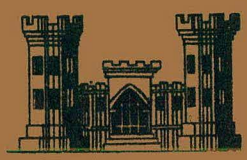
ARKANSAS RIVER LEVEES

PUMPING STATIONS
NORTH LITTLE ROCK

ARKANSAS

ANALYSIS OF DESIGN



U. S. ENGINEER OFFICE
LITTLE ROCK, ARK.
MARCH 1941

WAR DEPARTMENT
U. S. ENGINEER OFFICE
LITTLE ROCK, ARKANSAS

ANALYSIS OF DESIGN

PUMPING STATIONS

NORTH LITTLE ROCK

ARKANSAS

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FOREWORD

This report supplements the plans and specifications for the pumps, motors, and pumping stations of North Little Rock, Arkansas, and is prepared for the purpose of facilitating the examination and review by higher authority.

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WAR DEPARTMENT
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ANALYSIS OF DESIGN

PUMPING STATIONS - NORTH LITTLE ROCK, ARKANSAS

1. Authority. - The North Little Rock Pumping Stations were authorized for construction by the War Department Civil Appropriation Act, 1941, approved June 24, 1940.

2. Purpose. - The levee and floodwall constructed under previous authority provide adequate flood protection to the city but make necessary some means of disposing of drainage and sanitary sewage when the normal outlets are blocked by Arkansas River floodwaters. An existing pumping station known as the Baring Cross Station serves the western two-thirds of the area. The proposed pumping stations will serve the remaining part of the area, which includes the business section of North Little Rock, and thus will render the flood protection works fully effective.

3. Scope. - This analysis is supplementary to the Basis of Design which forms a part of the Definite Project Report. Reference is made thereto for a general description of the area concerned, including the existing Baring Cross Pumping Station, and a discussion of the hydrology upon which the design of the project is based. This report summarizes the findings of the Basis of Design and discusses data with regard to the pumps as adopted and the structural design and principal features of the proposed pumping stations. It has been

prepared for submission to facilitate the review of the construction plans and specifications for the North Little Rock Pumping Stations by higher authority.

4. Summary of Findings Developed in Basis of Design.

a. Stations Required. - The studies outlined in the Basis of Design developed the need for three pumping stations to be located near the floodwall and levee: a Main Street Station to dispose of the storm water run-off from an area of 150 acres including the main business section of North Little Rock; a Hickory Street Station to dispose of the storm water run-off from a residential and partly undeveloped area of 220 acres; and a Cedar Street Station to dispose of the sanitary sewage from an estimated population of about 5,000. The stations will be located as shown on Plate I, page 25.

b. Maximum Flow Rates. - The probable maximum flow rates, based on a 20-year frequency as determined by correlating run-off with river stages requiring pumping, were found to be as follows: at the Main Street Station, 73,000 gallons per minute; at the Hickory Street Station, 66,000 gallons per minute; and at the Cedar Street Station, 566 gallons per minute.

c. Pump Capacities. - At the Main Street Station, pump capacity equal to the maximum flow rate, or 73,000 gallons per minute, was considered desirable. At the Hickory Street Station, the study disclosed that present sewer capacity was about 16,000 gallons per minute; that there was little prospect of extensive future storm water sewer improvements; and that a considerable

volume of storage was available. It was concluded that a present pump capacity of 20,000 gallons per minute would be satisfactory but that provision should be made at the pumping station for a future increase in capacity. At the Cedar Street Station, the conclusion was reached that a capacity of 750 gallons per minute should be provided together with a stand-by unit of like capacity and provision for a future increase in capacity.

5. Approved Project. - The Definite Project was approved by the Office, Chief of Engineers, subject to the following conditions:

"a. The capacity of the Hickory Street Station should be increased to provide for the initial installation of two 15,000 g.p.m. pumps, with provision for an additional 15,000 g.p.m. pump if future conditions indicate that such action is necessary. * * *

"b. Provision should be made to keep the sanitary sewage out of the buildings. * * * Other changes in the lay-out of the pumping stations, * * * should be made. These are briefly as follows: * * *

"(1) Alter the intake to the Main Street Station so that the normal flow will reach the small pump without passing through the main pumping pit.

"(2) Provide a bypass in the Main Street Station so that the storm water pumps will not have to start and stop too frequently.

"(3) Use full voltage starters for the motors if this is not objectionable to the Power Company."

Present plans conform to these requirements except that:

(1) In conference, it was pointed out that no sanitary sewage reaches the Main Street Station and it was agreed full compliance with requirement b(1) would not be necessary.

(2) Requirement b(3) was discussed with officials of the city of North Little Rock, who made strenuous objection to such procedure. The municipally owned power company now restricts such commercial installations and objects to the use of full voltage starters on motors of more than 50 hp. As this appears in line with general commercial practice, plans are made in conformity therewith.

In summary, the approved project provides for the following equipment:

Station	Number of Pumps	Type	Rated Capacity	Total Capacity
Main Street	1	Volute	3,000	
	2	Propeller	10,000	
	2	Propeller	25,000	73,000
Hickory Street	2 (1)	Propeller	15,000	30,000
Cedar Street	2 (1)	Volute	750	750 (2)

(1) Provision is made for the future installation of an additional unit.

(2) One unit of present installation to be used for standby service.

6. Functioning of Stations.

a. General. - The Main and Hickory Street Stations will receive storm water run-off; the Cedar Street Station, only sanitary sewage.

b. Main Street Station. - The normal gravity flow now passes through a 5-foot diameter opening in the floodwall at the foot of Main Street where a slide gate is provided to prevent

backflow. The pumping station lay-out will provide a separate bypass through the floodwall into a suction well from which the pumps will discharge back into a chamber which connects to a 4-foot by 7-foot conduit leading into the gravity outlet at the existing gate well on the riverside of the wall. A slide gate will be provided in the bypass inlet to the suction well just landward of the floodwall to prevent gravity flow from entering the sump. In operating the station, the gravity outlet will first be closed, the gate in the bypass inlet opened, the switchboard energized, and pumping started under manual control. Thereafter, provision is made for automatic operation. A 24-inch pipe, controlled by a hand-operated gate valve designed for low heads, will connect the suction well with the outlet conduit. This bypass can be operated to return flow to the sump so as to obviate frequent starting and stopping of the pumps or, at river stages exceeding elevation 247, to admit water to the sump before opening the inlet slide gate and thereby equalize the stage on opposite sides of the gate. A low weir in the outlet conduit will be provided in order to cause the 24-inch bypass to run full under low-water pumping conditions. Lay-out and sections are shown on Plate II, page 26.

c. Hickory Street Station. - Gravity flow now passes through the levee in a reinforced concrete culvert with a gate at the river end. The station will be located adjacent to the culvert on the landside with the suction well at the same level as the culvert inlet (elevation 236). When the gravity outlet is closed, flow will be ponded above, and at stage 239 (elevation of inlet weir) will have

free access to the suction well. The estimated minimum pump drawdown level is elevation 241, at which stage the heading up due to the inlet weir is estimated as less than 1/2 inch. The pumps will discharge through pipes over the top of the levee. As at the Main Street Station, pumps will be started under manual control, and thereafter operation will continue automatically until power is again cut off from the switchboard. Lay-out and a section are shown on Plate III, page 27.

d. Cedar Street Station. - This station will be located landward of the existing gravity outlet through the floodwall so as to provide a distance of 24 feet between the wall and the building. The lay-out provides for directing the flow by means of two gate valves, one in the gravity outlet and one in the inlet to a depressed suction well. Pumps will be set in a dry pit and will discharge back into the gravity line below the gate valve and landward of the floodwall. In starting operation, the gravity outlet will first be closed, then flow will be admitted to the suction well, and pumping started manually. Thereafter, operation will continue automatically. Lay-out and sections are shown on Plate IV, page 28.

