Piscataquog River
New Hampshire

Everett Lake Dam-Break Flood Analysis

SEPTEMBER 1983

US Army Corps
of Engineers
New England Division

DAM-BREAK FLOOD ANALYSIS
EVERETT LAKE

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EVERETT LAKE
DAM-BREAK FLOOD ANALYSIS

1. PURPOSE

This report presents the findings of a dam-break flood analysis performed for Everett Lake. The dam is located on the Piscataquog River in East Weare, New Hampshire, approximately 16 miles above the confluence of the Piscataquog and Merrimack Rivers in the city of Manchester and 9 miles above the town of Goffstown. The location of the dam is shown on plates 1, 2 and 3.

Included in the report are sections describing pertinent features of the dam and dikes, procedures used for the analysis, assumed dam-break condition, and effects of varying conditions (sensitivity tests) on the resulting downstream flood, discharges and stages. This study was not performed due to any known likelihood of a dam-break at Everett Lake. Its only purpose was to provide quantitative information for emergency planning use in accordance with Corps of Engineers regulation (ER 1130-2-419).

2. PROCEDURE

The Everett dam-break analysis was made using the "National Weather Service Dam-Break Flood Forecasting Computer Model", developed by D. L. Fread, Research Hydrologist, Office of Hydrology, National Weather Service, NOAA, Silver Spring, Maryland 20910. Input to the computer model consisted of: (a) storage characteristics of the reservoir, (b) selected geometry and timing of the dam-break, and (c) hydraulic characteristics of the downstream river channel including tributary inflows, roughness coefficients, contraction-expansion loss coefficients, and active and inactive flow regions. Based on input data, the program simulates a prebreach high flow steady state condition, then computes the dam-break outflow hydrograph and routes it downstream. Calibration of the model is accomplished by comparing model computer prebreach stage-discharge relations with known stage-discharge relations at various index locations along the river (i.e., at dams, gages, etc.). The dynamic unsteady flow routing is performed by a "honing" iterative process governed by requirements of both the principle of conservation of mass and the principle of conservation of momentum. The analysis provides output on the attenuation of the flood hydrograph, resulting flood stages, and timing of the flood wave as it progresses downstream. A listing of the computer input data used for the base flood is shown on plates 13-1 through 13-4.

3. DESCRIPTION

a. General. The study extended from Everett Lake in East Weare, New Hampshire downstream along the Piscataquog River to its confluence with the Merrimack River at Manchester, New Hampshire, for a total distance of about 21 miles. The drainage area of the Piscataquog River in the study reach increases from 64 square miles at Everett Lake to 220 miles at the confluence of the Merrimack River. Hopkinton Lake, a Corps of Engineers flood control project located in the village of West Hopkinton on the Contoocook River, was built in conjunction with Everett Lake to form the Hopkinton-Everett Lakes flood control project. This two reservoir system is operated, along with three other Corps reservoirs in the basin to reduce flooding at major industrial, commercial and residential areas along the Merrimack River. Hopkinton Lake also reduces flooding at communities along the Contoocook River; in the same way Everett Lake reduces flooding at communities along the Piscataquog River.

b. Everett Lake. Everett Lake is a flood control project with water based recreational activities, built and operated by the Corps of Engineers. Construction was initiated in November 1959 and completed in December 1961. Everett Lake is operated to control flooding on the Piscataquog River (in the communities of Riverdale, Goffstown, Grasmere, Pinardville and Manchester), and is one of 5 existing Corps reservoirs operated to reduce downstream flooding along the main stem of the Merrimack River. A map of the Merrimack River basin, with existing Corps reservoirs, is shown on plate 1. A watershed map is shown on plate 2 and a reservoir map on plate 3.

Everett Lake is a rolled earthfill embankment with an impervious core and rock slope protection. The dam is about 2,000 feet long with a maximum height, at elevation 435 feet NGVD, of 115 feet above the streambed. A general plan of the dam is shown on plate 5 and an areal photo on plate 4. The spillway consists of an uncontrolled concrete ogee weir chute spillway with a crest elevation of 418.0 feet NGVD and a length of 175 feet. The spillway approach channel is about 100 feet in length and the chute-type discharge channel is about 1500 feet long. The spillway is located on the east abutmetn of the dam. The outlet works, located at the center of the dam, consists of about a 300-foot long intake channel, a gated structure with gate tower, an 8-foot inside diameter concrete conduit 350 feet in length through rock and an outlet channel about 600 feet in length. The outlet works are controlled by three 3-foot 6-inch by 6-foot high hydraulic operated slide gates. A plan and profile of the outlet works are shown on plate 6. Pertinent data on Everett Lake are listed in table 1.

Hopkinton Lake, with a net drainage area of 382 square miles, is another Corps of Engineers project located on the Contoocook River in the town of Hopkinton, New Hampshire and is physically connected to Everett Lake by a system of two canals. During minor floods the two projects act independently as separate reservoirs but during moderate to major floods, when the Hopkinton pool level exceeds elevation 401 feet NGVD, flows pass from Hopkinton to Everett through the canal system. At elevation 401 feet NGVD, Everett has a storage capacity of 50,250 acre-feet and Hopkinton 25,300 acre-feet. At spillway crest elevation 418 feet NGVD Everett has a storage capacity of 92,500 acre-feet and at spillway crest elevation of 416 feet NGVD, Hopkinton has a storage capacity of 70,800 acre-feet. Therefore, the combined storage capacity of the two projects is 163,300 acre-feet equivalent to 6.9 inches of runoff from their combined net drainage area of 446 square miles.

c. Dikes P-1 and P-2. The Everett dam project includes two remote saddle dikes, P-1 and P-2, located about 3 miles northeast of the main dam on the divide between Stark Brook and Bela Brook watersheds. Location of the dam and dikes are shown on plate 3.

Dike P-1 has a total length of 4,050 feet with a top elevation of 435 feet NGVD and a maximum height of 50 feet. Maximum impoundment with project filled to spillway crest (elevation 418) would be about 24 feet. The dike is equipped with a gated conduit to permit local drainage through the dike to Stark Brook during normal periods and prevent backflow during periods of flood storage above about elevation 390 feet NGVD. Dike P-2 has a total length of 2,630 feet with a top elevation of 435 feet NGVD and a maximum height of

TABLE 1

EVERETT LAKE
PERTINENT DATA

LOCATION	Piscataquog River, East Weare, New Hampshire
DRAINAGE AREA	64 Square Miles
STORAGE USE	Flood Control and Recreation
RESERVOIR STORAGE	
Inlet Elevation	325 feet NGVD
Recreation Pool	340 feet NGVD
Maximum Surcharge	430 feet NGVD
Top of Dam	435 feet NGVD
EMBANKMENT	
Type	Rolled earthfill, rock slope protection, impervious core
Length	2,000 feet
Top Width	24 feet
Top Elevation	435 feet NGVD
Maximum Height	115 feet
SPILLWAY	
Location	East abutment
Type	Uncontrolled, ogee weir, chute, saddle spillway
Crest Length	175 feet
Crest Elevation	418 feet NGVD
Surcharge	12 feet
Capacity	28,500 cfs
OUTLET CONDUIT	
Type	One circular concrete tunnel
Size	8 feet inside diameter
Length	350 feet
Service Gates type	Hydraulic operated slide
Service Gates size	Three 3'-6" wide x 6' high
Discharge Capacity at spillway crest	4,600 cfs
Downstream channel capacity	2,000 cfs

about 30 feet. With the project filled to spillway crest the maximum impoundment by the dike would be about 5 feet.

In the event of sudden failure of either dikes P-1 or P-2, with the project filled to elevation 400 feet NGVD or above, flows would discharge into the Bela Brook watershed. Bela Brook flows northeasterly for about 4 miles, as a relatively flat gradient stream, discharging into the Turkey Pond complex in Concord, a two-pond system with an inter connecting canal that passes beneath Interstate Highway 89. From the Turkey Pond control structure, discharges flow southeasterly in Turkey River a distance of about 4 miles discharging to the Merrimack River inthe town of Bow about one-half mile downstream of the Bow-Concord town line and about 0.9 mile upstream of Garvins Falls Dam.

The dam-break flood analysis for the main Everett dam did not permit detailed analysis of breaks at the lower P-1 and P-2 saddle dikes. Until more detailed studies can be performed it is recommended that for emergency planning, it be assumed that peak stages along Bela Brook and Turkey River would generally not be over 10 feet above normal river level as a result of a sudden failure at dikes P-1 or P-2 with the Everett storage filled to spillway crest (elevation 418).

d. Downstream Valley. The Piscataquog River, downstream of Everett Lake, flows through six communities within south-central New Hampshire on its way to the Merrimack River, namely in downstream order; Riverdale, Parker, Goffstown, Grasmere, Pinardville and Manchester. River cross sectional data used for the model was obtained from available survey information and augmented as required with information from USGS topographical maps.

Within the study reach, the Piscataquog River has a total fall of 230 feet in a distance of 21 miles for an average gradient of about 11 feet per mile. The South Branch of the Piscataquog River adds 113 square miles of drainage area and joins the Piscataquog River in Goffstown, 7 miles downstream of Everett Lake. From Everett Dam in East Weare to Greggs Falls Dam in Goffstown, a distance of about 8 miles, the river falls 40 feet for a gradient of 5 feet per mile. From Greggs Falls Dam in Goffstown to Kelleys Falls Dam in Pinardville, a distance of 5 miles, the fall is 60 feet for a gradient of 12 feet per mile. From Kelleys Falls Dam in Pinardville to the Merrimack River in Manchester near the Municipal Airport, a distance of 8.5 miles, the river falls another 40 feet for a gradient of 5 feet per mile.

There are 21 river crossings from Everett Lake to the Merrimack River including four Interstate-type highway crossings, two State highways, two railroads and nine local roads. Also crossing the river in this reach are four dams which are described below.

(1) Riverdale Dam. This dam is located about 5 miles downstream of Everett Lake and provides a fire protection pool for the town of Weare. The Corps of Engineers rebuilt the dam, and installed a hinged leaf gate, as part of the construction of Hopkinton and Everett, to provide needed downstream channel capacity. The dam is a concrete structure on rock with a 60-foot wide by 4-foot high leaf gate. The total dam width is about 150 feet and has a height of about 6 feet. The top elevation of the dam is 312 feet NGVD with the gate up and the gate sill is at 308 feet NGVD.

(2) U.S. Bobbin Company Dam. This dam is located in Goffstown about 8 miles downstream of Everett Lake. From field investigations it appears that this dam is not presently used. Available information indicates that it has a top elevation of 285 feet NGVD, a length of about 200 feet and a height of 10 feet.

(3) Greggs Falls Dam. This dam was originally a hydropower facility owned by the Public Service Company of New Hampshire, however, the New Hampshire Water Resources Board now owns the dam structure and a Mr. William Barris owns the old power station. The dam is presently used simply to maintain a recreation pool. The dam (located 1.5 miles downstream from U.S. Bobbin Company Dam) is 60 feet high and 1360 feet long with a top elevation of 279 feet NGVD. The spillway is 462 feet long with a crest elevation of 270 feet NGVD.

(4) Kelleys Falls Dam. Until 1973 this dam was used to generate electrical power, presently its impoundment is used only for recreational purposes. The dam is located on the Piscataquog about 2 miles upstream of the confluence with the Merrimack River

in the city of Manchester, and is owned by the New Hampshire Water Resources Board, Concord, New Hampshire. The dam is a concrete gravity structure 503 feet in length with a top elevation of 168 feet NGVD. The spillway has a length of 192 feet at a crest elevation of 158 feet NGVD.

4. ASSUMED DAM-BREAK CONDITIONS

a. General. The magnitude of a flood resulting from a dam-break depends not only on the size of the project but also on the conditions of failure including the initial reservoir level, size of breach, rate of breach formation, and hydraulic features and initial flows in the downstream river channels. The selected input parameters for the dam-break analysis at Everett Lake were considered the most severe that might be reasonably expected.

b. Selected Input Parameters - (Base Flood)

(1) Initial Reservoir Level - Full to spillway crest, elevation 418 feet NGVD. Failure storage equals Everett storage (92,500 acre-feet) plus Hopkinton Lake storage above elevation 401 feet NGVD (53,000 acre-feet).

(2) Reservoir Inflow - Recurring 1936 flood of record, peak inflow to Everett, with present Hopkinton-Everett complex - 21,500 cfs.

(3) Breach Invert - Elevation 325 feet NGVD

(4) Breach Base Width (3x Height) = 310 feet, trapezoidal side slope: 2V:1H.

(5) Time to Complete Formation of Breach - (Duration of Breach) - one hour.

(6) Prebreach Downstream Flow - March 1936 flood of record as modified by Everett Lake.

(7) Downstream Channel Roughness - From Everett Lake to U.S. Bobbin Company Dam - Manning's "n" = 0.08 to 0.10, U.S. Bobbin Company Dam to Greggs Falls Dam - Manning's "n" = 0.08 to 0.095 Greggs Falls Dam to Kelleys Falls Dam - Manning's "n" 0.08 to 0.10, Kelleys Falls Dam - to the junction of the Merrimack River - Manning's "n" = 0.08 to 0.095, 5 miles downstream of the junction on the Merrimack River Manning's "n" = 0.04 to 0.06.

(8) Downstream Dam Failure - All four dams were assumed to remain.

5. RESULTS

The resulting peak stage flood profile and flood delineations for the base flood are shown on plan and profile sheets 1 and 2 (reference plates 8 and 9). A flood profile index map is shown on plate 7. Timing of peak and leading edge of the flood wave are also noted on the plan and profile plates. The adopted pre-failure flow was based on the recurring record March 1936 flood as modified by the present system of reservoirs.

Development of the peak stage profile, discharge and stage hydrographs for three selected stations downstream of Everett Lake (river miles 0.00, 7.55 and 20.80) are graphically shown on plate 10.

The peak dam-break discharge from Everett Lake was 774,600 cfs and attenuated to 502,800 cfs at the junction with the South Branch Piscataquog River and further attenuated to 451,700 cfs at Greggs Falls Dam. In this 7 and 9.5 mile reach, the peak stages would be about 50 and 45 feet above normal riverflow, respectively.

The study continued to 5 miles below the junction with the Merrimack River an additional total distance of 11.5 miles. In this reach, the peak discharge reduces to 401,400 cfs and then increases to 458,400 cfs at the junction with Merrimack River due to the prefailure Merrimack River floodflow of 78,000 cfs. The peak flood stage would vary from about 45 feet to about 60 feet above normal river level. At the confluence with the Merrimack River, the peak flood stage would be about 55 feet above normal river level or about 30 feet above assumed pre-breach high flow. The Merrimack River has a very flat gradient in this reach, and would maintain high stages for a considerable distance downstream. The dam break computation was carried to river mile 25.2 miles, 9 miles downstream of the junction with the Piscataquog River. At this location the dam-break flood stage would still be about 50 feet above normal river level or about 30 feet above pre-breach high flow, or about 10 feet above the actual experienced March 1936 flood of record.

The leading edge of the dam-break flood would reach Goffstown about 1.60 hours after start of failure and the resultant peak flood stage would occur about 3.00 hours after the start of dam-break. The city of Manchester would experience the leading edge of the dam-break 2.20 hours after the start of failure and the resultant peak flood stage would occur about 4.50 hours after dam-break.

The computer model analysis was terminated 5 miles downstream of the confluence of the Piscataquog and Merrimack Rivers. Peak stages of the breach flood wave at the confluence was about 25 feet higher than that produced by the record flood of March 1936.

