.033	.217	.016	.318	75.62
45,000	.001	.014	.015	.023	.012	.002	.041	.269	.021	.397	75.70
50,000	.001	.017	.019	.029	.014	.002	.051	.326	.026	.485	75.78
55,000	.001	.021	.023	.035	.017	.003	.061	.389	.031	.580	75.88
60,000	.001	.025	.027	.041	.021	.003	.073	.456	.037	.684	75.98
65,000	.001	.029	.031	.048	.024	.004	.086	.528	.043	.795	76.09
70,000	.001	.034	.037	.056	.028	.004	.100	.604	.050	.914	76.21
75,000	.002	.039	.042	.064	.032	.005	.114	.685	.058	1.041	76.34
80,000	.002	.044	.048	.073	.037	.006	.130	.771	.066	1.176	76.48
85,000	.002	.050	.054	.083	.041	.006	.147	.862	.074	1.319	76.62
90,000	.002	.056	.060	.093	.046	.007	.165	.957	.083	1.469	76.77
95,000	.002	.062	.067	.103	.052	.008	.183	1.057	.093	1.627	76.93
100,000	.003	.069	.074	.115	.057	.008	.203	1.160	.103	1.792	77.09
105,000	.003	.076	.082	.126	.063	.009	.224	1.269	.113	1.965	77.27
110,000	.003	.083	.090	.139	.069	.010	.246	1.382	.125	2.146	77.45
115,000	.003	.091	.099	.152	.076	.011	.269	1.499	.136	2.334	77.63
120,000	.004	.099	.107	.165	.082	.012	.293	1.620	.148	2.530	77.83
125,000	.004	.107	.116	.179	.089	.013	.317	1.746	.161	2.732	78.03
130,000	.004	.116	.126	.194	.096	.014	.343	1.876	.174	2.943	78.24
140,000	.005	.134	.146	.225	.112	.016	.398	2.148	.202	3.385	78.69
150,000	.006	.154	.168	.258	.128	.018	.457	2.437	.232	3.857	79.16
160,000	.006	.176	.191	.293	.146	.020	.520	2.743	.263	4.358	79.66
170,000	.007	.198	.215	.331	.165	.022	.587	3.065	.297	4.888	80.19
179,533	.008	.221	.240	.369	.184	.025	.655	3.386	.332	5.420	80.72 ***
180,000	.008	.222	.241	.371	.185	.025	.658	3.402	.333	5.446	80.75
190,000	.009	.248	.269	.414	.206	.027	.733	3.756	.371	6.033	81.33
200,000	.009	.274	.298	.458	.228	.030	.813	4.126	.412	6.649	81.95

RADIUS PUMP DISCHARGE PIPE (FT.)= 3.500
RADIUS OF DISCHARGE HEADER (FT)= 5.250
AREA PUMP DISCHARGE PIPE (SQ. FT) 38.465

DIAMETER OF HEADER (FT.)= 10.500
AREA OF HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT.)= 97.002
STATIC HEAD (FT.)= 75.300

LOSSES FOR 84" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 2 ------ALL PUMPS RUNNING --------

FLOW GPM	INLET CONDUIT	FSI	84" PUMP CONTROL VALVE	84" GATE VALVE	30 DEG. BEND	84" PIPE 1 PUMP	84" TO 126" EXPANSION	126" PIPE 3 PUMPS	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP
10,000	.000	.001	.001	.001	.001	.000	.002	5.518	.565	6.089	81.39
15,000	.000	.002	.002	.003	.001	.000	.005	5.735	.590	6.337	81.64
20,000	.000	.003	.003	.005	.002	.000	.008	5.956	.615	6.592	81.89
25,000	.000	.004	.005	.007	.004	.001	.013	6.181	.640	6.854	82.15
30,000	.000	.006	.007	.010	.005	.001	.018	6.410	.666	7.124	82.42
35,000	.000	.008	.009	.014	.007	.001	.025	6.642	.693	7.400	82.70
40,000	.000	.011	.012	.018	.009	.002	.033	6.878	.719	7.683	82.98
45,000	.001	.014	.015	.023	.012	.002	.041	7.118	.747	7.972	83.27
50,000	.001	.017	.019	.029	.014	.002	.051	7.362	.775	8.269	83.57
55,000	.001	.021	.023	.035	.017	.003	.061	7.609	.803	8.573	83.87
60,000	.001	.025	.027	.041	.021	.003	.073	7.860	.832	8.883	84.18
65,000	.001	.029	.031	.048	.024	.004	.086	8.115	.862	9.200	84.50
70,000	.001	.034	.037	.056	.028	.004	.100	8.373	.892	9.525	84.82
75,000	.002	.039	.042	.064	.032	.005	.114	8.635	.923	9.855	85.16
80,000	.002	.044	.048	.073	.037	.006	.130	8.901	.954	10.193	85.49
85,000	.002	.050	.054	.083	.041	.006	.147	9.170	.985	10.538	85.84
90,000	.002	.056	.060	.093	.046	.007	.165	9.443	1.017	10.889	86.19
95,000	.002	.062	.067	.103	.052	.008	.183	9.720	1.050	11.247	86.55
100,000	.003	.069	.074	.115	.057	.008	.203	10.000	1.083	11.612	86.91
105,000	.003	.076	.082	.126	.063	.009	.224	10.284	1.117	11.984	87.28
110,000	.003	.083	.090	.139	.069	.010	.246	10.571	1.151	12.362	87.66
115,000	.003	.091	.099	.152	.076	.011	.269	10.862	1.185	12.747	88.05
120,000	.004	.099	.107	.165	.082	.012	.293	11.157	1.221	13.139	88.44
125,000	.004	.107	.116	.179	.089	.013	.317	11.455	1.256	13.537	88.84
130,000	.004	.116	.126	.194	.096	.014	.343	11.757	1.293	13.942	89.24
140,000	.005	.134	.146	.225	.112	.016	.398	12.371	1.367	14.773	90.07
150,000	.006	.154	.168	.258	.128	.018	.457	12.999	1.443	15.630	90.93
160,000	.006	.176	.191	.293	.146	.020	.520	13.641	1.521	16.514	91.81
170,000	.007	.198	.215	.331	.165	.022	.587	14.298	1.601	17.425	92.72
179,533	.008	.221	.240	.369	.184	.025	.655	14.937	1.679	18.317	93.62 ***
180,000	.008	.222	.241	.371	.185	.025	.658	14.968	1.683	18.362	93.66
190,000	.009	.248	.269	.414	.206	.027	.733	15.652	1.767	19.325	94.63
200,000	.009	.274	.298	.458	.228	.030	.813	16.350	1.854	20.315	95.62

RADIUS PUMP DISCHARGE PIPE (FT.)= 3.500
RADIUS OF DISCHARGE HEADER (FT)= 5.250
AREA PUMP DISCHARGE PIPE (SQ. FT) 38.465

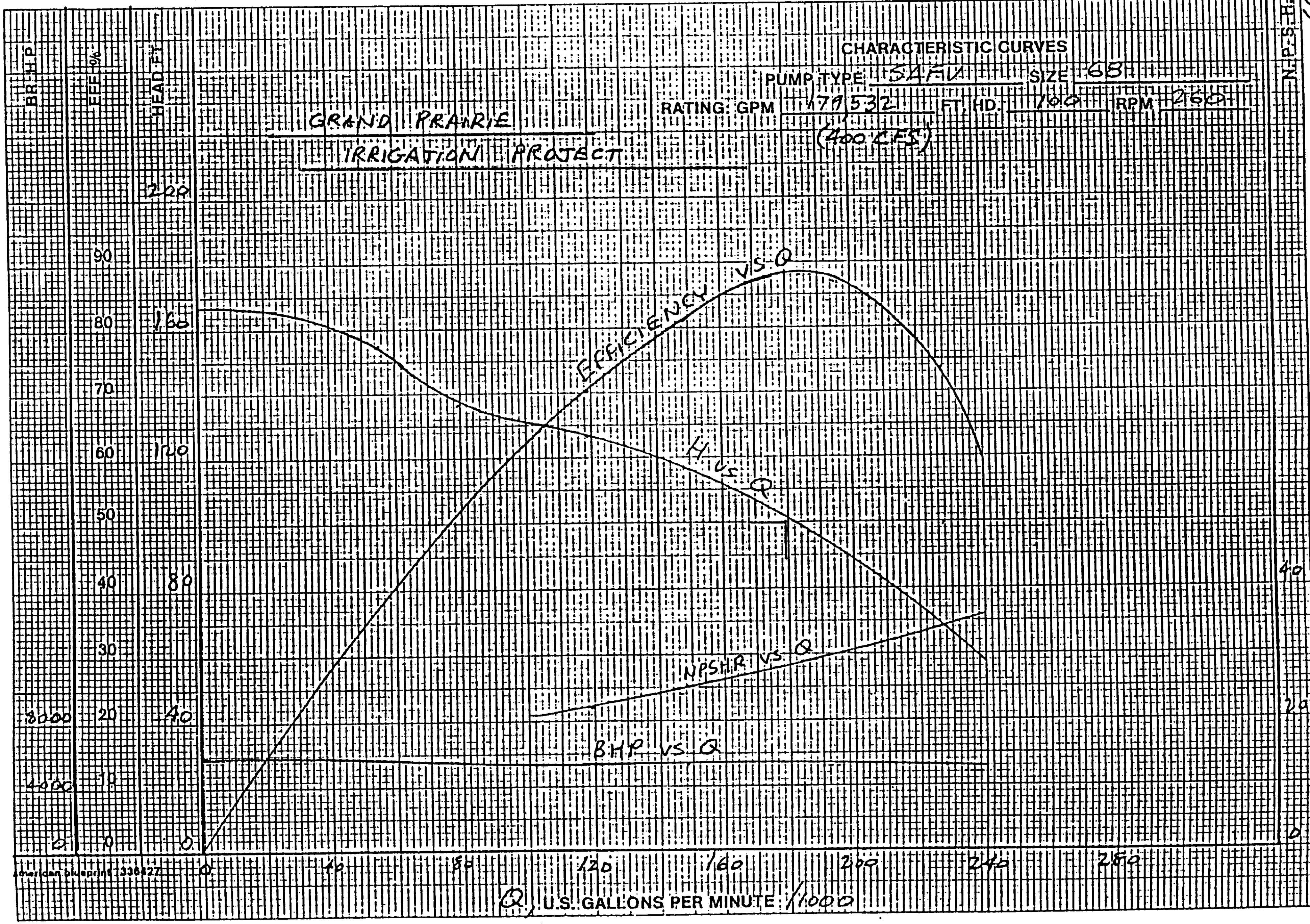
DIAMETER OF HEADER (FT.)= 10.500
AREA OF HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT.)= 97.002
STATIC HEAD (FT.)= 75.300

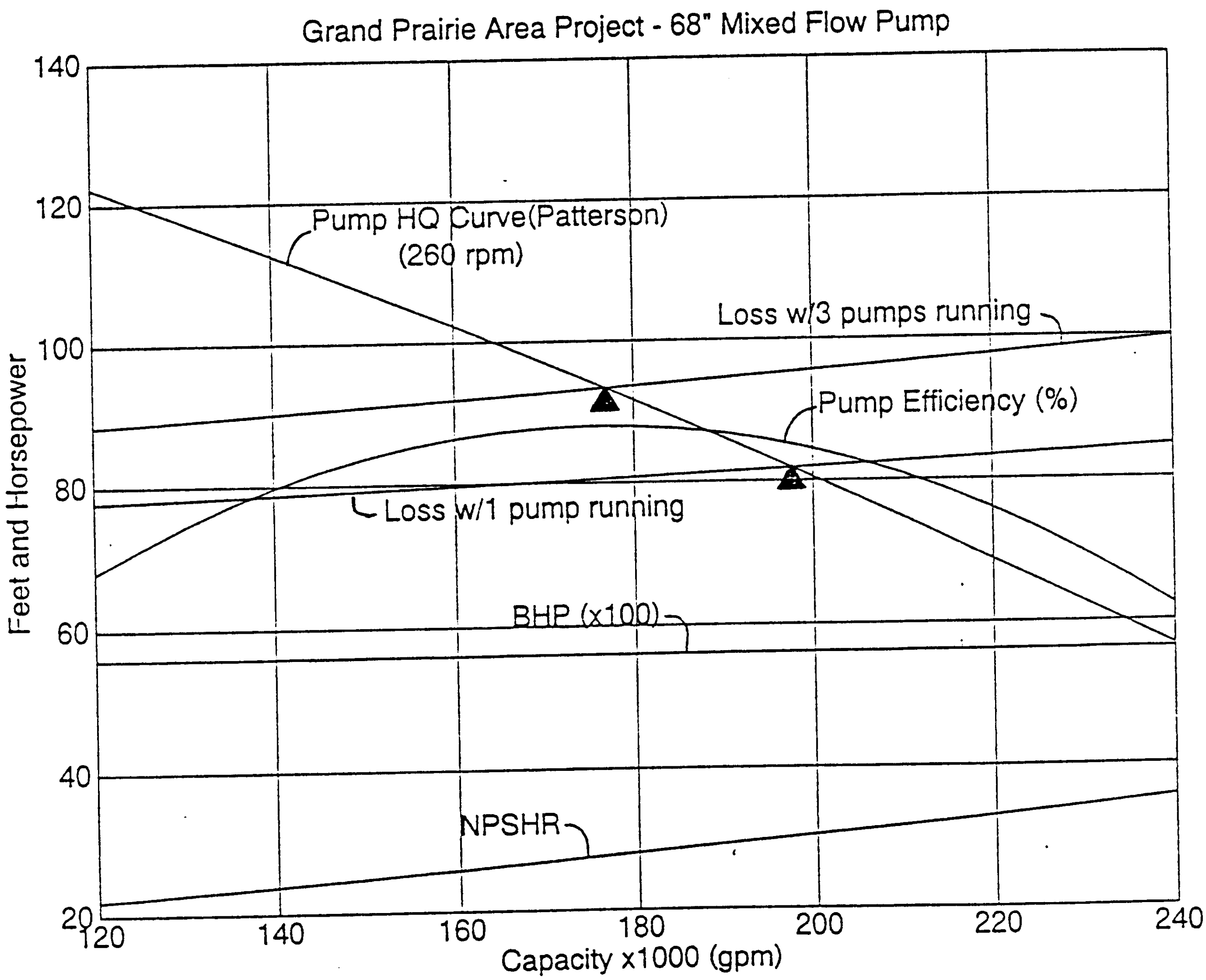
4.4747
× D-6756

PATTERSON PUMP COMPANY
A SUBSIDIARY OF THE GORMAN-RUPP CO.

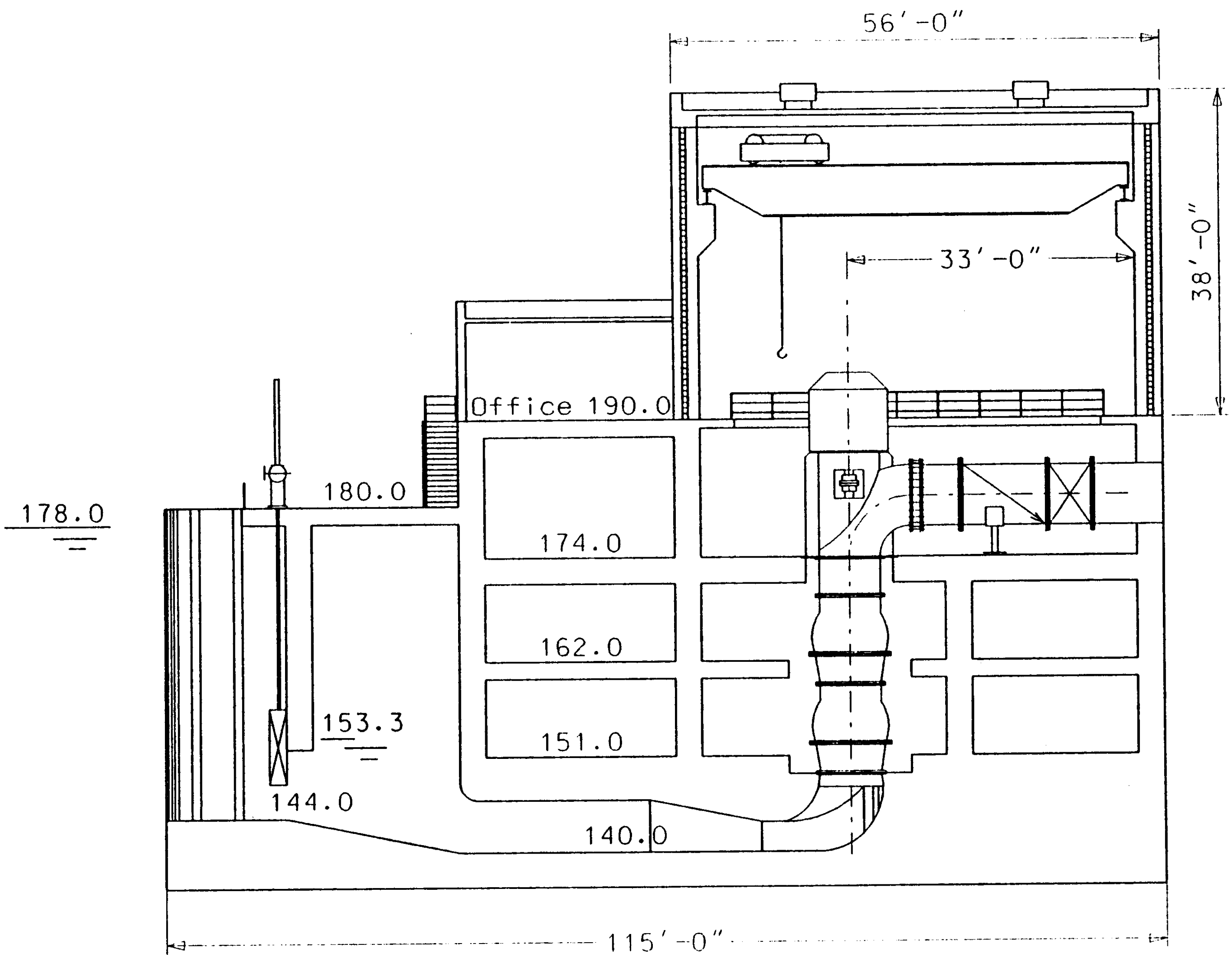
CURVE NO. ____________

REF.





Appendix V-B-10



TRANSVERSE VIEW
SCALE: 1"= 20'-0"

ALTERNATE 2

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

ELEVATION AT LARGE PUMP

PLATE
V-B-1

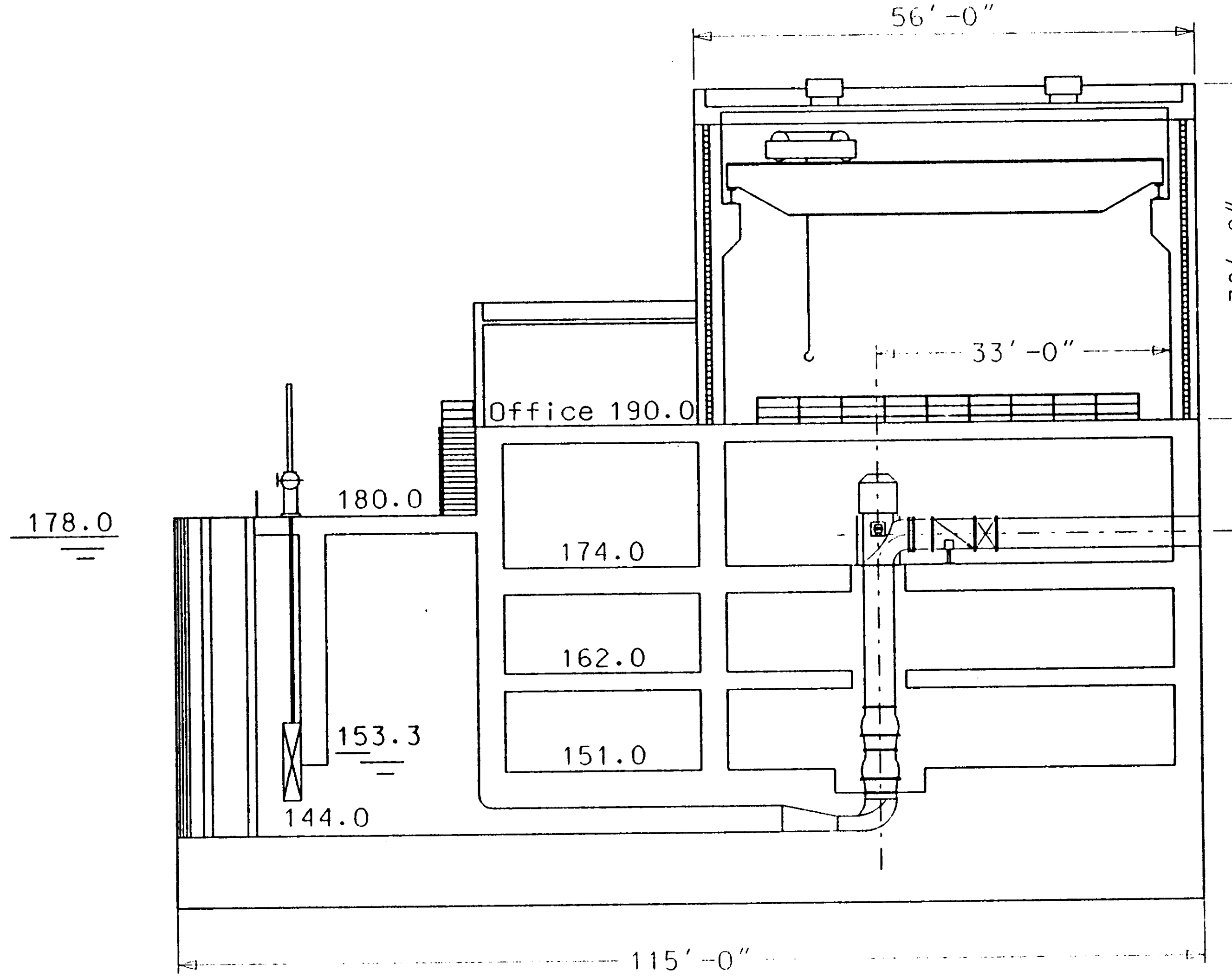
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

ELEVATION AT SMALL PUMP

PLATE V-B-II



TRANSVERSE VIEW
SCALE: 1"= 20'-0"

ALTERNATE 2

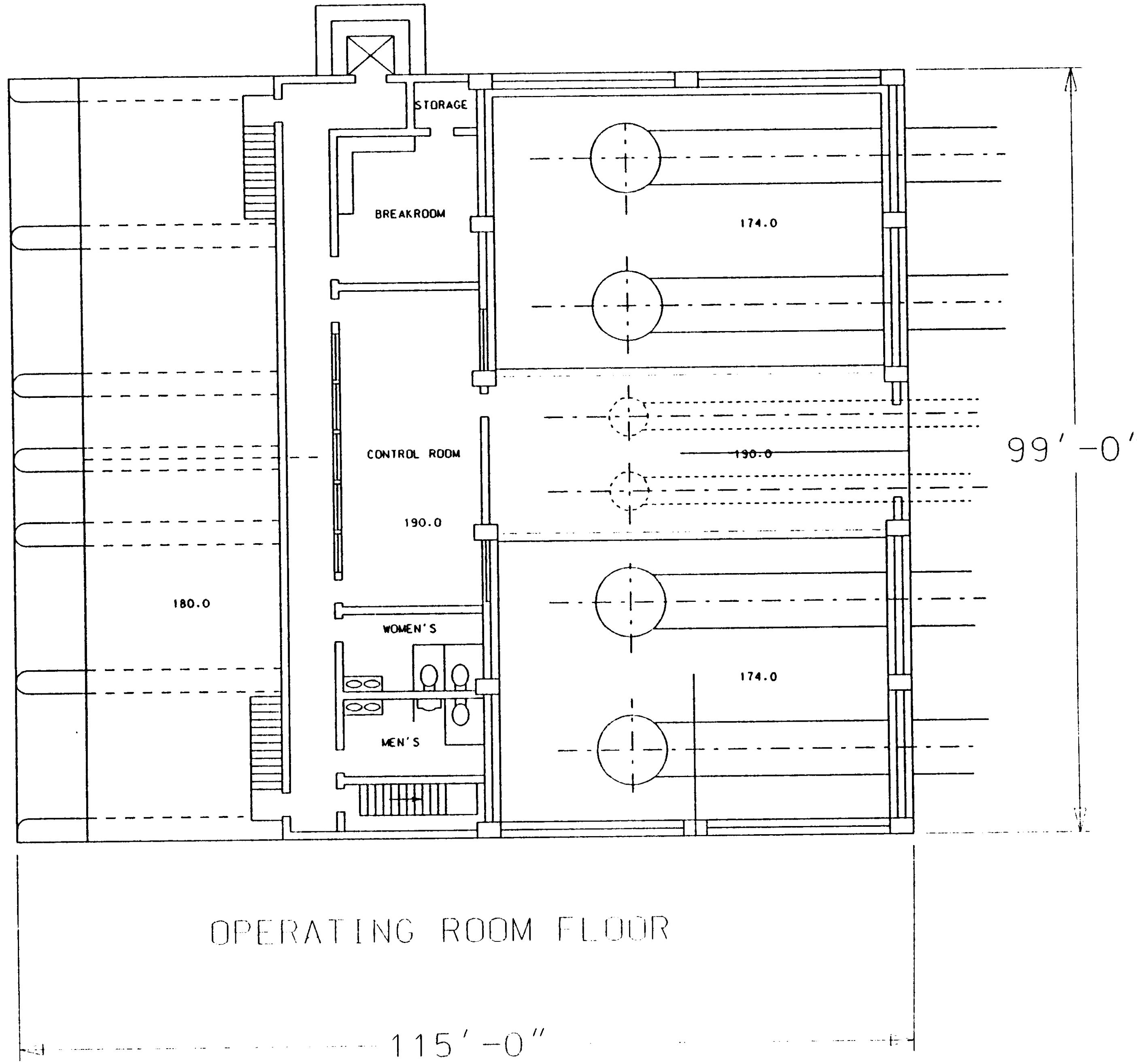
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

FLOOR PLAN
ELEVATION 190.0

PLATE
V-B-III



US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

FLOOR PLAN ELEVATION 174.0

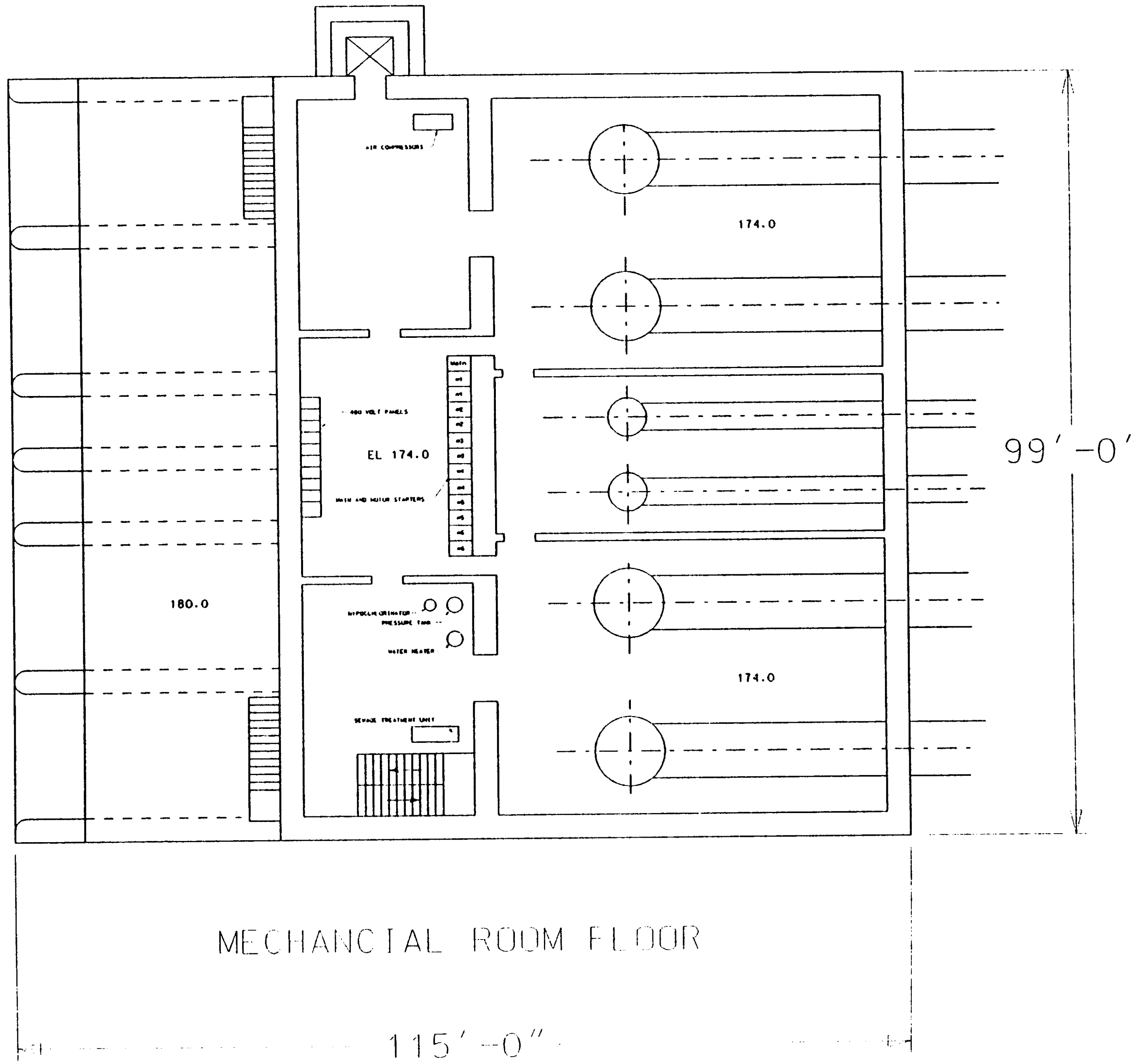


PLATE V-B-IV

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-C

GRAND PRAIRIE PUMPING STATION

ALTERNATE NUMBER 3

STATION LAYOUT AND PUMP CURVES

U.S. Army Corps of Engineers
Memphis District

Appendix V-C-1

LOSSES FOR 42" - GRAND PRAIRIE PUMPING ST[illegible]ION ALTERNATE 3 — ONE PUMP RUNNING

FLOW GPM	INLET CONDUIT	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 126" TEE	126" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	HEAD 1 PUMP
10,000	.001	.004	.013	.020	.058	.02	.017	.001	.130	75.430
15,000	.001	.009	.029	.045	.121	.04	.036	.002	.281	75.581
20,000	.002	.016	.052	.080	.205	.07	.061	.004	.487	75.787
25,000	.003	.025	.081	.125	.309	.10	.092	.006	.745	76.045
30,000	.004	.036	.117	.180	.431	.15	.128	.009	1.055	76.355
35,000	.005	.049	.159	.245	.571	.20	.170	.013	1.417	76.717
40,000	.007	.064	.208	.320	.729	.27	.217	.016	1.828	77.128
44,883	.008	.081	.262	.403	.900	.34	.268	.021	2.279	77.579 ***
45,000	.008	.082	.263	.405	.905	.34	.269	.021	2.290	77.590
50,000	.010	.101	.325	.500	1.097	.42	.326	.026	2.801	78.101
55,000	.012	.122	.393	.605	1.306	.50	.389	.031	3.362	78.662
60,000	.014	.145	.468	.720	1.531	.60	.456	.037	3.971	79.271
65,000	.016	.170	.549	.845	1.773	.70	.528	.043	4.629	79.929
70,000	.018	.197	.637	.980	2.031	.82	.604	.050	5.335	80.635
75,000	.021	.227	.731	1.125	2.304	.94	.685	.058	6.089	81.389
80,000	.023	.258	.832	1.280	2.593	1.07	.771	.066	6.890	82.190
85,000	.026	.291	.939	1.445	2.897	1.20	.862	.074	7.739	83.039
90,000	.029	.326	1.053	1.620	3.216	1.35	.957	.083	8.635	83.935
95,000	.032	.364	1.173	1.805	3.551	1.50	1.057	.093	9.579	84.879
100,000	.035	.403	1.300	2.000	3.900	1.67	1.160	.103	10.569	85.869
105,000	.038	.444	1.433	2.205	4.264	1.84	1.269	.113	11.606	86.906
110,000	.041	.488	1.573	2.420	4.643	2.02	1.382	.125	12.689	87.989
115,000	.045	.533	1.719	2.645	5.037	2.20	1.499	.136	13.819	89.119
120,000	.049	.580	1.872	2.880	5.445	2.40	1.620	.148	14.995	90.295
125,000	.052	.630	2.032	3.125	5.867	2.60	1.746	.161	16.217	91.517
130,000	.056	.681	2.197	3.380	6.304	2.82	1.876	.174	17.486	92.786
140,000	.064	.790	2.548	3.921	7.219	3.27	2.148	.202	20.160	95.460
150,000	.073	.907	2.925	4.501	8.191	3.75	2.437	.232	23.016	98.316
160,000	.082	1.032	3.328	5.121	9.218	4.27	2.743	.263	26.054	101.354
170,000	.092	1.165	3.758	5.781	10.299	4.82	3.065	.297	29.273	104.573
180,000	.102	1.306	4.213	6.481	11.435	5.40	3.402	.333	32.673	107.973
190,000	.113	1.455	4.694	7.221	12.624	6.02	3.756	.371	36.252	111.552
200,000	.124	1.612	5.201	8.001	13.867	6.67	4.126	.412	40.009	115.309

