HOUSATONIC RIVER FLOOD CONTROL

DERBY, CONN.

LOCAL PROTECTION

HOUSATONIC & NAUGATUCK RIVERS, CONNECTICUT

DESIGN MEMORANDUM NO.5

STRUCTURES AND PUMPING STATION

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

AUGUST 1968

10

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-E

30 August 1968

SUBJECT: Derby Local Protection Project, Housatonic and Naugatuck Rivers, Connecticut, Design Memorandum No. 5, Structures and Pumping Station

Chief of Engineers
ATTN: ENGCW-E

There is submitted herewith, for review and approval, Design Memorandum No. 5, Structures and Pumping Station, for Derby Local Protection Project, Housatonic River Basin, Connecticut, in accordance with EM 1110-2-1150.

FOR THE DIVISION ENGINEER:

1 Incl (10 cys)
as

JOHN Wm. LESLIE
Chief, Engineering Division

FLOOD CONTROL PROJECT

DERBY LOCAL PROTECTION PROJECT
HOUSATONIC AND NAUGATUCK RIVERS
HOUSATONIC RIVER BASIN
CONNECTICUT

DESIGN MEMORANDUM NO. 5

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1	Hydrology and Interior Drainage	10 Jan 1968	14 Mar 1968
2	General Design (Including Site Geology and Concrete Materials)	28 Feb 1968	24 Apr 1968
3	Hydraulic Analysis	18 Apr 1968	4 Jun 1968
4	Embankments, Foundations and Channel Improvements	3 Jul 1968	
5	Structures and Pumping Station		

DERBY LOCAL PROTECTION PROJECT
Housatonic and Naugatuck Rivers
Housatonic River Basin
Connecticut

DESIGN MEMORANDUM NO. 5

STRUCTURES AND PUMPING STATION

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Structural Computations

APPENDIX B

Mechanical Computations

DERBY LOCAL PROTECTION PROJECT
HOUSATONIC AND NAUGATUCK RIVERS
HOUSATONIC RIVER BASIN
CONNECTICUT

A. PERTINENT DATA

1. PURPOSE	Flood Control
2. LOCATION	
State	Connecticut
County	New Haven
City	Derby
Rivers	Housatonic and Naugatuck Rivers in the City of Derby
3. STRUCTURES	
a. "T" WALLS	
Length	(1) 300 ft. @ Bridge Street (2) 85 ft. @ R.R. Structure No. 2
Base	(1) Sloping (2) Flat
Elevation	(1) 34.0 ft. above m.s.l. (2) 30.0 ft. above m.s.l.
Type, both	Reinforced Concrete
Average Height	(1) 18.0 ft. (2) 13.o ft.
b. "I" WALLS	
Length	(1) 47 ft. @ South End of Sloping "T" Wall (2) 140 ft. @ R.R. Structure No. 1

3. STRUCTURES (Cont'd)

	(3) 166 ft. @ R.R. Structure No. 2 (4) 162 ft. @ R.R. Structure No. 3
Elevation	(1) 34.0 ft. above m.s.l. (2) 30.0 ft. above m.s.l. (3) 30.0 ft. above m.s.l. (4) 34.0 and 32.0 ft. above m.s.l.
Type, all	Reinforced Concrete and Steel Sheet Piling

c. RAILROAD GATE STRUCTURES

Number	3
Location	No. 1 @ Route 34 Underpass No. 2 @ Route 8 Underpass No. 3 @ Left Bank Housatonic River R.R. Alignment Crossing
Type, all	Reinforced Concrete Abutments with Steel Swing Gate Leaves
Size Opening	No. 1 28'-0" x 10'-9" No. 2A 26'-0" x 11'-8" No. 2B 39'-6" x 9'-1" No. 3 28'-0" x 10'-9"
Operating Mechanism	Manual Operated, all

d. GATED CONDUITS

Number	2
Structure	Reinforced Concrete
Location	(1) Station 11+50 Naugatuck River (2) Station 13+95 Housatonic River

3. STRUCTURES (Cont'd)

Size	(1) 6x6 ft. (2) 8x6 ft.
Gates	(1) One Each Sluice & Flap 6x6 ft. (2) One Each Sluice & Flap 8x6 ft.
Operating Mechanism (Sluice Gates)	(1) & (2) Manual & Motor Operated

e. PUMPING STATION

Number	One
Structure	Brick & Concrete
Building Size	42'-8" x 22'-0"
Number of Pumps	3
Pump Capacity (each)	30,000 g.p.m. @ approximately 30 ft. t.d.h.
Approximate Pump Horsepower	280

DEPARTMENT OF THE ARMY
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FLOOD CONTROL PROJECT

DERBY LOCAL PROTECTION PROJECT
Housatonic and Naugatuck Rivers
Housatonic River Basin
Connecticut

DESIGN MEMORANDUM NO. 5

STRUCTURES AND PUMPING STATION

B. INTRODUCTION

1. PURPOSE. - The purpose of this design memorandum is to present for review and approval the basic design criteria for the structures and pumping station for the Local Protection Project, Derby, Connecticut. Basic criteria, typical structural and mechanical design computations and other pertinent data are presented.

C. HYDROLOGY AND HYDRAULICS

2. GENERAL. - Approved Design Memoranda Nos. 1 and 3 contain the basic hydrologic and interior drainage and the hydraulic design criteria for the project.

D. GEOLOGY

3. GENERAL. - Approved Design Memorandum No. 2 "General Design" contains the detailed geological studies for the project.

E. FOUNDATIONS

4. FOUNDATION STABILITY AND SEEPAGE CONTROL FOR FLOOD WALLS, CONDUITS AND RAILROAD GATE STRUCTURES. -

a. Flood Walls.

(1) Housatonic Flood Wall.

(a) Characteristics of Foundation Materials. The characteristics of the foundation materials for the Housatonic Flood Wall are discussed in Design Memorandum No. 4, "Embankment, Foundations and Channel Improvements" submitted 3 July 1968 and referred to hereinafter as DM No. 4.

(b) Foundation Treatment. A typical section of the Housatonic Flood Wall with adjoining fill and drainage features is shown on Plate No. 5-14. The foundation grades for the wall have been established so that the base slab will be on moderately compact granular material and so that the foundation drain will extend through the relatively impervious materials near the ground surface on the landside of the wall.

(c) Foundation Seepage Control. A pervious zone of compacted sand fill with a filtered subdrain pipe will be constructed on the landside of the wall to provide foundation seepage control. Between Stas. 2+50 and 4+00, where the heads will be higher, the pervious zone will include a section of compacted processed gravel fill. Reference is made to DM No. 4 for the gradation specifications for the sand and processed gravel fill materials.

(d) Foundation Stability. The flood wall section at Sta. 3+50 was selected for foundation stability analysis as being the most critical section for uplift and foundation stability. The flow net for this section was drawn assuming that the upper 8 feet of the material on the landside was much less pervious than the underlying soils and that the foundation drain materials were free draining. The minimum factor of safety against foundation shear failure is 2.23. The flow net and analysis are shown on Plate No. 5-14.

(2) T-Wall for Railroad Gate No. 2.

(a) Characteristics of Foundation Materials. The characteristics of the foundation materials for the T-Wall for Railroad Gate No. 2 are discussed in DM No. 4.

(b) Foundation Treatment. A typical section of the T-wall for Railroad Gate No. 2 is shown on Plate No. 5-15. Foundation treatment will consist of the removal from the foundation area

of a fill of loose cinders and ashes extending from the ground surface down to Elev. 5.0. Special compacted gravel fill will be placed in the resulting excavation up to the base slab elevation of 8.0. It is not planned to remove the slightly compressible foundation materials underlying the cinders and ashes. The estimated foundation loadings for this wall are relatively low and any resulting settlements in these materials are considered to be structurally tolerable.

(c) Foundation Seepage Control. A pervious zone of compacted sand fill and a zone of compacted impervious fill will be constructed on the landside and riverside of the wall, respectively.

(d) Foundation Stability Analysis. The flow net and foundation stability analysis of the T-Wall for Railroad Gate No. 2 are shown on Plate No. 5-15. The flow net was drawn assuming the same permeability for the special compacted gravel fill layer beneath the slab and the underlying sandy silt and silty fine sand. This flow net is considered to result in an uplift pressure distribution that is more critical than will actually be the case. The minimum factor of safety against foundation shear failure is 1.69.

b. Conduits and Railroad Gate Structures. The characteristics of foundation materials, foundation treatment, seepage control and foundation stability considerations for the conduits and railroad gate structures are discussed in DM No. 4.

F. CONCRETE

5. GENERAL. - Concrete materials are discussed in detail in approved Design Memorandum No. 2 "General Design" (including Site Geology and Concrete Materials).

G. STRUCTURAL DESIGN - FLOODWALLS, RAILROAD GATES, PUMPING STATION AND MISCELLANEOUS STRUCTURES

6. PURPOSE AND SCOPE. - This section presents the design criteria, basic data, assumptions and the procedure used in the structural design of floodwalls, railroad gate structures, pumping station, conduits and miscellaneous drainage structures. Typical computations, including stability analyses, are included showing the maximum loading conditions and design of critical sections.

7. DESIGN CRITERIA. -

a. General. All working stresses conform to those specified in the Engineering Manual EM 1110-1-2101 dated 1 November 1963. General loading conditions, design assumptions and other design criteria are based on the following applicable parts of the Engineering Manual for Civil Works: Standard Practice for Concrete (EM 1110-2-2000, Dec. 1965), Structural Design of Pumping Stations (EM 1110-2-3104 dated June 1958), Retaining Walls (EM 1110-2-2502 dated May 1961) and Wall Design (Part CXXV, Chapter 1, change 2, dated 15 March 1961).

b. Concrete. Concrete working stresses will be in general accordance with ACI Standard Building Code Requirements for reinforced concrete, using concrete with a minimum ultimate compressive strength of 3000 lbs. per square inch, except for conduits which will be 4000 lbs. per square inch.

Flexure (Extreme fiber stresses in comp.)	p.s.i.
Roof and Floor Systems of Pumping Station	1350
Conduits	1800
All other concrete	1050

c. Reinforcement.

(1) Grade and Working Stresses. All reinforcement in the structures, including temperature and shrinkage reinforcement is designed for the working stresses of new billet steel, intermediate grade, deformed bars which is 20,000 p.s.i. in flexural tension. The reinforcement will conform to the requirements of Federal Specification QQ-S-632, Type II, Grade C and to ASTM A-305-56T.

(2) Spacing. The clear distance between parallel bars will not be less than $1\frac{1}{2}$ times the diameter of round bars except that in no case will the clear distance between parallel bars be less than 1-inch, or $1\frac{1}{2}$ times the maximum size of the coarse aggregate.

(3) Minimum Cover for Reinforcement.

Item	Min. Cover (Inches)
Pumping Station	
Interior slabs	3/4"
Exposed concrete (water or atmosphere below grade)	3"
Bottom of base slab	4"
Concrete above grade (interior)	2"

Floodwalls and Other Structures

Concrete poured against forms	3"
Concrete poured against earth	4"

(4) Splices. All splices will be in accordance with the ACI Building Code and as set forth in Table 14c of Reinforced Concrete Design Handbook, ACI Publication SP-3.

(5) Temperature and Shrinkage Reinforcement. Temperature and shrinkage reinforcement will be provided where the main reinforcement extends in only one direction. Such reinforcement will provide for a ratio of steel area to concrete area (bd) of 0.002 with a minimum of .0012 in each face up to a maximum of #6 bars at 12" cc.

d. Structural Steel. Structural steel is designed for the working stresses of bridge and building steel with a yield point of 36,000 p.s.i. minimum (A36). Design conforms to the latest specification for the Design Fabrication and Erection of Structural Steel for Buildings and to EM 1110-1-2101. Basic working stress is 22,000 p.s.i., except for sheet piling which is 20,000 p.s.i.

e. Increase in Normal Working Stresses. Allowable working stresses are increased 33-1/3% only where wind loads were used.

f. Waterstops. Rubber or polyvinyl waterstops will be used in all concrete wall joints and in conduit contraction joints.

g. Castings and Misc. Items. Hinge shoes for structural gates will be of cast steel conforming to Federal Specification QQ-S-681d. The hinge bushings and washers will be a self lubricating bronze and the hinge pins of a corrosion resistant steel.

8. BASIC DATA AND ASSUMPTIONS. -

a. Loads.

(1) Dead Loads.

Concrete	150 p.s.f.
Steel	490 p.s.f.
Soil dry	115 p.c.f.
Soil Moist	120 p.c.f.
Soil saturated	130 p.c.f.
Soil submerged	67 p.c.f.

(Note: Soil values are considered as average, and high and low values above and below these will also be used if critical.)

(2) Live Loads. The following live loads are used:

General.

Water	62.5 p.c.f.
Wind (Tee Walls)	50 p.s.f.
Wind (Pumping Station)	30 p.s.f.

Pumping Station.

Design load on roof slab	30 p.s.f.
Crane load	4 tons
Operating floor slab	225 p.s.f.
Operating floor beams	100 p.s.f. plus equip loads

R. R. Gate Structures.

Track Loading	Cooper E72

b. External Water Pressure. Hydraulic pressure under flood condition is assumed to act over the entire area in question under the full head on the riverside heel and varying by the creep method to zero at the ground line on the landside.

c. Earth Pressure. Earth pressures are determined in general accordance with EM 1110-2-2502, Retaining Walls dated 29 May 1961.

d. Earthquake Forces. Earthquake forces are considered to be of no consequence on these structures and have been neglected.

e. Frost Protection. All structures will have a minimum of 4'-0" cover for frost protection.

f. Location of Resultant. In the investigations for stability of the walls and gate structures, the resultant of the horizontal and vertical forces has been held within the middle half when flood is at the top of the wall and within the middle third when the flood is within three feet of the top of the wall.

g. Sliding. Sliding will be resisted either by friction on the base slab when it is within allowable limits or by passive pressure on the landside of the structure. For the floodwalls, the safety factor against foundation failure may be found in the Soils section of this memorandum.

9. PREPARATION OF DESIGN COMPUTATIONS. - Extensive use of computer programming has been used in preparing computations. The Mathatron desk-top computer was used to analyze the tee walls, conduits, pumping station columns, beams and substructure. The railroad gate foundation slab was designed as a beam on an elastic foundation by means of a Fortran program based on the Popov method of successive approximations. The skin plate and steel framing members of the railroad gates were also determined by means of a Fortran program. All of these programs have been previously used on other projects.

10. TEE WALLS AND I WALLS. -

a. General. A sloped base tee-type floodwall will be utilized for approximately 300 feet along the Housatonic River. An I-wall will be utilized to connect the Tee Wall and the dike. At railroad gate No. 2 between the two gate structures there will be a flat based tee-type wall. At all railroad gates, short stretches of I-type wall will be utilized to connect the gate structures either into the dike or into high ground. Berms have been utilized to hold the projecting height of the I-wall to not over 10 feet. A 3'-0" surcharge is included on the landside stem of Tee Walls to allow for vehicular loading.

b. Loading Conditions.

(1) Loading I - Channel full, water surface to top of wall. Path of creep for uplift considerations, considered starting at the bottom of the base slab and ending at the ground surface on the landside. Resultant to fall within the middle half of the base.

(2) Loading II - Same as I except water surface 3 feet below the top of the wall and the resultant to fall within the middle third of the base.

(3) Loading III - Channel empty, 50 lbs. per sq. ft. wind load applied from landside and parking lot surcharge applied where applicable.

c. Typical Design Sections. Design computations are included in the appendix for typical sections of wall. These sections represent the most critical areas, and other sections following these procedures will be developed where required. During final design a straight batter from top of wall to top of base will be considered. Soil pressures do not exceed the allowable pressures and resultant of load falls within the allowable limits for each case. Splices in critical stress steel will be staggered. The I-walls will have a concrete section above the ground line to present a pleasing appearance and prevent steel corrosion.

11. PUMPING STATION. -

a. General. The station is located in back of the protection. It will be brick and concrete construction 42'-8" by 22'-0" outside dimensions of the superstructure. The intake chamber will be 8'-0" wide, while the gravity flow discharge will be in an 8'-0" x 6'-0" conduit. Flood discharge will be by three (3) 36-inch steel pipes carried over the dike.

b. Roof Slab and Superstructure. The roof slab will be a 6-inch minimum slab sloped to drain at the center of the slab. The slab will be supported on steel spandrel beams encased in concrete and one transverse steel beam at the center of the structure. Steel columns will be utilized to support the roof framing plus the crane beams which are designed to support a four ton crane.

c. Operating Floor. The operating floor is slab and beam construction with beams framing each pump opening. The floor slab is designed for a 225 lbs. per sq. ft. live load while the beams are designed for 100 lbs. per sq. ft. plus equipment loads. The exterior deck is designed for a nominal live load of 100 lbs. per sq. ft. plus a gate leaf load located at mid-span.

d. Stability. Stability computations were made assuming the station empty below minimum pumping elevation and with ground water on the exterior at ground surface. The station will also be investigated for the intake and discharge chambers full and the pump chamber empty. Presentation is for first condition only which is considered to be the most critical.

e. Substructure. The substructure is designed by utilizing a vertical transverse frame with top of frame supported at the floor slab. The wall between the discharge chamber and pump chamber is also designed as supported at the floor and fixed at the base with a full water load in the discharge chamber.

12. CONDUITS. -

a. General. Two reinforced concrete conduits will be utilized on the project. The largest is an 8'-0" x 6'-0" discharge conduit passing under the dike and serving as the gravity flow discharge for the pumping station. The second conduit is a 6'-0" x 6'-0" drainage conduit through the dike. Both conduits will have sluice gate structures on the riverside connected to the dike by means of precast concrete access bridges. At the discharge ends of the conduits, concrete outlet structures with flap gates will be used. The drainage structure will also have a small concrete inlet structure.

b. Loads. The conduits are designed for the following loading conditions:

(1) Case I. Flood stage with river at maximum elevation, conduit empty, 150% of vertical projected weight of fill on roof and lateral earth pressure coef. K= .5 (.33 of vert.)

(2) Case II. Water down, embankment moist weight, conduit empty, 150% of vertical projected weight of fill on roof, and lateral earth pressure coef. K= .5 (.33 of vert.)

(3) Case III. Flood stage with river at maximum elevation, 100% of vertical projected weight of fill and lateral pressure 100% of the vert.

The gate towers will be analyzed for stability with embankment pressures against the tower as determined in the Retaining Wall Manual (EM 1110-2-2502) and also including drag forces on the ends of the tower. A value of .6 will be used for "K".

c. Design.

(1) The Pumping Station Conduit was investigated by the computer program and found to require roof and base slab thickness of 1'-9" with side walls 1'-6". Small haunches are provided in the corners to improve shear. The factor of safety for allowable shear was checked by the University of Illinois method.

(2) The Drainage Conduit was investigated and found to require a roof slab of 1'-8" and a base slab of 1'-9" and walls 1'-6". No haunches are required and design computations are similar to the Pumping Station Conduit.

(3) Gate Towers are designed as horizontal rings. The vertical steel in the tower walls will be designed to take embankment loads by cantilever action above the conduit roof.

13. RAILROAD GATES.

a. General. There are three railroad gate closures. However, gate structure No. 2 has been divided into two separate structures and are hereafter referred to as Railroad Gate Structures 2A and 2B. The gates will be of the swing gate type, and because of the difficulty in placing the gate sill between the tracks and track ties, it is necessary to use a single flat leaf hinged on one end and bearing against the abutment on the other. Gates 1 and 3 will have a

28'-0" clear opening. Gate No. 2A will have a 26'-0" clear opening and Gate No. 2B will have a 39'-6" clear opening. These opening widths were determined in conjunction with the New Haven R.R. considering critical sight distances and proximity of switches. The height of the gates vary as shown in the table in the next paragraph. The concrete sill will extend across the opening and project up between the railroad ties to approximately top of rail. The gates will be hung with a 2-inch clearance between bottom of gate and top of rail and an adjustable steel plate at the bottom of the gate will be utilized to close the 2-inch gap further. Sandbags will be used to seal off the remaining gap plus the gap around the rails.

b. Critical Elevations. The following are the critical elevations and dimensions for each gate:

Item	Gate No. 1	Gate No. 2A	Gate No. 2B	Gate No. 3
Elevation of top of rail m.s.l.	19.3	18.3	20.9	23.3
Elevation of bottom of base slab m.s.l.	+8.0	-2.0	-2.0	-2.0
Height of gate leaf	10'-9"	11'-8"	9'-1"	10'-9"
Clear opening	28'-0"	26'-0"	39'-6"	28'-0"

c. Loading Conditions. Stability computations for all gates will be made for the following conditions of loading. Computations for Railroad Gate No. 1 are included in the Appendix.

(1) Case I. Concrete only.

(2) Case II. Normal condition with concrete and earth loads; gate in the pocket, but hanging on the hinges. Earth weight considered saturated, but no uplift considered.

(3) Case III. Same as Case II, but with gate in the closed position.

(4) Case IV. Flood stage condition with water to the top of the gate. Uplight assumed as full head to the face of sheet piling on riverside and varying to zero at ground surface on landside by creep method.

(5) Case V. Same as Case II and Cooper E 72 maximum train loads applied to the toe.

(6) Case VI. Same as Case II and Cooper E 72 maximum train loads applied to the heel.

d. Concrete Abutment Design. The abutments sill and base slab for all three railroad gates are similar, except for depth and applied loads. Foundation conditions permit gate No. 1 to be founded at Elevation plus 8.0 m.s.l., the other gates must be carried to a lower elevation because of poor material. The base slab of Railroad Gate No. 1 has been divided into a series of five strips, and analyzed for each condition of loading. Computations for Case IV loading for the strip at landside edge, assuming the strip is a beam on an elastic foundation and the end reactions taken by the abutments, are included in the Appendix for Gate No. 1. The computations were made using E. P. Popov's method of "Successive Approximations for Beams on Elastic Foundation," (ASCE papers 1950). Reinforcing requirements in the transverse direction are minimum. Computations included in the Appendix show the computer printout of the program developed for this analysis. The other strips and similar strips in the other gates will be investigated in a similar manner.

e. Steel Gate Design. The skin plate is designed to span continuously over the supporting wide flange members using A36 steel. The plate will be 1/4" thick minimum to 3/8" maximum for the various gates depending on the height. The horizontal wide flange members will be A36 steel spaning between end posts on each side of the gate. At the hinge end, the end post spans as a beam between top and bottom hinges where the reaction will be taken into the abutment. At the opposite end the vertical post will transmit the load directly to the abutment by means of a bearing bar. Computations included herein are for Gate No. 1. The remaining gates will follow a similar procedure. However, at Gate No. 2B due to the shallow depth and 42'-6" length of leaf, it may be necessary in the detail design of the hinges to heighten the end post thus widening the distance between hinges. From the top of the post, a diagonal member will be carried out to some advantageous point on the gate. This will also require some modification of the abutment at this point in order to accommodate the higher post and hinge.

14. MISCELLANEOUS DRAINAGE STRUCTURES. Where drainage gate structures are required for pipes passing through the protection or are located in back of the protection, they will be designed for maximum loading conditions that can be applied.

H. MECHANICAL DESIGN

15. GENERAL. Plate 12 shows the general arrangement of pumps and other mechanical equipment, and Pages M-1 through M-16 show pump computations and curves. Electric service is not considered adequately reliable at any of the stations for electric motor drive.

16. PUMPING EQUIPMENT. All pumps will be driven by diesel engines through right angle gear units. The pumps will be vertical, fixed blade, propeller or mixed-flow type of standard construction using steel columns and discharge elbows, cast iron bowls and suction bells, cast steel or bronze impellers, stainless steel pump shafts and bronze bearings. Each pump will be provided with manually operated centralized lubrication system. All pumps will be capable of operation against all river stages up to the top of the dike.

Trash racks are not required as all inlets to the drains leading to the sump are adequately screened.

Three pumps will be provided with each pump having a capacity of 66.7 c.f.s. (30,000 gpm), one-third of the required station capacity, against the standard project flood with suction sump at low water elevation. Each pump will discharge over the top of the dike. Three sluice gates, one located in front of each pump, will seal off the pump sump except when opened for activation of the station. Gates will be sized for an entrance velocity of approximately 2.5 f.p.s. with all pumps operating. A sluice gate will be provided on the river side of the dike to close off the gravity flow conduit.

17. SLUICE GATES. All sluice gates at the pumping stations will be seating pressure type of standard cast iron construction with bronze seals. Manually operated floorstands will be installed for operation of each gate. A portable electric operator for attachment to the hand crankshaft will be provided to reduce the time required to operate the gates.

18. TRAVELING CRANE. The station will be provided with a hand-operated, single girder, traveling crane with a low headroom, and hand-operated chain hoist of capacity required to handle the heaviest piece of equipment.

19. SUMP PUMP. An electric motor-operated wet pit type sump pump will be provided in the pumping station for dewatering and for handling any leakage into the sump.

20. HEATING. The station will be equipped with gas or oil-fired warm air furnace thermostatically controlled to maintain inside temperature at 55°F. In addition, a humidistat will override the thermostat to operate the heater as necessary to maintain the relative humidity at not higher than 50 percent.

21. VENTILATION. A small fan with ductwork will be provided for ventilation of the sump. The diesel engines will be radiator cooled with each radiator connected to exterior wall louver by ductwork to prevent short circuiting of cooling air. Inlet louvers will be provided for air supply to the radiators.

22. WATER LEVEL INDICATORS. Indicators for both the station sump and the river water levels will be provided in the station.

I. ELECTRICAL DESIGN

23. ELECTRIC SERVICE. Electric service will be obtained from the United Illuminating Company at 120/240 v, 3-phase, 4-wire. (See Plate No. 13.) The service will be extended from existing lines overhead to the station.

24. INTERIOR ELECTRICAL FEATURES.

a. Wiring System. All conductors will have heat and moisture resisting type insulation and will be installed in rigid steel conduit.

b. Communication System. Conduit will be installed for use by the Southern New England Telephone Company in providing telephone service.

c. Emergency Lighting. Battery-operated emergency lighting unit will be provided.

25. ELECTRIC LOAD DATA.

Item	Conn.	Demand
Sluice Gate	2.6 hp	
Sump Pump	1/3 hp	
Fan	1/4 hp	
Furnace	1/2 hp	.5 kva
Lighting & Receptacles	3 kva	2 kva
Total demand load		2.5 kva

J. COST ESTIMATES

26. ESTIMATES OF COST. The estimated cost of the project is as follows. It has been revised to reflect the changes in unit quantities and unit prices due to more advanced design and from data obtained from recent bid openings, respectively.

FIRST COST
(August 1968 Base)

TABLE NO. 1

Item	Quantity	Unit	Unit Price	Amount	Total Amount
Lands and Damages					$240,000
Relocations					
Utilities				$44,000	
Contingencies				6,000	
Total Relocations					50,000
Levees and Floodwalls					
Site Preparation	27	Ac.	L.S.	25,000	
River Control	1	Job	L.S.	100,000	
Excavation, Unclassified	165,000	C.Y.	1.50	247,500	
Stripping	100,000	C.Y.	1.50	150,000	
Impervious Fill	260,000	C.Y.	3.00	780,000	
Compacted Random	70,000	C.Y.	0.75	52,500	
Dump Random Fill	500	C.Y.	0.20	100	
Dump Gravel Fill	5,300	C.Y.	3.50	18,550	
Compacted Gravel Fill	5,000	C.Y.	3.75	18,750	
Compacted Proc. Gravel Fill	13,700	C.Y.	4.00	54,800	
Compacted Sand Fill	38,000	C.Y.	3.00	114,000	
Class I Stone Protection	17,000	C.Y.	15.00	255,000	
Class II " "	27,000	C.Y.	15.00	405,000	
Class III " "	1,600	C.Y.	15.00	24,000	
Class IV " "	1,100	C.Y.	15.00	16,500	
Filter Sand	4,100	C.Y.	3.50	14,350	
Class I Gravel Bedding	7,900	C.Y.	6.00	47,400	
Class 2 " "	17,000	C.Y.	5.00	85,000	

TABLE NO. 1 (Cont'd)

Item	Quantity	Unit	Unit Price	Amount	Total Amount
Levees and Floodwalls, Cont'd.					
Road Gravel	1,000	C.Y.	3.25	3,250	
Topsoil	7,800	C.Y.	3.50	27,300	
Relief Wells,					
Naugatuck	8	Ea.	5,000.00	40,000	
Housatonic	8	Ea.	5,000.00	40,000	
Steel Sheet Piling					
Cofferdams 2-32	43,600	S.F.	5.00	218,000	
I-wall 2-27	16,400	S.F.	5.50	90,200	
RR Structure No. 1	1	Job	L.S.	93,690	
RR Structure No. 2	1	Job	L.S.	283,325	
RR Structure No. 3	1	Job	L.S.	132,740	
T-Wall at RR Structure No. 2					
Concrete	220	C.Y.	80.00	17,600	
Steel Reinforcement	39,600	Lbs.	0.17	6,732	
T-Wall at Bridge St.					
Concrete	1,610	C.Y.	70.00	112,700	
Steel Reinforcement	289,800	Lbs.	0.17	49,266	
Excavation	9,000	C.Y.	2.50	22,500	
Concrete - Box Culvert & Gate Structure Complete, 6'x6'	400	C.Y.	70.00	30,800	
Steel Reinforcement	44,000	Lbs.	0.17	7,480	
Sluice Gate, Installed Complete, 6'x6'	1	Job	L.S.	8,000	
Flap Gate, Installed Complete, 6'x6'	1	Job	L.S.	4,000	
Access Bridge (6'x6')	1	Job	L.S.	3,900	
Concrete - Box Culvert & Gate Structure Complete, 8'x6'	580	C.Y.	70.00	40,600	
Steel Reinforcement	58,000	Lbs.	0.17	9,860	
Access Bridge	1	Job	L.S.	3,900	
Sluice Gate, Installed Complete, 8'x6'	1	Job	L.S.	12,000	
Flap Gate, Installed Complete, 8'x6'	1	Job	L.S.	8,000	
Cement	8,700	Bbls.	5.00	43,500	
Remove 24" Storm Drain 1st Street	1	Job	L.S.	300	
Storm Drains					
15" R.C.P.	115	L.F.	10.00	1,150	
18" "	370	L.F.	11.25	4,160	
27" "	310	L.F.	17.50	5,420	
54" "	205	L.F.	50.00	10,250	
60" "	240	L.F.	55.00	13,200	
66" "	325	L.F.	65.00	21,150	

TABLE NO. 1 (Cont'd.)

Item	Quantity	Unit	Unit Price	Amount	Total Amount
Levees and Floodwalls, Cont'd.					
Std. Drain Manhole	9	Ea.	700.00	6,300	
Connect Existing Storm Drain to New D.M.H.	4	Ea.	50.00	200	
Under Drains					
6" B.C.C.M.	790	L.F.	3.00	2,370	
8" "	1,175	L.F.	4.00	4,700	
10" "	55	L.F.	5.00	275	
Under Drain Manhole	5	Ea.	250.00	1,250	
Observation Risers	13	Ea.	100.00	1,300	
Press. Cond. Storm 36" R.C.P.	15	L.F.	25.00	375	
Spec. Manhole	1	Ea.	3,000.00	3,000	
Conduit Intake Structure	1	Job	L.S.	1,000	
Special Drain Inlet Structure, 1st St.	1	Job	L.S.	1,000	
Remove Existing Storm Drain Lines under Protection	620	L.F.	2.00	1,240	
Connect Existing Storm Drain to New Interceptor Storm Drain (12" R.C.P.)	50	L.F.	8.00	400	
Connect Sanitary Sewer Effluent Pipe to New Interceptor Storm Drain	1	Job	L.S.	100	
				$3,796,933	
Contingencies				533,067	
Total Levees and Floodwalls					$4,330,000
Pumping Station	1	Ea.	L.S.	$260,000	
Contingencies				40,000	
Total Pumping Station					$300,000
Engineering and Design					500,000
Supervision and Administration					380,000
TOTAL PROJECT CONSTRUCTION COST.					$5,800,000

K. ECONOMICS

27. a. General. Derby is a small city in one of the most densely settled and highly industrialized sections of the State of Connecticut. Physically limited in size (only 5.5 square miles in area) the city's economic development has also been restricted in the past by a topography which has confined commercial and industrial activities to the flood plains of the Housatonic and Naugatuck Rivers or the areas just above the flood plains along Routes 8 and 34.

There has been some increases in the industrial sector of the city's economy in the recent past and manufacturing is still the largest employer. There has been an increase in population, some 5% between 1960 and 1966, and a corresponding increase in housing, an amazing growth considering the limited amount of land available in a city with a density of over 2,200 people per square mile in 1960. Derby's location, only ten miles from the major cities of Bridgeport and New Haven and only 17 miles from Waterbury, is such that there will be a continuing demand for all available land and pressure to increase the utilization of presently occupied land, some in the flood plain, to the greatest extent possible.

b. Flood Losses. Recurring losses in the area considered for protection amount to $4.5 million at current (1968) price levels. This represents an increase of 50% over the losses reported in the project document. The increase in losses reflects (1) a change in alignment of the Naugatuck River dike giving protection to four additional facilities and additional railroad trackage; (2) a change in use in one of the more sizeable properties on the Housatonic River bank with substantially higher losses now possible and (3) a change in price level.

Annual losses in the project area amount to $344,000 at 1968 price level. These losses reflect the operation of all authorized projects in the Naugatuck River Basin.

Annual losses in Derby grew at a rate of 8.7% annually from 1962 to 1968. The increase was due primarily to more intensive economic activity in the flood plain. While it is unlikely that this rate would be maintained over a long period due to physical limitations of the flood plain, it can be expected that a further growth in losses will take place before the project is placed in operation in 1971. Annual losses and benefits have been projected to grow at a rate of 5% annually over the next three years.

c. Annual Benefits. Construction of the Derby project will give protection against the Standard Project Flood as modified by all authorized projects on the Naugatuck River. The project is credited with benefits for flood damages prevented in all floods up to and including the S.P.F. Benefits in 1971 will amount to $396,000.

d. Annual Costs. - Total annual charges amounting to $212,900 are summarized below.

ESTIMATED ANNUAL CHARGES
(100-Year Life)
LOCAL PROTECTION WORKS

DERBY LOCAL PROTECTION PROJECT, CONN.
HOUSATONIC AND NAUGATUCK RIVERS
HOUSATONIC RIVER BASIN

Item No.	Item	Cost	Total Cost
1.	Federal Investment		
	a. Federal First Cost.....	$5,510,000	
	b. Interest During Construction (1a x 0.0325 x ½ T) (T= 2 yrs)	179,100	
	c. Total Federal Investment	$5,689,100	
2.	Federal Annual Charges		
	a. Interest (1c x 0.0325).....	$ 184,900	
	b. Amortization (1c x 0.00138)	7,900	
	c. Total Federal Annual Charges		$192,800
3.	Non-Federal Investment		
	a. Contributed Funds.....		
	b. Lands, Easements & Rights-of-Way	290,000	
	c. Improvements by Local Interests		
	d. Total Non-Federal First Cost	$ 290,000	
	e. Interest During Construction (3d x 0.0325 x ½ T)	$ 9,400	
	f. Total Non-Federal Investment	$ 299,400	
4.	Non-Federal Annual Charges		
	a. Interest (3f x 0.0325).....	$ 9,700	
	b. Amortization (3f x 0.00138).....	400	
	c. Maintenance and Operation.....	4,700	
	d. Interim Replacements (1).....	5,300	
	e. Net Loss of Productivity (2)....		
	f. Total Non-Federal Annual Charges		$ 20,100
5.	Total Annual Charges (2c + 4f)		$212,900
6.	Total Annual Benefits		$396,000

28. BENEFIT-COST RATIO. The ratio of benefits to costs is 1.9 to 1.

CORPS OF ENGINEERS — U. S. ARMY

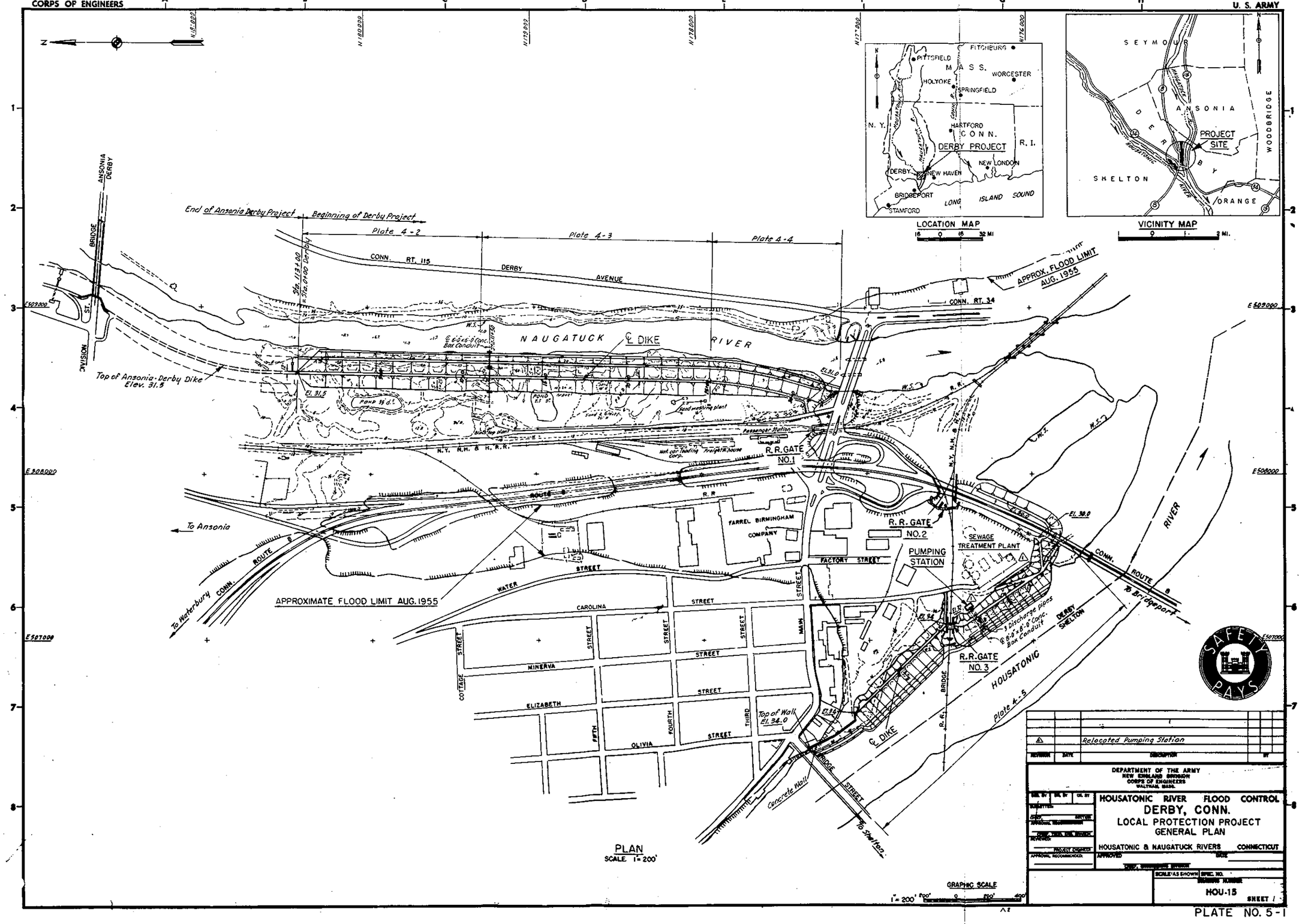
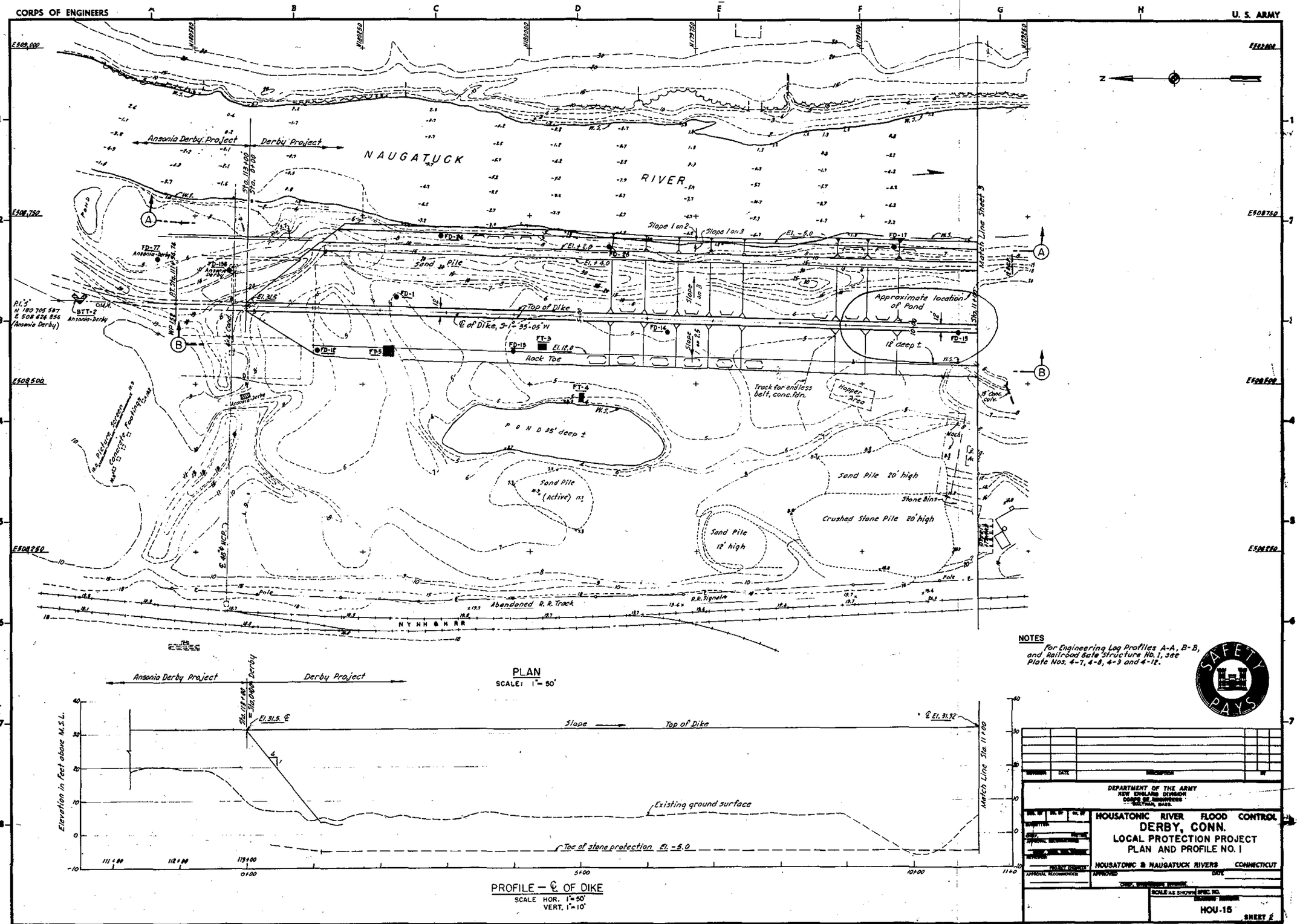


PLATE NO. 5-1

CORPS OF ENGINEERS U. S. ARMY



NOTES

For Engineering Log Profiles A-A, B-B, and Railroad Gate Structure No. 1, see Plate Nos. 4-7, 4-8, 4-9 and 4-12.