6. SENSITIVITY TESTS

In addition to the analysis with the assumed dam-break conditions, other studies were made to determine the sensitivity that individual selected parameters would have on the resulting downstream flood. Following is a listing of conditions used and a description of results obtained.

a. Breach Width. For the Base Flood analysis, a breach width of 310 feet (3 x height) was used, a comparative run was made with a breach width of 450 feet. The 450-foot breach width produced a peak flow that was 30 percent greater, resulting in stage increases from about 10 feet at the start to about 4 feet at river mile 25.2. Comparative profiles for the 310 and 450-foot breach width are shown on plate 11.

b. Duration of Dam-Break. The selected duration for the dam failure was one hour. Runs were also completed for failure times of 2 and 5 hours. Changes in failure time resulted in stage reductions of 6 feet in the upper river reach to 3 feet in the lower reaches. Relative effects of the three failure times on the flood profiles are shown on plate 11.

c. Initial Pool Level. An important factor in determining the magnitude of a dam-break flood is the level of the reservoir when the break occurs. Though a full reservoir condition was adopted, a run was also completed with the reservoir initially one-half full. Comparative downstream profiles are shown on plate 11. With the one-half full condition, the resulting peak discharge at Everett Lake was 29 percent less than the adopted full pool condition. Peak flood levels related to this reduction within the study reach were from 12 to 11 feet less.

d. Channel Roughness. Varying values of Manning's "n" were tested to determine the effect on downstream flow attenuation, resulting stage, and timing, with Manning's "n" 5 percent greater and then 15 percent less than that for the base flood condition. Reducing the channel roughness values resulted in faster movement of the flood wave with somewhat less attenuation. Increasing the channel roughness values resulted in slower progression of the flood wave downstream with somewhat greater attenuation. However, the resulting variation in the downstream flood profile was relatively small and is shown on plate 12. The most significant effect of changing the channel roughness was the difference in timing of the peak flood stage. At the Greggs Falls Dam in Goffstown, the timing varied from 3.00 to 3.75 hours, and at the junction of the Merrimack River it varied from 5.50 to 5.75 hours for the smallest to the largest "n" values, respectively.

e. Downstream Dams. There are four dams on the river between Everett Lake and the Merrimack River: Riverdale, U.S. Bobbin Company, Greggs Falls, and Kelleys Falls Dams. In the event of a major dam-break at Everett Lake under full pool conditions, these dams could be seriously damaged or fail. The adopted base flood conditions assumed that all dams remained intact; however, the effects of possible failure was also considered. The Greggs Falls Dam was selected to determine the effects of a secondary failure on upstream and downstream flood levels. It was selected over the others because it was the highest and because of its location within the town of Goffstown and also upstream of the city of Manchester. There is no appreciable storage behind any of the four dams.

Parameters used and results obtained in the failure of Greggs Falls Dam were as follows: (1) the dam failed when the upstream water surface reached elevation 294 feet NGVD, or about 15 feet above top of dam, and (2) a 400-foot rectangular breach formed in a period of 1 hour. The failure of Greggs Falls Dam, occurring just prior to the peak failure discharge from Everett, would reduce levels just upstream by about 6 feet and increase levels in downstream areas by about 0.5 foot. Plate 12 shows comparative results of the Greggs Falls Dam failure analysis.

f. Antecedent Riverflows. For the base dam-break flood analysis, it was assumed that a high flow was occurring in the river at the time of dam-break. This approach was considered appropriate because if a dam-break were to occur, it is conceivable that it would happen at a time of abnormally high flow conditions. The assumed base flow conditions used were recurring March 1936 flood of record flows, as modified by the now existing system of Corps flood control reservoirs.

The Everett outflow with the reservoir at spillway crest was 2,000 cfs, the estimated regulated discharge for the March 1936 flood. Downstream tributary inflows of the recurring 1936 flood was 14,000 cfs from the South Branch Piscataquog River and 62,000 cfs for the Merrimack River.

The adopted antecedent flow and comparative estimated and experienced 1936 discharges are as follows:

	Adopted Antecedent	Experienced March 1936
Everett Lake	2,000 (est.)	6,000 (est.)
Below So. Br. Piscataquog R.	16,000 (est.)	20,000 (est.)
Merrimack R. at Manchester	78,000	144,000

An analysis was also completed using lower antecedent riverflows at the time of dam-break and the comparative flood stages are shown on plate 12. The lower antecedent flows used were, 1,000 cfs for the Everett outflow, 7,000 cfs below the junction with the South

Branch Piscataquog River and 32,000 cfs at the junction with the Merrimack River. It is unlikely that these flows would occur coincidentally with Everett Lake filled to spillway crest. However, these flows were considered reasonable for the comparative purposes of this analysis.

7. DISCUSSION

The dam-break analysis for Everett Lake was based on engineering application of certain laws of physics, considering the physical characteristic of the project and downstream channel conditions at failure. Due to the highly unpredictable nature of a dam-break and the ensuing sequence of events, results of this study should not be viewed as exact but only as an approximate quantification of the dam-break flood potential. For purposes of analysis, downstream conditions are assumed to remain constant and no allowance is made for possible enlargement or relocation of river channels due to scour or the temporary damming effect of debris, all of which could affect the resulting magnitude and timing of flooding downstream.

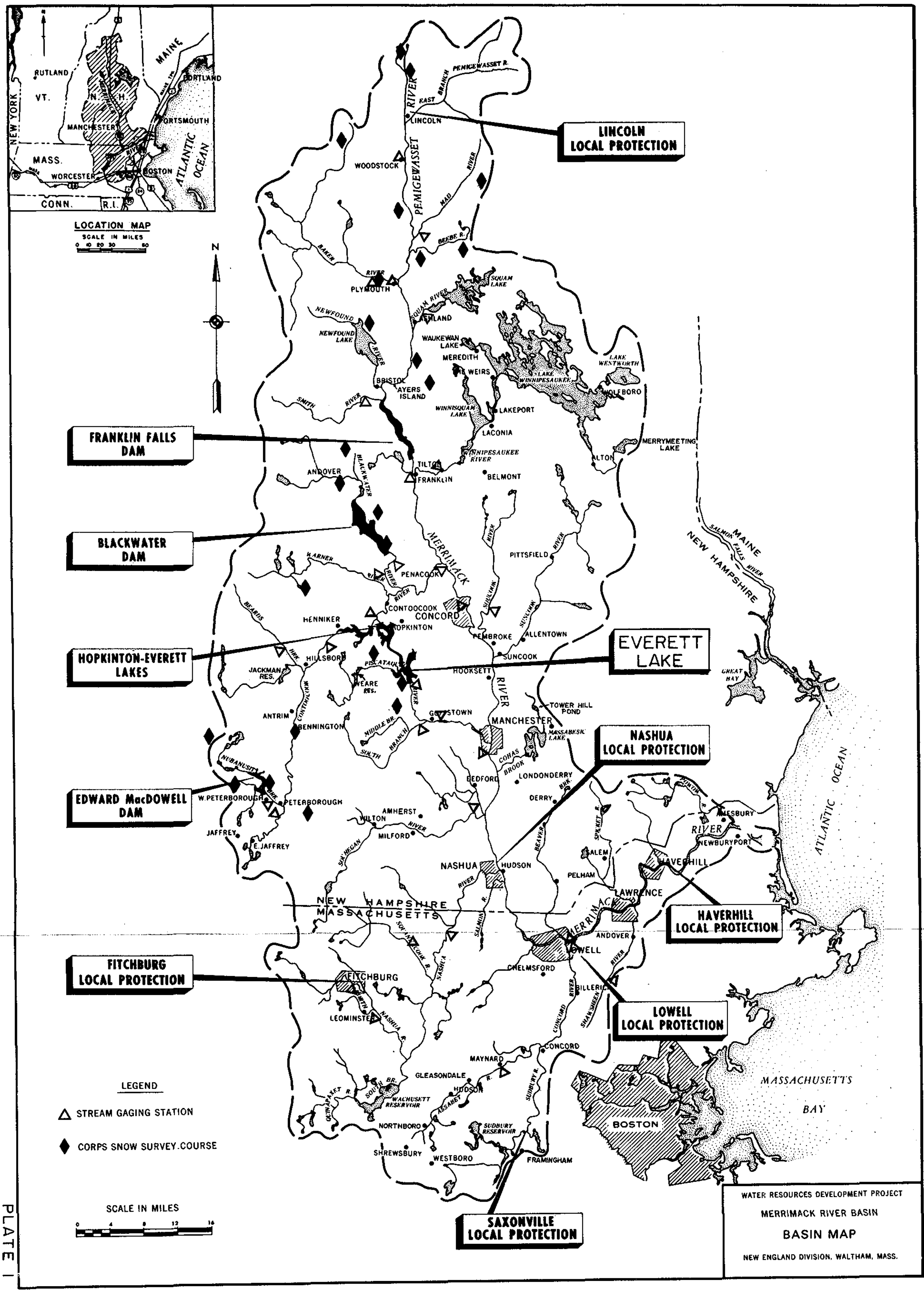
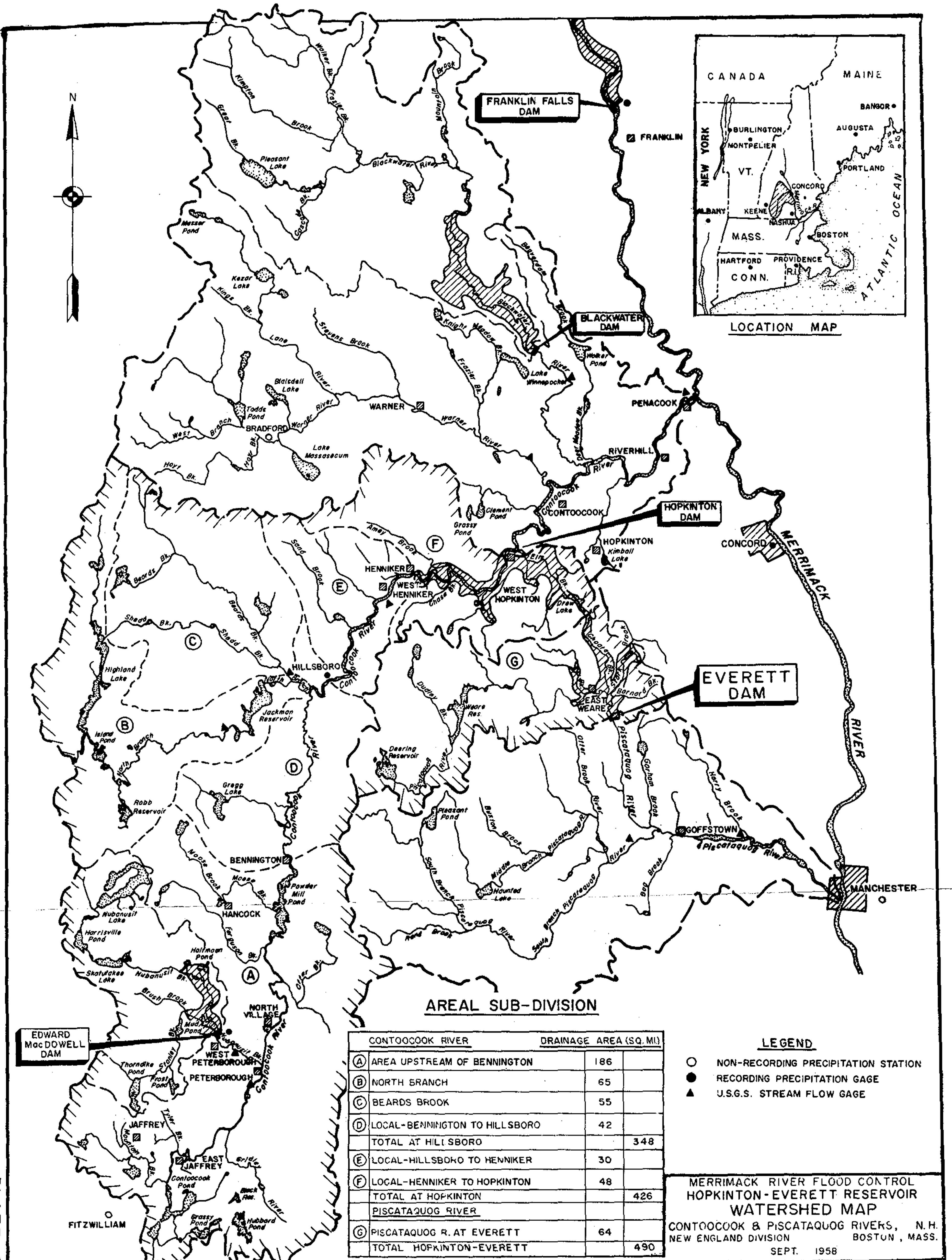

LOCATION MAP
SCALE IN MILES
0 10 20 30 60
NEW YORK
VT.
RUTLAND
N. H.
MAINE
PORTLAND
PORTSMOUTH
MANCHESTER
MASS.
WORCESTER
BOSTON
ATLANTIC OCEAN
CONN.
R.I.
N
LINCOLN LOCAL PROTECTION
FRANKLIN FALLS DAM
BLACKWATER DAM
HOPKINTON-EVERETT LAKES
EVERETT LAKE
NASHUA LOCAL PROTECTION
EDWARD MacDOWELL DAM
HAVERHILL LOCAL PROTECTION
FITCHBURG LOCAL PROTECTION
LOWELL LOCAL PROTECTION
SAXONVILLE LOCAL PROTECTION
PEMIGEWASSET RIVER
EAST BRANCH PEMIGEWASSET R.
LINCOLN
WOODSTOCK
MAD RIVER
BEEBE R.
BAKER RIVER
PLYMOUTH
SQUAM LAKE
SQUAM RIVER
ASHLAND
NEWFOUND LAKE
NEWFOUND RIVER
WAUKEWAN LAKE
MEREDITH
THE WEIRS
LAKE WINNIPESAUKEE
LAKE WENTWORTH
WOLFEBORO
BRISTOL
AYERS ISLAND
SMITH RIVER
WINNISQUAM LAKE
LAKEPORT
LACONIA
WINNIPESAUKEE RIVER
TILTON
FRANKLIN
BELMONT
ALTON
MERRYMEETING LAKE
ANDOVER
BLACKWATER RIVER
MERRIMACK
PITTSFIELD
WARNER RIVER
PENACOOK
CONTOOCOOK RIVER
CONCORD
HENNIKER
HOPKINTON
PEMBROKE
ALLENTOWN
SUNCOOK
HILLSBORO
JACKMAN RES.
PISCATAQUOG
WEARE RES.
HOOKSETT
RIVER
ANTRIM
BENNINGTON
GOFFSTOWN
MANCHESTER
TOWER HILL POND
MASSABESIC LAKE
MIDDLE BR.
SOUTH BRANCH
COHAS BROOK
BEDFORD
LONDONDERRY
DERRY
NUBANUSIT
W. PETERBOROUGH
PETERBOROUGH
JAFFREY
E. JAFFREY
AMHERST
WILTON
MILFORD
SOUHEGAN
MAINE
NEW HAMPSHIRE
SALMON FALLS RIVER
GREAT BAY
ATLANTIC OCEAN
AMESBURY
NEWBURYPORT
RIVER
SALEM
HAVERHILL
PELHAM
NASHUA
HUDSON
LAWRENCE
NEW HAMPSHIRE
MASSACHUSETTS
ANDOVER
MERRIMACK
LOWELL
CHELMSFORD
BILLERICA
FITCHBURG
LEOMINSTER
NASHUA R.
CONCORD
MAYNARD
GLEASONDALE
HUDSON
WACHUSETT RESERVOIR
SOUTH BR.
NORTHBORO
SHREWSBURY
WESTBORO
SUDBURY RESERVOIR
FRAMINGHAM
MASSACHUSETTS BAY
BOSTON
LEGEND
STREAM GAGING STATION
CORPS SNOW SURVEY COURSE
SCALE IN MILES
0 4 8 12 16
WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
BASIN MAP
NEW ENGLAND DIVISION, WALTHAM, MASS.