RADIUS OF PUMP DISCHARGE PIPE (FT 1.750
RADIUS OF DISCHARGE HEADER (FT)= 5.250
AREA OF PUMP DISCHARGE PIPE (SQ. 9.616
DIAMETER OF HEADER (FT.)= 10.500

AREA OF HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT. 43.162
STATIC HEAD (FT.)= 75.300

LOSSES FOR 42" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 3 THREE PUMPS RUNNING

FLOW GPM	INLET CONDUIT	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 126" TEE	126" PIPE 3 PUMP	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP	
10,000	.001	.004	.013	.020	.058	.02	12.662	1.402	14.175	89.475	
15,000	.001	.009	.029	.045	.121	.04	12.977	1.440	14.660	89.960	
20,000	.002	.016	.052	.080	.205	.07	13.297	1.479	15.197	90.497	
25,000	.003	.025	.081	.125	.309	.10	13.619	1.518	15.784	91.084	
30,000	.004	.036	.117	.180	.431	.15	13.945	1.558	16.421	91.721	
35,000	.005	.049	.159	.245	.571	.20	14.275	1.598	17.107	92.407	
40,000	.007	.064	.208	.320	.729	.27	14.608	1.639	17.842	93.142	
44,883	.008	.081	.262	.403	.900	.34	14.937	1.679	18.606	93.906	***
45,000	.008	.082	.263	.405	.905	.34	14.945	1.680	18.625	93.925	
50,000	.010	.101	.325	.500	1.097	.42	15.285	1.722	19.457	94.757	
55,000	.012	.122	.393	.605	1.306	.50	15.629	1.764	20.335	95.635	
60,000	.014	.145	.468	.720	1.531	.60	15.976	1.807	21.261	96.561	
65,000	.016	.170	.549	.845	1.773	.70	16.326	1.851	22.235	97.535	
70,000	.018	.197	.637	.980	2.031	.82	16.680	1.894	23.255	98.555	
75,000	.021	.227	.731	1.125	2.304	.94	17.038	1.939	24.322	99.622	
80,000	.023	.258	.832	1.280	2.593	1.07	17.399	1.984	25.435	100.735	
85,000	.026	.291	.939	1.445	2.897	1.20	17.763	2.029	26.595	101.895	
90,000	.029	.326	1.053	1.620	3.216	1.35	18.131	2.075	27.801	103.101	
95,000	.032	.364	1.173	1.805	3.551	1.50	18.502	2.122	29.053	104.353	
100,000	.035	.403	1.300	2.000	3.900	1.67	18.876	2.169	30.350	105.650	
105,000	.038	.444	1.433	2.205	4.264	1.84	19.254	2.216	31.694	106.994	
110,000	.041	.488	1.573	2.420	4.643	2.02	19.635	2.264	33.083	108.383	
115,000	.045	.533	1.719	2.645	5.037	2.20	20.020	2.313	34.517	109.817	
120,000	.049	.580	1.872	2.880	5.445	2.40	20.408	2.362	35.997	111.297	
125,000	.052	.630	2.032	3.125	5.867	2.60	20.800	2.411	37.522	112.822	
130,000	.056	.681	2.197	3.380	6.304	2.82	21.195	2.461	39.092	114.392	
140,000	.064	.790	2.548	3.921	7.219	3.27	21.994	2.563	42.367	117.667	
150,000	.073	.907	2.925	4.501	8.191	3.75	22.807	2.667	45.822	121.122	
160,000	.082	1.032	3.328	5.121	9.218	4.27	23.634	2.773	49.455	124.755	
170,000	.092	1.165	3.758	5.781	10.299	4.82	24.474	2.880	53.266	128.566	
180,000	.102	1.306	4.213	6.481	11.435	5.40	25.327	2.990	57.254	132.554	
190,000	.113	1.455	4.694	7.221	12.624	6.02	26.193	3.102	61.419	136.719	
200,000	.124	1.612	5.201	8.001	13.867	6.67	27.073	3.216	65.761	141.061	

RADIUS OF PUMP DISCHARGE PIPE (FT 1.750
RADIUS OF DISCHARGE HEADER (FT)= 5.250
AREA OF PUMP DISCHARGE PIPE (SQ. 9.616
DIAMETER OF HEADER (FT.)= 10.500

AREA OF HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT. 43.162
STATIC HEAD (FT.)= 75.300

LOS FOR 54" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 7 ONE PUMP RUNNI' -------

FLOW GPM	INLET CONDUIT	FSI	54" TO 66" EXPANSION	66" PUMP CONTROL VALVE	66" GATE VALVE	66" PIPE 1 PUMP	66" TO 96" EXPANSION	30 DEG. BEND	96" PIPE 1 PUMP	96" TO 126" EXPANSION	126" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	TOTAL HEAD 1 PUMP
10,000	.000	.002	.002	.001	.001	.001	.001	.000	.000	.000	.017	.001	.028	75.33
15,000	.000	.005	.004	.003	.002	.001	.003	.001	.001	.001	.036	.002	.059	75.36
20,000	.001	.009	.006	.005	.004	.002	.005	.001	.001	.002	.061	.004	.102	75.40
25,000	.001	.015	.010	.008	.006	.003	.008	.002	.002	.003	.092	.006	.156	75.46
30,000	.002	.021	.014	.012	.008	.004	.012	.003	.003	.004	.128	.009	.220	75.52
35,000	.002	.029	.019	.017	.011	.005	.016	.004	.004	.005	.170	.013	.295	75.59
40,000	.003	.038	.025	.022	.014	.007	.021	.005	.005	.007	.217	.016	.380	75.68
45,000	.004	.048	.032	.027	.018	.009	.026	.007	.006	.009	.269	.021	.475	75.78
50,000	.004	.059	.039	.034	.022	.011	.032	.008	.007	.011	.326	.026	.580	75.88
55,000	.005	.072	.048	.041	.027	.013	.039	.010	.009	.013	.389	.031	.695	76.00
60,000	.006	.085	.057	.049	.032	.015	.046	.012	.010	.016	.456	.037	.820	76.12
65,000	.007	.100	.067	.057	.037	.017	.054	.014	.012	.018	.528	.043	.955	76.25
70,000	.008	.116	.077	.066	.043	.020	.063	.016	.014	.021	.604	.050	1.099	76.40
75,000	.009	.133	.089	.076	.050	.022	.072	.019	.016	.024	.685	.058	1.253	76.55
80,000	.010	.151	.101	.087	.056	.025	.082	.021	.018	.028	.771	.066	1.417	76.72
85,000	.011	.171	.114	.098	.064	.028	.093	.024	.020	.031	.862	.074	1.590	76.89
90,000	.012	.192	.128	.110	.071	.031	.104	.027	.022	.035	.957	.083	1.772	77.07
95,000	.014	.213	.142	.122	.079	.034	.116	.030	.024	.039	1.057	.093	1.964	77.26
100,000	.015	.237	.158	.135	.088	.037	.129	.033	.026	.043	1.160	.103	2.166	77.47
105,000	.017	.261	.174	.149	.097	.041	.142	.037	.029	.048	1.269	.113	2.376	77.68
110,000	.018	.286	.191	.164	.107	.045	.156	.040	.031	.052	1.382	.125	2.596	77.90
115,000	.020	.313	.209	.179	.116	.048	.170	.044	.034	.057	1.499	.136	2.825	78.13
119,688	.021	.339	.226	.194	.126	.052	.184	.048	.037	.062	1.612	.147	3.049	78.35
120,000	.021	.341	.227	.195	.127	.052	.185	.048	.037	.062	1.620	.148	3.064	78.36
125,000	.023	.370	.247	.212	.138	.056	.201	.052	.040	.068	1.746	.161	3.312	78.61
130,000	.024	.400	.267	.229	.149	.061	.217	.057	.043	.073	1.876	.174	3.568	78.87
140,000	.028	.464	.309	.265	.173	.069	.252	.066	.049	.085	2.148	.202	4.109	79.41
150,000	.032	.532	.355	.305	.198	.079	.289	.075	.056	.097	2.437	.232	4.687	79.99
160,000	.036	.605	.404	.347	.225	.089	.329	.086	.062	.111	2.743	.263	5.300	80.60
170,000	.040	.683	.456	.391	.254	.099	.372	.097	.070	.125	3.065	.297	5.949	81.25
180,000	.044	.766	.511	.439	.285	.110	.417	.108	.077	.140	3.402	.333	6.635	81.93
190,000	.049	.854	.570	.489	.318	.121	.464	.121	.086	.156	3.756	.371	7.355	82.66
200,000	.054	.946	.631	.542	.352	.133	.514	.134	.094	.173	4.126	.412	8.111	83.41

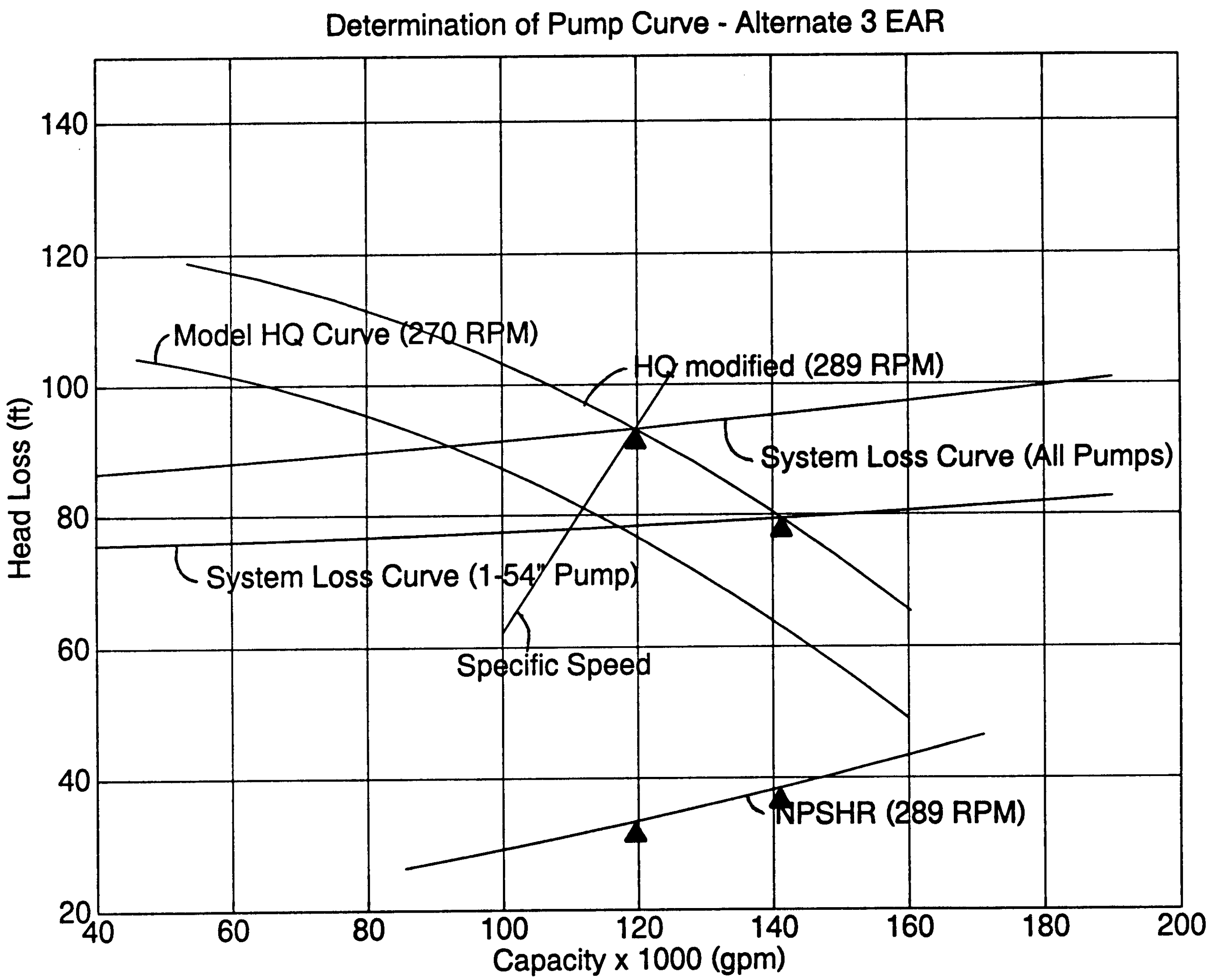
RADIUS 66" PUMP DISCHARGE PIPE (FT.)=	3.500	DIAMETER OF 126" HEADER (FT.)=	10.500
RADIUS 126" DISCHARGE HEADER (FT)=	5.250	AREA OF 126" HEADER (SQ. FT)=	86.546
AREA 126" DISCHARGE PIPE (SQ. FT)=	38.465	AREA OF CONDUIT (SQ. FT.)=	56.000
RADIUS 96" DISCHARGE PIPE (FT.)=	4.000	STATIC HEAD (FT.)=	75.300
AREA 96" DISCHARGE PIPE (SQ. FT)=	50.240		

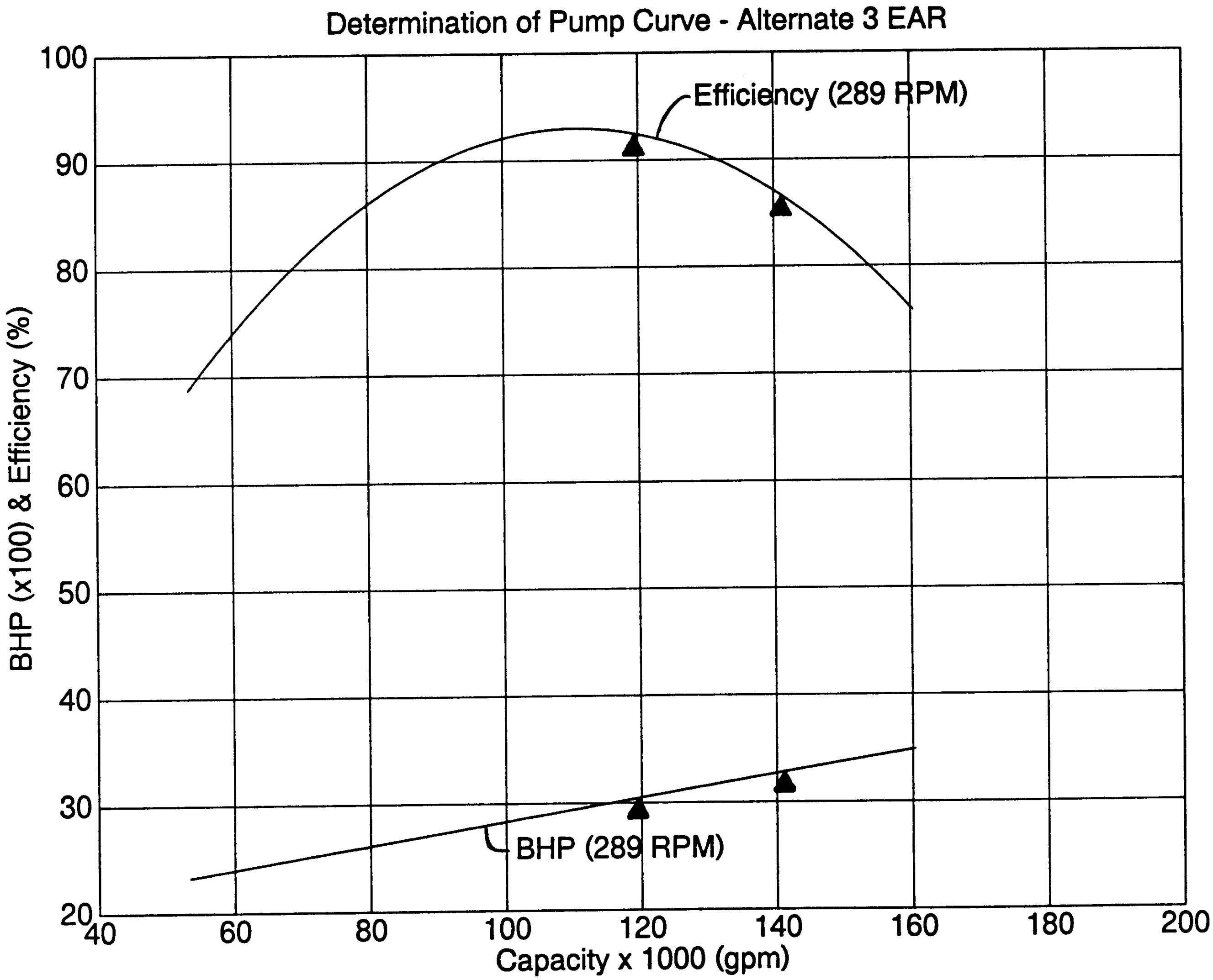
OSSES FOR 54" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 3 ------ALL PUMPS NG --------

FLOW GPM	INLET CONDUIT	FSI	54" TO 66" EXPANSION	66" PUMP CONTROL VALVE	66" GATE VALVE	66" PIPE 1 PUMP	66" TO 96" EXPANSION	30 DEG. BEND	96" PIPE 1 PUMP	96" TO 126" EXPANSION	126" PIPE 3 PUMPS	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP	
10,000	.000	.002	.002	.001	.001	.001	.001	.000	.000	.000	8.365	.891	9.265	84.57	
15,000	.000	.005	.004	.003	.002	.001	.003	.001	.001	.001	8.627	.922	9.570	84.87	
20,000	.001	.009	.006	.005	.004	.002	.005	.001	.001	.002	8.893	.953	9.882	85.18	
25,000	.001	.015	.010	.008	.006	.003	.008	.002	.002	.003	9.162	.984	10.204	85.50	
30,000	.002	.021	.014	.012	.008	.004	.012	.003	.003	.004	9.435	1.016	10.534	85.83	
35,000	.002	.029	.019	.017	.011	.005	.016	.004	.004	.005	9.711	1.049	10.872	86.17	
40,000	.003	.038	.025	.022	.014	.007	.021	.005	.005	.007	9.991	1.082	11.220	86.52	
45,000	.004	.048	.032	.027	.018	.009	.026	.007	.006	.009	10.275	1.116	11.576	86.88	
50,000	.004	.059	.039	.034	.022	.011	.032	.008	.007	.011	10.562	1.150	11.940	87.24	
55,000	.005	.072	.048	.041	.027	.013	.039	.010	.009	.013	10.853	1.184	12.313	87.61	
60,000	.006	.085	.057	.049	.032	.015	.046	.012	.010	.016	11.148	1.220	12.695	87.99	
65,000	.007	.100	.067	.057	.037	.017	.054	.014	.012	.018	11.446	1.255	13.085	88.38	
70,000	.008	.116	.077	.066	.043	.020	.063	.016	.014	.021	11.747	1.291	13.483	88.78	
75,000	.009	.133	.089	.076	.050	.022	.072	.019	.016	.024	12.053	1.328	13.890	89.19	
80,000	.010	.151	.101	.087	.056	.025	.082	.021	.018	.028	12.361	1.365	14.306	89.61	
85,000	.011	.171	.114	.098	.064	.028	.093	.024	.020	.031	12.674	1.403	14.730	90.03	
90,000	.012	.192	.128	.110	.071	.031	.104	.027	.022	.035	12.989	1.441	15.163	90.46	
95,000	.014	.213	.142	.122	.079	.034	.116	.030	.024	.039	13.309	1.480	15.604	90.90	
100,000	.015	.237	.158	.135	.088	.037	.129	.033	.026	.043	13.631	1.519	16.053	91.35	
105,000	.017	.261	.174	.149	.097	.041	.142	.037	.029	.048	13.958	1.559	16.511	91.81	
110,000	.018	.286	.191	.164	.107	.045	.156	.040	.031	.052	14.288	1.600	16.977	92.28	
115,000	.020	.313	.209	.179	.116	.048	.170	.044	.034	.057	14.621	1.640	17.452	92.75	
119,688	.021	.339	.226	.194	.126	.052	.184	.048	.037	.062	14.937	1.679	17.905	93.20	***
120,000	.021	.341	.227	.195	.127	.052	.185	.048	.037	.062	14.958	1.682	17.935	93.24	
125,000	.023	.370	.247	.212	.138	.056	.201	.052	.040	.068	15.298	1.724	18.427	93.73	
130,000	.024	.400	.267	.229	.149	.061	.217	.057	.043	.073	15.642	1.766	18.927	94.23	
140,000	.028	.464	.309	.265	.173	.069	.252	.066	.049	.085	16.340	1.852	19.952	95.25	
150,000	.032	.532	.355	.305	.198	.079	.289	.075	.056	.097	17.051	1.941	21.010	96.31	
160,000	.036	.605	.404	.347	.225	.089	.329	.086	.062	.111	17.777	2.031	22.102	97.40	
170,000	.040	.683	.456	.391	.254	.099	.372	.097	.070	.125	18.516	2.123	23.227	98.53	
180,000	.044	.766	.511	.439	.285	.110	.417	.108	.077	.140	19.268	2.218	24.385	99.69	
190,000	.049	.854	.570	.489	.318	.121	.464	.121	.086	.156	20.035	2.315	25.577	100.88	
200,000	.054	.946	.631	.542	.352	.133	.514	.134	.094	.173	20.814	2.413	26.801	102.10	

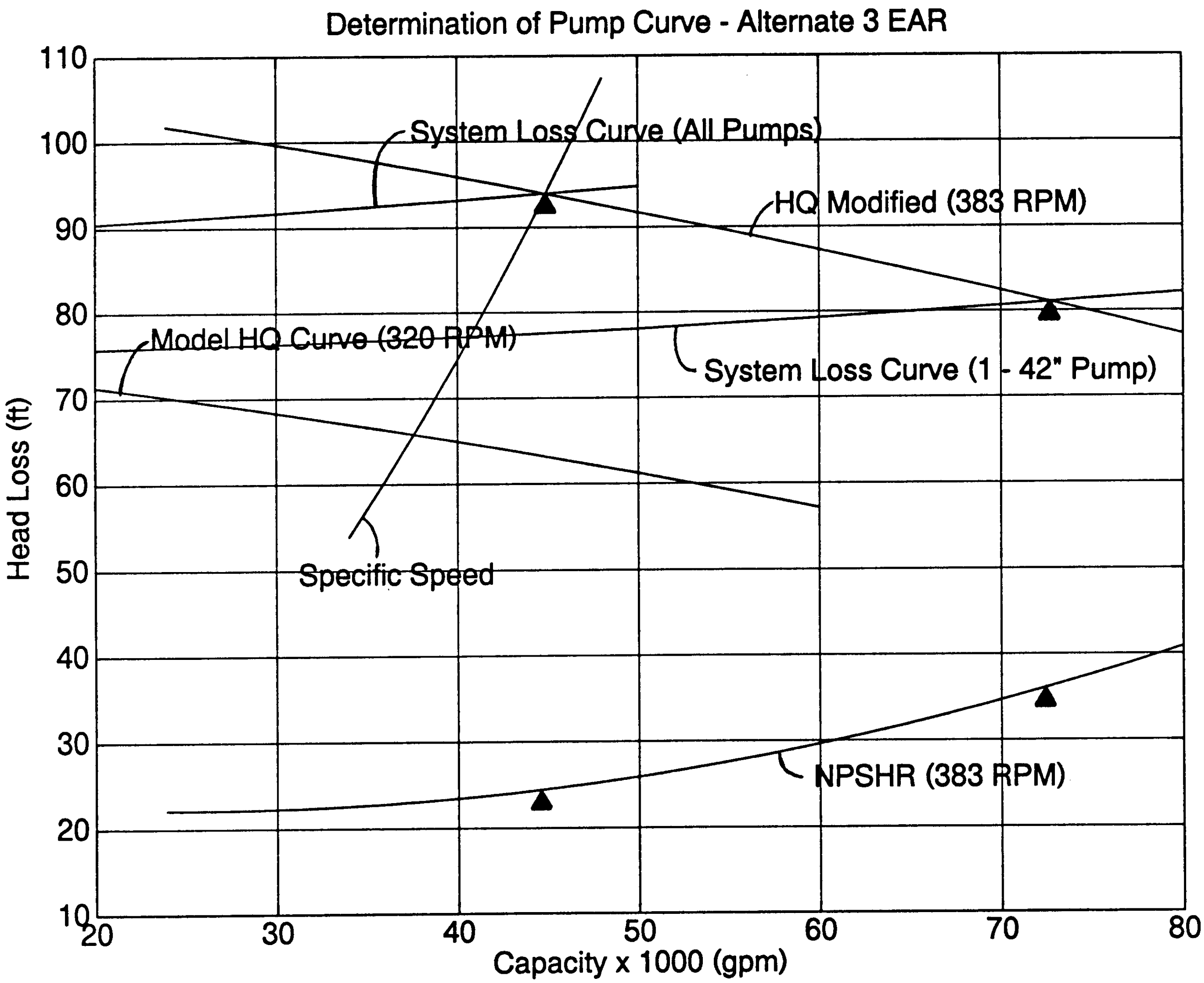
RADIUS 66" PUMP DISCHARGE PIPE (FT.)= 3.500
RADIUS 126" DISCHARGE HEADER (FT)= 5.250
AREA 126" DISCHARGE PIPE (SQ. FT)= 38.465
RADIUS 96" DISCHARGE PIPE (FT.)= 4.000
AREA 96" DISCHARGE PIPE (SQ. FT)= 50.240

DIAMETER OF 126" HEADER (FT.)= 10.500
AREA OF 126" HEADER (SQ. FT)= 86.546
AREA OF CONDUIT (SQ. FT.)= 56.000
STATIC HEAD (FT.)= 75.300

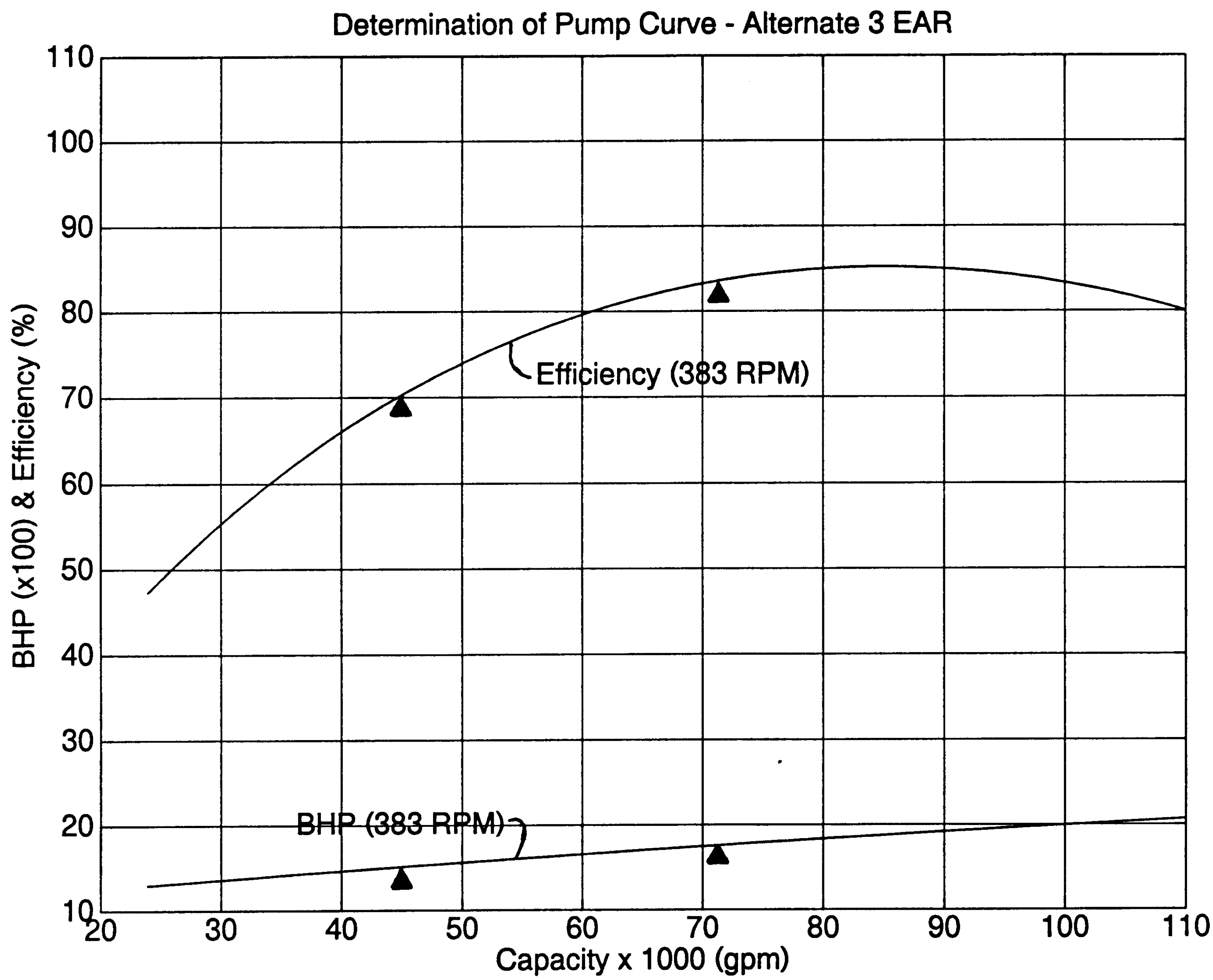

Determination of Pump Curve - Alternate 3 EAR
Head Loss (ft)
Capacity x 1000 (gpm)
140
120
100
80
60
40
20
40
60
80
100
120
140
160
180
200
Model HQ Curve (270 RPM)
HQ modified (289 RPM)
System Loss Curve (All Pumps)
System Loss Curve (1-54" Pump)
Specific Speed
NPSHR (289 RPM)



Appendix V-C-6



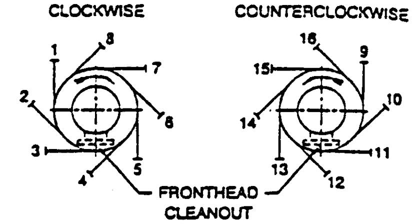
Appendix V-C-7


Determination of Pump Curve - Alternate 3 EAR
BHP (x100) & Efficiency (%)
110
100
90
80
70
60
50
40
30
20
10
20
30
40
50
60
70
80
90
100
110
Capacity x 1000 (gpm)
Efficiency (383 RPM)
BHP (383 RPM)

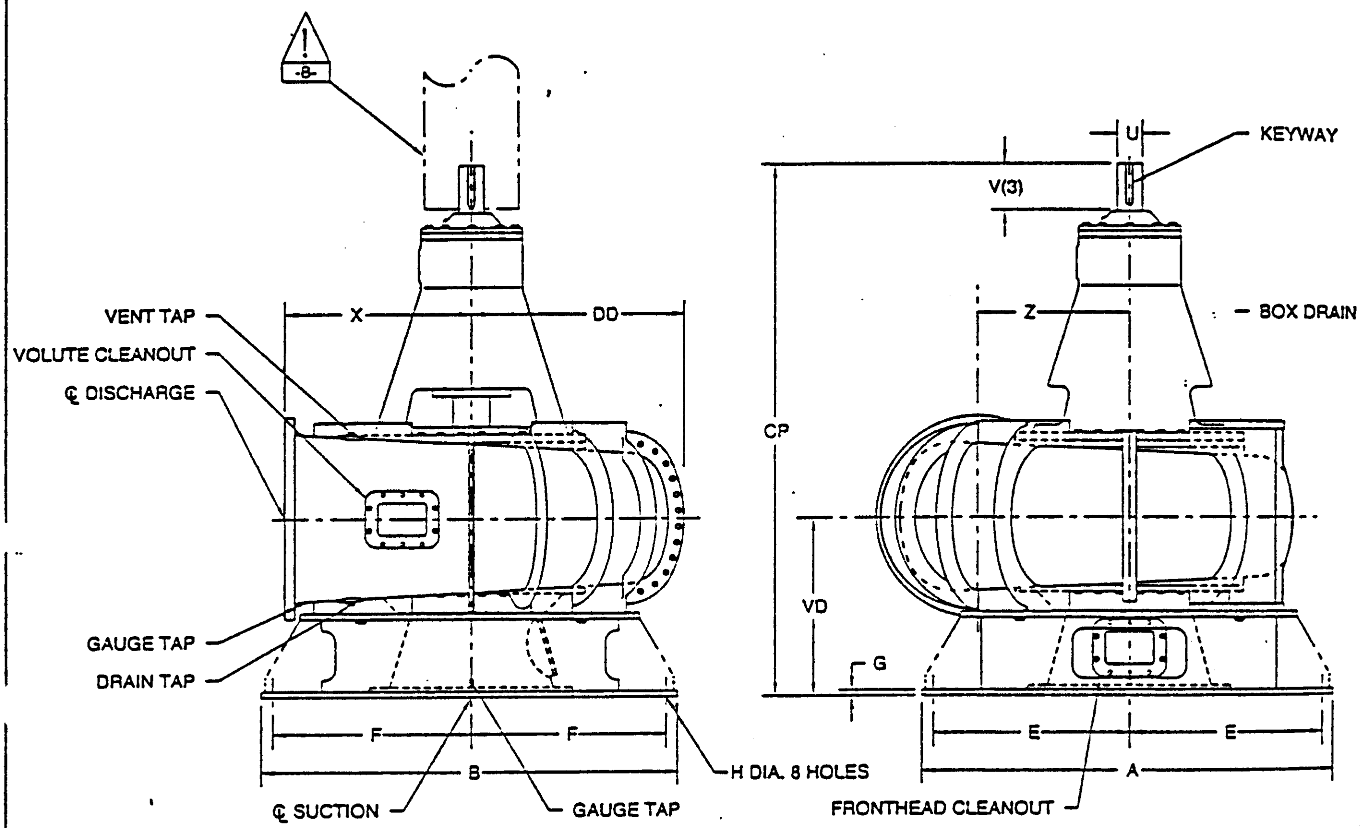
WARNING

DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

-A- SUPPLIED BY FMPC -B- SUPPLIED BY OTHERS



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.



