HOUSATONIC RIVER FLOOD CONTROL

ANSONIA - DERBY

LOCAL PROTECTION

NAUGATUCK RIVER, CONNECTICUT

DESIGN MEMORANDUM NO.9

HYDRAULIC ANALYSIS AND MISCELLANEOUS SUPPLEMENTS

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

MAY 1967

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

IN REPLY REFER TO:

NEDED-E

31 May 1967

SUBJECT: Ansonia-Derby Local Protection Project, Naugatuck River, Connecticut - Design Memorandum No. 9 - Hydraulic Analysis and Miscellaneous Supplements

TO: Chief of Engineers
ATTN: ENGCW-E

1. There is submitted herewith, for review and approval, Design Memorandum No. 9 - Hydraulic Analysis and Miscellaneous Supplements, for the Ansonia-Derby Local Protection Project, Housatonic River Basin, in accordance with EM 1110-2-1150.

2. The contract plans and specifications for this project were submitted to your office for review on 16 May 1967. For this reason, it is requested that the review of this design memorandum be made concurrently with the review of the contract plans and specifications.

FOR THE DIVISION ENGINEER:

J. W. Leslie

JOHN Wm. LESLIE
Chief, Engineering Division

Incl (10 cys)
Des Memo No. 9

FLOOD CONTROL PROJECT

ANSONIA-DERBY LOCAL PROTECTION PROJECT
NAUGATUCK RIVER
HOUSATONIC RIVER BASIN
CONNECTICUT

DESIGN MEMORANDA INDEX

No.	Title	Date Submitted	Date Approved
1	Hydrology and Interior Drainage	30 Apr 65	16 Jun 65
2	Omitted		
3	General Design and Site Geology	14 Jan 66	1 Apr 66
4	Concrete Materials	16 Feb 66	29 Mar 66
5	Omitted		
6	Embankments, Foundations and Channel Improvements	28 Feb 66	11 Apr 66
7	Detailed Design of Structures	29 Apr 66	9 Jun 66
8	Pumping Stations	27 Jul 66	13 Sep 66
9	Hydraulic Analysis and Miscellaneous Supplements	31 May 67	

ANSONIA-DERBY LOCAL PROTECTION PROJECT

NAUGATUCK RIVER
CONNECTICUT

DESIGN MEMORANDUM NO. 9

CONTENTS

Paragraph	Subject	Page No.
	1. INTRODUCTION	
a	Purpose	1
b	Coordination With Local Authorities	1
	2. PROJECT DESIGN FLOODS	
a	Naugatuck River	1
b	Beaver Brook	2
	3. HYDRAULIC MODEL STUDIES	
a	General	2
b	Model Test Program	2
	(1) General	2
	(2) River Discharge and Tailwater	2
	(3) Plans of Improvement Tested	2
c	Model Test Results	3
	(1) Water Surface Data	3
	(2) Velocity Data	3
	4. HYDRAULICS OF RIVER CHANNELS	
a	General Plan	3
b	Naugatuck River	4
	(1) Channel Improvements	4
	(2) Design Water Surface Profiles	5
	(3) Freeboard Design	7
	(a) General	7
	(b) Capacity Test	7
	(c) Right Bank Protection	8

Paragraph	Subject	Page No.
b	Naugatuck River (Cont'd)	
	1. Ansonia Manufacturing Company	8
	2. Lower Right Bank Protection	8
	(d) Left Bank Protection	9
c	Beaver Brook	9
	(1) Channel Improvements	9
	(a) General	9
	(b) Upper Box Conduit	9
	1. General	9
	2. Hydraulic Analysis	10
	(c) Stilling Basin	10
	1. General	10
	2. Hydraulic Analysis	11
	(d) Open Channel Section	11
	(e) Pressure Conduit	12
	(f) Freeboard Design	13
	5. HYDRAULIC DESIGN OF STONE RIPRAP CHANNEL PROTECTION	
a	General	13
b	Characteristics of Flow	13
c	Average and Local Unit Boundary Shear	13
d	Permissible Boundary Shear	14
e	Channel Cross Sections	14
f	Depth of Flow, Hydraulic Radii and Slope of Energy Gradient	15
g	Analyses of Bends	15
h	Equivalent Stone Diameter D_{50} Minimum Values	15
i	Treatment of Extremities	19
	(1) Riprap Blankets	19
	(2) Toe of Riprap	19
j	Size and Layer Thickness of Stone Protection	20

Paragraph	Subject	Page No.
	6. INTERIOR DRAINAGE AREA NO. 5, REVISIONS	
a	Original Concept	21
b	First Revision	21
c	Hydraulic Model Study Revision	21
	7. RIVER STREET PUMPING STATION, REDESIGN	
a	General	21
b	New Design	22
c	Mechanical Design	22
d	Structural Design	22

APPENDICES

No.	Title
A	HYDRAULIC MODEL INVESTIGATION
	(Report to be prepared by Waterways Experiment Station and submitted at a later date)
B	MECHANICAL DESIGN COMPUTATIONS
C	CURRENT COST ESTIMATE

LIST OF TABLES

Number	Title	Page No.
9-I	Design Water Surface Elevation - Left Bank Naugatuck River and Right Bank Naugatuck River	5
9-II	Design Flood Velocity - Two Feet Above Bottom Surface at Selected Locations - Naugatuck River	16
9-III	Classes of Stone Riprap	20
9-IV	Interior Drainage Area No. 5 - Design Discharges and Rational Formula Data	21

LIST OF PLATES

Plate No.	Title
9-1	General Plan
9-2	Plan 1
9-3	Plan 2
9-4	Plan 3
9-5	Plan 4
9-6	Plan 5
9-7	Plan 6
9-8	Plan 7
9-9	Plan 8
9-10	Maple Street Wall, Plan, Elevation and Typical Sections
9-11	Left Bank Profile No. 1
9-12	Left Bank Profile No. 2
9-13	Right Bank Profile No. 1
9-14	Right Bank Profile No. 2
9-15	Beaver Brook Plan No. 1
9-16	Beaver Brook Plan No. 2
9-17	Beaver Brook Profiles
9-18	Beaver Brook Stilling Basin
9-19	Representative Cross Sections and D_{50} MIN's, sheet 1
9-20	Representative Cross Sections and D_{50} MIN's, sheet 2
9-21	Representative Cross Sections and D_{50} MIN's, sheet 3
9-22	Representative Cross Sections and D_{50} MIN's, sheet 4

LIST OF PLATES (Cont'd)

Plate No.	Title
9-23	Left Bank Typical Section No. 1
9-24	Left Bank Typical Section No. 2
9-25	Left Bank Typical Section No. 3
9-26	Right Bank Typical Section No. 1
9-27	Right Bank Typical Section No. 2
9-28	River Channel Sections at Bridges
9-29	Beaver Brook Dike Typical Sections
9-30	River Street Pumping Station, Mechanical, Plans and Sections

ANSONIA-DERBY LOCAL PROTECTION PROJECT

NAUGATUCK RIVER
CONNECTICUT

DESIGN MEMORANDUM NO. 9

HYDRAULIC ANALYSIS AND
MISCELLANEOUS SUPPLEMENTS

1. INTRODUCTION

a. Purpose. The purpose of this memorandum is to present for review and approval the hydraulic analysis made for the design of a local protection project on the Naugatuck River and Beaver Brook at Ansonia and Derby, Connecticut. Included are sections describing the project design floods, hydraulic model studies, hydraulics of river channels, pressure conduit and stilling basin on Beaver Brook, stone riprap channel protection design, alinement changes, interior drainage revisions, redesign of the River Street pumping station and the current cost analysis.

b. Coordination with local authorities. As the result of detailed studies, two changes in the general plan described in Design Memorandum No. 3, "General Design and Site Geology" are required as follows: (1) realignment of the tieback dike on the right bank immediately upstream of the Ansonia Manufacturing Company plant, and (2) modification of the protective works just downstream of the Anaconda American Brass Company (ABC) hydroplant on the left bank. These changes have been developed with the knowledge of representatives of the companies and officials of the city of Ansonia.

2. PROJECT DESIGN FLOODS

a. Naugatuck River. The standard project flood developed for the Naugatuck and Housatonic Rivers was used as the basis for design of the protective works on the Naugatuck River. Design grades for dikes and floodwalls and criteria for the stone channel protection were determined from analyses of the standard project flood resulting from: (1) the standard project storm centered over the basin, (2) with concurrent floodflow in the Housatonic River from the same storm, and (3) with an abnormal tide in Long Island Sound. These conditions resulted in a peak discharge of 75,000 cfs in the Naugatuck River, as modified by the system of flood control reservoirs concurrent with a flow of 145,000 cfs in the Housatonic River and an abnormal tide of 26 feet msl in the Housatonic River at the confluence of the Naugatuck River.

b. Beaver Brook. Design elevations in the lower portion of Beaver Brook, below station 9+79, result from the standard project flood stages in the Naugatuck River and the backwater gradient produced by the concurrent discharge of 1,000 c.f.s. in Beaver Brook.

3. HYDRAULIC MODEL STUDIES

a. General. Due to the complex flow conditions resulting from the irregularity and configuration of the channel sections and skewed bridges for which hydraulic losses could not be reliably computed, a hydraulic model was constructed to a scale of 1 to 120 at the U. S. Army Waterways Experiment Station, Vicksburg, Mississippi.

The model was constructed to reproduce the Housatonic River from the mouth of the Naugatuck River to Bridge Street in Derby, a distance of 3,800 feet, and the Naugatuck River from its mouth to the Anaconda American Brass Company hydroplant, a distance of 16,000 feet. Water was supplied to the model at the upstream ends simulating the flows of the two rivers and a movable tailgate was provided at the lower end to reproduce the desired tailwater or tide effects. A detailed description and layout of the model will be shown in Appendix A, entitled: "Hydraulic Model Study, Ansonia-Derby Local Protection Project," to be forwarded at a later date.

b. Model test program.

(1) General. Various tests were made using prescribed rates of flow to simulate the concurrent design flood discharges in the Naugatuck and Housatonic Rivers and setting the tailgate to produce river stages corresponding to produce normal and abnormal tide conditions in Long Island Sound. In addition, some qualitative analyses of the movement of streambed material were made.

(2) River discharge and tailwater. The tests were run in the model simulating the following conditions of riverflow and tailwater:

(a) Concurrent discharges of 75,000 c.f.s. in the Naugatuck River, 145,000 c.f.s. in the Housatonic River and tailwater elevations of 24.0 and 26.0 feet m.s.l., respectively at the confluence.

(b) Concurrent discharges of 21,500 c.f.s. in the Naugatuck River, 198,500 c.f.s. in the Housatonic River and tailwater elevations of 24.0 and 26.0 feet m.s.l., respectively at the confluence.

(3) Plans of improvement tested. Plans of improvement that were tested in the model area as follows:

(a) Original dike and floodwall plan described in Design Memorandum No. 3, "General Design and Site Geology", dated 14 January 1966.

(b) Evaluation of stream deflector on the upstream end of the pier of the New York, New Haven and Hartford Railroad bridge 10.25 in Ansonia.

(c) Modification of the original plan by extension of right bank protection from immediately upstream of the Ansonia Manufacturing Company plant to upstream of the American Brass Company bridge by successive alternate layouts.

(d) Modification of the original plan by extension of the right bank floodwall from above Maple Street bridge downstream to about 250 feet above Bridge Street.

(e) Evaluation of extensive channel improvements in the vicinity of the New York, New Haven and Hartford Railroad bridge 10.25 in Ansonia.

(f) Modification of the original plan by extension of right bank protection from above the American Brass Company bridge to high ground opposite the American Brass Company hydroplant.

c. Model test results. Details of the model layout, test programs and results will be included in the final report to be prepared by the Waterways Experiment Station and submitted at a later date as Appendix A of this memorandum. Results of the model test program for the final selected plan are summarized in the following paragraphs.

(1) Water surface data. Water surface profiles were determined for the most critical design conditions, namely, 75,000 c.f.s. in the Naugatuck River, concurrent flow of 145,000 c.f.s. in the Housatonic River and an abnormal tide in Long Island Sound resulting in a tailwater elevation 26.0 feet m.s.l. at the confluence.

(2) Velocity data. The magnitude of the velocity was determined for critical locations throughout the model. These data combined with other hydraulic characteristics of open channel flow were used in the design of the freeboard allowance and as a guide in the design of stone channel riprap protection.

4. HYDRAULICS OF RIVER CHANNELS

a. General plan. Pertinent features of the Ansonia-Derby local protection project requiring hydraulic analyses include:

(1) Construction of dikes and floodwalls along the left bank of the Naugatuck River from the American Brass Company hydroplant downstream to the mouth of Beaver Brook, a distance of about 8,000 feet.

(2) Construction of dikes and floodwalls along the right bank of the Naugatuck River from about 750 feet above the American Brass Company bridge to about 500 feet above Maple Street bridge.

(3) Construction of a dike along the right bank from the upstream side of railroad bridge 10.25 to about 1,200 feet downstream of Division Street bridge.

(4) Construction of an improved channel section in the Naugatuck River from about 100 feet above the American Brass Company bridge downstream to about 150 feet below the Maple Street bridge, a distance of about 1,500 feet.

(5) Relocation of about 2,000 feet of the Naugatuck River from the New York, New Haven and Hartford Railroad bridge 10.25 to about 1,000 feet upstream of Division Street bridge.

(6) Construction of a concrete box conduit and U-shaped concrete channel in Beaver Brook from about 500 feet upstream of Central Street to about 150 feet below Central Street, terminating in an impact-type stilling basin.

(7) Relocation of Beaver Brook in a new channel from Central Street downstream for a distance of about 800 feet.

(8) Relocation of the lower 700 feet of Beaver Brook in a concrete box conduit.

(9) Construction of dikes and floodwall along the right bank of Beaver Brook from the lower end of the stilling basin to the upper end of the box conduit, about 180 feet upstream of the existing Main Street bridge.

(10) Construction of 4 railroad gates, 4 street gates and one access gate at separated locations on both banks of the Naugatuck River.

The general plan of protection is shown on plate 9-1.

b. Naugatuck River.

(1) Channel improvements. Channel sections will be improved in those reaches where stone riprap protection will extend across the channel bottom as well as in the areas where the channel will be relocated. In general, excavation will be limited to scraping and shaping necessary to remove irregulariness while maintaining the overall bottom profile. The maximum excavation will be about 2 feet of lowering below the existing thalweg. The finished grade of the channel invert is shown on plates 9-11 through 9-14.

(2) Design water surface profiles. Water surface elevations along both banks of the river obtained with scheme A-3 in the model and as described in paragraph 3 above are shown in table 9-I. These data are also shown on the detailed plans and profiles, plates 9-2 through 9-10 and 9-11 through 9-14, respectively. The profiles of the design flood-water surface were drawn from the model test data.

TABLE 9-I

DESIGN WATER SURFACE ELEVATION
LEFT BANK NAUGATUCK RIVER

East Coordinate	North Coordinate	Water Surface Elevation (ft,msl)
507,705	189,500	49.8
507,735	189,600	47.7
507,747	188,911	47.1
507,847	188,739	47.4
507,928	188,585	46.5
508,020	188,425	46.3
508,117	188,262	46.3
508,218	188,086	46.2
508,303	187,938	46.1
508,338	187,877	45.1
508,348	187,800	43.0
508,356	187,722	40.6
508,413	187,560	40.3
508,516	187,373	40.5
508,645	187,160	39.3
508,747	187,044	37.8
508,900	186,930	38.9
509,035	186,830	39.6
509,095	186,780	40.0
509,125	186,750	40.0
509,159	186,700	40.0
509,175	186,650	39.9
509,191	186,600	39.7
509,203	186,550	39.7

East Coordinate	North Coordinate	Water Surface Elevation (ft,msl)
509,205	185,700	38.6
509,144	185,400	37.8
509,083	185,100	37.8
509,098	184,800	34.0
509,184	184,600	33.6
509,335	184,400	33.1
509,375	184,300	33.1
509,520	184,000	32.4
509,750	183,500	33.0
509,995	183,000	32.6

RIGHT BANK NAUGATUCK RIVER

East Coordinate	North Coordinate	Water Surface Elevation (ft,msl)
507,070	188,655	49.0
507,400	188,580	49.0
507,585	188,530	46.7
507,690	188,455	46.6
507,885	188,124	46.4
507,986	187,953	46.0
508,086	187,820	45.4
508,220	187,570	41.6
508,940	184,260	32.0
508,992	184,210	31.3
509,086	184,000	31.9
509,315	183,500	32.9
509,561	183,000	32.5
509,746	182,500	31.8
509,670	182,000	31.7
509,323	181,500	28.7
509,055	181,250	27.8
508,834	181,000	28.9
508,632	180,500	29.1

Between the New York, New Haven and Hartford railroad bridge 10.25 and Maple Street bridge, the water surface elevations were obtained with the design flood discharges and tailwater level previously described and with the northerly waterway opening of railroad bridge 10.25 filled 75 percent to simulate a condition likely to occur during future major floods. Model tests indicated that even with the span completely filled with sediment and debris, no appreciable further rise in water surface would occur. The backwater effects of the bridge were found to extend upstream to about Maple Street bridge, a principal hydraulic control during major floods.

(3) Freeboard design.

(a) General. In establishing the design grades of dikes and floodwalls for the project, reference was made to paragraph 3c of Civil Works Engineer Bulletin 54-14, dated 23 April 1954, subject: "Improvements in Design and Construction Practices in Civil Works." The selected freeboard allowance was based on several factors, the more important being:

1. The location of the separable elements of the protective works, insuring that, in the event of any overtopping due to floods exceeding the design flood, initial overflow will occur in the downstream portion of the project.

2. The proximity to primary hydraulic controls where localized flow characteristics are of special concern, such as, upstream of highway and railroad bridges.

3. The magnitude of potential damage within the protected area should overtopping occur.

4. As the water surface has been determined by model study and is considered reasonably reliable, a minimum freeboard of 2 feet has been selected for the downstream sections of the project where velocities are low and the water surface is produced principally by tidal backwater.

(b) Capacity test. Model tests were made to determine the discharge capacity of the Ansonia-Derby project as finally designed. Simulated discharges for the Housatonic and Naugatuck Rivers were increased in a 2:1 proportion and the tailwater control was adjusted to reproduce abnormal tide conditions in Long Island Sound.

The tests indicated that, except for a short section of floodwall adjacent to railroad gate No. 3 on the left bank at station 70+34, the concurrent capacity discharges of the project are 87,000 c.f.s.

in the Naugatuck River and 174,000 c.f.s. in the Housatonic River. These discharges are 16 and 20 percent greater than the standard project flood in the respective rivers. It was concluded that the selected freeboard design is generally adequate.

Near railroad gate No. 3, overtopping of the wall was noted with a discharge of 82,000 c.f.s., which is 9 percent in excess of the standard project flood. Consideration has been given to raising this section about one foot to provide the same overall capacity of the project. However, it was concluded that such raising at this time is unwarranted due to the very short duration of time that high stages would take place and the small volume of overtopping.

(c) Right bank protection.

1. Ansonia Manufacturing Company. The protection will consist of dikes and floodwalls which will extend from station 12+51.38, about 750 feet upstream of the American Brass Company bridge, to station 28+47.88, about 500 feet upstream of Maple Street bridge, with tieback structure at both ends. Also included in this element are street gates 2, 3 and 4. This element will provide protection to the Ansonia Manufacturing Company plant and an adjacent parking area used by the Anaconda American Brass Company. The floodwalls, dikes and street gates are designed with a minimum freeboard allowance of 3 feet except for the tieback floodwall at the lower end which is designed with a minimum freeboard allowance of 2 feet. The downstream tieback floodwall is located in the backwater area upstream of Maple Street bridge where velocities will be very low and wave action will be at a minimum.

2. Lower right bank protection. The lower right bank protective works will consist entirely of a dike section which will extend from station 67+12 just upstream of railroad bridge 10.25 to station 112+00, the lower terminus of the Ansonia-Derby project. Depending upon the sequence of design and progress of construction, the lower end will either be closed with an interim tieback dike or by continuation of the dike as part of the Derby local protection project. The upstream portion, between stations 67+12 and 70+00, including railroad gate 3 is designed with a minimum freeboard allowance of 3 feet above the water surface profile obtained from the model with the northerly span of railroad bridge 10.25 about 75 percent filled.

Downstream of station 70+00, the top grade of the dike includes a minimum freeboard allowance of 2 feet, except upstream of Division Street bridge where the design includes a freeboard allowance of about 4 feet above the design water surface. The selected design grade includes some allowance for collection of debris on the bridge piers and recovery of velocity head.

(d) Left bank protection. The left bank protection begins immediately below the Anaconda American Brass Company hydroplant at station 0+25 and extends downstream to station 91+00 just below the present mouth of Beaver Brook, a total distance of about 8,100 feet. From the upstream end to station 70+50, about 350 feet below railroad bridge 10.25, the protection will consist of floodwall segments interconnected by railroad and street gates. This portion is designed with a minimum freeboard allowance of 3 feet above the design water surface which was obtained assuming the northerly span of the railroad bridge 75 percent filled with sediments and debris. Downstream of station 71+00 the design grade of dike includes a minimum freeboard of 2 feet. In this reach the channel is relatively straight and uniform in cross section. The velocity is moderately low and the flow is uniform and tranquil.

c. Beaver Brook.

(1) Channel improvements.

(a) General. The lower 3,000 feet of Beaver Brook channel will be improved or relocated to prevent overflow of the brook into the protected area. The channel improvements are designed for the project design floods as described in paragraph 2b above. In the uppermost 500 feet of the improvement, the brook will be enclosed in a concrete box conduit. At station 5+25.94, the channel will emerge from the Central Street crossing in a U-shaped concrete section and terminate in an impact type stilling basin at station 6+12. Below the stilling basin, between stations 6+79 and 24+32.44, the channel will be relocated or improved. The open channel section will be protected from the erosive action of the high velocity flow by stone riprap on the invert and dike slopes. Stone slope protection will also be provided wherever shaping of the side slopes is required. From station 24+32.44, the brook will flow in a pressure conduit to its relocated mouth at station 30+43. The plan and profile of Beaver Brook are shown on plates 9-15 through 9-17.

(b) Upper box conduit.

1. General. At the upper end of the box conduit, station 1+00, Beaver Brook emerges from under the H. C. Cook Company plant in an unpaved rectangular channel with dry rubble walls. The entrance to the conduit will be immediately upstream of the building foundation walls. The invert of the entrance section will slope steeply from elevation 40.7 feet m.s.l., the existing invert of the brook, to elevation 38.0 feet msl in a distance of 7.5 feet. The minimum conduit area is 88 square feet at about station 0+96, where the conduit passes under the sill of the building. The area of the full section of the 8' x 14'-6" box conduit will be 112 square feet, so that, the hydraulic control will remain in the existing section under the building.

The proposed plan of improvement will provide ample waterway area should the channel under the building be improved in the future. In the event that the existing channel capacity is exceeded, any overflow will be returned to the brook at Central Street by the intercepting roadway grating in Beaver Street.

From station 1+00, the conduit will be uniform in cross section and extend through the Central Street crossing. The invert of the box conduit will have a slope of 3 percent from station 1+00 to station 3+00 and 1 percent from station 3+00 to station 6+12. This portion of the improved channel is unaffected by backwater from the Naugatuck River and is designed for a discharge of 2,500 c.f.s.

2. Hydraulic analysis. Under the design conditions with a discharge of 2,500 c.f.s. in Beaver Brook, the box conduit will have open channel flow characteristics. The flow will enter the conduit with a velocity of about 28 f.p.s. Dropdown computations were made starting at station 1+00 and assuming a friction coefficent of 0.015. The depth of flow at the upper end will be 5.6 feet and corresponding velocity will be 31 f.p.s. Below station 1+00 the flatter slope will cause the flow to decelerate, and at the entrance to the stilling basin (station 6+12) the velocity will be about 25 f.p.s. The corresponding depth of flow at this station will be 6.8 feet. The water surface will tend to superelevate around the channel bends, thus the need for the conduit roof in the reach above the Central Street crossing. Below the bridge the channel will be U-shaped, 14.5 feet wide and with the top of walls at elevation 42.0 feet m.s.l., the same as the lower end of the grated roof of the Central Street crossing. The selected top of wall elevation provides about 4 feet of freeboard above the water surface in the stilling basin and allows for cross wave action in the open channel section below the Central Street crossing.

(c) Stilling basin.

1. General. The conventional, hydraulic jump stilling basin designed as shown on plate 7-15 of Design Memorandum No. 7, "Detailed Design of Structures," dated April 1966, was reviewed at the Waterways Experiment Station (WES). In the opinion of the Waterways Experiment Station engineers, the proposed shallow, hydraulic jump-type basin would be very sensitive to unequal flow distribution. It was considered likely that the channel bends upstream from the basin would cause unequal distribution of flow which could result in loss of the jump in the stilling basin and undesirable basin action. Therefore, the impact-type stilling basin suggested by Waterways Experiment Station and shown on plate 9-18 has been adopted.

2. Hydraulic analysis. The stilling basin is designed for a discharge of 2,500 c.f.s. in Beaver Brook. At station 6+12, the approach depth of flow and velocity will be 6.7 feet and 25 f.p.s., respectively. From station 6+12 the channel will flare from a width of 14.5 to 25 feet in a length of 30 feet. The invert in this section will slope downward from elevation 28.9 to 25.0 feet m.s.l. At the upper end of the basin, station 6+42, the depth of flow (d_1) will be 2.96 feet and the corresponding velocity (V_1) will be 33.8 f.p.s. For a basin width of 25 feet, the theoretical depth (d_2) will be 13.1 feet and velocity (V_2) will be 7.6 f.p.s. With the stilling basin floor at elevation 25.0 feet m.s.l. and assuming 0.95 theoretical depth d_2, the resulting energy gradient elevation will be 38.5 feet m.s.l.

The computed tailwater elevation in the 10-foot wide trapezoidal channel downstream of the basin is 36.2 feet m.s.l. The invert elevation at station 6+79 will be 28.0 feet m.s.l., so that with the computed depth of 8.2 feet and velocity head of 2.3 feet, the resulting energy gradient elevation will be 38.5 feet m.s.l. The overall length of the stilling basin is 37 feet, which is equivalent to 2.7 times the theoretical depth (d_2) of 13.1 feet.

The stilling action of the basin will be largely produced by the chute blocks in the flared entrance section and the single row of baffle blocks located at the upper third point in the basin. Both the chute and baffle blocks will be 3 feet high, 2.5 feet wide and spaced 2.5 feet apart. The baffle blocks will be 8 feet downstream of the lower end of the chute blocks and their centers will be offset 2.5 feet. The basin will also have a low, sloping end-sill, 1-foot high, at station 6+66. From elevation 26 feet m.s.l. it will slope upward to elevation 28 feet msl in a length of 12 feet. Between stations 6+66 and 6+79 the walls will diverge with a flare angle of about 45°, measured from the channel centerline, and slope downward from elevation 42 to 39 feet m.s.l. The channel invert and side slopes will be protected from bottom and side rollers with heavy stone riprap for a distance of 50 feet downstream of the concrete apron.

