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FLOODING ANALYSIS OF THE UPPER STILL RIVER DANBURY, CONNECTICUT

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The purpose of this study was to conduct a hydrologic and hydraulic flood analysis of the upper Still River located in Danbury, Connecticut The results of this report can be used by the community to gain a better understanding of flooding along the upper Still River and possible options for flood control. The Corps of Engineers conducted this study at the request of the City of Danbury, under authority of the Flood Plain Management Services (FPMS) program. This study determined that either raising the finished first floors of existing buildings or construction of a dike/floodwall along the banks of Lake Kenosia to be potential flood reduction options that could reduce flood damages within the Jensen property. However, removing constrictions at the Mill Plain Swamp (Route 7/Segar Street) or the Kenosia Avenue bridge to allow flow downstream is not considered a viable option due to its potential to increase flooding of downstream areas

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FLOODING ANALYSIS OF THE UPPER STILL RIVER DANBURY, CT

BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT, CORPS OF ENGINEERS
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FLOODING ANALYSIS OF THE UPPER STILL RIVER
DANBURY, CT

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FLOODING ANALYSIS OF THE UPPER STILL RIVER DANBURY, CONNECTICUT

I. PURPOSE AND SCOPE

The purpose of this study was to conduct a hydrologic and hydraulic flood analysis of the upper Still River located in Danbury, Connecticut (see Plate 1). The results of this report can be used by the community to gain a better understanding of flooding along the upper Still River and possible options for flood control. The Corps of Engineers (COE) conducted this study at the request of the City of Danbury, under authority of the Flood Plain Management Services (FPMS) Program. Included in this report are sections describing the watershed, climatology, flood history, hydrologic and hydraulic analysis, and study results. Plate 2 presents the location of the upper Still River watershed analyzed in this study.

II. DESCRIPTION OF WATERSHED

The Still River, a principle tributary to the Housatonic River, is located in southwestern Connecticut. The Still River headwaters lie approximately 3-miles west of Danbury where it has its source in Lake Kenosia. From this source, the river, known as the upper Still River, travels eastward through the Mill Plain Swamp toward the City of Danbury.

Lake Kenosia is located in the north-central portion of the study area and is bounded by the Jensen mobile home park to the north, Mill Plain Swamp to the east, and hilly, lightly developed property to the south and west. The lake has a surface area of 65-acres, a maximum depth of 15-feet, a mean depth of 11.6-feet, and a volume of 643-acre-feet. The Lake Kenosia watershed is approximately 5.1-square miles (sq. mi.) and is sparsely developed with wooded, mountainous terrain and discharges to the Mill Plain Swamp at Kenosia Avenue. The lake is primarily used for recreation, offering swimming, boating and fishing.

The Mill Plain Swamp is a 200-acre wetland bounded by Interstate-84 to the north, Danbury Shopping Mall to the east and southeast, Danbury Airport to the south and Lake Kenosia to the west. The swamp is fed from Lake Kenosia and an 8.6-sq. mi. watershed that discharges directly to the swamp. The upper Still River meanders through the swamp for approximately 3.2-miles where it discharges from the swamp at Route-7/Segar Street/River Mile (RM) 8.2. The entire swamp, and some distance beyond, is located in the 100-yr flood plain as delineated by the Federal Emergency Management Agency (FEMA) National Flood Insurance Program.

III. CLIMATOLOGY

Danbury has a variable climate that experiences conflicts between cold dry air masses flowing out of the great subpolar region to the northwest and the warmer

moisture-bearing tropical air from the south. Historically, most major storms have occurred as a result of hurricanes and tropical storms that hit the coast. In the winter, Danbury typically escapes the severity of cold and depth of snowfall that occur in the northern portions of the Housatonic River Basin due to its proximity to the Atlantic Ocean. The mean annual temperature is approximately 49-degrees Fahrenheit (°F). Temperatures range from an average 26.6 °F in January to an average 71.3 °F in July. The average yearly rainfall is approximately 46-inches while the average annual snowfall over the area is 40-inches.

IV. FLOOD HISTORY

A. General. Though floods can occur any season of the year, historically, most high frequency storms have occurred as a result of hurricanes and tropical storms that hit the Connecticut coast. Major flooding occurred along the upper Still River as a result of storm events in the 1930s, 1950s and most recently, tropical storm Floyd in September 1999.

B. September 1999. Total rainfall amounts resulting from the September 16, 1999 storm event were recorded between 7 and 11 inches for western Connecticut. A site visit was made on June 1, 2000 where local residents and city officials estimated the high water marks produced during this storm event at the Jensen mobile home park, Kenosia Avenue and the Danbury shopping mall.

No organized streamflow data were documented for the upper Still River during this storm event. The tropical storm Floyd rainfall data utilized in this study was provided by NOAA and totaled 9.66-inches of rain over a 24-hour period, see table below.

Table 1
September 16, 1999 Storm Event (Tropical Storm Floyd)
Hourly Rainfall Recorded at Brookfield, Ct. Middle School

Time (hrs)	Rainfall (inches)	Time (hrs)	Rainfall (inches)
00:00	0.00	13:00	0.33
01:00	0.02	14:00	0.58
02:00	0.00	15:00	0.62
03:00	0.05	16:00	0.43
04:00	0.04	17:00	0.71
05:00	0.05	18:00	1.07
07:00	0.08	19:00	1.50
08:00	0.11	20:00	1.14
09:00	0.27	21:00	1.03
10:00	0.31	22:00	0.41
11:00	0.34	23:00	0.04
12:00	0.52	24:00	0.01

V. HYDROLOGIC ANALYSIS

A. General. There are no streamflow records available for the upper Still River; therefore, three indices were used for hydrologic evaluation of the 13.1-sq. mi. drainage area. The first indice included an analysis of the September 1999 storm event (tropical storm Floyd) rainfall data and high water marks, which were then used to calibrate the COE hydrologic (HEC-HMS) and hydraulic (HEC-RAS) models. The second indice included the drainage-area-ratio method of a characteristically similar watershed with USGS gage data to estimate the flood flow regime. The third indice referenced the 1982 Flood Insurance Study (FIS) for the City of Danbury, Connecticut and the COE Still River Local Protection Project (LPP).

B. HEC-HMS. The COE Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) model was used to simulate reservoir storage routings and the rainfall-runoff process. The upper Still River watershed contains a total of 13.1 sq. mi. of drainage area and outlets at the Mill Plain Swamp at Route-7/Segar Street/RM 8.2. The upper Still River watershed was sub-divided into 4 sub-basins. See Plate 2 for the sub-drainage locations and Plate 3 for the watershed schematic. Soil Conservation Service (SCS) dimensionless unit hydrographs based on the time of concentration were used to represent runoff regimes for each sub-basin. Loss rates were based on SCS curve numbers (CN) that represent land use in each sub-basin. The lag time, a weighted time of concentration dependent upon physical properties of the watershed, was calculated for each sub-basin using the SCS lag time equation. A tabulation of SCS curve numbers, loss rates, lag time, area, and the base flow rates are given in Table 2.