PUMP	SUCT	DISCH	A	B	E	F	G	H	U	V	X	Z	CP	DD	VD	KEYWAY
42" C5711	42	42	108	108	51	51	1½	1⅞	6½	12½	48	39½	139	55¾	47	1¾ X ⅞ X 8
54" C5711	54	54	128	128	61	61	1½	1⅞	7⅞	14	61½	50¾	161	70¼	60	2 X 1 X 8

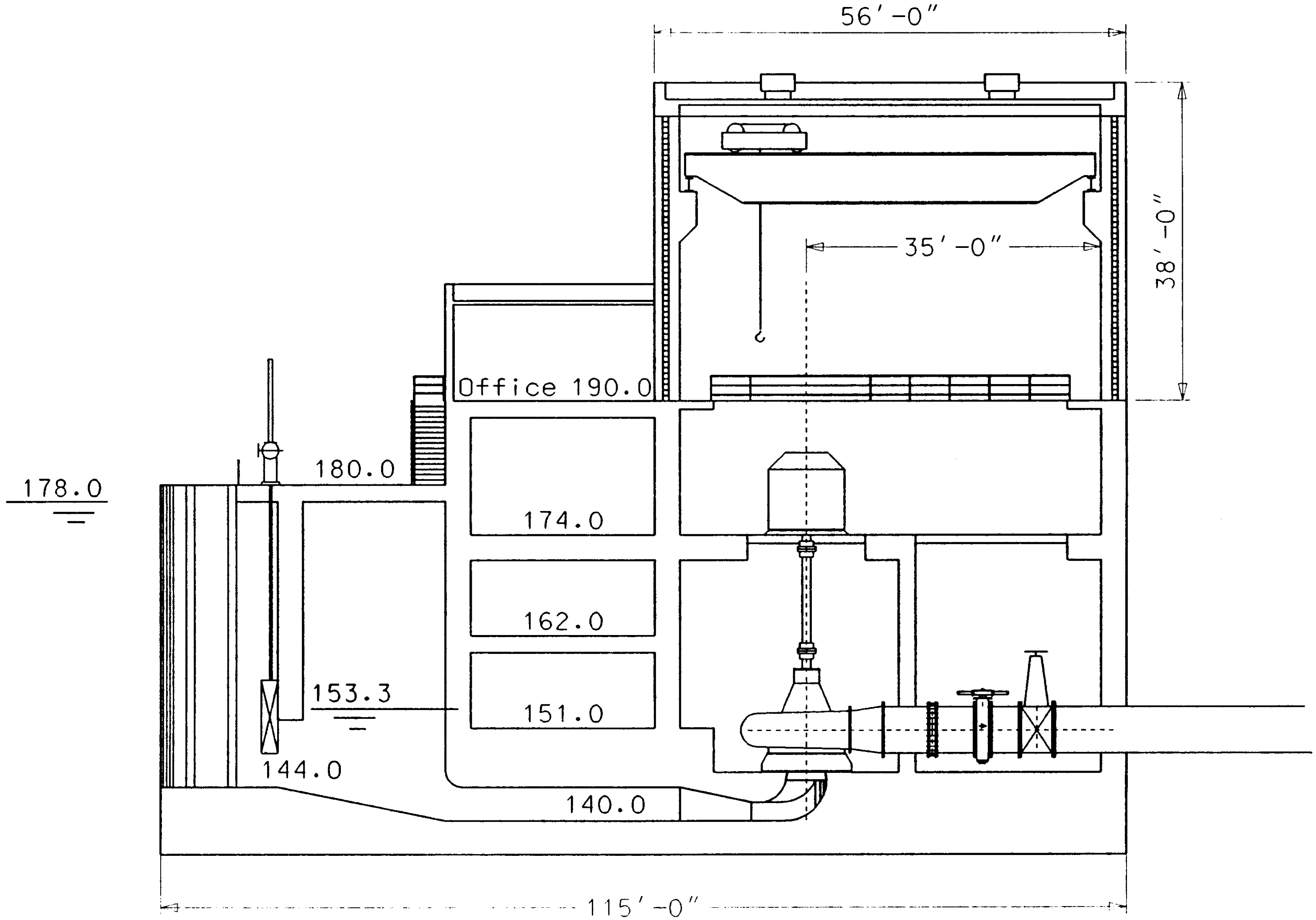
NOTES:

(1) ALL FLANGES ARE 125# ANSI DRILLING UNLESS NOTED.
(2) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(3) DIMENSIONS REFLECT USABLE SHAFT LENGTH.
(4) BASES ARE DESIGNED TO HAVE FULL CONTACT WITH GROUT OR A SOLE PLATE GROUTED IN PLACE.
(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.

CUSTOMER				P.O. NO.		Fairbanks Morse Pump Corporation
JOB NAME				TAG NAME		BASIC PUMP DIMENSIONS 42" & 54" C5711
PUMP SIZE AND MODEL	GPM	TDH	RPM	ROTATION	DISCH POS	
MOTOR	HP / FRAME	PHASE	HERTZ	VOLTS	ENCLOSURE	
CERTIFIED FOR		CERTIFIED BY		DATE		DWG NO 5710S011 REV NO 0

1/1/92

Fai-banks Morse Pump Corporation



TRANSVERSE VIEW
SCALE: 1"= 20'-0"

ALTERNATE 3

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

ELEVATION AT LARGE PUMP

PLATE
V-C-I

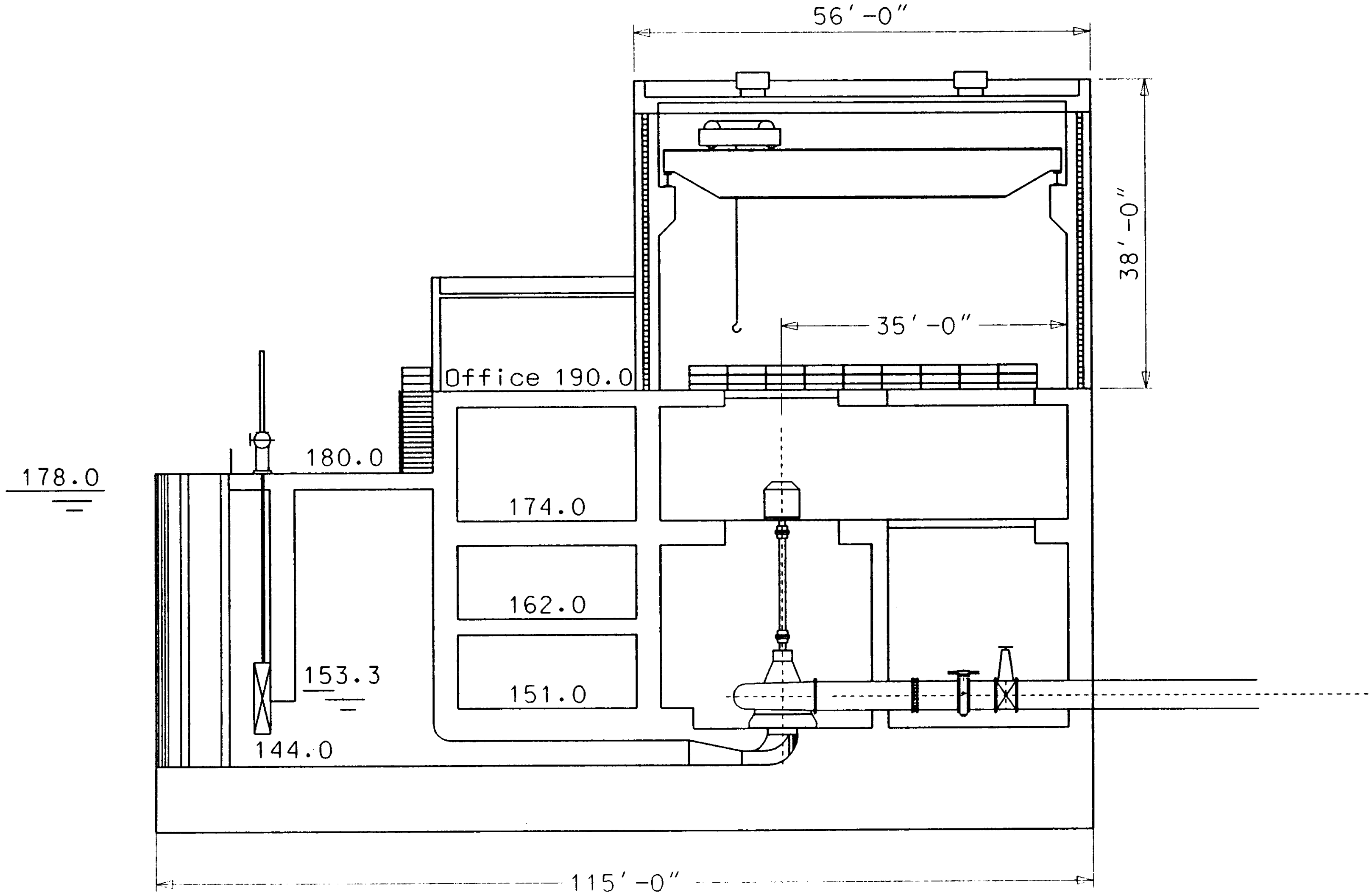
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

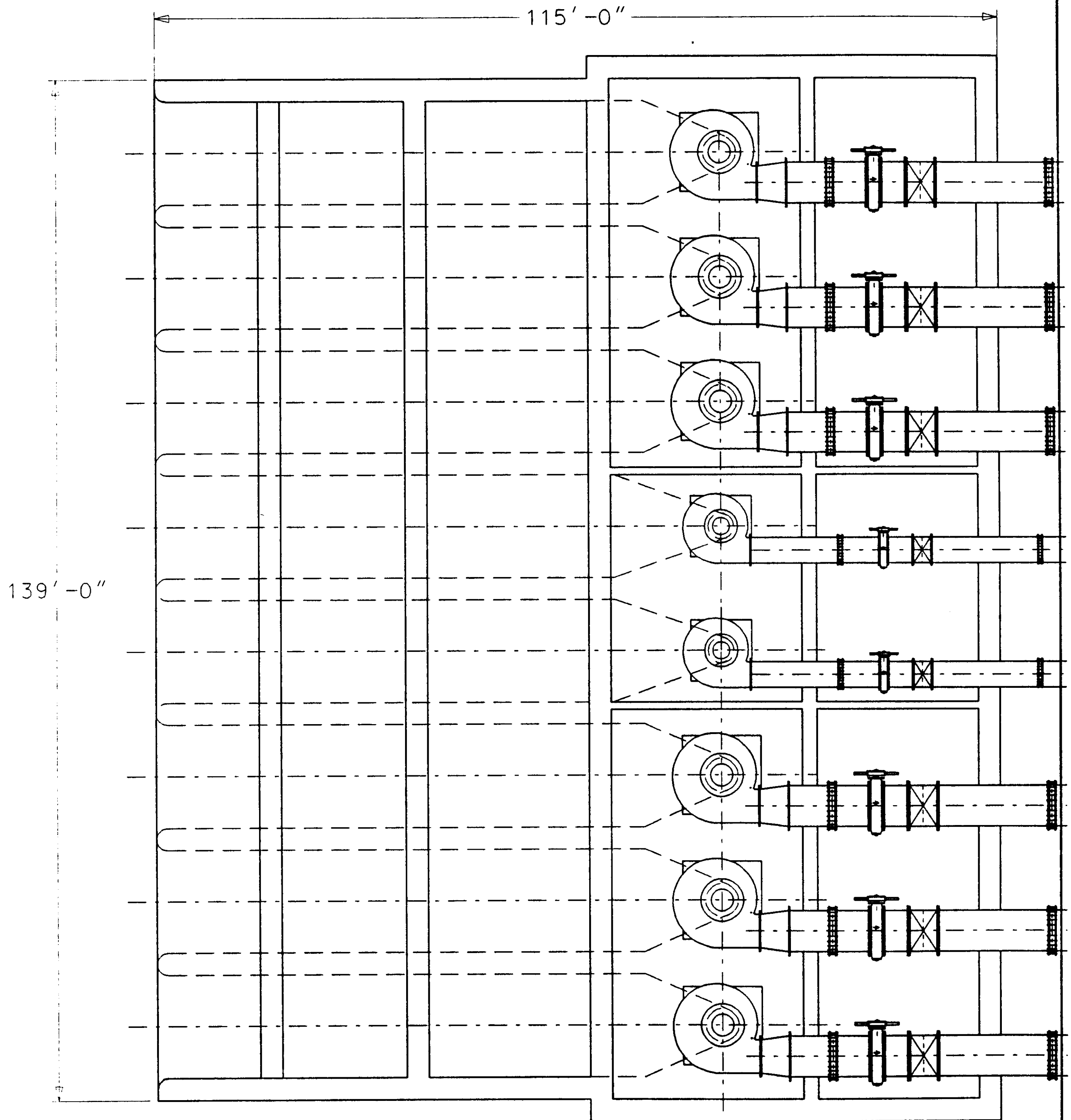
ELEVATION AT SMALL PUMP

PLATE
V-C-II



TRANSVERSE VIEW
SCALE: 1″= 20′-0″

ALTERNATE 3



ALTERNATE 3

US Army Corps of Engineers

U. S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

DISCHARGE PIPE LAYOUT

PLATE
V-C-III

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-D

GRAND PRAIRIE PUMPING STATION

LIFE CYCLE COST ANALYSIS

COST COMPARISON AND BAR GRAPHS

U.S. Army Corps of Engineers
Memphis District

GRAND PRAIRIE AREA DEMONSTRATION PROJECT		***ALTERNATE 1***		8 BAYS
HORIZONTAL ELECTRIC MOTORS				
SPLIT CASE CENTRIFUGAL PUMPS				
Discount Rate = 7.75				
I. FIRST COST OF PUMPING STATION				
DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
CIVIL				
MOBILIZATION & DEMOBILIZATION	50,000	1	LS	50,000
CLEARING & GRUBBING	25,000	1	LS	25,000
ASPHALT ROAD	45,000	1	LS	45,000
DEWATERING	500,000	1	LS	500,000
COFFERDAM	174,000	1	LS	174,000
EXCAVATION	2	342,000	CY	513,000
STRUCTURAL EXCAVATION	3	173,000	CY	432,500
RANDOM BACKFILL	3	120,000	CY	360,000
GRANULAR BACKFILL	10	30,000	CY	300,000
TOTAL FIRST COST CIVIL				2,399,500
STRUCTURAL				
CAST-IN-PLACE CONCRETE	250	30,066	CY	7,516,500
96" REINFORCED CONCRETE PIPE	120	500	LF	60,000
24" REINFORCED CONCRETE PIPE	20	600	LF	12,000
PUMPING PLANT SUPERSTRUCTURE	71	14,015	SF	995,065
MISCELLANEOUS METALS	9,800	1	LS	9,800
TOTAL FIRST COST STRUCTURAL				8,593,365

DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
MECHANICAL				
PUMP UNIT (48" x 60" CENTRIFUGAL) 3300 hp	1,144,888	8	EA	9,159,104
60" GATE VALVE	124,200	8	EA	993,600
48" GATE VALVE	72,400	8	EA	579,200
48" AUTOMATED CONTROL VALVE	87,200	8	EA	697,600
MODEL TESTING	50,000	1	JOB	50,000
STEEL PIPE(1)				
INLET PIPE - 60" diameter	402	160	LF	64,320
DISCHARGE PIPE - 48" diameter	323	320	LF	103,200
DISCHARGE HEADER - 126" diameter	738	17,600	LF	12,988,800
DRESSER COUPLING - 126" diameter (2)	8,810	356	EA	3,136,182
COMBINATION AIR RELEASE VALVES (8)	7,035	10	EA	70,350
PUMP PRIMING SYSTEM	16,933	1	JOB	16,933
PLUMBING	51,500	1	JOB	51,500
SLUICE GATES (10'x8') & OPERATORS	55,000	8	EA	440,000
TRASH RACKS	70,367	8	EA	562,936
OVERHEAD TRAVELING CRANE	200,000	1	JOB	200,000
SUMP DEWATERING SYSTEM	64,043	1	JOB	64,043
FLOOR DRAINAGE SYSTEM	96,065	1	JOB	96,065
COMPRESSED AIR SYSTEM (PUMPS/TANK)	80,472	1	JOB	80,472
POTABLE WATERWELL - FULLY DEVELOPED	50,000	1	JOB	50,000
HEAT/AIR CONDITIONING	175,000	1	JOB	175,000
MOBILE CRANE	250,000	1	EA	250,000
SEWAGE DISPOSAL	7,500	1	JOB	7,500
REFRIGERATOR	1,516	1	JOB	1,516
ELECTRIC RANGE & VENTILATOR HOOD	1,060	1	JOB	1,060
ELEVATOR/HYDRAULIC EQUIPMENT (3)	30,000	1	JOB	30,000
VENTILATION SYSTEM				
MOTORIZED ROOF VENTILATORS (4)	3,357	8	EA	26,856
OPERABLE LOUVERS (5)	666	8	EA	5,328
STATIONARY LOUVERS (6)	834	8	EA	6,672
TOTAL FIRST COST MECHANICAL				29,908,237
ELECTRICAL				
LIGHTING	58,000	1	JOB	58,000
GROUNDING SYSTEM	1,500	1	JOB	1,500
CATHODIC PROTECTION	20,000	1	JOB	20,000
WIRE AND CABLE	309,000	1	JOB	309,000
ALARM SYSTEM	33,500	1	JOB	33,500
TRANSFORMERS	7,500	1	JOB	7,500
4160 VOLT MOTOR CONTROL CENTER	134,500	1	JOB	134,500
480 VOLT MOTOR CONTROL CENTER	126,288	1	JOB	126,288
SAFETY SWITCHES	12,000	1	JOB	12,000
WATER LEVEL SENSORS	18,000	1	JOB	18,000
COMMUNICATIONS	4,500	1	JOB	4,500
CONTROL ROOM	25,000	1	JOB	25,000
SWITCHGEAR (MAIN) AND BUSWORK	178,906	1	JOB	178,906
MISCELLANEOUS	864,260	1	JOB	864,260
TOTAL FIRST COST ELECTRICAL				1,792,954
TOTAL FIRST COST				42,694,056

	PLANT COST	LIFE	L.C.C.	ANNUAL COST
II.REPLACEMENT COST				
PUMP IMPELLERS (20%)	1,120,000	40	59,419	4,608
ELECTRIC MOTOR STATOR (40%)	960,000	35	75,580	5,861
MOTOR CONTROL CENTERS	260,788	35	20,532	1,592
ROOF (129 SQUARES)	375,000	20	108,423	8,408
IV.OPERATING COST				
LABOR			2,608,427	202,269
ENERGY CHARGES (7)			43,808,670	3,397,119
V.SUMMARY				
TOTAL FIRST COST MECHANICAL			29,908,237	2,319,218
TOTAL FIRST COST ELECTRICAL			1,792,954	139,034
TOTAL FIRST COST CIVIL			2,399,500	186,068
TOTAL FIRST COST STRUCTURAL			8,593,365	666,368
REPLACEMENT COST			263,954	20,468
OPERATING COST			46,417,097	3,599,388
TOTAL			89,375,106	6,930,543

(1) Cost quoted from the R. J. Gallagher Co., Memphis, TN.

(2) Cost quoted from Central Pipe Supply, Memphis,TN.,a Dresser representative.

(3) Cost quoted from Dover Elevators, Memphis,TN.

(4) Cost quoted from Gorham - Schaffler, Inc., Memphis, TN., a Greenheck Representative

(5) Cost quoted from Mills - Wilson - George, Memphis, TN., an Industrial Louver representative.

(6) Cost quoted from Tom Barrow Co., Memphis, TN., a Ruskin Louver representative.

(7) Based on $0.047 per KWH of firm power to operate all 8 pumps.

(8) Cost quoted from Valve and Primer Corp., Chicago, IL

GRAND PRAIRIE AREA DEMONSTRATION PROJECT	*ALTERNATE 2*			6 BAYS
HORIZONTAL ELECTRIC MOTORS				
Discount Rate = 7.75				
I. FIRST COST OF PUMPING STATION				
DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
CIVIL				
MOBILIZATION & DEMOBILIZATION	50,000	1	LS	50,000
CLEARING & GRUBBING	25,000	1	LS	25,000
ASPHALT ROAD	45,000	1	LS	45,000
DEWATERING	500,000	1	LS	500,000
COFFERDAM	174,000	1	LS	174,000
EXCAVATION	2	342,000	CY	513,000
STRUCTURAL EXCAVATION	3	173,000	CY	432,500
RANDOM BACKFILL	3	120,000	CY	360,000
GRANULAR BACKFILL	10	30,000	CY	300,000
TOTAL FIRST COST CIVIL				2,399,500
STRUCTURAL				
CAST-IN-PLACE CONCRETE	250	18,409	CY	4,602,250
96" REINFORCED CONCRETE PIPE	120	500	LF	60,000
24" REINFORCED CONCRETE PIPE	20	600	LF	12,000
PUMPING PLANT SUPERSTRUCTURE & OFFICE	71	809	SF	57,439
MISCELLANEOUS METALS	9,800	1	LS	9,800
TOTAL FIRST COST STRUCTURAL				4,741,489

DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
<u>MECHANICAL</u>				
PUMP UNIT (84") 6000 bhp	1,252,000	4	EA	5,008,000
PUMP UNIT (42") 1500 bhp	320,000	2	EA	640,000
84" PUMP CONTROL VALVE	75,762	4	EA	303,048
84" GATE VALVE	221,725	4	EA	886,900
42" GATE VALVE	55,386	2	EA	110,772
42" PUMP CONTROL VALVE	14,474	2	EA	28,948
STEEL PIPE(1)				
DISCHARGE PIPE -42" diameter	297	250	LF	74,250
DISCHARGE PIPE - 84" diameter	519	350	LF	181,650
DISCHARGE HEADER - 126" diameter	738	17,600	LF	12,988,800
DRESSER COUPLING - 126" diameter (2)	8,810	356	EA	3,136,182
DRESSER COUPLING - 84" diameter	3,729	12	EA	44,743
DRESSER COUPLING - 42" diameter	715	8	EA	5,720
COMBINATION AIR RELEASE VALVES (8)	7,035	10	EA	70,350
PUMP PRIMING SYSTEM	16,933	1	JOB	16,933
PLUMBING	51,500	1	JOB	51,500
SLUICE GATES (6.5'x6.5') & OPERATORS	26,698	2	EA	53,396
ROLLER GATES (16'-2"x8') & OPERATORS	89,898	4	EA	359,592
TRASH RACKS	70,367	8	EA	562,936
OVERHEAD TRAVELING CRANE	200,000	1	JOB	200,000
SUMP DEWATERING SYSTEM	64,043	1	JOB	64,043
FLOOR DRAINAGE SYSTEM	96,065	1	JOB	96,065
COMPRESSED AIR SYSTEM (PUMPS/TANK)	80,472	1	JOB	80,472
POTABLE WATERWELL - FULLY DEVELOPED	50,000	1	JOB	50,000
HEAT/AIR CONDITIONING	208,130	1	JOB	208,130
MOBILE CRANE	250,000	1	EA	250,000
SEWAGE DISPOSAL	7,500	1	JOB	7,500
REFRIGERATOR	1,516	1	JOB	1,516
ELECTRIC RANGE & VENTILATOR HOOD	1,060	1	JOB	1,060
ELEVATOR/HYDRAULIC EQUIPMENT (3)	30,000	1	JOB	30,000
VENTILATION SYSTEM				
MOTORIZED ROOF VENTILATORS (4)	3,357	6	EA	20,142
OPERABLE LOUVERS (5)	666	6	EA	3,996
STATIONARY LOUVERS (6)	834	6	EA	5,004
TOTAL FIRST COST MECHANICAL				25,541,648
<u>ELECTRICAL</u>				
LIGHTING	46,400	1	JOB	46,400
GROUNDING SYSTEM	1,200	1	JOB	1,200
CATHODIC PROTECTION	16,000	1	JOB	16,000
WIRE AND CABLE	231,750	1	JOB	231,750
ALARM SYSTEM	25,128	1	JOB	25,128
TRANSFORMERS	6,000	1	JOB	6,000
4160 VOLT MOTOR CONTROL CENTER	116,009	1	JOB	116,009
480 VOLT MOTOR CONTROL CENTER	94,716	1	JOB	94,716
SAFETY SWITCHES	17,100	1	JOB	17,100
WATER LEVEL SENSORS	13,500	1	JOB	13,500
COMMUNICATIONS	4,500	1	JOB	4,500
CONTROL ROOM	23,750	1	JOB	23,750
SWITCHGEAR (MAIN) AND BUSWORK	134,178	1	JOB	134,178
MISCELLANEOUS	691,408	1	JOB	691,408

	PLANT COST	LIFE	L.C.C.	ANNUAL COST
TOTAL FIRST COST ELECTRICAL				1,421,639
TOTAL FIRST COST				34,104,276
	PLANT COST	LIFE	L.C.C.	ANNUAL COST
II.REPLACEMENT COST				
PUMP IMPELLERS (20%)	225,670	40	11,972	928
ELECTRIC MOTOR STATOR (40%)	300,890	35	23,689	1,837
MOTOR CONTROL CENTERS	210,725	35	16,590	1,286
ROOF (93 SQUARES)	270,135	20	78,104	6,057
IV.OPERATING COST				
LABOR			2,608,427	202,269
ENERGY CHARGES (7)			43,808,670	3,397,119
V.SUMMARY				
TOTAL FIRST COST MECHANICAL			25,541,648	1,980,613
TOTAL FIRST COST ELECTRICAL			1,421,639	110,240
TOTAL FIRST COST CIVIL			2,399,500	186,068
TOTAL FIRST COST STRUCTURAL			4,741,489	367,676
REPLACEMENT COST			130,355	10,108
OPERATING COST			46,417,097	3,599,388
TOTAL			80,651,727	6,254,093

(1) Cost quoted from the R. J. Gallagher Co., Memphis, TN.
(2) Cost quoted from Central Pipe Supply, Memphis,TN.,a Dresser representative.
(3) Cost quoted from Dover Elevators, Memphis,TN.
(4) Cost quoted from Gorham - Schaffler, Inc., Memphis, TN., a Greenheck Representative
(5) Cost quoted from Mills - Wilson - George, Memphis, TN., an Industrial Louver representative.
(6) Cost quoted from Tom Barrow Co., Memphis, TN., a Ruskin Louver representative.
(7) Based on $0.047 per KWH of firm power to operate all 6 pumps.
(8) Cost quoted from Valve and Primer Corp., Chicago, IL

GRAND PRAIRIE AREA DEMONSTRATION PROJECT		***ALTERNATE 3***		8 BAYS
HORIZONTAL ELECTRIC MOTORS				
Discount Rate = 7.75				
I. FIRST COST OF PUMPING STATION				
DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
CIVIL				
MOBILIZATION & DEMOBILIZATION	50,000	1	LS	50,000
CLEARING & GRUBBING	25,000	1	LS	25,000
ASPHALT ROAD	45,000	1	LS	45,000
DEWATERING	500,000	1	LS	500,000
COFFERDAM	174,000	1	LS	174,000
EXCAVATION	2	342,000	CY	513,000
STRUCTURAL EXCAVATION	3	173,000	CY	432,500
RANDOM BACKFILL	3	120,000	CY	360,000
GRANULAR BACKFILL	10	30,000	CY	300,000
TOTAL FIRST COST CIVIL				2,399,500
STRUCTURAL				
CAST-IN-PLACE CONCRETE	250	24,149	CY	6,037,250
96" REINFORCED CONCRETE PIPE	120	500	LF	60,000
24" REINFORCED CONCRETE PIPE	20	600	LF	12,000
PUMPING PLANT SUPERSTRUCTURE & OFFICE	71	11,259	SF	799,389
MISCELLANEOUS METALS	9,800	1	LS	9,800
TOTAL FIRST COST STRUCTURAL				6,918,439

DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
MECHANICAL				
PUMP UNIT (54") 3500 bhp	977,500	6	EA	5,865,000
PUMP UNIT (42") 2000 bhp	747,500	2	EA	1,495,000
66" PUMP CONTROL VALVE	46,765	6	EA	280,590
66" GATE VALVE	150,282	6	EA	901,692
42" GATE VALVE	60,858	2	EA	121,716
42" PUMP CONTROL VALVE	14,474	2	EA	28,948
STEEL PIPE(1)				
DISCHARGE PIPE -96" diameter	633	100	LF	63,300
DISCHARGE PIPE -42" diameter	297	310	LF	92,070
DISCHARGE PIPE - 66" diameter	435	515	LF	224,025
DISCHARGE HEADER - 126" diameter	738	17,600	LF	12,988,800
DRESSER COUPLING - 126" diameter (2)	8,810	356	EA	3,136,182
DRESSER COUPLING - 66" diameter	1,250	16	EA	19,992
DRESSER COUPLING - 42" diameter	715	10	EA	7,151
COMBINATION AIR RELEASE VALVES (8)	7,035	10	EA	70,350
PUMP PRIMING SYSTEM	16,933	1	JOB	16,933
PLUMBING	51,500	1	JOB	51,500
ROLLER GATES (14'x8') & OPERATORS	77,849	6	EA	467,094
TRASH RACKS	70,367	8	EA	562,936
OVERHEAD TRAVELING CRANE	200,000	1	JOB	200,000
SUMP DEWATERING SYSTEM	64,043	1	JOB	64,043
FLOOR DRAINAGE SYSTEM	96,065	1	JOB	96,065
COMPRESSED AIR SYSTEM (PUMPS/TANK)	80,472	1	JOB	80,472
POTABLE WATERWELL - FULLY DEVELOPED	50,000	1	JOB	50,000
HEAT/AIR CONDITIONING	208,130	1	JOB	208,130
MOBILE CRANE	250,000	1	EA	250,000
SEWAGE DISPOSAL	117,155	1	JOB	117,155
REFRIGERATOR	1,516	1	JOB	1,516
ELECTRIC RANGE & VENTILATOR HOOD	1,060	1	JOB	1,060
ELEVATOR/HYDRAULIC EQUIPMENT (3)	30,000	1	JOB	30,000
VENTILATION SYSTEM				
MOTORIZED ROOF VENTILATORS (4)	3,357	8	EA	26,856
OPERABLE LOUVERS (5)	666	8	EA	5,328
STATIONARY LOUVERS (6)	834	8	EA	6,672
TOTAL FIRST COST MECHANICAL				27,530,575

ELECTRICAL				
LIGHTING	52,200	1	JOB	52,200
GROUNDING SYSTEM	1,350	1	JOB	1,350
CATHODIC PROTECTION	18,000	1	JOB	18,000
WIRE AND CABLE	309,000	1	JOB	309,000
ALARM SYSTEM	33,500	1	JOB	33,500
TRANSFORMERS	7,500	1	JOB	7,500
4160 VOLT MOTOR CONTROL CENTER	134,500	1	JOB	134,500
480 VOLT MOTOR CONTROL CENTER	126,288	1	JOB	126,288
SAFETY SWITCHES	18,000	1	JOB	18,000
WATER LEVEL SENSORS	18,000	1	JOB	18,000
COMMUNICATIONS	4,500	1	JOB	4,500
CONTROL ROOM	25,000	1	JOB	25,000
SWITCHGEAR (MAIN) AND BUSWORK	178,906	1	JOB	178,906
MISCELLANEOUS	864,260	1	JOB	864,260
TOTAL FIRST COST ELECTRICAL				1,791,004
TOTAL FIRST COST				38,639,518
	PLANT COST	LIFE	L.C.C.	ANNUAL COST
II.REPLACEMENT COST				
PUMP IMPELLERS (20%)	768,000	40	40,744	3,159
ELECTRIC MOTOR STATOR (40%)	1,024,000	35	80,619	6,252
MOTOR CONTROL CENTERS	260,788	35	20,532	1,592
ROOF (113 SQUARES)	326,511	20	94,404	7,320
IV.OPERATING COST				
LABOR			2,608,427	202,269
ENERGY CHARGES (7)			45,560,968	3,533,000
V.SUMMARY				
TOTAL FIRST COST MECHANICAL			27,530,575	2,134,843
TOTAL FIRST COST ELECTRICAL			1,791,004	138,882
TOTAL FIRST COST CIVIL			2,399,500	186,068
TOTAL FIRST COST STRUCTURAL			6,918,439	536,487
REPLACEMENT COST			236,298	18,324
OPERATING COST			48,169,395	3,735,269
TOTAL			87,045,211	6,749,873

(1) Cost quoted from the R. J. Gallagher Co., Memphis, TN.