(d) Open channel section. Between the end of the stilling basin at station 6+79 and the headwall of the pressure conduit at station 24+32, the brook will be relocated in a trapezoidal channel with a 10-foot bottom width and with variable side slopes and invert grades to satisfy local conditions. The selected top grade of the dike slopes from elevation 39 to 38 feet m.s.l. between station 6+79 and 9+79, respectively, and includes a minimum freeboard allowance of 3 feet above the design water surface. In this reach the maximum water surface results from the project design flood discharge of 2,500 c.f.s. in Beaver Brook concurrent

with low flow in the Naugatuck River. Between stations 9+79 and 24+32, the top grade of the dikes and floodwall is level at elevation 38 feet m.s.l. The freeboard allowance is 3 feet above the maximum design water surface (elevation 35 feet m.s.l.) resulting from design water level in the Naugatuck River and concurrent flow of 1,000 c.f.s. in Beaver Brook.

Hydraulic computations indicate that with the project design discharge of 2,500 c.f.s. and normal low flow in the Naugatuck River, the depth of flow will vary from 8.2 feet at station 6+79 to 11.5 feet at station 19+14. The corresponding velocities will be 12.2 and 6.6 f.p.s., respectively.

The depth of flow and velocity at the entrance to the pressure conduit, station 24+32, are related to the discharge characteristics of the conduit. Accordingly, at station 24+32 the water surface elevation and velocity with the design flow of 2,500 c.f.s. is 28.0 feet and 12.8 f.p.s., respectively.

(e) Pressure Conduit. Beaver Brook will flow in an 8 x 14.5 foot concrete box conduit between station 24+32 and the mouth of the brook at station 30+89. The conduit invert will vary from elevation 14.5 feet m.s.l. at the entrance to elevation 3.5 feet at its portal. The size of the conduit was selected, (a) to minimize the head differential between the standard project flood stages on the Naugatuck River and the Beaver Brook stages at the entrance to the conduit, and (b) to have acceptable velocities in the conduit during the design flow of 2,500 c.f.s.

The conduit will flow full and under backwater pressure at time of moderate and high stages on the Naugatuck River. With a standard project flood at elevation 32.6 on the Naugatuck River, the Beaver Brook stage at the conduit entrance for a concurrent flow of 1,000 c.f.s. will be 35 feet m.s.l. The velocity through the conduit will be 8.6 feet per second.

Discharge conditions in the conduit during a Beaver Brook flow of 2,500 c.f.s., and low stages in the Naugatuck River, are uncertain, but do not affect design considerations. Critical flow at the entrance will cause the conduit to fill using the total cross sectional area. However, the slope of the energy gradient in the length of the conduit is sufficient to produce supercritical flow conditions, and it is possible that the discharge may accelerate and drop below the

conduit roof. This condition could develop only if the tailwater in the Naugatuck River is below the roof of the conduit permitting a supply of air. If the river submerges the portal during the high flow the conduit will remain full throughout its entire length.

(f) Freeboard design. The dikes and floodwall between station 5+25 at Central Street and station 24+32 at the upper end of the pressure conduit will have a minimum freeboard allowance of 3 feet above the design flood profiles.

5. HYDRAULIC DESIGN OF STONE RIPRAP CHANNEL PROTECTION

a. General. The design of the channel protection is based on the procedures set forth in the draft report titled, "Criteria for Graded Stone Riprap Channel Protection," dated 20 April 1966 and recommended revisions and instructions made orally by representatives of OCE. Revisions were made in the requirements of shape characteristics of stones, bedding materials, and minimum stone sizes for protection on slopes steeper than 1 on 2. Where basic assumptions have been required to complete the analyses, assumed values were selected in accordance with OCE recommendations and accepted practices of this office.

b. Characteristics of flow. Each channel reach was initially analyzed as a straight channel with uniform flow. Subsequently, the design was adjusted for channel bends and for specific locations within the cross sections, i.e., channel bottoms without appreciable lateral slope, channel side slopes and for berms at various levels. For other localized areas of highly turbulent flow for which an analytical approach was considered inappropriate and test data were unavailable, the design is based on judgment, with the velocity values obtained from the model studies used as a guide. Highly turbulent flow will occur around the five highway and railroad bridges, along the right bank dike upstream of the American Brass Company bridge, and below the stilling basin in Beaver Brook.

c. Average and local unit boundary shear. The average boundary shear or tractive force at the representative cross section was determined from the equation:

$$\bar{\tau}_o = \gamma RS \text{ (du Boy's Law)}$$

Where $\bar{\tau}_o$ = Average unit boundary shear
γ = Unit weight of water
R = Hydraulic radius
S = Slope of energy gradient

The local unit boundary shear or maximum tractive force at specific locations in the cross sections was determined from the equations:

$$\tau_{oT} = \gamma YS \qquad \text{Where}$$

τ_{oT} = Local unit boundary shear
γ = Unit weight of water
Y = Depth of water at specific location
S = Slope of energy gradient

d. Permissible boundary shear. The relation between the permissible shear or tracture force on a horizontal surface and the equivalent diameter of the 50 percent by weight finer stones in the layer designated $D_{50\ MIN}$, is given by the following equation:

$$\tau_{PL} = 0.04\ (\gamma_s - \gamma)\ D_{50MIN}$$

Where: PL = Permissible tracture force on a horizontal surface
γ_s = Specific weight of stone
γ = Specific weight of water
$D_{50\ MIN}$ = Equivalent spherical diameter of stone 50 percent by weight finer in the riprap layer

The average or local boundary shear was equated to the permissible boundary shear to obtain the required by $D_{50\ MIN}$ values for horizontal surfaces.

The permissible boundary shear on the channel side slopes is related to the permissible boundary shear on the horizontal surface by the following equation:

$$\tau_{PS} = \tau_{PL} \left(1 - \frac{\sin^2 \phi}{\sin^2 \theta}\right)^{0.5}$$

τ_{PS} = Permissible boundary shear on channel side slopes
τ_{PL} = Permissible boundary shear on horizontal surface
ϕ = Angle of the side slopes with the horizontal
θ = Angle of repose of the material, suggested values of 40° for riprap materials

e. Channel cross sections. A representative cross section was developed for each reach having similar flow characteristics and therefore, assumed to have a typical velocity profile. The maximum local unit boundary shear was used in the design of the stone riprap, except for

two relatively short reaches where the average unit boundary shear was considered applicable. The representative cross sections used in the analyses and the limits over which they were applied are shown on plates 9-19 through 9-22.

f. Depth of flow, hydraulic radii and slope of energy gradient. The depth of flow at the representative cross sections was determined by averaging the difference between the improved channel invert and the design water surface throughout the reach. The depths of flow used in the analyses are shown on plates 9-19 through 9-22. For the two short reaches having symmetrical cross sections and uniform roughness, the hydraulic radius was used in the determination of the average unit boundary shear.

g. Analyses of bends. Increased tractive forces at bends were considered in the design of stone riprap protection. The increase in boundary shear, over that of a straight channel, was related to the ratio of radius of curvature to channel width as prescribed in chart 7 of the draft report on riprap design. Adjustments made for bends were as follows:

Bend Location	Station - Station	R/W	Percentage Increase in D_{50} MIN
Upstream of Maple Street	28+00 LB - 35+10 LB	5.2	40
Downstream of Maple Street	35+10 LB - 39+30 LB	1.8	130
Downstream of Beaver Brook Inlet	86+00 LB - 91+30 RB	1.5	150
Downstream of Division Street	113+00 RB -122+00 RB	2.5	100
Beaver Brook	12+50 - 15+00	2.0	90

h. Equivalent stone diameter D_{50} minimum values. The maximum local unit tractive forces and resulting D_{50} MIN's were used in the design of stone riprap protection for all but two areas. In the Beaver Brook channel between stations 6+79 and 24+32, where bottom and side slope roughness were the same, maximum average unit tractive forces were used for design. D_{50} MIN values for selected locations in the representative cross sections are shown on plates 9-19 through 9-22.

In the areas of highly turbulent flow the size of stone and thickness of riprap layer were increased to protect against the indeterminate tractive forces present. The velocities 2 feet above the

channel surface obtained from the model study were used as a guide in the design of the riprap in these problem areas. The velocity values at selected locations are shown in table 9-II and on plates 9-2 through 9-9 and 9-11 through 9-14.

TABLE 9-II

DESIGN FLOOD VELOCITY
TWO FEET ABOVE BOTTOM SURFACE AT
SELECTED LOCATIONS - NAUGATUCK RIVER

East Coordinate	North Coordinate	Velocity
507,600	189,650	2.7
507,500	189,625	4.8
507,300	189,575	4.8
507,665	189,300	1.0
507,550	189,225	3.8
507,300	189,300	3.8
507,400	189,230	5.5
507,500	188,900	8.7
507,600	188,930	7.9
507,700	188,950	7.9
507,890	188,600	8.7
507,810	188,565	8.7
507,600	188,560	11.8
508,085	188,250	7.9
508,015	188,210	7.9
507,920	188,145	6.8
508,265	187,960	9.6
508,190	187,925	10.3
508,085	187,860	7.9
508,255	187,900	18.0
508,205	187,870	18.0
508,155	187,845	14.7
508,325	187,860	15.2
508,210	187,760	16.1

East Coordinate	North Coordinate	Velocity
508,595	187,230	11.8
508,530	187,200	12.9
508,460	187,160	11.8
508,750	187,050	14.0
508,690	186,990	16.1
508,620	186,930	15.2
508,900	186,920	6.8
508,870	186,880	14.7
508,825	186,830	18.0
509,060	186,790	5.5
508,980	186,775	11.8
508,905	186,735	15.2
509,135	186,700	3.8
509,050	186,670	17.1
508,960	186,620	10.0
509,190	186,420	11.1
509,120	186,410	12.9
509,010	186,380	3.8
509,195	186,125	12.4
509,100	186,120	14.7
508,980	186,115	3.8
509,200	185,970	3.8
509,100	185,965	14.0
508,960	185,960	3.8
509,055	185,320	7.9
508,950	185,340	10.3
508,765	185,420	2.7
508,980	185,220	14.7
508,860	185,180	8.8
509,035	185,000	6.8
508,970	185,000	12.4
508,920	185,000	11.8
508,860	185,000	8.8
508,810	185,000	6.8
508,780	185,000	6.8
509,050	184,800	8.8

East Coordinate	North Coordinate	Velocity
508,930	184,725	14.7
508,800	184,700	6.8
508,900	184,640	11.1
508,850	184,500	9.6
508,960	184,650	0
508,955	184,615	16.6
508,945	184,570	14.7
508,940	184,530	3.8
508,930	184,485	12.9
508,920	184,430	12.9
508,900	184,350	16.2
509,005	184,695	15.2
509,000	184,600	17.9
508,970	184,565	19.6
508,980	184,460	13.5
508,935	184,350	14.1
509,160	183,960	0
509,280	184,025	11.1
509,440	184,105	6.8
509,360	183,510	3.8
509,530	183,615	10.3
509,660	183,670	6.8
509,510	183,135	5.5
509,675	183,210	9.6
509,840	183,290	6.8
509,755	182,600	7.9
509,880	182,715	9.6
510,045	182,805	5.5
509,805	182,415	5.5
509,935	182,430	9.6
510,110	182,445	5.5
509,405	181,575	7.9
509,550	181,500	9.6
509,650	181,465	9.6
509,400	181,420	16.2
509,480	181,450	16.2

East Coordinate	North Coordinate	Velocity
509,470	181,395	16.2
509,550	181,360	13.5
509,260	181,330	9.6
509,350	181,265	15.2
509,480	181,200	14.0
509,010	181,170	5.5
509,110	181,050	15.2
508,725	180,775	3.8
508,880	180,700	12.4
508,660	180,160	8.7

i. Treatment of extremities.

(1) Riprap blankets. The ends of riprap protection will be given special treatment as described in the draft report, chart 3, "Treatment of Extremities." The upstream ends of the riprap on the channel bottom will be protected with buried toes sloped 1 on 4. The downstream ends will be similarly protected with buried toes sloped 1 on 6. In those areas where raveling of the side slope riprap might be more serious than a maintenance problem and failure of the protection would be likely, the upstream and downstream ends of the slope protection have also been terminated in buried toes with 1 on 4 or 1 on 6 slopes, respectively.

(2) Toe of riprap. In the areas where stone protection will not be placed across the channel invert, the side slope riprap will extend below the channel bottom. This protection should extend below any probable depth of scour. The depth of scour in the Naugatuck River is not known precisely and appears to vary widely throughout the project area. During previous conferences between OCE and NED personnel, on stone riprap channel protection for the Ansonia-Derby project, it was decided to use the following criteria as a guide.

Design Thickness of slope Protection	Extent Below Invert Measured Vertically
(inches)	(feet)
12	5
24	7
36	10
48	15

j. Size and layer thickness of stone protection. Classes of stone protection were developed over a period of time for the project. In the final analysis, for any area a class was selected which, for all practical purposes, satisfies the $D_{50\ MIN}$ requirement shown on plates 19 through 22. The selected classes and areas of placement developed are shown in the following table and on plates 9-23 through 9-29.

TABLE 9-III

CLASSES OF STONE RIPRAP

Class	Basic Layer Thickness* (inches)	Stone Weight (lbs)		Percent by Weight (SSD) Finer	D_{50min} (ft)
I	12		90 (Max)	100	0.55
		Between 15-	25	50	
		Less than	10	15	
			4 (Min)	0	
II	21		450 (Max)	100	0.87
		Between 60-	135	50	
		Less than	40	15	
			15 (Min)	0	
IIA	27		1000 (Max)	100	1.08
		Between 110-	300	50	
			25 (Min)	0	
III	36		2400 (Max)	100	1.72
		Between 450-	700	50	
			100 (Min)	0	
IV	42		3500 (max)	100	2.00
		Between 700-	1100	50	
		Less than	500	10	
			200 (Min)	0	
VI**	24		500 (Min)	0	1.75
VII**	32		1600 (Min)	0	2.64

* The side slope stone protection thickness below water level at time of placement is increased by approximately 50 percent where the invert of the channel is not protected.

** Individually placed stones on slopes steeper than 1 on 2

6. INTERIOR DRAINAGE AREA NO. 5, REVISIONS

a. Original concept. Interior Drainage Area No. 5 was first presented in Design Memorandum No. 1 - Hydrology and Interior Drainage. The area was shown on Plate No. 8-1 and the design data was shown in Table 8-1.

b. First revision. The downstream tie-in of the protective alinement around the Ansonia Manufacturing Division was revised with a considerable decrease in the interior drainage area. The revised alinement was shown on Plate No. 3-4, and the revised pumping station capacity was presented in paragraph 25.a. of Design Memorandum No. 3 - General Design and Site Geology.

c. Hydraulic model study revision. As a result of the hydraulic model study, it was found necessary to revise the alinement on the right bank of the Naugatuck River upstream of the Ansonia Manufacturing Division. This, in turn, made it necessary to revise Interior Drainage Area No. 5. The revised data for this area are presented in Table 9-IV - Interior Drainage Area No. 5 - Design Discharges and Rational Formula Data.

TABLE 9-IV

INTERIOR DRAINAGE AREA NO. 5
DESIGN DISCHARGES AND RATIONAL FORMULA DATA

Drainage Area (acres)	45.
Composite Infiltration Factor "C"	0.7
Time of Concentration "Tc" (minutes)	20.0
100-Year Rainfall Rate (inches/hr)	6.0
10-Year Rainfall Rate (inches/hr)	4.0
100-Year "Q" (cfs)	190.0
10-Year "Q" (cfs)	126.0
"Q" Rainfall Rate 1.5"/hr, Tc=60 min. (cfs)	48.0

7. RIVER STREET PUMPING STATION, REDESIGN

a. General. As a result of the revision of Interior Drainage Area No. 5, it was necessary to redesign the River Street Pumping Station. Paragraph 26a, the upper half of Plate No. 8-6 and mechanical design computations sheets M-1 thru M-5 of Appendix B of Design Memorandum No. 8 - Pumping Stations are superseded by the new design.

b. New design. Two pumps will be provided with each pump having a capacity of 32 c.f.s. (14,400 g.p.m.), two-thirds of the required station capacity, against the standard project flood with suction sump at low water elevation. The flood wall will form one wall of the station and each pump will discharge through the flood wall with a flap valve on the end of the discharge line. Because of the limited space between the flood wall and the existing street, the center line through the two pumps is at right angles to the flood wall and one pump discharge is offset under the floor. This permits an economical inlet arrangement with the gravity flow passing directly past one side of the station with a sluice gate in the flood wall to shut off the river and a gate in the wall of the station sump so water will enter the sump at right angles to the line of pumps and no above ground appurtenances between the station and the street are required. Provisions will be made for installation of stop logs on the river side of each flap valve and the gravity discharge gate.

c. Mechanical design. The mechanical design computations and curves are presented in Appendix B, Pages Nos. M-1A thru M-10A. Plate No. 9-30 - River Street Pumping Station, Mechanical Plans and Section presents the layout of the station.

d. Structural design. The structural design of the River Street Pumping Station is similar to the design of the Maple Street Pumping Station as presented in Design Memorandum No. 8 - Pumping Stations submitted 27 July 1966 and approved 13 September 1966.

APPENDIX A

HYDRAULIC MODEL INVESTIGATION

ANSONIA-DERBY LOCAL PROTECTION PROJECT

(Report to be prepared by Waterways Experiment Station and submitted at a later date)

APPENDIX B

MECHANICAL DESIGN COMPUTATIONS

ANSONIA-DERBY LOCAL PROTECTION PROJECT

INDEX TO SHEETS

Title	Page No.
River Street Pumping Station	M-1A - M-10A

SUBJECT ANSONIA - DERBY FLOOD PROTECTION
COMPUTATION RIVER STREET PUMPING STATION.
COMPUTED BY _____ CHECKED BY JWF DATE March '67

STATION DESIGN CAPACITY

48 cfs
Standard Project Flood Elev 45.8
Top of Dike " 49.0
Suction Chamber High water elev. 30.0
" " Low " " 24.5
Two (2) Pumps (each to handle 2/3 of total.

PUMP DESIGN CONDITION POINT

$\frac{48 \times 2}{3} = 32$ cfs $= 14{,}400$ gpm

Dia of Disch. $\sqrt{\frac{4 \times 32}{12\pi}} = 1.84 = 22.1''$

USE 24" Pipe Discharge

Head:

Pool to pool	45.8 − 24.5 =	21.3
Vel Hd.	=	1.64
Disch Pipe & Flap Valve	=	.30
TOTAL HEAD		23.24 FEET

SYSTEM LOSSES (For longest Disch. Pipe)

GPM	Vel. Hd.	Pipe & Flap V	TOTAL
12 000	1.13	.20	1.33
13 000	1.31	.24	1.55
14 000	1.53	.28	1.81
16 000	2.00	.35	2.35
18 000	2.53	.43	2.96
20 000	3.13	.52	3.65

PUMP OPERATING CYCLE

PIPE STORAGE	35 000 Gallons
SUMP	13 000 "
TOTAL	48000 "

AVE PUMP CAPACITY 16 000 GPM

operating time (No inflow) $\frac{48000}{16000}$ = 3 Minutes

Min Pump operating Cycle (operating at full speed)
(Inflow = 50% Pump capacity)

Time to empty $\frac{48000}{8000}$ = 6 Minutes

Time to refill $\frac{48000}{8000}$ = 6 "

Minute between Starts = 12 Minutes

While this operating is less than desirable, it is tolerable for diesel driven units. However the cycle may be lengthened by either operating at less than full speed to reduce pump capacity or by partially opening the gravity discharge gate to allow some inflow from the river.

SUMMARY

Computations and Curves, Pages M-3A thru M-10A show that a pump with 24" discharge will satisfy the requirements. Pump based on Model curves Page M-7A, performance shown by curves on Page M-8A, operating at 910 RPM, 18.86 prop. dia, is best selection because of its higher capacity at required Max head than the pump with characteristic shown by curves on Page M-10A

FROM PAGE M-7A

AT 23.2 FT $Q = 13550$ GPM

$$D_p = \left(\frac{Q_p}{Q_m}\right)^{1/2} = 20\left(\frac{14400}{13550}\right)^{1/2} = 20.6''$$

Try 20" $Q_m = \frac{14400}{\left(\frac{20}{20}\right)^2} = 14400$

Model Condition

$H = 23.2$ $Q = 14400$

AT 20 $Q = 14400\left(\frac{20}{23.2}\right)^{1/2} = 13400$

Model Speed $N_m = N_x\left(\frac{Q_c}{Q_x}\right) = 974\left(\frac{14400}{13900}\right) = 1008$ RPM (1.036)

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{1008}{974}\right)\left(\frac{20}{20}\right)^2 = 1.036\,Q_x$$

$$H_p = H_m = H_x\left(\frac{1008}{974}\right)^2 = 1.071\,H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{1008}{974}\right)^2\left(\frac{20}{20}\right)^2 = 1.11\,P_x$$

Values from Curve			Prototype Values		
H	Q	P	H	Q	P
31	11200	109	33.2	11600	121
25.5	13000	98 (Max Eff)	27.3	13460	109
20	14300	87.5	21.4	14800	97.1
15	15250	77.5	16.1	15800	87.
10	16100	67	10.7	16700	74.4
5	16850	56	5.35	17355	62.1

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 1008\left(\frac{20}{20}\right) = 1008$ RPM

$$N_s = \frac{\sqrt{13460} \times 1008}{27.3^{3/4}} = 9900$$

SUCTION HEAD = 2 FT.
Not Suitable - Requires suction head.

SUBJECT ANSONIA-DERBY FLOOD PROTECTION
COMPUTATION RIVER STREET PUMPING STATION
COMPUTED BY _____ CHECKED BY _____ DATE March '67

FROM PAGE M-7A

AT 23.2 FT $Q = 13550$ GPM

$$D_p = \left(\frac{Q_p}{Q_m}\right)^{1/2} = 20\left(\frac{14400}{13550}\right)^{1/2} = 20.6''$$

Try 24" $Q_m = \dfrac{14400}{\left(\frac{24}{20}\right)^2} = 10000$

Model Condition

$H = 23.2$ $Q = 10{,}000$

AT 28 $Q = 10000\left(\frac{28}{23.2}\right)^{1/2} = 11000$

AT 32 $Q = 10000\left(\frac{32}{23.2}\right)^{1/2} = 11750$

Model Speed $N_m = N_x\left(\frac{Q_c}{Q_x}\right) = 974\left(\frac{10000}{11500}\right) = 847$ RPM

PROTOTYPE PUMP

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{847}{974}\right)\left(\frac{24}{20}\right)^2 = 1.252\,Q_x$$

$$H_p = H_m = H_x\left(\frac{847}{974}\right)^2 = .757\,H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{847}{974}\right)^3\left(\frac{24}{20}\right)^2 = .947$$

Values from Curve			Prototype Values		
H	Q	P	H	Q	P
31	11200	109	23.5	14050	103
25.5	13000	98 (Max Eff)	19.6	16300	92.7
20	14300	87.5	15.15	17900	82.7
15	15250	77.5	11.38	19100	73.3
10	16100	67	7.57	20200	63.4
5	16850	56	3.79	21100	53.0

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 847\left(\frac{20}{24}\right) = 705$ RPM

$$N_s = \frac{\sqrt{16300 \times 705}}{19.8^{3/4}} = 9670$$

SUCTION LIFT = 8 FT.

Not suitable - Max. head inadequate for top of dike flood.

SUBJECT ANSONIA-DERBY FLOOD PROTECTION
COMPUTATION RIVER STREET PUMPING STA
COMPUTED BY _____ CHECKED BY _____ DATE March '67

FROM PAGE M-7A

AT 23.2 FT $Q = 13550$ GPM

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} = 20\left(\frac{14400}{13550}\right)^{1/2} = 20.6''$$

Try 21" (18.86" dia Prop) $Q_m = \frac{14400}{\left(\frac{21}{20}\right)^2} = 13,100$

Model Condition
$H = 23.2$ $Q = 13,100$

AT 25 $Q = 13100\left(\frac{25}{23.2}\right)^{1/2} = 13,600$

Model Speed $N_m = N_x\left(\frac{Q_c}{Q_x}\right) = 974\left(\frac{13100}{13350}\right) = 955$ RPM (.981)

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{955}{974}\right)\left(\frac{21}{20}\right)^2 = 1.08\ Q_x$$

$$H_p = H_m = H_x\left(\frac{955}{974}\right)^2 = .96\ H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{955}{974}\right)^3\left(\frac{21}{20}\right)^2 = 1.04\ P_x$$

Values from Curve			Prototype Values			
H	Q	P	H	Q	P	EFF %
31	11200	109	29.8	12100	113.2	80.3
25.5	13000	98 (Max Eff)	24.5	14050	102.	85.
20	14300	87.5	19.2	15450	91	82.3
15	15250	77.5	14.4	16450	80.5	74.3
10	16100	67	9.6	17400	69.7	60.5
5	16850	56	4.8	18200	58.2	38.

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 955\left(\frac{20}{21}\right) = 910$ RPM

$$N_s = \frac{\sqrt{14050} \times 910}{24.5^{3/4}} = 9800$$

SUCTION LIFT = 2 FT

Satisfactory - SEE CURVES, PAGE M-8A

SUBJECT ANSONIA-DERBY FLOOD PROTECTION
COMPUTATION RIVER STREET PUMPING STATION
COMPUTED BY _____ CHECKED BY _____ DATE March '67

FROM PAGE M-9A

AT 23.2 FT $Q = 12100$ GPM

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} = 20\left(\frac{14400}{12100}\right)^{1/2} = 21.8''$$

Try 24" (21.55" prop) $Q_m = \frac{14400}{\left(\frac{24}{20}\right)^2} = 10000$

Model Condition

$H = 23.2 \quad Q = 10000$

At $H = 26 \quad Q = 10000\left(\frac{26}{23.2}\right)^{1/2} = 10600$

At $H = 29 \quad Q = 10000\left(\frac{29}{23.2}\right)^{1/2} = 11200$

Model Speed $N_m = N_x\left(\frac{Q_c}{Q_x}\right) = 1037\left(\frac{10000}{11000}\right)^{.91} = 944$ RPM

PROTOTYPE PUMP $H_p = H_m$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_x\left(\frac{944}{1037}\right)\left(\frac{24}{20}\right)^2 = 1.31\,Q_x$$

$$H_p = H_m = H_x\left(\frac{944}{1037}\right)^2 = .827\,H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_x\left(\frac{944}{1037}\right)^3\left(\frac{24}{20}\right)^2 = 1.082\,P_x$$

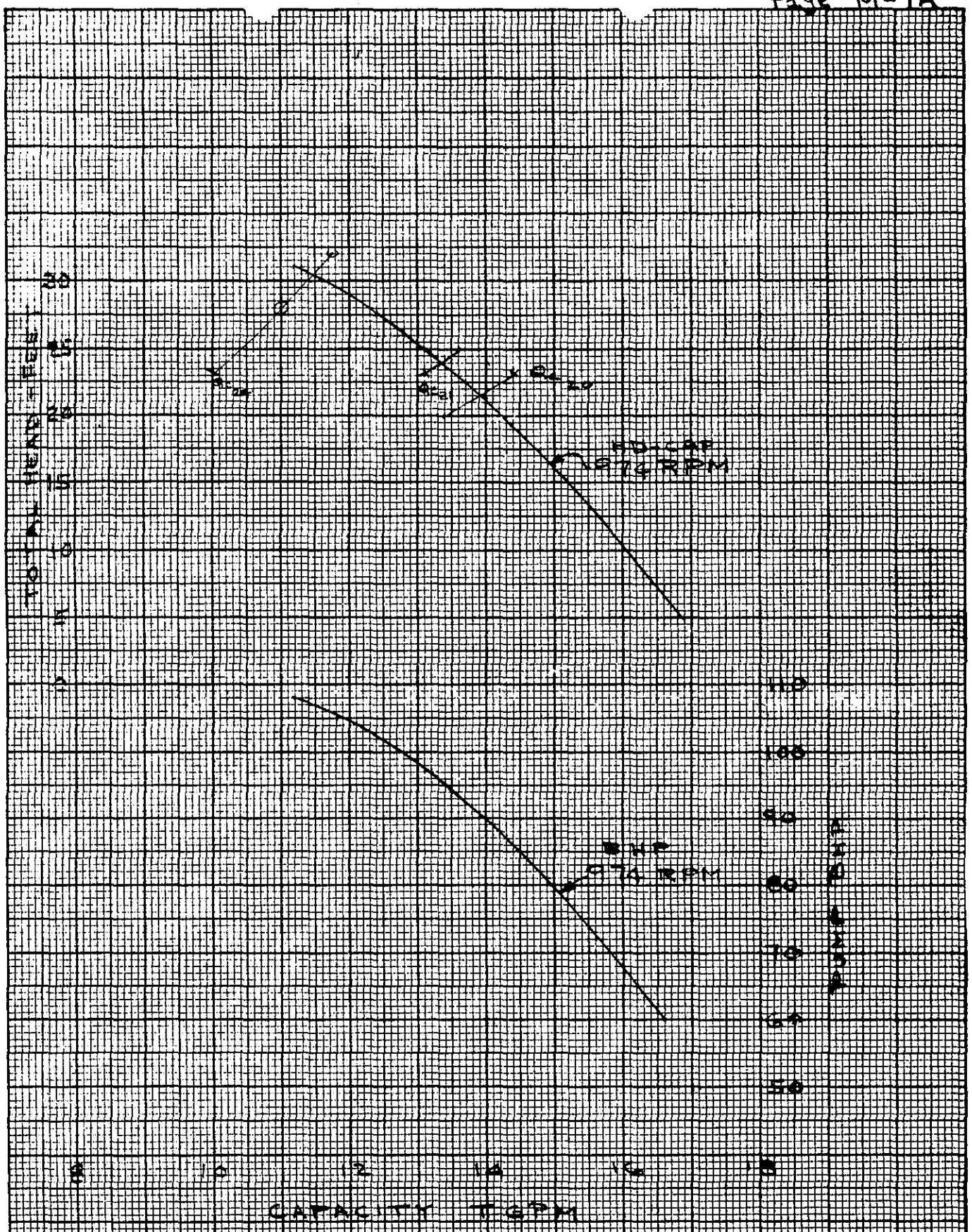
Values from Curve			Prototype Values			
H	Q	P	H	Q	P	EFF %
32.5	9550	97	26.9	12500	105	80.8
30	10400	95	24.8	13650	103	82.7
25	11600	86 (Max Eff)	20.7	15200	93	85.3
20	12650	77	16.5	16550	83.5	83.
15	13500	67	12.4	17700	72.5	76.4
10	14200	58	8.27	18600	62.8	61.8
5	14800	48	4.14	19400	52.	39.