PLATE I



AREAL SUB-DIVISION

CONTOOCOOK RIVER	DRAINAGE AREA (SQ. MI)	
(A) AREA UPSTREAM OF BENNINGTON	186	
(B) NORTH BRANCH	65	
(C) BEARDS BROOK	55	
(D) LOCAL-BENNINGTON TO HILLSBORO	42	
TOTAL AT HILLSBORO		348
(E) LOCAL-HILLSBORO TO HENNIKER	30	
(F) LOCAL-HENNIKER TO HOPKINTON	48	
TOTAL AT HOPKINTON		426
PISCATAQUOG RIVER		
(G) PISCATAQUOG R. AT EVERETT	64	
TOTAL HOPKINTON-EVERETT		490

MERRIMACK RIVER FLOOD CONTROL
HOPKINTON-EVERETT RESERVOIR
WATERSHED MAP
CONTOOCOOK & PISCATAQUOG RIVERS, N.H.
NEW ENGLAND DIVISION BOSTON, MASS.
SEPT. 1958

PLATE 2

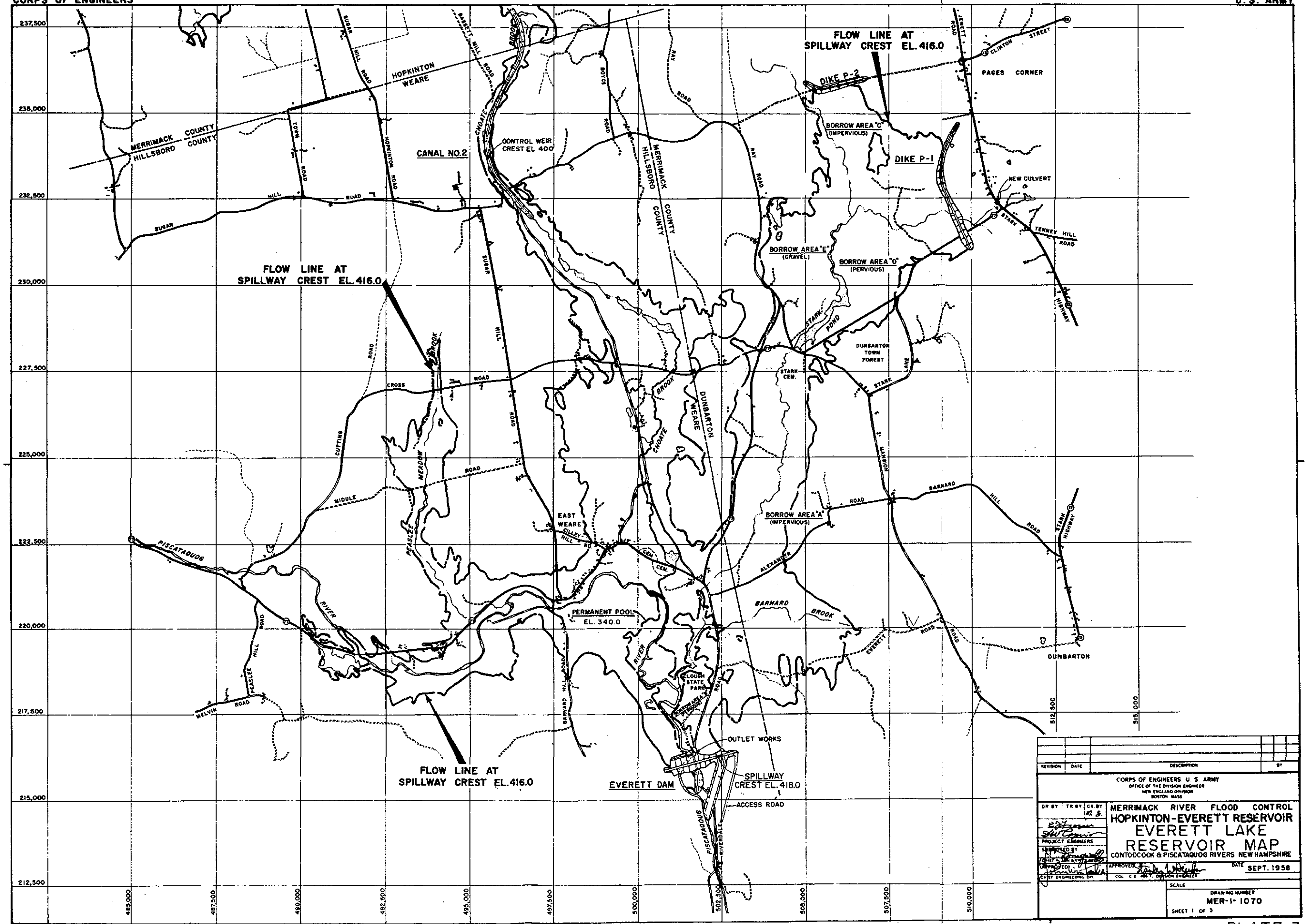
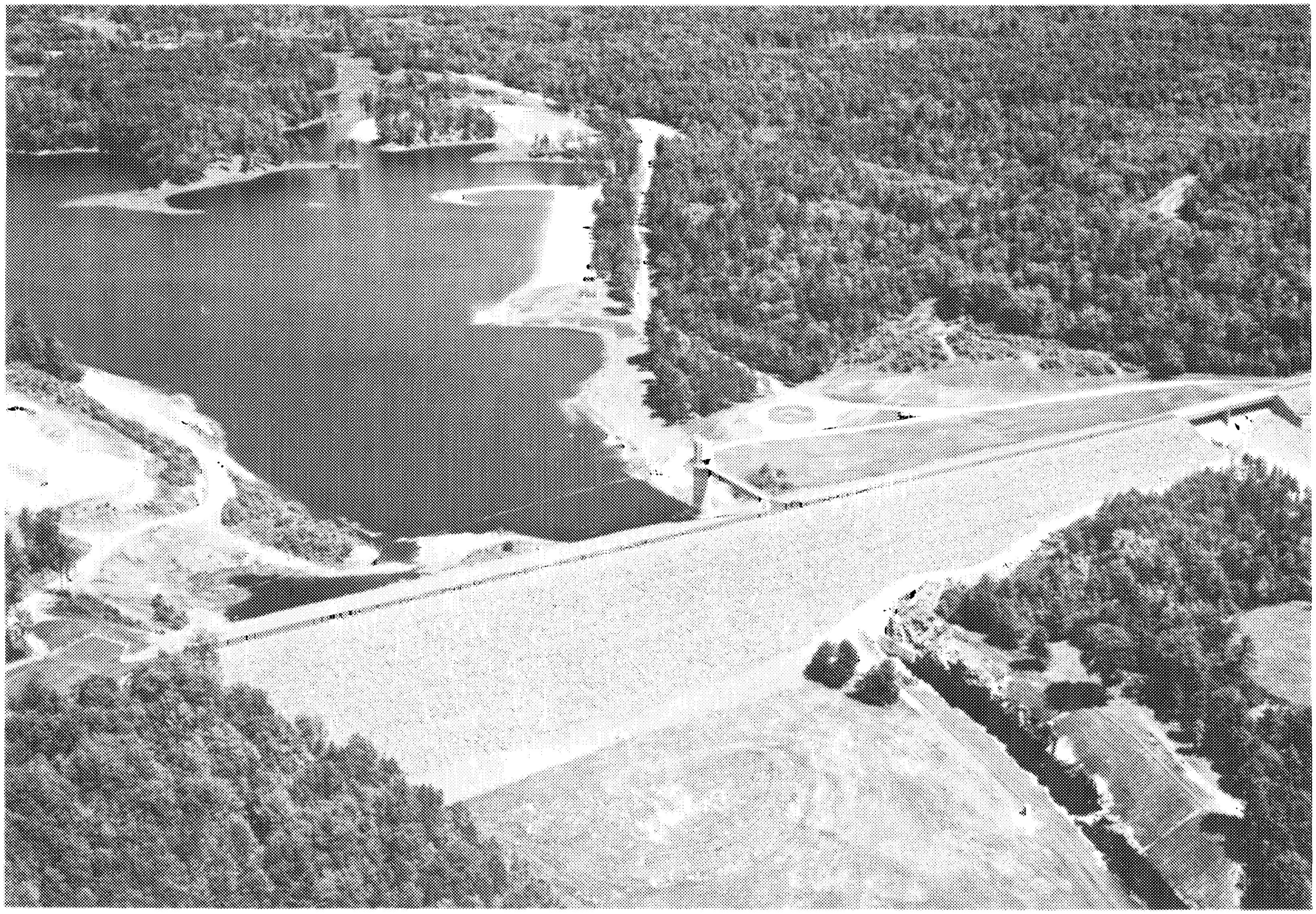

FLOW LINE AT SPILLWAY CREST EL. 416.0
DIKE P-2
PAGES CORNER
CLINTON STREET
BORROW AREA "C" (IMPERVIOUS)
DIKE P-1
NEW CULVERT
TENNEY HILL ROAD
HOPKINTON
WEARE
MERRIMACK COUNTY
HILLSBORO COUNTY
CANAL NO.2
CONTROL WEIR CREST EL 400
SUGAR HILL ROAD
BORROW AREA "E" (GRAVEL)
BORROW AREA "D" (PERVIOUS)
FLOW LINE AT SPILLWAY CREST EL. 416.0
STARK POND
DUNBARTON TOWN FOREST
STARK CEM.
STARK LANE
CROSS ROAD
CUTTING ROAD
MIDDLE ROAD
MEADOW BROOK
PEASLEE BROOK
EAST WEARE
CHOATE BROOK
DUNBARTON
BORROW AREA "A" (IMPERVIOUS)
BARNARD HILL ROAD
STARK HIGHWAY
ALEXANDER ROAD
PISCATAQUOG RIVER
BARNARD BROOK
PERMANENT POOL EL. 340.0
DUNBARTON
CLOUGH STATE PARK
MELVIN ROAD
PEASLEE HILL ROAD
OUTLET WORKS
FLOW LINE AT SPILLWAY CREST EL. 416.0
EVERETT DAM
SPILLWAY CREST EL. 418.0
ACCESS ROAD
RIVERDALE
CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS
MERRIMACK RIVER FLOOD CONTROL
HOPKINTON-EVERETT RESERVOIR
EVERETT LAKE
RESERVOIR MAP
CONTOOCOOK & PISCATAQUOG RIVERS NEW HAMPSHIRE
PROJECT ENGINEERS
CHIEF ENGINEERING DIV.
DATE SEPT. 1958
DRAWING NUMBER
MER-1-1070
SHEET 1 OF 3