(2) Cost quoted from Central Pipe Supply, Memphis,TN.,a Dresser representative.

(3) Cost quoted from Dover Elevators, Memphis,TN.

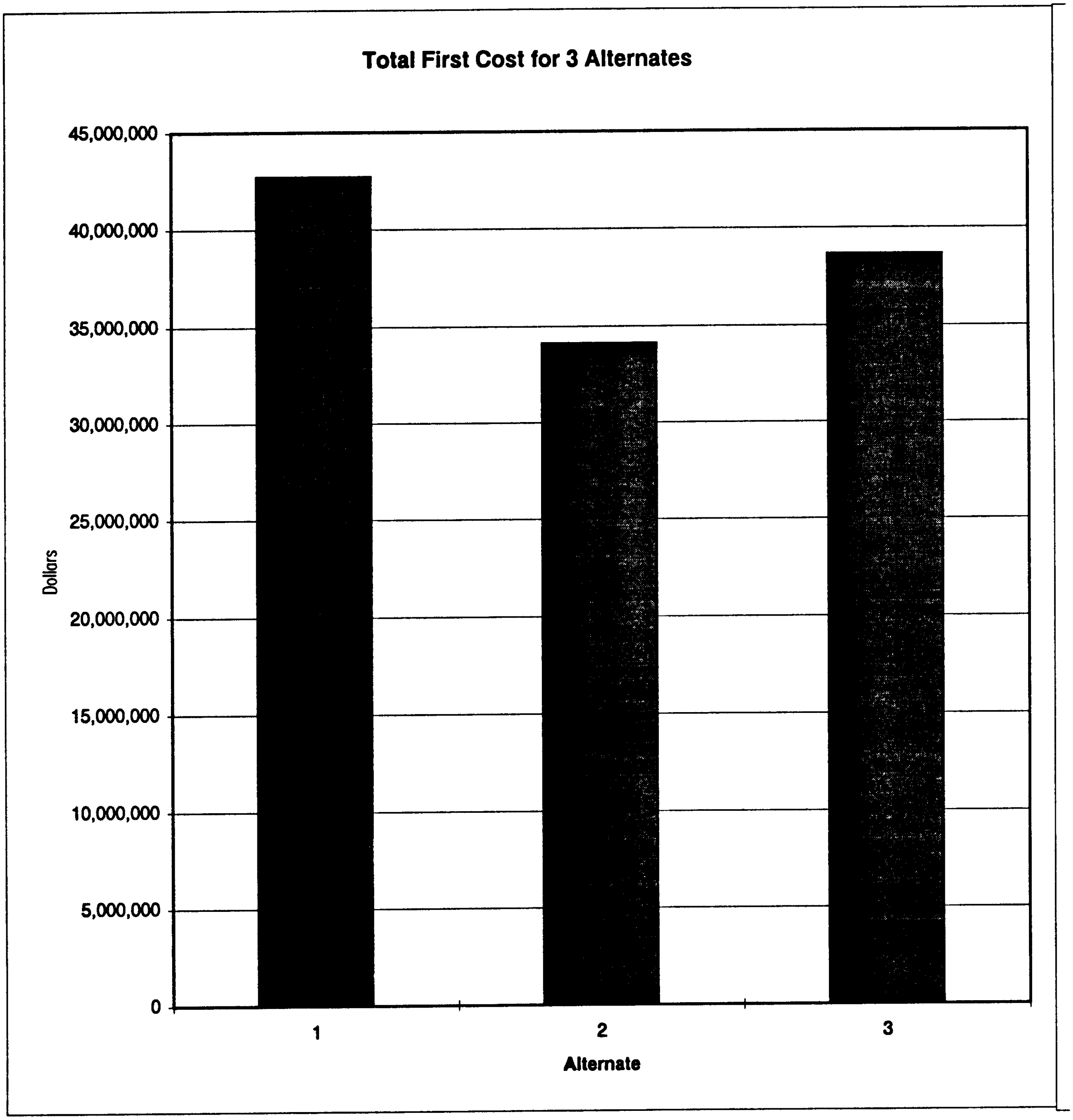
(4) Cost quoted from Gorham - Schaffler, Inc., Memphis, TN., a Greenheck Representative

(5) Cost quoted from Mills - Wilson - George, Memphis, TN., an Industrial Louver representative.

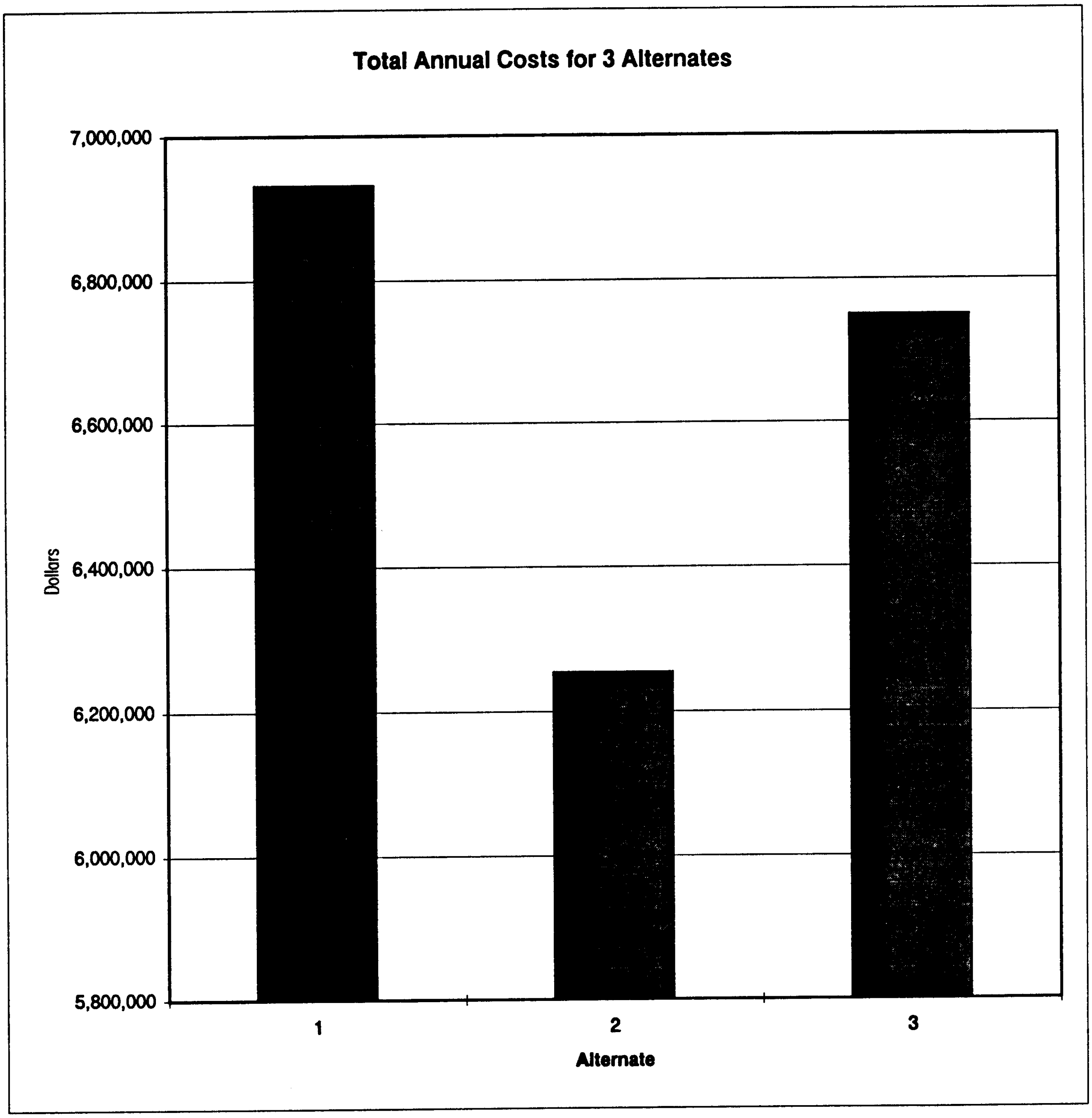
(6) Cost quoted from Tom Barrow Co., Memphis, TN., a Ruskin Louver representative.

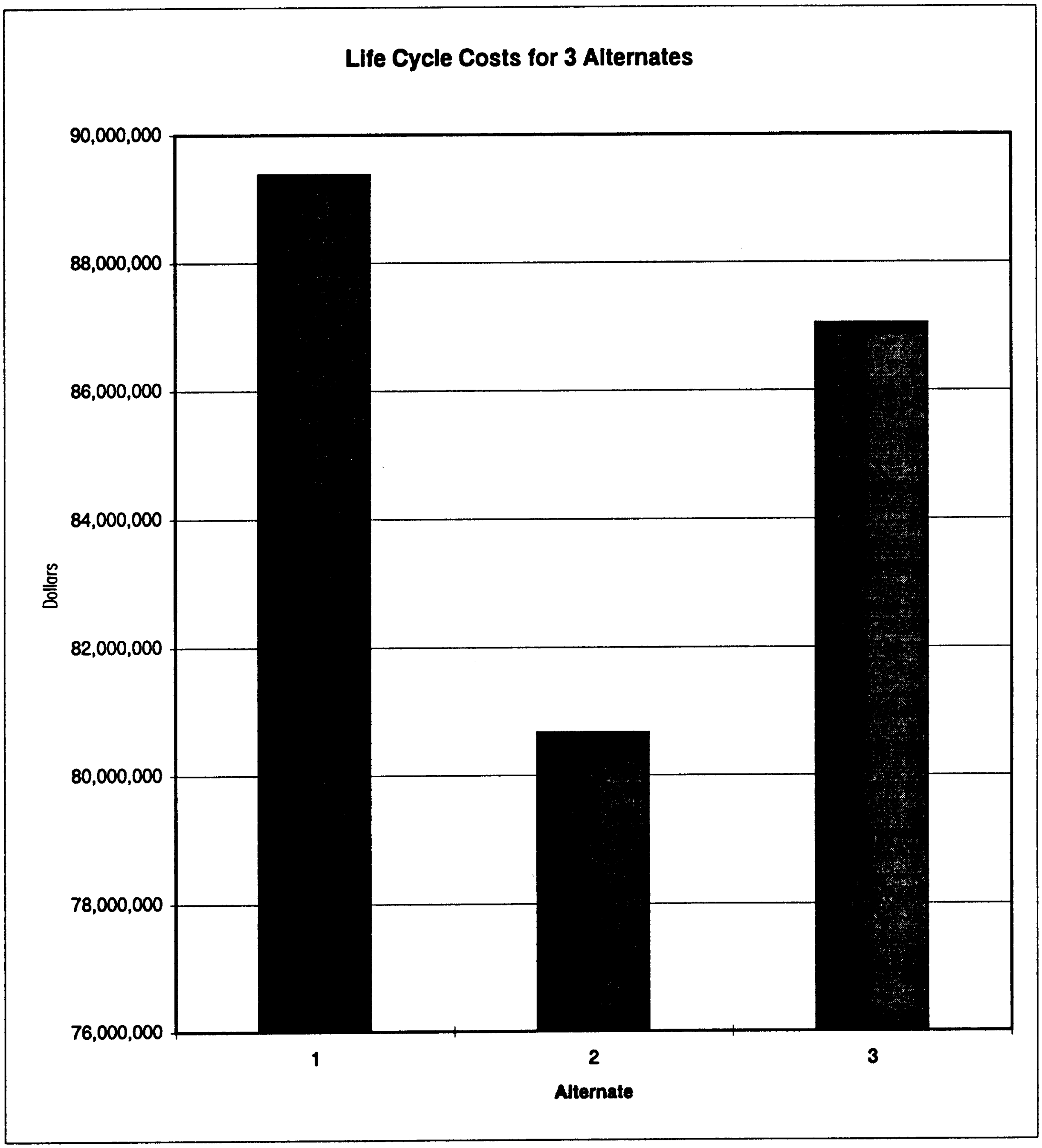
(7) Based on $0.047 per KWH of firm power to operate all 8 pumps.

(8) Cost quoted from Valve and Primer Corp., Chicago, IL



Appendix V-D-10


Total Annual Costs for 3 Alternates
7,000,000
6,800,000
6,600,000
6,400,000
6,200,000
6,000,000
5,800,000
Dollars
1
2
3
Alternate



Life Cycle Costs for 3 Alternates
90,000,000
88,000,000
86,000,000
84,000,000
82,000,000
80,000,000
78,000,000
76,000,000
Dollars
1
2
3
Alternate

APPENDIX V-E

GRAND PRAIRIE PUMPING STATION

MECHANICAL DESIGN DEVELOPMENT

STATION LAYOUT AND PUMP CURVES

U.S. Army Corps of Engineers
Memphis District

CALCULATIONS FOR GRAND PRAIRIE PUMPING STATION
1640 CFS PUMPING STATION
84" VERTICAL MIXED FLOW PUMPS - 360 CFS EACH

1. DISCHARGE PIPE DIAMETER

FLOW RATE THRU SINGLE HEADER = 1640 CFS/2 = 820 CFS
DESIRED VELOCITY THRU HEADER = 10 FT/SEC
NOMINAL DIAMETER OF HEADER = (4*820/(10*3.14))**1/2 = 10.22 FT. DIAMETER
USE 10 FOOT DIAMETER HEADER W/ DESIGN VELOCITY OF 10.44 FT/SEC

2. DESIGN CRITERIA

A. HISTORICAL HIGH WATER	187.6 NGVD
B. 100 YEAR FLOOD	188.0 NGVD
B. AVERAGE LOW WATER	158.0 NGVD
C. HISTORICAL LOW WATER	153.3 NGVD
D. CANAL WATER ELEVATION	233.3 NGVD
E. STATION DESIGN FLOW	1640 CFS
F. LARGE PUMP DESIGN FLOW RATE	360 CFS
G. SMALL PUMP DESIGN FLOW RATE	100 CFS

3. CONDITION POINTS

A. MAXIMUM HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
MINIMUM RIVER	= 153.3 NGVD
Hst (Static Head)	= 80.0 NGVD

NPSHA = Hp + Hse - Hf - Hvpa
Hp = Atmospheric Pressure
Hse = Height of Water Above Pump Impeller Datum (EL. 149.18')
Hf = Friction Loss in Formed Suction Inlet
Hvpa = Vapor Pressure of Water
NPSHA = 33.9' + 4.12' - 2.98' - 1.38'
NPSHA = 33.66'

B. DESIGN HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
AVERAGE LOW RIVER	= 158.0 NGVD
Hst (Static Head)	= 75.3 NGVD

NPSHA = 33.9' + 8.82' - 3.27' - 1.38'
NPSHA = 38.1'

C. MINIMUM HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
RIVER PERIOD OF RECORD	= 187.6 NGVD
Hst (Static Head)	= 45.7 NGVD

NPSHA = 33.9' + 38.42' - 5.21' - 1.38'
NPSHA = 66.73'

D. MAXIMUM HEAD WITH ONE 360 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
MINIMUM RIVER ELEVATION	= 153.3 NGVD
Hst (Static Head)	= 80.0 NGVD

NPSHA = 33.9' + 4.12' - 3.75' - 1.38'
NPSHA = 32.89'

E. DESIGN HEAD WITH ONE 360 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
AVERAGE LOW RIVER	= 158.0 NGVD
Hst (Static Head)	= 75.3 NGVD

NPSHA = 33.9' + 8.82' - 4.06' - 1.38'
NPSHA = 37.28'

F. MINIMUM HEAD WITH ONE 360 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
HISTORICAL HIGH RIVER	= 187.6 NGVD
Hst (Static Head)	= 45.7 NGVD

NPSHA = 33.9' + 38.42' - 6.05' - 1.38'
NPSHA = 64.89'

3. CONCLUSIONS

A. MAXIMUM PUMP HORSEPOWER (ALL PUMPS RUNNING) = 4700 HP
B. MAXIMUM PUMP HORSEPOWER (1 PUMP RUNNING) = 4800 HP
C. DESIGN PUMP HORSEPOWER (ALL PUMPS RUNNING) = 4400 HP
D. DESIGN PUMP HORSEPOWER (1 PUMP RUNNING) = 4560 HP
E. MAXIMUM MOTOR HORSEPOWER REQ'D = 4800 x 110% = 5280 HP
F. MOTOR SIZE REQUIRED = 5300 HP

LOSSES FOR 84" PUMP(360 CFS) - GRAND PRAIRIE 1640 CFS PUMPING STATION   ONE PUMP RUNNING -------

FLOW GPM	INLET CONDUIT	FSI	84" PUMP CONTROL VALVE	84" GATE VALVE	30 DEG. BEND	84" PIPE 1 PUMP	84" TO 120" EXPANSION	120" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	TOTAL HEAD 1 PUMP HST=45.7	DESIGN HEAD 1 PUMP HST=75.3	TOTAL HEAD 1 PUMP HST=80	
10,000	.000	.012	.001	.001	.001	.000	.002	.022	.001	.040	45.74	75.34	80.04	
15,000	.000	.028	.002	.003	.001	.000	.005	.046	.003	.087	45.79	75.39	80.09	
20,000	.000	.050	.003	.005	.002	.001	.008	.077	.005	.150	45.85	75.45	80.15	
25,000	.000	.077	.005	.007	.004	.001	.013	.116	.008	.231	45.93	75.53	80.23	
30,000	.000	.111	.007	.010	.005	.001	.018	.162	.011	.327	46.03	75.63	80.33	
35,000	.000	.152	.009	.014	.007	.002	.025	.215	.015	.439	46.14	75.74	80.44	
40,000	.000	.198	.012	.018	.009	.002	.033	.275	.020	.567	46.27	75.87	80.57	
45,000	.001	.251	.015	.023	.012	.002	.041	.341	.025	.711	46.41	76.01	80.71	
50,000	.001	.309	.019	.029	.014	.003	.051	.413	.031	.870	46.57	76.17	80.87	
55,000	.001	.374	.023	.035	.017	.004	.061	.492	.038	1.044	46.74	76.34	81.04	
60,000	.001	.446	.027	.041	.021	.004	.073	.577	.045	1.234	46.93	76.53	81.23	
65,000	.001	.523	.031	.048	.024	.005	.086	.668	.053	1.439	47.14	76.74	81.44	
70,000	.001	.606	.037	.056	.028	.006	.100	.765	.061	1.660	47.36	76.96	81.66	
75,000	.002	.696	.042	.064	.032	.006	.114	.868	.070	1.895	47.59	77.19	81.89	
80,000	.002	.792	.048	.073	.037	.007	.130	.976	.080	2.145	47.84	77.44	82.14	
85,000	.002	.894	.054	.083	.041	.008	.147	1.091	.090	2.410	48.11	77.71	82.41	
90,000	.002	1.002	.060	.093	.046	.009	.165	1.211	.101	2.690	48.39	77.99	82.69	
95,000	.002	1.117	.067	.103	.052	.010	.183	1.337	.113	2.985	48.68	78.28	82.98	
100,000	.003	1.238	.074	.115	.057	.011	.203	1.469	.125	3.294	48.99	78.59	83.29	
105,000	.003	1.364	.082	.126	.063	.012	.224	1.606	.138	3.618	49.32	78.92	83.62	
110,000	.003	1.497	.090	.139	.069	.013	.246	1.749	.151	3.957	49.66	79.26	83.96	
115,000	.003	1.637	.099	.152	.076	.014	.269	1.897	.165	4.310	50.01	79.61	84.31	
120,000	.004	1.782	.107	.165	.082	.015	.293	2.051	.180	4.678	50.38	79.98	84.68	
125,000	.004	1.934	.116	.179	.089	.016	.317	2.210	.195	5.061	50.76	80.36	85.06	
130,000	.004	2.091	.126	.194	.096	.017	.343	2.374	.211	5.458	51.16	80.76	85.46	
140,000	.005	2.426	.146	.225	.112	.020	.398	2.719	.245	6.295	51.99	81.59	86.29	
150,000	.006	2.784	.168	.258	.128	.022	.457	3.085	.281	7.190	52.89	82.49	87.19	
160,000	.006	3.168	.191	.293	.146	.025	.520	3.472	.320	8.142	53.84	83.44	88.14	
161,579	.006	3.231	.194	.299	.149	.026	.530	3.535	.327	8.297	54.00	83.60	88.30	***
170,000	.007	3.576	.215	.331	.165	.028	.587	3.879	.361	9.151	54.85	84.45	89.15	
180,000	.008	4.010	.241	.371	.185	.031	.658	4.307	.405	10.216	55.92	85.52	90.22	
190,000	.009	4.467	.269	.414	.206	.035	.733	4.755	.452	11.339	57.04	86.64	91.34	
200,000	.009	4.950	.298	.458	.228	.038	.813	5.222	.500	12.517	58.22	87.82	92.52	
210,000	.010	5.457	.329	.505	.252	.042	.896	5.710	.552	13.752	59.45	89.05	93.75	
220,000	.011	5.990	.361	.555	.276	.045	.983	6.218	.605	15.044	60.74	90.34	95.04	
230,000	.012	6.546	.394	.606	.302	.049	1.075	6.745	.662	16.391	62.09	91.69	96.39	
240,000	.013	7.128	.429	.660	.329	.053	1.170	7.291	.720	17.793	63.49	93.09	97.79	

RADIUS PUMP DISCHARGE PIPE (FT.)= 3.500

RADIUS OF DISCHARGE HEADER (FT)= 5.000

DIAMETER OF HEADER (FT.)= 10.000

AREA OF HEADER (SQ. FT)= 78.500

LOSSES FOR 84" PUMP(360 CFS) - GRAND PRAIRIE 1640 CFS PUMPING STATION ------ALL PUMPS RUNNING --------

FLOW GPM	INLET CONDUIT	FSI	84" PUMP CONTROL VALVE	84" GATE VALVE	30 DEG. BEND	84" PIPE 1 PUMP	84" TO 120" EXPANSION	120" PIPE 3 PUMPS	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP HST=45.7	DESIGN HEAD 3 PUMP HST=75.3	TOTAL HEAD 3 PUMP HST=80
10,000	.000	.012	.001	.001	.001	.000	.002	6.037	.586	6.640	52.34	81.94	86.64
15,000	.000	.028	.002	.003	.001	.000	.005	6.294	.613	6.946	52.65	82.25	86.95
20,000	.000	.050	.003	.005	.002	.001	.008	6.557	.641	7.266	52.97	82.57	87.27
25,000	.000	.077	.005	.007	.004	.001	.013	6.824	.670	7.601	53.30	82.90	87.60
30,000	.000	.111	.007	.010	.005	.001	.018	7.096	.699	7.949	53.65	83.25	87.95
35,000	.000	.152	.009	.014	.007	.002	.025	7.373	.729	8.311	54.01	83.61	88.31
40,000	.000	.198	.012	.018	.009	.002	.033	7.655	.760	8.687	54.39	83.99	88.69
45,000	.001	.251	.015	.023	.012	.002	.041	7.941	.791	9.077	54.78	84.38	89.08
50,000	.001	.309	.019	.029	.014	.003	.051	8.233	.823	9.481	55.18	84.78	89.48
55,000	.001	.374	.023	.035	.017	.004	.061	8.529	.855	9.899	55.60	85.20	89.90
60,000	.001	.446	.027	.041	.021	.004	.073	8.830	.888	10.330	56.03	85.63	90.33
65,000	.001	.523	.031	.048	.024	.005	.086	9.135	.922	10.776	56.48	86.08	90.78
70,000	.001	.606	.037	.056	.028	.006	.100	9.445	.956	11.235	56.93	86.53	91.23
75,000	.002	.696	.042	.064	.032	.006	.114	9.760	.991	11.708	57.41	87.01	91.71
80,000	.002	.792	.048	.073	.037	.007	.130	10.080	1.026	12.195	57.89	87.49	92.19
85,000	.002	.894	.054	.083	.041	.008	.147	10.404	1.063	12.696	58.40	88.00	92.70
90,000	.002	1.002	.060	.093	.046	.009	.165	10.733	1.099	13.210	58.91	88.51	93.21
95,000	.002	1.117	.067	.103	.052	.010	.183	11.067	1.137	13.738	59.44	89.04	93.74
100,000	.003	1.238	.074	.115	.057	.011	.203	11.405	1.175	14.280	59.98	89.58	94.28
105,000	.003	1.364	.082	.126	.063	.012	.224	11.748	1.213	14.836	60.54	90.14	94.84
110,000	.003	1.498	.090	.139	.069	.013	.246	12.095	1.253	15.405	61.10	90.70	95.40
115,000	.003	1.637	.099	.152	.076	.014	.269	12.447	1.293	15.988	61.69	91.29	95.99
120,000	.004	1.782	.107	.165	.082	.015	.293	12.804	1.333	16.585	62.28	91.88	96.58
125,000	.004	1.934	.116	.179	.089	.016	.317	13.165	1.374	17.195	62.89	92.49	97.19
130,000	.004	2.092	.126	.194	.096	.017	.343	13.531	1.416	17.819	63.52	93.12	97.82
140,000	.005	2.426	.146	.225	.112	.020	.398	14.275	1.501	19.108	64.81	94.41	99.11
150,000	.006	2.785	.168	.258	.128	.022	.457	15.038	1.589	20.451	66.15	95.75	100.45
160,000	.006	3.168	.191	.293	.146	.025	.520	15.819	1.680	21.849	67.55	97.15	101.85
161,579	.006	3.231	.194	.299	.149	.026	.530	15.944	1.694	22.075	67.77	97.37	102.07 ***
170,000	.007	3.577	.215	.331	.165	.028	.587	16.618	1.773	23.301	69.00	98.60	103.30
180,000	.008	4.010	.241	.371	.185	.031	.658	17.435	1.868	24.808	70.51	100.11	104.81
190,000	.009	4.468	.269	.414	.206	.035	.733	18.269	1.966	26.368	72.07	101.67	106.37
200,000	.009	4.950	.298	.458	.228	.038	.813	19.122	2.066	27.983	73.68	103.28	107.98
210,000	.010	5.458	.329	.505	.252	.042	.896	19.991	2.169	29.652	75.35	104.95	109.65
220,000	.011	5.990	.361	.555	.276	.045	.983	20.878	2.275	31.374	77.07	106.67	111.37
230,000	.012	6.547	.394	.606	.302	.049	1.075	21.783	2.383	33.151	78.85	108.45	113.15
240,000	.013	7.129	.429	.660	.329	.053	1.170	22.705	2.493	34.981	80.68	110.28	114.98

RADIUS PUMP DISCHARGE PIPE (FT.)= 3.500
RADIUS OF DISCHARGE HEADER (FT)= 5.000
AREA PUMP DISCHARGE PIPE (SQ. FT) 38.465

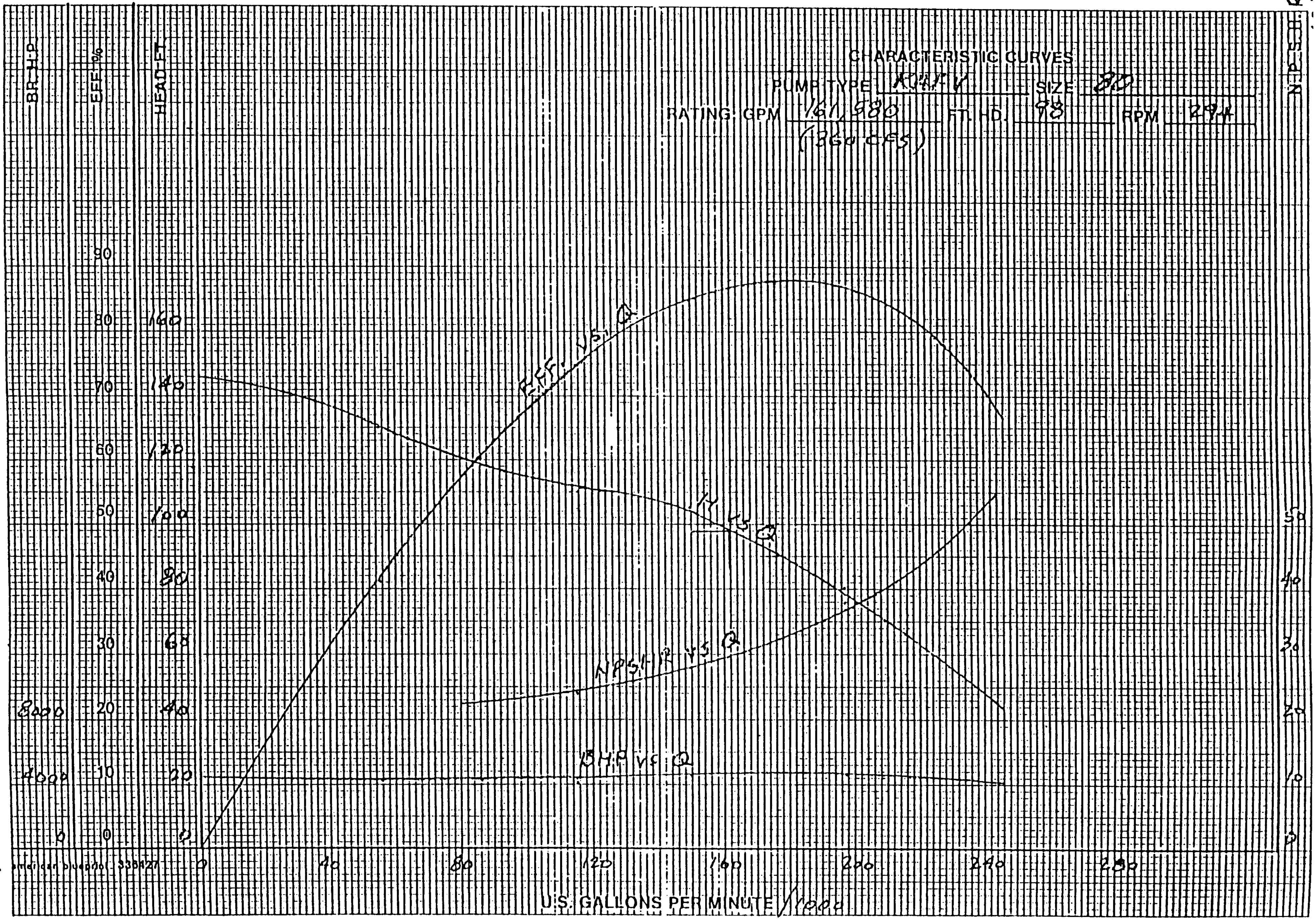
DIAMETER OF HEADER (FT.)= 10.000
AREA OF HEADER (SQ. FT)= 78.500
AREA OF CONDUIT (SQ. FT.)= 97.002

6.014x 14KAFV
New ( ).
New diff.