7. Type of Pumping Equipment.

a. General. - The storm water pumps must have large capacity, will be used infrequently, and ordinarily will operate under heads of 10 feet to 15 feet with a possible maximum head of about 20 feet. Vertical, propeller type pumps are particularly adapted to such service in that they are comparatively inexpensive.

develop good efficiency, and require a minimum of space, particularly when driven by vertical motors. Accordingly, the large pumps will be of the vertical, propeller type. In addition to the storm water pumps, there is a need for one trash pump and two sanitary sewage pumps. In this case, the choice was determined by the ability of the pumps to pass comparatively large solids and be relatively free from stoppage due to clogging of the impeller or pump passages. Nonclogging trash and sewage pumps of the volute type are outstanding in such service and have been adopted. All pumps will be powered by electric induction motors. The study outlined in the Basis of Design indicated this source of power to be economical, reliable, and convenient, especially since the city of North Little Rock operates its own electric distribution system.

b. Propeller Pumps.

(1) Setting. - General data from pump manufacturers indicate that these pumps should be set so as to draw water from a sump area 2-1/2 to 3 times the pump diameter and that the suction bell should be about one diameter above the pump floor. In general, the data indicate that best performance will be secured by a pump setting which tends to prevent prerotation of the water and a consequent tendency to vortex formation with attendant noise and vibration. Tests made for the U. S. Engineer Office, Memphis, Tennessee, in connection with the design of the Nonconnah pumps, indicated that a width of suction bay equal to about 2-1/2 times the pump diameter gave excellent results, and that the suction bell could be set at a minimum distance

of 0.8 of the pump diameter above the sump floor and still secure good performance. These indicated settings appear to agree reasonably well with the practice of the Bureau of Reclamation. A recent design of this bureau provides about this individual sump width, together with a shaping of the back wall of the sump, in somewhat the same manner as a turbine scroll case; that is, the back wall is made up of two concave curves which meet in a line contacting the edge of the suction bell. Such construction should prevent prerotation of the incoming flow and guide it directly into the suction intake. In general, there appears to be an advantage in setting these pumps in individual sump compartments rather than collectively in one large pit without division walls. The individual settings make more certain that each pump will operate to capacity without undue influence from adjacent pumps. Subsequent to the design, model test results have become available relative to the setting of propeller pumps. These data appear in Technical Memorandum No. VI, of the University of California, College of Engineering, and are in general agreement with the principles discussed herein.

(2) Speed. - The pump speed which will prove satisfactory under service conditions is dependent upon the head, capacity, and suction submergence. The relation between head, capacity, and speed is expressed by the specific speed formula which is as follows:

$$N_s = \frac{\sqrt{g.p.m.} \times r.p.m.}{H^{3/4}}$$

where N_s indicates specific speed;
g.p.m. is discharge in gallons per minute;
r.p.m. is speed in revolutions per minute;
H is the total dynamic head in feet.

Specific speed applies to the point or zone of maximum pump efficiency and not to the entire range of operation. It indicates the speed in r.p.m. at which a geometrically similar impeller must run if of such size as to discharge one gallon per minute against a head of one foot. It has been found that for a given head and capacity, a pump of low speed and consequently low specific speed will operate safely with less submergence than one of higher speed. The Hydraulic Institute has recommended and published upper limits of specific speed for centrifugal, mixed flow, and propeller type pumps in the form of a chart. Recent practice with respect to specific speed requirements for propeller pumps is indicated below:

SPECIFIC SPEED OF PROPELLER PUMPS INDICATED BY RECENT DATA

Agency and project	Ref. No.	Pump characteristics: Capacity 1,000 g.p.m.	Pump characteristics: Approx. head feet	Specific speed	Source of data
U. S. Engineer Department:					
Coredo-Kenova	1	5 -18.5	20-40	13,000	Spec. 516-39-297 dated May 1939
Huntington	2	17 -25	13-36	11,000	Spec. 516-41-41 dated Sept. 1940
Nonconnah and Cypress Creek	3	225	25	10,000	Report of tests July 1940
U. S. Bureau of Reclamation:					
Tule Lake - Klamath Project	4	3.6 -7.2	10-13.5	11,000	Spec.1442-D, dated Oct. 1940
Contra Costa Plants 1 to 4	5	16 -32	23-33	8,000	Spec. 758, dated Feb. 1938
	6	15 -30	50.5	6,000	
Buford-Trenton	7	36	21-31	8,100	Spec.1447-D, dated Nov. 1940

Note: Pumps included under reference numbers 5, 6, and 7, will operate a much greater proportion of the time than others listed.

Specifications provide that the North Little Rock propeller pumps have a specific speed not exceeding 11,000.

c. Volute Pumps. - The volute pumps required are of small capacity and present no unusual features. Specifications require that the sewage pumps pass a 4-inch sphere and the trash pump pass a 5-inch sphere, the intention being to secure 6-inch and 8-inch pumps, respectively. Specific speed for these pumps has been limited to 4,000.

8. Equipment Incidental to Operation.

a. Controls. - Automatic, multiple-switch, float controls will be provided at all stations so as to maintain the level of water in the several suction wells at safe elevations and provide for varying rates of flow. One float will control all the pumps in any station (sump pump at Cedar Street excepted) by energizing successive circuits through tilting mercury switches causing various pump combinations to become operative. Only at the Main Street Station, where it will be necessary to control five pumps, will the system be well developed. The type of control provided will be such as to permit ready adjustment of the stage setting at which units function.

b. Gates and Valves.

(1) Main Street Station. - A 5-foot by 5-foot square slide gate will be provided at the inlet behind the trash racks to prevent the normal gravity flow from reaching the station sump. A light gate, designed for a head of 15 feet, is specified. The gate

will be hand operated and geared so that one man can open it against a head of 10 feet. The bypass at the station insures that it will not be necessary to operate the gate under a greater head. At this station all pump discharge lines will be closed against backflow by flap gates of rugged design. This type of gate will permit automatic operation and has given satisfactory service under like operating conditions. No other provision against backflow is considered necessary.