PLATE 3



EVERETT DAM

PLATE 4

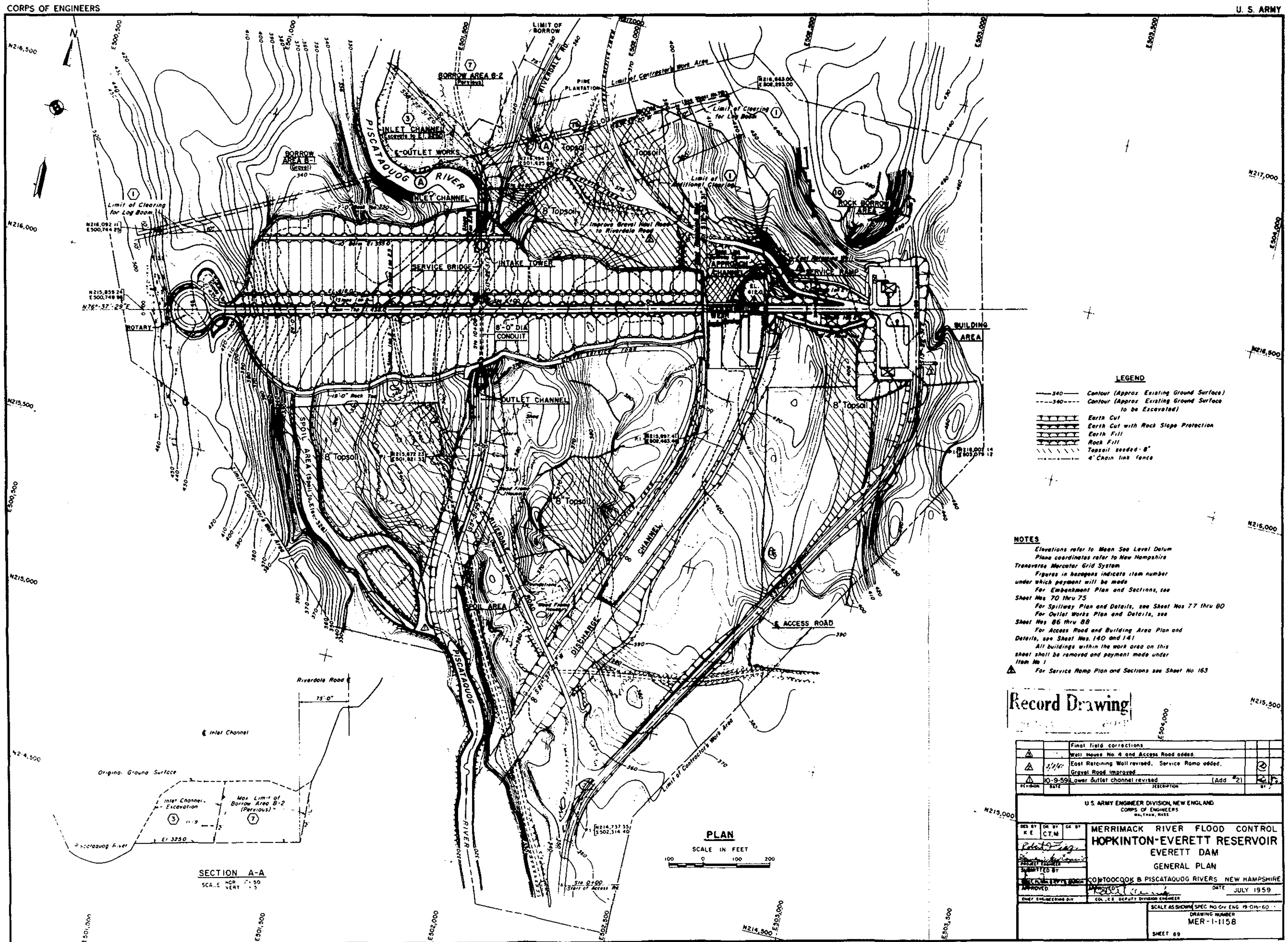

CORPS OF ENGINEERS
U. S. ARMY
BORROW AREA B-2 (Pervious)
LIMIT OF BORROW
RIVERDALE RD.
PINE PLANTATION
Limit of Contractor's Work Area
Limit of Clearing for Log Boom
INLET CHANNEL
OUTLET WORKS
PISCATAQUOG RIVER
BORROW AREA B-1 (Gravel)
Topsoil
Limit of Additional Clearing
ROCK BORROW AREA
8" Topsoil
Improve Gravel Haul Road to Riverdale Road
SERVICE BRIDGE
INTAKE TOWER
APPROACH CHANNEL
SERVICE RAMP
ROTARY
8'-0" DIA CONDUIT
BUILDING AREA
OUTLET CHANNEL
SPOIL AREA
DISCHARGE CHANNEL
ACCESS ROAD
Sta 0+00 Start of Access Rd
LEGEND
Contour (Approx. Existing Ground Surface)
Contour (Approx. Existing Ground Surface to be Excavated)
Earth Cut
Earth Cut with Rock Slope Protection
Earth Fill
Rock Fill
Topsoil seeded - 8"
4' Chain link fence
Riverdale Road
Inlet Channel
Original Ground Surface
Inlet Channel Excavation
Max Limit of Borrow Area B-2 (Pervious)
Piscataquog River
SECTION A-A
PLAN
SCALE IN FEET
100 0 100 200
NOTES
Elevations refer to Mean Sea Level Datum
Plane coordinates refer to New Hampshire Transverse Mercator Grid System.
Figures in hexagons indicate item number under which payment will be made
For Embankment Plan and Sections, see Sheet Nos 70 thru 75
For Spillway Plan and Details, see Sheet Nos 77 thru 80
For Outlet Works Plan and Details, see Sheet Nos 86 thru 88
For Access Road and Building Area Plan and Details, see Sheet Nos. 140 and 141
All buildings within the work area on this sheet shall be removed and payment made under Item No 1
For Service Ramp Plan and Sections see Sheet No 163
Record Drawing
Final field corrections
3 Well House No. 4 and Access Road added.
2 East Retaining Wall revised. Service Ramp added. Gravel Road improved
1 10-9-59 Lower Outlet channel revised (Add #2)
REVISION DATE DESCRIPTION BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS
DES BY K E
DR BY CT.M
CK BY
PROJECT ENGINEER
SUBMITTED BY
APPROVED
CHIEF ENGINEERING DIV
MERRIMACK RIVER FLOOD CONTROL
HOPKINTON-EVERETT RESERVOIR
EVERETT DAM
GENERAL PLAN
CONTOOCOOK & PISCATAQUOG RIVERS NEW HAMPSHIRE
APPROVED
DATE JULY 1959
COL., C.E. DEPUTY DIVISION ENGINEER
SCALE AS SHOWN
SPEC NO CIV ENG 19-016-60
DRAWING NUMBER
MER-1-1158
SHEET 89

PLATE 5

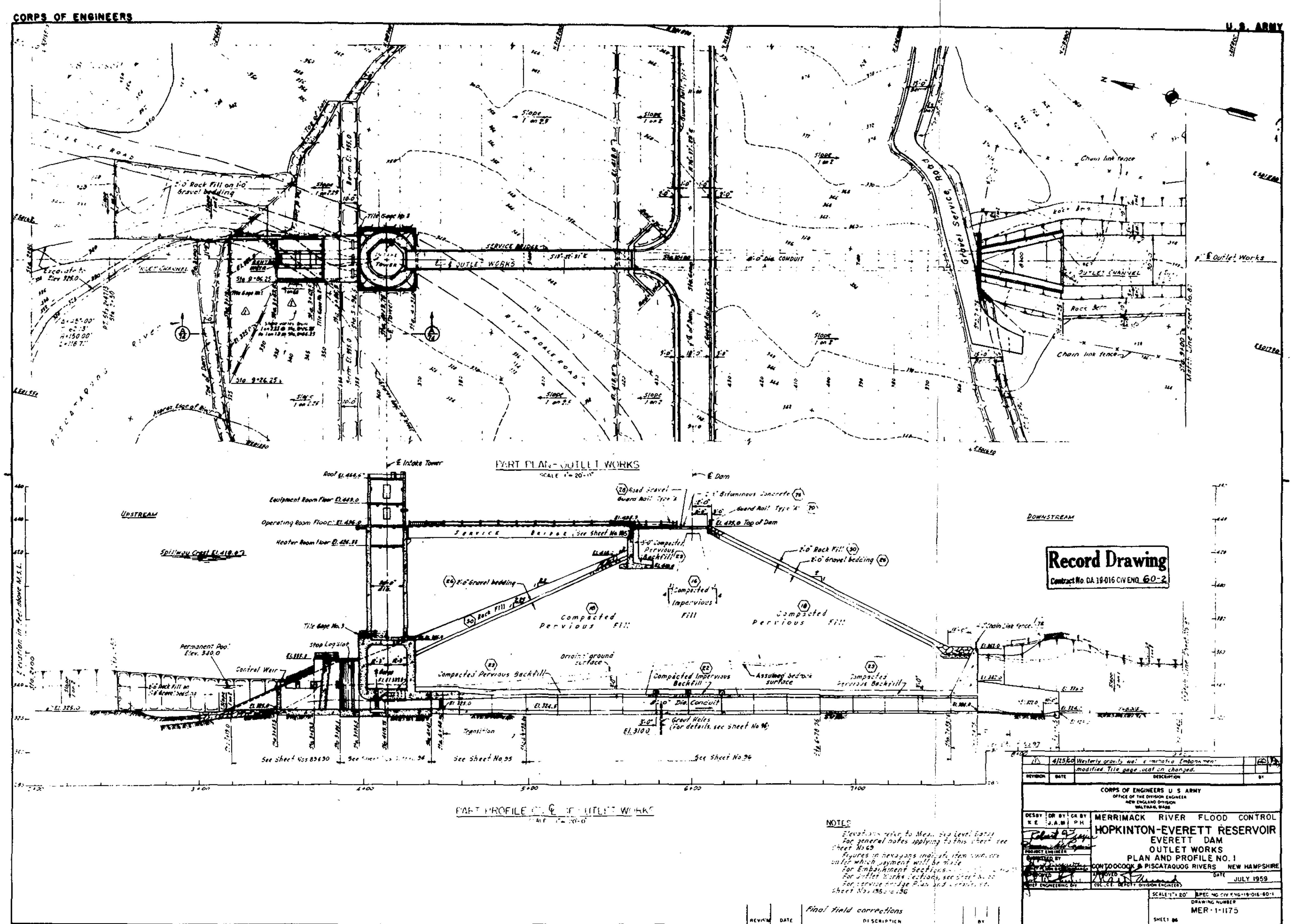
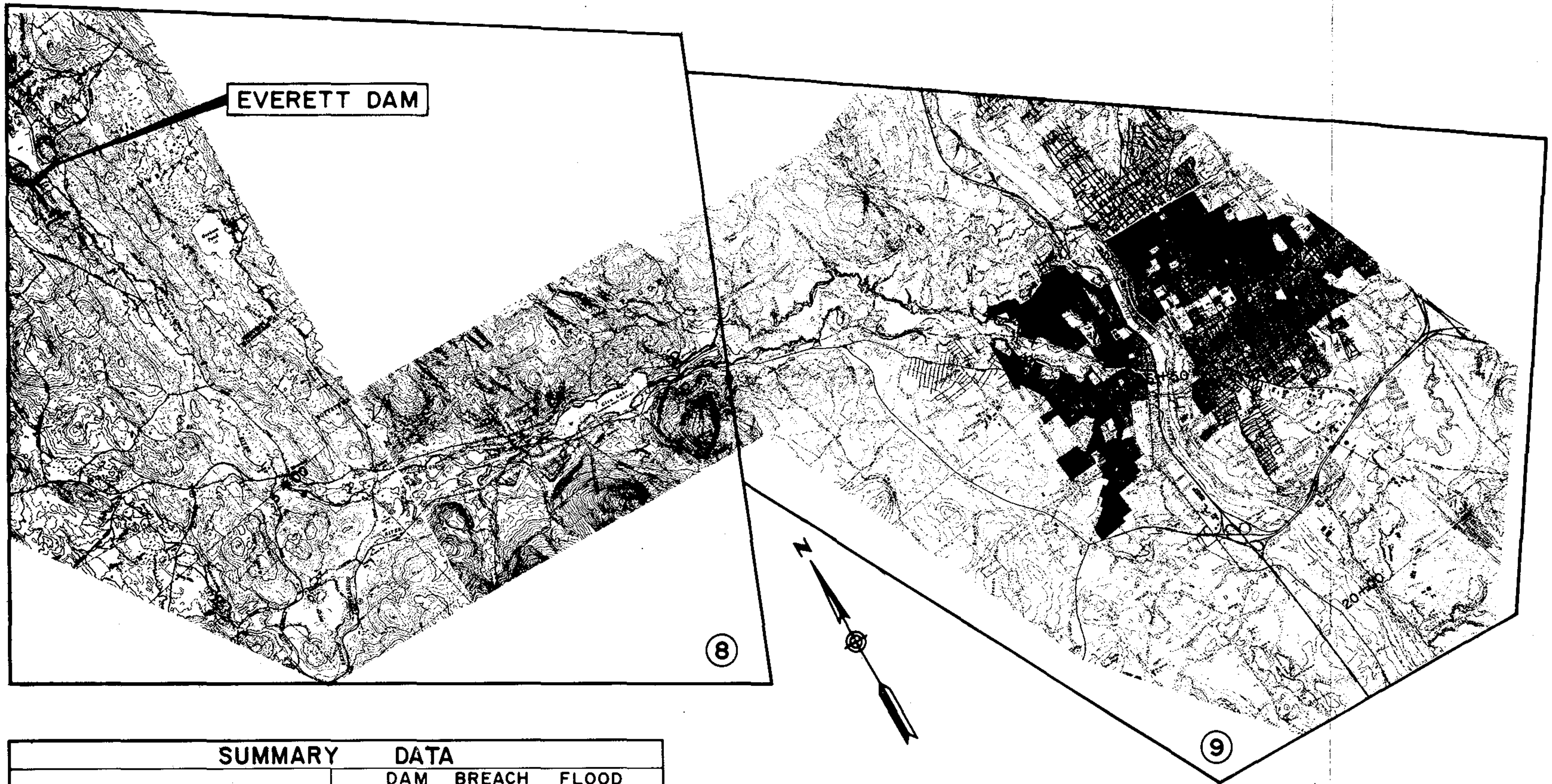

CORPS OF ENGINEERS
U. S. ARMY
PART PLAN - OUTLET WORKS
SCALE 1" = 20'-0"
PART PROFILE ON ℄ OF OUTLET WORKS
SCALE 1" = 20'-0"
UPSTREAM
DOWNSTREAM
Service Bridge
Compacted Pervious Fill
Compacted Impervious Fill
Compacted Pervious Backfill
Compacted Impervious Backfill
Original ground surface
Assumed bedrock surface
Record Drawing
Contract No. DA 19-016 CIV ENG 60-2
NOTES
Final field corrections
CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
WALTHAM, MASS.
MERRIMACK RIVER FLOOD CONTROL
HOPKINTON-EVERETT RESERVOIR
EVERETT DAM
OUTLET WORKS
PLAN AND PROFILE NO. 1
CONTOOCOOK & PISCATAQUOG RIVERS NEW HAMPSHIRE
JULY 1959
MER-1-1175

PLATE 6



SUMMARY DATA						
				DAM BREACH FLOOD		
PLATE NO.	SECTION NO.	RIVER MILE	DIST. D/S FROM DAM (MI.)	* ARRIVAL TIME (HOURS)	* PEAK TIME (HOURS)	PEAK EL. (FT. NGVD)
8	1.00	1.00	1.00	0.40	1.10	395.1
8	5.33	5.33	5.33	1.20	2.00	348.2
8	9.56	9.56	9.56	1.60	3.50	298.2
9	11.27	11.27	11.27	1.80	3.50	222.0
9	14.50	14.50	14.50	2.20	4.50	197.6
9	16.75	16.75	16.75	2.40	4.50	173.0
9	20.80	20.80	20.80	2.60	5.50	165.4

