FLOOD PLAIN INFORMATION

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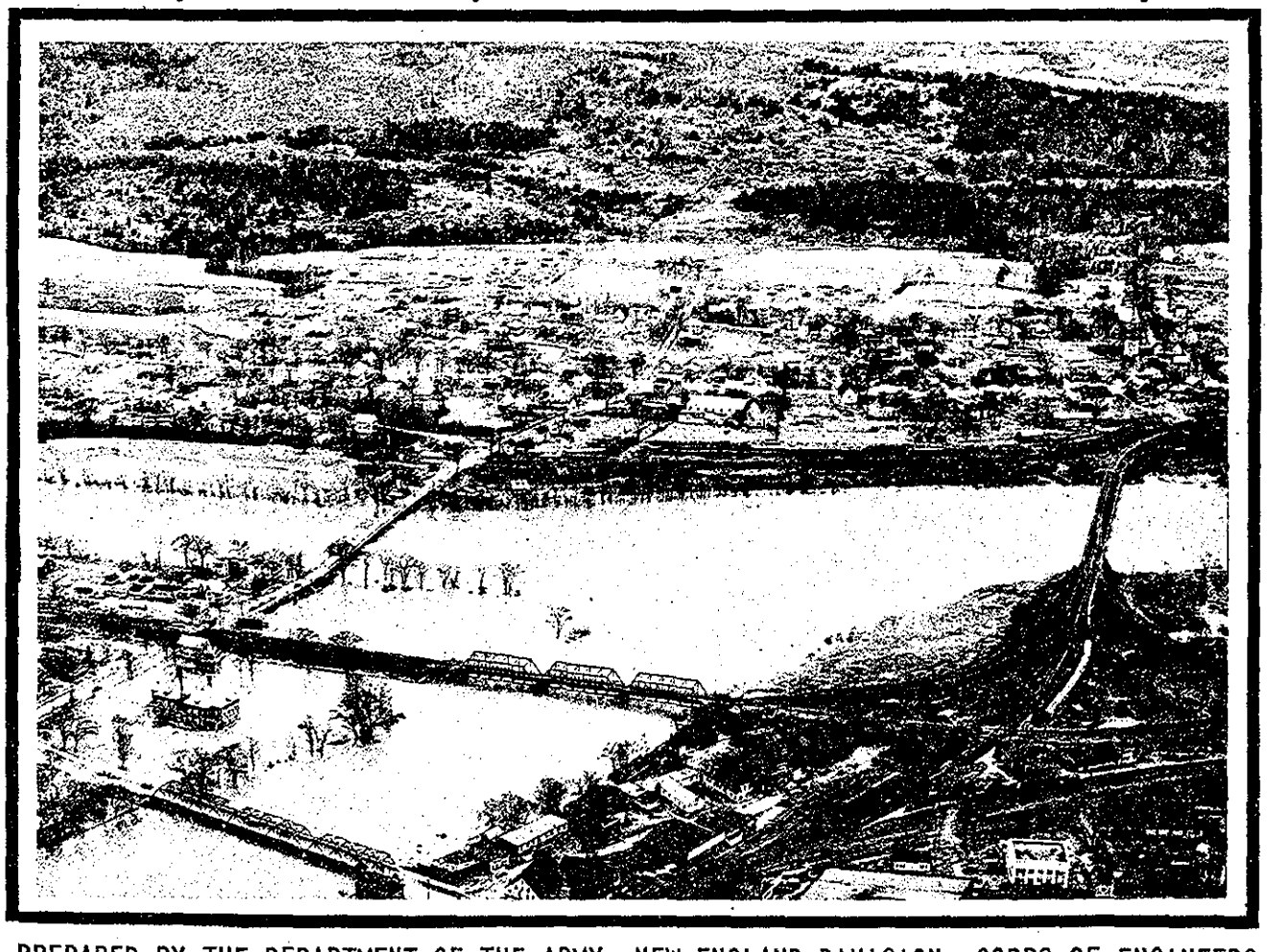
CONNECTICUT – WHITE – MASCOMA RIVERS

THETFORD, NORWICH, HARTFORD & HARTLAND, VT.
LYME, HANOVER, LEBANON & PLAINFIELD, N.H.



PREPARED BY THE DEPARTMENT OF THE ARMY, NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

MAY 1972

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INTRODUCTION

This report relates to the flood situation in Vermont in the towns of Thetford, Norwich, Hartford and Hartland, along the Connecticut River and along the White River in Hartford. It also relates to the flood situation in New Hampshire in Lyme, Hanover, Lebanon and Plainfield along the Connecticut River and along the Mascoma River in Lebanon. The information was requested by the Boards of Selectmen of the above towns and by the city of Lebanon, New Hampshire through the New Hampshire and Vermont Water Resources Boards to aid in the solution of local flood problems and in the best utilization of land subject to overflow. The report is based upon information on rainfall, runoff, historical flood heights, bridges and other technical data pertinent to the frequency and size of floods on the Connecticut, White, and Mascoma Rivers in the above towns and city. It is intended to encourage those affected to help themselves.

Two phases of the flood situation along the rivers are covered in this report. The first relates a record of the largest known historic flood in the area. The second discusses the probability of future floods of various magnitudes.

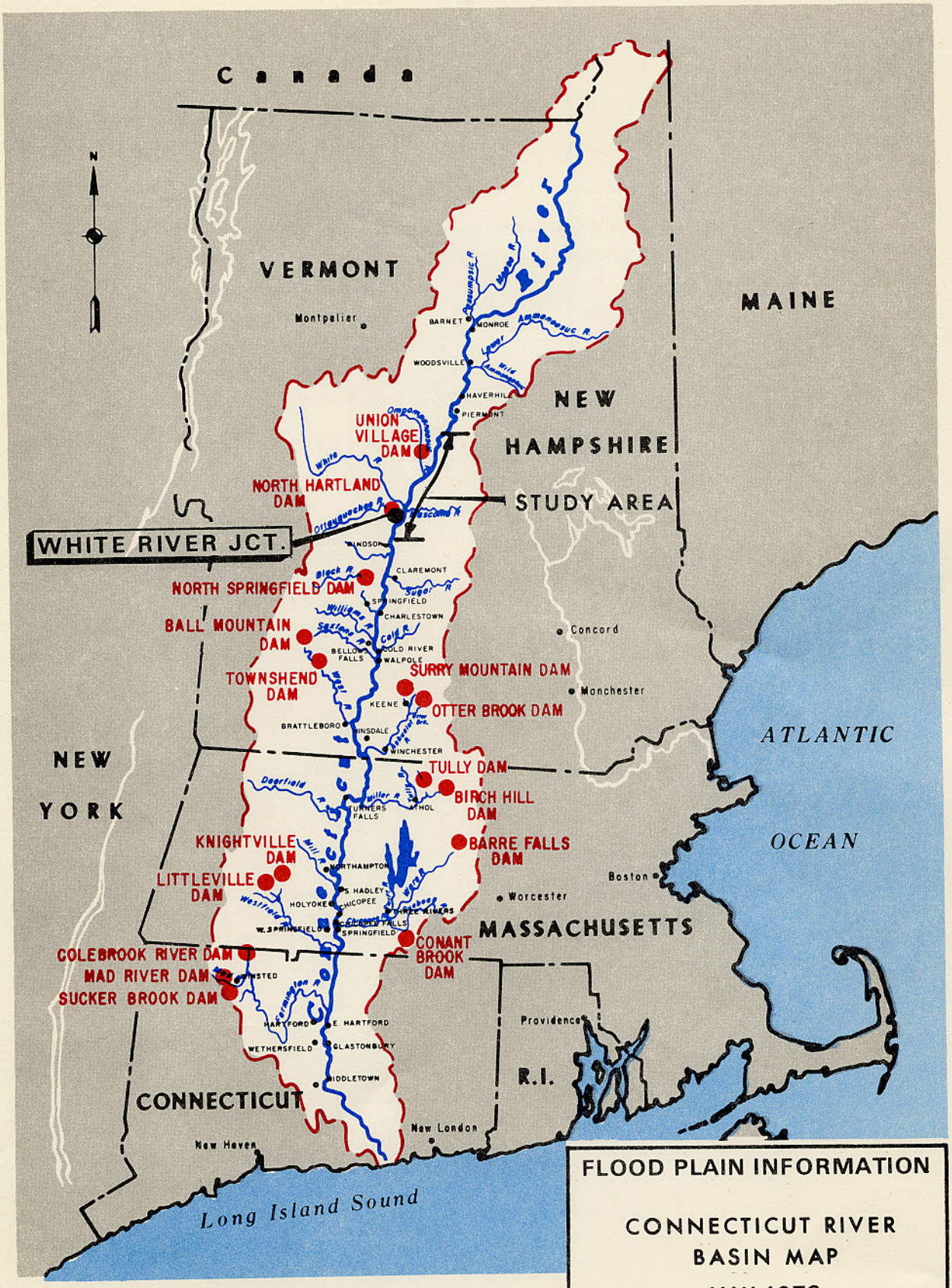
In problems concerned with the control of developments in the floodplains of the Connecticut, White and Mascoma Rivers and in reaching decisions on the size of floods to consider for this purpose, appropriate consideration should be given to the possible future occurrence of floods of the size of those that have occurred in the past, the Standard Project and the Intermediate Regional Floods. Maps and profiles which indicate the extent of flooding that has been experienced and which might occur in the future in the study area are included in

this report. From these the depth of probable flooding at any location may be learned. With this information, floor levels for buildings may be planned high enough to avoid flood damage, or if at lower elevations, with recognition of the chances and hazards of flooding that are being taken.

The report does not include plans for the solution of flood problems. Rather, it is intended to provide the basis for further study and planning on the part of the towns included in this report in arriving at solutions to minimize vulnerability to flood damages. This involves local planning programs to guide developments by controlling the type of use made of the floodplain through zoning and subdivision regulations and possibly through the construction of flood protection works.

This report is not intended to extend any Federal authority over zoning or other regulation of floodplain use, and the report is not to be construed as committing the Federal Government in the future to investigate, plan, design, construct, operate or maintain any facilities discussed, or to imply any intent to undertake such activities unless specifically authorized by the Congress. It is intended, as mentioned before, as an aid to local authorities.

The New England Division, Corps of Engineers will, upon request, provide technical assistance to Federal, State and local agencies in the use of the information contained herein and will provide other pertinent data which are available.



FLOOD PLAIN INFORMATION

CONNECTICUT RIVER BASIN MAP

MAY 1972

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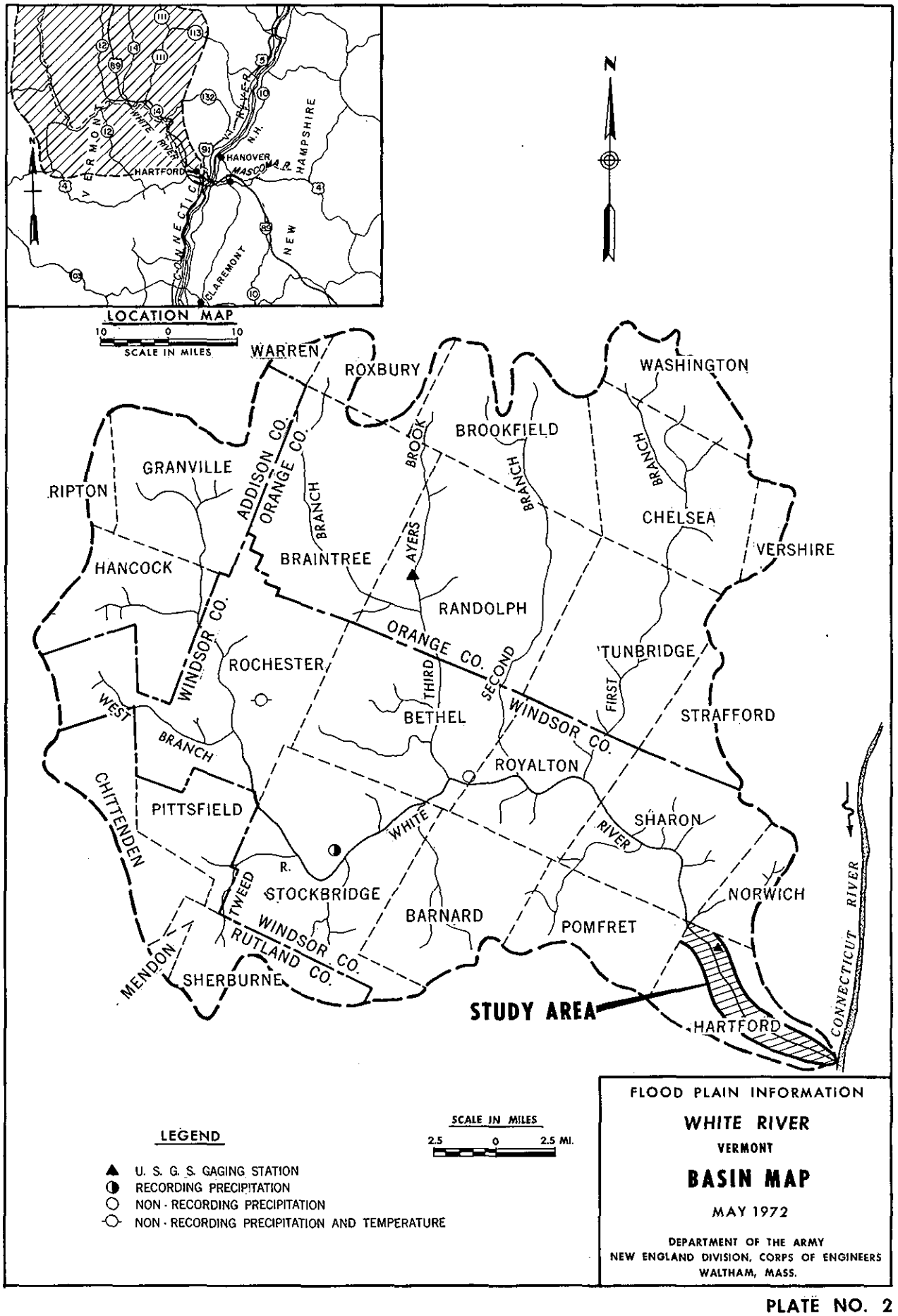