(2) Hickory Street Station. - No slide gates, flap gates, or gate valves will be employed in the construction of this station. An existing slide gate will protect against backflow. Automatic siphon break valves will be used in the discharge lines over the levee to prevent backflow due to siphon action when pumping stops.

(3) Cedar Street Station. - The design provides two 24-inch gate valves (see subparagraph 6d) designed for a 30-foot head. Smaller gate valves will be used in the suction and discharge lines of each pump to provide for dismantling under flood conditions. Check valves in each individual discharge line will permit automatic pump operation and prevent backflow.

c. Cranes. - For the installation and ready servicing of pumps, hand-operated cranes will be provided at the Main Street and the Hickory Street Stations of 5-ton and 4-ton capacity, respectively. At the Main Street Station a distance of 12 feet will be provided between the motor floor and the lifting hook in raised position. At the Hickory Street Station this distance will be 11 feet 6 inches.

Pump columns and shafts will be made in such lengths as to permit installation and removal with this available head room. The travel of the cranes will be sufficient to service the station sumps.

9. Main Street Station.

a. Equipment. - A pump capacity of 73,000 g.p.m., or about 160 c.f.s., is to be provided. The low flow is only about 1,000 g.p.m., or slightly more than 2 c.f.s., and since relatively little storage is available, the variations in flow must be absorbed by the station equipment. Two means toward this end are provided: a comparatively large number of units so as to provide flexibility in operation and a gated bypass between suction sump and discharge outlet such that inflow may be made to approximate outflow, and frequent starting and stopping of the pumps thus prevented. Units selected include one volute type sump pump of 3,000 g.p.m. capacity, two propeller pumps of 10,000 g.p.m. capacity, and two propeller pumps of 25,000 g.p.m. capacity.

b. Operation. - Evidently all of the pumps should not be started at the same time, for in such case the suction sump probably would be emptied before normal inflow could be established. The automatic operation desired requires that each pump be assigned a range in which it will operate such that additional units come into operation at successively higher stages. The sump elevation must then be such as to provide adequate submergence for the pumps first in service. This consideration led to fixing

the sump level at elevation 234 at this station. A pit will be provided in the sump floor to make possible the unwatering of the sump chamber. The floodgate in the gravity outlet probably will be closed when the river stage reaches elevation 245 and run-off thereafter pumped until the river again recedes. However, the design permits closing the outlet at a lower stage and maintaining a suction level limited only by the capacity and draw-down of the pumps. The operation assumed in the design is indicated in the following tabulation:

ASSUMED PUMP OPERATION

Pump No.	1	2	3	4	5
Capacity, g.p.m.	3,000	10,000	10,000	25,000	25,000
Starting Stage	237	241	243	245	247
Cut-off Stage	233	239	240	242	243
Minimum Submergence, ft.	1	3	4	5	6

c. Design Conditions. - The grade of the flood protection works is such as to provide a 3-foot freeboard above the 1927 flood and the design of the floodwall considers water at its top. The maximum river stage considered in pump operation is one foot below top of wall, or about elevation 259, and the stage at which the pumps are designed to give rated capacity is 253, or slightly above the midpoint in the range of expected operation (245-259). Assumed design conditions are set out in further detail in the following tabulation:

DESIGN CONDITIONS - MAIN STREET STATION

Item	Rated Condition			Maximum Operating Condition		
Pump No.	1	2 & 3	4 & 5	1	2 & 3	4 & 5
Capacity, g.p.m.	3,000	10,000	25,000	(1)	(1)	(1)
c.f.s.	6.67	22.2	55.6			
Assumed discharge diameter, inches	10	20	36			
River stage, elevation	253	253	253	259	259	259
Suction level	233	239	242	233	239	242
Static head, feet	20	14	11	26	20	17
Estimated losses beyond pump, feet	3	0.3	0.2	2	0.3	0.2
Equivalent static head on pump, feet	23	14.3	11.2	28	20.3	17.2

(1) Assumed as about 90% of rated capacity.

10. Hickory Street Station.

a. Equipment. - Two propeller pumps of 15,000 g.p.m. capacity each will be installed initially with provision for the future installation of a third unit. The relatively large volume of storage available at the site will absorb variations in flow and makes a bypass within the station, such as is supplied at the Main Street Station, unnecessary. About 150 feet of discharge piping will be required at this station to carry pumpage over the levee and discharge it safely. Embedded pipe sections will be Class B cast iron; the remaining sections will be 3/8-inch welded pipe made of corrosion-resisting steel. Pipes will be supported at approximately 18-foot centers on concrete pedestals. At the outlet end a depressed concrete apron will be provided to still the discharge and prevent erosion of the sandy earth material. The apron headwall will incorporate a large block of concrete to which the pipes will be securely anchored so as to transfer the dynamic reactions incident to operation. Outlet piping was designed to discharge at least 5 feet below flood stage in the river.

b. Operation. - The expectation is that the gravity outlet will be closed at about the same time as that at Main Street but the design permits some latitude in action. The suction level which can be maintained will depend upon the capacity and limit of draw-down of the pumps. The sump level was fixed by the elevation of the culvert inlet at 236 and the limit of feasible draw-down was considered as about 241. It is assumed that one pump will come into operation at a suction level of 243 and the other at a suction level of 245. Pumps would cut off at an elevation not lower than 241.

c. Design Conditions. - The grade of the levee is at about elevation 259 and the center of the discharge line will reach an elevation of about 261. The maximum river stage considered in pump operation is 258 and the stage for rated flow delivery is taken as 252. These conditions are comparable to those assumed at the Main Street Station. The design conditions are set out in further detail below:

DESIGN CONDITIONS - HICKORY STREET STATION

Item	Rated Condition	Starting Condition	Maximum Operating Condition
Pump capacity, g.p.m.	15,000	(1)	(1)
c.f.s.	33.3		
Assumed discharge diameter, inches	24		
River stage or control elevation	252	261 (2)	258
Suction level	241	243	241
Static head, feet	11	18	17
Estimated losses beyond pump, feet (3)	2	2	2
Equivalent static head on pump, feet	13	20	19

(1) Assumed as 80% to 90% of rated capacity.
(2) Assumed high point on center of discharge.
(3) Based on 135 feet of 24-inch pipe with flared discharge. (Flare omitted in final design.)

