Little River

Massachusetts

# BUFFUMVILLE LAKE DAM - BREAK FLOOD ANALYSIS

SEPTEMBER 1984



US Army Corps
of Engineers
New England Division

# BUFFUMVILLE LAKE DAM

THAMES RIVER BASIN

MASSACHUSETTS

DAM-BREAK FLOOD ANALYSIS

FOR

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASSACHUSETTS

SEPTEMBER 1984

BY


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BUFFUMVILLE LAKE DAM

DAM-BREAK ANALYSIS

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# DAM-BREAK FLOOD ANALYSIS

## 1. INTRODUCTION AND PURPOSE

This report presents the findings of a dam-break flood analysis performed for the Buffumville Lake Dam, an existing Corps of Engineers Flood Control Project, which is located near Oxford, Massachusetts. The dam is situated on Little River approximately one and three-quarter miles upstream of the confluence of Little River with the French River. Included in this report is a description of the pertinent features of the dam, the procedure used for the analysis, the assumed dam-break conditions and resulting effects on downstream flooded areas, and the effects of varying conditions (sensitivity tests) on the resulting downstream flood. This study was not performed because of any known likelihood of a dam-break at Buffumville Lake Dam. Its purpose is to provide quantitative information for emergency planning use in accordance with Corps of Engineers Regulations (ER 1130-2-419).

## 2. PROCEDURE

The Buffumville Lake dam-break analysis was made using the HEC version of 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 for the model consisted of: (a) storage characteristics of the reservoir, (b) selectd geometry and duration of the breach development, (c) hydraulic inflows, (d) hydraulic roughness coefficients, and (e) active and inactive flow regions. Based on the input data, the model computes the dam-break outflow hydrograph and routes it downstream. Dynamic unsteady flow routing is performed by a "honing" iterative process governed by the requirements of both the principles of conservation of mass and momentum. The analysis provides output on the attentuation of the flood hydrograph, resulting flood stages, and timing of the flood wave as it progresses downstream.

The approach used in this hypothetical dam-break analysis was first to apply the model using a selected set of conditions thought to be reasonably possible in a failure situation. The flood resulting from this analysis is termed the Base Flood Condition. Because any one of the major variables used in the model (initial pool elevation, antecedent riverflow, time of breach development, breach width, Manning's "n"), could in fact have different values occuring in different combinations from those used in the Base Flood determination, sensitivity analysis were employed to determine the effects that changed values of these parametes have upon the resulting flood wave.

Calibration of the model was accomplished by comparing computed stage-discharge relationships with those known to exist during the August 1955 flood at various locations along the river reach being modeled (i.e., at dams, stream flow gages, high watermarks, etc.).

3. DESCRIPTION OF STUDY AREA

a. General: The study area extends from Buffumville Lake Dam, downstream along the Little River to its confluence with the French River near Oxford, MA, down the French River to its confluence with the Quinebaug River above Putnam, CT and down the Quinebaug River to the U.S.G.S. gage below Putnam. The total study reach distance is 19.2 miles. Along the study reach, the drainage area increases from 26.5 square miles at Buffumville Lake Dam to 331 square miles at the U.S.G.S. gage below Putnam. The study reach has no major tributaries but there are several minor tributaries including Mill Brook on the French River above Webster and Little River on the Quinebaug River below Putnam. The main purpose of Buffumville Lake Dam, in conjunction with the upstream system of reservoirs, is to provide flood protection for the local communities along the French River and Quinebaug River. A map of the Thames River Basin showing the location of Buffumville Lake Dam is shown on Plate 1.

b. Buffumville Lake Dam: This dam is located in the Town of Charlton, MA. The Corps of Engineers constructed the dam as a multi-purpose project, and placed it in operation in 1958. Flood control and recreational activities are provided by the dam and impounded lake. The project is 1 of 6 flood control reservoirs in the Quinebaug River Watershed and Thames River Basin which were built by the Corps of Engineers. Buffumville Lake Dam is a rolled earthfill embankment having a length of 3,255 feet, a maximum height of 66 feet (a photo of the structure is shown on Plate 2). Top width of the dam is 20 feet and the side slope is 1V on 2H on upstream and downstream faces. The General Plan and Outlet Works (profile and sections) are shown on Plates 3 and 4 respectively. When filled to spillway crest elevation, 524 feet, the reservoir has a total capacity of 12,720 acre-feet, equivalent to 9.02 inches of runoff from the 26.5 square mile drainage area. The reservoir length, at spillway crest, formed by this 530 acre pool is 3 miles. A recreation pool of 200 acre-feet at an elevation of 492.5 feet NGVD is permanently maintained. Other pertinent data is listed in Table 1.

c. Downstream Valley: The study reach which consist of the Little River, French River and the Quinebaug River travel though four communities prior to reaching the limit of study below Putnam, CT. The communities are Webster, MA, North Grosvenor Dale, CT, Grosvenor Dale, CT., all on the French River, and Putnam, CT. on the Quinebaug River. Little River is a narrow waterway, dropping 30 feet in its 1.75 mile course from Buffumville Lake Dam to the French River. Its width averages 25 feet. The floodplain of the Little River is wide, typically 500 to 1000 feet. The French River normally is 60 feet wide but can be up to 750 feet wide. The French River floodplain is generally 1000 feet wide but can widen to 3000 feet. The French River drops 160 feet in the 14.5 mile course of the study reach. The majority of the drop occurs at doms. The Quinebaug River, in the study reach, is typically 200 feet wide with a wide floodplain, up to 2000 feet. The Quinebaug River, between the French River and U.S.G.S. gage is controlled by 3 dams with a total drop of 70 feet of which approximately 60 feet occurs at the 3 dams.

Eleven dams are located on Little River, French River and Quinebaug River in the study reach. They are: Gordan Dam, Dudley Woolen Co. Dam, American Woolen Co. Dam, Webster Record Co. Dam, Wilsonville Dam, Cluett-Peabody Co. Dam, Upper Belding Co. Dam, Consol Bleaching Co. Dam, Bel-Hem Dam, Quinebaug Valley Cold Storage Co. Dam and Cargil Dam.

The following is a brief description of the dams in downstream order. This information has been taken from the Corps of Engineers Inventory of Dams and Phase I Inspection Reports. This information has not been field verified.

# TABLE 1

## BUFFUMVILLE LAKE DAM

## PERTINENT DATA

| | |
|---|---|
| LOCATION: | Little River, Oxford, MA. |
| DRAINAGE AREA: | 26.5 square miles |
| RESERVOIR: | Outlet works intake (Invert) 481.5 feet NGVD<br>Recreational Pool: 492 feet NGVD<br>Flood Control Pool (Spillway Crest): 524 feet NGVD |
| DAM: | Type : Rolled earth fill with rock protection<br>Length: 3255 feet<br>Top width: 20 feet<br>Top Elevation: 539 Feet NGVD<br>Maximum Height: 66 feet |
| SPILLWAY: | Type: Concrete, ogee weir<br>Length: 220 feet<br>Crest Elevation: 524 feet NGVD<br>Surcharge: 10.3 feet<br>Capacity: 29,800 cfs |
| OUTLET WORKS: | Type: Three, rectangular concrete conduits<br>Length: 44 feet<br>Gates: Number 3<br>Size: 3' x 4.5'<br>Normal Regulated Maximum Flow: 350 cfs<br>Maximum Capacity at Spillway Crest: 1820 cfs |

(1) Gordon Dam: This structure is located 1/2 mile from Buffumville Lake Dam on the Little River and has a top elevation of approximately 479 feet NGVD. It is a masonry block structure with a hydraulic height of 15 feet and a spillway length of 65 feet. Buffum Pond is impounded by this structure with a significant but unknown volume.

(2) Dudley Wooden Co. Dam: This dam is located 5.8 miles below Buffumville Lake Dam on the French River, in Webster, MA. It is also a masonry block structure with a hydraulic height of 12 feet and a spillway length of 225 feet. No significant storage is maintained by this dam.

(3) American Wooden Co. Dam: This dam, also known as South Village Pond Dam is 6.5 miles below Buffumville Lake Dam on the French River, in Webster, MA. It has a concrete ogee spillway with a height of 20 feet and a spillway length of 125 feet. It has no significant storage capacity.

(4) Webster Record Co. Dam: This dam is located 9.2 miles below Buffumville Lake Dam on the French River. It is masonry block structure with a height of 15 feet and a spillway length of 150 feet. No significant storage is impounded by this dam.

(5) Wilsonville Dam: This dam, also known as Lagers Pond Dam, is 10.2 miles below Buffumville Lake dam on the French River. The dam is constructed of stone masonry and is 12 feet high with a spillway length of 150 feet. It is a run-of-the-river facility and has no significant storage.

(6) Cluett-Peabody Co. Dam: This dam, also known as North Grosvenordale Pond Dam is located 11.6 miles below Buffumville Lake Dam on the French River in Norh Grosvenor Dale, CT. It is a composite masonry and earth dam, with a height of 22 feet and a spillway length of 200 feet. The dam impounds 840 acre-feet when water elevation is at top of dam.

(7) Upper Belding Co. Dam: This dam is located 13.5 miles below Buffumville Lake Dam on the French River in North Grosvenor Dale, CT. It is a granite block structure 15 feet high with a spillway length of 110 feet. The dom impounds no significant amount of storage.

(8) Consol-Bleaching Co. Dam: This dam, also known as Mechanicsville Dam, is located 16 miles below Buffumville Lake Dam on the French River in Mechanicsville, CT, just above the Quinebaug River confluence. This dam is a composite masonry and earth dam 18 feet high with a spillway length of 300 feet. It has no significant storage capacity.

(9) Belding Hemingway Co. Dam: Located in Putnam, CT, about 17.9 miles downstream from Buffumville Lake Dam, this masonry stone gravity structure is about 200 feet long and 12 feet high. The overflow type spillway is about 150 feet long with an abandoned powerhouse on the right bank. Spillway capacity is 7300 cfs with water at the top of the abutments. The dam has a drainage area of 289 square miles and a maximum storage capacity of approximately 287 acre-feet.

(10) Quinebaug Valley Cold Storage: Located in Putnam, CT, about 18.2 miles downstream from Buffumville Lake Dam, this masonry stone, gravity structure is 150 feet long and has a maximum height of 16 feet. A hydroelectric powerhouse on the right bank is presently being rehabilitated. The dam has a 290 square mile drainage area and a maximum spillway discharge of 8900 cfs occurs when water is at the top of abutment.

(11) Cargill Dam: Located in Putnam CT, 19.0 miles downstream from Buffumville Lake Dam. It is a concrete structure, equipped with a Bascule gate to control flow over its 150 foot long spillway. The structure has a maximum height of 23 feet, a spillway capacity of 36,000 cfs, and a maximum storage capacity of 129 acre-feet. The drainage area of the dam is 291 square miles.

4. ASSUMED DAM-BREAK CONDITIONS

a. General: The magnitude of a flood resulting from the hypothetical failure of Buffumville Lake Dam is a function of many different parameters including size of breach, initial pool level and storage, rate of breach formation, channel and overbank roughness, and antecedent flow conditions. Engineering assumptions of conditions which could be reasonably expected to exist prior to a failure of Buffumville Lake Dam, were used in the base flood analysis as presented below:

(1) Initial Pool Level - Buffumville Lake Dam: Water surface at spillway crest elevation: 524 feet NGVD indicating 100% use of available flood control storage.

(2) Reservoir Inflow: Actual August 1955 (flood of record) riverflow, 7700 cfs.

(3) Breach Invert: 482 feet NGVD.

(4) Breach Base Width: 200 feet, trapezodial side slopes 1V:.5H.

(5) Time to Complete Formation of Breach: 1 hour.

(6) Downstream Channel Roughness: Mannings's "n" = .030 to .100.

(7) Pre-Breach Flow- Little River: A constant discharge of 1800 cfs from Buffumville Lake Dam, equivalent to the maximum outlet works capacity of the pool at spillway crest, was selected for this study to provide computational stability in the numerical simulation technique. Actual releases equivalent to the nondamaging channel capacity of 350 cfs are normally made. (This difference in flow would have little effect on dam failure flood wave elevations).

b. Selected Base Flood: Antecedent flow conditions on the Little River, French River and the Quinebaug River were selected to equal the recurring August 1955 record flood flows as modified by the existing system of Corps of Engineers flood control reservoirs in the Quinebaug River Watershed. Specifically, model input data for inflow into Buffumville Lake consisted of the recessional side of the August 1955 flood hydrograph. This was then routed through the reservoir assuming the pool was already filled to spillway crest level during the rising side of the same hydrograph. The initial and peak inflow rate just prior to the beginning of failure was equal to 7700 cfs and outflow from Buffumville Lake Dam's regulating gates was assumed to be a constant 1800 cfs. Peak inflows to the study reach below Buffumville Lake Dam include 525 cfs at the confluence with the French River and 3100 cfs as local inflow in the town of Webster, 3600 cfs as local inflow at mouth of French River, 2300 cfs at the confluence with the Quinebaug River. The adopted initial antecedent flows and the comparative experienced 1955 discharges, as applicable, are shown in Table 2.

TABLE 2

FLOWS

| | ADOPTED ANTECEDENT | EXPERIENCED AUGUST 1955 |
|---|---|---|
| Buffumville Outflow | 1,800 | 7,700 |
| At Confluence with French River | 2,325 | 11,000 |
| At Webster | 4,900 | 14,000 |
| At Putnam | 12,400 | 48,000 |

5. RESULTS

The resulting peak stage flood profile and the areal extent of inundation for the base flood conditions are shown on Plate 6 through 9. Timing of the peak stage and leading edge of the flood wave are also indicated on the plan and profile. Peak discharge throughout the study reach associated with the development of the peak stage profile along with discharge and stage hydrographs for three stations downstream from Buffumville Lake Dam are shown on Plate 10. The three stations are located .05, 2.96 and 18.54 miles downstream of the dam.

The peak dam-break discharge from Buffumville Lake Dam is 141,600 cfs producing a rise of approximately 22 feet above the pre-breach river depth at a point .05 miles downstream from the dam. From Buffumville Lake Dam to the Little River confluence with the French River, a distance of 1.80 miles, the peak flow would attentuate to 82,300 cfs and the depth of flow on the Little River at this location would be approximately 22 feet above pre-breach river stage.