The SCS hydrologic characteristics determined in this study represent the land use in each sub-basin at the time of this study. Sub-basin 1 is located in the north portion of the study area, includes 5.1 sq. mi., is sparsely developed with wooded, mountainous terrain and discharges to Lake Kenosia near the Jensen mobile home park. Sub-basin 2 is located on the east-side of the study area, includes 6.2 sq. mi., and is also sparsely developed with wooded, mountainous terrain and discharges to the Mill Plain Swamp at the Danbury Municipal Airport. Sub-basin 3 is located in the east-central portion of the study area and primarily encompasses the Danbury Municipal Airport, includes 1.65 sq. mi., and drains to the Mill Plain Swamp. Sub-basin 4 is located in the south portion of the study area and primarily encompasses the Danbury shopping mall, includes 0.13 sq. mi., and also drains to the Mill Plain Swamp. See Plate 2 for the sub-basin location map.

The outflow from sub-basins 1, 2, 3 and 4 and the upper Still River water surface profile is influenced by Lake Kenosia and the Mill Plain Swamp; therefore, the HEC-HMS model was used to simulate reservoir storage routings and calculate overland stormwater run-off. Storage routings are based on the continuity equation (inflow = outflow + change in storage). Input for the model consisted of storage characteristics for Lake Kenosia and the Mill Plain Swamp, inflow hydrographs, and the Kenosia Avenue bridge discharge characteristics.

Area-capacity relationships were determined for Lake Kenosia and Mill Plain Swamp surface areas as provided in the *Environmental Review Team Report – Kenosia Aquifer Watershed* prepared by King's Mark Resource Conservation and Development Area and 2-foot contour interval topographic maps provided by the City of Danbury.

The elevation-outflow relationships for the storage areas were calculated using the HEC-RAS model since water surface elevations (WSE) at the Kenosia Avenue bridge are impacted by downstream backwater from the Mill Plain Swamp. Random flow rates were input into the HEC-RAS model, which was developed from 2-foot contour mapping and expected bridge and channel characteristics, to determine the corresponding upstream WSE associated with assumed flow rates. These computed elevation-outflow relationships were then input into the HEC-HMS model, together with associated storage relationships. This provided elevation and flow characteristic information necessary to calibrate the HEC-HMS and HEC-RAS models. Refer to Section VI for discussion of the HEC-RAS model. See Tables 3 and 4 for the adopted elevation-storage-outflow relationships used for these areas.

The September 1999 flood hydrographs were computed based on the above hydrologic characteristics and the rainfall data shown in Table 1. Hydrographs were then routed through Lake Kenosia and Mill Plain Swamp to calibrate the HEC-HMS model. The calculated September 1999 peak outflow rates at Lake Kenosia (RM 10.58) and Mill Plain Swamp (RM 8.2) were 2038 cfs and 3792 cfs, respectively, which estimates a return frequency of approximately 300 years.

After the HEC-HMS model was calibrated, 10-, 50-, and 100-yr storm events were computed and routed through the upper Still River watershed. The rainfall data used to calculate these storm events was provided by the U.S. Weather Bureau Technical Paper No. 40 (TP-40) and shown in Table 5. The results of these simulated storm events are presented in Table 6. See Appendix A for the HEC-HMS summary of calculated flow rates for various storm events.

C. Streamflow. There are no streamflow records available for the upper Still River. The USGS gage on the Burlington Brook, #01188000, near Burlington, Connecticut has continuous streamflow data beginning in water year 1932 to 1996, a drainage area of 4.1-sq. mi., and an average slope of 77-feet per mile. The analysis of the Burlington Brook gage flow records was used to develop estimated flow characteristics of the upper Still River and to calibrate the HEC-HMS model. The drainage area ratio method was used to estimate the flow regime of sub-basin 1 and sub-basin 2.

Peak discharge frequencies were determined for the USGS gage data using the COE Hydrologic Engineering Center - Flood Frequency Analysis (HEC-FFA) computer program. The data was analyzed in a log Pearson Type III distribution and resulted in a mean log of 2.43, a standard deviation of 0.29, a regional skew of 1.0, a computed skew of –0.18 and an adopted skew of 0.10. The streamflow analysis results (as transposed to subbasin 1 and subbasin 2) are presented in Table 7.

D. 1982 Flood Insurance Study (FIS). The 1982 Danbury FIS was prepared by Anderson-Nicoles & Co., Inc., for the Federal Emergency Management Agency (FEMA). The main stem Still River FIS analysis was based on an application of data developed for the COE Danbury Still River Local Protection Project (LPP) released in 1968. The LPP determined the frequency of flooding along the Still River from recorded gage data at Lanesville, Connecticut and developed discharge-frequency curves at both Lanesville and Triangle Street in Danbury.

The upstream limit of the FIS detailed analysis of the Still River is at the confluence of Mill Plain Swamp with Route-7/Segar Street/RM 8.2. Remaining upstream portions of the Still River, referred to as the upper Still River, were evaluated using approximate methods. Table 8 presents a comparison of flow rates established by the FIS and the HEC-HMS model at Route-7/Segar Street/RM 8.2. As can be seen, there is close agreement between the published FEMA FIS and the HEC-HMS model 10-yr and 50-yr flow rates. However, the HEC-HMS 100-yr flow rate is approximately 80 percent of the FEMA 100-yr flow rate, which, is also considered reasonable given the extreme magnitude of this event.

Table 2
Sub-Basin Hydrologic Characteristics

Sub-Drainage Area	Watershed Area Sq.Mi (Ac.)	Curve No. (CN)	Lag Time (Min.)	Baseflow (cfs)	% Impervious
1– Upper D.A.	5.1 (3264)	72	250	10	5
2- Lower D.A.	6.2 (3968)	72	240	10	5
3–Airport/Swamp	1.65 (1056)	45	40	10	5
4-Danbury Mall	0.13(83)	95	15	10	98

Table 3
Lake Kenosia
Stage-Storage Properties

Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
448.0	0	0
449.9	117	200
451.3	193	400
451.8	241	600
452.1	260	1000
454.1	390	2000
457.5	611	6000
458.2	656	8000

Table 4
Mill Plain Swamp
Stage-Storage Properties

Elevation (Ft. NGVD)	Storage (Ac-Ft)	Outflow (cfs)
447.0	0	0
447.1	50	100
447.2	100	200
448.0	150	400
449.5	375	600
452.0	750	1000
454.0	1050	2000
457.3	1574	6000
458.0	1650	8000

Table 5
Technical Paper No. 40 Data
(Rainfall Depth in inches)

Time (hrs)	2yr/ 12hr	5yr/ 12hr	10yr/ 12hr	25yr/ 12hr	50yr/ 12hr	100yr/ 12hr
1	1.3	1.7	2.0	2.3	2.5	2.8
2	1.6	2.1	2.5	2.8	3.3	3.5
3	1.8	2.3	2.8	3.3	3.5	4.0
6	2.3	3.0	3.4	4.0	4.7	5.0
12	3.3	3.6	4.2	4.8	5.7	6.0

Table 6
HEC-HMS Peak Discharge (cfs) Results
Upper Still River Watershed

Sub-Drainage Area	Area Sq.Mi. (Acre)	10yr/24 hr (cfs)	50yr/24hr (cfs)	100yr/ 24hr (cfs)
1	5.1 (3264)	870	1406	1640
Kenosia Lake	5.1 (3264)	546	1183	1365
2	6.2 (3968)	1087	1757	2051
3 – Airport	1.65 (1056)	163	450	532
4 - Danbury Mall	0.13 (83)	164	208	228
Mill Plain Swamp	13.1 (8384)	775	1686	1934