11. Cedar Street Station.

a. Equipment. - The Cedar Street Station will dispose of only sanitary sewage. Pumps will be of the nonclog sewage volute type and will be placed in a dry pit with suction sump so located as to exclude sewage and gases from the building and pump pit. To care for the maximum anticipated flow of 566 g.p.m. and to provide reserve capacity, a service unit of 750 g.p.m. capacity and a like stand-by unit is provided. Provision is also made at the station for the future installation of an additional unit. A small sump pump will care for seepage and leakage.

b. Operation. - The top of the 24-inch inlet (fixed by present sewer grade) will be about elevation 235 and it is probable that the gravity outlet will be closed sometime after the river stage reaches this elevation. The suction sump is set at elevation 231 so as to provide a limited volume of storage and to permit sufficient draw-down within the sump to establish free outflow in the main sewer above and thus prevent deposition. Pumping, once started, will continue under automatic control. It is assumed that the starting elevation will be set at 237 and the cut-off about elevation 230.5.

c. Design Conditions. - The river stages assumed in pump operation are 258.5 as a maximum and 252.5 when the pumps are delivering their rated capacity. These are comparable to the conditions considered at the other stations. The design conditions are set out in further detail in the following tabulation:

DESIGN CONDITIONS

Description	Rated Condition	Maximum Operating Condition
Pump capacity, g.p.m.	750	(1)
c.f.s.	1.67	
Assumed discharge diameter, inches	6	
River stage	252.5	258.5
Suction level	230.5	230.5
Static head, feet	22	28
Estimated losses exclusive of pump	5	4
Equivalent static head on pump	27	32

(1) Assumed as 90% of rated capacity.

12. Soil Investigations. - The field explorations made in preparation for the design of the stations consisted of auger borings with visual field classifications at each of the three sites. Locations of holes and logs of materials encountered are shown on Plates II, III, and IV, pages 26, 27, and 28, respectively. In general, all materials may be considered cohesionless. No laboratory tests were made to determine physical properties of the materials. Accordingly, unit weights and pressures were estimated. Values used in the design are set out in subparagraph 13a(1). As a result of the investigations, the conclusion was reached that the foundations will safely support any load likely to be imposed by the design. The maximum foundation pressure at each station was estimated to be as follows:

Station	Maximum Foundation Pressure Lbs. per Sq. Ft.
Main Street	2,100
Hickory Street	2,000
Cedar Street	1,900

13. Structural Design Criteria.

a. Assumed Loadings.

(1) Unit Weights and Horizontal Pressures. - The following unit weights and horizontal pressures for material were assumed in the design of the structure:

	Weight Lbs. per Cu. Ft.	Horizontal Pressure Lbs. per Sq. Ft.
Water	62.5	62.5
Moist Earth	124	41.5
Saturated Earth	124	83
Concrete	150	-
Steel	490	-
Wind Load	-	30

(2) Hydrostatic Uplift. - The uplift pressure was assumed to be 100 percent of the hydrostatic pressure applied over the base of the pump houses. Elevations considered are indicated below:

	Main Street	Hickory Street	Cedar Street
Outside Hydrostatic	260	250	252
Sump Level	234	238*	230

*Approximate elevation of pump suction bell.

(3) Roof. - The roof slab and beams were designed for dead load plus a live load of 40 pounds per square foot.

(4) Motor Floors. - The motor floors were designed to carry the weight of all pumps suspended from the floor plate as well as a surrounding uniform live load of 250 pounds per square

foot, or a concentrated live load due to the heaviest single part of one pump. To the machinery loads (pumps and motors), an impact factor of 50 percent has been added. The weights of pumps and motors used in the design are as follows:

Capacity of Unit g.p.m.	Approximate Weight, Lbs.
25,000	18,000
15,000	9,000
10,000	7,000
3,000	3,800
750	1,800

Estimated weights accompanying contract bids indicate that the above-assumed weights are sufficiently close for design purposes.

(5) Columns and Crane Runway. - The columns were designed to carry the full loads from the roof; dead load, live load, and impact effect from the traveling crane; and bending due to the eccentric loads. In the design a hinged condition at the base was assumed. Crane runways were designed to carry the rated crane load, plus a vertical impact of 25 percent. At the Cedar Street Station an overhead beam designed for a concentrated live load of 1,000 pounds will be provided to support tackle required in installation or removal of pumps.

(6) Transformer Platforms. - The design loads included the estimated weight of transformers, plus a live load of 250 pounds per square foot.

(7) Stairway at Main Street Station. - A live load of 100 pounds per square foot was used.

(8) Trash Racks. - The vertical trash rack bars will be spaced at 3-1/2-inch centers and were designed to carry a water load of 5 feet, or 312.5 pounds per square foot.

(9) Underground Structures. - In general, these structures were designed for the unit loads indicated in subparagraph 13a(1). At the Main Street inlet chamber the north wall is designed for an added surcharge of 1,000 pounds per linear foot to take care of the load imposed by the adjacent railroad, and the top slab below ground level was also designed for this railroad loading. The grating and top slab above ground level were designed for a live load of 250 pounds per square foot. The outlet culvert along the floodwall on the riverside at the Main Street Station was designed to resist internal pressure due to pumping and external pressure due to a saturated earth load with top of fill at elevation 252, plus a live load of 200 pounds per square foot.

b. Unit Stresses.

(1) Reinforced Concrete. - The allowable working stresses in concrete, as used in the design, are based on a compressive strength of 3,000 pounds per square inch at 28 days. The working stresses tabulated below, except for reinforcing steel, are the same as those contained in "Standards of Design for Concrete," U.S. Navy Department, Bureau of Yards and Docks (No. 3Yb, November 15, 1929).

(a) Flexure

	Lbs. per Sq. In.
Extreme fiber stress in compression	1,050
Extreme fiber stress in compression adjacent to supports of continuous or fixed beams or of rigid frames	1,200

	Lbs. per Sq. In.
(b) Shear.	
Beams with no web reinforcement and without special anchorage of longitudinal steel	60
Beams with no web reinforcement but with special anchorage of longitudinal steel	90
Beams with properly designed web reinforcement but without special anchorage of longitudinal steel	180
Beams with properly designed web reinforcement and with special anchorage of longitudinal steel	270
(c) Bond.	
Deformed bars	150
Deformed bars with special anchorage of longitudinal steel	300
(d) Bearing.	
Load over entire area	750
(e) Steel Stresses.	
Tension	18,000
Web reinforcing	16,000

(2) Structural Steel. - The design of structural steel members was carried out in accordance with the "Standard Specifications for Steel Construction" of the American Institute of Steel Construction.

(3) Bearing on Soil. 5,000 Lbs. per Sq. Ft.

(4) Moduli of Elasticity.

		Lbs. per Sq. In.
Steel	Es =	30,000,000
Concrete (3,000 p.s.i.)	Ec =	3,000,000

Value of n = Es/Ec = 10

(5) Coefficient of Expansion.

.0000065 parts per degree Fahrenheit.

