HYDRAULIC MODELING OF STREAM CHANNELS AND STRUCTURES IN HARBOR AND CROW HOLLOW BROOKS, MERIDEN, CONNECTICUT

By Lawrence A. Weiss, Michael P. Sears, and Michael A. Cervione, Jr.

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BRUCE BABBITT, Secretary

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Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.59	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

National Geodetic Vertical Datum of 1929 (NGVD)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Effects of urbanization have increased the frequency and size of floods along certain reaches of Harbor Brook and Crow Hollow Brook in Meriden, Conn. A flood-profile-modeling study was conducted to model the effects of selected channel and structural modifications on flood elevations and inundated areas. The study covered the reach of Harbor Brook downstream from Interstate 691 and the reach of Crow Hollow Brook downstream from Johnson Avenue. Proposed modifications, which include changes to bank heights, channel geometry, structural geometry, and streambed armoring on Harbor Brook and changes to bank heights on Crow Hollow Brook, significantly lower flood elevations.

Results of the modeling indicate a significant reduction of flood elevations for the 10-year, 25-year, 35-year, 50-year, and 100-year flood frequencies using proposed modifications to (1) bank heights between Harbor Brook Towers and Interstate 691 on Harbor Brook, and between Centennial Avenue and Johnson Avenue on Crow Hollow Brook; (2) channel geometry between Coe Avenue and Interstate 691 on Harbor Brook; (3) bridge and culvert opening geometry between Harbor Brook Towers and Interstate 691 on Harbor Brook; and (4) channel streambed armoring between Harbor Brook Towers and Interstate 691 on Harbor Brook. The proposed modifications were developed without consideration of cost-benefit ratios.

INTRODUCTION

Flooding in the urban part of Meriden, along Harbor Brook and Crow Hollow Brook, has become a concern for City officials (fig. 1). Flooding from even low-magnitude floods has been a common event for residents and businesses. The drainage area of Harbor Brook below Interstate 691 is highly urbanized (Weiss, 1990), which, in conjunction with intense rainfall of even low magnitude, can cause significant flood damage (U.S. Department of Agriculture, 1984). Since the construction of Meriden's Hub Mall in the early 1970's, the economic effect of flooding in Meriden has increased significantly. The floods of January 1979, June 1982, and June 1992, which resulted in 3 to 5 ft of flood water in the downtown area, damaged buildings and forced the closure of businesses for cleaning and repairs.

Flooding in the urban part of Meriden along Harbor Brook, from Interstate 691 to Hanover Pond, and on Crow Hollow Brook downstream from Johnson Avenue, affects 141 industrial, commercial and residential buildings that are in the 100-year frequency flood plain. Floods of much lower magnitudes can affect nearly 50 percent of these buildings. Previous studies have shown that the construction of flood-control reservoirs is not a feasible solution to the flooding problem. Conversion of existing Baldwins Pond on Harbor Brook to a flood-control reservoir would have no effect on flooding because of its small size. Land purchases to accommodate other possible reservoir sites on either of the two streams would be very costly. Raising bank heights, modifying channels and structures, and armoring the streambed may be effective solutions.

In April 1993, the U.S. Geological Survey (USGS), in cooperation with the Department of Public Works, City of Meriden, Conn., conducted a flood-profile-modeling study to analyze the effects of proposed channel and structural modifications on flood elevations. The study focused on Harbor Brook and Crow Hollow Brook, although additional streams, including the Quinnipiac River, Sodom Brook, Willow Brook, and Spoon Shop Brook were considered for modeling. Streams other than Harbor Brook and Crow Hollow Brook were found to have no significant flooding problems that would cause structural damage or other economic loss. The results of this study can be used for future flood-plain management in similar areas.

Purpose and Scope

This report presents the results of the flood-profile-modeling study on Harbor Brook and Crow Hollow Brook, Meriden, Conn. The results of the model indicate the effect of the proposed channel and structural modifications on stream elevations on the reach of Harbor Brook downstream from Interstate 691 and on the reach of Crow Hollow Brook downstream from Johnson Avenue.

Effects of proposed modifications on flood elevations for the 10-year, 25-year, 35-year (as defined by the flood on June 6, 1992), 50-year, and 100-year frequency floods are included in the report. Proposed modifications for Harbor Brook include changes to (1) bank heights (by adding or increasing the height of side walls or rail crossings), (2) stream channel geometry (deepening the channel), (3) structural geometry (by raising or removing bridges or other structures), and (4) streambed armoring. Proposed modifications for Crow Hollow Brook include only changes to bank heights. The new flood elevations are shown in tables and presented graphically in stream profiles. The proposed modifications were developed without consideration of cost-benefit ratios.

Description of the Study Area

Meriden is located in the northeastern corner of New Haven County, approximately halfway between Hartford and New Haven. It is bordered on the west by Cheshire and Southington, on the north by Southington and Berlin, on the east by Middletown and Middlefield, and on the south by Wallingford (fig. 1). The city has an area of 24.0 mi^2 and a 1991 population of 59,479 persons (Connecticut State Register and Manual, 1991). The population density—about 2,478 persons per square mile—is one of the highest in the region and reflects the degree of urbanization in the city. Annual precipitation in this part of Connecticut is about 45 in., and annual runoff is about 26 in.

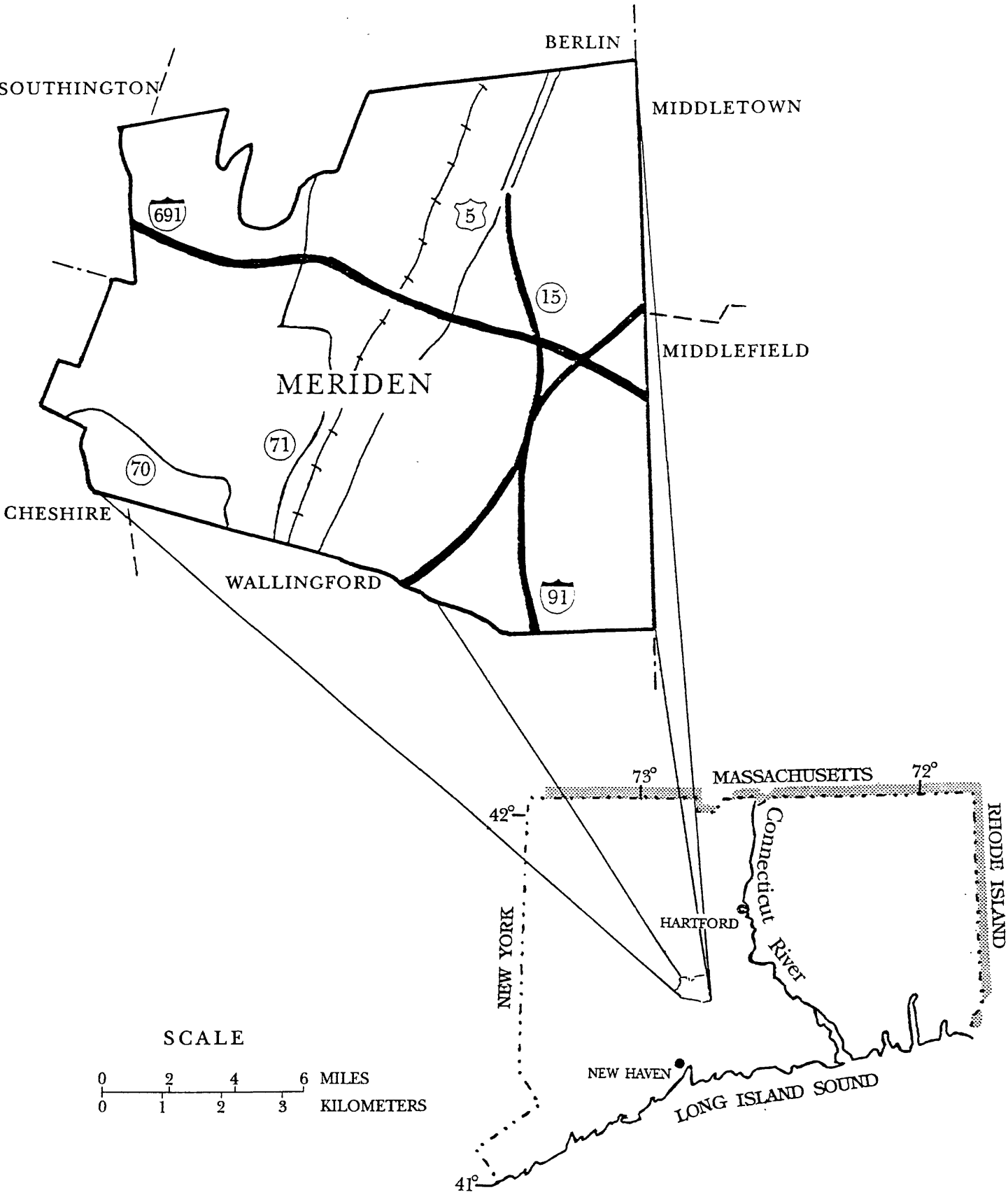

Figure 1. Location of the study area, Meriden, Conn.

Meriden's transportation network is extensive. Interstate 91, Connecticut Route 15 (Wilbur Cross Parkway), and Interstate 691 are multi-lane highways with several interchanges in the eastern half of the city. Other major routes include U.S. 5 and Connecticut Routes 70 and 71. Conrail, the Boston and Maine Railroad, and Amtrak's New York to Springfield line serve Meriden.

Harbor Brook originates in the northeastern corner of Meriden. It begins on the southeastern flank of Lamentation Mountain just upstream from Bradley Hubbard Reservoir and flows southwestward to Baldwins Pond (7 acres) (fig. 2). Upstream from Baldwins Pond, Harbor Brook is joined by Willow Brook, which flows from the south. Downstream from Baldwins Pond, Harbor Brook flows southwestward through the business district of downtown Meriden, where it is contained within conduits, and onto its outlet in Hanover Pond (64 acres) on the Quinnipiac River (U.S. Department of Agriculture, 1984).

The watershed of Harbor Brook is 12.1-mi^2 (7,744 acres). The topography is hilly, and elevations range from 892 ft NGVD (National Geodetic Vertical Datum) on Higby Mountain to 87 ft NGVD at Hanover Pond. The bedrock is mostly reddish arkose and feldspathic sandstone, but the steep hills in the north and east are underlain by resistant basaltic lava flows. All rocks are part of the Newark Supergroup of Triassic age. A thin layer of glacial till covers much of the watershed, but large areas of water-deposited sand and gravel are present (22 percent of the basin), principally along Willow Brook and in the downtown area. Muck and peat are present in the swampy wetlands.

Land use in the Harbor Brook watershed consists of about 48 percent urban/residential land, 20 percent forested land, 23 percent open land (including agricultural areas), and 9 percent wetlands and ponds. At least 60 percent of the urban/residential land lies within the 3.78 mi^2 of basin downstream from Baldwins Pond. The wetlands in the basin serve as areas of flood storage, but encroachment for home sites and roads have decreased this area's ability to lower flood peaks.

Crow Hollow Brook originates in the northwestern part of Meriden near Hubbard Park (fig. 3) and flows southeastward along West Main Street until Centennial Avenue, where it turns southward to its confluence with Sodom Brook, just downstream from Coe Avenue. Below the intersection of West Main and Centennial Streets, Crow Hollow Brook is highly channelized and flows in culverts; however, a section of the stream between West Main Street and Centennial Street is subject to frequent overbank flow on the east bank.

The watershed of Crow Hollow Brook is 1.4-mi^2 (about 900 acres). The topography is hilly, and elevations range from 150 ft NGVD at Johnson Avenue to 420 ft NGVD at Hubbard Park. The basin has the same type of bedrock as Harbor Brook basin, and a thin layer of glacial till covers most of the watershed. Small areas of water-deposited sand and gravel are present (4 percent of the basin). Land use in Crow Hollow Brook watershed consists of about 22 percent urban/residential land and 78 percent forested land. A very small part of the basin is in wetlands and ponds.