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 1

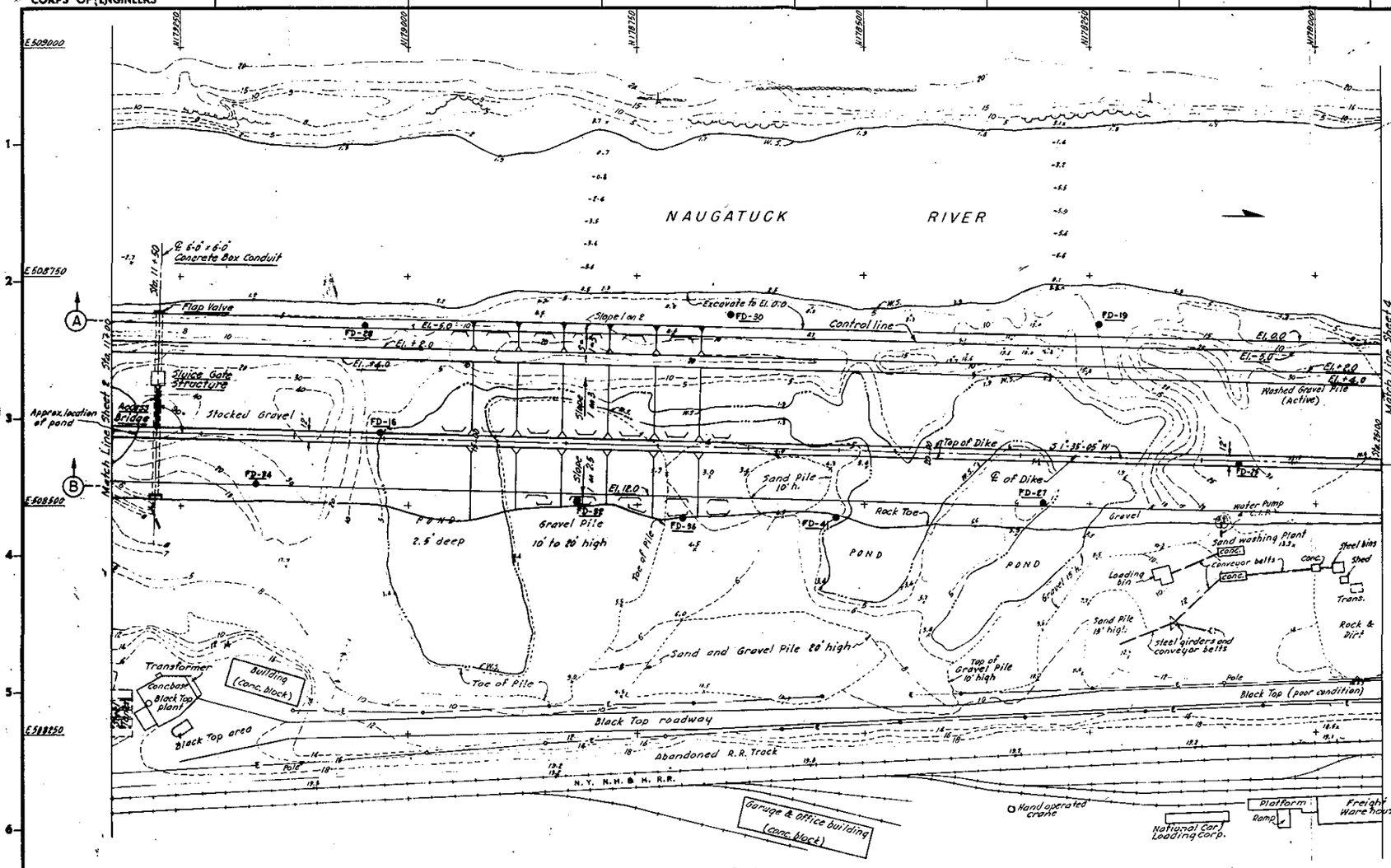
HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

SCALE: AS SHOWN SPEC. NO.
DRAWING NUMBER
HOU-15
SHEET 2

PLATE NO. 5-2

CORPS OF ENGINEERS

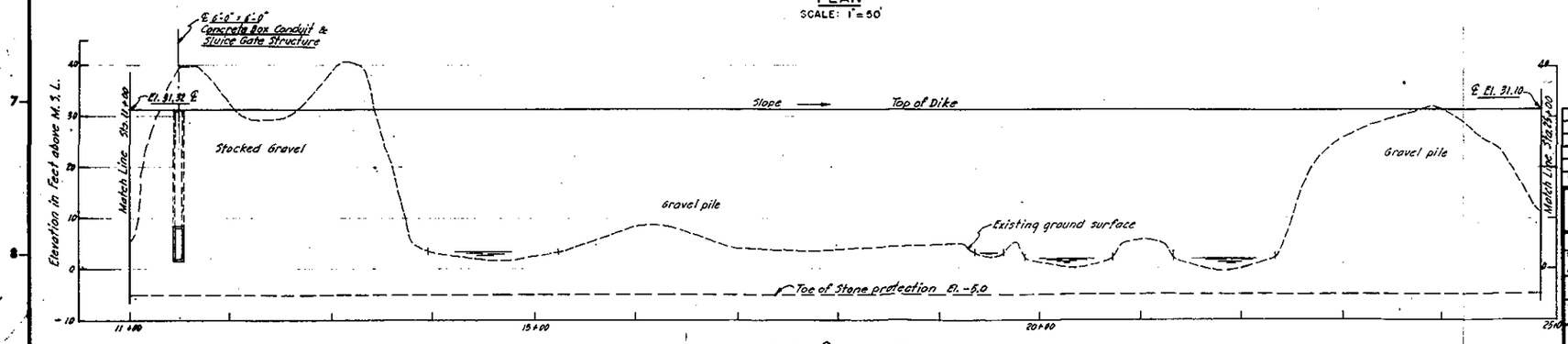
U. S. ARMY



PLAN

SCALE: 1" = 50'

NOTES



PROFILE — ℄ OF DIKE

SCALE HOR. 1" = 50'
VERT. 1" = 10'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ADM. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:

HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 2

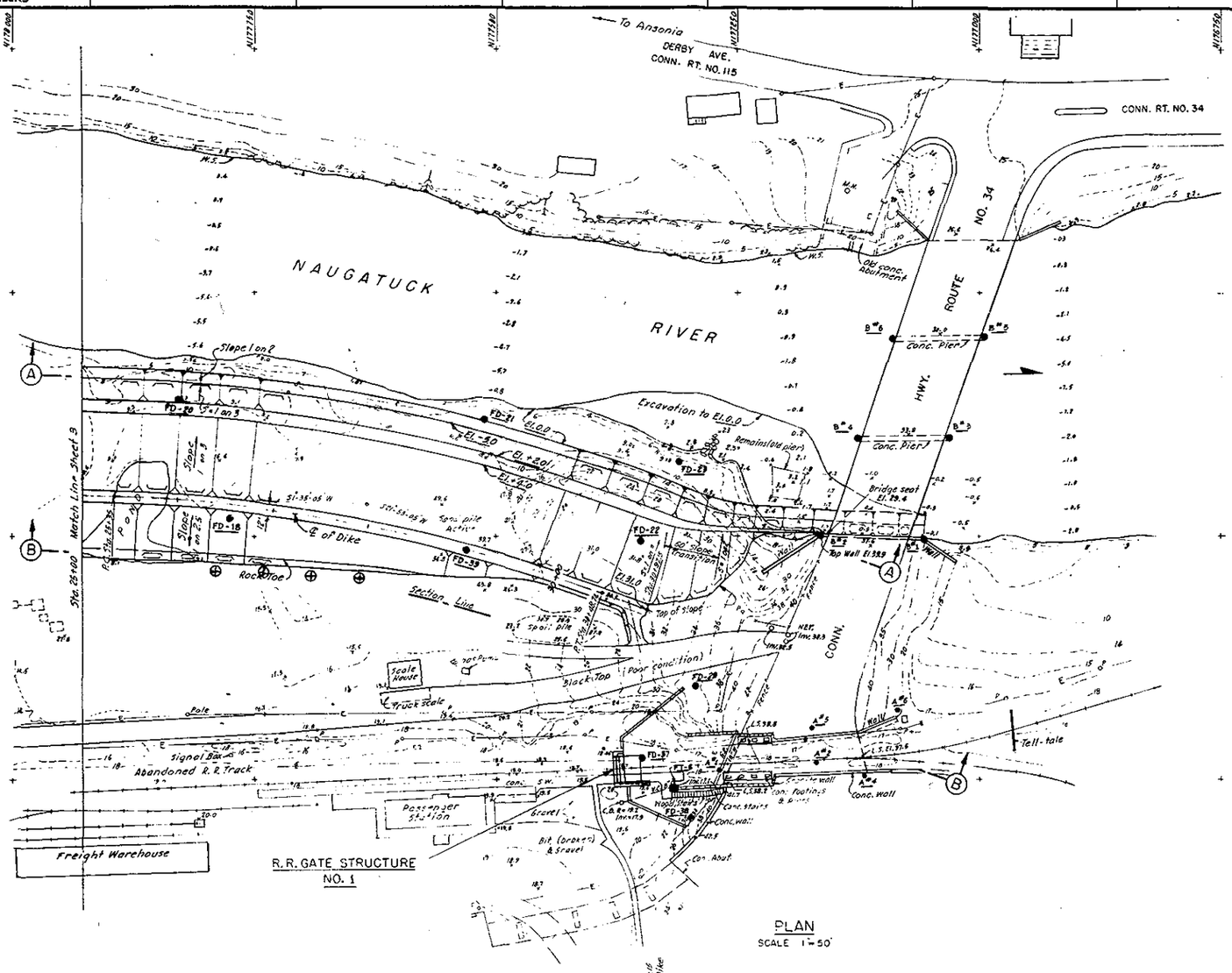
HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE: AS SHOWN | SPEC. NO. -
DRAWING NUMBER
HOU-15
SHEET 3

PLATE NO. 5-7

CORPS OF ENGINEERS — U. S. ARMY



R. R. GATE STRUCTURE
NO. 1

PLAN
SCALE 1" = 50'

PROFILE — ℄ OF DIKE
SCALE HOR. 1" = 50'
VERT. 1" = 10'

NOTES

⊕ Relief Wells

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

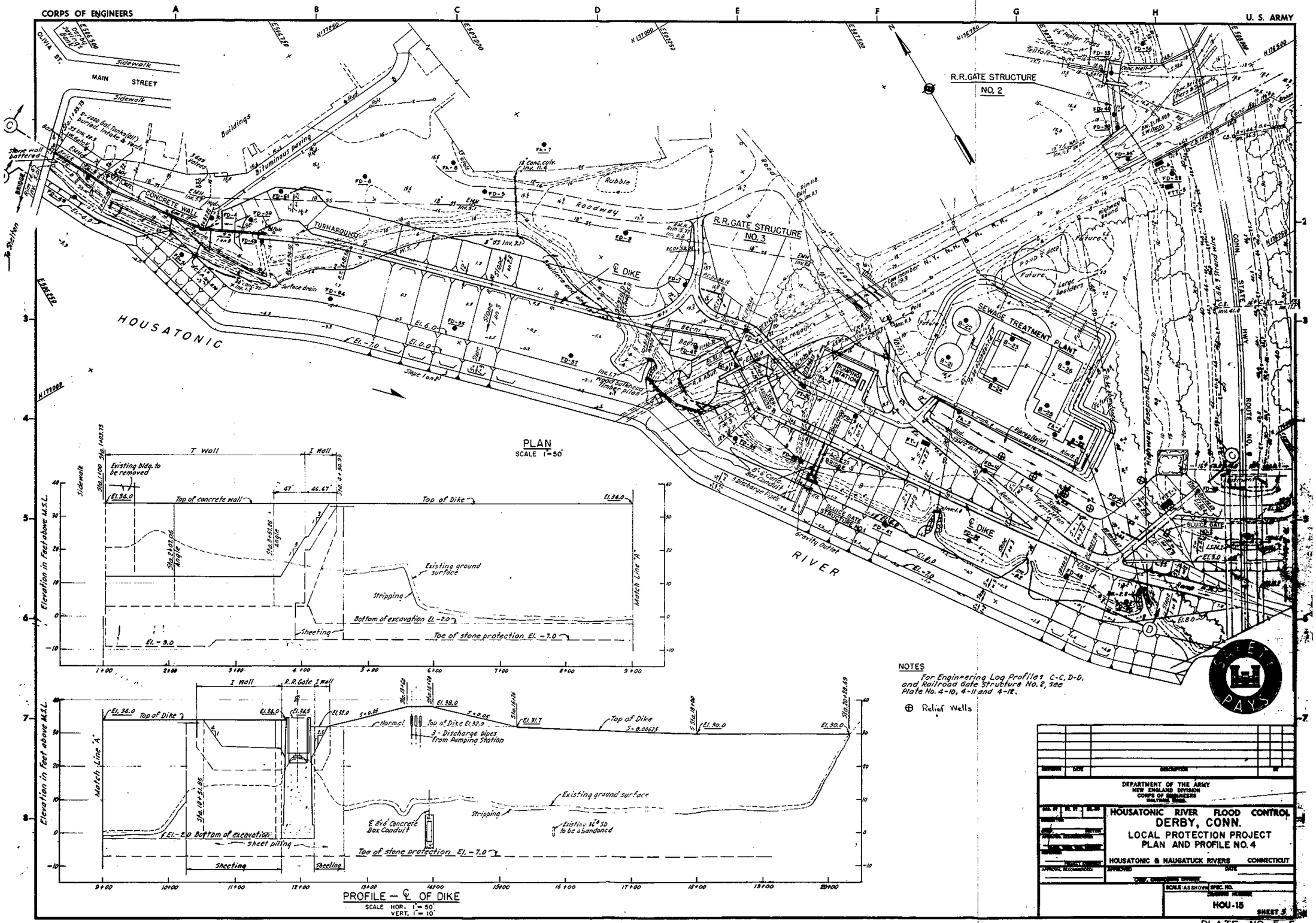
HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 3

HOUSATONIC & NAUGATUCK RIVERS — CONNECTICUT

SCALE: AS SHOWN — SPEC. NO.
DRAWING NUMBER
HOU-15
SHEET 4

PLATE NO. 5-4

CORPS OF ENGINEERS U. S. ARMY



NOTES

For Engineering Log Profiles C-C, D-D, and Railroad Gate Structure No. 2, see Plate No. 4-10, 4-11 and 4-12.

⊕ Relief Wells

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
DERBY, CONN.
LOCAL PROTECTION PROJECT
PLAN AND PROFILE NO. 4

HOUSATONIC & NAUGATUCK RIVERS CONNECTICUT

SCALE: AS SHOWN SPEC. NO.
DRAWING NUMBER
HOU-15
SHEET 5

PLATE NO. 5-5

CORPS OF ENGINEERS

U. S. ARMY

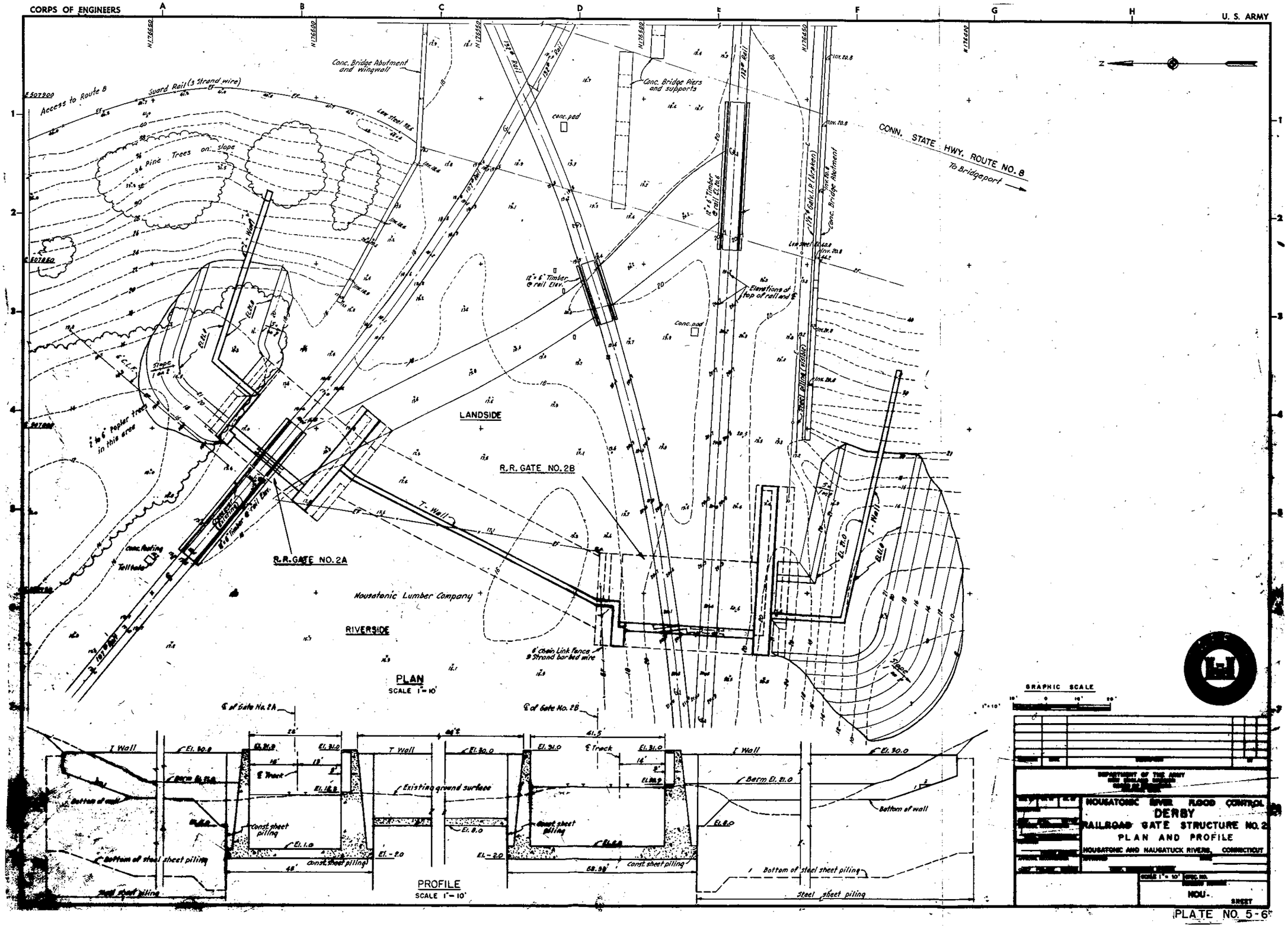
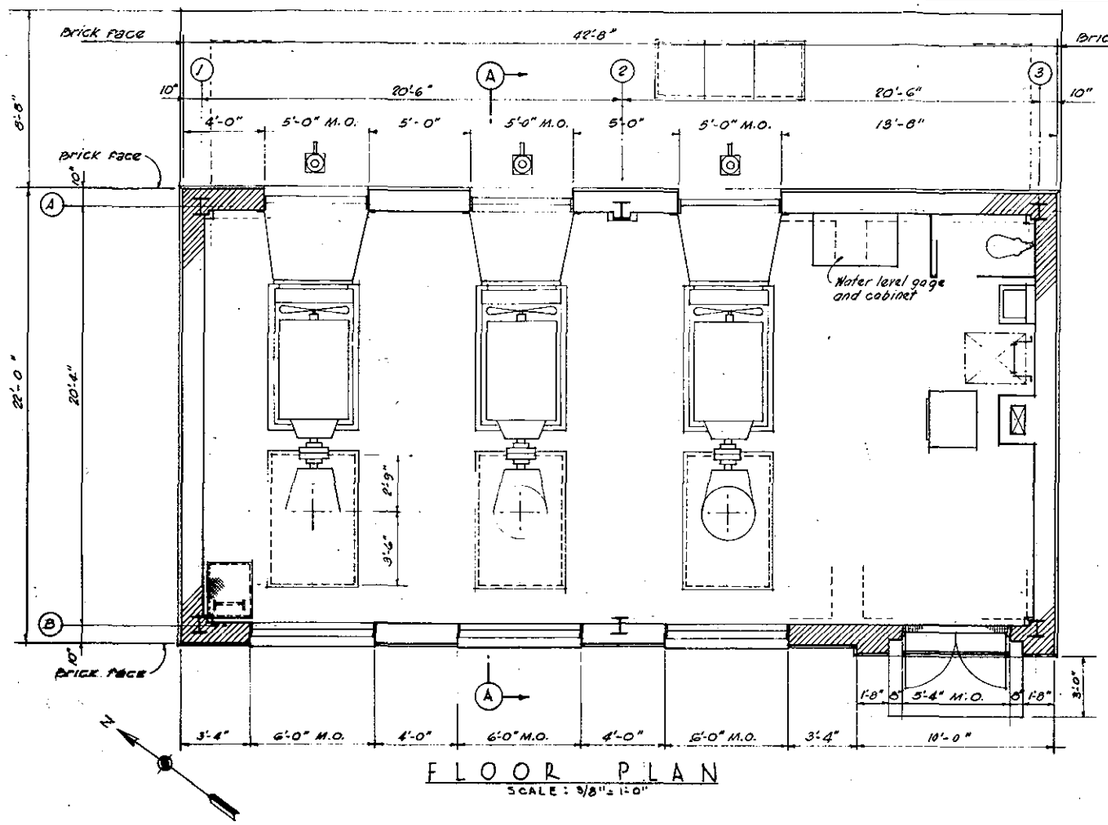
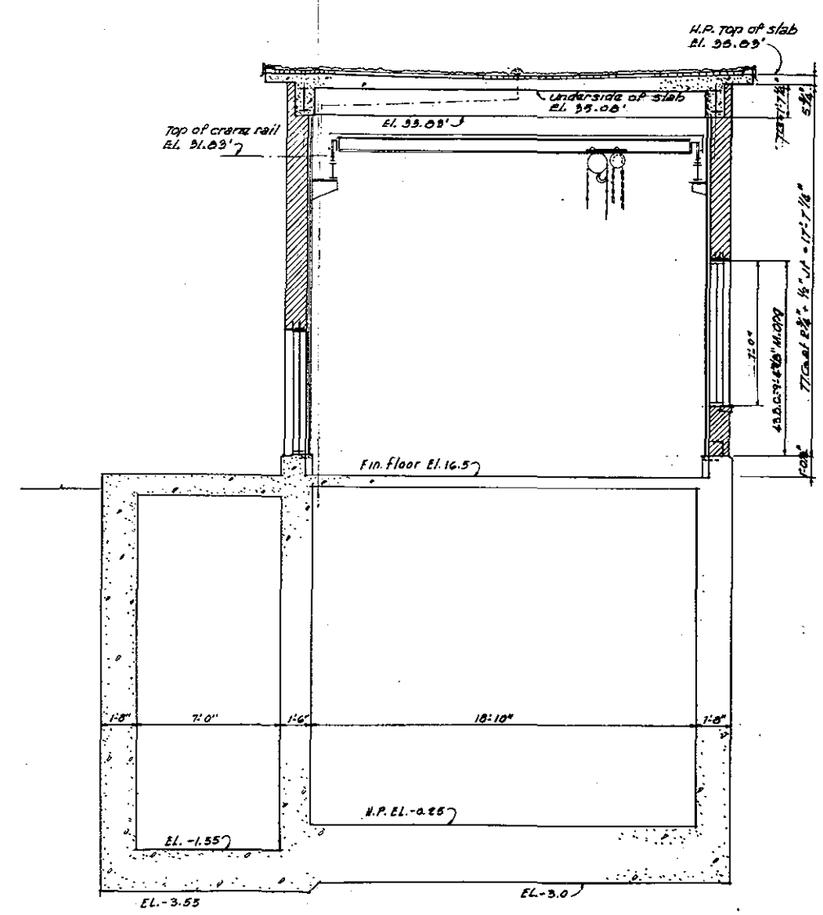


PLATE NO. 5-6

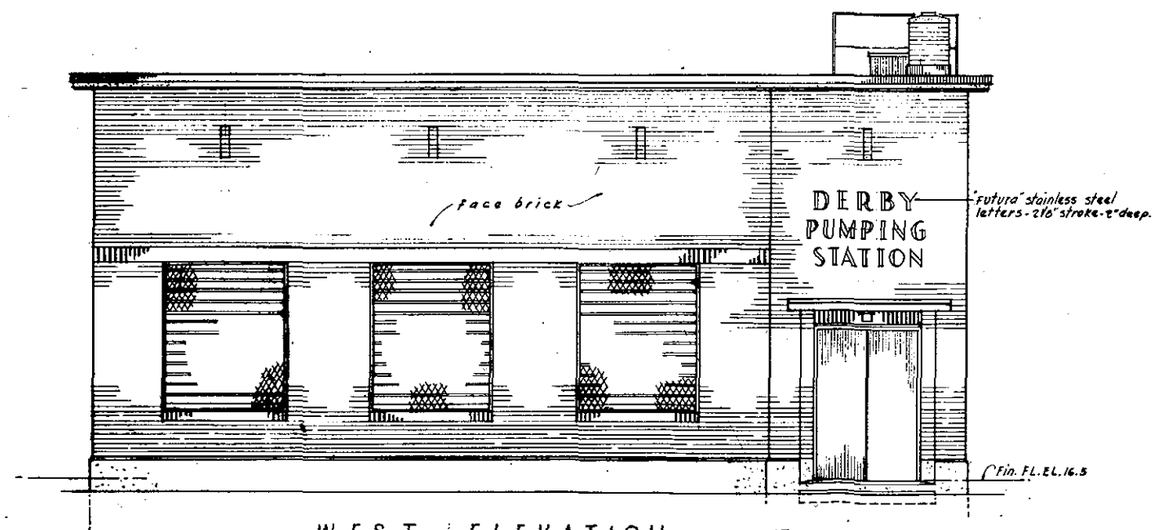
CORPS OF ENGINEERS — U. S. ARMY



FLOOR PLAN
SCALE: 3/8" = 1'-0"



SECTION "A-A"
SCALE: 3/8" = 1'-0"



WEST ELEVATION
SCALE: 3/8" = 1'-0"

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

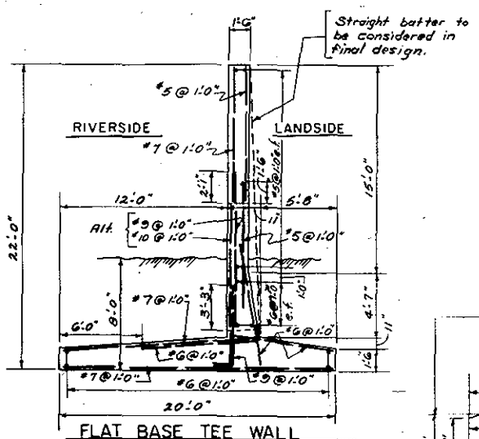
DES. BY | DR. BY | CK. BY
SUBMITTED:
CHIEF, ARCH'L SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
DERBY
DERBY PUMPING STATION
ARCHITECTURAL
PLAN ELEVATION AND SECTION
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

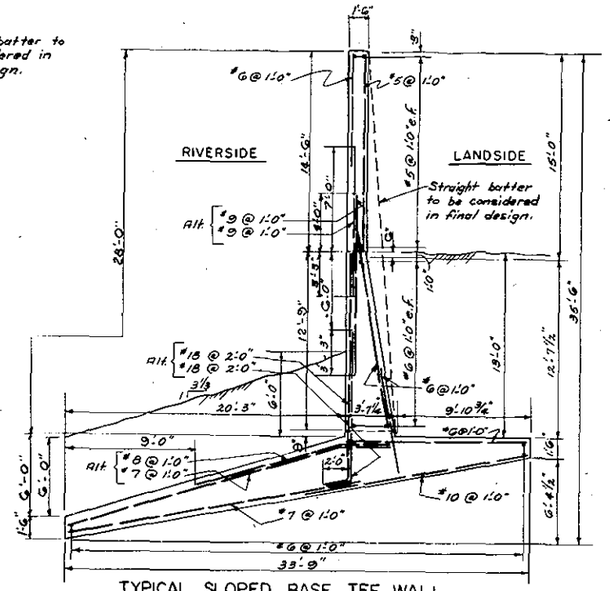
APPROVED: CHIEF, ENGINEERING DIVISION — DATE

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

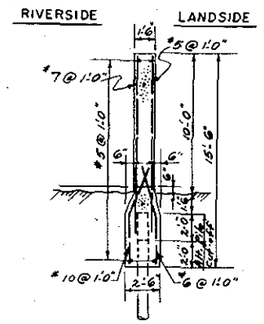
PLATE NO. 5-7



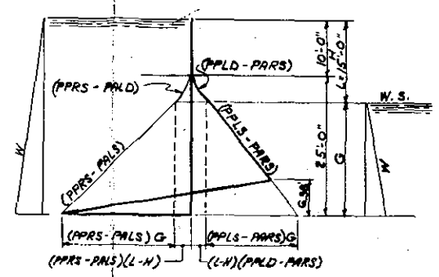
FLAT BASE TEE WALL
BETWEEN RAILROAD GATES 2A & 2B
SCALE 1/4" = 1'-0"



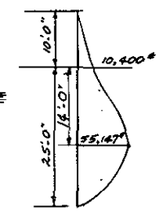
TYPICAL SLOPED BASE TEE WALL
(HOUSATONIC RIVER)
SCALE 1/4" = 1'-0"



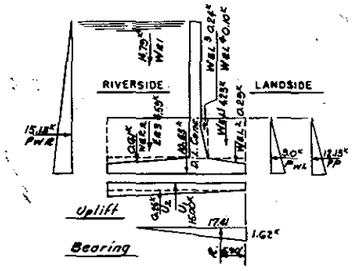
TYPICAL I WALL
SCALE 1/4" = 1'-0"



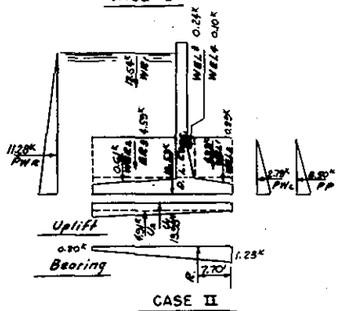
LOADING DIAGRAM
SCALE 1" = 10'



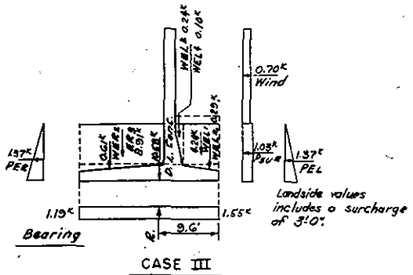
MOMENT DIAGRAM
SCALE 1" = 10'



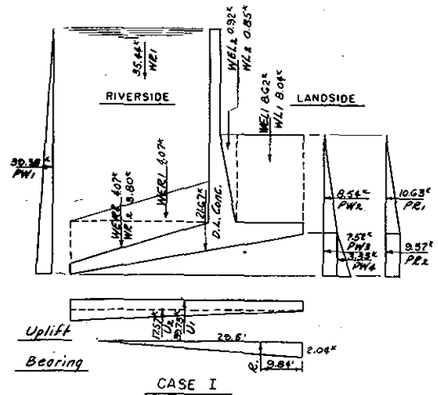
CASE I



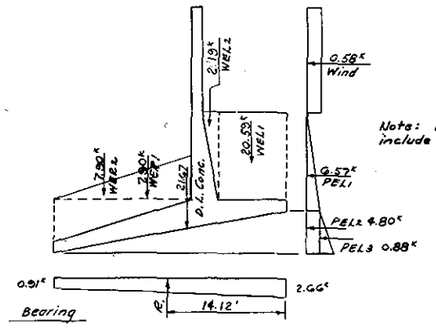
CASE II



CASE III

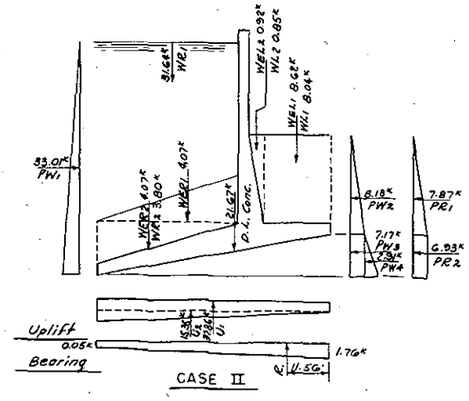


CASE I



CASE III

Note: Landside values include a 3'-0" surcharge.



CASE II

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY H.E.W. | DR. BY C.M.A. | CK. BY H.E.W.

SUBMITTED: CHIEF, STRUCT. SECTION
APPROVAL RECOMMENDED: CHIEF, WORK DEV. BRANCH
REVIEWED: PROJECT ENGINEER
APPROVAL RECOMMENDED: CHIEF, PROJECT BRANCH

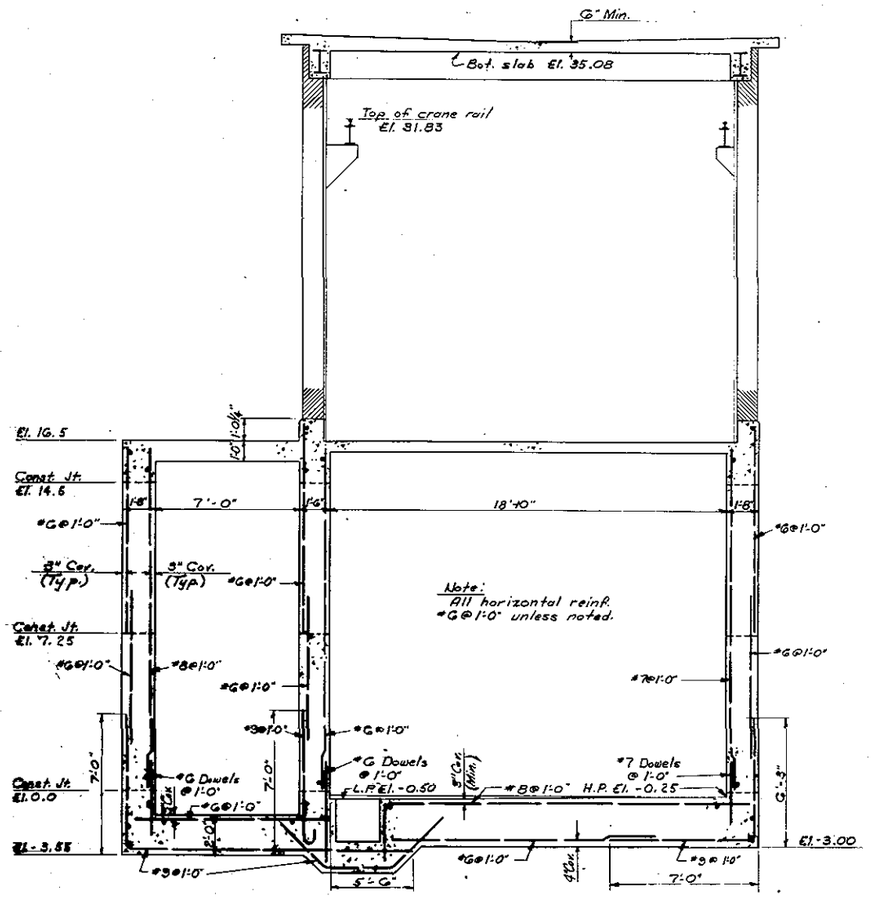
HOUSATONIC RIVER FLOOD CONTROL
DERBY
STRUCTURAL
FLOOD WALLS AND STABILITY DIAGRAMS
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

APPROVED: CHIEF, ENGINEERING DIVISION DATE

SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER HOU-15
SHEET

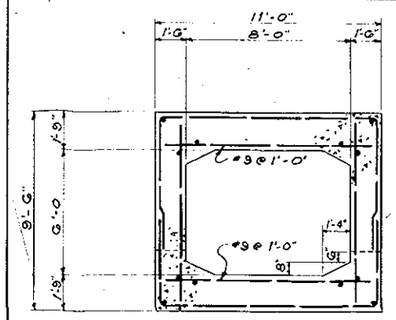
PLATE NO. 5-8

CORPS OF ENGINEERS — U. S. ARMY



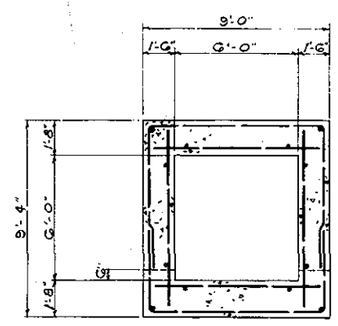
SECTION THRU PUMPING STATION

SCALE: 3/8" = 1'-0"



Note:
All reinf. steel #6@1'-0" except as shown.