(6) Protective Cover for Principal Reinforcement. - The thickness of concrete covering, measured from the face of concrete to the face of the reinforcement, shall not be less than indicated below:

Slabs	1 inch
Beams	1-1/2 inches
Slabs and beams exposed to water or earth, but poured against forms	2 inches
Members poured directly against the ground	3 inches

14. Type of Construction. - All three stations will be of the same general type of construction embodying reinforced concrete substructures with superstructures above the motor floor of hollow tile with brick veneer. Flat roofs of reinforced concrete supported on structural steel beams and covered with 5-ply tar and gravel roofing will be provided. In the design of the Main Street and Hickory Street buildings, structural steel frames were provided to carry the crane and roof loads. The Cedar Street building will be comparatively small so that the structural steel columns have been omitted in the design and the roof beams supported on the 12-1/2-inch walls. The 12-1/2-inch walls will be common to all stations. Glass block panels will be used for architectural effect and for lighting. Each building will be provided with roof ventilators and louvers of ample size to provide for the circulation of air. Superstructure

exteriors will be of face brick with cut stone trim. The substructures were designed as reinforced concrete rigid frames, carrying horizontal and/or vertical loads as may be permitted by the special wall openings required in any particular case. No contraction joints will be provided except in the outlet culvert at the Main Street Station opposite similar joints in the floodwall.

15. Incidental Work not Included in Construction Plans.

a. Riprap Protection at Main Street and Hickory Street Outlets. - As set out in the Basis of Design, riprap protection at these outlets is contemplated. However, experience in doing like work along the Arkansas River in the vicinity of Little Rock indicates that the work can be done most economically and satisfactorily under a separate contract. Accordingly, it is proposed to do the work in this manner rather than as a part of the general contract for constructing the stations.

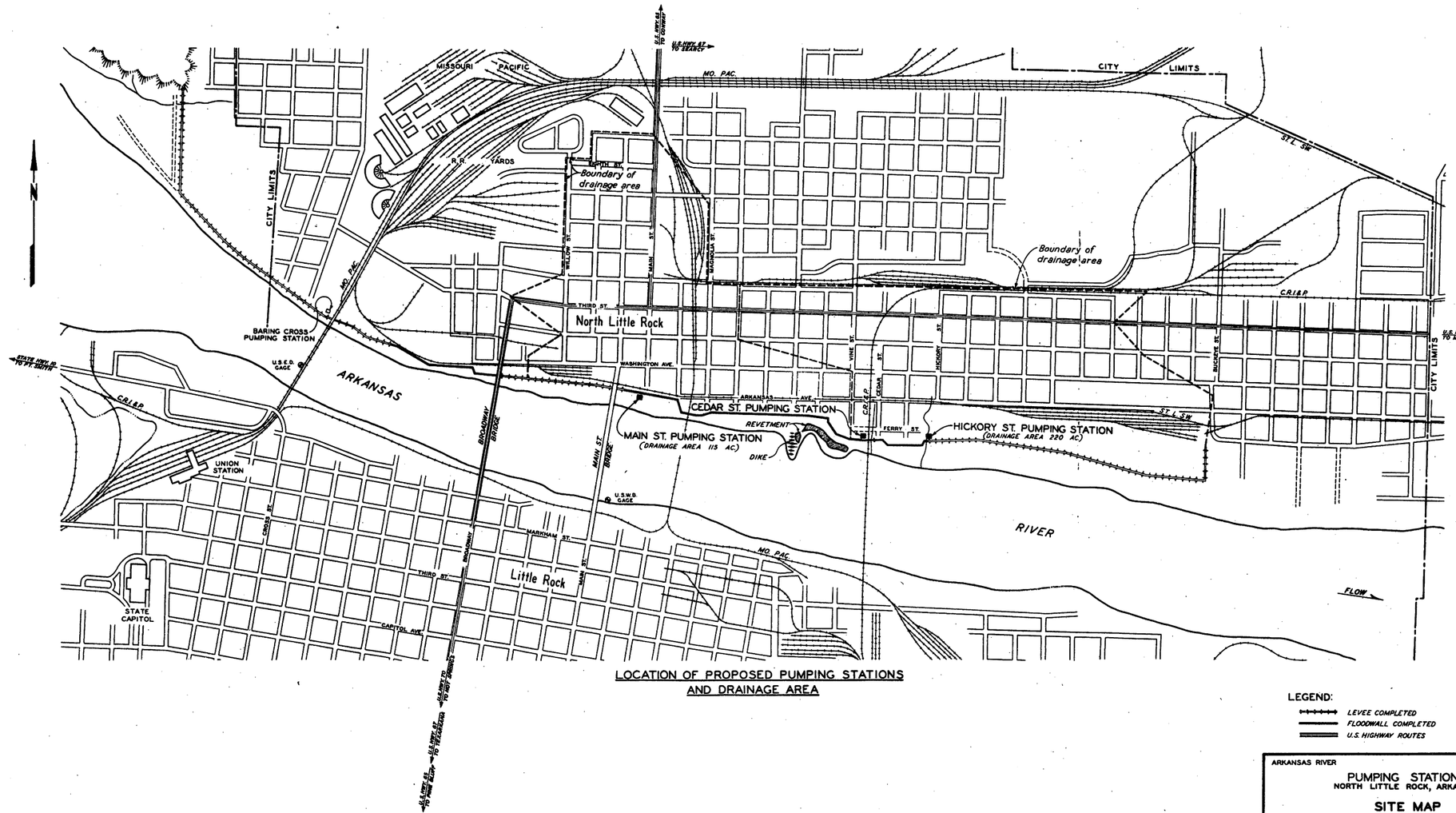
b. Access Road at Hickory Street Station. - The city of North Little Rock has agreed to construct an access road to this station. Such a solution appears preferable to that considered in the Basis of Design where steep side slopes and sharp curvatures were necessary to construct a roadway over the existing culvert.

16. Time of Completion.

a. Pumping Units. - A separate contract for the pumping units exclusive of discharge piping valves and switch gear is considered desirable as permitting representative pump manufacturers to make direct proposals for the work rather than to deal indirectly

through a general contractor. The separate contract has the further advantage of getting work under way sooner and of providing data as to the pumps to be installed in advance of completing construction plans for the stations. Speedy delivery of the pumps would be difficult to accomplish because of the present unfavorable market conditions. Furthermore, the time at which the pumps can be put into operation is dependent upon construction of the buildings in which the pumps are to be housed. In view of these conditions a period of 180 days is allowed for delivery of the pumping units.

b. Buildings and Appurtenant Works. - It appears that this work can be advertised in March 1941 and awarded sometime during April. Completion is requisite before the next flood season which may be considered to start sometime after January 1. Accordingly, the period from May 1 to December 1, or about 210 days, should be available for construction. It is concluded that the contract time should be limited to 210 days.