*Note: See Plate 3 for Watershed Schematic

Table 7
Streamflow vs. HEC-HMS
Peak Discharge Frequency Analysis
Sub-basin 1 and Sub-basin 2

Storm Event	Sub-basin 1		Sub-basin 2	
	Burlington Bk. Streamflow (cfs)	HEC-HMS (cfs)	Burlington Bk. Streamflow (cfs)	HEC-HMS (cfs)
10-yr/24-hr	757	870	975	1087
50-yr/24-hr	1282	1406	1650	1757
100-yr/24-hr	1515	1640	1951	2051

Table 8
1982 Flood Insurance Study (F.I.S.) vs. HEC-HMS
Peak Discharge Frequency Analysis
Mill Plain Swamp Outlet (Route-7/Segar Street/River Mile 8.2)

Storm Event	Peak Discharge Frequency (cfs)	
	Flood Insurance Study (F.I.S.) (cfs)	HEC-HMS (cfs)
10-yr/24-hr	780	775
50-yr/24-hr	1700	1686
100-yr/24-hr	2400	1934

VI. HYDRAULIC ANALYSIS

A. General. A hydraulic backwater analysis was performed along the upper Still River to determine peak water surface elevations throughout the Lake Kenosia and Mill Plain Swamp sub-basins. The COE Hydrologic Engineering Center – River Analysis System (HEC-RAS) model was used to simulate flood levels during various storm events. This model calculates the WSE along a river channel using the standard step method. The results and effects of backwater along the channel are a function of several parameters used in the HEC-RAS program including flow rate, channel cross-section data, initial downstream WSE, and channel and overbank roughness factors.

B. HEC-RAS. The HEC-RAS backwater analysis of the upper Still River started approximately 500-feet upstream from the confluence of the upper Still River with the

main stem Still River at Route-7/Segar Street/RM 8.2. Approximately 15 cross-sections and 1 bridge were input into the model along the 3.2-mile channel length. Two-foot contour mapping provided the cross-section information and the bridge characteristics were provided by the Kenosia Avenue bridge inspection report conducted by the State of Connecticut – Department of Transportation. See Plate 4 for location of cross sections.

The computed September 1999 storm event flow rate was used to calibrate the hydraulics based on the estimated high water marks provided by local residents and city officials along Mill Plain Swamp and Lake Kenosia. The 1982 FIS was used as a guide in determining the expected downstream (Route-7/Segar Street/RM 8.2) WSE for various storm events, including the September 1999 event. This study determined a starting downstream (Route-7/Segar Street/RM 8.2) WSE of 456.0-feet NGVD for the September 1999 storm event. The model was run iteratively, adjusting the model parameters until the WSE along the channel depicted the expected elevations achieved during the September 1999 storm event. Approximate high water mark locations provided by City officials and local residents was used as a guide in calibrating the HEC-RAS WSE for the September 1999 flood event. Manning's 'n' value of the overbank areas was 0.1 and ranged between 0.05 to 0.10 in the channel.

Once the model was developed, the adopted flow rates were used to calculate the WSE along the upper Still River between R.M. 8.27 and R.M. 11.47. The starting downstream (Route-7/Segar Street/RM 8.2) WSE as provided by the 1982 FIS were 450.2, 454.0, and 454.5-feet NGVD for 10-yr, 50-yr, 100-yr storm events, respectively. A sensitivity analysis was conducted to determine any effects the starting downstream WSE may have on upstream water surface profiles along the upper Still River. See Section VII.D. for discussion of the sensitivity analysis.

VII. STUDY RESULTS

A. General. The steep topography associated with the upper Still River watershed generates high flow rates for high frequency storm events. The flow rates calculated by the model provide guidance as to the channel and bridge characteristics necessary to identify options for flood control improvements.

The flow rates generated by the HEC-HMS model were analyzed for each sub-basin. Sub-basin 1 and sub-basin 2 flow rates ranged from a peak 10-yr discharge of 870 cfs and 1087 cfs, respectively, to a peak 100-yr discharge of 1640 cfs and 2051 cfs, respectively. However, due to Lake Kenosia and Mill Plain Swamp attenuation, the flow rates discharging from the 13.1 sq. mi. watershed at the upper Still River outlet (Route-7/Segar Street/RM 8.2), ranged from a peak 10-yr discharge of 775 cfs to a peak 100-yr discharge of 1934 cfs.

Plate 5 presents the 100-yr/24-hr flood hydrograph developed for the upper Still River watershed. As can be seen, the time-to-peak flow rate for sub-basin 1 and sub-basin 2 are synchronized, and therefore, in combination contribute heavily to flooding along the upper Still River.

As computed by the HEC-HMS model, sub-basin 3 and sub-basin 4 had maximum releases of 163 cfs and 164 cfs, respectively, during a 10-yr storm event and 533 cfs and 228 cfs, respectively, during a 100-yr storm event. As presented in Plate 5, sub-basin 3 and sub-basin 4 peak prior to sub-basin 1 and sub-basin 2 and contribute minimal flow to the upper Still River; therefore, sub-basin 3 and sub-basin 4 are not major contributors to flooding along the upper Still River.

The calibrated HEC-RAS model was used to conduct a backwater analysis along the upper Still River. Water surface profiles were generated based on starting downstream WSE provided by the 1982 FIS. Plate 6 presents the water surface profiles for 10-yr, 50-yr, 100-yr and September 1999 storm events. As can be seen, the high downstream WSE at Route-7/Segar Street/RM 8.2 is constricted causing backwater along the Mill Plain Swamp to the Kenosia Avenue bridge tailwater during storm events greater than 10-yr.

Mill Plain Swamp appears to be storing runoff from sub-basins 2, 3 and 4, as is expected, since it is a natural flood plain. The 100-yr flood is contained in the flood plain surrounding the Danbury shopping mall; however, the amount of attenuation (storage) provided by the swamp has reduced over time as commercial development has encroached upon the natural flood plain.

The Lake Kenosia outflow is restricted by Kenosia Avenue, which should act as a weir, allowing overflow from Lake Kenosia to the Mill Plain Swamp. Kenosia Avenue has a crest elevation of approximately 450.6 feet NGVD, which is exceeded during storm events of 10-yr and greater. However, due to backwater flooding along the Mill Plain Swamp, the swamp and Lake Kenosia function as one large flood plain during high frequency storm events, resulting in backwater flooding along Lake Kenosia and the Jensen mobile home park (RM 11.0).

A rating curve developed for the Kenosia Avenue bridge, with backwater effects, is presented on Plate 7. As can be seen, the Kenosia Avenue bridge tailwater-headwater difference is minimal during high frequency storm events, due to backwater within Mill Plain Swamp. Flood water elevations exceed (overtop) the Kenosia Avenue bridge during storm events of 10-yr and greater, resulting in backwater flooding along Lake Kenosia and the Jensen mobile home park (RM 11.0).

The rating curve was combined with the adopted flow rates to establish the stage-frequency relationship at the Jensen mobile home park (RM 11.0), shown on Plate 8. As can be seen, the WSE at the Jensen mobile home park (RM 11.0) will be approximately 451.9, 454.1, 454.6 and 456.2 feet NGVD for the 10-yr, 50-yr, 100-yr, and September 1999 storm events, respectively. The Lake Kenosia channel bank elevation at RM 11.0 is approximately 450.0 feet NGVD and ground elevations within the Jensen mobile home park range roughly between 448.0 and 457.0 feet NGVD.

