TECHNICAL REPORT H-69-4

ANSONIA - DERBY LOCAL PROTECTION PROJECT, NAUGATUCK AND HOUSATONIC RIVERS, CONNECTICUT

Hydraulic Model Investigation

by

G. A. Pickering

T. E. Murphy

April 1969

Sponsored by

U. S. Army Engineer Division
New England

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

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VICKSBURG, MISSISSIPPI
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FOREWORD

The model investigation reported herein was authorized by the Office, Chief of Engineers, on 19 April 1966 at the request of the U. S. Army Engineer Division, New England. The studies were conducted in the Hydraulics Division of the U. S. Army Engineer Waterways Experiment Station during the period August 1966 to June 1967 under the general supervision of Mr. E. P. Fortson, Jr., Chief of the Hydraulics Division, and Mr. T. E. Murphy, Chief of the Structures Branch. The tests were conducted by Messrs. H. H. Allen and G. A. Pickering under the direct supervision of Mr. J. L. Grace, Jr., Chief of the Spillway and Conduit Section. This report was prepared by Messrs. Pickering and Murphy.

During the course of the model investigation, Mr. Sam Powell, Office, Chief of Engineers, and Messrs. Edwin Coffin, Jr., and Edgar Story, New England Division, visited the Waterways Experiment Station to discuss test results and to correlate these results with design studies that were being conducted in the New England Division.

Directors of the Waterways Experiment Station during the conduct of the study and the preparation and publication of this report were COL John R. Oswalt, Jr., CE, and COL Levi A. Brown, CE. Technical Directors were Mr. J. B. Tiffany and Mr. F. R. Brown.
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<td></td>
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CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

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<tr>
<th>Multiply</th>
<th>By</th>
<th>To Obtain</th>
</tr>
</thead>
<tbody>
<tr>
<td>inches</td>
<td>2.54</td>
<td>centimeters</td>
</tr>
<tr>
<td>feet</td>
<td>0.3048</td>
<td>meters</td>
</tr>
<tr>
<td>miles</td>
<td>1.609344</td>
<td>kilometers</td>
</tr>
<tr>
<td>feet per second</td>
<td>0.3048</td>
<td>meters per second</td>
</tr>
<tr>
<td>cubic feet per second</td>
<td>0.0283168</td>
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SUMMARY

The Ansonia-Derby project will provide protection for the cities of Ansonia and Derby, Conn., from flooding of the Naugatuck and Housatonic Rivers. The proposed plan for containing the river flows requires about 13,300 ft of earth dikes and 6850 ft of floodwalls, extending about 2-1/2 miles along the Naugatuck River and 2000 ft along the Housatonic River. A 1:120-scale model was used in the investigation and reproduced approximately 4000 ft of the Housatonic River and 16,000 ft of the Naugatuck River. Tests were concerned with flow conditions at bridges and channel transitions, water-surface elevations for selection of grades for the dikes and floodwalls, and velocities for use in the design of riprap to be placed on the river side of the dikes and in portions of the channel.

Flow conditions were poor and water surfaces were higher than expected in the upper reach of the project; however, a satisfactory design was developed for this area.

Water-surface profiles and bottom velocities were obtained with the final design for both the design discharge and the capacity flow.
Fig. 1. Vicinity map

Fig. 2. Debris along the banks of the Naugatuck River following crest of flood. New Haven Railroad bridge No. 10.25 in background
ANSONIA-DERBY LOCAL PROTECTION PROJECT, NAUGATUCK AND HOUSATONIC RIVERS, CONNECTICUT

Hydraulic Model Investigation

PART I: INTRODUCTION

THE PROTOTYPE

1. The Ansonia-Derby and Derby local protection projects are located in the cities of Ansonia and Derby, New Haven County, Conn., on the Naugatuck and Housatonic Rivers (fig. 1). The combined flood protection from these projects will extend about 2-1/2 miles* along the Naugatuck River, beginning at the Route 34 Bridge in Derby, and terminating near the American Brass Company (ABC) hydroelectric plant in Ansonia. These projects also will provide 2000 ft of protection on the left bank of the Housatonic River.