FLOOD PLAIN INFORMATION

WHITE RIVER

VERMONT

BASIN MAP

MAY 1972

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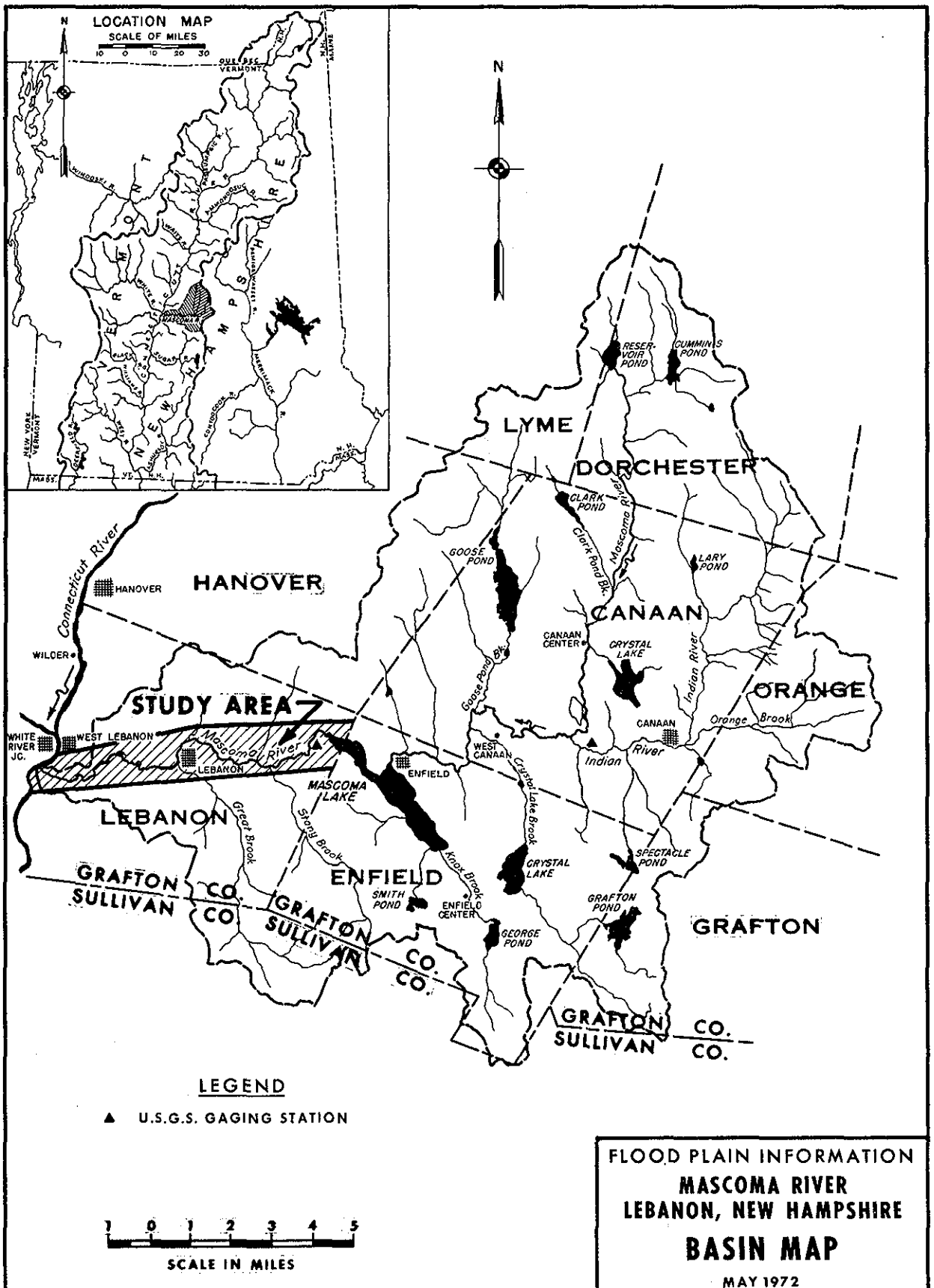

FLOOD PLAIN INFORMATION

MASCOMA RIVER
LEBANON, NEW HAMPSHIRE

BASIN MAP

MAY 1972

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PLATE NO. 3

SUMMARY OF FLOOD SITUATION

The towns of Thetford, Norwich, Hartford and Hartland, Vermont are located on the west bank of the Connecticut River. The towns of Plainfield, Lebanon, Hanover, and Lyme, New Hampshire, are located on the east bank. White River flows through Hartford and joins the Connecticut River at the village of White River Junction. The Mascoma River flows through Lebanon, New Hampshire, and joins the Connecticut River at West Lebanon.

The principal residential and commercial communities are located at White River Junction, Vermont and Lebanon and Hanover, New Hampshire.

The U.S. Geological Survey maintains gaging stations on the right bank of the Connecticut River just downstream of White River and on the White River at West Hartford. Stream gaging stations are also maintained on the Mascoma River at West Canaan and at the community of Mascoma in the city of Lebanon, 1,000 feet below the outlet of Mascoma Lake. The New England Power Company records daily flows on the Connecticut River at Wilder Dam. Residents along the rivers have been interviewed, newspaper files and historical documents have been searched and the New England Power Company has made their records available to the Corps of Engineers. From these investigations and records and from studies of possible future floods on the Connecticut, White, and Mascoma Rivers, the past and future flood situation has been developed. The following paragraphs summarize the significant findings which are further discussed in more detail in succeeding sections of this report.

ICE JAM FLOODS usually occur more on the White River than on the Connecticut and Mascoma Rivers within the limits of this report. However, ice jams have occurred on the Connecticut River in Windsor, Vermont and have caused high water in that area. In recent years, ice jams have occurred with increasing frequency on the White River. Peak discharges may, or may not, be concurrent with the highest stage occurring as a result of the ice jam. For example, in March 1964, the ice jam on the White River broke and caused its major damage when the discharge was approximately 16,000 cubic feet per second (cfs). The maximum discharge of 23,000 cfs occurred 12 hours after the jam had moved. Other recent ice jam breakups were not considered because stages were lower than the March 1964 flood. Table 1 shows a partial list of recent ice jams which have been experienced on the White River in Hartford and the relative peak discharge.

TABLE 1

ICE JAM FLOODS - WHITE RIVER

DATE	DISCHARGE cfs
March 1964	23,000
April 1959	11,300
January 1959 (Two floods)	(1)
March 1953	26,300
March 1946	27,800

(1) Peak discharges unknown.

The removal of rock in the river bottom at Hartford is intended to relieve future ice jams in this area.

NON-ICE JAM FLOODS are caused by heavy rainfall alone or by a combination of heavy rain and melting snow. Table 2 is a list of known major floods with their corresponding peak discharges that have occurred on the White, Connecticut and Mascoma Rivers in the vicinity of White River Junction.

TABLE 2

NON-ICE JAM FLOODS

Date	White River cfs	Connecticut River cfs	Mascoma River cfs
November 1927	120,000	136,000	3,230
March 1936	45,400	120,000	5,840
March 1913	-	113,000	-
April 1922	35,500	89,000	-
September 1938	47,600	82,400	4,400
March 1953	26,300 (1)	73,300	4,880
June 1947	31,100	63,400	-

(1) Ice Jam

* * * * * *

THE GREATEST FLOOD on the Connecticut River downstream of Wilder Dam, to the downstream limit of this report, occurred in November 1927. From Wilder Dam to the upstream report limit, the greatest flood occurred in March 1936. On the White River the greatest flood occurred in November 1927 (see Figure 1) and on the Mascoma River the greatest flood occurred in March 1936.

* * * * * *

ANOTHER GREAT FLOOD on the Connecticut River below Wilder Dam, to the downstream limit of this report, occurred in March 1936. This was about 2.2 feet lower than the flood of November 1927. Upstream of Wilder Dam, the flood of 1927 was about 3 feet lower than the March 1936 flood. On the White River, the flood of September 1938 was about 10 feet lower than that of November 1927. On the Mascoma River, the flood of March 1953 was generally about a foot lower than the March 1936 flood.

* * * * * *

OTHER GREAT FLOODS have been recorded on the Connecticut and White Rivers in March 1913, April 1922, September 1938, March 1953 and June 1947. On the Mascoma River, significant recorded floods have occurred in March 1936, March 1925, November 1927, April 1933 and April 1934.

* * * * * *

OTHER FLOODS causing damage have occurred in the study area since the founding of the first settlements in the basin. Although there is little reliable information on the magnitudes of most of the early floods, available records indicate that the floods of September 1828 and October 1869 were severe and caused considerable damage. Minor flooding occurred in April 1926, April 1932 and April 1951.

* * * * * *

INTERMEDIATE REGIONAL FLOOD is a flood that has an average frequency of occurrence in the order of once in 100 years. However, this flood could occur in any year or even twice in the same year.

WHITE RIVER JUNCTION, VERMONT

Birdseye view of White River Junction, Vt., looking across the White River from "Tafts Flats." Many people were rescued in boats in various parts of the city.

WHITE RIVER BRIDGE, WHITE RIVER JUNCTION, VERMONT (Nov. 1927)

Figure 1

It is determined from a statistical analysis of floods on these streams and other streams in the same general area. For the Connecticut River and the White River the determination is made with the realization that Union Village and North Hartland Dams will be in operation at the time of the storm.

In the case of the Mascoma River, determination of the flood is based on flows at the Mascoma gaging station, with the realization that frequency and magnitudes of floods on the Mascoma River in the future will depend to a large degree on the operation plan for the spillway gates at the Mascoma Lake Dam.

* * * * * *

STANDARD PROJECT FLOOD on the Connecticut, White and Mascoma Rivers is the largest flood that may be experienced. It is not practicable to assign a frequency to the Standard Project Flood as the occurrence of such a flood would be a rare event. However, it could occur in any year. Floods larger than the Standard Project Flood are possible and should not be overlooked in the study of any problems.

* * * * * *

FLOOD DAMAGES will be substantial from recurrences of major known floods. Additional damages would be caused by the Standard Project Flood because of its wider extent, greater depth and higher velocities.

* * * * * *

MAIN FLOOD SEASON on the Connecticut, White and Mascoma Rivers has been in the spring, as most of the higher floods have resulted from heavy rains and melting snow. However, records reveal that of the five major floods two have occurred in the fall, including the greatest flood on record. Floods may occur any time and have been experienced in nine months of the year.

* * * * * *

FLOOD DAMAGE PREVENTION MEASURES in the Connecticut River Valley, as well as in other drainage areas in New England, have been an active program of the New England Division of the Corps of Engineers. Two flood control dams modify floodflows in the report area.

* * * * * *

FUTURE FLOOD HEIGHTS that would be reached if the Intermediate Regional Flood and the Standard Project Flood should occur in the vicinity of this report area are shown in Table 3. The table gives the comparison of these flood crests and also shows the comparison with the March 1953 flood on the Connecticut, White and Mascoma Rivers.

TABLE 3

RELATIVE FLOOD HEIGHTS

CONNECTICUT RIVER

At White River Junction, Vt. - USGS Gage

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953	73,300	0	346.0
Intermediate Regional	99,000	4.7	350.7
Standard Project	110,000	6.6	352.6

WHITE RIVER

At West Hartford, Vt. - USGS Gage

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953	26,300 (1)	-	389.9
Intermediate Regional (Same as experienced 1936 Flood)	45,000	3.4	393.3
Standard Project (Same as 1927 Flood Modified)	72,000	7.6	397.5

(1) Ice Jam Flood

MASCOMA RIVER

At Hanover Street Bridge, Lebanon, N.H.

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953	4,900	0	574.5
March 1936	5,900	0.7	575.2
Intermediate Regional	7,000	1.7	576.2
Standard Project	10,000	3.7	578.2

TABLE 5

BRIDGES ACROSS THE CONNECTICUT RIVER

Miles Above Mouth	Identification	Floor Elev. ft. msl	Inter-mediate Regional Flood Crest ft. msl	Standard Project Flood Crest ft. msl	Underclearance Elev. Bottom Chord ft. msl	Underclearance Above IRF Flood feet	Underclearance Below IRF Flood feet
213.7	Interstate 89	-	350.5	358.0	384.8	34.3	-
215.0	B & M RR	371.9(1)	353.3	359.8	357.9	4.6	-
215.3	U.S. Route 4	362.9	354.4	361.5	359.4	5.0	-
219.3	State Route 10A	401.0	391.0	394.7	393.2	2.2	-
229.6	East Thetford	405.8	400.6	405.8	402.3	1.7	-
231.8	North Thetford	401.3	403.0	408.8	397.8	-	5.2

(1) Top of Rail.

TABLE 3

RELATIVE FLOOD HEIGHTS

CONNECTICUT RIVER

At White River Junction, Vt. - USGS Gage

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953	73,300	0	346.0
Intermediate Regional	109,500	7.3	353.3
Standard Project	157,000	13.8	359.8

WHITE RIVER

At West Hartford, Vt. - USGS Gage

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953	26,300 (1)	-	389.9
Intermediate Regional	75,000	8.1	398.0
Standard Project (Same as 1927 Flood)	120,000	13.9	403.8

(1) Ice Jam Flood

MASCOMA RIVER

At Hanover Street Bridge, Lebanon, N.H.

Flood	Estimated Peak Discharge cfs	Above 1953 Flood feet	Elev. ft msl
March 1953 (1)	4,900	0	573.0
March 1936 (1)	5,900	1.0	574.0
Intermediate Regional	7,000	2.0	575.0
Standard Project	10,000	5.5	578.5

(1) Under present conditions.

Revised 5 July 1972

GENERAL CONDITIONS AND PAST FLOODS

General

This section of the report is a history of floods along the Connecticut, White and Mascoma Rivers in an area which includes the towns of Plainfield, New Hampshire and Hartland, Vermont up to and including the towns of Lyme, New Hampshire and Thetford, Vermont. The important residential and business sections in the area are White River Junction in Vermont and Hanover and Lebanon in New Hampshire. The drainage area of the Connecticut River above the lower limits of this study is 4,619 square miles. The drainage area of the White River above its confluence with the Connecticut River is 712 square miles. The drainage area of the Mascoma River above its confluence with the Connecticut River is 194 square miles.

United States Geological Survey gage records of river stages on the Connecticut River at White River Junction, Vt. date from October 1911, and on the White River at West Hartford, Vt. date from June 1915, and on the Mascoma River at Mascoma, N.H. date from August 1923. Flood history was searched in order to develop the flood information on the rivers. Descriptions of the early floods of the Connecticut River basin were collected in the field from numerous and diverse sources such as files of old newspapers, old town histories, diaries, letters, etc. Keeping of systematic flood records for the major New England rivers began about 1904. It is fairly certain that the recent floods exceeded all historical floods back to the date of the first settlement - some 200 to 300 years ago. Even though the magnitude of the early floods cannot now be determined, the fact that there is no historical evidence that they were as high as the great recent floods is valuable.