LOCATION OF PROPOSED PUMPING STATIONS AND DRAINAGE AREA

LEGEND:
- LEVEE COMPLETED
- FLOODWALL COMPLETED
- U.S. HIGHWAY ROUTES

ARKANSAS RIVER — LEVEES

PUMPING STATIONS
NORTH LITTLE ROCK, ARKANSAS

SITE MAP

IN 4 SHEETS — SCALE: 1 INCH = 500 FEET (500' 0 500' 1000') — SHEET NO. 1

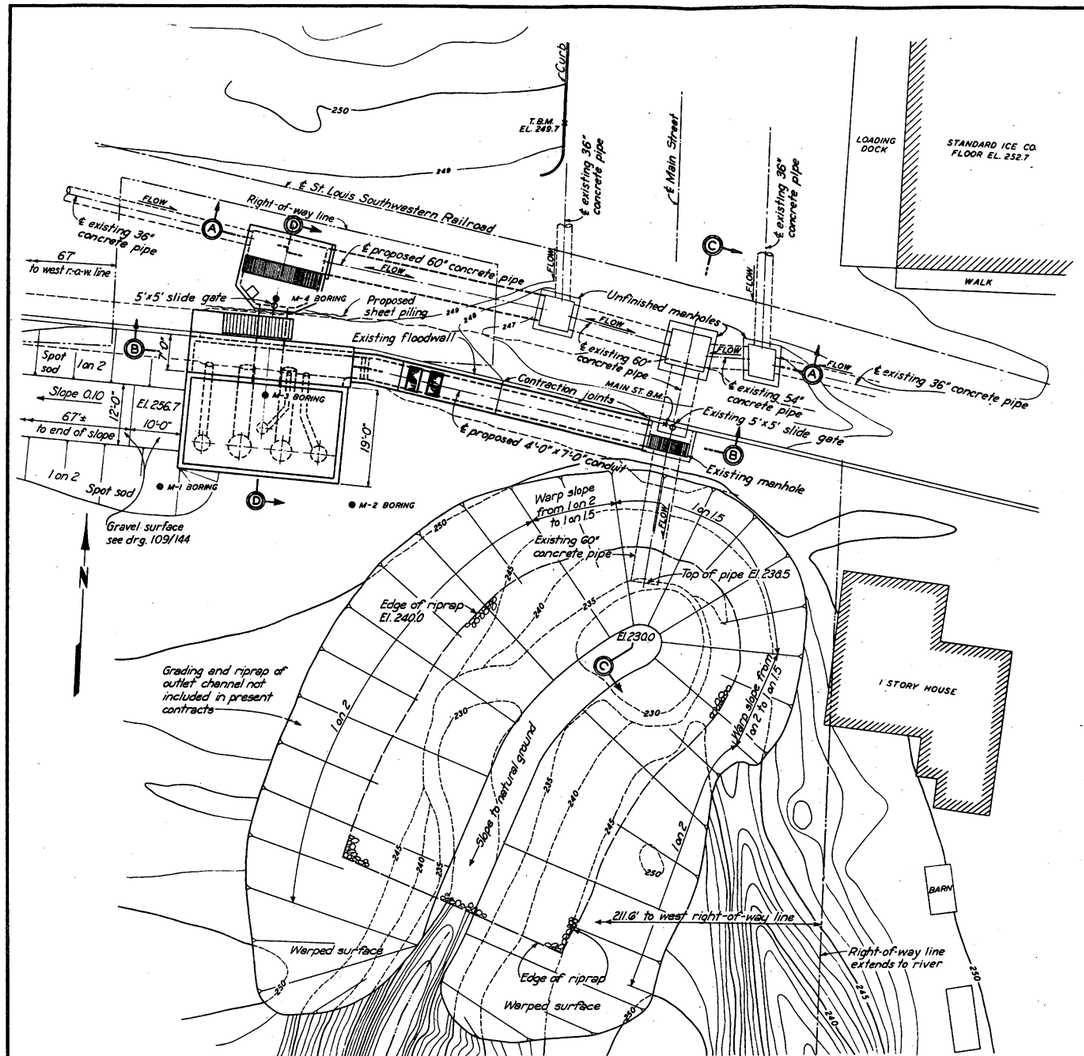
U. S. ENGINEER OFFICE, LITTLE ROCK, ARK. MARCH 1941

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
SENIOR ENGINEER HEAD, DESIGN SEC.	MAJOR, CORPS OF ENGINEERS CHIEF, ENGINEERING DIV.	MAJOR, CORPS OF ENGINEERS DISTRICT ENGINEER

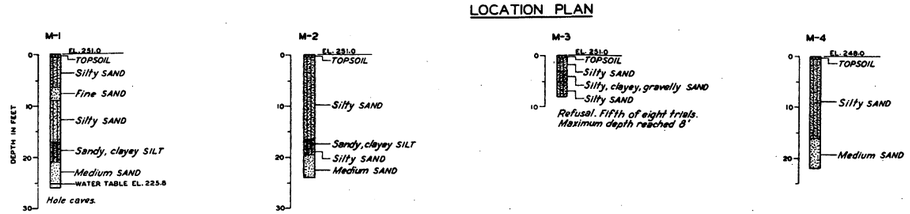
DRAWN J. M. A. P. M. K.
TRACED J. M. A. F. L.
CHECKED P. M. K. W. M. M.

SERIAL 3338
109/171

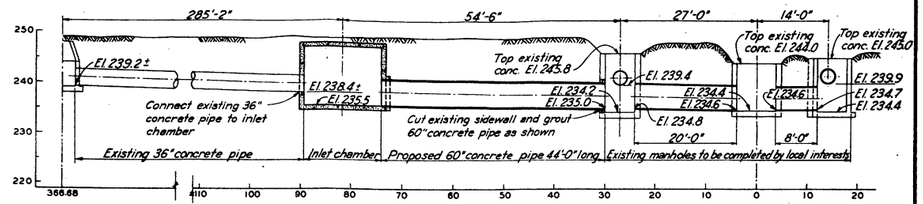
This drawing has been reduced to one-third the original scale.