* FROM START OF BREACH FORMATION

LEGEND

INUNDATION MAP PLATE ⑧ — LOCATION OF MAP PANELS

5+00 — RIVER MILES FROM EVERETT DAM

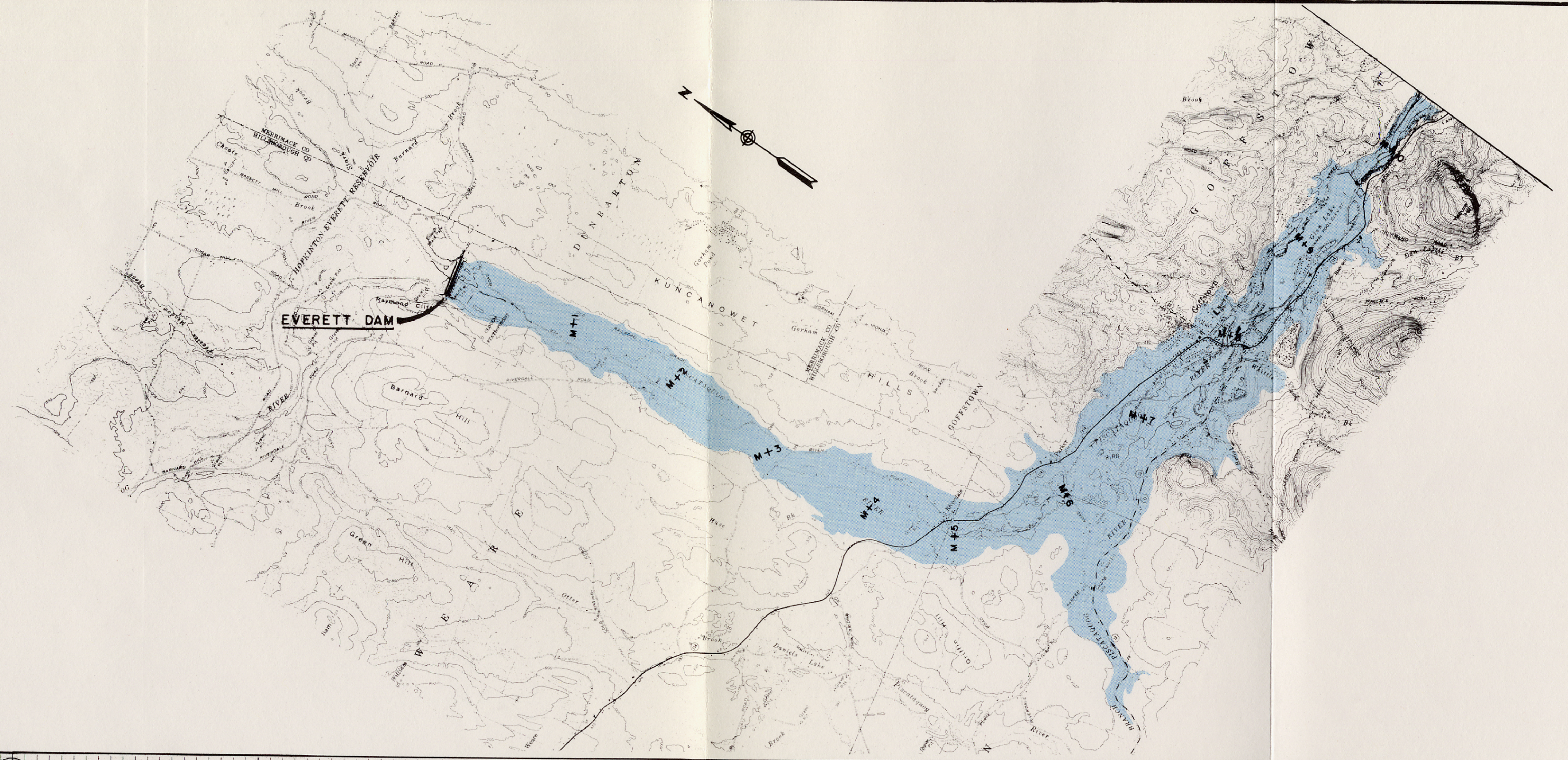
MERRIMACK RIVER BASIN

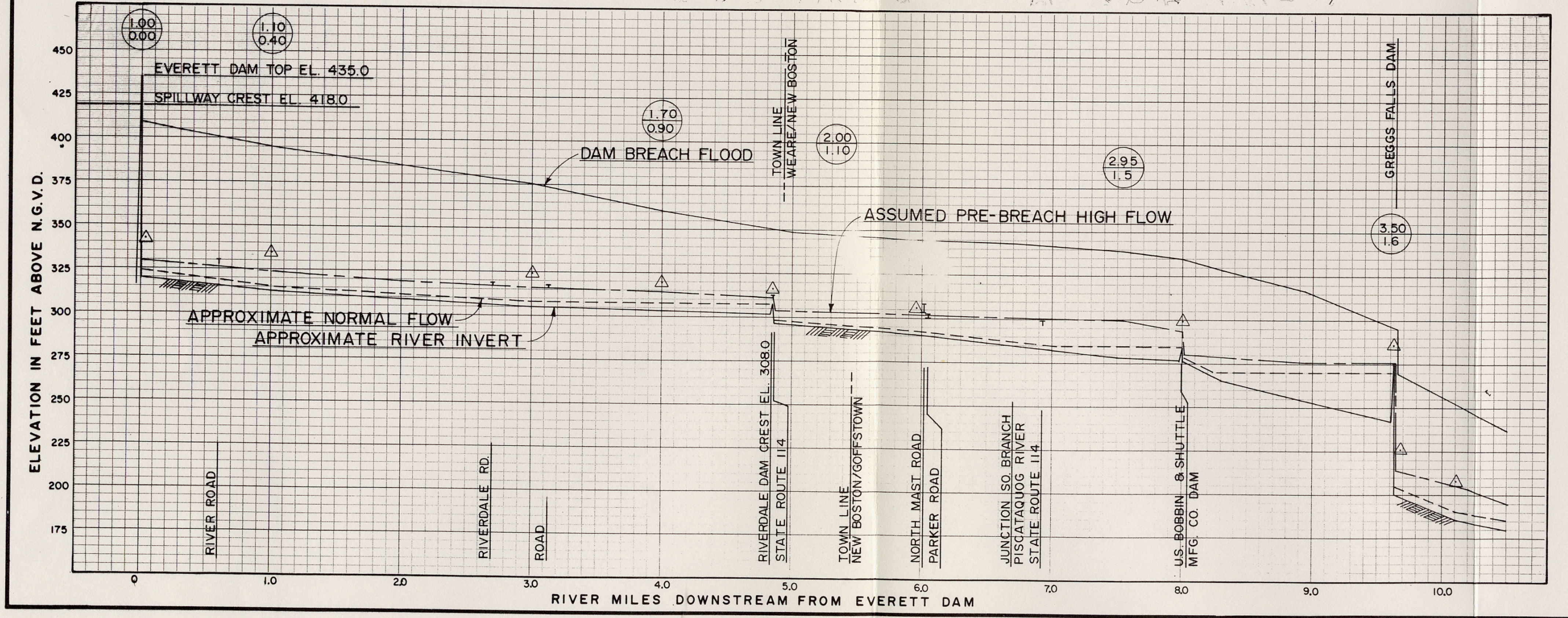
EVERETT LAKE BREACH FLOOD

INDEX MAP

PISCATAQUOG RIVER N.H.
HYDRO. ENG. SECT SEPT. 1983

PLATE 7





LEGEND

- △ EXPERIENCED MARCH 1936 FLOOD ELEVATION
- (2 / .5) HOURS FROM START OF FAILURE TO PEAK STAGE / HOURS TO INITIAL RIVER RISE
- LIMITS OF BREACH FLOOD

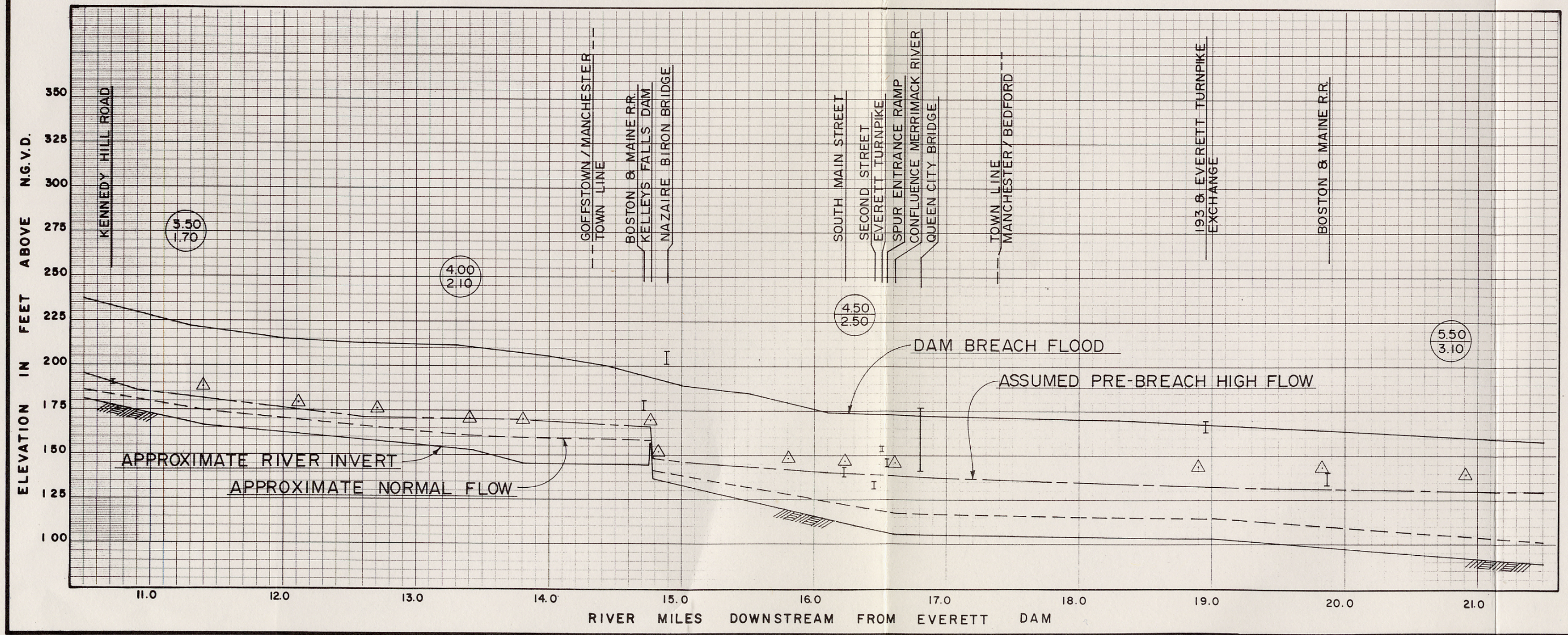
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

MERRIMACK RIVER BASIN

EVERETT DAM BREACH FLOOD

PLAN AND PROFILE NO. 1

HYDRO. ENG. SECT. SEPTEMBER 1983



LEGEND

- △ EXPERIENCED MARCH 1936 FLOOD ELEVATION.
- 2 — HOURS FROM START OF FAILURE TO PEAK STAGE.
- .5 — HOURS TO INITIAL RIVER RISE.
- LIMITS OF BREACH FLOOD.

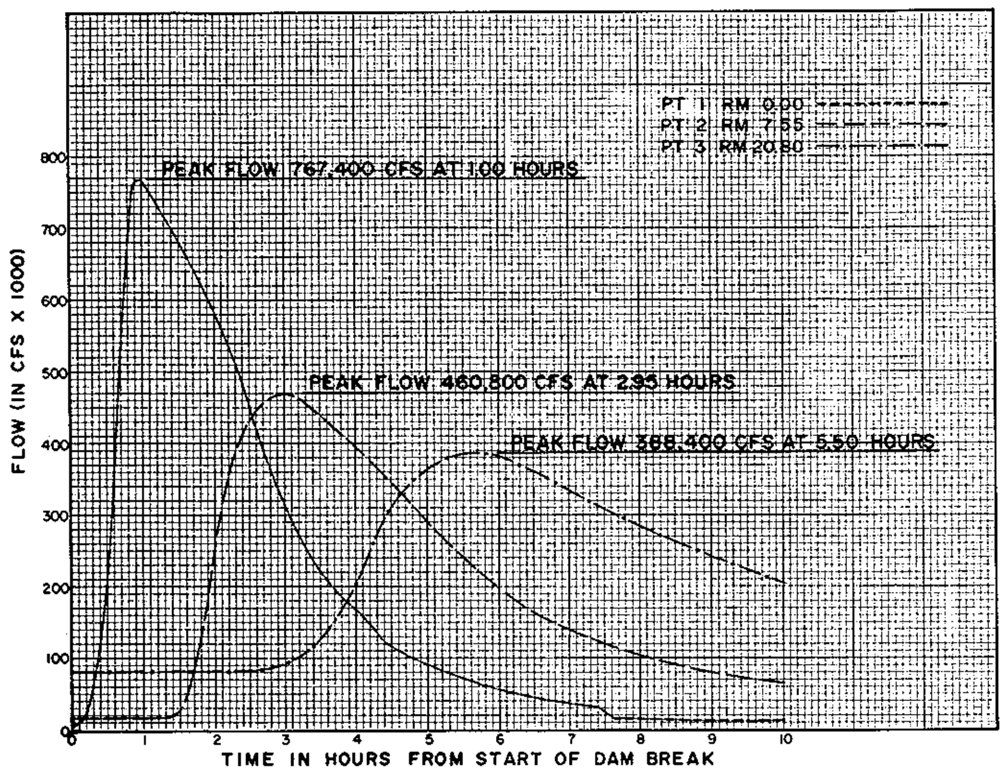
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

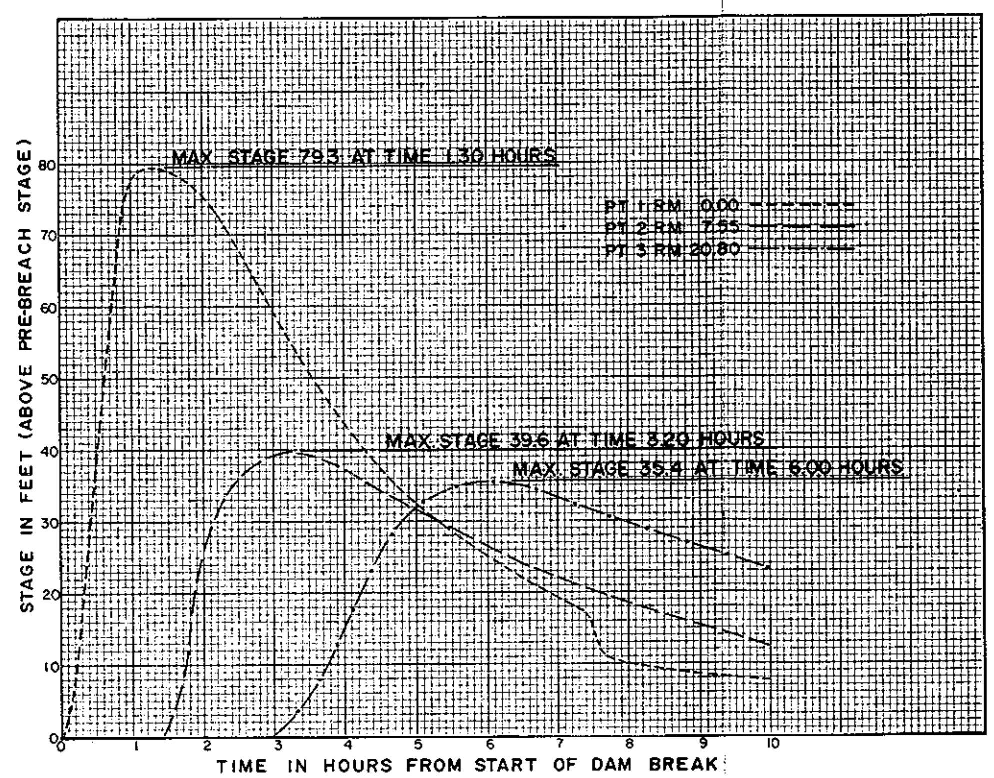
MERRIMACK RIVER BASIN

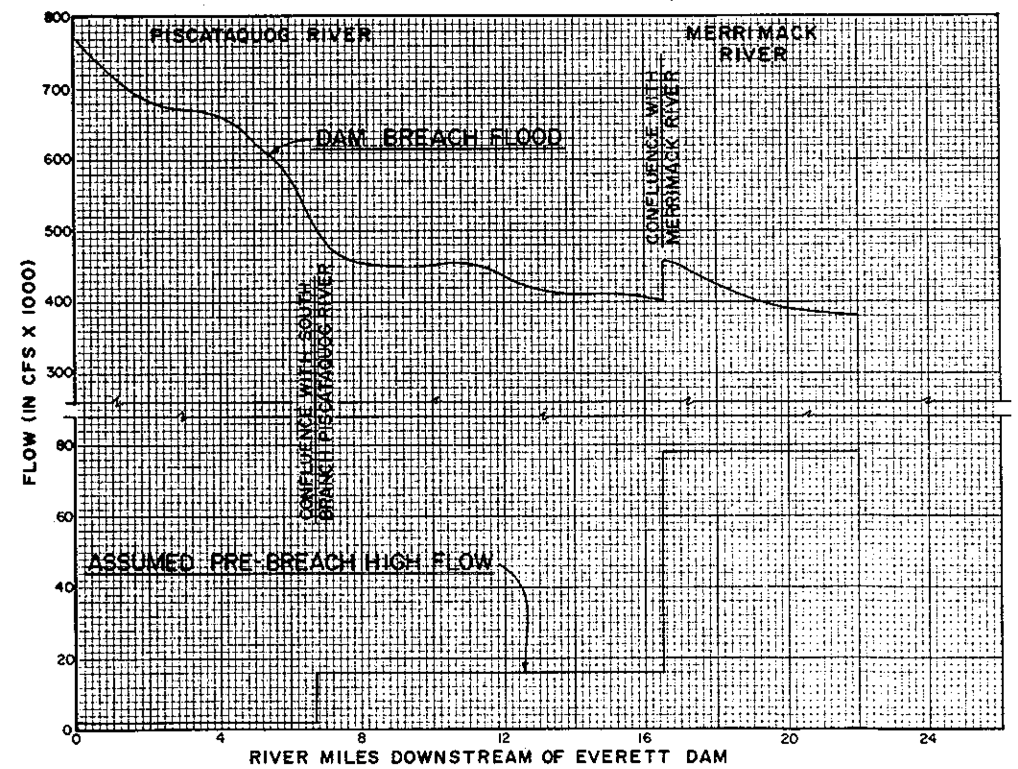
EVERETT DAM BREACH FLOOD

PLAN AND PROFILE NO. 2

HYDRO. ENG. SECT. SEPTEMBER 1983







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CORPS OF ENGINEERS
WALTHAM, MASS.