Settlement

Until the close of the French and Indian Wars, colonists found this region unsafe for settlement. The first settlers arrived in the area between 1760 and 1765 after hostilities had ceased and peace restored to the region.

Economic development of the region in the early days centered around agriculture and dairy products. Today, dairying is still important but is limited to small farming for local consumption. Light industry has been established in Lebanon and White River Junction. White River Junction is well known as a primary railroad center.

Lebanon was founded and chartered as a town in 1761 and is located on the falls of the Mascoma River, near the Connecticut River. It became a city in 1957 and the council-manager form of government was adopted. It lies 45 miles northwest of Concord, New Hampshire, and 4 miles south of Hanover, New Hampshire. The altitude is 550 feet above mean sea level. Population in 1950 was 8,495 and rose to 9,299 in 1960.

Water power, for use by grist mills and saw mills, was developed early. Later, the water power was redeveloped for textile production and other manufacturing processes. Today, bricks, clothing, watchmaker tools, leather goods, electrical supplies, sporting goods and dairy products are produced in Lebanon.

Lebanon Regional Airport offers direct flights to New York and Boston daily. Interstate Highway 89 and 91 form an important intersection at White River Junction, and provide fast, direct service to major U.S. and expanding Canadian markets.

Many educational institutions exist in and around the study area. Among them are Lebanon Community College, Dartmouth College, Thayer School of Engineering, Tuck School of Business Administration, Dartmouth Medical School, nursing schools, and public and parochial schools. Adult and vocational programs are offered at all levels. Museums and libraries are available.

Several hospitals and clinics, including a Veterans Administration Hospital provide in-patient and out-patient care.

There are many recreational facilities in the region, such as lakes, streams, golf courses, ski areas, summer camps, and summer theater. State and local parks, as well as the Appalachian Trail and other trails, provide for hiking, picnicking, mountain climbing, and horseback riding.

Research also plays an important part in the region with such facilities as the Cold Regions Research and Engineering Laboratory of the U.S. Army Corps of Engineers, Thermal Dynamics Corporation, Combustion Products, Inc., CREARE, Inc., and Don West Associates, Inc. Extensive research is also conducted at Dartmouth College, Thayer School of Engineering, Dartmouth Medical School and Mary Hitchcock Hospital.

Flood Damage Prevention Measures

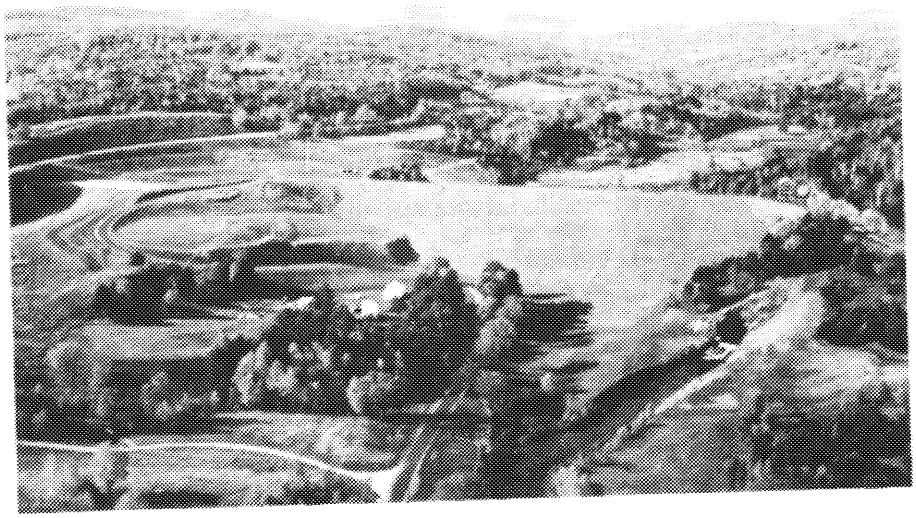
There are two flood control projects which affect the study area. Union Village Dam is located on the Ompompanoosuc River four miles above its junction with the Connecticut River, and was completed in June 1950 at a cost of $4,210,000. To date total damages prevented since completion of the project has been $1,355,000. In a recurrence of the March 1936 basin flood of record the dam would prevent $8,680,000 in damages. At spillway crest the dam has a storage capacity of 38,000 acre-feet, which is equivalent to 5.7 inches of runoff from its drainage area of 126 square miles. When full, a 720-acre pool will extend about 3 miles upstream.

North Hartland Lake is situated on the Ottauquechee River, and was completed in June 1961 at a cost of $7,660,000. To date there have been six significant storage operations which have prevented damages of $720,000. In a recurrence of the March 1936 basin flood of record it would prevent damages of $16,640,000. The reservoir is operated for flood control purposes and at spillway crest has a capacity of 71,400 acre-feet which is equivalent to 6.1 inches of runoff from the drainage area of 220 square miles. When filled to spillway crest a 1,173 acre reservoir would extend 5.5 miles upstream to Quechee. A 220-acre seasonal conservation lake is held behind the dam from mid May to mid October for recreation and fishery enhancement. This area was dedicated as "George Perkins Marsh Lake" in 1967 by Mrs. Lyndon Johnson.

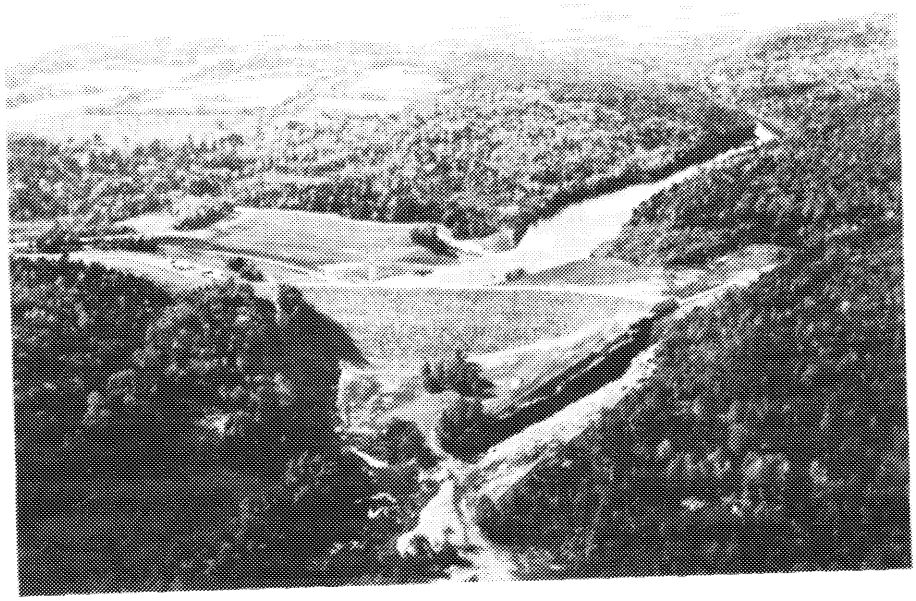
Some areas that have been flooded in the past can expect flooding in the future. Any existing developments in the flood plains should consider floodproofing the buildings. By elevating floors above the flood level and utilizing low ground for parking facilities, flood damage can be minimized.

The Mascoma River has no existing or authorized flood control measures in or above the study area except for the gate operation schedule at the Mascoma Lake Dam. No major flood has occurred in the area in recent years so the effectiveness of the present operating schedule has not been proven.

The only flood control measure taken in the White River study area was at Hartford, Vermont where rock ledge was removed from the channel bottom to eliminate flooding caused by ice jams.



Union Village Dam



North Hartland Lake

Figure 2

Flood Warning and Forecasting Service

The U. S. Department of Commerce, National Weather Service, is responsible for forecasting high water on the nation's rivers and for issuing flood warnings for the protection of life and property. The National Weather Service River Forecast Center at Hartford, Connecticut is responsible for issuing flood warnings for the Connecticut River basin. A comprehensive network of rainfall and river data reporting stations has been established with cooperative observers. The flood warnings are issued by teletype simultaneously to the press services, State Police, Civil Defense and many other State and local agencies. In the event of communication failure, the State Police and Civil Defense have an emergency plan for receiving flood warnings and notifying the responsible officials.

It should be reiterated that a flood warning system is only one phase of preventative flood damage measures. The other phase is the preparation of Federal and local governments and private citizens to combat the impending storm. Without a sufficient storm warning and an ability to react to the warning, the residences, industrial and commercial establishments in low-lying areas will be defenseless against the raging flood waters of the Connecticut, White and Mascoma Rivers.

In addition to the flood warning and forecasting service, the Corps of Engineers operates an Automatic Hydrologic Radio Reporting Network. This network, under computer programmed control, will immediately provide read-out information which is essential for the regulation of flood control dams. River stages are reported from the gaging stations on the Connecticut River at White River Junction, Vt., and on the White River at West Hartford, Vt. The real time print-out on the computer will assure early warning to Division personnel of high stream flows for immediate operation of Union Village and North Hartland Dams.

CONNECTICUT RIVER

The Stream and Its Valley

The Connecticut River rises in Fourth Connecticut Lake in the mountainous semi-wilderness area of northern New Hampshire, adjacent to the Canadian border. The river basin is long and narrow in shape and extends from the Canadian border to Long Island Sound. It includes small areas of the State of Maine and the Province of Quebec, and large areas of Vermont, New Hampshire, Massachusetts and Connecticut.

Hilly uplands prevail throughout much of the basin and in the upper reaches steep mountain streams create a fast runoff. Important ranges of hills and mountains are the Berkshire Hills, Green Mountains, and the White Mountains. The highest elevation in the basin is 6,288 feet msl on Mount Washington. From the First Connecticut Lake to the White River gage the total fall is 1,321 feet in a distance of 189 miles.

The river has a drainage area of 3,105 square miles at the upper end of the study area at the Thetford-Lyme townline. Within the reach covered by this investigation, the drainage area is 1,514 square miles, making the total drainage area at the downstream limits of the study 4,619 square miles.

The principal tributaries within the study area are the Ompompanoosuc, White, Mascoma and Ottauquechee Rivers. The White River and the Mascoma River will be discussed separately in later sections of this report. Pertinent drainage areas of the Connecticut River, within the study limits, are given in Table 4.

TABLE 4

DRAINAGE AREAS IN REPORT AREA OF CONNECTICUT RIVER
(in square miles)

Location	Tributary	Total
Thetford-Lyme Town Line	-	3,105
Local Area	74	3,179
Ompompanoosuc River	136	3,315
Local Area	62	3,377
White River	712	4,089
Mascoma River	194	4,283
Local Area	40	4,323
Ottauquechee River	222	4,545
Local (Plainfield-Hartford T/L)	74	4,619

Developments in the Floodplain

Plates 6 through 13 show the floodplains of the Connecticut River in the reach covered by this report. Development is at a minimum in the towns of Hartland and Plainfield as the land along the river is utilized for general farming and residences. Development in White River Junction, Hanover and West Lebanon is limited to residential, light industry and commercial establishments. Above Wilder Dam the floodplains are used for general farming and residences.

Bridges Across the Stream

Five highway bridges and one railroad bridge cross the Connecticut River in the reach included in this study. Table 5 lists pertinent elevations for these structures and shows their relation to the crest of the November 1927 flood, the Intermediate Regional Flood and the Standard Project Flood. Figure 3 shows photographs of some of the bridges.

The underclearances of the Interstate 89 Bridge, the Boston and Maine Railroad Bridge at Mile 215.0 and the U.S. Route 4 Bridge at Mile 215.3 are all above the elevations of the Intermediate Regional Flood and the Standard Project Flood. The bridges would not obstruct the flow of these floods. The underclearance of the state Route 10A highway bridge at Mile 219.3 would come about 3.6 feet above the Intermediate Regional Flood while the Standard Project Flood would come to just about the elevation of the underclearance. This bridge would offer little if any impedance to the two floodflows. At Mile 229.6 the underclearance of the East Thetford Bridge would be about 1.3 feet above the Intermediate Regional Flood and would not be an obstruction to that flood. However, the Standard Project Flood would rise to about 2.7 feet above the underclearance and the bridge would be an obstruction to that floodflow. At Mile 231.8 the underclearance of the North Thetford highway bridge would come about 5.2 feet below the Intermediate Regional Flood and about 11 feet below the Standard Project Flood. This bridge would be completely inundated by both floods. The floor of the bridge would be about 1.7 feet below the Intermediate Regional Flood and about 7.5 feet below the Standard Project Flood. This bridge would be a considerable obstruction to both floodflows.

Dams on the Stream

Wilder Dam, a hydroelectric power station on the Connecticut River, was relocated in 1950 about three quarters of a mile downstream from its former site. The dam has a permanent power pool and is not used for flood control purposes. Since the dam is capable of passing a discharge 75 percent greater than the maximum flood of record, it offers no obstruction to floodflows. The owners and operators of the

dam have an arrangement with the Corps of Engineers whereby the drawdown is controlled during flood events. There are no other dams in the study area on the Connecticut River.

Obstructions to Floodflows

The effect of obstructions due to bridges was described in previous paragraphs. With the exception of the bridges there are no significant obstructions to flows in the Connecticut River reach included in this study. Wilder Dam is a control on the river but is not an obstruction in passing floodflows.

TABLE 5

BRIDGES ACROSS THE CONNECTICUT RIVER

Miles Above Mouth	Identification	Floor Elev. ft. msl	Intermediate Regional Flood Crest ft. msl	Standard Project Flood Crest ft. msl	Underclearance Elev. Bottom Chord ft. msl	Underclearance Above IRF Flood feet	Underclearance Below IRF Flood feet
213.7	Interstate 89	-	350.5	358.0	384.8	34.3	-
215.0	B & M RR	371.9(1)	353.3	359.8	357.9	4.6	-
215.3	U.S. Route 4	362.9	354.4	361.5	359.4	5.0	-
219.3	State Route 10A	401.0	391.0	394.7	393.2	2.2	-
229.6	East Thetford	405.8	400.6	405.8	402.3	1.7	-
231.8	North Thetford	401.3	403.0	408.8	397.8	-	5.2

(1) Top of Rail.