PUMPING STATION CONDUIT



Note:
All reinf. steel #6@1'-0"

DRAINAGE CONDUIT

CONDUIT LOADING

Case I. Max. flood stage, conduit empty, 150% of Vert. projected weight of fill, lateral earth pressure co-ef. K = .50 (.33 of vert.)

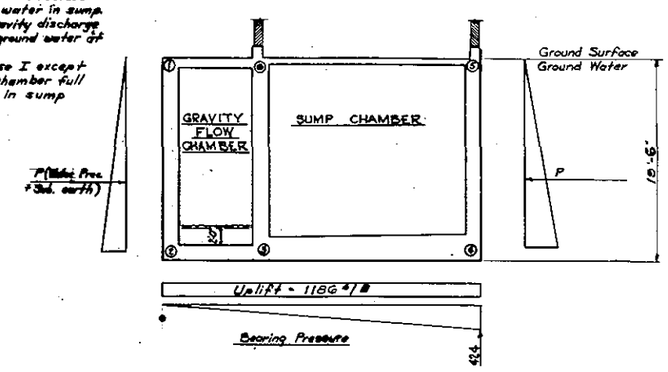
Case II. Water down, embankment moist, 150% of Vert. projected weight of fill and lateral earth pressure co-ef. K = .5 (.33 of vert.)

Case III. Water at flood stage, 100% of Vert. projected weight of fill and lateral pressure at 100% of vert. pressure.

LOADING CONDITIONS

Case I. Dead weight of structure and equipment. No water in sump. 2 ft. of water in gravity discharge chamber. Exterior ground water at ground surface.

Case II. Same as Case I except gravity discharge chamber full and 2'-6" of water in sump chamber.



LOADING DIAGRAM

Case I

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY L.B.F. / DR. BY R.P.M. / CK. BY

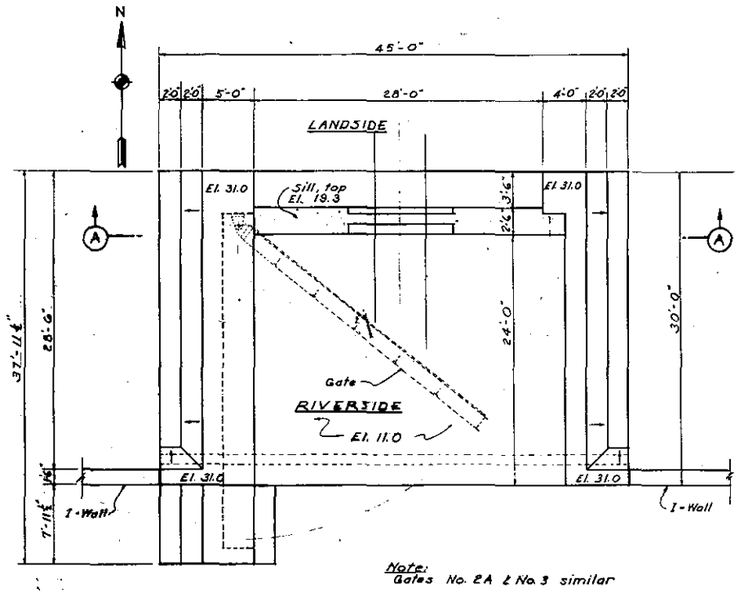
SUBMITTED:
CHIEF, STRUCT. SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
DERBY
STRUCTURAL
PUMPING STATION & CONDUITS
HOUSATONIC AND NAUGATUCK RIVERS CONNECTICUT

APPROVED: CHIEF, ENGINEERING DIVISION
DATE

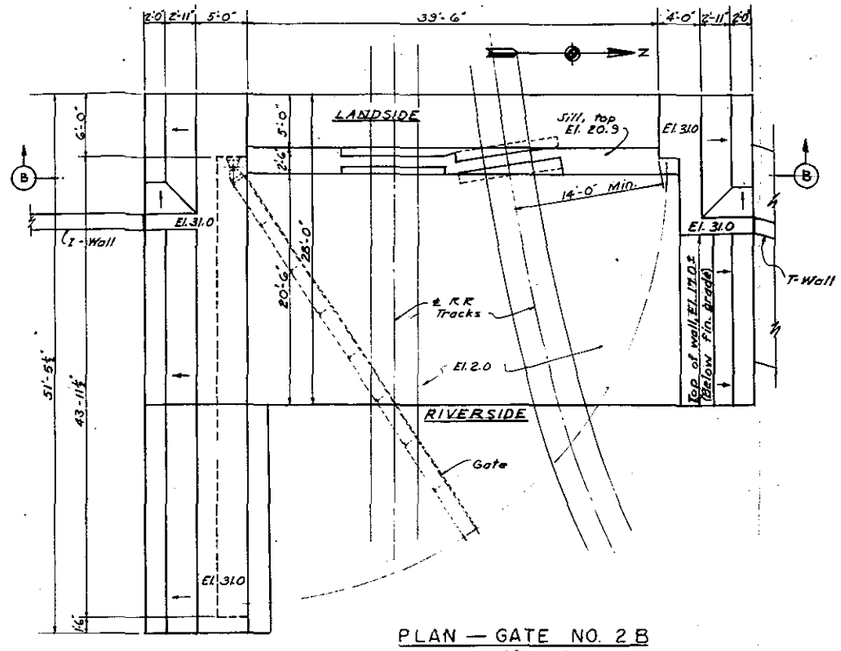
SCALE
SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 5-9



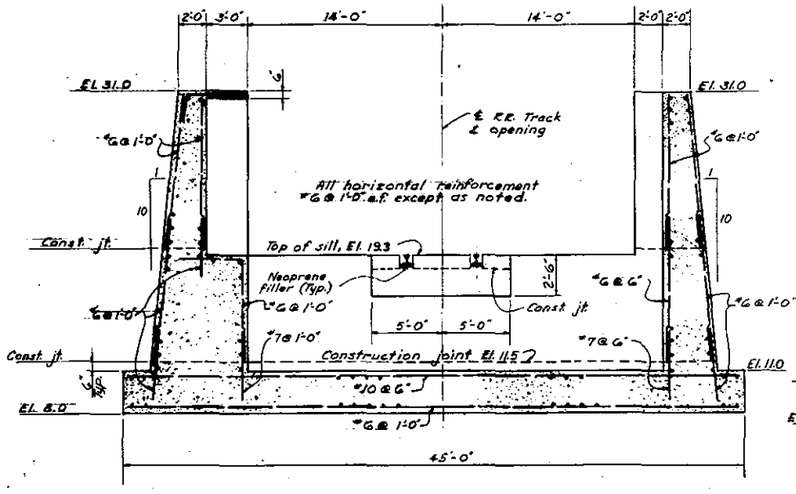
PLAN — GATE NO. 1

SCALE 3/16" = 1'-0"



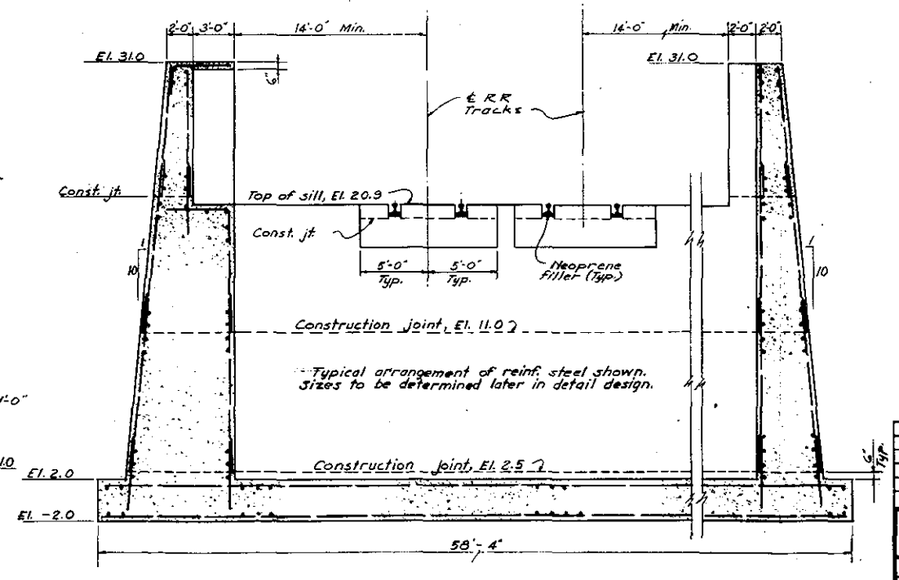
PLAN — GATE NO. 2 B

SCALE 3/16" = 1'-0"



SECTION A—A

SCALE 1/4" = 1'-0"



SECTION B—B

SCALE 1/4" = 1'-0"

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY A.S. | DR. BY K.A.T. | CK. BY

SUBMITTED: CHIEF, STRUCT. SECTION — APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. DIVISION — REVIEWED:
PROJECT ENGINEER — APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
DERBY
STRUCTURAL
RAILROAD GATES - CONCRETE DETAILS
HOUSATONIC AND NAUGATUCK RIVERS CONNECTICUT

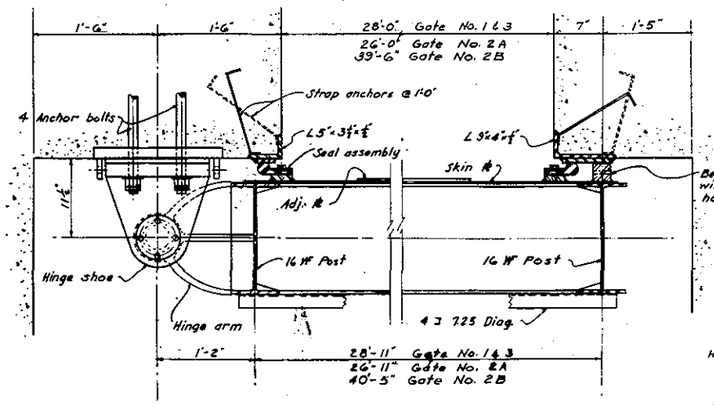
APPROVED: CHIEF, ENGINEERING DIVISION — DATE

SCALE | SPEC. NO. | DRAWING NUMBER | SHEET

SAFETY PAYS

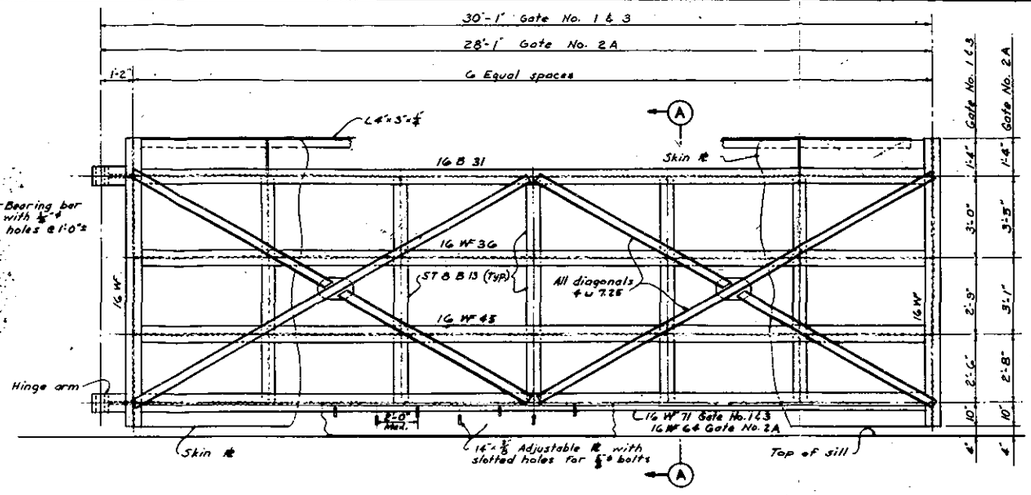
PLATE NO. 5-10

CORPS OF ENGINEERS — U. S. ARMY



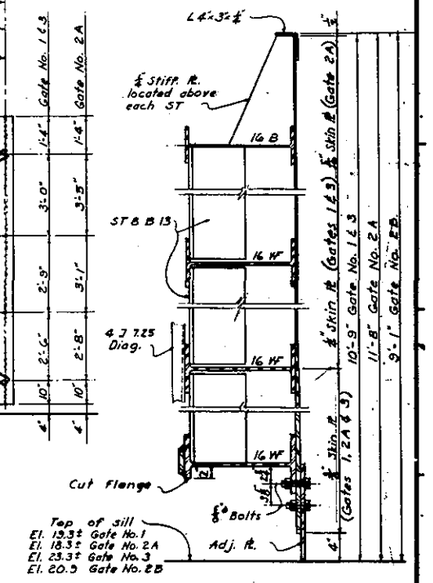
SECTIONAL PLAN — GATE NO. 1, 2A, 2B & 3

SCALE 1½" = 1'-0"



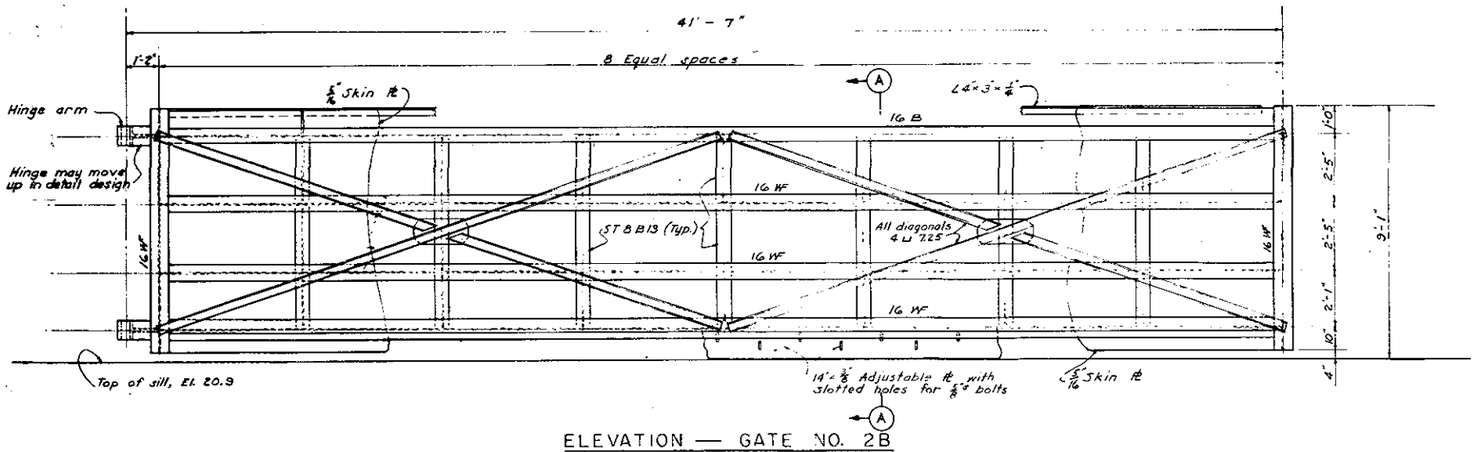
ELEVATION — GATE NO. 1, 2A & 3

SCALE ¼" = 1'-0"



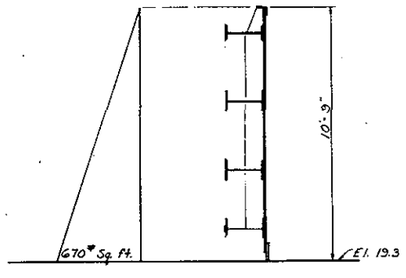
SECTION A-A

SCALE 1½" = 1'-0"

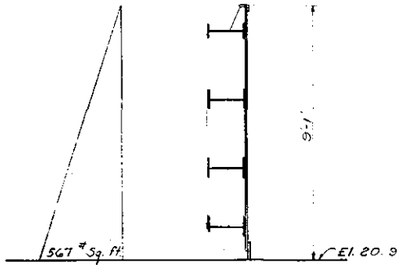


ELEVATION — GATE NO. 2B

SCALE ¼" = 1'-0"



GATE NO. 1



GATE NO. 2B

LOADING DIAGRAMS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY G.E.K. | DR. BY K.J.T. | CK. BY

SUBMITTED: CHIEF, STRUCT. SECTION

APPROVAL RECOMMENDED: CHIEF, STRUC. DES. BRANCH

REVIEWED: PROJECT ENGINEER

APPROVAL RECOMMENDED: CHIEF, PROJECT BRANCH

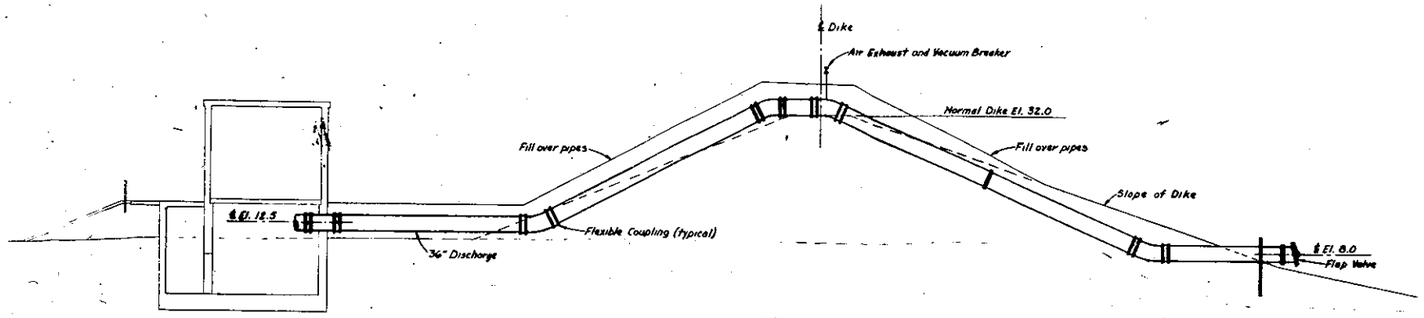
HOUSATONIC RIVER FLOOD CONTROL
DERBY
STRUCTURAL
RAILROAD GATES - GATE LEAF DETAILS
HOUSATONIC AND NAUGATUCK RIVERS — CONNECTICUT

APPROVED: CHIEF, ENGINEERING DIVISION — DATE

SCALE | SPEC. NO. | DRAWING NUMBER | SHEET

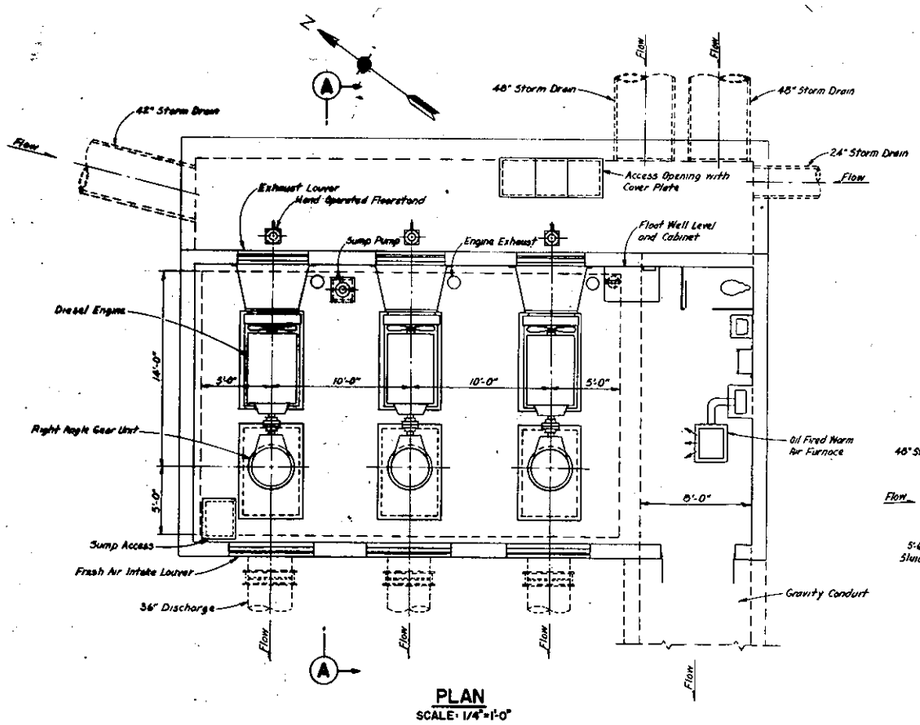
PLATE NO. 5-11

CORPS OF ENGINEERS — U. S. ARMY



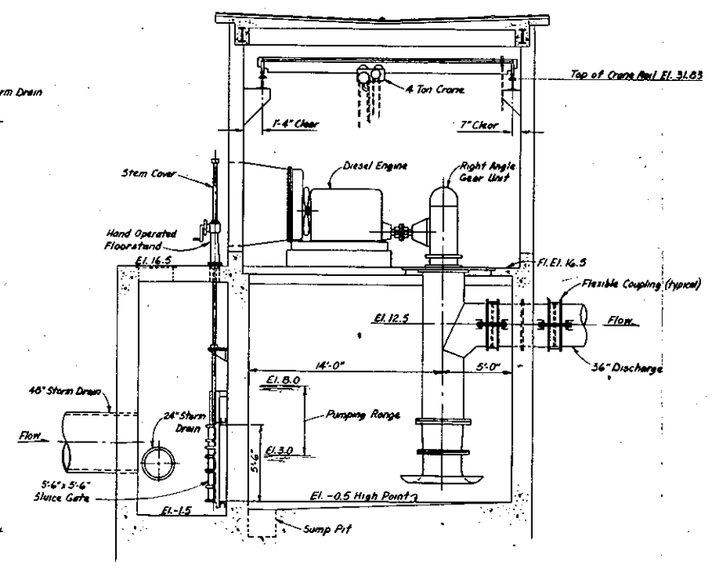
SECTION AT DIKE

SCALE: 1" = 10'



PLAN

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



SECTION A-A

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

GRAPHIC SCALES

1" = 10'-0" 10' 0 10' 20'

1/4" = 1'-0" 4' 0 4' 8'

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY JTS | DR. BY RDP | CK. BY

SUBMITTED: CHIEF, MECHANICAL SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

REVIEWED: CHIEF, ENGINEERING DIVISION

APPROVAL RECOMMENDED: CHIEF, PROJECT BRANCH

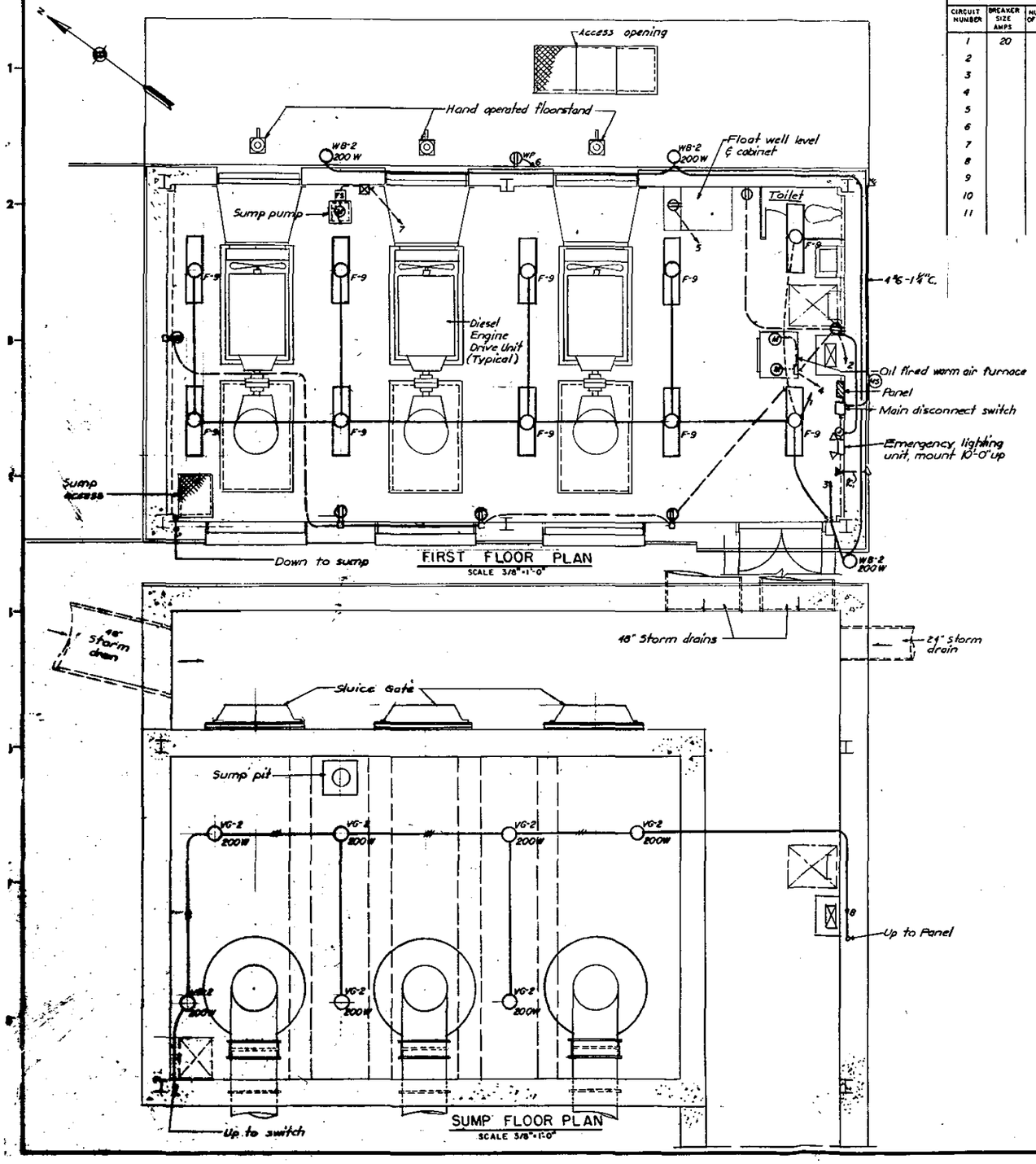
HOUSATONIC RIVER FLOOD CONTROL
DERBY
DERBY PUMPING STATION
MECHANICAL
PLAN AND SECTIONS
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

APPROVED: CHIEF, ENGINEERING DIVISION — DATE

SCALE AS SHOWN — SPEC. NO. — DRAWING NUMBER — SHEET

PLATE NO. 5 - 12

CORPS OF ENGINEERS — U. S. ARMY



FIRST FLOOR PLAN
SCALE 3/8"=1'-0"

SUMP FLOOR PLAN
SCALE 3/8"=1'-0"

PANEL

120/240 V 3ϕ 4 WIRE
50 AMP MAIN BREAKER

CIRCUIT NUMBER	BREAKER SIZE AMPS	NUMBER OF POLES	SERVES	CONNECTED LOAD KVA
1	20	1	Lighting	1.0
2			Receptacles	1.2
3			Lighting — Exterior	.6
4			Furnace	
5			Float well	
6			Receptacle — Exterior	.2
7		2	Sump pump	
8		1	Lighting	1.4
9		3	Sluice gate	2.6
10		1	Spare	
11		3	Spare	

LEGEND

SYMBOL	DESCRIPTION
○	Ceiling outlet
⊢○	Wall outlet
▭	Fluorescent fixture - 2-40 W.
⊕	Junction box
⊕	Duplex convenience outlet-W.P. indicates weatherproof
(M) 3/4	Motor-HP as indicated
(MS)	Meter socket
	Emergency lighting unit
▨	Panel
⊠	Controller
◄	Telephone outlet, 1'-0" up
——	Branch circuit concealed in ceiling or wall.
— —	Branch circuit in floor
——→	Home run to panelboard. Note: Any circuit without further designation indicates a two-wire circuit. For a greater number of wires indicate as follows —\\\\— (3 wires) —\\\\\\— (4 wires) etc.
s	Single pole switch, 4'-0 up.
FS	Float switch

GRAPHIC SCALES
3/8"=1'-0"

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY L.F.F. | DR. BY R.S.P. | CK. BY

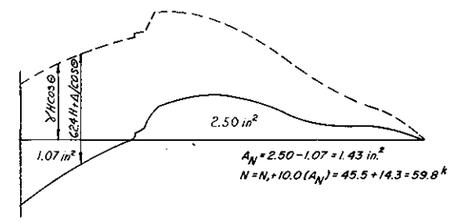
SUBMITTED:
CHIEF, ELECTRICAL SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF PROJECT BRANCH

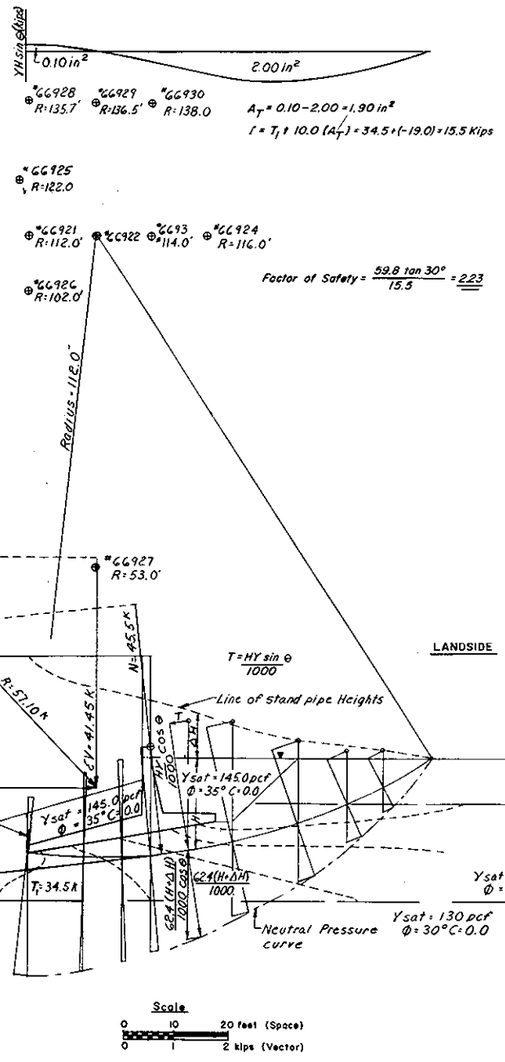
HOUSATONIC RIVER FLOOD CONTROL
DERBY
DERBY PUMPING STATION
ELECTRICAL
PLANS
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

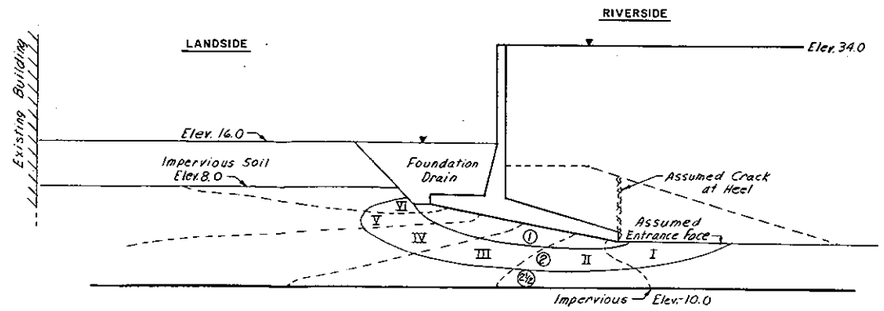
APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO. | DRAWING NUMBER
SHEET

PLATE NO. 5-13







$N_f/N_d = \frac{2.5}{6}$

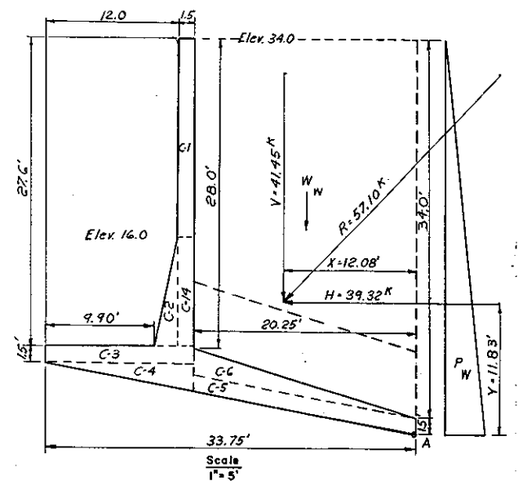
$\Delta h = \frac{18.0}{6} = 3.0'$

$\frac{K_H}{K_V} = 16$

Transformation Factor = $\sqrt{\frac{K_H}{K_V}} = 4$

FLOW NET FOR STA. 3+50

Scale: 1" = 10'

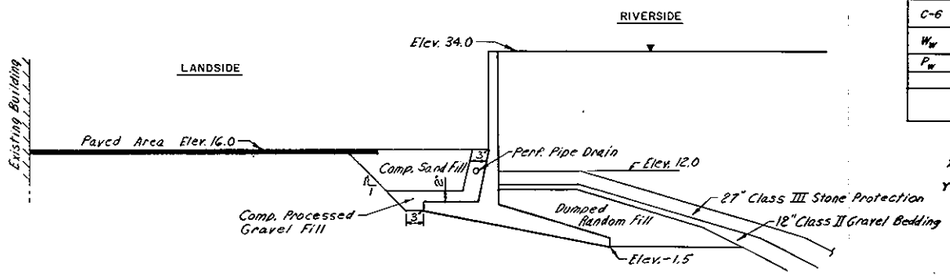


Force	Factors	Force − Kips ↓	→	Arm Ft.	Mom. @ A Ft.-Kips
C-1	1.5 x 18.0 x 0.150	4.05	–	21.00	85.0
C-1A	1.5 x 9.6 x 0.050	0.72	–	21.00	15.1
C-2	$\frac{2.1}{2}$ x 9.6 x 0.050	0.50	–	22.45	11.2
C-3	1.5 x 13.5 x 0.050	1.01	–	27.00	27.3
C-4	$\frac{2.5}{2}$ x 13.5 x 0.050	0.84	–	24.75	20.7
C-5	1.5 x 20.25 x 0.050	1.52	–	10.125	15.4
C-6	$\frac{20.25}{2}$ x 2.4 x 0.050	1.22	–	13.50	16.5
W_W	$\frac{28+22}{2}$ x 20.25 x 0.0624	31.59	–	9.80	309.6
P_W	$(35.5)^2$ x 0.0624 x 1/2	–	-39.32	11.833	-485.7
				ΣM_V =	500.8
	ΣV =	41.45			
	ΣH =		-39.32	ΣM_H =	-485.7

Location of Resultant

$X = \frac{\Sigma M_V}{\Sigma V} = \frac{500.8}{41.45} = 12.08'$

Y = 11.83'



SECTION STA. 3+50

Scale: 1" = 10'

SUMMARY STABILITY ANALYSIS

Circle No.	Factor of Safety	Remarks
66921	2.55	
66922	2.23	Minimum
66923	2.55	
66924	2.70	
66925	2.45	
66926	2.54	
66927	3.10	
66928	2.31	
66929	2.41	
66930	2.65	

GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

1" = 10' 10' 0 10' 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED: Chief, Geology Section

APPROVAL RECOMMENDED: Chief, F & M Branch

REVIEWED: Project Engineer

APPROVAL RECOMMENDED: Chief Project Branch

HOUSATONIC RIVER FLOOD CONTROL
DERBY
FOUNDATION STABILITY ANALYSIS
HOUSATONIC FLOOD WALL
STATION 3+50
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

APPROVED DATE

CHIEF, ENGINEERING DIVISION

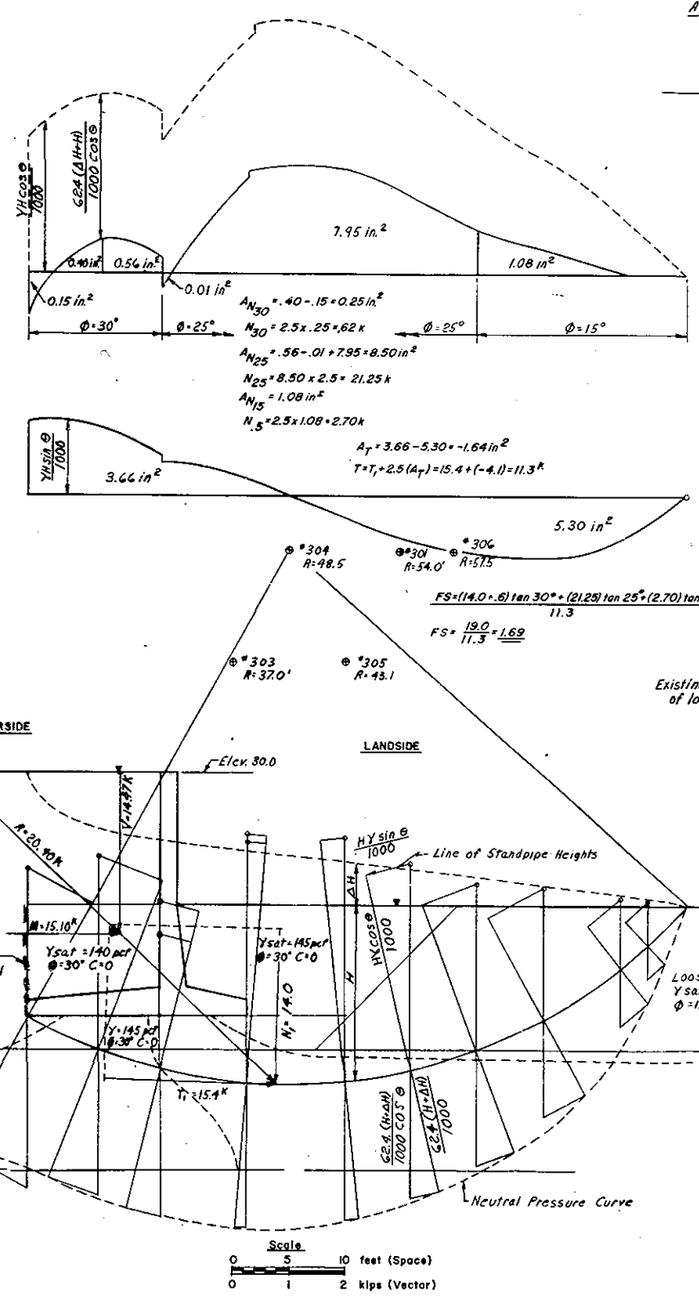
SCALE AS SHOWN SPEC. NO.