2. The Naugatuck River basin has experienced five major floods within the past 30 years as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Naugatuck River</th>
<th>Housatonic River</th>
<th>Water-Surface Elevation** at Division St. Bridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 1936</td>
<td>27,000</td>
<td>60,000</td>
<td>21±</td>
</tr>
<tr>
<td>Sept 1938</td>
<td>30,000</td>
<td>60,000</td>
<td>21.3</td>
</tr>
<tr>
<td>Dec 1948</td>
<td>32,000</td>
<td>50,000</td>
<td>18.8</td>
</tr>
<tr>
<td>Aug 1955</td>
<td>112,000</td>
<td>40,000</td>
<td>27.9</td>
</tr>
<tr>
<td>Oct 1955 (see fig. 2)</td>
<td>40,000</td>
<td>75,000</td>
<td>23.8</td>
</tr>
</tbody>
</table>

3. The flood-control plan for the Naugatuck River includes seven reservoirs that should result in a reduction of about 50 percent in flood discharges.

4. The proposed plan for containing the main river flow requires about 13,300 ft of dikes, 6850 ft of floodwalls, and about 6100 ft of channel improvement. A general layout of these dikes and floodwalls is shown in plate 1. The dikes will be rolled-fill earth embankments with stone slope protection on the river side. The thickness and size of the stone slope protection will vary as required for the various velocities in the channels. The heights of the dikes will vary from approximately 10 to 30 ft. Concrete floodwalls will be provided in areas where space for dikes is lacking; and heights of these walls also will vary from 10 to 30 ft. Channel improvements consist of excavating the channel of the Naugatuck River for a distance of 1500 ft, with a bottom width of approximately 120 ft, between the ABC Bridge and the Maple Street Bridge and providing the channel bottom with riprap protection. Channel excavations will also be made on a 4600-ft-long reach of the Naugatuck River downstream of the N.Y.,N.H.,&H. Railroad bridge.

PROJECT DESIGN FLOOD

5. The protective works on the Naugatuck River will be designed for the maximum river stage resulting from concurrent flows of 75,000 cfs in the Naugatuck River and 145,000 cfs in the Housatonic

* A table of factors for converting British units of measurement to metric units is presented on page vii.
** All elevations (el) cited herein are in feet referred to mean sea level.
River with an abnormal tide in Long Island Sound. The protective works on the Housatonic River will be designed for the maximum river stage resulting from concurrent flows of 198,500 cfs in the Housatonic River and 21,500 cfs in the Naugatuck River with an abnormal tide in Long Island Sound. These standard project floods were based on the standard project storm rainfall and unit hydrographs derived from analyses of record floods.

PURPOSE OF MODEL STUDY

6. Because of the complex flow conditions resulting from the combination of abrupt changes in channel section, skewed bridges, and bends, hydraulic losses could not be reliably computed. It was therefore considered desirable to conduct model tests of the proposed protection measures and improvements to ensure adequate and economical design. A model study was also considered desirable to obtain channel velocities for use in the design of riprap protection.

7. This investigation was concerned with development of detail plans for the flood protection works on the Naugatuck River between sta 56+00 and 160+00 (Ansonia-Derby protection project). Only the general adequacy of flood-control plans on the Housatonic River and on the Naugatuck River downstream of sta 56+00 (Derby and Shelton protection projects) was to be determined. Detail plans for these latter projects are scheduled for study in future tests.
PART II: THE MODEL

DESCRIPTION

8. The model, constructed to a scale of 1:120, reproduced approximately 4000 ft of the Housatonic River and 16,000 ft of the Naugatuck River. Fig. 3 shows the lower portion of the Naugatuck River in the prototype and in the model with the proposed flood-control features installed. Ten bridges, approximately 6850 ft of floodwalls, and approximately 13,300 ft of dikes were reproduced. The model limits and general layout are shown in plate 1. The bridges, including piers, and floodwalls were constructed of sheet metal. The channel topography and dikes were molded in cement mortar to sheet metal templates. The protective riprap placed on the river side of the dikes and in portions of the channel bottom was simulated with crushed stone 1/8 to 1/4 in. in diameter.