At a distance of 2.96 miles, below Buffumville Lake Dam, the peak flow would attenuate to 56,600 cfs and the rise over pre-breach stage would be 18 feet. At a distance of 18.54 miles, in Putnam, CT, the wave would alternate to a flow of 37,700 cfs with an attendant maximum rise over pre-breach stage of 4 feet. Most of the attenuation of the flood wave occurs in the first four miles below Buffumville Lake Dam.

The dam-break analysis was terminated at the U.S.G.S. gage below Putnam, CT. The water surface elevation produced from the dam-break flow analysis, at the gage, was lower than that experienced in th August 1955 flood.

## 6. SENSITIVITY TESTS

In addition to the analysis under the assumed dam-break conditions, subsequent studies were made to determine the sensitivity of certain selected paramenters on the resulting downstream flood. Following are the variables considered:

a. Breach Width: The breach width was set at 200 feet for the base flood analysis. For sensitivity testing, two additional cases were analyzed with breach widths of 100 and 400 feet. As shown by comparative profile on plate 11, the 100 foot breach resulted in a flood stage 6 feet lower than the base flood at the dam, this difference reduces to 1 foot by the 9.1 mile point. The 400 foot breach width had a flood stage 4 feet higher than the base flood at the dam, this difference reduced to less than a 1 foot by mile 1.80.

b. Antecedent Flow: A sensitivity analysis was made assuming a moderate river flow or 1200 cfs on the French River as an antecedent flow and the resulting comparative flood stage is shown on plate 12. The moderate antecedent flow dam-break stage is 1 to 2 feet lower than the base flood throughout the study reach.

c. Duration of Dam-Break: Though the selected duration for the failure time was 1 hour, runs were also made for failure times of 1/2, 3 and 5 hours. The relative effects of the three additional failure times on downstream flood profiles are illustrated on plate 13.

The 1/2 hour failure time had only a slightly higher stage, typically 1 to 2 feet throughout the study reach. The 3 hour failure time had a flood stage 5 feet lower at the dam, reduced to about 2 feet at mile 6.51. The 5 hour failure time had a flood stage 9 feet lower at the dam, than the base flood; this difference reduced to a 4 feet at mile 6.51.

d. Initail Pool Level: While a full reservoir condition (spillway crest 524.0 feet N.G.V.D., 12,720 acre-feet) was assumed for the base flood, a test of sensitivity of the dam-break flood to initial pool level was made assuming a on half-full pool condition (elevation 512.0 feet N.G.V.D. 6100 acre-feet). The difference was significatnt, 6 feet lower below the dam, expanding to 8 feet at mile 6.51. Comparative water surface profiles are shown on plate 14.

e. Channel Roughness: Manning's "n" sensitvity tests were made to determine their effects on downstream flood attenuation, resulting stages and timing. Tests were made with the Manning's "n" 20 percent less and 20 percent greater than the base flood. Increasing the channel roughness resulted in slower progression downstream and decreasing the channel roughness resulted in a faster progression downstream. The stage for the high Manning's "n" was slightly higher than the base flood for the first 7 miles. From mile 7 to the limit of study, the base flood then had the higher stage. The reason for this is the flood wave associated with high Manning's "n" had significantly more attenuation the first 7 miles because of the higher stages than the base flood's flood wave. Low Manning's "n" had the opposite effect - lower stages than the base flood above mile 7 and higher stages below that point. Plate 15 compares water surface profiles.

f. Downstream Dams Failure: There are numerous dams on the Little French and Quinebaug Rivers. The first and third dams, Gordam Dam at mile 0.48 and American Woolen Co. Dam at mile 6.51, were selected for failure because of their proximity to Buffumville Lake Dam. In the event of a major dam-break at Buffumville Lake Dam, under fullpool conditions, these dams could be seriously damaged or fail. The base flood assumed all dams remained intact and operated properly. For purposes of this test both dams were assumed to fail just prior to peak flow conditions. The subsequent increase in stage was substantial, a 7 foot rise at mile 6.51. Plate 16 shows the comparative water surface profiles.

## 7. DISCUSSION

The dam-break analysis for Buffumville Lake Dam was based on the engineering application of certain laws of physics, considering the physical characteristics of the project and downstream channel, and conditions of failure. Due to the highly unpredictable nature of a dam-break and the ensuing sequence of events, the 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 the river channel due to scour or the temporary damming effect all of which could affect, to some extent, the resulting magnitude and timing of flooding downstream.

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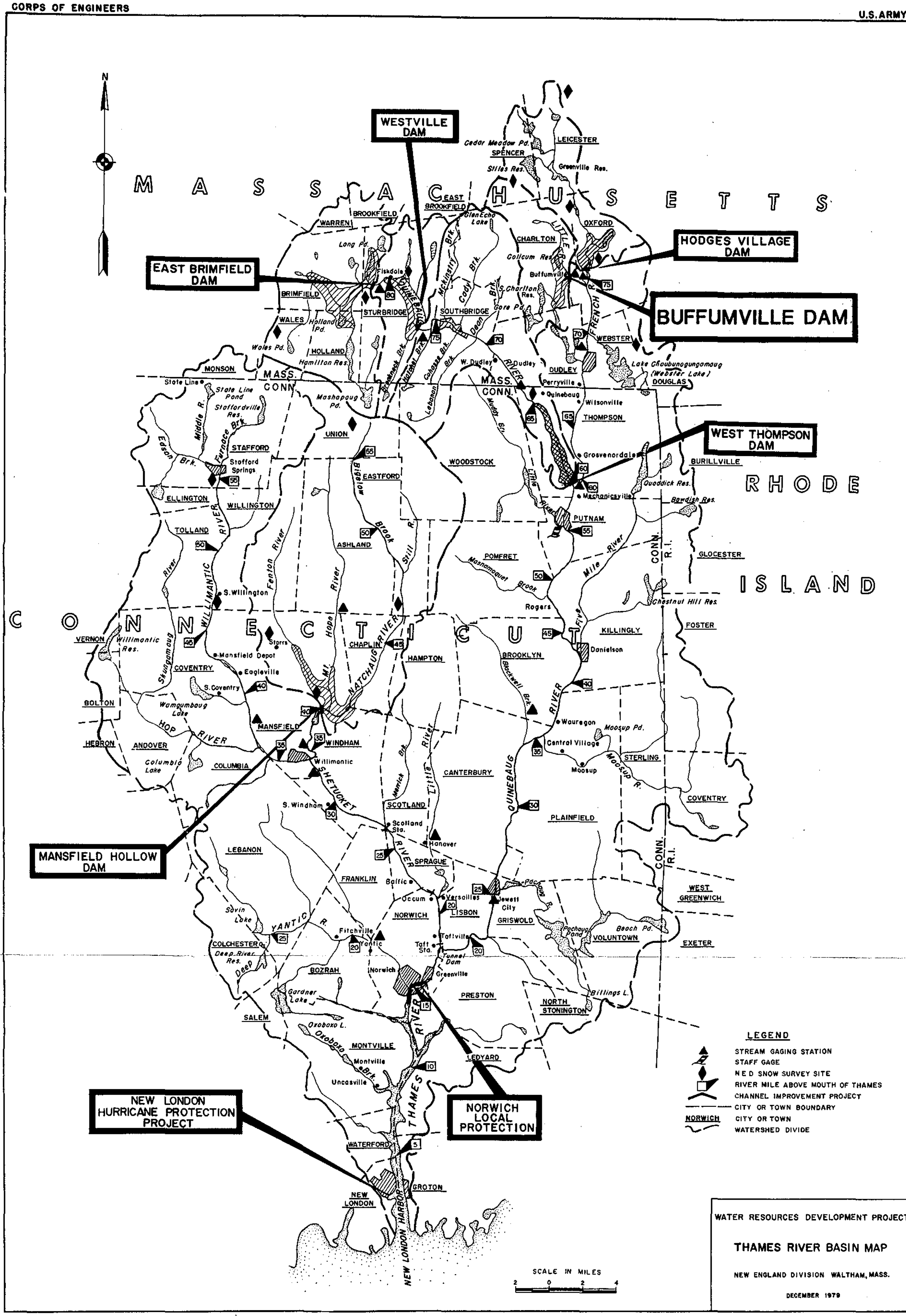
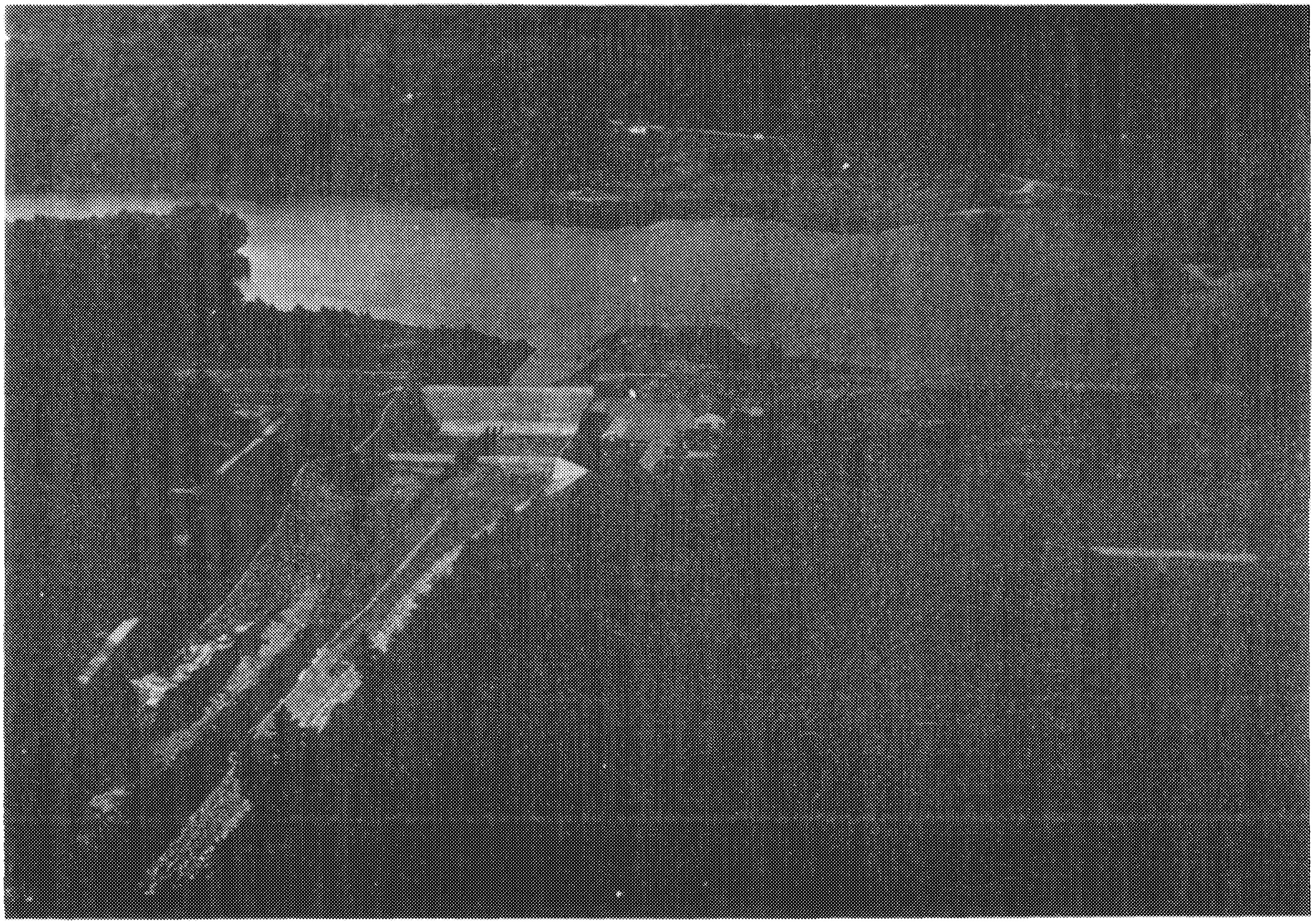