B. Future Food Reduction Investigations. The flow requirement for Corps involvement in flood reduction improvements is a 10-yr discharge of 800 cfs or a 100-yr discharge of 1800 cfs (as per ER 1165-2-21). This investigation determined sub-basin 1 and sub-basin 2 peak 10-yr discharges to be approximately 870 cfs and 1087 cfs,

respectively. The 10-yr and 100-yr discharges from the Mill Plain Swamp at Route-7/Segar Street/RM 8.2 were determined to be approximately 775 cfs and 1934 cfs, respectively. Therefore the outlets to sub-basin 1, sub-basin 2 and the Mill Plain Swamp qualify for futher flood damage reduction improvements.

This investigation also determined sub-basin 3, sub-basin 4 and Lake Kenosia (RM 10.58) peak 10-yr outflows to be approximately 163 cfs, 164 cfs and 546 cfs, respectively, which does *not* meet the COE flow criteria for future flood reduction investigations.

C. Flood Improvement Options.

1. Flooding (backwater) along the upper Still River primarily effects the Jensen mobile home park (RM 11.0). Raising existing buildings approximately 1-foot above the 100-yr flood elevation, or approximately 455.6-feet NGVD, is considered an option to reduce flood damages during large storm events, as determined in this study.

2. This study also determined construction of a dike/floodwall along the banks of Lake Kenosia to be a potential flood reduction option that could reduce flooding within the Jensen property. A dike/floodwall approximately 5-6-feet high and 1800-feet long, surrounding the Jensen mobile home park may protect against a 100-yr storm event and a dike/floodwall approximately 6-8 feet high and 2200-feet long, may protect against a 200-300 year storm event, similar to Tropical Storm Floyd (September 1999). Such a dike system most likely would require interior drainage facilities, which would be evaluated if further studies are conducted.

3. Removing constrictions at the Mill Plain Swamp outlet (Route-7/Segar Street/RM 8.2) or Kenosia Avenue bridge (RM 10.57) to allow for a reduction in upstream flood levels could be considered, however, this would result in increasing downstream flood flows and levels. Therefore, this is *not* considered an option due to flooding of downstream businesses and the resulting extensive flood mitigation requirements, which would be needed downstream. Per Executive Order (EO) 11988, modifications to floodplains that may induce downstream flooding shall be evaluated to avoid adverse effects within the floodplain.

D. Sensitivity Analysis.

Since organized streamflow data is not available for the upper Still River, the hydrologic and hydraulic characteristics of the river determined in this study are based on downstream flow data and associated WSE determined by the FEMA 1982 FIS.

Therefore, a sensitivity analysis was conducted to determine any effects the starting downstream WSE at Route-7/Segar Street/RM 8.2, as determined in the FEMA 1982 FIS, may have on the upper Still River water surface profile. The model applied the adopted 10-yr, 50-yr, 100-yr, and September 1999 flow rates, varying one parameter in each simulation.

determined from the FEMA 1982 FIS (see Table 9). The sensitivity analysis determined the WSE along both the Mill Plain Swamp and Lake Kenosia sensitive to the starting downstream WSE for storm events greater than the 10-yr. The combination of high flow rates and elevated downstream WSE during large storm events increases the WSE along the upper Still River creating a continuous floodplain across Mill Plain Swamp and Lake Kenosia in which the WSE is indicative of the starting downstream WSE.

During storm events of 10-yr and less, Lake Kenosia is not sensitive to the starting downstream WSE due to the Kenosia Avenue bridge constriction, which controls outflow from Lake Kenosia regardless of the backwater elevation of Mill Plain Swamp during low frequency events.

Therefore, the predicted WSE at the area of interest, the Jensen Mobil Home Park, was determined sensitive to the starting downstream WSE during storm events greater than 10-yr.

Table 9
Sensitivity Analysis Summary
Starting Downstream Water Surface Elevations (WSE)

		Water Surface Elevations (Ft NGVD)		
Storm Event	Sensitivity Analysis Downstream WSE	Rt-7/Segar St/ RM 8.2	RM 10.57 Bridge Tailwater	RM 11.0 Lake Kenosia (Jenson's Trailer Park**)
10-yr	Adopted	450.2	450.3	451.9
	1-ft increase	451.2	451.3	451.9
	1-ft decrease	449.2	449.5	451.9
	2-ft decrease	448.2	449.4	451.9
50-yr	Adopted	454.0	454.1	454.1
	1-ft increase	455.0	455.0	455.1
	1-ft decrease	453.0	453.1	453.3
	2-ft decrease	452.0	452.1	452.6
100-yr	Adopted	454.5	454.6	454.6
	1-ft increase	455.5	455.5	455.6
	1-ft decrease	453.5	453.6	453.7
	2-ft decrease	452.5	452.6	453.0
T.P. Floyd*	Adopted	456.0	456.1	456.2
	1-ft increase	457.0	457.1	457.1
	1-ft decrease	455.0	455.2	455.3
	2-ft decrease	454.0	454.2	454.6

* September 1999 (Tropical Storm Floyd)
** Jensen's mobile home park

VIII. SUMMARY

This investigation conducted a hydrologic and hydraulic analysis of the upper Still River between Route-7/Segar Street/RM 8.2 and RM 11.33 (Lake Kenosia headwater), with particular attention given to the Jensen mobile home park vicinity located along the shore of Lake Kenosia at RM 11.0. The COE HEC-HMS model was used to simulate reservoir storage routings while the HEC-RAS model was used to conduct a backwater analysis along the 3.2-mile channel.

This investigation determined the Mill Plain Swamp, a natural flood plain, capable of storing runoff from upstream watersheds. However, the amount of attenuation (storage) provided by the Mill Plain Swamp has reduced over time as commercial development has encroached upon the natural flood plain. The downstream channel constriction at Route-7/Segar Street/RM 8.2 causes backwater effects between the Mill Plain Swamp and the Kenosia Avenue bridge.

Lake Kenosia inflow is primarily received from sub-basin 1, a 5.1 sq. mi watershed consisting mainly of wooded mountainous terrain. Lake Kenosia drains to the Mill Plain Swamp; however, Kenosia Avenue restricts outflow. Mill Plain Swamp and Lake Kenosia respond as one continuous flood plain during high frequency storm events, resulting in backwater flooding along Lake Kenosia and the Jensen mobile home park (RM 11.0) during 10-yr storm events and greater.

Sub-basin 1 and sub-basin 2 peak 10-yr discharges were determined to be approximately 870 cfs and 1087 cfs, respectively while the 10-yr and 100-yr discharges for the Mill Plain Swamp (Route-7/Segar Street/RM 8.2) were determined to be approximately 775 cfs and 1934 cfs, respectively. Therefore the outlets to sub-basin 1, sub-basin 2 and the Mill Plain Swamp would qualify for futher flood damage reduction improvements under COE authorities.

This investigation also determined sub-basin 3, sub-basin 4 and Lake Kenosia (RM 10.58) peak 10-yr outflows to be approximately 163 cfs, 164 cfs and 546 cfs, respectively, which does *not* meet the COE flow criteria for future flood reduction investigations.