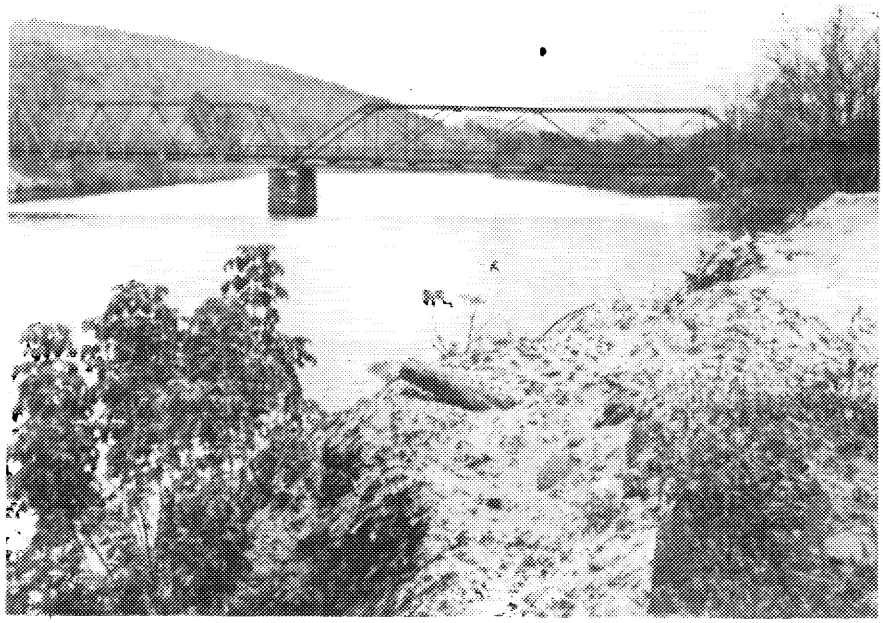
Revised 5 July 1972

TABLE 5

BRIDGES ACROSS THE CONNECTICUT RIVER

Miles Above Mouth	Identification	Floor Elev. ft. msl	Intermediate Regional Flood Crest ft. msl	Standard Project Flood Crest ft. msl	November 1927 Flood Crest ft. msl	Underclearance Elev. Bottom Chord ft. msl	Underclearance Above 1927 Flood feet	Underclearance Below 1927 Flood feet
213.7	Interstate 89	-	348.6	351.8	354.0	384.8	30.8	-
215.0	B & M RR	371.9(1)	350.7	352.6	356.6	357.9	1.3	-
215.3	U.S. Route 4	362.9	353.0	355.0	359.4	359.4	-	-
219.3	State Route 10A	401.4	391.0	394.7	389.1	394.6	5.5	-
229.6	East Thetford	405.8	401.0	405.0	397.2	402.3	5.1	-
231.8	North Thetford	401.3	403.0	408.8	399.2	397.8	-	1.4

(1) Top of Rail.



Connecticut River, Lyme-Thetford (North) Highway Bridge
Looking Downstream

Lebanon, N.H.-Hartford, Vt. - Looking Downstream
at U.S. Routes 4 and 5 Highway Bridge

Figure 3

FLOOD SITUATION

Flood Records

Records of river stages and discharges on the Connecticut River, at White River Junction, have been available since 1911 when a gaging station was established approximately 500 feet downstream from the mouth of the White River.

Records have been maintained since 1940 on the Ompompanoosuc River and after completion of Union Village Dam and Reservoir in 1950, the gage was relocated downstream of the dam. Flow on the river is regulated by the dam.

On the Ottauquechee River the gage is located one mile upstream from its mouth. Records have been available since 1930 and flow on the river is regulated by power dams upstream and by the North Hartland Dam.

Flood Stages and Discharges

Table 6 lists the crest stages and discharges for the known floods exceeding a flood stage of 20 feet at the gaging station on the Connecticut River 500 feet downstream from White River. Table 7 lists the highest eleven floods in order of magnitude.

Flood Occurrences

Floods on the Connecticut River in the vicinity of the study area have occurred on an average of once every two years, as indicated by Table 6.

TABLE 6

FLOOD CREST ELEVATIONS ABOVE FLOOD STAGES

1912 - 1967

CONNECTICUT RIVER AT WHITE RIVER JUNCTION, VERMONT

The table includes all known floods above flood stage of 20.0 feet at the U.S. Geological Survey gaging station 500 feet downstream on the right bank from the mouth of the White River. Drainage area = 4,092 square miles. Zero of gage = 321.52 ft. m.s.l., datum of 1929, non-recording prior to November 3, 1930, recording thereafter.

Date of Crest	Gage Heights		Discharge
	Stage	Elevation	
	ft.	ft. msl	cfs
April 8, 1912	23.0	344.52	69,800
March 27, 1913	30.0	351.52	113,000
April 21, 1914 (1)	22.8	344.32	68,800
March 28, 1919	20.8	342.32	59,200
April 12, 1922	27.0	348.52	89,500
May 1, 1923	22.2	343.72	66,000
March 29, 1925 (1)	22.8	344.32	68,800
April 25, 1926	20.6	342.12	58,300
November 4, 1927	35.0	356.52	136,000
April 12, 1932	20.6	342.12	51,900
April 19, 1933 (1)	24.2	345.72	68,700
April 12, 1934	21.8	343.32	57,200
March 19, 1936	32.6	354.12	120,000
May 15, 1937	20.65	342.17	51,500
September 22, 1938	26.7	348.22	82,400
April 26, 1939	20.9	342.42	52,800
May 5, 1940	22.32	343.82	59,600
June 3, 1947	22.55	344.07	63,400
June 2, 1952	21.15	342.67	56,500
March 27, 1953	24.48	346.00	73,300
April 25, 1958	21.33	342.85	57,400
January 22, 1959 (1)	23.08	344.60	--
November 28, 1959	20.07	341.59	51,500
April 5, 1960	21.24	342.76	57,000

(1) Ice Jam

TABLE 7

HIGHEST ELEVEN KNOWN FLOODS IN ORDER OF MAGNITUDE

CONNECTICUT RIVER AT WHITE RIVER JUNCTION, VERMONT

Order No.	Date of Crest	Gage Height Stage ft.	Gage Height Elevation ft. msl	Estimated Peak Discharge cfs
1	November 4, 1927	35.0	356.52	136,000
2	March 19, 1936	32.6	354.12	120,000
3	March 27, 1913	30.0	351.52	113,000
4	April 12, 1922	27.0	348.52	89,500
5	September 22, 1938	26.7	348.22	82,400
6	March 27, 1953	24.48	346.00	73,300
7	April 19, 1933 (1)	24.2	345.72	68,700
8	January 22, 1959 (1)	23.08	344.60	--
9	April 8, 1912	23.0	344.52	69,800
10	April 21, 1914 (1)	22.8	344.32	68,800
11	March 29, 1925 (1)	22.8	344.32	68,800

(1) Ice Jam

Flooded Areas and Flood Profiles

Plates 6 through 13 show the approximate areas along the Connecticut River that will be inundated by the Intermediate Regional Flood and the Standard Project Flood in the reach covered by this report. The actual limits of flooding on the ground may vary some from those shown on the map because the 20-foot contour interval and scale of the map do not permit precise plotting of the flooded area boundaries.

Also shown on the same plates are profiles for the study floods. These profiles may be used to determine the depth of flooding at any particular location by standard survey methods. High water marks are shown for various locations for the November 1927 and March 1936 floods. The only available high water marks of the March 1913, April 1922 and the September 1938 floods are shown at the U.S.G.S. gage on the Connecticut River at White River Junction, Vermont.

FLOOD DESCRIPTIONS

Following are descriptions of known large floods that have occurred on the Connecticut River in the reach covered by this study. These are based upon newspaper accounts, historical records and field investigations.

November 4, 1927

The flood of November 1927 was produced by torrential rains falling over much of New England, causing severe flooding throughout the region. The rainfall from November 2 to 4 broke all records for continuous rain in Vermont and also all 24-hour records. At the time of this storm the ground had been thoroughly saturated by heavy rains which fell from the 18th to the 21st of October. The natural lakes and swamps were already filled, and most of the rivers had been raised to medium high stages, so that practically all the surface storage available was utilized less than two weeks before the storm. As a result the rivers quickly overflowed their banks and the grades of the streams were so steep that excessively high velocities were attained, with the rushing waters washing out bridges, retaining walls, dams, road embankments, buildings and farmlands. In many sections of the mountainous country near the headwaters, the flood peaks arrived suddenly, at night. The inhabitants were taken unaware, and many, being unable to reach safety, were drowned in their homes.

At White River Junction the Connecticut River was 5 feet higher than the former record of March 1913. The principal floodwave in the Connecticut Valley came from the White River, which had a higher runoff per square mile in proportion to the size of its drainage basin than any other stream in New England. At the time White River was discharging its peak flow of 120,000 cfs on the morning of the fourth, the Connecticut River above the mouth of the White River was discharging only about 16,000 cfs.

The flood of November 1927 was a major catastrophe in Vermont's history. The swollen and swift flowing streams destroyed whole villages, washed out or damaged over 60 dams, completely disrupted transportation and commerce, forced the Central Vermont Railroad into receivership, and caused damage and lengthy shutdown to over 50 mills.

The average rainfall over the Connecticut Valley for November 3-4 was 4.43 inches (9 stations), with maxima of 6.41 and 6.39 inches at White River Junction and St. Johnsbury, Vermont, respectively. Unofficial reports from other points in New Hampshire and Vermont indicated even heavier rains - as much as 15 inches in some mountain sections.

On the White River the November 1927 flood has been considered a very rare flood due to its magnitude and approximates the Standard Project Flood.

March 1936

From March 9 through 22 there occurred in close succession over the northeastern United States two extraordinarily heavy rainstorms. At the time of the rain there were accumulations of snow on the ground over much of the area having a water content of over 5 inches in Vermont and New Hampshire. The floods resulting from this combination of events were unusually devastating.

The flood resulting from the first storm was accompanied by the breaking up of the heavy ice on the streams and was distinctively an "ice" flood.

The water from the melting snows and the extraordinary rainfall of the second storm flowed, therefore, into river systems that were still burdened with the waters of the first flood and so put into action the processes of flood destruction and demoralization. Many of the rivers carried large quantities of ice during the second flood, and damages to some structures were due to both ice and water.

The first storm had one major center of precipitation which was in the White Mountain Region with the rainfall ranging from 2 to 5 inches resulting in a peak stage of 19.6 feet.

The second storm had much the same general pattern as the first; it likewise was centered in the White Mountains. The total rainfall for the period between March 9 and 22 ranged from 5 to 12 inches in this area. Plate 4 shows the rate of rise and duration of the second storm.

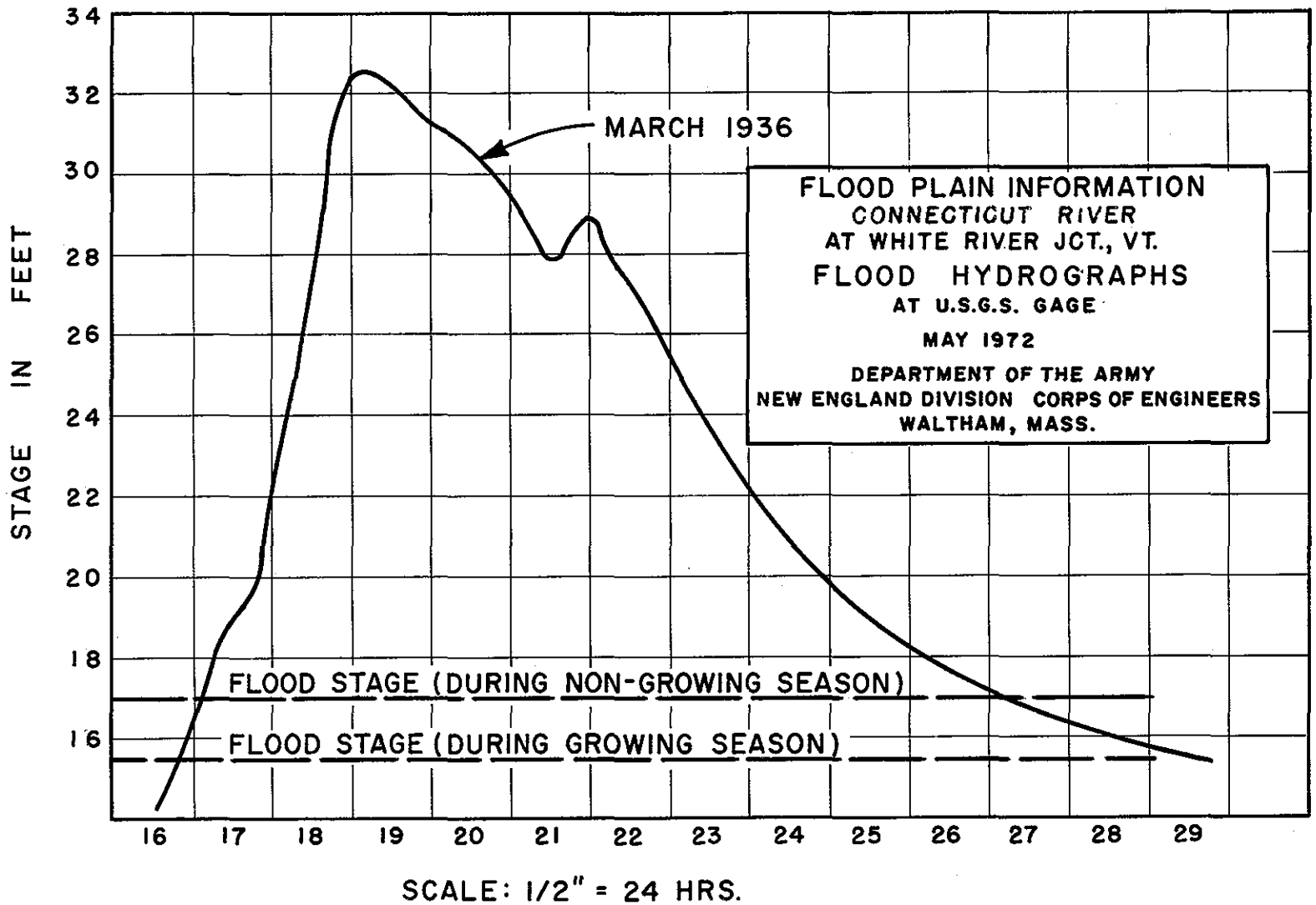

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
AT WHITE RIVER JCT., VT.
FLOOD HYDROGRAPHS
AT U.S.G.S. GAGE
MAY 1972
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS.
MARCH 1936
FLOOD STAGE (DURING NON-GROWING SEASON)
FLOOD STAGE (DURING GROWING SEASON)
STAGE IN FEET
34
32
30
28
26
24
22
20
18
16
16
17
18
19
20
21
22
23
24
25
26
27
28
29
SCALE: 1/2" = 24 HRS.