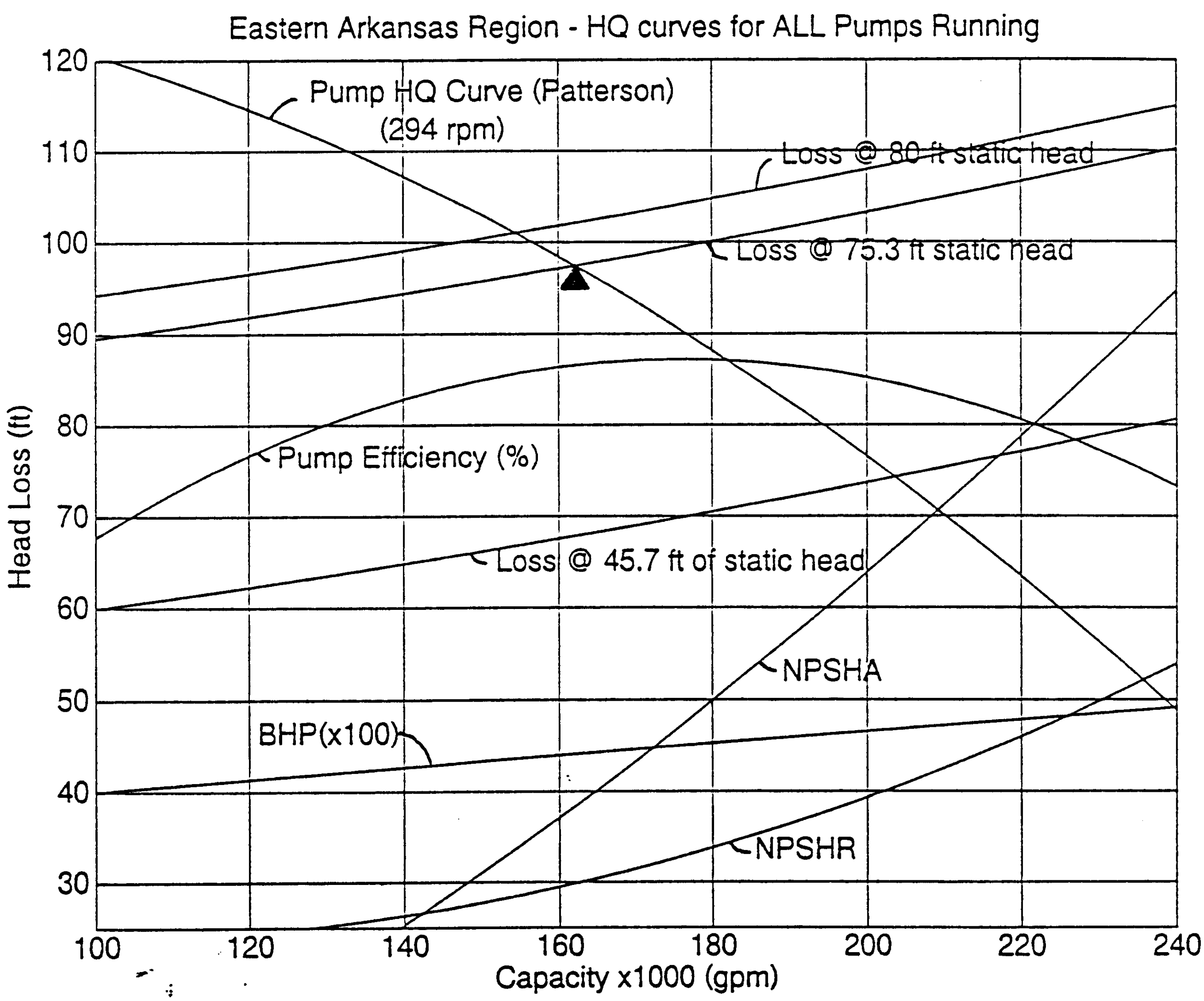
PATTERSON PUMP COMPANY
A SUBSIDIARY OF THE GORMAN-RUPP CO.

REF.

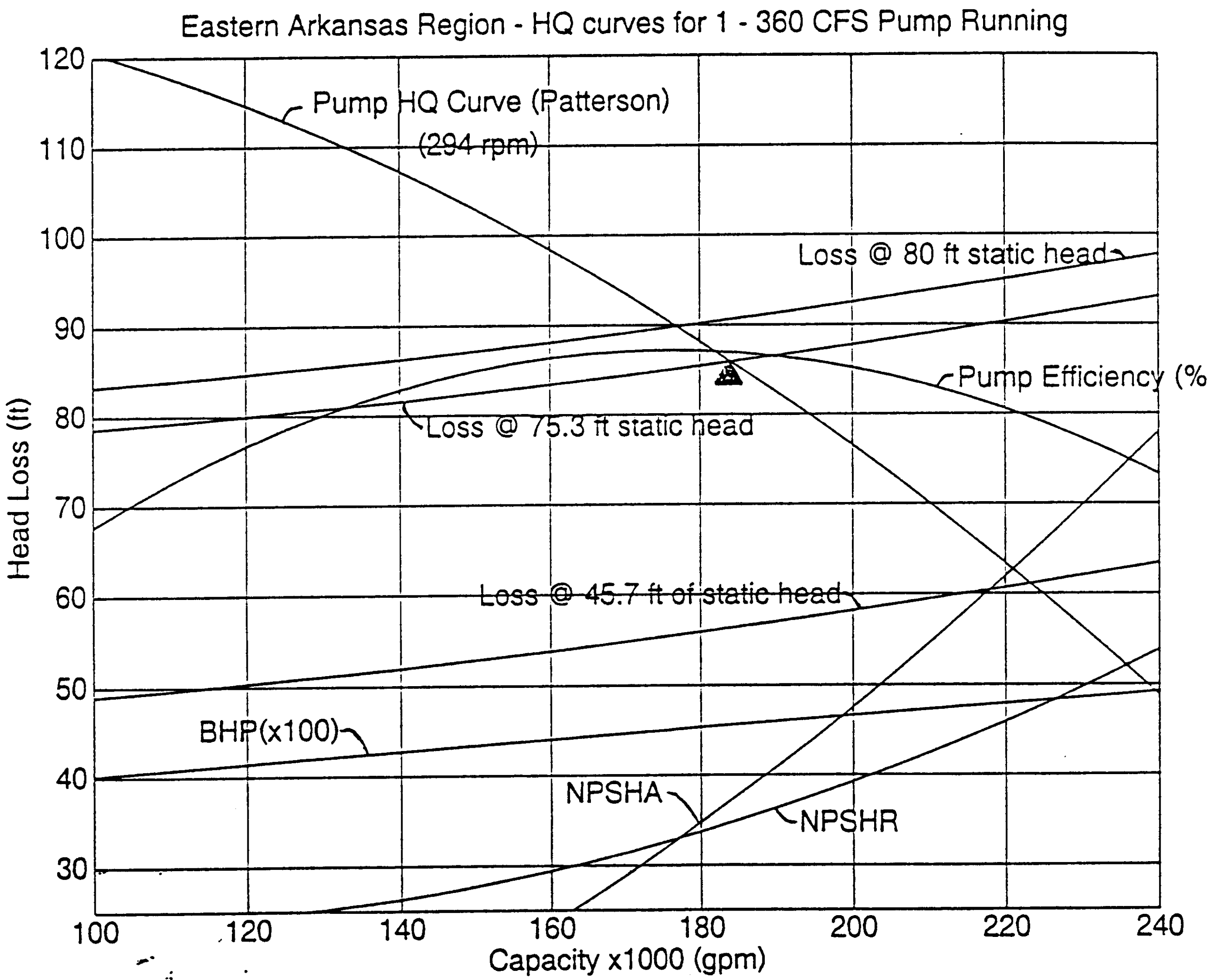
CURVE NO.



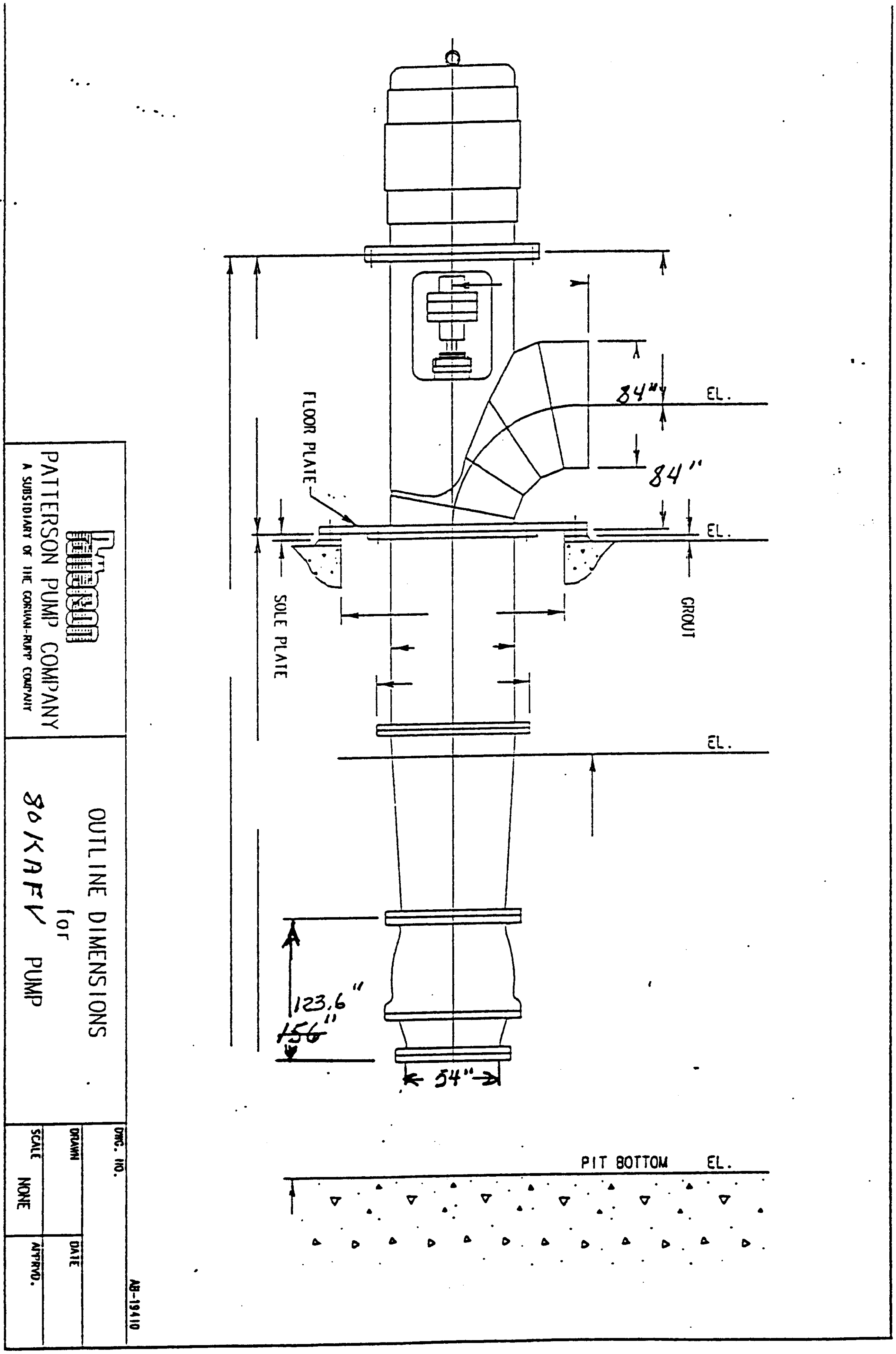
Appendix V-E-6



84" PUMP - 360 CFS



84" PUMP - 360 CFS



Appendix V-E-9

Use 54" Eye Diameter

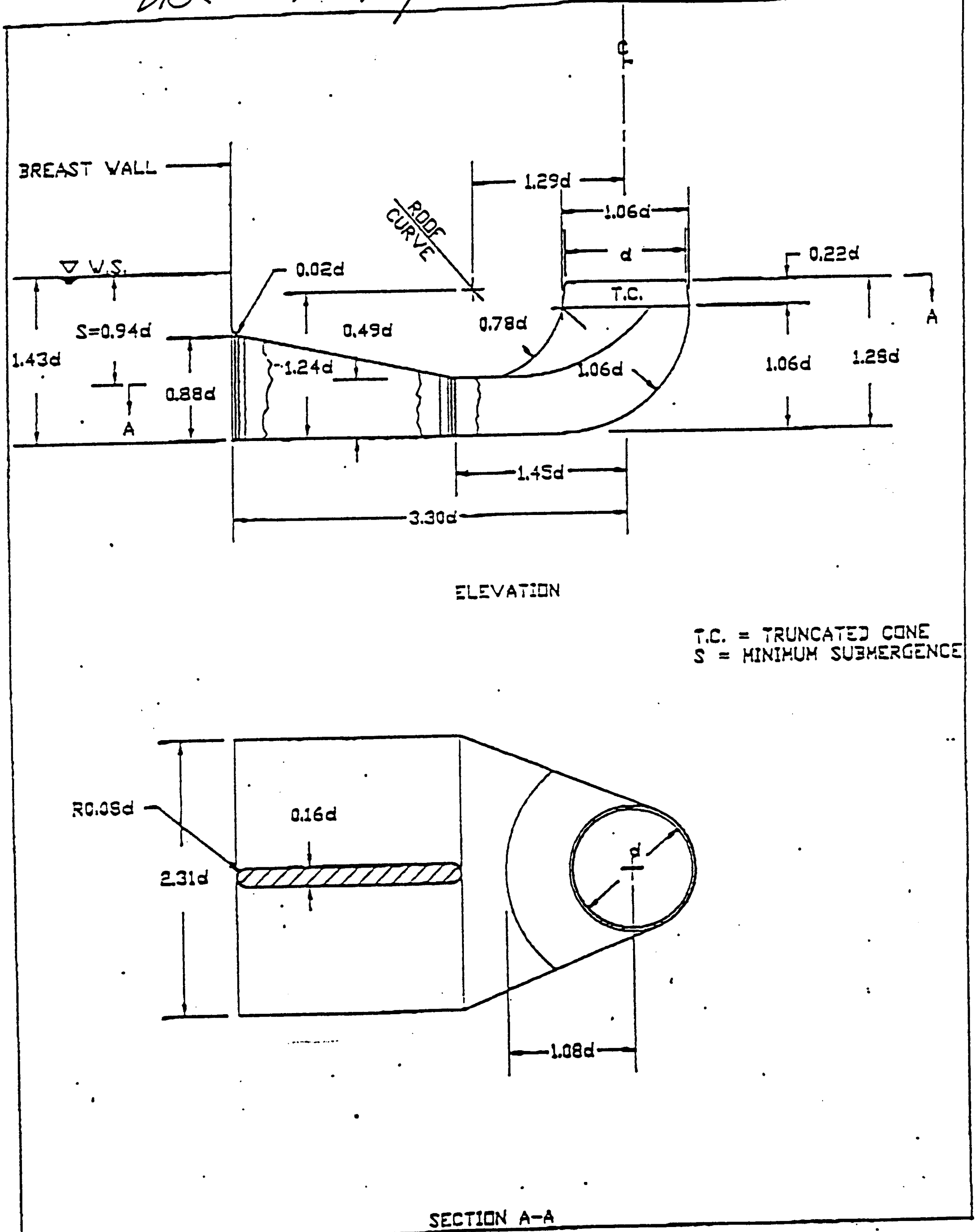


Figure 2. FSI type 10 design

CALCULATIONS FOR GRAND PRAIRIE PUMPING STATION
1640 CFS PUMPING STATION
42" VERTICAL MIXED FLOW PUMPS - 100 CFS EACH

1. DESIGN CRITERIA

A. HISTORICAL HIGH WATER	187.6 NGVD
B. 100 YEAR FLOOD	188.0 NGVD
B. AVERAGE LOW WATER	158.0 NGVD
C. HISTORICAL LOW WATER	153.3 NGVD
D. CANAL WATER ELEVATION	233.3 NGVD
E. STATION DESIGN FLOW	1640 CFS
F. LARGE PUMP DESIGN FLOW RATE	360 CFS
G. SMALL PUMP DESIGN FLOW RATE	100 CFS

2. CONDITION POINTS

A. MAXIMUM HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
MINIMUM RIVER	= 153.3 NGVD
Hst (Static Head)	= 80.0 NGVD

NPSHA = Hp + Hse - Hf - Hvpa
Hp = Atmospheric Pressure
Hse = Height of Water Above Pump Impeller Datum (EL. 147.88')
Hf = Friction Loss in Formed Suction Inlet
Hvpa = Vapor Pressure of Water
NPSHA = 33.9' + 5.42' - .205' - 1.38'
NPSHA = 37.74'

B. DESIGN HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
AVERAGE LOW RIVER	= 158.0 NGVD
Hst (Static Head)	= 75.3 NGVD

NPSHA = 33.9' + 10.12 '- .271' - 1.38'
NPSHA = 42.36'

C. MINIMUM HEAD WITH ALL PUMPS RUNNING

CANAL ELEVATION	= 233.3 NGVD
RIVER PERIOD OF RECORD	= 187.6 NGVD
Hst (Static Head)	= 45.7 NGVD

NPSHA = 33.9' + 39.72' - .747' - 1.38'
NPSHA = 71.49'

D. MAXIMUM HEAD WITH ONE 100 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
MINIMUM RIVER ELEVATION	= 153.3 NGVD
Hst (Static Head)	= 80.0 NGVD

NPSHA = 33.9' + 5.42' - .48' - 1.38'
NPSHA = 37.46'

E. DESIGN HEAD WITH ONE 100 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
AVERAGE LOW RIVER	= 158.0 NGVD
Hst (Static Head)	= 75.3 NGVD

NPSHA = 33.9' + 10.12' - .562' - 1.38'
NPSHA = 42.07'

F. MINIMUM HEAD WITH ONE 100 CFS PUMP RUNNING

CANAL ELEVATION	= 233.3 NGVD
HISTORICAL HIGH RIVER	= 187.6 NGVD
Hst (Static Head)	= 45.7 NGVD

NPSHA = 33.9' + 39.72' - 1.004' - 1.38'
NPSHA = 71.236'

3. CONCLUSIONS

A. MAXIMUM PUMP HORSEPOWER (ALL PUMPS RUNNING) = 1470.0 HP
B. MAXIMUM PUMP HORSEPOWER (1 PUMP RUNNING) = 1469.3 HP
C. DESIGN PUMP HORSEPOWER (ALL PUMPS RUNNING) = 1453.0 HP
D. DESIGN PUMP HORSEPOWER (1 PUMP RUNNING) = 1467.9 HP
E. MAXIMUM MOTOR HORSEPOWER REQ'D = 4800 x 110% = 1617.0 HP
F. MOTOR SIZE REQUIRED = 1650.0 HP

LOSSES FOR ~~33"~~X 42" PUMP(100 CFS) - GRAND PRAIRIE 1640 CFS PUMPING STATION -----ONE PUMP RUNNING -----

FLOW GPM	INLET CONDUIT	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 120" TEE	120" PIPE 1 PUMP	EXIT LOSSES	LOSSES 1 PUMP	TOTAL HEAD 1 PUMP HST=45.7	DESIGN HEAD 1 PUMP HST=75.3	TOTAL HEAD 1 PUMP HST=80	
10,000	.001	.012	.013	.020	.000	.017	.022	.001	.087	45.79	75.39	80.09	
15,000	.003	.028	.029	.045	.001	.038	.046	.003	.191	45.89	75.49	80.19	
20,000	.005	.049	.052	.080	.001	.067	.077	.005	.336	46.04	75.64	80.34	
25,000	.007	.077	.081	.125	.002	.104	.116	.008	.520	46.22	75.82	80.52	
30,000	.010	.111	.117	.180	.002	.150	.162	.011	.744	46.44	76.04	80.74	
35,000	.013	.151	.159	.245	.003	.204	.215	.015	1.006	46.71	76.31	81.01	
40,000	.017	.198	.208	.320	.004	.267	.275	.020	1.307	47.01	76.61	81.31	
44,883	.020	.249	.262	.403	.005	.336	.339	.025	1.639	47.34	76.94	81.64	***
45,000	.021	.250	.263	.405	.005	.338	.341	.025	1.647	47.35	76.95	81.65	
50,000	.025	.309	.325	.500	.005	.417	.413	.031	2.025	47.73	77.33	82.03	
55,000	.030	.374	.393	.605	.007	.504	.492	.038	2.442	48.14	77.74	82.44	
60,000	.035	.445	.468	.720	.008	.600	.577	.045	2.897	48.60	78.20	82.90	
65,000	.040	.522	.549	.845	.009	.704	.668	.053	3.390	49.09	78.69	83.39	
70,000	.046	.605	.637	.980	.010	.817	.765	.061	3.922	49.62	79.22	83.92	
75,000	.052	.695	.731	1.125	.012	.938	.868	.070	4.491	50.19	79.79	84.49	
80,000	.059	.790	.832	1.280	.013	1.067	.976	.080	5.098	50.80	80.40	85.10	
85,000	.066	.892	.939	1.445	.015	1.204	1.091	.090	5.743	51.44	81.04	85.74	
90,000	.073	1.000	1.053	1.620	.016	1.350	1.211	.101	6.426	52.13	81.73	86.43	
95,000	.081	1.115	1.173	1.805	.018	1.504	1.337	.113	7.146	52.85	82.45	87.15	
100,000	.089	1.235	1.300	2.000	.020	1.667	1.469	.125	7.905	53.60	83.20	87.90	
105,000	.097	1.362	1.433	2.205	.021	1.838	1.606	.138	8.701	54.40	84.00	88.70	
110,000	.106	1.494	1.573	2.420	.023	2.017	1.749	.151	9.534	55.23	84.83	89.53	
115,000	.115	1.633	1.719	2.645	.025	2.204	1.897	.165	10.405	56.10	85.70	90.40	
120,000	.124	1.778	1.872	2.880	.027	2.400	2.051	.180	11.313	57.01	86.61	91.31	
125,000	.134	1.930	2.032	3.125	.029	2.605	2.210	.195	12.259	57.96	87.56	92.26	
130,000	.144	2.087	2.197	3.380	.032	2.817	2.374	.211	13.243	58.94	88.54	93.24	
140,000	.164	2.421	2.548	3.921	.036	3.267	2.719	.245	15.321	61.02	90.62	95.32	
150,000	.186	2.779	2.925	4.501	.041	3.751	3.085	.281	17.549	63.25	92.85	97.55	
160,000	.210	3.162	3.328	5.121	.046	4.267	3.472	.320	19.926	65.63	95.23	99.93	
170,000	.234	3.569	3.758	5.781	.052	4.817	3.879	.361	22.451	68.15	97.75	102.45	
180,000	.260	4.001	4.213	6.481	.057	5.401	4.307	.405	25.125	70.83	100.43	105.13	
190,000	.287	4.458	4.694	7.221	.063	6.018	4.755	.452	27.947	73.65	103.25	107.95	
200,000	.316	4.940	5.201	8.001	.069	6.668	5.222	.500	30.918	76.62	106.22	110.92	
210,000	.345	5.446	5.734	8.821	.076	7.351	5.710	.552	34.036	79.74	109.34	114.04	
220,000	.376	5.978	6.293	9.681	.083	8.068	6.218	.605	37.301	83.00	112.60	117.30	
230,000	.403	6.533	6.878	10.582	.090	8.818	6.745	.662	40.714	86.41	116.01	120.71	
240,000	.441	7.114	7.489	11.522	.097	9.601	7.291	.720	44.275	89.97	119.57	124.27	

RADIUS OF PUMP DISCHARG 1.750 AREA OF HEADER (SQ. FT)= 78.500

RADIUS OF DISCHARGE HEA 5.000 AREA OF CONDUIT (SQ. FT.)= 22.526

LOSSES FOR 3[redacted] 42" PUMP - GRAND PRAIRIE PUMPING STATION ALTERNATE 2 -- THREE PUMPS RUNNING --

FLOW GPM	INLET CONDUIT	FSI	42" PUMP CONTROL VALVE	42" GATE VALVE	42" PIPE 1 PUMP	42" X 120" TEE	120" PIPE 3 PUMP	EXIT LOSSES	LOSSES 3 PUMP	TOTAL HEAD 3 PUMP HST=45.7	DESIGN HEAD 3 PUMP HST=75.3	TOTAL HEAD 3 PUMP HST=80	
10,000	.001	.012	.013	.020	.000	.017	13.289	1.388	14.741	60.44	90.04	94.74	
15,000	.003	.028	.029	.045	.001	.038	13.656	1.430	15.229	60.93	90.53	95.23	
20,000	.005	.049	.052	.080	.001	.067	14.028	1.473	15.755	61.45	91.05	95.75	
25,000	.007	.077	.081	.125	.002	.104	14.404	1.516	16.317	62.02	91.62	96.32	
30,000	.010	.111	.117	.180	.002	.150	14.785	1.560	16.915	62.62	92.22	96.92	
35,000	.013	.151	.159	.245	.003	.204	15.170	1.605	17.550	63.25	92.85	97.55	
40,000	.017	.198	.208	.320	.004	.267	15.560	1.650	18.222	63.92	93.52	98.22	
44,883	.020	.249	.262	.403	.005	.336	15.945	1.694	18.914	64.61	94.21	98.91	***
45,000	.021	.250	.263	.405	.005	.338	15.954	1.695	18.931	64.63	94.23	98.93	
50,000	.025	.309	.325	.500	.005	.417	16.353	1.742	19.676	65.38	94.98	99.68	
55,000	.030	.374	.393	.605	.007	.504	16.756	1.789	20.457	66.16	95.76	100.46	
60,000	.035	.445	.468	.720	.008	.600	17.164	1.836	21.276	66.98	96.58	101.28	
65,000	.040	.522	.549	.845	.009	.704	17.576	1.885	22.130	67.83	97.43	102.13	
70,000	.046	.605	.637	.980	.010	.817	17.992	1.933	23.021	68.72	98.32	103.02	
75,000	.052	.695	.731	1.125	.012	.938	18.413	1.983	23.949	69.65	99.25	103.95	
80,000	.059	.790	.832	1.280	.013	1.067	18.839	2.033	24.913	70.61	100.21	104.91	
85,000	.066	.892	.939	1.445	.015	1.204	19.268	2.084	25.914	71.61	101.21	105.91	
90,000	.073	1.000	1.053	1.620	.016	1.350	19.703	2.135	26.951	72.65	102.25	106.95	
95,000	.081	1.115	1.173	1.805	.018	1.504	20.141	2.187	28.025	73.72	103.32	108.02	
100,000	.089	1.235	1.300	2.000	.020	1.667	20.584	2.240	29.134	74.83	104.43	109.13	
105,000	.097	1.362	1.433	2.205	.021	1.838	21.031	2.293	30.281	75.98	105.58	110.28	
110,000	.106	1.494	1.573	2.420	.023	2.017	21.483	2.347	31.464	77.16	106.76	111.46	
115,000	.115	1.633	1.719	2.645	.025	2.204	21.939	2.401	32.683	78.38	107.98	112.68	
120,000	.124	1.778	1.872	2.880	.027	2.400	22.399	2.456	33.938	79.64	109.24	113.94	
125,000	.134	1.930	2.032	3.125	.029	2.605	22.864	2.512	35.230	80.93	110.53	115.23	
130,000	.144	2.087	2.197	3.380	.032	2.817	23.333	2.569	36.558	82.26	111.86	116.56	
140,000	.164	2.421	2.548	3.921	.036	3.267	24.283	2.683	39.324	85.02	114.62	119.32	
150,000	.186	2.779	2.925	4.501	.041	3.751	25.251	2.800	42.235	87.93	117.53	122.23	
160,000	.210	3.162	3.328	5.121	.046	4.267	26.237	2.920	45.291	90.99	120.59	125.29	
170,000	.234	3.569	3.758	5.781	.052	4.817	27.239	3.042	48.492	94.19	123.79	128.49	
180,000	.260	4.001	4.213	6.481	.057	5.401	28.258	3.167	51.838	97.54	127.14	131.84	
190,000	.287	4.458	4.694	7.221	.063	6.018	29.294	3.294	55.329	101.03	130.63	135.33	
200,000	.316	4.940	5.201	8.001	.069	6.668	30.347	3.423	58.965	104.67	134.27	138.97	
210,000	.345	5.446	5.734	8.821	.076	7.351	31.417	3.555	62.746	108.45	138.05	142.75	
220,000	.376	5.978	6.293	9.681	.083	8.068	32.504	3.690	66.672	112.37	141.97	146.67	
230,000	.408	6.533	6.878	10.582	.090	8.818	33.607	3.827	70.743	116.44	146.04	150.74	
240,000	.441	7.114	7.489	11.522	.097	9.601	34.727	3.967	74.958	120.66	150.26	154.96	