APPURTENANCES

9. Water used in the operation of the model was supplied by pumps, and discharges were measured by means of venturi meters. Steel rails set to grade along the sides of the flumes provided a reference plane for measuring devices. Water-surface elevations were measured by means of point gauges, and velocities were measured with a pitot tube. Tailwater elevations were regulated by a flap gate at the downstream end of the model flume.

SCALE RELATIONS

10. The accepted equations of hydraulic similitude, based on the Froudeian relation which assumes gravity to be the predominant factor of flow, were used to express mathematical relations between dimensions and hydraulic quantities of model and prototype. General relations for transference of model data to prototype equivalents are as follows:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Ratio</th>
<th>Scale Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>( L_r )</td>
<td>1:120</td>
</tr>
<tr>
<td>Area</td>
<td>( A_r = L_r^2 )</td>
<td>1:14,400</td>
</tr>
<tr>
<td>Velocity</td>
<td>( V_r = L_r^{1/2} )</td>
<td>1:10,955</td>
</tr>
<tr>
<td>Discharge</td>
<td>( Q_r = L_r^{5/2} )</td>
<td>1:157,744</td>
</tr>
<tr>
<td>Roughness coefficient</td>
<td>( n_r = L_r^{1/6} )</td>
<td>1:2.221</td>
</tr>
</tbody>
</table>

MODEL ADJUSTMENT

11. The coefficient of roughness (Manning's \( n \)) of the prototype channel on which the computed water-surface elevations were based was 0.035. Basing similitude on the Froudeian relation, the above \( n \) value would be equivalent to a model \( n \) of 0.0158. In order to reproduce this \( n \) value, the model was
a. Unimproved prototype

b. Model with improvement works installed

Fig. 3. Prototype and model views of lower portion of Naugatuck River
first made rougher than required by sprinkling pea gravel on the fresh mortar bed of the model. After the mortar had set, tests were conducted and some of the pea gravel was gradually removed until the model flow lines in the relatively straight and uniform reaches were the same as the computed flow lines. This degree of roughness was then simulated throughout the entire model. Center-line profiles through the original design model channels with roughness adjusted and a computed profile are plotted in plate 2.
PART III: TESTS AND RESULTS

TEST PROCEDURE

12. After the proper $n$ value was reproduced in the model, tests were conducted with various plans for improvement of flow conditions. These tests were conducted with concurrent flows of either 75,000 cfs in the Naugatuck River and 145,000 cfs in the Housatonic River, or 21,500 cfs in the Naugatuck River and 198,500 cfs in the Housatonic River. Tests to determine water-surface elevations were conducted with the tailwater elevation at the confluence of the two rivers set at 26.0 (abnormal tide in Long Island Sound) and tests to determine velocities were conducted with the tailwater set at el 24.0 (normal tide in Long Island Sound).

13. Data obtained during the model study consisted of water-surface elevations along the banklines, photographic records of flow conditions, and velocity measurements. Locations of water-surface elevations and velocity data were obtained from the model in terms of the north and east coordinates shown on the layout in plate 1. Unless otherwise stated, the data will be presented in terms of these coordinates.

HOUSATONIC RIVER

14. The city of Derby on the north (left) bank of the Housatonic River will be protected by a floodwall extending 295 ft downstream from Bridge Street and a 1650-ft-long earth dike downstream from the floodwall (plate 1 and fig. 4). Data were collected with these improvements installed in the model, then additional data were obtained with improvements on the south (right) bank consisting of a 2260-ft-long wall and a 560-ft-long dike extending downstream from Bridge Street. The latter improvements are expected to be part of a future project for the protection of the city of Shelton, Conn.

15. The New Haven Railroad bridge No. 11.00 produced more turbulence and a greater head loss than had been assumed (see photograph 1a and plate 2). Installation of the south bank protective works actually improved the flow pattern through this reach (photograph 1b). Stages and velocities with protective works on the north bank only and on both banks are shown in plates 3 and 4.