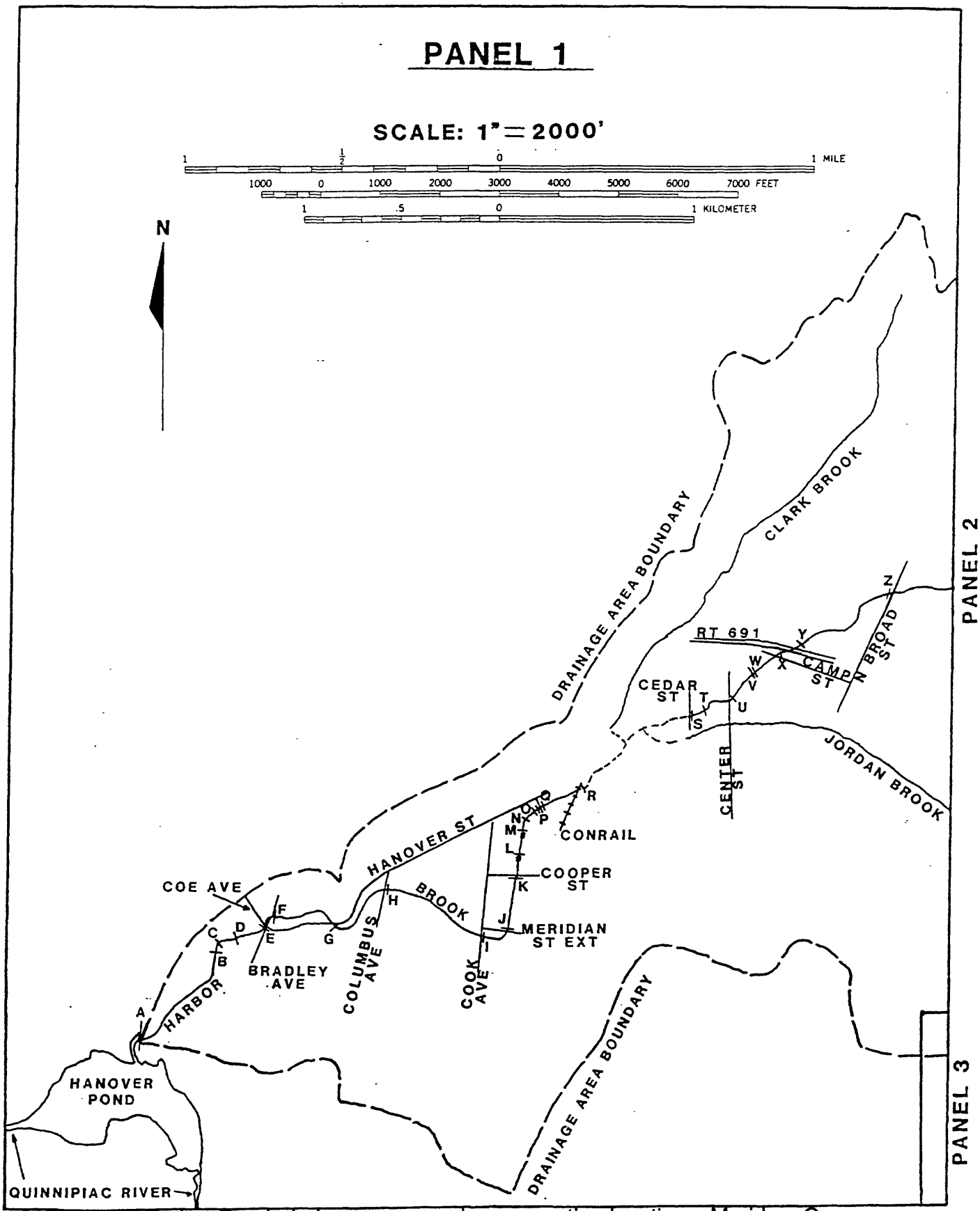

Figure 2. Harbor Brook drainage area and cross-section locations, Meriden, Conn.

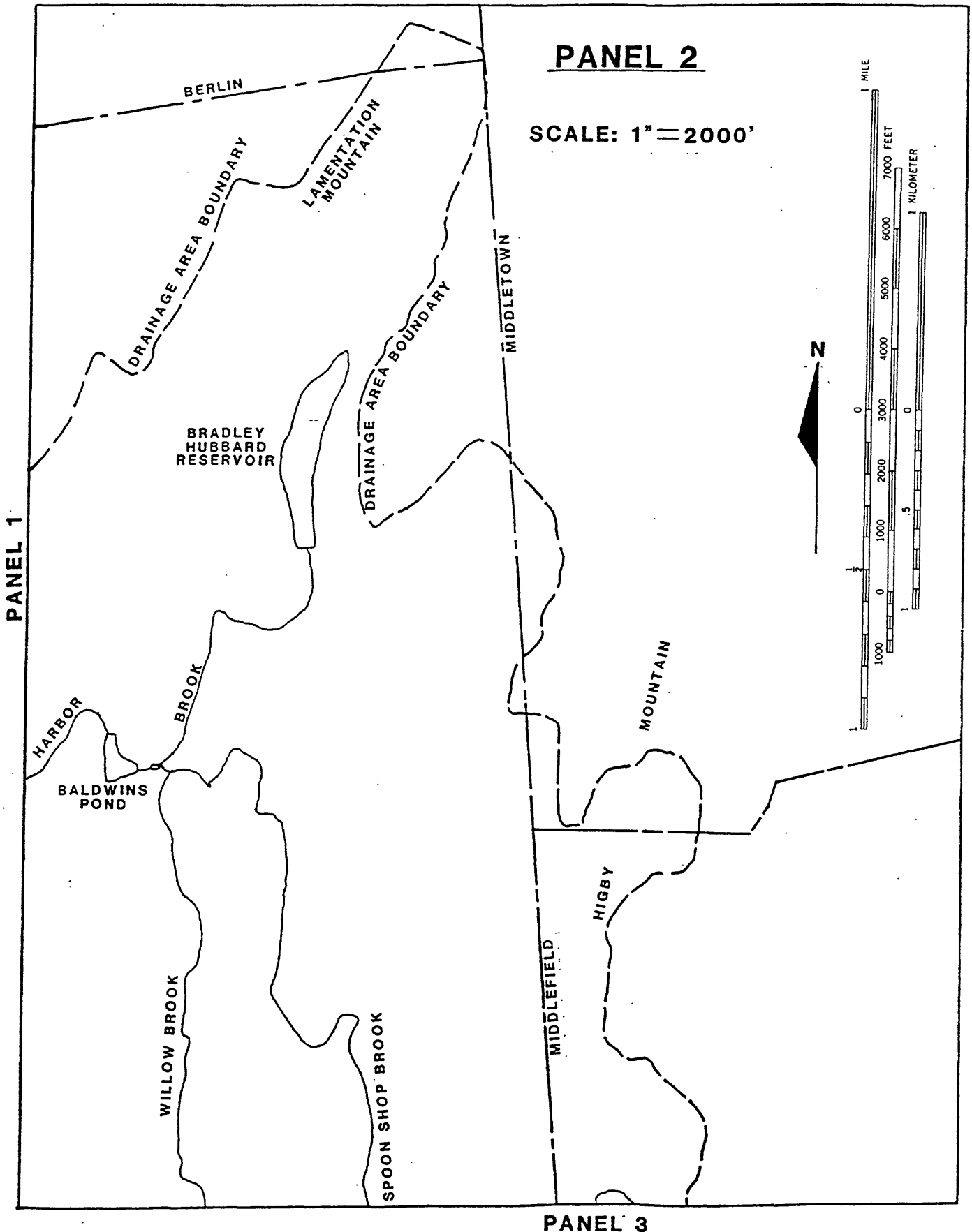

Figure 2. Harbor Brook drainage area and cross-section locations, Meriden, Conn.—Continued

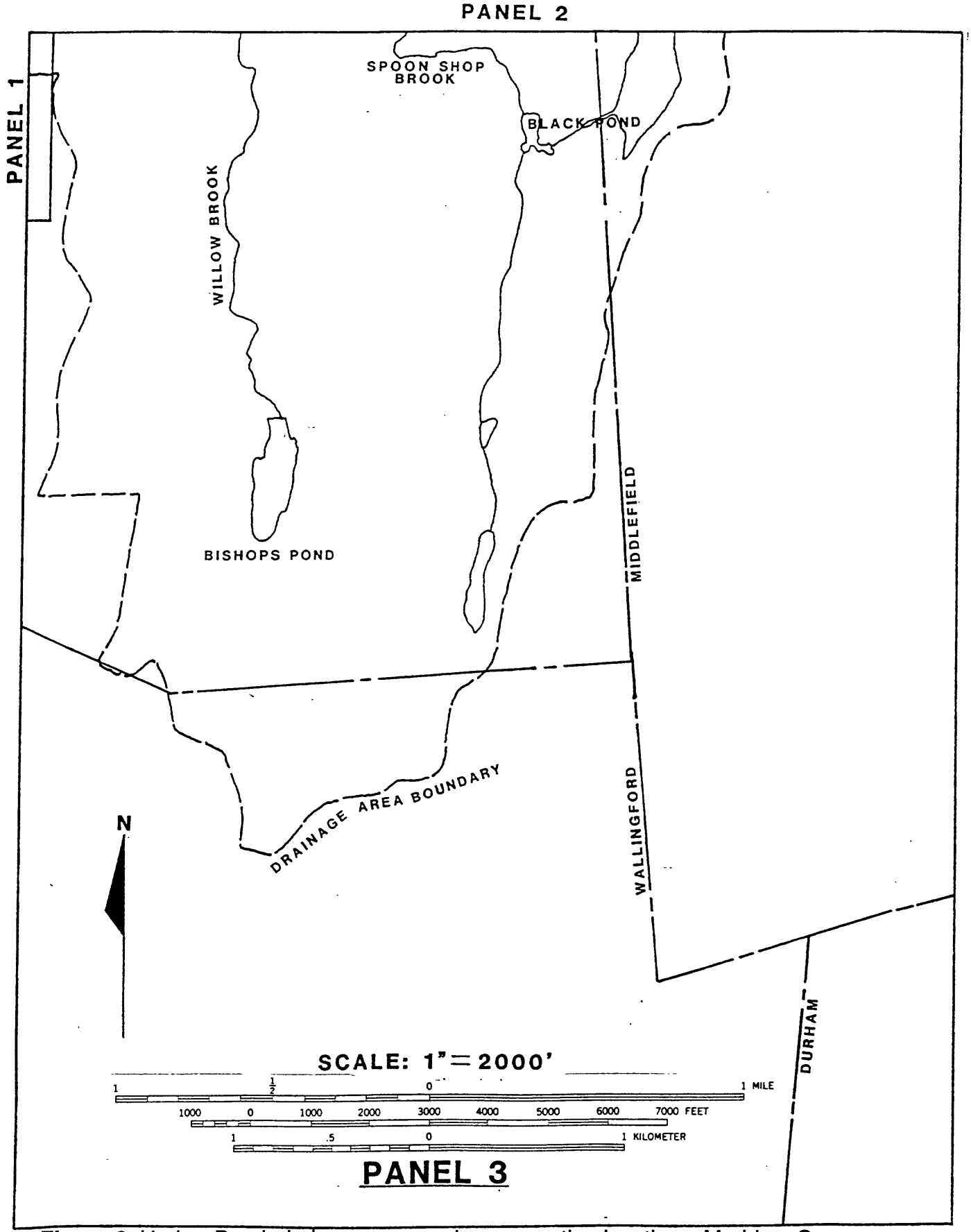

Figure 2. Harbor Brook drainage area and cross-section locations, Meriden, Conn.—Continued

