407-362

BLACKSTONE RIVER FLOOD CONTROL

LOWER WOONSOCKET

LOCAL PROTECTION PROJECT

STUDY - HAMLET TRENCH COMPLEX

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August 2, 1962

Division Engineer
U. S. Army Engineer Division
New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention: Mr. Edwin F. Coffin, Project Engineer

Re: Contract No. DA-19-016-CIVENG-62-224
Line Item No. 7 - Study - Hamlet Trench Complex
Lower Woonsocket - Local Protection Project
Woonsocket, Rhode Island

Dear Sir:

In accordance with the provisions of our contract agreement dated 12 March 1962, we have prosecuted a series of engineering studies of the Hamlet Trench Complex. Three separate alignment locations for the flood control dike were evaluated. These location studies included hydraulic, soils and foundations, utility modifications and economic considerations. The results of these studies are described in detail and plans and schematic representations are enclosed to augment the accompanying text.

The enclosed preliminary engineering estimates of the alternate dike location schemes consider basic construction costs with contingency allowances, but without land acquisitions costs or cost of relocation or modification of the low tension electrical distribution system.

In view of the fact that under each scheme studied, varying amounts of dike protected land are made available, which in turn portions of this land must be made available for the new locations of the electrical transmission system, the initial cost of land acquisition for construction purposes may not necessarily represent the final net land acquisition cost to the local interests. Accordingly, estimates of initial land acquisition costs have not been included at this time in the evaluation of the four schemes studied.

Similarly we are awaiting receipt of the basic data on the water usages and rights of the major industrial users of the Hamlet Trench supply before an engineering evaluation of the extent and nature of supplemental water supply and possible process water disposal in the trench can be made. This will be the subject of a supplement to this report.

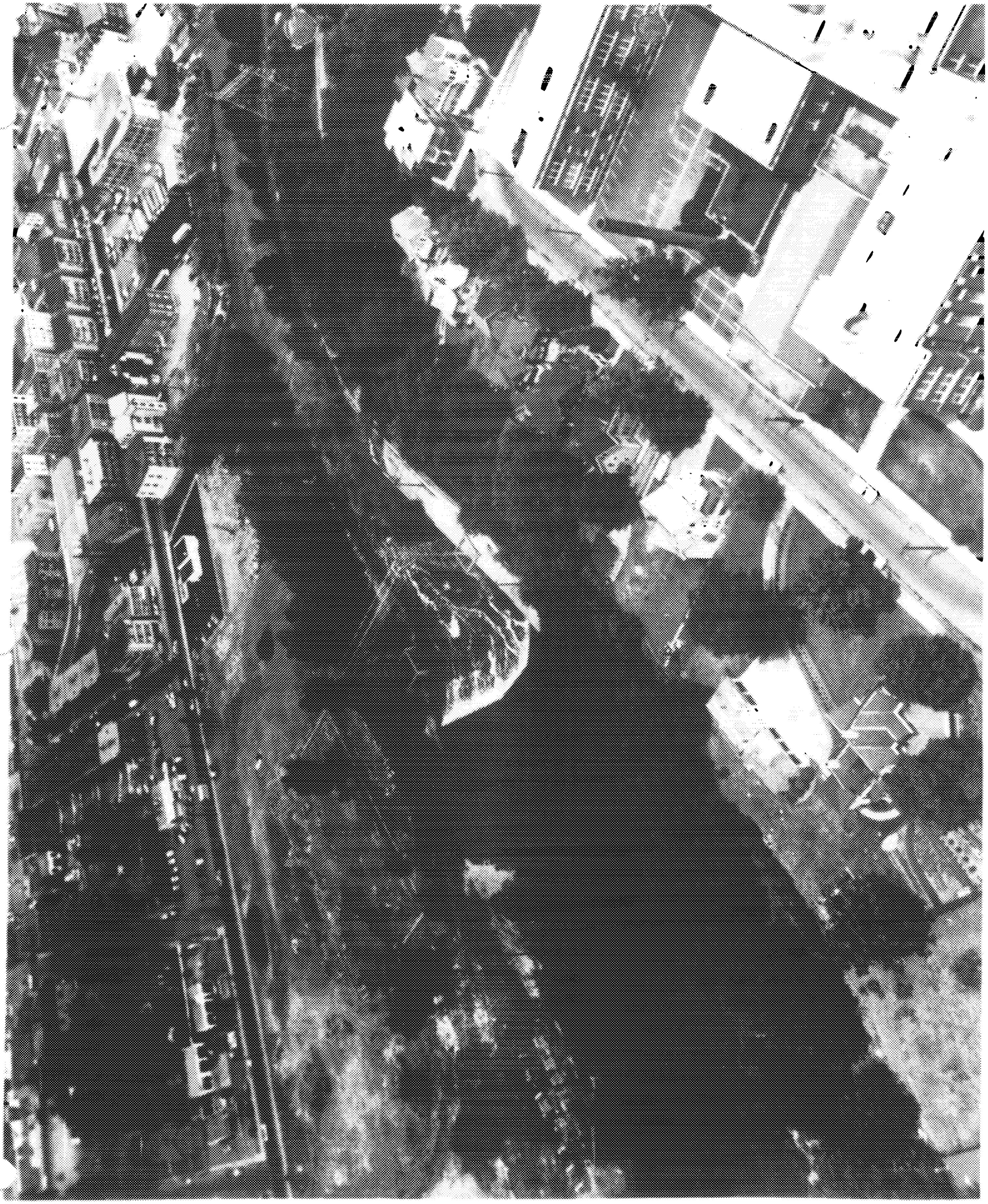
In addition, preliminary engineering estimates of the costs of relocation or modification of the low tension wooden pole transmission system will be transmitted as the subject of a separate letter report pending receipt of additional information from the Blackstone Valley Gas and Electric Company.

We are of the opinion that the enclosed studies are sufficient to permit a critical appraisal of the several schemes studied and permit a valid preferential choice to be made at this time. In any event, serious consideration should be given the recommended scheme by both the local and federal agencies involved in view of the fact that it requires the least amount of otherwise developable land.

Very truly yours,

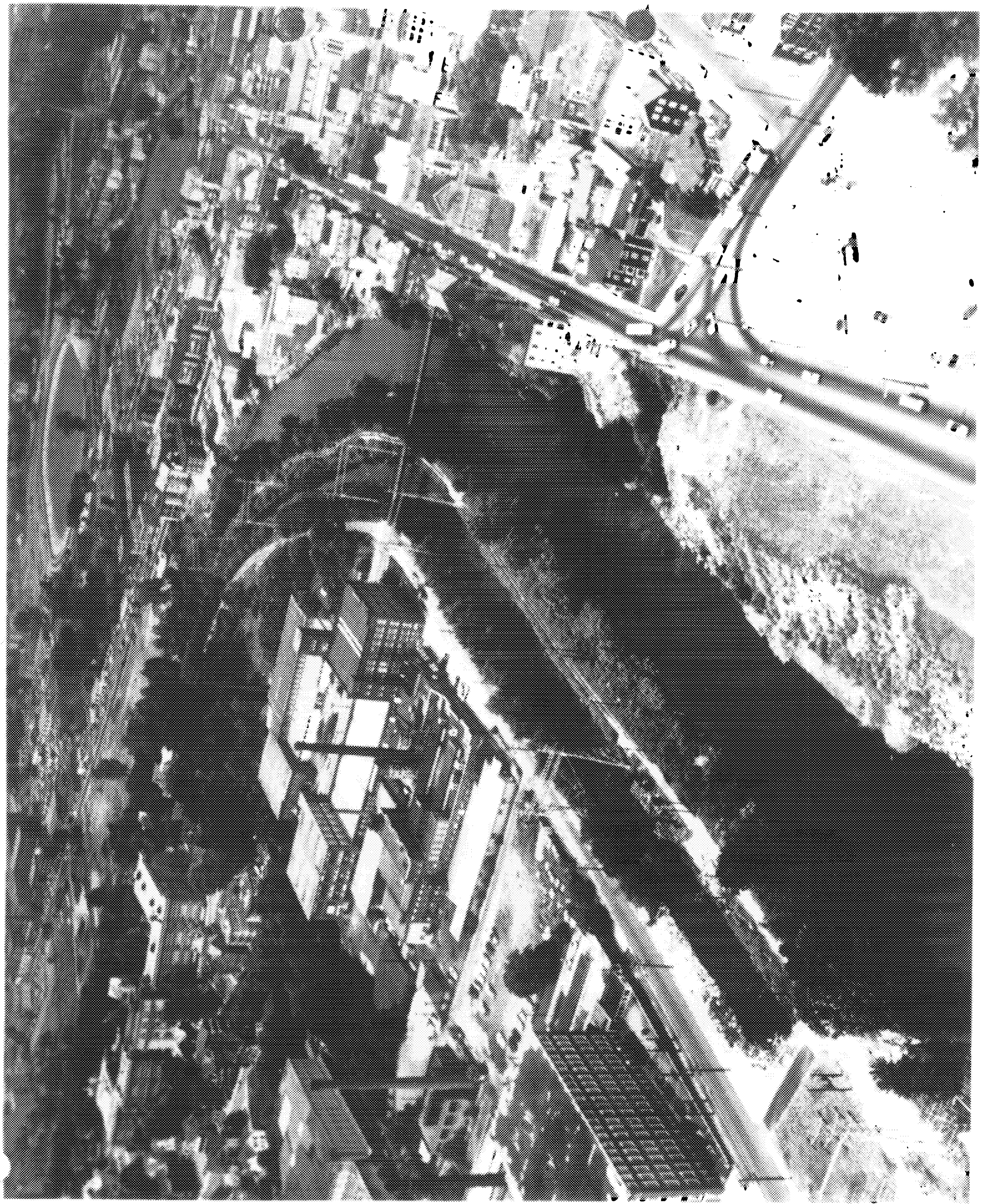
CHARLES A. MAGUIRE & ASSOCIATES

F. C. Pierce



Aerial View - Hamlet Trench

PLATE NO. A



Aerial View - Hamlet Trench

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STUDY - HAMLET TRENCH COMPLEX

DISCUSSION OF THE STUDY AND INVESTIGATIONS INVOLVED

This report covers that reach of the Blackstone River extending from the Hamlet Dam downstream to a point approximately 1,000 feet below Hamlet Avenue Bridge. At the Hamlet Dam the main channel flow of the Blackstone River is impounded at an elevation of 115.8 msl, which allows a partial diversion to the Hamlet Trench for industrial uses. From the Hamlet Dam the Blackstone River flows downstream, first easterly, then bends and flows in a general southeasterly direction. As the Blackstone River bends to the southeast it is joined by the Mill and Peters Rivers. From the Hamlet Dam downstream, the Blackstone River is paralleled by the Hamlet Trench which borders a highly industrialized flood plain. To the east, the Blackstone River's bank climbs steeply to a residential strip bordering Cumberland Street. Continuing downstream the river flows beneath the Kendrick Avenue footbridge to the present Hamlet Avenue highway bridge. Downstream of this highway bridge the main channel is relatively confined on the easterly bank to a point near the present project limit, while on the westerly bank the trench borders Davison Avenue and a lowlying industrial area that is highly susceptible to flooding. Within this reach of the river the normal water surface elevation drops 8 feet plus or minus in approximately 4,300 feet. The river channel crosses two inverted sewer siphons, one opposite Girard Avenue and the other just downstream of the Hamlet Avenue Bridge. This entire area is interlaced with overhead power lines and transmission towers which straddle both the main channel and the Hamlet Trench. Paralleling the trench on its west bank a 36 inch brick sanitary sewer trunk main passes through this area. On the so-called island created between the main channel of the Blackstone River and the Hamlet Trench, the Blackstone Valley Gas and Electric Company maintains its Hamlet Substation which feeds a large part of the industry of the immediate area.

GENERAL

During the record flood of August 1955, flood flows inundated an estimated 270 acres of the highly developed and thickly settled area of lower Woonsocket. Public utilities, highways and railroads were severely damaged. Polluted flood waters caused a serious menace to public health. Without flood protection there is little doubt that possibilities for further development and utilization of available lands will remain unrealized under the threat of flood repetition. The scope of this report is to properly locate earth dikes and flood walls in the Hamlet area within a carefully integrated general plan of lower Woonsocket. The study investigated dike elevations, channel improvements and associated improvements based on sound engineering principles and economics. The accompanying text and data support the recommendations made in this report.

DESCRIPTION OF ALL PLANS AND SCHEMES

To determine the best possible location of the flood protection dike within this complex, four separate locations were developed and their corresponding problems evaluated. To clarify the presentation each trial location will be discussed separately.

SCHEME 1

Scheme 1 on Plate 1-A is essentially the location discussed in the Interim Report dated May 29, 1957. This scheme positions the major portion of the dike astride the strip of land located between the Blackstone River and the Hamlet Trench. The Hamlet Dam would be removed by demolition. A rolled earth dike with a top width of 10 feet and side slopes of 2 on 1 would commence just downstream of the present location of the Hamlet Dam from the high ground on the west bank at Elevation 135.2. The dike position would remain west of the Blackstone Valley Gas and Electric Company's access road until it approaches the Kendrick Avenue footbridge where it would tie into small retaining walls with a gated opening at Elevation 133.6. In this area access would be provided to the Blackstone Valley Gas and Electric Company's Riverside station from Villanova Street by ramping over the dike as shown on Plates 4-A and 4-B. Existing grade at the Kendrick Avenue footbridge is approximately 131.7 so that the gated opening to the bridge and its retaining walls would not present any unusual construction problems. Opposite Girard Avenue some provision must be made during flood stage to by-pass the sewage flow from the Social district and pass it through the Social pumping station. This would prevent possible drainage flowing through the siphon to the 36-inch brick sewer on the west bank. This would also require sealing of the Court Street siphon as well. Under Scheme 1 the flood protection dike would cross the 36-inch brick sewer line at the location of the access road to Villanova Street. Sinze this sewer is 65 years old with uncertain bedding and trench conditions and of unknown structural soundness, sound engineering dictates the replacement of that portion of the sewer under the dike embankment with a new reinforced concrete pipe of equal diameter. From [illegible] Avenue footbridge to the Hamlet Avenue bridge, the flood protection [illegible] parallels Florence Drive, centered beneath the legs of the overhead high tension transmission towers and skirting the Hamlet Substation. This section of the dike runs from Elevation 133.6 to Elevation 131.7 where it fades into the existing slope. Lot curbs or small toe walls would hold the toe of the dike slope away from any interference with the substation and tower legs in this segment of the scheme. Provision would have to be made to take drains which now empty into the Hamlet Trench and allow them to drain into the main river channel or collect them and pipe them down to Florence Drive to empty into the Hamlet Trench below the Hamlet Avenue Bridge. Access to the Hamlet Substation would be provided by a ramp just upstream of the Hamlet Avenue Bridge and continued utilization of the existing road on the so-called island would be made for maintenance of the power lines. Preliminary borings indicate significant amounts of organic sediments lining the trench which would have to be removed in order to position the dike on suitable foundations in this reach. Below the Hamlet Avenue Bridge, the flood protection dike which ties into the wingwall of the bridge would be positioned astride the so-called island incorporating in it the Hamlet pumping station. Our studies indicate it feasible and desirable to place the pumping station below the Hamlet siphon and provide sluice control of the siphon on the right bank of the main channel of the Blackstone River as well as a by-pass structure to divert the flow through the pumping station at times of flood flow. The flood protection dike would continue downstream passing over the existing Hamlet Trench lower control gates, then swing into the higher terrain approaching the railroad property at Elevation 129.70 and tie into the existing railroad embankment. Access to the city dump would be provided by another ramp over the dike as shown on Plate 1-A.

Advantages

1. Provides easy access to the high tension towers and Hamlet Substation.

2. Makes available 4.5 acres of dike protected land (based on curb lines of Davison, Florence and access road, to the toe of dike).

Disadvantages

1. Would require the demolition of approximately seven buildings.

2. Leaves power equipment outboard the flood protection dike vulnerable to future flooding.

3. Requires four access ramps.

4. Necessitates revision to drains emptying in Hamlet Trench and new storm drainage collection system.

5. Would require considerable siphon control and by-pass work.

6. Requires substantial quantities of pervious borrow.

SCHEME 2

Scheme 2, shown on Plate 1-B, has the dike alignment on the westerly bank of the main channel for the entire length of 3,500 feet of the Hamlet Complex Study. This scheme begins just downstream of the demolished Hamlet Dam with the same flood protection dike section at Elevation 136.0, crosses the previously discussed 36-inch brick sewer and the Hamlet Trench, then borders the main channel of the Blackstone River to the footbridge at

Villanova Street. This segment of dike construction would require retaining walls or envelopes to protect three high tension transmission towers (alternate modifications shown on Plates 3-G, 3-H and 3-I) and extensive revision to the siphon crossing at Girard Avenue with replacement of the sewer line at the dike crossing. At the Kendrick Avenue footbridge the dike at Elevation 133.2 could return to the existing slope with small wingwalls added to the bridge abutment or take an alternate alignment and pass beneath the decking of the footbridge on the bank of the main channel. This would necessitate raising the span of the bridge which passes over the so-called island and encasement of the bridge legs. Between the Kendrick Avenue footbridge (dike at Elevation 133.2) and the Hamlet Avenue Bridge (where the dike is at Elevation 131.2) the dike alignment would require protective walls at two high tension transmission towers, relocation of the Hamlet Avenue Substation and considerable revamping to the overhead low tension power lines crisscrossing the so-called island. Widening the dike to accommodate the relocated substation on top could reduce the relocation costs somewhat. Access to the high tension transmission towers would be provided by an access ramp from Florence Drive and use of the top of the rolled earth flood protection dike as a maintenance road. By placing the flood protection dike on the bank of the main channel of the Blackstone River, the Hamlet Trench could be used to carry the interior drainage to the pumping station below Hamlet Avenue. Downstream of Hamlet Avenue, the dike again follows the west bank of the main channel, crossing the downstream Hamlet Trench control gates and then returns into the higher topography at the railroad spur line embankment at Elevation 129.70. As in Scheme 1, the Hamlet pumping station has been positioned within the dike and placed below the siphon crossing. Access to the pumping station would be provided by using the top of the dike. Ramping over the flood protection dike at the existing access road to the dump would make that property accessible.

Advantages

1. Makes available 8.48 acres of land.

2. Would maintain the Hamlet Trench for interior drainage.

3. Requires smaller quantity of pervious borrow.

4. Relocates substation to higher ground above flood flow.

Disadvantages

1. Requires demolition of approximately six buildings, for overbank flow improvement.

2. Requires four access ramps.

3. Requires extensive revamping of low tension overhead lines on so-called island.

4. Necessitates rebuilding a portion of the Girard Avenue siphon.

5. Larger retaining walls required at high tension transmission towers.

6. Requires rebuilding a portion of the 36-inch brick sewer.

SCHEME 3

The general alignment of Scheme 3 follows the Hamlet Trench. Supplementing the demolition of the Hamlet Dam a flood protection dike would be constructed beginning at Elevation 135.4 on the west bank below the present location of the Hamlet Dam, cross the previously described brick sewer from

Court Street and then follows the course of the Hamlet Trench to the end of the present local protection project. The dike centers itself beneath three high tension transmission towers from its upstream beginning to the Kendrick Avenue footbridge. The flood protection dike crosses the 36-inch brick sewer requiring reconstruction of this utility and the new surcharge loading in the trench resulting from the dike would entail rebuilding the affected portion of the siphon. At the Kendrick Avenue footbridge where the dike elevation is 132.8, the flood protection dike alignment as shown on Plate 1-C could either fade into small wingwalls at the footbridge or continue under an alternate plan beneath the footbridge and require some modification to the supports of that structure. From Elevation 132.8 at the Kendrick Avenue footbridge to Elevation 130.7 at the Hamlet Avenue Bridge, the flood protection dike would interfere with two high tension transmission towers (requiring retaining walls), skirt the Hamlet Avenue Substation and fade into the higher slope at the Hamlet Avenue Bridge. Access to the substation and transmission towers would be provided by ramping over the dike just upstream of the Hamlet Avenue Bridge and continued utilization of existing roadway on the so-called island. Downstream of Hamlet Avenue Bridge, the dike would occupy the trench, then terminate as before, into high terrain at Elevation 129.70. Contained within the dike below the highway bridge would be the Hamlet pumping station still required to discharge the interior drainage of the area. Much longer discharge channels would be required to empty this facility into the Blackstone River, and expensive, time-consuming rebuilding of the interior drainage collection system would be mandatory. Access to the station could be readily attained from Davison Avenue and a ramp to the city dump road at the terminus of the dike would maintain the access to that property.

Advantages

1. Makes available 4.56 acres of dike protected land.
2. Would eliminate a ramp at the Hamlet pumping station.
3. Reduces the amount of revision to the low tension overhead lines.

Disadvantages

1. Would require removal and disposal of organic sediments from Hamlet Trench.
2. Necessitates extremely expensive drainage alterations and collection system.
3. Places Hamlet pumping station at more costly location.
4. Requires replacement of siphon across trench.
5. Leaves Hamlet Substation vulnerable to flooding.
6. Requires demolition of approximately seven buildings.
7. Requires utility modifications.

SCHEME 4

Scheme 4, shown on Plate 1-D, is essentially a combination of Scheme 3 from the Hamlet Dam plus some channel improvement downstream to the Kendrick Avenue footbridge, then it incorporates the alignment of Scheme 2 to the end of the project limit. As in the prior schemes, the removal by demolition of Hamlet Dam is necessary. Channel improvements consist of excavation to Elevation 107.0 within the limits shown, with the flood protection dike alignment employed in Scheme 3 and slope streamlining to the footbridge. The dike elevation would vary in this reach of the river from 135.5 to 133.20. Considerable excavation would be involved in the removal of the so-called island in this area. This would require protection to the high tension transmission tower immediately downstream of the dam as shown on Plates 3-A to 3-I. This dike alignment, as in Scheme 3, would require rebuilding the portion of 36-inch brick sewer crossed by the dike embankment and the Girard Avenue siphon crossing the trench. Three high tension transmission towers would require wall protection or encasement. An access ramp over the dike would be needed for continued access to the Riverside Substation. The alternate alignment could still be employed at the Kendrick Avenue footbridge. Dike elevations and alignment downstream of this point would be essentially those used in Scheme 2. From the Kendrick Avenue footbridge to the Hamlet Avenue Bridge two high tension transmission towers are affected and the Hamlet Avenue Substation would need to be relocated. Access to the high tension transmission towers would be provided by a roadway on top of the dike and a ramp just upstream of Hamlet Bridge. Relocation and modification of the low tension overhead power lines would be proportionate to the similarity of the previously discussed schemes. Below Hamlet Bridge the dike borders the main channel, then returns into higher terrain above the city dump. The Hamlet pumping station would again be located downstream of the siphon. Admittance to the pumping station would be from a ramp south of the highway bridge and another at the terminus of the dike would provide admittance to the city dump property.

Advantages

1. Would leave the Hamlet Trench open for collection of interior drainage.
2. Provides 7.65 acres of available land.
3. Relocates Hamlet Substation to high ground.

Disadvantages

1. Requires demolition of approximately six buildings.
2. Requires extensive reconstruction of siphon opposite Girard Street.
3. Protection required at seven high tension transmission towers.
4. Requires rebuilding a segment of the 36-inch brick sewer.
5. Requires four ramps.

HAMLET COMPLEX HYDRAULIC ANALYSIS

The Standard Project Flood, modified by the West Hill Reservoir, developed by the Corps of Army Engineers, is used for the Project Design Flood. The flow for the Standard Project Flood is 40,000 cfs below the confluence of the Mill and Peter Rivers and 33,000 cfs above their confluence.

Three basic schemes of dike location were studied. All schemes included the removal of the Hamlet Dam and the construction of the walls and dikes for the Social District.

Scheme 1: The dike location is approximately the same as shown in the Interim Report (see Plan Plate 1-A) with no channel improvement.

Scheme 2: The dike is located near the bank of the main river channel (see Plan Plate 1-B) with some channel excavation to make the slope from the top of the dike to the bottom of the channel a continuous slope.

Scheme 3: The dike is located in the Hamlet Trench (see Plan Plate 1-C) with a minimum of 8 feet from the toe of the dike to the edge of the existing road with no channel improvement.

Scheme 3A: The dike location is the same as Scheme 3 (see Plan Plate 1-C) except the main channel from Kendrick Avenue footbridge to Hamlet Dam is to be excavated to Elevation 107.0 to widen the main channel to a minimum width of 135 feet.

Scheme 4: The dike and channel improvement is the same (see Plan Plate 1-D) as Scheme 2 downstream of the Kendrick Avenue footbridge and the same as Scheme 3A upstream of the footbridge.

Profiles of the river channel, the water surface elevation and hydraulic gradient are shown on Plates 1-G and 1-G_1.

Cross-sections at key locations showing the three schemes of dike location are shown on Plates 1-H_1 to 1-H_{13}.

For existing conditions an "n" value, for the Manning's formula of 0.035, was selected for the main channel and 0.045 was selected for the flow in the Hamlet Trench. The "n" value for overbank flow varies from 0.040 to 0.100 depending on conditions encountered in the field.

For the schemes for improved channel an "n" value of 0.035 was still used because the improvement was more in channel alignment than in channel roughness.

The overbank flow area between the dike and the main channel was assumed to be cleaned up and maintained and accordingly an "n" of 0.040 was selected.

In general, an allowance was made for contraction and expansion losses by introducing an eddy loss factor of 0.2 and 0.5 times the change in velocity head. The hydraulic losses caused by minor isolated obstructions such as tower footings and bridge piers are neglected in the study of relative water surface and hydraulic gradient profiles because their effect would be about the same for all schemes and backwater caused by such obstructions would be relatively minor. For instance, the three piers of the Kendrick Avenue footbridge in the main channel were considered in the backwater calculations for existing conditions. The elevations of the water surface and hydraulic gradient were increased 0.14 foot and 0.11 foot respectively. The increase in water surface elevations was checked by Method I as shown in the U. S. Bureau of Public Roads publication, "Hydraulics of Bridge Waterways", and was found to be about 0.15 foot.

The confluence of the Peters and Mill Rivers is assumed to be at the same location as existing for purposes of this study. Changing the location of the confluence of the Mill River will change the backwater profile in the reach between the change but the influence on the overall profile should be small.

Location of the dike near the bank of the main river channel has the advantage of conserving developable and taxable land as well as eliminating the problem of maintaining the overbank flow area between the dike and the edge of the main channel. If the overbank area is not kept free of trees, weeds and trash it could become practically worthless as a flow area and the flow characteristics of the overall channel area could be less than that for a scheme where the dike is contiguous to the main channel bank and is protected with rock fill that discourages scrub and vegetative growth.

The Interim Report indicates the elevation of the top of the dike or floodwall at each location is based upon the elevation of the design discharge plus a minimum freeboard allowance of 3 feet. This study indicates that the velocity head will exceed 2 feet in certain reaches of all three schemes. The elevation of the top of the dikes or floodwalls at each location should be a minimum of 3 feet above water surface elevation, or a minimum of 1.5 feet above the hydraulic gradient elevation for the design discharge.

The profiles of the water surface and hydraulic gradient for the various schemes are shown at a distorted scale on Plate 1-G and tabulated at key locations along the river on Plate 1-G_1. It can be seen that the greatest increase in water surface elevation at the upstream end of the Social Dike would be 1.0 foot plus or minus, and accordingly the choice of schemes for the dike location would not be determined by one scheme having far superior hydraulic properties. It is desirable though to maintain the water surface elevation outside areas protected by the dike to an elevation that will not increase possible damages in these areas.

Schemes 1, 3A and 4 meet the criteria of not increasing flood levels in those areas not protected by the dike. Upstream of the Kendrick Avenue footbridge Schemes 3A and 4 have the same dike location and channel improvement, so the choice between Schemes 1 and 3A in this reach of the river should be based on other than hydraulic considerations. Schemes 2 and 3 without channel widening would require the dikes and floodwalls upstream of the Kendrick Avenue footbridge to be about one foot higher and would subject the unprotected area of the Blackstone Valley Gas and Electric Substation to about one foot greater flooding.

meet the design requirement for the top of the dikes or floodwall, to be 3 feet minimum above water surface elevation or 1.5 feet minimum above the elevation of the hydraulic gradient, whichever is greater, the top elevations of the upstream end of dikes should be as follows: At the Kendrick Avenue footbridge, Scheme 1, Elevation 133.6; Scheme 2, Elevation 133.2; Scheme 3, Elevation 132.8; at the Hamlet Avenue Bridge, Scheme 1, Elevation 131.7; Scheme 2, Elevation 131.2; and Scheme 3, Elevation 130.7. Opposite the sewage treatment plant at the downstream end of the project, the top of dike elevation should be 129.7, 3 feet above flood elevation existing conditions for all three schemes.

Because of the small difference in dike elevations for all three schemes, the choice of flood protection dike location should be made on other than back-water conditions. The storm water runoff that now flows into the Hamlet Trench would have to be carried in a closed drain to the pumping station for the entire length of Scheme 3 because the existing trench would be filled and there would not be space enough between the toe of the dike embankment and the road to construct an open ditch. The same would be true of Scheme 1 between the Hamlet Avenue Bridge and the Kendrick Avenue footbridge. Schemes 1 and 2 leave the existing trench open from the downstream end of the project to the Hamlet Avenue Bridge and Scheme 2 also leaves the existing trench open from the Hamlet Avenue Bridge nearly to the Kendrick Avenue footbridge. The existing trench may be regraded and used to collect interior drainage in these reaches until such time land values justify closed drainage or relocating the channel nearer the toe of the dike.

Maintenance of the overbank flow area between the main river channel and the dike to insure good flow characteristics would be required for Scheme 1 and Scheme 3, where Scheme 2 or Scheme 4 would not require such maintenance.

All schemes would require about the same amount of relocation and modifications to existing utilities except where the channel is to be widened for Schemes 3A and 4. This widening will require extensive modification of the inverted siphon opposite Girard Street.

SOILS

a. Subsurface Investigations

As part of the preliminary investigations of this area, six borings were taken in 1961 by the Corps of Engineers. Data from three of these borings were considered for this study; they are as follows: FD-86, FD-88, FD-89. From soil samples recovered from these borings, two mechanical analyses for FD-88, and one mechanical analysis for FD-89 were performed. A generalized soil profile and summary sheets of test results of mechanical analyses for FD-86, FD-88 and FD-89 are shown on Plate 1-G4 and Appendix.

Because this site is one of rather complicated soil engineering considerations, resulting from prior excavation and filling operations, a more detailed exploration and investigation program has been requested in order to fully determine the soil characteristics necessary to design the proposed structures. Until the supplemental program of soil sampling and laboratory testing is accomplished, the actual strength, seepage and consolidation characteristics of the subsurface soil strata can only be approximated based upon available data.

Based upon the available information, it is anticipated that this strip of land paralleling the Hamlet Trench can meet the requirements of the proposed construction.

Since no advance borings or probings were taken in the Hamlet Trench, it is rather difficult at this time to present any detailed evaluation for engineering foundation consideration. Some limited field investigations by land auger boring were performed by our own personnel. The results of these investigations indicate that about 2 feet of soft organic deposit was along the trench. However, a more detailed investigation and exploration should be performed due to a more complicated situation in soil engineering.

b. Soil Properties

The properties of the soils involved in this study were determined and estimated on the basis of gradations correlated with test data for similar soils at other projects.

(1) Permeability: For the pervious sand and gravel foundation materials, the estimated natural permeability is 100 x 10^{-4} cm/sec with ratio of horizontal to vertical permeability of 4. In the granular portion of the dikes, the estimated permeability is 50 x 10^{-4} cm/sec, the lower permeability value resulting from the higher density to be expected in the embankment and lesser degree of stratification.

(2) Estimated permeability of the sandy glacial till is 0.5 x 10^{-4} cm/sec, which approaches the higher values observed on similar glacial tills in laboratory tests.

(3) Shear: All of the soils indicated in the description of subsurface exploration and mechanical analyses are classified as granular and cohesionless and are considered high in shear strength, with a probable angle of internal friction (C-D values) in excess of 35 degrees. For stability analysis, a value of 30 degrees was assumed. These values are

considered fairly conservative; however, it has been previously determined that no advantage can be taken, in design, of possible greater strengths for the type and height of dikes necessary for this project.

(4) Consolidation: No consolidation tests were performed on samples of foundation materials for this study. However, in view of the relatively light structure loading and absence of compressible foundation soils, it was considered that foundation or embankment consolidation will be negligible and can be neglected in design.

Design of Embankment

On the basis of the results of hydraulic studies, four schemes of different locations were proposed as shown in 1-A to 1-D. The following description is presented from the soil engineering standpoint.

(1) Criteria: Current design criteria as set forth in the pertinent sections of the Engineering Manual - U. S. Army Corps of Engineers, have been followed in the preliminary design of the embankments for this study.

(2) Selection of embankment sections: Typical embankment sections for this study are shown on Plates 1-G_{12} and 1-G_{13}. The embankment sections selected for the flood protection dikes have been developed from the preliminary investigations and studies of foundation conditions and of characteristics of available construction materials and foundation soils. The selected section is essentially of the homogeneous rolled earth fill type with stone slope protection on the river slope and seeded topsoil in the land slope. Side slopes of one vertical on 2 horizontal have been adopted for the section.