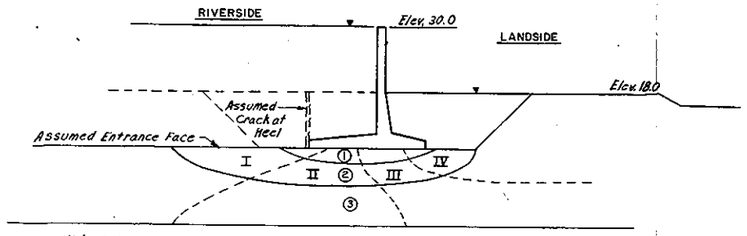
DRAWING NUMBER

SHEET

PLATE NO. 5-14

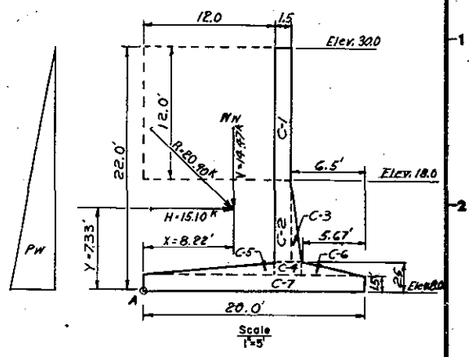
CORPS OF ENGINEERS — U. S. ARMY





FLOW NET FOR T-WALL FOR RAILROAD GATE NO. 2

Scale: 1" = 10'

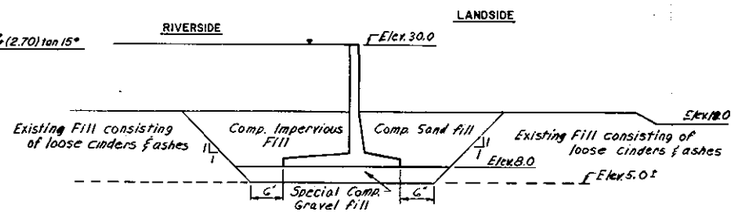


Force	Factors	Force – Kips ↑	Force – Kips →	Arm Ft.	Mom. @ A Ft.-Kips
C-1	1.5 x 12.0 x 0.150	2.70	–	12.75	34.4
C-2	1.5 x 7.5 x .050	0.56	–	12.75	7.1
C-3	$\frac{8.3}{2}$ x 7.5 x .050	0.16	–	13.80	2.2
C-4	1.0 x 2.33 x .050	0.12	–	13.16	1.6
C-5	$\frac{1.0}{2}$ x 12.0 x .050	0.30	–	8.00	2.4
C-6	$\frac{1.0}{2}$ x 5.67 x .050	0.14	–	16.22	2.3
C-7	1.5 x 20.0 x .050	1.50	–	10.00	15.0
W_W	12 x 12 x 0.0624	8.99	–	6.00	53.9
P_W	$\frac{(22.0)^2}{2}$ x 0.0624	–	15.10	7.33	110.2
	ΣV =	14.47			ΣM_V = 118.9
		ΣH =	15.10		ΣM_H = 110.2

Location of Resultant

$X = \frac{\Sigma M_V}{\Sigma V} = \frac{118.9}{14.47} = 8.22'$

Y = 7.33'



SECTION OF T-WALL FOR RAILROAD GATE NO. 2

Scale: 1" = 10'

SUMMARY STABILITY ANALYSIS

Circle No.	Factor of Safety	Remarks
301	1.72	
303	2.02	
304	1.69	Minimum
305	1.77	
306	1.87	

GRAPHIC SCALES

1" = 5' 5' 0 5' 10'

1" = 10' 10' 0 10' 20'

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY | CK. BY

SUBMITTED:
CHIEF, GEOLOGY SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
DERBY
FOUNDATION STABILITY ANALYSIS
T-TYPE FLOOD WALL
FOR R.R. GATE NO. 2
HOUSATONIC AND NAUGATUCK RIVERS, CONNECTICUT

APPROVED
CHIEF, ENGINEERING DIVISION
DATE

SCALE: AS SHOWN | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 5-15

APPENDIX A

STRUCTURAL COMPUTATIONS

DERBY STRUCTURAL COMPUTATIONS

Index

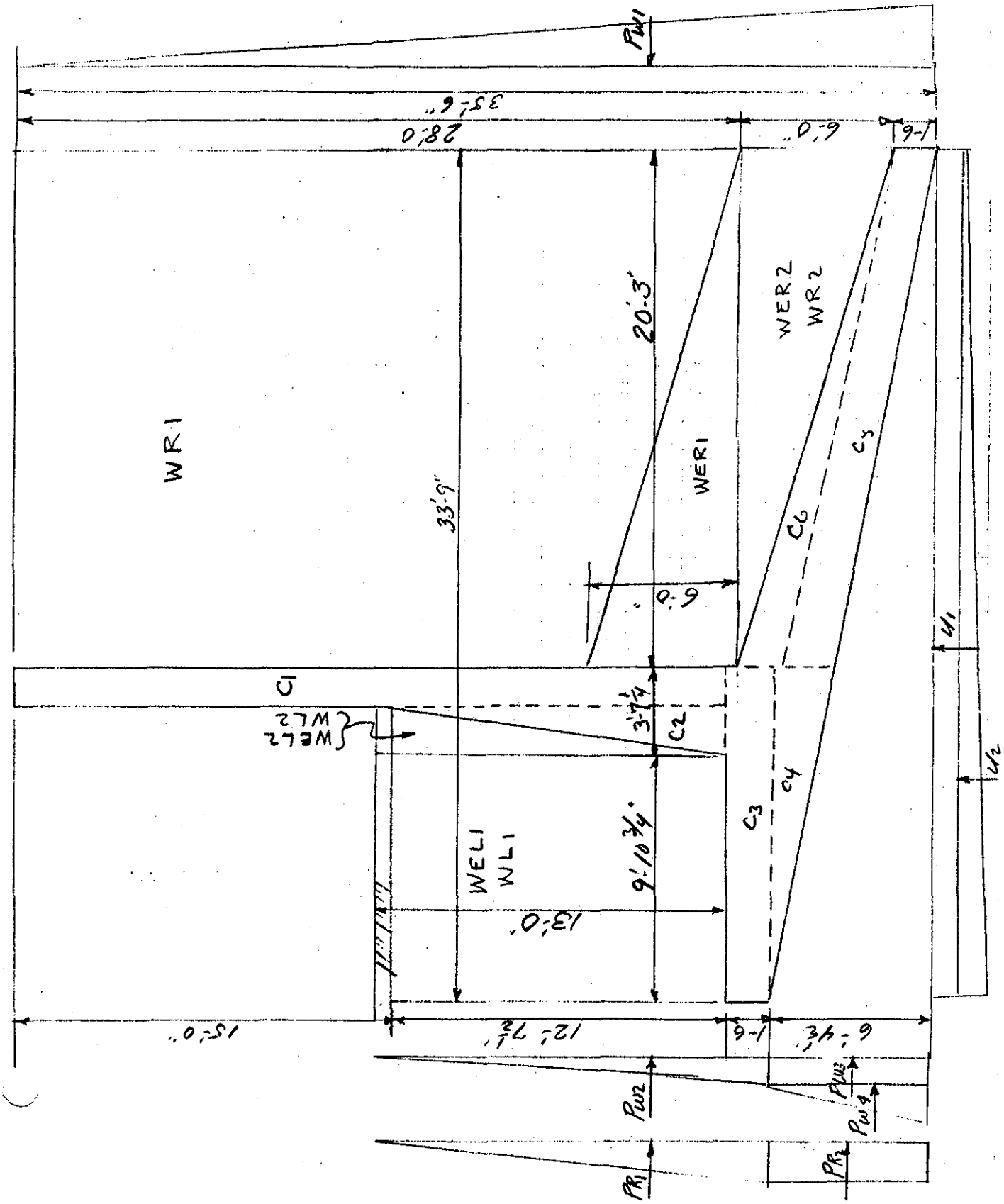
Item	Page
Sloped Base Floodwall	DM-1 to DM-5
Flat Base Floodwall	DM-6 to DM-10
I Wall	DM-11
Pumping Station Conduit	DM-12 to DM-18
Railroad Gate No. 1 - Stability Investigation	DM-19 to DM-24
Railroad Gate No. 1 - Base Slab Steel Reinforcement	DM-25 to DM-28
Railroad Gate No. 1 - Steel Gate Design	DM-29 to DM-30
Pumping Station	DM-31 to DM-54

NED FORM 2.5
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE D.N-1

SUBJECT Derby Local Protection
COMPUTATION Tee Type Flood Wall
COMPUTED BY H.E.W. CHECKED BY DATE May 1[illegible]



NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE DM-2

SUBJECT Derby Local Protection
COMPUTATION Tee Type Flood Wall -
COMPUTED BY H.E.W CHECKED BY DATE May 1968

```
LOADING CONDITIONS:- #1 WATER TO TOP OF WALL
                     #2 WATER 3 FT BELOW TOP OF WALL
                     #3 WATER DOWN 50PSF WIND LOAD ON LANDSIDE
ALL UNITS IN POUNDS AND FEET
INSTRUCTIONS:-----
                     #1 SET MAGNITUDE 7, DECIMAL 2
                     #2 CONTROL MODE = AUTO, PROGRAM MODE = AUTO
                     #3 SWITCH, ANSWERS ONLY ON, AUTOMATIC TAB
                     #4 READER & PUNCH @ AUTO
                     #5 TO CLEAR: RESET MEMORY, ((=
ENTER FOLLOWING ITEMS:


HEIGHT OF WALL (FROM BOT. OF BASE)=35.5
WEIGHT OF CONCRETE =150
   "   "  WATER =62.5
   "   "   EARTH (SUB) =67
LATERAL ACTIVE EARTH PRESSURE  KA=.33
HEIGHT OF RIVER SIDE HORIZ. PROJECTION OF BASE=6.0
  "    "  EARTH RIVERSIDE =6.0
  "    "    "   RIVERSIDE STEM=6.0
  "    "    "   LANDSIDE =13.0          ..0000

        ..0000

DIMENSIONS (FEET):------
WIDTH BASE                      =       33.75
HORIZ. PROJ OF BASE             =       6.0
WIDTH OF STEM @ TOP             =        1.5
  "   "   "   @  "  OF BASE     =        3.60
  "   "  BASE @ HEEL & TOE      =        1.5
HEIGHT OF STEM RIVERSIDE        =       28.00
  "    "   "   LANDSIDE         =       27.61
  "    "   "   TAPER            =       12.61
  "    "   "   STRAIGHT         =       15.00
  "    "  BASE SLOPE            =        6.38
THICKNESS OF BASE AT R. STEM    =        3.66
    "     "   "   "  L. STEM =          3.37
HEEL TO RIVERSIDE STEM          =      20.25
TOE  "  LANDSIDE   "            =       9.89
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NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Local Protection
COMPUTATION Tee Type Flood Wall
COMPUTED BY H.E.W CHECKED BY DATE May 1966

CONCRETE ONLY:----

	LOAD#	MOMENT#FT
C1 =	6212.50	79209.37
C2 =	1988.00	22463.19
C3 =	3037.50	20503.12
C4 =	2587.49	23287.49
C5 =	4556.25	107641.40
C6 =	3290.62	66635.15
CONC=	21672.37	319739.75

CUBIC YARDS/LF OF WALL = 5.35

CONDITION #1:----
CREEP RATIO = 3.34

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	21672.37				319739.75	
WEL1=	8621.28				42667.38	
WEL2=	915.35				9701.64	
WER1=	4070.25				82422.56	
WER2=	4070.25				109896.75	
WR1 =	35437.50				837210.94	
WR2 =	3796.87				102515.62	
WL1 =	8042.24				39801.66	
WL2 =	853.87				9050.04	
U1 =		39734.35				670517.23
U2 =		17574.22				395420.17
PW1 =			39382.81			214417.53
PW2 =				8535.52	41255.05	
PW3 =				7521.72		24027.74
PW4 =				3326.80		14169.74
PR1 =				10630.69	51381.71	
PR2 =				9368.04		29925.70
SUMS=	87480.01	57308.58	39382.81	39382.81	1645643.12	1348478.11
SUMV=	30171.43					
SUMH=			-.00			
SUMM=					297165.01	

M/V = 9.84
SBL= 2010.56PSF
SBR= -222.62PSF
IF SBR IS NEGATIVE THEN SBR =0 & SBL = 2042.22PSF
BEARING LENGTH= 29.54FT.

SUBJECT Derby Local Protection
COMPUTATION Tee Type Flood Wall
COMPUTED BY H.E.W CHECKED BY DATE May 1968

CONDITION #2:

CREEP RATIO = 4.20

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	21672.37				319739.75	
WEL1=	8621.28				42667.38	
WEL2=	915.35				9701.64	
WER1=	4070.25				82422.56	
WER2=	4070.25				109896.75	
WR1 =	31640.62				747509.77	
WR2 =	3796.87				102515.62	
WL1 =	8042.24				39801.66	
WL2 =	853.87				9050.04	
U1 =		37855.97				638819.53
U2 =		15349.35				345360.55
PW1 =			33007.81			146701.39
PW2 =				8132.02	39304.78	
PW3 =				7166.15		22891.87
PW4 =				2905.63		12375.87
PR1 =				7869.33	38035.12	
PR2 =				6934.66		22152.39
SUMS=	83683.14	53205.32	33007.81	33007.81	1540645.09	1188301.60
SUMV=	30477.81					
SUMH=			-.00			
SUMM=					352343.49	
M/V =	11.56					
SBL=	1756.21PSF					
SBR=	49.87PSF					

CONDITION #3:-----
WEIGHT OF EARTH(SAT.)=130
HEIGHT OF EARTH LANDSIDE PLUS SURCHARGE=16.0

NO CREEP

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	21672.37				319739.75	
WEL1=	20588.14				101892.26	
WEL2=	2185.92				23168.11	
WER1=	7897.50				159924.37	
WER2=	7897.50				213232.50	
WIND=				580.55	13530.16	
PEL1=				6569.06	38319.53	
PEL2=				4796.45		15322.01
PEL3=				875.54		3729.16
SUMS=	60241.45			12821.62	869806.71	19051.18
SUMV=	60241.45					
SUMH=				-12821.62		
SUMM=					850755.52	
H/V =	-.21					
M/V =	14.12					
SBL =	2658.38PSF					
SBR =	911.48PSF					

SUBJECT Derby Local Protection

COMPUTATION Tee Type Flood Wall

COMPUTED BY H.E.W CHECKED BY DATE May 1964

CASE 1 LOADING - STEM

ENTER FOLLOWING ITEMS:----
HEIGHT OF EARTH R.S. =6.0
HEIGHT OF WATER R.S. =28.0
HEIGHT OF EARTH L.S. =13.0
WEIGHT OF EARTH =58

	DIST	D IN	V LBS	M FT LBS	AS SQ IN	V #/SQ IN
0 =		39.72	23227.19	222347.27	3.76	44.78
1/5=	5.60	28.52	15157.47	115784.87	2.73	
2/5=	11.20	17.32	8820.00	49392.00	1.92	
3/5=	16.80	14.50	3920.00	14634.66	.67	

CASE 3 LOADING - STEM
ENTER FOLLOWING
WEIGHT OF EARTH =130
HEIGHT OF EARTH L.S.=16
HEIGHT OF " R.S.=3.0
HEIGHT OF WIND LOAD =16.0

0 =		39.72	840.75	16223.79	.27
1/5=	5.60	28.52	817.84	11581.86	.27
2/5=	11.20	17.32	800.00	7040.00	.27
3/5=	16.80	14.50	560.00	3136.00	.14

CASE I LOADING LANDSIDE BASE
ENTER FOLLOWING ITEMS
LENGTH OF BEARING =29.54
BEARING =2042.22
HEIGHT OF WATER =35.5
" " EARTH =13.0
WEIGHT OF EARTH =58

	DIST	D IN	V #	M FT LBS	AS SQ IN	V #/SQ IN
STEM=		35.98	-10868.86	-59178.76	-1.10	-28.25
1/3=	3.29	28.48	-7971.69	-27898.09	-.65	
2/3=	6.59	20.99	-4348.73	-7373.63	-.23	

CASE 3 LOADING LANDSIDE BASE
ENTER FOLLOWING ITEMS:
WEIGHT OF EARTH =130
HEIGHT OF EARTH =16.0
BEARING P (HEEL) =911.48
BEARING P (TOE) =2658.38

STEM=		35.98	428.72	-4355.78	-.08	

CASE I LOADING RIVERSIDE BASE

STEM=		40.50	6631.82	77518.56	1.28	15.31
1/3=	6.75	31.83	5622.82	39859.94	.84	
/3=	13.50	23.16	3881.65	12373.03	.35	

CASE 3 LOADING RIVERSIDE BASE

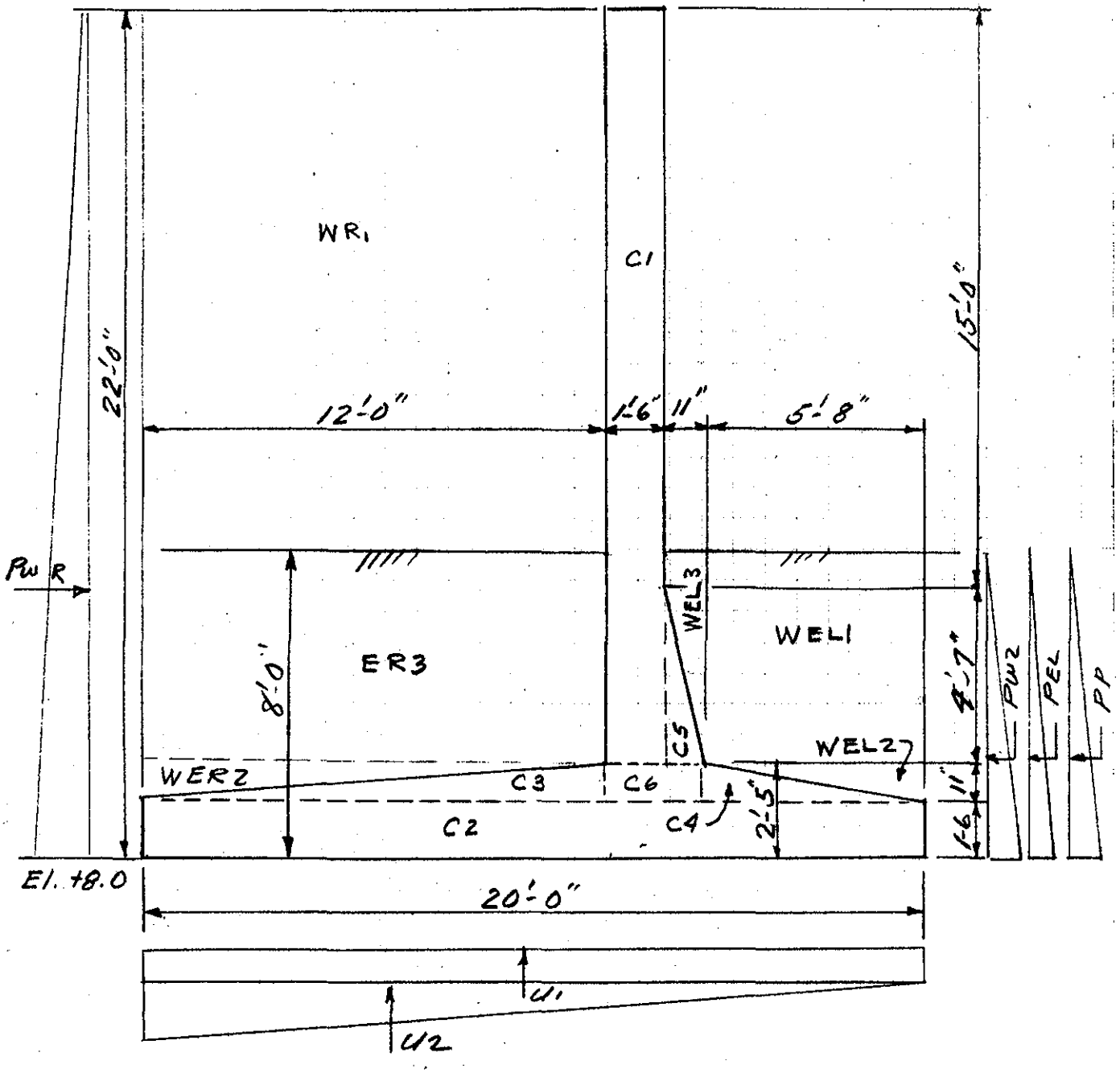
STEM=		40.50	-5428.01	-30247.57	-.50
1/3=	6.75	31.83	-1991.61	-13673.20	-.28

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE DM-6

SUBJECT Derby Conn.
COMPUTATION Tee Type Flood Wall - Vicinity of Gate No 2
COMPUTED BY H.E.W CHECKED BY DATE May 1950



Wt sub. eq = 67.5
" moist " = 120.0

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby Conn.
COMPUTATION Tee Type Flood Wall- Vicinity of Gate No 2
COMPUTED BY H.E.W CHECKED BY DATE May 1968

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ENTER FOLLOWING ITEMS:----
PROJECT NAME                          =DERBY LOCAL PROTECTION
STATION                               =VICINITY OF GATE NO 2
DATE                                  =MAY 1968
HEIGHT OF WALL (FROM BOT. OF BASE)    =22.0
WEIGHT OF CONCRETE                    =150
   "   "  WATER                       =62.5
   "   "  EARTH (SUB)                 =67
   "   "  EARTH (DRY)                 =130
COEFF. FRICTION                       =.40
LATERAL ACTIVE EARTH PRESSURE  KA     =.33
HEIGHT OF EARTH RIVERSIDE             =8.0
   "   "    "   LANDSIDE             =8.0


        -.00


DIMENSIONS(FEET):----

WIDTH,BASE                =      20.0
  "  ,STEM@TOP            =       1.5
  "  ,STEM @ TOP OF BASE=         2.28
  "  ,BASE @ HEEL & TOE =         1.5
  "  ,BASE @ STEM         =       2.28
HEIGHT,STEM               =      19.71
  "   ,STEM TAPER         =       4.71
  "   ,STEM STRAIGHT      =      15
HEEL TO RIVERSIDE STEM    =      12.00
TOE TO LANDSIDE STEM      =       5.71
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NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Conn.
COMPUTATION Tee Type Flood Wall - Vicinity of Gate No 2
COMPUTED BY H.E.W. CHECKED BY DATE May 1968

CONCRETE ONLY:------

	LOAD#	MOMENT#FT
C1 =	4435.71	56555.35
C2 =	4500.00	45000.00
C3 =	707.14	5657.14
C4 =	336.73	5451.89
C5 =	277.80	3823.14
C6 =	269.38	3540.52
CONC=	10526.78	120028.06

CUBIC YARDS/LF OF WALL= 2.59

CONDITION #1:------

CREEP RATIO= 2.00
INSTRUCTIONS:-------SET DECIMAL 1

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	10526.7				120028.0	
WR1 =	14785.7				88714.2	
WER2=	610.5				2442.0	
ER3 =	4594.2				27565.7	
WEL1=	4228.5				72489.7	
WEL2=	290.7				5260.5	
WEL3=	239.8				3363.4	
WEL4=	101.7				1413.5	
U1 =		15000.0				150000.0
U2 =		6250.0				41666.6
PWR =			15125.0		110916.6	
PWL =				3000.0		8000.0
PEL =				-		-
PP =				12125.0		32333.3
SUMS=	35378.1	21250.0	15125.0	15125.0	432194.1	231999.9

SUMV= 14128.1#
SUMH= -.0#
SUMM= 200194.1#FT
H/V =&41 -.0
M/V = 14.1FT
SBPL= 1590.0PSF
SBPR= -177.2PSF
IF SBPR IS NEGATIVE, THEN SBPR=0 & SBPL= 1615.5PSF
BRGL= 17.4FT

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby Conn.
COMPUTATION Tee Type Flood Wall - Vicinity of Gate No 2
COMPUTED BY HEW CHECKED BY DATE May 196-

CONDITION #2 W/ PASSIVE PRES. :------

CREEP RATIO= 2.5

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	10526.7	..	..	..	120028.0	
WR1 =	12535.7	..	..	..	75214.2	
WER2=	610.5	..	..	..	2442.0	
ER3 =	4594.2	..	..	..	27565.7	
WEL1=	4228.5	..	..	..	72489.7	
WEL2=	290.7	..	..	..	5260.5	
WEL3=	239.8	..	..	..	3363.4	
WEL4=	101.7	..	..	..	1413.5	
U1 =	..	13928.5	..	..	..	139285.7
U2 =	..	4910.7	..	..	..	32738.0
PWR =	..	..	11281.2	..	71447.9	
PWL =	..	..	..	2785.7	..	7428.5
PEL =	..	..	..		..	
PP =	..	..	..	8495.5	..	22654.7
SUMS=	33128.1	18839.2	11281.2	11281.2	379225.3	202107.1
SUMV=	14288.8#					
SUMH=	..	..	-.0#			
SUMM=	..	..	..	..	177118.2#FT	
H/V =&41	-.0					
M/V =	12.3FT					
SBPL=	1227.8PSF					
SBPR=	201.0PSF					

CONDITION #3 :-------

NO CREEP

	+VERT#	-VERT#	+HORIZ#	-HORIZ#	+MOMENT#FT	-MOMENT#FT
CONC=	10526.7	..	..	..	120028.0	
WER2=	612.8	..	..	..	2451.4	
ER3 =	8914.2	..	..	..	53485.7	
WEL1=	4244.8	..	..	..	72769.6	
WEL2=	291.8	..	..	..	5280.8	
WEL3=	240.7	..	..	..	3376.4	
WEL4=	102.1	..	..	..	1419.0	
PEL =	..	..	..	1372.8	..	3660.8
PER =	..	..	1372.8	..	3660.8	
PWND=	..	..	..	700.0	..	10500.0
PSUR=	..	..	..	1029.6	..	4118.4
SUR =	2535.0	..	..	..	42461.2	
PP =	..	..	..		..&41	.0
SUMS=	27468.5		1372.8	3102.4	304933.2	18279.2
SUMV=	27468.5#					
SUMH=	..	..	-1729.6#			
SUMM=	..	..	..	..	286654.0#FT	
H/V =	-.0					
M/V =	10.4FT					
SBPL=	1552.9PSF					
SBPR=	1193.9PSF					

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE DM-10

SUBJECT Derby Conn.
COMPUTATION Tee Type Flood Wall - Vicinity of Gate No 2
COMPUTED BY H.E.W. CHECKED BY DATE May 1961

STEM DESIGN: CASE #1
X MEASURED FROM TOP OF STEM @ 1/5 PT'S, REINF @R.S.FACE, 3.5"MIN COV.

X FT	SHEAR#	MOMENT#FT	D REQD"	D GIV"	SHEAR,PSI	REINFX10
-19.7	11594.2	79180.6	22.8	23.9	40.3	22.9
-15.7	7772.6	40861.0	16.3	16.0	40.3	17.6
-11.8	4371.9	17236.9	10.6	14.5	25.1	8.2
-7.8	1942.8	5106.4	5.7	14.5	11.1	2.4
-3.9	485.5	638.0	2.0	14.5	2.7	.3

TOE DESIGN:
X MEASURED FROM L.S. TOE @ 1/3 PT'S, REINF @ BOT FACE, 4.5" MIN COV.

-5.7	-8464.8	-19213.9	11.2	22.9	30.7	5.8
-3.8	-5410.4	-8831.7	7.6	19.7	22.7	3.0
-1.9	-2588.2	-2279.7	3.8	16.6	12.9	.9

HEEL DESIGN:
X MEASURED FROM R.S. HEEL @ 1/3 PT'S, REINF @ TOP FACE, 3.5" MIN COV.

-11.9	4987.9	-37029.7	15.6	23.9	17.3	10.7
-7.9	4184.2	-18362.6	10.9	20.7	16.7	6.1
-3.9	2423.8	-4824.8	5.6	17.6	11.4	1.8

STEM DESIGN: CASE #3
X MEASURED FROM TOP OF WALL @ 1/3 PT'S,REINF@L.S.FACE,3.5"MIN COV.

X FT	SHEAR#	MOMENT#FT	D REQD"	D GIV"	SHEAR,PSI	REINFX10
-19.7	-1435.2	-10999.3	8.5	23.9	4.9	3.1
-13.1	-657.0	-4316.6	5.3	14.5	3.7	2.0
-6.5	-328.3	-1078.2	2.6	14.5	1.8	.5

TOE DESIGN:
X MEASURED FROM L.S. TOE @ 1/3 PT'S, REINF@TOP FACE IF +M, 3.5"MIN COV.

-5.7	-193.1	-873.7	2.3	-22.9	.7	.2
-3.8	-203.8	-483.5	1.7	-19.7	.8	.1
-1.9	-139.4	-144.6	.9	-16.6	.6	.0

EL DESIGN:
X MEASURED FROM R.S. HEEL @ 1/3 PT'S, REINF@BOT FACE IF +M, 4.5"MIN COV.

-11.9	-2684.8	13712.0	9.4	22.9	9.7	4.1
-7.9	-1523.3	5382.6	5.9	19.7	6.4	1.8
-3.9	-628.2	1167.2	2.7	16.6	3.1	.4

NED FORM 225
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

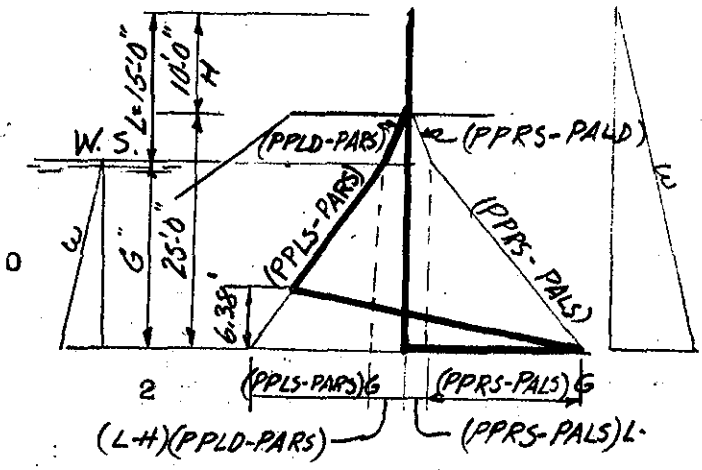
PAGE DM-11

SUBJECT Derby Local Protection
COMPUTATION I Wall - Near Gate Structure No 2
COMPUTED BY H.E.W CHECKED BY DATE May 1964

LOADING:-------RIVERSIDE WATER TO TOP OF WALL
LANDSIDE WATER AT ANY HEIGHT
GRADE EQUAL BOTH SIDES
DRY AND SUBMERGED PASSIVE PRESSURE CONSIDERED DUE TO T.W.

ALL UNITS POUND-FEET

WGT OF EARTH(SAT) =130
KA =.4
KP =2
WGT OF WATER =62.5
WALL HGT ABOVE GRADE =10.0
L.S. WATER TO TOP WALL=15.0
GUESS PENETRATION (X),(>ACTUAL)=30.0



X, Z, KP = 22.05 5.87 2

FIND KP AND Z WHEN PENETRATION (X) IS GIVEN (MUST BE > MINIMUM)
LOADING SAME AS ABOVE

GIVEN PENETRATION (X)=25.0

X, Z, KP = 25.0 6.38 1.80

FIND POINT OF ZERO SHEAR(DIST.DOWN FROM GRADE) =XO FT
FIND MAXIMUM MOMENT =M FT-LBS
FIND SECTION MODULUS FOR FS=20000PSI =SM CU-IN

XO, M, SM = 14.00 55147.70 33.08

PPLD= 234.65
PPRS= 121.83
PALD= 52.00
PALS= 27.00

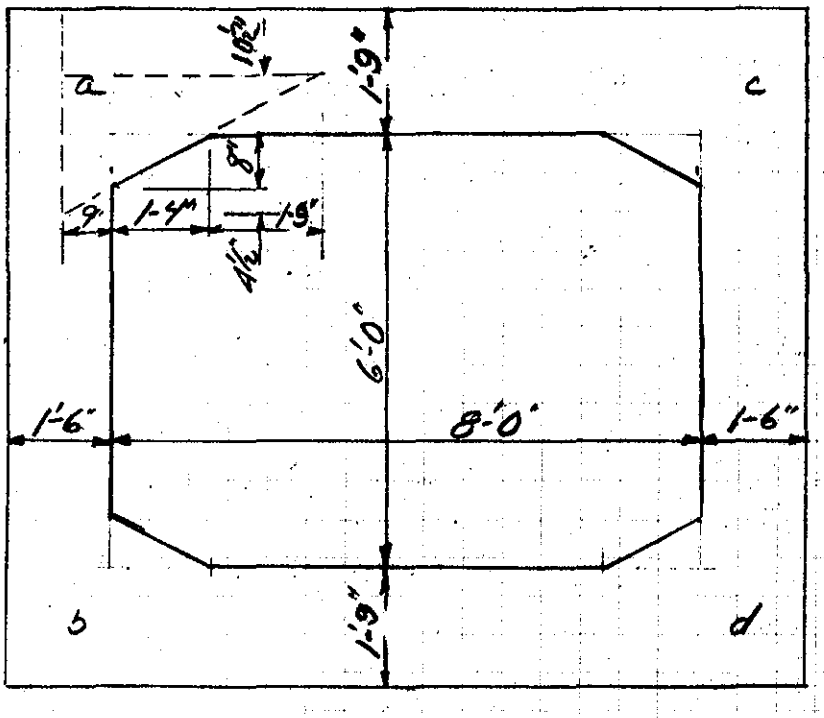
Use MZ-32 with 25'-0" penetration

END

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby Local Protection
COMPUTATION Pumping Station Conduit
COMPUTED BY H.E.W. CHECKED BY DATE May 1968



Frame Constants from PCA Handbook

Member ac $a_A = a_C = \frac{2.08}{9.50} = .219$ $r_a = r_c = \frac{1.04}{1.75} = .594$

Member ab $a_a = a_b = \frac{1.54}{7.75} = .199$ $r_a = r_b = \frac{3.08}{1.5} = 2.05$

Member ac		Member ab	
Carry factor	= .618	Carry over factor	= .711
Stiffness	= 6.51	Stiffness	= 10.05
F.E.M Co-ef	= .0954	F.E.M Co-ef	= .1039

Height of water to top of conduit = 21.0'
" " Sub. earth to top of conduit = 21.0'
" " Moist earth = 11.0'

Roof load = 21 x 62.5 x 11 + 21 x 67 x 11 x 1.5 + 11 x 11 x 120 x 1.5 = 59433
Unit load = 59433 ÷ 11 + 150 x 1.75 = 5665 #/ft

Program Input Data

DESCRIPTION:-THIS PROGRAM DETERMINES REQUIRED RE-STEEL DUE BENDING AND DIRECT STRESSES FOR TOP SLAB, WALLS & BASE SLAB.

ALLOWABLE STRESSES: F'C=4000PSI
FC=1800PSI
FS=20000PSI
~~V=60PSI~~

ALL UNITS IN POUNDS-FEET

Case I - Flood stage, conduit empty
150% vert projected weight of fill, lat. earth pressure coef, K=.50 (.33 of vert.)

ENTER FOLLOWING ITEMS:----

PROJECT NAME	=DDRBY LOCAL PROTECTION
STATION	=PUMPING STATION CONDUIT
DATE	=JUNE 1968
CLEAR HEIGHT OF CONDUIT OPENING	=6.0
CLEAR WIDTH " " "	=8.0
THICKNESS, TOP SLAB	=1.75
" ,WALLS	=1.5
" ,BASE SLAB	=1.75
HEIGHT OF WATER TO TOP OF CONDUIT	=21.0
HGT. EARTH(SUB) TO TOP OF CONDUIT	=21.0
HEIGHT OF EARTH(MOIST)	=11.0
WEIGHT OF WATER	=62.5
" " EARTH(SUB)	=67
" " EARTH(MOIST)	=120
EMBANKMENT LOAD FACTOR	=1.5
LATERAL PRESSURE FACTOR	=.33
ROOF CARRY OVER FACTOR	=.618
ROOF STIFFNESS FACTOR	=6.51
ROOF FEM COEFF.	=.0954
WALL CARRY OVER FACTOR	=.711
WALL STIFFNESS FACTOR	=10.05
WALL FEM COEFF.	=.1039

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE DM-14

SUBJECT Derby Local Protection
COMPUTATION Pumping Station Conduit
COMPUTED BY H.E.W CHECKED BY DATE May 1968

Print-out of Program answers

CENTER LINE	ROOF	WALLTOP	WALLBOT	BASE
FEM MOMENT=	48779.1	-18987.5	19912.8	-56004.5
FINAL MOM.=	33072.5	-33072.5	39371.7	-39371.7
-1	1791.6	2672.6	-2671.8	-1792.1
WALMD MOM@=	3.6	-.0	-.....&	
SHEAR =	26911.1	10675.2	13147.7	30897.3

DESIGN:--------

ROOF HAUNCH DEPTH =.67
WALL " " =1.33

	MS#FT	SHEAR#	AXIAL#	D REQD"	SHEAR,PSI	REINF.X10
ROOFB=	31887.7	-.0	13106.1	9.9	-.0	6.1
ROOFT=	27391.0	22662.0	13106.1	9.1	64.0	-.0
WALTP=	41433.5	8240.0	31160.2	11.3	25.9	-4.6
WALMD=	-890.3	-.0	33468.0	1.1	-.0	-17.1
WALBT=	48451.2	10203.6	35775.8	12.2	32.0	-5.1
BASEB=	31767.8	26018.8	16004.3	9.9	76.0	-.2
BASET=	35778.3	-.0	16004.3	10.5	-.0	6.2

IF REINF. IS (-) USE MIN. STEEL
IF " " " AND DREQD IS > D GIVEN, DESIGN IS OK

Check Shear by Univ of Ill. assumptions

Find M_0 in roof $V = 5665 \times 4.75 = 26910$

$26910x - 5665\frac{x^2}{2} - 33072.5 = 0 \qquad x = 1.45'$

$p = \frac{.79}{12 \times 18} = .0037 = .37\% \qquad \frac{l'}{d} = \frac{6.60 \times 12}{16.5} = 4.80$

V of pt. of contraflexure $= 5665 \times 3.30 = 18694$

$N/V = 13106/18694 = .701$

$wc = \frac{231(.046 + .0037)(12 + .70)}{4.80(19 + 4.80)} = 1.276$

$\frac{5665}{12} = 472 \qquad \frac{1.276}{.472} = 2.70$

Allow. S.F. $= 1.25 + \frac{1}{4} \times 4.80 = 2.45 < 2.70$

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PROJECT Derby Local Protection
COMPUTATION Pumping Station Conduit
COMPUTED BY H.E.W CHECKED BY DATE June 1968

Base Slab

Find M_o $V = 30.897^{k}$

net unit load = 30.897/4.75 = 6500 #/□'

$30,897x - 6500\frac{x^2}{2} - 39371.7 = 0$ $x_o = 1.51$

$p = .0037$ $\frac{d'}{d} = \frac{6.23 \times 12}{16.5} = 4.53$

V at pt. of contraflexure = 6500 × 3.115 = 20,248

N/V = 16004.3/20248 = .79

$w_c = \frac{231(.046 + .0037)(12 + .79)}{4.53(19 + 4.53)} = 1.378$

$\frac{6500}{12} = .541$ $\frac{1.378}{.541} = 2.55$

Allow S.F = 1.25 + $\frac{1}{4}$ × 4.53 = 2.38 < 2.55 OK

Case II Loading
Water down, embankment moist, 150% vert. proj weight of fill, lateral earth pressure coef K = .5 (.33 of vert.)

ENTER FOLLOWING ITEMS:----

PROJECT NAME	=DERBY LOCAL PROTECTION
STATION	=PUMPING STATION CONDUIT
DATE	=JUNE 1968
CLEAR HEIGHT OF CONDUIT OPENING	=6.0
CLEAR WIDTH " " "	=8.0
THICKNESS, TOP SLAB	=1.75
" ,WALLS	=1.5
" ,BASE SLAB	=1.75
HEIGHT OF WATER TO TOP OF CONDUIT	=0
HGT, EARTH(SUB) TO TOP OF CONDUIT	=0
HEIGHT OF EARTH(MOIST)	=32
WEIGHT OF WATER	=62.5
" " EARTH(SUB)	=67
" " EARTH(MOIST)	=120
EMBANKMENT LOAD FACTOR	=1.5
ATERAL PRESSURE FACTOR	=.33
OOF CARRY OVER FACTOR	=.618
ROOF STIFFNESS FACTOR	=6.51
ROOF FEM COEFF.	=.0954
WALL CARRY OVER FACTOR	=.711
WALL STIFFNESS FACTOR	=10.05
WALL FEM COEFF.	=.1039

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Local Protection
PUTATION Pumping Station Conduit
COMPUTED BY H.E.W CHECKED BY DATE June 1968

Case II cont.

CENTER LINE	ROOF	WALLTOP	WALLBOT	BASE
FEM MOMENT=	51852.8	-14234.9	15160.3	-59078.2
FINAL MOM.=	32304.6	-32304.6	38603.8	-38603.8
-1	2217.3	3307.4	-3306.7	-2217.8
WALMD MOM@=	3.6	-.0	-.....&	
SHEAR =	28606.8	7724.1	10196.7	32593.0

DESIGN:--------

ROOF HAUNCH DEPTH =.67
WALL " " =1.33

	MS#FT	SHEAR#	AXIAL#	D REQD"	SHEAR,PSI	REINF.X10
ROOFB=	34113.2	-.0	9488.6	10.2	-.0	8.8
ROOFT=	23629.6	24090.0	9488.6	8.5	68.0	.8
WALTP=	43306.3	5955.3	33123.7	11.5	18.7	-5.1
WALMD=	-4040.6	-.0	35431.5	-1.7	-.0	-19.6
WALBT=	50324.1	7918.9	37739.3	12.4	24.9	-5.6
BASEB=	28378.9	27446.8	12386.9	9.3	80.2	.7
BASET=	38003.9	-.0	12386.9	10.8	-.0	8.9

IF REINF. IS (-) USE MIN. STEEL
IF " " " AND DREQD IS > D GIVEN, DESIGN IS OK

Check Shear (Use Mom and V at face of support)
Roof slab
Unit load = 24,090 ÷ 4 = 6022 #/'
$M_o = 24090x - 6022\frac{x^2}{2} - 23630$ $x_o = 1.15'$
$p = .0037$ $\frac{l'}{d} = \frac{5.70 \times 12}{16.5} = 4.14$
V @ pt of contraflexure = 6022 x 2.85 = 17,163
N/V = 9489/17163 = .55
$wc = \frac{231(.046 + .0037)(124 \cdot .55)}{4.14(19 + 4.14)} = 1.504$
$\frac{6022}{12} = .501$ 1.504/.501 = 3.00
Allow S.F 1.25 + $\frac{1}{4}$ x 4.14 = 2.28 < 3.00 OK

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

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SUBJECT Derby Local Protection
COMPUTATION Pumping Station Conduit
COMPUTED BY H.E.W. CHECKED BY DATE May 1964

Case II (cont.)
Base slab
Unit load = 27.447 ÷ 4 = 6862
Find M_o
$27.447x - 6862\frac{x^2}{2} - 38.375 = 0$ $x_o = 1.80$
$p = .0037$ $\frac{d'}{d} = \frac{4.40 \times 12}{16.5} = 3.20$
V at pt of contraflexure = 6862 x 2.20 = 15096
N/V = 12386.9/15096 .820
$wc = \frac{231(.0464 + .0037)(12 + .82)}{3.20(19 + 3.20)} = 2.072$
6862/12 = .572 2.072/.572 = 3.63
Allow S.F. = 1.25 + 1/4 x 3.20 = 2.05 < 3.63 OK

Case III Loading
Water at Flood stage 100% of vert projected weight of fill, lateral pressure 100% of vert.

ENTER FOLLOWING ITEMS:----

PROJECT NAME	=DERBY LOCAL PROTECTION
STATION	=PUMPING STATION CONDUIT
DATE	=JUNE 1968
CLEAR HEIGHT OF CONDUIT OPENING	=6.0
CLEAR WIDTH " " "	=8.0
THICKNESS, TOP SLAB	=1.75
" ,WALLS	=1.5
" ,BASE SLAB	=1.75
HEIGHT OF WATER TO TOP OF CONDUIT	=21.0
HGT, EARTH(SUB) TO TOP OF CONDUIT	=21.0
HEIGHT OF EARTH(MOIST)	=11.0
WEIGHT OF WATER	=62.5
" " EARTH(SUB)	=67
" " EARTH(MOIST)	=120
EMBANKMENT LOAD FACTOR	=1
LATERAL PRESSURE FACTOR	=1
ROOF CARRY OVER FACTOR	=.618
ROOF STIFFNESS FACTOR	=6.51
ROOF FEM COEFF.	=.0954
WALL CARRY OVER FACTOR	=.711
WALL STIFFNESS FACTOR	=10.05
WALL FEM COEFF.	=.1039

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby Local Protection
UTATION Pumping Station Conduit
COMPUTED BY H.E.W CHECKED BY DATE June 1961

Case III cont

CENTER LINE	ROOF	WALLTOP	WALLBOT	BASE
FEM MOMENT=	37039.5	-28420.8	29673.4	-44264.9
FINAL MOM.=	31782.1	-31782.1	38129.4	-38129.4
-1	631.0	941.7	-941.0	-631.5
WALMD MOM@=	3.7	-.0	-.....&	
SHEAR =	20434.5	16569.4	19503.8	24420.7

DESIGN:--------

ROOF HAUNCH DEPTH =.67
WALL " " =1.33

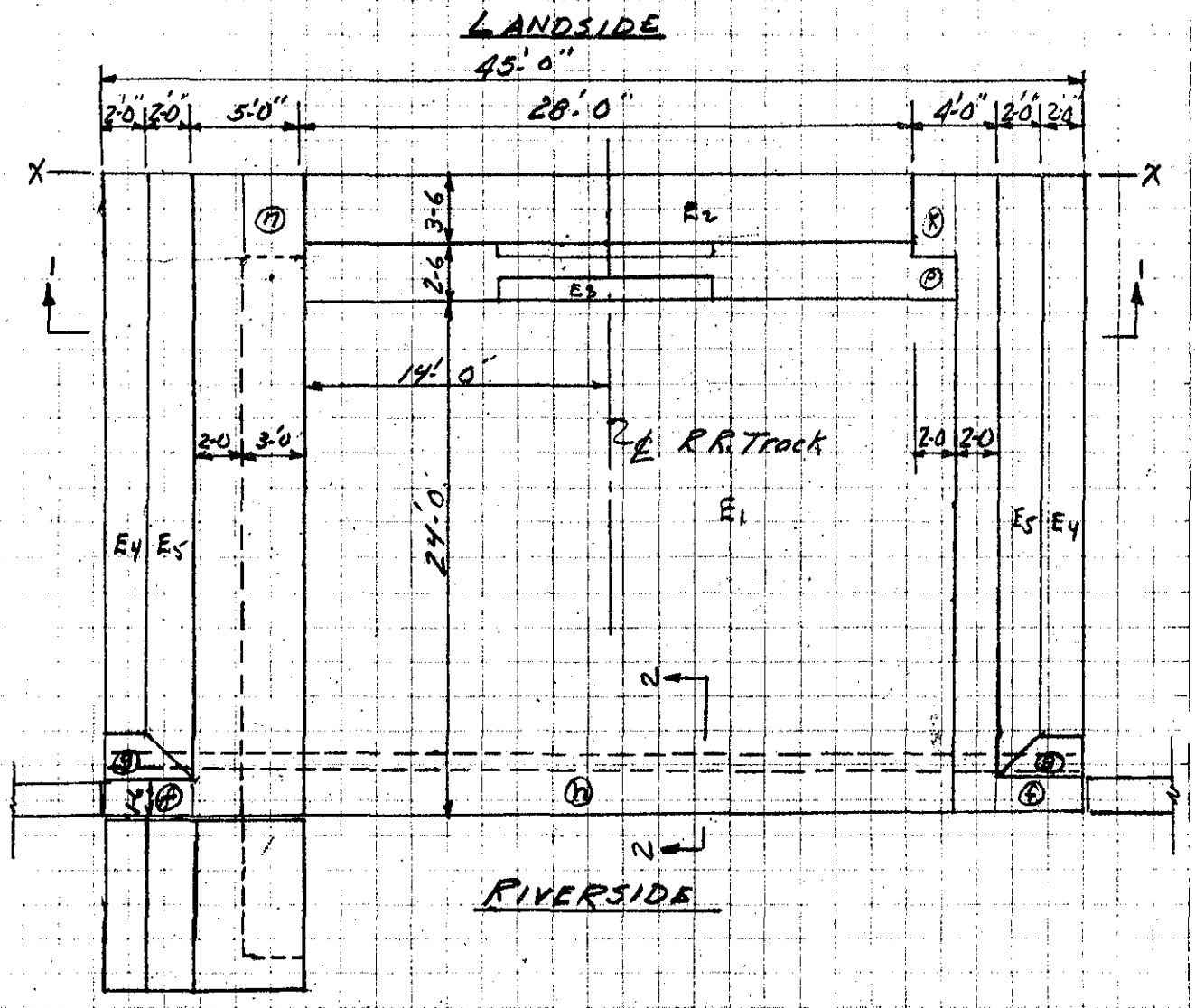
	MS#FT	SHEAR#	AXIAL#	D REQD"	SHEAR,PSI	REINF.X10
ROOFB=	23692.2	-.0	20316.5	8.5	-.0	-.7
ROOFT=	33615.9	17208.0	20316.5	10.1	48.6	-2.2
WALTP=	33193.9	12886.2	23661.0	10.1	40.5	-3.0
WALMD=	6913.6	-.0	25968.8	4.6	-.0	-9.6
WALBT=	39990.3	15041.5	28276.6	11.1	47.3	-3.6
BASEB=	37635.2	20564.8	23902.4	10.7	60.1	-2.7
BASET=	27942.6	-.0	23902.4	9.2	-.0	-.8

IF REINF. IS (-) USE MIN. STEEL
IF " " " AND DREQD IS > D GIVEN, DESIGN IS OK

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT DERBY LOCAL PROTECTION
COMPUTATION RAILROAD GATE NO 1
COMPUTED BY EJM CHECKED BY NCW DATE March 1968



PLAN OF GATE
1/8" = 1'-0"

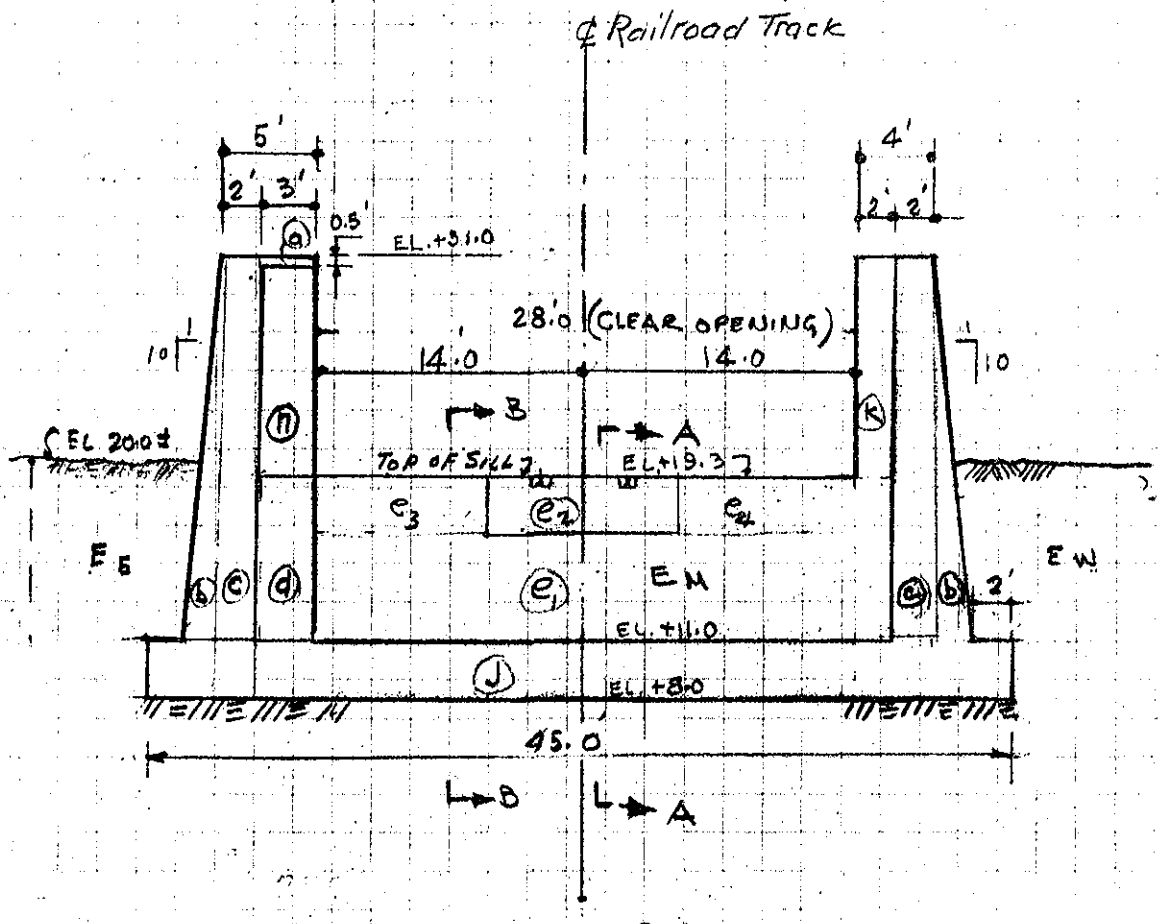
Concrete Data
f'_c = 3000 psi
f_c = 1050
f_s = 20,000 psi
a = 1.44
v = 60 psi
k = 152

Weights
weight of water = 62.5
" " Conc = 150
" " Ea. Sat = 130
" " Ea Sub = 67
" " Ea. moist = 120

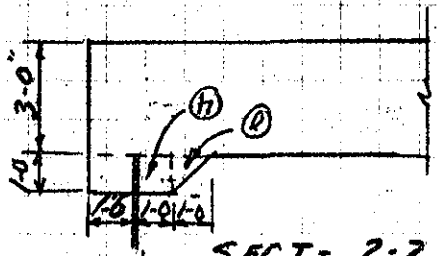
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

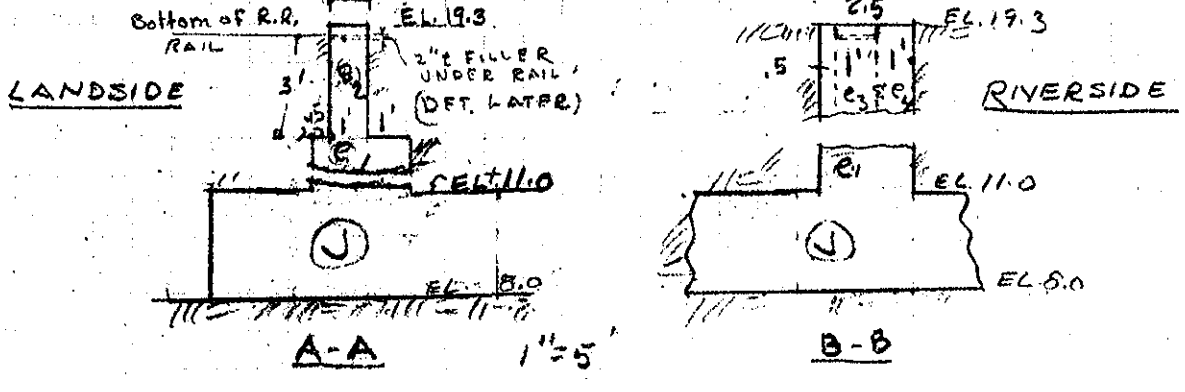
SUBJECT DERBY - FLOOD CONTROL
COMPUTATION RAILROAD GATE No. 1
COMPUTED BY EJM CHECKED BY HEW DATE MARCH 1958



ELEVATION 1-1



SECT- 2-2



A-A 1"=5' B-B

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT DERBY - FLOOD CONTROL
COMPUTATION RAILROAD GATE - No. 1
COMPUTED BY EJM CHECKED BY AP DATE MARCH 13, 62

CASE I - CONCRETE ONLY (STABILITY) (A) PORTION
- TAKE MOMENTS ABOUT X-X AXIS -

ITEM	FACTORS	+	↑	→	←	ARM	↻ MOM XX ↺
(a) Conc.	0.150 x 3 x 26 x 0.5	15.85				17.00	199.5
(b) Conc	0.150 x 2 x 20 x 0.5 x 27.5 x 2	165.00				13.75	2268.8
(c) Conc.	0.150 x 2 x 20 x x 26 x 2	312.00				17.00	5304.0
(d) Conc	0.150 x 3 x 8.3 x 26	97.11				17.00	1650.9
(e1) Conc	0.150 x 2.5 x 5.3 x 28	55.65				4.75	264.3
(e2) Conc	0.150 x 1.0 x 3 x 10	4.50				4.50	20.3
(e3) Conc	0.150 x 3 x 2.5 x 9	10.13				4.75	48.1
(e4) Conc	0.150 x 3 x 2.5 x 9	10.12				4.75	48.1
(f) Conc	0.150 x 4.0 x 1.5 x 20 x 2	36.0				29.25	1053.0
(g) Conc	0.150 x 3.0 x 2.0 x 20 x .5 x 2	18.0				27.50	495.0
(h) Conc	0.150 x 2.5 x 1.0 x 45	16.88				28.75	485.3
(j) BASE CONC	0.150 x 45 x 30 x 3	607.50				15.00	9112.5
(k) Conc	0.150 x 4 x 8 x 20	48.00				2.00	96.0
(l) Conc	0.150 x 1 x 1 x .5 x 45	3.37				27.17	91.6
(m) Conc	0.150 x 4 x 5 x 20	60.00				2.00	120.0
(p) "	0.150 x 2 x 2 x 8.3	5.00				5.00	25.00
	Σ_V =	1455.12					ΣM = 21,182.4

$$\frac{\Sigma M}{\Sigma V} = \frac{21\,182.4}{1455.12} = 14.56 > 10.00 < 20.00 \quad \text{IN MIDTHIRD}$$

$$BP = \frac{1455.12}{30 \times 45}\left(1 \pm \frac{6 \times 14.4}{30}\right) = 1173 \text{ max} \qquad 983 \text{ min}$$

Case I - Concrete only

Case II - Normal condition with gate in pocket but not jacked

Case III - Normal condition with gate closed

Case IV Flood condition, gate closed and water to top of gate

Case V Normal condition with train load max. at toe

Case VI Normal condition with train load max. at heel

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT: Derby Local Protection
COMPUTATION: Railroad Gate No 1
COMPUTED BY: H.E.W. CHECKED BY: R DATE: June 1964

Case II Gate in Pocket (Not Jacked) Plus Earth Load

Item	Factors	↓	↑	→	←	Arm	↷	↶
Conc		1455.12						21182.4
E1	.130 x 8.3 x 30 x 24.0	776.88				18.0		13983.8
E2	.130 x 8.3 x 28 x 3.5	105.74				1.75		185.0
E3	.130 x 3.5 x 10 x 1.5	6.82				4.75		32.4
E4	.130 x 2.0 x 27.5 x 9 x 2	128.70				13.75		1769.6
E5	.130 x 2.0 x 27.5 x 9 x .5 x 2	64.35				13.75		884.8
Gate	16.	16.0				19.0		304.0
		2553.6						38342.0

$$\frac{\Sigma M}{\Sigma V} = \frac{38342}{2553.6} = 15.02$$

$$BP = \frac{2553.6}{30 \times 45}\left(1 \pm \frac{6 \times .02}{30}\right) = \text{Heel } 1895^{\#} \text{ max} \quad \text{Toe } 1888 \text{ min}$$

Case III Gate in Closed Position – No Water

Item	Factors	↓	↑	→	←	Arm	↷	↶
Conc		1455.12						21,182.4
Earth		1082.49						16 855.6
Gate	16.0	16.0				4.5		72.0
		2553.6						38110.0

$$\frac{\Sigma M}{\Sigma V} = \frac{38110}{2553.6} = 14.92$$

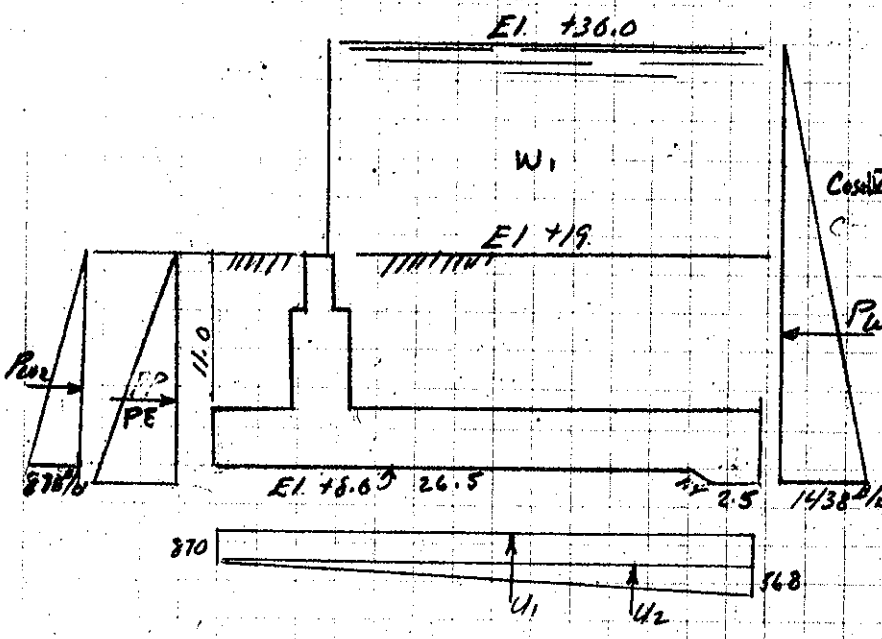
$$B.P = \frac{2553.6}{30 \times 45}\left(1 \pm \frac{6 \times .08}{30}\right) = \text{Toe } 1922^{\#}/\text{□}' \text{ max} \quad \text{Heel } 1861^{\#}/\text{□}' \text{ min.}$$

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Local Protection
COMPUTATION Railroad Gate No 1
COMPUTED BY H.E.W CHECKED BY A DATE June 1968

Case IV Gate Closed Flood Stage Condition



Creep Dist = 41.4'

Head @ heel = 23 × 62.5 = 1438 (Case IV)

Head @ toe = (11×11/41.4 + 11) 62.5 = 870 (Case IV)

Head on Landside at I wall at El. +8.0
11 × 62.5 = 690

Note - Use Case III plus height of water above ground, plus lateral loads and uplift pressures

Item	Factors	↓	↑	→	←	Arm	↶	↷
Case III		2553.6						38110.0
W1	25 × 33 × 11 × .0625	567.2				17.5		9925.8
U1	.87 × 45 × 30		1174.5			15.0	17617.5	
U2	.568 × 45 × 30 × .5		383.4			20.0	7668.0	
Pw1	1.438 × 23 × .5 × 45				744.2	6.67	4963.6	
Pw2	.870 × 11 × .5 × 45			215.3		3.67		790.2
PE	12 × .067 × 33 × 12 × .5 × 45			71.6		3.00		214.8
		3120.8	1557.9	286.9	744.2		30,249.1	49,040.8
		1562.9			457.3			18791.7

$\frac{\Sigma H}{\Sigma V} = \frac{457.3}{1562.9} = .29$ OK

$\frac{\Sigma M}{\Sigma V} = \frac{18791.7}{1562.9} = 12.02 > 10$ inside mid third

Bear P = $\frac{1562.9}{45 \times 30}\left(1 \pm \frac{6 \times 2.98}{30}\right)$ = 1847 #/□' max (Toe) 468 min (Heel)

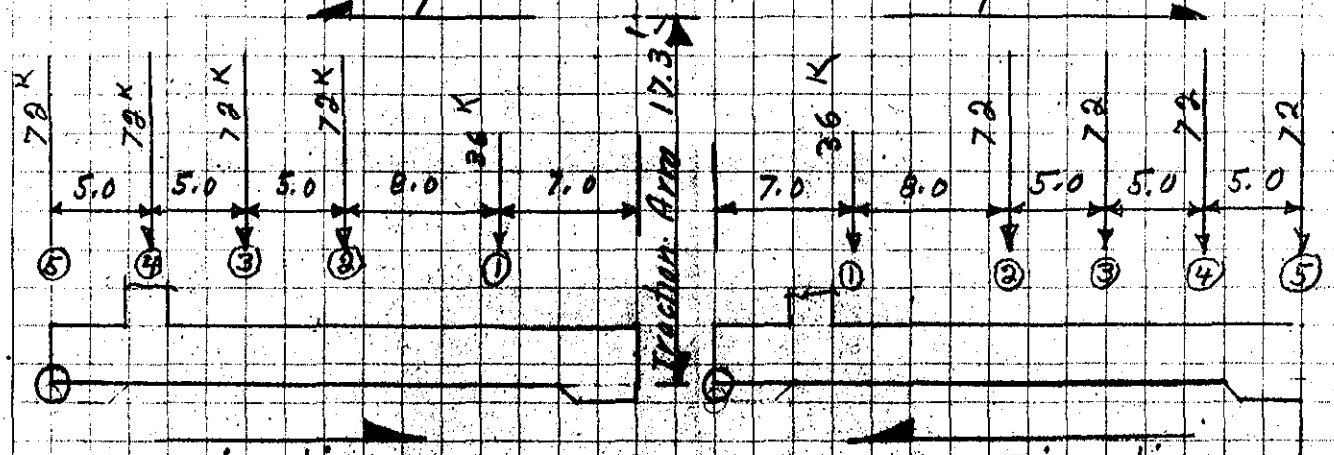
The above uplift assumptions are conservative due to relief at sides of structure. Investigation shows that if uplift were assumed to be only 690 #/□' the resultant would fall at 13.90 ft, max bear would be 1978 #/□' and min bear 1265 #/□'

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT: DERBY FLOOD CONTROL
COMPUTATION: RAILROAD GATE No 1
COMPUTED BY: AP CHECKED BY: KEW DATE: June 63

Case V — Traction 72.0 Kips — Case VI



Case V	Kip ↓	Kip ↑	Kip →	Kip ←	Arm Ft.	Mom ↺	Foot Kip ↻
Totals Case II	2553.7						38342
Train → ②③④⑤	288.0				7.5		2160
①	36.0				23.0		828
T				72.0	17.3	1246	
						1246	41,330
	2877.7			72.0	13.93		40084

$P = \frac{W}{A}\left[1 \pm \frac{6e}{L}\right]$; $\frac{W}{A} = \frac{2877.7}{1357} = 2.132$; $\frac{6e}{L} = \frac{(6)}{30} 1.07 = 0.214$

$P = 2,132(1 \pm 0.214) = 2588$ / 1674 #/□' Land Side

Case VI	Kip ↓	Kip ↑	Kip →	Kip ←	Arm Ft	Mom ↺	Foot Kip ↻
Totals Case II	2553.7						38342
Train → ②③④⑤	288.0				22.5		6480
①	36.0				7.0		252
T				72.0	17.3		1246
	2877.7			72.0	16.1		46320

$P = \frac{W}{A}\left[1 \pm \frac{6e}{L}\right)$ $\frac{W}{A} = 2.132$ K/□' $\frac{6e}{L} = \frac{6}{30} \times (-1.1) = 0.220$ (1.09)

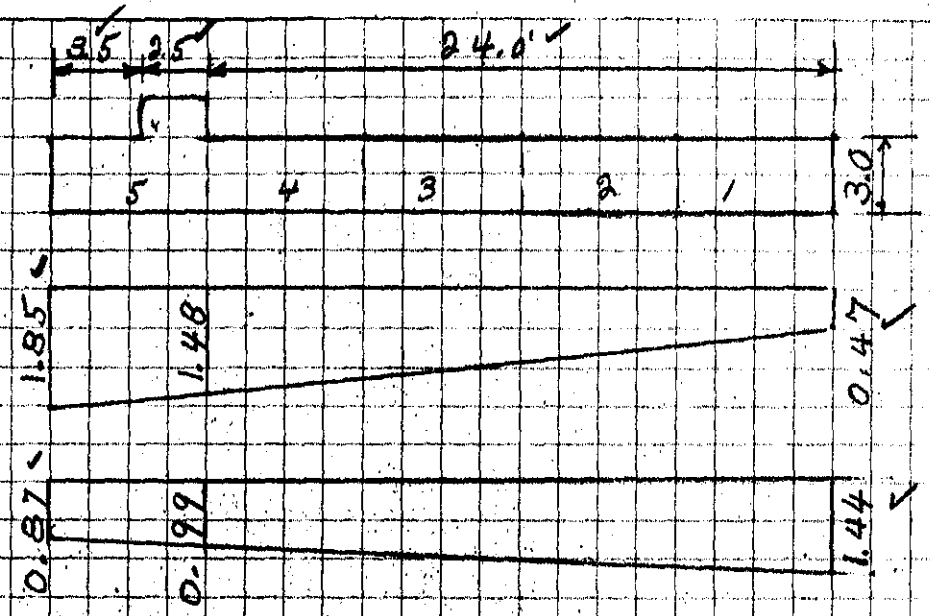
$P = 2,132 \times 0.78 = 1,663$ #/□' Land Side
$2,132 \times 1.22 = 2,601$

NED FORM 223
27 Sept 49

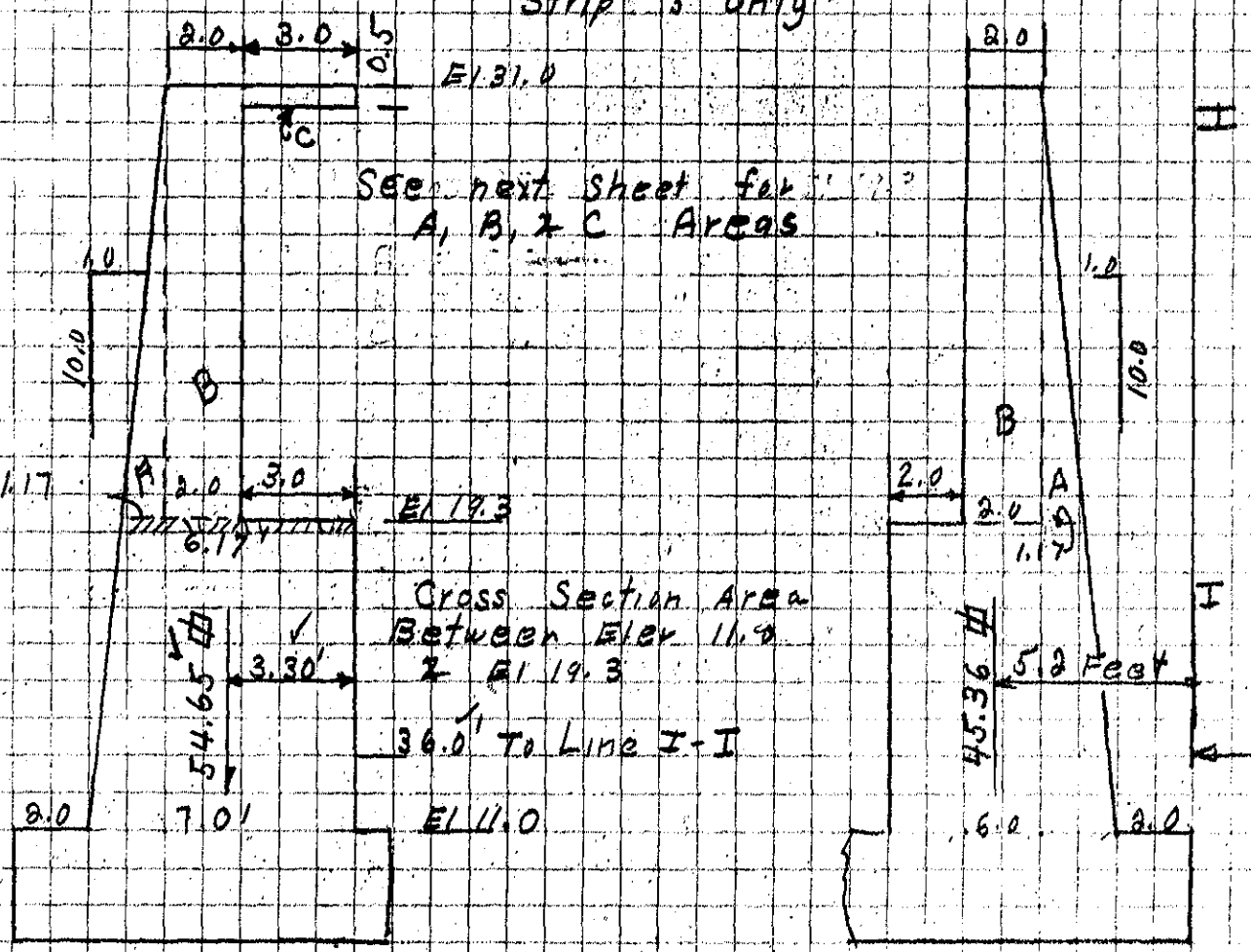
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT DERBY LOCAL PROTECTION
COMPUTATION RAILROAD GATE No 1
COMPUTED BY AP CHECKED BY KEW DATE

CASE IV
Strip No 5 of
5 Strips of 6.00'
Strip Nos



Strip 5 Only



Left Abutment

Right Abutment

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT DERBY LOCAL PROTECTION
COMPUTATION RAILROAD GATE 1
COMPUTED BY A CHECKED BY HEW DATE June 69

Case IV Strip 5 @ 6.0 Feet Cont.
Abutments Above El 19.3

A = 1.17 x 11.7 x 0.5 x 0.15 = 1.02 Kips Per LF
B = 8.0 x 11.7 x 0.15 = 3.51
C = 8.0 x 0.5 x 0.15 = 0.23

					Item	ΣV Kips	Arm Feet
Left		Kip	Arm	Mom			
A over 6.0	1.02 x 6	6.12	41.39	253.3			
B " 2.0	3.51 x 2	7.02	40.00	280.8			
C " 2.0	0.23 x 2	0.46	37.50	17.3			
		13.60	40.54	551.4	2	13.6	40.5

Right Abutment Upper
Item A & B Same as Above 8 13.7 4.2
6.12 x 4.61 + 7.02 x 5 = 4.3 @
13.14

* 4.2 Was used on Computer Neglect

Left Lower (150 # - 130) = 20 #/cf 3 6.6 39.3
54.65 x 6 x 0.02 = 6.55
Right Lower
45.3 x 6 x 0.02 = 5.44 9 5.4 5.2

Pylons Above Elev 19.3
Left = 0.15 x 11.7 x 4 x 5 = 35.1 4 35.1 38.5
Rt = 0.15 x 11.7 x 4 x 4 = 28.1 7 28.1 6.0

Cut-off + Gate taken @ 16.0
8.5 x 8.3 x 0.02 x 14 + 8.0 = 13.8 5 13.8 37.5
6 13.8 7.0

* These errors compensate

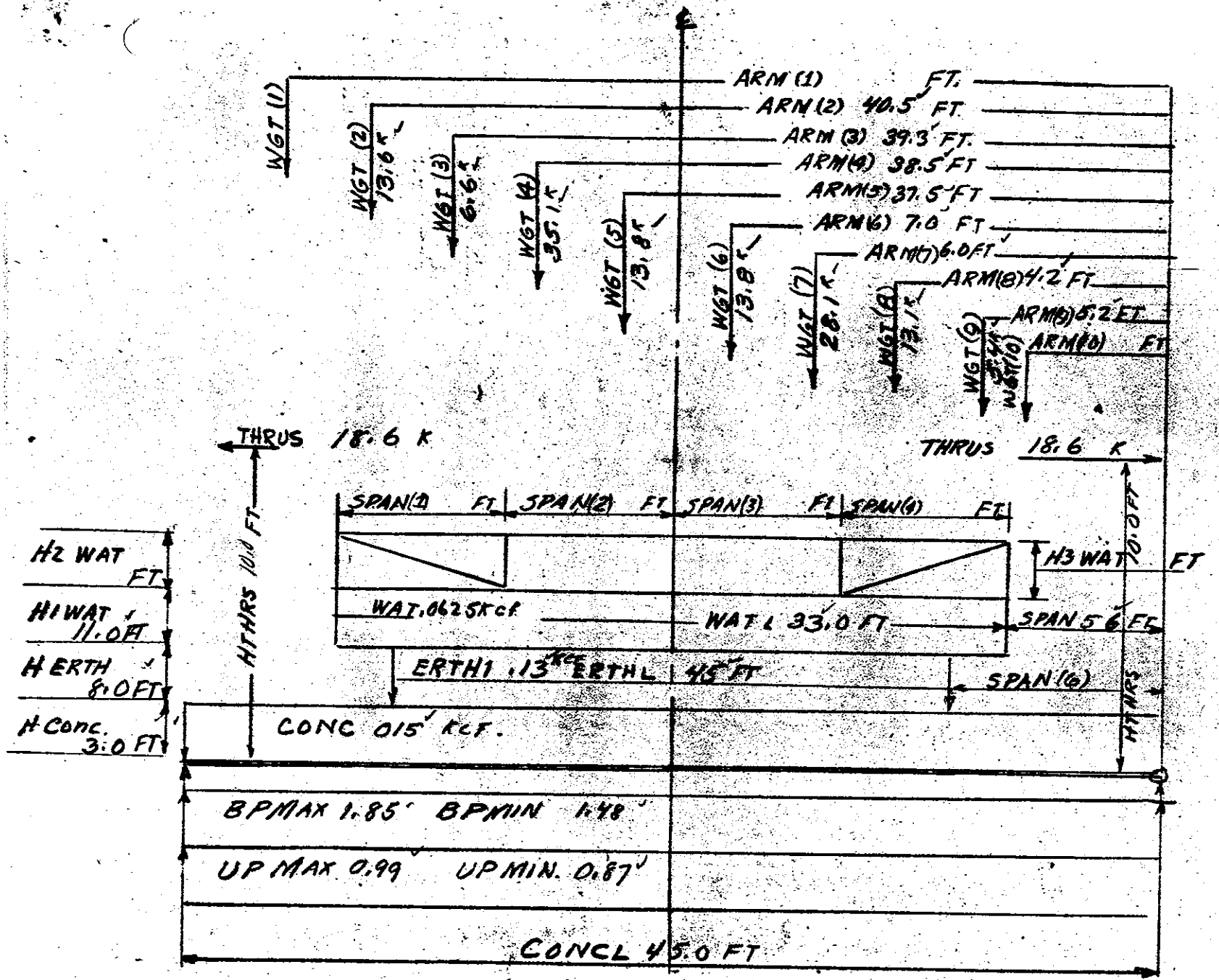
	ΣH	Arm	
A = .6875 x 11 x 0.5	3.78	14.67	55.45
B = .6875 x 8.0	5.50	7.00	38.50
One Foot Strip	9.28		93.95
	9.3		

Strip 5
ΣH For Strip = 18.6 Kips
Arm = 10.0'

RAILROAD GATE NO 1

CASE IV STRIP 5

LOADING DIAGRAM FOR COMPUTER



ARMY ENGRS RAILROAD GATE DESIGN G.ROCHEFORD FEB 1967

PART 1 DESIGN OF SKIN PLATE

DERBY RR GATE NO 1

TOT.HGT(D)	NO.BMS(N)	NO.SPANS(M)	PL.TH(TA)	PL.TH(TB)	WT.WATER(W)
129.	4	5	0.375	0.240	62.4

SPA 1	SPA 2	SPA 3	SPA 4	SPA 5
16.	36.	33.	30.	14.

FLG 1	FLG 2	FLG 3	FLG 4
5.5	7.0	7.0	8.5

MOMENT DISTRIBUTION INCH LBS

	SUP 1	SUP 2	SUP 3	SUP 4	SUP 5	SUP 6	SUP 7	SUP 8
DF	0.	1.00	0.48	0.52	0.19	0.81	1.00	0.
	-296.	1423.	-1760.	2564.	-2824.	3152.	-3347.	5280.
	-0.	-1127.	-385.	-420.	-63.	-266.	-1933.	-0.
	0.	-192.	-563.	-32.	-210.	-956.	-133.	0.
	0.	192.	285.	310.	226.	950.	133.	0.
	0.	142.	96.	113.	155.	66.	475.	0.
	-0.	-142.	-100.	-109.	-43.	-179.	-475.	-0.
	0.	-50.	-71.	-21.	-55.	-237.	-90.	0.
	0.	50.	44.	48.	56.	236.	90.	0.
	0.	22.	25.	28.	24.	45.	118.	0.
	-0.	-22.	-25.	-28.	-13.	-56.	-118.	-0.
	0.	-13.	-11.	-7.	-14.	-59.	-28.	0.
	0.	13.	8.	9.	14.	59.	28.	0.
SUM	OF	ABOVE						
	-296.	296.	-2457.	2457.	-2745.	2745.	-5280.	5280.

SHEAR AT EACH SUPPORT, SIMPLE SHEAR PLUS OR MINUS MOM DIFF PER SPAN EQUALS TOTAL SHEAR IN LBS PER FT WIDTH

SUP 1	SUP 2	SUP 3	SUP 4	SUP 5	SUP 6	SUP 7	SUP 8
55.	218.	312.	450.	529.	617.	682.	740.
0.	-60.	60.	-9.	9.	-84.	84.	0.
55.	158.	372.	442.	538.	533.	767.	740.

TOTAL LOAD AT EACH BEAM SUPPORT LBS PER FT

1	2	3	4
214.	814.	1071.	1507.

MOMENTS NEAR FLANGE EDGE EACH SIDE OF EACH SUPPORT INCH LBS

SUP 1	SUP 2	SUP 3	SUP 4	SUP 5	SUP 6	SUP 7	SUP 8
0.	0.	1589.	1426.	1490.	1501.	3107.	3054.

PLATE STRESSES WITH TWO THICKNESSES.THICKER PL AT BOTTOM SUPPORTED BY TWO BOTTOM BMS
ALLOWABLE FOR A36=18000.PSI ~~FOR A441=25000.PSI~~

SUP 1	SUP 2	SUP 3	SUP 4	SUP 5	SUP 6	SUP 7	SUP 8
0.	0.	13793.	12382.	12936.	5338.	11047.	10860.

POSITIVE MOMENTS AT INTERIOR SPANS INCH LBS

SPA 2	SPA 3	SPA 4
1055.	1441.	909.

PLATE STRESSES AT MID SPANS,ALLOWABLE AS ABOVE

SPA 2	SPA 3	SPA 4
9156.	12511.	3232.

PART 2 DESIGN OF SUPPORTING BEAMS.

DESIGNED FOR A36 BEAMS.ALLOWABLE STRESSES 18000 PSI PER ENG MANUAL GROUP B HYDRAULIC WITH WATER TO TOP OF GATE.

CLEAR OPENING(CLOP)	ADD TO TOP+BOT BMS(XA)	ADD TO INTERM BMS(XB)
28.00	2.50	1.00

SUPPORTING BM NO	SIZE	Use	TENSION STRESS	COMPR STRESS
1	8WF20	16B31	8139.	15700.
2	14WF38	16WF36	11009.	17232.
3	14WF48	16WF45	10456.	17571.
4	18WF60	16WF71	9928.	17406.

VERTICAL POST SIZE ADJACENT TO HINGES PLUS STRESS
10WF25 17173.

SKIN PL COMBINED STRESSES.MAX SHEARS FOR TWO PLATE THICKNESSES.ALLOWABLE FOR A36=12000.PSI ~~FOR A441=16700.PSI~~

SUP 1	SUP 2	SUP 3	SUP 4	SUP 5	SUP 6	SUP 7	SUP 8
4070.	4070.	12401.	11696.	11696.	7897.	10487.	10394.

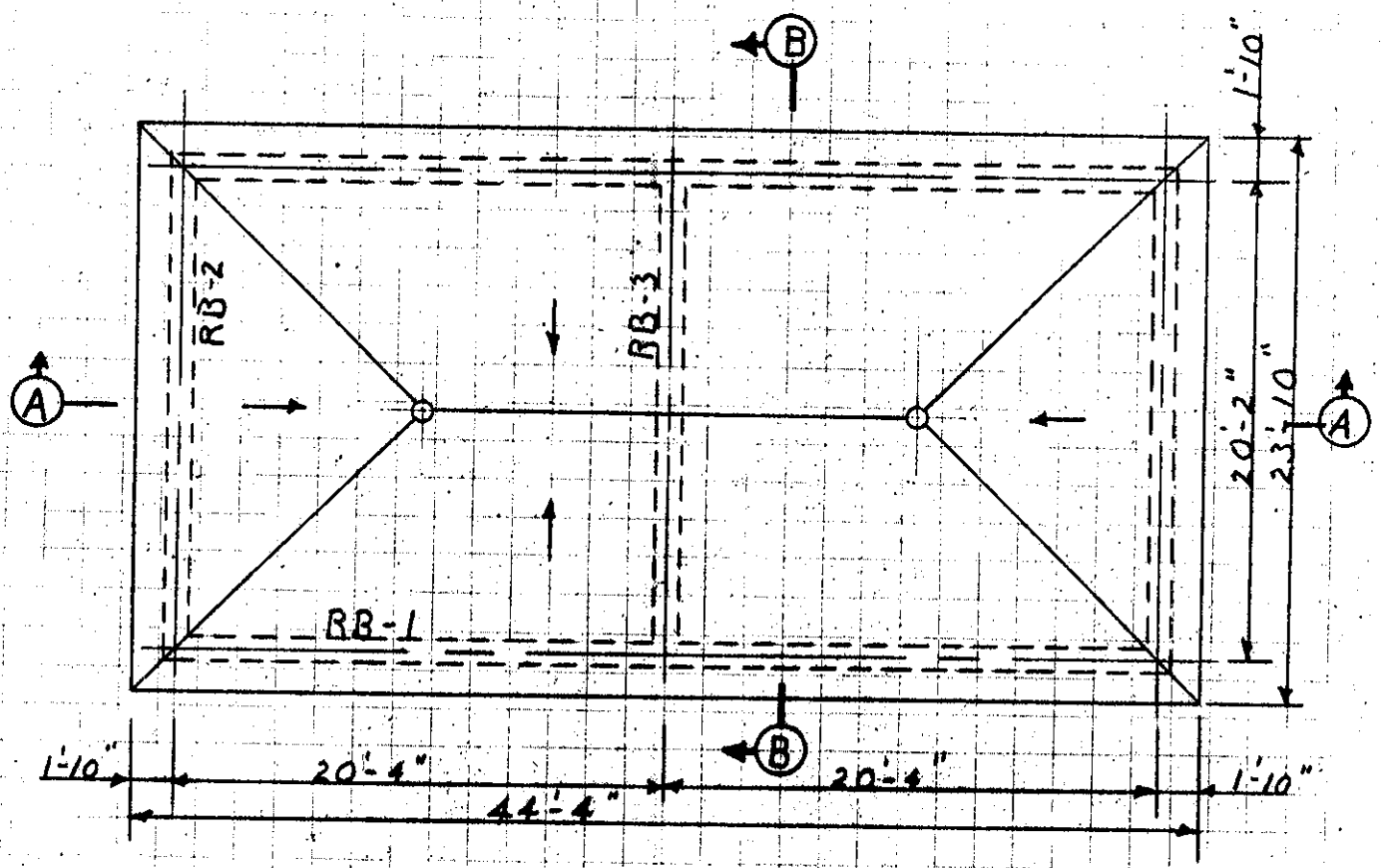
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

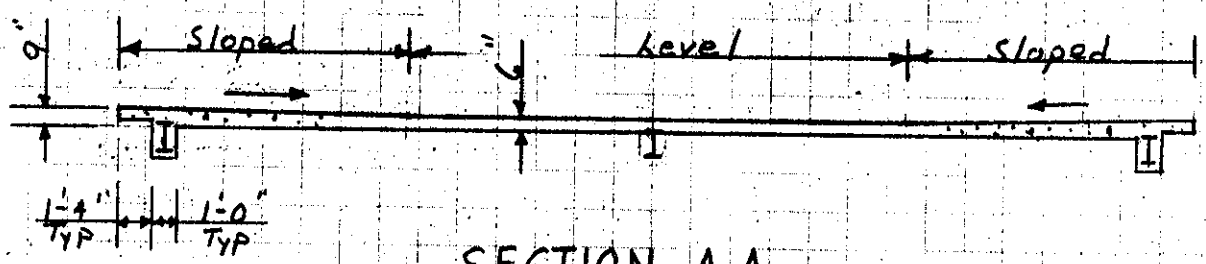
PAGE DM-31
PS-1

SUBJECT Derby Conn. - Pumping Station
COMPUTATION Roof
COMPUTED BY LSP CHECKED BY P DATE 5/14/68

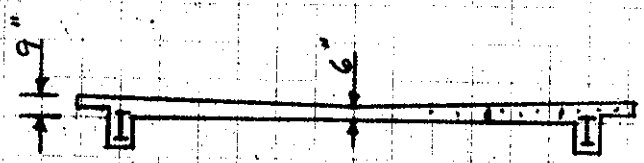
Roof Layout



PLAN



SECTION A-A



SECTION B-B

SUBJECT Derby Conn. - Pumping Station
COMPUTATION Roof
COMPUTED BY LSP CHECKED BY R DATE 5/14/68

Loads

Live Load = 30 psf
Dead Load
Concrete $(6+9)/2 \times 1/12 \times 150$ pcf = 93.7 psf
5 Ply T&G 6.5
100.2 psf Say 100 psf

Dead + Live Load (w) = 130 psf

Criteria

Concrete (f'_c = 3000 psi)
Extreme fiber stress in compr. f_c = 1350 psi
Allowable shear v = 60 psi
n = 9
Min. cover for reinf = 3/4"

Steel (Reinf) f_s = 20,000 psi

Design

Ref.: ACI Building Code - 318-63, Ch 20, § 2002 and Appendix A, Method 2

Min thickness of slab (§ 2002 e)
(1) 3 1/2
(2) Perimeter/180
$(2 \times 20'\text{-}4'' + 2 \times 20'\text{-}2'')12/180 = 5.4''$
Min thickness = 6"

Moment & Shear
$m = \frac{20'\text{-}2''}{20'\text{-}4''} = \frac{242}{244} = 0.992$ Say 1.0

S = length of short span = 20'-2" = 20.17'

From Table 1 Case 4
Middle Strips (Short Span Coeff = Long Span Coeff.)
$M = C w S^2$

Neg. Mom. Cont. Edge $-M_c = 0.058 \times 130\ \#/ft \times 20.17^2 = -3070\ \#/ft$ (52,900)
Neg. Mom. Disc. Edge $-M_{DC} = 0.029 \times 52{,}900'' = -1{,}530\ \#/ft$
Positive Mom @ Mid Span $+M = 0.044 \times 52{,}900'' = +2{,}330\ \#/ft$

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE DM-33 PS-3

SUBJECT Derby Conn. - Pumping Station
COMPUTATION Roof
COMPUTED BY LSP CHECKED BY R DATE 5/16/6X

Column Strips
Moments = 2/3 of Middle Strips (§ A2002(b))

Cantilever Strips
$L = 1'-4'' + 6'' = 1'-10''$ $w = 130\ \#/ft \pm$
$-M = \frac{130\ \#/ft \times 1.83^2}{2} = \underline{-218\ '\#/'}$

Shear (§ A2002 (c))
$V_{max} = \frac{1}{2} \times 130\ \#/ft \times (20.33 - 1.0) = \underline{1,260\ \#/ft}$

Reinforcing Steel
$K = 226$, $k = 0.383$, $j = 0.872$

Max. $d_{reqd} = \sqrt{\frac{M}{bK}} = \sqrt{\frac{3070''\#\times 12''/'}{12''/'\times 226}} = (13.6)^{\frac{1}{2}} = 3.7''$ Sat

Avail d Low Point Supports: Outer $= 6'' - \frac{3}{4}'' - \frac{1}{4}'' = 5''$ Inner $= 6'' - \frac{3}{4} - \frac{5}{8} - \frac{1}{4} = 4.375''$
$\frac{3}{143}'' \times 12''/' = 0.25''/ft$ for 10' $\Delta d = 2.5''$
$\therefore$ Outer $= 7.5''$ Inner $= 6.875''$

Negative Steel
Cont. Edge $-A_s = \frac{3070''\#\times 12''/'}{20,000\ \#/\square'' \times 0.872 \times 5.0''} = 0.424\ \square''/ft$ (Outer)
(0.402 for d = 5.25")
#4 @ 6" $A_s = 0.40\ \square''/ft$ $\Sigma_o = 3.1''/ft$
#5 @ 9" $A_s = 0.41\ \square''/ft$ $\Sigma_o = 2.6''/ft$ ← Use
#4 @ 10" $A_s = \frac{2}{3} \times 0.402 \frac{5.25}{6.25} = 0.23$ (Column Strip) ← Use

Discont Edge
$-A_s = \frac{1530''\#\times 12''/ft}{20,000\ \#/\square'' \times 0.872 \times 7.5''} = 0.140\ \square''/ft$ (Outer)
#4 @ 12" $A_s = 0.20\ \square''/ft$ $\Sigma_o = 1.6''$ ← Use
$-A_s = \frac{1530''\#\times 12''}{20,000 \times 0.872 \times 6.875} = 0.153\ \square''/ft$ (Inner)
#4 @ 12" $A_s = 0.20\ \square''/ft$ $\Sigma_o = 1.6''$ ← Use

Cantilever
Obvious #4 @ 12" cc adequate

Positive Steel
Mid Span $+A_s = \frac{2330''\#}{3070''\#}(0.424'') = 0.322\ \square''/ft$ (Outer)
$+A_s = \frac{5.0''}{4.375''}(0.322\ \square''/ft) = 0.365\ \square''/ft$ (Inner)
#4 @ 6" $A_s = 0.40\ \square''/ft$ $\Sigma_o = 3.1''$
#5 @ 10" $A_s = 0.37\ \square''/ft$ $\Sigma_o = 2.4''$ ← Use

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Conn. - Pumping Station
COMPUTATION Roof
COMPUTED BY LSP CHECKED BY A DATE 5/17/68

Check Shear & Bond Stresses

Shear $v_c = \frac{V_{max}}{bd} = \frac{1260^{\#}}{12'' \times 6.875''} = 15^{\#}/_{\square''} < 60^{\#}/_{\square''}$ OK

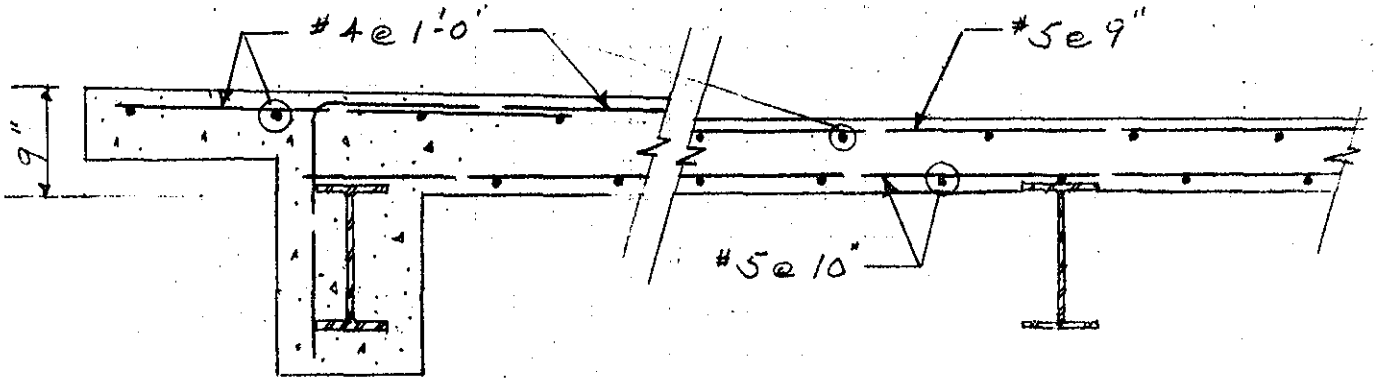
Bond $u = \frac{V_{max}}{\Sigma o j d} = \frac{1260^{\#}}{1.6 \times 0.872 \times 6.875''} = 131^{\#}/_{\square''} < 3$

Min Temperature Reinforcing
At max. thickness of 9" d = 8"

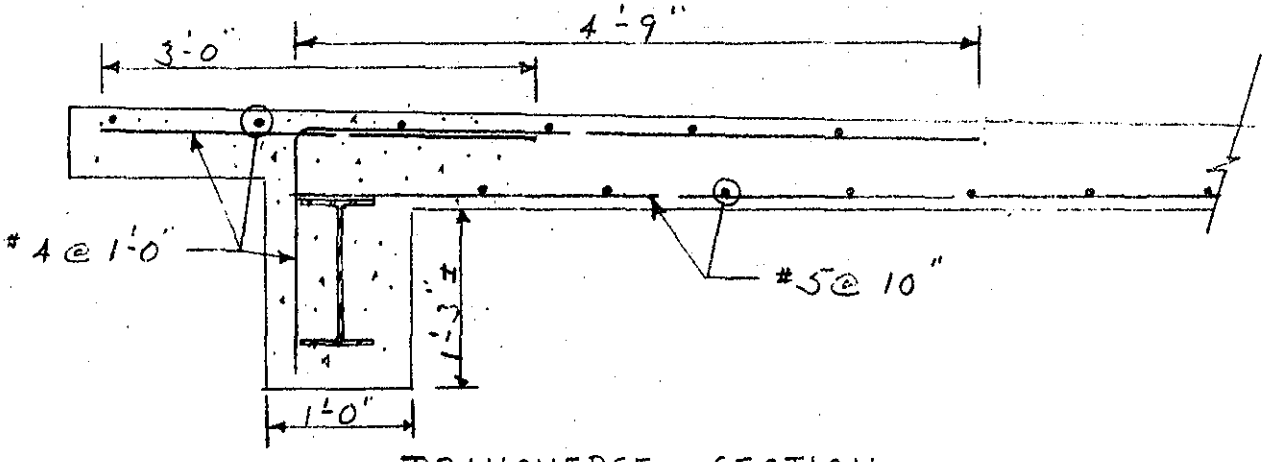
$A_{Temp} = 0.002 \times 12'' \times 8'' = 0.19 \text{ in}^2$ (Both Faces)

$A_{Temp} = 0.0012 \times 12 \times 8 = 0.115 \text{ in}^2$ (Each Face)

Use a minimum of #4 @ 12"



LONGITUDINAL SECTION



TRANSVERSE SECTION

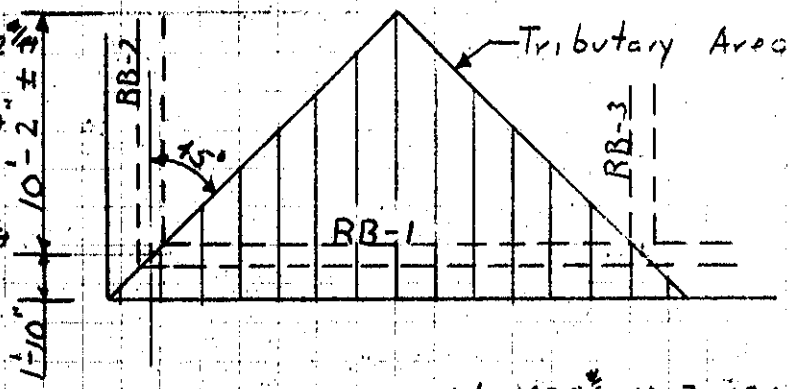
SUBJECT Derby Conn - Pumping Station
COMPUTATION Roof Beams
COMPUTED BY LSP CHECKED BY R DATE 5/21/68

RB-1 & RB-2 (ASTM A36)
Span Length = 20-4" (RB-1 = 20'-4"; RB-2 = 20'-2")

Loading: Ref. ACI g A2002 (d)

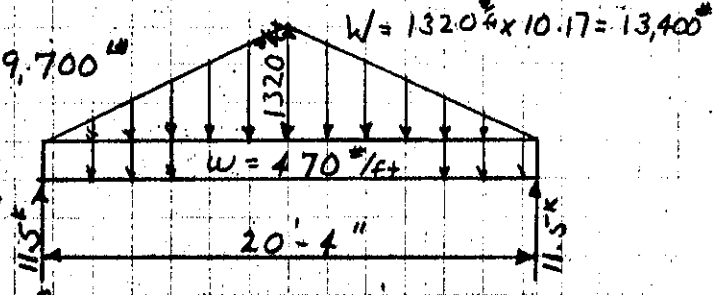
Triangular
$w_{max} = 130\,\#/ft \times 10.17 = 1{,}322\,\#/ft$

Uniform
Roof $130\,\#/ft^2 \times 1.83' = 238\,\#/ft$
Conc Bm $150\,\#/ft^3 \times 1.25\,ft^2 = 188$
Steel Bm 40
466 #/ft
Say 470 #/ft



$+M = \frac{1}{8} \times 470\,\#/ft \times \overline{20.33}^2 + \frac{13{,}400\,\# \times 20.33}{6}$

$= +24{,}300'^{\#} + 45{,}400 = 69{,}700'^{\#}$



$V = \frac{470\,\#/ft \times 20.33}{2} + \frac{13{,}400\,\#}{2}$

$= 4{,}800\,\# + 6{,}700\,\# = 11{,}500\,\#$

Check by ACI
Equiv. uniform load $= \frac{w_s}{3} = \frac{130\,\#/ft \times 20.33}{3} = 881\,\#/ft$

Tribut. Area + Beam $= 881\,\#/ft + 470\,\#/ft = 1351\,\#/ft$

$M = \frac{1}{8} \times 1351\,\#/ft \times \overline{20.33}^2 = 69{,}800'^{\#}$ vs $69{,}700'^{\#}$

Design
Allowable Stresses: EM 1110-1-2101, 1963 & AISC 6th Ed.,
w/ Basic Stress of 0.6 F_y

Try 12WF31 $S_x = 39.4\ in^3$

$f_b = \frac{69{,}700'^{\#} \times 12''/ft}{39.4\ in^3} = 21{,}200\,\#/\square'' < {}^{*}23{,}800\,\#/\square''$ (0.66 F_1) Sat

$v = \frac{11{,}500\,\#}{12.09'' \times 0.265''} = 3{,}600\,\#/\square'' < 14{,}400\,\#/\square''$ (0.4 F_1) Sat

Min Depth (AISC, Sect 1.13)

$f_b/600{,}000 \times L = \frac{21{,}200\,\#/\square}{600{,}000} \times 20.33' \times 12''/' = 8.6''$

$8.6 < 12''$ Sat

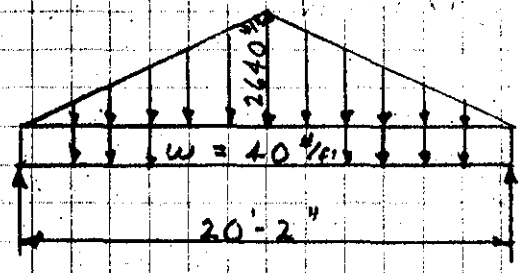
* Compression flange continuously supported since encased in concrete & compact section.

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Roof Beams & Crane Beams
COMPUTED BY LSP CHECKED BY R DATE 5/21/68

Conclusion: For RB-1 and RB-2 use 12 WF 31 made of steel conforming to ASTM A36. A 12WF 27 would have bending stresses f_b = 24,500 #/□" i.e. greater than 0.66 F_y

RB-3

Span Length = 20'-2"



Loading & Moments

Triangular

w_{max} = 2 x 1320 #/ft = 2640 #/ft

W = 2640 #/ft x 10.08 = 26,600#

Uniform w = 40 #/ft

$+M = \frac{1}{8} \times 40\ \#/ft \times \overline{20.17}^2 + \frac{26{,}600\# \times 20.17}{6} = 2{,}000 + 89{,}400 = 91{,}400''$

$V = 40\ \#/ft \times 10.08' + 26.6^k/2 = 0.4^k + 13.3^k = 13.7^k$

Design

Try 12 WF 36 S = 45.9 in³

$f_b = \frac{91{,}400''\# \times 12''/ft}{45.9\ in^3} = 23{,}900\ \#/□'' \simeq 23{,}800\ \#/□''$ Sat

$v = \frac{13{,}700\#}{12.24 \times 0.305''} = 3{,}700\ \#/□'' < 14{,}400\ \#/□''$ Sat

Min Depth = $\frac{23{,}900\ \#/□''}{600{,}000}(20.17' \times 12''/ft) = 9.6'' < 12''$ Sat

Conclusion: Use a 12WF36 for RB-3 made of steel conforming to ASTM A36.

Crane Beams

Span Lengths 2 @ 20'-4" (C. to C. columns)

Crane Characteristics

Type: Top Running, Single Bridge, Hand Operated

Capacity 4T = 8,000#

Wt. of Bridge = 2,150#

Wt. of Hoist 650#

Max Wheel Load 4,800#

Wheel Spacing 3'-6 to 4'-6 (3'-6" more critical)

Rail ASCE 30#/yd.

Secondary Forces

Impact = 0 (Hand Operated)

Longit. = 10% (Max. Vert Wheel Loads) = 480#/wheel

Lateral = 10% (Trolley + Capacity) = 865#