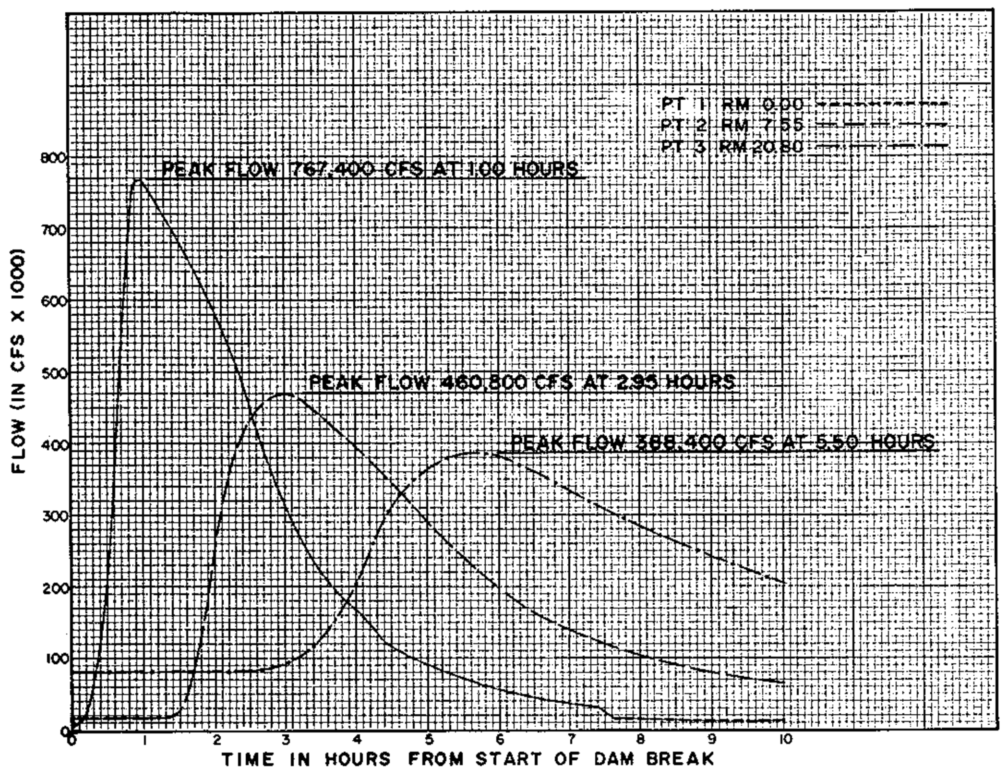
MERRIMACK RIVER BASIN

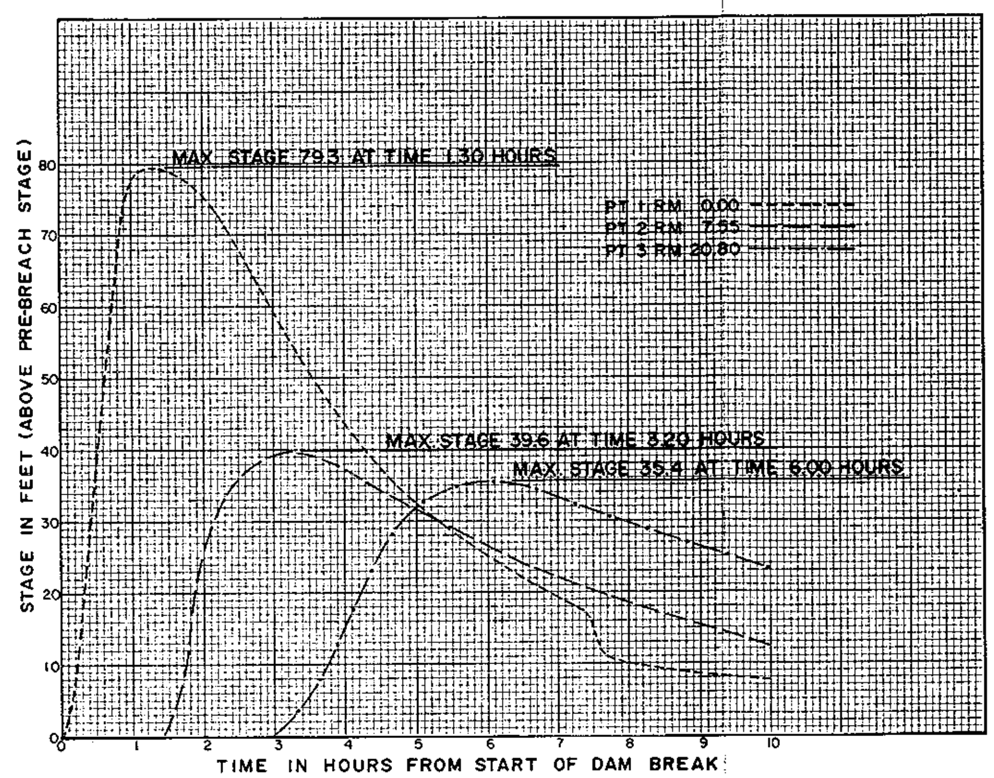
EVERETT DAM BREACH FLOOD

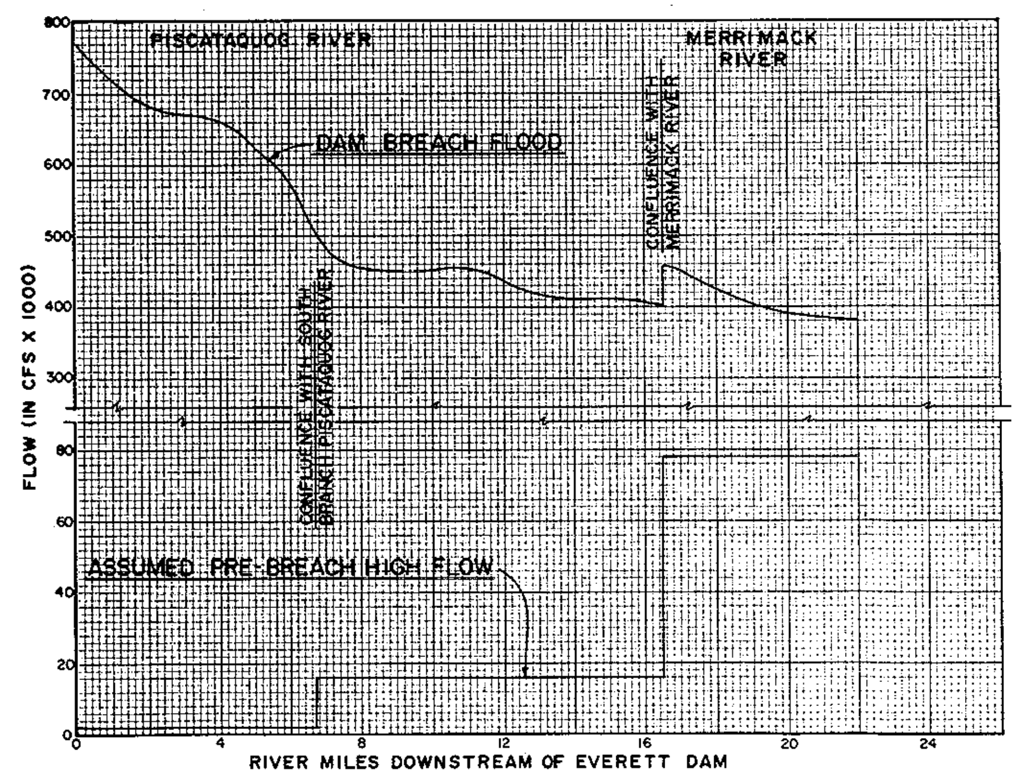
FLOOD DISCHARGES, STAGES AND TIMING

HYDRO. ENG. SECT. SEPTEMBER 1983

PLATE 10







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

MERRIMACK RIVER BASIN

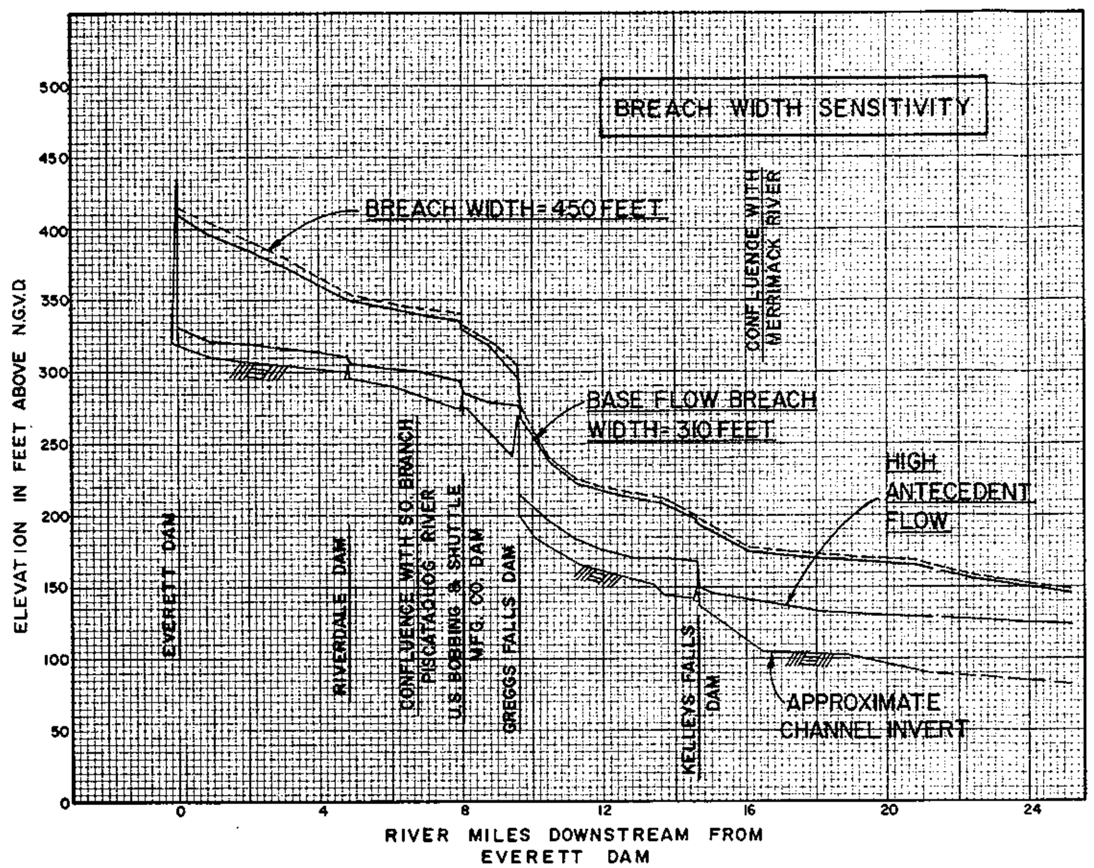
EVERETT DAM BREACH FLOOD

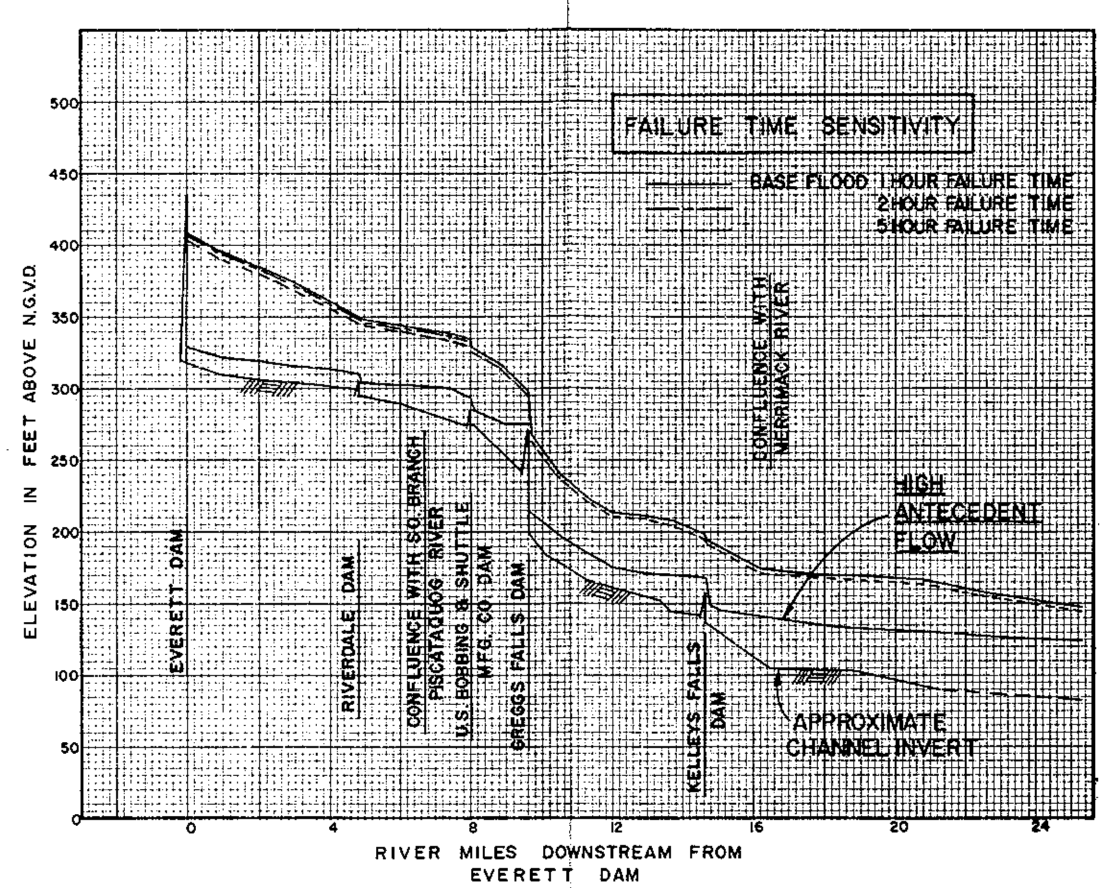
FLOOD DISCHARGES, STAGES AND TIMING

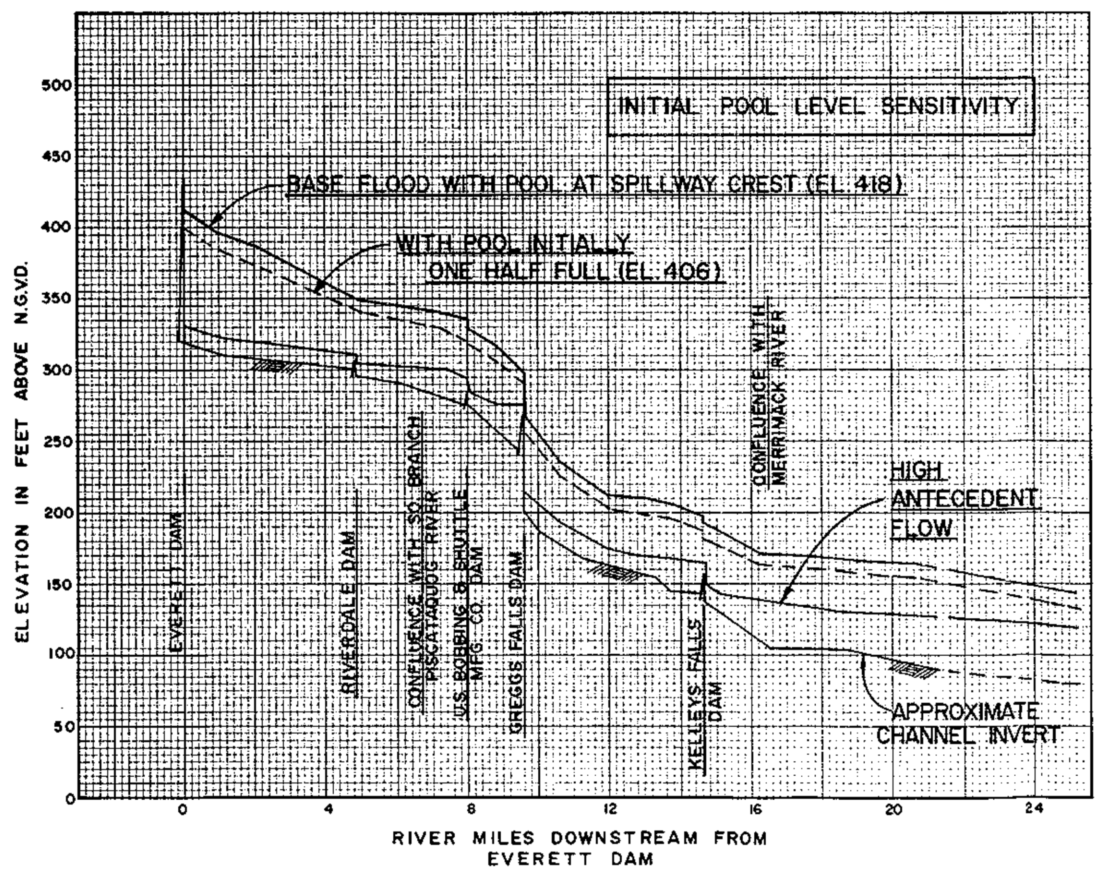
HYDRO. ENG. SECT.