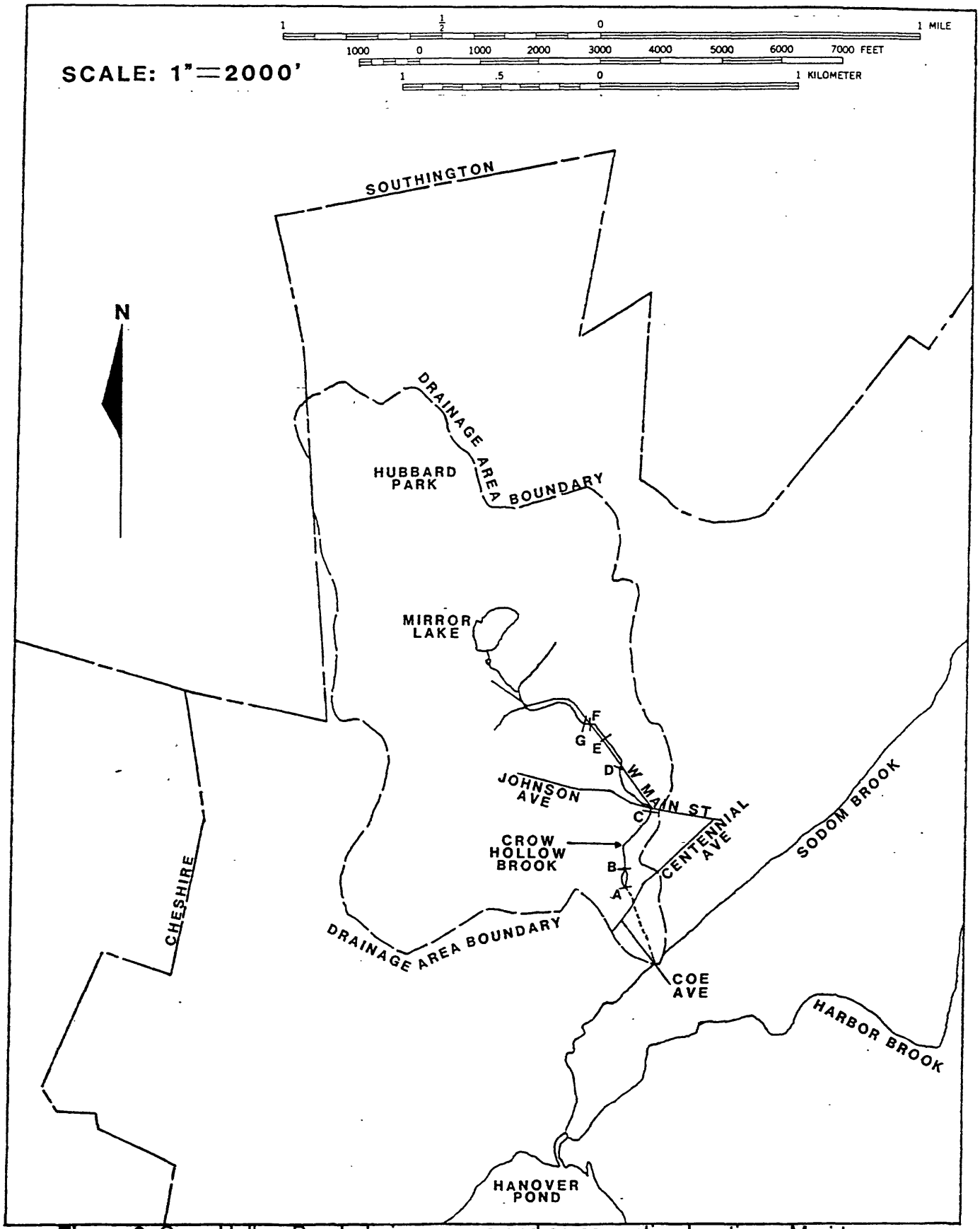

Figure 3. Crow Hollow Brook drainage area and cross-section locations, Meriden, Conn.

Flood History

Flooding has been a fairly common event for the residents and business people of Meriden. Area newspapers have reported 10 significant floods since 1869. Intense rainstorms, often in conjunction with rapid snowmelt or hurricanes, have generally been the cause of Meriden's flooding problems.

Three noteworthy floods took place during the 1800's. In October 1869, "the floodgate of Heaven opened and the rain descended." (Meriden Daily Republican, October 5, 1869). The ensuing floodwaters destroyed newly paved roads, washed out the Harbor Brook bridges over Camp and Center Streets, caused the dam at Baldwins Pond to fail, and inundated numerous homes and businesses. In January 1891 and in February 1896, heavy rains, coupled with high winds and melting ice and snow, threatened bridges and caused flood damage to factories along Harbor Brook.

Serious flooding continued into the 1900's. In March 1936, backyards were flooded, basements were flooded to depths of 2 ft, and stores on Pratt Street were damaged. The September 1938 hurricane caused record flooding and damage, with up to 6 ft of water on State and Pratt Streets. Merchants, businesses, and factories were especially hard hit. The Meriden Record reported that "Meriden was swept by the most destructive storm in all its history" and that floodwaters kept "much of the center of the City under water for several days."

In August 1955, during hurricane Diane, 5 in. of rain fell on Meriden. Although Harbor Brook flowed out-of-bank, damages consisted primarily of flooded cellars. Nearly 3.5 in. of rain, combined with rapid snowmelt, caused Harbor Brook to overflow its banks in February 1970, and streets and basements were flooded. On January 24 to 25, 1979, 3.65 in. of rain fell on frozen, saturated ground. The ensuing floodwaters and mud disrupted traffic, caused significant property damages, and threatened personal safety. The Meriden Hub Mall, constructed in the early 1970's, was flooded for the first time, and merchandise, fixtures, furnishings, and equipment were damaged. The mall and other downtown businesses were closed for 1 to 4 days for cleanup and repair of damages.

Widespread heavy rainfall during June 5 to 6, 1982 caused substantial damage to the City of Meriden's water-pollution-control plant, pumping station, storm drains, parks, street pavement, and various city-owned dams and bridges (L.R. Johnston Associates, 1983). Basements of many residential and business properties were flooded, and City crews were busy pumping out basements along Harbor Brook. The movie theaters in the Meriden Hub Mall received up to 3 ft of water, and vehicles parked along flooded streets were damaged. Although many roads and streets were closed to protect public safety, the inconvenience to public schools and traffic flow was minimized because the flood occurred on a weekend (U.S. Department of Agriculture, 1984).

During June 5 to 6, 1992, the local sewage-treatment plant in Meriden recorded a 50-year frequency rainfall of 6.25 inches in an 8-hour period (Connecticut Department of Environmental Protection, 1992). Flows calculated by indirect measurement averaged 2,300 ft^3/s, which is about a 35-year frequency; this caused the most widespread flooding on Harbor Brook since the Meriden Hub Mall was built. Water spilled over the channel walls below the Conrail Bridge and above Cedar Street (fig. 2), and the average water depth in the center of Meriden was 4 to 5 ft.

DATA COMPILATION AND HYDRAULIC ANALYSIS

Data on peak discharges, valley cross sections, and channel and structural geometry were available from previous studies (Federal Emergency Management Agency, 1982; in press). Additional cross-section data were collected in 1993 by the USGS. Channel modification data and bridge and culvert design data were furnished by the Engineering Department, City of Meriden. Peak discharge data for each flood frequency used in this analysis are shown in table 1.

Table 1. Peak discharges used in analyses, Harbor and Crow Hollow Brooks, Meriden, Conn.

[-, not applicable; data from Weiss, 1990]

Stream	Meriden location	Peak discharge, in cubic feet per second, for recurrence interval, in years				
		10	25	35	50	100
Harbor Brook	Baldwins Pond	-	-	-	-	2,650
Harbor Brook	Cedar Street	1,500	1,900	2,100	2,500	3,000
Harbor Brook	East Main Street	1,500	1,900	2,100	2,500	3,000
Harbor Brook	Columbus Avenue	1,500	1,900	2,100	2,500	3,000
Harbor Brook	Mouth	1,650	2,100	2,300	2,700	3,300
Crow Hollow Brook	Notch Road	-	-	-	-	130
Crow Hollow Brook	West Main Street	-	-	-	-	310
Crow Hollow Brook	Mouth	-	-	-	-	440

These data were input to the J635 step-backwater computer model (Shearman, 1976) to determine the baseline flood elevations for Harbor Brook and Crow Hollow Brook for each flood frequency. The step-backwater model was used to do the following:

(1) Analyze the effect of proposed bank-height modifications in containing the 10-year, 25-year, 35-year, (as defined by the flood of June 5 to 6, 1992), 50-year, and 100-year frequency floods between Harbor Brook Towers and Interstate 691 on Harbor Brook (fig. 2) and between Centennial Avenue and Johnson Avenue on Crow Hollow Brook (fig. 3).

(2) Analyze the effect of proposed stream channel geometry modifications for these flood frequencies between Coe Avenue and Interstate 691 on Harbor Brook (fig. 2).

(3) Analyze the effect of proposed bridge and culvert opening geometry modifications, at hydraulically critical backwater locations, for these flood frequencies on Harbor Brook.

(4) Analyze the effect of proposed channel streambed armoring to decrease friction and enhance flow movement for these flood frequencies between Harbor Brook Towers and Interstate 691 on Harbor Brook.

The J635 model cannot evaluate long-barrel culverts; therefore, these computations were performed manually using techniques described by Bodhaine (1969). Dam computations were performed using techniques described by Hulsing (1967).

HYDRAULIC MODELING OF STREAM CHANNELS AND STRUCTURES IN HARBOR AND CROW HOLLOW BROOKS, MERIDEN, CONN.

Harbor Brook

In this report, selected locations along Harbor Brook are identified using distance points measured upstream from the confluence of Harbor Brook with the Quinnipiac River.

Flooding in Meriden was analyzed by City officials who considered the frequency of the previous floods and the reaches where the most serious flood damage had taken place. Harbor Brook was subdivided into three reaches to evaluate the effects of proposed channel and structural modifications on flood elevations. These reaches were established in consultation with City of Meriden officials and were based on previous flood-damage estimates. The reaches are (1) Coe Avenue (distance point 3,410 ft) to Harbor Brook Towers culvert (distance point 10,345 ft), (2) Harbor Brook Towers culvert (distance point 10,345 ft) to the upstream end of Meriden Hub Mall (distance point 11,410 ft), and (3) upstream from Cedar Street (distance point 13,500 ft) to Interstate 691 (distance point 15,660 ft). The reaches were modeled to determine the effect of each proposed modification on (*a*) the 10- and 25-year floods, (*b*) the 35- (June 5-6, 1992) and 50-year floods, and (*c*) the 100-year flood. The proposed modifications used for each flood frequency and reach, developed jointly by the USGS and the City of Meriden, were channel bank height modifications, channel geometry modifications, bridge and culvert opening geometry modifications, and channel streambed armoring.

Modeling 10- and 25-year floods

The section between Harbor Brook Towers and Interstate 691 is subject to a great deal of damage from low-magnitude floods (U.S. Department of Agriculture, 1984). Modeling was done along this section to determine the effect of proposed modifications on the 10- and 25-year floods.

Downstream from Harbor Brook Towers

The reach between distance point 9,400 ft and the Harbor Brook Towers culvert (distance point 10,190 to 10,345 ft), was analyzed by modeling the effects of (1) adding a 3-ft side wall on the west bank from distance point 10,190 to 10,345 ft; this includes a 30-ft wide rail crossing at the driveway at distance point 10,345 ft to elevation 124 ft NGVD; (2) removing 3 to 4 ft of streambed material to elevation 108 ft NGVD; and (3) armoring the channel bottom from distance point 10,190 to 10,345 ft. The resulting stream elevations are shown in table 2, and the profiles are shown in figures 4 and 5.

Downstream from Meriden Hub Mall

The reach between the downstream end of the Harbor Brook Tower culvert (distance point 10,345) to the exit of the Meriden Hub Mall culvert (distance point 11,410 ft) was analyzed by modeling the effects of (1) adding 90 ft of 5-ft high rail crossings and 60 ft of 2-ft high rail crossings, as well as adding 5 ft-high side walls on each bank from distance point 10,705 to 11,245 ft at the Conrail Bridge, (2) removing 3 to 4 ft of streambed material from distance point 10,345 (elevation 108 ft NGVD) to distance point 11,410 ft (elevation 110 ft NGVD); and (3) armoring the channel bottom from distance point 10,345 to 11,410 ft. The resulting stream elevations are shown in table 2, and profiles are shown in figures 4 and 5.

Table 2. Streambed and water-surface elevations based on proposed channel and structural modifications to contain the 10-year and 25-year floods, Harbor Brook, Meriden, Conn.