(3) Control of seepage: (a) Seepage through the dike: In order to eliminate the hydraulic static pressure in the dike, a blanket of impervious fill is proposed to be placed along the slope on the river side; also, a zone of gravel fill has been incorporated into the river side toe of the dike section to control the entrance of the seepage.

(b) Foundation seepage: In order to preliminarily evaluate the foundation seepage aspect for the various dike types and location schemes, flow nets of the typical sections for each scheme were made. The quantity of seepage has been approximated as follows:

Scheme 1 - 7.75×10^{-4} cu.ft./sec/lin.ft.

Scheme 2 - 16.8×10^{-4} cu.ft./sec/lin.ft.

Scheme 3 - 7.6×10^{-4} cu.ft./sec/lin.ft.

Scheme 4 - 8.74×10^{-4} cu.ft./sec/lin.ft.

Based upon the hydraulic studies, a flood stage elevations versus time study was made (see Plate 1-G5). From the Blackstone River, evaluations of percentage of lowering elevations of water surface versus time are tabulated as follows:

Percentage of Lowering River Elevation	Time (Hours)
10	13.5
20	21.0
30	33.0
40	48.0
50	64.0
60	84.0

In view of the above figures, it can be stated that neither the sudden drawdown case nor the steady state seepage case (for a given head) are applicable.

(c) Exit gradients: Quick conditions for the typical sections of each scheme were evaluated, a rational value of 3+ for the factor of safety with respect to exit gradient is in evidence.

Slope Stability

Slope stabilities for typical sections of each scheme were evaluated. It was found that the typical section of one vertical on 2 horizontal slope will consistently result in a reasonable value of factor of safety of approximately 1.5.

Transmission Tower Foundation

Considering the foundation problem of increases in surcharge loading on the footings of the high tension transmission towers, it is anticipated that the existing foundation materials would meet such increased bearing load requirements on the basis of available information.

STORM DRAINAGE

Prior to the construction of the Hamlet Avenue Bridge after the 1955 floods, practically no storm water was discharged into the Hamlet Trench because of the fact the water was used for various industrial processes. There were one or two catch basins in Florence Drive and one or two in Davison Avenue that discharged into the trench and of course what fell on these two streets and the adjacent buildings ran overland into the trench. All other drain lines ran under or around the trench. After the Hamlet Avenue Bridge was reconstructed some of the drainage in the Hamlet Avenue area was picked up by a new drainage system and discharged into the trench.

At this time a portion of the trench was filled under the bridge [illegible] a 60-inch pipe was installed. Provisions were also made to intercept the existing 36-inch brick main in Hamlet Avenue and tie that into the trench through a new 54-inch line. However, the [illegible] connection between the two was not made although a blanked-off stub of the 54-inch line was brought up to the 36-inch brick line.

Under all of the proposed dike schemes any of the drain lines that go into the Blackstone River will have to be intercepted and cut off from the river or pressurized to prevent the river backing up into the protected area. The major lines that are not pressurized will have to discharge into either the trench or a trunk main or a combination of the two, and the run-off will have to be carried to the Hamlet pumping station to be discharged either by gravity or pumping depending on the river conditions.

There are a number of combinations of schemes that can be used to take care of the drainage in the area so no difficulty in the design of an adequate drainage system is anticipated. Basically there are two conditions that would exist depending on which scheme is used. Either the trench will be filled or it will be left open. If the trench is left open the interior drainage system can be altered to discharge into the existing trench. This can be done as follows:

(1) The 24-inch line from Villanova Street would be plugged in the manhole at the footbridge and a new manhole constructed in the Villanova Street-Florence Drive intersection. A new line would be constructed from this manhole to a point that would allow gravity discharge into the remains of the trench. A stub should be provided in the new manhole to pick up the area west of Villanova Street when and if it is developed. The local drainage in Florence Drive would still discharge into the trench.

(2) The 36-inch brick line down Hamlet Avenue would be plugged at the manhole near the Hamlet Avenue Bridge to prevent backflow from the river during flood stages. The line would then be tied into the 54-inch storm drain left by the State for this purpose. The drainage in Davison Avenue will be collected in the trench without any revisions to the system.

(3) The line down Davison Avenue from Manville Road will be made a pressure line and a portion of the flow will be carried under the dike and not through the pumping station. The portion of the run-off that by-passes the collecting structures of this line would be channelized into the Hamlet Trench at the nearest accessible point. One other point that should be mentioned at this time is the privately owned yard drainage systems in the factory complex. It is not apparent from field investigations where most of these systems discharge into the river. However, some provision must be made to cut them off from a direct connection to the river and intercept them.

The existing trench has some accumulation of silt and debris so it is recommended that this material be removed and the trench be regraded and dressed with a blanket of new clean granular fill. It is also recommended that the trench be lined with some form of paving of light riprap to cut down on the weed growth choking the drainage flow in the trench.

If the trench is filled, then an interceptor trunk main would have to be run from Villanova Street about 1,500 feet to the pumping station. A complete drainage system would also have to be constructed in Florence Drive and Davison Avenue. This system would have to be of such a capacity that it would preclude any extensive flooding of the lower-lying factory areas that would normally pond up and then flow across the two roadways into the open trench.

A proposed drainage layout for the recommended dike scheme is shown on Plate 2-A.

TRANSMISSION TOWER MODIFICATIONS

Immediately downstream of the Hamlet Dam the Blackstone River is bridged by an electric high tension transmission tower owned by the Blackstone Valley Gas and Electric Company. One tower leg is founded in the east bank of the main river channel while the other is located on a platform of the non-overflow dam section between the main stream and the Hamlet mill trench (see Plate 3-A). Because of the size and complexity of this structure it has been studied from the standpoint of modifying or protecting the existing footings in order to retain the towers intact, rather than to consider the expensive alternate of a replacement, to span an improved channel. Four schemes for footing protection were studied as shown on Plates 3-B to 3-F, with the most feasible proving to be a simple dumped rock island shaped to protect the individual footings of the west tower legs and offering a minimum of channel interference (see Plate 4-B). Placing of stone at the towers to suit the improved channel cross-section and consistent with adequate protection of footings appears entirely feasible and would not disturb the utility or disrupt service.

Downstream are other similar towers straddling the Hamlet Trench. These apparently pose no particular problem since the proposed flood protection dike, following along the trench, will simply add fill around some of the footings. Depending on the final dike embankment alignment, it may be necessary to protect the steel tower framing by corrosion-resistant coating or encasement or provide isolated retaining walls at certain towers to carry the dike fill around the footings where its depth may prove undesirable (see Plates 3-G to 3-I). Foundation soils are considered adequate for the anticipated increase in surcharge loadings. Access by catwalk to the tower leg from the river bank could be provided for a nominal cost, if required by the utility. The cost of protecting the tower footings with the riprap island is estimated at $5,000 and a 4-foot wide catwalk at $2,500. No allowance has been made for possible necessary repair work to footings if excavations reveal the necessity for same.

ACCESS TO RIVERSIDE SUBSTATION

Under the three dike alignment schemes studied in the vicinity, the present access road from Villanova Street to the substation would be buried by the flood protection dike at certain points. Scheme 1 would affect the road only at its beginning at Villanova Street, and a ramp over the dike approximately 240 feet long, graded to 6 percent slopes, would connect Villanova Street with the present roadway (see Plates 4-A and 4-B). Schemes 2 and 3 would affect the road only at about river station 35 where the dike ties into high ground. A ramp over the dike approximately 250 feet long, graded to 6 percent slopes, would connect the present roadway each side of the dike embankment. For estimating purposes, it was assumed that the ramp pavement will be 16 feet wide, with a 2-foot shoulder each side. Riverside slopes of the ramp embankment would be covered with riprap similar to dike embankment slopes.

Under Scheme 1 the substation access ramp cost is estimated at $4,000 while under Schemes 2 and 3 the ramp cost is estimated at $4,400.

ACCESS TO STRIP OF LAND

The present access to transmission tower footings is provided by local streets on the land side of the trench and by an outer road (dirt) atop the "island" on the river side of the trench. The dike layout under Scheme 1 affects this dirt road access only at its connection with Florence Drive about opposite river station 57. A ramp over the dike connecting Florence Drive with the existing roadway would be required (see Plates 4-A and 4-B). A gravel surfaced roadway of 12 feet width and 2 feet shoulders has been assumed as an adequate replacement. The ramp would be about 470 feet long and its cost is estimated at approximately $6,000. The river side of the embankment slopes would be riprapped.

Under Scheme 2, a ramp or access road would be required on top of the dike itself south of the footbridge; the transformer bank would be relocated; and certain of the tower legs must be encased in concrete or otherwise protected from burial in the dike embankment. This work is estimated at approximately $12,000.

Under Scheme 3 a ramp would be required in the vicinity of the transformer bank similar to Scheme 1. This ramp would be about 480 feet long and is estimated to cost approximately $7,000.

SEWER AND OTHER UTILITIES

a. General: A 12-inch gas main which crossed the Blackstone River just downstream of the Kendrick Avenue footbridge has been abandoned so there should be no problem with respect to this line.

Correspondingly a 12-inch water main which was carried beneath the deck of the footbridge was abandoned after the 1955 flood and replaced with a new 12-inch service in the river bed just downstream of the bridge and will require consideration during final design.

The principal sanitary sewer affected by the flood protection dike embankment is the 36-inch brick main running along Florence Drive and the access road to the substation. Under Scheme 1 the dike crosses this line at one point, in the access road adjacent to Villanova Street. Under Schemes 2 and 3 the dike crosses this line at one point, in the access road to the substation opposite river station 35. Since this sewer is over 65 years old with uncertain bedding and trench conditions, and of unknown structural condition, it is believed the wisest policy to replace that portion under dike embankment with new reinforced concrete pipe of equal diameter. The length of pipe work required under Scheme 1 is 210 feet and under Schemes 2 and 3 is 250 feet with the costs estimated at $4,000 and $5,000 respectively.

A concentration of utilities exists in the west approach to the Hamlet Avenue Bridge at the Hamlet, Davison and Florence Streets intersection. (See Plate 5-E.) Under the three basic dike layout schemes no special problem is created for the sanitary sewers, other than the siphons, water lines, electric or telephone services. The principal concern here is the storm and mill drainage and this depends on the dike scheme selected. Under Schemes 1 and 2 the trench is left intact, most existing drains can remain in operation, and the only necessary modification is to the 36-inch brick storm drain and the 18-inch and 12-inch waste lines from nearby mills.

The 36-inch storm line would be connected to the existing 54-inch line connecting to the 60-inch culvert at the trench, but the 18-inch and 12-inch lines carrying mill wastes are below the storm drain levels and must be shut off in time of flood flows. This means that the contributing mills must discontinue their use at such periods. Such lines should in any event be connected to the city sewerage system if the treatment plant can handle them.

b. Sewer Siphon at Girard Street: The existing sanitary sewer line from Girard and Clinton Streets crossing at the river at about station 40 presents a special problem. The sewage flows by gravity to a valve chamber structure No. 1 (see Plates 5-A to 5-C) on the east bank, travels via a 3-pipe siphon under the main river to manhole structure No. 2, rises to flow by gravity across the so-called island to valve chamber structure No. 3, then enters another 3-pipe siphon section to cross under the Hamlet Trench to manhole structure No. 4 where the flow rises to resume gravity flow on the west bank.

On the east bank the proposed flood wall will pass just back of the valve chamber structure No. 1 which can remain in place, and projects above the berm of the dike. It seems most feasible here to leave the present structure undisturbed but replace a portion of the brick sewer with a reinforced concrete pipe under the wall. Some distance back of the wall, at the edge of Girard Street, a new valve box would be built to provide for closing off the line at the time of high flood levels and diverting the outflowing sewage to the Social District pumping station nearby. This means that the present valve chamber would be inundated by floods but the water would be sealed off back of the dike at the new valve box. No special attention therefore need be paid the exposed valve chamber in front of the dike and wall at flood times. The alternate possibility of completely removing the present valve chambers and rebuilding back of the dike and wall was studied and rejected as being more costly and would further increase the length of siphon by about 40 feet.

At existing manhole structure No. 2, the end of the river siphon, the proposed new channel excavation work would destroy this structure as well as valve chamber structure No. 3 on the canal edge of the so-called island. It will be necessary to install new 8-inch, 10-inch and 12-inch pipes, encased in concrete, to continue the siphon from structure No. 2 to a new manhole near structure No. 3 located in the berm separating dike slope and channel slope.

Under the recommended scheme the proposed flood protection dike at the siphon crossing will fill in completely the existing Hamlet Trench. This condition eliminates the need for a siphon at the trench and it is therefore recommended that the trench siphon be replaced by a new 36-inch reinforced concrete gravity line between the new manhole No. 5 at the berm and the existing manhole structure No. 4 at the west bank. It will be necessary to rebuild this structure No. 4 to enlarge the body to provide a sluice gate to shut off the oncoming flow from the 36-inch reinforced concrete pipe during times of flood. The alternate possibility of reconnecting to the existing trench siphon was rejected as undesirable since it would be necessary to reinforce the siphon to withstand the dike loading (23 feet of fill). Substituting a section of gravity line for a siphon section will compensate for increasing the river section siphon to manhole No. 5. Control of the shutoff is situated land side of the dike here on the west bank similar to the shutoff on the east.

c. Sewer Siphon at Hamlet Avenue Bridge: A short distance downstream from Hamlet Avenue another siphon crosses the river between a valve chamber on the west bank and a manhole on the east bank (see Plates 5-D and 5-E). The sewage flow approaches the siphon in a 36-inch brick gravity main running diagonally in front of the dike. In order to control the sewage flow at times of flooding a new valve chamber must be installed in the line at a location convenient to the top of the dike to permit shutting off of the flow to the siphon and diverting it to the trench and thence to the Hamlet pumping station intake. The existing siphon and control structures can therefore remain undisturbed. There will be some minor surcharging by the dike embankment over the 36-inch brick sewer but this should not necessarily require replacement of the brick with reinforced concrete. Construction would consist of the new valve chamber and the overflow by-pass consisting of about 30 feet of pipe and a headwall.

KENDRICK AVENUE FOOTBRIDGE

The required grade of the top of dike in the vicinity of the footbridge is Elevation 133± and this is about the same as the deck grade of the bridge. One scheme studied is simple and appears most feasible. It would tie in the dike embankment to existing river bank and to small new walls flanking the bridge entrance (see Plates 6-A, 4-A and 4-B). The gap between would be sandbagged at times of high water. The alternate scheme of a portion of floodwall carrying through the bridge has been studied and compared with the possible third scheme of raising the bridge to clear the proposed dike. Estimates indicate that constructing new and higher footings, jacking up the bridge, and resetting existing steel framing to a new grade sufficient to clear the dike embankment may be slightly more economical than the floodwall section if no revisions are necessary to the present framework. It seems prudent to avoid disturbing the present bridge structure and use either the retaining wall-sandbag scheme or the flood wall scheme and save any unforeseen complications in an attempt to raise the bridge. It would be possible also to raise the span directly over the dike to clear, but would necessitate ramps or stairs on the deck at either end of the span involved.

HAMLET DISTRICT PUMPING STATION

After careful study and consideration the Hamlet District pumping station was located on the easterly side of the Hamlet Trench about 350 feet south of the Hamlet Avenue Bridge. The pumping station was located in the dike proper and as near to Hamlet Avenue as possible. By locating the station in the dike proper the tie-in to the station of both the inlet channel and outlet channel was greatly simplified. Also direct access to the station can be had from the high ground adjacent to the Hamlet Avenue Bridge. This would preclude any possibility of the vehicular access to the station being cut off during emergency by a freak storm of a local nature that could flood the lower-lying land at the southerly end of Davison Avenue. Also by locating the station some 500 feet to 600 feet upstream from the location shown in the Interim Report it is located nearer the center of the drainage collection system and therefore the hydraulic gradient required is less than would be required for the Interim Report scheme.

It should be noted that the station has been located to prevent any conflict with existing utilities. However, it is close enough to the siphon chamber so that during flood stages the interior sewage flows can be by-passed to the station and pumped.

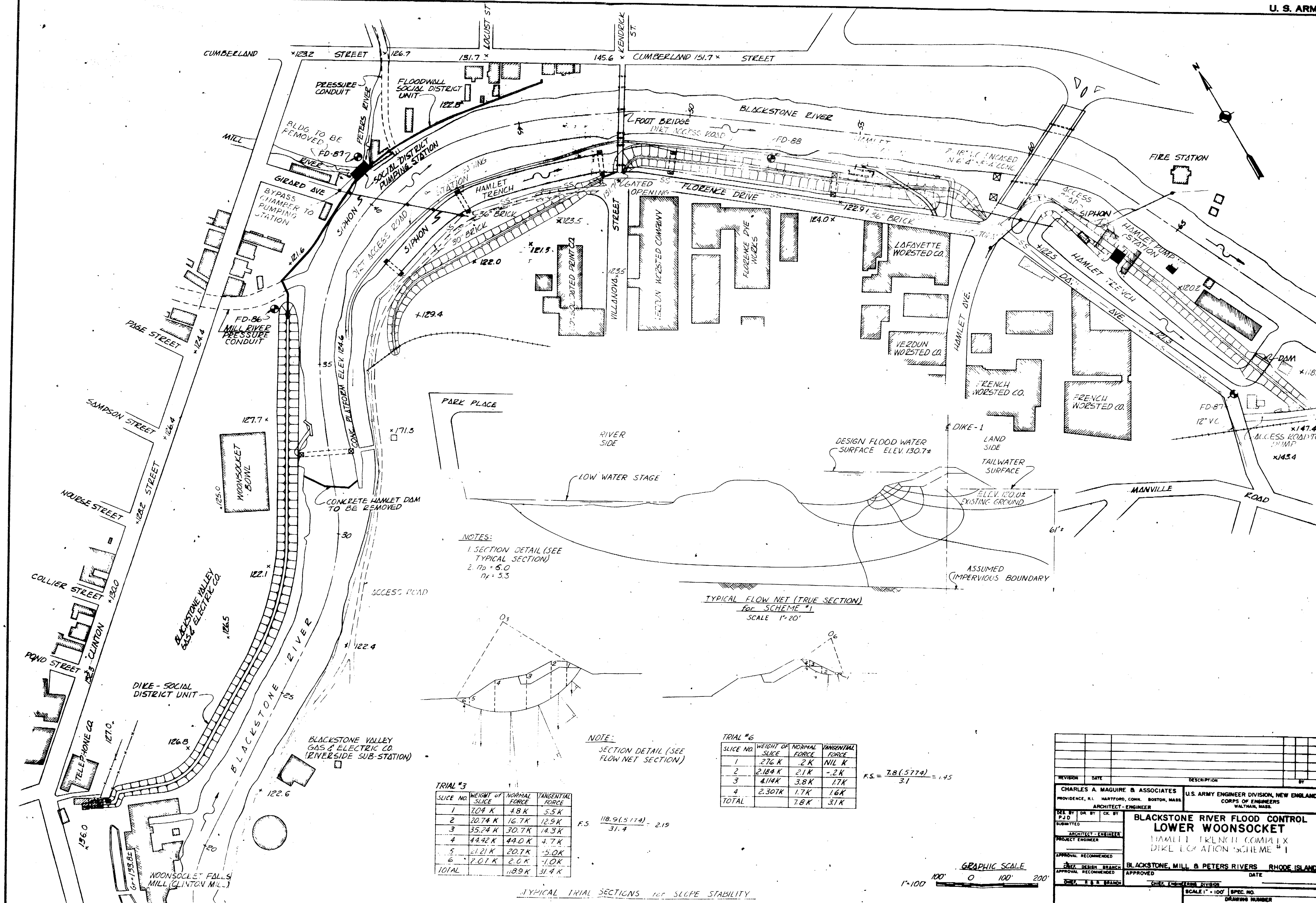
These flows would be so diluted that no special problem is anticipated with the operation of the pumps. If at a later date the Hamlet Trench is replaced with an underground system, a small portion of the trench in the vicinity of the station can be left open to act as a collector basin. Because of the possibility of a system such as this being installed, no effort to use the trench as a ponding area was made. It should be noted, however, that until an underground system is installed the trench is in fact a storage basin and will provide an additional factor of safety during storms greater than the design storm.

RECOMMENDATIONS

In order to properly align the rolled earth dike embankment in the reach of river designated as the Hamlet Trench Complex, many factors have been considered. Hydraulically, no one scheme offers outstanding properties over the others, and based on backwater computations one does not find appreciable difference in dike heights. Preliminary investigations indicate adequate foundation soils for the anticipated surcharge loadings of the schemes. It would appear, objectively speaking, that local interests would be best served by using the alignment of Scheme 4. This alignment provides

7.65 acres of available dike protected land for future development and eliminates the expense of maintaining the overbank for proper stream flow at flood stage. As part of the entire flood protection plan, this alignment would not increase flood levels of unprotected areas and would maintain the trench below Villanova Street for the collection of storm water runoff, which could be piped at a future date to provide more available land. Comparing the specifics of each scheme, all schemes would require an access ramp to the Riverside Substation, some revision to the 36-inch brick sewer line, a ramp to the city dump facility and like modification to the Kendrick Avenue Footbridge. Providing an access road to the pumping station, as in Scheme 1, 2 and 4, would compare to the extended discharge channel needed by Scheme 3 at the pumping station. Ramping over the dike to maintain the existing roadway on the island between the main channel and the trench would be equal to ramping up to use the top of dike as a maintenance road. Scheme 3 would require removal of organic sediments in the trench and its associated problems of disposal for its entire length. It would require immediate local participation in installation of a storm water collection system. Furthermore, it provides little area for development and accordingly was eliminated from serious consideration. Scheme 1 (the Interim Report alignment) appears to be the least expensive but in turn provides the fewest benefits. It would make available the smallest parcel of developable land, would eliminate the trench along Florence Drive and would require maintenance of considerable overbank areas. Probably more noteworthy, it would leave the Hamlet Avenue Substation and the maze of overhead power lines along the so-called island subject to flooding with its resulting loss of power to the city and downtime charges to industry, which would now be protected from flood damage but could be left without power during periods of high flood flow. It would seem incongruous to provide protection to the industrial plants and neglect their power supply and ability for quick resumption of operation. Immediate installation of facilities of collection of storm water runoff would have to be considered. Schemes 2 and 4 would require relocation of the Hamlet Avenue Substation and the overhead low tension power lines of the so-called island. The substation could be positioned on top of the dike which would reduce the cost of a total relocation and would allow the use of the same line alignment. Overhead low tension power lines could be raised to maintain adequate grade clearances. Either scheme would eliminate the cost of continuing overbank maintenance. Scheme 4 then, would provide better access to the high tension transmission towers and would require less costly protection at other tower legs. Removal of the dam and subsequent channel excavation to Elevation 107.0 would remove the so-called island and isolate one of the main towers, but all towers now have catwalk facilities so that access to one leg provides maintenance to the entire structure. This island removal and channel excavation of Scheme 4 would reduce the water surface elevation by .8 foot over Scheme 2. Attempting to maintain the Clinton Street siphon in Scheme 2 would seriously restrict the main channel opposite the confluence of the Mill and Peters Rivers so that extending the siphon as in Scheme 4 to the trench and then employing a gravity line beneath the trench would appear to be the more practical solution. Maintaining the trench downstream of the footbridge as a collection basin for the interior drainage eliminates cost of a new system and an added benefit might be the use of the trench as a supply reservoir to the industrial plants along Florence Drive by the addition of a small pumping facility from the main channel.

It is the recommendation of this report to propose the alignment of Scheme 4 as the one that should be developed for the final design of this phase of the Lower Woonsocket Local Protection Project.



TRIAL #3

SLICE NO.	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	7.04 K	4.8 K	5.5 K
2	20.74 K	16.7 K	12.9 K
3	35.24 K	30.7 K	14.3 K
4	44.42 K	44.0 K	4.7 K
5	21.21 K	20.7 K	-5.0 K
6	2.07 K	2.0 K	-1.0 K
TOTAL		118.9 K	31.4 K

$$F.S. = \frac{118.9(.5774)}{31.4} = 2.19$$

TRIAL #6

SLICE NO.	WEIGHT OF SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	.276 K	.2 K	NIL K
2	2.184 K	2.1 K	-.2 K
3	4.114 K	3.8 K	1.7 K
4	2.307 K	1.7 K	1.6 K
TOTAL		7.8 K	3.1 K

$$F.S. = \frac{7.8(.5774)}{3.1} = 1.45$$

REVISION	DATE	DESCRIPTION	BY

CHARLES A. MAGUIRE & ASSOCIATES
PROVIDENCE, R.I. HARTFORD, CONN. BOSTON, MASS.
ARCHITECT - ENGINEER

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
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WALTHAM, MASS.

DES. BY PJD | DR. BY | CK. BY

SUBMITTED ARCHITECT - ENGINEER

PROJECT ENGINEER

APPROVAL RECOMMENDED CHIEF, DESIGN BRANCH

APPROVAL RECOMMENDED CHIEF, R & R BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET TRENCH COMPLEX
DIKE LOCATION SCHEME #1

BLACKSTONE, MILL & PETERS RIVERS RHODE ISLAND

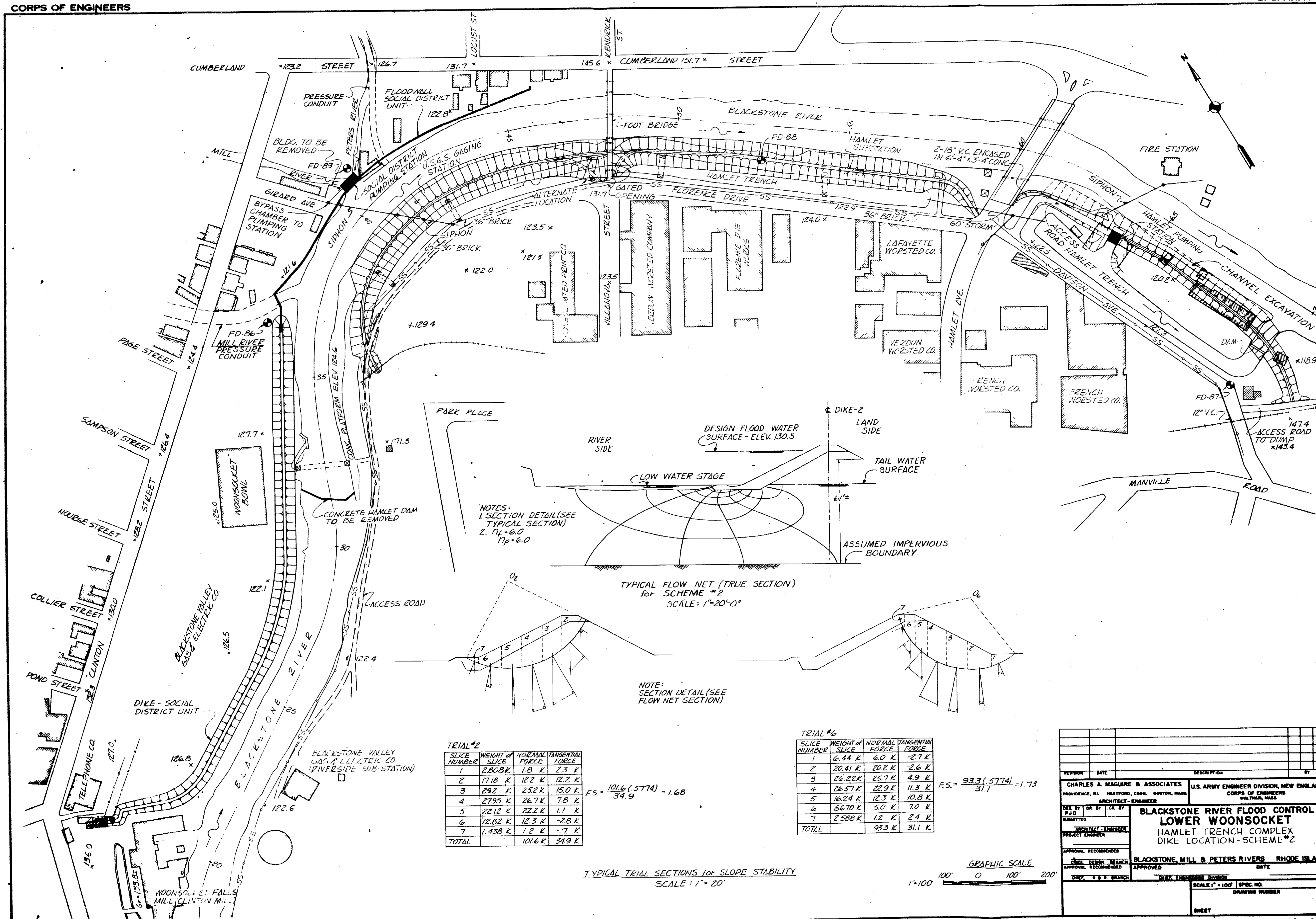
APPROVED CHIEF, ENGINEERING DIVISION DATE

SCALE 1" = 100' | SPEC. NO.