SPEED $N_p = N_m\left(\frac{D_m}{D_p}\right) = 944\left(\frac{20}{24}\right) = 787$ RPM

$$N_s = \frac{\sqrt{15200} \times 787}{20.7^{3/4}} = 10000$$

SUCTION LIFT = 7 FT

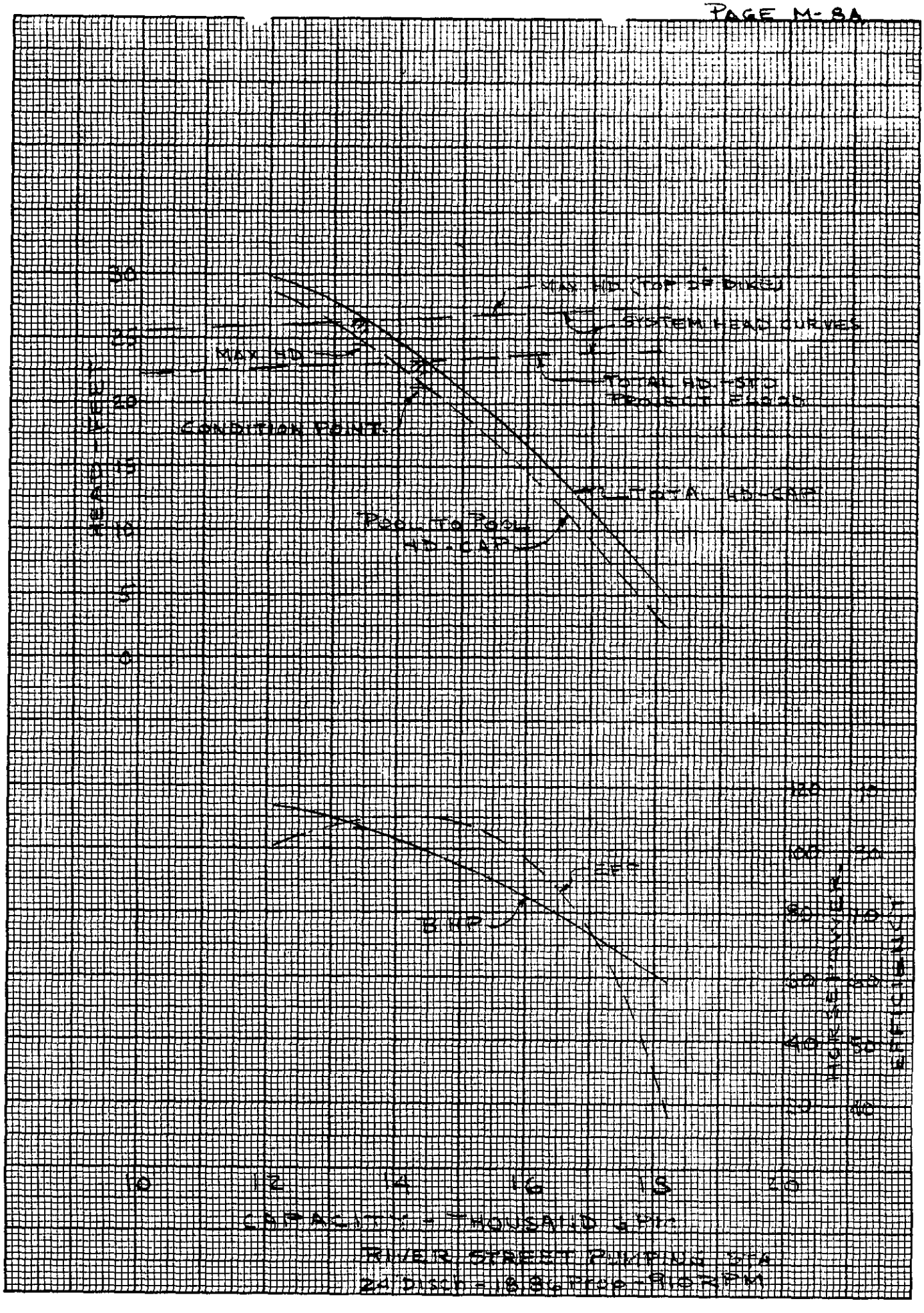
Satisfactory - See Curves Page M-10A

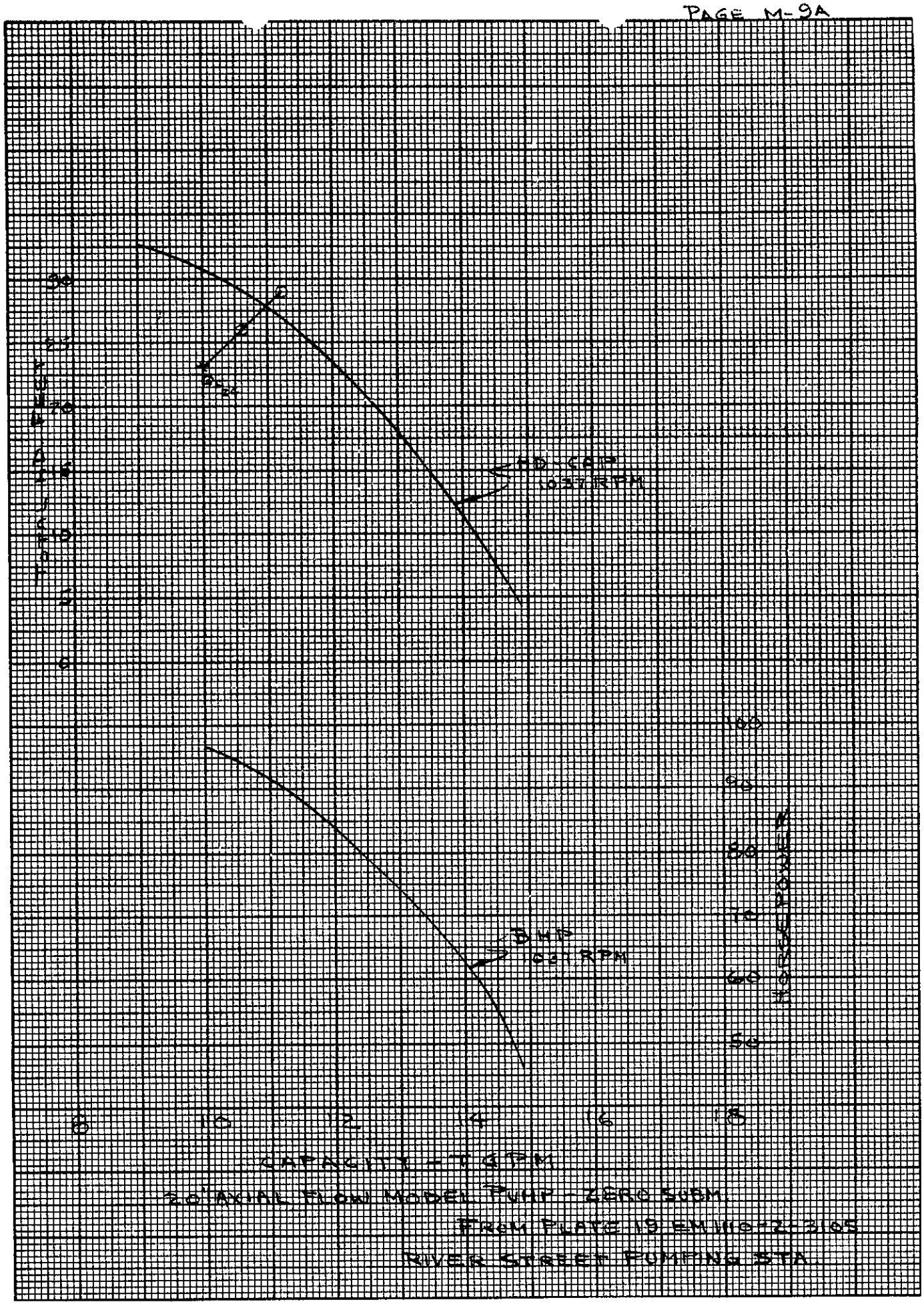


20 AXIAL FLOW MODEL PUMP - ZERO SUBM

FROM PLATE 1B EM 1110-2-2105

RIVER STREET PUMPING STA.

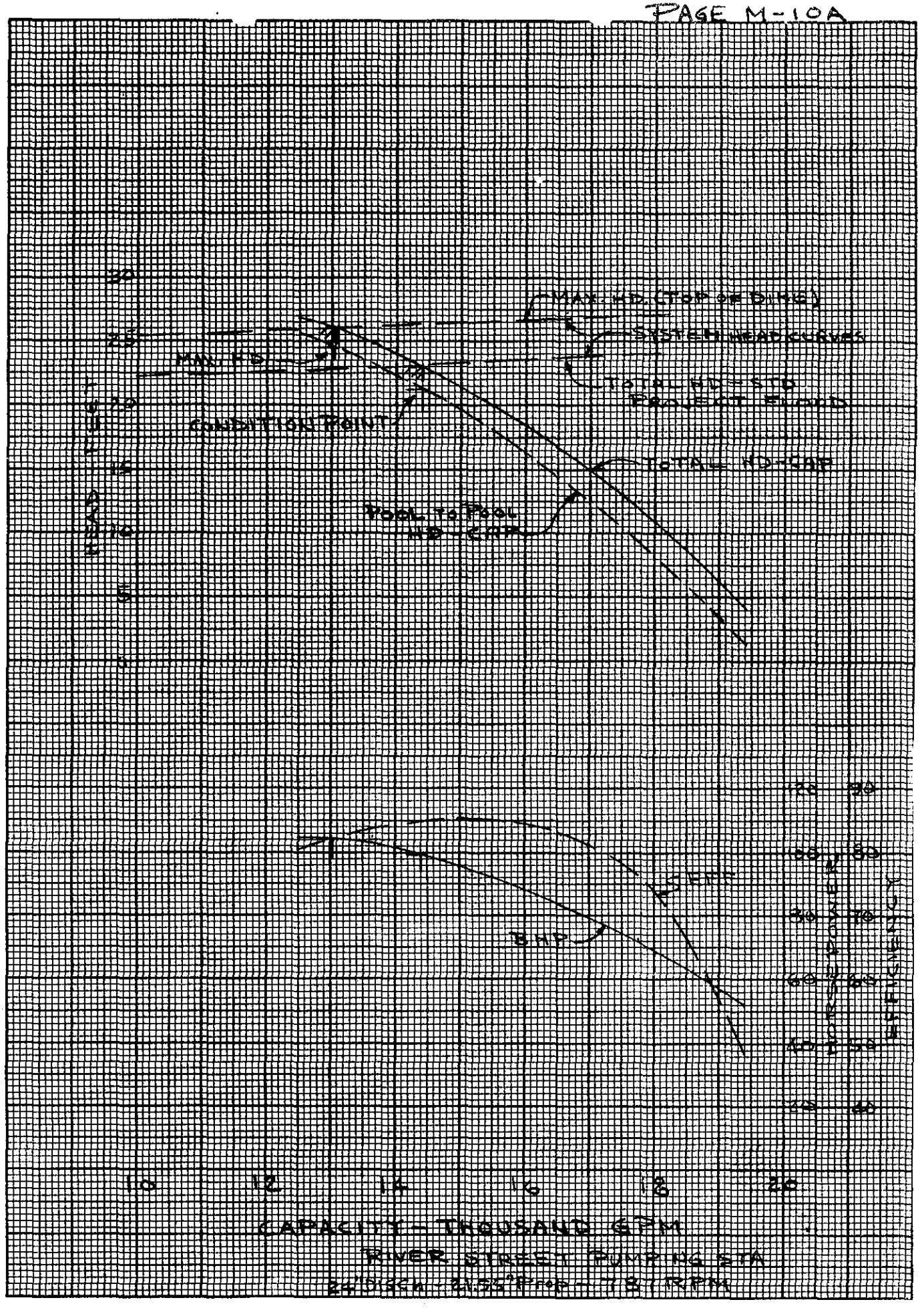

MAX HD (TOP OF DIKE)
SYSTEM HEAD CURVES
MAX HD
TOTAL HD - STD PROJECT FLOOD
CONDITION POINT
TOTAL HD - CAP
POOL TO POOL HD - CAP
HEAD - FEET
30
25
20
15
10
5
0
EFF
BHP
HORSEPOWER
EFFICIENCY
120
100
80
60
40
20
10
12
14
16
18
20
CAPACITY - THOUSAND GPM
RIVER STREET PUMPING STA
24 DISCH - 18.86 PROP - 910 RPM



20" AXIAL FLOW MODEL PUMP - ZERO SUBM.

FROM PLATE 19 EM 110-2-3105

RIVER STREET PUMPING STA.


MAX. HD. (TOP OF DIKE)
SYSTEM HEAD CURVES
MAX. HD
TOTAL HD - STD PROJECT FLOOD
CONDITION POINT
TOTAL HD - CAP
POOL TO POOL HD - CAP
HEAD FEET
30
25
20
15
10
5
0
SEFF
BHP
HORSEPOWER
EFFICIENCY
120
100
80
60
40
20
90
80
70
60
50
40
10
12
14
16
18
20
CAPACITY - THOUSAND GPM
RIVER STREET PUMPING STA
24" DISCH - 21.55" PROP - 787 RPM

APPENDIX C

CURRENT COST ESTIMATE

ANSONIA-DERBY LOCAL PROTECTION PROJECT

APPENDIX C

CURRENT COST ESTIMATE

CURRENT COST ESTIMATE

The total estimated cost of the Ansonia-Derby Local Protection Project is $11,510,000. A summary of the costs of the various features of the work described in this memorandum and in previously submitted memoranda are shown in Tables I and II below.

TABLE I

SUMMARY OF FEDERAL COSTS

	Project Feature	Cost
09.	Channels and Canals	$ 840,000
11.	Levees and Flood Walls	7,650,000
13.	Pumping Plants	530,000
30.	Engineering and Design	830,000
31.	Supervision and Administration	700,000
	TOTAL Estimated Federal First Costs	$ 10,550,000

LOCAL INTERESTS FIRST COST

The estimated local interests first cost in connection with the Ansonia-Derby Local Protection Project is $960,000. A summary of the cost of the various features of the work is shown in Table II below.

TABLE II

SUMMARY OF LOCAL INTERESTS COST

	Project Feature	Cost
01.	Lands and Damages	$ 750,000
02.	Relocations	210,000
	TOTAL Estimated Local Interests First Costs	$ 960,000

(1) Total land costs based on fair market value.

(2) Other local costs, in project area for bridges replaced since the 1955 floods, total $1,444,000.

COMPARISON OF ESTIMATES

The following tabulation shows the comparison of the current cost estimate with the latest estimate as submitted in Design Memorandum No. 8, "Pumping Stations", submitted 27 July 1966 and approved 13 September 1966.

Cost Account No.	Project Feature	D.M. #8 Estimate	Current Estimate (1)
09.	Channels & Canals	$ 738,000	$ 840,000
11.	Levees & Flood Walls	7,240,000	7,650,000
13.	Pumping Plants	527,000	530,000
30.	Engineering & Design	795,000	830,000
31.	Supervision & Admn.	690,000	700,000
	TOTAL Federal Cost	$9,990,000	$10,550,000
01.	Lands & Damages	$ 720,000	$ 750,000
02.	Relocations	147,000	210,000
	Non-Federal Contributions	0	0
	TOTAL Local Interests Cost	$ 867,000	$ 960,000
TOTAL ESTIMATED PROJECT COST		$10,857,000	$11,510,000

(1) Revision of estimate based upon the detailed studies presented in this Design Memorandum.

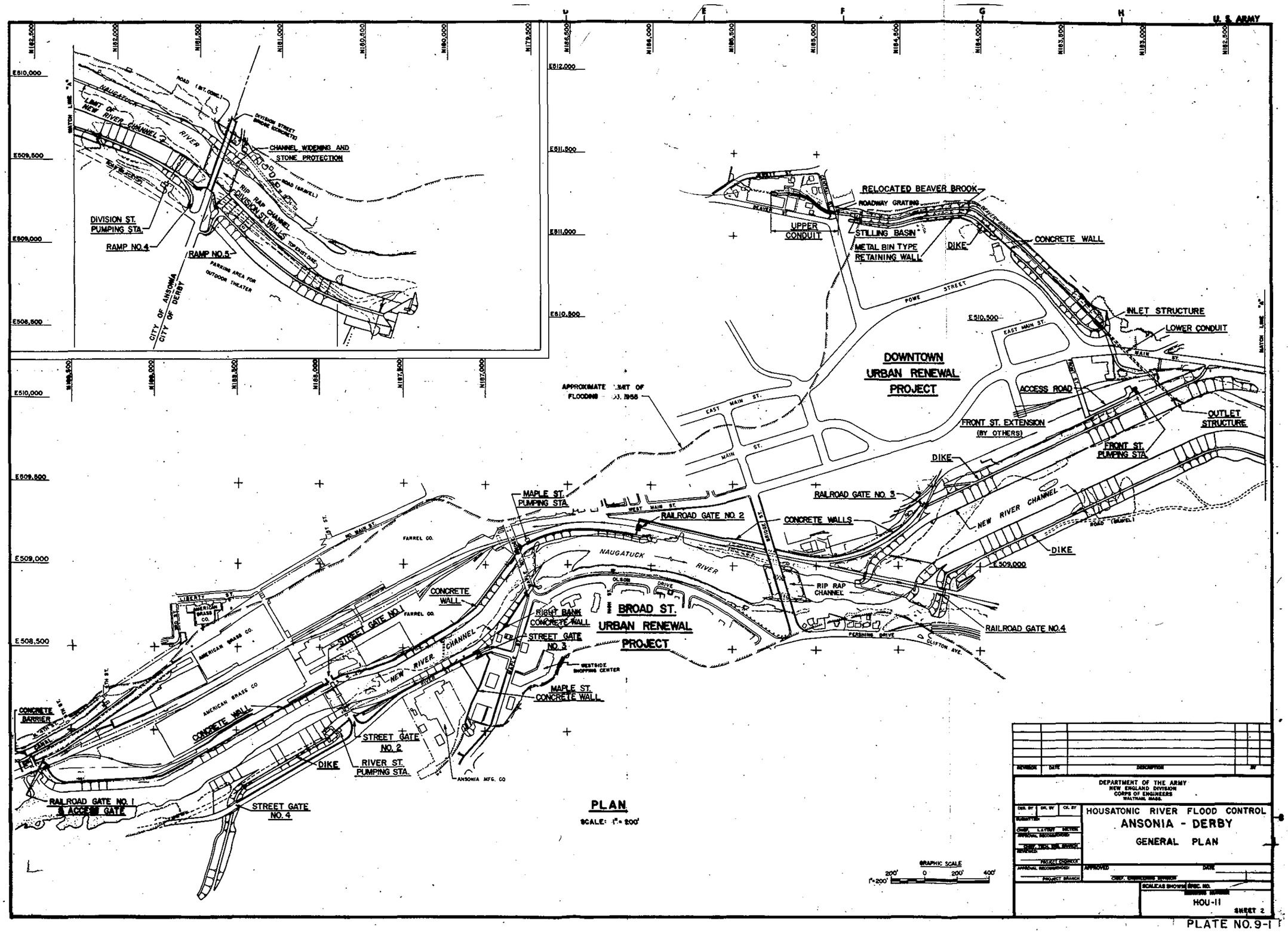

U. S. ARMY
DIVISION ST. PUMPING STA.
RAMP NO.4
RAMP NO.5
CHANNEL WIDENING AND STONE PROTECTION
RIP RAP CHANNEL
DIVISION ST. WALLS
PARKING AREA FOR OUTDOOR THEATER
CITY OF ANSONIA
CITY OF DERBY
RELOCATED BEAVER BROOK
ROADWAY GRATING
UPPER CONDUIT
STILLING BASIN
METAL BIN TYPE RETAINING WALL
DIKE
CONCRETE WALL
INLET STRUCTURE
LOWER CONDUIT
DOWNTOWN URBAN RENEWAL PROJECT
ACCESS ROAD
FRONT ST. EXTENSION (BY OTHERS)
FRONT ST. PUMPING STA.
OUTLET STRUCTURE
APPROXIMATE LIMIT OF FLOODING JAN. 1955
MAPLE ST. PUMPING STA.
RAILROAD GATE NO. 2
RAILROAD GATE NO. 3
CONCRETE WALLS
NEW RIVER CHANNEL
NAUGATUCK RIVER
RIP RAP CHANNEL
RAILROAD GATE NO.4
BROAD ST. URBAN RENEWAL PROJECT
RIGHT BANK CONCRETE WALL
STREET GATE NO. 3
WESTSIDE SHOPPING CENTER
MAPLE ST. CONCRETE WALL
CONCRETE WALL
STREET GATE NO. 1
AMERICAN BRASS CO.
FARREL CO.
CONCRETE BARRIER
STREET GATE NO. 2
RIVER ST. PUMPING STA.
ANSONIA MFG. CO
RAILROAD GATE NO. 1 & ACCESS GATE
STREET GATE NO. 4
PLAN
SCALE: 1" = 200'
GRAPHIC SCALE
200' 0 200' 400'
1" = 200'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
GENERAL PLAN
SCALE AS SHOWN
HOU-11
SHEET 2

PLATE NO. 9-1

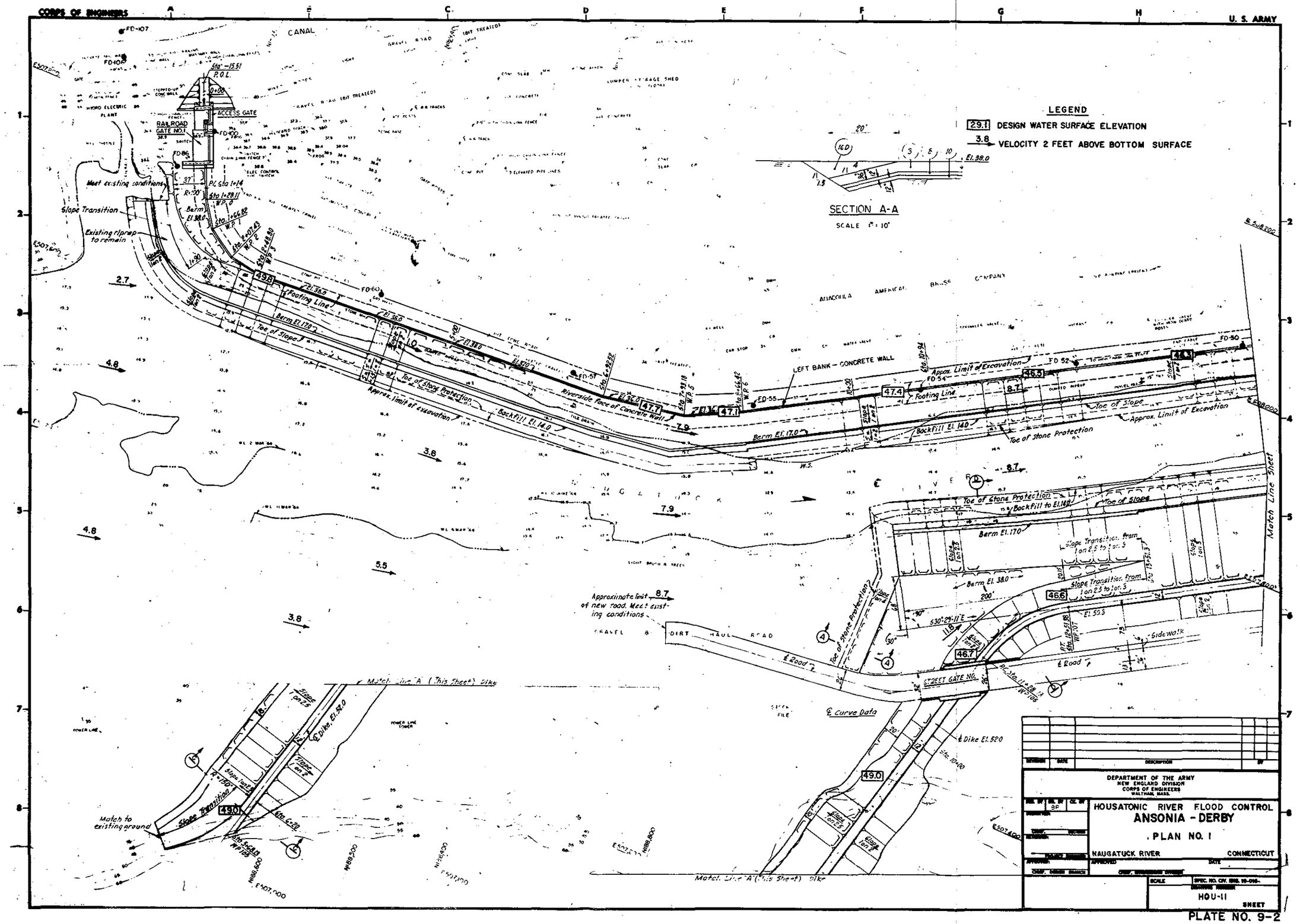

CORPS OF ENGINEERS
U. S. ARMY
LEGEND
29.1 DESIGN WATER SURFACE ELEVATION
3.8 VELOCITY 2 FEET ABOVE BOTTOM SURFACE
SECTION A-A
SCALE 1" = 10'
CANAL
ACCESS GATE
RAILROAD GATE NO. 1
Meet existing conditions
Slope Transition
Existing riprap to remain
Footing Line
Berm El. 17.0
Toe of Slope
Toe of Stone Protection
Approx. limit of excavation
Backfill El. 14.0
Riverside face of Concrete Wall
LEFT BANK - CONCRETE WALL
Approx. Limit of Excavation
Approximate limit of new road. Meet existing conditions
DIRT HAUL ROAD
Match Line Sheet
Match Line "A" (This Sheet) Dike
Curve Data
Dike El. 52.0
Match to existing ground
Sidewalk
STREET GATE NO.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 1
NAUGATUCK RIVER
CONNECTICUT
HOU-11
SHEET