[NGVD, National Geodetic Vertical Datum]

Cross section	Distance upstream from mouth, in feet	Elevation, in feet (NGVD) for indicated flood frequency			
		Streambed, 10 year	Streambed, 25 year	Water surface, 10 year	Water surface, 25 year
A	0	81.0	81.0	90.8	90.8
B	2,340	91.1	91.1	94.8	95.8
C	2,540	92.7	92.7	97.0	97.2
D	2,840	94.2	94.2	98.6	99.2
E	3,410	96.0	96.0	100.8	101.2
F	3,730	98.2	98.2	105.0	105.6
G	4,910	104.4	104.4	110.1	111.0
H	6,230	107.0	107.0	115.2	116.3
I	8,125	107.7	107.7	119.0	119.7
J	8,550	109.0	109.0	119.5	120.1
K	9,400	110.4	110.4	119.7	120.4
L	9,900	108.0	108.0	121.0	122.1
M	10,190	108.0	108.0	121.0	122.2
N	10,345	108.0	108.0	121.0	122.2
O	10,705	108.5	108.5	121.7	123.3
P	10,875	108.8	108.8	122.2	124.2
Q	10,965	109.0	109.0	122.3	124.4
R	11,410	110.0	110.0	122.4	124.7
S	13,700	120.0	120.0	129.5	130.5
T	13,980	120.0	120.0	129.8	130.8
U	14,440	123.2	123.2	131.1	132.4
V	15,005	132.0	132.0	136.6	137.6
W	15,030	132.0	132.0	136.6	137.6
X	15,660	134.6	134.6	141.4	141.9
Y	16,260	137.3	137.3	142.6	143.4
Z	17,840	149.6	149.6	153.9	155.0

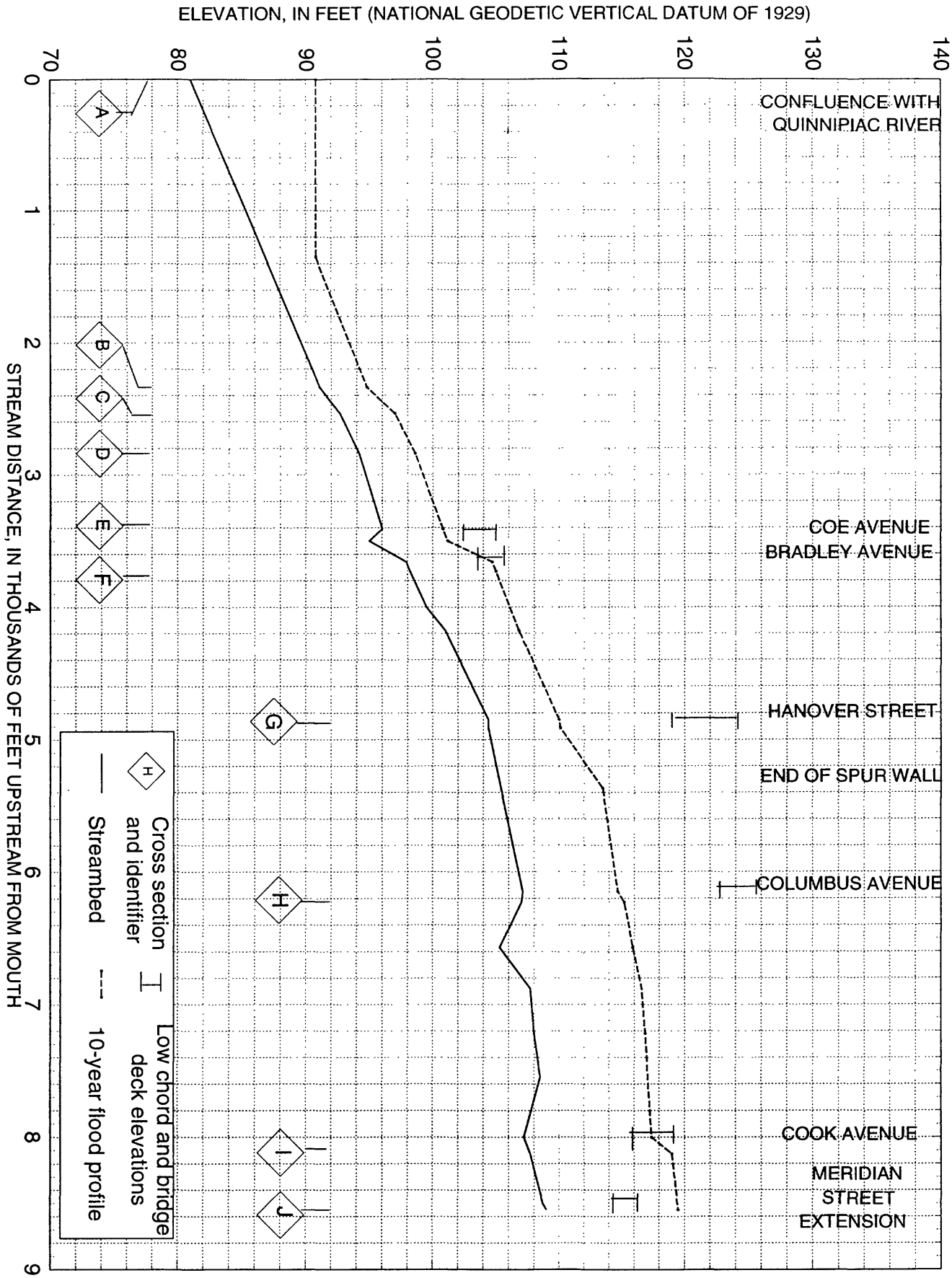

Figure 4. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 10-year flood.

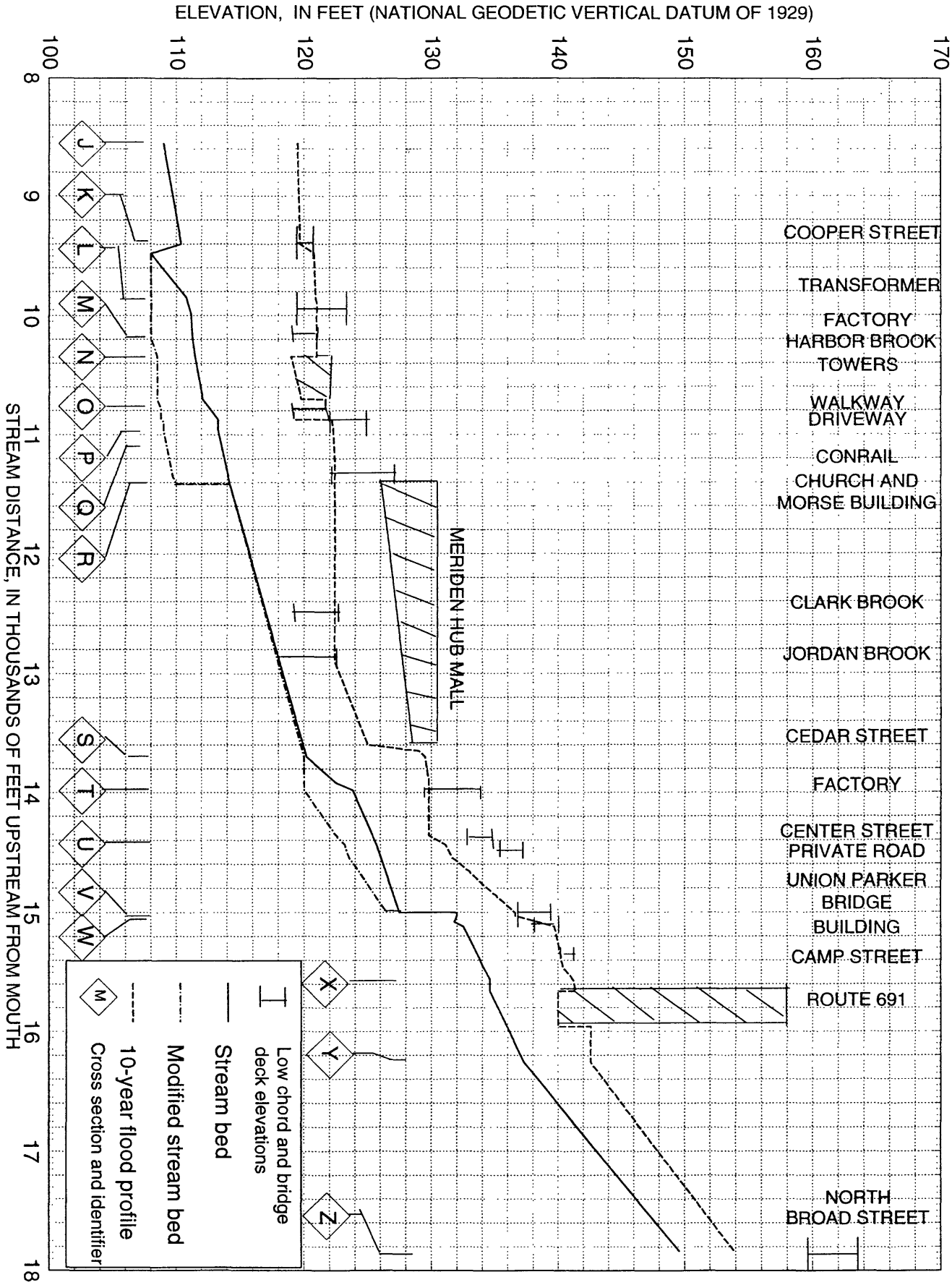

Figure 4. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 10-year flood.—Continued

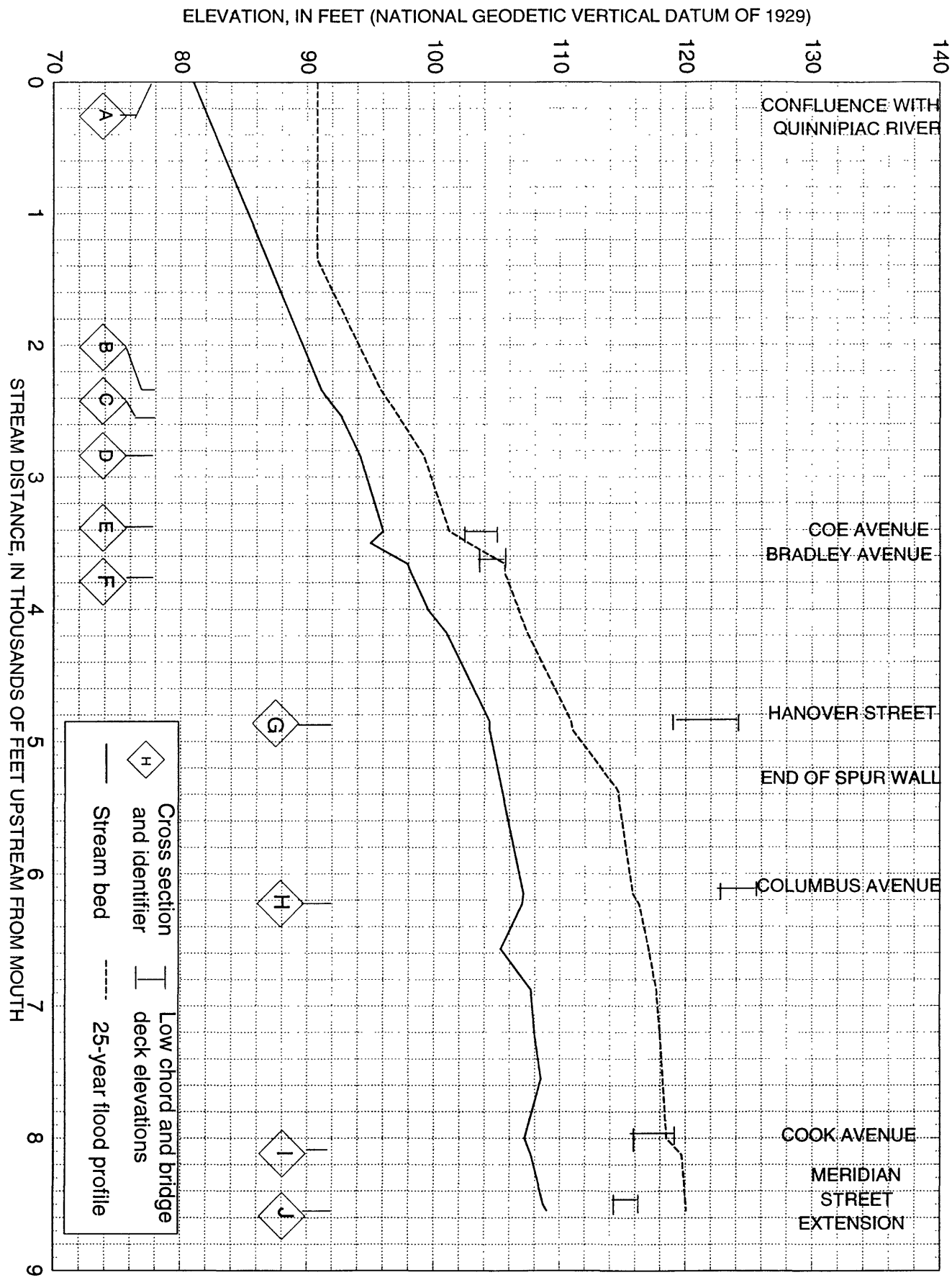

Figure 5. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 25-year flood.