PLATE 1



VIEW OF BUFFUMVILLE LAKE DAM

PLATE 2

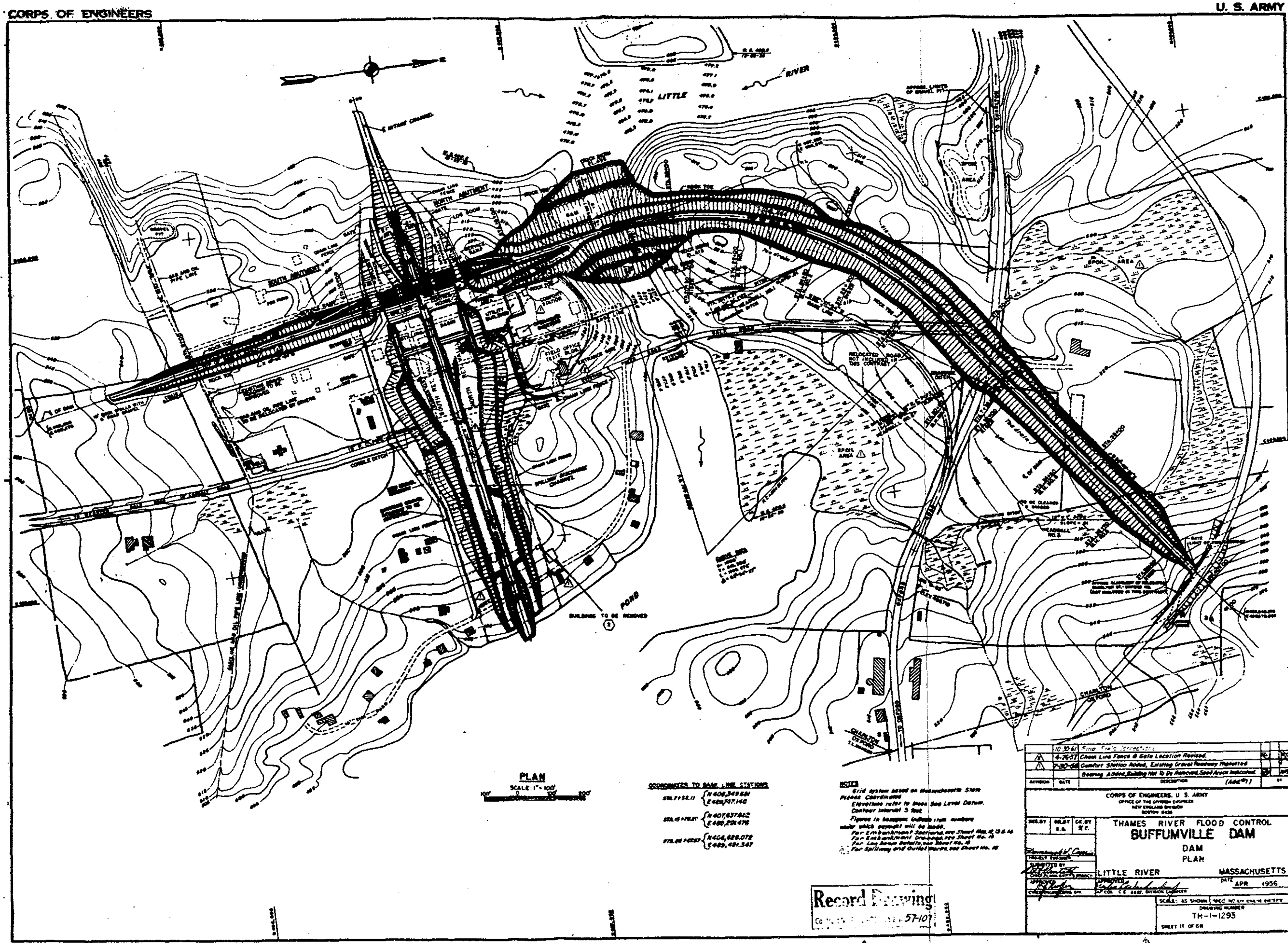

CORPS OF ENGINEERS
U. S. ARMY
LITTLE RIVER
SOUTH ABUTMENT
NORTH ABUTMENT
SPOIL AREA
CHARLTON OXFORD
BUILDINGS TO BE REMOVED
POND
PLAN
SCALE: 1" = 100'
COORDINATES TO BASE LINE STATIONS
STA. 7+32.11 N 406,349.681 E 489,717.148
STA. 15+78.57 N 407,637.852 E 489,291.476
STA. 26+82.57 N 464,626.072 E 489,491.547
NOTES
Grid system based on Massachusetts State Planes Coordinates
Elevations refer to Mean Sea Level Datum.
Contour interval 5 feet
Figures in hexagons indicate item numbers under which payment will be made.
For Embankment Sections, see Sheet Nos. 12, 13 & 14
For Embankment Drainage, see Sheet No. 15
For Log Boom Details, see Sheet No. 18
For Spillway and Outlet Works, see Sheet No. 16
10-30-61 Final Field Corrections
4-26-57 Chain Link Fence & Gate Location Revised.
7-30-56 Comfort Station Added, Existing Gravel Roadway Replotted
Bearing Added, Building Not To Be Removed, Spoil Areas Indicated.
REVISION DATE DESCRIPTION BY
CORPS OF ENGINEERS, U. S. ARMY
THAMES RIVER FLOOD CONTROL
BUFFUMVILLE DAM
DAM
PLAN
LITTLE RIVER
MASSACHUSETTS
DATE APR. 1956
SCALE: AS SHOWN
DRAWING NUMBER
TH-1-1293
Record Drawing

PLATE 3

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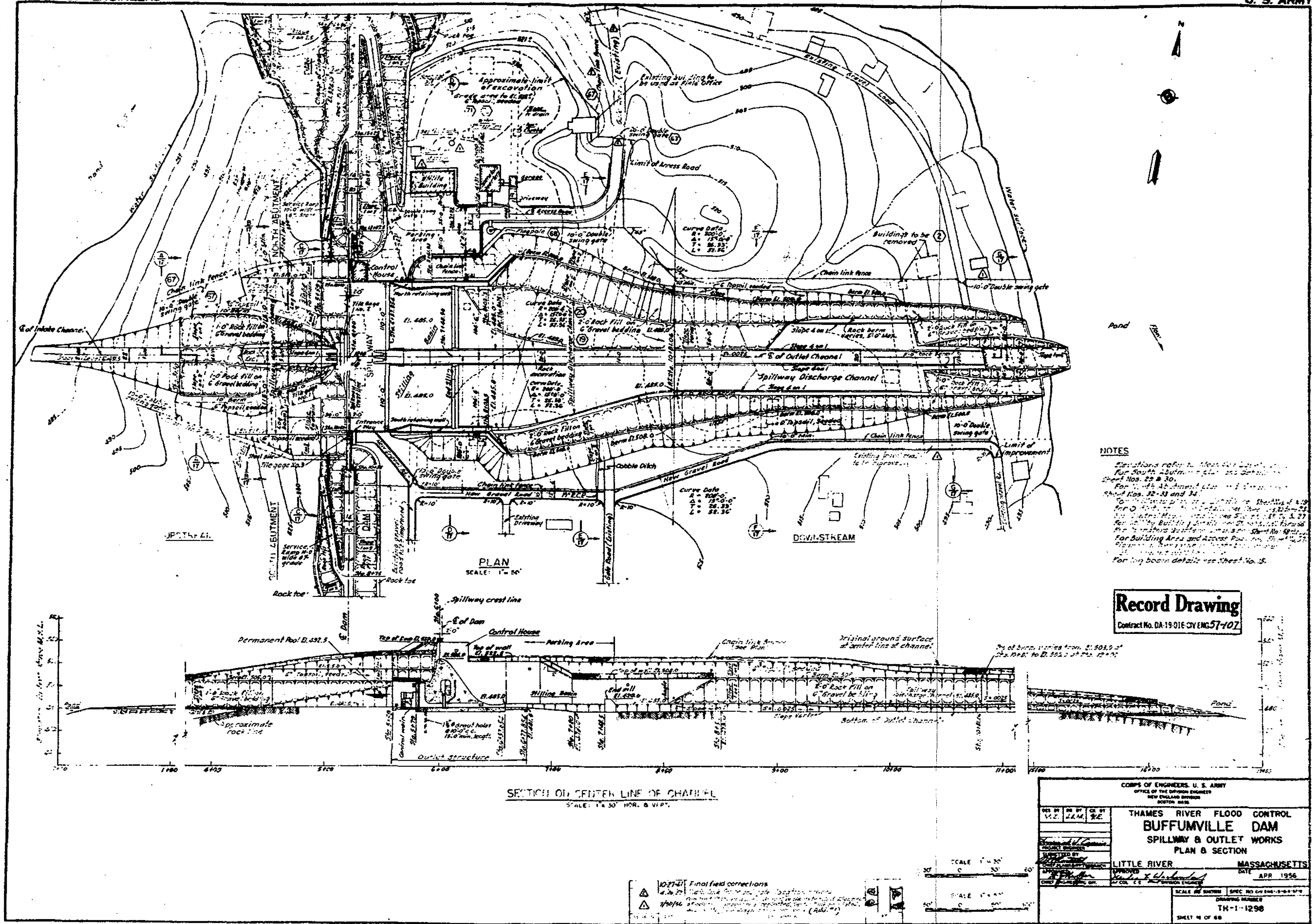
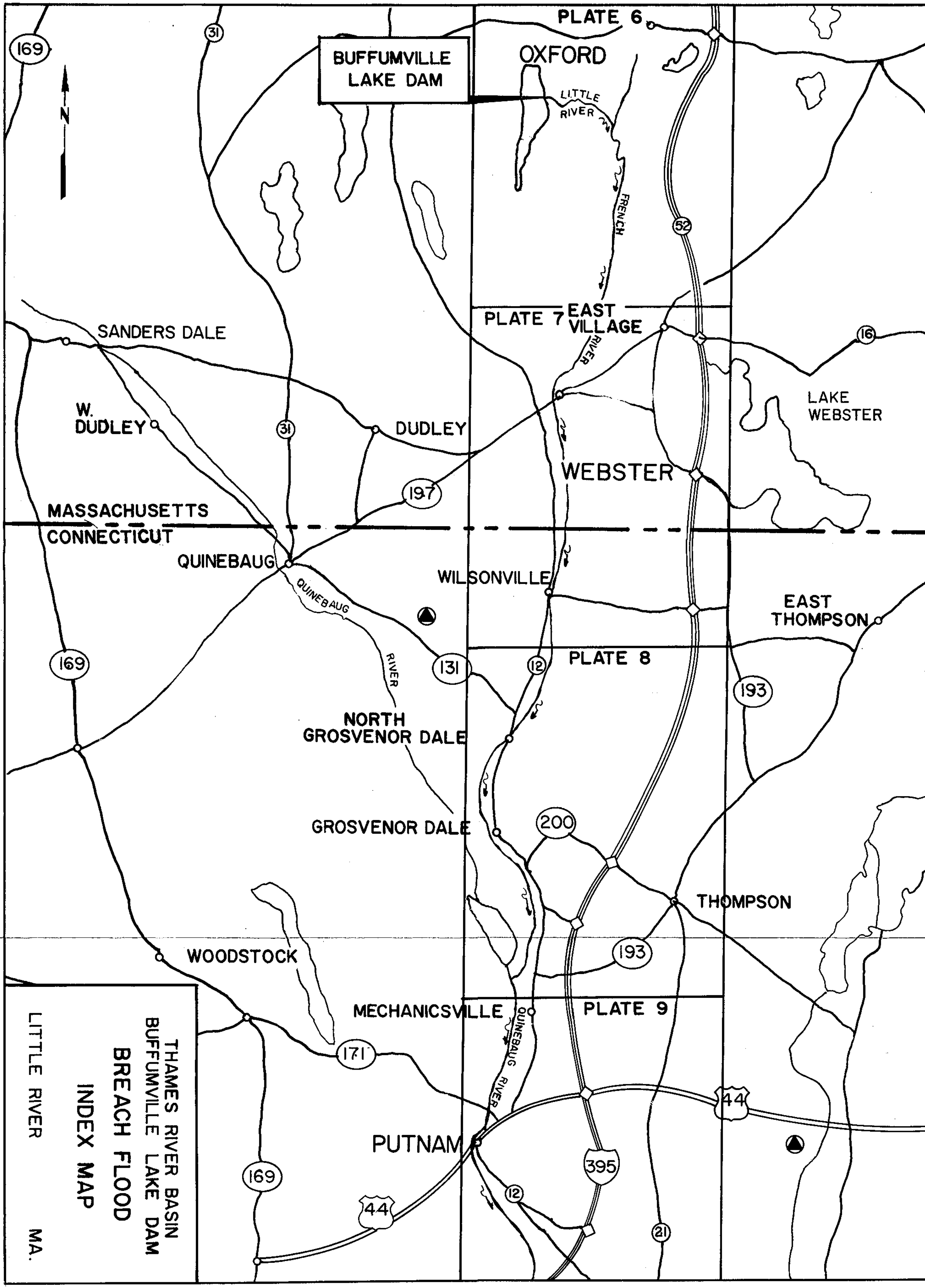