PLATE NO. 9-2

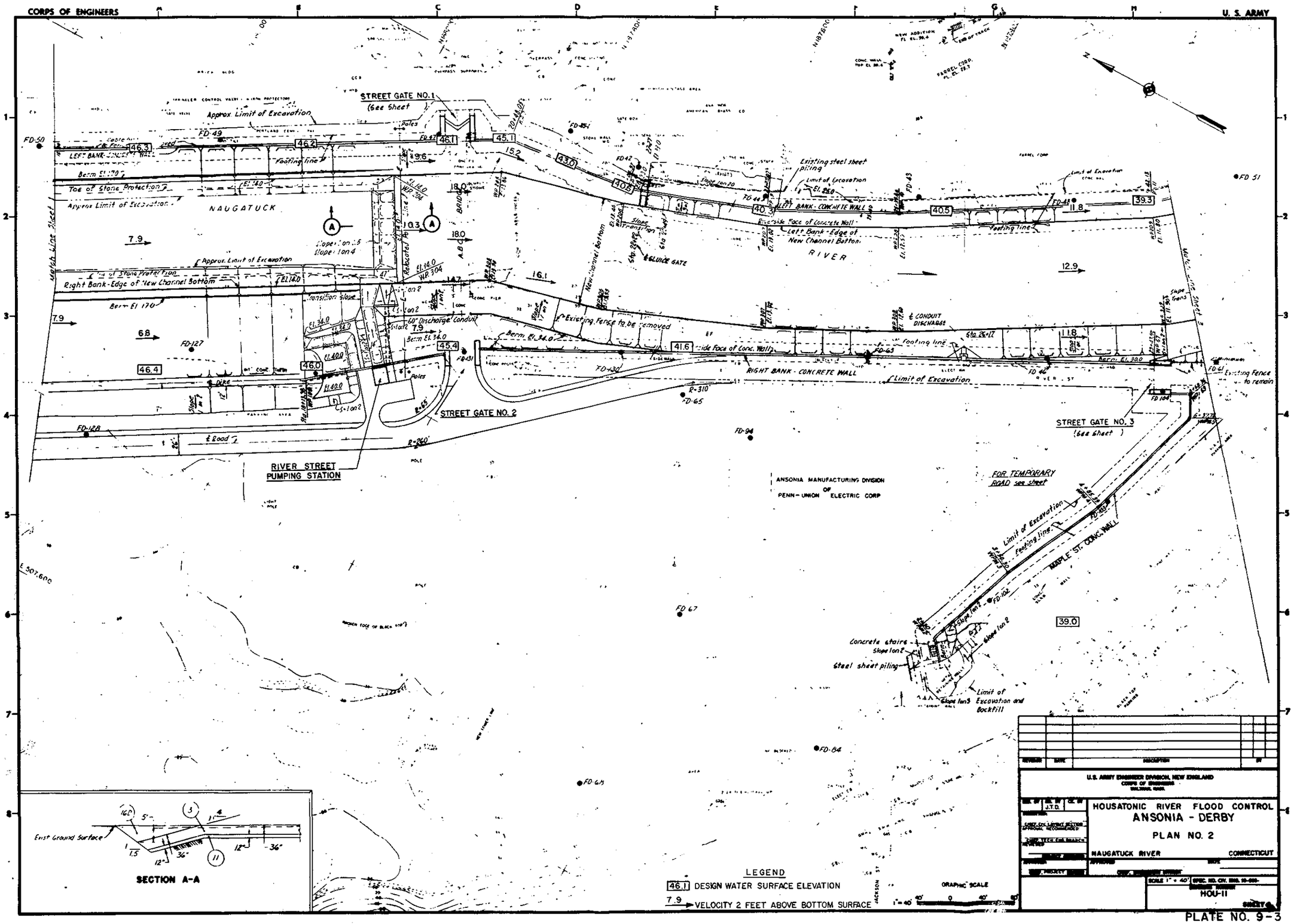

CORPS OF ENGINEERS
U. S. ARMY
STREET GATE NO. 1
(See Sheet)
Approx. Limit of Excavation
NAUGATUCK
RIVER
Existing steel sheet piling
Limit of Excavation
LEFT BANK - CONCRETE WALL
Riverside Face of Concrete Wall
Left Bank - Edge of New Channel Bottom
Footing line
Toe of Stone Protection
Approx. Limit of Excavation
Right Bank - Edge of New Channel Bottom
Berm El. 17.0
Match Line Sheet
60" Discharge Conduit
Existing Fence to be removed
Side Face of Conc. Wall
RIGHT BANK - CONCRETE WALL
Limit of Excavation
STREET GATE NO. 2
STREET GATE NO. 3
(See Sheet)
RIVER STREET PUMPING STATION
ANSONIA MANUFACTURING DIVISION OF PENN-UNION ELECTRIC CORP
FOR TEMPORARY ROAD see sheet
MAPLE ST. CONC. WALL
Concrete stairs
Steel sheet piling
Limit of Excavation and Backfill
Existing Fence to remain
SECTION A-A
Exist Ground Surface
LEGEND
46.1 DESIGN WATER SURFACE ELEVATION
7.9 VELOCITY 2 FEET ABOVE BOTTOM SURFACE
GRAPHIC SCALE
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 2
NAUGATUCK RIVER
CONNECTICUT
HOU-11

PLATE NO. 9-3

CORPS OF ENGINEERS U. S. ARMY

MAPLE STREET PUMPING STATION

PLAN
SCALE 1" = 40'

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

SECTION E-E

SECTION F-F

SECTION G-G

TYPICAL SECTIONS
SCALE 1" = 10'

LEGEND

40.0 DESIGN WATER SURFACE ELEVATION

3.8 → VELOCITY 2 FEET ABOVE BOTTOM SURFACE

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 3

NAUGATUCK RIVER CONNECTICUT

NOU-11

PLATE NO. 4

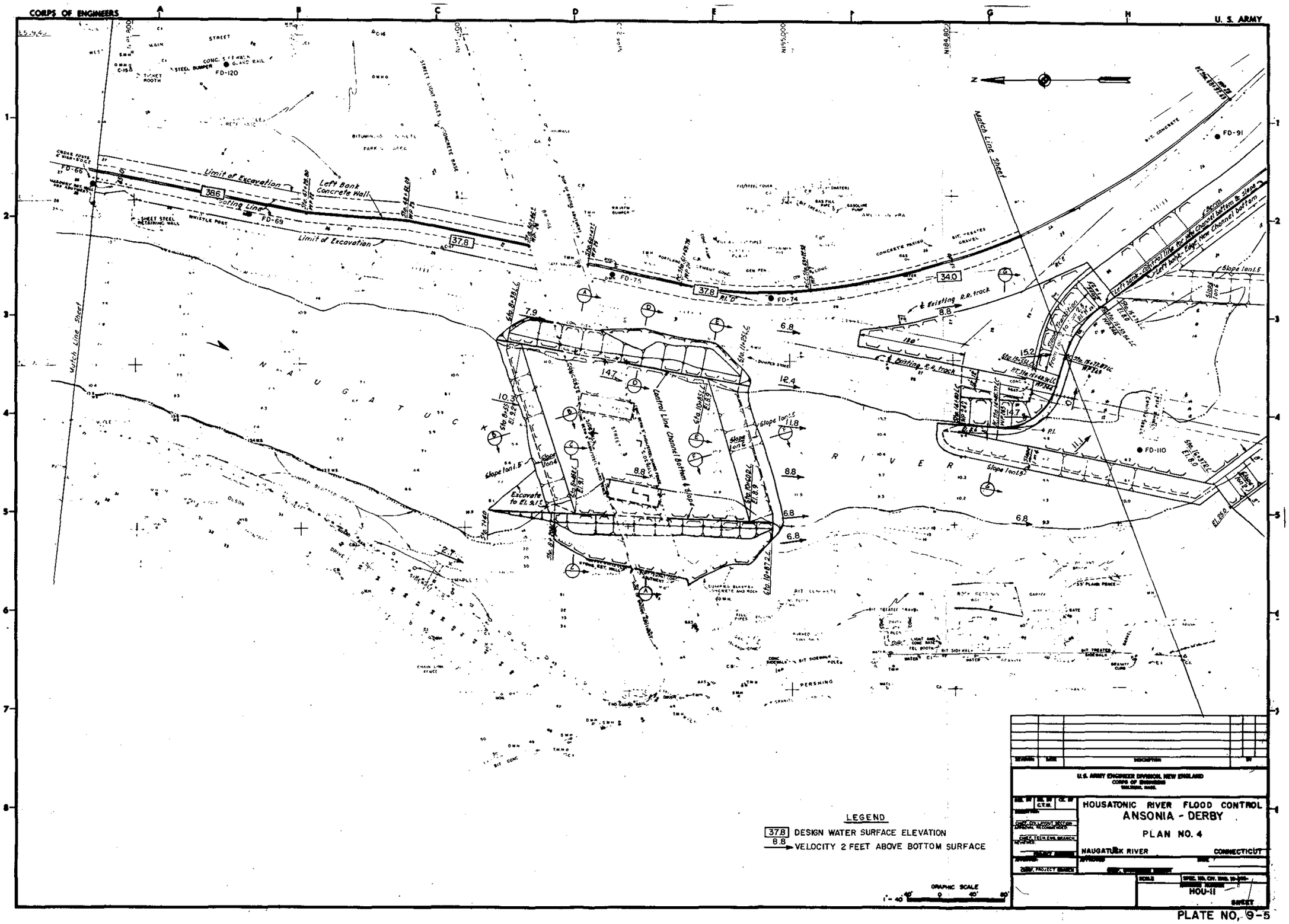

CORPS OF ENGINEERS
U. S. ARMY
Match Line Sheet
Limit of Excavation
Left Bank Concrete Wall
Boting Line
Limit of Excavation
Match Line Sheet
N A U G A T U C K
R I V E R
Existing R.R. track
Existing R.R. track
Control Line Channel Bottom & Slope
Excavate to El. 9.1±
Slope 1 on 1.5
Slope 1 on 4
Slope 1 on 6
Slope 1 on 1.5
Slope 1 on 1.5
Slope 1 on 2
Slope 1 on 6
Slope 1 on 1.5
Left bank - Control line for New Channel bottom & slope
Left bank - Edge New Channel bottom
Berm
FD-66
FD-69
FD-120
FD-75
FD-74
FD-91
FD-110
38.6
37.8
37.8
34.0
7.9
6.8
8.8
12.4
14.7
10.3
11.8
8.8
6.8
6.8
15.2
14.7
11.1
2.7
LEGEND
37.8 DESIGN WATER SURFACE ELEVATION
8.8 VELOCITY 2 FEET ABOVE BOTTOM SURFACE
GRAPHIC SCALE
1" = 40'
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 4
NAUGATUCK RIVER
CONNECTICUT
HOU-11
SHEET

PLATE NO. 9-5

CORPS OF ENGINEERS

U. S. ARMY

TEMPORARY RAILROAD BYPASS
(By Others)

21° Curve

LEFT BANK CONCRETE WALL

R.R. GATE NO. 3

℄ RAMP NO. 1

Compacted random fill

Bottom of slope

LEFT BANK ℄ DIKE

Slope Transition From 1 on 2.5 to 1 on 3

Left bank control line for channel bottom & slope

Left bank edge of new channel bottom

Bottom of stone protection

Limit of backfill

Berm El. 11.0

RELOCATED RIVER CHANNEL

New Channel bottom

Control line for channel bottom & slope

Right bank - Edge of new channel bottom

RIGHT BANK ℄ DIKE

LOWER RAMP

TURNAROUND

RAMP NO. 3

Waste fill area
Fill to El. 20 ±

Match Line Sheet

LEGEND

33.1 DESIGN WATER SURFACE ELEVATION

6.8 → VELOCITY 2 FEET ABOVE BOTTOM SURFACE

NOTES

RC denotes Right Channel Line
LC denotes Left Channel Line
For details of Ramps No. 1 & No. 3 see Sheets
For details of R.R. Gate No. see Sheets

GRAPHIC SCALE

1" = 40'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY | DR. BY C.T.M. | CK. BY

SUBMITTED:
CHIEF, CIV. & LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY

PLAN NO. 5

NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE 1" = 40' | SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER HOU-11
SHEET

PLATE NO. 9-6

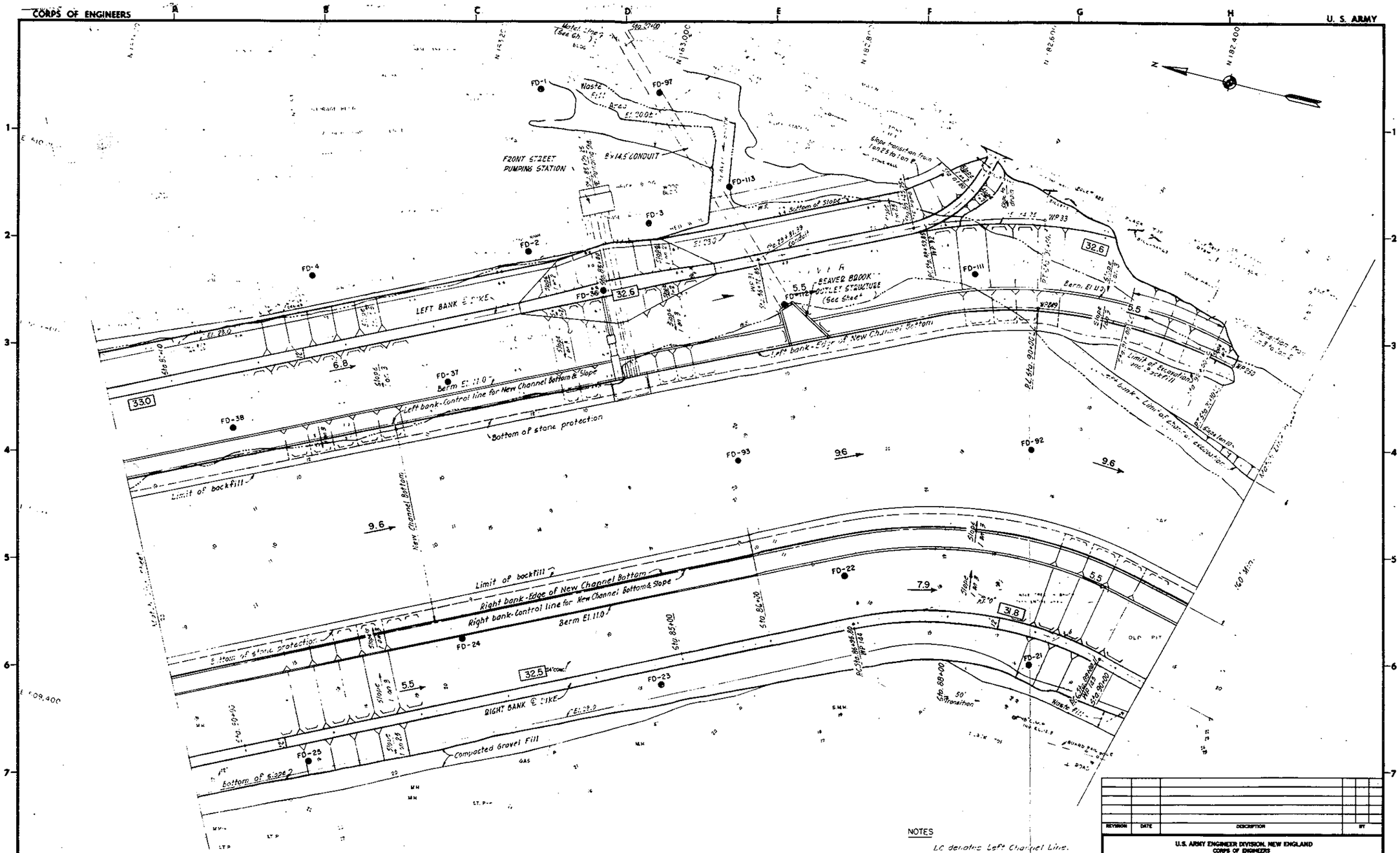
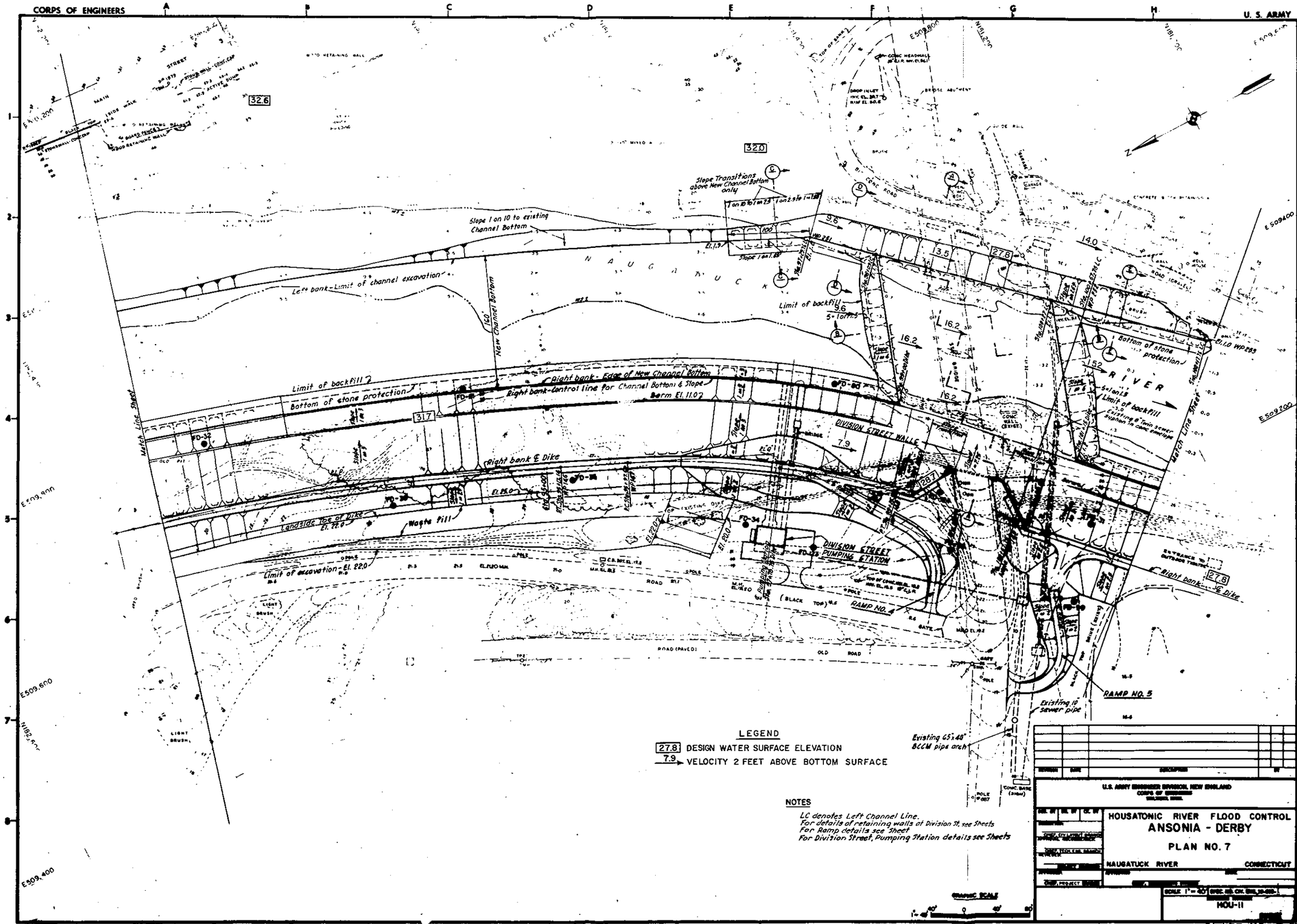

CORPS OF ENGINEERS
U. S. ARMY
FRONT STREET PUMPING STATION
8'x14.5' CONDUIT
LEFT BANK ℄ DIKE
BEAVER BROOK OUTLET STRUCTURE (See Sheet)
Left bank-Edge of New Channel Bottom
Left bank-Control line for New Channel Bottom & Slope
Bottom of stone protection
Limit of backfill
Right bank-Edge of New Channel Bottom
Right bank-Control line for New Channel Bottom & Slope
Berm El. 11.0
RIGHT BANK ℄ DIKE
Compacted Gravel Fill
Bottom of Slope
Limit of Excavation and Backfill
Waste Fill
33.0
32.6
32.5
31.8
6.8
9.6
7.9
5.5
FD-1
FD-2
FD-3
FD-4
FD-97
FD-113
FD-111
FD-36
FD-37
FD-38
FD-93
FD-92
FD-22
FD-24
FD-23
FD-21
FD-25
NOTES
LC denotes Left Channel Line.
LEGEND
33.0 DESIGN WATER SURFACE ELEVATION
8.7 VELOCITY 2 FEET ABOVE BOTTOM SURFACE
GRAPHIC SCALE
1" = 40'
40' 0 40' 80'
REVISION
DATE
DESCRIPTION
BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
DES. BY
DR. BY E.J.K.
CK. BY
SUBMITTED:
CHIEF, CIV. LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVED:
CHIEF, PROJECT BRANCH
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 6
NAUGATUCK RIVER
CONNECTICUT
APPROVED
DATE
CHIEF, ENGINEERING DIVISION
SCALE: 1" = 40'
SPEC. NO. CIV. ENG. 19-016-
DRAWING NUMBER
HOU-11
SHEET 6

PLATE NO. 9-7

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

27.8 DESIGN WATER SURFACE ELEVATION

7.9 VELOCITY 2 FEET ABOVE BOTTOM SURFACE

NOTES

LC denotes Left Channel Line.
For details of retaining walls of Division St. see Sheets
For Ramp details see Sheet
For Division Street, Pumping Station details see Sheets

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 7

NAUGATUCK RIVER — CONNECTICUT

SCALE 1" = 40'

HOU-11

PLATE NO. 9-8

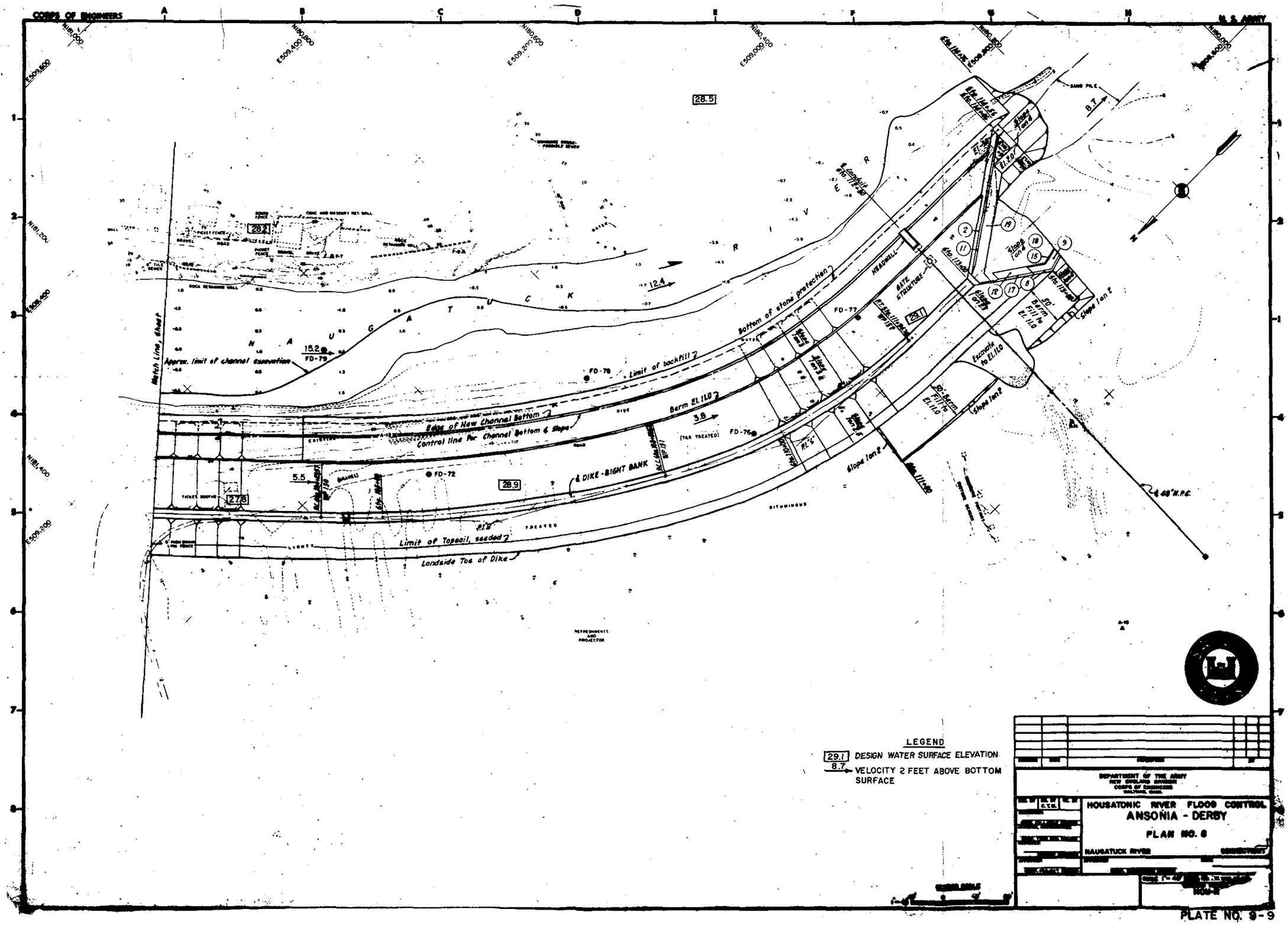
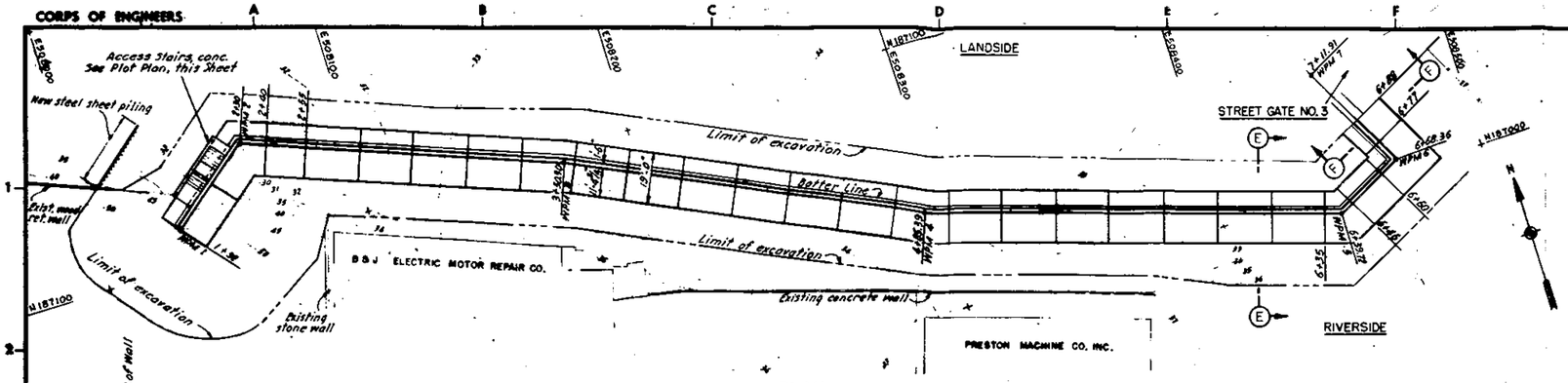
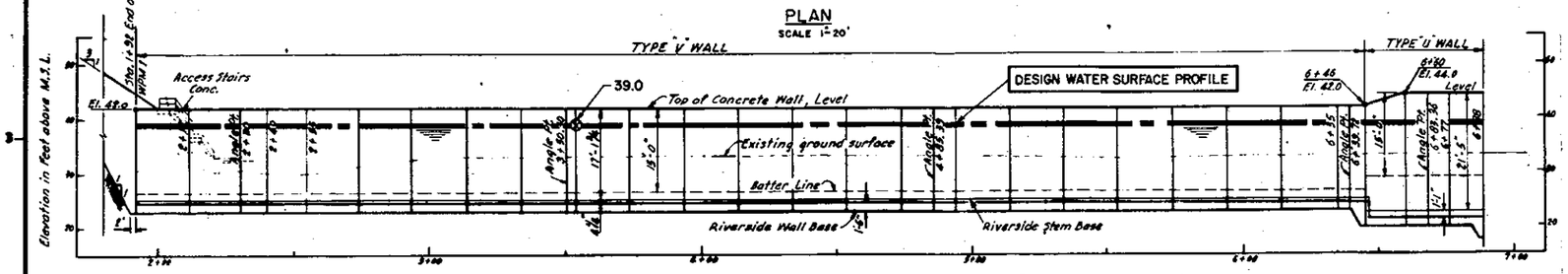