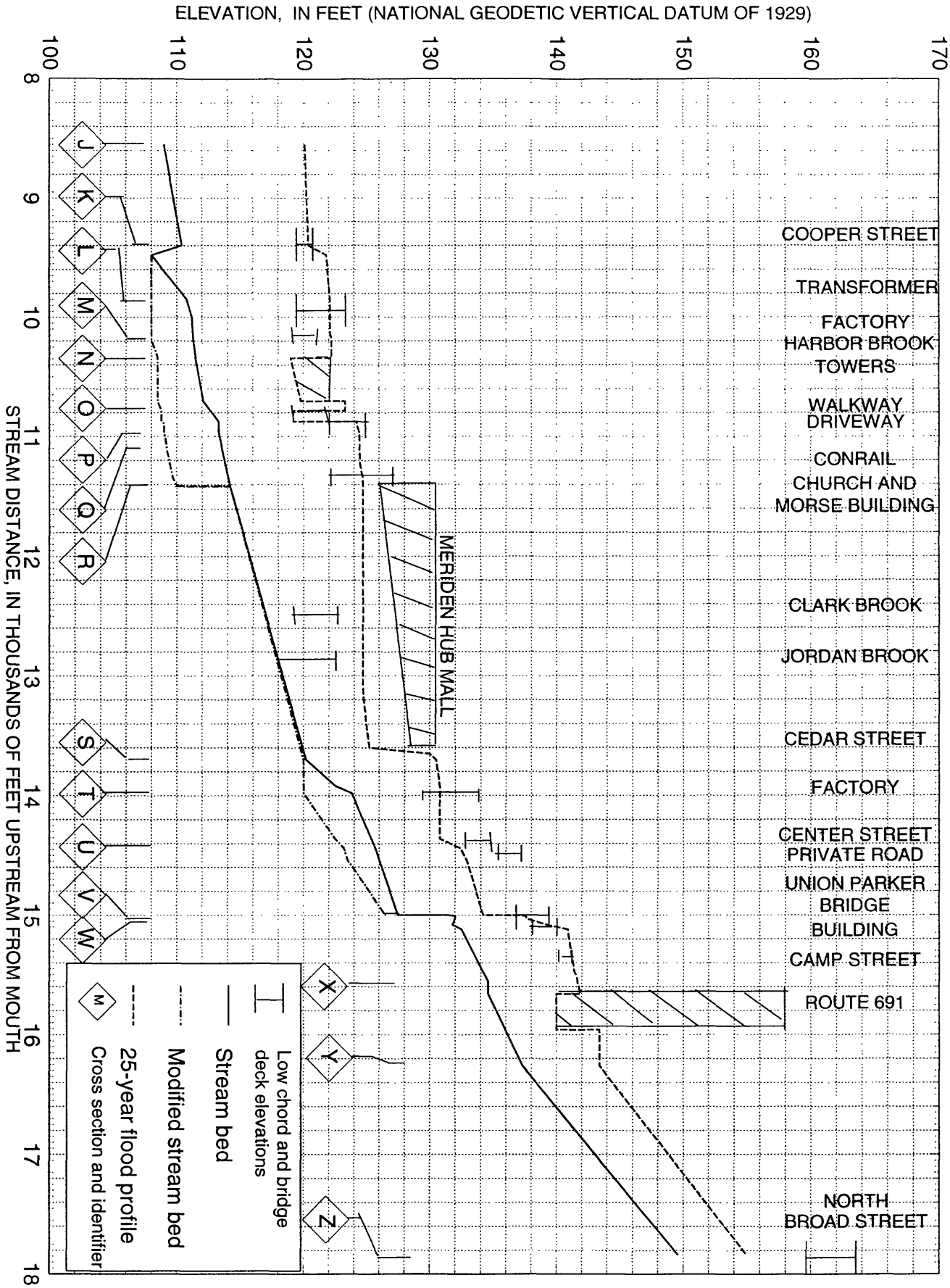

Figure 5. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 25-year flood.—Continued

Modeling 35- and 50-year floods

The 35-year flood, analyzed in this report, is approximately equal to that experienced in Meriden on June 5 to 6, 1992. This flood and the 50-year flood (table 1) were evaluated with the same degree of proposed channel and structural modification. Flood abatement for these frequencies, for the reaches below the Conrail Bridge (distance point 11,245 ft), was achieved principally through proposed modifications to bridge geometry. The following modifications are in addition to those given in the previous section.

Downstream from Harbor Brook Towers

The Cook Avenue bridge was analyzed with the following proposed modifications. The bottom beam elevation was raised to 118 ft NGVD, and the width of the opening was increased to 30 ft. The streambed elevation was left at 107.7 ft NGVD, and the top of the road was raised to 120.5 ft NGVD. Resulting elevations from the model, using these proposed modifications, are shown in table 3, and profiles are shown in figures 6 and 7.

Downstream from Meriden Hub Mall

The walkway upstream from the Harbor Brook Towers culvert is a major impediment to flood flows and significantly increases upstream flood elevations for 35- and 50-year frequency floods. The proposed modification for this section of Harbor Brook is to remove the walkway. Resulting elevations from the model, with walkway removal, are shown in table 3, and profiles are shown in figures 6 and 7.

Modeling 100-year floods

A 100-year flood in the most developed areas along Harbor Brook would be catastrophic to the City of Meriden. For this frequency, modeling was based on extensive proposed channel modifications that would protect vulnerable areas from the 100-year discharge (table 1). A map showing areal extent of flooding for the 100-year flood under present conditions can be found in a recent report for the City of Meriden (Federal Emergency Management Agency, in press).

Downstream from Harbor Brook Towers

Decreasing the 100-year flood elevations downstream from the Harbor Brook Towers culvert (distance point 10,345 ft) would require an additional 1.26 mi of channel modifications from an elevation of 95 ft NGVD at Coe Avenue (distance point 3,410 ft) to 108 ft NGVD at the exit of Harbor Brook Towers culvert. Average channel deepening would be 4 to 5 ft. Resulting elevations are shown in table 4, and profiles are shown in figure 8.

Upstream From Cedar Street

The channel and bridge modifications proposed for the reach of Harbor Brook upstream from Cedar Street would improve all flood elevations up to the 100-year frequency. The proposed modifications include the following: (1) Using side-wall elevations of 135.00 ft NGVD from Cedar Street (distance point 13,700 ft) to Center Street (distance point 14,440 ft), and using side-wall elevations of 138.00 ft NGVD upstream from Center Street to just downstream from the Union Parker bridge (distance point 15,005 ft); (2) deepening the channel between Cedar Street to the base of the dam at the Union Parker bridge by 3 ft; (3) raising the bridge at Center Street by 2 ft to a low chord elevation of 135.00 ft NGVD, with a bed elevation of 123.2 ft NGVD; and (4) armoring the channel to reduce bed friction and erosion from Cedar Street (distance point 13,700 ft) to the approach section for Center Street (distance point 14,440 ft). The resulting elevations for the 100-year flood with the proposed channel modifications are shown in table 6, along with elevations under present conditions. The profile is shown in figure 8.

Table 3. Streambed and water-surface elevations based on proposed channel and structural modifications to contain the 35-year and 50-year frequency floods, Harbor Brook, Meriden, Conn.

[NGVD, National Geodetic Vertical Datum]

Cross section	Distance upstream from mouth, in feet	Elevation, in feet (NGVD) for indicated flood frequency			
		Streambed, 35 year	Streambed, 50 year	Water surface, 35 year	Water surface, 50 year
A	0	81.0	81.0	90.8	90.8
B	2,340	91.1	91.1	96.2	96.3
C	2,540	92.7	92.7	97.4	97.5
D	2,840	94.2	94.2	99.6	99.8
E	3,410	96.0	96.0	101.5	101.6
F	3,730	98.2	98.2	106.1	106.3
G	4,910	104.4	104.4	111.7	112.1
H	6,230	107.0	107.0	117.3	117.6
I	8,125	107.7	107.7	120.0	120.2
J	8,550	109.0	109.0	120.5	120.7
K	9,400	110.4	110.4	120.8	120.9
L	9,900	108.0	108.0	122.6	122.8
M	10,190	108.0	108.0	122.7	122.9
N	10,345	108.0	108.0	122.7	122.9
O	10,705	108.5	108.5	124.3	124.8
P	10,875	108.8	108.8	124.4	125.0
Q	10,965	109.0	109.0	124.8	125.5
R	11,410	110.0	110.0	125.2	126.0
S	13,700	120.0	120.0	131.7	132.5
T	13,980	120.0	120.0	132.0	132.8
U	14,440	123.2	123.2	133.8	134.5
V	15,005	132.0	132.0	139.3	139.7
W	15,030	132.0	132.0	139.3	139.7
X	15,660	134.6	134.6	142.4	142.5
Y	16,260	137.3	137.3	144.2	144.5
Z	17,840	149.6	149.6	155.5	155.7

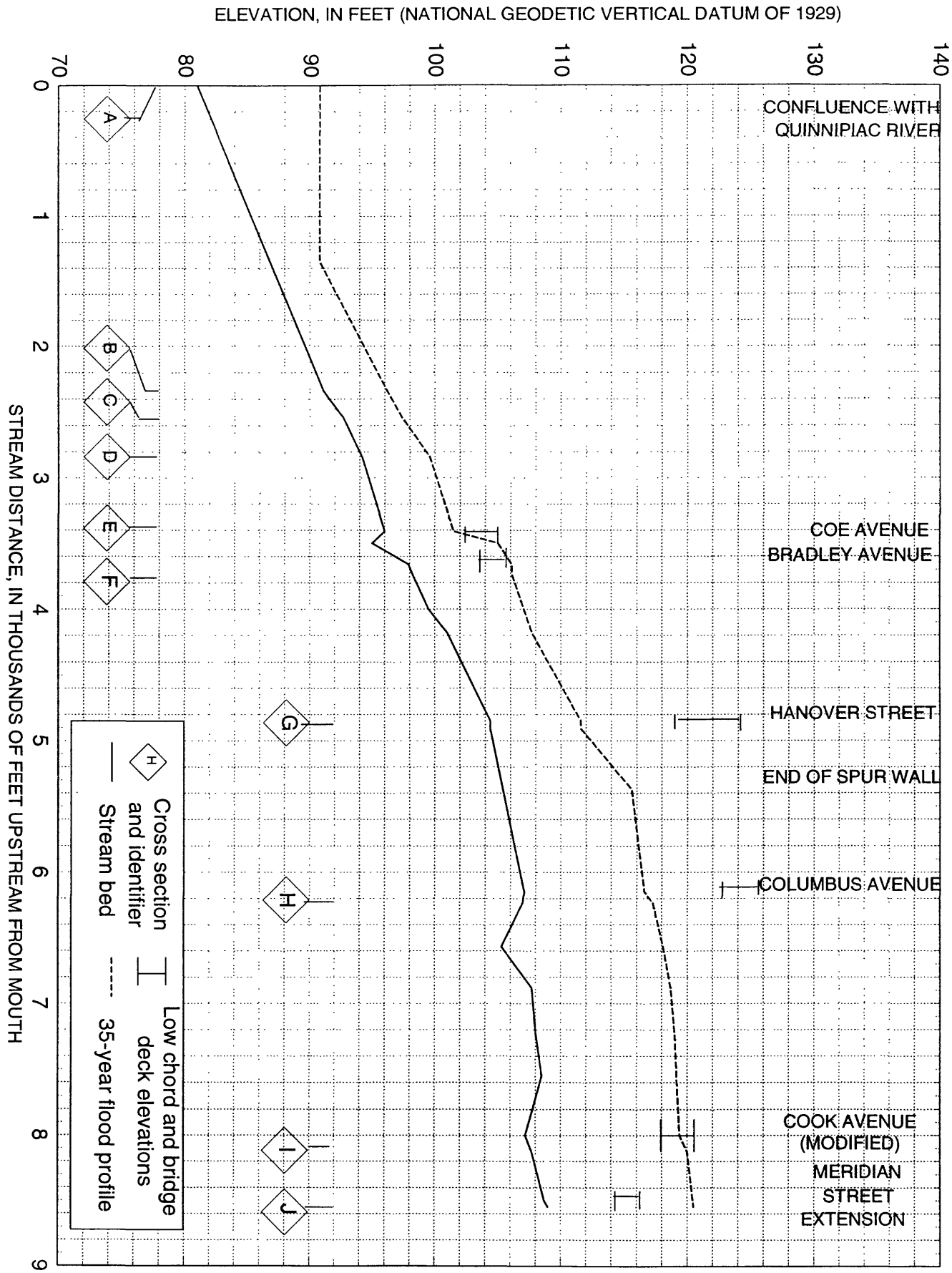

Figure 6. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 35-year flood.