DRAWING NUMBER

SHEET

PLATE NO. 1A



TRIAL #2

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	2.808 K	1.8 K	2.3 K
2	17.18 K	12.2 K	12.2 K
3	29.2 K	25.2 K	15.0 K
4	27.95 K	26.7 K	7.8 K
5	22.12 K	22.2 K	1.1 K
6	12.82 K	12.3 K	-2.8 K
7	1.438 K	1.2 K	-.7 K
TOTAL		101.6 K	34.9 K

$$F.S. = \frac{101.6(.5774)}{34.9} = 1.68$$

TRIAL #6

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	6.44 K	6.0 K	-2.7 K
2	20.41 K	20.2 K	-2.6 K
3	26.22 K	25.7 K	4.9 K
4	26.57 K	22.9 K	11.3 K
5	16.24 K	12.3 K	10.8 K
6	8.670 K	5.0 K	7.0 K
7	2.588 K	1.2 K	2.4 K
TOTAL		93.3 K	31.1 K

$$F.S. = \frac{93.3(.5774)}{31.1} = 1.73$$

REVISION	DATE	DESCRIPTION	BY

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DES. BY PJD | DR. BY | CK. BY
SUBMITTED — ARCHITECT - ENGINEER
PROJECT ENGINEER
APPROVAL RECOMMENDED — CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED — CHIEF, P & R BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET TRENCH COMPLEX
DIKE LOCATION - SCHEME #2

BLACKSTONE, MILL & PETERS RIVERS RHODE ISLAND

APPROVED — CHIEF, ENGINEERING DIVISION DATE

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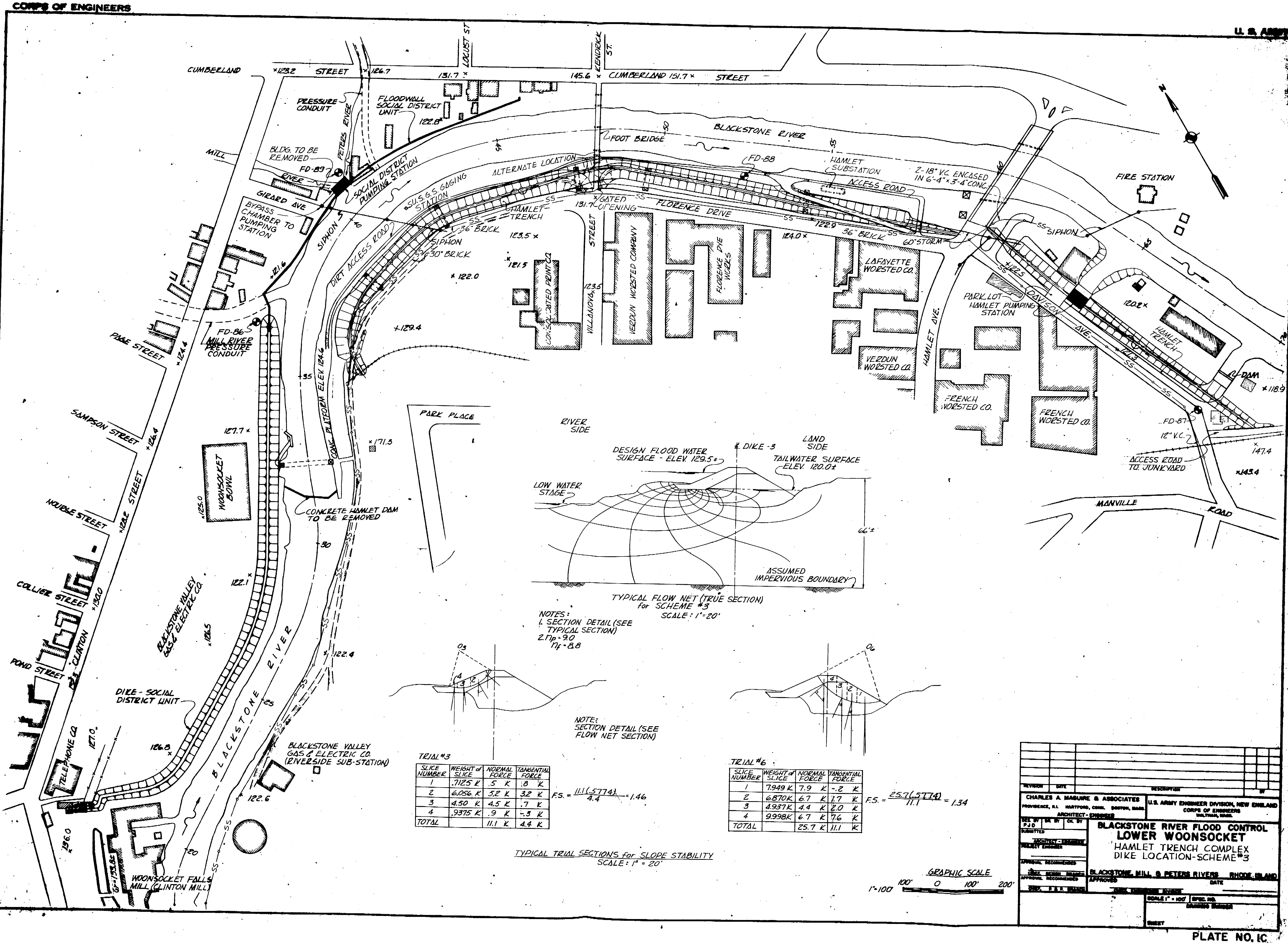
CORPS OF ENGINEERS

U. S. ARMY



TRIAL #3

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	.7125 K	.5 K	.8 K
2	6.056 K	5.2 K	3.2 K
3	4.50 K	4.5 K	.7 K
4	.9375 K	.9 K	-.3 K
TOTAL		11.1 K	4.4 K

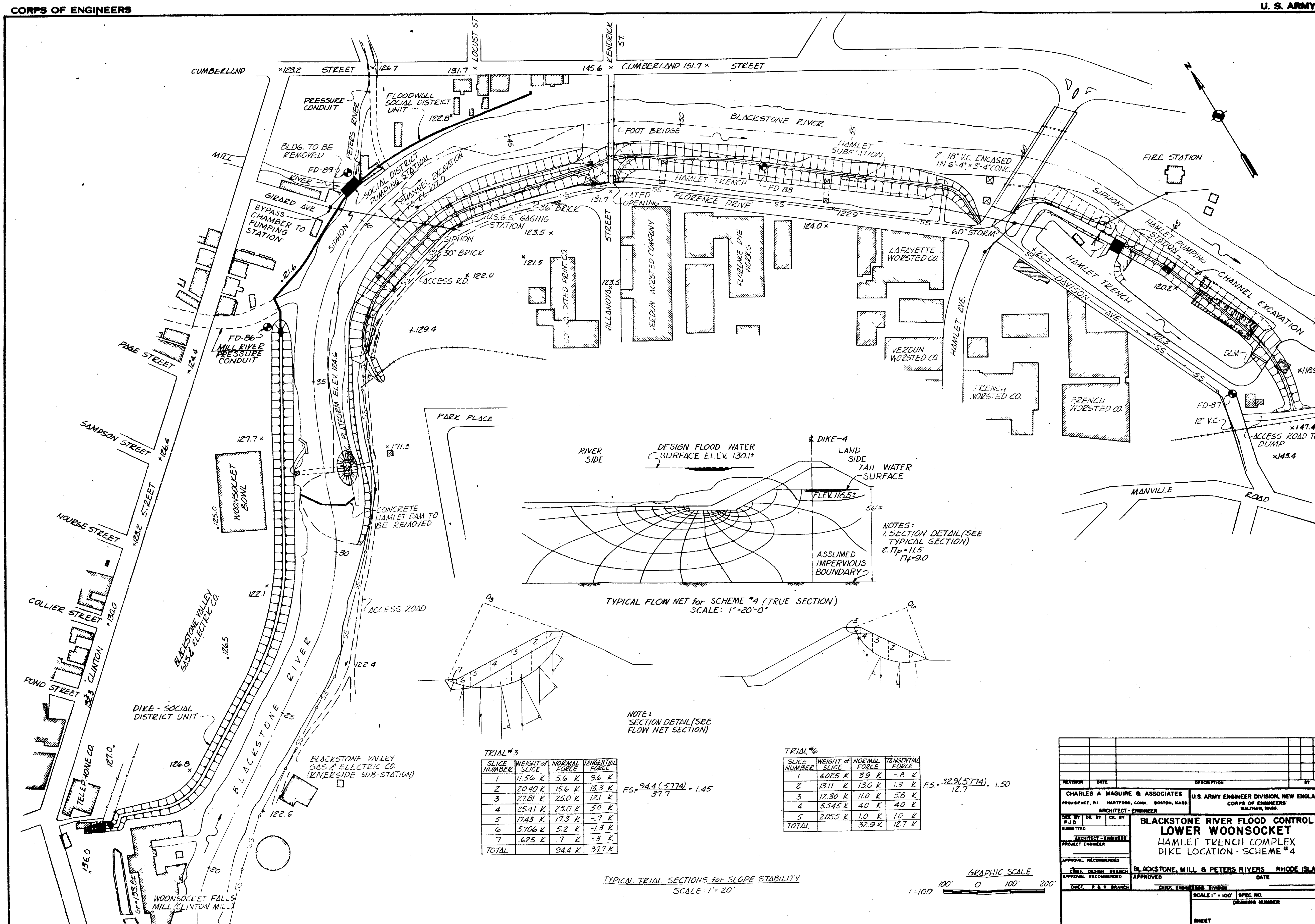
$F.S. = \frac{11.1(.5774)}{4.4} = 1.46$

TRIAL #6

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	7.949 K	7.9 K	-.2 K
2	6.870K	6.7 K	1.7 K
3	4.937K	4.4 K	2.0 K
4	9.998K	6.7 K	7.6 K
TOTAL		25.7 K	11.1 K

$F.S. = \frac{25.7(.5774)}{11.1} = 1.34$

PLATE NO. 1C



TRIAL #3

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	11.56 K	5.6 K	9.6 K
2	20.40 K	15.6 K	13.3 K
3	27.81 K	25.0 K	12.1 K
4	25.41 K	25.0 K	5.0 K
5	17.43 K	17.3 K	-.7 K
6	5.706 K	5.2 K	-1.3 K
7	.625 K	.7 K	-.3 K
TOTAL		94.4 K	37.7 K

$F.S. = \frac{94.4(.5774)}{37.7} = 1.45$

TRIAL #6

SLICE NUMBER	WEIGHT of SLICE	NORMAL FORCE	TANGENTIAL FORCE
1	4.025 K	3.9 K	-.8 K
2	13.11 K	13.0 K	1.9 K
3	12.30 K	11.0 K	5.8 K
4	5.545 K	4.0 K	4.0 K
5	2.055 K	1.0 K	1.0 K
TOTAL		32.9 K	12.7 K

$F.S. = \frac{32.9(.5774)}{12.7} = 1.50$

REVISION | DATE | DESCRIPTION | BY

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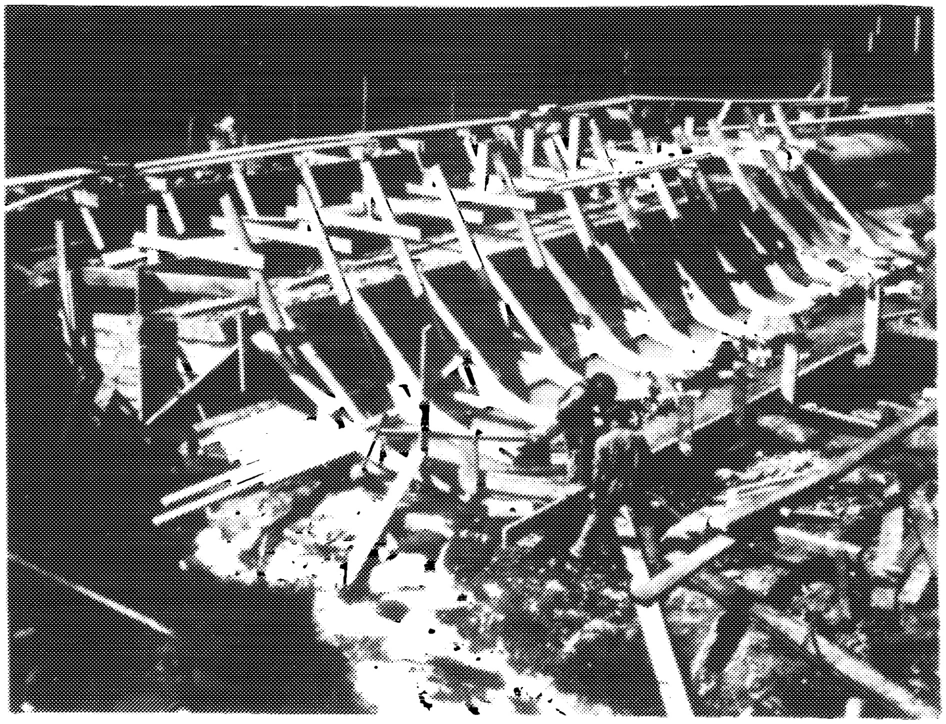
DES. BY PJD | DR. BY | CK. BY

SUBMITTED
ARCHITECT-ENGINEER
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P & R BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET TRENCH COMPLEX
DIKE LOCATION - SCHEME #4

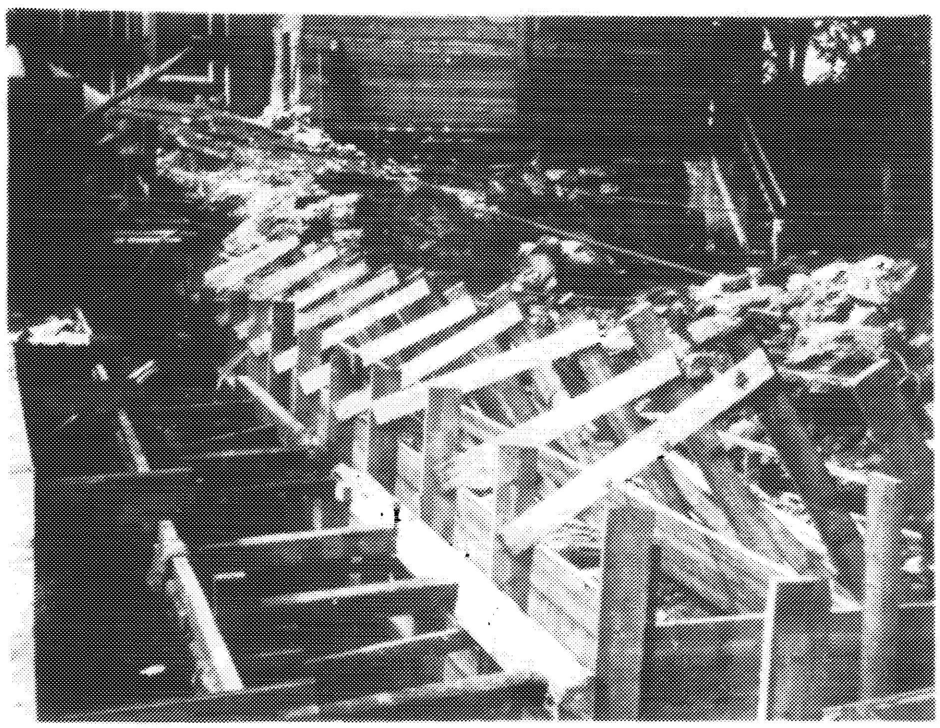
BLACKSTONE, MILL & PETERS RIVERS RHODE ISLAND

APPROVED | DATE
CHIEF, ENGINEERING DIVISION
SCALE 1" = 100' | SPEC. NO.
DRAWING NUMBER
SHEET



HAMLET DAM CONSTRUCTION - 1912

PLATE NO. 1E



HAMLET DAM CONSTRUCTION - 1912

PLATE NO. 1F

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

BLACKSTONE RIVER PROFILE

CHARLES A. MAGUIRE & ASSOCIATES

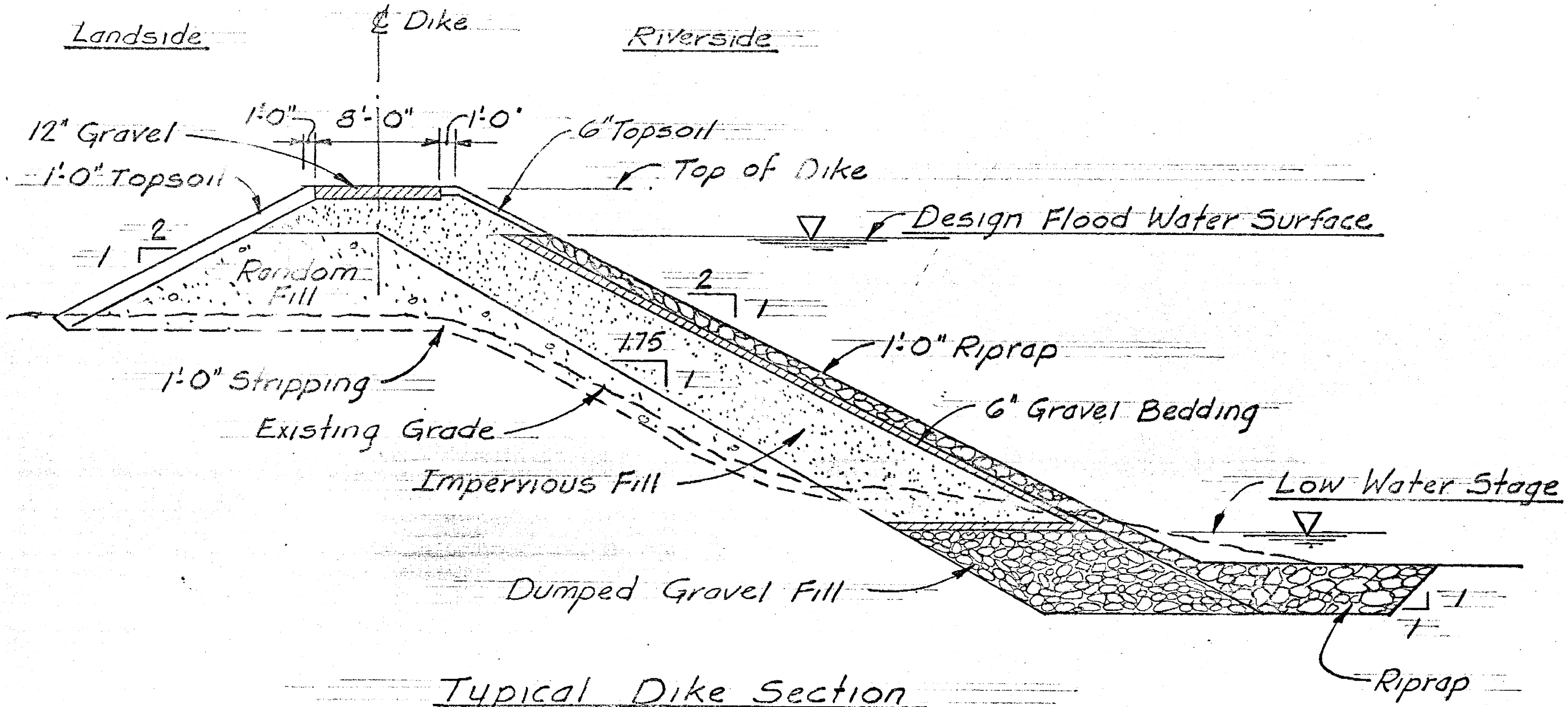
PLATE NO. 16

CHARLES A. MAGUIRE & ASSOCIATES, ENGINEERS

PROJECT Woonsocket Flood Control Project
SUBJECT Water Surface & Hydraulic Gradient
COMP. ____ CHECK ____
ACC. NO. ____ SHEET NO. ____ OF ____
DATE ____ 19__ CONT. NO. ____

Table II
Water Surface & Hydraulic Gradient Elevations at Key Points

Approximate Station	Water Surface Elevations for Schemes						Hydraulic Gradient Elevations for Schemes						Location
	Exist	1	2	3	3A	4	Exist	1	2	3	3A	4	
72+60	126.70	126.70	126.70	126.70	126.70	126.70	127.40 (1.97)	127.40 (2.61)	127.40 (2.09)	127.40 (1.77)	127.40 (1.77)	127.40 (2.09)	Opposite Sewage Treatment Plant
60+50	127.77	128.68	128.07	127.73	127.73	128.07	129.37 (1.62)	130.01 (1.62)	129.49 (2.23)	129.17 (2.16)	129.17 (2.16)	129.49 (2.23)	Hamlet Avenue Bridge
48+00	129.57	130.59	129.72	129.20	129.20	129.72	130.99 (1.45)	131.63 (1.44)	131.72 (2.19)	131.33 (2.51)	131.33 (1.47)	131.72 (1.32)	Kendrick Avenue Foot Bridge
35+50	131.60	132.17	133.04	132.43	132.21	132.47	132.44 (1.01)	133.07 (0.48)	133.91 (0.46)	133.84 (0.59)	132.80 (0.40)	133.04 (0.39)	End of Hamlet Dike
30+20	132.69	132.68	133.55	133.60	132.42	132.67	133.45 (0.82)	133.55 (1.06)	134.37 (0.86)	134.43 (0.88)	133.20 (1.19)	133.45 (1.10)	120 ft. U.S. Hamlet Dam
22+30	132.94	133.13	133.89	133.97	132.91	133.06	134.27	134.61	135.23	135.31	134.39	134.53	End of Social Dike



Typical Dike Section
(Where slope intercepts river bottom)

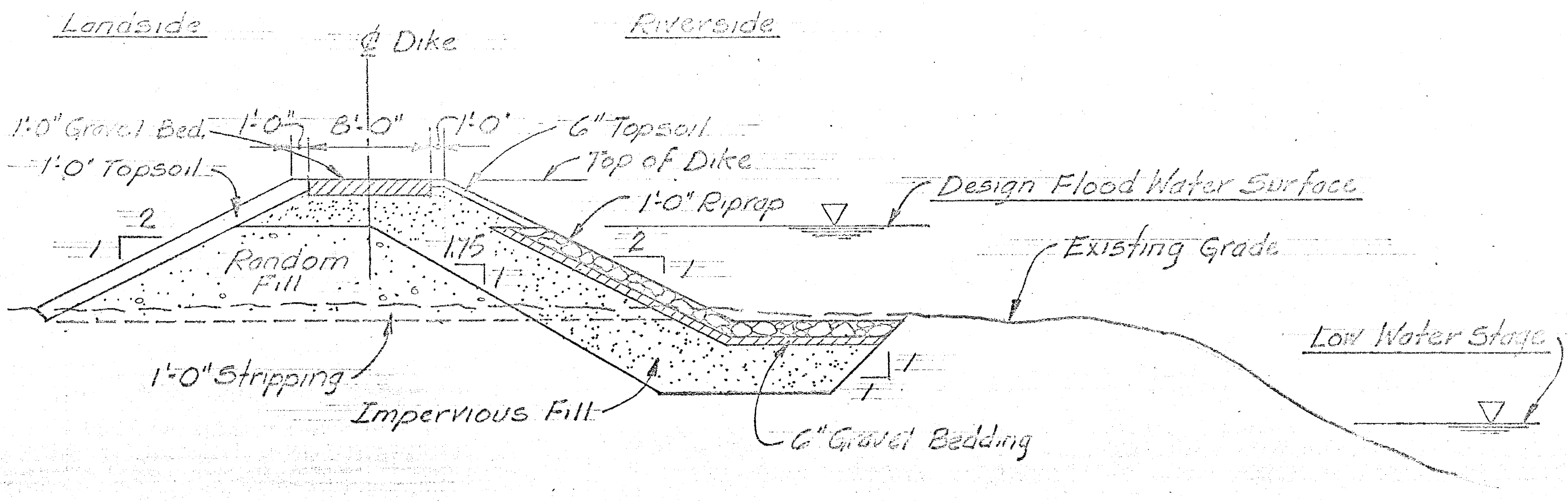
Scale 1" = 10'-0"

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

DIKE SECTION

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1"=10'

PLATE NO. 1G2



Typical Dike Section

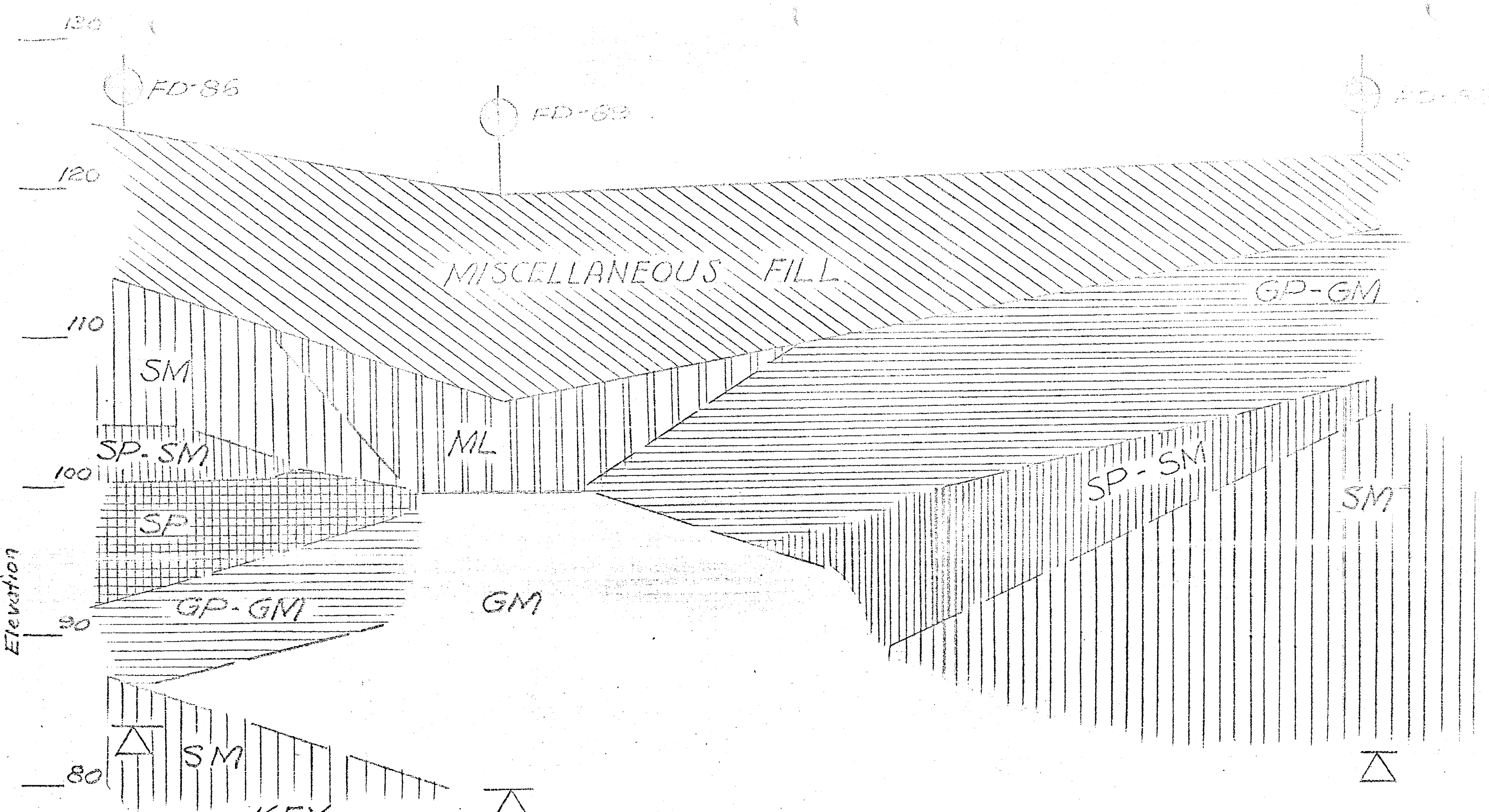
Scale 1" = 10'-0"

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

DIKE SECTION

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 10'

PLATE NO. 16₃



KEY

GM	Silty Gravels, Gravel, Silt, Sand Mixtures
GP	Poorly Graded Gravels, Gravel Sand Mixtures
ML	Inorganic Silts, Very Fine Sands, Clayey Silts
SM	Silty Sands, Sand, Silt Mixtures
SP	Poorly Graded Sands, Little or No Fines

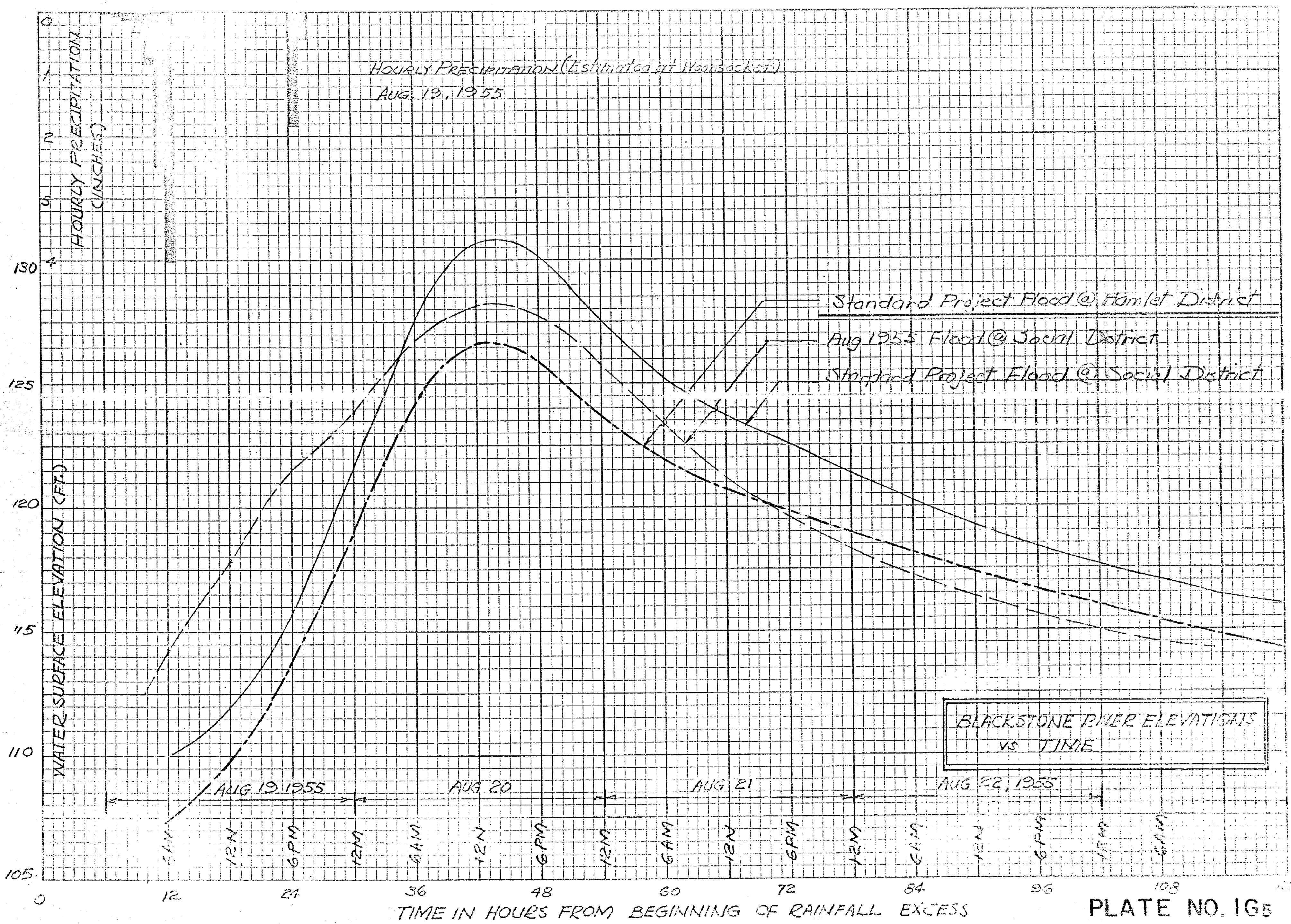
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

GENERALIZED SOIL PROFILE

CHARLES A. MAGUIRE & ASSOCIATES

HORIZONTAL SCALE 1" = 200'
VERTICAL SCALE 1" = 10'

PLATE NO. 16 4



HOURLY PRECIPITATION (Estimated at Woonsocket)
AUG. 19, 1955
HOURLY PRECIPITATION (INCHES)
WATER SURFACE ELEVATION (FT.)
Standard Project Flood @ Hamlet District
Aug 1955 Flood @ Social District
Standard Project Flood @ Social District
BLACKSTONE RIVER ELEVATIONS vs TIME
AUG 19 1955
AUG 20
AUG 21
AUG 22, 1955
6AM
12N
6PM
12M
TIME IN HOURS FROM BEGINNING OF RAINFALL EXCESS