CORPS OF ENGINEERS
U. S. ARMY
N A U G A T U C K R I V E R
Match Line, Sheet
Approx. limit of channel excavation
Limit of backfill
Bottom of stone protection
Edge of New Channel Bottom
Control line for Channel Bottom & Slope
Berm El. 11.0
(TAR TREATED)
℄ DIKE - RIGHT BANK
Limit of Topsoil, seeded
Landside Toe of Dike
HEADWALL
GATE STRUCTURE
Excavate to El. 11.0
50' Berm Fill to El. 11.0
Slope 1 on 2
℄ 48" N.P.C.
28.5
28.2
28.9
27.8
29.1
12.4
15.2
5.5
3.8
8.7
FD-72
FD-76
FD-77
FD-78
FD-79
LEGEND
29.1 DESIGN WATER SURFACE ELEVATION
8.7 VELOCITY 2 FEET ABOVE BOTTOM SURFACE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
PLAN NO. 8
NAUGATUCK RIVER
CONNECTICUT

PLATE NO. 9-9

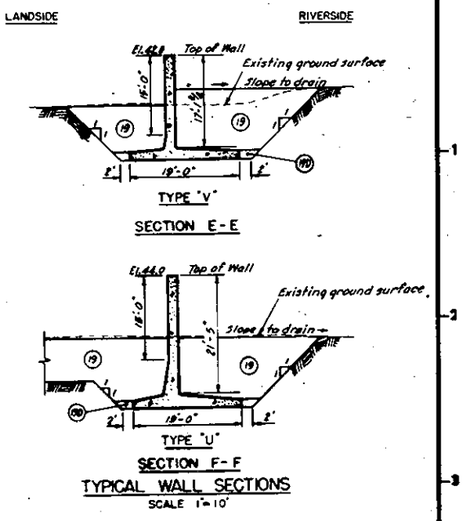
CORPS OF ENGINEERS — U. S. ARMY



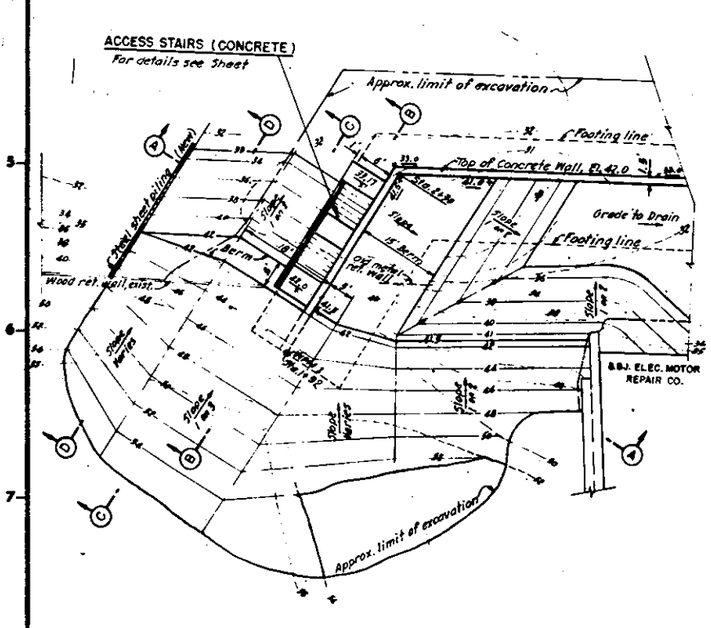
PLAN
SCALE 1"=20'



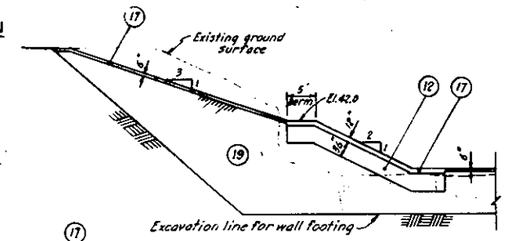
RIVERSIDE ELEVATION
SCALE HOR. 1"=20' VERT. 1"=10'



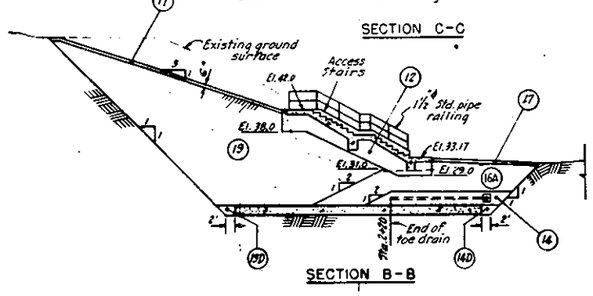
TYPICAL WALL SECTIONS
SCALE 1"=10'



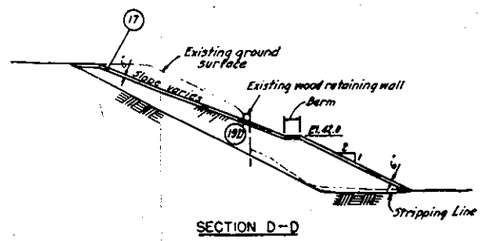
PLOT PLAN
SCALE 1"=10'



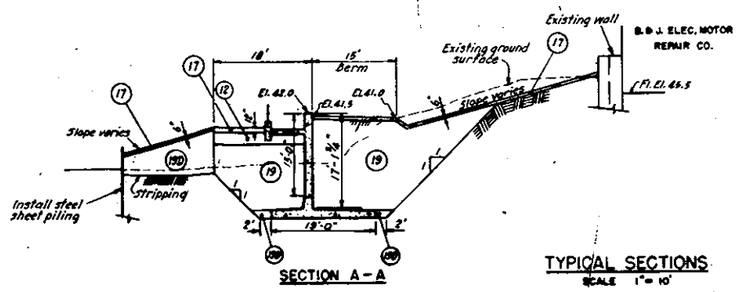
SECTION C-C



SECTION B-B



SECTION D-D



SECTION A-A

TYPICAL SECTIONS
SCALE 1"=10'

GRAPHIC SCALE

SAFETY PAYS

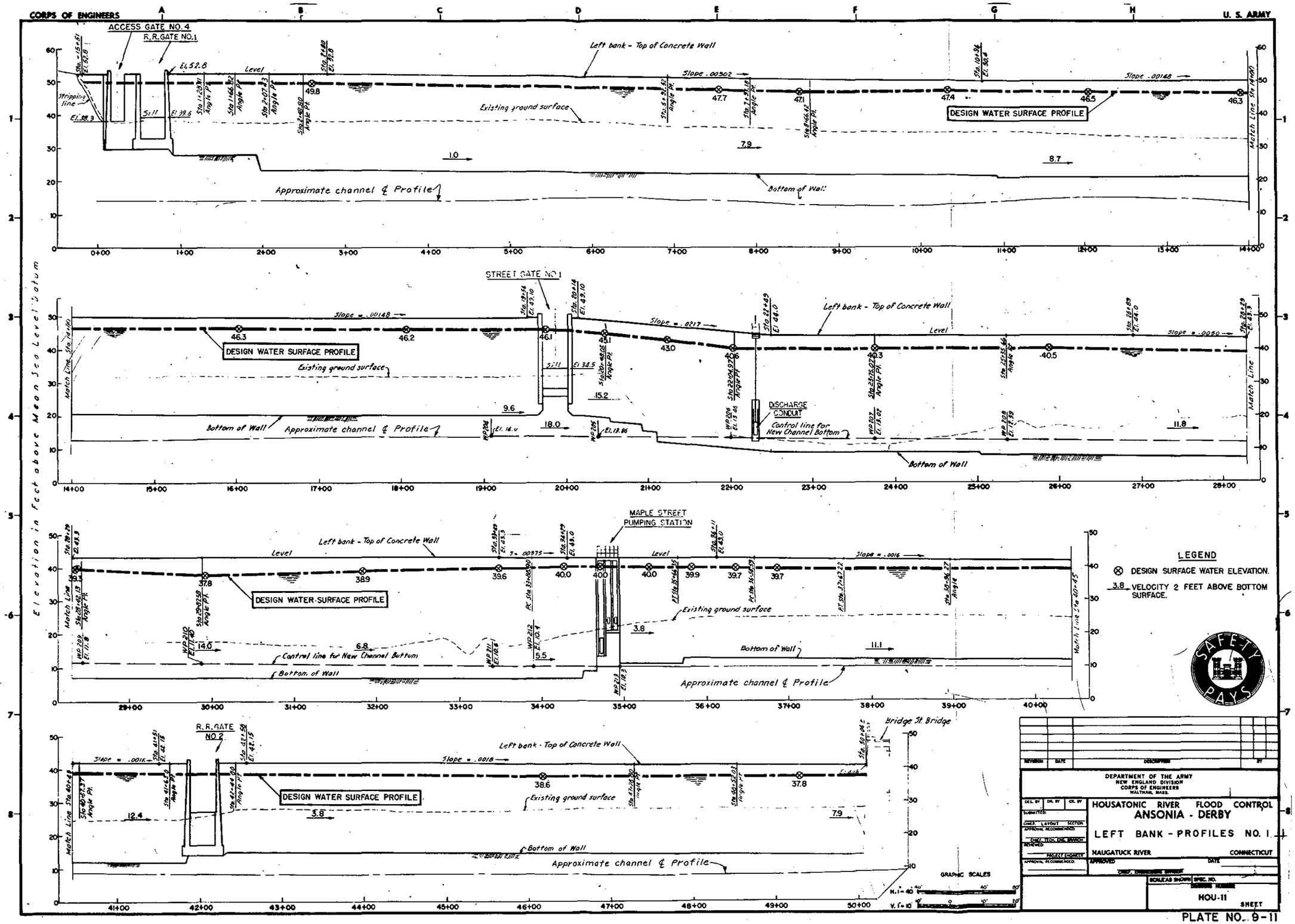
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
MAPLE STREET WALL
PLAN ELEVATION AND TYPICAL SECTIONS
HOUSATONIC RIVER CONNECTICUT

SCALE AS SHOWN
HOU-11

PLATE NO. 9-10

CORPS OF ENGINEERS — U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

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

DES. BY | DR. BY | CK. BY

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

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY

LEFT BANK - PROFILES NO. 1

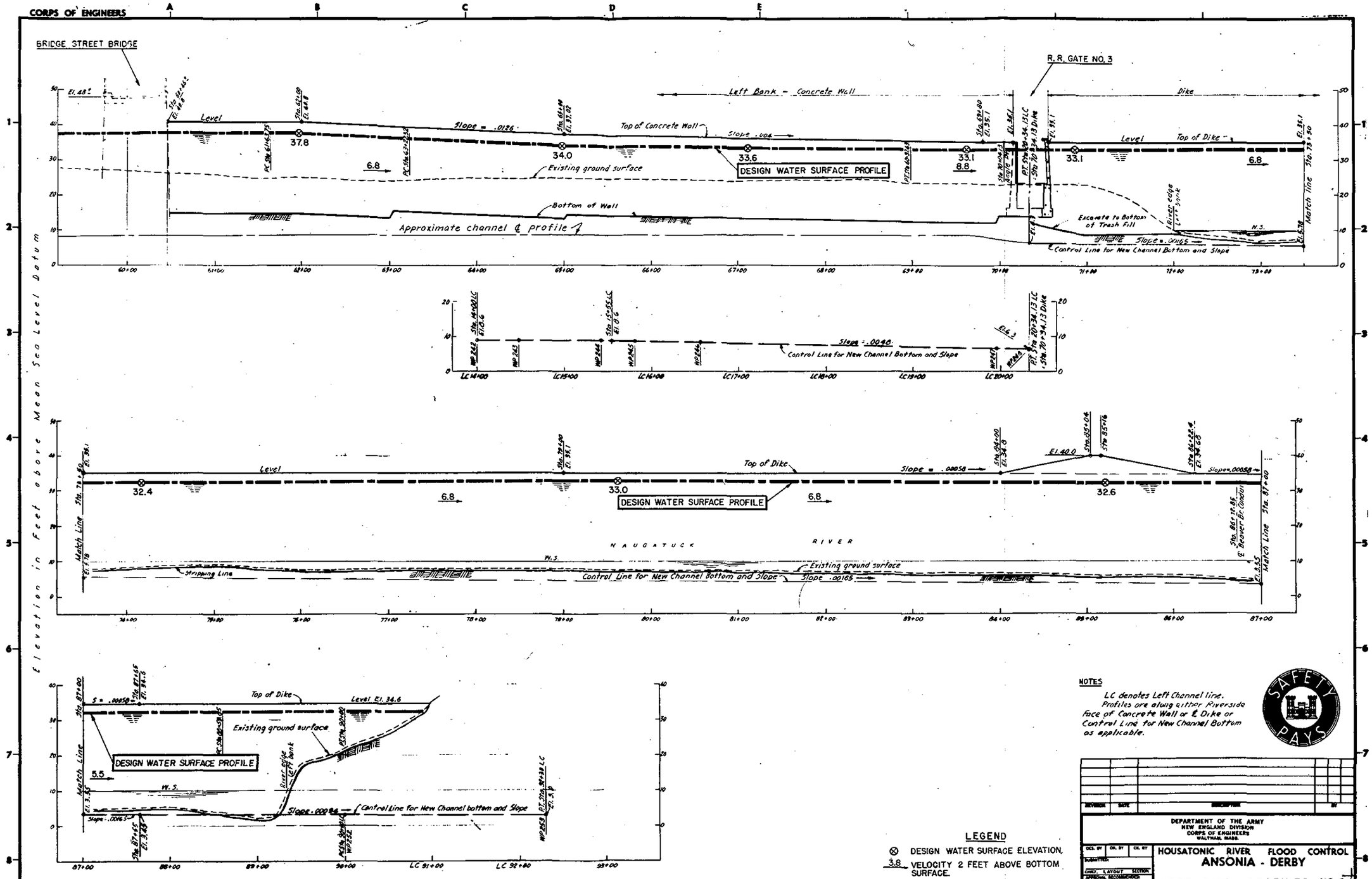
NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE: AS SHOWN | SPEC. NO.
DRAWING NUMBER: HOU-11 | SHEET

PLATE NO. 9-11

CORPS OF ENGINEERS



NOTES

LC denotes Left Channel line.
Profiles are along either Riverside Face of Concrete Wall or ℄ Dike or Control Line for New Channel Bottom as applicable.

LEGEND

⊗ DESIGN WATER SURFACE ELEVATION.
3.8 VELOCITY 2 FEET ABOVE BOTTOM SURFACE.

PROFILES

SCALES: HOR. 1"=40' VERT. 1"=10'

GRAPHIC SCALES

H. 1"=40' 40' 0 40' 80'
V. 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, LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, DESIGN BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY

LEFT BANK - PROFILES NO. 2

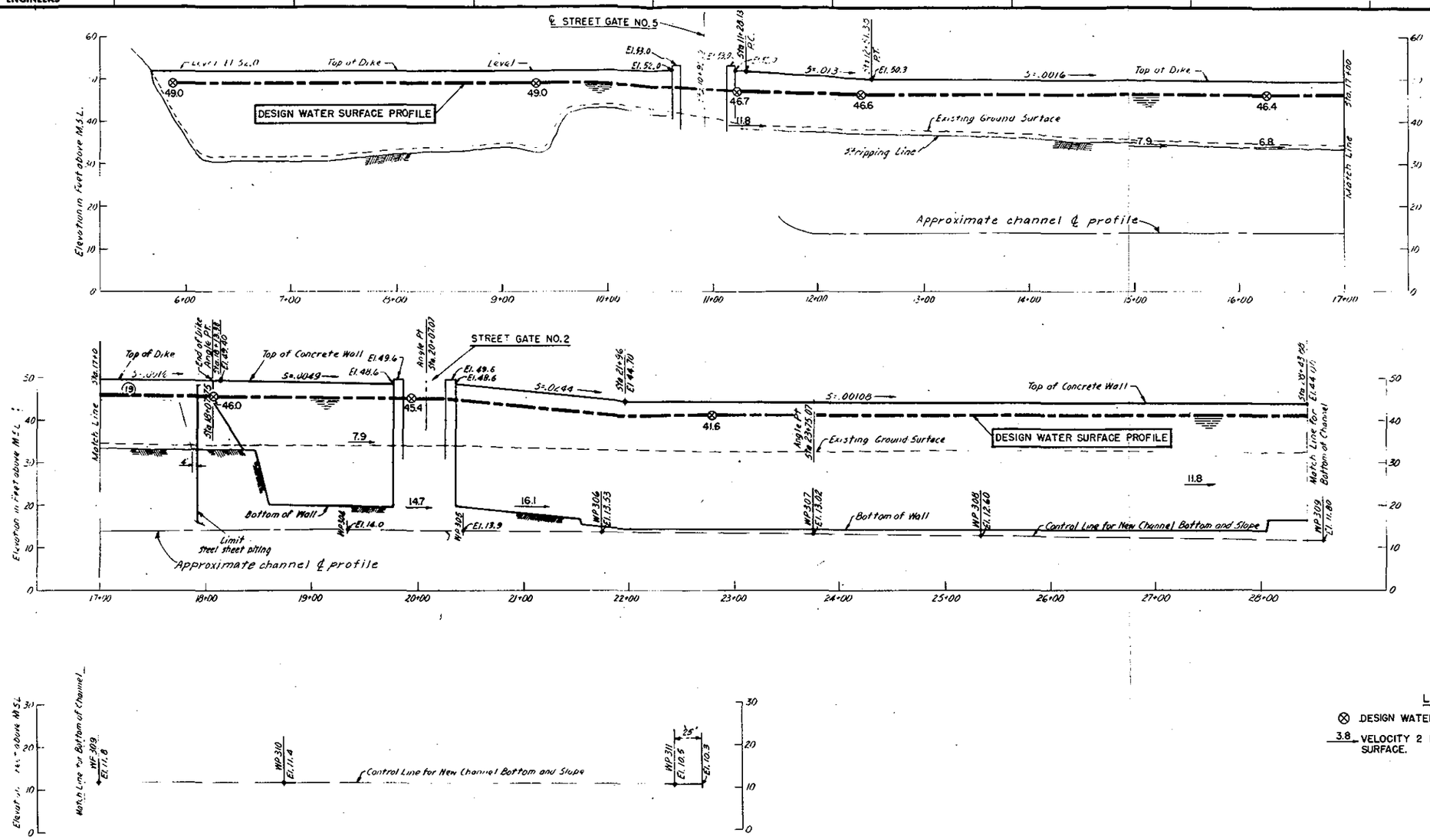
NAUGATUCK RIVER CONNECTICUT

APPROVED DATE
CHIEF, ENGINEERING DIVISION

SCALES SHOWN | SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET

PLATE NO. 9-12

CORPS OF ENGINEERS — U. S. ARMY



LEGEND

⊗ DESIGN WATER SURFACE ELEVATION.

3.8 VELOCITY 2 FEET ABOVE BOTTOM SURFACE.

GRAPHIC SCALES

H. 1" = 40' — 40' 0 40' 80'

V. 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, LAYOUT SECTION

APPROVAL RECOMMENDED:

CHIEF, TECH. ENG. BRANCH

REVIEWED:

CHIEF, ENGINEERING DIVISION

APPROVAL RECOMMENDED:

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY

RIGHT BANK - PROFILES NO. 1

NAUGATUCK RIVER — CONNECTICUT

APPROVED: — DATE:

CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO.

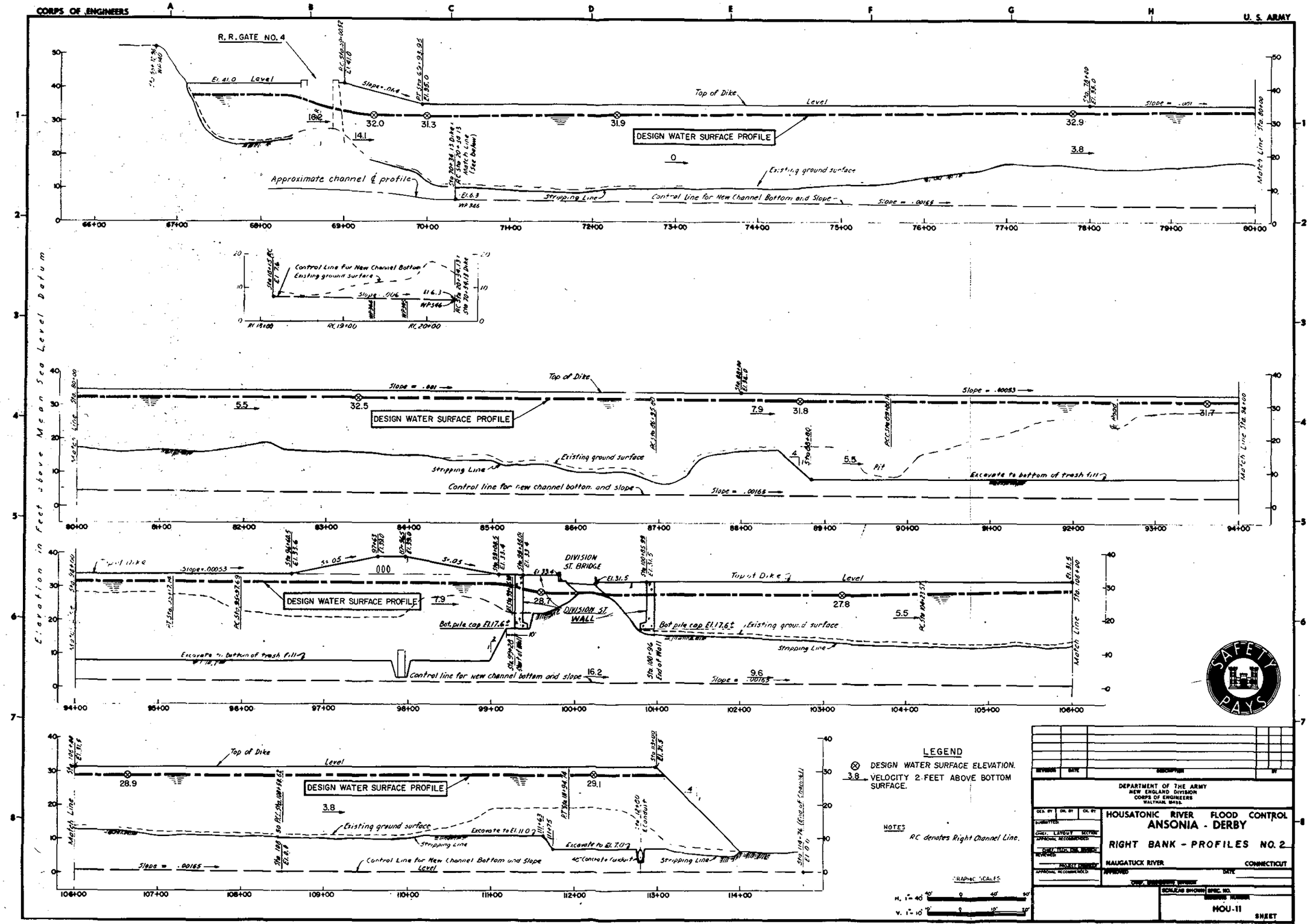
DRAWING NUMBER:

HOU-11

SHEET

PLATE NO. 9-13

CORPS OF ENGINEERS — U. S. ARMY



LEGEND

⊗ DESIGN WATER SURFACE ELEVATION.

3.8 → VELOCITY 2 FEET ABOVE BOTTOM SURFACE.

NOTES

RC denotes Right Channel Line.