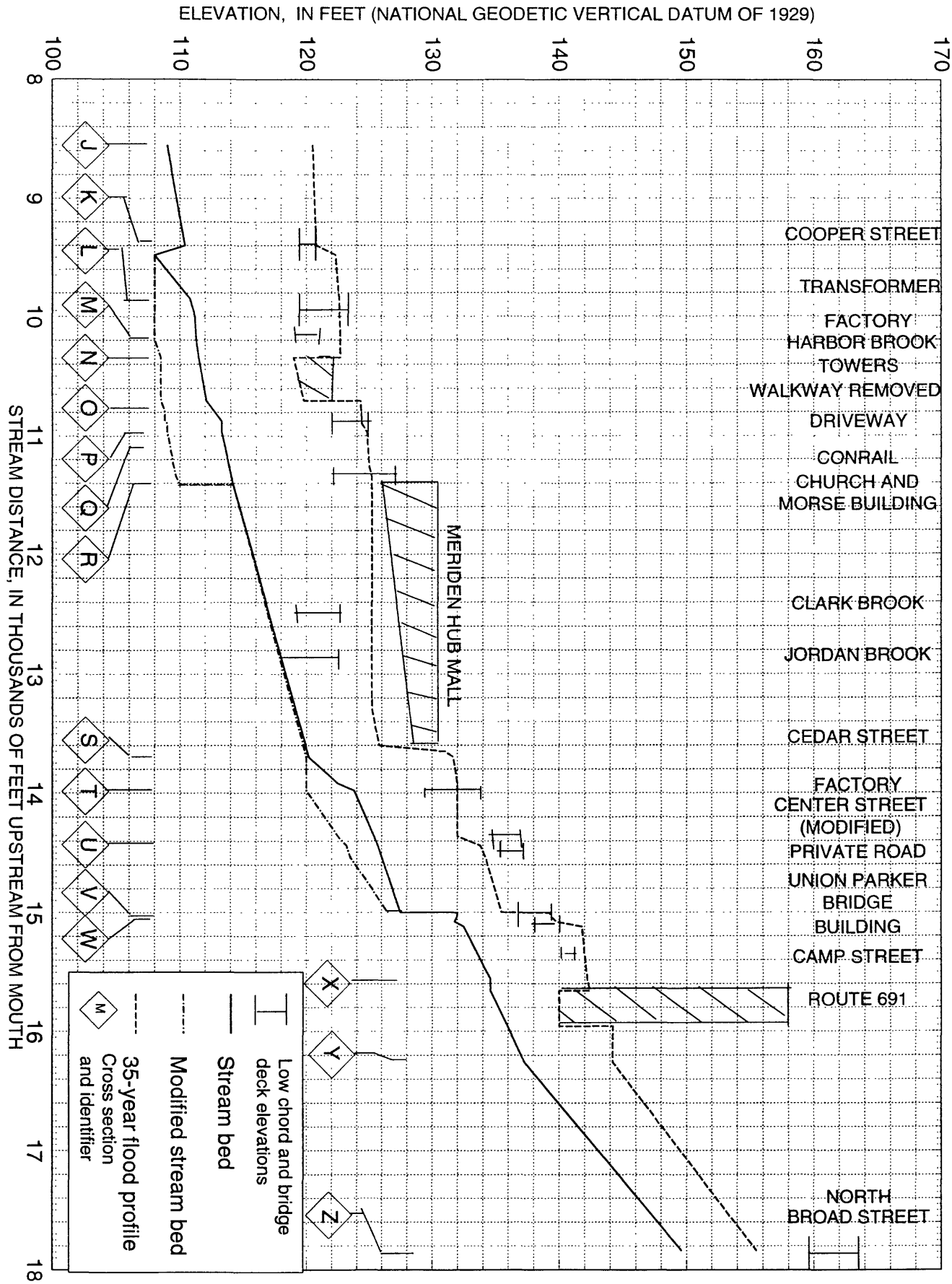

Figure 6. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 35-year flood.—Continued

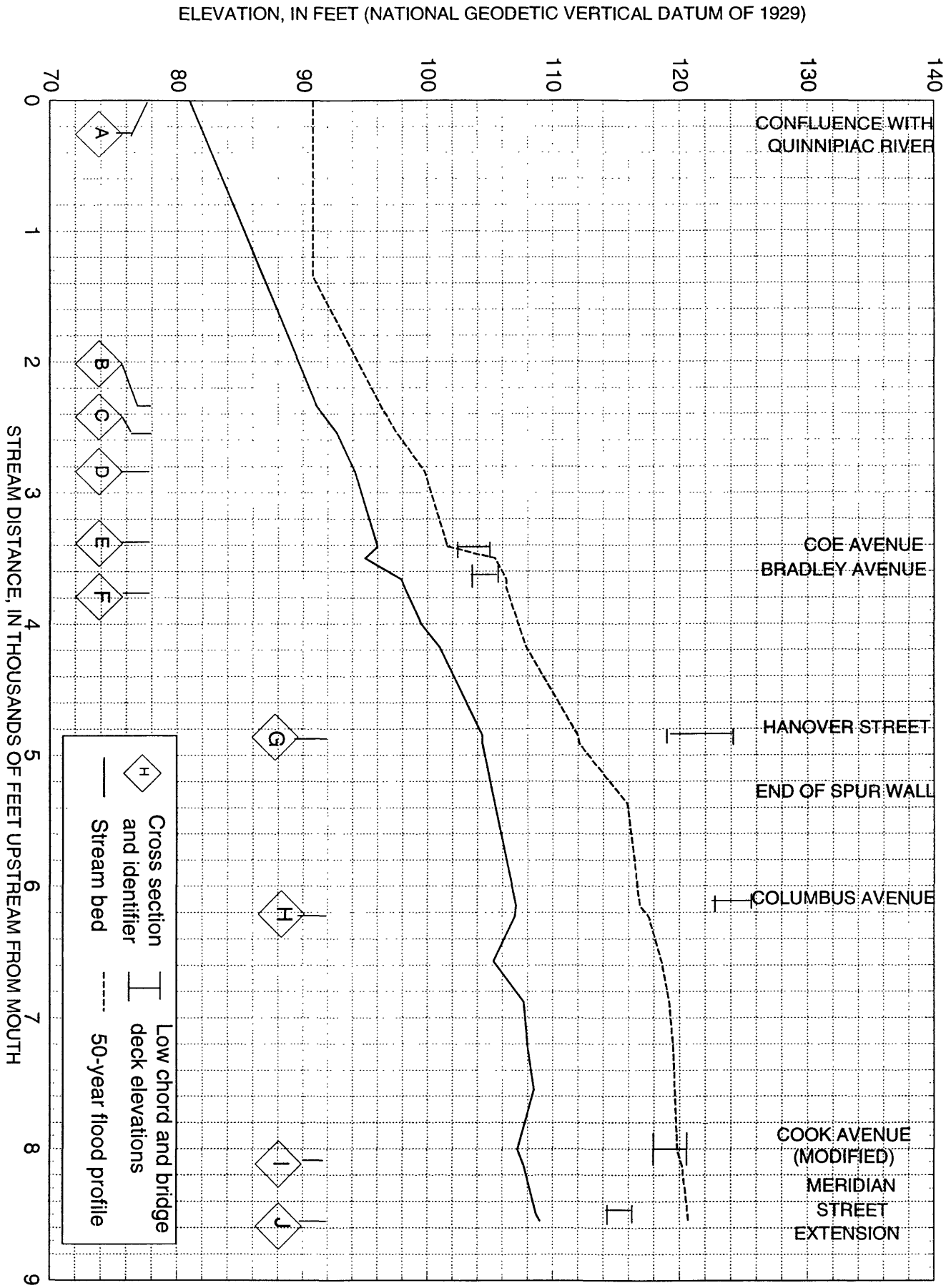

Figure 7. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 50-year flood.

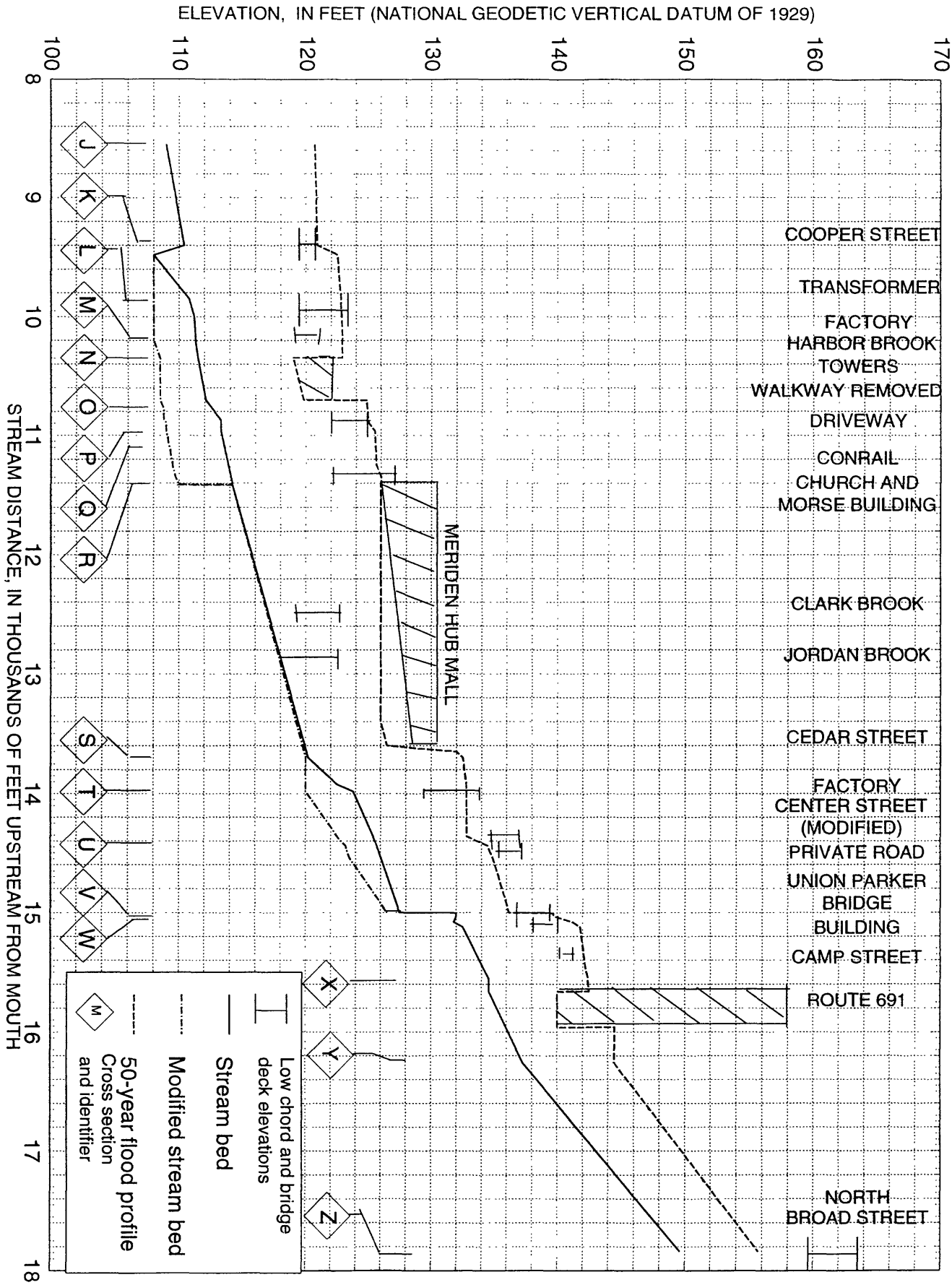

Figure 7. Profile of Harbor Brook at Meriden, Conn., as a result of proposed channel and structural modifications for the 50-year flood.—Continued

Table 4. Streambed and water-surface elevations based on proposed and present channel and structural conditions for the 100-year flood, Harbor Brook, Meriden, Conn.