PLATE NO. IG5

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

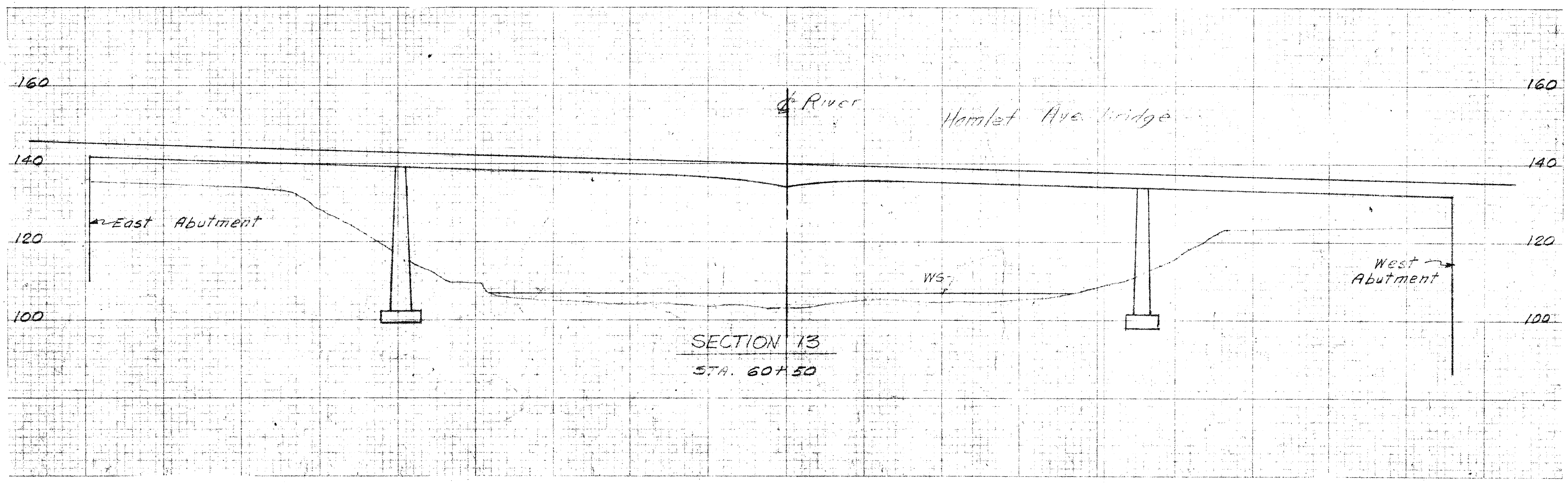
PLATE IH1

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20

PLATE 1H2

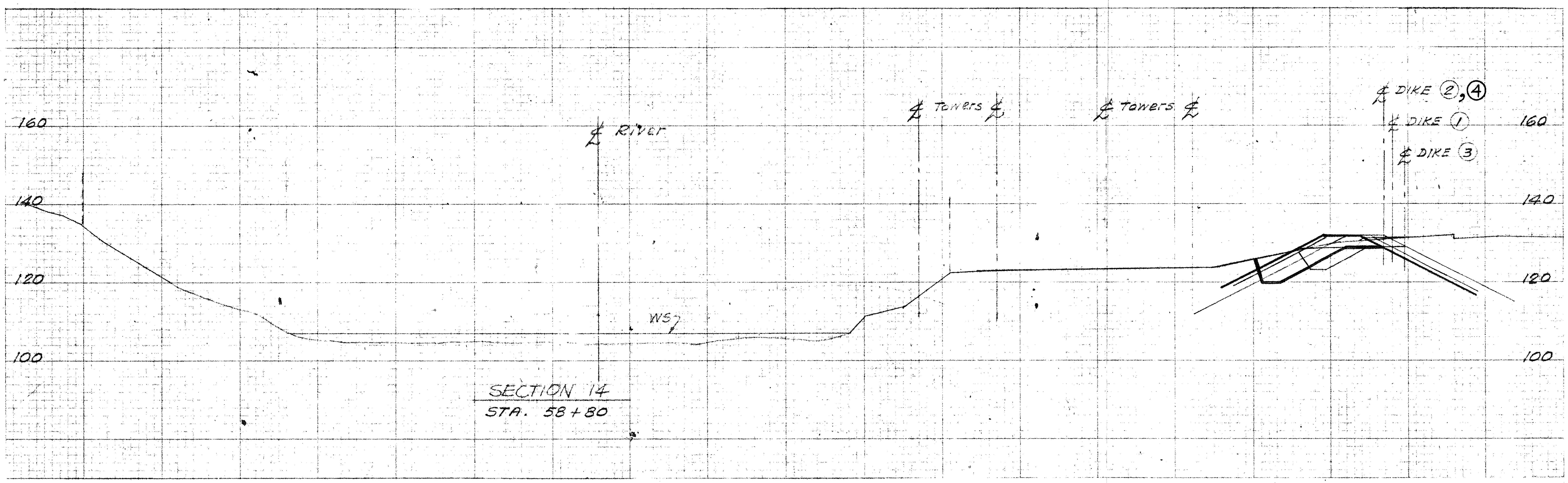


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

PLATE 1H3

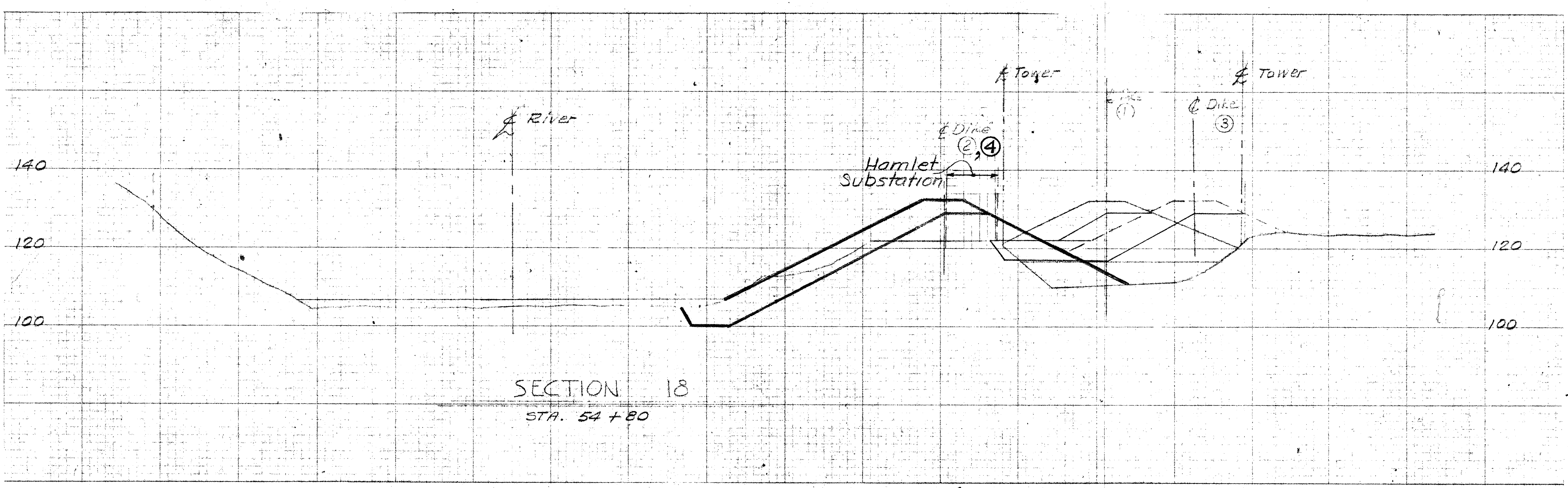


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

PLATE I H4

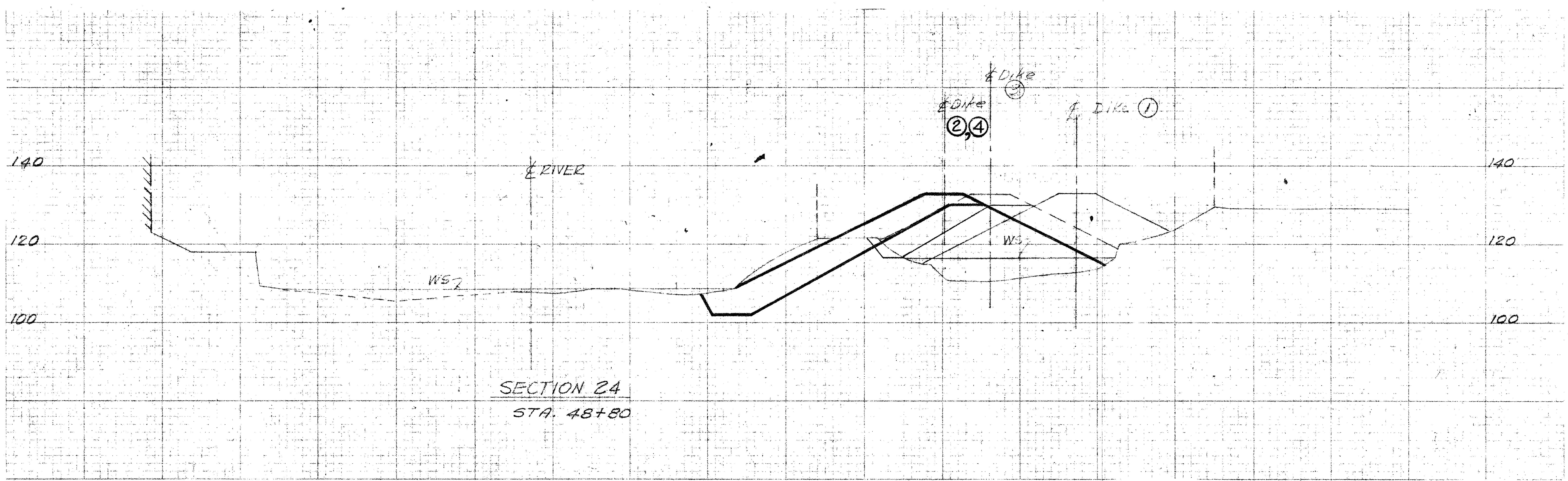


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20

PLATE 1H5

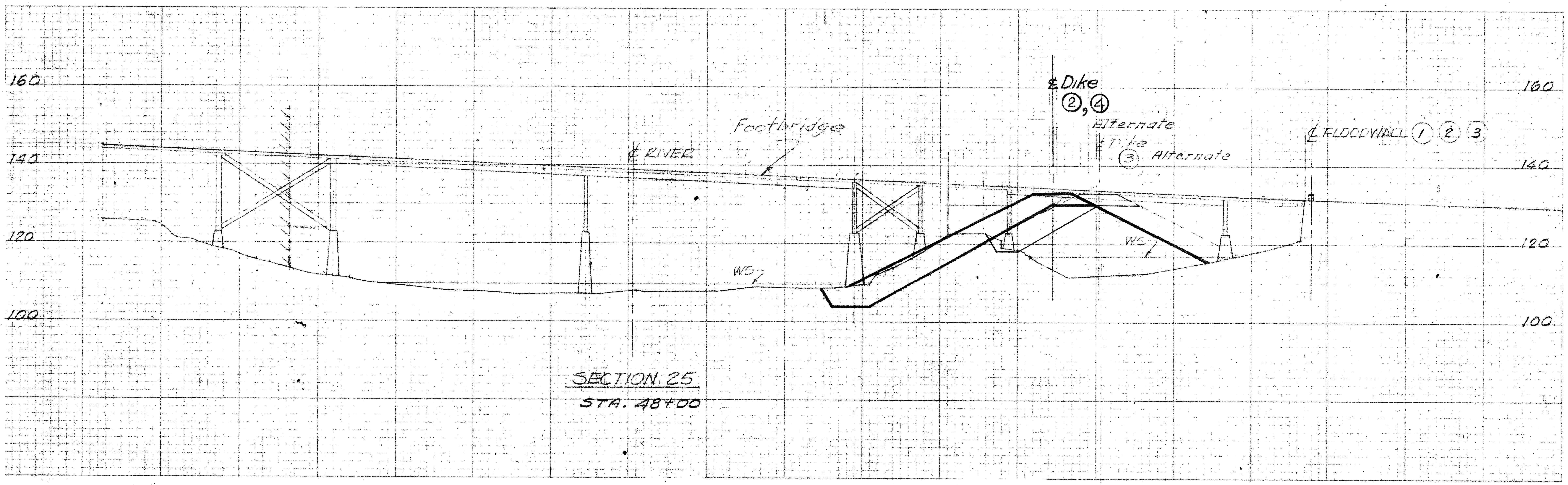


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

PLATE 1H6

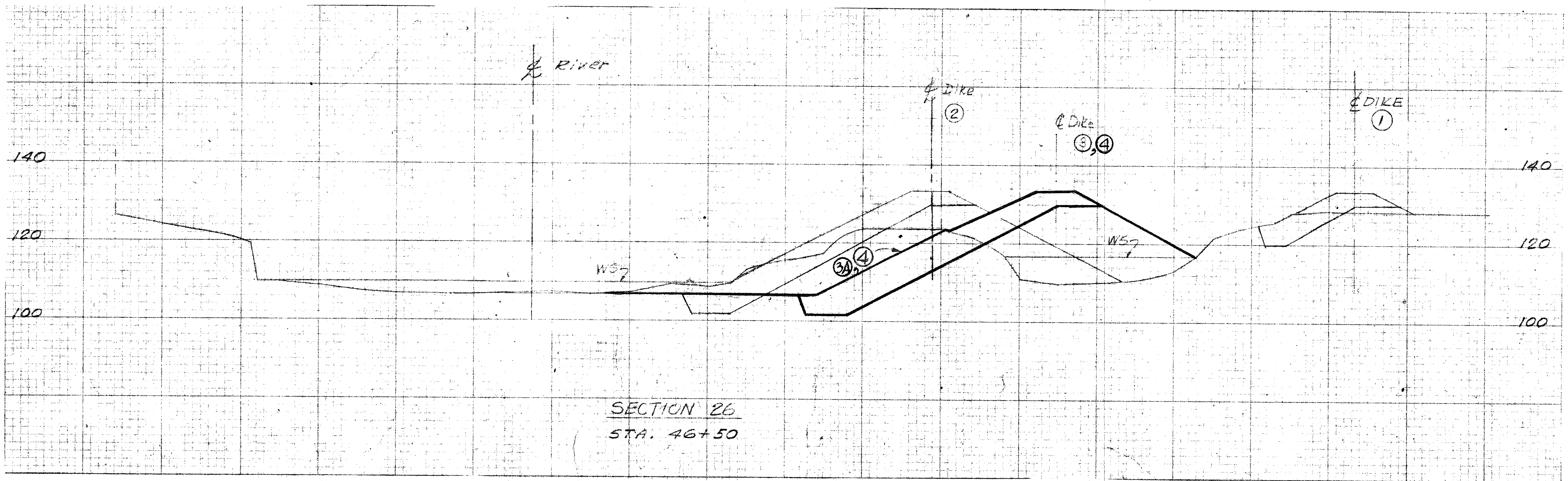


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

PLATE 1H7

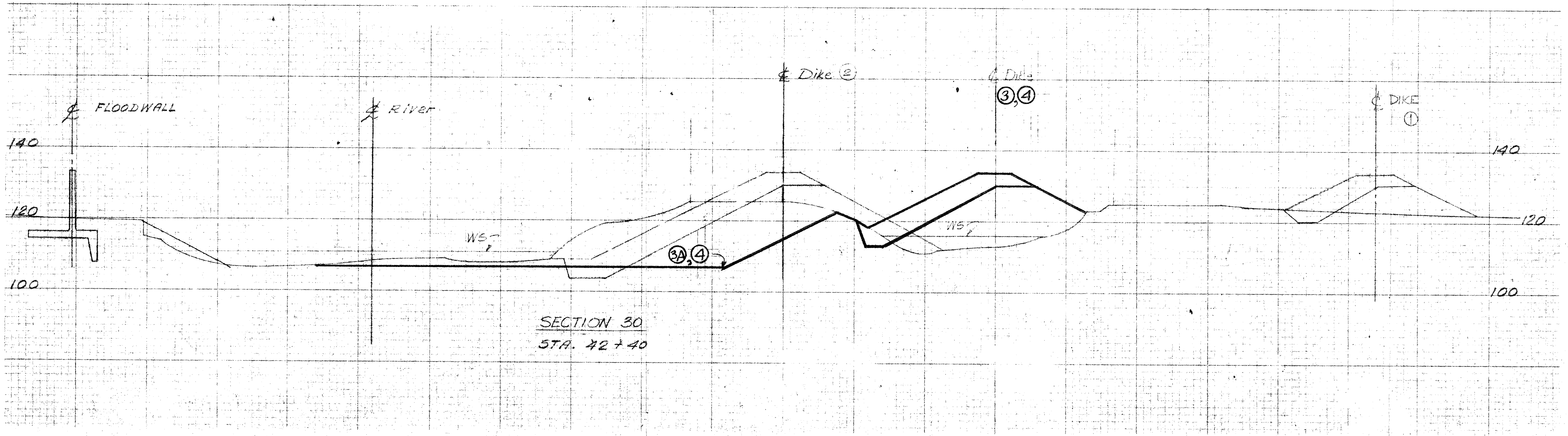


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

PLATE IH8



BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

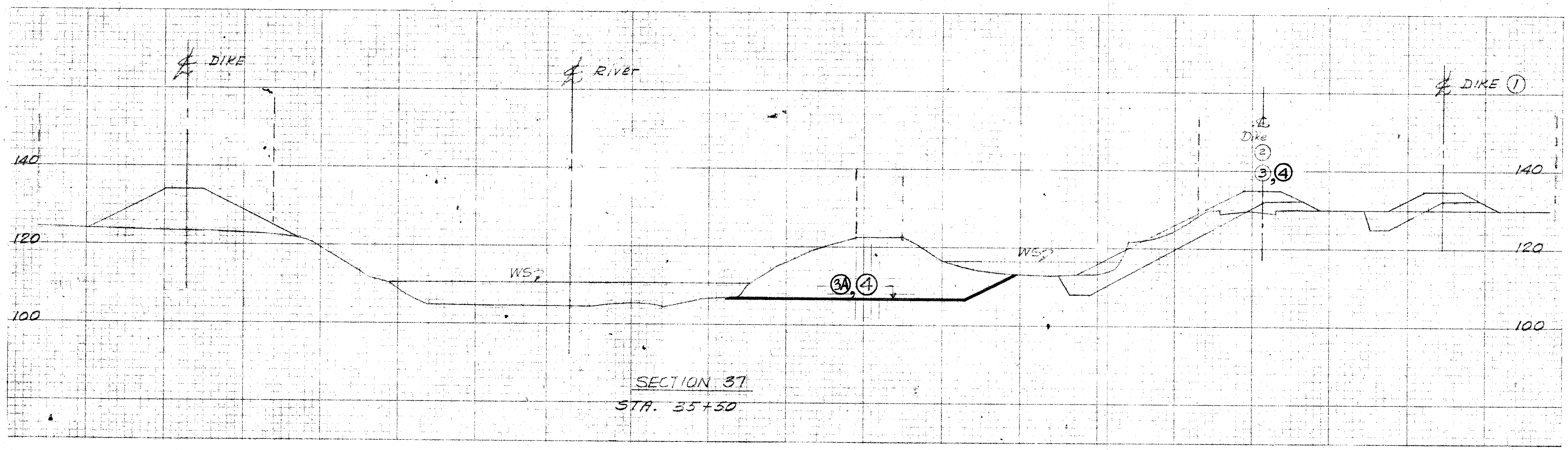
PLATE 1H9

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

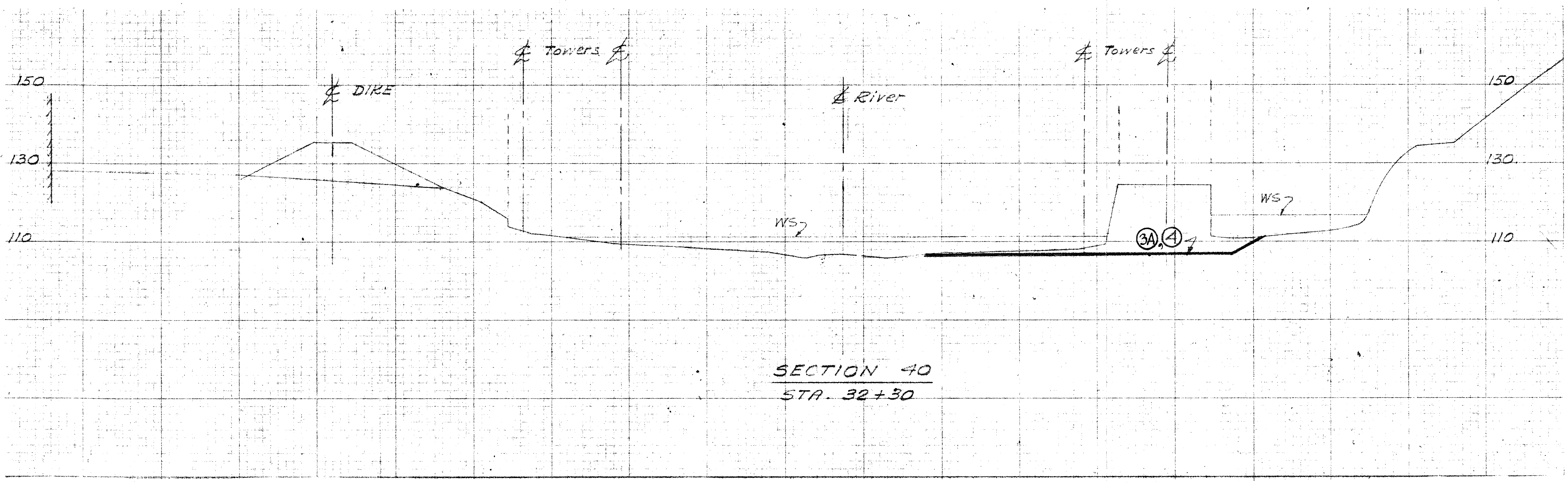
PLATE 1H10



BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

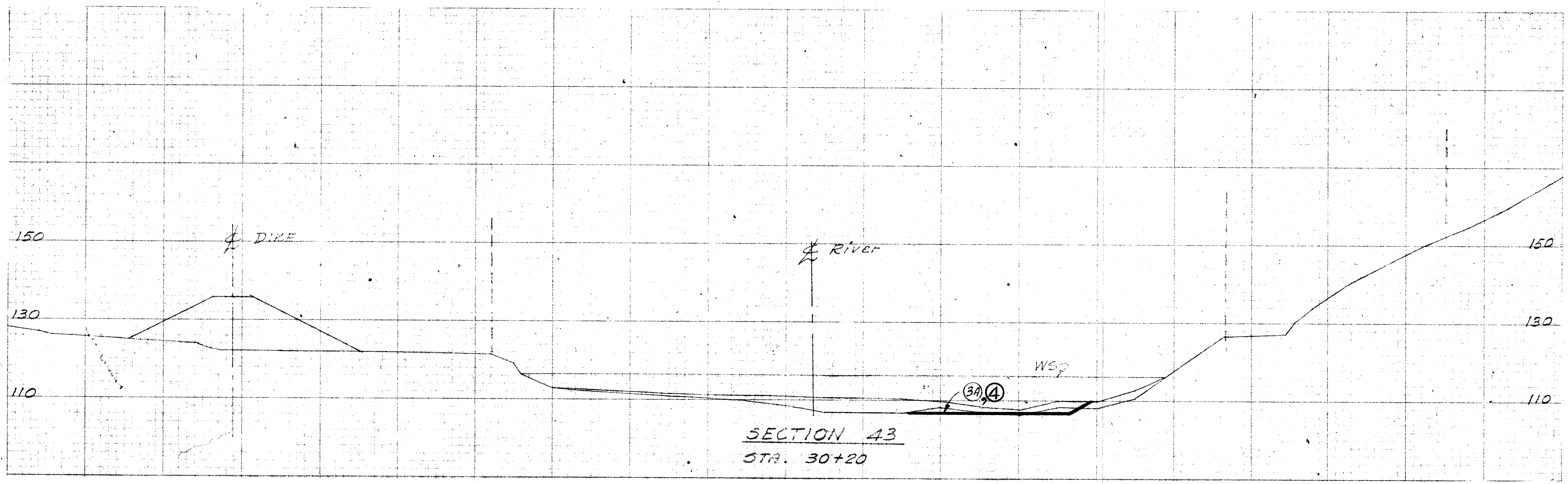
CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'



BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'



BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TYPICAL SECTIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1" = 20'

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

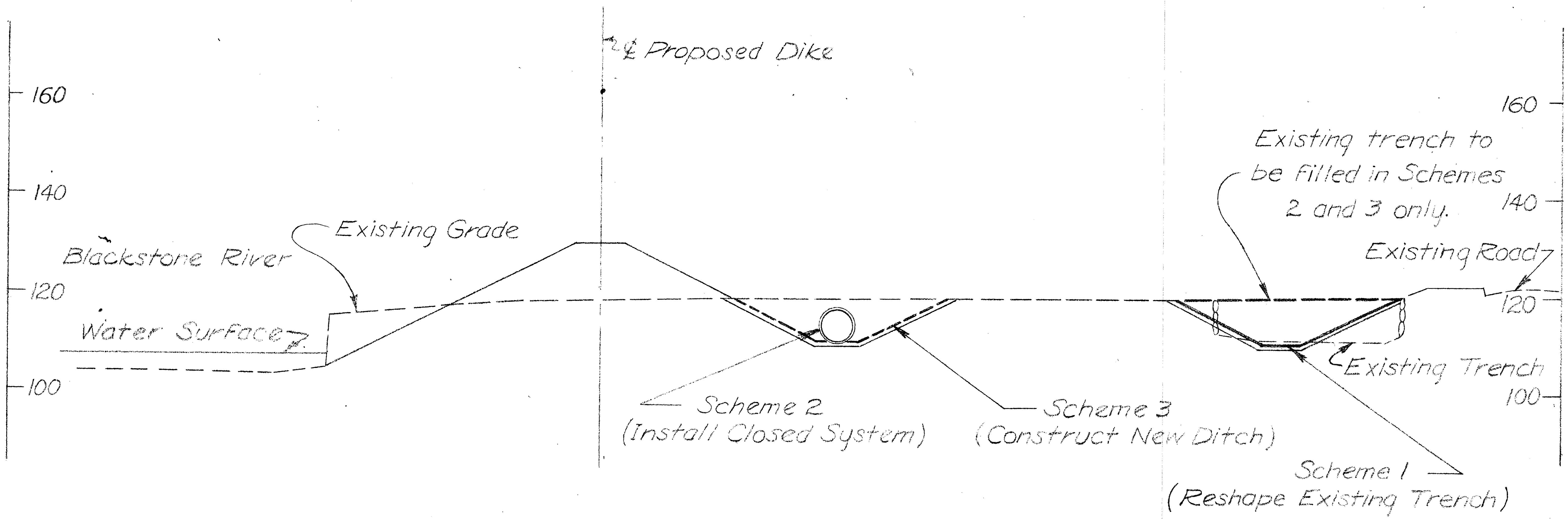
HAMLET TRENCH COMPLEX

STORM DRAINAGE

CHARLES A. MAGUIRE & ASSOCIATES

SCALE 1" = 100'

PLATE NO. 2A

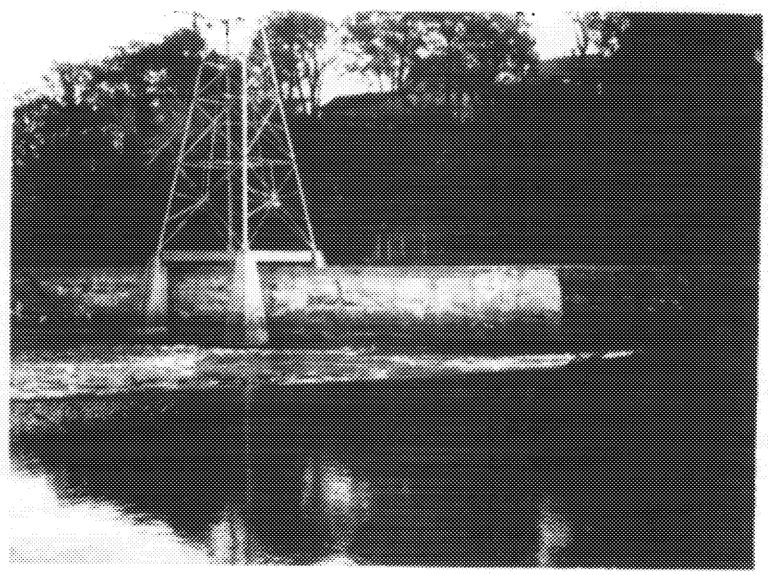


BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

PROPOSED SCHEMES
FOR COLLECTING
INTERIOR DRAINAGE

CHARLES A. MAGUIRE & ASSOCIATES
SCALE 1"=20'

PLATE NO. 2 A_1



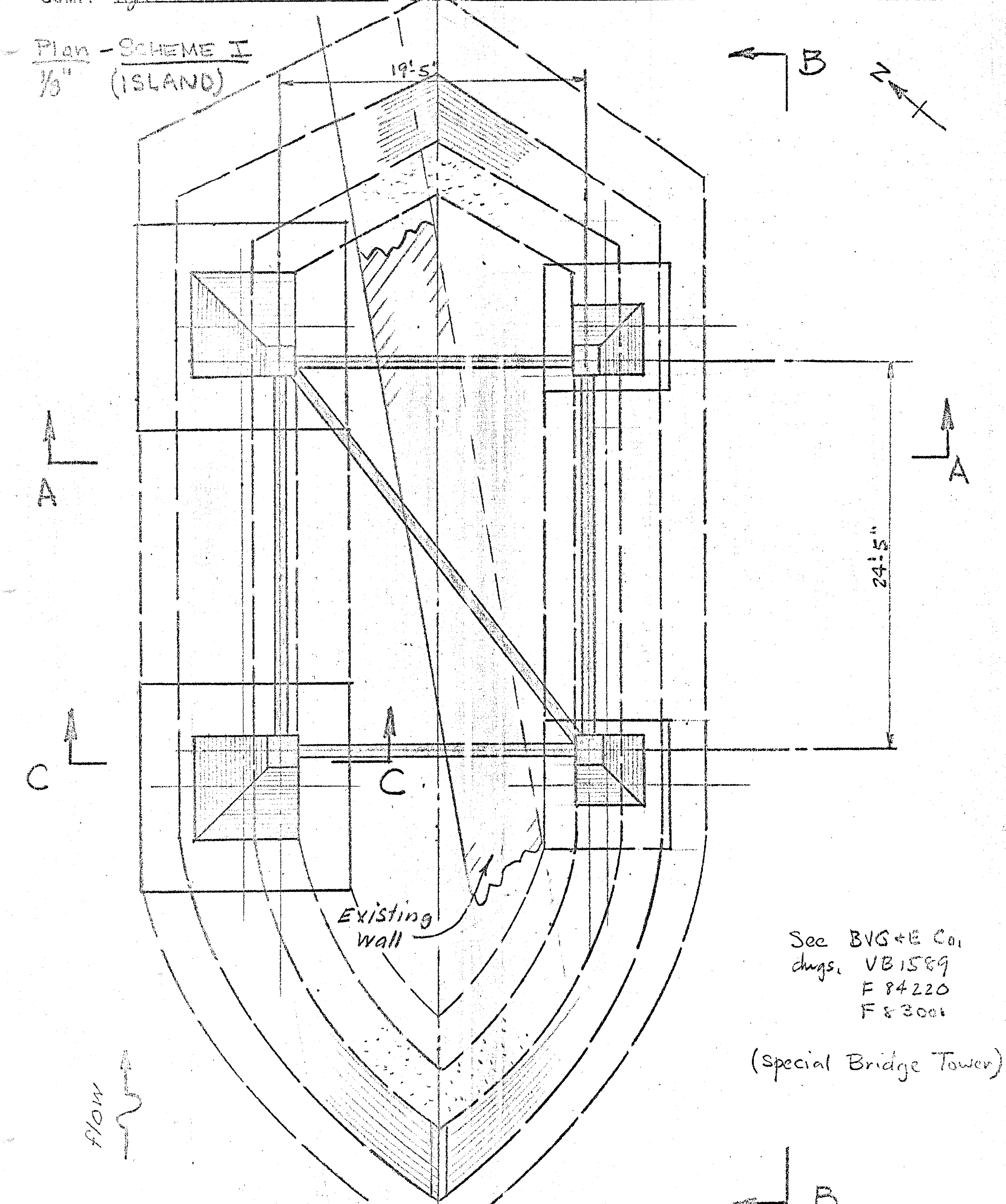
Hamlet Dam Headrace
South Bank of River

PROJECT Woonsocket Flood Control ACC. NO.

SUBJECT Elect. Tower - Hamlet Canal (Intake & Dam) SHEET NO. OF

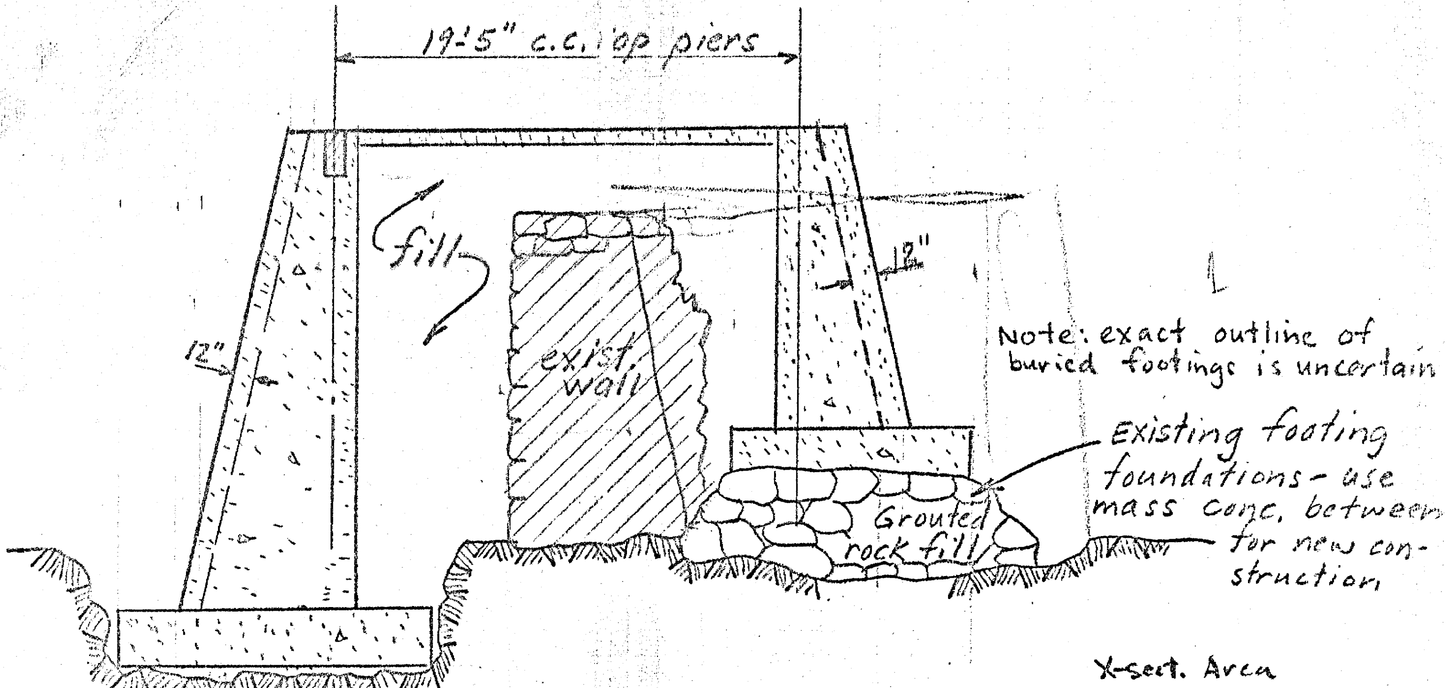
Tower on South side on Dam DATE 19

COMP. [illegible] CHECK CONT. NO.