PLATE 4


THAMES RIVER BASIN
BUFFUMVILLE LAKE DAM
BREACH FLOOD
INDEX MAP
LITTLE RIVER MA.
BUFFUMVILLE LAKE DAM
PLATE 6
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LAKE WEBSTER
SANDERS DALE
W. DUDLEY
DUDLEY
WEBSTER
MASSACHUSETTS
CONNECTICUT
QUINEBAUG
QUINEBAUG RIVER
WILSONVILLE
EAST THOMPSON
PLATE 8
NORTH GROSVENOR DALE
GROSVENOR DALE
THOMPSON
WOODSTOCK
MECHANICSVILLE
PLATE 9
PUTNAM
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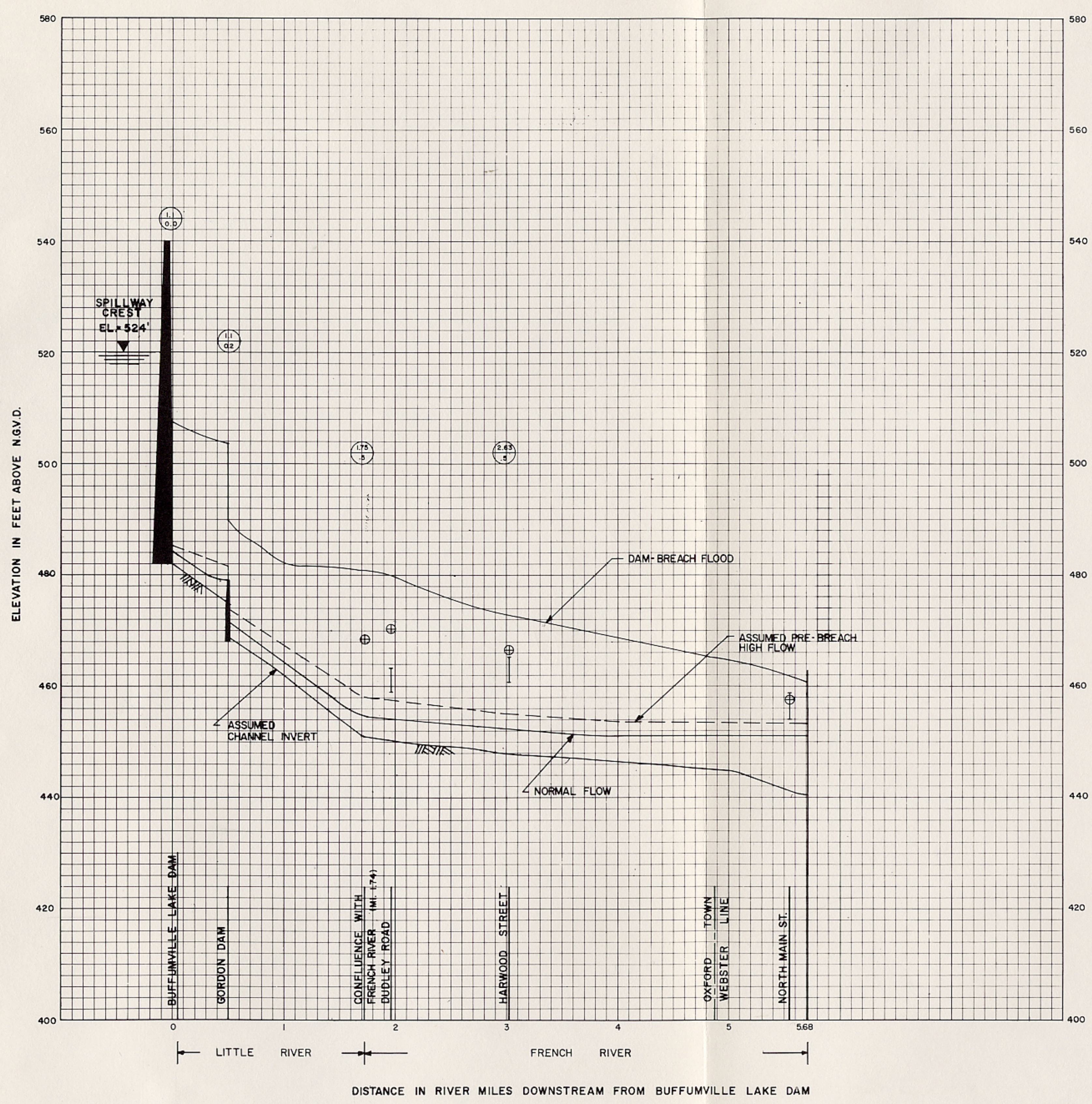
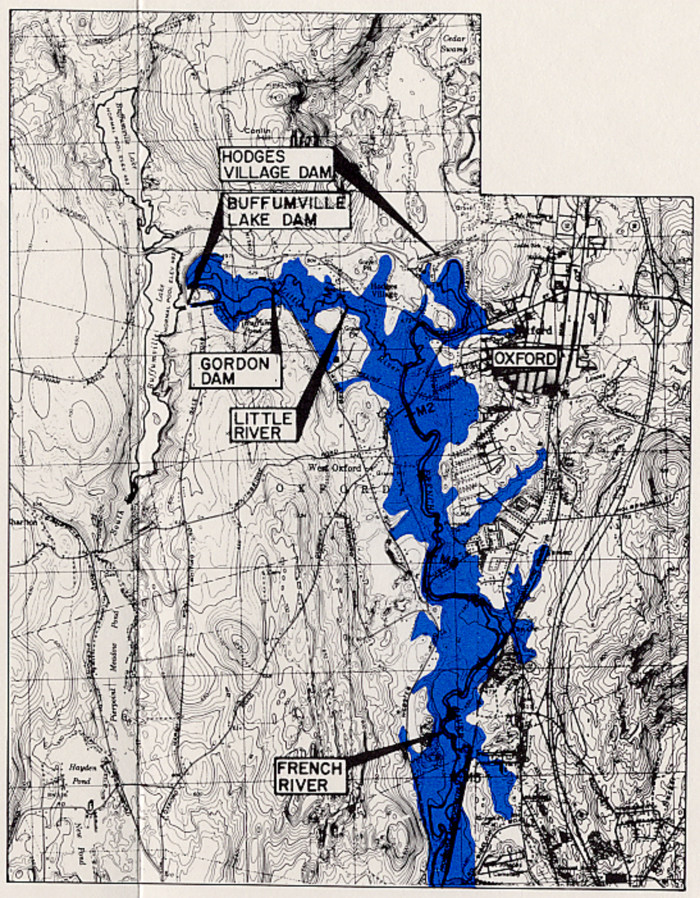
169
31
52
16
197
131
12
193
200
171
44
395
21

PLATE 5




## LEGEND

- ⊕ EXPERIENCED AUG., 1955 FLOOD ELEVATIONS
- HOURS FROM START OF FAILURE TO PEAK STAGE
- HOURS TO INITIAL RIVER RISE
- + MI RIVER MILES DOWNSTREAM FROM BUFFUMVILLE LAKE DAM
- LIMITS OF BREACH FLOOD

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BOSTON, MA

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORP OF ENGINEERS
WALTHAM, MA

THAMES RIVER BASIN
FRENCH RIVER WATERSHED
BUFFUMVILLE LAKE DAM BREACH FLOOD
PLAN & PROFILE # 1

PLATE 6

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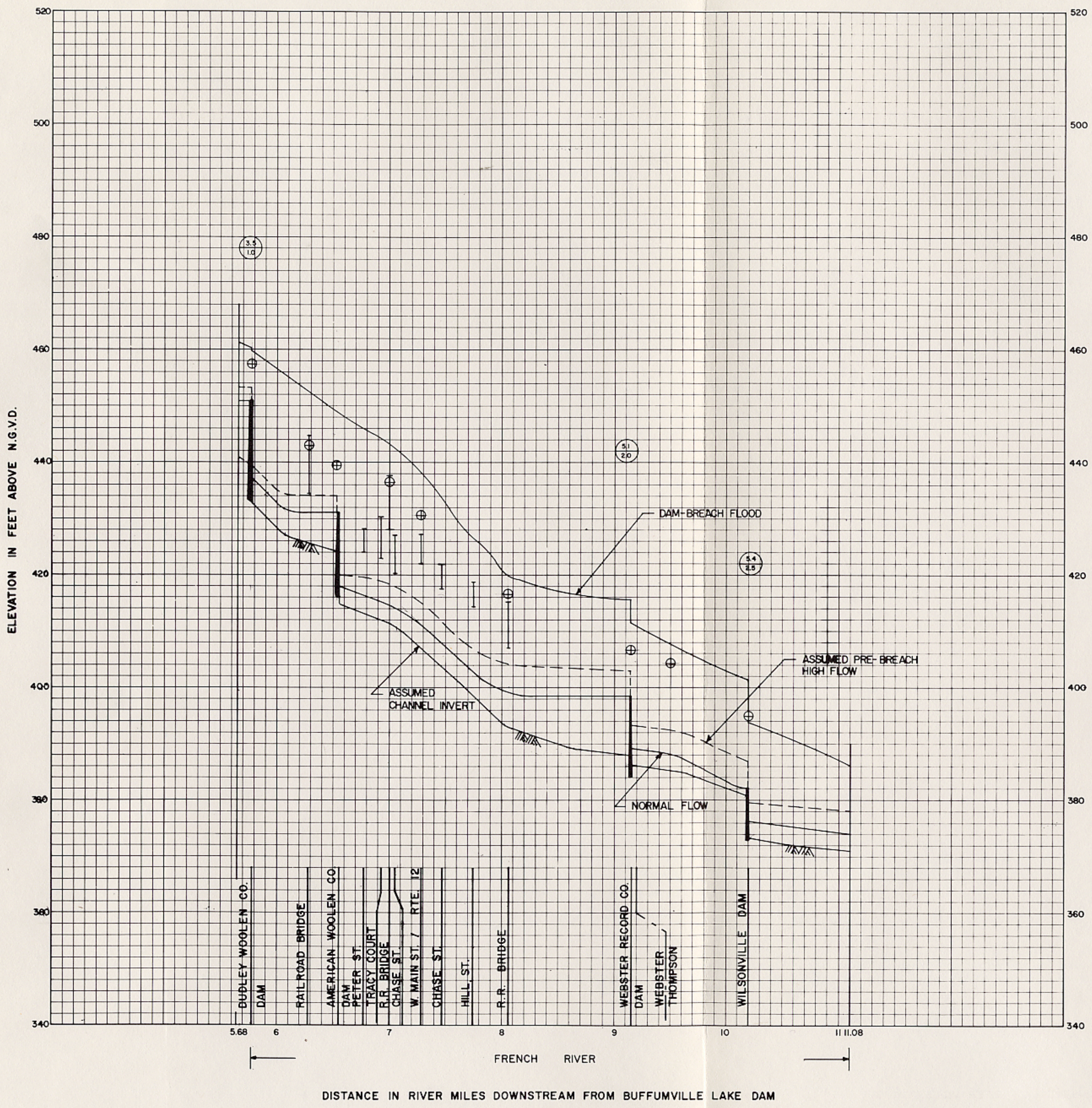


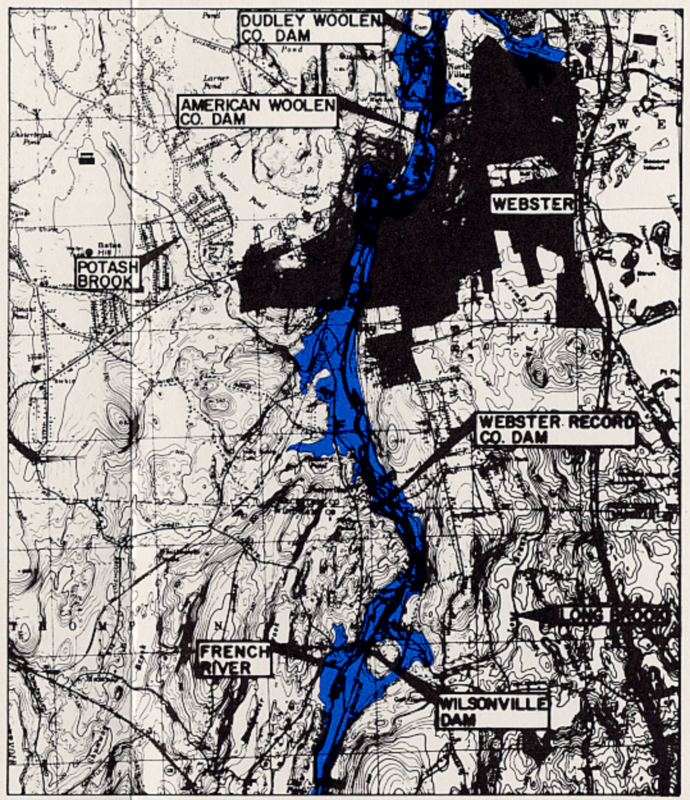


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## LEGEND

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- + MI RIVER MILES DOWNSTREAM FROM BUFFUMVILLE LAKE DAM
- LIMITS OF BREACH FLOOD

0 0.5 1.0
SCALE IN MILES

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|---|---|

THAMES RIVER BASIN
FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

PLAN & PROFILE # 2

PLATE 7

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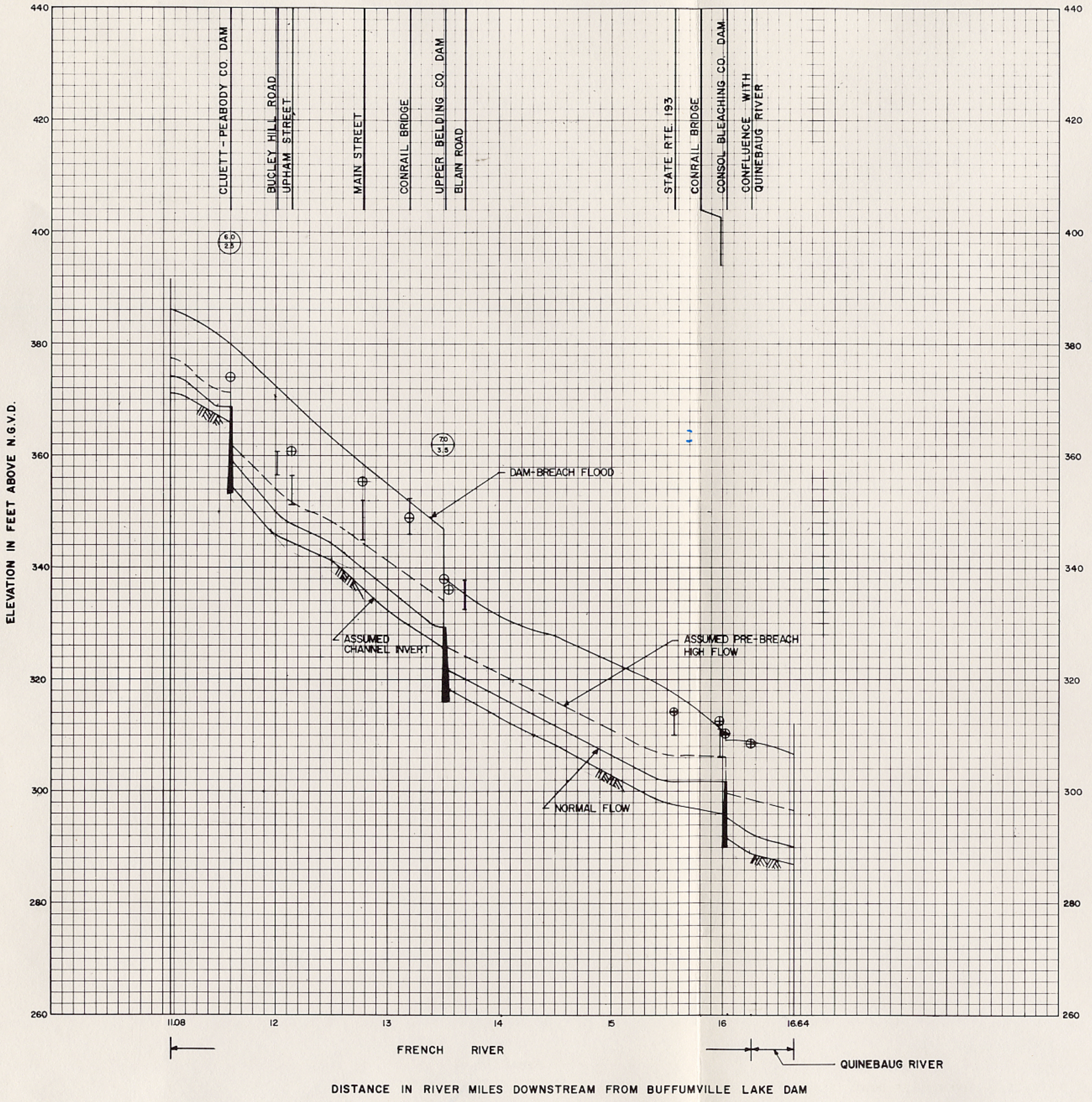