```
STEEL CRANE BEAM---DERBY LOCAL PROTECTION   DATE MAY 1968
ENTER FOLLOWING ITEMS:---FY =36000          -..........&02


FORCES AND DIMENSIONS IN POUNDS AND FEET

BEAM SPAN                =20.33
CRANE CAPACITY           =8000
WHEEL LOAD               =4800
TROLLEY WEIGHT           =650
WHEEL SPACING            =3.5
DEPTH OF CRANE RAIL      =.33          ..........&02
TRY 10WF25          ..0000
10"WF25#  NO GOOD

TRY 10WF33          ..0000
10"WF33  NO GOOD

TRY 10WF39
                         OK
PERTINENT DATA---:
MAX. REACT               =     9170.07
DIST TO FIRST WHEEL      =        9.29
CRANE WHEEL M            =    40753.53
M DUE TO LONG FORCE      =     1876.80
MXX                      =    44645.21
MYY                      =     2754.04
FX                       =    12695.32
FY                       =     5901.53
COMBINED FS              =    18596.85
FB FORM 4 5-18 AISC      =    21528.39
FB  "   S 5-18  "        =    20842.53
FB ALLOWABLE             =    21600.00
DEFLECTION               =          .46 INCHES ← Excessive

TRY 12WF40
                         OK
PERTINENT DATA---:                          Use 12WF40
MAX. REACT               =     9180.23
DIST TO FIRST WHEEL      =        9.29
CRANE WHEEL M            =    40753.53
M DUE TO LONG FORCE      =     1916.80
MXX                      =    44736.87
MYY                      =     2754.04
FX                       =    10343.78
FY                       =     6008.83
COMBINED FS              =    16352.61
FB FORM 4 5-18 AISC      =    21525.41
FB  "   S 5-18  "        =    17020.20
FB ALLOWABLE             =    21600.00
DEFLECTION               =          .31 INCHES