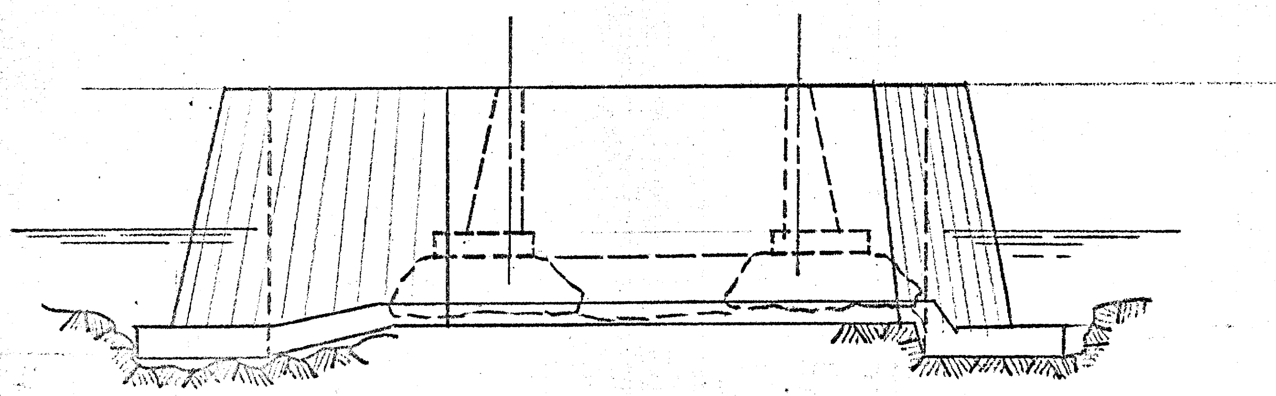
CHARLES A. MAGUIRE & ASSOCIATES, ENGINEERS

PLATE NO. 3B

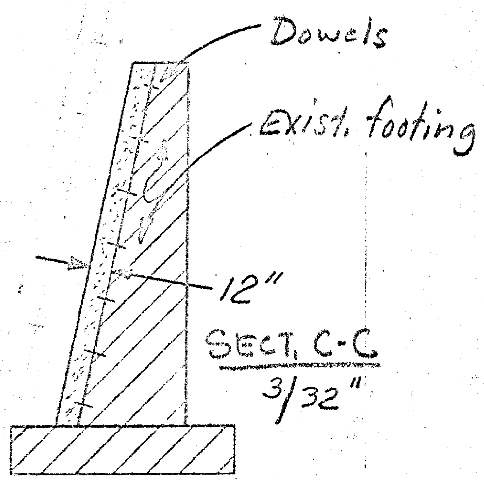


X-sect. Area
28 × 18 = 500 □'±

SECT. A-A
1/8"



ELEV. B-B
1/16"

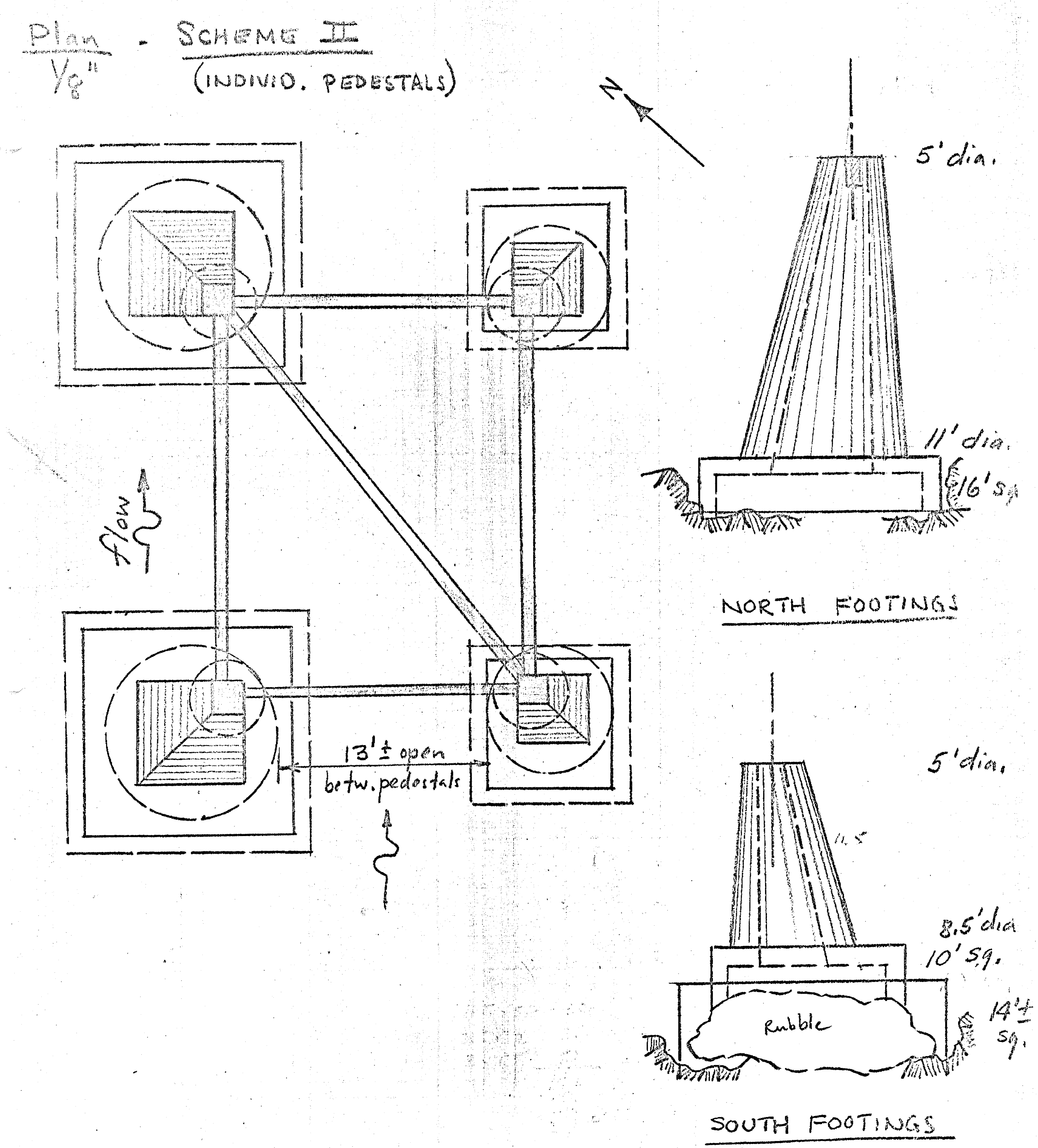


SECT. C-C
3/32"

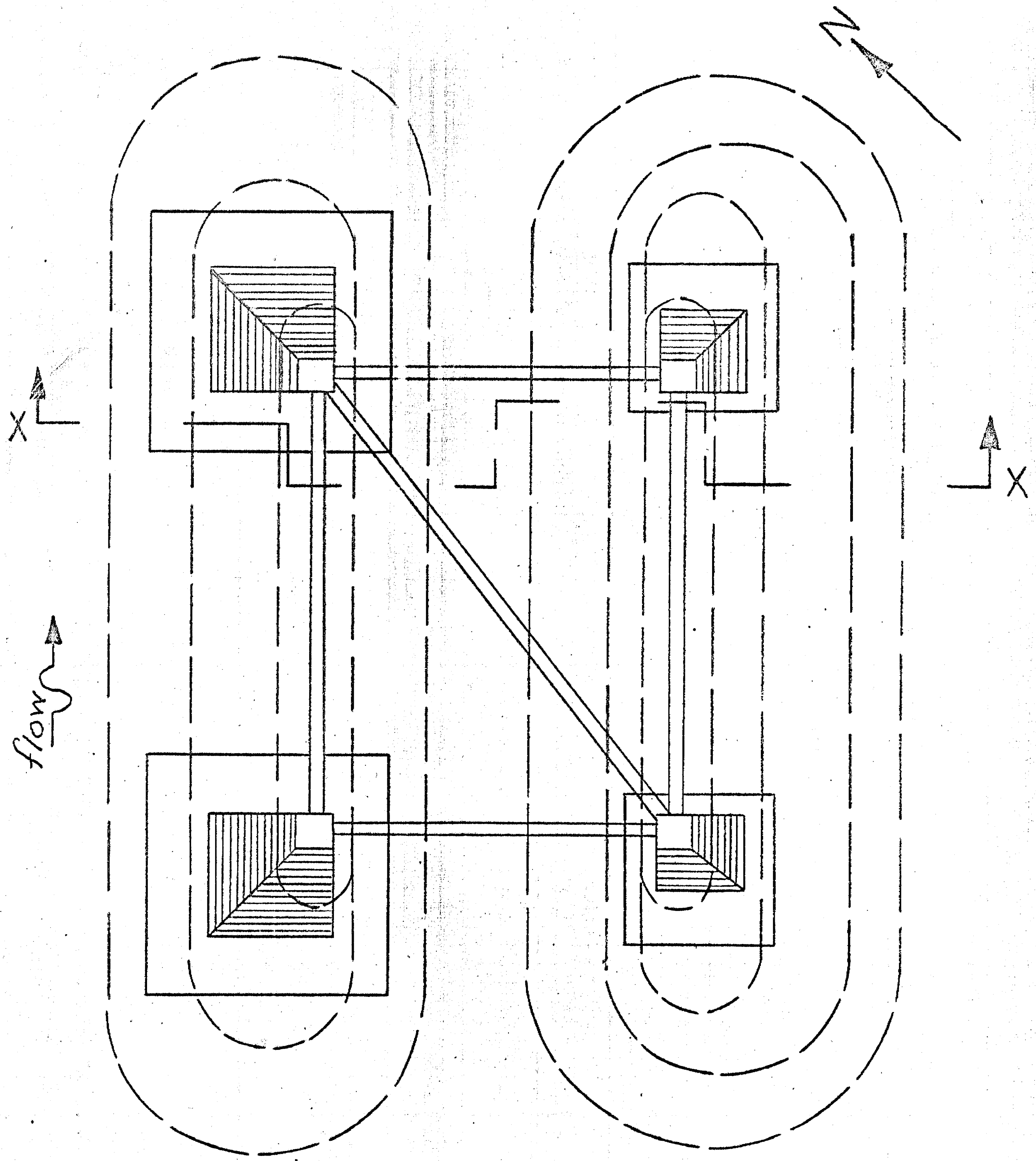
SCHEME I
(ISLAND)

NOTE: New wall to line up with inside face of existing footings, cover slope face with 12" conc., line up with exist. footings ±

CHARLES A. MAGUIRE AND ASSOCIATES PROVIDENCE · HARTFORD · BOSTON	TITLE Woonsocket ELECT. TOWER - HAMLET CANAL	C.A.M. JOB NO.
		SCALE
	DRAWN BY / DATE	DWG. NO. PLATE NO. 3C



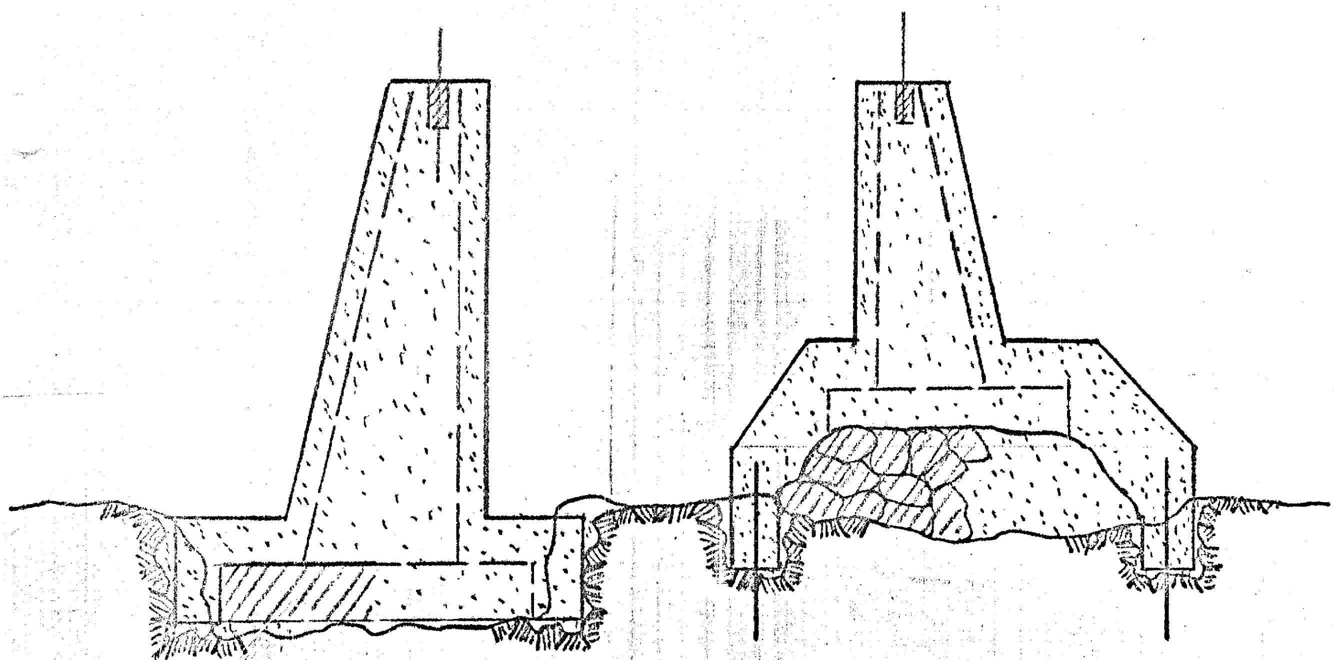
CHARLES A. MAGUIRE AND ASSOCIATES PROVIDENCE · HARTFORD · BOSTON	TITLE Woonsocket ELEC. TOWER	C.A.M. JOB NO.
		SCALE
	DRAWN BY / DATE	DWG. NO. PLATE NO. 3



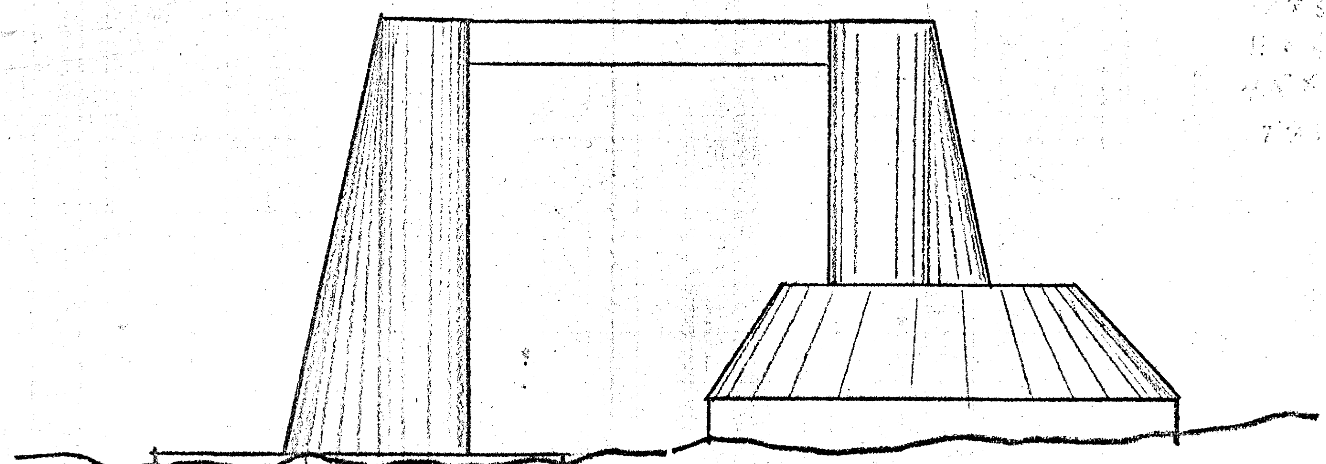
Plan- SCHEME IV (2 PIERS)

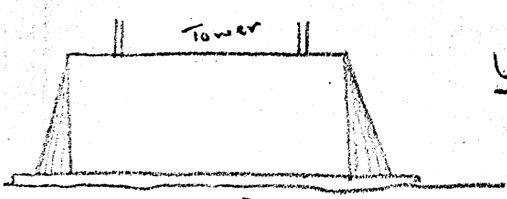
CHARLES A. MAGUIRE AND ASSOCIATES PROVIDENCE · HARTFORD · BOSTON	TITLE Woonsocket	C.A.M. JOB NO.
		SCALE 1/8"=1'-0"
	DRAWN BY	DATE
		DWG. NO. PLATE NO. 3E

SCHEME IV (2 PIERS)



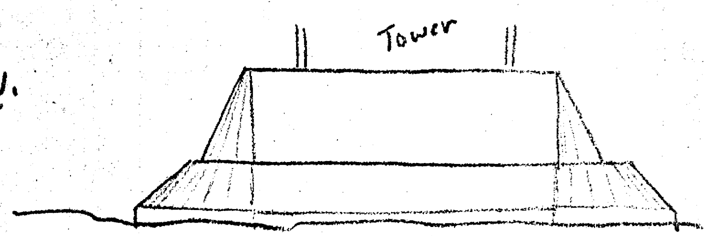
SECT. X-X
1/8"





North Pier
N.T.S.

UPSTREAM ELEV.
1/8"



South Pier
N.T.S.

CHARLES A. MAGUIRE
AND
ASSOCIATES

PROVIDENCE · HARTFORD · BOSTON

TITLE *Woonsocket*

C.A.M. JOB NO.

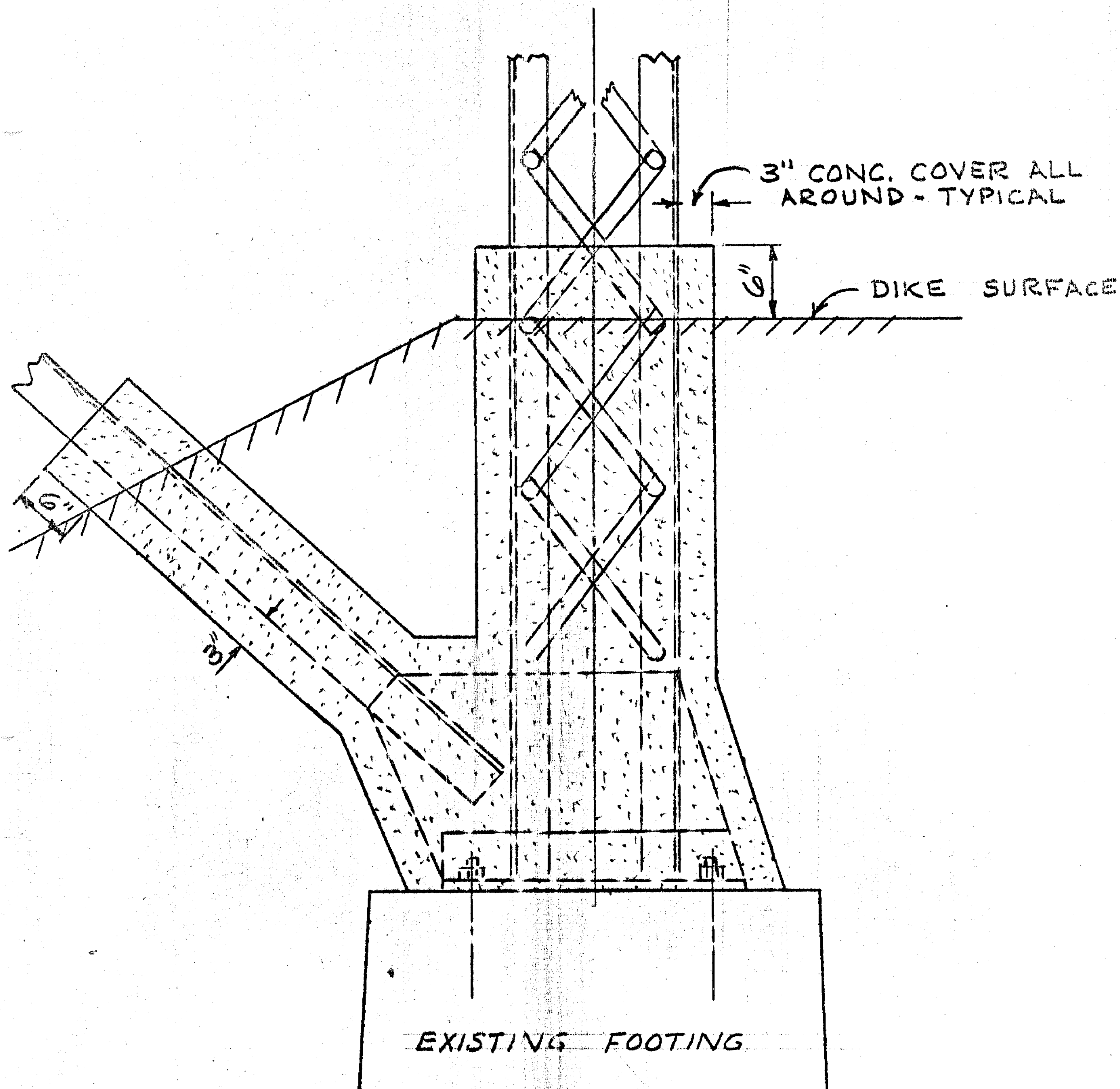
SCALE

DRAWN BY

DATE

DWG. NO.

PLATE NO. 3



TOWER STEEL PROTECTION (CONCRETE)

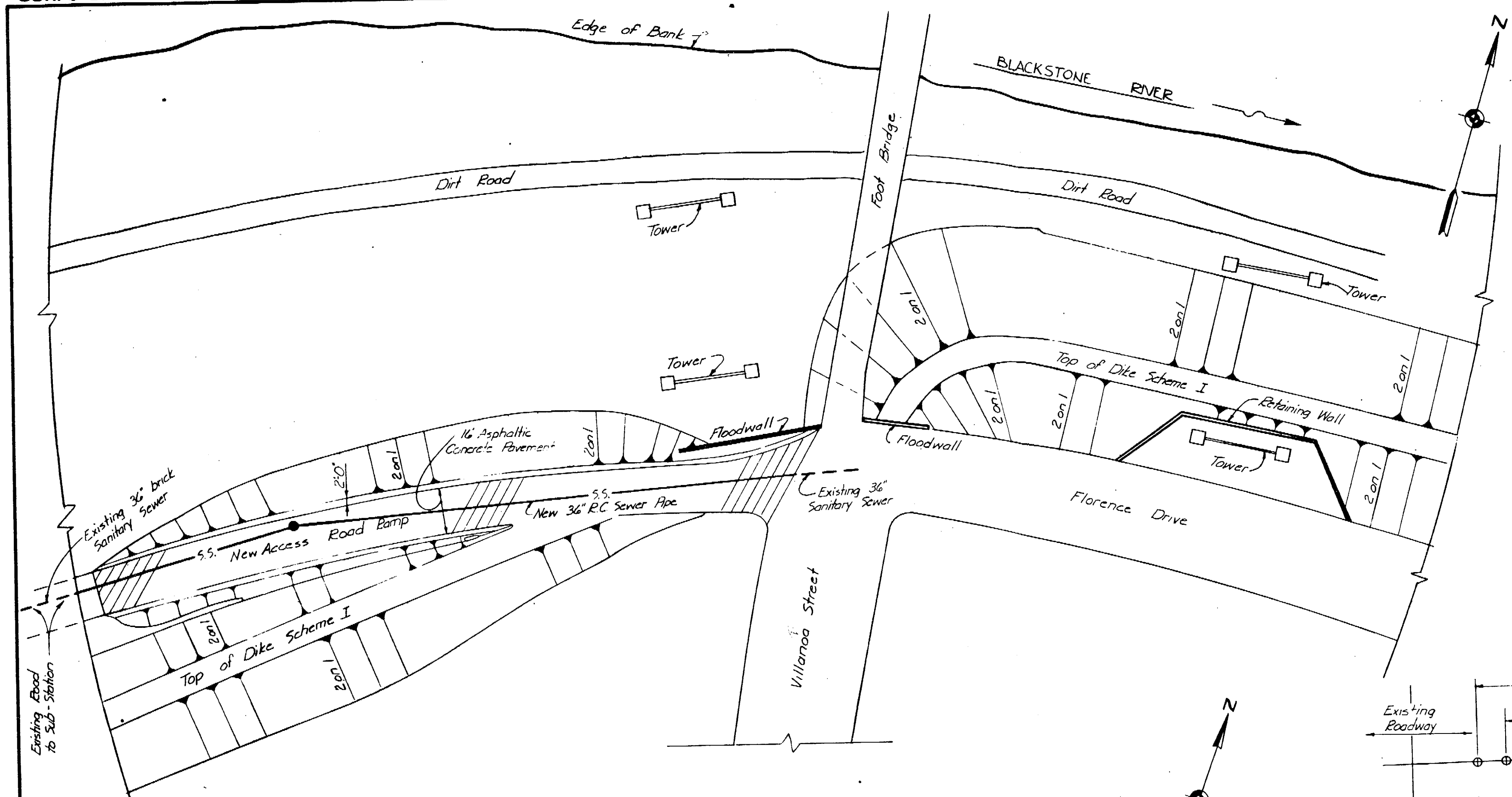
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TOWER MODIFICATIONS

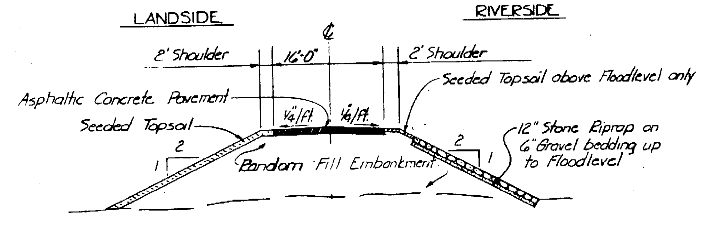
CHARLES A. MAGUIRE & ASSOCIATES

SCALE 3" = 1'-0"

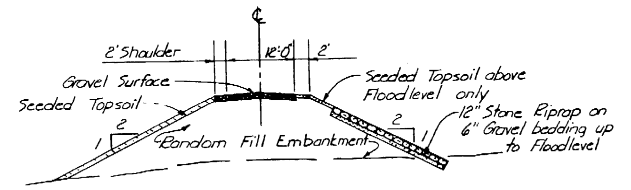
PLATE NO. 36



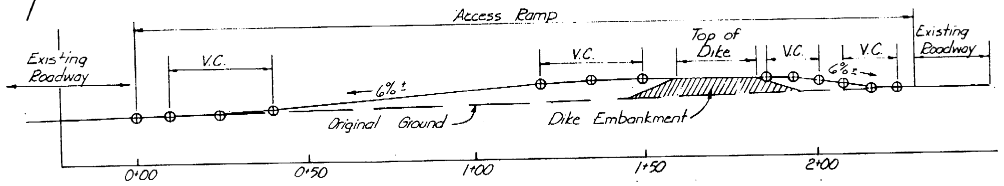
PLAN – SUBSTATION ACCESS RAMP
(STATION 35 - DIKE SCHEME I)
Scale 1" = 20'



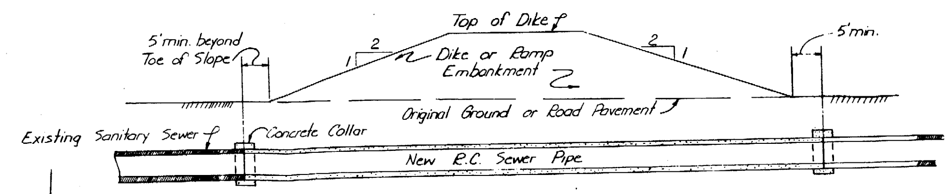
TYPICAL SECTION
PAVED - SUB-STATION ACCESS RAMP
Scale: 1" = 10'



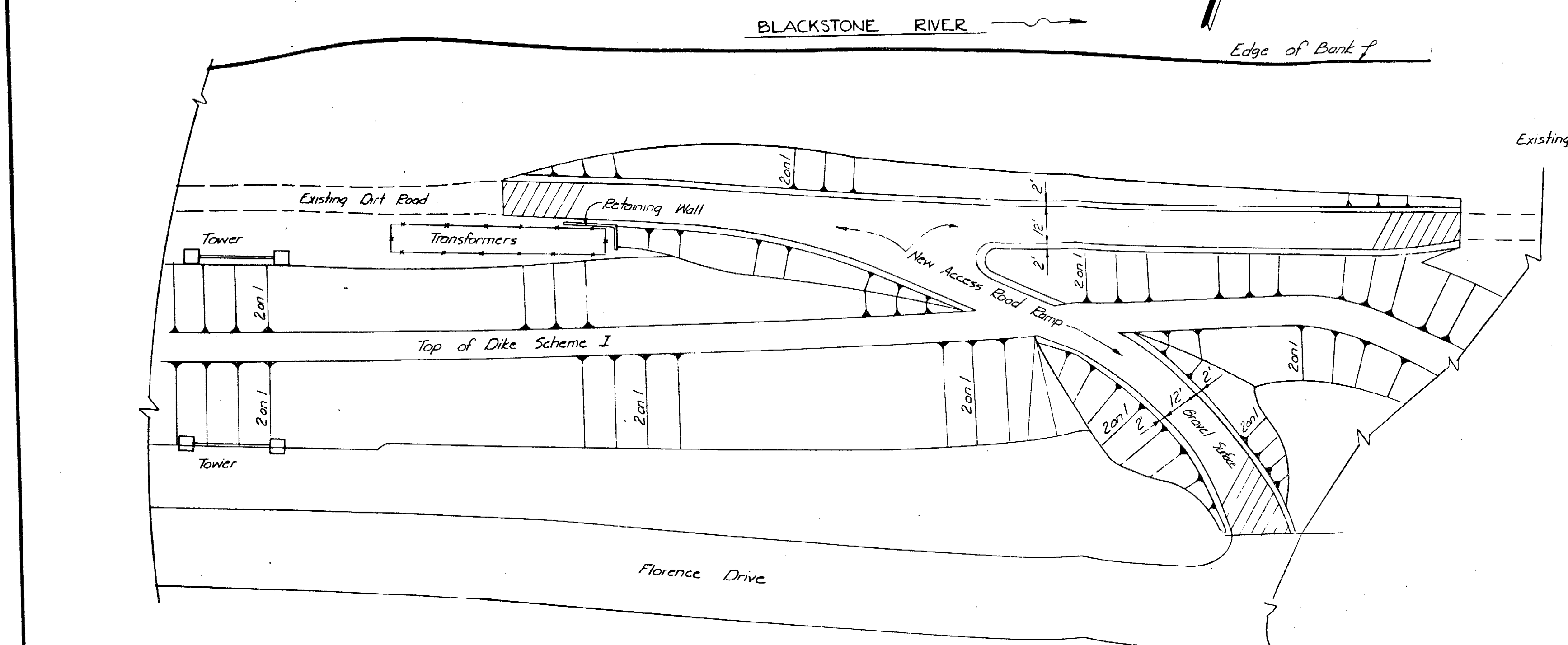
TYPICAL SECTION
GRAVEL - OUTER ROAD ACCESS RAMP
Scale: 1" = 10'



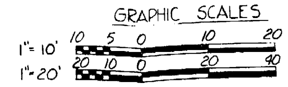
TYPICAL RAMP PROFILE
Scale: 1" = 10' Vert.
1" = 20' Horiz.