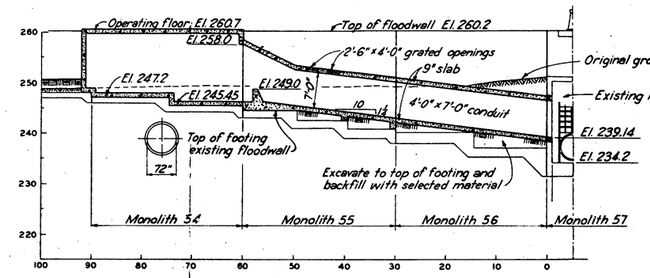
LOCATION PLAN



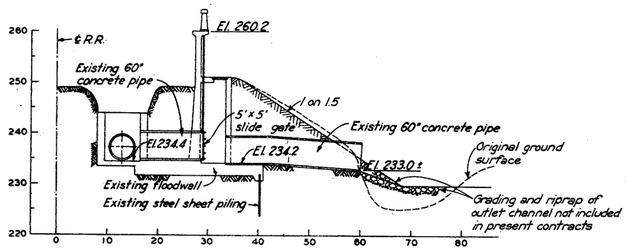
TEST BORINGS



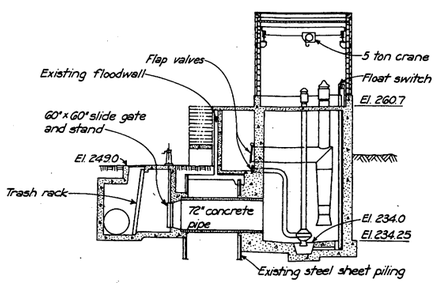
PROFILE-SECTION A-A



PROFILE-SECTION B-B



PROFILE-SECTION C-C



SECTION D-D

ARKANSAS RIVER — LEVEES

PUMPING STATIONS
NORTH LITTLE ROCK, ARKANSAS
MAIN STREET
LAY-OUT AND SECTIONS

IN 4 SHEETS — SCALE: 1 INCH = 10 FEET — SHEET NO. 2

U. S. ENGINEER OFFICE, LITTLE ROCK, ARK. MARCH 1941

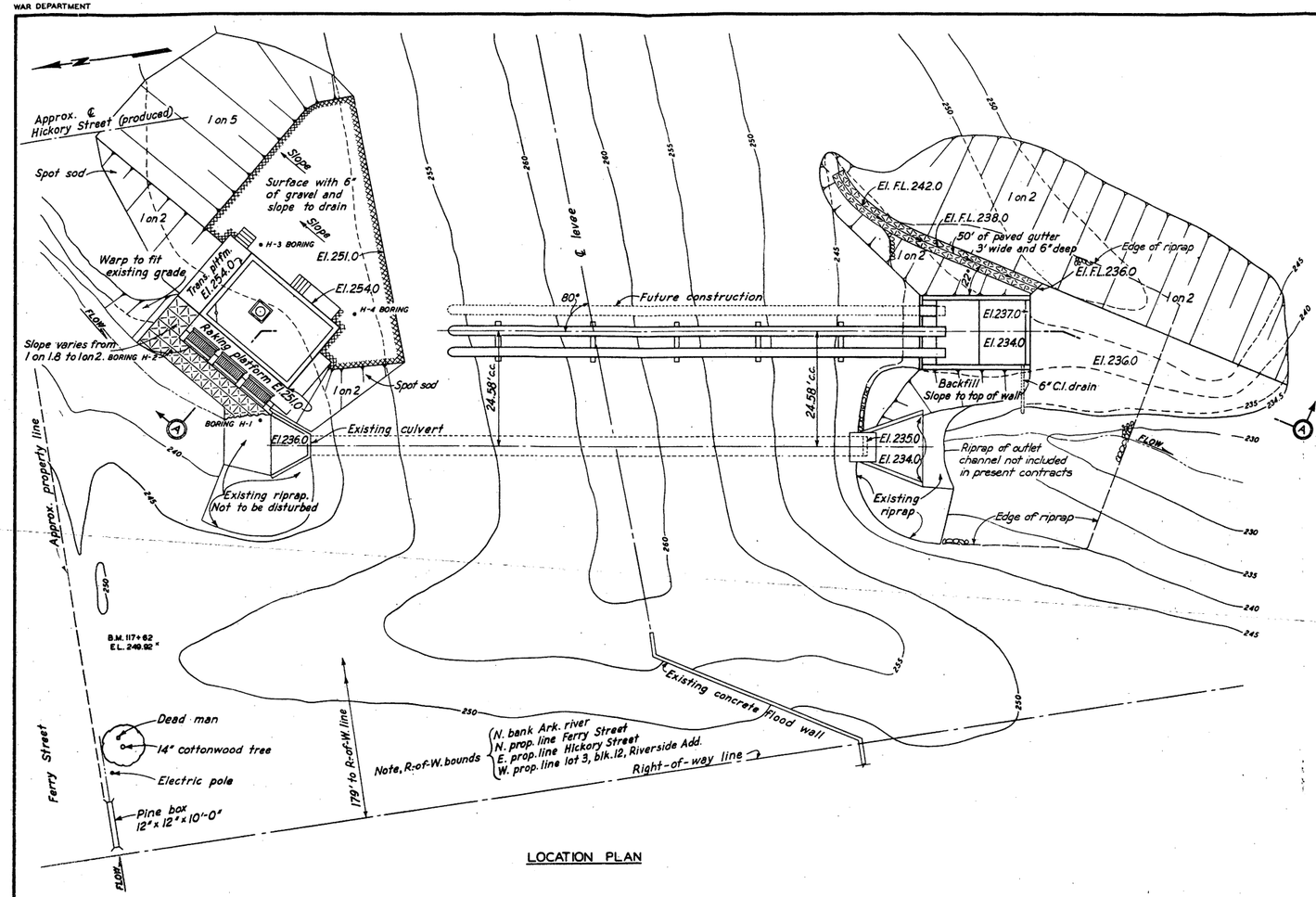
SUBMITTED: APPROVAL RECOMMENDED: APPROVED:

SENIOR ENGINEER, HEAD, DESIGN SEC. — MAJOR, CORPS OF ENGINEERS, CHIEF, ENGINEERING DIV. — MAJOR, CORPS OF ENGINEERS, DISTRICT ENGINEER

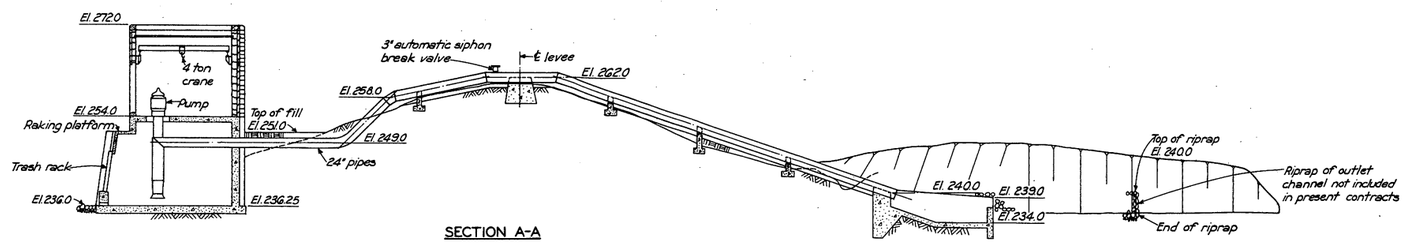
DRAWN O.L.G. R.W.U.
TRACED E.J.P. L.L.
CHECKED E.J.P. W.M.M.