This study determined that either raising the finished first floor of existing buildings or construction of a dike/floodwall along the banks of Lake Kenosia to be potential flood reduction options that could reduce flood damages within the Jensen property. However, removing constrictions at the Mill Plain Swamp (Route-7/Segar Street/RM 8.2) or Kenosia Avenue bridge (RM 10.57) to allow flow downstream is *not* considered a viable option due to its potential to increase flooding of downstream businesses. Modifications to floodplains that may induce downstream flooding must be evaluated to avoid adverse effects within the floodplain, per Executive Order 11988.

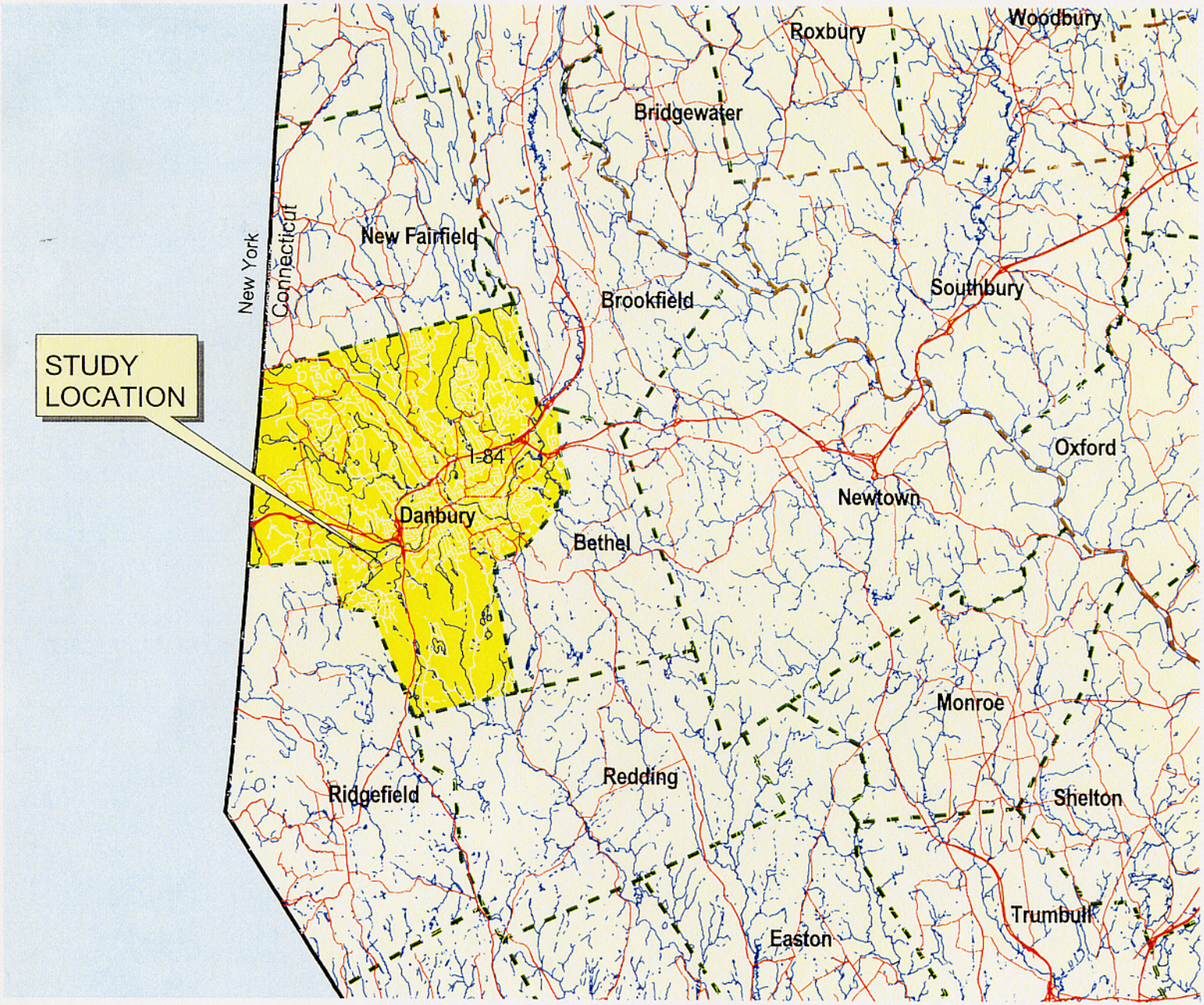

Plate 1
Location Map
Upper Still River
Danbury, Ct.