[NGVD, National Geodetic Vertical Datum; --, not determined]

Cross section	Distance upstream from mouth, in feet	Elevation, in feet (NGVD)			
		Streambed		Water surface	
		Proposed	Present	Proposed	Present
A	0	81.0	81.0	90.8	90.8
B	2,340	91.1	91.1	96.6	96.6
C	2,540	92.7	92.7	97.8	97.8
D	2,840	94.2	94.2	100.3	100.3
E	3,410	96.0	96.0	102.1	102.1
F	3,730	95.4	98.2	106.7	106.7
G	4,910	98.1	104.4	108.6	113.1
H	6,230	101.0	107.0	112.3	119.0
I	8,125	104.3	107.7	116.7	121.3
J	8,550	105.2	109.0	118.1	121.7
K	9,400	106.5	110.4	119.0	122.0
L	9,900	107.2	110.8	120.0	123.6
M	10,190	107.8	111.4	121.0	123.8
N	10,345	108.0	111.4	121.0	123.6
O	10,705	108.5	112.6	125.0	124.3
P	10,875	108.8	113.4	125.1	124.5
Q	10,965	109.0	113.6	126.0	124.6
R	11,410	110.0	114.3	126.7	127.5
S	13,700	120.0	120.7	133.4	133.7
T	13,980	120.0	123.7	133.8	133.8
U	14,440	123.2	126.2	135.8	138.0
V	15,005	132.0	132.0	140.3	140.3
W	15,030	132.0	132.0	140.3	142.0
X	15,660	134.6	134.6	142.9	143.0
Y	16,260	137.3	137.3	145.4	145.4
Z	17,840	--	149.6	--	156.1
AA	18,940	--	160.0	--	167.2
AB	20,160	--	168.7	--	180.2
AC	21,200	--	190.8	--	198.9
AD	22,280	--	191.5	--	202.7
AE	22,510	--	191.8	--	202.8

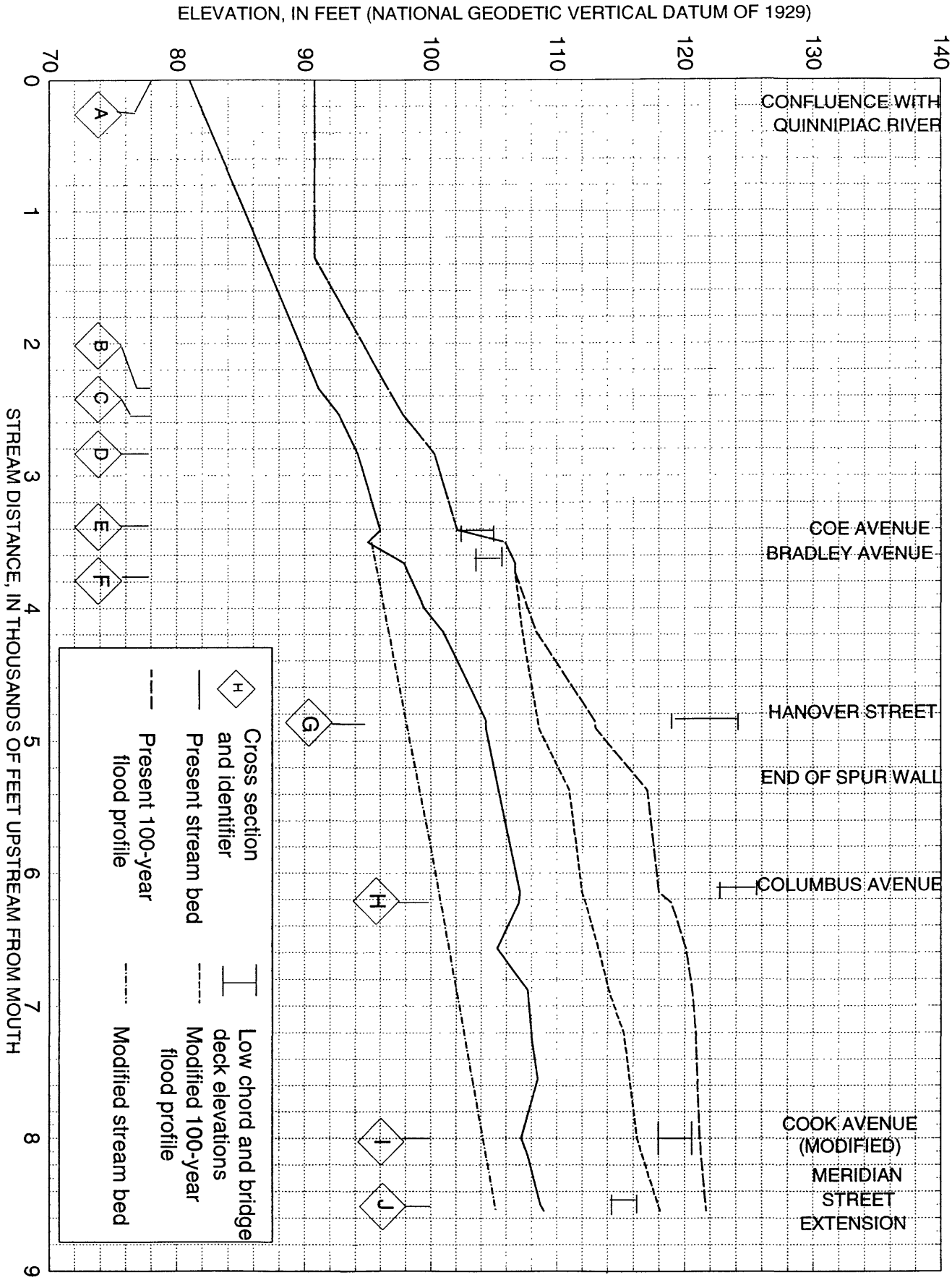

Figure 8. 100-year flood profiles of present and modified channel and structural conditions on Harbor Brook at Meriden, Conn.

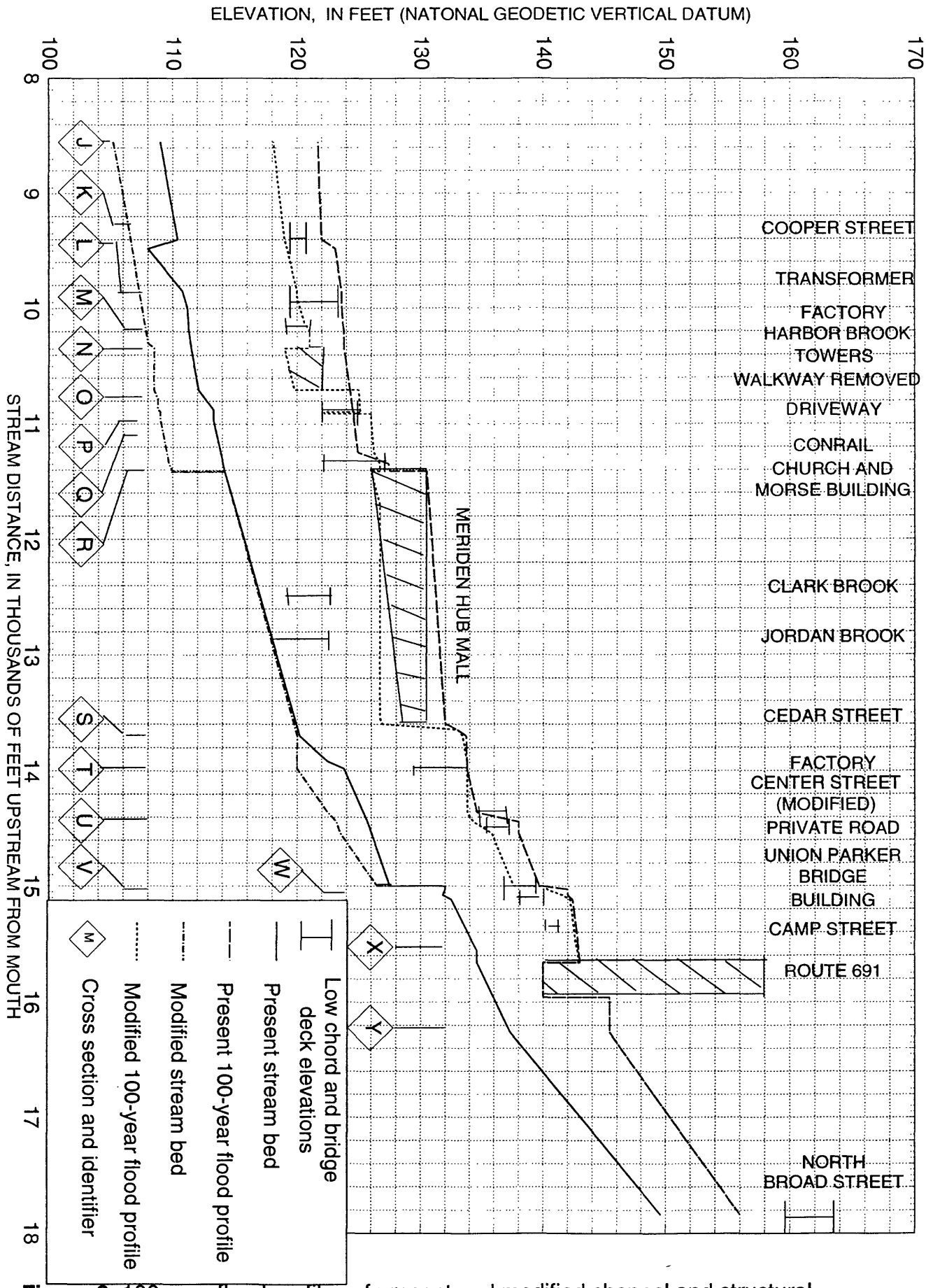

Figure 8. 100-year flood profiles of present and modified channel and structural conditions on Harbor Brook at Meriden, Conn.—Continued

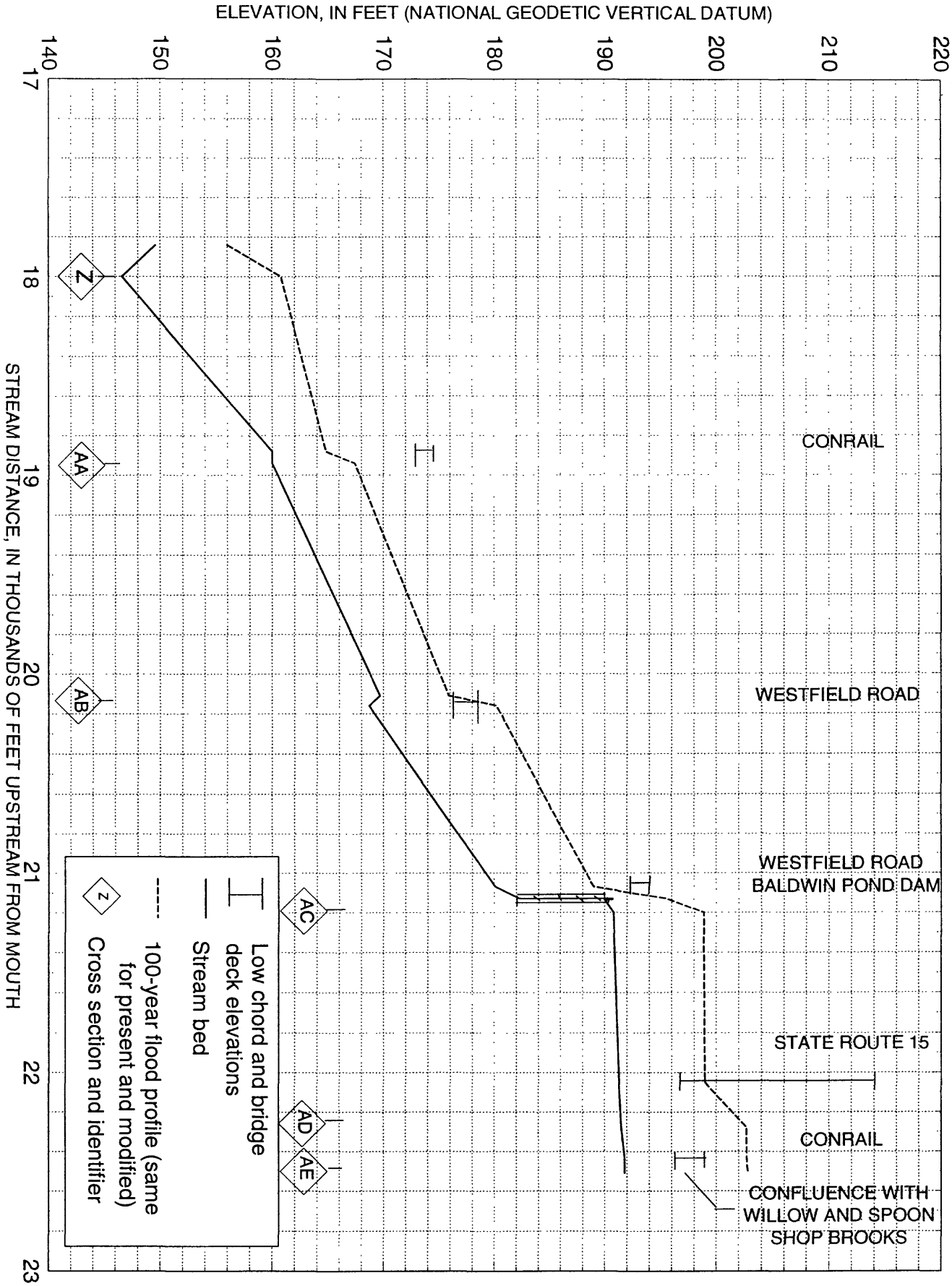

Figure 8. 100-year flood profiles of present and modified channel and structural conditions on Harbor Brook at Meriden, Conn.—Continued

Crow Hollow Brook

Flooding on Crow Hollow Brook, upstream from West Main Street, occurs at flood frequencies higher than the 50-year flood, but in the reach between Johnson Avenue and Coe Avenue, even 10-year floods can flow over the east bank of the stream and onto Centennial Avenue. Distance points for Crow Hollow Brook modifications are measured upstream from the confluence of Crow Hollow Brook with Sodom Brook.