SERIAL 3336
109/172

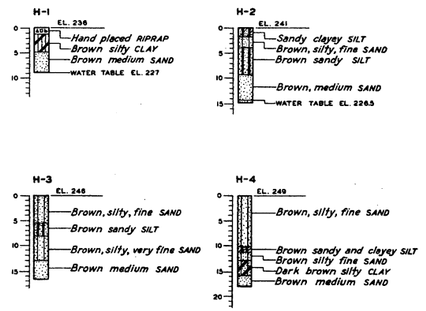
This drawing has been reduced to one-third the original scale.



LOCATION PLAN



SECTION A-A



TEST BORINGS

ARKANSAS RIVER — LEVEES

PUMPING STATIONS
NORTH LITTLE ROCK, ARKANSAS
HICKORY STREET
LAY-OUT AND SECTION

IN 4 SHEETS — SHEET NO. 3

SCALE: 1 INCH = 10 FEET (10' 0 10' 20')

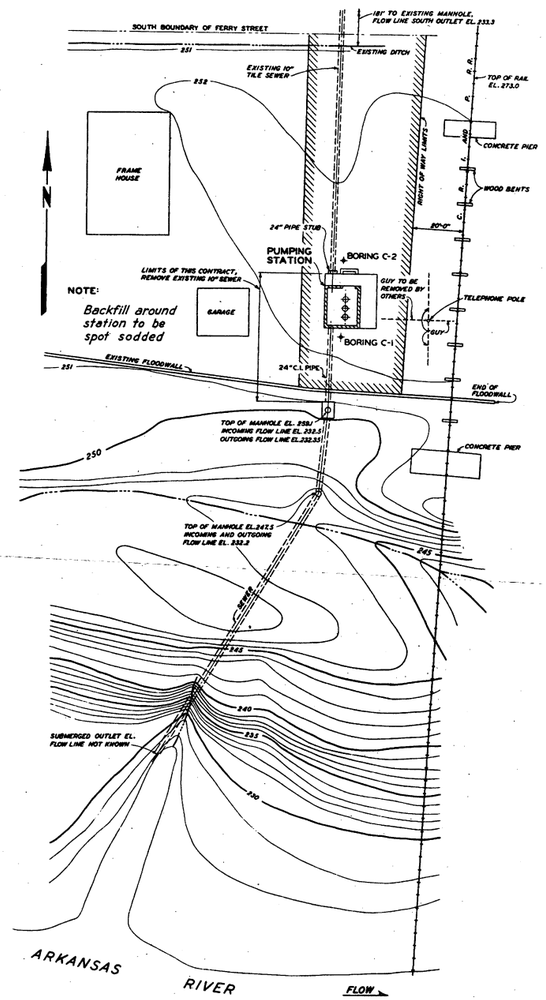
U. S. ENGINEER OFFICE, LITTLE ROCK, ARK. — MARCH 1941

SUBMITTED: W. Schroeder, SENIOR ENGINEER, HEAD, DESIGN SEC.
APPROVAL RECOMMENDED: J. L. Crum Jr., MAJOR, CORPS OF ENGINEERS, CHIEF, ENGINEERING DIV.
APPROVED: J. H. Ware, MAJOR, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN O. L. C. R. W. U.
TRACED D. O. B. F. L.
CHECKED R. W. U. W. N. M.

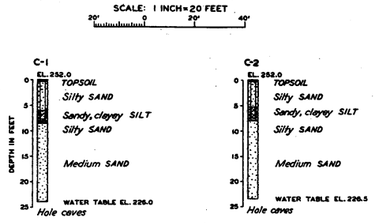
SERIAL 3336
109/173

This drawing has been reduced to one-third the original scale.



LOCATION PLAN

SCALE: 1 INCH = 20 FEET



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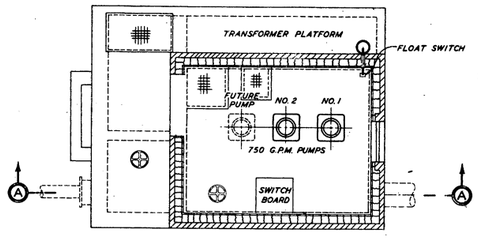
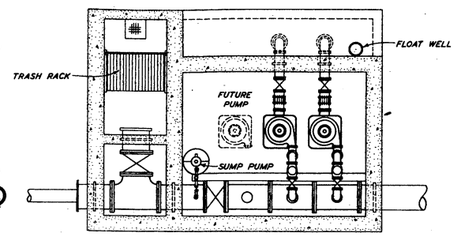
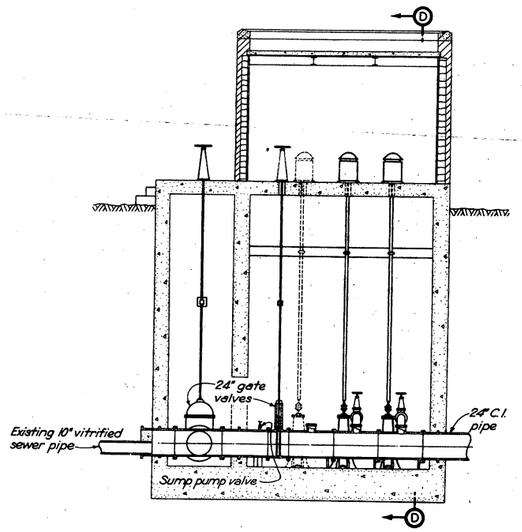


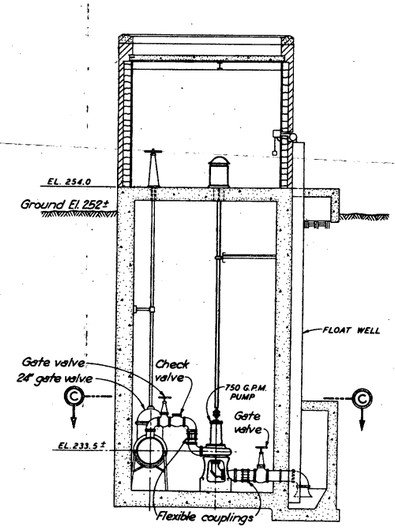
MOTOR FLOOR PLAN



SECTION C-C



SECTION A-A



SECTION D-D

ARKANSAS RIVER — LEVEES

PUMPING STATIONS
NORTH LITTLE ROCK, ARKANSAS
CEDAR STREET
LAY-OUT AND SECTIONS

IN 4 SHEETS — SCALE: 1/2 INCH = 1 FOOT — SHEET NO. 4

U.S. ENGINEER OFFICE, LITTLE ROCK, ARK. MARCH 1941

SUBMITTED:	APPROVAL RECOMMENDED:	APPROVED:
SENIOR ENGINEER HEAD, DESIGN SEC.	MAJOR, CORPS OF ENGINEERS CHIEF, ENGINEERING DIV.	MAJOR, CORPS OF ENGINEERS DISTRICT ENGINEER

DRAWN L.D.C. D.G.G.
TRACED F.W.W. F.L.
CHECKED C.M.G. W.M.M.

SERIAL 3336
109/174

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