END
```

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Columns
COMPUTED BY LSP CHECKED BY A DATE 5/28/68

Column Heights

El. Underside of Roof Slab El. 34.83 } Diff. = 18.33'
El. Fin Floor El. 16.50

Conc. Projection of ℄ 1'-0 1/2" } Sum = 1.50'
1/2 Depth of Spandrel Beam (-1/2) 5 1/2"

16.83 ft

Height of Columns Say 17.0 ft (204")

Intermediate Column Loading

Roof

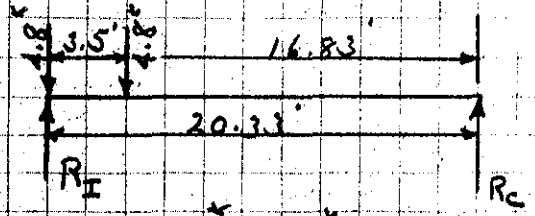
2 RB-1 = 2 x 11,500# = 23.0^k e = 0" (Concentric)

1 - RB-3 = 13.7^k e = 1/2 Depth of Column

Crane Beam

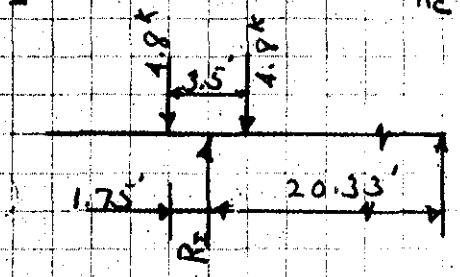
(1) Wheel @ Support R_I

$R_1 = 4.8^k + \frac{16.83}{20.33}(4.8) = 8.8^k$



(2) Wheel Straddling Support R_I

$R_1 = 2 \times \frac{18.58}{20.33}(4.8) = 8.8^k$



(3) Uniform Ld (Beam, Rail)

$\omega = (40\#/ft + \frac{30\#/ft}{3}) = 50\#/ft$

$P_{cr} = 50\#/ft \times 20.33' = 1{,}000\#$

∴ Crane Ld = 9,800# @ 1'-4" from face of Col.

End Column Loading

Roof

1 - RB-1 = 11.5^k @ e = 1/2 Web thickness 0"±

1 - RB-2 = 11.5^k @ e = 1/2 Depth of column

Crane (Ref PS-8) = 9,180# @ 1'-4" from face of col.

STEEL COLUMN SUBJECT TO COMBINED BENDING AND AXIAL LOAD

THIS PROGRAM ANALYSES A STEEL COLUMN SUBJECT TO A COMBINED AXIAL LOAD AND BENDING. IT WILL ANALYZE A COLUMN WITH UP TO FOUR BEAM LOADS AT TOP AND A CRANE LOAD ON THE SIDE. PROGRAM SELECTS A WF SECTION THAT WILL SATISFY THE REQUIREMENTS OF THE AISC CODE.

MACHINE INSTRUCTIONS: SET MAGNITUDE AT 7 AND DECIMAL AT 2. SET PROGRAM MODE AT AUTO AND CONTROL MODE AT AUTO. SWITCH ANSWERS ONLY "ON" AND AUTO TAB "ON". TURN AUX. READER TO AUTO AND START PROGRAM BY TURNING READER ON AND THEN TO AUTO.

STRUCTURAL STEEL COLUMN ---INT. COL. DERBY CONN. DATE MAY 1968

ENTER FOLLOWING ITEMS:----FY =36000 -.....&02

FORCES AND DIMENSIONS IN POUNDS AND INCHES
COLUMN LENGTH =204
FORCE P1 =0
FORCE P2 =23000 P2 ARM (-LEFT +RIGHT) =0
FORCE P3 =13700
FORCE P4 =9800 P4 ARM =20
FORCE H1 =865 D TO TOP OF COL=46
DETERMINE FROM AISC, SECTION 5, THE FOLLOWING
K =1 CM =.85
TRY 8WF20 ..0000

8WF20 NO GOOD
TRY 8WF24 ..0000

8WF24 NO GOOD
TRY 8WF28 ..0000

8WF28 NO GOOD
TRY 8WF31

OK

Use 8WF31

PERTINENT DATA---:

V	46500.00
M	281617.74
KL/R	101.49
CC	126.09
F'E	43110.68
F1 (ACTUAL)	5098.68
FA	12788.03
F2 (ACTUAL BENDING)	10278.01
} FORM. 4 5-18 AISC	14603.79
FB " 5 5-18 "	21600.00
F1/FA	.39
F1/FA +F2/FB	.00
FORM. 7A 5-20 AISC	.85

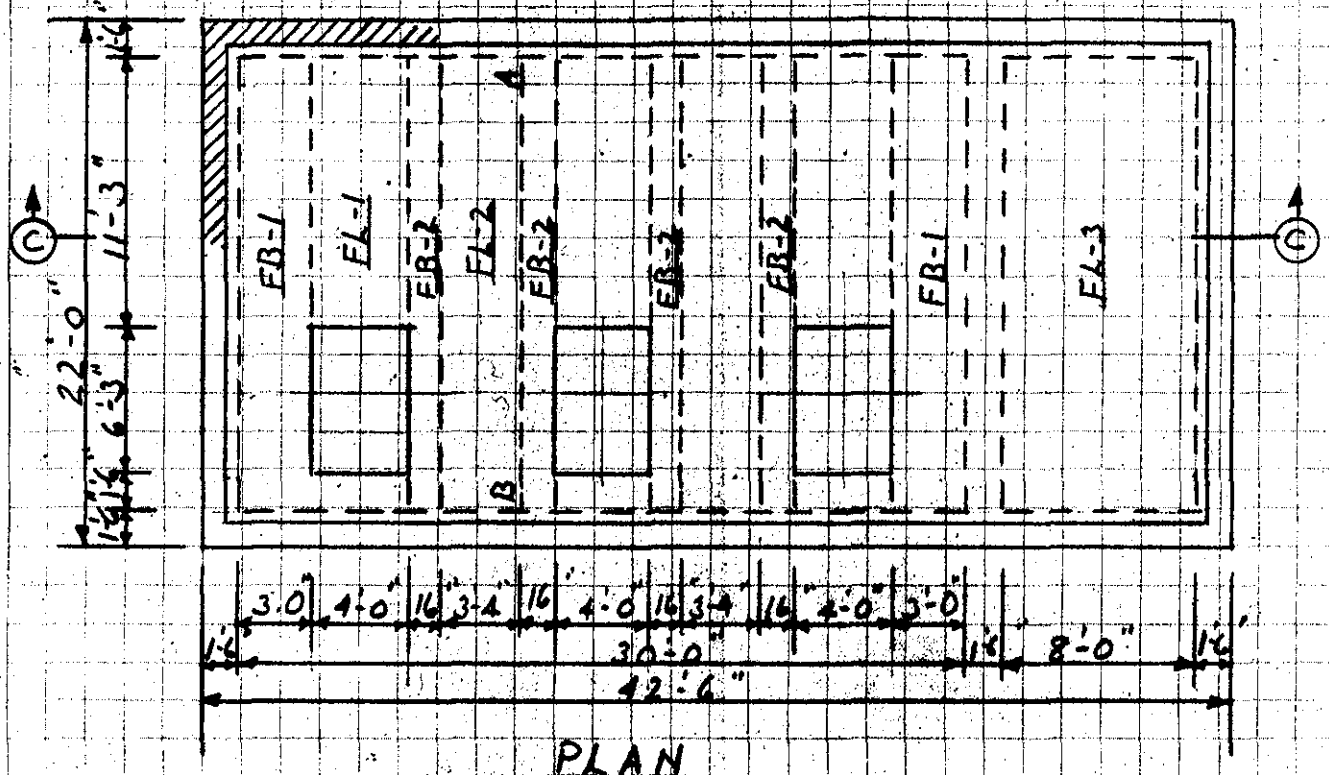
END

SUBJECT Derby, Conn. - Pumping Station

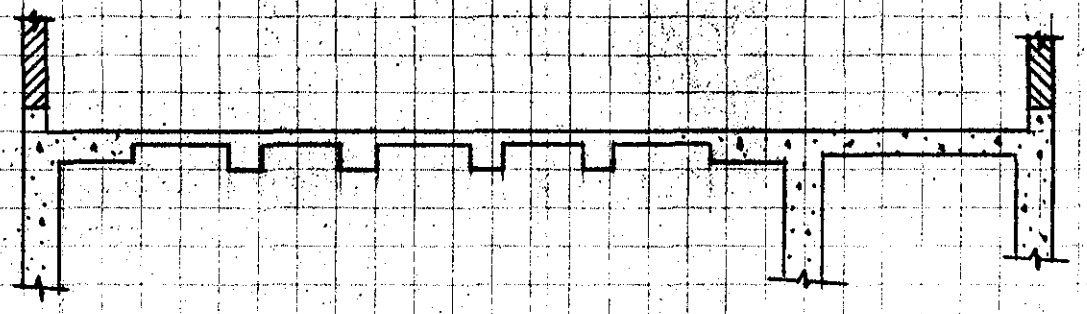
COMPUTATION Operating Floor

COMPUTED BY LSP CHECKED BY R DATE 6/4/68

Layout



PLAN



SECTION C-C

SUBJECT Derby, Conn. - Pumping Station

COMPUTATION Operating Floor

COMPUTED BY LSP CHECKED BY R DATE 6/6/68

Floor Area

Loading Conditions

Ref. EM 1110-2-3104

Condition I - D.L. + L.L. (Pumping apparatus in design location)

Condition II - D.L. + L.L. + Concentrated load of heaviest piece of equipment

Loads

Dead Load

Slab Say 8" $w_{DL} = \frac{2}{3} \times 150^{\#}/cf = 100^{\#}/ft$

Equipment

Engine Pad $1.25 \times 4.0 \times 8.0 \times 150^{\#}/cf = 6000^{\#}$ } $11{,}000^{\#}$

Engine $5000^{\#}$

Pump Gear Unit $2{,}500^{\#}$ } $9{,}500^{\#}$

Pump $7{,}000^{\#}$

Live Load

Slab $w_{LL} = 100^{\#}/\square'$ (EM 1110-2-3104)

Pump Thrust - not included since pump and motor have a common support

Water Column $\frac{\pi \times 5.0^2}{4} \times (13+2) \times 62.4^{\#}/cf = 6{,}600^{\#}$

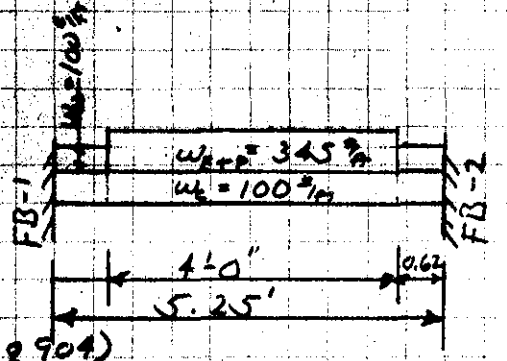
Area FL-1 (8" Slab)

Span $= 4'-0" + 1.25' = 5.25'$ ±

Condition I

Eng. + Pad $= \frac{11{,}000^{\#}}{8 \times 4} = 345^{\#}/\square'$

w 8" Slab $= 100^{\#}/\square'$ $w_{LL} = 100^{\#}/ft$



Say Uniform Ld of $445^{\#}/ft$

Moments & Shear (ACI 318-36 § 904)

$+M = \frac{1}{14} w l^2 = \frac{1}{14} \times 445^{\#}/\square' \times 5.25^2 = \underline{+876'^{\#}/ft}$

$-M = \frac{1}{12} w l^2 = \frac{14}{12}(876'^{\#}/_1) = \underline{-1022'^{\#}/ft}$

$V = 445 \times 5.25 \div 2 = \underline{1{,}200^{\#}/ft}$

Condition II

Heaviest piece of equipt $= 7000^{\#}$ (Pump)

Distr. Over 5'-6" (Pump dia + 2t Pad) $= 7000/5.6' = 1{,}250^{\#}/ft$

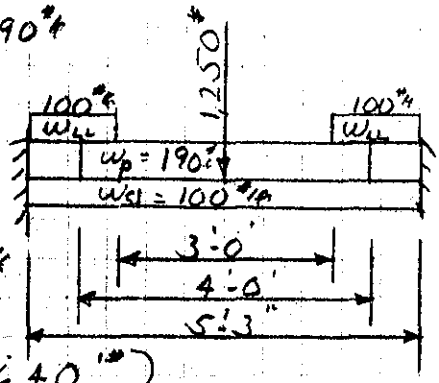
Equiv. $w = 7000/5.5 \times 5.5 = 225^{\#}/ft$

SUBJECT Derby Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY DATE 6/6/68

Condition could exist with engine out and with pump resting on concrete pad.

$w_{pad} = \frac{6000^{\#}}{32.0^{\square'}} = 188^{\#}/ft$ Say $190^{\#}/ft$

$w_{LL} = 100^{\#}/ft$ (Area not covered by pump)



Positive Moment

Uniform ld = 290#/ft (±)

$+M = \frac{1}{14} \times 290^{\#}/ft \times \overline{5.25}^2 = +570'^{\#}/ft$

Concent. Ld.

Simple Bm $+M = \frac{1{,}250^{\#} \times 5.25}{4} = +1{,}640'^{\#}$

Fixed Bm $+M = \frac{PL}{8} = \frac{1640}{2} = +820'^{\#}$

Avg = 1,230 '#/ft

∴ Posit Mom = +570'# + 1,230'# = **+1,800 '#/ft** Crit.

Negative Moment

Uniform Load

$-M = \frac{1}{12} \times 290^{\#}/ft \times \overline{5.25}^2 = -666'^{\#}$

Conc. Ld

$-M = \frac{PL}{8} = \frac{1{,}250^{\#} \times 5.25}{8} = -820'^{\#}$

∴ Neg. Mom = -666'# + (-820'#) = **-1,486 '#/ft** Crit.

$V = 1250^{\#} + \frac{290 \times 5.25}{2} = 1{,}250^{\#} + 760^{\#} = 2{,}010^{\#}/ft$ Crit

Steel Reqd.

$f_c = 1350^{\#}/\square'$, $f_s = 20{,}000^{\#}/\square'$, $K = 226$, $j = 0.872$, $n = 9.2$

$d_{reqd} = \sqrt{\frac{M}{bK}} = \left(\frac{1{,}800'^{\#} \times 12''}{12 \times 226}\right)^{\frac{1}{2}} = (7.96)^{\frac{1}{2}} = 2.8''$ ±

$d_{Top} = 8'' - \underbrace{\frac{3}{4}''}_{cover} - \underbrace{\frac{3}{8}''}_{\frac{1}{2}\,Bar} = 6\frac{7}{8}'' = 6.875''$

$d_{bot} = 6.875''$

$+A_s = \frac{+1{,}800'^{\#} \times 12''}{20{,}000 \times 0.872 \times 6.875''} = 0.18\ \square''/ft$

Try #4 @ 12" $\begin{cases} A_s = 0.20\ \square''/ft \\ \Sigma_o = 1.6\ in \end{cases}$ **Use**

$-A_s = \frac{1486}{1{,}800}(0.18) = 0.15\ \square''/ft$

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY A DATE 6/7/68

Try #4 @ 12" $\begin{cases} A_s = 0.20 \text{ □}'' \\ \Sigma_o = 1.6 \text{ "} \end{cases}$ Use

$v = \frac{2010^{\#}}{12 \times 6.875} = 24 \text{ \#/□}'' < 60 \text{ \#/□}''$ Sat

$u = \frac{2010^{\#}}{1.6 \times 0.872 \times 6.875} = 210 \text{ \#/□}'' < 350 \text{ \#/□}''$ Sat

Min Temp Reinf.
$A_s = 0.0012 \times 12 \times 8 = 0.115$ Use #4 @ 12"

Area FL-2 (8" Slab)
Span = 6'-0" - (2 x 7½") = 4'-9" < 5'-3"
Obvious less critical than Area FL-1; therefore use same steel & thickness

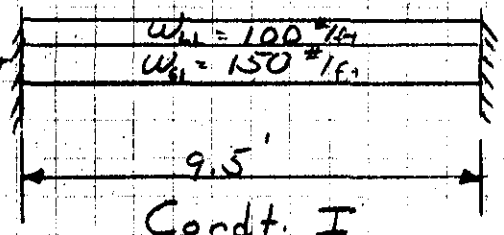
Area FL-3 (12" Slab)
Span = 8'-0" + 1'-6" = 9'-6"
Try 12" slab thickness $w_{sl} = 150$ #/ft

Condition I
$w_{LL} = 100$ #/ft

$+M = \frac{1}{14} \times 250 \text{ \#/ft} \times 9.5^2 = +1,610$ '#/ft

$-M = \frac{14}{12}(1610 \text{ '\#/ft}) = -1,877$ '#/ft

$V = 250 \text{ \#/ft} \times 9.5' \div 2 = 1,187$ #/ft



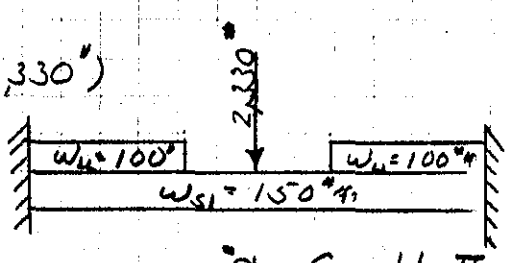
Condt. I

Condition II
Concentrated Load ($\frac{7000^{\#}}{3.0} = 2,330$")
Simple Bm (Posit. Mom.)
$+M = \frac{2030 \times 9.5}{4} = +4820$ '#

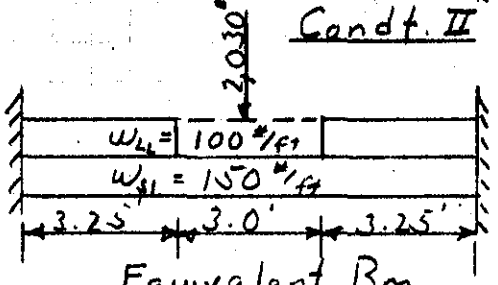
Fixed Bm (Posit. Mom.)
$+M = \frac{4820}{2} = +2410$ '#
$+7230$ '#

Mean $= \frac{7230}{2} = +3,615$ '#/ft

Fixed Bm (Neg. Mom)
$-M = \frac{2030 \times 9.5}{8} = -2410$



Condt. II



Equivalent Bm

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY R DATE 6/10/68

Moments & Reactions (Uniform Ld + Conc. Ld.)

$+M = +1{,}610'^{\#} + 3{,}615'^{\#} = +5{,}225'^{\#}$ Crit

$-M = -1{,}877'^{\#} - 2410'^{\#} = -4{,}287'^{\#}$ Crit

$V = 1{,}187^{\#} + 2{,}330^{\#} = 3{,}517^{\#}$ Crit

Steel Reqd.

$d_{reqd} = \sqrt{\frac{M}{b\,K}} = \sqrt{\frac{5{,}225'^{\#} \times 12''/'}{12 \times 226}} = (23.11)^{\frac{1}{2}} = 4.8''$

$d_{avail} = 12'' - \frac{3}{4} - \frac{3}{8}'' = 10.875$

$+A_s = \frac{5{,}225'^{\#} \times 12''}{20{,}000\,\#/\square'' \times 0.872 \times 10.875''} = 0.330\ \square''/ft$

Try #5 @ 12" $\left\{ \begin{array}{l} A_s = 0.31\ \square''/ft \\ \Sigma_o = 2.0'' \end{array} \right.$ Use

$-A_s = \frac{4287}{5225}(0.330) = 0.27$

Try #4 @ 9" $\left\{ \begin{array}{l} A_s = 0.27\ \square''/ft \\ \Sigma_o = 2.1'' \end{array} \right.$ Use

$v = \frac{3{,}517^{\#}}{12 \times 10.875} = 27\ \#/\square'' < 60\ \#/\square''$ Sat

$u = \frac{3{,}517^{\#}}{2.1 \times 0.872 \times 10.875} = 176\ \#/\square'' < 350\ \#/\square''$ Sat

Min. Temp Steel

$A_m = 0.0012 \times 12 \times 12 = 0.1728\ \square''$ Use #4 @ 12"

Floor Beams

* Independent Check (Load Dist by DEF.)

Beam FB-1 (Depth = 15")

Relative Stiffness ($K = \frac{I}{L}$) I is constant

Cantilever Action (Effect L = 2l)

$L = 3'\text{-}0'' + 9'' = 3'\text{-}9''$ $K_c = \frac{1}{3.75 \times 2} = 0.1333$ (Cant.)

Beam Action (Effect L = ½ l)

$L = 22'\text{-}0'' - 1'\text{-}6'' = 20'\text{-}6$ $K_B = \frac{2}{20.5'} = 0.0976$

0.2309

Distribution

Cant $= \frac{0.1333}{0.2309} = 0.578$

Beam $= \frac{0.0976}{0.2309} = 0.42$

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY R see FS-16 DATE 6/11/68

Cantilever Beam Action
At Floor Area FL-1

The distribution of loads according to the relative stiffness (beam vs cantilever) holds for the load from FL-1 on to FB-1. Actual loads within FB-1 are not distributed in accordance with the relative stiffness since this relationship does not hold true for the strips closer to wall.

Condition I

$P_{FL-1} = 445\,\#/ft \times 2.0' = 890\,\#/ft$ (Ref PS-13)

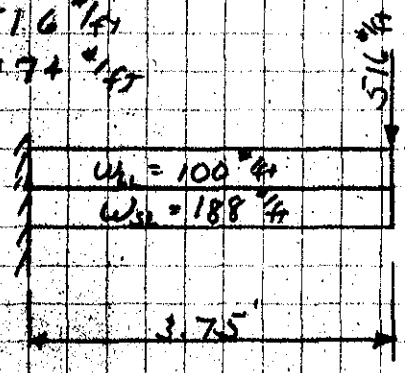
$P_{cant} = 890\,\#/ft \times 0.58 = 516\,\#/ft$

$P_{Bm} = 890\,\#/ft - 516\,\#/ft = 374\,\#/ft$

Try 15" Slab

$w_{slab} = 1.25 \times 150 = 188\,\#/ft$

$w_{LL} = 100\,\#/ft$



$Span = 3'\text{-}0" + \frac{1.5}{2} = 3.75'$

$-M = -516\,\# \times 3.75' - \frac{288\,\#/ft \times 3.75'^2}{2}$

$= -1935'\# - 2024'\# = \underline{-3{,}959\,'\#/ft}$

$V = 516\,\# + 288\,\#/ft \times 3.75' = \underline{1596\,\#/ft}$ (1080)

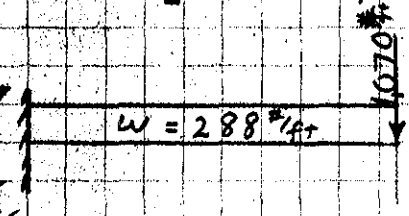
Condition II - Heaviest piece of equipt in place of engine.

From FL-1

$P_{pad+slab} = 290\,\#/ft \times 2.0' = 580\,\#/ft$

$P_{equipt} = \frac{7{,}000\,\#}{5.5} = 1270\,\#$

$1850\,\#/ft$



$P_{cant} = 1850\,\#/ft \times 0.58 = 1070\,\#/ft$

$P_{Bm} = 1850\,\#/ft \times 0.42 = 770$

$-M = -1070\,\# \times 3.75' - 2024'\# = -4012 - 2024 = \underline{-6{,}036\,'\#/ft}$

$V = 1070\,\# + 1080 = 2150\,\#/ft$

Condition IIA - Heaviest piece of equipt on slab

From FL-1

$P_{pad+engine+slab} = (345\,\#/ft^2 + 100\,\#/ft^2) \times 2.0' = 890\,\#/ft$

(Ref PS-13)

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY A DATE 6/12/68

Heaviest Piece of equpt = 7000#

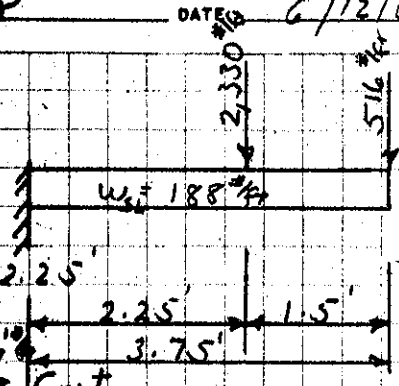
Distr over 3' (Dia of pump)

$P_p = \frac{7000^{\#}}{3.0^{\#}} = 2{,}330^{\#}/ft$

$-M = -1935^{'\#} - \frac{188 \times 3.75^2}{2} - 2330 \times 2.25'$

$= -1935^{'\#} - 1322 - 5240 = \underline{-8497^{'\#}}$ Crit

$V = 188 \times 3.75' + 2{,}330^{\#} + 516^{\#} = \underline{3{,}550^{\#}/ft}$ Crit



At Pump Area (Ref PS-13)

Pump + Gear Unit + Water Col = 9,500# + 6,600# = 16,100#

Distribution (2 Beams) = 8,050 #/bm Distr. over 6'-3"

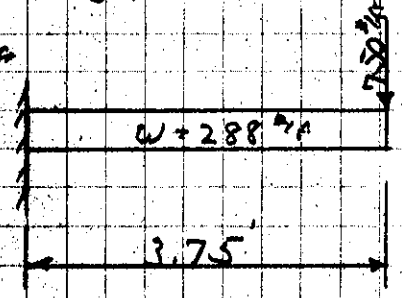
Condition I

$Ld/Ft = 8050^{\#} \div 6.25' = 1290^{\#}/ft$

$P_{cant} = 1{,}290^{\#} \times 0.58 = 750^{\#}$

$P_{Bm} = 1{,}290^{\#} \times 0.42 = 540^{\#}$

$w_{sl} + w_{LL} = 188 + 100 = 288^{\#}/ft$



Obviously Not as critical as Condt II on Sh PS-17

Condition II

Not feasable to have pump in place w/ heaviest piece of equipt on beam - pump would have to be out - obviously not as critical as Condt IIA

Reinforcing Steel Reqd.

$d_{req_1} = \sqrt{\frac{8{,}497^{'\#} \times 12''/ft}{12 \times 226}} = (37.6)^{\frac{1}{2}} = 6.1''$

$d_{avail} = 15'' - 3/4'' - \frac{1}{4} = 14''$

$-A_s = \frac{8{,}497^{'\#} \times 12''/ft}{20{,}000 \times 0.872 \times 14''} = 0.417 \; \square''/ft$

Try #5 @ 9" $\begin{cases} A_s = 0.41 \; \square''/ft \\ \Sigma_\phi = 2.6 \end{cases}$

or

#4 @ 6" $\begin{cases} A_s = 0.40 \; \square'' \\ \Sigma_\phi = 3.1 \end{cases}$ Use

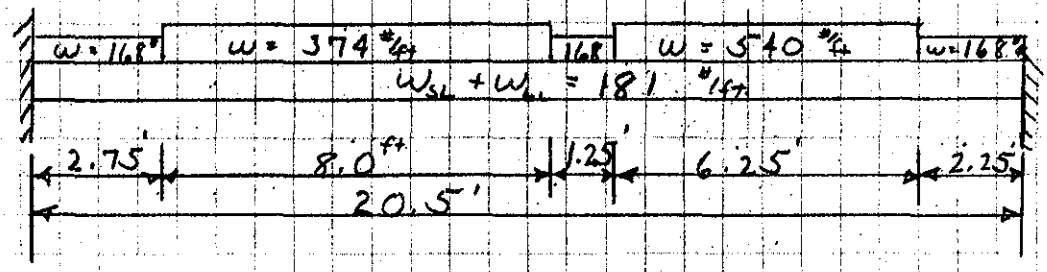
Permitted to reduce moment to face of support - therefore steel is O.K

SUBJECT Derby, Conn - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY A see PS-1b DATE 6/13/62

$$v = \frac{3,550}{12 \times 14} = 21\ \#/\square' < 60\ \#/\square' \quad \underline{Sat}$$

$$u = \frac{3,550^{\#}}{2.6 \times 0.872 \times 14} = 11.2\ \#/\square' < 298\ \#/\square' \quad \underline{Sat}$$

Beam Action
Assume 1'-6" width acting as beam
Condition I



$w_{SL} + w_{LL} = (188\ \#/ft + 100\ \#/ft)\,1.5 = 432\ \#/ft$

$w_{Bm} = 432\ \#/ft \times 0.42 = 181\ \#/ft$ (Beam Action)

$w_{FL-1} = 374\ \#/ft$ for 8'-0" (Ref PS-13 & 17)

$w_{FL-1} = (100 + 100) \times 2 \times 0.42 = 168\ \#/ft$ (Fl-1 outside engine pad or pump)

$w_{pump} = 540\ \#/ft$ (PS-18)

Avg. $w = (374 + 540) \div 2 + 181 = 638\ \#/ft$ Conservative

Moments & Reactions

$-M = \frac{1}{12} \times 638\ \#/ft \times \overline{20.5}^2 = \underline{-22,300}\ '\#$ (For 1.5 ft)

$+M = \frac{1}{14} \times 638 \times \overline{20.5}^2 = \underline{+19,140}\ '\#$ (For 1.5 ft)

$V = 638\ \#/ft \times 20.5 \times \frac{1}{2} = \underline{6,540}\ \#$ "

$d_{reqd} = \left(\frac{22,300'' \times 12''/ft}{18'' \times 226}\right)^{\frac{1}{2}} = (65.8)^{\frac{1}{2}} = 8.1''$

$d_{avail} = 15'' - 1\frac{1}{2} - \frac{1}{2}'' = 13''$ (Top Reinf.)

$d_{avail} = 15'' - 1\frac{1}{2}'' - \frac{1}{2} - \frac{1}{2} = 12\frac{1}{2}''$ (Bot. Reinf.)

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY LSP CHECKED BY R DATE 6/17/68

$$-A_s = \frac{-22{,}300''^{\#} \times 12''/'}{20{,}000 \times 0.872 \times 13.0} = 1.18 \square''$$

Try 4-#5 @ 6" $\left\{ \begin{array}{l} A_s = 1.24 \square'' \\ \Sigma_\phi = 8.0'' \end{array} \right.$ Use

$$+A_s = \frac{19{,}140''^{\#} \times 12''/'}{20{,}000 \times 0.872 \times 12.5} = 1.05 \square''$$ Use

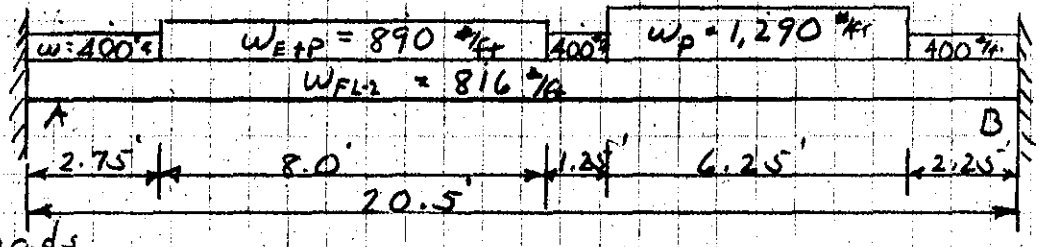
Try 4-#5 @ 6" $\left\{ \begin{array}{l} A_s = 1.24 \square'' \\ \Sigma_\phi = 8.0 \end{array} \right.$

$$v = \frac{6540^{\#}}{18 \times 13.0} = 28 \ \#/\square'' < 60 \ \#/\square''$$ Sat

$$u = \frac{6540^{\#}}{8.0 \times 0.872 \times 13.0} = 72.1 \ \#/\square'' < 298 \ \#/\square''$$ Sat

Min $A_s = 0.0012 \times 12 \times 15 = 0.22 \square''$ #4 @ 12"

Beam FB-2 (16" x 21" Beam)
Try 16" x 21" beam



Loads
FL-2 & FB-2
8" Slab (FL-2 & FB-2) = 8/12 x 150 #/ft³ x 3.0 ft = 300 #/ft
Beam (-8" slab) = 13/12 x 1.33 x 150 #/ft³ = 216
Live Load = 100 #/ft² x 3.0 = 300
816 #/ft

FL-1
Eng. + Pad 345 #/ft² x 2.0 ft = 690 # (PS-13)
8" Slab 100 #/ft² x 2.0 = 200
890 #/ft

Outside Engine + Pad Area
8" Slab 200 #/ft²
100 #/ft² LL x 2.0 200 #/ft²
400 #/ft

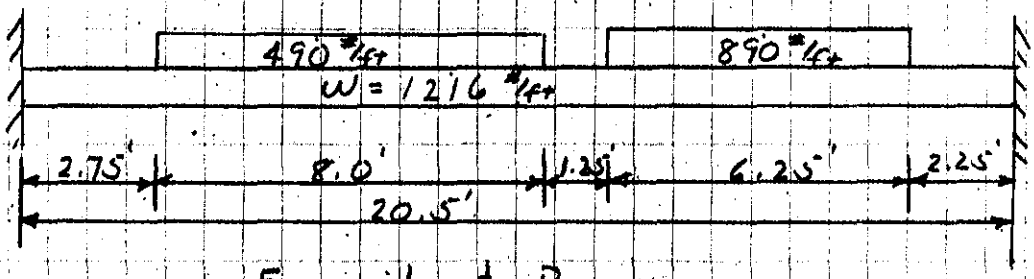
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE DM-49
PS-21

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Operating Floor
COMPUTED BY L.S.P. CHECKED BY A DATE

Pump & Gear Unit
Pump, Gear Unit & Water Col = 8,050#/6m (PS-18)
LL/ft = 8050#/6.25' = 1,290#/ft



Equivilant Beam

BEAM NO. FB-2

ENTER FOLLOWING ITEMS:----

SPAN IN FEET = 20.5 BEAM WIDTH B = 16
BEAM HEIGHT B = 21.0 TEE BM. WIDTH B'= 18.0
LL PLUS DL = 1216 K = 226
LL #1 = 490 DIST TO LL = 2.75 LENGTH OF LL = 8.0
LL #2 = 890 DIST TO LL = 12.0 LENGTH OF LL = 6.25
CONC.LD.#1= DIST TO LOAD =
CONC.LD.#2= DIST TO LOAD =
CONC.LD.#3= DIST TO LOAD =

ANSWERS

$d = 21'' - 1\frac{1}{2} - \frac{1}{2} - \frac{1}{2} = 18.5$ (Cov, Stirr, ½ Bar)

L REACT= 16551.72 R REACT= 17858.77
UNIT V L = 49.26 UNIT V R= 53.15 < 60 Sat
XO= 10.49 stirrups not req'd.
+M= 92045.89 REQ'D= 16.47 < 18.5 OK
AS = + 3.45

END Use 4 - #9 for positive steel (Bottom)

Neg. Steel $-M = \frac{3}{4}(+M)$

$-A_s = \frac{3}{4}(3.45) = 2.60$ □''

Try 4 - #8 $\begin{cases} A_s = 3.16 \text{ □''} \\ \Sigma_0 = 12.4'' \end{cases}$ Use Top Steel

$u_0 = \frac{17,859^{\#}}{12.4 \times 0.872 \times 18.5} = 89$ #/□'' Sat

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby, Conn - Pumping Station
COMPUTATION Stability
COMPUTED BY LSP CHECKED BY A DATE 6/19/68

Stability Analysis

Reference Points: For x - West Wall; For y - North Wall

Item	Factor	Vert. Wt. (K)	x (ft)	M_x (ft·K)	y (ft)	M_y (ft·K)
Dead Load - Concrete, Steel, Brick						
Roof						
Tar & Gravel	44.33 x 23.83 x 0.0065	6.9	11.0	75.6	21.25	146.0
Conc.	$\frac{7.5}{12}$ x 44.33 x 23.83 x 0.150	99.0	11.0	1089.0	21.25	2103.7
Span. Bm	1.25 x 1.0 x 2 (40.7 + 20.2) 0.150	22.7	11.0	249.7	21.25	482.4
Steel Frame						
Spand. Bm.	2 (60.9) x 0.031 k/ft	3.8	11.0	41.8	21.25	80.8
Can. Bm	20.2 x 0.036	0.7	11.0	7.7	21.25	14.9
Colmns.	6 x 17.5 x 0.031 k/ft	3.2	11.0	35.2	21.25	68.0
Crane Bm	2 x 41.0 x 0.040 k/ft	3.3	10.67	35.2	21.25	70.1
Brick						
E + W Walls	2 x 42.33 x 16.08 x 0.120	163.3	11.0	1,796.3	21.25	3470.1
N + S Walls	2 x 19.83 x 16.08 x 0.120	76.5	11.0	841.5	21.25	1,625.6
Spand. Bm	2 (42.33 + 19.83) 1.25 x 0.040	6.2	11.0	68.2	21.25	131.7
- Intake Louvers	3 x 6.0 x 7.0 x 0.120	- 15.1	0.58	- 8.8	16.42	- 247.9
- Exhaust "	3 x 5.0 x 6.0 x 0.120	- 10.8	21.42	- 231.3	16.58	- 179.0
- Door	5.33 x 7.17 x 1.33 x 0.120	- 6.1	0.33	- 2.0	37.58	- 229.2
Entrance Proj	9.67 x 17.33 x 0.040	6.7	-0.17	- 1.1	37.58	251.8
Chimney	2.67 x 1.67 x 22.0 x 0.120	11.8	11.0	129.8	40.58	478.8
- Liner	0.67 x 1.33 x 22.0 x 0.120	- 2.3	11.0	- 25.3	40.75	- 93.7
Operating Floor						
Perimeter Proj	1.08 x 2 (42.5 + 19.83) 0.150	20.2	11.0	222.2	21.25	429.2
8" Slab	0.67 x 42.5 x 22.0 x 0.150	94.0	11.0	1034.0	21.25	1,997.5
Δ FB-1 (15"-8")	2 x 0.58 x 3.0 x 19.0 x 0.150	9.9	11.0	108.9	16.5	163.3
Δ FB-2 (21"-8")	4 x 1.33 x 1.08 x 19.0 x 0.150	16.4	11.0	180.4	16.5	270.6
Δ FL-3 (12"-8")	0.333 x 8.0 x 19.0 x 0.150	7.6	11.0	83.6	37.0	281.2
- Pump Open	3 x 4.0 x 6.25 x 0.67 x 0.15	- 7.5	6.1	- 45.8	16.5	- 123.7
Sump [illegible]						
Ext. Walls	2 (42.5 + 19.0) x 1.5 x 16.20 x 0.15	448.3	11.0	4931.3	21.25	9526.4
Int. Wall	1.5 x 19.0 x 16.20 x 0.150	69.3	11.0	762.3	32.25	2234.9
Slab @ Sump	2.625 x 22.0 x 33.0 x 0.150	285.9	11.0	3,144.9	16.5	4717.4
Δ Vert Wall @ Gr. Flow	2 x 8.0 x 1.0 x 1.5 x 0.150	4.0	11.0	44.0	37.0	148.0
" " "	22.0 x 1.1 x 1.5 x 0.150	5.4	11.0	59.4	41.75	225.4
Slab @ Gr. Flow	1.5 x 9.5 x 22.0 x 0.150	47.0	11.0	517.0	37.75	1,774.2
- Sluice Gt. Open	- 3 x 5.0 x 4.0 x 1.5 x 0.150	- 13.5	21.25	- 286.9	16.50	- 222.7
- Pump Disch.	- 3 x (π x 5.0² ÷ 4) x 1.5 x 0.150	- 4.8	0.75	- 3.6	16.50	- 79.2
- Cond. Open.	- 6.0 x 8.0 x 1.5 x 0.150	- 10.8	0.75	- 8.1	37.0	- 399.6
- Grav. Conn. Open	- 8.0 x 14.0 x 1.5 x 0.150	- 25.2	21.25	- 535.5	37.0	- 932.4

SUBJECT Derby, Conn. - Pumping Station

COMPUTATION Stability

COMPUTED BY LSP CHECKED BY R DATE 6/20/68

East Gravity	Sump					
Deck	8.5 x 42.5 x 1.0 x 0.15	54.2	26.25	1422.7	21.25	1151.8
End Walls	2 x 7.0 x 1.5 x 16.5 x 0.15	52.0	25.5	1326.0	21.25	1105.0
Slab	1.5 x 8.5 x 42.5 x 0.15	81.3	26.25	2134.1	21.25	1727.6
Front Wall	42.5 x 16.5 x 1.5 x 0.15	157.8	29.75	4694.5	21.25	3353.2
- Deck Opening	-7.0 x 2.5 x 1.0 x 0.15	- 2.6	27.75	- 72.1	26.50	- 68.9
Engine Pads	3 @ 6,000#	18.0 k	14.50	261.0	16.50	297.0
Total Dead Load =		1676.7		24,076 k		35,750 k
Mechanical Equipment						
Engines	3 @ 5,000#	15.0	14.5	217.5	16.50	247.5
Gear Units	3 @ 2,500#	7.5	6.5	48.8	16.50	123.8
Pump	3 @ 7,000#	21.0	6.5	136.5	16.50	346.5
Wall Piece	3 @ 2,000#	6.0	0.75	4.5	16.50	99.0
Sluice Gate	3 @ 8,400	25.2	22.0	554.4	16.50	415.8
Total Mech. Equipt. =		74.7 k		961.7 k		1232.6 k
Water (Vertical)						
Low Range	(El 3.0)					
Sump	19.0 x 30.0 x 3.375 x 0.0624	120.0	11.0	1320.0	16.50	1980.0
S. Gr. Flow	8.0 x 22.0 x 4.5 x 0.0624	49.4	11.0	543.4	37.0	1827.8
E. " "	7.0 x 39.5 x 4.5 x 0.0624	77.6	25.5	1978.8	21.25	1649.0
Total Water Low Range		247.0 k		3,842.2		5,456.8
High Range	(El 8.0)					
Sump	19.0 x 30.0 x 8.375 x 0.0624	297.9	11.0	3,276.9	16.5	4915.3
S. Gr. Flow	8.0 x 22.0 x 9.50 x 0.0624	104.3	11.0	1,147.3	37.0	3859.1
E Gr. Flow	7.0 x 39.5 x 9.50 x 0.0624	163.9	25.5	4,179.5	21.25	3482.9
		566.1 k		8,603.7		12,257.3

Loading Conditions

I Normal Condition
- a. Concrete
- b. Equipment
- c. Earth & Water (Saturated Condition)
- d. No Water in Sump; 2 Ft. Water in Gravity Flow
- e. Uplift

II Operating Condition — Not Critical
- a. Concrete
- b. Equipment
- c. Earth (Saturated)
- d. Water in Sump Varies between El 3.0 to El 8.0
- e. Gravity Flow Chamber Full
- f. Uplift

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT Derby Conn - Pumping Station
COMPUTATION Stability
COMPUTED BY LSP CHECKED BY A DATE 6/26/68

Condition I

Item	Factor	Vertical ↓	Vertical ↑	X	M_x	Y	M_y
Concrete		1,677			24,076 ↻		35,750 ↺
Equipt		75			962 ↻		1,233 ↺
Uplift	19.0x0.0624x30.5x42.5		1536	15.25	23,420 ↺	21.25	32,640 ↺
Water S. Cond	2x0.0624x8.0x22.0	22		11.0	242 ↻	37.0	814 ↻
" E. Cond	2x0.0624x7.0x39.5	35		25.5	892 ↻	21.25	744 ↺
	Summation =	273 ↓			2,752 ↻		5,901 ↺

$\bar{X} = \frac{2752'^{k}}{273^{k}} = 10.08'$ $\bar{Y} = \frac{5901'^{k}}{273^{k}} = 21.61'$

$e_x = \frac{30.5}{2} - 10.08' = 5.17'$

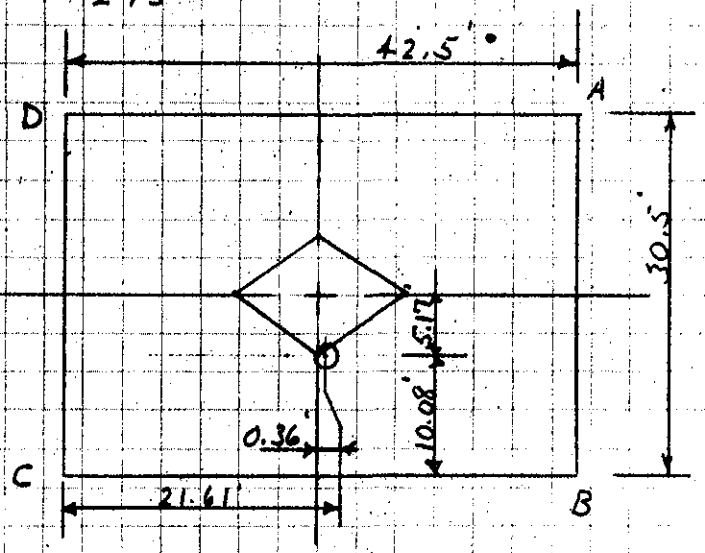
$5.08 - 5.17 = -0.09$

Lies 0.09 Outside mid 1/3

$e_y = 21.25 - 21.61 = -0.36'$

$7.08' - 0.36' = 6.72$

Lies 6.72' Inside mid 1/3



Base Pressures

$I_{xx} = 100,400\ ft^4$

$I_{yy} = 195,000\ ft^4$

@ A $P_A = \frac{273^k}{42.5 \times 30.5} - \frac{273^k \times 5.17' \times 15.25}{100,400\ ft^4} + \frac{273^k \times 0.36' \times 21.25}{195,000\ ft^4}$

$= +0.210 - 0.214 + 0.011 = +0.007\ k/ft^2$

@ B $P_B = +0.210 + 0.214 + 0.011 = +0.435\ k/ft^2$

@ C $P_C = +0.210 + 0.214 - 0.011 = +0.413\ k/ft^2$

@ D $P_D = +0.210 - 0.214 - 0.011 = -0.015\ k/ft^2$
(Say 0.0 k/ft²)

Avg. A & D = 0.0 k/ft²

Avg B & C = 0.435 + .413 k/ft² = 0.424 k/ft²

Avg A & B = 0.007 + 0.435 = 0.221 k/□'

Avg C & D = 0.413 + 0.0 = 0.207 k/□'

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE DM-53
PS-25

SUBJECT Derby, Conn - Pumping Station
COMPUTATION Reinforcing
COMPUTED BY LSP CHECKED BY DATE 7/1/68

THIS PROGRAM ANALYSES A PUMPING STATION HAVING AN INTAKE CHAMBER TO GROUND SURFACE AND A SUMP. IT WILL CONSIST OF THREE VERTICAL WALLS ON A BASE SLAB OF VARYING THICKNESS. GROUND WATER IS ASSUMED AT GROUND SURFACE AND NO WATER WITHIN THE STATION EXCEPT WHEN ANALYZING THE INTERMEDIATE VERTICAL WALL. TWO ADJACDNT WALLS ARE OF THE SAME THICKNESS. MACHINE INSTRUCTIONS SET MAGNITUDE AT 6 AND DECIMAL AT 2. ANSWERS ONLY ON AND AUTO TAB ON

PROJECT- DERBY LOCAL PROTECTION TITLE-PUMP STATION DATE- JUNE 1968

```
ENTER FOLLOWING ITEMS
HEIGHT OF STRUCTURE H= 19.25
WIDTH OF INTAKE      A= 7.0
  "   "  SUMP        B= 19.0
THICKNESS OF INTAKE WALLS C= 1.67
   "      OF SUMP WALL  D= 1.67
   "      OF INTAKE BASE F= 2.0
   "      OF SUMP BASE G= 2.5
LAT. PRES. OF SUBMERGED EARTH =22
BEARING PRESSURE AT 2 = 0
  "        "    AT 4 = 424
     ..........&02
MEMBER 1-2 FEM01 =  17120.80 FEM02 =  25681.20
           H01 =   4690.63   H02 =   9381.26
  "    2-3 FEM02 =  5971.17 FEM03 =   6128.14
           V02 =   5396.59   V03 =   5577.64
  "    3-4 FEM03 =  38199.62 FEM04 =  40326.66
           V03 =  10882.61   V04 =  11911.66
  "    4-5 FEM04 =  24640.20 FEM05 =  16426.80
           H04 =   9126.00   H05 =   4563.00
```

Since the shear stresses exceeded the allowable (1st run), the wall thicknesses were increased to 20". The base slab & intake increased to 2.0 to provide better stress flow. Corrections not included in the base pressure computations since relatively small and less conservative.

Note
See Plate No 9 for numbering of members

```
MEMBER 1-2 FINAL M01=       FINAL M02=  26591.29
           ADJ H01=   3233.57   ADJ H02=  10838.31
  "    2-3 FINAL M02=  26591.29 FINAL M03=  20015.08
           ADJ V02=   6155.09   ADJ V03=   4819.13
  "    3-4 FINAL M03=  20015.08 FINAL M04=  37053.09
           ADJ V03=  10058.32   ADJ V04=  12735.95
  "    4-5 FINAL M04=  37053.09 FINAL M05=
           ADJ H04=  11184.50   ADJ H05=   2504.49
```

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

SUBJECT Derby, Conn. - Pumping Station
COMPUTATION Reinforcing Steel
COMPUTED BY LSP CHECKED BY DATE 7/1/68

```
MEMBER 1-2 M@TOP OF SLAB=   6725.58          -AS=      .28
  "        H@TOP OF SLAB=   9338.44            V=    54.70
              REQUIRED D=      6.65           VO=     8.74
                     +AS=       .79           MO=    15.15
  "     4-5 M@TOP OF SLAB=  15581.67          -AS=      .65
           H@TOP OF SLAB=  10553.20            V=    61.82
              REQUIRED D=     10.12           VO=     7.69
                     +AS=       .53           MO=    13.33
      -...........&02
      -...........&02
  "     2-3          -AS@2=      .94        -AS@3=      .71
                      V@2=    30.58          V@3=    23.94
                 REQD D@2=    13.22     REQD D@3=    11.47
      -...........&02
      -...........&02
       ...........&02

MEMBER 3-4          -AS@3=      .54        -AS@4=     1.00
                     V@3=    38.22          V@4=    48.39
                      +M=  30506.73          +AS=      .79
                 REQD D@3=    11.47     REQD D@4=    15.61

                      VO=     9.81 (FROM END WITH LEAST BP)
                      MO=     2.22   "     "    "    "   "
                      MO=    17.17   "     "    "    "   "
      -..0.......&0

MEMBER 3-6             -M=  21387.30          -AS=      .89
                      +M=   9450.14          +AS=      .39
                       V=     43.23