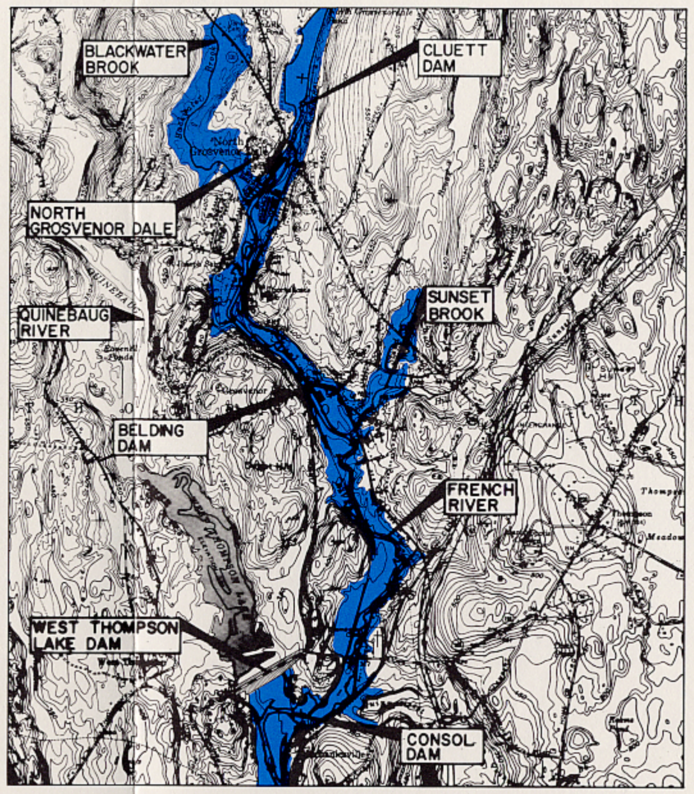


**LEGEND**

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- HOURS FROM START OF FAILURE TO PEAK STAGE
- HOURS TO INITIAL RIVER RISE
- + MI RIVER MILES DOWNSTREAM FROM BUFFUMVILLE LAKE DAM
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THAMES RIVER BASIN
FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

PLAN & PROFILE #3

PLATE 8

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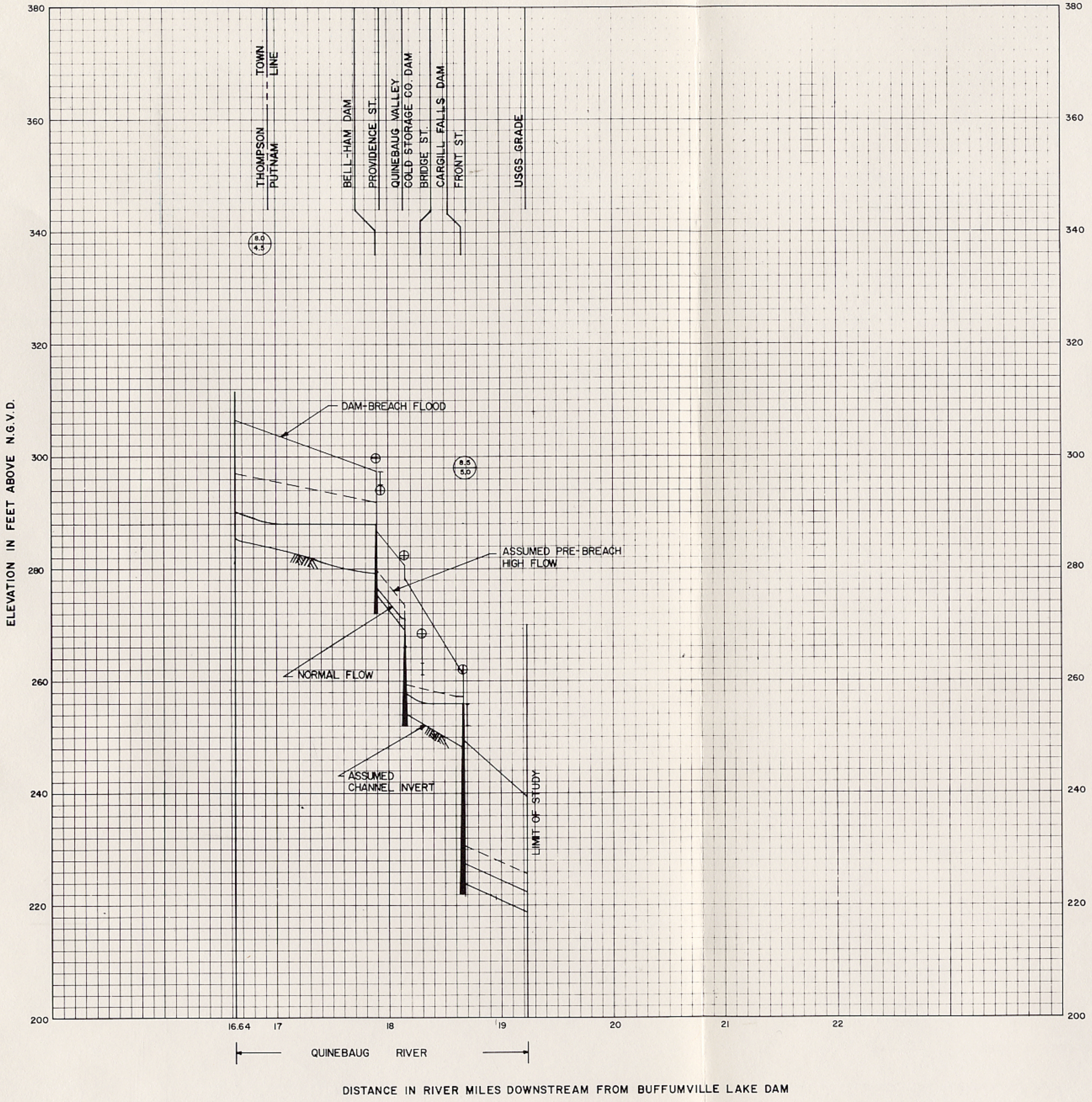


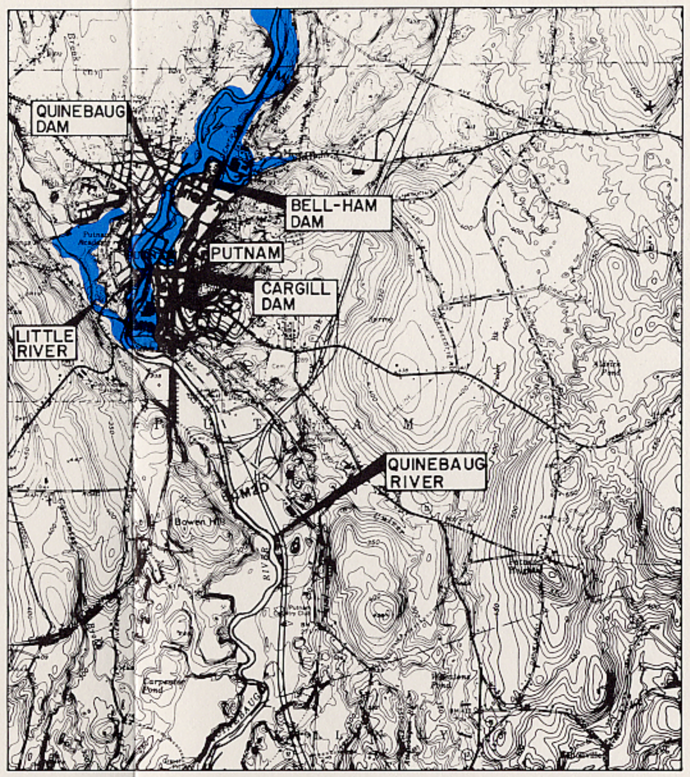


N

SCALE IN MILES

## LEGEND

- ⊕ EXPERIENCED AUG., 1955 FLOOD ELEVATIONS
- HOURS FROM START OF FAILURE TO PEAK STAGE
- HOURS TO INITIAL RIVER RISE
- + MI RIVER MILES DOWNSTREAM FROM BUFFUMVILLE LAKE DAM
- LIMITS OF BREACH FLOOD