The reach of Crow Hollow Brook between Johnson Avenue and Coe Avenue was modeled for abatement of flood frequencies up to the 100-year flood. Because only minor bank modifications are needed to differentiate between abatement of the 10-year and the 100-year flood elevations, side-wall heights were computed to abate the 100-year flood. The proposed modifications are as follows: (1) Use side walls, at a height of 3.5 ft above existing ground elevation, only on the left bank, from distance point 1,420 ft (elevation 128.5 NGVD) to distance point 1,870 ft (elevation 136.0 NGVD); and (2) use 3 to 5-ft high side walls on both left and right banks from distance point 1,870 ft (elevation 136.0 NGVD) to distance point 2,890 ft (elevation 141.5 NGVD). The resulting elevations for the proposed modifications and the present conditions, for the 100-year flood, are shown in table 5. The flood profiles are shown in figure 9.

Table 5. Water-surface elevations for the 100-year flood based on proposed and present channel and structural conditions, Crow Hollow Brook, Meriden, Conn.

[NGVD, National Geodetic Vertical Datum]

Cross section	Distance upstream from mouth (feet)	Elevation, in feet (NGVD)	
		Proposed[1]	Present
A	1,420	127.6	127.6
B	1,860	133.6	131.8
C	2,890	139.7	139.5
D	3,870	170.6	170.6
E	4,485	185.0	185.0
F	4,710	189.4	189.4
G	4,790	192.6	192.6

[1] "Proposed" assumes the addition of walls, which would increase elevations but contain flood water within the channel.

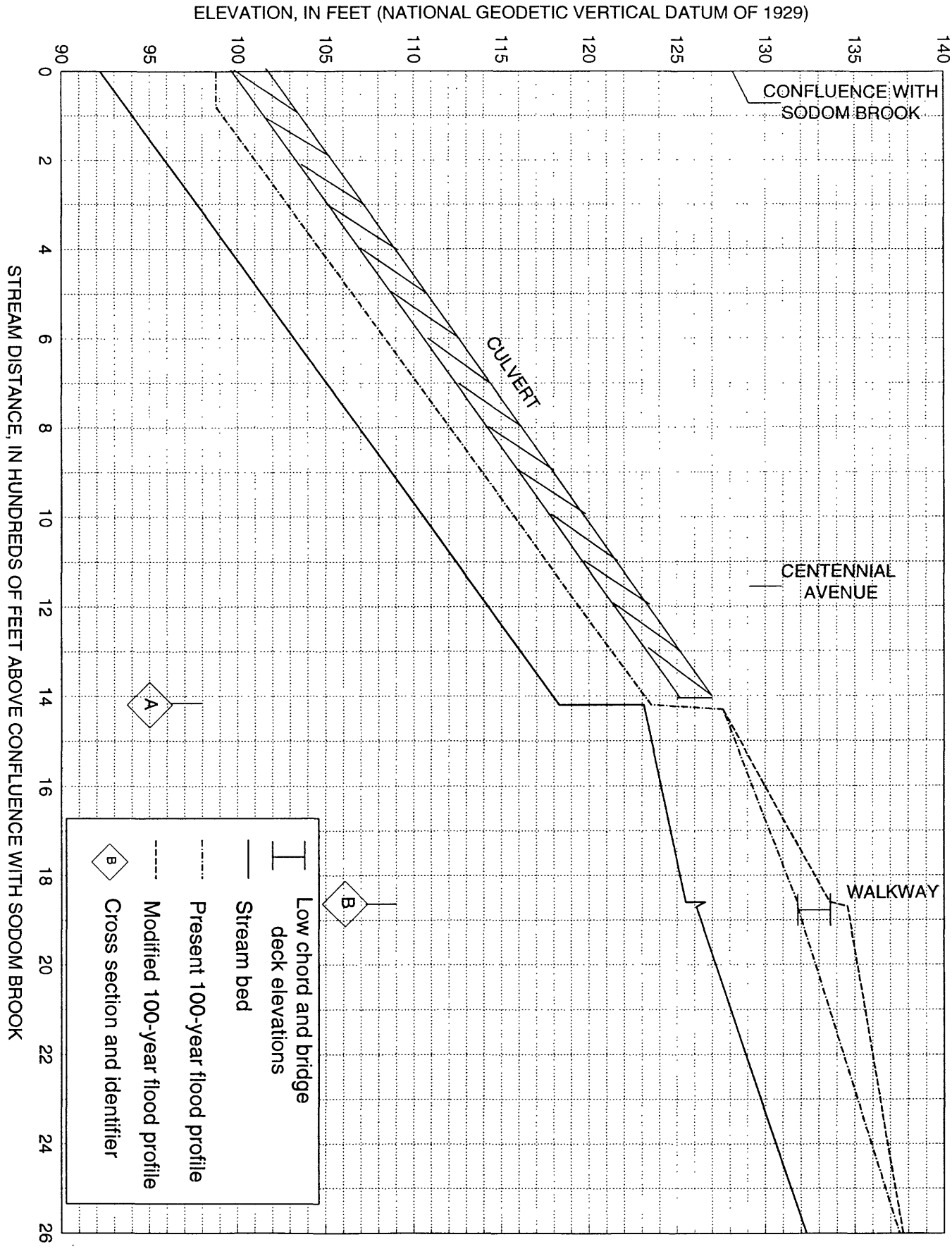

Figure 9. 100-year flood profiles of present and modified channel and structural conditions on Crow Hollow Brook at Meriden, Conn.

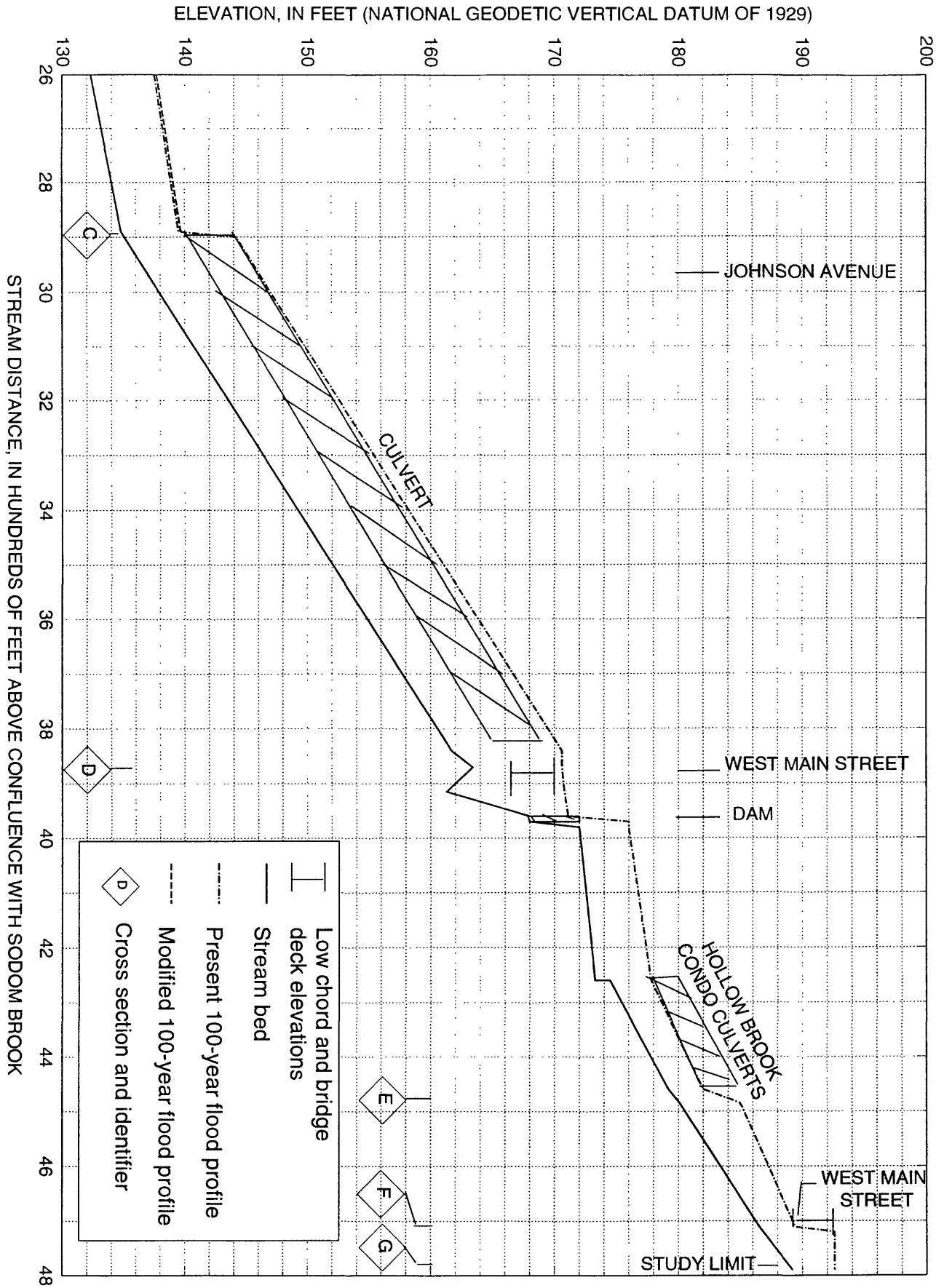

Figure 9. 100-year flood profiles of present and modified channel and structural conditions on Crow Hollow Brook at Meriden, Conn.—Continued

SUMMARY

In a flood-profile-modeling study conducted in Meriden, Conn., the effects of proposed channel and structural modifications to reaches of Harbor Brook and Crow Hollow Brook were analyzed. Modifications that were derived jointly by the USGS and the City of Meriden were incorporated into the model and were developed without consideration of cost-benefit ratios. Modifications were made to bank heights (adding or increasing the height of side walls and rail crossings), channel geometry (deepening the channel), structural geometry (raising or removing bridges or other structures), and streambed armoring. Analyses were done for the 10-, 25-, 35-, 50-, and 100-year floods on Harbor Brook and the 100-year flood on Crow Hollow Brook.

Harbor Brook was subdivided into three reaches—Coe Avenue to Harbor Brook Towers, Harbor Brook Towers to the Meriden Hub Mall, and Cedar Street to Interstate 691. The reaches downstream from Harbor Brook Towers and downstream from the Meriden Hub Mall had three levels of proposed flood-elevation modifications. The first level, to contain the 10- and 25-year floods, required walls, channel deepening, and armoring. The second level, to contain the 35- and 50-year flood, required bridge geometry modifications to the Cook Street bridge and removal of the walkway at the Harbor Brook Towers. The third level, to contain the 100-year flood, required extensive channel deepening between Coe Avenue and the Harbor Brook Towers. The reach upstream from Cedar Street required only one analysis because the same proposed modifications were used for all frequencies analyzed. Because of the proposed modifications, the flood level at the Meriden Hub Mall culvert exit was reduced, and the new flood elevations at Cedar Street were governed by the culvert's improved ability to convey the flow.

Crow Hollow Brook was analyzed for modifications to abate the 100-year flood in the reach downstream from West Main Street. Side walls were used to contain this flow.

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