END
```

APPENDIX B

MECHANICAL COMPUTATIONS

SUBJECT DERBY, CONN. LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION
COMPUTED BY J.S. CHECKED BY JWF DATE JULY 1953

STATION DESIGN CAPACITY

200 cfs
Standard Project Flood Elev. 29.0
Top of Dike 32.0
Suction Chamber High Water +8.0
" Low " +3.0
Three (3) Pumps (Each to Handle 1/3 of total)

PUMP DESIGN CONDITION POINT

$\frac{200}{3} = 66.7$ cfs = 30,000 GPM

Dia of Disch $= \sqrt{\frac{4 \times 66.7}{12\pi}} = 2.66' = 31.9''$

Use 36" Pipe Discharge (See system losses below)

Head
Pool to pool 29 − 3 = 26.0
Vel. Hd. $\frac{9.46^2}{64.4}$ = 1.39
Pipe friction = 2.06

Total = 29.45 feet

SYSTEM LOSSES (EACH PUMP)

For 36" Disch Pipe (Using C=130+15% & 300' equiv length)

GPM	Vel	Vel. Hd.	Pipe H_f	TOTAL
25000	7.88	.97	1.50	2.47
28000	8.83	1.21	1.89	3.10
30000	9.46	1.39	2.06	3.45
35000	11.03	1.89	2.85	4.74
40000	12.60	2.47	3.72	6.19

For 30" Disch Pipe (Using C=130+15% & 300' equiv length)

25000	11.4	2.00	3.75	5.75
28000	12.7	2.50	4.62	7.12
30000	13.6	2.88	5.40	8.28
35000	15.9	3.92	7.35	11.27
40000	18.2	5.12	9.42	14.54

Velocity too high in 30" disch. pipe. Exceeds 15 fps when pumping at pool to pool heads of 15' and less. See curves page M-1-6. Also higher HP would require next larger size engines.

PUMP OPERATING CYCLE

Pipe Storage	177,000	Gallons
Sump "	21,300	"
Total	198,300	"

Ave. Pump Capacity = 32,000 Gpm

Operating time (No inflow) $\frac{198,300}{32,000}$ = 6.2 minutes

Min. Pump operating cycle (operating at full speed)
(Inflow = 50% of pump capacity)

Time to empty $\frac{198,300}{16,000}$ = 12.4 minutes

Time to refill $\frac{198,300}{16,000}$ = 12.4 "

Minutes between starts 24.8 "

This is not too frequent starting, however the pumps are diesel engine driven and may be operated at less than full speed so that capacity approximately matches inflow, if desired to practically eliminate intermittent operation.

SUMMARY

Computations and curves, pages M-6 & M-15 show that a mixed flow pump with 26.41" impeller, operating at 691 RPM, using a 36" discharge pipe satisfactorily meet requirement and is the best selection.

Computations and curves, pages M-7 & M-16 are included to show head-capacity and horse-power requirements if 30" discharge pipe over dike is used.

SUBJECT DERBY CONN., LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION
COMPUTED BY JS CHECKED BY JWT DATE JULY 1963

FROM PAGE M-8

AT 29.5 FT $Q = 11800$

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} = 20\left(\frac{30000}{11800}\right)^{1/2} = 31.9''$$

Try 32 $Q_m = \dfrac{30000}{\left(\frac{32}{20}\right)^2} = 11{,}700\ (Q_c)$

MODEL CONDITION
$H = 29.5$ $Q = 11{,}700$

AT $H = 31$ $Q = 11700\left(\frac{31}{29.5}\right)^{1/2} = 12000$

MODEL SPEED $N_M = N_x\left(\frac{Q_c}{Q_x}\right) = 974\left(\frac{11700}{11750}\right) = 971$

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{971}{974}\right)\left(\frac{32}{20}\right)^2 = 2.55\ Q_x$$

$$H_p = H_m = H_x\left(\frac{971}{974}\right)^2 = 994\ H_x$$

$$D_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{971}{974}\right)^3\left(\frac{32}{20}\right)^2 = 2.54\ P_x$$

Values from Curve			Prototype Values		
H_x	Q_x	P_x	H_p	Q_p	P_p
31	11200	109	30.8	28600	277
25.5	13000	98 (Max Eff)	25.4	33200	249
20	14300	87.5	19.9	36400	222
15	15250	77.5	14.9	38900	197
10	16100	67	9.9	41000	170
5	16850	56	5	42900	142

Speed $N_p = N_m\left(\frac{D_m}{D_p}\right) = 971\left(\frac{20}{32}\right) = 607$ RPM

$$N_s = \frac{607 \times \sqrt{33200}}{25.4^{3/4}} = 9800$$

SUCTION LIFT = 1 FT

Pump not satisfactory. Max head (℄ Pipe over dike) above usable range of pump, See curves Page M-9

SUBJECT DERBY, CONN. LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION.
COMPUTED BY _____ CHECKED BY FWT DATE JULY 68

FROM PAGE M-10

AT 29.5 $Q = 10550$

$$D_P = D_m \left(\frac{Q_P}{Q_m}\right)^{1/2} = 20\left(\frac{30000}{10550}\right)^{1/2} = 33.8''$$

Try 34" $Q_m = \dfrac{30000}{\left(\frac{34}{20}\right)^2} = 10{,}380 \ (Q_c)$

MODEL CONDITION
AT 29.5 $Q_c = 10{,}380$

AT 31 $Q_c = 10380\left(\frac{31}{29.5}\right)^{1/2} = 10630$

MODEL SPEED $N_m = N_x\left(\frac{Q_c}{Q_x}\right) = 1037\left(\frac{10380}{10420}\right) = 1033$ RPM

PROTOTYPE PUMP $H_P = H_m$

$$Q_P = Q_m\left(\frac{D_P}{D_m}\right)^2 = Q_x\left(\frac{1033}{1037}\right)\left(\frac{34}{20}\right)^2 = 2.88\,Q_x$$

$$H_P = H_m = H_x\left(\frac{1033}{1037}\right)^2 = .992\,H_x$$

$$P_P = P_m\left(\frac{D_P}{D_m}\right)^2 = P_x\left(\frac{1033}{1037}\right)^3\left(\frac{34}{30}\right)^2 = 2.86\,P_x$$

Values from Curve			Prototype Values		
H_x	Q_x	P_x	H_P	Q_P	P_P
32.5	9550	97	32.2	27500	277
30	10450	95	29.8	30050	272
25	11600	86 (Max Eff)	24.8	33400	246
20	12650	77	19.8	36400	220
15	13500	67	14.9	38850	192
10	14200	58	9.9	40900	166
5	14800	48	4.96	42600	137

SPEED $N_P = N_m\left(\frac{D_m}{D_P}\right) = 1033\left(\frac{20}{34}\right) = 608$ RPM

$$N_S = \frac{607 \times \sqrt{33400}}{24.8^{3/4}} = 10{,}100$$

SUCTION LIFT ZERO

Pump not satisfactory. Max. head (℄ pipe over dike) above usabe range of pump. See curves Page M-11. Try mixed-flow pump.

SUBJECT DERBY, CONN. LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION
COMPUTED BY J.S CHECKED BY JWF DATE JULY 68

FROM PAGE M-12

At 29.5 ft. $Q = 8{,}500$
USING PROPELLER DIAMETER.

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} \qquad D_p = 13.438\left(\frac{30{,}000}{8{,}500}\right)^{1/2} = 25.260 \text{ in}$$

Model Condition

$H_x = 29.5 \qquad Q_x = 8{,}500$

Model Speed = 1288 rpm

Prototype Pump $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{1288}{1288}\right)\left(\frac{25.260}{13.438}\right)^2 = 3.53\,Q_x$$

$$H_p = H_m = H_x\left(\frac{1288}{1288}\right)^2 = H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{1288}{1288}\right)^3\left(\frac{25.260}{13.438}\right)^2 = 3.53\,P_x$$

Values From Curve			Prototype Values			
H_x	Q_x	P_x	H_p	Q_p	P_p	Eff_p
37.5	7,350	82.5	37.5	24950	291.5	81.1
35	7750	82.3 (Max Eff)	35	27400	290.5	83.4
30	8450	81.0	30	29850	286	79.2
25	8950	78.5	25	31600	277	72.0
20	9350	75.0	20	33000	265	62.8
15	9600	71.0	15	33900	251	51.1
10	9800	65.0	10	34650	230	38.0
8	9900	61.0	8	35000	215	32.8

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 1288\left(\frac{13.438}{25.260}\right) = 685$ RPM

$$N_s = \frac{685 \times \sqrt{24950}}{35^{3/4}} = 7{,}220$$

SUCTION LIFT 1 FT

Meets pumping requirements, but horsepower required at max head condition is 289 (See curves page M-13 compared to 274 (See curves M-15)

SUBJECT DERBY, CONN., LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION
COMPUTED BY _____ CHECKED BY JWF DATE JULY 68

FROM PAGE M-14

AT 29.5 FT $Q = 7550$

Using impeller diameter

$$D_p = D_m \left(\frac{Q_p}{Q_m}\right)^{1/2} \qquad D_p = 13.25\left(\frac{30000}{7550}\right)^{1/2} = 26.41''$$

MODEL CONDITION

$H_x = 29.5 \qquad Q_x = 7550$

MODEL SPEED = 1378 RPM

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{1378}{1378}\right)\left(\frac{26.41}{13.25}\right)^2 = 3.97\,Q_x$$

$$H_p = H_m = H_x\left(\frac{1378}{1378}\right)^2 = H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{1378}{1378}\right)^3\left(\frac{26.41}{13.25}\right) = 3.97\,P_x$$

Values from Curve			Prototype Values			
H_x	Q_x	P_x	H_p	Q_p	P_p	Eff.
40	5900	69.5	40	23450	276	85.6
36	6650	69 (Max Eff)	36	26400	274	87.6
30	7500	66.5	30	29800	264	85.5
25	8100	63.2	25	32200	251	81.0
20	8620	60.1	20	34250	242	71.5
15	9100	56.8	15	36100	226	60.7
10	9470	54.0	10	37600	215	44.2

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 1378\left(\frac{13.25}{26.41}\right) = 691$ RPM.

$$N_s = \frac{691 \times \sqrt{26400}}{36^{3/4}} = 7600$$

SUCTION LIFT 1 FT OK

Meets all pumping requirements. Has lowest horsepower requirements at max head. (See curves page M-15)

SUBJECT DERBY, CONN, LOCAL PROTECTION
COMPUTATION DERBY PUMPING STATION
COMPUTED BY _____ CHECKED BY JWT DATE JULY 63

FROM PAGE M-14

AT 34.3 FT $Q_{x_1} = 6870$ (Using 30" discharge pipe over dike)

USING impeller diameter...

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} \qquad D_p = 13.25\left(\frac{30000}{6870}\right)^{1/2} = 27.68''$$

MODEL CONDITION

$H_x = 34.3 \qquad Q = 6870$

MODEL SPEED = 1378 RPM

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{1378}{1378}\right)\left(\frac{27.68}{13.25}\right)^2 = 4.37\,Q_x$$

$$H_p = H_m = H_x\left(\frac{1378}{1378}\right)^2 = H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{1378}{1378}\right)^3\left(\frac{27.68}{13.25}\right)^2 = 4.37\,P_x$$

Values from Curve				Prototype Values			
H_x	Q_x	P_x		H_p	Q_p	P_p	Eff
40	5900	69.5		40	25800	304	85.5
36	6650	69	(Max Eff)	36	29000	301	87.4
30	7500	66.5		30	32750	290	85.5
25	8100	63.2		25	35400	276	80.8
20	8620	60.1		20	37600	262	72.5
15	9100	56.8		15	39700	248	60.7
10	9470	54.0		10	41300	236	43.1

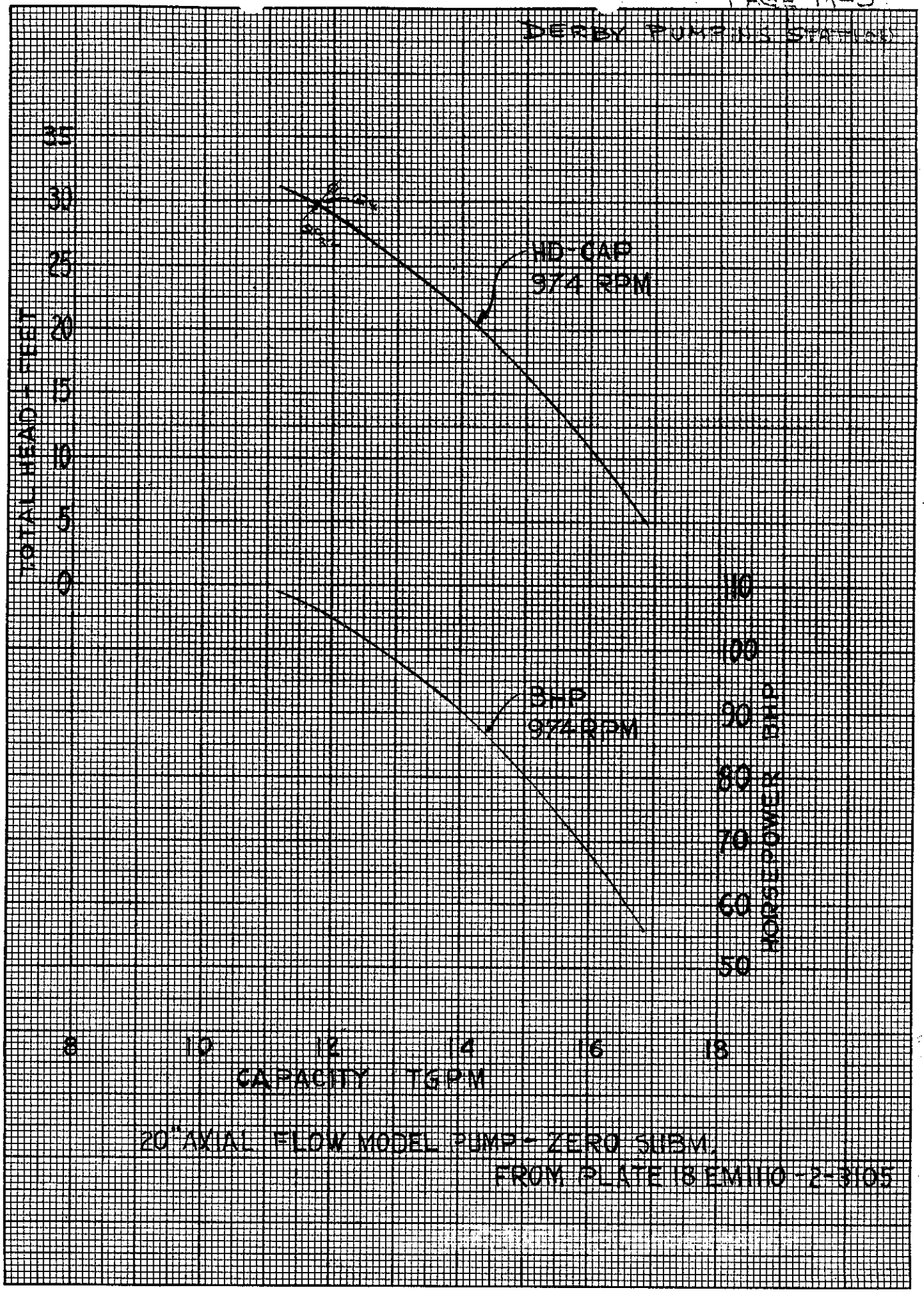
$$\text{SPEED } N_p = N_m\left(\frac{D_m}{D_p}\right) = 1378\left(\frac{13.25}{27.68}\right) = 660\text{ RPM}$$

$$N_s = \frac{660 \times \sqrt{29000}}{36^{3/4}} = 7600$$

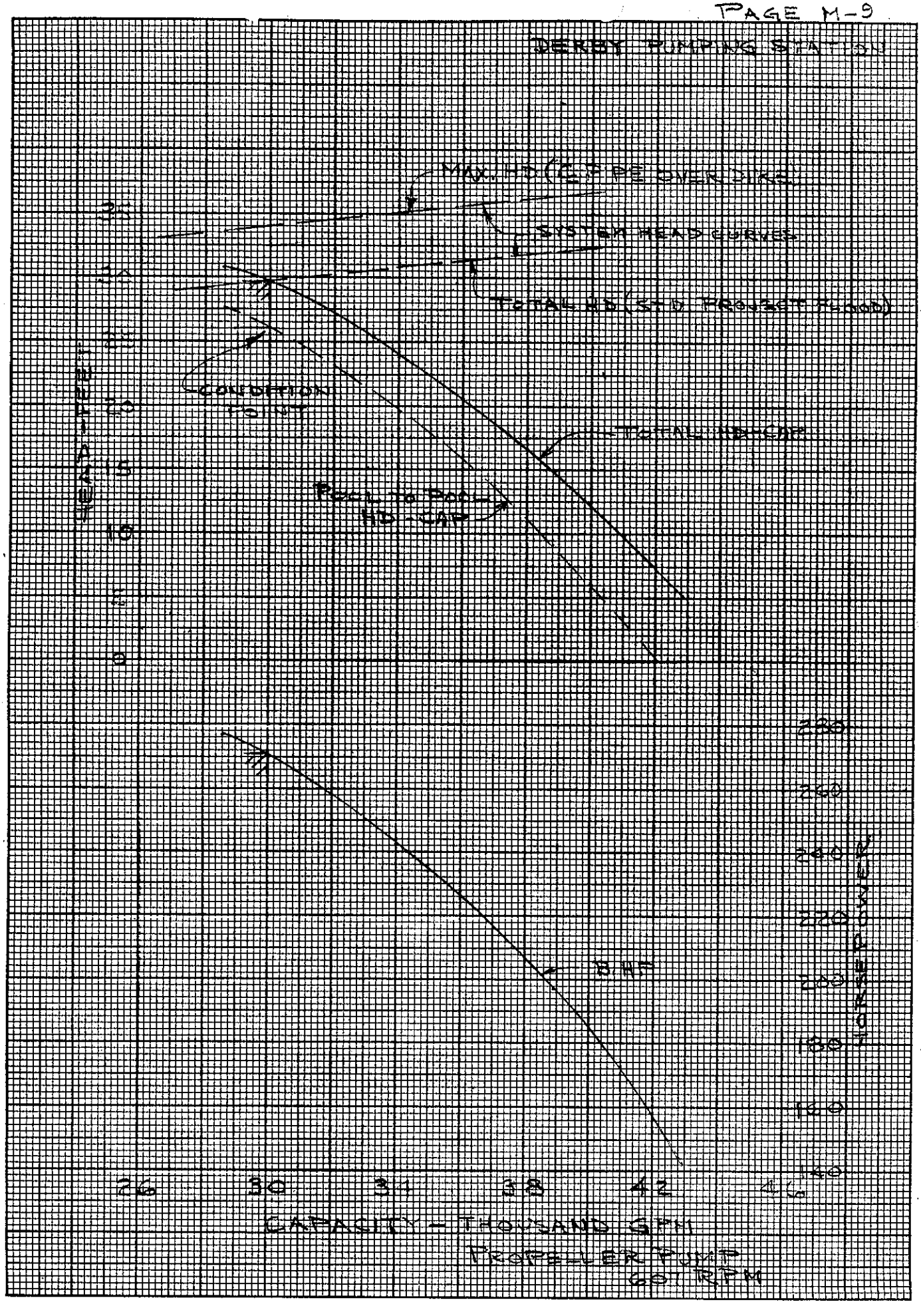
SUCTION LIFT 1 FT. OK

Meets pumping requirement, but the higher pipe losses increases horsepower above continuous rating of engines suitable for pumps with 36" discharge over dike. Also Velocity exceed 15 fps (see M-1)

DERBY PUMPING STATION

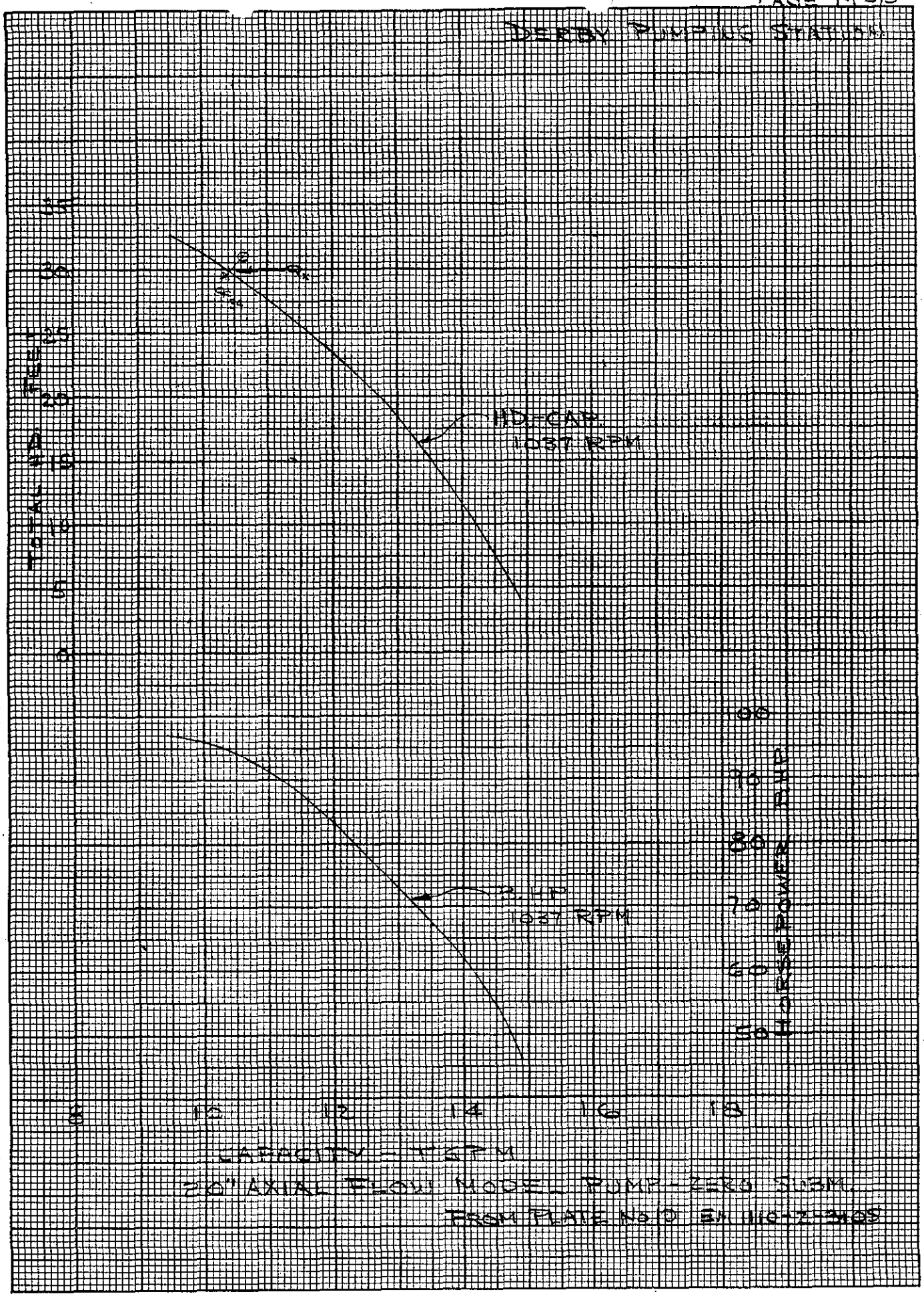


20" AXIAL FLOW MODEL PUMP - ZERO SUBM.
FROM PLATE 18 EM110-2-3105



KEUFFEL & ESSER CO. MADE IN U.S.A.

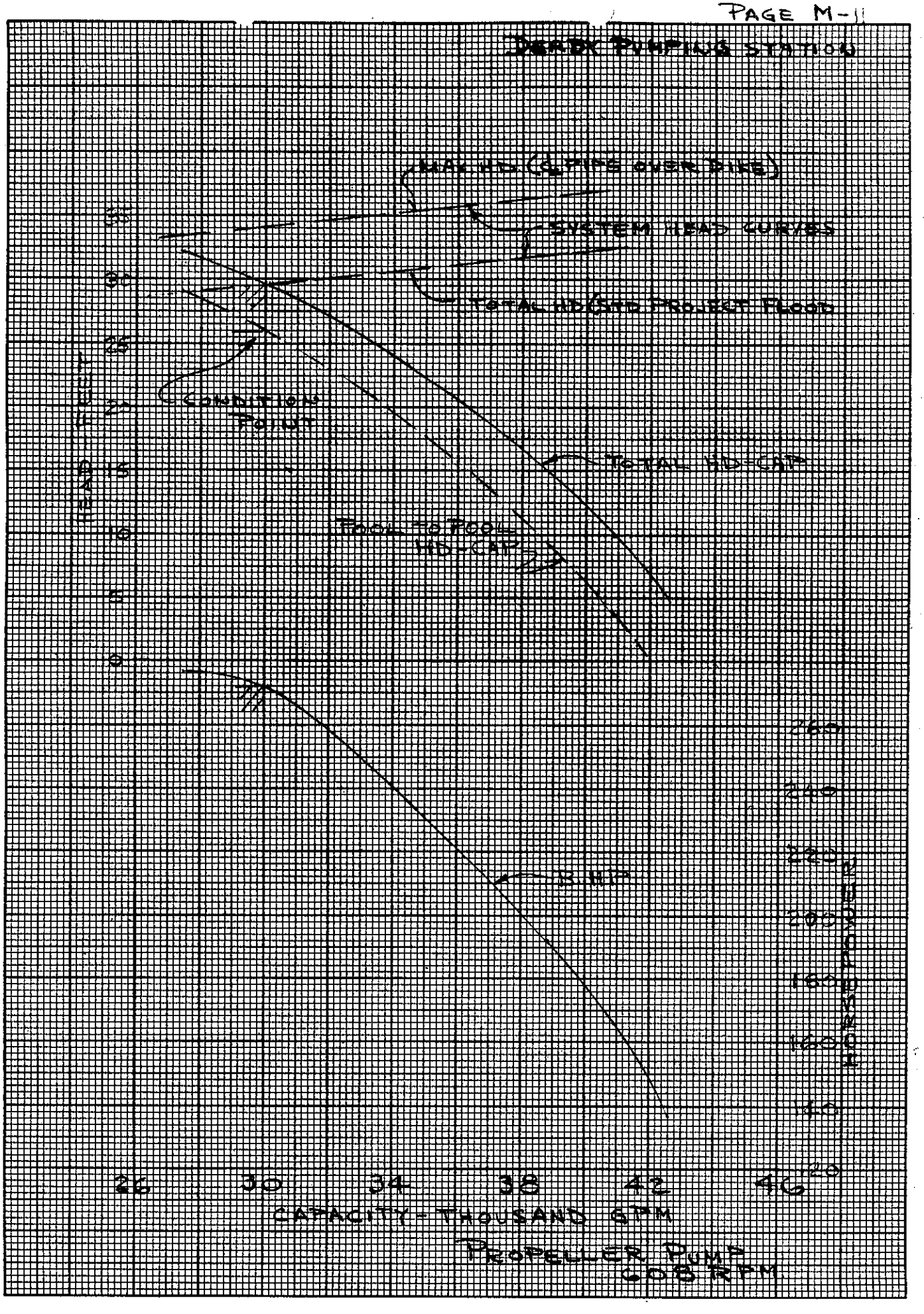
DERBY PUMPING STATION



20" AXIAL FLOW MODEL PUMP - ZERO SUBM.

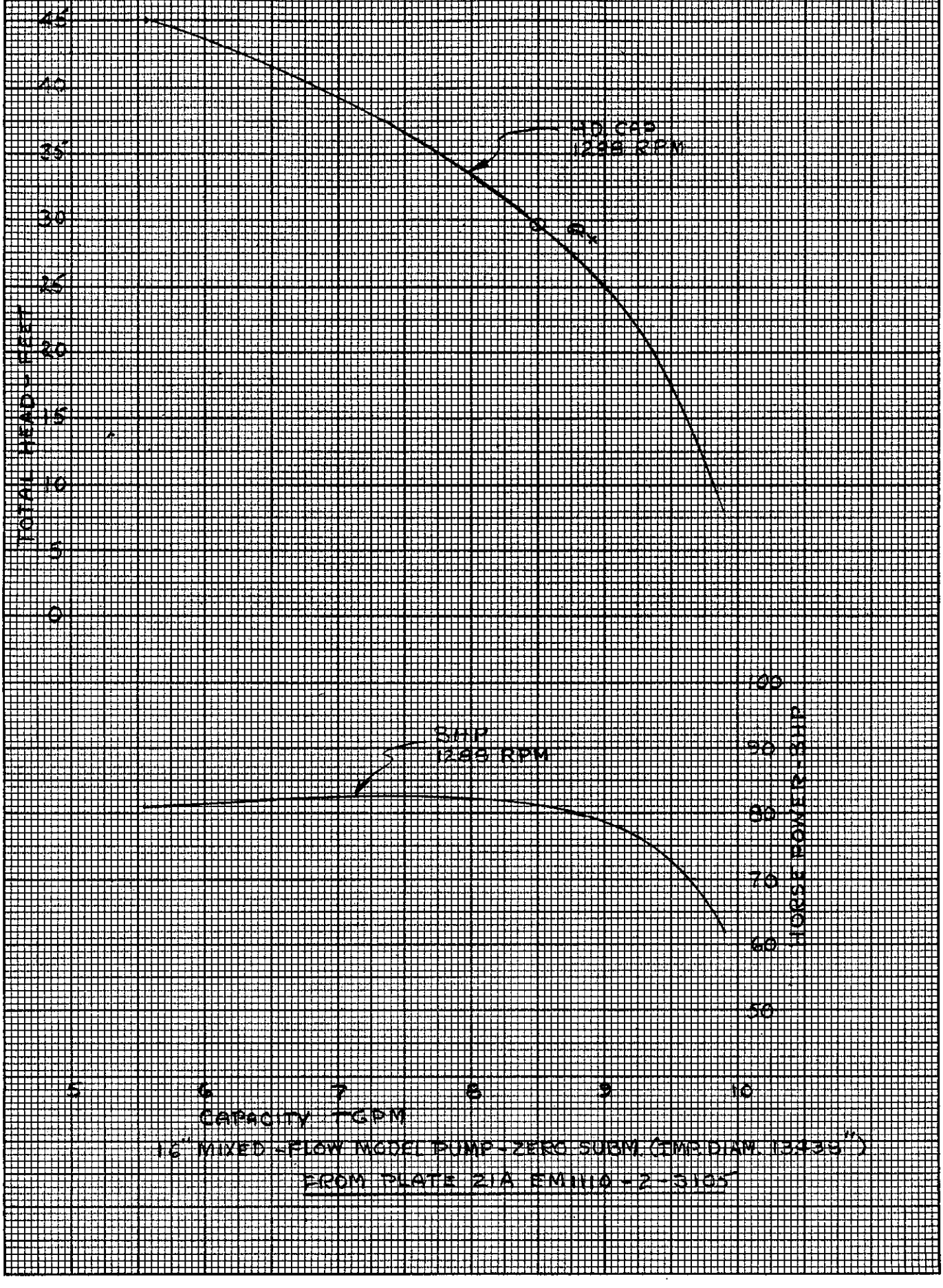
FROM PLATE No 10 BY HIGGINS-SMITH

KEUFFEL & ESSER CO. MADE IN U.S.A.



KEUFFEL & ESSER CO. MADE IN U.S.A.

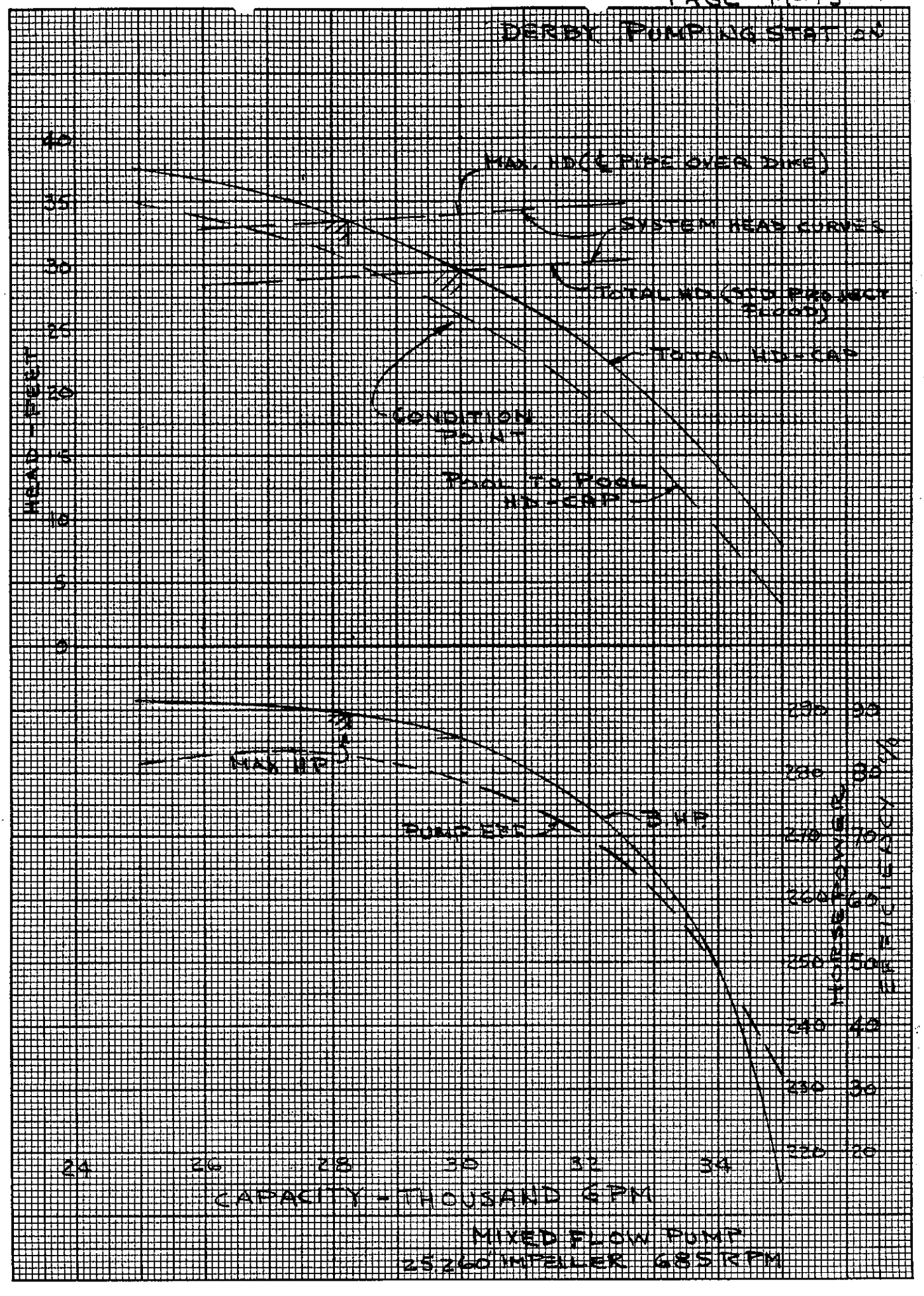
DERBY PUMPING STATION



16" MIXED-FLOW MODEL PUMP - ZERO SUBM. (IMP. DIAM. 13.438")

FROM PLATE 21A EM1110-2-3105

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

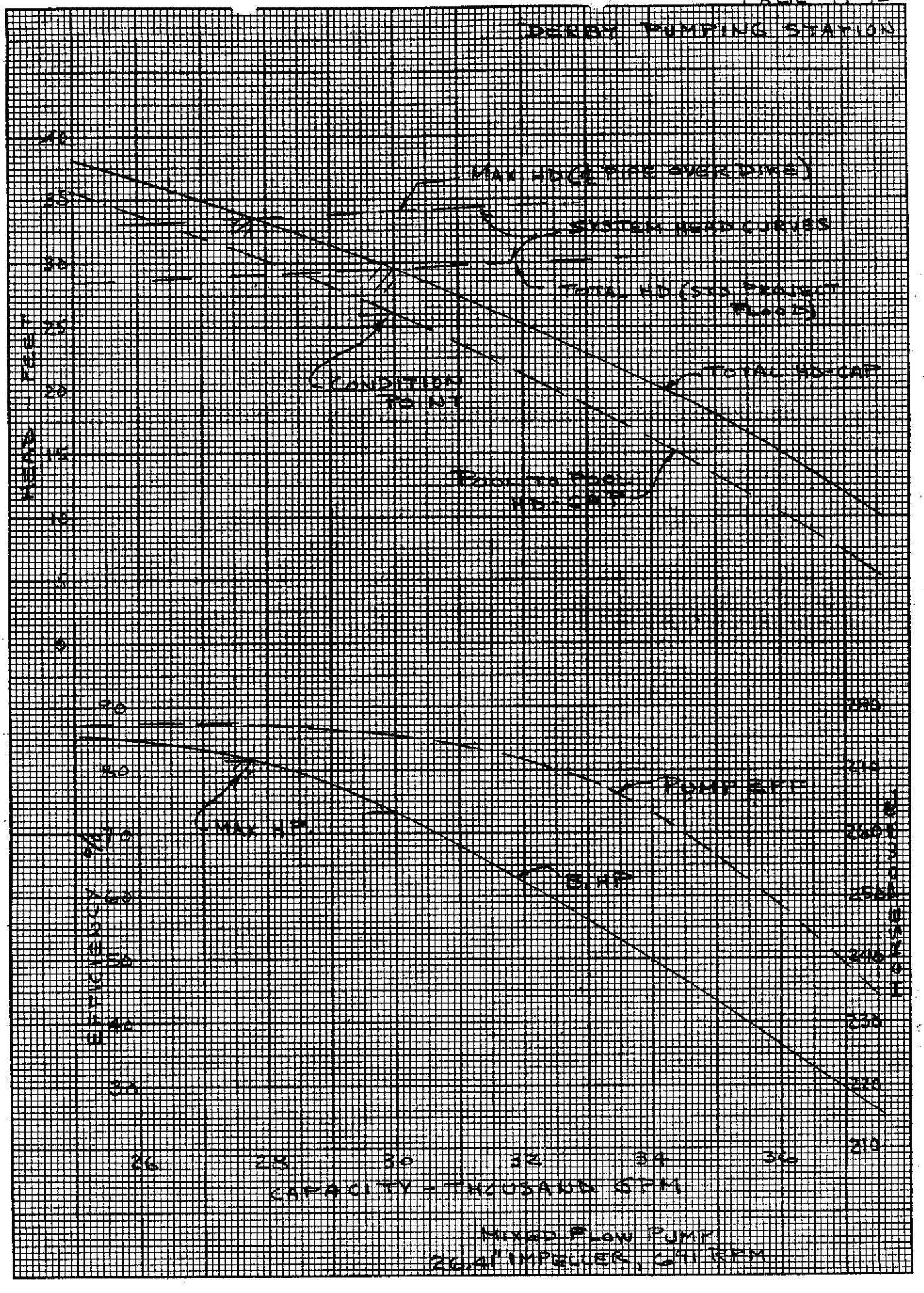


K+E 10 X 10 TO THE ½ INCH 359-11 KEUFFEL & ESSER CO. MADE IN U.S.A.

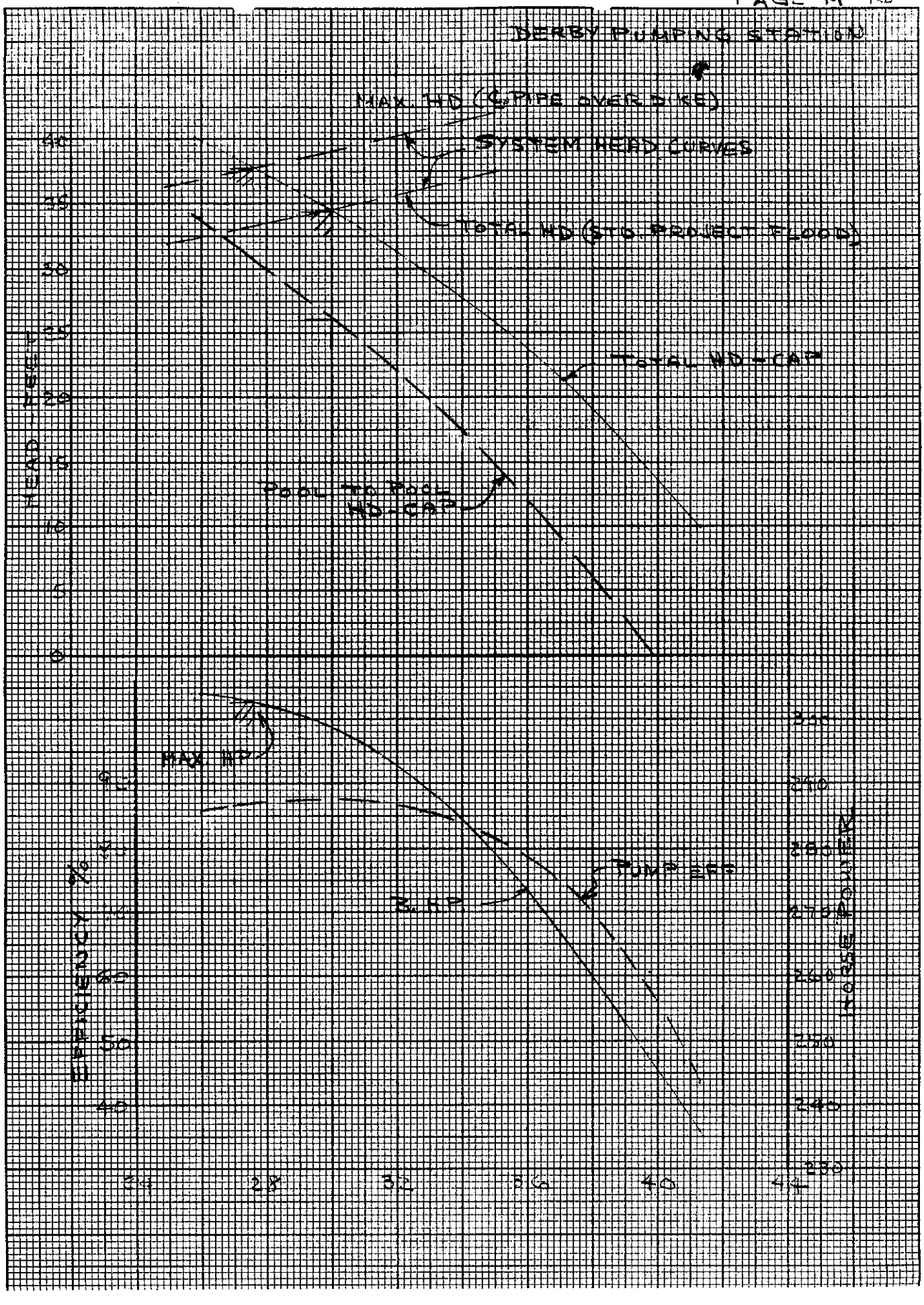
16" MIXED-FLOW MODEL PUMP - ZERO SUBM. (Imp. Diam. 13.25")

FROM PLATE 21C EMILIO-R-3105

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



K+E 10 X 10 TO THE ½ INCH 359-11 KEUFFEL & ESSER CO. MADE IN U.S.A.



K+E 10 X 10 TO THE ½ INCH 359-11 KEUFFEL & ESSER CO. MADE IN U.S.A.