NAUGATUCK RIVER, STA 0+00 TO 56+00

16. Protection for the city of Derby on the west (right) bank of the Naugatuck River will consist of a 3300-ft-long dike from the Route 34 Bridge to the Ansonia-Derby protection works (plate 1 and fig. 3). At the design flow, water-surface elevations observed in the model through this reach of the Naugatuck River were in close agreement with those computed (plate 2).

17. It will not be feasible to raise the New Haven Railroad bridge No. 8.59 (sta 11+00) above the flow lines, and the trusses on this bridge will be partially submerged. However, model tests indicated that due to adequate flow area under the bridge and over the approach embankments (photograph 2) stoppage of all flow through the trusses, as might be done by floating debris, had negligible effect on water-surface elevations upstream from the bridge.

18. During the tests, the dike between Division Street and Route 34 Bridges was realigned to provide additional usable space on the land side (see plate 5). Velocities in the Naugatuck River with the realigned dike are also plotted in plate 5; water-surface profiles with the original and realigned
a. Unimproved prototype

b. Model with improvement works installed

Fig. 4. Housatonic River
The realigned dike, which reduced the cross-sectional area of the channel, raised water-surface elevations by 1.0 to 1.5 ft along the channel banks downstream of Division Street Bridge and upstream from this bridge about 200 ft.

NAUGATUCK RIVER, STA 56+00 TO 165+00

19. The Ansonia-Derby flood protection project extended from sta 56+00 up the Naugatuck River to about sta 160+00. Improvement works (plate 1) consisted of a new channel and dikes from sta 56+00 to the New Haven Railroad bridge No. 10.25 (about sta 105+00); a floodwall and dike on the east (left) bank of the river from Railroad bridge No. 10.25 to Maple Street Bridge (about sta 126+00); and a new river channel, floodwalls, and dikes between sta 126+00 and 160+00. At the design flow the computed and model water-surface profiles agreed closely from sta 56+00 to Railroad bridge No. 10.25; however, upstream from sta 105+00 the model profile was higher than the computed profile, indicating greater losses through the railroad bridge than had been assumed.

Sta 56+00 to Railroad Bridge No. 10.25

20. Flow conditions in this reach were considered satisfactory and water-surface elevations were about as anticipated. A low flow in the unimproved prototype and a flood flow in the improved model channel in the vicinity of Division Street Bridge are shown in photograph 3.

Railroad Bridge No. 10.25

21. It was not considered practical to change the skewed alignment or raise the superstructure of this railroad bridge (shown in fig. 2). Thus it was expected that losses through the bridge would be appreciable. A principal purpose of the model study was to observe flow conditions at this bridge and determine whether significant improvements could be made by feasible modifications.

22. Initial tests indicated a head loss of about 2.5 ft through Railroad bridge No. 10.25 (plate 2). Under design conditions, flow passed over the overbank around both ends of the bridge and some flow passed through the bridge trusses; but the major portion of the flow passed through the right or downstream span of the bridge. This is difficult to discern in photograph 4a which shows the pattern of surface currents.

23. In an effort to obtain more flow through the left or upstream span of the bridge, deflectors or flow interceptors, such as is shown in fig. 5a, were added to the center pier. These deflectors resulted in more flow through the left span mainly by concentrating flow at the center pier, less flow through the right span, and very little effect on the total head loss through the bridge (photograph 4b). The concentration of flow increased the scouring action around the pier. The deflectors tested were not considered advantageous and it was decided that a deflector sufficiently long to improve the flow pattern would not be economically feasible.

24. In another scheme to obtain a better distribution of flow through the two spans of the bridge, a riprapped fill (fig. 5b) was placed along the right bank of the river in an effort to cause flow to pass under the bridge more normal to the existing bridge alignment. Again little effect was produced on flow lines upstream from the bridge (photograph 4c).