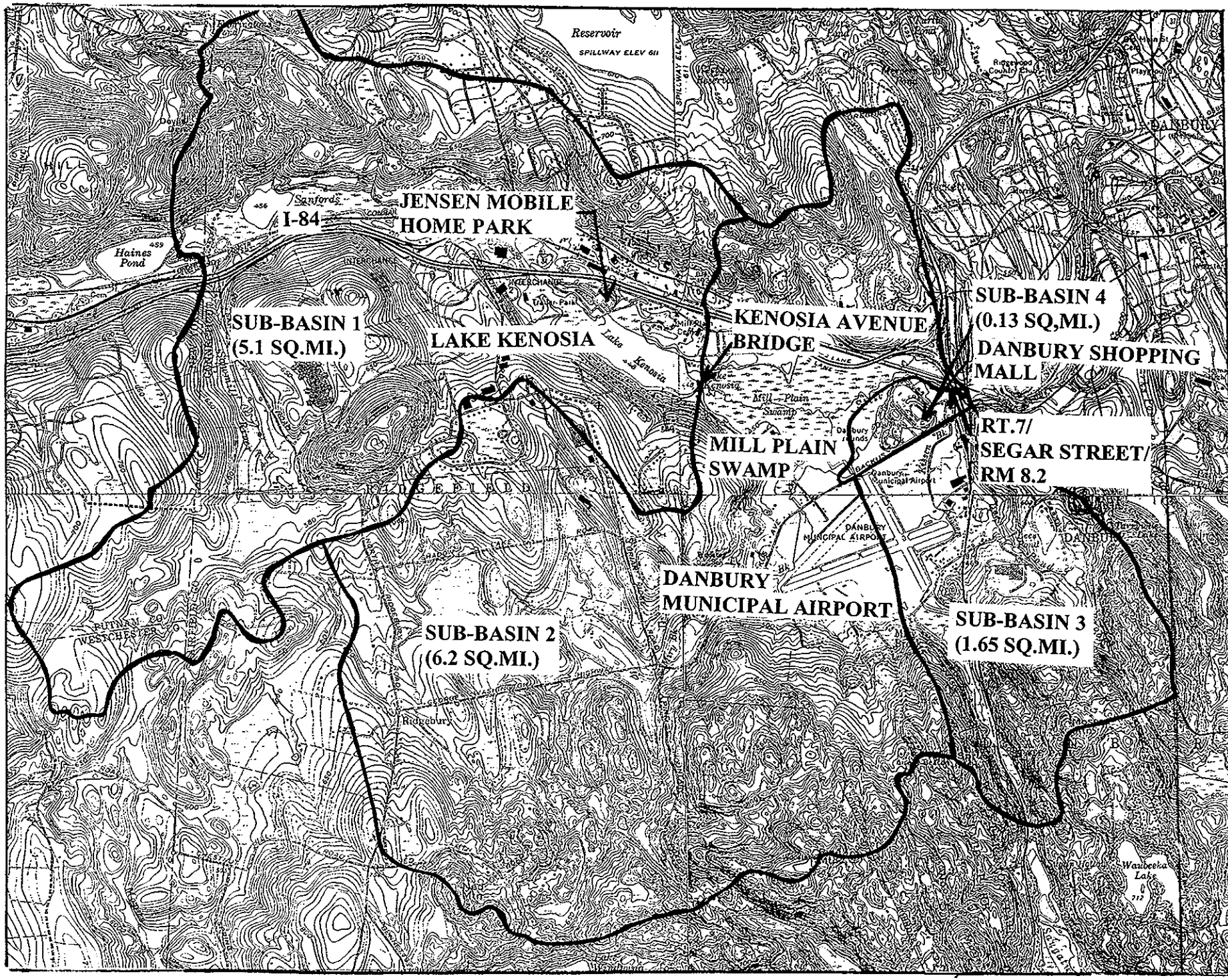

PLATE 2
SUB-BASIN LOCATION MAP
UPPER STILL RIVER
DANBURY, CT

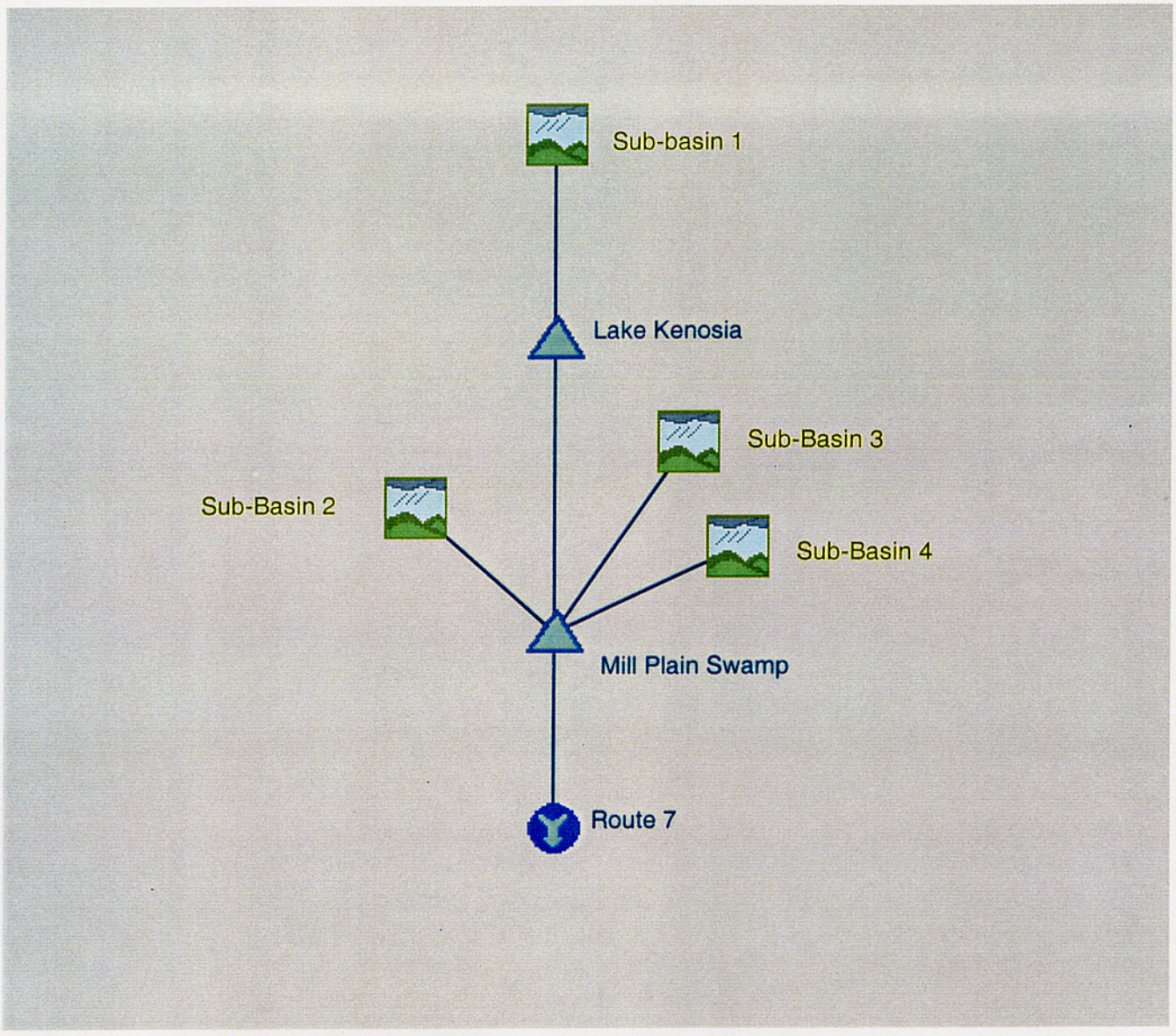

PLATE 3
HEC-HMS WATERSHED SCHEMATIC
UPPER STILL RIVER
DANBURY CT.