PLATE NO. 4

WHITE RIVER

The Stream and Its Valley

The White River has a drainage area of 712 square miles, and rises on the slopes of Bartell Mountain in the town of Ripton, Vermont. It flows in a general southeasterly direction to its confluence with the Connecticut River at White River Junction. The Basin has a rugged watershed with steep slopes and with very little concentrated fall and channel pondage.

The White River has a total length of 58 miles, with a total fall of 2,170 feet, of which 1,600 feet occurs in its upper nine-mile reach. The lower reach of the river has a relatively flat gradient dropping 4.5 feet in 1.5 miles to the mouth of the river. The highest elevation is 3,780 ft. m.s.l. on Mt. Wilson in the town of Ripton.

The three principal tributaries of the White River are the First, Second, and Third Branches and comprise about 44 percent of the total drainage area. The First Branch, with a drainage area of 103 square miles, rises in the town of Washington. It is 21 miles long with a fall of 880 feet. The Second Branch, with a drainage area of 73 square miles, rises in the town of Williamstown. It has a length of 25 miles with a fall of 430 feet. The Third Branch rises in Roxbury and has a length of 26 miles, with a drainage area of 136 miles and a total fall of about 470 feet.

The White River joins with its three principal tributaries, First, Second, and Third Branches, within a distance of about 7 miles to form a nearly simultaneous concentration of four parallel main branches.

Developments in the Floodplain

Plates 14 and 15 show the floodplains on the White River in the town of Hartford, Vermont. Development is limited to residential, light industry and commercial establishments with most of the development occurring near the mouth of the river.

Bridges Across the Stream

Six highways and two railroad bridges cross the White River in the reach covered by this study. Table 8 lists pertinent elevations for these structures and also indicates the relation of these elevations to the Intermediate Regional Flood and the Standard Project Flood. (November 1927) Figure 4 shows views of two of the bridges. Interstate Routes 91 and 89 cross the river at Miles 0.9 and 6.6 respectively with no problem of passing floodflows. Old U.S. Route 5 (figure 4) crosses the river at Mile 0.2. This was a steel truss structure until 1964 when an ice jam flood carried away a portion of the bridge. Steel girders were used to replace the damaged section. Although the Intermediate Regional Flood will not affect the bridge the Standard Project Flood would produce a stage about three feet above the roadway. New U.S. Route 5 crosses at Mile 0.3 and will pass both the Intermediate Regional and Standard Project Floods with the northern approach under water during a Standard Project Flood. Woolen Mill Road at Mile 1.5 will pass both floods except that the southern approach will be under water during a Standard Project Flood. All floods will pass under the Central Vermont Railroad at Mile 4.8. The West Hartford Bridge at Mile 7.4 will have about a half foot of water over the low steel during an Intermediate Regional Flood and with both approaches to the bridge under water. The Standard Project Flood would be about two feet over the roadway of the bridge.

Dams on the Stream

There are no existing dams in the study area.

Obstructions to Floodflows

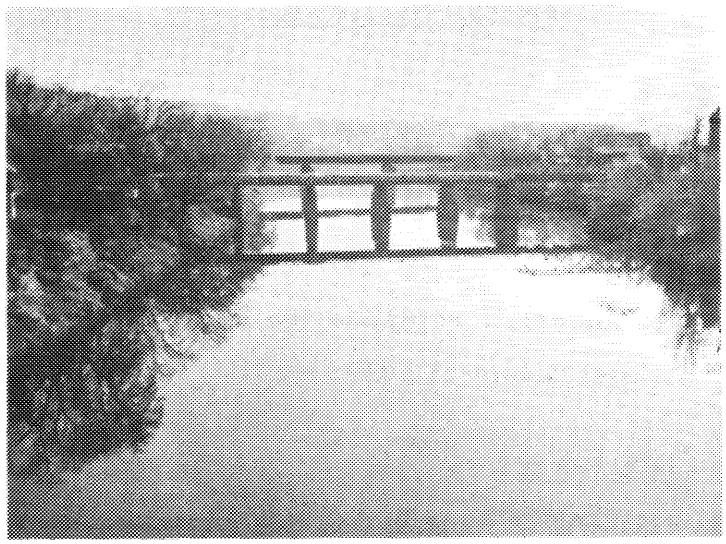
The effect of obstructions due to bridges has been discussed in the previous paragraphs.

Ice jam flooding occurs frequently in the lower section of the river due to bends, rock outcrops and sills in the river upstream and downstream of the Hartford Bridge. The slowdown in the lower reach due to a decreased slope in the river further increases the concentration of ice at Hartford. A local protection project contract to clear the rock outcrops was awarded in June 1970.

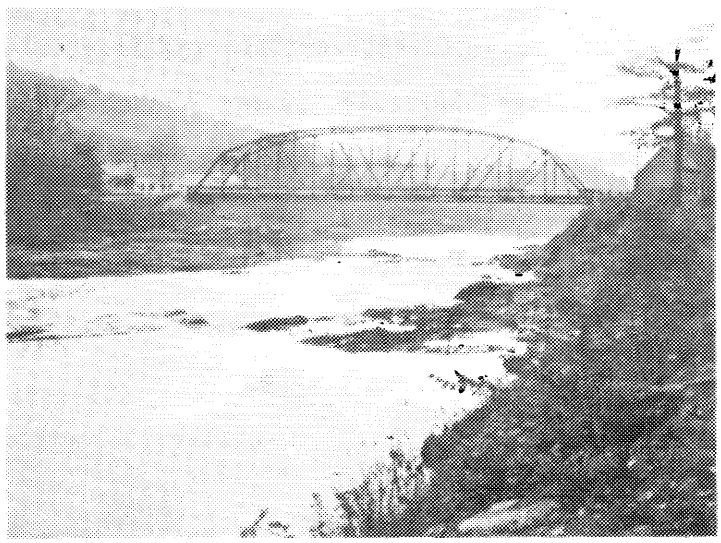
TABLE 8

BRIDGES ACROSS THE WHITE RIVER

Mile Above Mouth	Identification	Intermediate Regional Flood Crest Elevation ft msl	Nov. 1927 Flood Crest Elevation ft msl	Underclearance Bottom Chord Elev. ft msl	Above 1927 Flood feet	Below 1927 Flood feet
0.1	Boston & Maine RR	353.3	359.4	361.4	2.0	--
0.2	Old U.S. 5	353.5	360.4	353.6	--	6.8
0.35	New U.S. 5	354.5	--	365.2	--	--
0.9	I-91	357.7	--	436.7	--	--
1.5	Woolen Mill Rd.	361.0	--	367.3	--	--
4.75	Central Vermont RR	384.0	387.4	405.5	18.1	--
6.6	I-89	393.5	399.1	433.9	34.8	--
7.35	Road at West Hartford	397.5	403.0	397.4	--	6.4



WHITE RIVER - Looking Downstream at Old U.S. Highway Routes 4 and 5 in Hartford, Vermont



WHITE RIVER - Looking Downstream at Highway Bridge in West Hartford, Vermont

Figure 4

FLOOD SITUATION

Flood Records

A staff gage was established in 1915 on the White River at its present location, 500 feet upstream from the highway bridge at West Hartford, and about 7.4 miles upstream from its mouth. In October 1927, a water-stage recorder replaced the staff gage. Zero of gage is 374.53 ft. above msl datum of 1929.

Flood Stages and Discharges

Table 9 lists crest stages and discharges for the known floods exceeding a flood stage of 18.0 feet at the gaging station at West Hartford. Table 10 lists the highest ten known floods in order of magnitude.

Flood Occurrences

Records reveal that 22 significant floods, occasioned by runoff and snowmelt, occurred prior to 1927. More recent floods of outstanding importance are those of March 1936 and September 1938.

Ice jam floods occur frequently on the White River and three notable ones of approximately equal magnitude were 1867, 1908 and March 1964. It is reported that stages about 10 feet below those of March 1964, occur as a result of ice jams on an average of every two years.

TABLE 9

FLOOD CREST ELEVATIONS ABOVE FLOOD STAGE

1927 - 1967

WHITE RIVER AT WEST HARTFORD, VERMONT

The table includes all known floods above flood stage of 18.0 feet at the U.S. Geological Survey gaging station at West Hartford, Windsor County.

Drainage Area = 690 square miles.

Zero of Gage = 374.53 ft., above m.s.l. datum of 1929, non-recording prior to October 30, 1927, recording thereafter.

Date of Crest	Gage Heights		Discharge
	Stage feet	Elevation feet msl	cfs
November 4, 1927	29.3	403.83	120,000
April 3, 1934 (1)	19.94	394.47	---
March 18, 1936	18.89	393.42	45,400
September 22, 1938	19.26	393.79	47,600

(1) Ice Jam

TABLE 10

HIGHEST TEN KNOWN FLOODS IN ORDER OF MAGNITUDE

WHITE RIVER AT WEST HARTFORD, VERMONT

Order No.	Date of Crest	Estimated Peak Discharge cfs
1	November 4, 1927	120,000
2	September 22, 1938	47,600
3	March 18, 1936	45,400
4	April 12, 1922	35,500
5	March 29, 1925	31,200
6	June 3, 1947	31,100
7	December 31, 1948	31,000
8	October 1869	(1)
9	February 1867	(1)
10	July 1830	(1)

(1) Peak discharge unknown.

Flooded Areas and Flood Profiles

Plates 14 and 15 show the approximate areas along the White River in Hartford that will be inundated by the Intermediate Regional and Standard Project Floods. The actual limits of flooding on the ground may vary some from those shown on the map because the 20-foot contour interval and scale of the map does not permit precise plotting of the flooded area boundaries.

Also shown on the same plates are profiles for floods that are being studied. These profiles may be used to determine the depth of flooding at any particular location by standard survey methods. High water marks are shown for various locations for the November 1927, March 1936 and September 1938 floods on the profiles.

FLOOD DESCRIPTIONS

The White River basin has suffered from severe and destructive floods at many periods in its history. Its roads have been repeatedly torn up and its bridges carried away. Grist mills, sawmills, dams and buildings have been swept away or destroyed by the sudden rise of the river or its Second and Third Branches. The damage to property has at times been enormous and the loss of life appalling. A good idea of the extent and frequency of flood disasters in this basin may be obtained from reports like the following.

February 1824. - (From "New Hampshire Patriot" of February 23, 1824)

> "Between this town, (Concord, N.H.) and Burlington all the bridges on White River from the Connecticut to Royalton . . . are swept away.
>
> "The public and private losses, in bridges, dams and mills, in lumber and materials collected for rafting the ensuing spring during the late freshet in the State of New Hampshire alone, must have amounted to at least $200,000."

September 1828. - (From "Springfield Weekly Republican" of October 1, 1828)

> "The Late Freshet
>
> "The following particulars are from the 'Vermont Advocate', published at Royalton:-
>
> "'In this town the bridges over the small streams are almost wholly swept away. The Turnpike bridge over White River, near Fox's, is so far destroyed as to be impassible, and must be wholly rebuilt. The mills on Broad Brook are much injured . . . . saw mills gone.

"'Up White River in Bethel, one grist mill, six saw mills, and one potash (mill) lost entirely. The Factory rendered useless. The bridge across White River gone. One flock of sheep lost. Loss in Bethel estimated at $20,000.

"' Up the first branch of White River, all the bridges but one lost and destroyed.

"'At Chelsea, one trip hammer shop, one bark mill destroyed, and the factory in the upper village much injured, the bridges all swept off, and the gardens considerably damaged.

"'At Bradford the paper mill gone.

"'At Randolph, on the 3rd branch of White River, great injury has been done.'"

Freshet of 1830. -

"Bethel, like most towns situated on streams of water, has suffered from freshets at various periods in its history. Its roads have been torn up and its bridges carried away by the sudden rise of small streams coming down from the hills, and greater damage has sometimes been caused along the valley of the White River and the valleys of its 2nd and 3rd Branches.

"But the freshet that wrought the most damage, and has been the longest remembered is that which is known as the freshet of 1830. There had been a freshet two years earlier in 1828, causing some damage, and especially weakening the foundations of some of the buildings on the banks of the Third Branch of the river in the village. But about the 25th of July, 1830, there were unusually heavy rains, and yet it is hardly probable that these would have caused unusual damage had it not been that milldams along the Third Branch of the White River, in Braintree and Randolph gave way one after another, letting loose an enormous flood of waters.

"There was a large pond at West Randolph, it not having become filled up as it now is, and the dam had not been built many years, but this could not withstand the pressure from above it, and gave way, carrying along with it the factory of Ford and Moulton, bridges, etc. This volume of water, together with the natural increase from a heavy rain, came into Bethel in a vast flood, freighted with crops and every movable thing that came its way. The water spread out over the meadows near Finlay Bridge, covering them as far back as to the foot of the hills to a considerable depth..... The water in its progress thus swept away most of the business portion of the village, doing a damage that has never been wholly repaired. Every bridge in the town was swept away wholly or in part. .....

"The freshet which occurred on October 4, 1869 was very destructive of crops, bridges, roads, etc. The town lost 29 bridges and travel was suspended on the public roads and on the railroad during five or six days. The river was very low at the time, and many of the smaller streams were dry, but in 36 hours the water rose so high that some barely escaped with their lives in attempting to ford them. Corn in the shock, pumpkins, fences, the wreck of bridges, upturned trees, with an occasional dead animal, were borne along in a promiscuous mass down the river. In this freshet the only extensive damage in the village was done to the chair factory before mentioned, which was swept away."

Book 2, page 38, of scrap book:

"Freshet of 1830 at West Randolph took a couple of houses, a factory and grist mill, a bridge and the dam.

"Freshet of July 22, 1811, every bridge on Locust Creek to White River was swept away."

From "History of Hartford, Vermont" by William Howard Tucker, for period 1761 to 1889; Published 1889:

> "The greatest and most disastrous freshet ever known in the Valley of White River occurred on Sunday morning, February 10th, 1867, during which the village of West Hartford was inundated, a large amount of property destroyed, and one person was drowned..... That of October, 1869 was very disastrous in its effect."

From "The Landmark", April 19, 1895:

> "The flood which has existed for a week past has proved more exciting and annoying than actually disastrous in character, at least in this section of the state. To those who have lived in this town for a period of fifty years the present flood is not a phenomenal one. Looking backward we see that the individual and corporate losses now sustained are really insignificant as compared with those resulting from the flood of Feb. 10, 1867, or that of October 1869, both of which were very disastrous in their effects. Aside from flooding of numerous cellars and basements of houses on Maple and Bridge streets and the engine house, the rise caused no material damage in this locality..... The total rise of water in White and Connecticut Rivers to Monday noon (April 15th), when it was highest, was about 18 feet, being within a few inches of the floor of the White River bridge and touching the floor of the old Toll Bridge. The last-named bridge sustained a damage of some kind that led to its being closed to travel. It is estimated that the damage to highways in this town will be not far from $1000. No damage of moment has occurred to the railroad lines located within the town, but great damage has occurred elsewhere, necessitating the cancelling of trains and shutting off the mails from Boston and New York."