TYPICAL PROFILE
SEWER LINES UNDER EMBANKMENT
Scale: 1" = 10'



PLAN - OUTER ROAD RAMP
(STATION 57+50 - DIKE SCHEME I)
Scale 1" = 20'



REVISION	DATE	DESCRIPTION	BY

CHARLES A. MAGUIRE & ASSOCIATES
PROVIDENCE, R.I. HARTFORD, CONN. BOSTON, MASS.
ARCHITECT - ENGINEER

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

DES. BY J. L. | DR. BY D.M.G. | CK. BY J. L.
SUBMITTED
ARCHITECT - ENGINEER
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P & R BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET COMPLEX
ACCESS ROAD RAMP

BLACKSTONE RIVER — RHODE ISLAND
APPROVED — DATE
CHIEF, ENGINEERING DIVISION
SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 4A

CORPS OF ENGINEERS U. S. ARMY

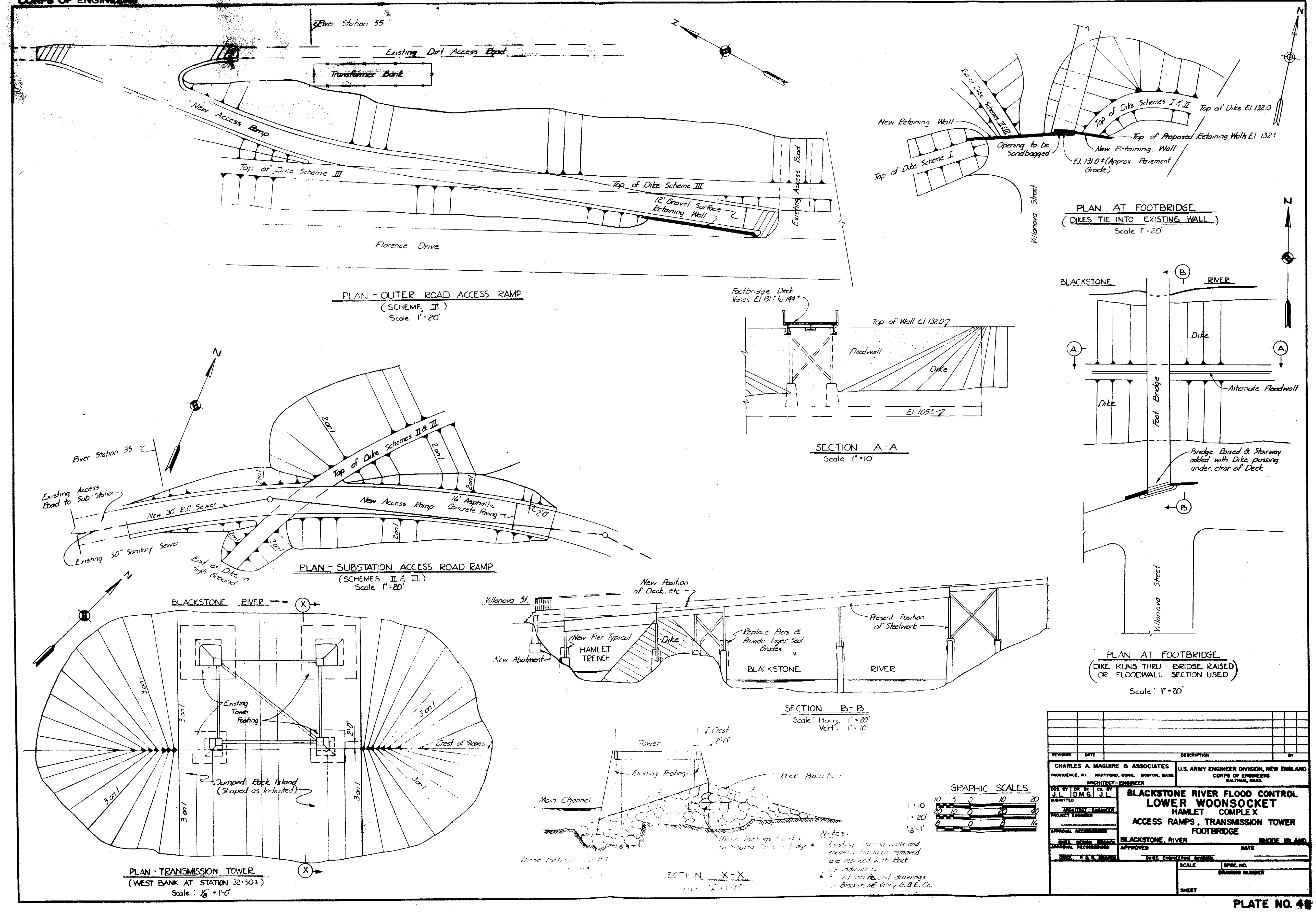


PLATE NO. 48

GENERAL PLAN OF EXISTING SIPHON

Scale 1"=20'

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

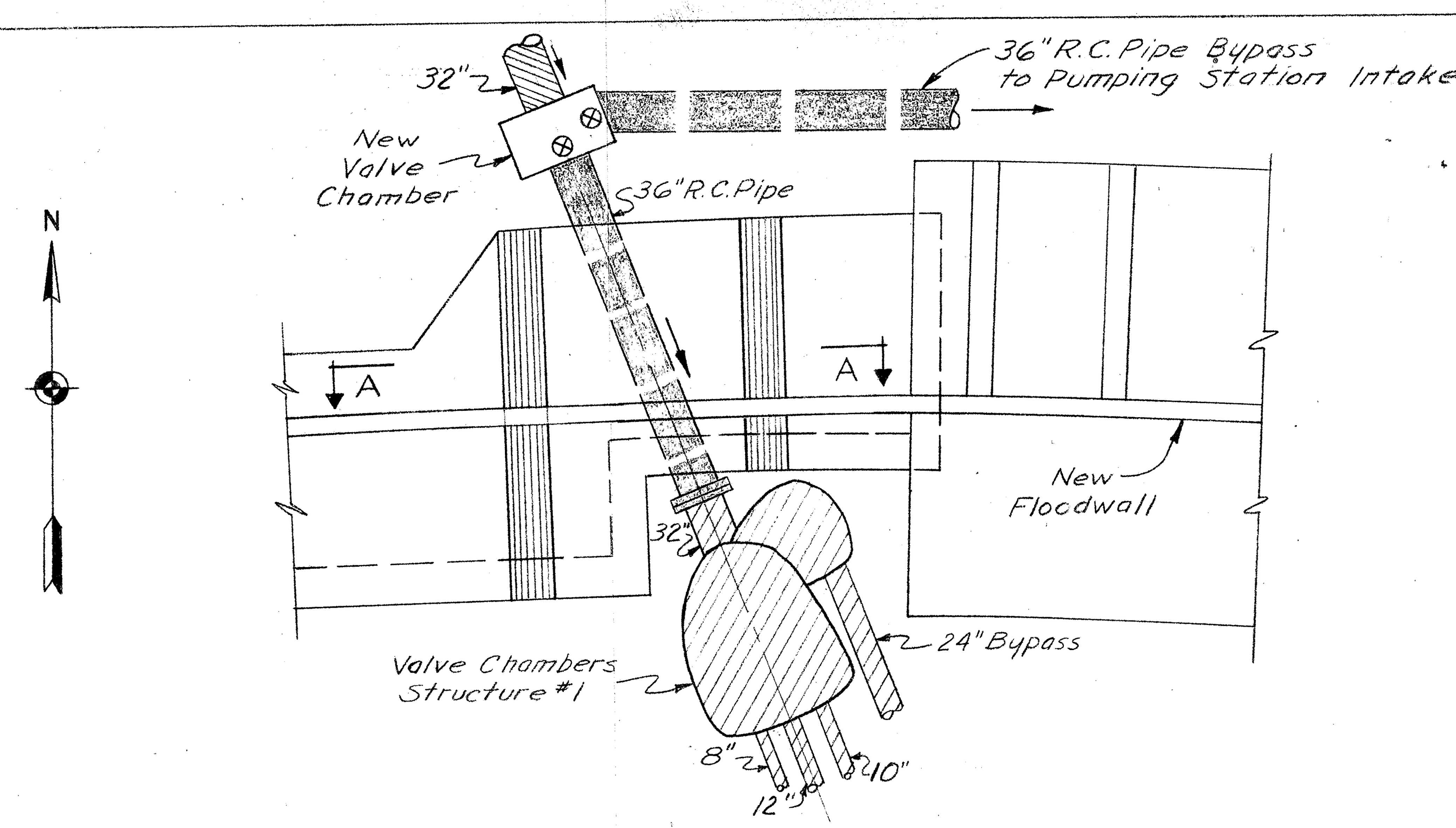
HAMLET COMPLEX

CLINTON STREET SIPHON

CHARLES A. MAGUIRE & ASSOCIATES

SCALE 1"= 20'

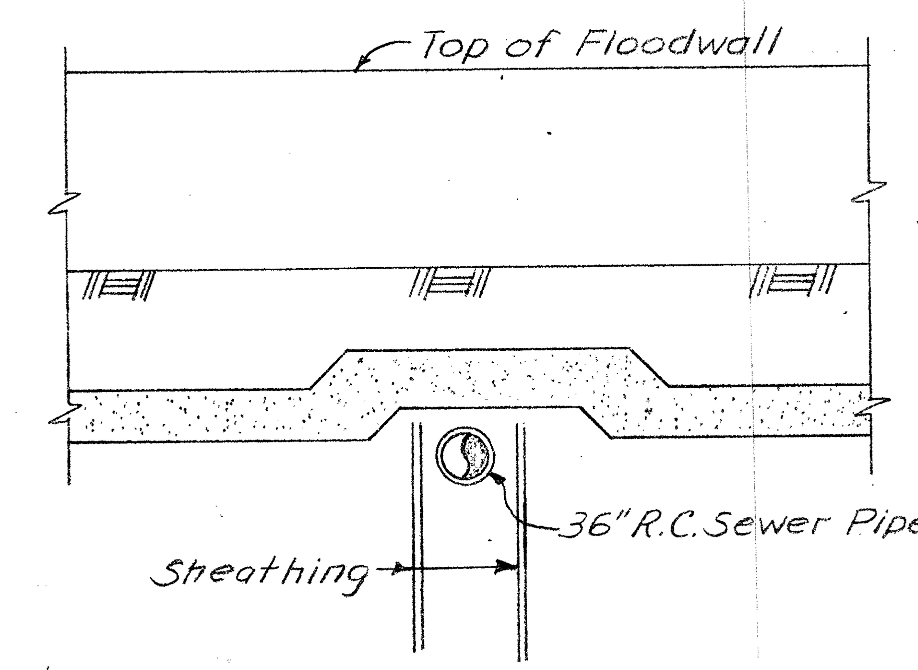
PLATE NO. 5A



PLAN

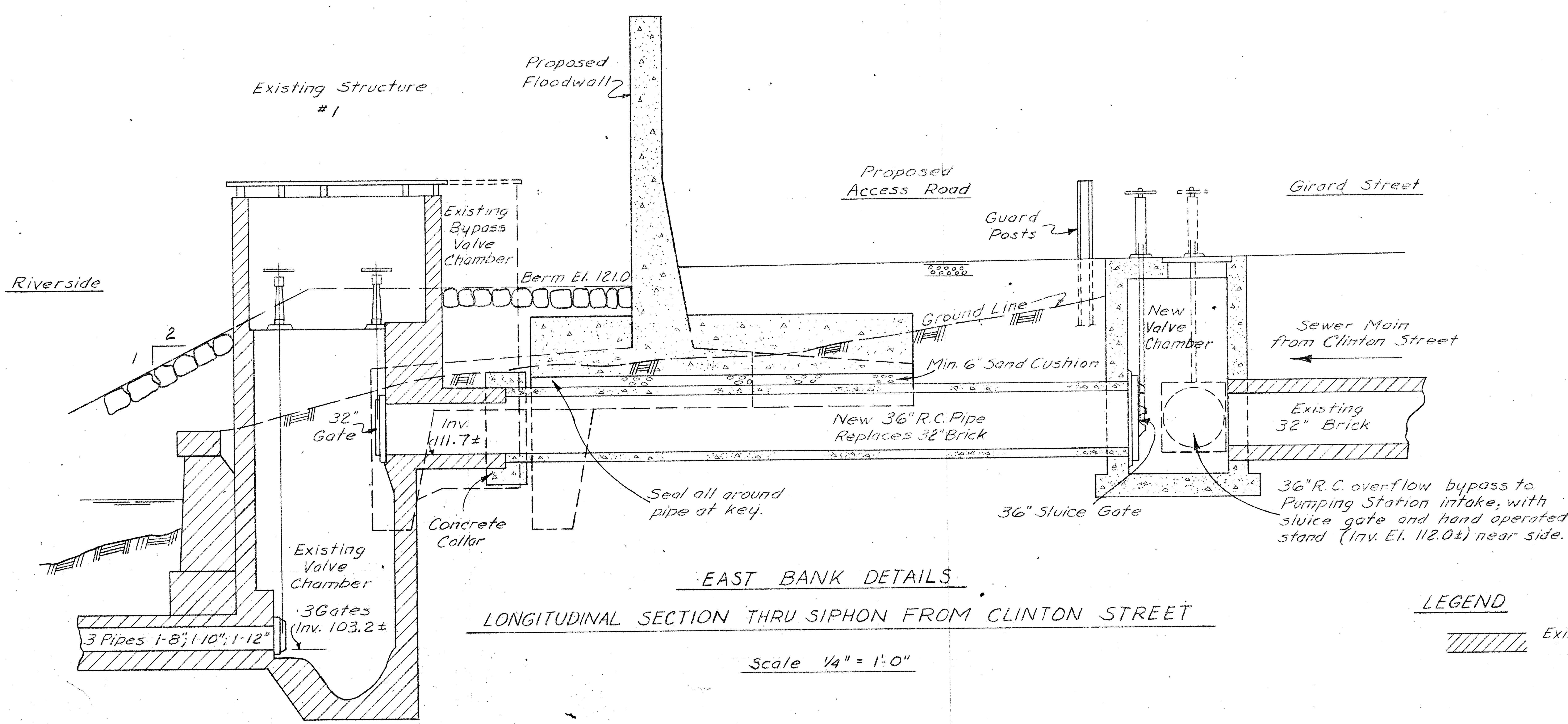
Scale 1" = 10'

(Located at River Sta. 40±)



SECTION A-A

Scale 1" = 10'



EAST BANK DETAILS

LONGITUDINAL SECTION THRU SIPHON FROM CLINTON STREET

Scale 1/4" = 1'-0"

NOTES:

1. Existing chambers left intact; replace brick sewer with 36" R.C. pipe (28' long); build new valve box with 2 gates; build new overflow to Pumping Station intake.

LEGEND

Existing Structures and Pipes

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

HAMLET COMPLEX

CLINTON STREET SIPHON

CHARLES A. MAGUIRE & ASSOCIATES

SCALE 1" = 20'

PLATE NO. 51

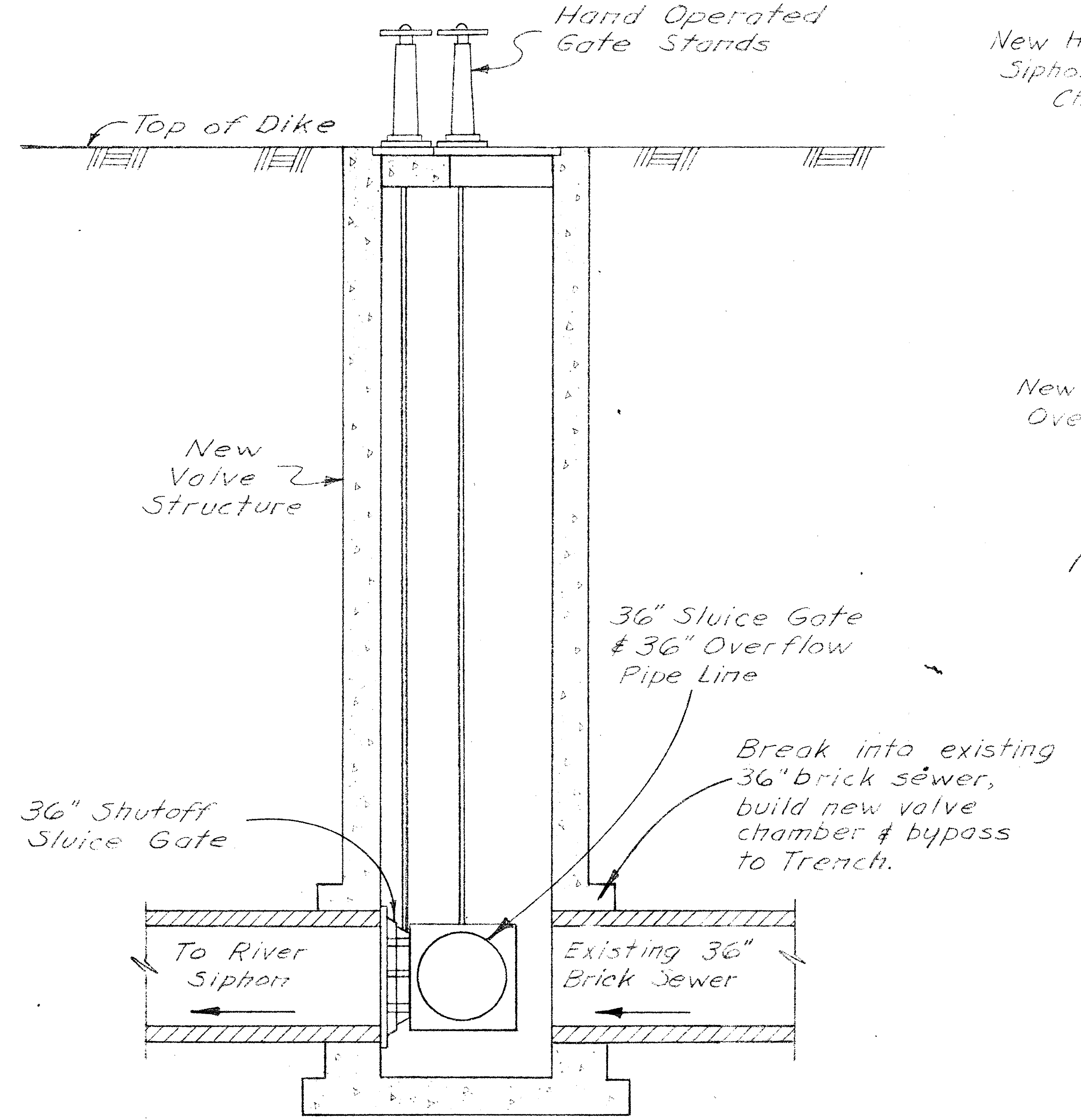
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

HAMLET COMPLEX

CLINTON STREET SIPHON

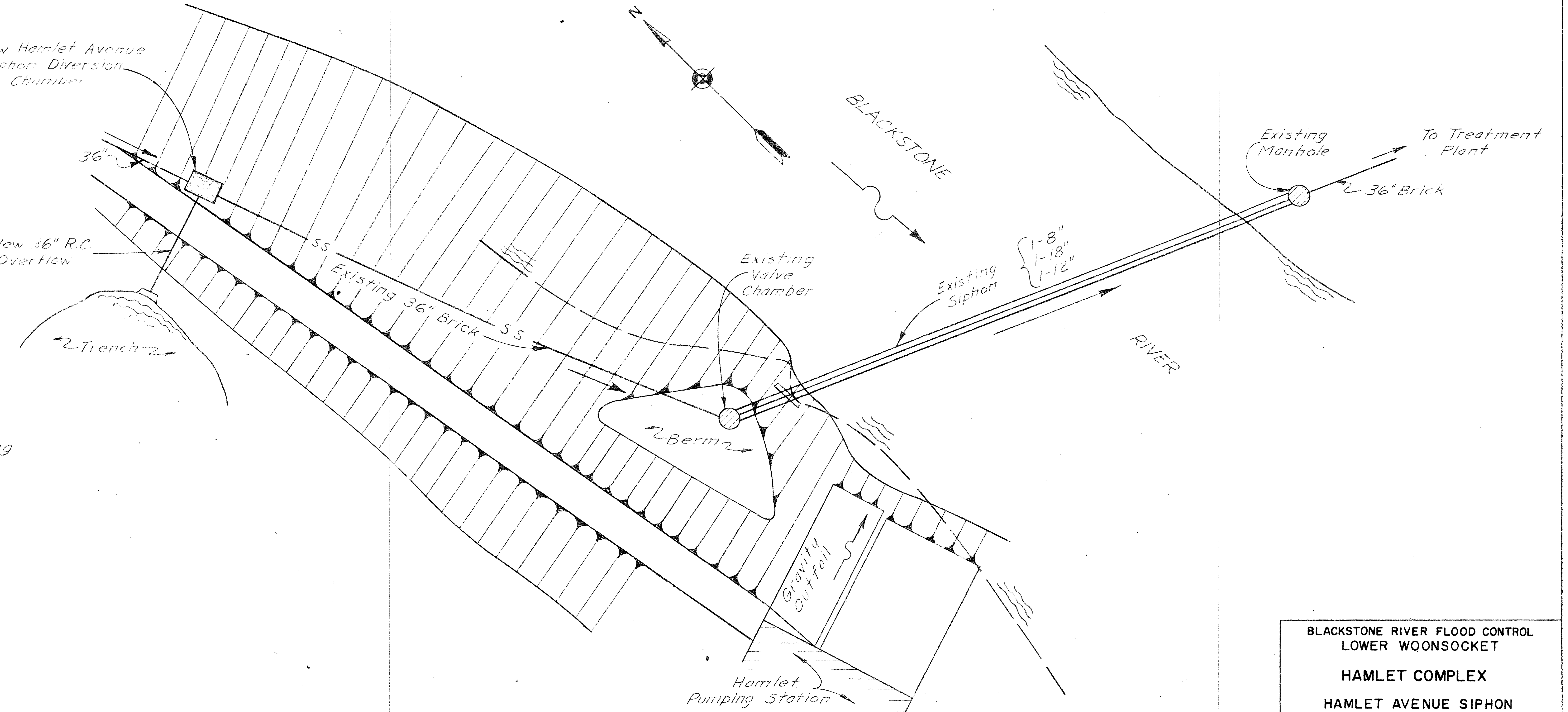
CHARLES A. MAGUIRE & ASSOCIATES

SCALE AS NOTED



HAMLET AVENUE SIPHON DIVERSION CHAMBER

Scale 1/4" = 1'-0"



PLAN- HAMLET AVENUE SIPHON

Scale 1" = 20'

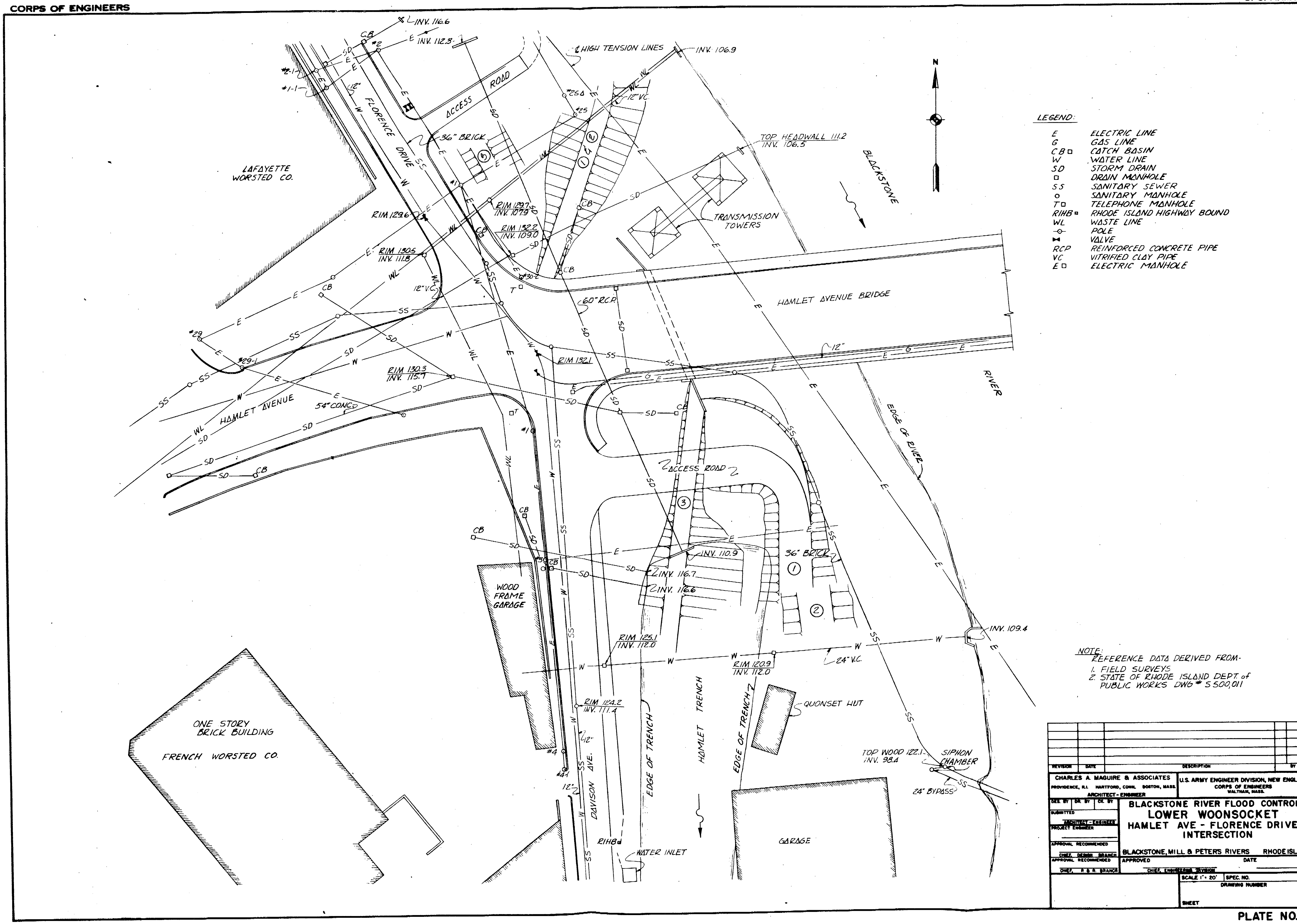
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

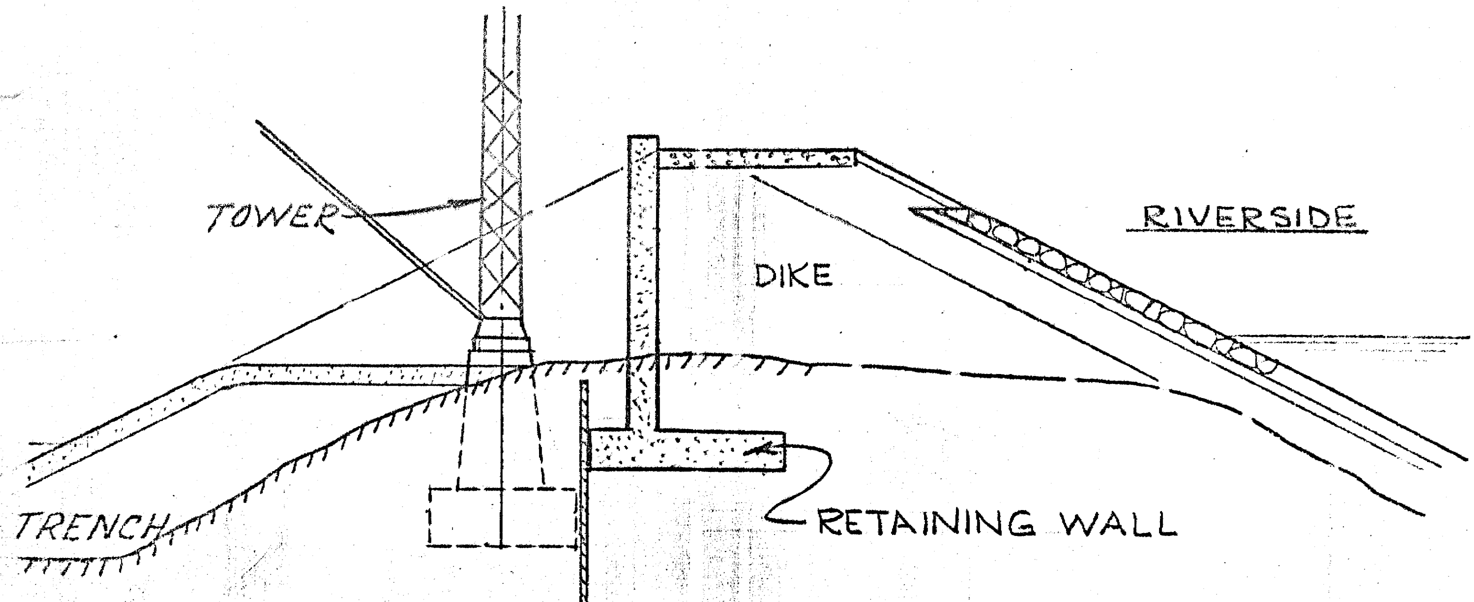
HAMLET COMPLEX

HAMLET AVENUE SIPHON

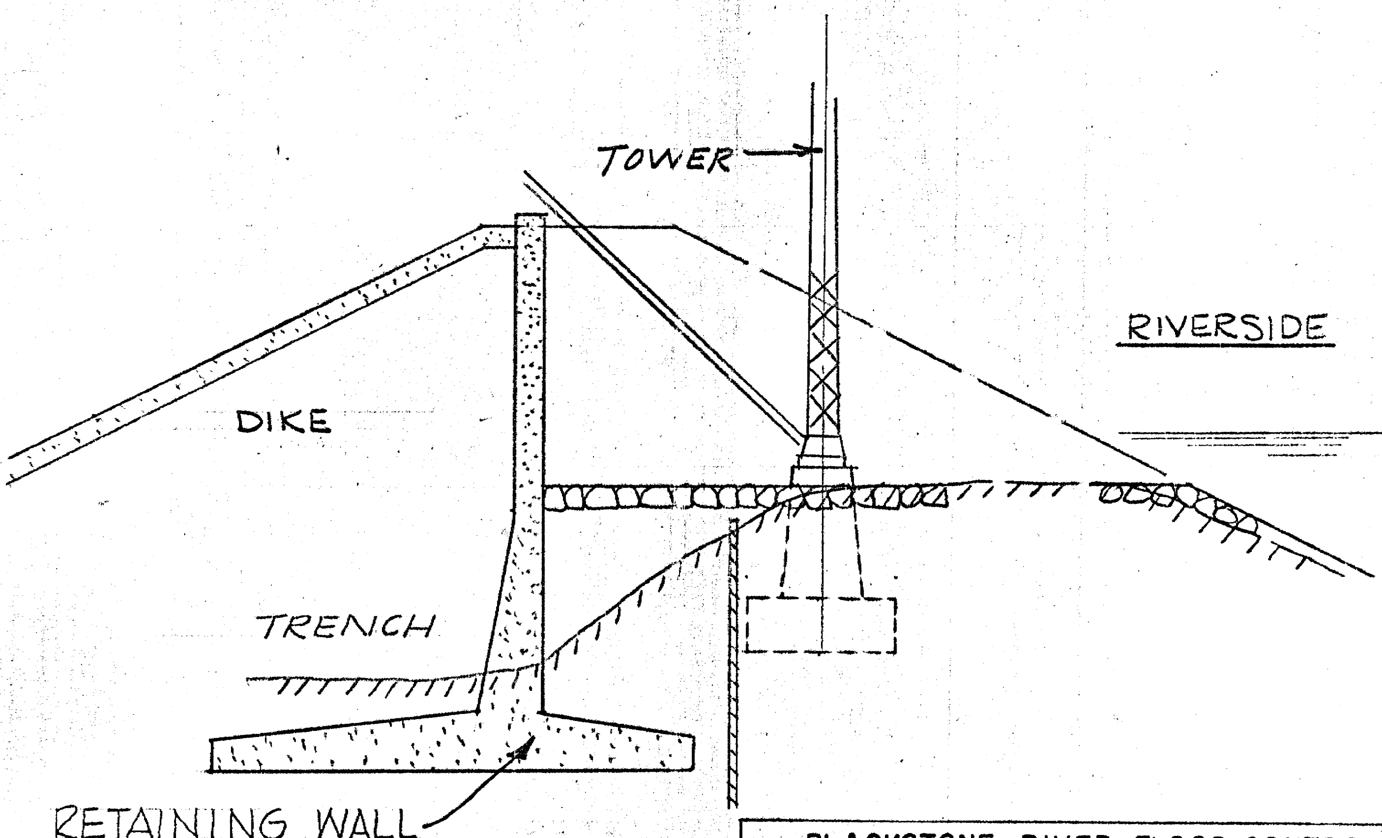
CHARLES A. MAGUIRE & ASSOCIATES
SCALE AS NOTED

PLATE NO. 5D


LEGEND:
E ELECTRIC LINE
G GAS LINE
CB □ CATCH BASIN
W WATER LINE
SD STORM DRAIN
□ DRAIN MANHOLE
SS SANITARY SEWER
o SANITARY MANHOLE
T□ TELEPHONE MANHOLE
RIHB ▫ RHODE ISLAND HIGHWAY BOUND
WL WASTE LINE
POLE
VALVE
RCP REINFORCED CONCRETE PIPE
VC VITRIFIED CLAY PIPE
E□ ELECTRIC MANHOLE
NOTE:
REFERENCE DATA DERIVED FROM-
1. FIELD SURVEYS
2. STATE OF RHODE ISLAND DEPT. of PUBLIC WORKS DWG # S 500,011
N
LAFAYETTE WORSTED CO.
FLORENCE DRIVE
ACCESS ROAD
HIGH TENSION LINES
INV. 116.6
INV. 112.3
INV. 106.9
TOP HEADWALL 111.2
INV. 106.5
BLACKSTONE
RIVER
TRANSMISSION TOWERS
36" BRICK
12" V.C.
RIM 129.6
RIM 129.7
INV. 107.9
RIM 132.2
INV. 109.0
RIM 130.5
INV. 111.8
60" R.C.P.
HAMLET AVENUE BRIDGE
RIM 132.1
RIM 130.3
INV. 115.7
54" CONC.
HAMLET AVENUE
EDGE OF RIVER
ACCESS ROAD
INV. 110.9
INV. 116.7
INV. 116.6
WOOD FRAME GARAGE
RIM 125.1
INV. 112.0
RIM 120.9
INV. 112.0
24" V.C.
INV. 109.4
RIM 124.2
INV. 111.4
QUONSET HUT
ONE STORY BRICK BUILDING
FRENCH WORSTED CO.
DAVISON AVE.
EDGE OF TRENCH
HAMLET TRENCH
EDGE OF TRENCH
TOP WOOD 122.1
INV. 98.4
SIPHON CHAMBER
24" BYPASS
GARAGE
WATER INLET
RIHB
REVISION
DATE
DESCRIPTION
BY
CHARLES A. MAGUIRE & ASSOCIATES
PROVIDENCE, R.I. HARTFORD, CONN. BOSTON, MASS.
ARCHITECT - ENGINEER
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
DES. BY
DR. BY
CK. BY
SUBMITTED
ARCHITECT - ENGINEER
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P & R. BRANCH
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET AVE - FLORENCE DRIVE
INTERSECTION
BLACKSTONE, MILL & PETERS RIVERS
RHODE ISLAND
APPROVED
DATE
CHIEF, ENGINEERING DIVISION
SCALE 1" = 20'
SPEC. NO.
DRAWING NUMBER
SHEET