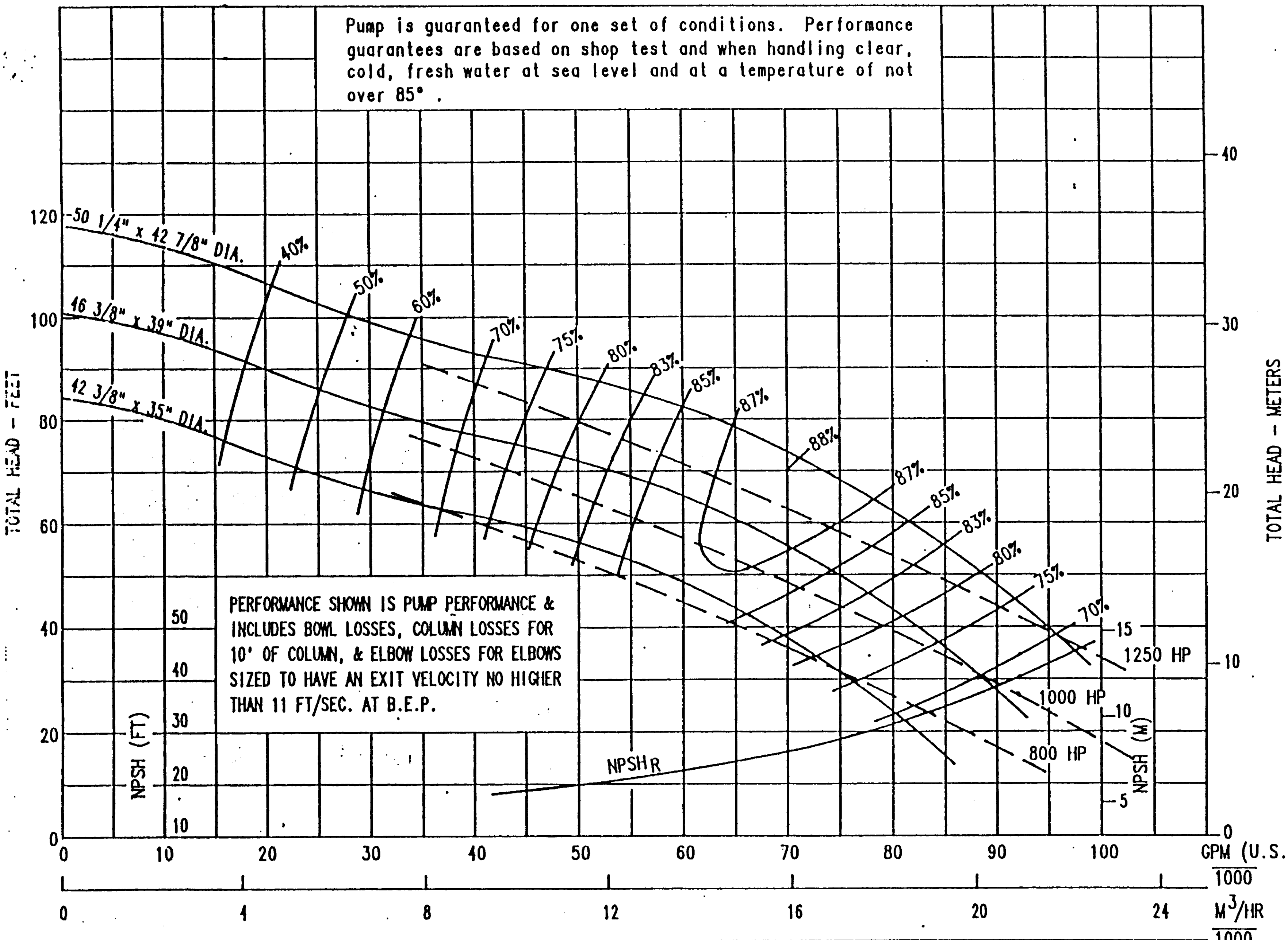
RADIUS OF PUMP DISCHARG 1.750 AREA OF HEADER (SQ. FT)= 78.500

RADIUS OF DISCHARGE HEA 5.000 AREA OF CONDUIT (SQ. FT.)= 22.526

G-133

V-E-16

FORM E-13122-24

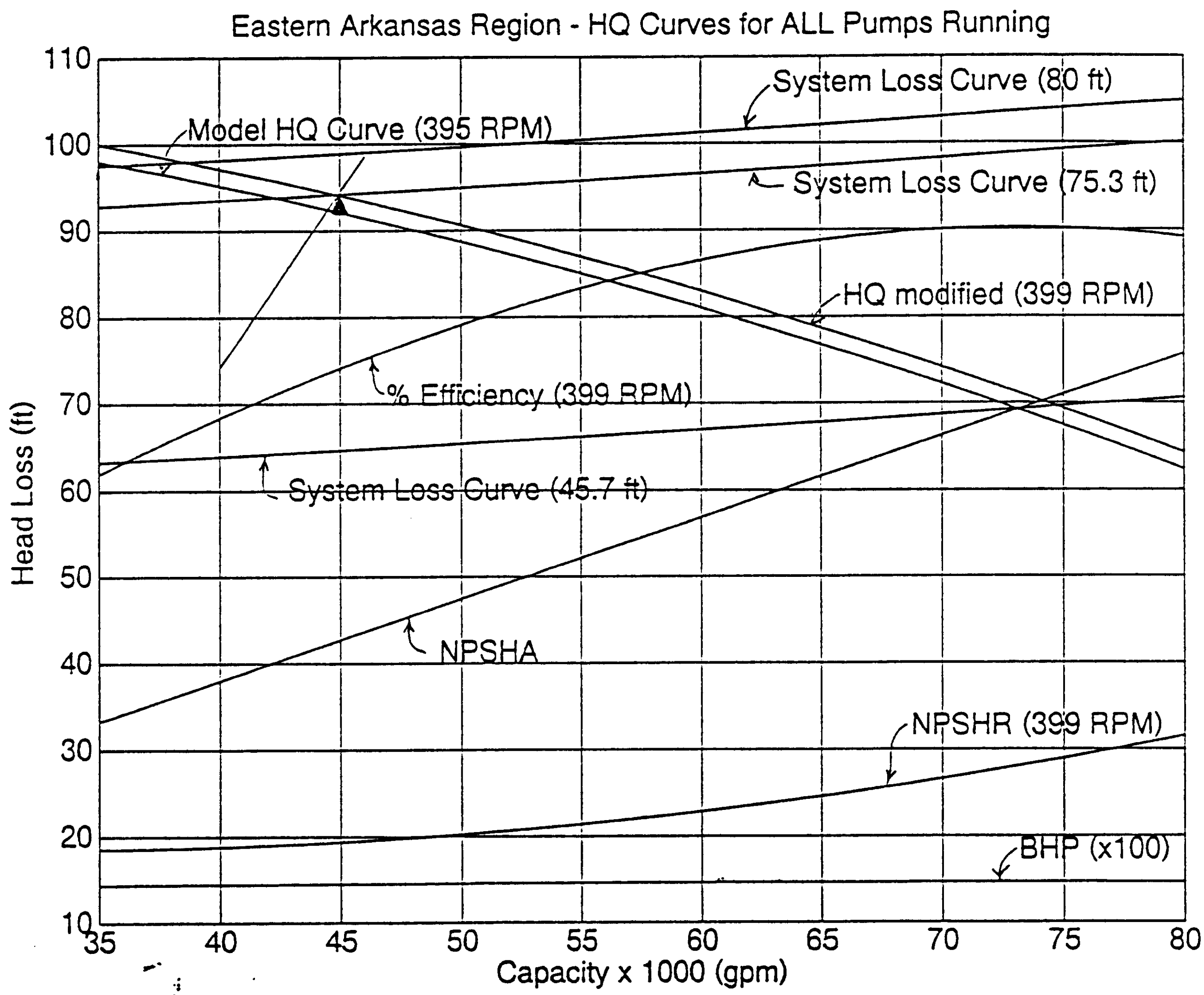


SIZE & TYPE 54 KAFV	RPM 395 REF.	EYE AREA 952 SQ. IN.
CURVE NO. 54KAF-B	IMPELLER D-5896	MAX. SPHERE 7 1/2"

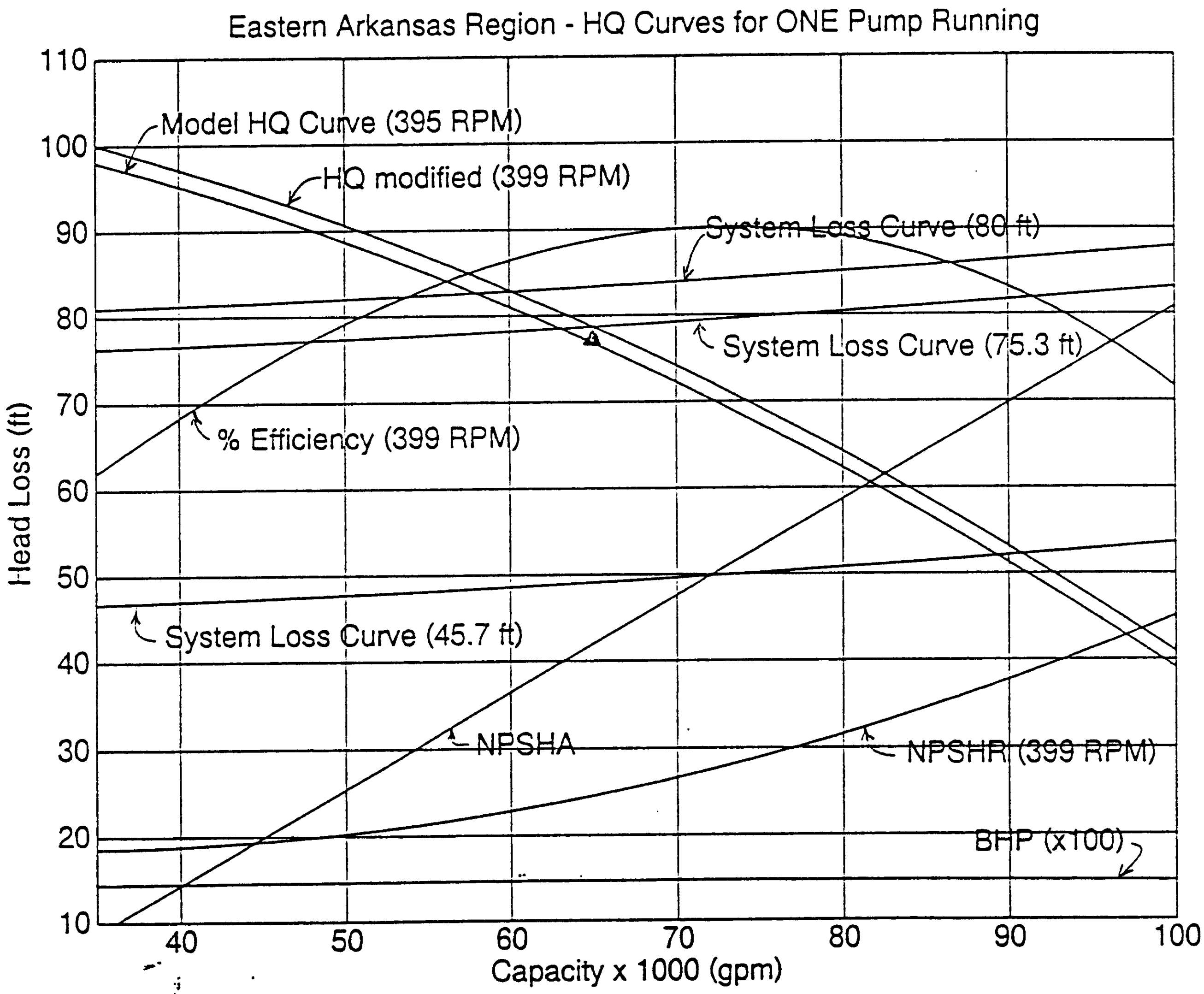
PATTERSON PUMP COMPANY
A subsidiary of The Gorman-Rupp Co.

TELEPHONE:
(706) 886-2101
Post Office Box 790
Toccoa, Georgia 30577

Section G



42" PUMP - 100 CFS



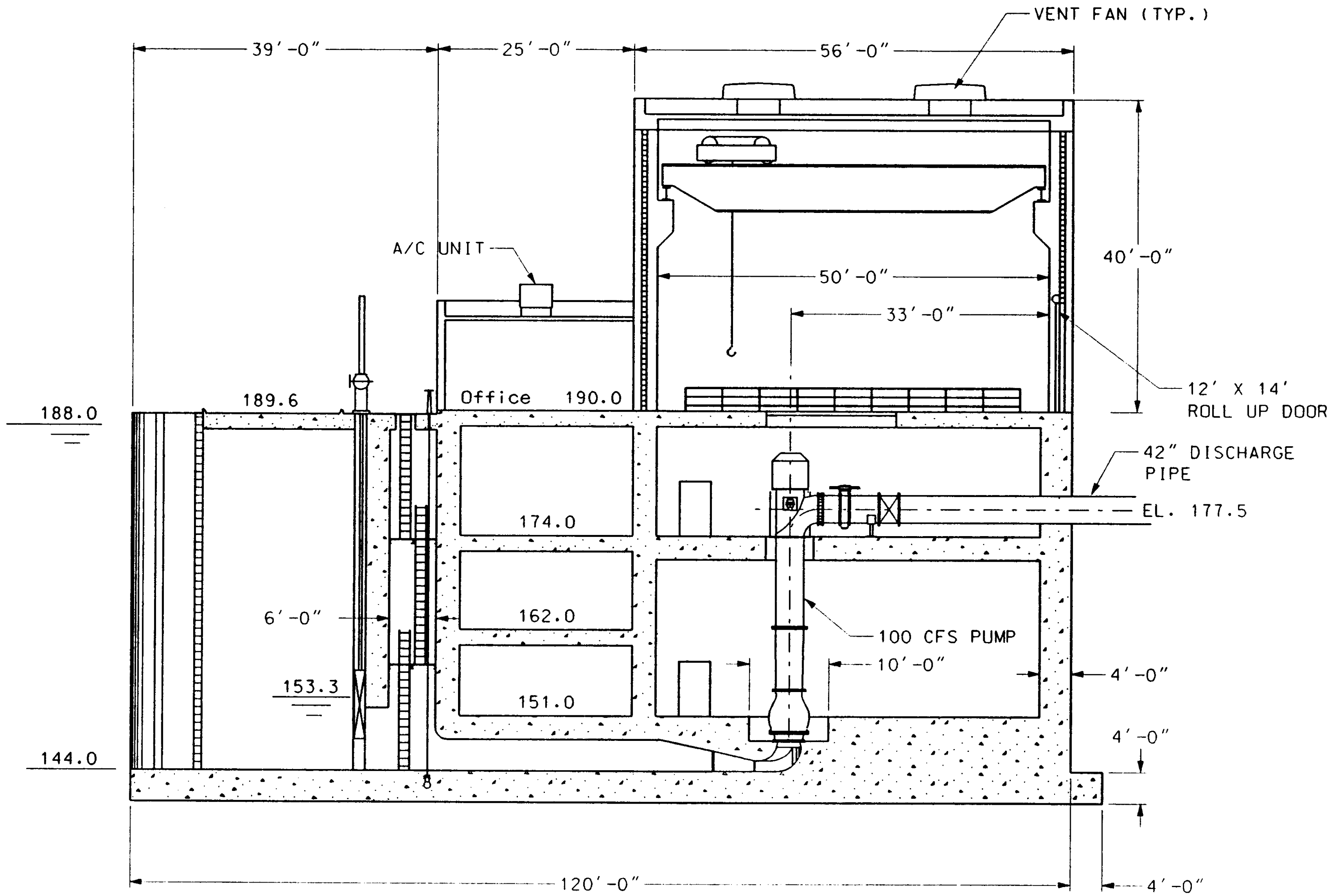
42" PUMP - 100 CFS

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

ELEVATION AT SMALL PUMP



TRANSVERSE VIEW
SCALE: 1"= 20'-0"

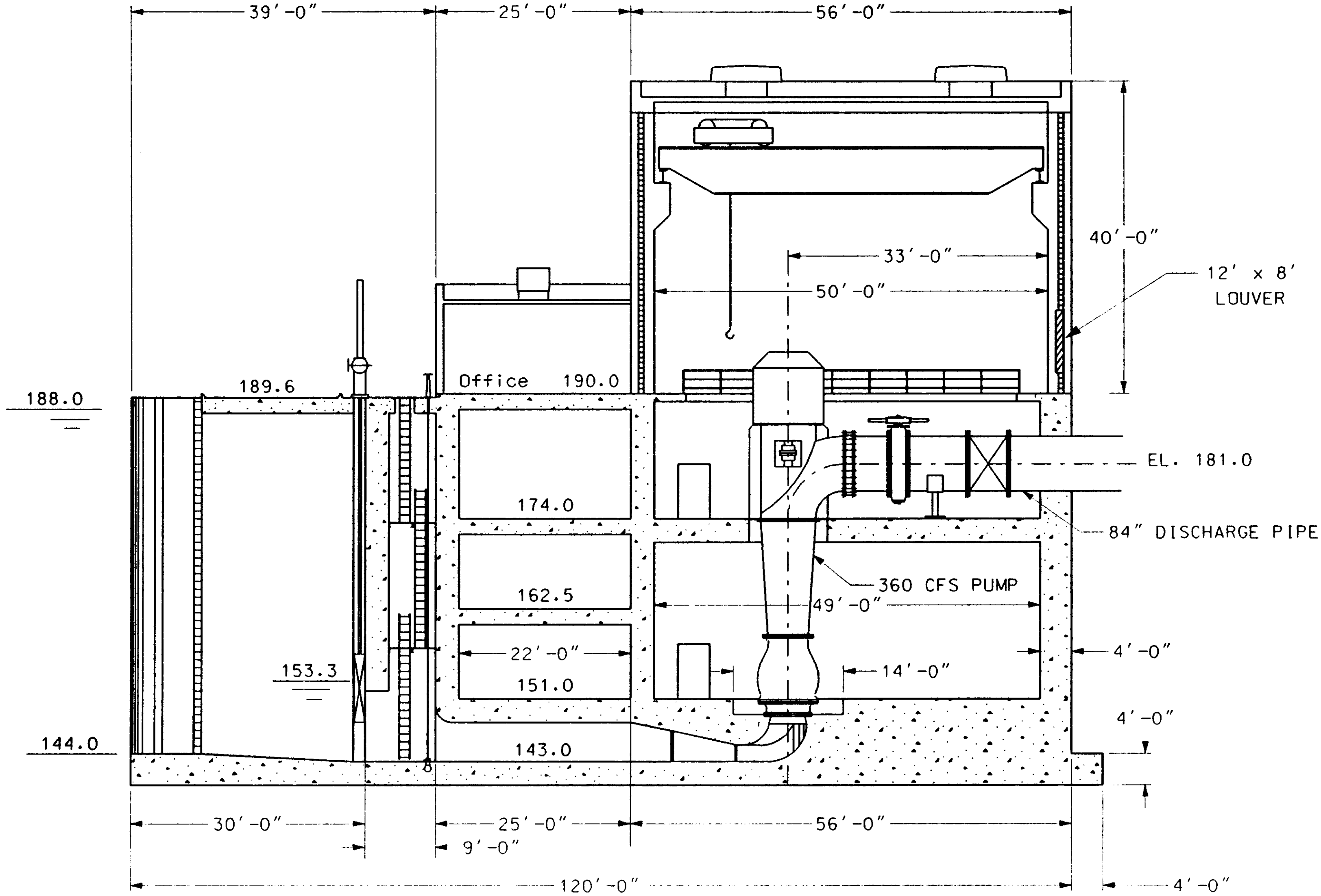
PLATE
V-E-I

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

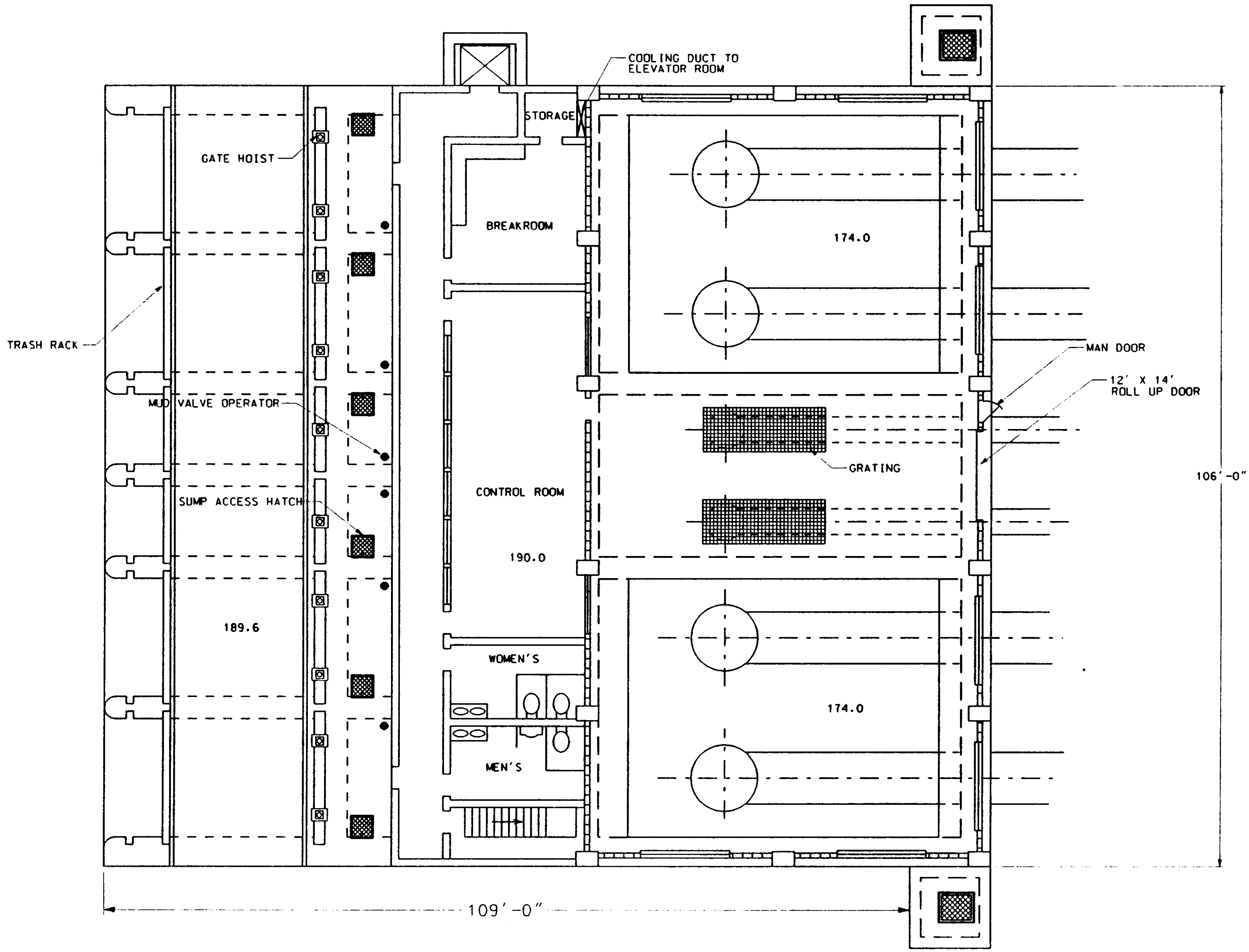
EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

ELEVATION AT LARGE PUMP



TRANSVERSE VIEW
SCALE: 1″= 20′-0″

PLATE
V-E-II



OPERATING ROOM FLOOR EL 190.0
SCALE: 1" = 20'

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

FLOOR PLAN ELEVATION 190.0

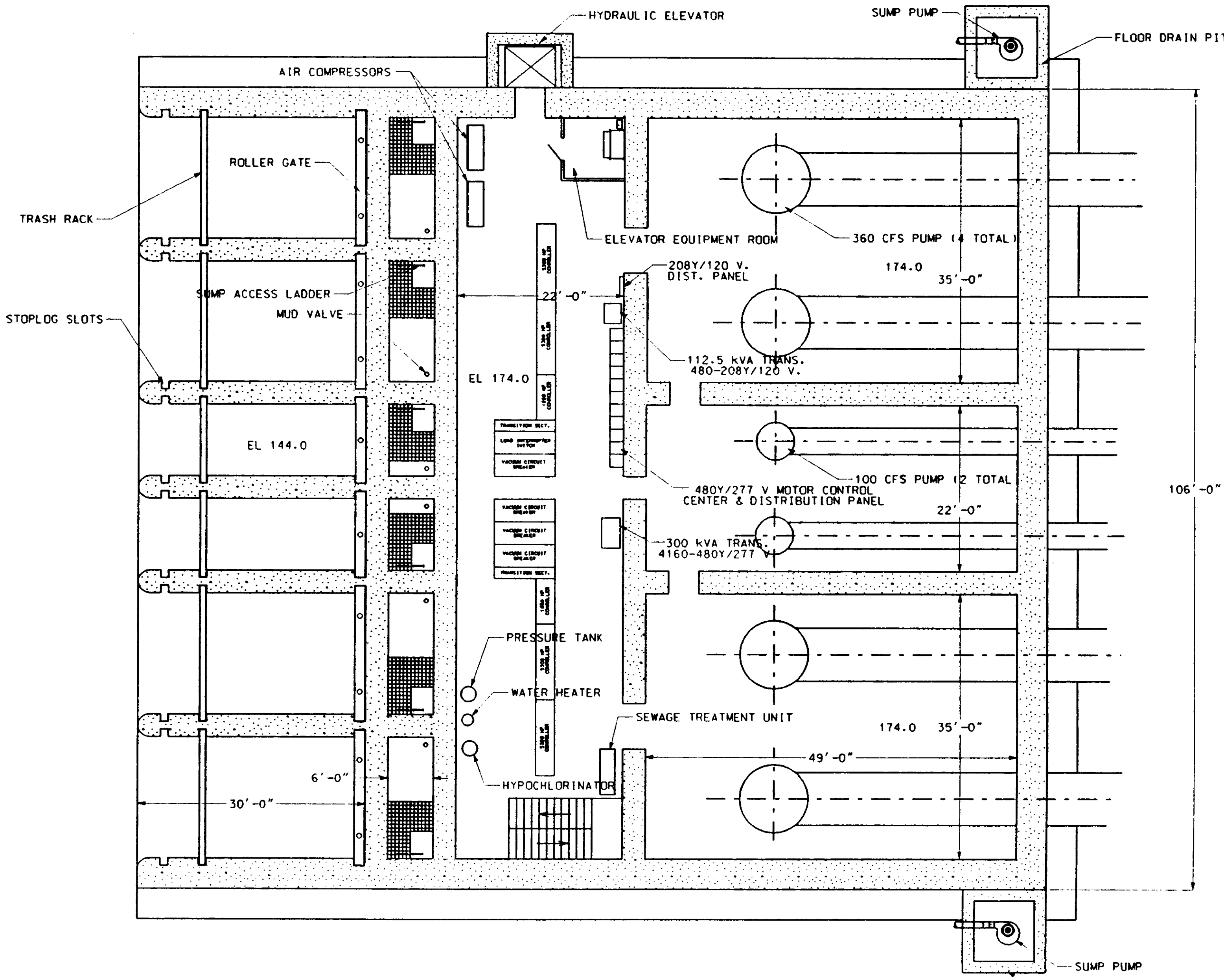
PLATE
V-E-III

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

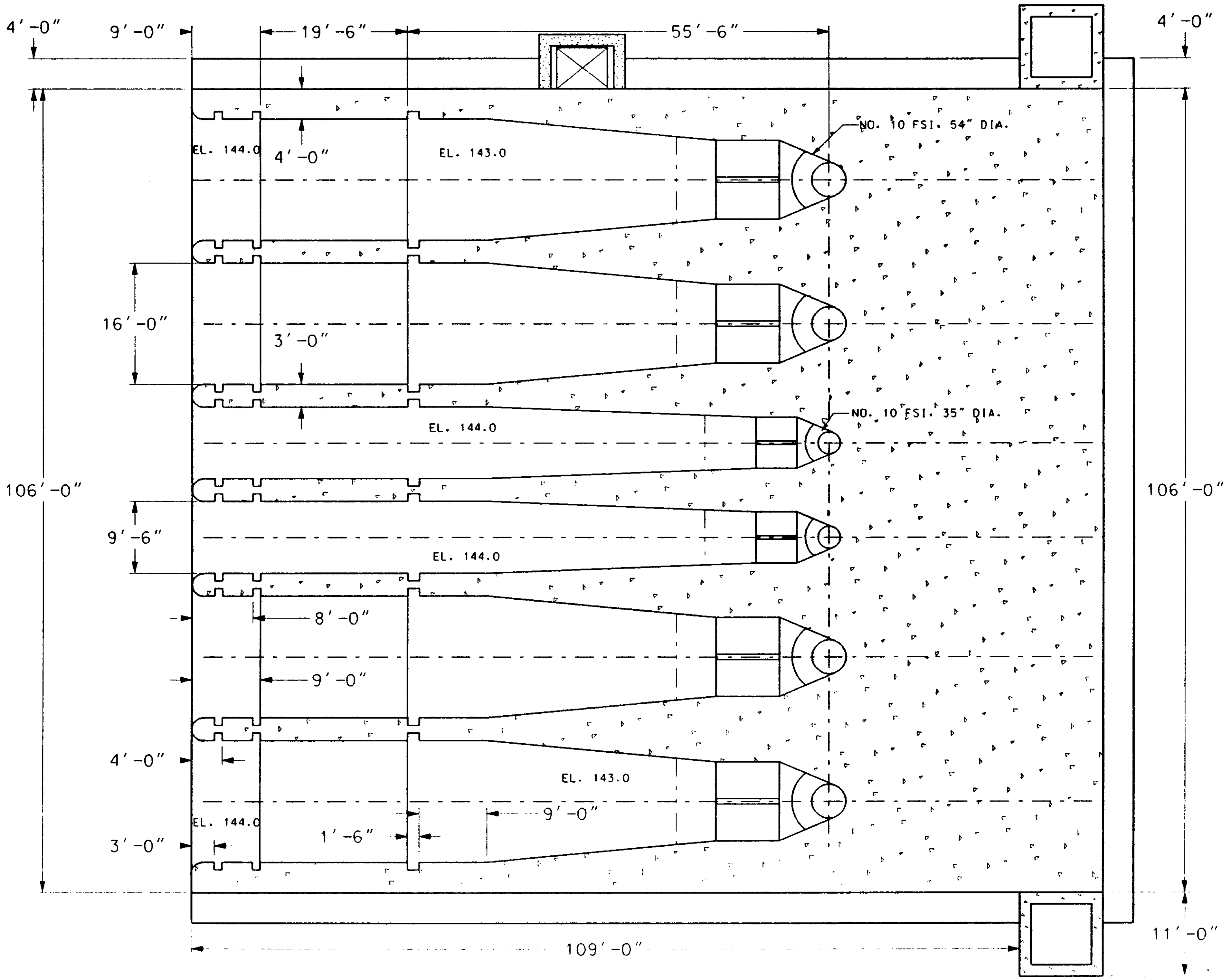
EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