From "Herald and News", Randolph, Vermont, Thursday, April 18, 1895:

"A Spring Freshet

"..... No such flood has been known in Randolph since July 27, 1830, when four dwellings and a woolen factory, which stood where the grist mill now stands, were washed away ..... The water in Branch River rose 8 feet and began to work around one end of the grist mill dam, but its progress in that direction was promptly checked before it had made much headway. At Prince's mill the engine room and lower floor of the shop were flooded, and some of the stock that was packed away was badly water-soaked. The water flowed between the engine house and main building like a little river, and three families living below the mill, in Lower Canada, found it advisable to remove their goods from the houses.

"On School Street, the water stood from 3 to 4 feet in the cellars of several houses. On Central Street, also, the water was very high.....

"Ayers Brook was so swollen by the rain and melting snow that one of the abutments of the iron bridge near the Valley farm was moved out 10 or 15 feet, and that end of the bridge settled nearly two feet. 'At Bellows Falls, the Connecticut River was higher than during the flood of 1869 and lacked but two feet of the record of 1862'."

From "The Landmark", March 6, 1896:

"This week will long be remembered by all New England people and by railroad people especially..... The railroad bridge at Penacook was swept away and there is little prospect of getting trains past there this week. The W. U. Tel. Co.'s wires have been in bad shape and Boston business had to be sent by way of Springfield, Mass.; all wires over the Northern being down. In this place (White River Junction) a large amount of sand was washed on the Misses Lyman's land. The Taft hill

road was so badly gullied that a $1000 will have to be expended in repairing it, probably. Near E. J. Wallace's a culvert and the fair ground road were washed out, the cost of repairs will be about $500, it is estimated. Many cellars were filled with water. The water in the river was 3 or 4 feet of the high water mark of last April (1895). Considerable damage was done in other parts of the town. Much damage to bridges was done in Bethel."

The following is from "The Dartmouth", Hanover, N.H., of May 3, 1895:

"The Flood

"During the recent flood in the Connecticut the water reached the highest mark since '69. At the Norwich bridge it was 21 feet over low water mark, making it about 45 feet deep at the pier. The road across the river above the station was five feet under water. The water was 12 feet deep on the dam at Olcott, and invaded the engine room of the paper mill, shutting off the power....."

A letter written at Dartmouth College October 22, 1775, by Silvanus Ripley, Professor at Dartmouth, to Mr. David Macchure of Portsmouth, reads as follows:

".....Your brother is now with us -- has been detained several days on account of the great rain that has lately fell, which amounts almost to a deluge. Our river has swelled into a little sea, and carries down hay, pumpkins, timber, mills, etc., and almost everything before it....."

From "The Dartmouth", Hanover, N.H., of Saturday, March 29, 1913, comes this article:

"Hanover isolated by Connecticut River Floods -- No Trains on Boston and Maine since Thursday night. -- Transfer mail by overland coach.

"Bridge at Junction Destroyed

".....The heaviest damage caused in the region about Hanover resulted from the breaking of a dam Thursday afternoon at Sharon, which released into the White River 3,000,000 feet of lumber. With all the added force of high water the logs struck the covered carriage bridge at White River Junction. The old, insecure structure crumbled before the shock. The wreckage massed against the Boston and Maine Railroad bridge, placing it in danger, but causing no immediate damage. The financial loss of the carriage bridge will fall heavily on White River Junction, since the town is already deeply in debt....."

From "A Book of Remembrances of Old Things in Hartford, Vermont" compiled by Mrs. Kate Morris Cone the following is learned:

"March 28, 1913. Highest water in memory of man -- about four P.M. three million feet of logs came down White River -- in going under bridge on road from Point to Junction (meaning Lyman Point, the north side of White River at White River Junction), they lifted it off piers and swung it round against east shore. Many thought it might be floated back. It was taken to pieces and a temporary bridge made."

(From "Spirit of the Age", Woodstock, Vermont, March 29, 1913)

"Along the White River

"The high flood rushing down the White River threatened the 50-foot wooden dam of the Woodbury Granite Company's power station at Bethel. Water early Thursday evening was washing around the edges. Any further rise in the river meant that the dam would go out, according to watchers at that point. The water was within 4 feet of the iron bridge across the river at Bethel. The structure is 25 feet above normal water....."

From Book III, page 63, of Guy Wilson's scrap book:

"March 5, 1896 -- Locust Creek. Ice went out March 1st. Lower dam on Branch (Third) middle part went out. Bridge 2 and 3 gone at Locust Creek.

"Feb. 15, 1900 -- Ice out, but lodges in Blue Hill pond. Braces removed from White River Bridge.

"March, 1902 -- Covered River Street bridge out. - Ice.

"March 5, 1903 -- High water. Seper house at Locust Creek undermined. Nathan Parker meadow washed out.

"March 31, 1904 -- Ice took out J. E. Safford Mill at Gaysville; Also washed out Rock. railroad and Dunham farm.

"March 3, 1910 -- Ice hits new iron bridge.

"April 3, 1913 -- Washout, Blue Hill.

"March 5, 1915 -- Ice dynamited in Blue Hill pond. Broke many windows in store sheds. Highest for ten years."

From Book III, pp. 45-b - 47-b. Clippings from Bethel Courier", April 2, 1925:

"Randolph suffered $50,000 flood damage Sunday. Branch encircles Morse Mill-dam, cutting new channel, washing away property and endangering new cement bridge.

"Loss variously estimated at from $35,000 to $75,000 resulted from floods in Randolph Village, Sunday. Not since the memorable day in winter of 1834, when most of the business section of the town lay in ashes has it been so hard hit. The great freshet of 1830 is the only parallel in water damage.....

"..... Dynamite and fire employed to fight devastating torrent. Four barns and two foundry buildings float away. Messer Block burnt to lessen danger to threatened Main Street bridge. One abutment nearly wrecked. Dam broken down by explosive....."

From the "Bethel Courier", March 31, 1925:

"At Bethel, the water was the highest in twelve years (since 1913) in the White River. The meadows were flooded for miles up and down the stream. The water caused great anxiety for a time, but actual damage was only about $1,000 in village."

November 3, 1927. - The White River Flood of 1927 undoubtedly ranks as the most devastating tributary flood in Connecticut River history. Many volumes have been written describing the havoc wrought. The seriousness of the damage may be brought out by mentioning that nine lives were lost and direct damages exceeded four million dollars. This damage figure is almost equal to the total of all damages in the 1927 Flood in the Connecticut Basin, excluding Vermont.

March 18, 1936. - While not approaching the 1927 Flood in severity in this area, the 1936 Flood may be considered as a major one. Two lives were lost, and direct damage reached $42,000.

MASCOMA RIVER

The Stream and Its Valley

The Mascoma River lies wholly in New Hampshire and originates at the outlet of Reservoir Pond on the boundary between Dorchester and Lyme. It flows southerly through Dorchester into Canaan, then westerly through Canaan, Enfield and Lebanon to its confluence with the Connecticut River about 0.8 miles south of the community of West Lebanon. On its course the river flows through Mascoma Lake, a 1200-acre body of water in Enfield. The river is about 35 miles long from its source to its confluence with the Connecticut River and has a drainage area of 194 square miles. The river has a total fall of about 1,017 feet.

The topography of the basin is marked by several small mountains with elevations ranging from about 3,200 feet above mean sea level at the upper or northerly end of the basin to about 324 feet in the stream bed at its mouth. From Reservoir Pond to Canaan Center the average slope is about 39 feet per mile. From Canaan Center to Mascoma Lake the average slope is about 13 feet per mile while from Mascoma Lake to the mouth of the Mascoma River the average slope is about 42 feet per mile, with the greatest drop in this reach being in the city of Lebanon.

The Mascoma River offers one of the best contrasts in tributary floods. Its watershed is subject to excessive rainfall and the depth of snow is fairly large. The river drains the steep slopes of several small mountains. However, the flat gradients just at the foot of the mountains, together with the swamps and ponds, greatly delay the

progress of floods from the upper half of the basin. The river has ponds at many of its sources and marshy flats at others, with the good sized Mascoma Lake forming an enlargement of the river about midway in its course. The ponds and Mascoma Lake are all subject to control by dams which regulate the streamflow. Pertinent drainage areas of the Mascoma River are given in Table 11.

This section of the report discusses the flood situations along the lower 12 miles of the Mascoma River from the Enfield-Lebanon line to its mouth.

TABLE 11

DRAINAGE AREAS IN

MASCOMA RIVER BASIN

Location	River Mile	Drainage Area (sq. mile)
USGS Gaging Station West Canaan, N.H.	18.2	80.5
USGS Gaging Station Mascoma, N.H.	10.0	153
Confluence with Connecticut River	0	194

Developments in the Floodplains

Plate 16 shows the floodplains of the Mascoma River for the reach covered in this report.

The principal floodplain is in the area in the city of Lebanon known as the Mahan Flats and is also where the principal flood damages have occurred. This area is in the reach about a mile long between the Cummings Tannery Dam at about river Mile 5.14 to about the Bank Street Bridge at river Mile 6.26. This area experiences some flooding almost every spring.

The area involved comprises about 80 acres and is located on both sides of the river. New Interstate Highway 89 runs alongside the north bank of the river in this reach but does not seriously affect the floodplain. The area contains residences, business establishments, gardens and farmland and is sometimes flooded to depths varying from 2 to 5 feet. Damages incurred in this area have been reported as shown below and are based on 1955 prices:

March 1936	-	$146,000
September 1938	-	93,000
March 1953	-	100,000

Another considerable floodplain exists at the mouth of the Mascoma River and extends inland from the Connecticut River to about State Highway 12A. (South Main Street in West Lebanon) This highway, as well as residences and other buildings in the area, would be inundated by the Standard Project Flood. The floodplain from Route 12A to the Connecticut River is covered under the Connecticut River section of this report.

In general, except for the two flood prone areas mentioned above, the banks of the Mascoma River in the study area are fairly steep, resulting in a narrow floodplain which is comparatively invulnerable to floods, with a few minor exceptions.

Bridges Across the Stream

There are 12 highway bridges and 14 railroad bridges crossing the Mascoma River in the reach included in this study. Table 12 lists pertinent elevations for these structures and shows their relationship to the Intermediate Regional Flood and the Standard Project Flood.

Inspection of the water surface profiles indicate that of the 26 bridge crossings 20 of them have their underclearances well above both the Standard Project Flood and the Intermediate Regional Flood, as well as the 1936 flood of record. These structures offer no impedance to any of the floodflows. The following six bridge structures would cause restrictions to floodflows:

At South Main Street (State Route 12A) the Standard Project Flood would come to the floor of this bridge thereby causing some restriction to flows caused by this flood. However, the elevation of the Standard Project Flood at this bridge depends to a great extent upon backwater from the Connecticut River and must be considered to be in the Connecticut River floodplain as well as that of the Mascoma River. The Intermediate Regional Flood would come to the underclearance of this structure and would cause no impedance to this flood.

The Standard Project Flood would come to the bottom of the underclearance of the railroad bridge at river Mile 2.15 and would cause little if any restriction to floodflows.

The bridge over the river at Mechanic Street (State Route 10 and U.S. 4) would be affected only by the occurrence of the Standard Project Flood. This flood would reach about 2 feet above the underclearance of the bridge and about 2 feet below the floor causing some restriction to the flow of this flood. The Intermediate Regional Flood would come to the bottom of the underclearance and cause no restriction to this flood.

The Hanover Street Bridge at river Mile 5.2 in Lebanon was formerly a major restriction to floodflows. However, this bridge has now been replaced with a new structure in conjunction with the construction of new Highway 120. The span has been lengthened and the roadway and underclearance elevated, thus increasing the effective waterway area and is no longer a restriction to floodflows. The Standard Project Flood would come 1.1 feet below the underclearance of the new bridge.

The Spencer Street Bridge at river Mile 5.8 offers some impedance to the Standard Project Flood and the Intermediate Regional Flood. The Standard Project Flood would come to about 3 feet above the underclearance but 1 foot below the floor. The Intermediate Regional Flood would come to 2 feet above the underclearance and 3 feet below the floor of the bridge.

The railroad bridge at river Mile 7.2 would cause some impedance to the Standard Project Flood which would come to about 1 foot above the underclearance. However, the floor of the bridge would be about 3 feet above the flood. The underclearance would come just above the Intermediate Regional Flood and would be no restriction to that flood.

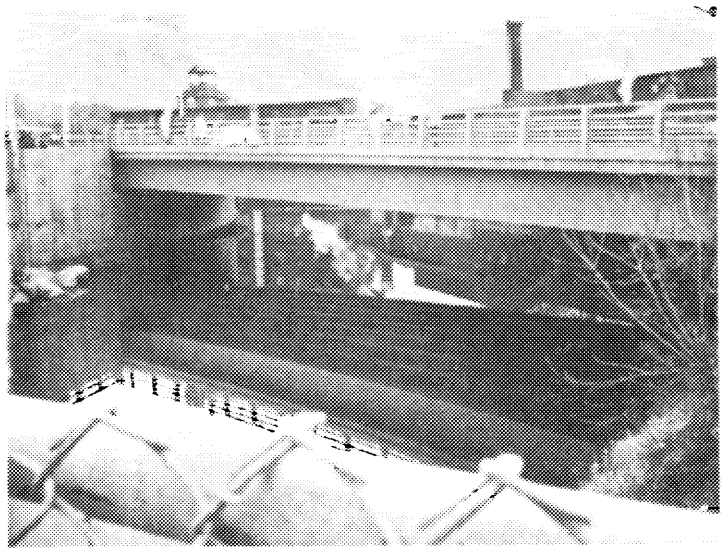
Views of some of the bridge structures are shown in Figures 5 and 6.