CONDITION 1- DIKE OUTSIDE OF TOWER LEG



CONDITION 2-
DIKE INSIDE TOWER LEG

CANAL
TOWER PROTECTION

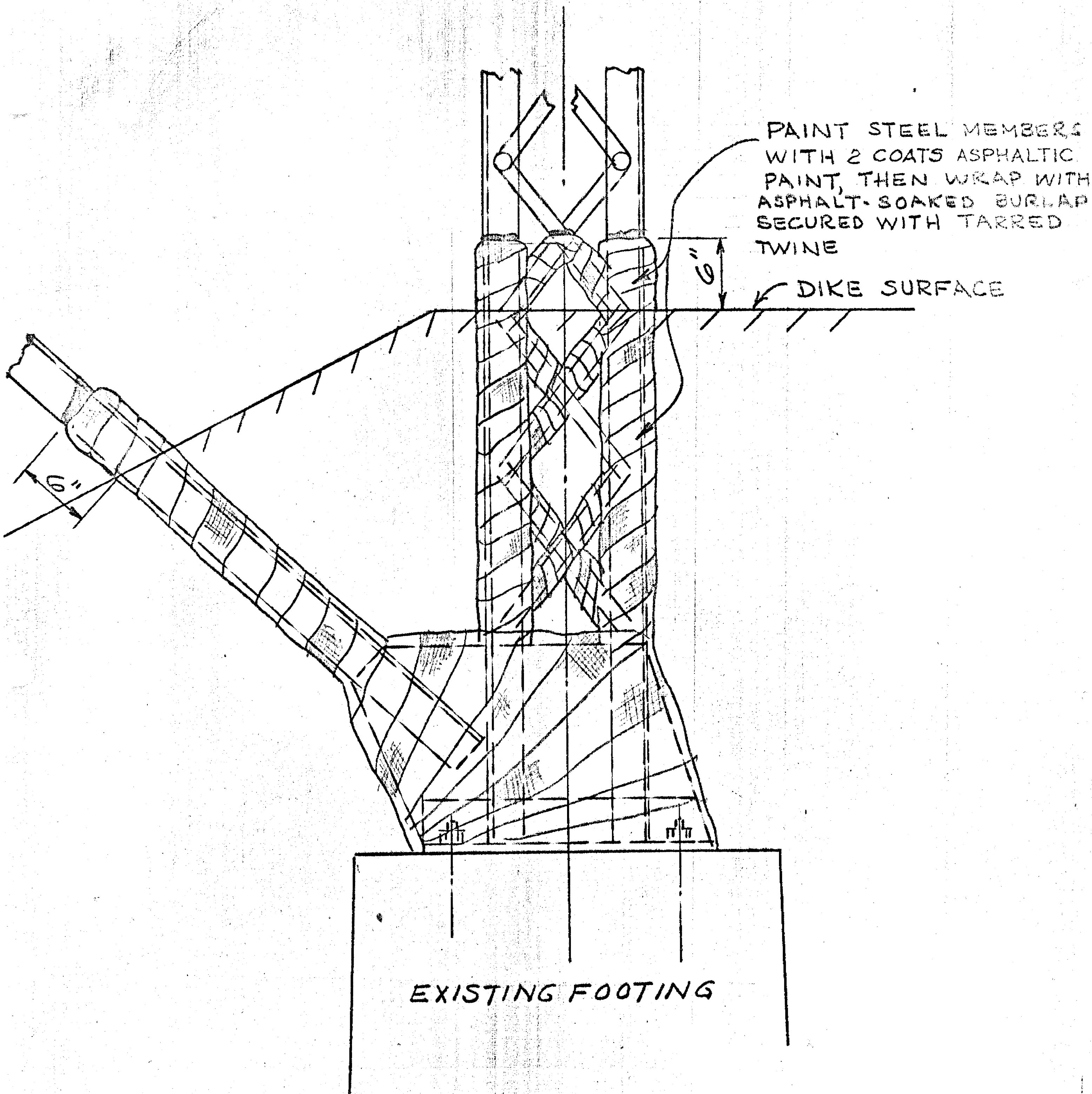
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TOWER MODIFICATIONS

CHARLES A. MAGUIRE & ASSOCIATES

SCALE 1" = 10'

PLATE NO. 3H



TOWER STEEL PROTECTION
(ASPHALT)

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET

TOWER MODIFICATIONS

CHARLES A. MAGUIRE & ASSOCIATES
SCALE : NONE

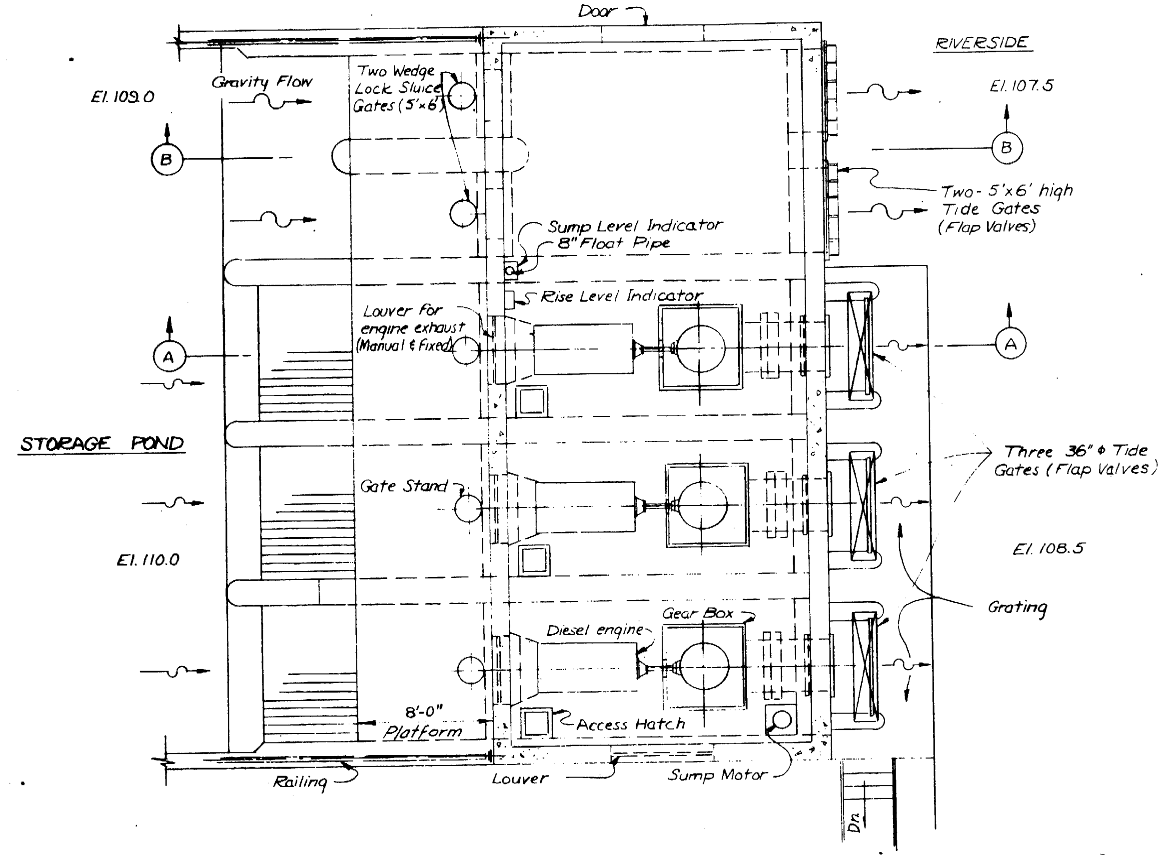
PLATE NO. 3-

Kendrick Avenue Footbridge

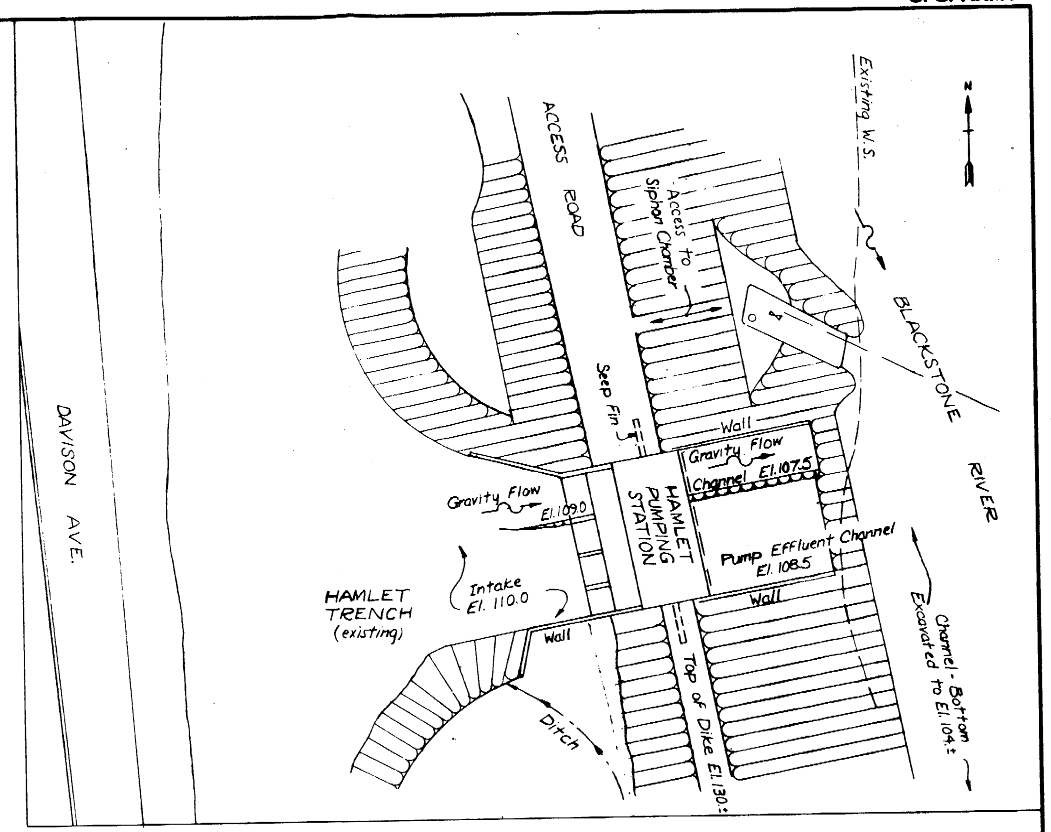
PLATE NO. 6A

CORPS OF ENGINEERS

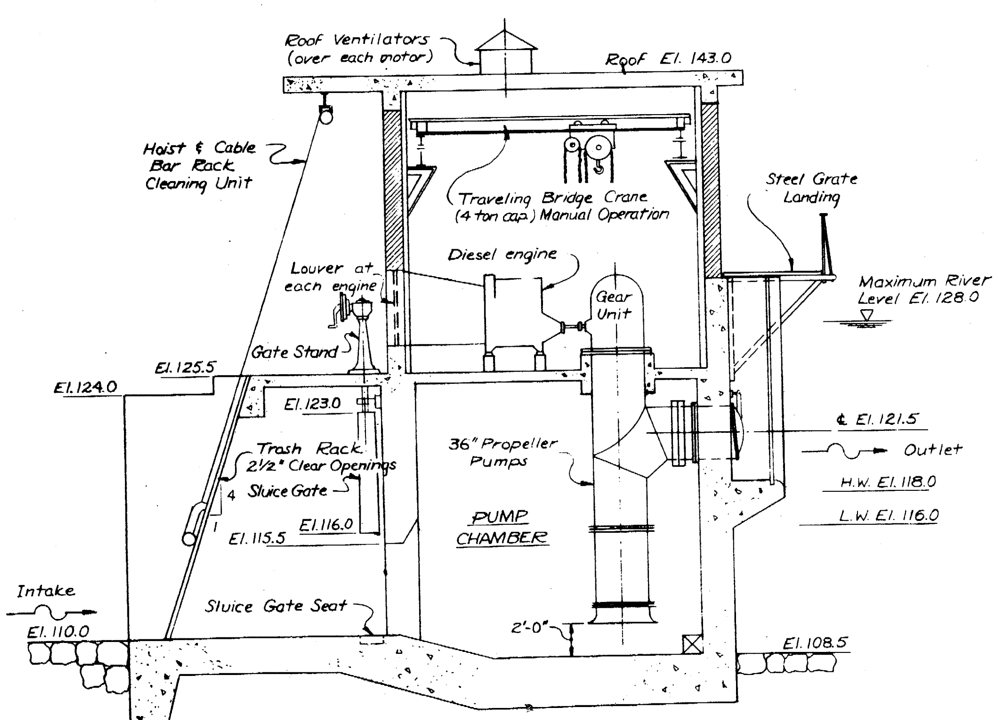
U. S. ARMY



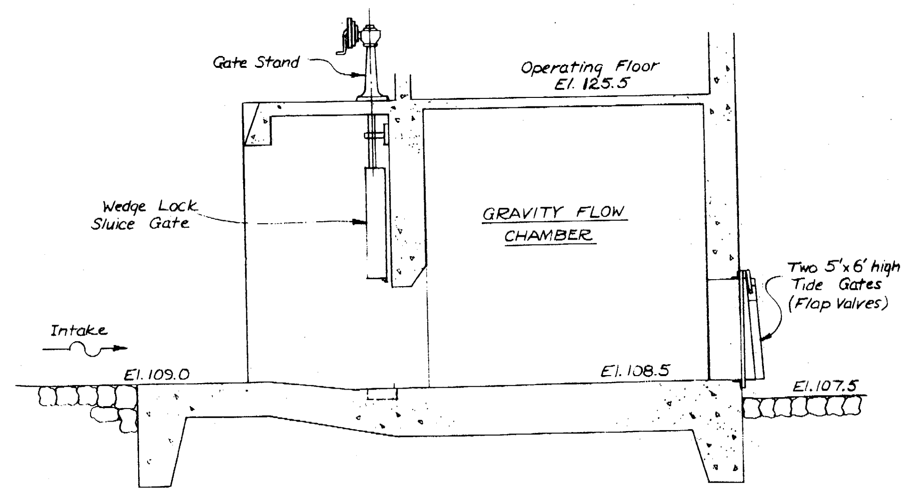
PLAN
SCALE: 1/4" = 1'-0"



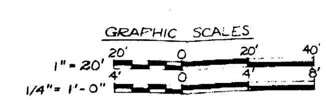
LOCATION MAP
SCALE: 1" = 20'



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



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



REVISION	DATE	DESCRIPTION	BY

CHARLES A. MAGUIRE & ASSOCIATES
PROVIDENCE, R.I. HARTFORD, CONN. BOSTON, MASS.
ARCHITECT - ENGINEER

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

DES. BY | DR. BY | CK. BY

SUBMITTED
ARCHITECT - ENGINEER
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, DESIGN BRANCH
APPROVAL RECOMMENDED
CHIEF, P. & R. BRANCH

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
HAMLET PUMPING STATION
BLACKSTONE, MILL & PETERS RIVERS RHODE ISLAND

APPROVED
CHIEF, ENGINEERING DIVISION
DATE

SCALE | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 7A

CHARLES A. MAGUIRE & ASSOCIATES

HAMLET DISTRICT - PRELIMINARY ESTIMATE

SCHEME NO.1

CONSTRUCTION

DIKES & FLOODWALLS	UNIT	QUANTITY	UNIT PRICE	TOTAL
Demolition Exist. Structures	L.S.			3,500.
Stream Control	L.S.			1,000.
Excavation				
General	C.Y.	6,700	.90	6,030.
Pervious Fill	C.Y.	6,700	.40	2,680.
Pervious Borrow	C.Y.	23,740	1.00	23,740.
Impervious Fill	C.Y.	15,160	1.50	22,740.
Rock Fill	C.Y.	2,375	4.50	10,678.
6" & 12" Topsoil	C.Y.	2,500	3.00	7,500.
12" Gravel Bedding	C.Y.	885	1.50	1,327.
6" Gravel Bedding	C.Y.	1,185	2.70	3,200.
Access Ramps	L.S.			19,000.
Retaining Walls				
Sub-station	L.S.			7,000.
Footbridge	L.S.			7,500.
Tower Modifications	L.S.			2,000.
36" Brick Sewer	L.S.			4,000.
Interior Drainage	L.S.			35,000.
Clinton St. Siphon Modifications	L.S.			8,000.
Hamlet Avenue " "	L.S.			7,200.
Miscellaneous Items	L.S.			10,000.
Contingencies				22,819.
Dam Demolition	L.S.			46,100.
		Total		$251,014.

CHARLES A. MAGUIRE & ASSOCIATES

HAMLET DISTRICT - PRELIMINARY ESTIMATE

SCHEME NO. 2

CONSTRUCTION

DIKES & FLOODWALLS	UNIT	QUANTITY	UNIT PRICE	TOTAL
Demolition Exist. Structure	L.S.			3,500.
Stream Control	L.S.			1,000.
Excavation				
General	C.Y.	43,345	.90	39,010.
Pervious Fill	C.Y.	38,195	.40	15,278.
Waste	C.Y.	5,150	.25	1,287.
Impervious Fill	C.Y.	41,390	1.50	62,085.
6" & 12" Topsoil	C.Y.	4,575	3.00	13,725.
12" Gravel Bedding	C.Y.	1,015	1.50	1,522.
6" Gravel Bedding	C.Y.	3,705	2.70	10,003.
Rock Fill	C.Y.	6,855	4.50	30,847.
Access Ramps	L.S.			26,400.
Tower Modifications	L.S.			5,000.
Retaining Walls @ Footbridge	L.S.			7,500.
36" Brick Sewer	L.S.			5,000.
Clinton St. Siphon Modif.	L.S.			18,000.
Hamlet Ave. " "	L.S.			7,200.
Interior Drainage	L.S.			30,000.
Miscellaneous	L.S.			10,000.
Contingencies				33,345.
Dam Demolition	L.S.			46,100.
		Total		$366,802.

HAMLET DISTRICT - PRELIMINARY ESTIMATE

SCHEME NO. 3

CONSTRUCTION

DIKES & FLOODWALLS	UNIT	QUANTITY	UNIT PRICE	TOTAL
Demolition of Exist. Structures	L.S.			4,500.
Stream Control	L.S.			1,000.
Excavation				
General	C.Y.	4,000	.90	3,600.
Pervious Fill	C.Y.	4,000	.40	1,600.
Pervious Borrow	C.Y.	60,000	1.00	60,600.
Impervious Fill	C.Y.	20,335	1.50	30,502.
Rock Fill	C.Y.	3,450	4.50	15,525.
6" & 12" Topsoil	C.Y.	3,085	3.00	9,255.
12" Gravel Bedding	C.Y.	890	1.50	1,335.
6" Gravel Bedding	C.Y.	1,715	2.70	4,630.
Access Ramps	L.S.			13,400.
Tower Modifications	L.S.			5,000.
Retaining Walls @ Footbridge	L.S.			7,500.
36" Brick Sewer	L.S.			5,000.
Clinton St. Siphon Modifications	L.S.			18,000.
Hamlet Ave. " "	L.S.			7,200.
Interior Drainage	L.S.			68,000.
Misc. Items	L.S.			10,000.
Contingencies				31,274.
Dam Demolition				46,100.
			Total	$344,021.

HAMLET DISTRICT - PRELIMINARY EST

SCHEME NO. 4

CONSTRUCTION

DIKES & FLOODWALLS	UNIT	QUANTITY	UNIT PRICE	TOTAL
Demolition Exist. Structures	L.S.			3,500.
Stream Control	L.S.			1,000.
Excavation				
General	C.Y.	77,160	.90	69,444.
Pervious Fill	C.Y.	61,795	.40	24,718.
Waste	C.Y.	15,365	.25	3,841.
Impervious Fill	C.Y.	39,710	1.50	59,565.
6" & 12" Topsoil	C.Y.	3,470	3.00	10,410.
12" Gravel Bedding	C.Y.	1,010	1.50	1,515.
6" Gravel Bedding	C.Y.	3,274	2.70	8,840.
Rock Fill	C.Y.	6,000	4.50	27,000.
Access Ramps	L.S.			26,400.
Tower Modifications	L.S.			10,000.
Retaining Walls @ Footbridge	L.S.			7,500.
36" Brick Sewer	L.S.			5,000.
Clinton St. Siphon Modif.	L.S.			18,000.
Hamlet Ave. " "	L.S.			7,200.
Interior Drainage	L.S.			30,000.
Misc. Items	L.S.			10,000.
Contingencies				37,003.
Dam Demolition	L.S.			46,100.
		Total		$407,036.

PROJECT Blackstone River Flood Control ACC. NO. 31478

SUBJECT Lower Woonsocket SHEET NO. 1 OF

Engineers Estimate DATE July 30 1962

COMP. A.R. CHECK CONT. NO.

Hamlet Dam Demolition

Item	Quantity	Unit	Unit Price	Cost
Conc. Demolition				
1.) Hamlet Dam Proper	320	yd^3	#12.00	#3840.00
2.) Hamlet "Island & Sluice"	730	yd^3	12.00	8760.00
Conc. Disposal	1050	yd^3	2.00	2100.00
Line Drilling	800	LF	8.00	6400.00
Control & Diversion		L.S.	-	20,000.00
Misc. Items	-	L.S.	-	5,000.00
				#46,100.00

PROJECT Lower Woonsocket Flood Control ACC. NO.
SUBJECT Hamlet Complex SHEET NO. OF
Sample Backwater Computations DATE 19
COMP. P.J. Dalley CHECK CONT. NO. Page 1

Sample Backwater Computations

Index

1. Compute Water Surface profiles as outlined in Manuel EM 1110-2-1409, Backwater Curves in River Channels Method I, with the following Modifications.

a) Compute Conveyance factor (q.01) and plot Area & q.01 curves for each cross section chosen for computations

1) Choose cross sections that seem to be average for reach, or at critical points.
2) Estimate Mannings Coefficient of roughness "n" for main channel and overbank flow area from field observations and photographs.

$$q.01 = \frac{.01486}{n} AR^{2/3}$$

n = Mannings Coeff. of Roughness
A = Area of flow
R = Hydraulic Radius = $A/W.P.$
W.P. = Wetted perimeter

b) Introduce Eddy Losses to compensate for change in channel cross section and alignment.

$$he = ce(hv_1 - hv_2)$$

he = Eddy Loss
Ce = Eddy Loss Coefficient,
In general Ce = 0.2 when $(hv_1 - hv_2)$ is plus & 0.5 when $(hv_1 - hv_2)$ is minus
Varies to 0.5 for sudden contraction & 1.0 for sudden expansion.
hv_1 = velocity head at downstream section of reach.
hv_2 = velocity head at upstream section of reach.

PROJECT Lower Woonsocket Flood Control ACC. NO.
SUBJECT Hamlet Complex SHEET NO. OF
Backwater Computations (Criteria) DATE 19
COMP. CHECK CONT. NO. 3 Page

c) Design Flow. Standard Project Flood 40,000 cfs downstream of the Mill and Peters River and 33,000 cfs upstream.

1. Assume Junction of Mill and Peters Rivers are at same as existing location.

d) Tailwater elevation at Downstream end of project as computed by the Corps. see sheet

f) Minor obstructions to flow, such as bridge piers and, Electric Transmission Towers are neglected in Relative Backwater computations for the various schemes.

1. They are about the same for all schemes. and cause only minor change in overall backwater.

2. The three piers of the footbridge in the main channel increase the water surface elevation only 0.15± just upstream of the bridge.

Sect. No.	W.S. Elev.	Main Channel n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	$q_{.01}$ cfs	Left Overbank n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	$q_{.01}$ cfs	Right Overbank n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	$q_{.01}$ cfs
3	125	.035	3196	165	19.35	7.21	9800	.040	1894	226	8.38	4.13	2920	.040	800	150	5.34	3.06	912
			(680)	(0)			(3690)		+(1100)	(0)			(3310)		(770)				(1748)
	130		3876	165	23.40	8.18	13490		2994	226	13.20	5.59	6230		1570	161	9.75	4.56	2660
5	125		3312	202	16.40	6.46	9110		694	121	5.74	3.21	830		NONE				
			(945)	(11)			(4270)		(605)	(10)			(1400)						
	130		4257	213	20.0	7.37	13380		1299	131	9.90	4.61	2230						
8	125		3410	193	17.65	6.78	9850		134	50	2.68	1.93	97.0		NONE				
			(900)	(11)			(4230)		(250)	(0)			459)						
	130		4310	204	21.17	7.65	14080		384	50	7.68	3.89	556						
10	125		3244	190	17.10	6.64	9160		NIL						NONE				
			(890)	(11)			(4090)												
	130		4134	201	20.60	7.52	13250												
12	125		3704	222	16.70	6.53	10300		NONE						NONE				
			(1090)	(21)			4510												
	130		4794	243	19.70	7.29	14810												
13	125	.035	3624	218	16.6	6.51	10,000		NONE						NONE				
			(948)	(11)			(4400)												
	130		4572	229	20.0	7.37	14400												
14	125	.035	3498	219	15.95	6.34	9450		NONE					.040	80	38	2.11	1.65	49
			(1066)	(10)			(4800)								(184)	(0)			[illegible]
	130		4564	229	19.90	7.34	14250								264	38	6.95	3.64	358

Tabulation of Hydraulic Elements
Scheme 2 (Hamlet)

P.C. CHECK REF

SHEET NO. 1 of 4
DATE 6-15-62
Page NO. 4

LES A. MAGUIRE & ASSOCIATES, ENGINEERS

SUBJECT: Tabulation of Hydraulic Elements Scheme 2 (Hamlet)

SHEET NO. 2 OF 4
DATE 6-15-62
CHECK P.C. R.E.F.
CONT. NO. 5 Page

Sect. No.	W.S. Elev.	Main Channel n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	q.01 cfs	Left Overbank n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	q.01 cfs	Right Overbank n	Area s.f.	W.P. ft.	R ft.	$R^{2/3}$	q.01 cfs
15	125	.035	3497	228	15.3	6.16	9150		NONE						NONE				
			(1148)	(22)			(4700)												
	130		4645	250	18.55	7.01	13850												
18	125		2848	194	14.7	6.00	7260		NONE						NONE				
			(933)	(19)			(3720)												
	130		3781	213	17.75	6.81	10980												
21	125		2740	190	14.4	5.92	6940		NONE						NONE				
			(940)	(11)			(3910)												
	130		3680	201	18.3	6.94	10850												
24	130		3556	204	17.4	6.72	10150		NONE						NONE				
			(940)	(11)			(4350)												
	135		4496	215	20.83	7.57	14500												
25	130		3604	204	17.7	6.79	10410		NONE						NONE				
			(973)	(11)			(4540)												
	135		4577	215	21.3	7.68	14950												
26	130		3410	212	16.10	6.38	9260		NONE						NONE				
			(1015)	(11)			(4550)												
	135		4425	223	19.85	7.33	13810												
27	130		3380	190	17.80	6.82	9800		NONE						NONE				
			(905)	(11)			(4200)												
	135		4285	201	21.30	7.68	14000												

CHARLES A. MAGUIRE & ASSOCIATES, ENGINEERS

PROJECT [illegible]
SUBJECT Tabulation of Hydraulic Elements SCHEME (Hamlet)
COMP. RC
CHECK DPT
ACC. NO. [illegible]
SHEET NO. 1 OF 3
DATE June 25 1962
CONT. NO. 6

Sect. No.	W.S. Elev.	Main Channel n	Area s.f.	W.P. ft.	R ft	$R^{2/3}$	q.01 cfs	Left Overbank n	Area s.f.	W.P. ft	R ft.	$R^{2/3}$	q.01 cfs	Right Overbank n	Area s.f.	W.P. ft	R ft	$R^{2/3}$	q.01 cfs
26	130	.035	4000	247	16.20	6.40	10900												
			(1175)				(5150)												
	135		5175	264	19.6	7.27	16050												
27	130		4520	270	16.75	6.55	12600												
			(1278)				(5700)												
	135		5798	287	20.20	7.42	18300												
28	130		4540	256	17.75	6.81	13200												
			(1250)				(5700)												
	135		5790	273	21.20	7.66	18900												
29	130		4480	264	17.00	6.61	12610												
			(1250)				(5590)												
	135		5730	280	20.40	7.47	18200												
30	130		4520	268	16.90	6.59	12700												
			(1270)				(5700)												
	135		5790	284	20.40	7.47	18400												
31	130		5000	280	17.88	6.84	14550												
			(1283)				(5950)												
	135		6283	296	21.20	7.66	20500												

CHARLES A. MAGUIRE & ASSOCIATES, ENGINEERS

Sect No.	W.S. Elev.	Main Channel n	Main Channel Area s.f.	Main Channel W.P. ft	Main Channel R ft	Main Channel R2/3	Main Channel 9.01 cfs	Left Overbank n	Left Overbank Area s.f.	Left Overbank W.P. ft	Left Overbank R ft	Left Overbank R2/3	Left Overbank 9.01 cfs	Right Overbank n	Right Overbank Area s.f.	Right Overbank W.P. ft	Right Overbank R ft	Right Overbank R2/3	Right Overbank 9.01 cfs
34	130	.035	4276	246	17.4	6.72	12200												
			(1172)				(5400)												
	135		5448	261	20.8	7.56	17600												
35	130		4464	247	18.1	6.89	13090												
			(1136)				(5260)												
	135		5600	262	21.4	7.71	18350												
37	130		4792	263	18.2	6.92	14400												
			(1316)				(6000)												
	135		6108	285	21.4	7.71	20100												
39	130		4648	253	18.00	6.87	13600												
			(1356)				(5850)												
	135		6004	287	21.00	7.61	19450												
40	130		5048	274	18.40	6.97	14980												
			(1392)				(6220)												
	135		6440	299	21.50	7.73	21200												
43	130		4000	270	14.80	6.05	10250												
			(1330)				(5470)												
	135		5330	291	18.30	6.94	15720												

CHARLES A. MAGUIRE & ASSOCIATES, ENGINEERS

SUBJECT Tabulation of Hydraulic Elements
Scheme 3A (Floodway)

COMP. PC CHECK DPT

SHEET NO. 3 OF 3
DATE June 26 1962
CONT. NO. 6

Sec. No.	W.S. Elev.	Main Channel						Left Overbank						Right Overbank					
		n	Area s.f.	W.P. ft	R ft	$R^{2/3}$	q.01 cfs	n	Area s.f.	W.P. ft	R ft	$R^{2/3}$	q.01 cfs	n	Area s.f.	W.P. ft	R ft	$R^{2/3}$	q.01 cfs
44	130	.035	3472	248	14.00	5.81	8580												
			(1223)				(4870)												
	135		4625	268	17.55	6.74	13450												
45	130		3280	228	13.95	5.80	8100												
			(1143)				(4700)												
	135		4423	250	17.70	6.79	12800												

To Section 51
Same as Scheme 1

Recomputed June 26, 62
D. Towle

PROJECT Lower Woonsocket Flood Protection — ACC. NO. 3112-9
SUBJECT Backwater Computations — SHEET NO. 1 OF 5
Scheme 2 - 40000 cfs (Hamlet) — DATE ______ 19__
COMP. P.C. — CHECK A.K. — CONT. NO. 9 Page

Sec. No.	Station	Reach L	Area A	Q.01	S	Mean S	hf	Q	V	V^2Q	V^2 avg.	hv	$hv_1 - hv_2$	Ce	Eddy Loss he	Total H	W.S. Elev.	Energy Gradient Elev.
1	72+60				.00059							.70					126.70	127.40
		200				.00058	.116						.00	.2	.0	.116		
3	70+60		3441	11130				26600	7.73	1,594,000							126.82	127.52
126.8	LO		2290	4110				9800	4.28	179,000								
	RO		1078	1542				3600	3.34	40,000								
				16782	.00057			40,000		1809000	45.2	.70						
		240				.00085	.204						-.64	.5	.32	-.116		
5	68+20		3650	10650				35600	9.78	3,400,000							126.70	128.04
126.8	C.O.		912	1334				4400	3.69	59600								
				11984	.00112			40,000		3459600	81.3	1.34						
		280				.00115	.322						-.48	.5	.24	.182		
8	65+40		3740	11420				39100	10.45	4,680,000							126.88	128.70
126.85			224	261				900	3.98	14,250								
				11681	.00118			40,000		4694250	117.3	1.82						
		190				.00128	.243						-.09	.5	.045	.198		
10	63+50		3600	10795	.00138			40,000	11.10	4930000	123.0	1.91					127.08	128.99
127.0																		
		220				.0017	.258						.58	.2	.116	.374		
12	61+30		4326	12870	.00097			40,000	9.24	3420000	85.4	1.33					128.03	129.36
127.85																		
		80				.00098	.078						-.09	.5	.05	.035		
13	60+50		4193	12640	.0010			40,000	9.53	3630000	91.2	1.42					128.01	129.43
128.																		
		170				.00099	.168						.09	.2	.018	.28		
14	58+80		4202	12620				39300	9.34	3430000							128.3	129.63
128.3			200	253				700	3.50	8600								
				12873	.00097			40,000		3438600	86.0	1.33						
		100				.00102	.102						-.04	.5	.02	.082		
15	57+80		4264	12300	.00106			40,000	9.38	3520000	88.0	1.37					128.43	129.80
128.3																		
							1.495								.844			

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PROJECT [illegible] Flood Protection

SUBJECT Backwater Computations [illegible]

Scheme [illegible] - 40000 cfs

COMP. R.C. CHECK A.R.