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THAMES RIVER BASIN

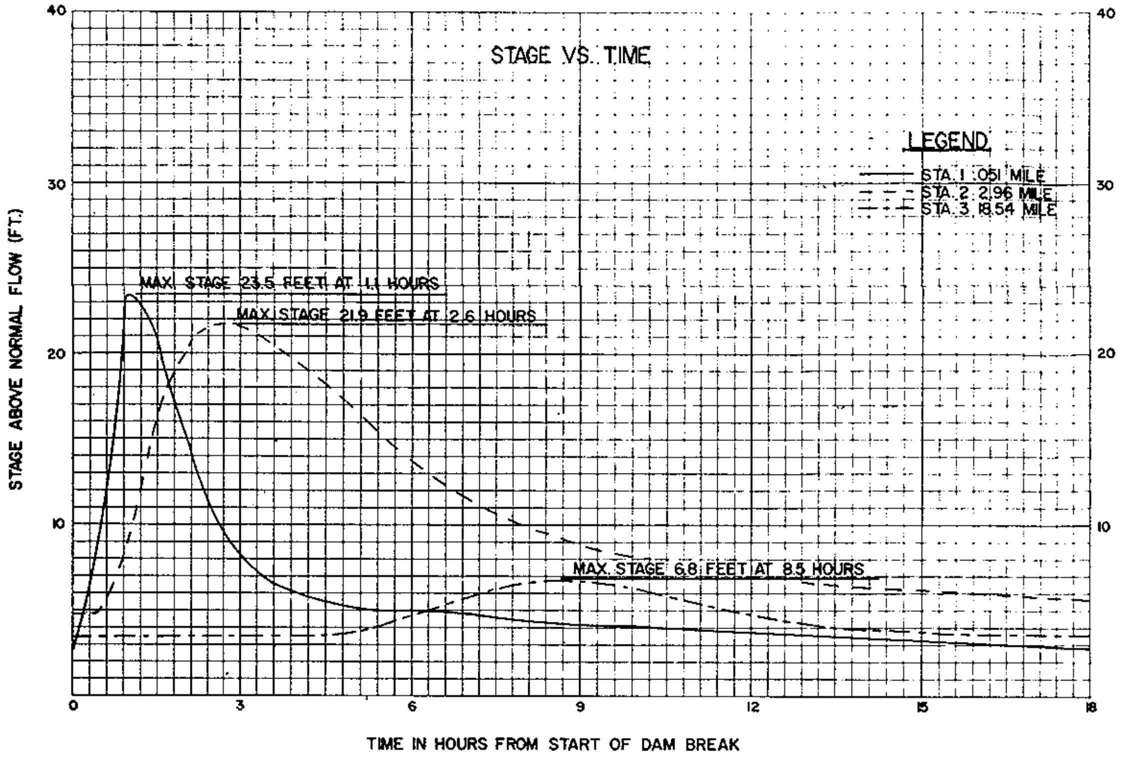
FRENCH RIVER WATERSHED

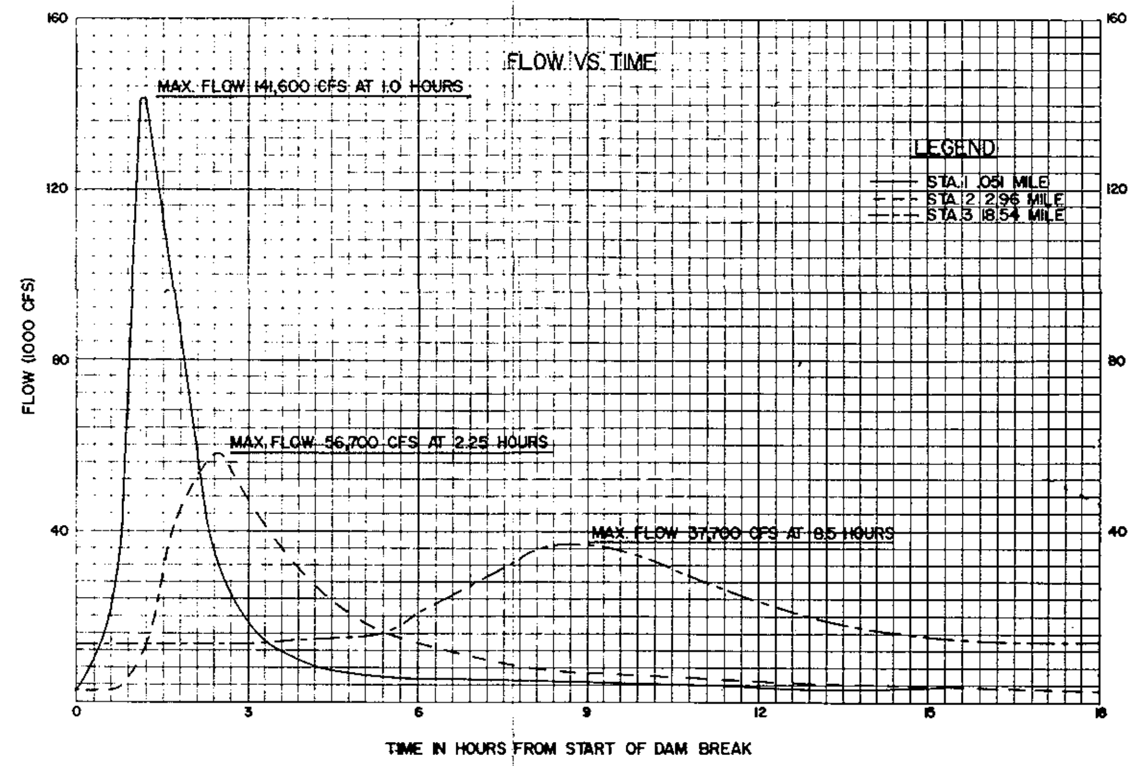
BUFFUMVILLE LAKE DAM BREACH FLOOD

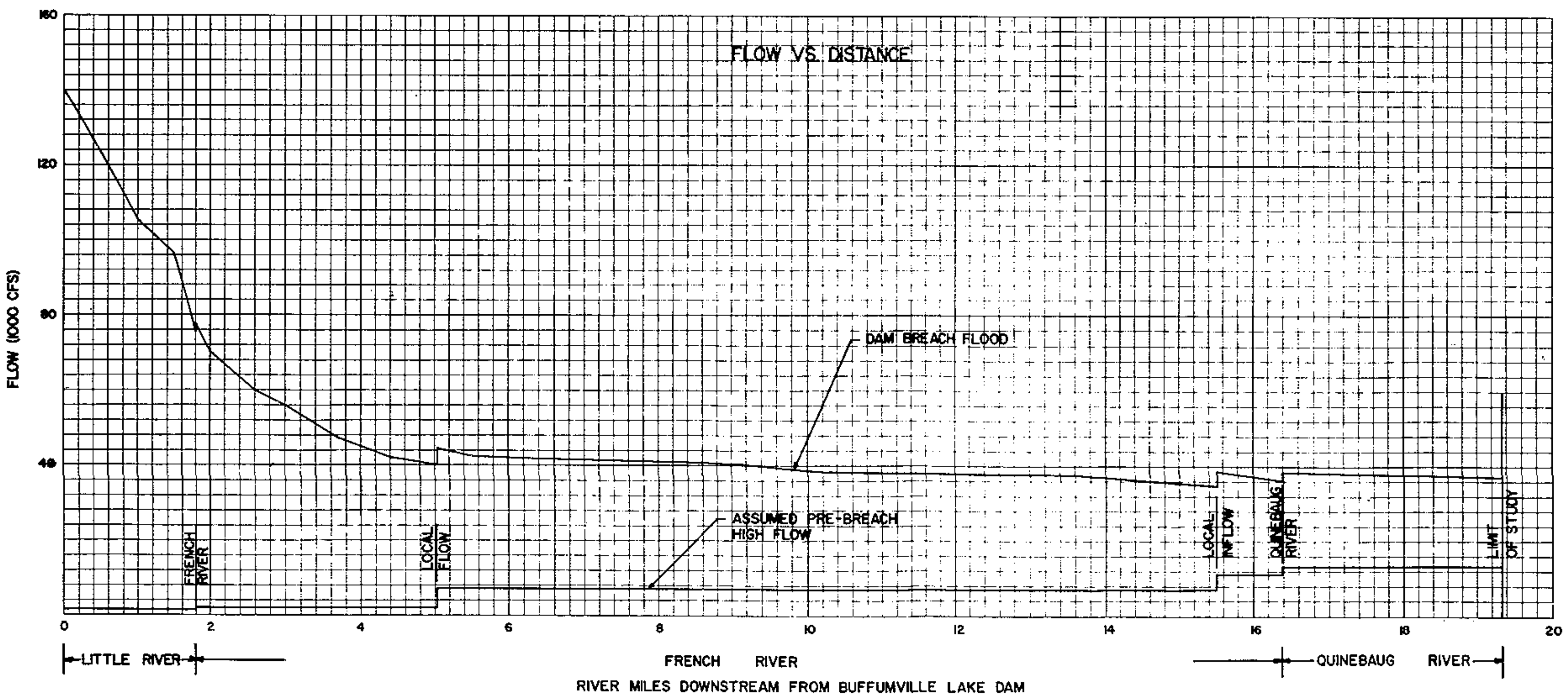
PLAN & PROFILE # 4

PLATE 9

CORPS OF ENGINEERS U. S. ARMY

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|---|---|
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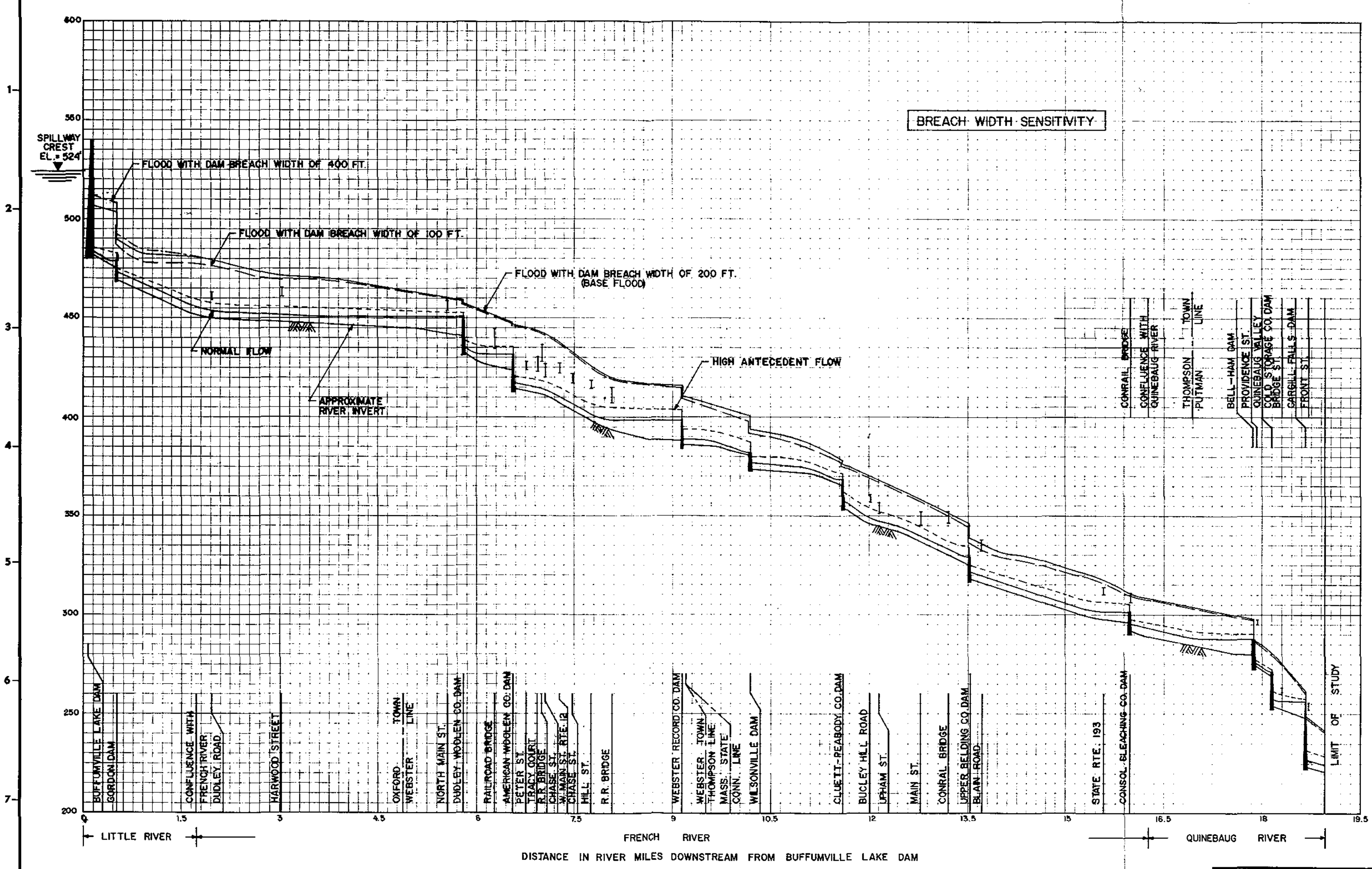
THAMES RIVER BASIN

FRENCH RIVER WATERSHED

**BUFFUMVILLE LAKE DAM BREACH FLOOD**

**BASE FLOOD DISCHARGES**
**STAGES & TIMING**

PLATE 10

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WALTHAM, MA

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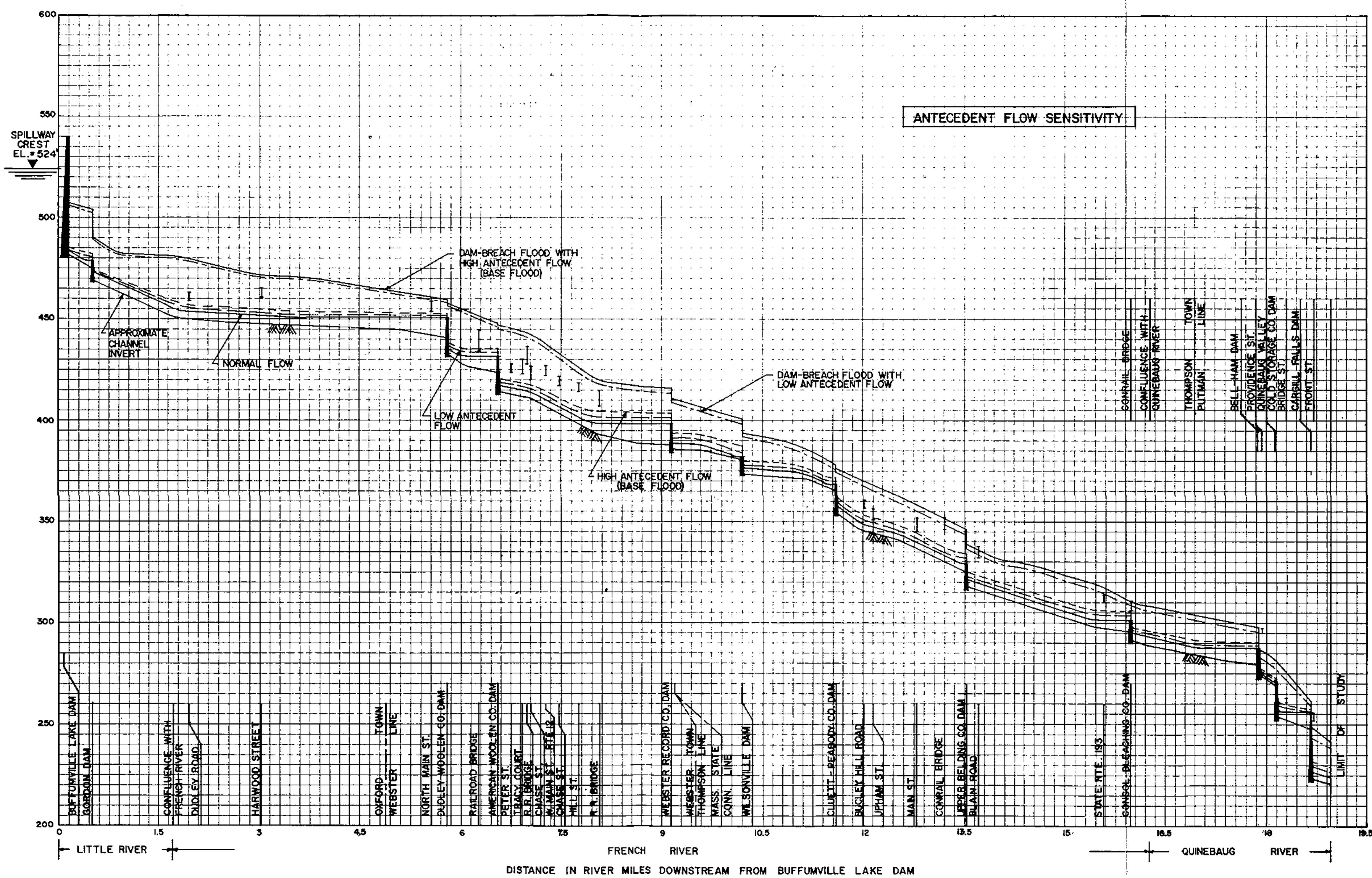
FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

SENSITIVITY OF INPUT

PLATE II

CORPS OF ENGINEERS U. S. ARMY

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|---|---|

THAMES RIVER BASIN

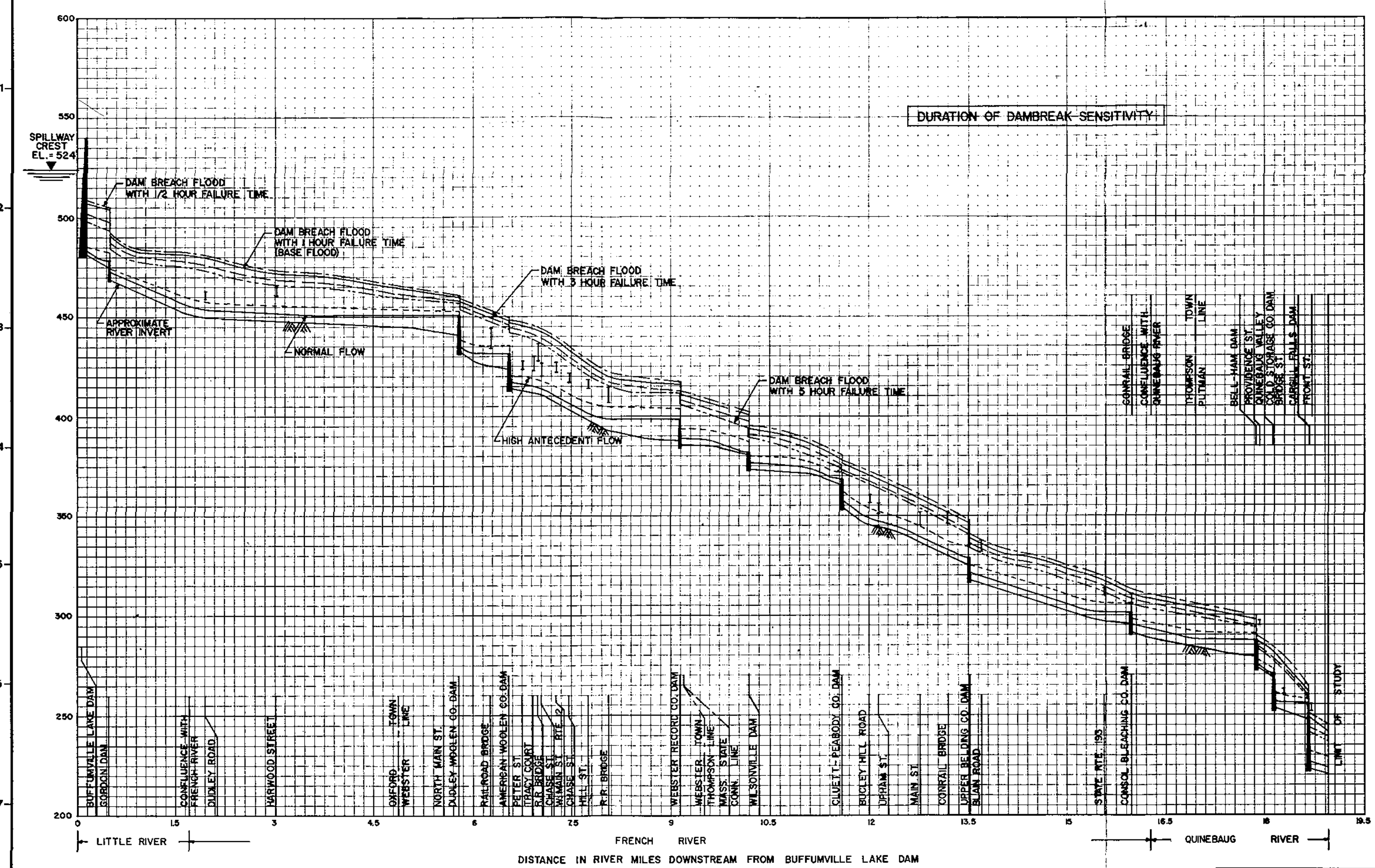
FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