TABLE 12

BRIDGES ACROSS THE MASCOMA RIVER

Miles Above Mouth	Identification	Normal Flow Elev. ft msl	Floor Elev. ft msl	IRF Crest ft msl	SPF Crest ft msl	Underclearance Relation to IRF Elev. ft msl	Above ft.	Below ft.
0.5	South Main St.	342.4	357.0	353.8	358.4	354.0	0.2	-
1.45	B & M RR	395.0	433.7(1)	403.0	404.5	425.0	22.0	-
1.65	B & M RR	411.5	438.6(1)	418.6	420.6	429.0	10.4	-
2.15	B & M RR	443.6	455.8(1)	451.0	452.3	452.0	1.0	-
2.17	Seminary Hill Rd.	443.8	497.2	451.2	453.0	-	-	-
3.14	B & M RR	460.2	484.8	466.9	468.3	481.0	14.1	-
3.25	Route I-89	460.2	497.5	467.0	468.5	493.5	26.5	-
3.70	Mechanic St.	465.5	476.8	473.2	474.8	474.0	0.8	-
4.25	Slayton Hill Rd.	488.0	502.8	494.5	496.5	499.9	5.4	-
5.06	Mascoma St.	540.5	557.2	547.5	548.5	552.0	4.5	-
5.10	B & M RR	545.0	569.1(1)	552.5	553.5	562.0	9.5	-
5.20	Hanover St.	568.4	585.4	575.0	578.5	579.6	4.6	-
5.80	Spencer St.	573.8	583.3	581.5	583.2	580.3	-	1.2
6.25	Bank St.	579.0	596.6	586.0	588.0	593.9	7.9	-
6.30	B & M RR	579.0	596.6(1)	586.0	588.0	596.0	10.0	-
6.84	B & M RR	599.1	621.9(1)	605.8	607.8	614.0	8.2	-
7.02	B & M RR	612.8	628.6(1)	619.2	621.4	625.0	5.8	-
7.20	B & M RR	627.0	638.3(1)	634.0	635.8	635.0	1.0	-
7.30	U.S. Rte. 4	630.5	650.4	637.2	639.0	647.0	9.8	-
7.70	B & M RR	644.0	660.2(1)	650.7	652.5	657.0	6.3	-
8.05	Route I-89	655.6	697.5	662.5	664.2	694.5	32.0	-
8.94	B & M RR	691.1	713.4(1)	698.0	699.3	710.0	12.0	-
9.05	B & M RR	697.1	718.5(1)	703.3	705.3	714.9	11.6	-
9.50	B & M RR	716.4	729.7(1)	723.0	724.8	726.0	3.0	-
9.96	B & M RR	743.0	755.5(1)	749.6	751.0	752.0	2.4	-
10.07	U.S. Rte. 4 & 4A	744.5	764.6	751.0	752.5	760.0	9.0	-

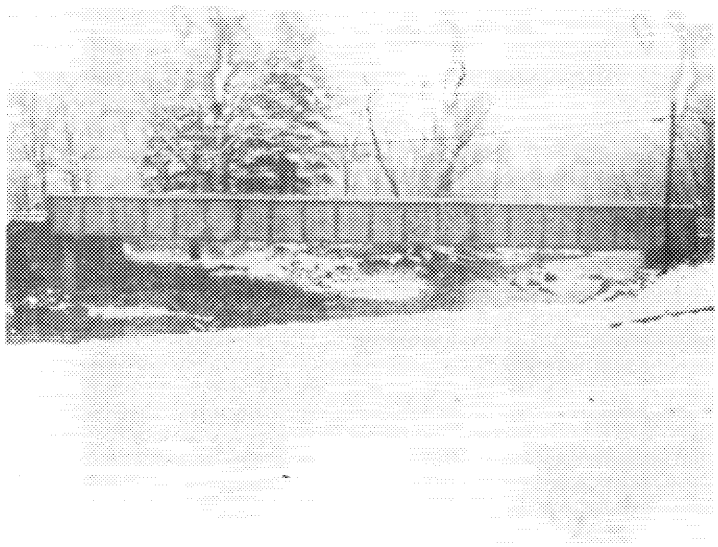
(1) Base of Rail



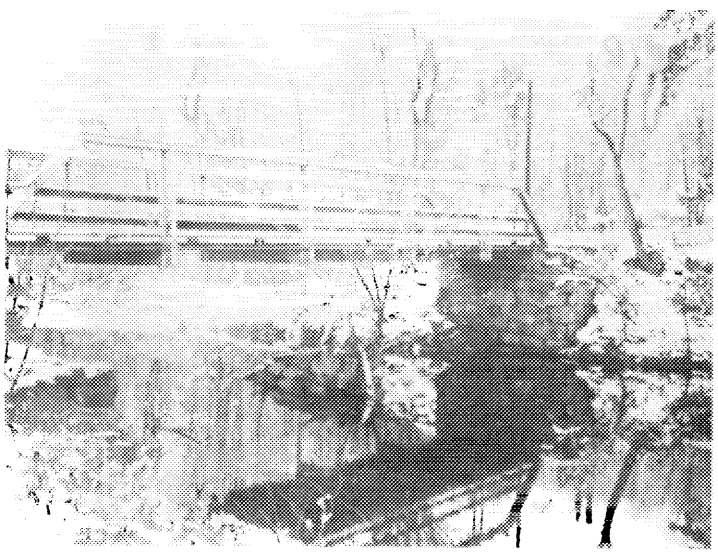
Hanover Street (State Route 120) Bridge in Lebanon - Mascoma River

Mascoma Street Bridge - Mascoma River

Figure 5



South Main Street - Route 12A Bridge - Mascoma River



Slayton Street Bridge - Mascoma River

Figure 6

Dams on the Stream

There are seven dams across the Mascoma River in the study reach. All but one of the dams offer little or no obstructions to floodflows. Table 13 lists pertinent elevations for the dams and shows their relationship to the Intermediate Regional Flood and the Standard Project Floods.

The Cummings Tannery Dam, just below the Hanover Street Bridge, was the principal cause of the flooding of Mahan Flats. The dam had 24-inch braced flashboards which did not go out in high water periods, however, the flashboards have now been removed and the dam does not offer as much impedance to floodflows as formerly. Upstream of the dam the channel capacity is small with low banks, islands and gravel deposits. The river is shallow but has a good slope. The backwater of the Tannery Dam extends about a mile upstream causing flooding of Mahan Flats.

Views of some of the dams are shown on Figures 7 and 8.

Obstructions to Floodflows

The effect of obstructions due to dams, bridges or bridge approaches has been discussed in the previous paragraphs. There are no other significant obstructions to flows in the Mascoma River reach included in this study.

Flood Records

The U.S. Geological Survey maintains two stream gaging stations on the Mascoma River. One of these is located in West Canaan, New Hampshire, 1.2 miles downstream from Indian River having a drainage area of 80.5 square miles and located upstream of the limits of this study. The station has been maintained since July 1939. The other station is located on the Mascoma River 1,000 feet downstream

from the Mascoma Lake Dam, which forms the upper limit of this study. This station has a drainage area of 153 square miles and has been maintained since August 1923. In addition to the records supplied by this gaging station, high water data was collected in connection with a local protection project study made in 1957 between river Miles 5 and 6.

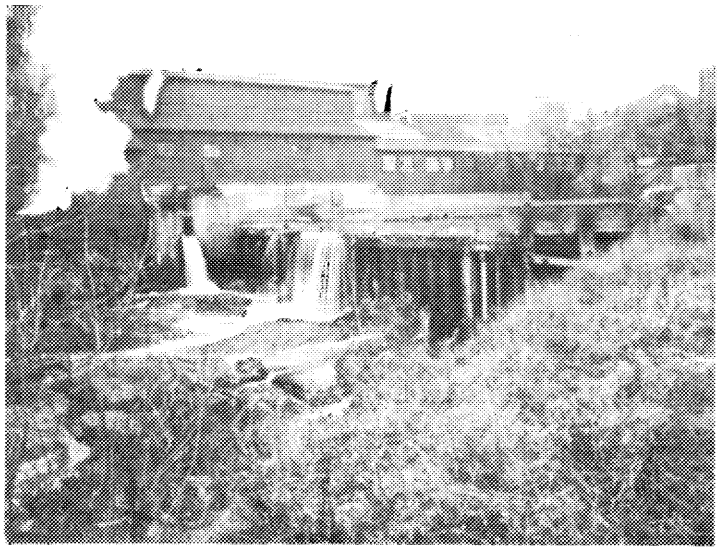
Records do not show any history of seriously damaging floods in this basin. The Mascoma basin has been relatively free from such occurrences and whenever extraordinarily high waters have occurred, the damages have been low in comparison with figures for other basins.

Information on floods was obtained from interviews with local residents and from a search of newspaper files and historical records. Information obtained by field investigations and office computations was used to establish the profile for the Intermediate Regional Flood and the Standard Project Flood.

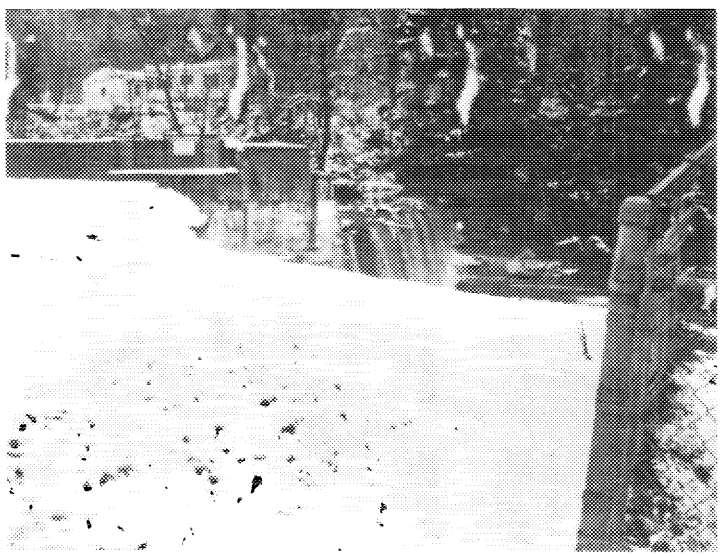
TABLE 13

DAMS ON THE MASCOMA RIVER

Miles Above Mouth	Identification	Crest Elev. ft.msl	IRF Crest ft.msl	SPF Crest ft.msl	Depth Over Dam IRF ft.	Depth Over Dam SPF ft.
1.50	Grafton County Electric Light & Power Co. Plant No. 3	411.7	418.5	420.2	6.8	8.5
2.20	Grafton County Electric Light & Power Co. Plant No. 2	458.8	465.0	467.0	6.2	8.2
4.20	Grafton County Electric Light & Power Co. Plant No. 1	488.0	494.5	496.5	6.5	8.5
4.65	American Woolen Company	502.7	507.5	509.0	4.8	6.3
5.13	Cummings Tannery	568.4	574.5	576.5	6.1	8.1
6.80	Lebanon Water Works	599.1	605.5	607.8	6.4	8.7
10.10	Mascoma River Improvement Co.	751.1	752.3	756.0	1.2	4.9

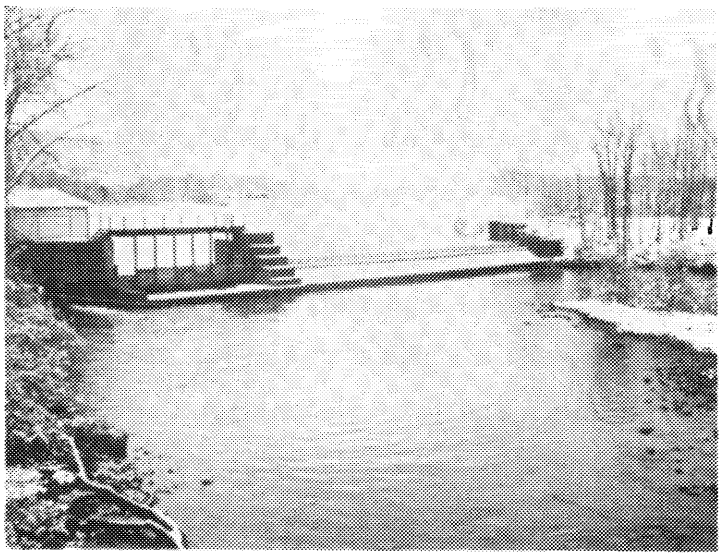


Tannery Dam in Lebanon - Mascoma River



Dam at River Mile 4+25 below Slayton Street Bridge
Mascoma River

Figure 7



Mascoma Lake Dam
Mascoma River

Dam at River Mile 1+50
Mascoma River

Figure 8

Flood Stages and Discharges

Stage - discharge relationship on the Mascoma River are a function of natural channel characteristics and man-made structures such as dams and bridges. Stage - discharge curves were developed for this study by analysis of: (a) the characteristics of the many dams, (b) the rating curve at the USGS gage, (c) the small amount of recorded high water data, and (d) information developed during a 1957 local protection study in Lebanon. Such analysis, of course, does not take into account the marked effect that debris or dam failures may have on stage - discharge relationship during a flood event. Flood damage starts at a stage of about 5.0 feet on the gage or about 745.0 feet above mean sea level which represents a flow of approximately 2600 cfs at the gage. Table 14 lists the ten highest known floods which have occurred in recent years.

Flood Occurrences

A discharge-frequency curve has been computed for the Mascoma gaging station. This curve indicates that nuisance flooding occurs an estimated once in two years and significant flooding about once in 5 years. The 10 greatest floods that have occurred since August 1923 are shown in order of magnitude in table 14.

TABLE 14

TEN HIGHEST KNOWN FLOODS

IN ORDER OF MAGNITUDE

MASCOMA RIVER AT MASCOMA, N.H.