ACC. NO. [illegible] SHEET NO. 2 OF 5 DATE June 18 1952 CONT. NO. [illegible]

Sec. No.	Station	Reach L	Area A	9.01	S	Mean S	hf	Q	V	V^2Q	V^2 avg.	hv	$hv_1 - hv_2$	Ce	Eddy Loss he	Total H	W.S. Elev.	Energy Gradient Elev.
15	57+80				.00106				9.38			1.37					123.93	129.6
		300				.00138	.419						-.69	.5	.35	.074		
18	54+80		3475	9750	.00169			40000	11.5	5300000	136.5	2.06					128.50	130.56
128.35																		
		300				.00166	.496						-.02	.5	.01	.488		
21	51+80		3469	9960	.00162			40,000	11.53	5340000	133.5	2.08					128.99	131.07
128.85																		
		300				.00166	.498						.0	.2	0	.5		
24	48+80		3462	9715	.00170			40000	11.55	5340000	133.5	2.08					129.49	131.57
129.5																		
		80				.00165	.132						.08	.2	.02	.148		
25	48+00		3526	10047	.00160			40000	11.35	5190000	129.5	2.00					129.72	131.72
129.6																		
		150				.00178	.267						-.18	.5	.09	.177		
26	46+50		3369	[illegible]	.00195			40000	11.85	5670000	140.5	2.18					129.70	[illegible]
129.8																		
		330				.00166	.548						.23	.2	.046	.502		
28	43+20		3570	10860	.00135			40000	11.20	5020000	125.5	1.95					130.70	132.61
[illegible]																		
		310				.0051	.317						-.25	.5	.13	.20		
31	41+10		3364	[illegible]	.00166			[illegible]	11.90	5650000	141.5	2.20					130.92	133.12
130.9																		
Jnc.	40+50	Junction of	Peters	River	(Assume	same	section	as #31)										
		60				.00131	.078						.86	.2	.17	1.11		
132.0	40+50		3346	10670	.00056			33000	9.40	2850000	86.4	1.34					132.03	133.37
			Peters &	Mill	Rivers			7000		Nil	Nil	Nil						
								40,000										
							2.775								.943			

Section	Station	Water Surface Scheme No. Exist.	1	2	3	3A	4	Energy Gradient Elev. Scheme No. Exist.	1	2	3	3A	4	Velocities Scheme No. Exist.	1	2	3	3A	4
1	72+60	126.13	126.78	126.70	126.70	Same as 3	Same as 2	127.45	127.46	127.46	127.4[illegible]	Same as 3	Same as 2	7.67	[illegible]	[illegible]	[illegible]	Same as 3	Same as 2
3	70+60	126.75	126.80	126.82	126.53			127.57	127.92	127.72	127.05			7.97	[illegible]	[illegible]	[illegible]		
5	68+20	[illegible]	126.78	126.70	126.65			127.91	127.85	[illegible]	[illegible]			9.37	9.00	[illegible]	9.12		
8	65+40	[illegible]	[illegible]	126.80	126.97			128.08	128.46	[illegible]	[illegible]			9.57	10.7	[illegible]	9.62		
10	63+30	[illegible]	[illegible]	127.08	127.1[illegible]			128.76	128.28	128.60	[illegible]			11.27	13.45	[illegible]	[illegible]		
11	61+30	[illegible]	[illegible]	126.59	127.1[illegible]			129.10	129.89	129.55	129.01			8.93	8.95	[illegible]	[illegible]		
12	60+20	[illegible]	[illegible]	126.07	127.75			129.17	130.01	129.09	129.11			10.14	[illegible]	9.57	[illegible]		
14	58+00	128.2[illegible]	128.33	128.35	128.01			129.60	130.17	129.63	129.36			9.50	9.30	9.57	[illegible]		
15	57+30	128.41	128.32	128.43	128.12			129.71	130.27	129.60	129.16			9.24	9.53	9.56	9.47		
18	54+30	128.34	129.07	128.50	128.25			130.01	130.76	130.56	130.01			9.05	10.60	11.50	10.32		
21	51+30	128.83	129.56	128.59	128.70			130.29	131.14	131.07	130.92			8.64	10.50	11.55	10.32		
24	48+60	128.38	130.48	129.49	128.90			130.79	131.55	131.57	131.17			9.95	9.22	11.55	12.20		
25	48+00	128.97	130.59	129.02	129.20	129.30	129.17	130.99	131.63	131.72	131.33	131.38	131.72	9.83	9.06	11.35	11.50	11.30	
26	46+90	130.09	130.60	130.0[illegible]	129.40	130.11	[illegible]	131.19	[illegible]	[illegible]	131.51	131.61	[illegible]	[illegible]	[illegible]	11.85	[illegible]	10.00	9.66
29	43+20	[illegible]	130.96	130.72	130.37	130.89	131.40	131.57	132.17	132.67	132.25	132.11	132.15	8.48	9.72	11.80	11.80	8.50	8.23
31	41+10	130.74	131.30	130.92	130.51	131.46	131.21	131.83	132.45	132.12	132.84	132.33	132.01	9.45	9.57	11.90	12.60	7.46	7.30
32	40+20	131.30	131.90	132.03	131.72	131.86	132.16	132.01	132.60	132.37	132.19	132.42	132.12	7.04	7.33	9.30	9.82	5.93	[illegible]
34	36+20	131.48	132.06	132.30	132.20	131.90	132.15	132.12	132.74	132.59	132.91	132.53	132.83	7.05	7.03	8.95	8.75	6.94	6.90
35	34+90	131.57	132.14	132.75	132.41	131.95	132.27	132.18	132.79	133.76	133.47	132.65	132.93	6.81	6.95	7.80	8.03	6.70	6.35
37	35+50	131.60	132.17	133.04	132.43	132.21	132.50	132.04	133.07	133.91	133.04	132.80	133.07	8.05	9.13	8.00	9.63	6.19	6.05
39	33+40	131.76	132.37	133.19	132.25	132.24	132.51	132.61	133.24	134.06	134.12	132.90	133.15	8.05	8.25	8.03	7.98	6.26	6.15
40	32+30	131.99	132.66	133.73	133.65	132.15	132.74	132.76	132.85	134.18	[illegible]	132.96	133.22	7.53	7.07	6.76	6.72	5.75	5.69
43	30+20	132.39	132.68	133.55	133.60	132.42	132.69	133.45	133.55	134.37	134.43	133.20	133.45	7.40	7.70	7.50	7.50	7.10	7.00
47	28+10	132.64	132.73	133.62	133.65	132.41	132.69	133.59	132.86	134.60	134.67	133.55	133.60	7.58	8.87	8.36	8.41	8.57	8.48
50	25+50	133.12	133.07	133.68	133.90	132.84	133.01	133.78	134.11	134.80	134.86	133.81	134.06	7.29	6.53	8.31	6.57	8.47	8.46
51	22+30	132.94	133.13	133.89	133.97	132.91	133.05	134.27	134.61	135.25	135.31	134.39	134.53	9.78	10.85	9.65	9.65	10.85	10.10
53	20+30	132.65						134.80						11.55					
55	18+30	133.14						135.13						11.52					
Br.	31+40x	131.66						133.25						10.10					

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SUBJECT ______ COMP. ______ CHECK ______ CONT. NO. ______ SHEET NO. ___ OF ___ DATE 7/21 1962

Sec. No.	Station	Reach L	Area A	q.01	S	Mean S	hf	Q	V	V^2Q	V^2 avg.	hv	hv_1-hv_2	Ce	Eddy Loss hc	Total H	W.S. Elev.	Energy Gradient Elev.
25	48+00				.0016							2.0					129.72	131.72
		150				.0014	.210						.55	.2	.11	.87		
26	46+50		4141	11518	.0012			40,000	9.66	3740000	93.42	1.45					130.59	132.04
130.6																		
		330				.0010	.330						.40	.2	.08	.81		
29	43+20		4855	14287	.00079			40,000	8.23	2710000	67.6	1.05					131.40	132.45
131.5																		
		210				.00068	.143						.224	.2	.045	.41		
31	41+10		5488	16810	.00057			40,000	7.30	2125000	53.2	.826					131.21	132.64
131.9																		
	40+50		Junction of Peters River (Assume same section as Section No. 31)															
132.3		60				.00046	.0276						.286	.2	.057	.37		
			5590	17290	.000365			33000	5.90	1150000	34.8	.540					132.18	132.72
	Peters	&	Mill Rivers					7000		Nil	Nil	Nil						
								40,000										
		160				.00044	.070						-.20	.5	.10	-.03		
34	38+90		4793	14580	.00051			33000	6.90	1570000	47.5	.74					132.15	132.89
132.2																		
		100				.00048	.048						.06	.2	.01	.12		
35	37+90		4986	15510	.00045			33000	6.63	1450000	43.9	.68					132.27	132.95
132.3																		
		240				.00041	.0985						.11	.2	.02	.23		
37	35+50		5450	17100	.000373			33000	6.05	1210000	36.6	.57					132.50	133.07
132.5																		
		210				.00038	.080						-.02	.5	.01	.07		
39	33+40		5353	16640	.000392			33000	6.15	1250000	37.9	.59					132.57	133.16
132.6																		

PROJECT Lower Woonsocket Flood Protection

ACC. NO. 3/4-?

SUBJECT Backwater Computations

Scheme No. 4 40,000 cfs - 33,000 cfs Hamlet

SHEET NO. ___ OF ___

DATE July 9 1962

COMP. RC

CHECK CBD

CONT. NO. ___

Sec. No.	Station	Reach L	Area A	$g.01$	S	Mean S	hf	Q	V	V^2Q	V^2 avg.	hv	$hv_1 - hv_2$	Ce	Eddy Loss hc	Total H	W.S. Elev.	Energy Gradient Elev.
39	33+40				.000392							.59					132.57	133.16
		110				.00036	.0396						.088	.2	.018	.144		
40	32+30		5800	18340	.000323			33000	5.69	1070000	32.4	.502					132.72	133.22
132.7																		
		210				.00047	.099						-.26	.5	.13	-.03		
43	30+20		4718	13210	.00062			33000	7.00	1615000	49.0	.76					132.69	133.45
132.7																		
		210				.00079	.166						-.36	.5	.18	-.014		
45	28+10		3897	10640	.00096			33000	8.48	2375000	72.0	1.12					132.68	133.84
132.7																		
		260				.00086	.224						.09	.2	.02	.33		
48	25+50		3421	10600				29000	8.46	2080000							133.01	134.02
133.0	LO		149	184				430	2.89	3590								
	RO		670	1305				3570	5.33	101500								
				12089	.00075			33000		2185090	66.3	1.03						
		320				.00089	.285						-.44	.5	.22	.07		
51	22+30		2948	9340				29800	10.70	3040000							133.08	134.53
133.1	Lo		140	153				489	3.56	6180								
	RO		492	834				2711	5.50	82000								
				10327	.00102			33000		3128180	95.0	1.47						

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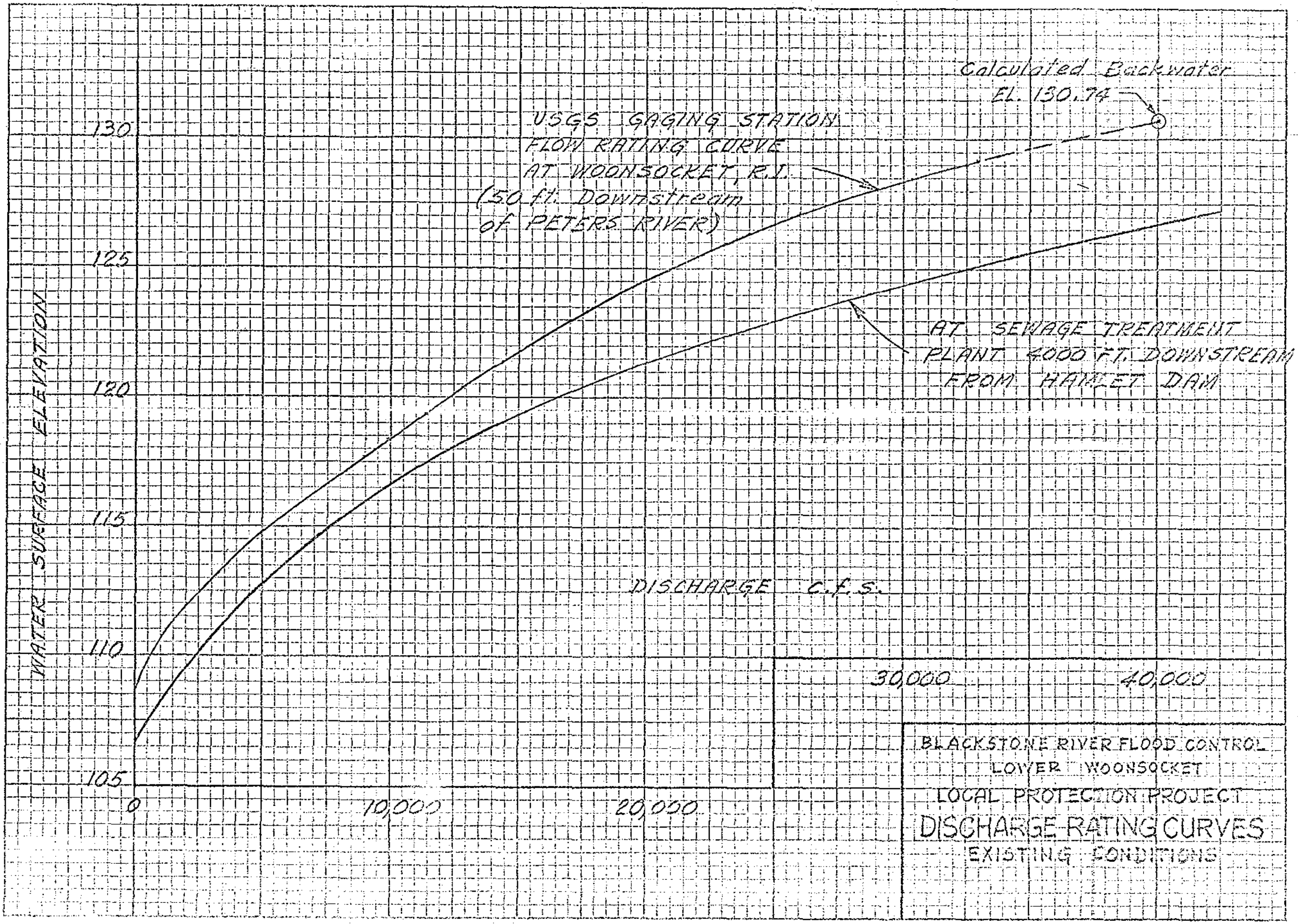

Calculated Backwater
EL. 130.74
USGS GAGING STATION
FLOW RATING CURVE
AT WOONSOCKET, R.I.
(50 ft. Downstream
of PETERS RIVER)
AT SEWAGE TREATMENT
PLANT 4000 FT. DOWNSTREAM
FROM HAMLET DAM
WATER SURFACE ELEVATION
130
125
120
115
110
105
DISCHARGE C.F.S.
0
10,000
20,000
30,000
40,000
BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
DISCHARGE RATING CURVES
EXISTING CONDITIONS

PROJECT: Woonsocket Flood Control Project ACC. NO. 3147-3
SUBJECT: Hamlet Complex Studies SHEET NO. ___ OF ___
Slope Stability Analysis DATE ______ 19__
COMP. ______ CHECK ______ CONT. NO. ______

Criteria for Slope Stability Analysis

1. The following analysis is based upon the Swedish Circular Arc Method

2. Investigations of stability include the slopes in river side and land side.

3. Unit Weights. – (i) It is assumed that the unit weight for random fill is 115 pcf
   (ii) It is assumed that the unit weight for impervious fill is 125 pcf
   (iii) It is assumed that the unit weight for riprap is 166 pcf with a void ratio 28 to 30%, ie unit wt = 125 pcf.

4. Assume $\phi = 30^{\circ}$

PROJECT	Woonsocket Flood Control Project	ACC. NO.	314.7-3
SUBJECT	Hamlet Complex Studies - Design and Analysis Criteria	SHEET NO.	1 OF
		DATE	23rd July 1962
COMP.	PC	CHECK.	CONT. NO.

Design and Analysis Criteria for Schemes 1 thru 4

1. Typical Sections
   Typical Sections of dike for schemes 1 thru 4 are as shown in Sheet 3.

2. Coefficients of Permeability
   Coefficients of permeability for pervious, impervious, and foundation were obtained from "Design Memorandum No. 3, Woonsocket Local Protection Project (May 1956)"

   (i) Natural permeability for the pervious sand and gravel foundation materials and embankment is 100×10^{-4} cm/sec with ratio of horizontal to vertical permeability of 4.

   (ii) The lower permeability value resulting from the higher density to be expected in the embankment and lesser degree of stratification, the estimated permeability is 50×10^{-4} cm/sec.

   (iii) The impervious glacial till is estimated to be 0.5×10^{-4} cm/sec. It is necessary to point out that the flow through the impervious blanket is assumed to be negligible on account of its relatively low value.

3. Horizontal transformed scale = (½)(Horizontal true scale)

4. Quantity of seepage (see Taylor, Fundamentals of Soil Mechanics chapter 9)

$$q = \frac{n_f}{n_d} k' h_t$$

where
k' = effective permeability
n_f = number of flow paths in flow net
n_d = number of potential intervals in flow net
h_t = hydraulic head
q = quantity of seepage

5. Design flood water surface is based upon hydraulic backwater computation

6. Tail water surface is assumed to be the same elevation of the existing ground.

PROJECT Woonsocket Flood Control Project ACC. NO. 3147-3
SUBJECT Hamlet Trench Complex - Design and Analysis Criteria SHEET NO. 2 OF
DATE 23rd July 1962
COMP. PC CHECK. CONT. NO.

Design and Analysis Criteria for Schemes 1 thru 4 (continued)

(7) Elevation of the top of dike is designed 3'-0" above the design flood water surface.

(8) Subsurface information is based upon the existing borings as follows:

FD-86	FD-87	FD-88
FD-89	FD-90	FD-91

(9) It is conservative to assume the impervious boundary at the depth of boring information

PROJECT Woonsocket Flood Control Project — ACC. NO. 314-7-3
SUBJECT Hamlet Complex Studies — SHEET NO. ____ OF ____
Seepage Analysis — DATE July 24 196_
COMP. PC — CHECK ____ — CONT. NO. ____

Evaluation of quantities of seepage

$$q = Kh \frac{n_f}{n_p}$$

where

q = quantity of seepage
$K = \sqrt{K_h K_v}$, coefficient of permeability
n_f = number of flow paths
n_p = number of potential paths.

<u>Scheme 1</u>

$$q = \left(\frac{5.3}{6.0}\right)(10.7)(10^{-4}) \frac{\sqrt{(100)(25)}}{30.5} = 7.75 \times 10^{-4} \text{ cu ft/sec/lin ft}$$

<u>Scheme 2</u>

$$q = \left(\frac{6.0}{6.0}\right)(20.5)(10^{-4}) \frac{\sqrt{(100)(25)}}{30.5} = 16.8 \times 10^{-4} \text{ cu ft/sec/lin ft}$$

<u>Scheme 3</u>

$$q = \left(\frac{8.8}{9.0}\right)(9.5)(10^{-4}) \frac{\sqrt{(100)(25)}}{30.5} = 7.6 \times 10^{-4} \text{ cu ft/sec/lin ft}$$

<u>Scheme 4</u>

$$q = \left(\frac{9.0}{11.5}\right)(13.6)(10^{-4}) \frac{\sqrt{(100)(25)}}{30.5} = 8.74 \times 10^{-4} \text{ cu ft/sec/lin ft}$$

Evaluation of the factors of safety against quick condition

Formula for critical hydraulic gradient

$$S_{cr} = \frac{G-1}{1+e}$$

where S_{cr} = critical hydraulic gradient
G = specific gravity of sand (2.65 is to be used)
e = void ratio (0.54 is to be used)

$$e = \frac{n}{100-n} \quad (\text{ie } n = 35\%)$$

$$\therefore \quad S_{cr} = \frac{2.65-1}{1-0.54} = 1.07$$

Factor of Safety with respect to quick condition =

$$F.S. = \frac{\text{Critical hydraulic gradient}}{\text{Actual hydraulic gradient}}$$

Scheme 1

$$S_1 = \text{Actual hydraulic gradient} = \frac{\Delta h}{L_1}$$

$$\Delta h = \frac{10.7}{6.0} = 1.78 \text{ ft}$$

$$L_1 = 6.0$$

$$\therefore \quad S_1 = \frac{1.78}{6.0} = 0.296$$

$$F.S. = \frac{1.07}{0.296} = 3.62$$

PROJECT Woonsocket Flood Control Project ACC. NO. 9147-3
SUBJECT Hamlet Avenue Studies SHEET NO. ___ OF ___
Seepage Analysis DATE July 24 1962
COMP. RC CHECK ___ CONT. NO. ___

Evaluation of the factor of safety against quick condition. (cont)

Scheme 2

$$\Delta h = \frac{20.5}{5.0} = 4.1 \text{ ft}$$

$$L_1 = 9.0$$

$$S_1 = \frac{4.1}{9.0} = 0.455$$

$$F.S. = \frac{1.07}{0.455} = \underline{\underline{2.35}}$$

Scheme 3.

$$\Delta h = \frac{9.5}{9.0} = 1.05 \text{ ft}$$

$$L_1 = 3.0$$

$$S_1 = \frac{1.05}{3.0} = 0.35$$

$$F.S. = \frac{1.07}{0.35} = 3.06$$

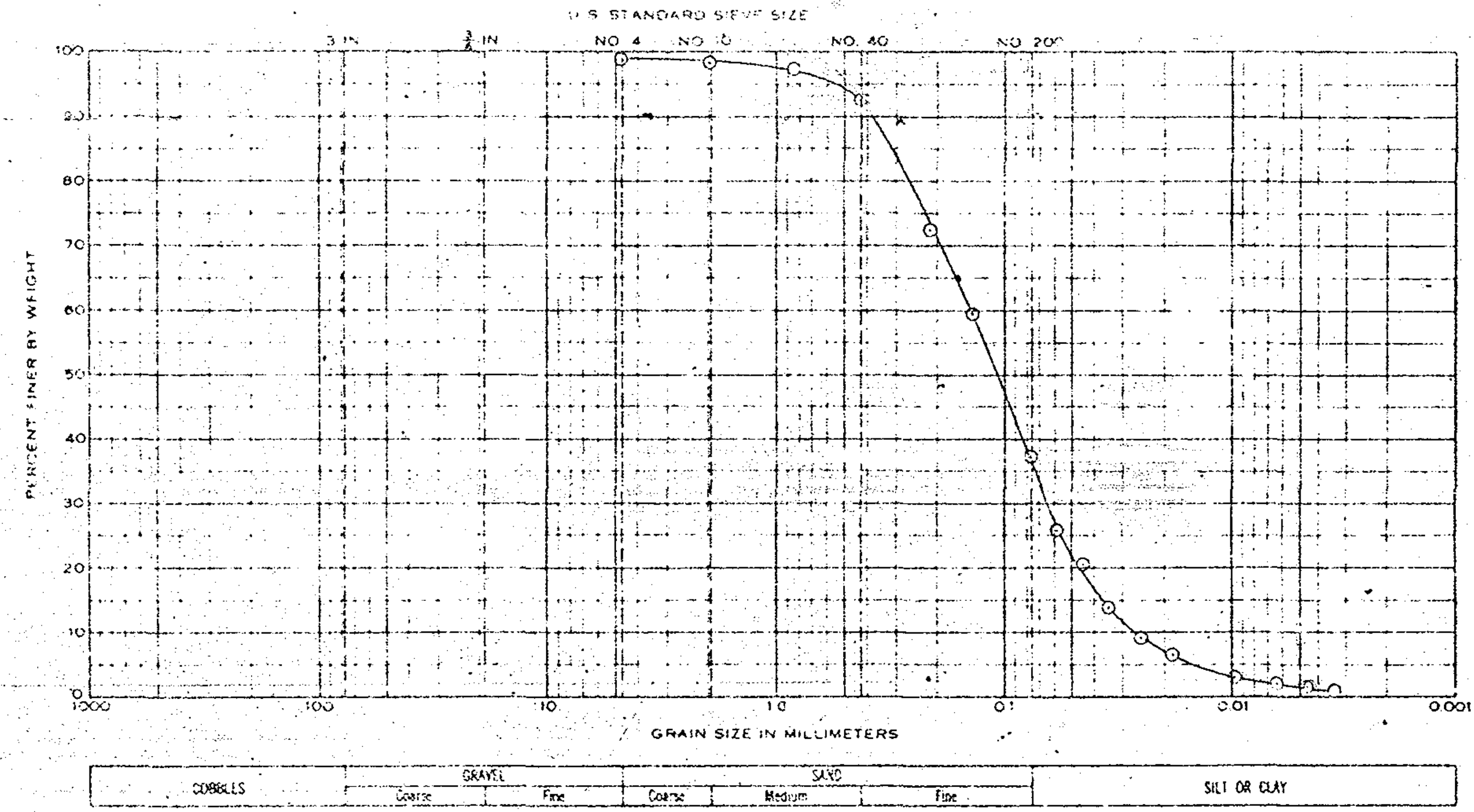
Scheme 4.

$$\Delta h = \frac{13.6}{11.5} = 1.18 \text{ ft}$$

$$L_1 = 3.5$$

$$S_1 = \frac{1.18}{3.5} = .337$$

$$F.S. = \frac{1.07}{.337} = 3.18$$



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI
B-3	2.0'-5.0'	silty fine SAND (SM)				

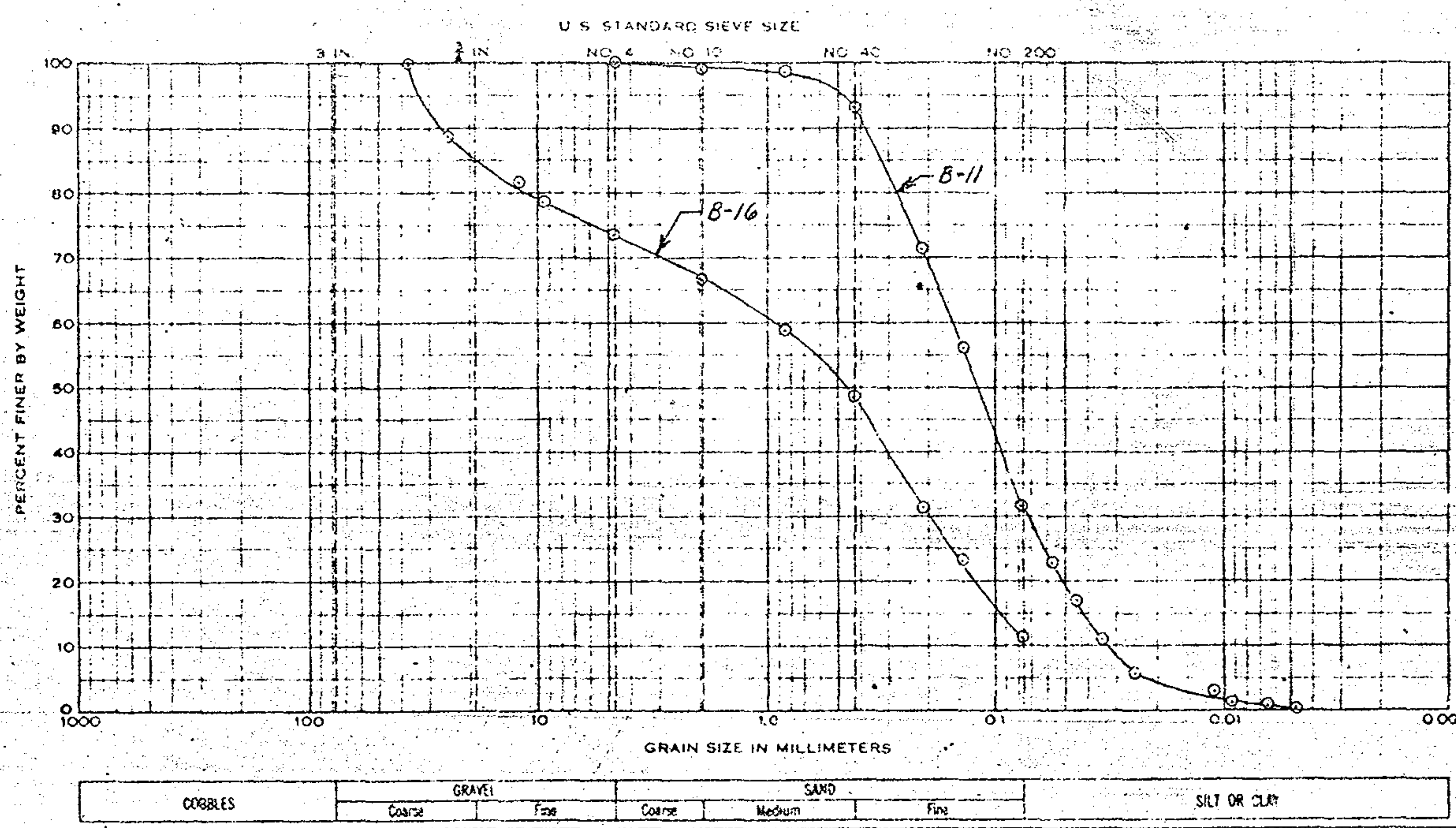
GRADATION CURVES

Project Woonsocket, Local Protection

Area

Boring No FD-88

Date 12 December 1961



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	
B-11	25.0'-30.0'	silty fine SAND (SM)					
B-16	35.5'-40.0'	silty gravelly SAND (SP-SM)					

Project Woonsocket, Local Protection

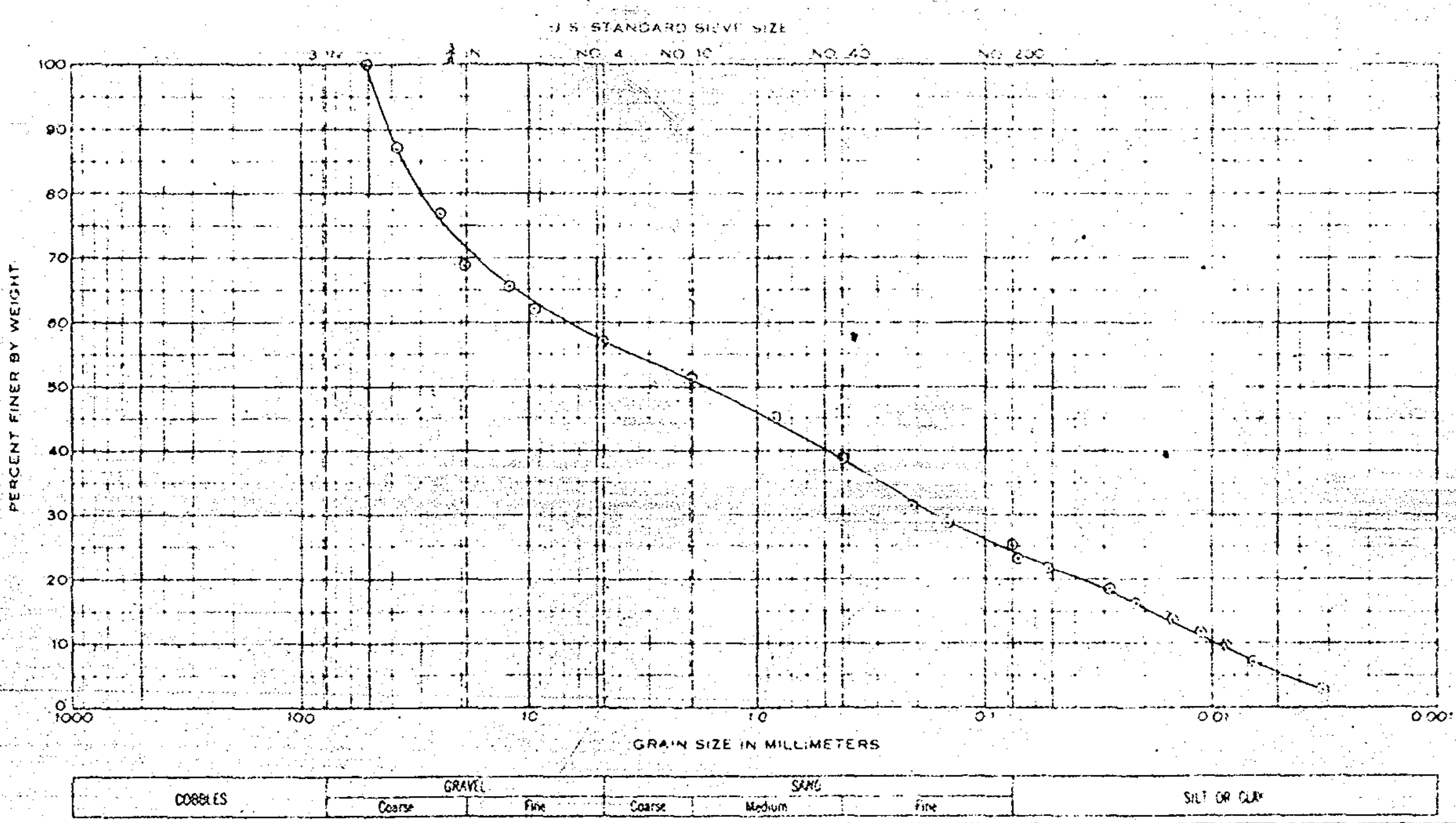
Area

Boring No. FD-88

Date 12 December 1961

GRADATION CURVES

2087



Sample No.	Elev or Depth	Classification	Nat WC	LL	PL	PI
B-11	20.0'-25.0'	silty sandy GRAVEL (GM)		Non-	Plastic	

Project Woonsocket, Local Protection

Area

Boring No FD-89

Date 12 December 1961

GRADATION CURVES