25. A study of the flow pattern led to the opinion that an additional bridge span on the left bank would carry little flow. Also, an additional span on the right bank would merely shift the majority of the flow from the present right span to the new span. Thus it was decided that no alterations would
a. Flow deflector added to center pier

b. Riprapped fill along right bank

Fig. 5. Modifications at New Haven Railroad bridge No. 10.25, Naugatuck River
be made to the bridge, but the walls and levees upstream would be made sufficiently high to contain the
design flow.

26. Tests conducted with the bridge trusses made solid to simulate their being clogged with debris
revealed little effect on flow lines.

27. The pattern of flow led to the conclusion that low flows might cause shoaling under the left
span on the bridge. Tests were conducted with the flow area under this span partially and fully constricted
(table 1). Full constriction of this span of the bridge resulted in an increase in water-surface elevations of
about 1.5 ft.

Railroad Bridge No. 10.25 to Sta 131+00

28. The approved project provided a floodwall on the left bank of the river through this reach but
no protection on the right bank (plate 1). However, since approval of the protection project, the Broad
Street urban renewal project has been completed on the right bank of the river (fig. 6a). Tests were con­
ducted with (fig. 6b) and without a floodwall along the right bank of the river.

29. Without protection on the right bank of the river, flooding into the Broad Street urban renewal
project began at a discharge of 42,000 cfs in the Naugatuck River with a concurrent flow of 84,000 cfs in
the Housatonic River and a tailwater elevation of 21.9. This initial overflow occurred along the right bank
at approximately N 186,100. Flow through this reach with protection on the left bank only and on both
banks of the river is shown in photograph 5. The wall on the right bank had only a minor effect on the
water-surface profile along the left bank (plate 7). Velocities in the channel with protection on both banks
are shown in plate 8.

Sta 131+00 to 165+00

30. The model water-surface elevations upstream from the ABC Bridge were considerably higher
than expected, and flow conditions were extremely turbulent where flow returned to the channel from the
overbank area just downstream from the bridge (photograph 6a). Several modifications to this area of the
project were studied in an attempt to improve flow conditions.

31. Scheme A. Scheme A (fig. 7a) consisted of a floodwall extending approximately 200 ft up­
stream from the ABC Bridge, a curved dike, and approximately 750 ft of riprap-lined channel upstream
of the ABC Bridge (plate 9).

32. Flow conditions were greatly improved with scheme A. Flow entering the channel from the
overbank area was more streamlined and surface conditions downstream from the ABC Bridge were im­
proved (photograph 6b). Water-surface elevations for a distance of about 1000 ft upstream of the ABC
Bridge also were lowered. Water-surface elevations along the banks with scheme A are shown in plate 10.

33. Scheme A-3. In scheme A-3 (fig. 7b) the dike on the right bank extended a greater distance
upstream and had less curvature than did the dike for scheme A. This plan offered a greater degree of
protection for land use on the right overbank area. A layout of scheme A-3 is shown in plate 9. Flow
conditions were improved by scheme A-3. Flow entering the channel from the overbank area was more
streamlined because of the new alignment of the dike, and there was less disturbance on the surface in
this area (photograph 6c). Bottom velocities are shown in plate 9, and water-surface profiles are shown
in plate 10.

34. Scheme B. Scheme B (fig. 7c) incorporated a dike on the right bank extending to high ground
near the upper limit of the model (plate 9). This scheme offered protection to all of the low, undeveloped
land on the right bank of the river between about sta 165+00 and 135+00.
a. Unimproved prototype

b. Model with protective wall

Fig. 6. Broad Street urban renewal project on right bank of Naugatuck River
Fig. 7. Modifications between sta 131+00 and 160+00, Naugatuck River
35. Since none of the overbank area on the right bank was flooded with scheme B, there was no return flow to cause a disturbance in this area; thus, flow conditions (photograph 6d) were very good with this design. Bottom velocities are shown in plate 9, and water-surface elevations are shown in plate 10.

FINAL DESIGN

36. After observing the model in operation and reviewing all model data, engineers of the New England Division made three revisions to the original project plans: (a) a slight realignment of the left floodwall at the Maple Street Bridge, (b) adoption of scheme A-3 for the right dike near the ABC Bridge, and (c) substitution of a floodwall for the dike on the left bank at the upstream end of the project. Also, top grades for the floodwalls and dikes were selected, based on profiles obtained in the model at the design discharge.