GRAPHIC SCALES

H. 1" = 40' 0 40' 80'

V. 1" = 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, LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY

RIGHT BANK - PROFILES NO. 2

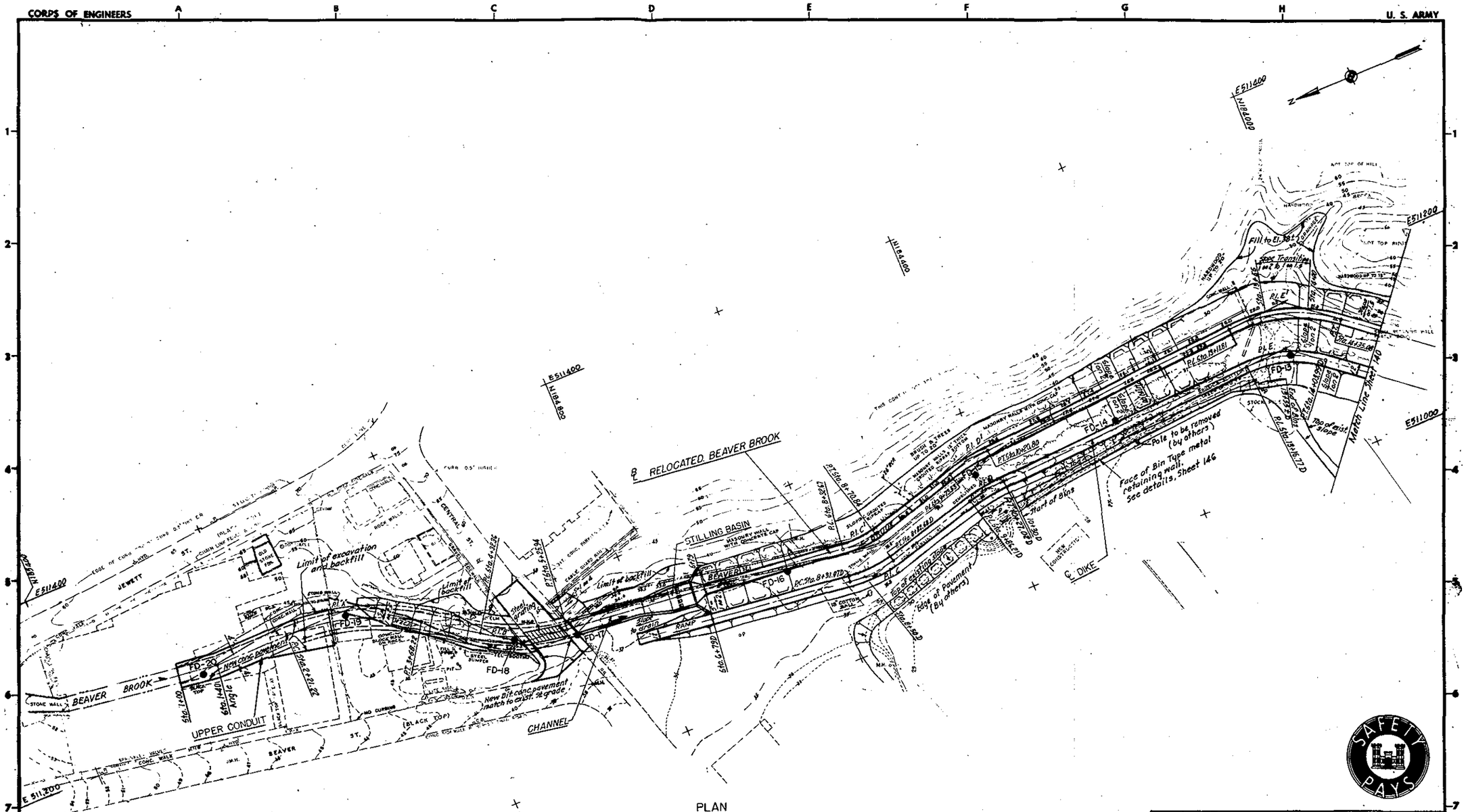
NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING BRANCH

SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET

PLATE NO. 9-14

CORPS OF ENGINEERS — U. S. ARMY



PLAN
SCALE 1"=40'

GRAPHIC SCALE
1"=40' 40' 0 40' 80'

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY — DR. BY E.J.K. — CK. BY

SUBMITTED:
CHIEF, LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
APPROVED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
BEAVER BROOK
PLAN - NO. 1
NAUGATUCK RIVER — CONNECTICUT

APPROVED: — DATE

SCALE: 1"=40' — SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET 139

PLATE NO. 9-15

CORPS OF ENGINEERS — U. S. ARMY

Note: For alignment data and other details in this area, see Sheet 144

INTAKE STRUCTURE

℄ LOWER CONDUIT

℄ RELOCATED BROOK

BEAVER BROOK

Slope Transition 1 on 1.5 to 1 on 2

Slope Transition 1 on 2 to 1 on 2.5

Slope Transition 1 on 2.5 to 1 on 2

Limit of Fill

Limit of topsoil

Limit of Excavation

Utility pole (existing)

CONCRETE WALL See Sheet 146

℄ DIKE

Twin Conduit to be Filled

Match Line Sheet 139

Match Line Sheet 16

FD-12 FD-10 FD-9 FD-82 FD-8 FD-96 FD-11 FD-95 FD-98

PLAN
SCALE 1"=40'

GRAPHIC SCALE
1" = 40' 40' 0 40' 80'

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
BEAVER BROOK
PLAN NO. 2

NAUGATUCK RIVER — CONNECTICUT

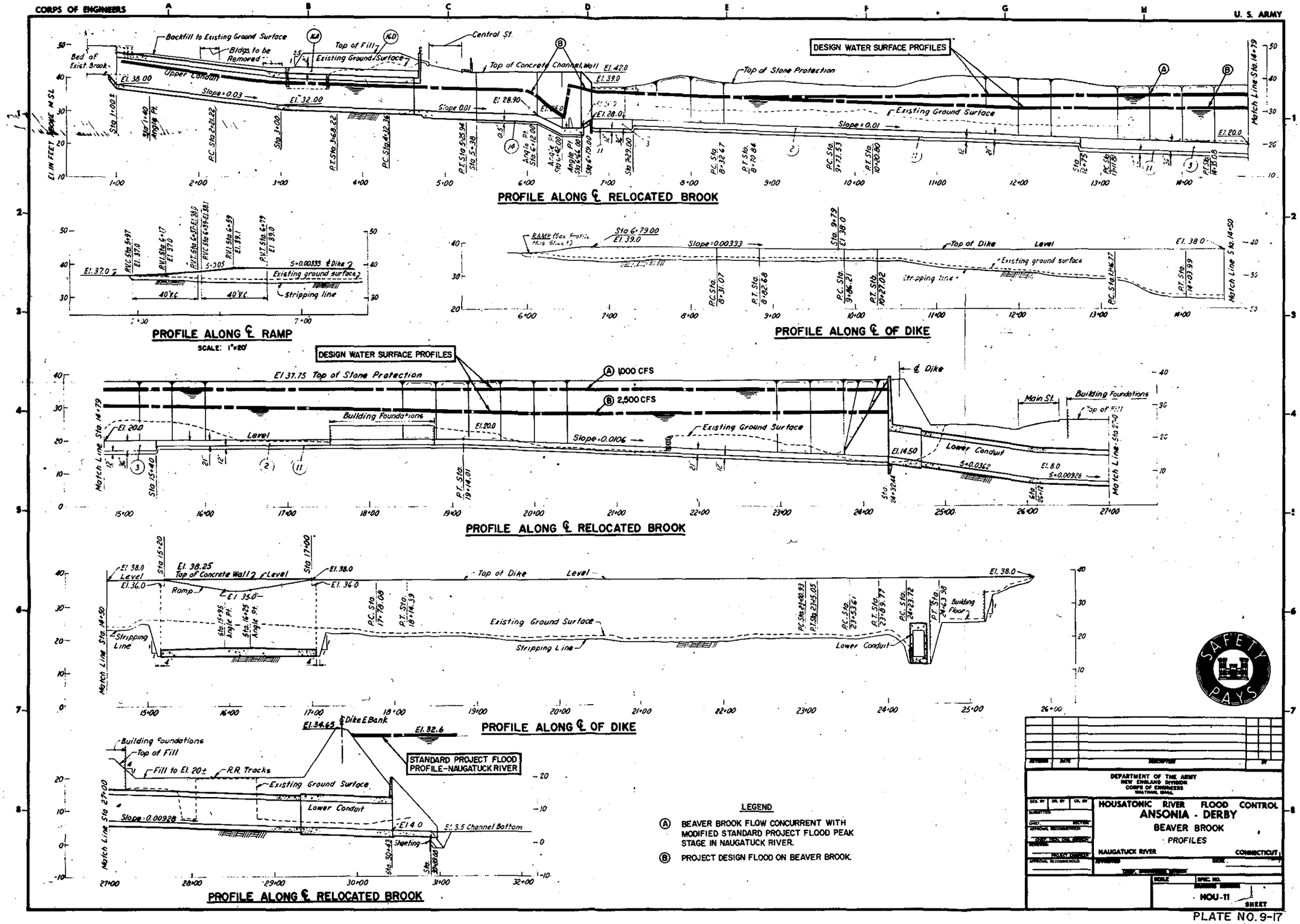
SCALE: 1" = 40'

HQU-11

SHEET 140

PLATE NO. 9-16

CORPS OF ENGINEERS U. S. ARMY



LEGEND

(A) BEAVER BROOK FLOW CONCURRENT WITH MODIFIED STANDARD PROJECT FLOOD PEAK STAGE IN NAUGATUCK RIVER.

(B) PROJECT DESIGN FLOOD ON BEAVER BROOK.

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

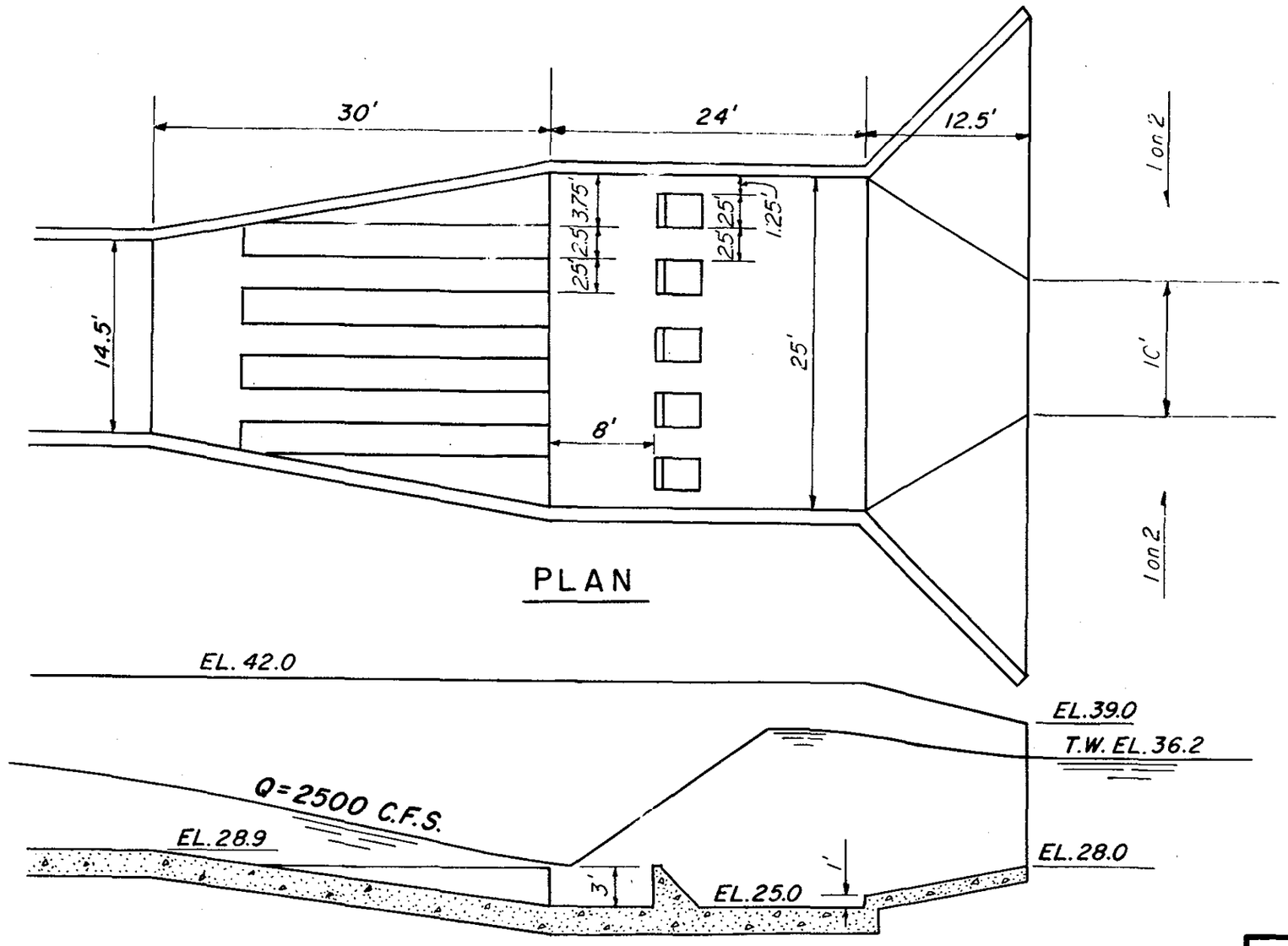
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
BEAVER BROOK
PROFILES

NAUGATUCK RIVER CONNECTICUT

SPEC. NO. HOU-11

PLATE NO. 9-17



CENTER LINE SECTION

SCALE: 1" = 10"

HOUSATONIC RIVER FLOOD CONTROL

ANSONIA - DERBY

BEAVER BROOK
STILLING BASIN

NAUGATUCK RIVER CONNECTICUT

PLATE NO. 9 - 18

NED FORM 223
27 Sept 49

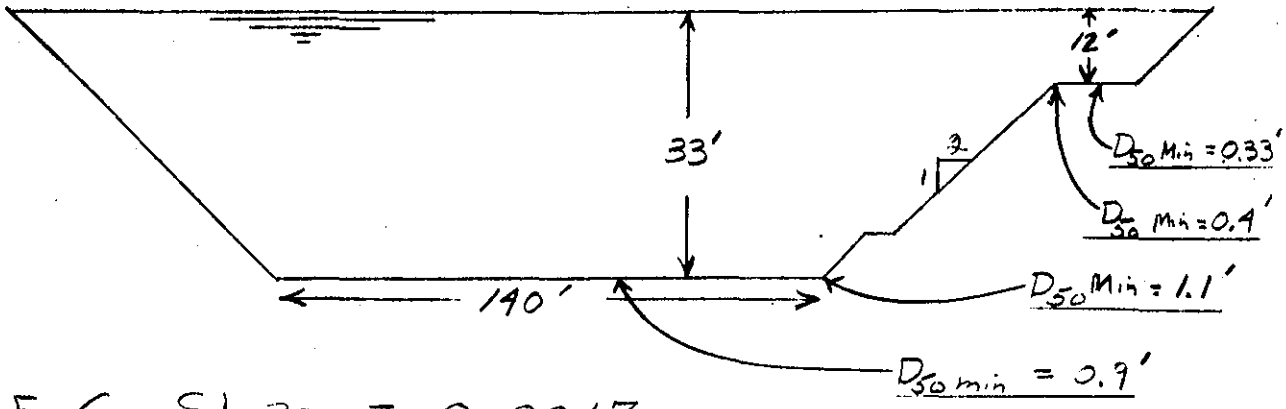
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE

SUBJECT ANSONIA-DERBY LPP
COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S
COMPUTED BY PLM CHECKED BY DATE 12-3-66

TYPICAL SECTION #1

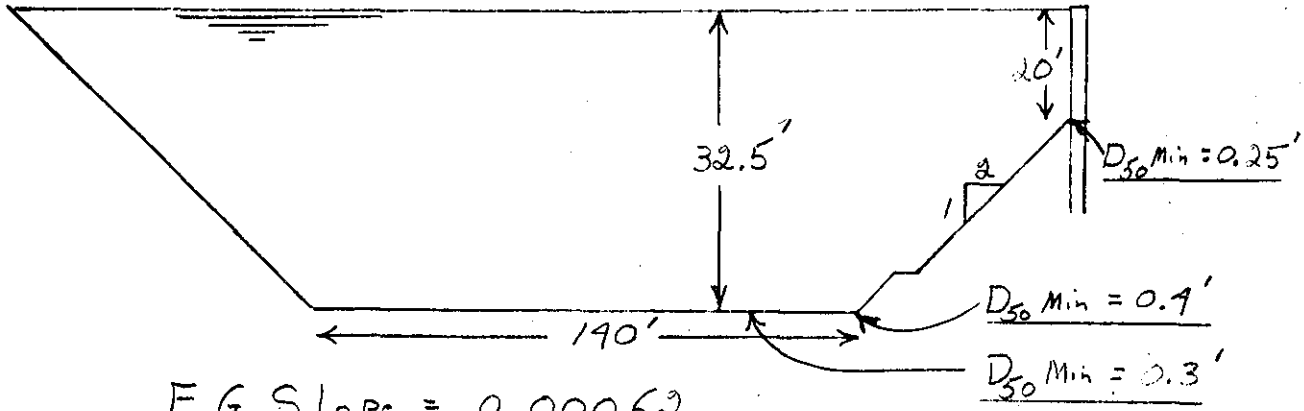
STa 2+49 To STa. 8+66.42 (Left Bank)



E.G. Slope = 0.0017

TYPICAL SECTION #2

STa. 8+66.42 To ABC Bridge



E.G. Slope = 0.00062

PLATE NO. 9-19

NED FORM 223
27 Sept 49

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

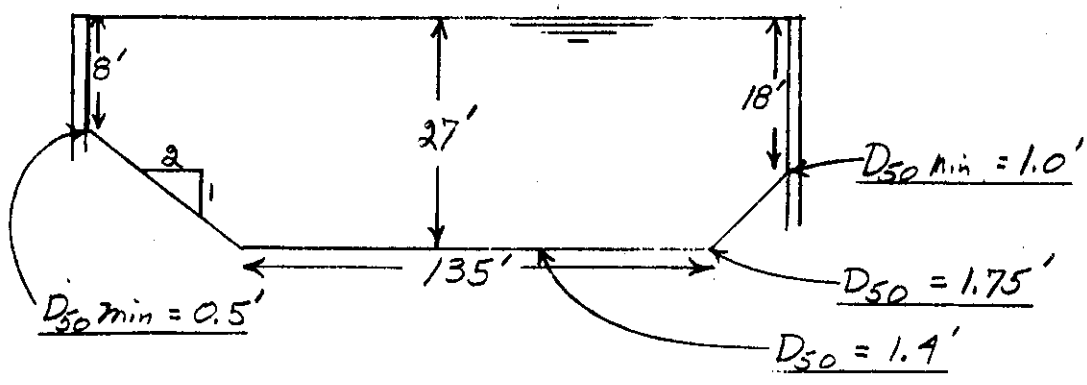
PAGE

SUBJECT ANSONIA-DERBY LPP.
COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S
COMPUTED BY PLM CHECKED BY DATE 12-3-66

TYPICAL SECTION #3

ABC Bridge To Maple ST. Bridge

STa 19+60 To 35+10 (Left Bank)
STa 20+10 To 35+10 (Right Bank)



E.G. Slope = 0.0033

R = 21.0

$\overline{D}_{50}$ = 1.3

PLATE NO. 9-20

NED FORM 223
27 Sept 49

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

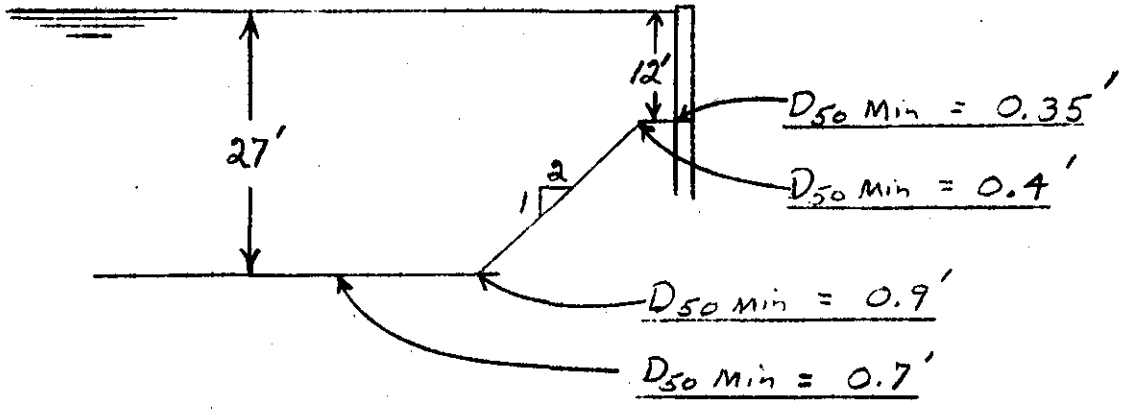
PAGE

SUBJECT: ANSONIA-DERBY LPP.
COMPUTATION: STONE RIPRAP DESIGN - D_{50} MIN'S
COMPUTED BY: PLM CHECKED BY: DATE: 12-3-66

TYPICAL SECTION #4

Below Maple ST.

STa. 35+10 To STa. 41+64 (Left Bank)

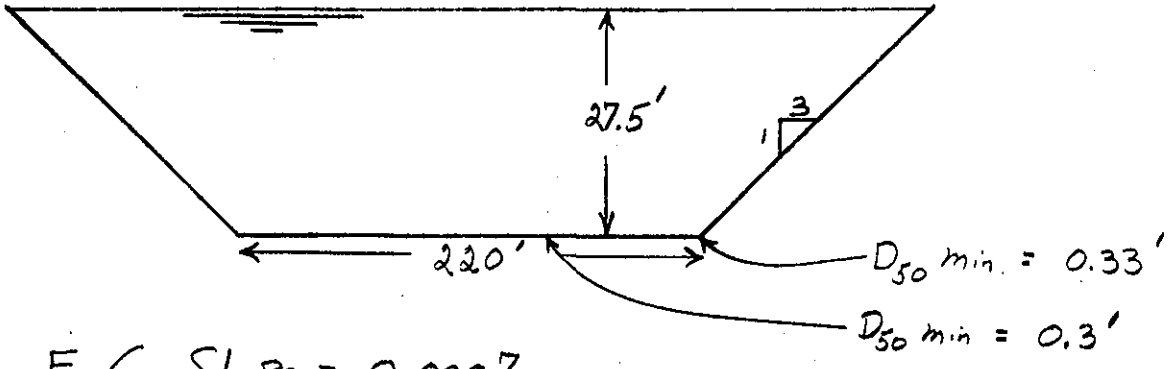


E. G. Slope = 0.0017

TYPICAL SECTION #5

Railroad Bridge - Division ST. Bridge

STa. 69+00 To 99+00 (Right Bank)
STa. 67+00 To 92+30 (LEFT Bank)



E.G. Slope = 0.0007

PLATE NO. 9-21

NED FORM 223
27 Sept 49

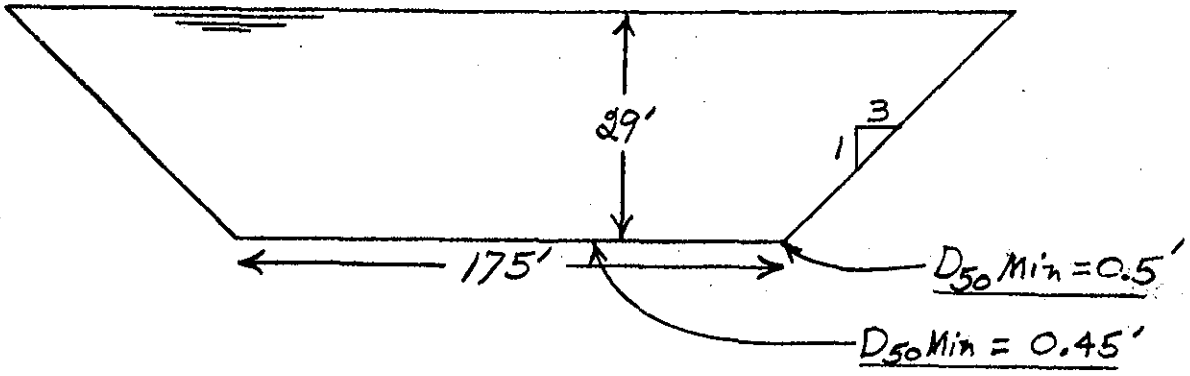
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE

SUBJECT ANSONIA-DERBY LPP.
COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S
COMPUTED BY PLM CHECKED BY DATE 12-3-66

TYPICAL SECTION #6

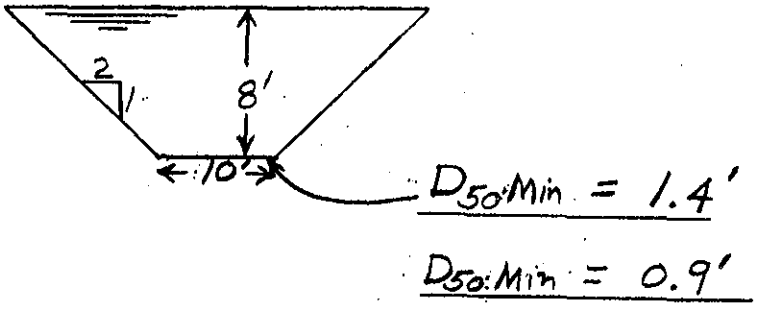
Below Division St. Bridge



E.G. Slope = 0.001

TYPICAL SECTION #7

Beaver Brook

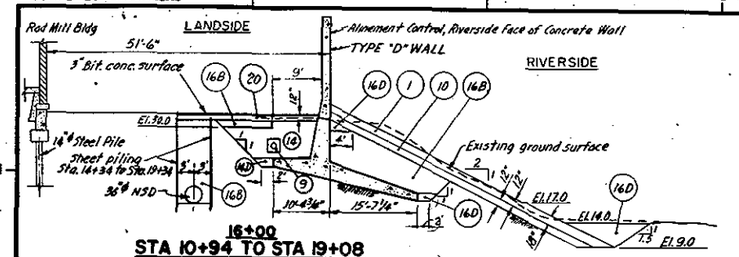


E.G. Slope = 0.01

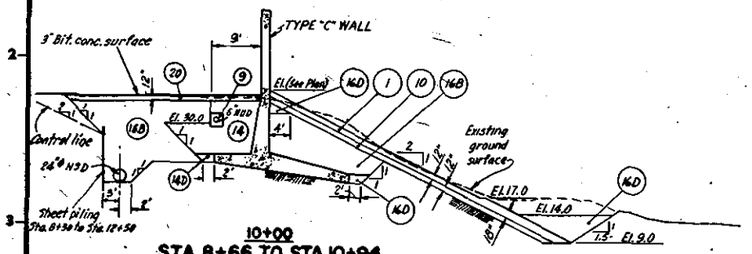
PLATE NO. 9-22

CORPS OF ENGINEERS

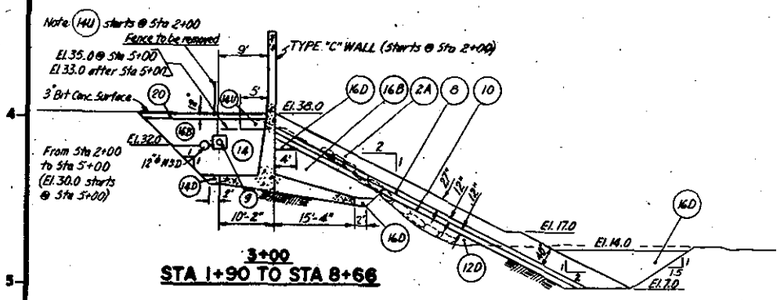
U. S. ARMY



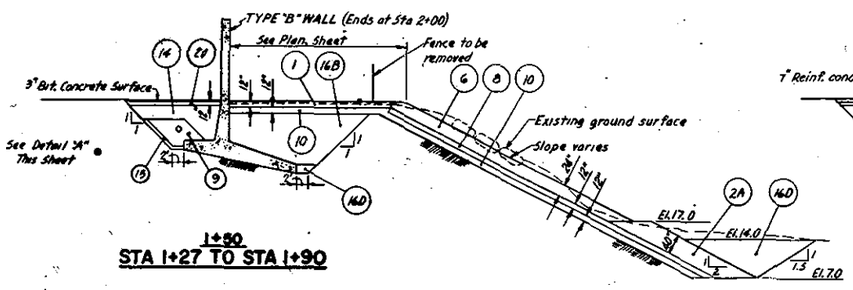
16+00
STA 10+94 TO STA 19+08



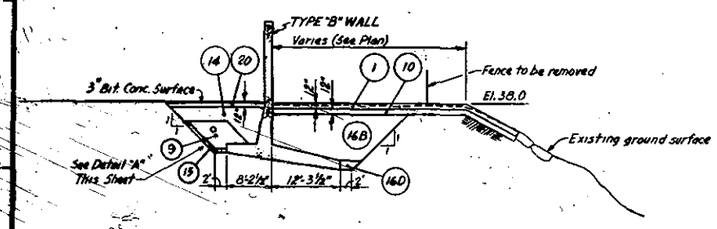
10+00
STA 8+66 TO STA 10+94



3+00
STA 1+90 TO STA 8+66

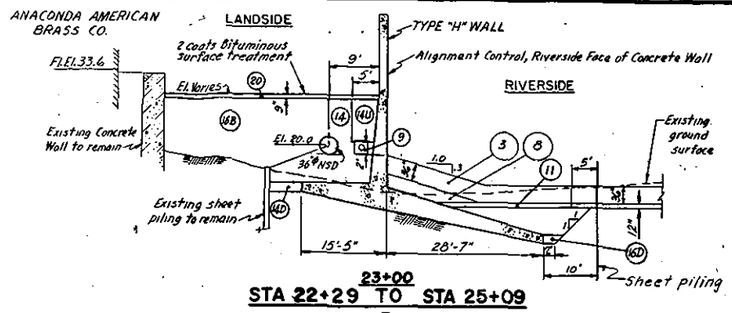


1+50
STA 1+27 TO STA 1+90

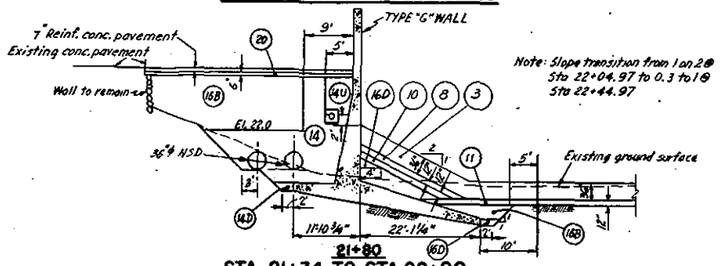


1+10
STA 0+90 TO STA 1+27

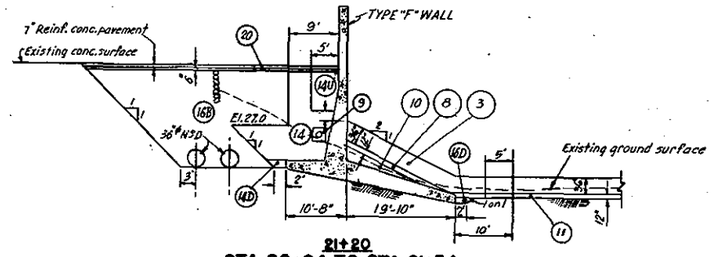
TYPICAL SECTIONS
SCALE 1" = 10'