SEPTEMBER 1983

PLATE 10







DEPARTMENT OF THE ARMY
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CORPS OF ENGINEERS
WALTHAM, MASS.

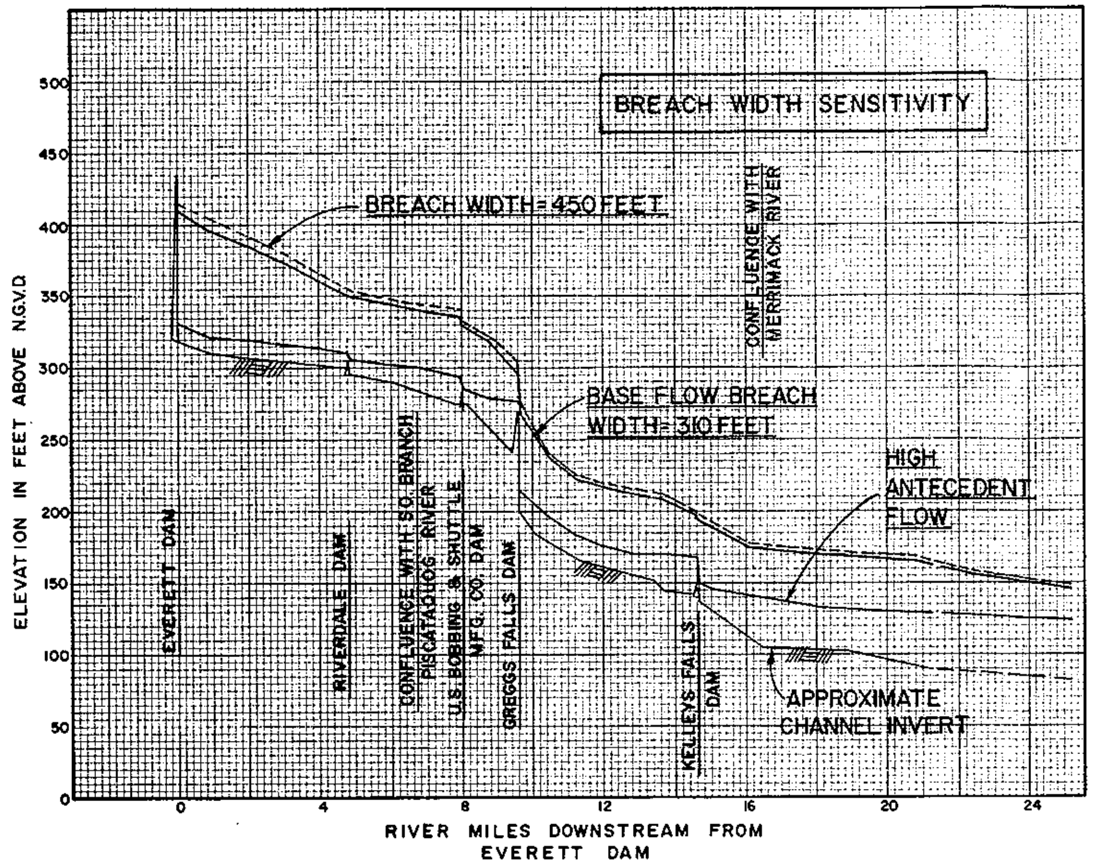
MERRIMACK RIVER BASIN

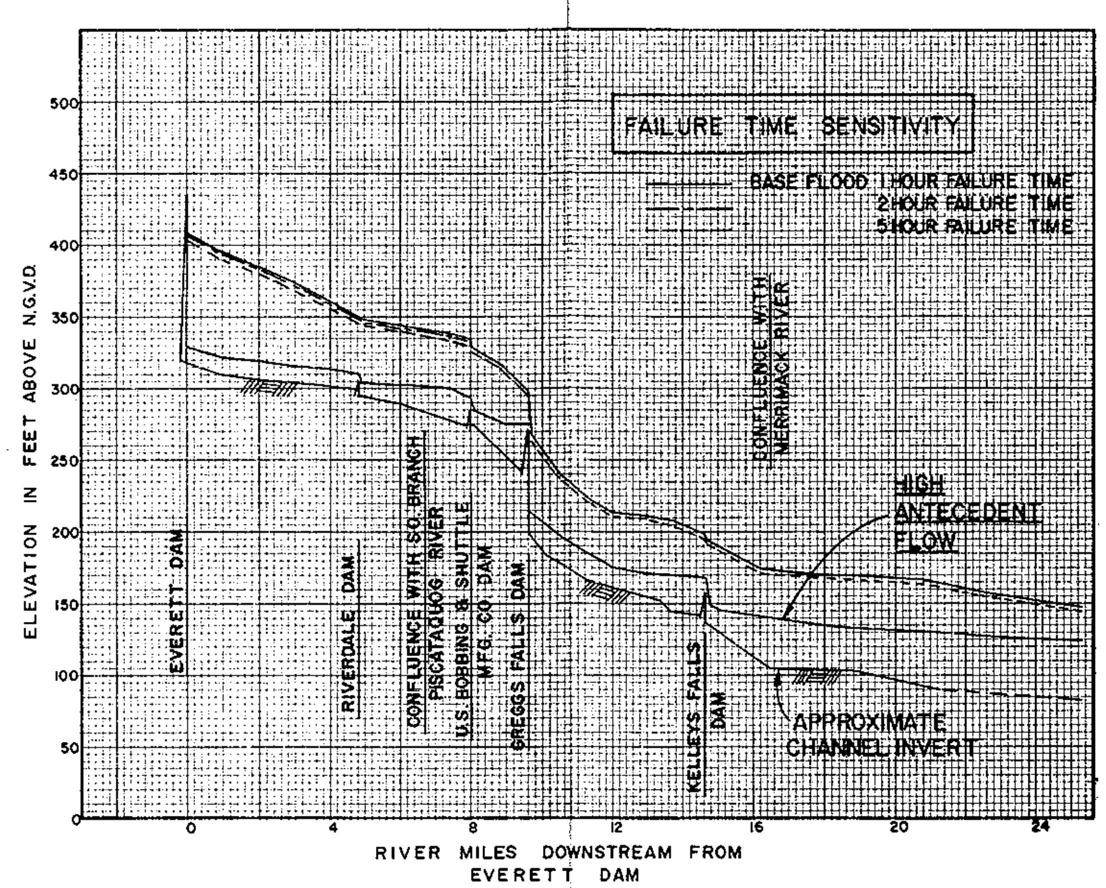
EVERETT DAM BREACH FLOOD

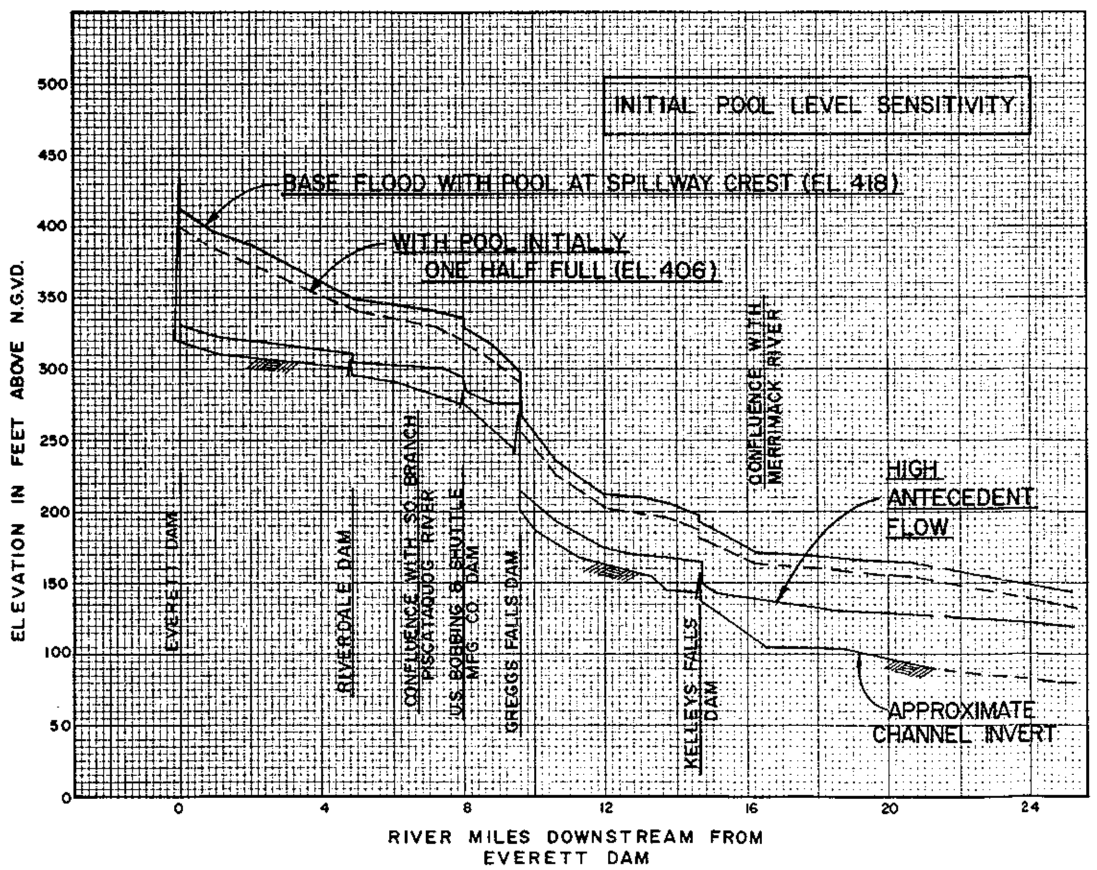
SENSITIVITY OF INPUT PARAMETERS # I

HYDRO. ENG. SECT. SEPTEMBER 1983

PLATE II







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

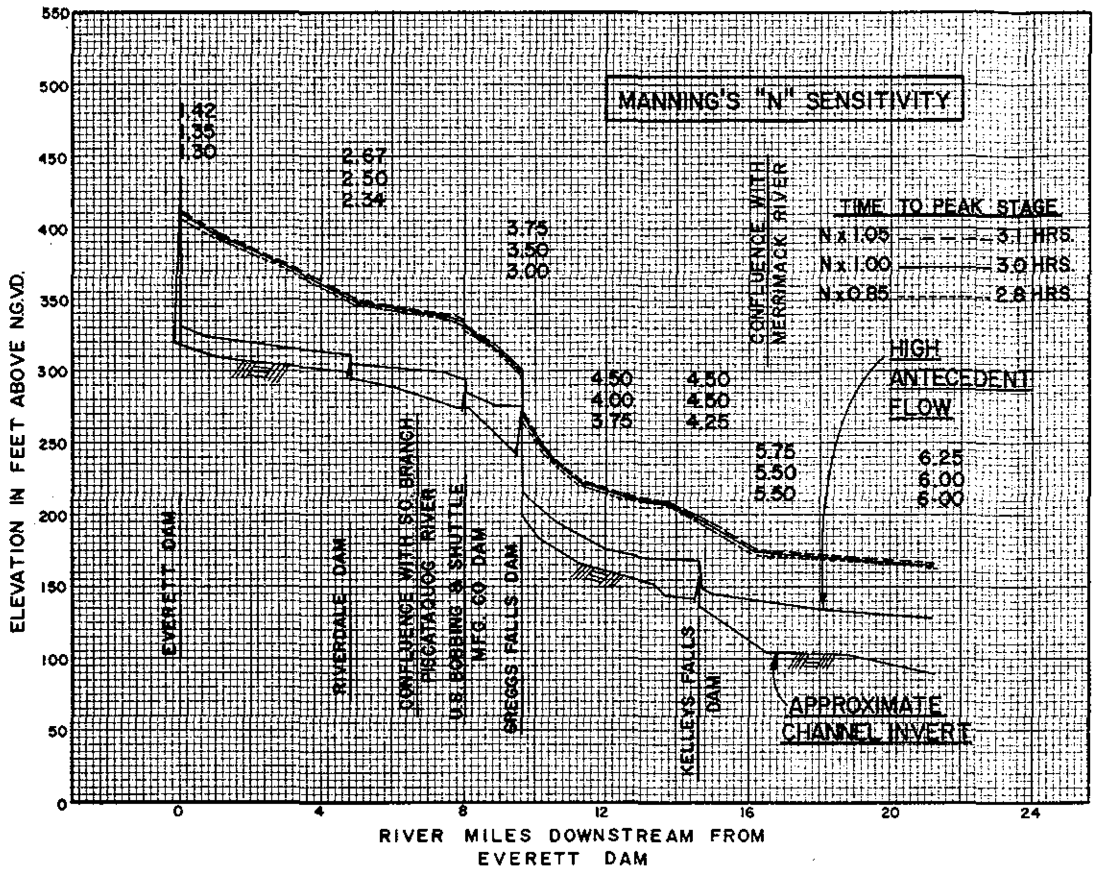
MERRIMACK RIVER BASIN

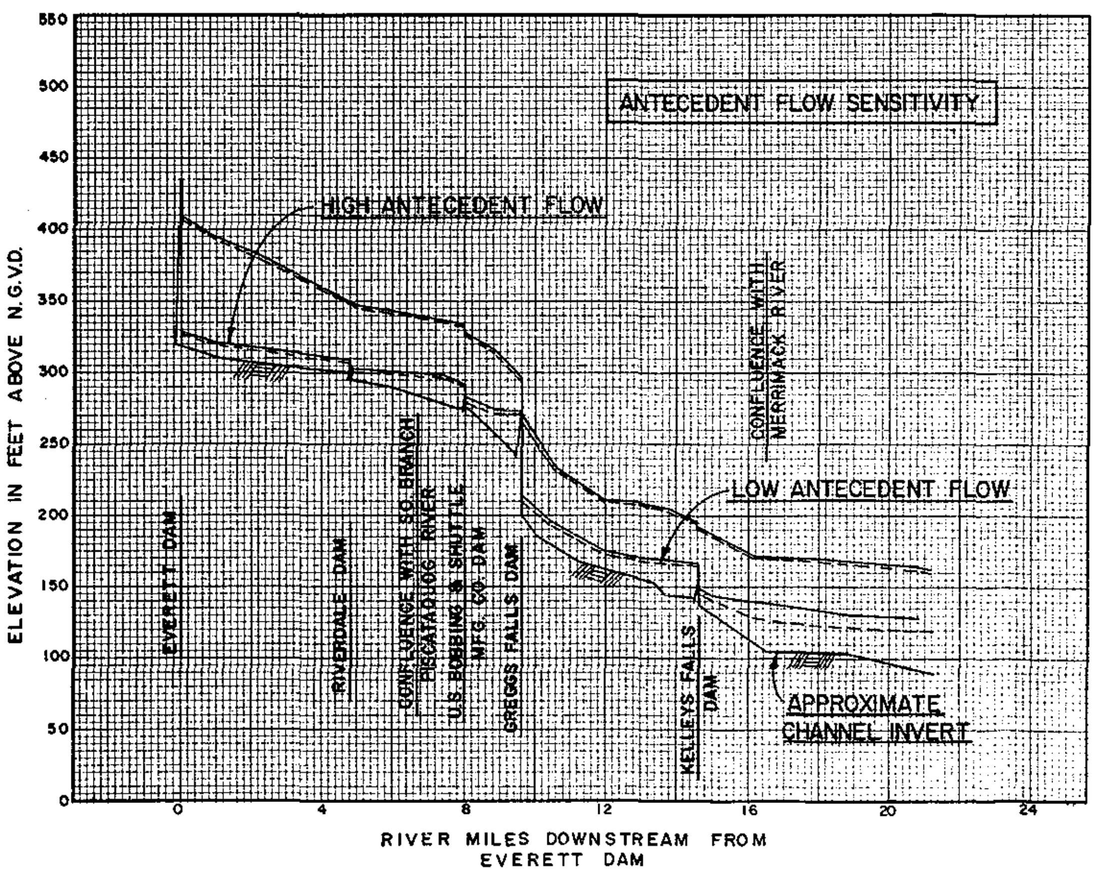
EVERETT DAM BREACH FLOOD

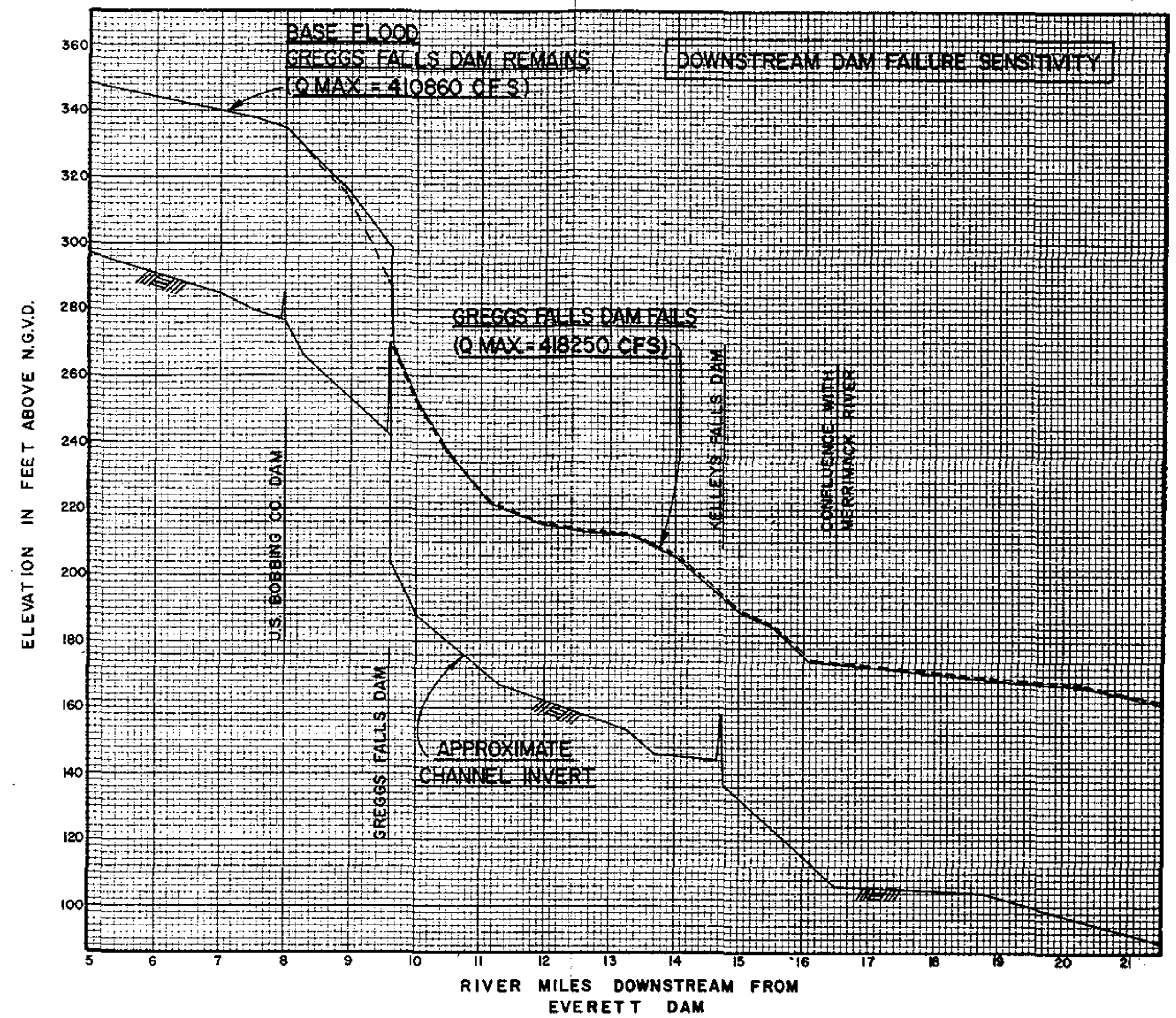
SENSITIVITY OF INPUT PARAMETERS # 1

HYDRO. ENG. SECT. SEPTEMBER 1983

PLATE 11







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

MERRIMACK RIVER BASIN

EVERETT DAM BREACH FLOOD

SENSITIVITY OF INPUT PARAMETERS # 2

HYDRO. ENG. SECT. SEPTEMBER 1983

PLATE 12

```
*HECFORMAT
*ECHO
*FORMATTED
*10FIELDS
*COMPOSITE
*NOCHECK
ID       EVERETT DAM
ID       PISCATAQUOG RIVER N H
ID       MIKE MICHIELUTTI C OF E NED
ID       BLD 115 NO X 162
ID       WALTHAM MASS
IO     9      10       0
IP     3       4
QI 21500   20700   19500   18000   16700   15200   14500   12000   10200    8700
QT  0.00    1.00    2.00    3.00    4.00    5.00    6.00    7.00    8.00    9.00
SN       EVERETT DAM
SE   420     418     416     411     406     401     386     325
SA  7200    6850    6500    5800    5000    2000    1300       0
DN       EVERETT DAM
DD   435     418       0     418      20     .08     325
DB     1     418     310     325       2       0
DO  2000     510       0    5800
DN       US BOBBIN CO DAM
DD   285     285       0     293      20     .08
DO     0     640       0     640
DN       GREGGS FALLS DAM
DD   279     270       0     275      50    0.08
DO     0    1420       0    2840
DN       KELLEYS FALLS DAM
DD   168     158       0     167      20    0.08
DO     0     615       0    1600
RN       BELOW EVERETT DAM
RC   293       0       0       0       0
RG     1       3       6       9      13
XI  0.00    0.00                                     0.2
XE   325     330     340     345     350     360     370     380
XC    80     300     440     470     500     720     880    1000
NC  0.08    0.08    0.08    0.09    0.09   0.095   0.095    0.10
XI  0.30    0.30                                     0.2
XE   318     320     330     340     350     360     370     380
XC    50      80     300     440     500     760     880    1000
NC  0.08    0.08    0.08    0.09    0.09   0.095   0.095    0.10
XI  1.00    1.00                                     0.3
XE   313     320     321     325     330     340     350     360
XC    70     110     490     560     650     800     910    1000
NC  0.08    0.08    0.08    0.09    0.09   0.095   0.095    0.10
XI  2.00    2.00                                     0.3
XE   309     314     316     317     320     330     340     360
XC    40      60      80     755     800     880    1000    1210
NC  0.08    0.08    0.08    0.09    0.09    0.09   0.095    0.10
XI  3.00    3.00                                     0.3
XE   305     312     314     322     330     340     350     360
XC    50      90     530     680     780    1230    1350    1470
NC  0.08    0.08    0.08    0.09    0.09    0.09   0.095    0.10
XI  4.00    4.00                                     0.3
```

XE	304	310	312	320	321	330	345	360		
XC	70	90	760	950	1160	1340	1830	2300		
NC	0.08	0.08	0.09	0.09	0.09	0.095	0.095	0.10		
XI	4.66	4.66					0.2			
XE	302	312	313	320	321	330	340	360		
XC	80	85	90	760	2140	2650	3220	3500		
NC	0.08	0.08	0.09	0.09	0.09	0.095	0.095	0.10		
XI	4.86	4.86					0.2			
XE	297	310	311	320	321	330	340	360		
XC	80	300	410	780	2160	2660	3220	3500		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
XI	5.33	5.33					0.2			
XE	294.5	300	302	305	310	316	319	325		
XC	90	150	2540	2600	2700	2790	3420	3740		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
XI	5.50	5.50					0.2			
XE	294	300	302	308	315	320	330	340		
XC	40	220	1150	1250	1530	1680	1760	2020		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
QN	6.10		SO BR PISCATAQUOG RIVER							
QL	14000	14000	14000	14000	14000	14000	14000	14000	14000	14000
XI	6.10	6.10					0.8			
XE	290	296	299	302	304	311	317	320		
XC	100	130	1510	1600	1720	1850	2220	3140		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
XI	6.70	6.70					0.5			
XE	286	291	292	302	304	311	317	320		
XC	100	130	1510	1600	1720	1850	2220	3140		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
XI	7.55	7.55					0.2			
XE	280	285	290	295	299	308	312	320		
XC	50	160	240	370	760	840	1320	2100		
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10		
XI	7.99	7.99					0			
XE	271	278	288	299	305	310	315	325		