FLOOR PLAN ELEVATION 174.4



MECHANICAL ROOM FLOOR EL 174.0
SCALE: 1" = 20'

PLATE
V-E-IV



SUMP PLAN
SCALE: 1"= 20'-0"

US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

SUMP FLOOR PLAN

PLATE
V-E-V

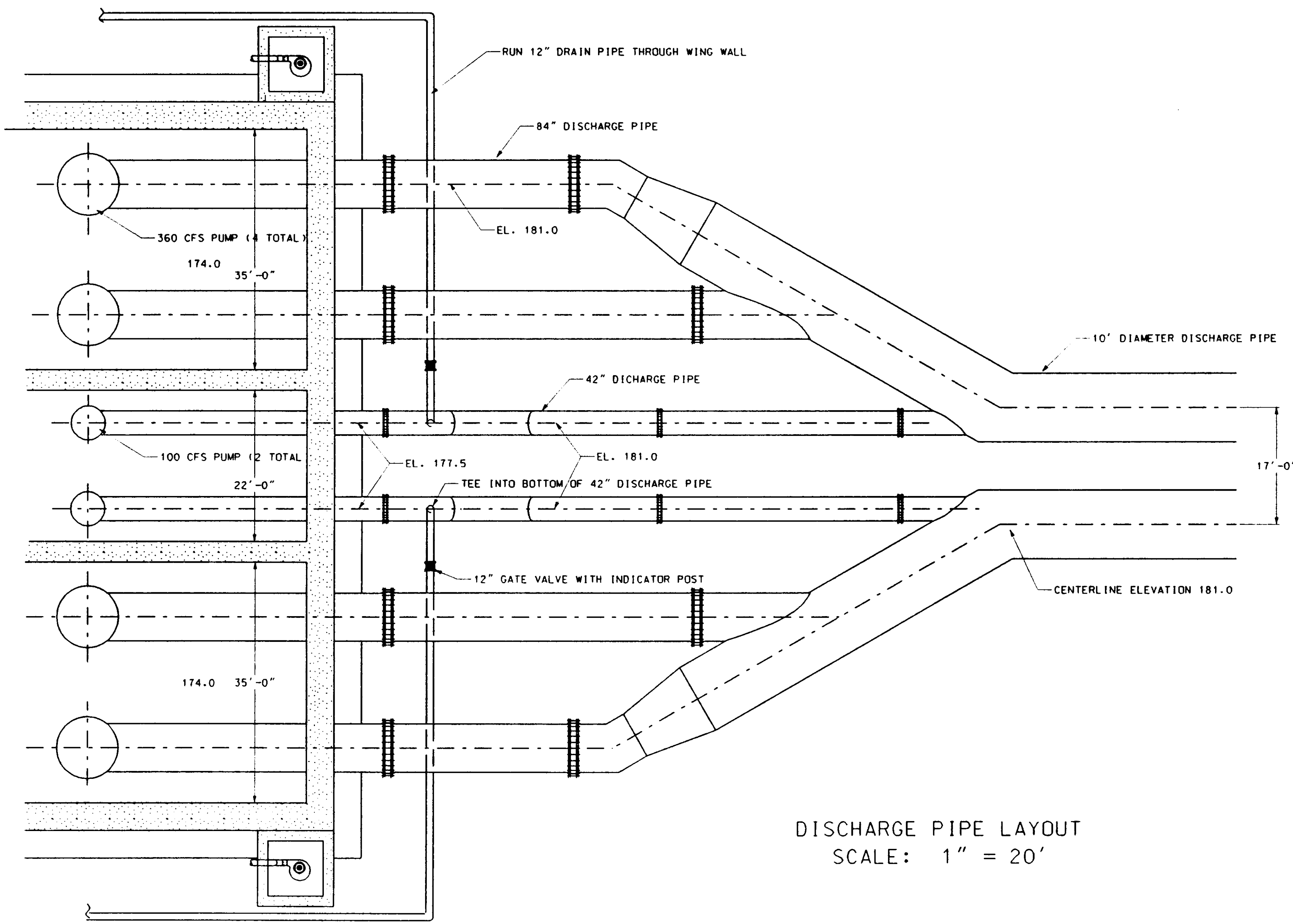
US Army Corps of Engineers

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

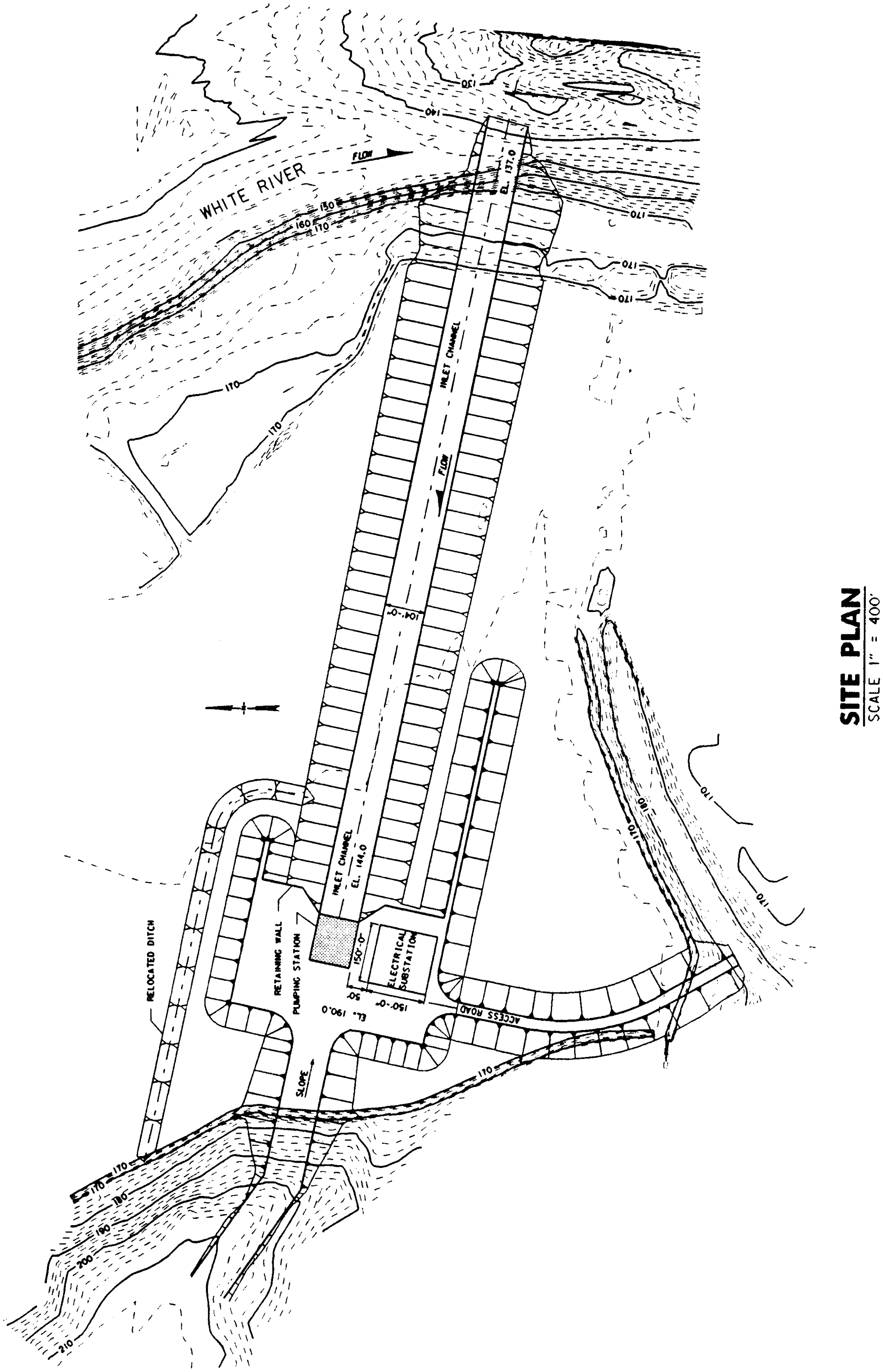
EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

DISCHARGE PIPE LAYOUT

PLATE
V-E-VI



DISCHARGE PIPE LAYOUT
SCALE: 1" = 20'



US Army Corps of Engineers

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CORPS OF ENGINEERS
MEMPHIS, TENNESSEE

EASTERN ARKANSAS REGION COMPREHENSIVE STUDY
GRAND PRAIRIE AREA
DEMONSTRATION PROJECT

PUMPING STATION SITE PLAN

PLATE
V–E–VII

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-F

GRAND PRAIRIE PUMPING STATION

MECHANICAL DESIGN DEVELOPMENT

SUMP UNWATERING SYSTEM

U.S. Army Corps of Engineers
Memphis District

Sump Dewatering System

Calculate volume of Formed Suction Inlet (FSI).

From the FSI shown in Figure A:
V_1 = Triangle
V_2 = Rectangle
V_3 = Approximates a cylinder and triangle
V_4 = Cone

V_1:

$$V_1 = (\frac{1}{2} b * w * h)$$

$$V_1 = (\frac{1}{2} * 1.17' * 8.33' * 9.68')$$

$$V_1 = 47.17\, ft^3$$

V_2:

$$V_2 = b * h * w$$

$$V_2 = 8.33' * 2.21' * (10.4' - 0.72')$$

$$V_2 = 178.20\, ft^3$$

V_3:

$$V_3 = V_{cylinder} + V_{traingle}$$

$$V_{cylinder} = \pi * R^2 * h$$

$$V_{cylinder} = \pi * (2.385')^2 * 2.56'$$

$$V_{cylinder} = 45.747\, ft^3$$

$$V_{triangle} = \frac{1}{2} * b * h * w$$

$$V_{triangle} = \frac{1}{2} 10.4' * 12.912' * 2.21'$$

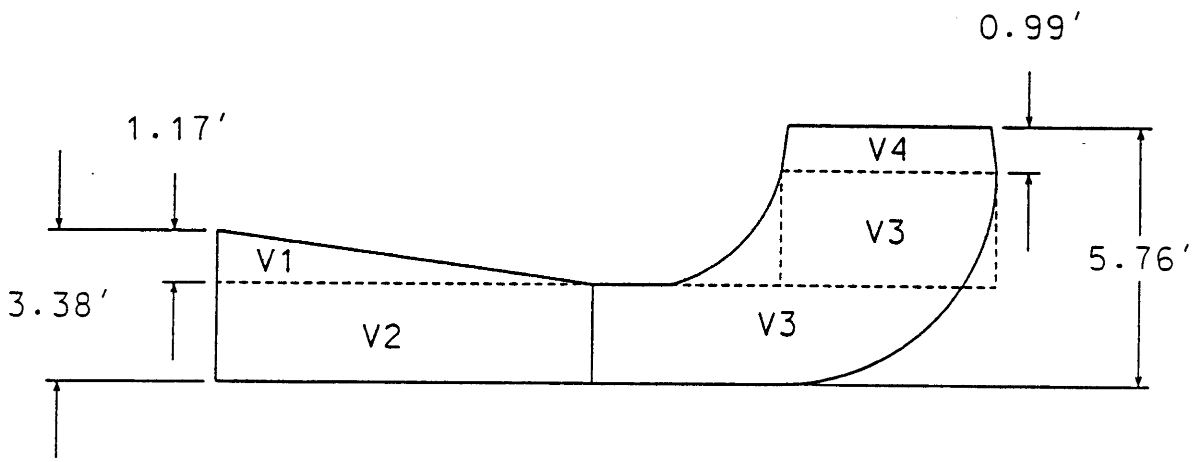
$$V_{triangle} = 148.386\, ft^3$$

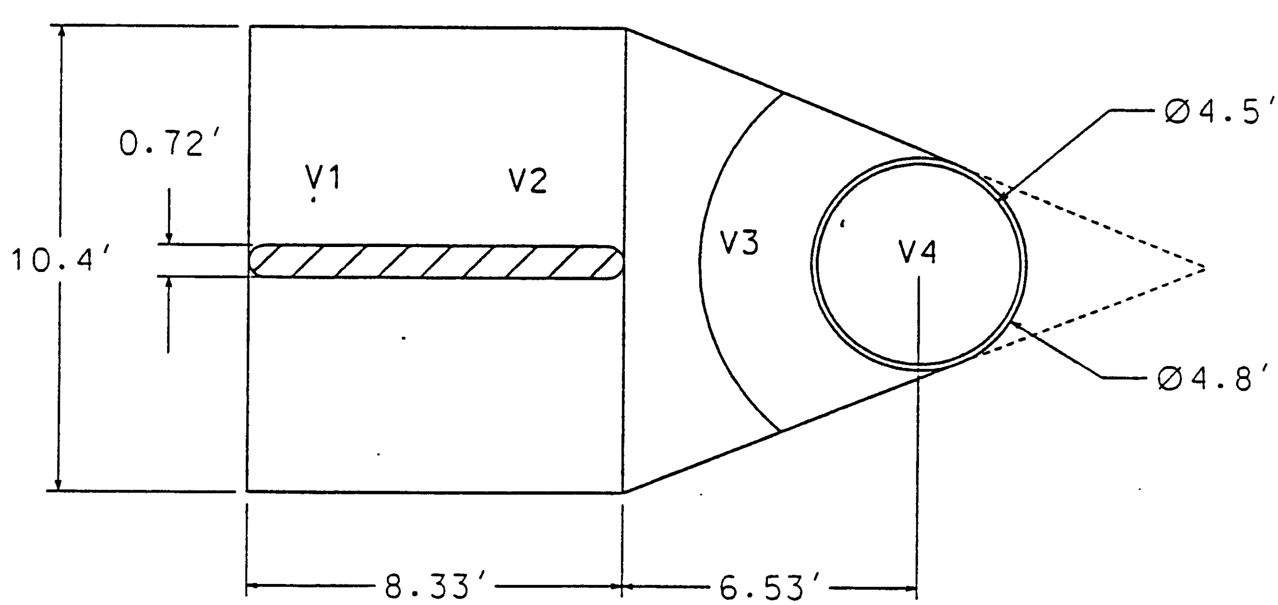
$$V_3 = 45.747\, ft^3 + 148.386\, ft^3$$

$$V_3 = 194.13\, ft^3$$

Figure A

FSI Type 10 Design
54" Eye Diameter
N.T.S





V_4:

$$V_4 = \frac{1}{3} (A_1 + A_2 + \sqrt{A_1 * A_2}) * H$$

$$A_1 = \pi * (2.385')^2 = 17.87\, ft^2$$

$$A_2 = \pi * (2.25')^2 = 15.90\, ft^2$$

$$V_4 = \frac{1}{3} [(17.87')^2 + (15.90')^2 + \sqrt{(17.87')^2 * (15.90')^2}] * 0.99'$$

$$V_4 = 16.71\, ft^3$$

Calculate volume of sump bay. From the 360 cfs sump bay shown in Figure B:

V_5 = Approximates a triangle and rectangle
V_6 = Trapezoid
V_7 = Rectangle
V_8 = Triangle

V_5:

$$V_5 = V_{triangle} + V_{rectangle}$$

$$V_{triangle} = \frac{1}{2} b*h*w$$

$$V_{triangle} = \frac{1}{2} * 5.146' * 1.042' * 10.396'$$

$$V_{triangle} = 27.86\, ft^3$$

$$V_{rectangle} = b*w*h$$

$$V_{rectangle} = 5.146' * 3.956' * 11.354'$$

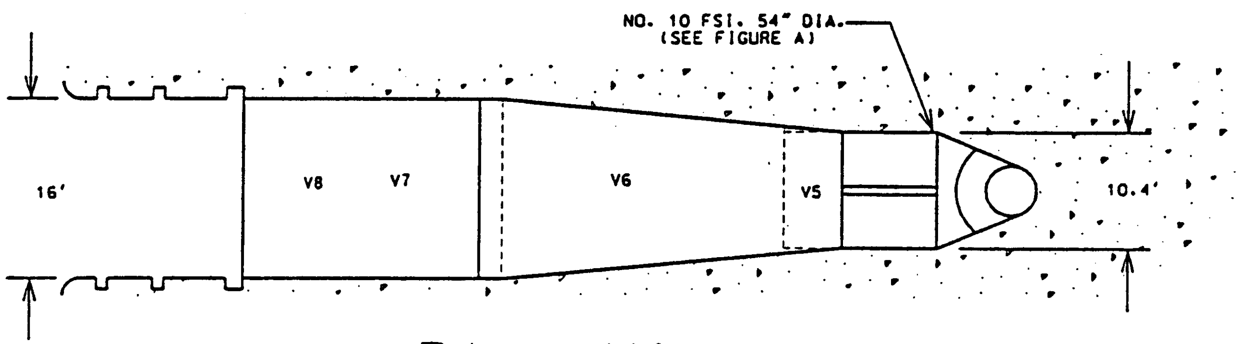
$$V_{rectangle} = 231.26\, ft^3$$

$$V_5 = 259.12\, ft^3$$

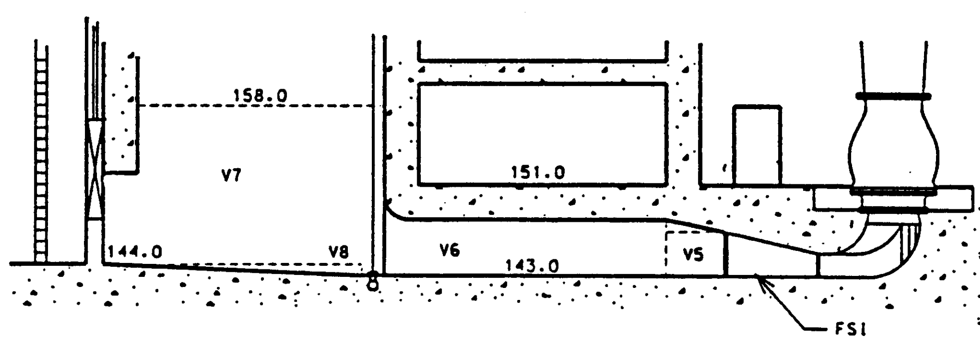
Figure B

Plan and Transverse View of the 360 cfs Pump Sump Bay

N.T.S



Plan View



Transverse View

V_6:

$$V_6 = A_{trapezoid} * w$$

$$A_{trapezoid} = (\frac{a+b}{2}) * h$$

$$A_{trapezoid} = (\frac{16'+11.354'}{2}) * 25'$$

$$A_{trapezoid} = 1367.71\ ft^2$$

$$V_6 = 1367.71'^2 * 5'$$

$$V_6 = 6838.54\,ft^3$$

V_7:

$$V_7 = A * w$$

$$V_7 = 333.5'^2 * 16'$$

$$V_7 = 5336\,ft^3$$

V_8:

$$V_8 = A * w$$

$$V_8 = 11.5'^2 * 16'$$

$$V_8 = 184\,ft^3$$

$$V_{total} = V_1 + V_2 + V_3 + V_4 + V_5 + V_6 + V_7 + V_8$$

□ $V_{total} = 13{,}053.87\,ft^3$

1 ft^3 = 7.4805 Gallons

V_{TOTAL} = 97,649.74 Gallons

$$Time\ for\ Dewatering\ One\ Sump = \frac{V_{total}}{Pump\ Capacity}$$

$$Pump\ Capacity = \frac{97,649.74\,gal}{90\,min}$$

$$Pump\ Capacity = 1,084.997\,gal$$

Consider a 10" diameter drain pipe:

$$A = \pi R^2$$
$$A = \pi * (5'')^2$$
$$A = 0.545\,ft^2$$

Determine drainage rate of sump.

$$Q = V * A$$
$$V = 1084.997\,\frac{gal}{min} * \frac{1}{0.545\,ft^2}$$
$$V = 266.134\,\frac{ft}{min}$$

$$H = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$
$$H = 0.02\left(\frac{70}{0.833}\right)\left[\frac{\left(266.134\,\frac{ft}{min}\right)^2}{231,840\,\frac{ft}{min^2}}\right]$$
$$H = 0.513\,ft$$

CONCLUSIONS:
A 1,000 GPM pump will satisfactorily dewater a single pump bay in approximately 97 minutes. There will be an ample flow rate from the sump with a head of approximately 0.5 foot to supply the pump. The pump selected is a Flygt Submersible pump, model CP3201.

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-G

GRAND PRAIRIE PUMPING STATION

MECHANICAL DESIGN DEVELOPMENT

VENTILATION SYSTEM

U.S. Army Corps of Engineers
Memphis District

ROOF VENTILATORS WITH MOTORIZED BACKDRAFT DAMPER AND 0.25" STATIC PRESSURE — 03/22/96

SELECTIONS MADE FROM THE GREENHECK FAN CORPORTATION CATALOG

FAN TYPE	MOTOR (hp)	16% HEAT LOSS	(BTU/HR)	GRADIENT (DEG)	FLOW (CFM)	MOTOR (hp)	VENT (CFM)	NO. OF FANS	LENGTH (FT)	WIDTH (FT)	HEIGHT (FT)
FFE 54	24000	3840	9,770,627	30	300,173	0.25	2,334	129	50	93	52.67
					300,173	1	9,094	33			
					300,173	1.5	10,887	28			
					300,173	1.5	12,055	25			
					300,173	1.5	14,482	21			
					300,173	2	16,629	18			
					300,173	2	19,307	16			
					300,173	3	21,597	14			
					300,173	3	24,723	**12**			
					300,173	5	26848	11			
					300,173	5	29348	10			
					300,173	5	31803	9			
					300,173	7.5	33393	9			
					300,173	7.5	35724	8			
					300,173	7.5	38028	8			

THIS FAN HAS 3.0 HP MOTOR, 630 RPM, 7.82 BHP, 8906 TS, AND 33.0 SONE →

FAN TYPE	MOTOR (hp)	16% HEAT LOSS	(BTU/HR)	GRADIENT (DEG)	FLOW (CFM)	MOTOR (hp)	VENT (CFM)	NO. OF FANS	LENGTH (FT)	WIDTH (FT)	HEIGHT (FT)
FFE 60	24000	3840	9,770,627	30	300,173	1	10,157	30	50	93	52.67
					300,173	1.5	12,652	24			
					300,173	1.5	15,107	20			
					300,173	2	17,711	17			
					300,173	2	20,243	15			
					300,173	3	22,573	13			
					300,173	3	24,562	**12**			
					300,173	3	26,506	11			
					300,173	5	28,946	10			
					300,173	5	31926	9			
					300,173	5	34892	9			
					300,173	7.5	37280	8			
					300,173	7.5	43106	7			
					300,173	10	46512	6			
					300,173	10	48757	6			

THIS FAN HAS 3.0 HP MOTOR, 465 RPM, 6.05 BHP, 7304 TS, AND 26.0 SONE →

FAN TYPE	MOTOR (hp)	16% HEAT LOSS	(BTU/HR)	GRADIENT (DEG)	FLOW (CFM)	MOTOR (hp)	VENT (CFM)	NO. OF FANS	LENGTH (FT)	WIDTH (FT)	HEIGHT (FT)
FE 48	24000	3840	9,770,627	30	300,173	0.5	5,214	58	50	93	52.67
					300,173	0.75	5,909	51			
					300,173	0.75	6,918	43			
					300,173	0.75	8,135	37			
					300,173	1	8,743	34			
					300,173	1	10,423	29			
					300,173	1.5	12,413	24			
					300,173	1.5	15,177	20			
					300,173	2	18,433	16			
					300,173	3	20561	15			
					300,173	3	22638	13			
					300,173	5	26084	**12**			
					300,173	5	28610	10			

THIS FAN HAS 5.0 HP MOTOR, 625 RPM, 4.32 BHP, 7854 TS, AND 26.4 SONE → (300,173 / 5 / 26084 / 12)

FAN TYPE	MOTOR (hp)	16% HEAT LOSS	(BTU/HR)	GRADIENT (DEG)	FLOW (CFM)	MOTOR (hp)	VENT (CFM)	NO. OF FANS	LENGTH (FT)	WIDTH (FT)	HEIGHT (FT)
FFE 42	24000	3840	9,770,627	30	300,173	0.5	3,158	95	50	93	52.67
					300,173	0.5	4,156	72			
					300,173	0.5	4,949	61			
					300,173	0.75	5,513	54			
					300,173	0.75	6,112	49			
					300,173	0.75	7,013	43			
					300,173	1	8,660	35			
					300,173	1	9,831	31			
					300,173	1.5	11,333	26			
					300,173	1.5	13630	22			
					300,173	2	16612	18			
					300,173	3	20034	15			
					300,173	5	22429	13			
					300,173	5	25141	**12**			

THIS FAN HAS 5.0 HP MOTOR, 850 RPM, 5.30 BHP, 9346 TS, AND 32.0 SONE → (300,173 / 5 / 25141 / 12)

The selection critieria for the roof ventilators is to maintain a 30 degree temperature difference between inside temperature and outside ambient based on heat loss from 84% efficient motors of 9,770,627 BTU/HR.

Four Greenheck Axial type Fabra Exhaust Fans were compared. The 48" fan was selected due to its slow speed, low noise, and size advantage.

Combination Louvers

The criteria for the combination louvers is listed below:

Velocity through each louver is 800 feet per minute (fpm)
The blades should be drainable
The louvers should be storm resistant

The total amount of free area needed is determined using the equation

$$Q = A * V \tag{1}$$

where Q is the flow rate in cubic feet per minute (cfm), V is the velocity in feet per minute (fpm), and A is the area in square feet (ft^2).

The lovers must accommodate the same flowrate as the roof ventilators. The flowrate is therefore, 26,084 ft^3/min per louver. Using equation (1), the total free area needed is determined.

$$A = \frac{300{,}173 \frac{ft^3}{\text{min}}}{800 \frac{ft}{\text{min}}} \tag{2}$$

$$A = 375.22\, ft^2$$

There will be 8 combination louvers. Each louver has approximately 60% free area. Each louver must accomodate 46.903 ft^2. This gives a total area of 78.17 ft^2. The louvers selected are 144" x 96" Dowco louvers. Each louver has a free area of 57.6 ft^2.

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-H

GRAND PRAIRIE PUMPING STATION

MECHANICAL DESIGN DEVELOPMENT

OFFICE HEATING AND AIR CONDITIONING

U.S. Army Corps of Engineers
Memphis District

	COOLING LOAD						
	DB	WB				U1	1.08
Outside Air	99	76				THD	13.46
Inside air	72					TD	16
Difference DBD	27						
Walls	SF	CLTD	U	BTU/HR			
North	336	20	0.0609	409.25			
West							
South	336	27	0.0609	552.48			
East	1260	39	0.0609	2,992.63			
Roof	1344	40	0.05	2,688.00			
		TD					
Partitions	2002	51	0.0596	6,085.28			
Floor	1344	51	0.0633	4,338.84			
Ceiling							
Int. glass	128	51	0.3312	2,162.07			
TOTAL SOLAR & TRANSMISSION LOAD				19,228.55	1		
INTERNAL SENSIBLE LOAD							
People	No.	BTU/HR					
Office	6	250		1,500.00			
Workshop							
	WATTS						
Lights	4032	3.4		13,708.80			
Mechanical	2000	3.4		6,800.00			
TOTAL INTERNAL SENSIBLE LOAD				22,008.80	2		
TOTAL SENSIBLE SPACE LOAD				41,237.35	1+2=3		
INTERNAL LATENT LOAD							
People	No.	BTU/HR					
Office	6	200		1,200.00			
Workshop							
TOTAL LATENT SPACE LOAD				1,200.00	4		
TOTAL SPACE LOAD				42,437.35	3+4=5		
Total Air Supply CFM		2,386.42					
MIN. OUTSIDE AIR							
10% Air Supply		238.64			A		
Exhaust Air		200.00			B		
TOTAL MIN. OUTSIDE AIR		438.64			A+B		
OUTSIDE AIR LOAD							
Sensible		12,790.80			6		
Total		26,273.34			7		
Grand Total Sensible		54,028.15			3+6=8		
Grand Total Load		68,710.69			9		
Space Sensible Ratio		0.97			3/5		
Total Sensible Ratio		0.79			8/9		
Tons of Refrigeration		5.73			10		
Area in SF Ton of Refrigeration		234.72			11		
Tons of Refrigeration Design		**6.30**			10*1.1		

Appendix V-H-1

	HEATING LOAD						
	DB						
Outside Air	20						
Inside air	72						
Difference TDW	52						
TRANSMISSION LOSS	SF	Temp Diff	U	BTU/HR			
Ext. Glass							
Ext. Net Wall	1932	52	0.0609	6,118.26			
Roof	1344	52	0.05	3,494.40			
Floor	1344	52	0.0633	4,423.91			
Partitions	2002	52	0.0596	6,204.60			
Int. Glass	128	52	0.3312	2,204.47			
TOTAL TRANSMISSION LOSS				22,445.63	12		
Outside Air Loss							
(A+B) x U1 x TDW				24,634.14	13		
TOTAL HEATING LOSS				47,079.77	12+13=14		
Unit selected is a 7.5 ton heat pump with a 7.5 KW auxillary heater							

Appendix V-H-2

U Factors			
Exterior Wall		R	U
Inside air	1/f = R	0.6900	
1/2" Gyp.	1/R	0.0992	
4" Insultn.	1/R	13.33	
8" Concr. Block	1/R	1.9600	
Outside air	1/f = R	0.3300	
		16.4092	**0.06094**
Interior Wall			
Inside air	1/f = R	0.6900	
8" Concr. Block	1/R	1.9600	
4" Insultn.	1/R	13.3300	
1/2" Gyp.	1/R	0.0992	
Inside air	1/f = R	0.6900	
		16.7692	**0.05963**
Floor			
Inside air	1/f = R	0.6900	
1/2" gyp.	1/R	0.0992	
2" Insultn.	1/R	13.3300	
12" Concrete	1/R	1.0000	
Inside air	1/f = R	0.6900	
		15.8092	**0.06325**
Dbl Pane Window			
w/ 1/4" air space			
Inside air	1/f = R	0.6900	
Window	1/R	1.6393	
Inside Air	1/f = R	0.6900	
		3.0193	**0.33120**
Roof		20.0000	**0.05000**

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-I

GRAND PRAIRIE PUMPING STATION

STRUCTURAL DESIGN DEVELOPMENT

SHEAR AND MOMENT CALCULATIONS

U.S. Army Corps of Engineers
Memphis District

COMPUTATION SHEET

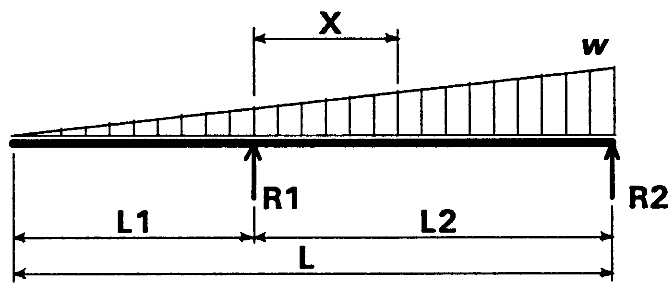
PROJECT: Grand Prairie Demostration Project
Eastern Arkansas

DESIGNED BY: Mike Watson

CHECKED BY: __________

SUBJECT: Grand Prairie Pumping Station (1640 CFS)

Load Case 1. Simple Beam with Cantilevered End - Load Increasing Uniformly to One End. Wall at discharge side of station.