## SENSITIVITY OF INPUT

PLATE 12

CORPS OF ENGINEERS U. S. ARMY

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CORP OF ENGINEERS
WALTHAM, MA

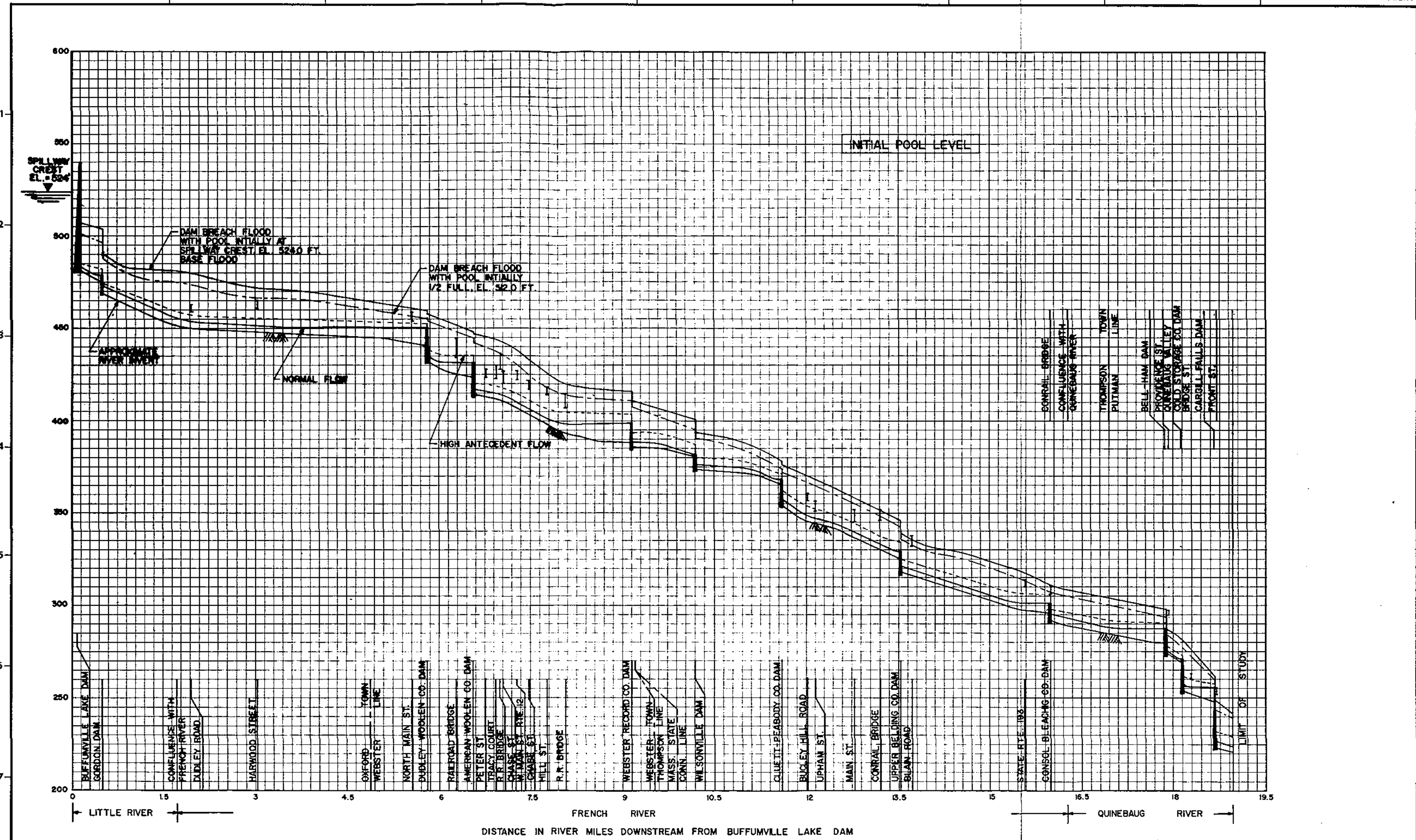
THAMES RIVER BASIN

FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

SENSITIVITY OF INPUT

PLATE 13

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CORP OF ENGINEERS
WALTHAM, MA

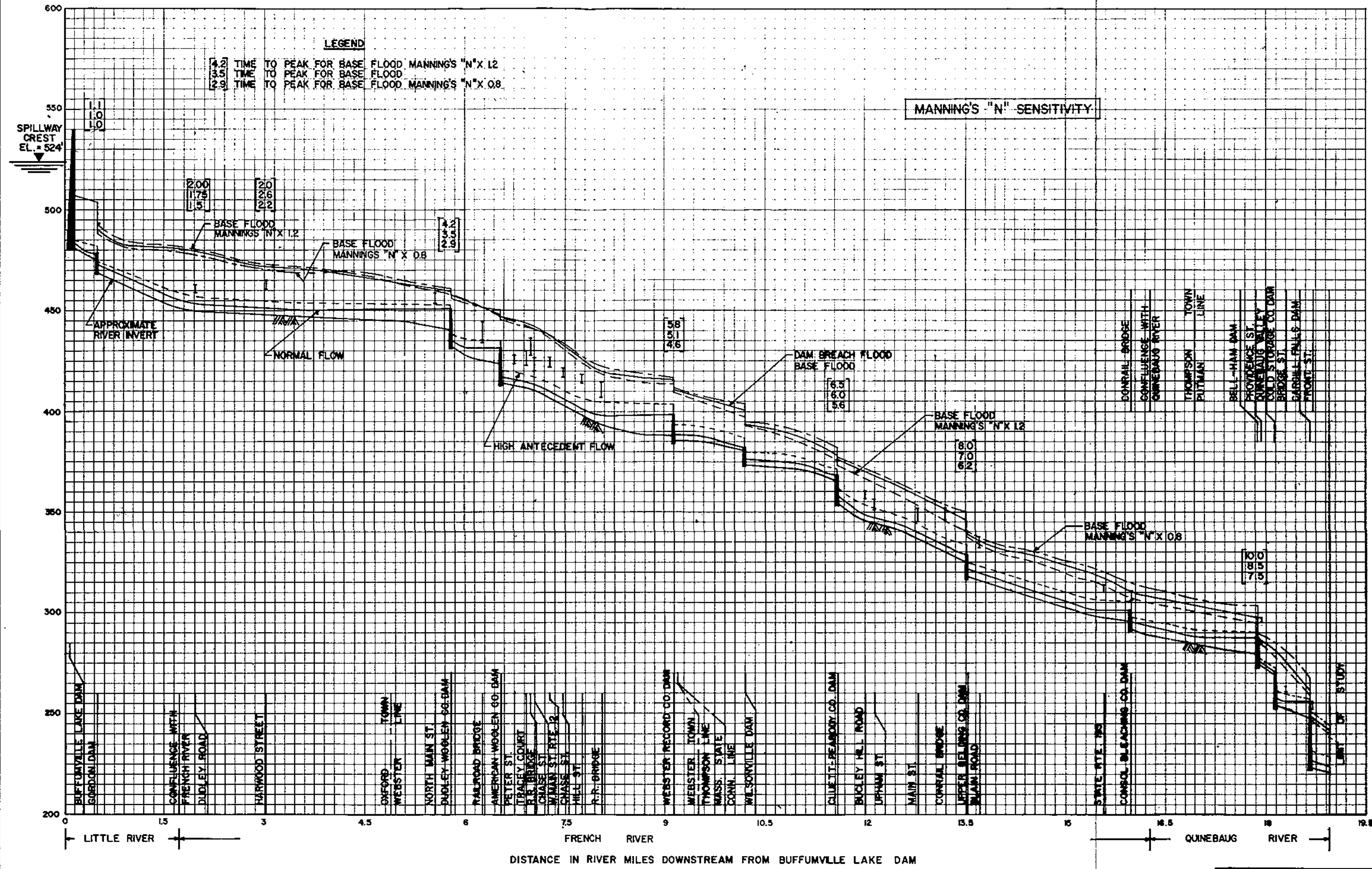
THAMES RIVER BASIN
FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

SENSITIVITY OF INPUT

PLATE 14

CORPS OF ENGINEERS | U. S. ARMY

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WALTHAM, MA

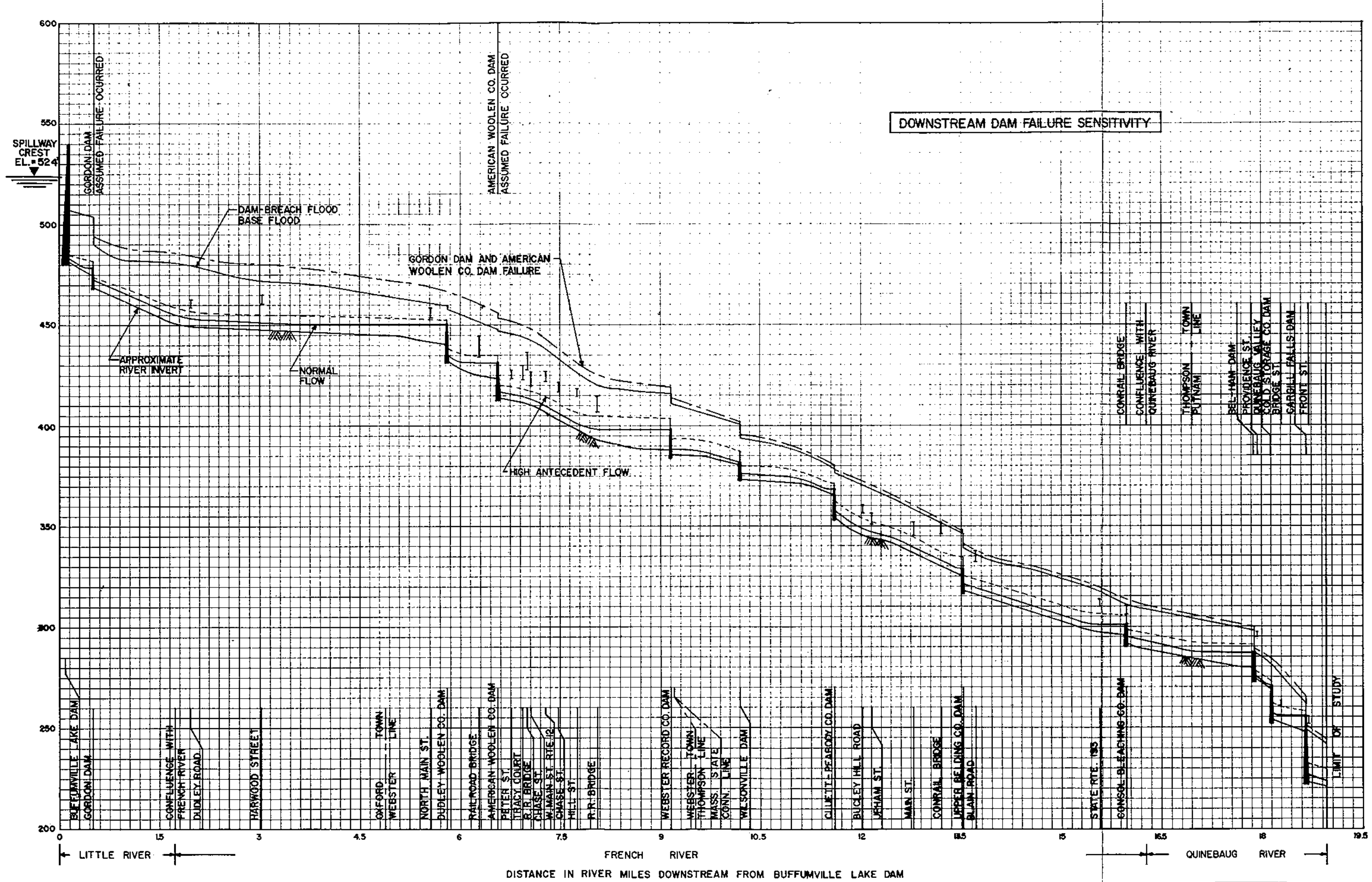
THAMES RIVER BASIN

FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

SENSITIVITY OF INPUT

CORPS OF ENGINEERS — U. S. ARMY

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CORP OF ENGINEERS
WALTHAM, MA

THAMES RIVER BASIN

FRENCH RIVER WATERSHED

BUFFUMVILLE LAKE DAM BREACH FLOOD

SENSITIVITY OF INPUT

```
*HECFORMAT
*NOECHO
*FORMATTED
*10FIELDS
*COMPOSITE
ID BUFFUMVILLE LAKE DAM
ID LITTLE RIVER
ID G. MERCER
ID CV&P ENGS.
ID BOSTON,MA.
IO      9       24       3
IP      0        0
IT      1        1       1       1       1       1       1       1       1       1
QI   7710     6370    4930    3780    2970    2380    1940    1620
SN BUFFEMVILLE LAKE
SE    524      518     512     506     500     494     488     482
SA    530      460     395     330     270     214     162       0
DN BUFFUMVILLE LAKE DAM
DD    539      524       0     524       5     .04     482
DB      1      524     200     482     0.5
DO   1820      825       0    6000
DN GORDAN DAM @ 0.48 MI.
DD    500      479       0              20     .04
DO      0     1000       0       0
DN AMERICAN WOOLEN CO. DAM @ 6.59 MI.
DD    500      431       0              10     .04
DO      0      600       0       0
DN WEBSTER RECORD CO. DAM @ 9.14 MI.
DD    500      399       0               4     .04
DO      0      600       0       0
DN WILSONVILLE DAM @ 10.19 MI.
DD    500      382       0               4     .04
DO      0      450       0       0
DN CLUETT-PEABODY CO. DAM @ 11.75 MI.
DD    500      368       0              15     .04
DO      0     1200       0       0
DN BELDING UPPER DAM @ 13.57 MI.
DD    500      330       0              10     .04
DO      0      700       0       0
DN BELDING LOWER DAM @ 17.88 MI.
DD    500      287       0               2     .06
DO      0     1070       0       0
DN CARGILL DAM @ 18.54 MI.
DD    500      254       0               5     .04
DO      0     2100       0       0
RN REACH 1 TO GORDAN DAM, 0.48 MI.
RG      1        2
RC  480.7        0     0.0     0.0
XI   0.05                                          .10
XE    482      490     500     505     510     520     530     540
XC     20      500     800    1200    1400    1600    1800    2000
XO      0      700     990     760     590     570     660     620
NC   .030     .040    .045    .050    .055    .060    .070    .080
XI   0.48
XE    475      479     480     490     500     510     520     530
```