JENSEN MOBILE HOME PARK

LAKE KENOSIA

KENOSIA AVENUE BRIDGE

MILL PLAIN SWAMP

RM 11.33

RM 11.0

RM 10.80

RM 10.66

RM 10.63

RM 10.58

RM 10.57

RM 10.55

RM 10.12

RM 9.12

RM 8.75

RT.7/ SEGAR ST RM 8.2

RM 8.27

RM 8.46

RM 8.70

RM – RIVER MILE

PLATE 4
CROSS-SECTION LOCATION MAP
UPPER STILL RIVER
DANBURY, CT

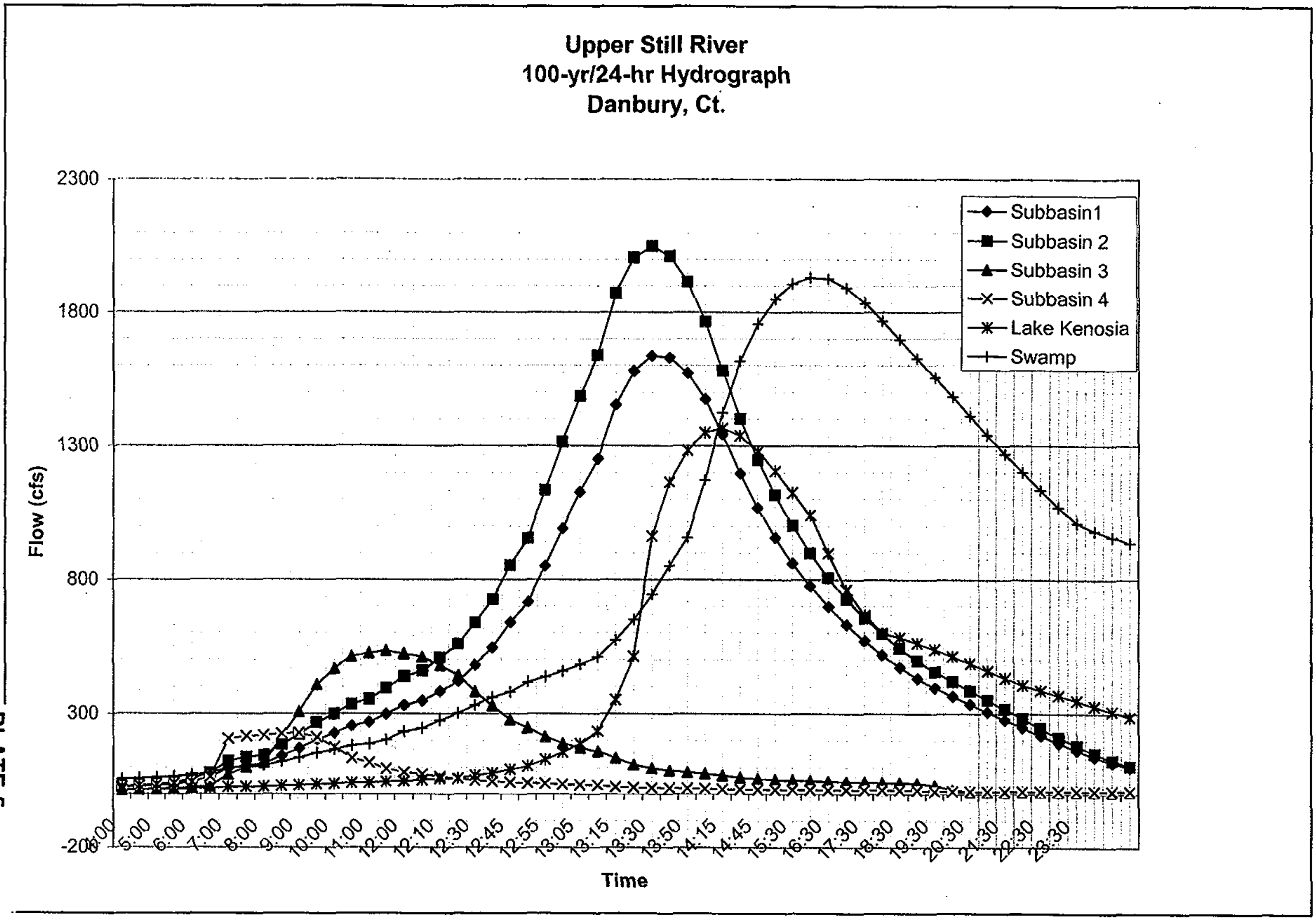

PLATE 5
100-YR/24-HR HYDROGRAPH
UPPER STILL RIVER
DANBURY, CT.

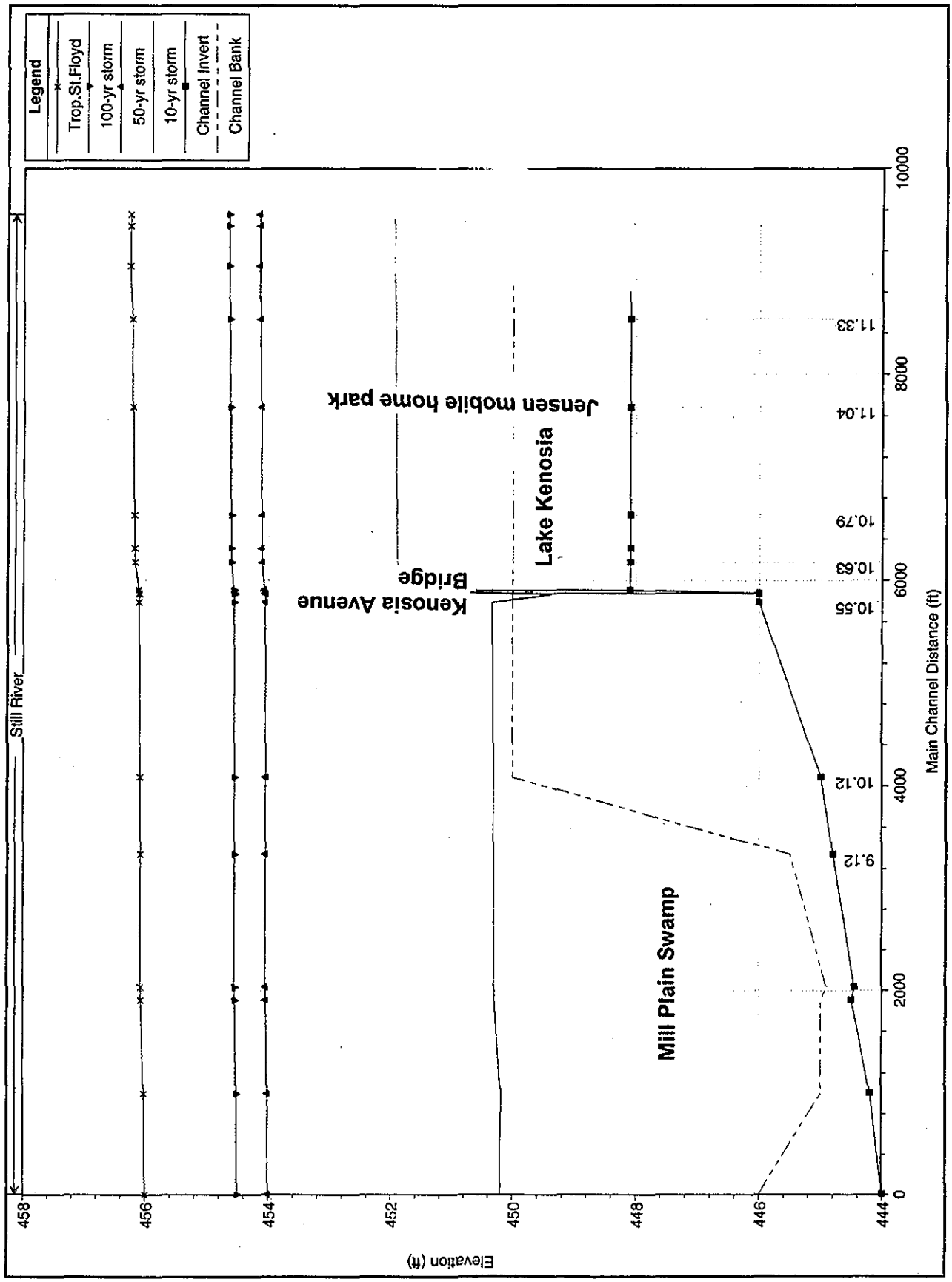

PLATE 6
WATER SURFACE PROFILE
UPPER STILL RIVER
DANBURY, CT.

Plate 7
Upper Still River Rating Curve
Danbury, Ct.