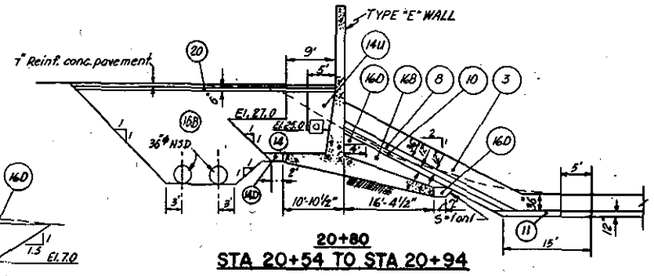
23+00
STA 22+29 TO STA 25+09



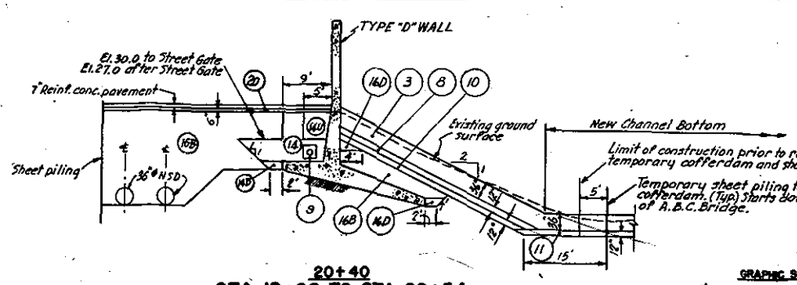
21+80
STA 21+34 TO STA 22+29



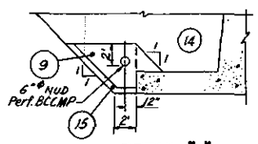
21+20
STA 20+94 TO STA 21+34



20+80
STA 20+54 TO STA 20+94



20+40
STA 19+08 TO STA 20+54
STA. 19+34 TO STA. 20+34 STREET GATE NO. 1, SEE SHEET 47



DETAIL "A"
(CRUSH STONE TOE DRAIN FROM R.R. GATE NO. 1 TO STA 2+00)
SCALE: 1" = 5'

GRAPHIC SCALE
1" = 5' 5' 0 5' 10'
1" = 10' 10' 0 10' 20'

MATERIALS LEGEND

DESIGNATION	TYPE OF MATERIAL	PAYMENT ITEM NO.
1	Class I Stone Protection	14
2	Class II Stone Protection	15
2A	Class II A Stone Protection	16
3	Class III Stone Protection	17
4	Class IV Stone Protection	18
6	Class VI Stone Protection	19
7	Class VII Stone Protection	20
8	Stone Bedding	22
9	Crushed Stone Fill	9
10	Class I Gravel Bedding	12
11	Class II Gravel Bedding	13
12	Compacted Gravel Fill	7
12U	Uncompacted Gravel Fill	7
12D	Dumped Gravel Fill	7
13	Road Gravel	11
14	Compacted Sand Fill	8
14U	Uncompacted Sand Fill	8
14D	Dumped Sand Fill	8
15	Filter Sand Fill	10
16A	Class "A" Compacted Random Fill	6
16B	Class "B" Compacted Random Fill	6
16U	Uncompacted Random Fill	6
16D	Dumped Random Fill	6
	Deleted	
17	Topsoil	119
18	Compacted Pervious Fill	5
18U	Uncompacted Pervious Fill	5
18D	Dumped Pervious Fill	5
19	Compacted Impervious Fill	4
19U	Uncompacted Impervious Fill	4
19D	Dumped Impervious Fill	4
20	Rolled Gravel Base	

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

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

DES. BY R.P. DR. BY CK. BY

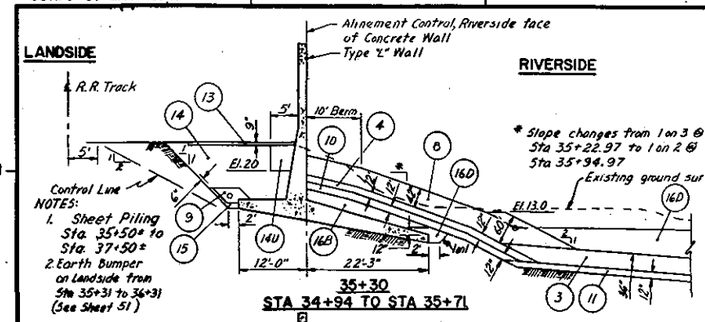
SUBMITTED:
CHIEF, CONST. SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. SECTION
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

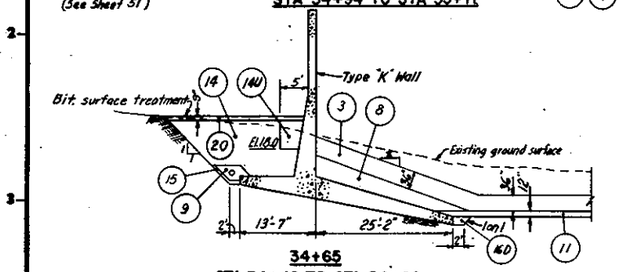
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
LEFT BANK
TYPICAL SECTIONS NO. 1
NAUGATUCK RIVER CONNECTICUT
APPROVED DATE
CHIEF, ENGINEERING DIVISION

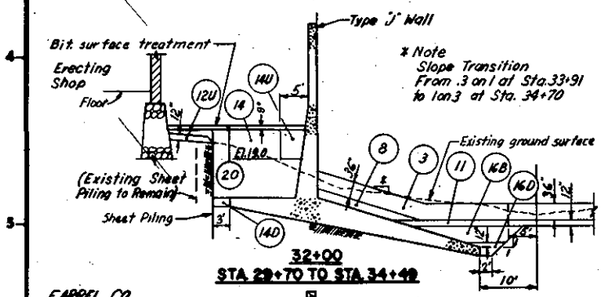
SCALES SHOWN SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET 31

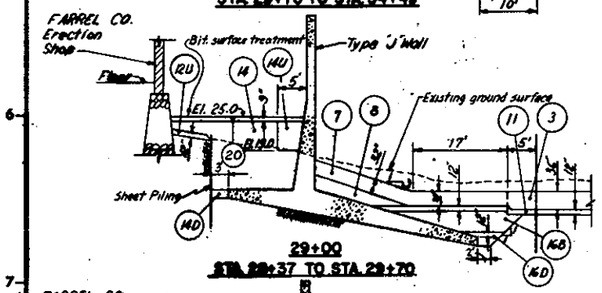
PLATE NO. 9-23

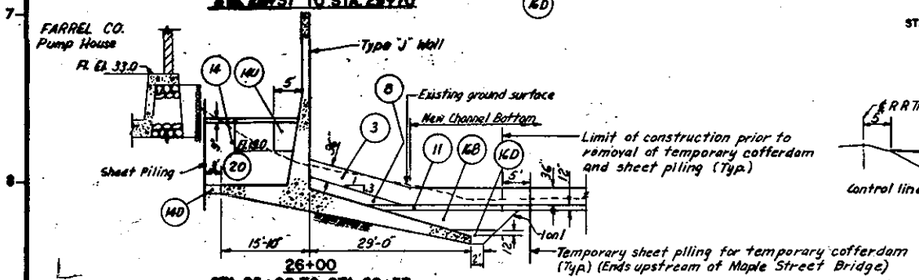
CORPS OF ENGINEERS — U. S. ARMY

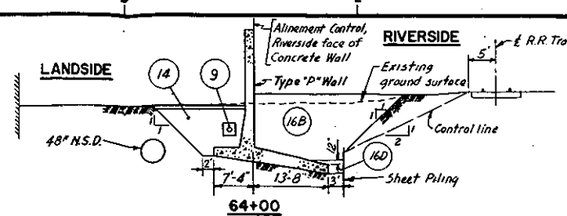


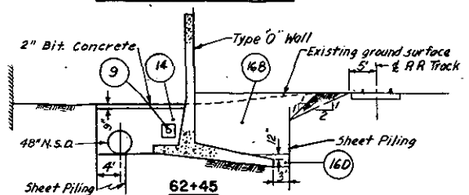


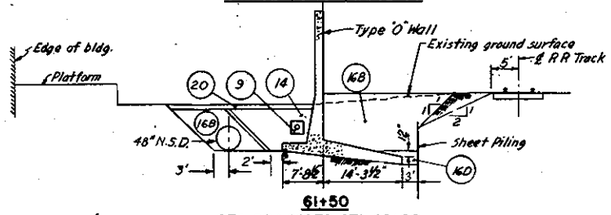


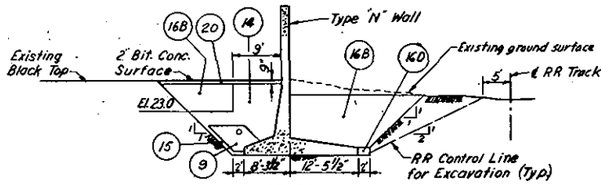


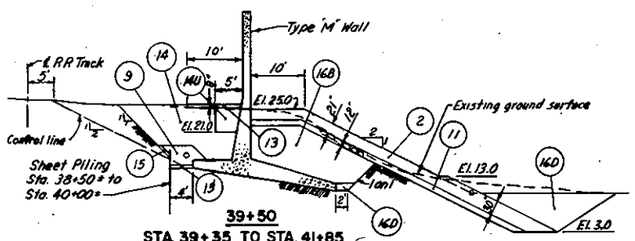


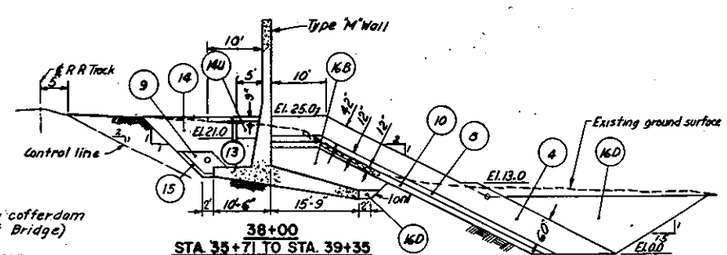


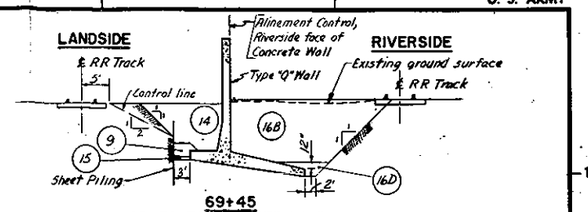


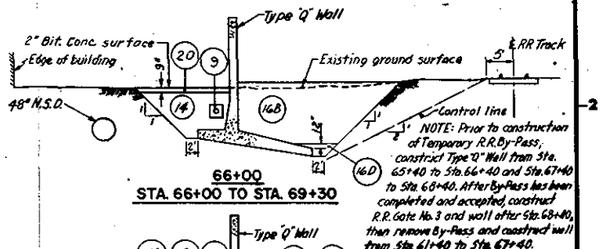


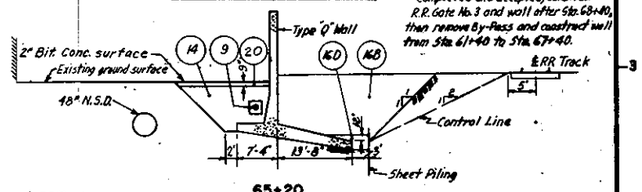


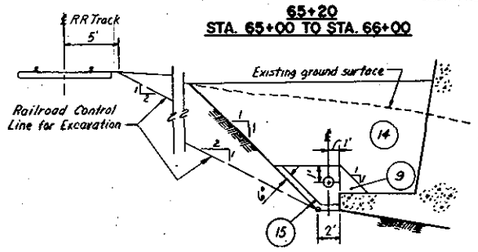




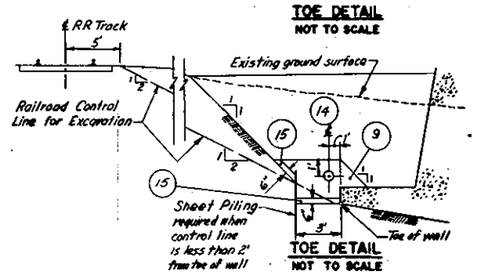








TOE DETAIL
NOT TO SCALE



TOE DETAIL
NOT TO SCALE

SAFETY PAYS

TYPICAL SECTIONS

SCALE = 1" = 10'

GRAPHIC SCALE 1" = 10' — 10' 0 10' 20'

REVISION	DATE	DESCRIPTION	BY

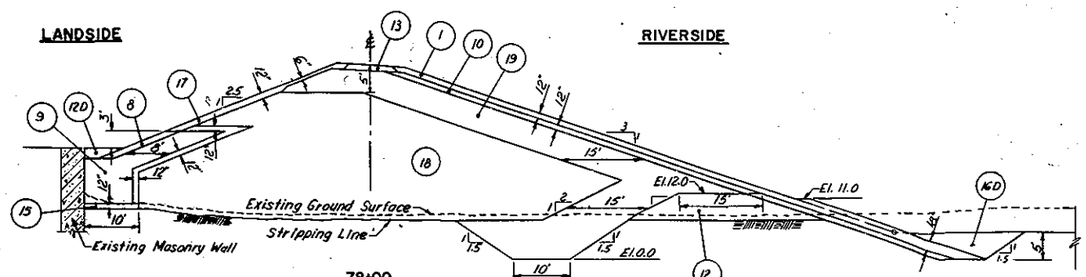
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY R.T.C. | DR. BY W.J.E. | CK. BY
SUBMITTED:
CHIEF, LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, HYDR. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

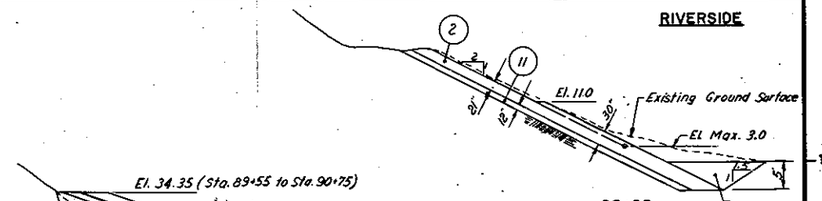
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
LEFT BANK
TYPICAL SECTIONS NO. 2
NAUGATUCK RIVER — CONNECTICUT
APPROVED — DATE
CHIEF, ENGINEERING DIVISION
SCALE 1" = 10' — SPEC. NO.
DRAWING NUMBER: HOU-11
SHEET 32

PLATE NO. 9-24

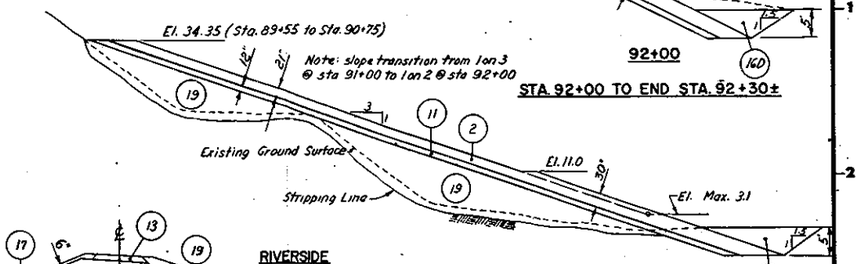
CORPS OF ENGINEERS — U. S. ARMY



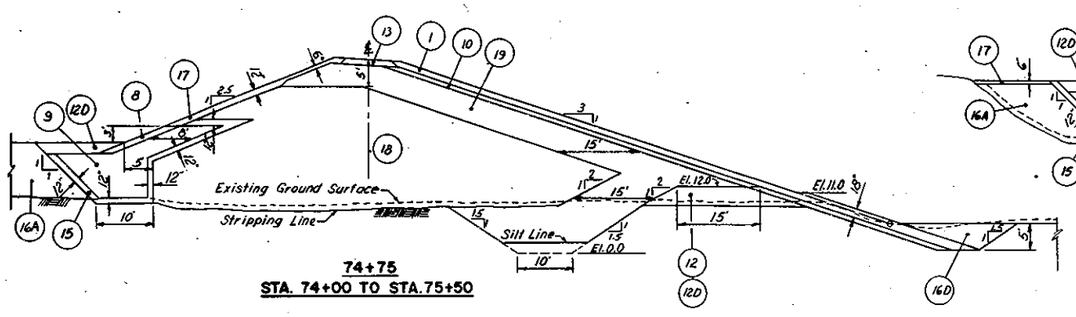
78+00
STA. 75+50 TO STA. 84+00
STA 84+00 TO STA 86+23
FRONT ST PUMPING STATION, SEE SHEET 54



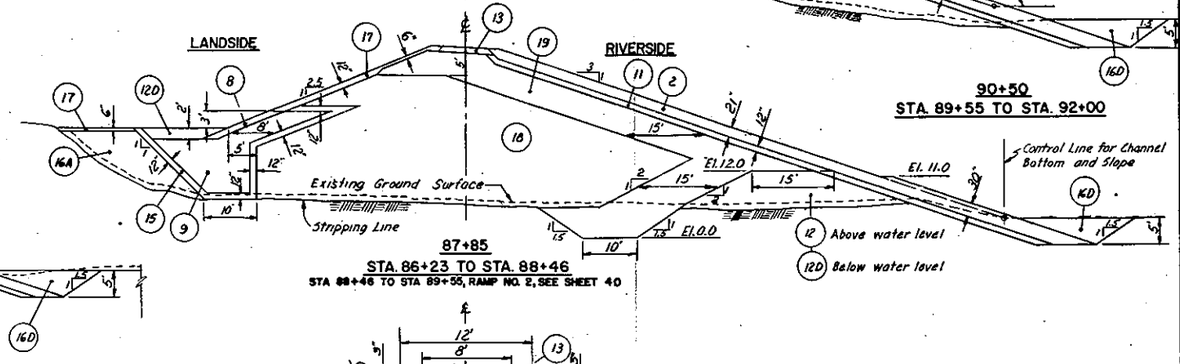
92+00
STA. 92+00 TO END STA. 92+30±



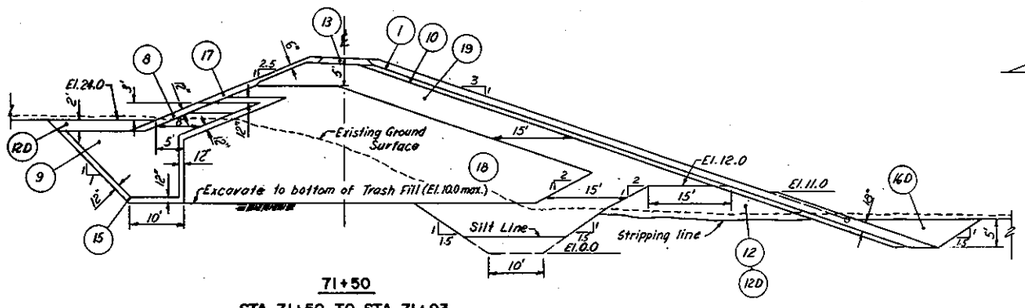
90+50
STA. 89+55 TO STA. 92+00



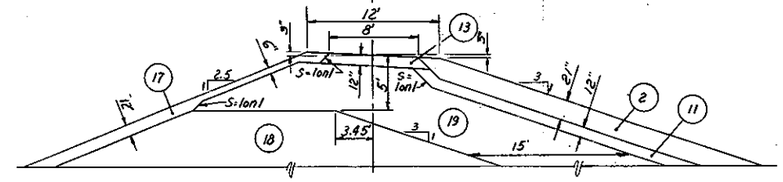
74+75
STA. 74+00 TO STA. 75+50



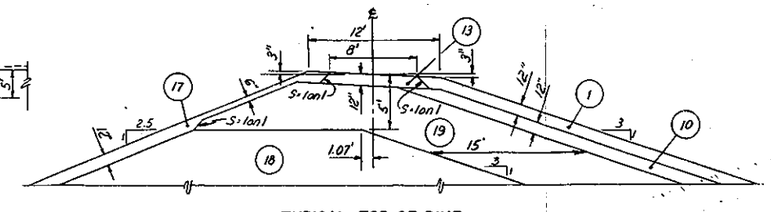
87+85
STA. 86+23 TO STA. 88+46
STA 88+46 TO STA 89+55, RAMP NO. 2, SEE SHEET 40



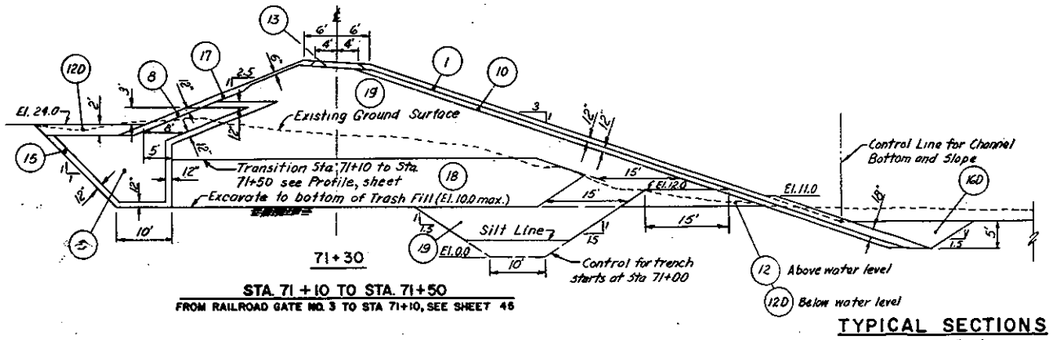
71+50
STA. 71+50 TO STA. 71+93
STA 71+93 TO STA 74+00
RAMP NO 1, SEE SHEET 40



TYPICAL TOP OF DIKE
STA. 86+30 TO STA. 88+46
NOT TO SCALE



TYPICAL TOP OF DIKE
RAILROAD GATE NO. 3 TO STA. 86+30
NOT TO SCALE



71+30
STA. 71+10 TO STA. 71+50
FROM RAILROAD GATE NO. 3 TO STA 71+10, SEE SHEET 46

TYPICAL SECTIONS
SCALE 1" = 10'

GRAPHIC SCALE
10 0 10 20
1" = 10'

REVISION	DATE	DESCRIPTION	BY

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

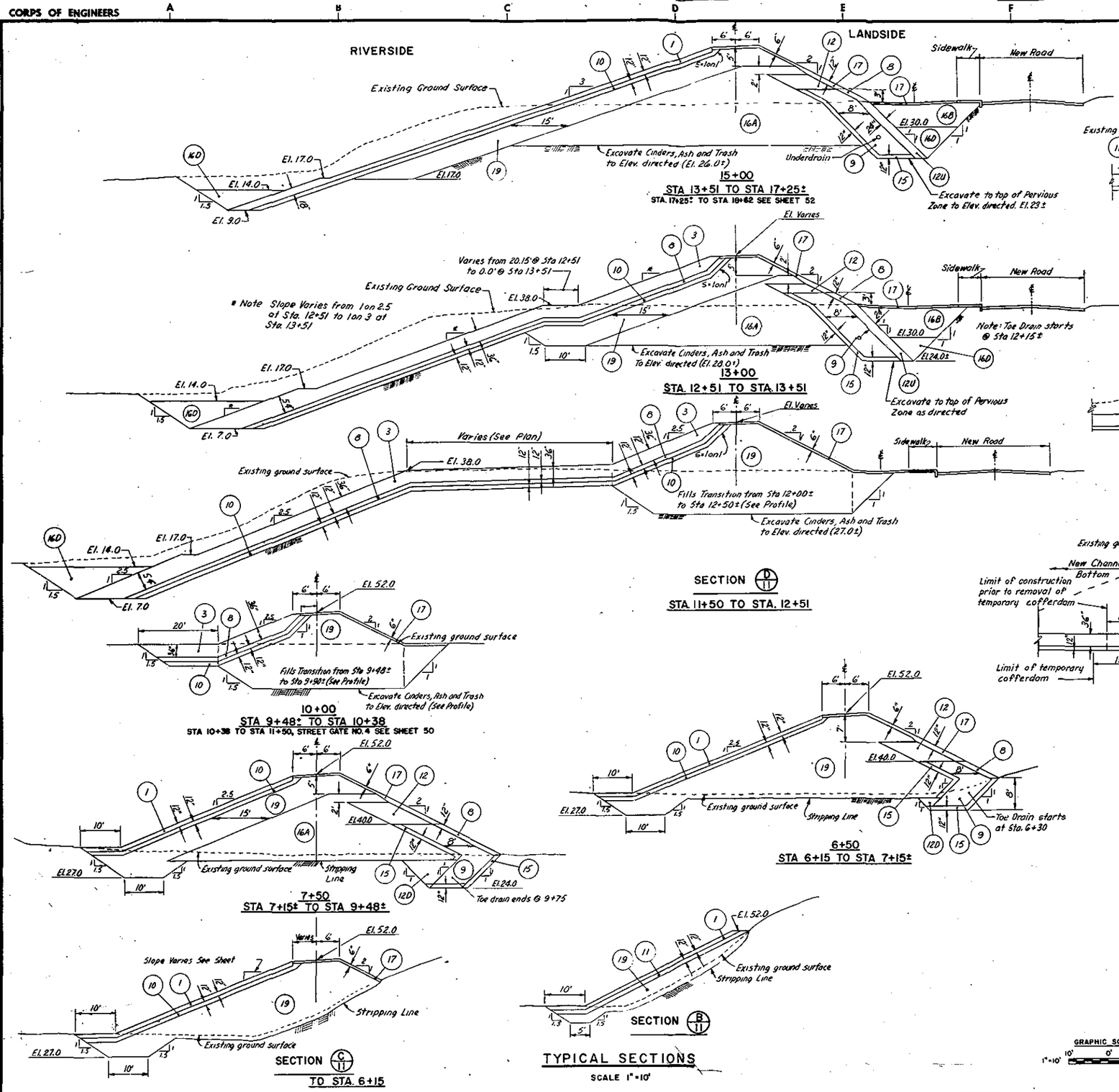
DES. BY R.T.C. | DR. BY W.A.F. | CK. BY
SUBMITTED:
CHIEF, LAYOUT SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
LEFT BANK
TYPICAL SECTIONS NO. 3
NAUGATUCK RIVER — CONNECTICUT
DATE
APPROVED:
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET 33