37. The revised project plans were reproduced in the model and all model walls and dikes were adjusted to the selected grades. Then a series of observations was made to determine the discharge at which the allowed freeboard was exceeded and overtopping of the walls or dikes occurred. It was found that overtopping of the floodwall on the left side of the channel at sta 70+34 occurred at concurrent discharges of 82,000 cfs in the Naugatuck River and 164,000 cfs in the Housatonic River. However, when the floodwall at this location was raised, overtopping did not occur at any location.
until concurrent discharges of 87,000 cfs in the Naugatuck River and 174,000 cfs in the Housatonic River were reached. Under these discharge conditions overtopping was incipient at several locations along the protective works. Thus, with the walls and dikes at grades indicated by model flow lines, adequate freeboard was provided at the design discharge of 75,000 cfs in the Naugatuck River and the actual capacity of the channel was 87,000 cfs. Model flow lines along the banks for these two discharges are plotted in plates 11 and 12. A layout of the final design together with velocities measured at the design discharge is shown in plate 13.
PART IV: DISCUSSION

38. In development of adequate plans for flood protection works on the Naugatuck and Housatonic Rivers in Ansonia and Derby, Conn., design engineers were confronted with many difficult problems. Local structures and topography dictated the alignments of the channels and there were obstructions in the channels (railroad bridges) that could not be removed feasibly. A model study was the only reliable means for prediction of flow patterns in the channels, determination of losses due to the obstructions, and development of feasible modifications to improve conditions.

39. A modification, developed in the model, to the floodwall and dike on the right bank of the Naugatuck River near the ABC Bridge resulted in a major improvement in flow conditions and a decrease in stages at the upstream end of the project.

40. Losses through the skewed railroad bridge across the Naugatuck River at about sta 105+00 were even greater than had been anticipated. However, none of the several modifications proposed resulted in an appreciable improvement in flow conditions. Observations made on the model led to the conclusion that modification to this structure was not justified.

41. Water-surface profiles measured in the model permitted dike and floodwall grades to be set so as to provide uniform protection throughout the project, thus resulting in the most economical design. Bottom velocities obtained from the model will be used to develop an adequate riprap plan.
<table>
<thead>
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<th>East Coordinate</th>
<th>North Coordinate</th>
<th>Open</th>
<th>25% Closed</th>
<th>50% Closed</th>
<th>75% Closed</th>
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<td>34.0</td>
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<td>508,870</td>
<td>184,242</td>
<td>35.6*</td>
<td>36.6*</td>
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<td>37.0*</td>
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</table>

Note: All elevations are in feet referred to mean sea level. 
Discharge: 145,000 cfs, Housatonic River, 75,000 cfs, Naugatuck River; tailwater el 26.0. 
* These readings taken on right bank near dike; all other readings taken on left bank.
a. Note turbulence at New Haven Railroad bridge No. 11.00 with improvement works only on left bank

b. Note better alignment of currents with improvements on both banks

Photograph 1. Housatonic River looking upstream from Naugatuck confluence. Discharge: 198,500 cfs (Housatonic), 21,500 cfs (Naugatuck); tailwater el 26.0
Photograph 2. Flow conditions in vicinity of New Haven Railroad bridge No. 8.59. Note trusses are partially submerged.
Discharge: 75,000 cfs (Naugatuck), 145,000 cfs (Housatonic); tailwater el 26.0
a. Unimproved prototype

b. Model with improvements; discharge 75,000 cfs

Photograph 3. Naugatuck River at Division Street Bridge
Photograph 4. Flow conditions at New Haven Railroad bridge No. 10.25 with flow of 75,000 cfs in Naugatuck River
Photograph 5. Flow conditions in vicinity of Broad Street urban renewal project with discharge of 75,000 cfs in Naugatuck River
Photograph 6. Flow conditions in Naugatuck River at upstream end of project; discharge 75,000 cfs (sheet 1 of 2)
c. Scheme A-3

d. Scheme B

Photograph 6 (sheet 2 of 2)
WATER SURFACE PROFILES
ORIGINAL DESIGN
WATER-SURFACE PROFILES
HOUSATONIC RIVER
DISCHARGE: 21,500 CFS NAUGATUCK
198,500 CFS HOUSATONIC
TAILWATER EL 260