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| XC | 100 | 312 | 420 | 675 | 1010 | 1232 | 1624 | 1890 |
| NC | .035 | .040 | .050 | .055 | .060 | .070 | .080 | .090 |
| RN | REACH 2+3 TO AMERICAN WOOLEN CO. DAM 6.51 MI | | | | | | | |
| RG | 4 | 5 | 16 | | | | | |
| RC | 435.5 | 0 | 0.0 | 0.0 | | | | |
| XI | .48 | | | | | | .10 | |
| XE | 467 | 475 | 480 | 490 | 500 | 510 | 520 | 530 |
| XC | 50 | 300 | 600 | 800 | 1100 | 1250 | 1510 | 1820 |
| NC | .030 | .040 | .050 | .055 | .060 | .070 | .080 | .090 |
| XI | 0.92 | | | | | | .10 | |
| XE | 463 | 470 | 478 | 490 | 500 | 510 | 520 | 530 |
| XC | 50 | 400 | 1000 | 1400 | 1800 | 2210 | 2850 | 3070 |
| XO | 0 | 635 | 500 | 0 | 0 | 0 | 0 | 0 |
| NC | .030 | .035 | .040 | .045 | .055 | .060 | .070 | .080 |
| XI | 1.30 | | | | | | .10 | |
| XE | 457 | 465 | 470 | 480 | 490 | 500 | 510 | 520 |
| XC | 50 | 670 | 1000 | 1230 | 1455 | 1570 | 1710 | 1980 |
| NC | .030 | .035 | .040 | .045 | .050 | .060 | .070 | .080 |
| XI | 1.70 | | | | | | .10 | |
| XE | 453 | 460 | 470 | 480 | 490 | 500 | 510 | 520 |
| XC | 50 | 700 | 1000 | 1500 | 2000 | 4090 | 4200 | 4480 |
| XO | 0 | 1540 | 1630 | 1470 | 1920 | 0 | 0 | 0 |
| NC | .030 | .040 | .045 | .050 | .055 | .060 | .070 | .080 |
| XI | 1.80 | | | | | | | |
| XE | 451.0 | 457 | 464 | 468 | 472 | 480 | 490 | 500 |
| XC | 50 | 200 | 682 | 1020 | 1070 | 1500 | 2500 | 3000 |
| XO | 0 | 0 | 300 | 0 | 0 | 2610 | 1660 | 1000 |
| NC | .030 | .035 | .040 | .050 | .055 | .060 | .080 | .090 |
| QN | 1.80 | | FRENCH RIVER CONFLUENCE | | | | | |
| QL | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 |
| XI | 2.05 | | | | | | | |
| XE | 450 | 455 | 459 | 463 | 467 | 470 | 480 | 490 |
| XC | 50 | 120 | 180 | 230 | 370 | 495 | 1010 | 4880 |
| XO | 0 | 0 | 0 | 0 | 0 | 0 | 2010 | 0 |
| NC | .030 | .035 | .040 | .045 | .050 | .055 | .070 | .080 |
| XI | 2.61 | | | | | | | |
| XE | 449.5 | 454 | 458 | 462 | 466 | 470 | 480 | 490 |
| XC | 50 | 310 | 475 | 543 | 647 | 955 | 2000 | 3000 |
| XO | 0 | 0 | 0 | 0 | 0 | 0 | 1220 | 1060 |
| NC | .030 | .040 | .045 | .050 | .055 | .060 | .070 | .080 |
| XI | 2.96 | | | | | | | |
| XE | 449 | 454 | 458 | 462 | 466 | 470 | 480 | 490 |
| XC | 50 | 165 | 540 | 565 | 600 | 660 | 1500 | 3000 |
| XO | 0 | 0 | 0 | 0 | 0 | 0 | 3540 | 2980 |
| NC | .030 | .040 | .045 | .050 | .055 | .060 | .070 | .080 |
| XI | 3.70 | | | | | | | |
| XE | 447 | 450 | 454 | 458 | 462 | 465 | 470 | 480 |
| XC | 50 | 190 | 585 | 750 | 1000 | 1400 | 2500 | 3500 |
| XO | 0 | 0 | 0 | 560 | 690 | 315 | 1090 | 920 |
| NC | .030 | .035 | .045 | .050 | .055 | .060 | .070 | .080 |
| XI | 4.38 | | | | | | | |
| XE | 446 | 449 | 453 | 457 | 461 | 465 | 470 | 480 |
| XC | 50 | 130 | 405 | 520 | 585 | 765 | 1610 | 3120 |
| NC | .030 | .035 | .045 | .050 | .055 | .060 | .070 | .080 |
| XI | 4.85 | | | | | | | |

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XE   445     449     453     457     461     465     470     480
XC   150     200     645     800    1110    1250    1800    2700
XO   125     200     200     125     140      80     400       0
NC  .030    .035    .045    .050    .055    .060    .070    .080
XI  5.02
XE   442     449     453     457     461     465     470     480
XC    60     205     700     900    1100    1300    1900    2825
XO     0       0     510     440     625     490    1150    3000
NC  .030    .040    .050    .055    .060    .065    .070    .080
QN  5.02            LATERAL  INFLOW  AT  WEBSTER
QL  5100    4000    3550    3250    3100    2900    2750    2650
XI  5.57
XE   439     446     451     456     461     465     470     480
XC    50     195     385     510     620     750     870    1660
NC  .030    .035    .040    .045    .050    .055    .070    .080
XI  5.90
XE   436     447     451     454     457     460     470     480
XC    50     160     350     520     630     700     800    2400
XO     0       0       0       0       0       0    1200       0
NC  .035    .040    .045    .050    .055    .060    .070    .080
XI  6.51
XE   424     430     436     442     447     452     460     470
XC    40     160     320     480     610     710    1000    2500
XO     0       0       0       0       0       0    1000       0
NC  .030    .035    .040    .045    .050    .055    .070    .080
RN REACH 4 TO WEBSTER RECORD CO. DAM, 9.10 MI.
RG     6
RC 403.5       0     0.0     0.0
XI  6.51
XE   415     421     427     433     439     445     450     460
XC    30      70     150     340     540     560     570    1980
NC  .040    .050    .060    .070    .080    .090    .100    .100
XI  7.06                                             .20
XE   411     416     421     426     431     435     440     450
XC    30      80     135     200     300     400     945    1720
XO     0       0       0     224     390     480     200       0
NC  .040    .050    .060    .070    .080    .090    .100    .100
XI  7.65                                             .20
XE   401     407     413     419     425     430     440     450
XC    30     100     150     300     400     700     880    1300
XO     0      50     150     230     270       0       0       0
NC  .040    .045    .050    .060    .070    .080    .090    .100
XI  8.05
XE   393     400     407     413     419     425     430     440
XC    25     100     150     400     900    1400    1820    1900
XO     0      40       0     445     680     350       0       0
NC  .030    .035    .040    .045    .050    .055    .065    .075
XI  8.65
XE   389     397     404     411     418     425     430     440
XC    20     145     375     860    1280    1515    2650    2900
NC  .030    .035    .040    .045    .050    .055    .070    .080
XI  9.10
XE   386     395     402     408     414     420     430     440
XC    35     145     280     600     745     825    1460    1520
NC  .030    .035    .040    .045    .050    .055    .070    .080
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RN REACH 5 TO WILSONVILLE DAM, 10.20 MI.
RG      3
RC 387.4        0       0.0       0.0
XI   9.10
XE    386     390     400     410     420     430     440     450
XC     50     175     400     700    1100    1300    1400    1800
XO      0     125     100       0       0       0       0       0
NC   .050    .055    .060    .070    .080    .090    .100    .110
XI   9.62
XE    384     390     400     410     420     430     440     450
XC     80     150     400     835     940    1100    1210    1470
XO      0      60     170       0       0       0       0       0
NC   .050    .055    .060    .070    .080    .090    .100    .110
XI  10.20
XE    378     390     400     410     420     430     440     450
XC    155     340     900    1900    2300    3100    3350    3400
XO      0       0    1220     910     670       0       0       0
NC   .030    .035    .055    .060    .065    .070    .080    .090
RN REACH 6 TO CLUETT-PEABODY CO. DAM, 11.60 MI.
RG      4
RC 370.9        0       0.0       0.0
XI  10.20
XE    373     380     390     400     410     420     430     440
XC     75     200     550     900    1320    2270    3040    3510
XO      0       0       0     250       0       0       0       0
NC   .040    .045    .050    .060    .070    .080    .090    .100
XI  10.61
XE    372     380     390     400     410     420     430     440
XC    110     400     835    1460    1590    2200    2330    2510
XO    200     170       0       0       0       0       0       0
NC   .040    .045    .050    .060    .070    .080    .090    .100
XI  11.18
XE    370     380     390     400     410     420     430     440
XC    200     300     800    1600    1825    1970    2150    2340
XO    250     275     540       0       0       0       0       0
NC   .035    .040    .050    .055    .060    .065    .075    .085
XI  11.60
XE    361     370     380     390     400     410     420     430
XC    100     250     600    1100    1300    1500    1700    1900
XO      0     250     300       0       0       0       0       0
NC   .030    .040    .045    .050    .055    .060    .070    .080
RN REACH 7 TO UPPER BELDING DAM, 13.51 MI.
RG      3
RC 334.1        0       0.0       0.0
XI  11.60
XE    353     360     370     380     390     400     410     420
XC     70     100     200     300     400     700     900    1100
NC   .040    .045    .050    .060    .070    .080    .090    .100
XI  12.51
XE    339     344     350     360     370     380     390     400
XC     50      75     200     600     800    1000    1400    1720
XO      0     125     325     150     300     200     350     200
NC   .040    .045    .050    .060    .070    .080    .090    .100
XI  13.51
XE    324     330     335     340     345     350     360     370
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XC    50     140     250     310     360     445     900    1050
NC  .040    .045    .050    .060    .070    .080    .090    .100
RN REACH 8 TO BELDING LOWER DAM, 17.88 MI.
RG     8
RC 292.0       0     0.0     0.0
XI 13.51
XE   318     325     329     333     337     340     350     360
XC    50     150     200     310     451     700     850    1050
NC  .050    .055    .060    .065    .070    .075    .080    .100
XI 14.02
XE   313     315     318     321     324     330     340     350
XC    45     130     300     725     750    1250    1650    2700
XO     0       0     130       0       0       0       0       0
NC  .030    .035    .045    .050    .055    .060    .070    .080
XI 14.50
XE   308     311     314     317     321     325     330     340
XC    40     110     360     460     520     650    1650    2050
NC  .030    .035    .040    .045    .050    .055    .065    .075
XI 14.99
XE   303     308     313     317     321     325     330     340
XC    50     100     200     680     865     930    1000    1050
NC  .030    .035    .040    .050    .055    .060    .070    .080
XI 15.43
XE   298     304     310     315     320     325     330     340
XC    65     110     240     520     770     950    1750    1900
NC  .030    .030    .035    .040    .045    .050    .060    .070
QN 15.43                 LATERAL INFLOW
QL  3600    3100    2000    1550    1250    1100     900     750
XI 16.04
XE   296     300     310     320     330     340     350     360
XC    90     200     300     800    1150    2000    2500    2850
XO     0     200     200       0       0       0       0       0
NC  .040    .045    .050    .055    .065    .075    .080    .100
XI 16.35
XE   288     295     300     305     310     330     350     400
XC   100     200     600     800     900    1800    2100    5000
XO     0     150     230     200     200       0       0       0
NC  .030    .035    .045    .060    .070    .080    .090    .100
QN 16.35                 QUINEBAUG RIVER CONFLUENCE
QL  2300    2300    2300    2300    2300    2300    2300    2300
XI 16.86
XE   283     285     290     295     300     310     330     350
XC    50     100     300     550     600     650    1000    1300
NC  .030    .030    .035    .040    .055    .075    .090    .100
XI 17.88
XE   279     285     290     295     300     310     330     350
XC    50     250     300    1250    2000    2000    2200    2800
XO     0       0       0       0       0     500    2000    2000
NC  .035    .040    .045    .055    .060    .070    .075    .100
RN REACH  9 TO CARGILL DAM, 18.54 MI.
RG     3
RC 257.2       0     0.0     0.0
XI 17.88
XE   275     280     290     300     310     320     330     350
XC   140     200     400     800    1000    1000    1000    1000
```

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| XO | 0 | 0 | 0 | 0 | 0 | 200 | 700 | 2000 |
| NC | .040 | .060 | .070 | .070 | .090 | .090 | .090 | .100 |
| XI | 18.03 | | | | | | | |
| XE | 269 | 270 | 280 | 290 | 300 | 310 | 320 | 330 |
| XC | 140 | 300 | 600 | 1000 | 1200 | 1200 | 1500 | 1600 |
| XO | 0 | 0 | 0 | 0 | 500 | 1000 | 1000 | 1500 |
| NC | .040 | .060 | .070 | .070 | .090 | .090 | .090 | .100 |
| XI | 18.54 | | | | | | | |
| XE | 250 | 260 | 270 | 280 | 290 | 300 | 330 | 350 |
| XC | 100 | 300 | 1400 | 2000 | 2400 | 2500 | 2800 | 2800 |
| XO | 0 | 0 | 0 | 0 | 0 | 0 | 2000 | 3000 |
| NC | .030 | .040 | .050 | .070 | .080 | .090 | .100 | .100 |
| RN | DUMMY | REACH | | | | | | |
| ZZ | | | | | | | | |