PLATE NO. 9-25

CORPS OF ENGINEERS — U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

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

DES. BY R.T.C. — DR. BY W.J.F. — CK. BY

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

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
RIGHT BANK
TYPICAL SECTIONS NO. 1

NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN — SPEC. NO.
DRAWING NUMBER
HOU-11
SHEET 34

PLATE NO. 9-26

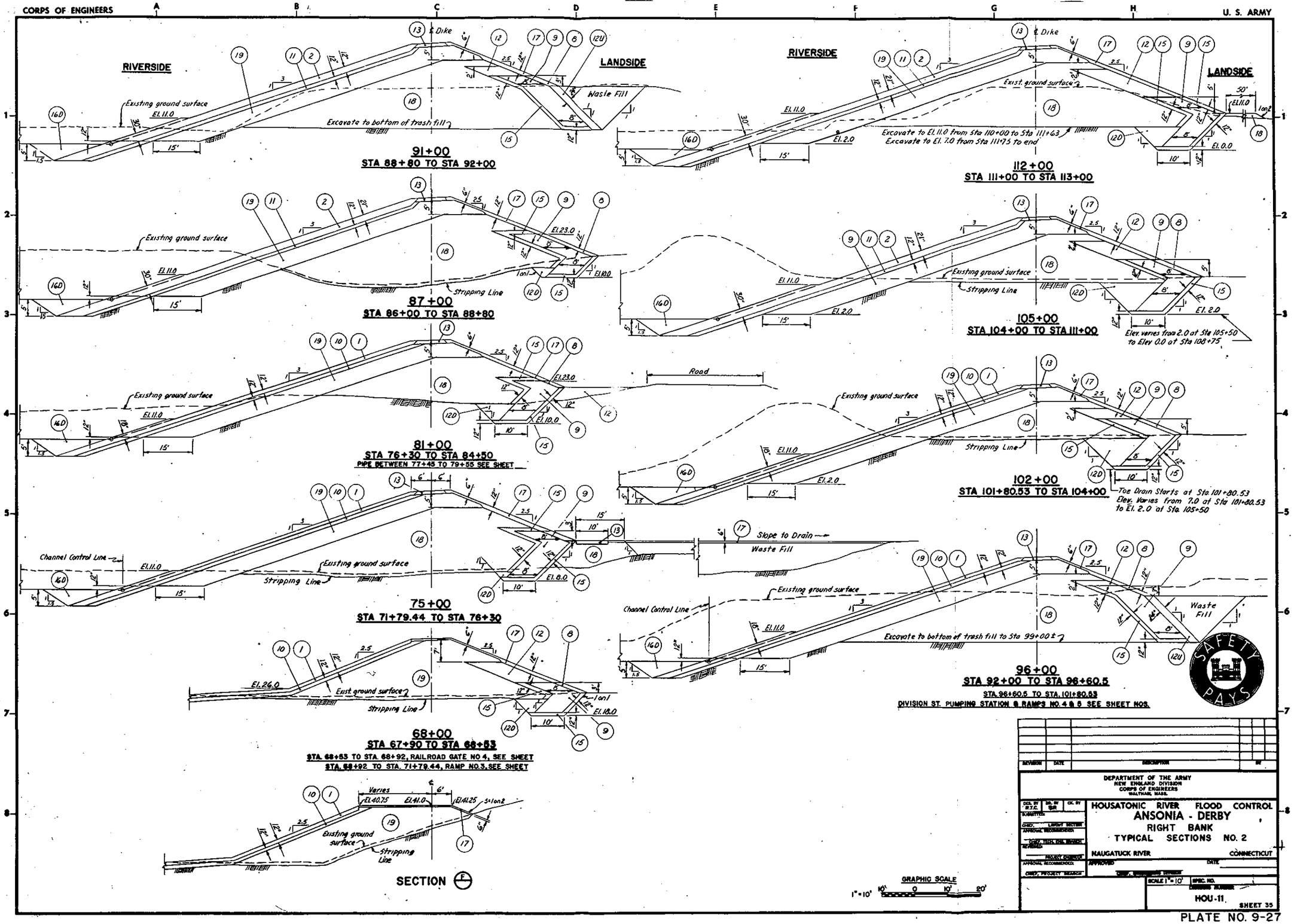
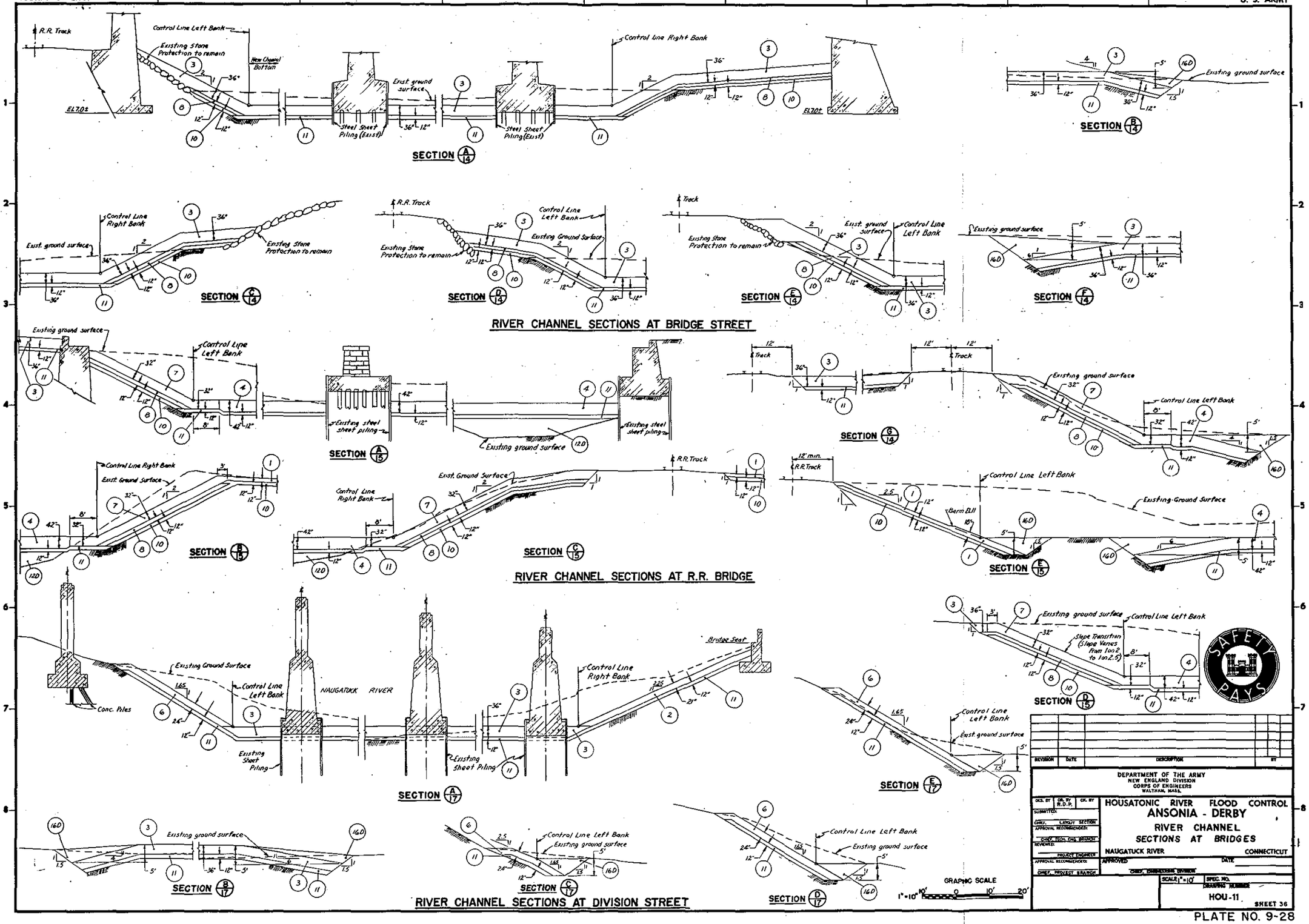

CORPS OF ENGINEERS
U. S. ARMY
RIVERSIDE
LANDSIDE
Existing ground surface
Excavate to bottom of trash fill
Waste Fill
91+00
STA 88+80 TO STA 92+00
Exist. ground surface
Excavate to El. 11.0 from Sta 110+00 to Sta 111+63
Excavate to El. 7.0 from Sta 111+75 to end
112+00
STA 111+00 TO STA 113+00
Stripping Line
87+00
STA 86+00 TO STA 88+80
105+00
STA 104+00 TO STA 111+00
Elev. varies from 2.0 at Sta 105+50 to Elev 0.0 at Sta 108+75
Road
81+00
STA 76+30 TO STA 84+50
PIPE BETWEEN 77+45 TO 79+55 SEE SHEET
102+00
STA 101+80.53 TO STA 104+00
Toe Drain Starts at Sta 101+80.53
Elev. Varies from 7.0 at Sta 101+80.53 to El. 2.0 at Sta 105+50
Channel Control Line
Slope to Drain
75+00
STA 71+79.44 TO STA 76+30
Excavate to bottom of trash fill to Sta 99+00±
96+00
STA 92+00 TO STA 96+60.5
STA 96+60.5 TO STA 101+80.53
DIVISION ST. PUMPING STATION & RAMPS NO. 4 & 5 SEE SHEET NOS.
68+00
STA 67+90 TO STA 68+53
STA 68+53 TO STA 68+92, RAILROAD GATE NO 4, SEE SHEET
STA 68+92 TO STA 71+79.44, RAMP NO.3, SEE SHEET
SECTION F
GRAPHIC SCALE
1"=10'
SAFETY PAYS
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
RIGHT BANK
TYPICAL SECTIONS NO. 2
NAUGATUCK RIVER
CONNECTICUT
SCALE 1"=10'
HOU-11
SHEET 35

PLATE NO. 9-27

CORPS OF ENGINEERS — U. S. ARMY



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

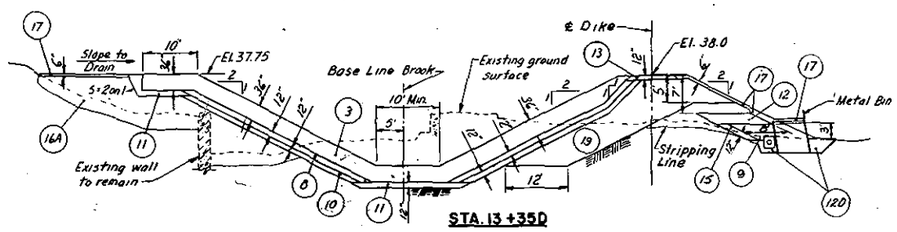
HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
RIVER CHANNEL
SECTIONS AT BRIDGES

NAUGATUCK RIVER — CONNECTICUT

SCALE 1" = 10' — SPEC. NO. — DRAWING NUMBER HOU-11 — SHEET 36

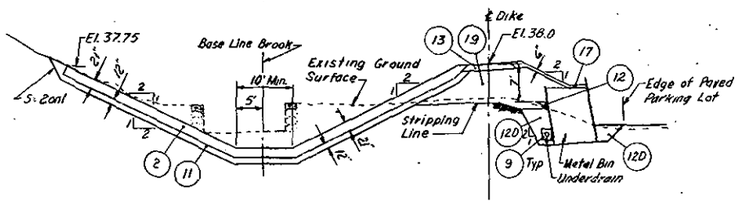
PLATE NO. 9-28

CORPS OF ENGINEERS — U. S. ARMY



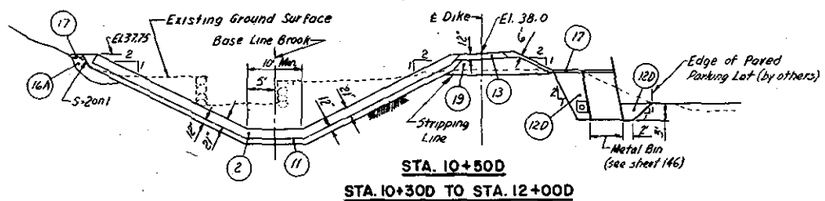
STA. 13+35D

STA. 12+75D TO STA. 13+45D



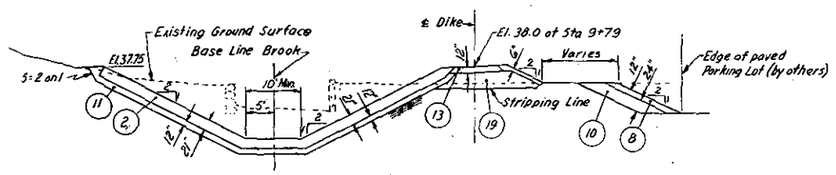
STA. 12+00D

STA. 12+00D TO STA. 12+75D



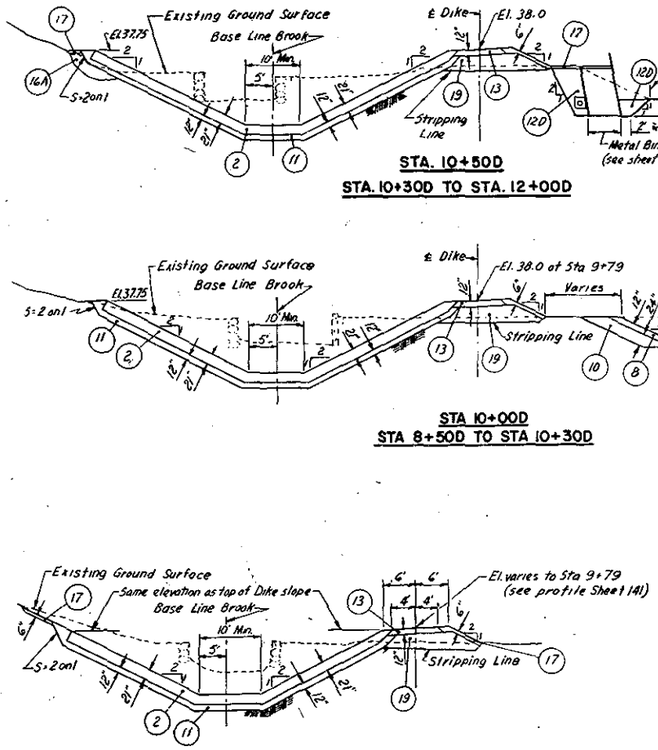
STA. 10+50D

STA. 10+30D TO STA. 12+00D



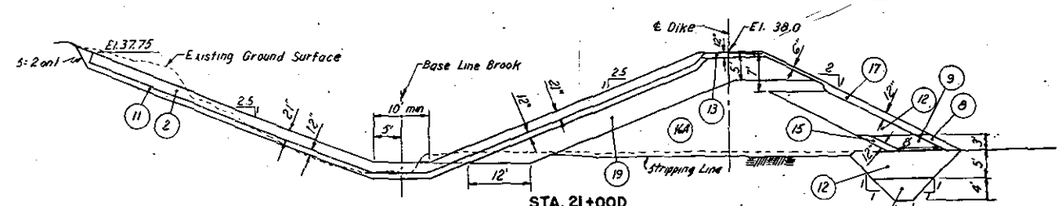
STA 10+00D

STA 8+50D TO STA 10+30D



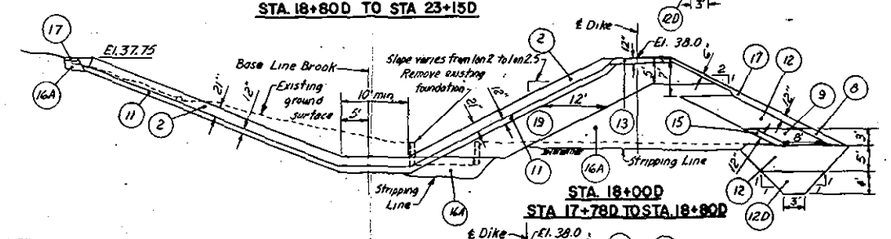
STA. 8+00D

STA. 7+29D TO STA. 8+50D



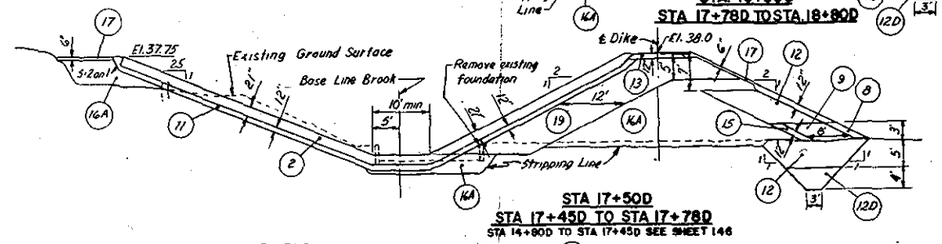
STA. 21+00D

STA. 18+80D TO STA 23+15D



STA. 18+00D

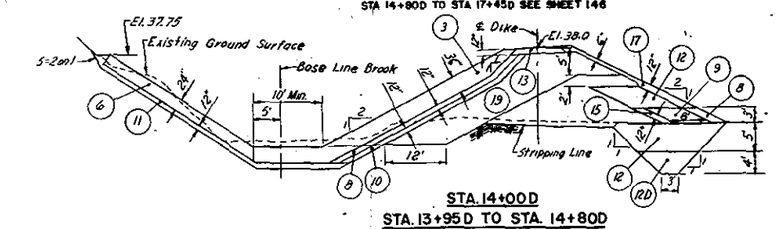
STA 17+78D TO STA 18+80D



STA 17+50D

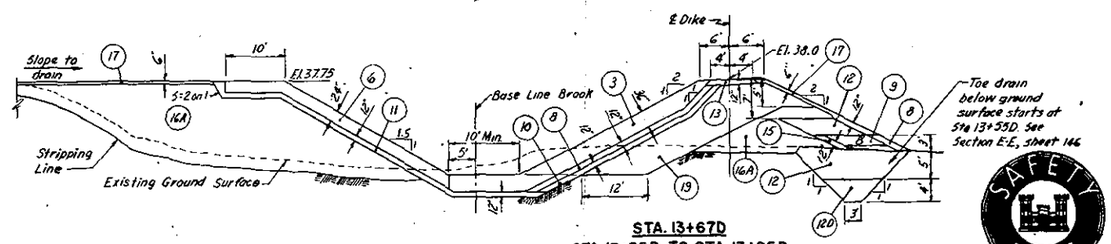
STA 17+45D TO STA 17+78D

STA 14+80D TO STA 17+45D SEE SHEET 146



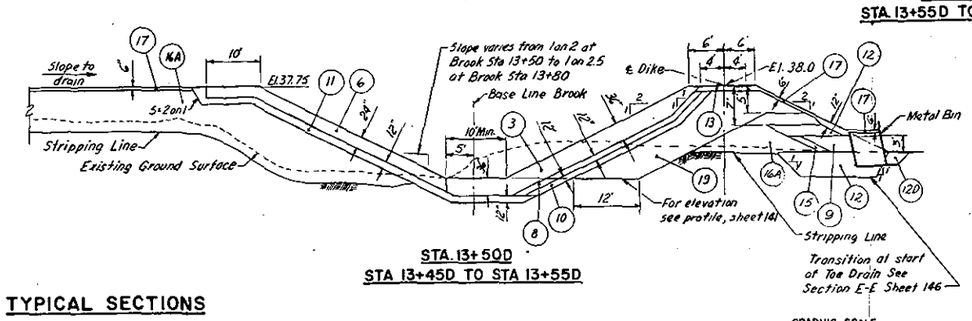
STA. 14+00D

STA. 13+95D TO STA. 14+80D



STA. 13+67D

STA. 13+55D TO STA. 13+95D



STA. 13+50D

STA 13+45D TO STA 13+55D

GRAPHIC SCALE

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

TYPICAL SECTIONS

SCALE 1" = 10'

REVISION	DATE	DESCRIPTION	BY

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

DES. BY | DR. BY W.J.F. | CK. BY

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

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
BEAVER BROOK
DIKE
TYPICAL SECTIONS

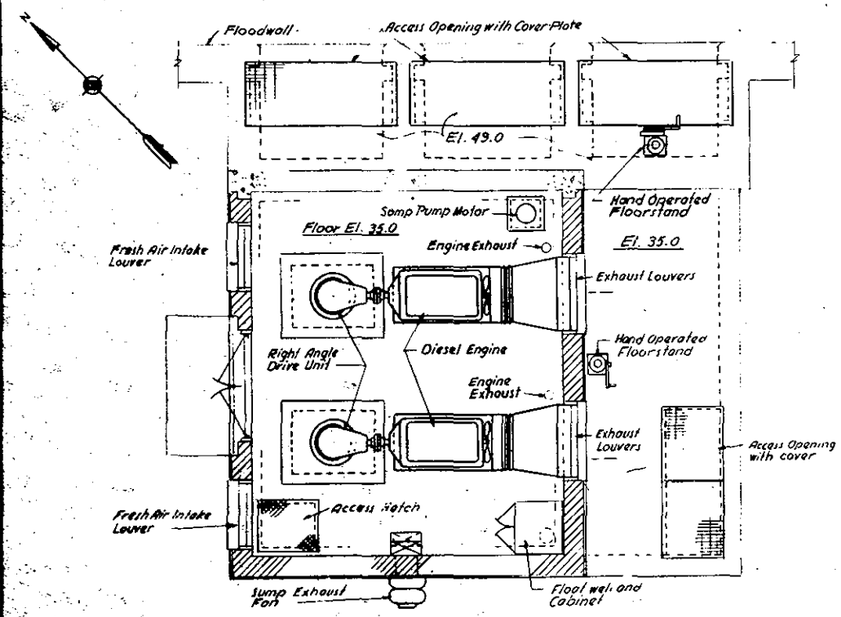
NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

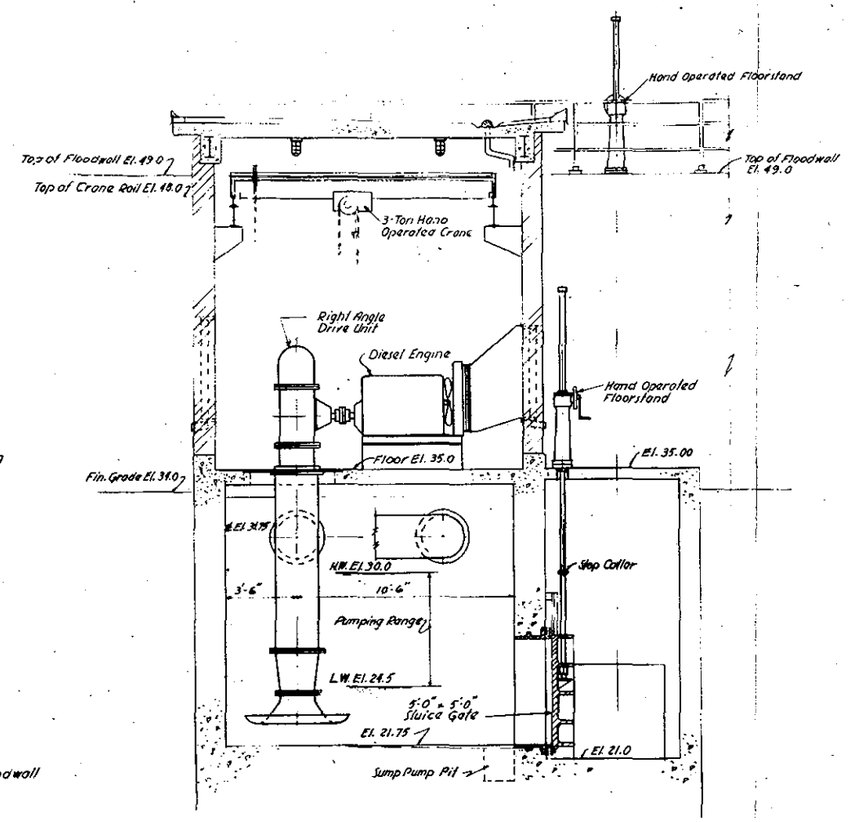
SCALE 1" = 10' | SPEC. NO. | DRAWING NUMBER HOU-11 | SHEET 142

PLATE NO. 9-29

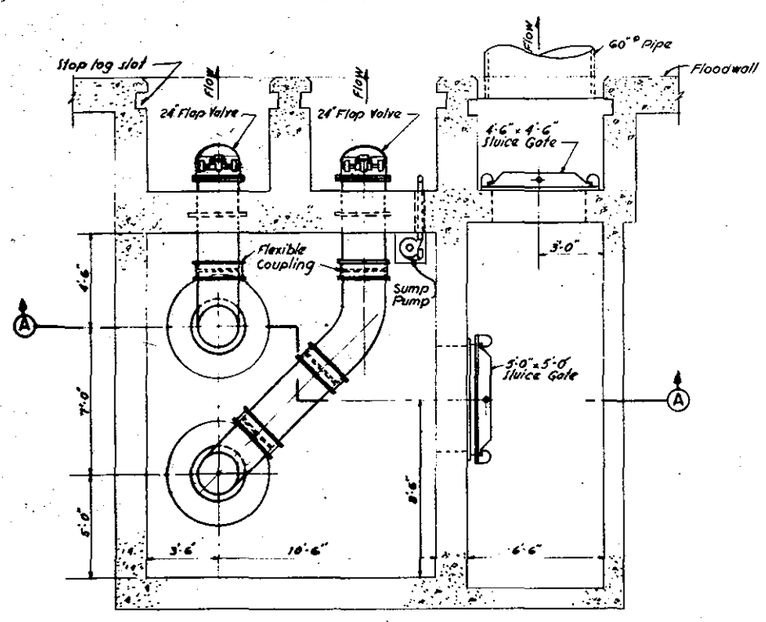
CORPS OF ENGINEERS — U. S. ARMY



PLAN – PUMP ROOM
SCALE 3/8" = 1'-0"



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



PLAN – SUMP
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, DES. & CONST. SECTION
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
CHIEF, CONSTRUCTION BRANCH
APPROVAL RECOMMENDED
CHIEF, PROJECT BRANCH

HOUSATONIC RIVER FLOOD CONTROL
ANSONIA - DERBY
RIVER STREET PUMPING STATION
MECHANICAL
PLANS AND SECTION
NAUGATUCK RIVER — CONNECTICUT

APPROVED — DATE
CHIEF, ENGINEERING DIVISION

SCALE | SPEC. NO. | DRAWING NUMBER
HOU-11
SHEET

PLATE NO. 9-30