LEGEND
D FLOOD PROTECTION ON NORTH (LEFT) BANK
O FLOOD PROTECTION ON BOTH BANKS
FLOOD PROTECTION ON NORTH (LEFT) BANK

FLOOD PROTECTION ON BOTH BANKS

NOTE: VELOCITIES ARE IN PROTOTYPE FEET PER SECOND.

BOTTOM VELOCITIES
HOUSATONIC RIVER
DISCHARGE: 198,500 CFS HOUSATONIC
21,500 CFS NAUGATUCK
TAILWATER EL 24.0

PLATE 4
BOTTOM VELOCITIES
DIKE REALIGNED BETWEEN DIVISION ST. AND ROUTE 34 BRIDGES

DISCHARGE: 75,000 CFS (NAUGATUCK)
145,000 CFS (HOUSATONIC)

TAILWATER EL. 24.0

SCALE IN FEET

NOTE: VELOCITIES (IN PROTOTYPE FEET PER SECOND) WERE MEASURED 2 FT ABOVE CHANNEL BOTTOM
WATER-SURFACE PROFILES
NAUGATUCK RIVER STA 0+00 TO STA 70+00
DISCHARGE: 75,000 CFS NAUGATUCK
145,000 CFS HOUSATONIC
TAILWATER EL 26.0

PLATE 6
WATER-SURFACE PROFILES
BROAD STREET PROTECTION PROJECT
DISCHARGE: 75,000 CFS NAUGATUCK
145,000 CFS HOUSATONIC
TAILWATER EL 26.0

LEGEND
Ø WITHOUT WALL EXTENDED (ORIGINAL DESIGN)
× WITH WALL EXTENDED
NOTE: VELOCITIES (IN PROTOTYPE FEET PER SECOND) WERE MEASURED 2 FT ABOVE CHANNEL BOTTOM

BOTTOM VELOCITIES
SCHEMES A, A-3, AND B
DISCHARGE: 75,000 CFS NAUGATUCK
145,000 CFS HOUSATONIC
TAILWATER ELEVATION 24.0

SCALE IN FEET

500 0 500 1000
WATER-SURFACE PROFILES
SCHEMES A, A-3, AND B

DISCHARGE: 75,000 CFS NAUGATUCK
145,000 CFS HOUSATONIC
TAILWATER EL 26.0
NOTE: VELOCITIES (IN PROTOTYPE FEET PER SECOND) WERE MEASURED 2 FT ABOVE CHANNEL BOTTOM

BOTTOM VELOCITIES
FINAL DESIGN
DISCHARGE: 75,000 CFS NAUGATUCK
145,000 CFS HOUSATONIC
TAILWATER ELEVATION 24.0
SCALE IN FEET
The Ansonia-Derby project will provide protection for the cities of Ansonia and Derby, Conn., from flooding of the Naugatuck and Housatonic Rivers. The proposed plan for containing the river flows requires about 13,300 ft of earth dikes and 6850 ft of floodwalls, extending about 2-1/2 miles along the Naugatuck River and 2000 ft along the Housatonic River. A 1:120-scale model was used in the investigation and reproduced approximately 4000 ft of the Housatonic River and 16,000 ft of the Naugatuck River. Tests were concerned with flow conditions at bridges and channel transitions, water-surface elevations for selection of grades for the dikes and floodwalls, and velocities for use in the design of riprap to be placed on the river side of the dikes and in portions of the channel. Flow conditions were poor and water surfaces were higher than expected in the upper reach of the project; however, a satisfactory design was developed for this area. Water-surface profiles and bottom velocities were obtained with the final design for both the design discharge and the capacity flow.
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<th>KEY WORDS</th>
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