Defined Units:

$kip := 1000 \cdot lbf$ $\quad ksi := \frac{kip}{in^2}$ $\quad ksi \equiv 1000 \cdot psi$ $\quad kcf := \frac{kip}{ft^2}$

Input Variables

Unit weights:

Soil weight: $\gamma_s := 0.125 \cdot kcf$

Water weight: $\gamma_w := 0.0624 \cdot kcf$

Span lengths:

Total length: $L := 39 \cdot ft$

Cantilever length: $L1 := 17.5 \cdot ft$

Simple span length $L2 = 21.5 \cdot ft$

Concrete properties:

Design compressive strength of concrete: $f_c := 4 \cdot ksi$

Unit weight of concrete: $w_c := 0.145 \cdot kcf$

Weight of reinforced concrete: $w_{rc} := 0.150 \cdot kcf$

Steel properties:

Specified yield strength of reinforcement: $f_y := 60 \cdot ksi$

Steel modulus of elasticity: $E_s := 29000 \cdot ksi$

Load Factors:

Live load: $LL := 2.21$

Dead load: $DL := 1.4$

COMPUTATION SHEET

PROJECT: Grand Prairie Demostration Project
Eastern Arkansas

DESIGNED BY: Mike Watson

CHECKED BY: __________

SUBJECT: Grand Prairie Pumping Station (1640 CFS)

Beam Analysis:

Equivalent fluid pressure:	$\gamma_e := \gamma_w + 0.5 \cdot (\gamma_s - \gamma_w)$	$\gamma_e = 0.094 \cdot kcf$
Uniform load at point 1:	$w_1 := L1 \cdot \gamma_e$	$w_1 = 1.64 \cdot \frac{kip}{ft}$
Uniform load at point 2:	$w_2 := L \cdot \gamma_e$	$w_2 = 3.65 \cdot \frac{kip}{ft}$
Reaction at point 1:	$R1 := \frac{w_2 \cdot L^2}{6 \cdot L2}$	$R1 = 43.09 \cdot kip$
Reaction at point 2:	$R2 := \frac{w_2 \cdot L}{2 \cdot L2} \cdot \left(L2 - \frac{L}{3}\right)$	$R2 = 28.17 \cdot kip$
Moment in L1:	$M_{L1}(x) := \frac{(-x)^3}{6 \cdot L1} \cdot w_1$	
Moment in L2:	$M_{L2}(x) := R1 \cdot (x - L1) - w_2 \cdot \frac{(x)^3}{6 \cdot L}$	
Moment at x:	$M(x) := if(x<L1, M_{L1}(x), M_{L2}(x))$	
Moment at point 1:	$M1 := M(17.5 \cdot ft)$	$M1 = -83.7 \cdot kip \cdot ft$
Shear in L1:	$V_{L1}(x) := \frac{(x)^2}{-2 \cdot L1} \cdot w_1$	
Shear in L2:	$V_{L2}(x) := R1 - w_2 \cdot \frac{(x)^2}{2 \cdot L}$	
Shear at x:	$V(x) := if(x<L1, V_{L1}(x), V_{L2}(x))$	

Determine zero shear location:

$x := L1$ $\quad$ $x_o := root(V(x), x)$ $\quad$ $x_o = 30.3 \cdot ft$

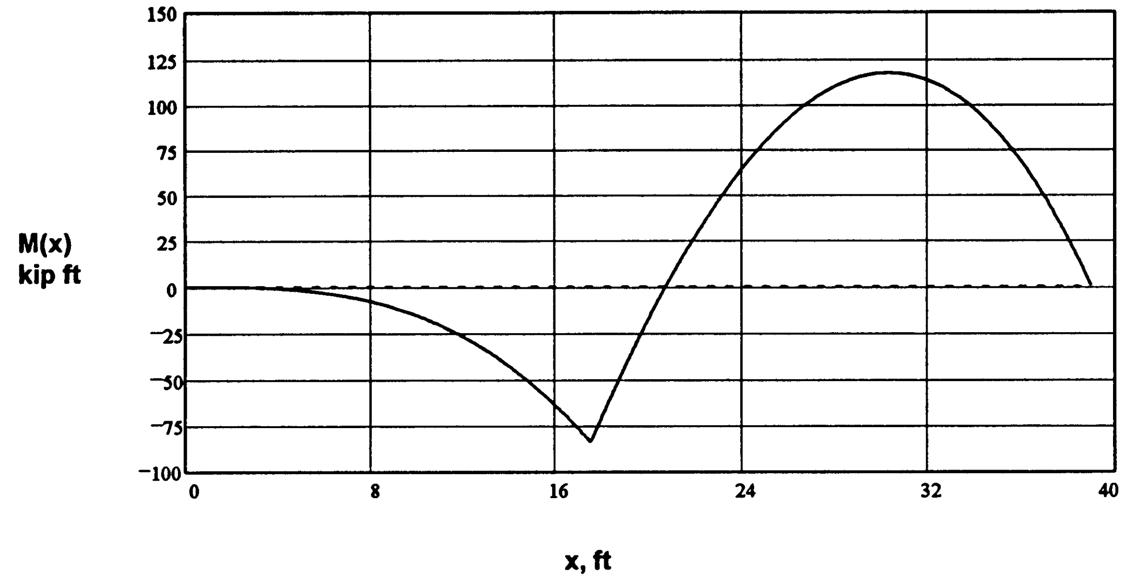
Maximum positivey moment coincides with zero shear:

$M_{pos} := M(x_o)$ $\quad$ $M_{pos} = 117.1 \cdot kip \cdot ft$

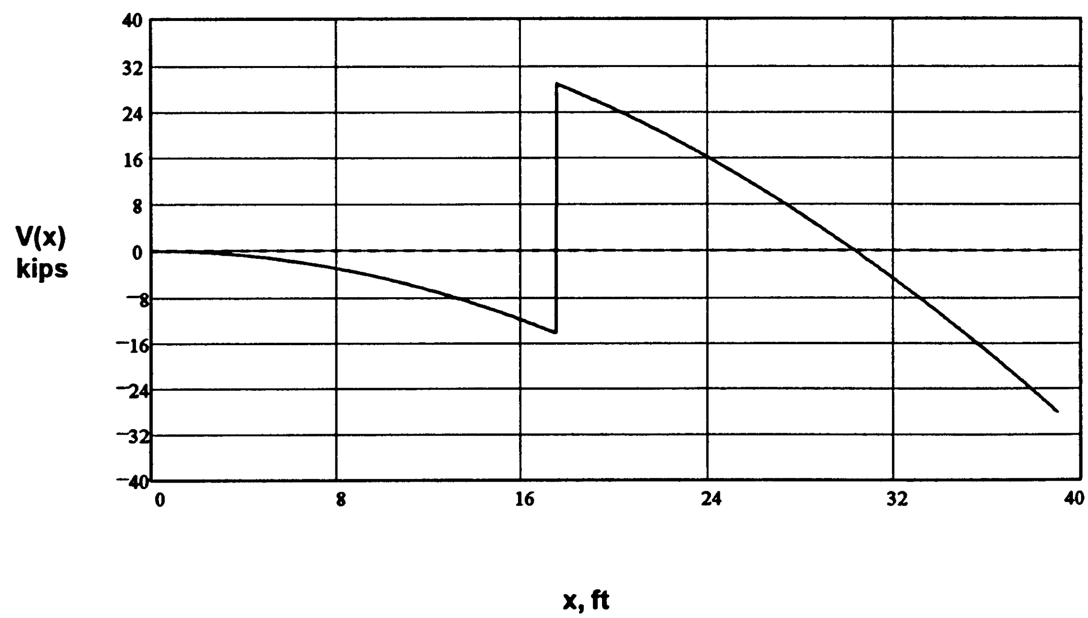
Plot of moment M(x) versus x for N points across the span

$N := 2000$ $M_{max} := M(x_o)$ $M_{max} = 117.085 \cdot kip \cdot ft$

$x := 0 \cdot ft, \frac{L}{N} .. L$



Plot of shear V(x) versus x for N points across the beam



Concrete Design:

$M_{max} := if(|M_{pos}| > |M1|, M_{pos}, M1)$ $M_{max} = 117.1 \cdot kip \cdot ft$

Factored moment required: $M_{req} := LL \cdot M_{max}$ $M_{req} = 258.8 \cdot kip \cdot ft$

Try:

$T := 48 \cdot in$ $b := 9 \cdot in$ $Bar := \frac{9}{8} \cdot in$ $cover := 4 \cdot in$ $\phi := 0.9$ ACI Sec. 9.3.2.1

$d := T - cover - \frac{Bar}{2}$ $d = 43.4 \cdot in$ $A_s := \frac{3.1416 \cdot Bar^2}{4}$ $A_s = 0.99 \cdot in^2$

$\beta_1 := if\left[f_c > 8 \cdot ksi, 0.65, if\left[f_c < 4 \cdot ksi, 0.85, 0.85 - \left(\frac{f_c - 4 \cdot ksi}{1 \cdot ksi}\right) \cdot 0.05\right]\right]$ $\beta_1 = 0.8$ ACI 10.2.7.3

$\rho_b := 0.85 \cdot \beta_1 \cdot \frac{f_c}{f_y} \cdot \left(\frac{87 \cdot ksi}{87 \cdot ksi + f_y}\right)$ $\rho_{max} := 0.35 \cdot \rho_b$ $\rho_{max} = 0.01$ ACI 10.3.3 & EM-1110-2-2104, pg 3-4

$\rho_{min} := 0.0018$ ACI 10.5.3 & 7.12

$\rho := \frac{A_s}{b \cdot d}$ $\rho = 0.0025$

$M_u := d^2 \cdot b \cdot f_y \cdot \phi \cdot \rho \cdot \left(1 - 0.59 \cdot \frac{f_y \cdot \rho}{f_c}\right) \cdot \frac{12 \cdot in}{b}$ $M_u = 253.2 \cdot kip \cdot ft$

$M_{req} = 258.8 \cdot kip \cdot ft$

$M_u > M_{max}$ OK

Horizontal shear:

$V_{req} := 1.7 \cdot V(L1)$ $V_{req} = 48.9 \cdot kip$

$b = 9 \cdot in$ $d = 43.4 \cdot in$ $\phi := 0.85$ ACI Sec. 9.3.2.3

$V_c := 2 \cdot \sqrt{f_c \cdot psi} \cdot b \cdot d \cdot \frac{12 \cdot in}{b}$ $V_u := \phi \cdot V_c$ $V_u = 56 \cdot kip$ ACI Sec. 11.3.1.1 & 11.5.5.1

$V_u > V_h$ OK

Summary

Wall thickness: $T = 48 \cdot in$

Vertical bars: $size := Bar \cdot \frac{8}{in}$ $size = 9$

$spacing := b$ $spacing = 9 \cdot in$

COMPUTATION SHEET

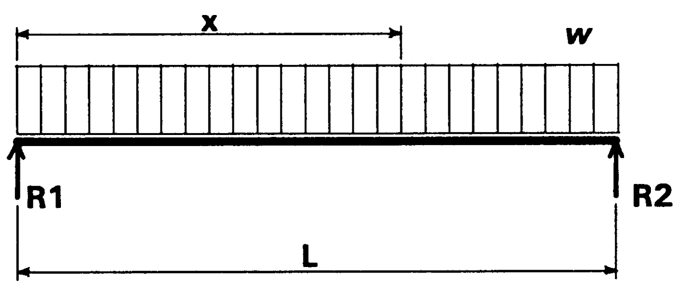
PROJECT: Grand Prairie Demostration Project
Eastern Arkansas

DESIGNED BY: Mike Watson

CHECKED BY: __________

SUBJECT: Grand Prairie Pumping Station (1640 CFS)

Load Case 2. Simple Beam Uniformly Loaded with Concentrated Load at Center of Span
Pump Bay Floor



Uniform Load Diagram

Defined Units:

$kip := 1000 \cdot lbf$ $\quad ksi := \frac{kip}{in^2}$ $\quad ksi \equiv 1000 \cdot psi$ $\quad kcf := \frac{kip}{ft^2}$

Input Variables

Span lengths:

Simple span length $L := 38 \cdot ft$

Concrete properties:

Design compressive strength of concrete: $f_c := 4 \cdot ksi$

Unit weight of concrete: $\gamma_c := 0.145 \cdot kcf$

Weight of reinforced concrete: $\gamma_{rc} := 0.150 \cdot kcf$

Steel properties:

Specified yield strength of reinforcement: $f_y := 60 \cdot ksi$

Steel modulus of elasticity: $E_s := 29000 \cdot ksi$

Load Factors:

Live load: $LL := 1.7$

Dead load: $DL := 1.4$

Hydraulic: $H_f := 1.3$

Uniform Load Analysis:

Slab thickness:	$T := 36 \cdot in$	
Uniform live load:	$w_L := 100 \cdot \frac{lbf}{ft}$	$w_L = 0.100 \cdot \frac{kip}{ft}$
Uniform dead load:	$w_D := T \cdot \gamma_{rc}$	$w_D = 0.450 \cdot \frac{kip}{ft}$
Total factored uniform load:	$w := H_f \left(DL \cdot w_D + LL \cdot w_L\right)$	$w = 1.040 \cdot \frac{kip}{ft}$
Reaction at point 1:	$R1 := \frac{w \cdot L}{2}$	$R1 = 19.76 \cdot kip$
Reaction at point 2:	$R2 := R1$	$R2 = 19.76 \cdot kip$

Factored moment at x: $M_w(x) := R1 \cdot x - \frac{w \cdot x^2}{2}$

Factored shear at x: $V_w(x) := R1 - w \cdot x$

Determine zero shear location:

$x := 0 \cdot ft$ $\quad x_o := root\left(V_w(x), x\right)$ $\quad x_o = 19 \cdot ft$

Maximum positive moment produced coincides with zero shear:

$M_{pos} := M_w\left(x_o\right)$ $\quad M_{pos} = 187.7 \cdot kip \cdot ft$

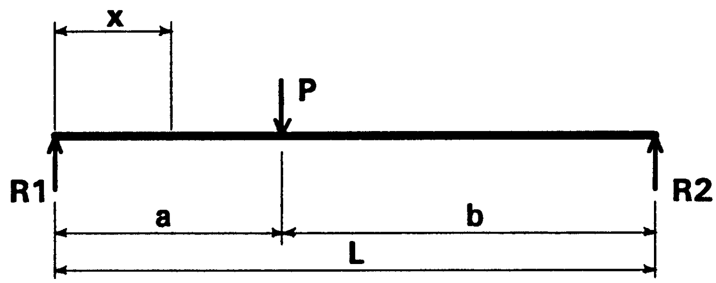
COMPUTATION SHEET

PROJECT: Grand Prairie Demostration Project
Eastern Arkansas

DESIGNED BY: Mike Watson

CHECKED BY: __________

SUBJECT: Grand Prairie Pumping Station (1640 CFS)



Concentrated Load Diagram

Concentrated Load Analysis:

Note: Assumed narrowest pump dimension is 54". Calculate concentrated load (P) to apply to a one foot strip of the floor slab by dividing crane capacity (60 kips) by 54" plus twice the slab thickness.

Crane Capcity:	$P_{crane} := 60 \cdot kip$	
Factored Concentrated Load:	$P := \left(H_f \cdot LL \cdot \frac{P_{crane}}{2 \cdot T + 54 \cdot in}\right) \cdot 12 \cdot in$	$P = 12.629 \cdot kip$
Concentrated Load Location:	$a := \frac{L}{2}$	$a = 19 \cdot ft$
	$b := L - a$	$b = 19 \cdot ft$
Reaction at point 1:	$R1 := \frac{P \cdot b}{L}$	$R1 = 6.31 \cdot kip$
Reaction at point 2:	$R2 := \frac{P \cdot a}{L}$	$R2 = 6.31 \cdot kip$
Moment at x<a:	$M_a(x) := R1 \cdot x$	
Moment at x>a:	$M_b(x) := (R1 \cdot x) - P \cdot (x - a)$	
Moment at x:	$M_p(x) := if(x<a, M_a(x), M_b(x))$	
Factored shear at x:	$V_p(x) := if(x<a, R1, -R2)$	

Maximum positive moments coincides with the concentrated loade:

$M_{pos} := M_p(a)$ $\qquad M_{pos} = 120 \cdot kip \cdot ft$

COMPUTATION SHEET

PROJECT: Grand Prairie Demostration Project
Eastern Arkansas

DESIGNED BY: Mike Watson

CHECKED BY: __________

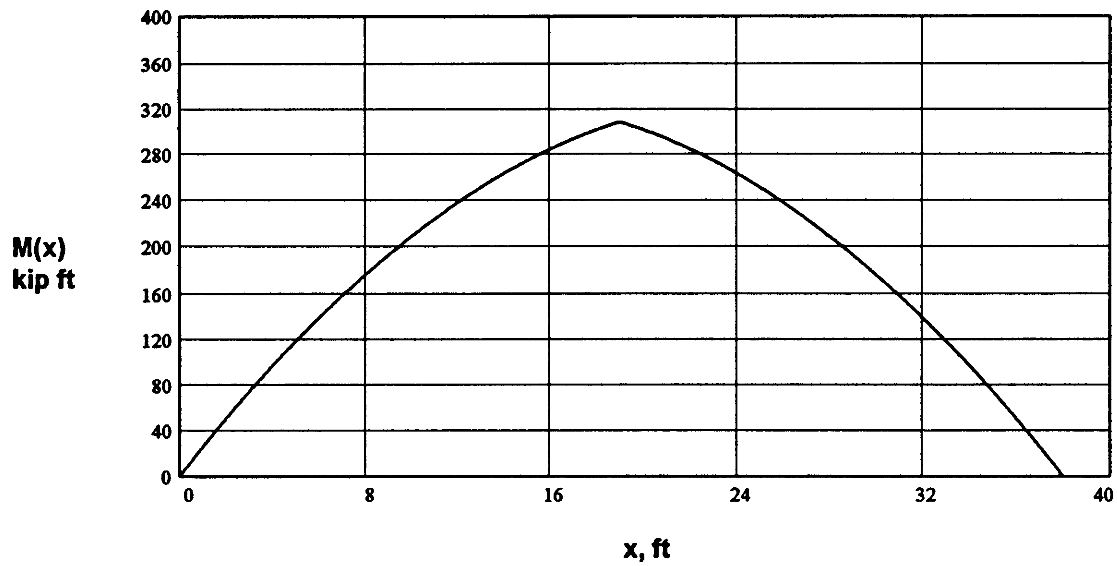
SUBJECT: Grand Prairie Pumping Station (1640 CFS)

Superimposed Shear and Moment Diagrams

Plot of moment M(x) versus x for N points across the span

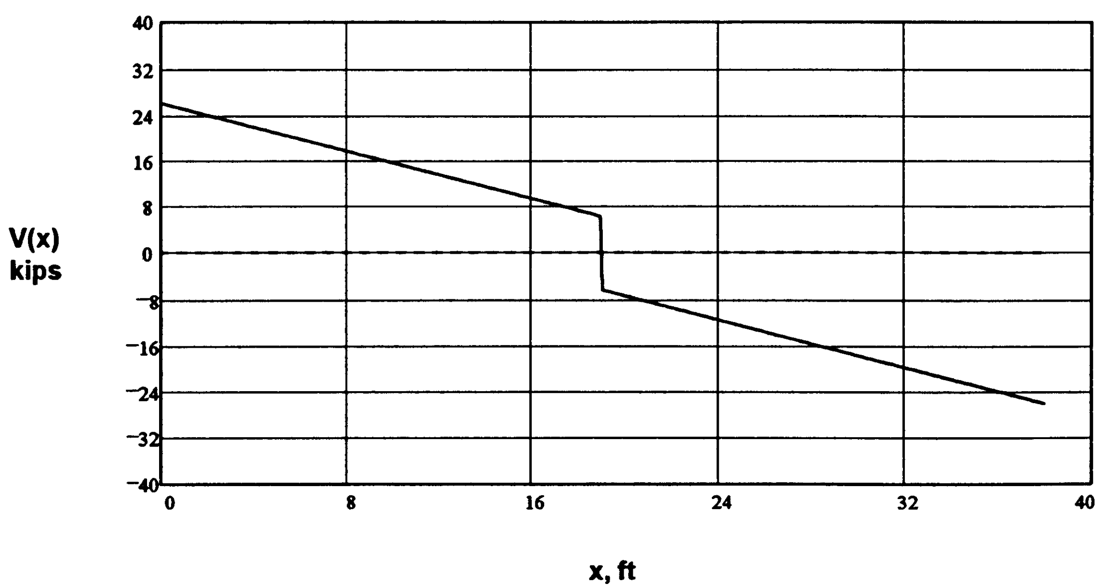
$N := 2000$ $\quad M(x) := M_w(x) + M_p(x)$ $\quad M_{max} := M\left(\frac{L}{2}\right)$

$x := 0 \cdot ft, \frac{L}{N} .. L$ $\quad M_{max} = 307.691 \cdot kip \cdot ft$



Plot of shear V(x) versus x for N points across the beam

$V(x) := V_w(x) + V_p(x)$



Concrete Design:

Note: Weight of the pumps, motors and vertical thrust will taken by pump column.

$M_{req} := M_{max}$

Factored moment required:

$M_{req} = 307.7 \cdot kip \cdot ft$

Try:

$T = 36 \cdot in$ $b := 5 \cdot in$ $Bar := \frac{9}{8} \cdot in$ $cover := 4 \cdot in$ $\phi := 0.9$ ACI Sec. 9.3.2.1

$d := T - cover - \frac{Bar}{2}$ $d = 31.4 \cdot in$ $A_s := \frac{3.1416 \cdot Bar^2}{4}$ $A_s = 0.99 \cdot in^2$

$\beta_1 := if\left[f_c > 8 \cdot ksi, 0.65, if\left[f_c \le 4 \cdot ksi, 0.85, 0.85 - \left(\frac{f_c - 4 \cdot ksi}{1 \cdot ksi}\right) \cdot 0.05\right]\right]$ $\beta_1 = 0.85$ ACI 10.2.7.3

$\rho_b := 0.85 \cdot \beta_1 \cdot \frac{f_c}{f_y} \cdot \left(\frac{87 \cdot ksi}{87 \cdot ksi + f_y}\right)$ $\rho_{max} := 0.35 \cdot \rho_b$ $\rho_{max} = 0.0100$ ACI 10.3.3 & EM-1110-2-2104, pg 3-4

$\rho_{min} := 0.0018$ ACI 10.5.3 & 7.12

$\rho := \frac{A_s}{b \cdot d}$ $\rho = 0.0063$

$M_u := d^2 \cdot b \cdot f_y \cdot \phi \cdot \rho \cdot \left(1 - 0.59 \cdot \frac{f_y \cdot \rho}{f_c}\right) \cdot \frac{12 \cdot in}{b}$

$M_u = 318.6 \cdot kip \cdot ft$

$M_{req} = 307.7 \cdot kip \cdot ft$

$M_u > M_{max}$ OK

Horizontal shear:

$V_{req} := \frac{V(0 \cdot ft)}{H_f}$ $V_{req} = 20.1 \cdot kip$

$b = 5 \cdot in$ $d = 31.4 \cdot in$ $\phi := 0.85$ ACI Sec. 9.3.2.3

$V_c := 2 \cdot \sqrt{f_c \cdot psi} \cdot b \cdot d \cdot \frac{12 \cdot in}{b}$ $V_u := \phi \cdot V_c$ $V_u = 40.6 \cdot kip$ ACI Sec. 14.2.3, 11.10.1, 11.3.1.1, 11.5.5.1

$V_u > V_h$ OK

Summary

$T = 36 \cdot in$ $L = 38 \cdot ft$ $P = 12.6 \cdot kip$ $w = 1.040 \cdot \frac{kip}{ft}$

$size := Bar \cdot \frac{8}{in}$ $size = 9$

$spacing := b$ $spacing = 5 \cdot in$

Grand Prairie Area Demonstration Project
Conceptual Design of Grand Prairie Pumping Station

APPENDIX V-J

GRAND PRAIRIE PUMPING STATION

DESIGN DEVELOPMENT

CONSTRUCTION COST ESTIMATE

U.S. Army Corps of Engineers
Memphis District

EAR - 1640 cfs Station

Discount Rate = 7.75				
'. FIRST COST OF PUMPING STATION				
DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
CIVIL				
MOBILIZATION & DEMOBILIZATION	50,000.00	1	LS	50,000.00
CLEARING & GRUBBING	25,000.00	1	LS	25,000.00
ASPHALT ROAD	45,000.00	1	LS	45,000.00
DEWATERING	500,000.00	1	LS	500,000.00
COFFERDAM	174,000.00	1	LS	174,000.00
EXCAVATION	1.50	342,000	CY	513,000.00
STRUCTURAL EXCAVATION	2.50	173,000	CY	432,500.00
RANDOM BACKFILL	3.00	120,000	CY	360,000.00
GRANULAR BACKFILL	10.00	30,000	CY	300,000.00
TOTAL FIRST COST CIVIL				2,399,500.00
STRUCTURAL - SUBSTRUCTURE				
CONCRETE				
SLAB ON GRADE	250.00	5,900	CY	1,475,000.00
ELEVATED SLABS	250.00	1,700	CY	425,000.00
VERTICAL WALLS	250.00	3,800	CY	950,000.00
COLUMNS	250.00	400	CY	100,000.00
REINFORCING STEEL				
SLAB ON GRADE	250.00	738	TON	184,500.00
ELEVATED SLABS	250.00	298	TON	74,500.00
VERTICAL WALLS	250.00	570	TON	142,500.00
COLUMNS	250.00	60	TON	15,000.00
STRUCTURAL - SUPERSTRUCTURE				
CONCRETE	250.00	800	CY	200,000.00
REINFORCING STEEL	600.00	140	TON	84,000.00
DECORATIVE CONCRETE BLOCK WALL	6.30	10,000	SF	63,000.00
METAL DOORS	550.00	9	EA	4,950.00
12 x 14 ROLL UP DOOR	2,625.00	1	EA	2,625.00
SUSPENDED CEILING	1.20	2,600	SF	3,120.00
10 FOOT HIGH STUD WALL	25.60	175	LF	4,480.00
SHEET ROCK WALL	0.80	6,100	SF	4,880.00
25 FOOT CHOCTOW BRIDGE TYPE UNITS	50.00	110	SF	5,500.00
BUILT-UP ROOFING	3.00	8,500	SF	25,500.00
STRUCTURAL STEEL (CRANE RAIL)	600.00	24	TON	14,400.00
GRATING (2 - 6 X 16 - SUPPORT TRUCKS)	25.00	192	SF	4,800.00
96" REINFORCED CONCRETE PIPE	120.00	500	LF	60,000.00
24" REINFORCED CONCRETE PIPE	20.00	600	LF	12,000.00
MISCELLANEOUS METALS	9,800.00	1	LS	9,800.00
TOTAL FIRST COST STRUCTURAL				3,865,555.00

EAR - 1640 cfs Station

DESCRIPTION	PRICE	QUANTITY	UNIT	TOTAL
MECHANICAL				
PUMP UNIT (84") 5300 bhp	1,190,000.00	4	EA	4,760,000.00
PUMP UNIT (42") 1650 bhp	315,000.00	2	EA	630,000.00
84" PUMP CONTROL VALVE	75,762.00	4	EA	303,048.00
84" GATE VALVE	221,725.00	4	EA	886,900.00
42" GATE VALVE	55,386.00	2	EA	110,772.00
42" PUMP CONTROL VALVE	14,474.00	2	EA	28,948.00
STEEL PIPE (1)				
DISCHARGE PIPE -42" diameter	297.00	250	LF	74,250.00
DISCHARGE PIPE - 84" diameter	519.00	350	LF	181,650.00
DISCHARGE HEADER - 120" diameter	702.58	17,600	LF	12,365,337.60
DRESSER COUPLING - 84" diameter	3,728.55	12	EA	44,742.60
DRESSER COUPLING - 42" diameter	715.05	8	EA	5,720.40
COMBINATION AIR RELEASE VALVES (6)	7,035.00	10	EA	70,350.00
PLUMBING	51,500.00	1	JOB	51,500.00
ROLLER GATES (9.5'x8') & OPERATORS	65,023.64	2	EA	130,047.28
ROLLER GATES (16'x8') & OPERATORS	97,881.92	4	EA	391,527.68
TRASH RACKS	70,367.00	6	EA	422,202.00
OVERHEAD TRAVELING CRANE	200,000.00	1	JOB	200,000.00
SUMP DEWATERING SYSTEM	54,662.36	1	JOB	54,662.36
FLOOR DRAINAGE SYSTEM	81,993.53	1	JOB	81,993.53
COMPRESSED AIR SYSTEM (PUMPS/TANK)	80,472.00	1	JOB	80,472.00
POTABLE WATER WELL - FULLY DEVELOPED	50,000.00	1	JOB	50,000.00
HEAT/AIR CONDITIONING	12,710.25	1	JOB	12,710.25
MOBILE CRANE	250,000.00	1	EA	250,000.00
SEWAGE DISPOSAL	7,500.00	1	JOB	7,500.00
REFRIGERATOR	1,516.00	1	JOB	1,516.00
ELECTRIC RANGE & VENTILATOR HOOD	1,060.00	1	JOB	1,060.00
ELEVATOR/HYDRAULIC EQUIPMENT (2)	40,000.00	1	JOB	40,000.00
MOTORIZED ROOF VENTILATORS (3)	3,167.25	12	EA	38,007.00
COMBINATION LOUVERS W/ MOTORS (4)	669.87	8	EA	5,358.96
TOTAL FIRST COST MECHANICAL				21,280,275.66
ELECTRICAL				
LIGHTING	46,400.00	1	JOB	46,400.00
GROUNDING SYSTEM	1,200.00	1	JOB	1,200.00
CATHODIC PROTECTION	16,000.00	1	JOB	16,000.00
WIRE AND CABLE	231,750.00	1	JOB	231,750.00
ALARM SYSTEM	25,128.00	1	JOB	25,128.00
TRANSFORMERS	6,000.00	1	JOB	6,000.00
4160 VOLT MOTOR CONTROL CENTER	116,009.00	1	JOB	116,009.00
480 VOLT MOTOR CONTROL CENTER	94,716.00	1	JOB	94,716.00
SAFETY SWITCHES	17,100.00	1	JOB	17,100.00
WATER LEVEL SENSORS	13,500.00	1	JOB	13,500.00
COMMUNICATIONS	4,500.00	1	JOB	4,500.00
CONTROL ROOM	23,750.00	1	JOB	23,750.00
SWITCHGEAR (MAIN) AND BUSWORK	134,178.00	1	JOB	134,178.00
MISCELLANEOUS	691,408.00	1	JOB	691,408.00
TOTAL FIRST COST ELECTRICAL				1,421,639.00
TOTAL FIRST COST				28,966,969.66

Appendix V-J-2

EAR - 1640 cfs Station

	PLANT COST	LIFE	L.C.C.	ANNUAL COST
II.REPLACEMENT COST				
PUMP IMPELLERS (20%)	225,670.00	40	11,972	928.39
ELECTRIC MOTOR STATOR (40%)	300,890.00	35	23,689	1,836.94
MOTOR CONTROL CENTERS	210,725.00	35	16,590	1,286.48
ROOF (93 SQUARES)	270,135.00	20	78,104	6,056.50
IV.OPERATING COST				
LABOR			2,608,427	202,269.00
ENERGY CHARGES (5)			43,808,670	3,397,119.00
V.SUMMARY				
TOTAL FIRST COST MECHANICAL			21,280,276	1,650,167.17
TOTAL FIRST COST ELECTRICAL			1,421,639	110,240.21
TOTAL FIRST COST CIVIL			2,399,500	186,067.90
TOTAL FIRST COST STRUCTURAL			3,865,555	299,752.32
REPLACEMENT COST			130,355	10,108.31
OPERATING COST			46,417,097	3,599,388.00
TOTAL			75,514,421	5,855,723.90

(1) Cost quoted from the R. J. Gallagher Co., Memphis, TN.

(2) Cost quoted from Dover Elevators, Memphis,TN.

(3) Cost quoted from Gorham - Schaffler, Inc., Memphis, TN., a Greenheck Representative

(4) Cost quoted from Mills - Wilson - George, Memphis, TN., an Industrial Louver representative.

(5) Based on $0.047 per KWH of firm power to operate all 6 pumps.

(6) Cost quoted from Valve and Primer Corp., Chicago, IL