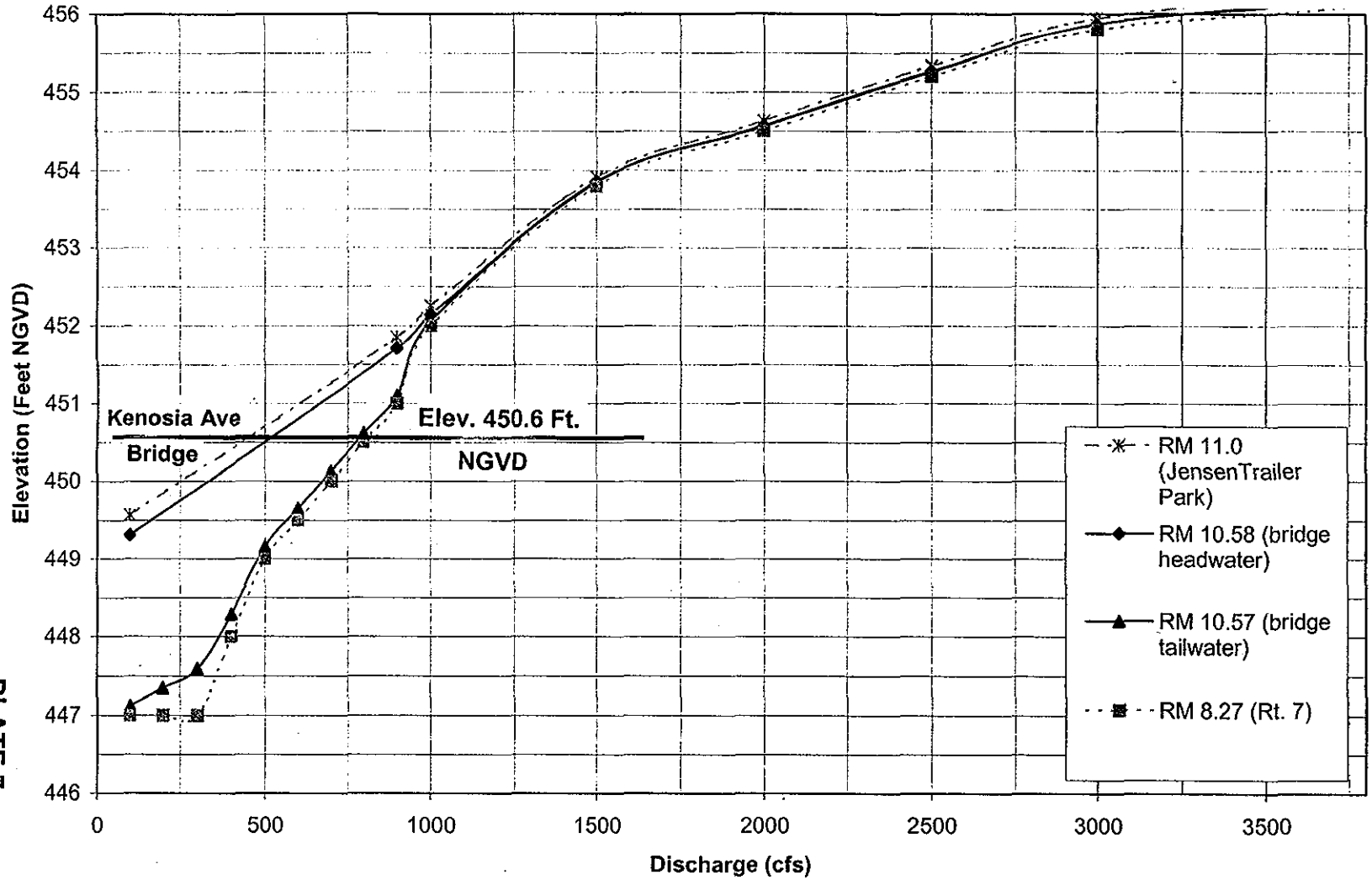

PLATE 7
RATING CURVE
UPPER STILL RIVER
DANBURY, CT.

K-E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 8003

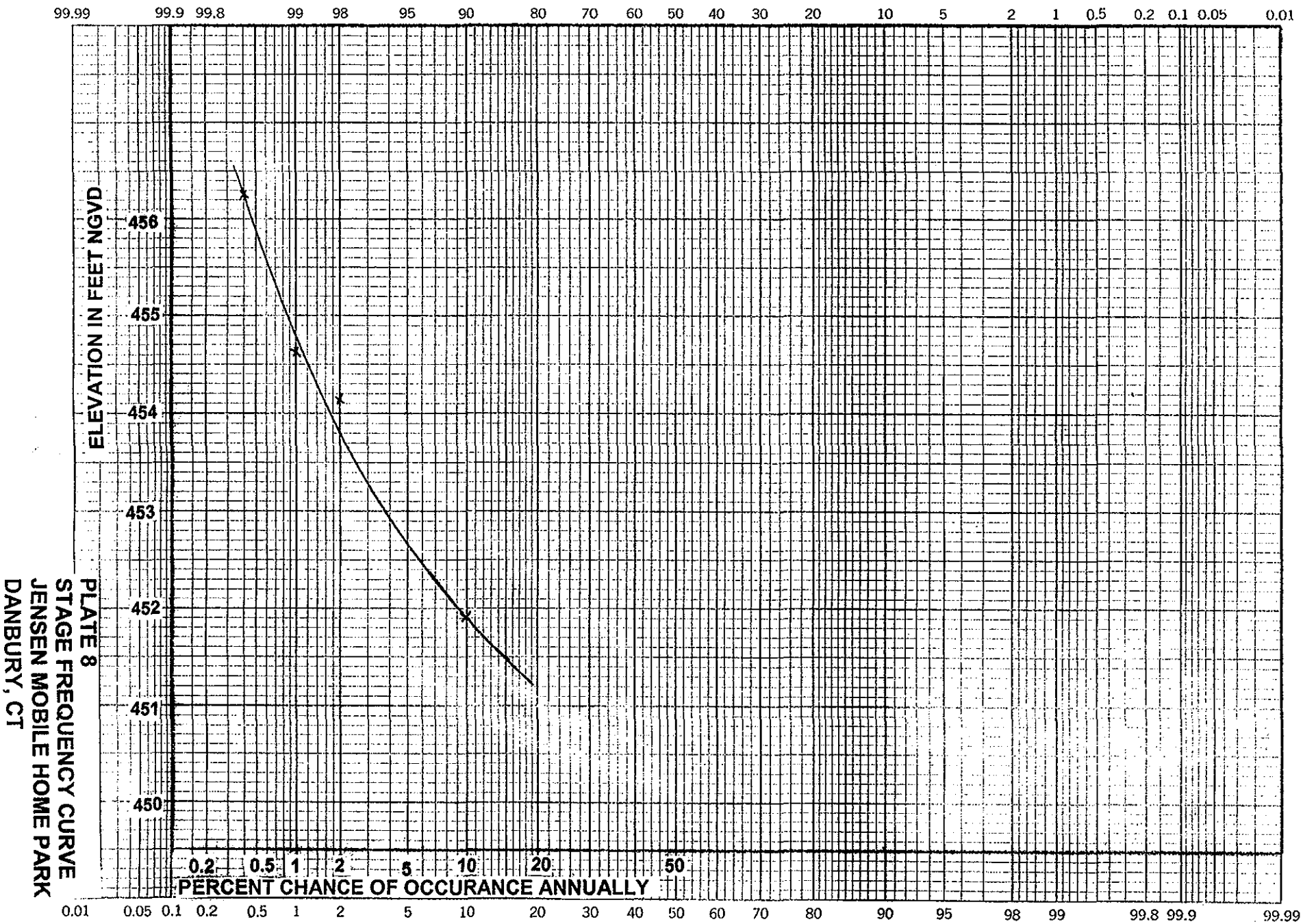

PLATE 8
STAGE FREQUENCY CURVE
JENSEN MOBILE HOME PARK
DANBURY, CT