XC	50	70	280	380	820	1320	3180	4530		
RN		BELOW U S BOBBIN CO DAM								
RC	275	0	0	0	0					
RG	2									
XI	8.32	8.32					0.5			
XE	266	271	275	285	293	305	306	310		
XC	50	130	200	450	660	1000	1400	1500		
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.10		
XI	9.56	9.56					0			
XE	243	260	270	281	283	290	298	300		
XC	200	500	610	660	1310	1420	1620	1970		
RN		BELOW GREGGS FALLS DAM								
RC	167	0	0	0	0					
RG	1	3	6	9						
XI	9.60	9.60					0.6			
XE	204	205	206	210	215	220	225	230		
XC	100	300	380	400	430	460	490	530		
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.10		
XI	10.12	10.12					0.3			
XE	185.8	191	196	203	206	213	220	230		

PLATE 13-2

XC	50	90	120	310	380	420	460	530
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.10
XI	11.27	11.27					0.3	
XE	166.5	173	178	185	190	195	199	205
XC	50	110	800	900	920	950	1260	1300
NC	0.08	0.08	0.08	0.09	0.09	0.095	0.095	0.10
XI	12.03	12.03					0.3	
XE	162	166	171	176	179	183	186	190
XC	100	120	150	1420	1560	1570	1580	1590
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10
XI	12.57	12.57					0.3	
XE	158.3	163	165	167	172	177	183	190
XC	30	200	280	1950	2000	2030	2080	2180
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10
XI	13.32	13.32					0.2	
XE	152.5	156	158	165	170	175	180	190
XC	40	120	1820	1870	1900	1950	1980	2060
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10
XI	13.72	13.72					0.2	
XE	145.7	156	167	169	174	180	190	200
XC	90	140	200	780	820	840	890	950
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.10
XI	14.00	14.00					0.5	
XE	146	157	162	165	166	187	189	200
XC	50	220	470	550	1220	1290	1680	1760
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10
XI	14.50	14.50					0	
XE	144	152	160	170	175	182	190	200
XC	40	300	560	680	780	850	950	1030
RN	BELOW KELLEYS FALLS DAM							
RC	122	0	0	0	0			
RG	1	5	8	12	15	18		
XI	14.73	14.73					0.1	
XE	137	140	145	150	155	160	170	180
XC	140	200	230	260	390	500	640	700
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.10
XI	15.00	15.00					0.2	
XE	132	140	150	155	160	167	174	180
XC	200	340	460	620	760	910	1050	1140
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.095	0.095
XI	15.50	15.50					0.5	
XE	121	130	135	140	150	153	160	170
XC	140	220	720	1160	1220	1360	1420	1460
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.095
XI	16.10	16.10					0.2	
XE	113	121	130	140	150	155	160	170
XC	100	130	160	200	340	430	500	650
NC	0.08	0.08	0.085	0.085	0.09	0.09	0.095	0.10
XI	16.30	16.30					0.2	
XE	110	120	129	130	135	140	145	150
XC	100	210	310	530	665	800	1310	1480
NC	0.08	0.08	0.08	0.085	0.085	0.09	0.09	0.095
XI	16.45	16.45					0.05	
XE	107	118	129	130	135	140	145	150
XC	180	270	360	640	930	1120	1480	1760

PLATE 13-3

NC	0.08	0.08	0.08	0.085	0.09	0.095	0.095	0.095		
QN	16.50		MERRIMACK RIVER JUNCTION							
QL	64000	64000	64000	64000	64000	64000	64000	64000	64000	64000
XI	16.50	16.50					0.4			
XE	106	116.5	118	140	142	153	155	163		
XC	100	230	500	630	1070	1750	2400	2600		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	16.75	16.75					0.1			
XE	105	120	130	135	140	145	150	160		
XC	200	320	460	670	1400	1770	2300	2570		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	17.80	17.80					0.5			
XE	105	113	121	130	135	143	150	160		
XC	400	470	530	600	750	1140	1400	1500		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	18.80	18.80					0.5			
XE	104.5	125	136.5	139	141	142.5	150	159		
XC	620	750	810	940	1340	1570	1680	1800		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	19.20	19.20					0.5			
XE	102.5	110	120	130	136	143	150	160		
XC	500	600	750	900	1140	1440	1710	2000		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	19.60	19.60					0.1			
XE	100	107	110	117	126	131	140	150		
XC	360	790	830	880	940	970	1430	1660		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	19.65	19.65					0.05			
XE	99.5	135	136	150	154	159	161.5	170		
XC	780	1200	1250	1690	2130	2170	2320	2400		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	19.70	19.70					0.5			
XE	99	102	107	112	116	140	141	160		
XC	160	240	370	640	690	690	2000	2050		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	20.80	20.80					0.5			
XE	93	100	105	110	116	123	131	140		
XC	100	310	450	520	600	700	820	1000		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	21.80	21.80					0.5			
XE	87	97	109	113	125	134	136	140		
XC	70	290	350	400	460	500	540	750		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	23.40	23.40					0.5			
XE	84	90	95	105	115	120	130	140		
XC	100	240	350	430	500	700	1060	1400		
NC	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06		
XI	25.20	25.20					0			
XE	81	87	90	120	124	130	135	140		
XC	150	300	380	1460	1640	1780	2620	2780		
ZZ										

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