Zero of Gage = 740.0 feet msl

Date of Crest	Elevation at Gage ft msl	Peak Discharge cfs
March 19, 1936	747.50	5,840
March 27, 1953	746.03	4,880
Sept. 22, 1938	746.85	4,400
April 19, 1933	746.67	3,630
March 30, 1925	746.25	3,540
April 13, 1934	746.55	3,500
Nov. 5, 1927	745.94	3,230
April 4, 1951	745.62	2,700
April 26, 1926	745.57	2,680
April 13, 1932	745.87	2,520

Duration and Rate of Rise

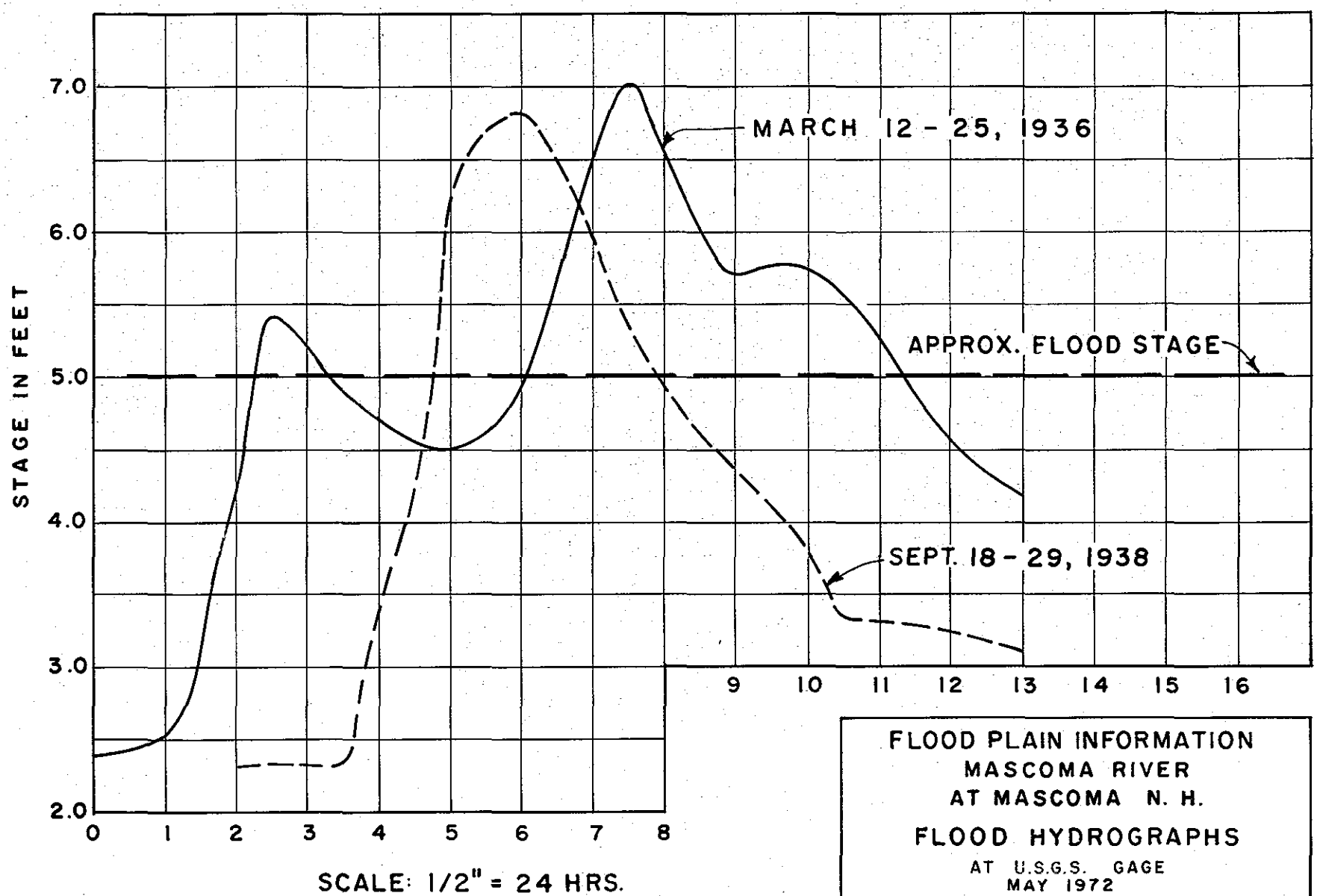
The Mascoma River is not generally a fast rising stream. The storage areas above Mascoma Lake tend to desynchronize peak inflows to the lake, and the lake itself acts as a retarding basin, reducing and retarding peak flows at the outlet. Most of the floods on the river occur in the spring, caused by a combination of rainfall and snowmelt. It is difficult to relate the runoff and resulting river rise to rainfall in floods of this type due to the importance of snow cover and temperature at the time of occurrence. In this type of flood a considerable length of

time may elapse between a major rainfall and the resulting flood crest. In the case of summer or fall storms, such as the hurricane of September 1938, the rainfall-runoff relationship is more direct.

During the March 1936 flood, the river stayed above flood stage for about 5 days. Flood stage was exceeded for about $2\frac{1}{2}$ days during the September 1938 flood. The maximum rate of rise at the Mascoma gage during the 1936 flood occurred on March 18 when the rise was 0.9 feet in 12 hours, an average rate of less than 1 inch per hour. During the 1938 flood the maximum rise, which occurred during the night of September 21 and the morning of September 22, was 1.05 feet in 12 hours, an average rate of 1.62" per hour. It is again noted that the operation of the gates at the Mascoma Lake Dam can have a marked effect in the future on the rate of rise and duration of flooding on the Mascoma River. Plate 4A graphically illustrates the duration and rate of rise of the March 1936 and September 1938 floods.

Velocities

During a flood of the magnitude of the March 1936 flood it is estimated that velocities would approximate 7 feet per second in the river channel and 1 foot per second in overbank flow. The velocities to be expected during an Intermediate Regional Flood are slightly greater than those, while during a Standard Project Flood channel velocities would be about 10 feet per second and overbank velocities between 1 and 2 feet per second.



FLOOD PLAIN INFORMATION
MASCOMA RIVER
AT MASCOMA N. H.

FLOOD HYDROGRAPHS

AT U.S.G.S. GAGE
MAY 1972
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. 4A

Flooded Areas and Flood Profiles

Plate 16 shows the approximate areas along the Mascoma River in the vicinity of the study area that would be inundated by the Intermediate Regional Flood and the Standard Project Flood. The actual limits of these overflow areas on the ground may vary some from those shown on the maps because the 20-foot contour interval and the scale of the map do not permit the precise plotting of the flooded area boundaries.

Plates 17 and 18 show the profiles for the Intermediate Regional Flood and the Standard Project Flood discussed later in this report.

No attempt was made to derive flood profiles between river Miles 5.0 and 5.13 in Lebanon due to the cascading nature of the river in this reach.

FLOOD DESCRIPTIONS

Following are descriptions of three large floods which have occurred in the Mascoma River basin.

March 1936 - The flood of March 1936 was the result of four distinct storm centers passing over the northeastern part of the country between March 9 and 22. The total precipitation for this period ranged from 4 inches in eastern Massachusetts up to 16 inches in north-central New Hampshire, with the first of this precipitation falling on a snow cover which had a water content ranging from 5 to 10 inches in northern New England and less in southerly portions. During the March 9-22 period the precipitation at Hanover, New Hampshire totalled 4.55 inches. The snow cover in the watershed had a water content at the beginning of the period of about 5 inches. The

ground had frozen early in the winter, and the rain which fell during the period March 9-22 was accompanied by unseasonably high temperatures. These factors combined to give many New England rivers their greatest flood peaks to date. At the Mascoma gage the river rose to elevation 745.5 feet above mean sea level (stage 5.5 feet) on March 14, dropped back to elevation 744.5 feet msl on the 16th, only to crest at elevation 747.5 feet msl on March 19, before receding to elevation 744.5 feet msl on the 25th. Stage comparisons indicate that the flood level at the Hanover Street Bridge crested at about elevation 582 feet msl. In general, the river rose 3 to 5 feet above flood stage.

March 1953 - The flood of March 1953 was caused by four separate coastal storms, combined with an upper level slow-moving "low" extending over the northeastern section of the country, and unseasonably high temperatures after March 11. A total of 1.71 inches of rain fell at Lebanon between the 13th and 16th, followed by 2.68 inches of rainfall between the 24th and 31st. Fortunately, snow cover was considerably below normal, otherwise flooding would have been much greater. At the Mascoma gage the river rose to about elevation 743.5 feet msl on the 18th, dropped to elevation 743.0 on the 24th, and then rose to elevation 746 feet msl before receding to about elevation 742.5 feet msl on April 3. A corresponding flood level of about 581 feet msl was attained at the Hanover Street Bridge. The crest was generally 2 to 4 feet above flood stage.

September 1938 - A tropical hurricane which was first located about 1,000 miles east-southeast of Miami, Florida, on September 18 moved up the coast, striking New Haven, Connecticut at 3:50 p.m. on the 21st, and passed through the Lebanon area at about 6:20 p.m.

Combining with a low pressure trough which had moved slowly across the country from the west, it produced torrential rainfall in New England between the 18th and 22nd, heavy rainfall having been caused between the 12th and 15th by the low pressure trough. At Hanover 2.64 inches of rain fell between the 18th and 22nd. The river at the Mascoma gage rose to elevation 746.8 feet msl on the 22nd before receding to elevation 743.7 feet msl on the 26th. The flood level is estimated to have crested at about elevation 580 feet msl at the Hanover Street Bridge, being generally about 2 to 3 feet above flood stage.

The following are brief descriptions of known floods that have occurred on the Mascoma River in the vicinity of Lebanon, New Hampshire, and were extracted from "Geological Survey Water-Supply Paper 1779-M, Historical Floods in New England." Outstanding floods occurred in August 1828, October 1869 and March 1936.

August or September 1828

"The records of 1828 indicate that sometime in August or early in September there was a great freshet doing much damage."

October 1869

"In the first Lebanon directory of 1882, the mention is made of the great flood of 1869 when the water stood 4.5 feet above the crest of the dams (a statement by Mr. S. H. Stevens in a surveyor's field book entitled "Highway No. 15 in the townhall of Lebanon, N.H.)"

March 19, 1936

"Mr. S. H. Stevens, the town civil engineer in Lebanon for many years, stated in "Highways No. 15" a surveyor's field notebook now in the Lebanon, N.H. townhall: "Water surface at Emerson's Gardens, No. 23 Spencer Street, 578.30 feet above mean sea level. Highest ever known in Lebanon."

"Crest of dam 568.29 showing height of water flowing over dam to be 5.5 feet. Estimated volume 6,000 second feet."

"In the first Lebanon Directory (1882) mention is made of the Great Flood of 1869 when the water stood 4.5 feet above the crests of the dams." The crest of the Everett Norfolk dam has never changed."

"Mr. Stevens said that, on the basis of his own personal experience, the 1936 flood was the greatest since at least 1890 and, on the basis of his reading of histories and old records, also the greatest since the vicinity was settled, about 1750."

FUTURE FLOODS

This section of the report discusses the Standard Project and the Intermediate Regional Floods on the Connecticut, White and Mascoma Rivers in the vicinity of this study, and some of the hazards of great floods. Floods of the size of the Standard Project Flood represent reasonable upper limits of expected flooding. Those of the size of the Intermediate Regional Flood represent floods that may reasonably be expected to occur more frequently, although they will not be as high as the infrequent Standard Project Flood.

DETERMINATION OF INTERMEDIATE REGIONAL FLOODS

The Intermediate Regional Flood is defined as a flood having an average frequency of occurrence in the order of once in 100 years, at a designated location, although the flood could occur in any year. Some probability estimates are based on statistical analyses of streamflow records available for the watershed under study and analyses of rainfall and runoff characteristics in the "general region" under study. The Intermediate Regional Flood represents a major flood, although it is much less severe than the Standard Project Flood.

Results of the studies indicate that the Intermediate Regional Flood on the Connecticut River at the gaging station, Mile 215.0, just downstream of White River would be about one foot lower than the March 1936 flood and about three feet lower than the maximum flood of November 1927. The analyses also show that the Intermediate Regional Flood on the Connecticut River would have a peak discharge of 110,000 cubic feet per second (c.f.s.) at the confluence of the White River.

The Intermediate Regional Flood at the U.S. Geological Survey gaging station on the White River at West Hartford at Mile 7.4 would be approximately five feet over the March 1936 and September 1938 floods but about five feet below the maximum flood of November 1927.

The determination of the Intermediate Regional Flood for the Mascoma River was based on statistical analyses of past recorded flows at the U.S. Geological Survey gaging station at Mascoma, about 1,000 feet below the outlet of Mascoma Lake. This flood would be about one foot over the 1936 flood. The discharge-frequency curve at the gage, based on the analyses, indicates that the Intermediate Regional Flood would have a peak discharge of 7,000 cubic feet per second.

DETERMINATION OF STANDARD PROJECT FLOODS

Only in rare instances has a specific stream experienced the largest flood that is likely to occur. Severe as the maximum known flood may have been on any given stream, it is a commonly accepted fact that, in practically all cases, sooner or later a larger flood can and probably will occur. The Corps of Engineers, in cooperation with the National Weather Service, has made broad and comprehensive studies and investigations based on the vast records of experienced storms and floods and has evolved generalized procedures for estimating the flood potential of streams. These procedures have been used in determining the Standard Project Floods. It is defined as the largest flood that can be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved.

A Standard Project Flood has been estimated for the Connecticut and White Rivers. The analyses indicate the Standard Project Flood would be about five feet higher than the March 1936 flood and approximately three feet higher than the November 1927 flood at the U.S.G.S. gaging station Mile 215.0, below the confluence of the White River. The peak discharge for this flood at the confluence of the White River would be about 157,000 cfs.

The Standard Project Flood on the White River at the U.S.G.S. gaging station at West Hartford, Mile 7.4, would be about equivalent to the November 1927 flood and approximately 10.0 feet higher than the March 1936 and September 1938 floods.

The Standard Project Flood on the Mascoma River at the U.S.G.S. gaging station on the Mascoma River, about 1,000 feet below the outlet of Mascoma Lake, would be about 3 feet over the March 1936 flood. This flood would have a peak discharge of 10,000 cubic feet per second at the gage.

Frequency

It is not practicable to assign a frequency to the Standard Project Flood. The occurrence of such a flood would be a rare event. However, it could occur in any year.

Possible Larger Floods

Floods larger than the Standard Project Flood are possible; however, the combination of factors that would be necessary to produce such floods would seldom occur. The consideration of floods of this magnitude is of greater importance in some problems than in others, but should not be overlooked in the study of any problem.

Hazards of Great Floods

The amount and extent of damage caused by any flood depends in general upon how much area is flooded, the height of flooding, the velocity of flow, the rate of rise and the duration of flooding.

Velocities, Rates of Rise and Duration

Velocities of flow during floods depend largely upon the size and shape of the cross section, the condition of the stream and the bed slope, all of which vary on different streams and at different locations along the same stream.

On the Mascoma River, the critical area above the Hanover Street Bridge, the Intermediate Regional Flood has an estimated maximum channel velocity of about 8 feet per second, with overbank velocities slightly in excess of 1 foot per second. The velocities to be expected in this area during a Standard Project Flood would be about 10 feet per second in the channel and 1 to 2 feet per second in overbank flow.

It is estimated that during an Intermediate Regional Flood the river would rise about 1 foot in 12 hours, while the corresponding 12-hour rise for a Standard Project Flood would be about 0.8 feet. An Intermediate Regional Flood would remain above flood stage for about 5 days, while it is estimated that the flooding duration of the Standard Project Flood would be about $3\frac{1}{2}$ days.

These rates of rise and durations are based on the assumption that the Intermediate Regional Flood would be of the rainfall-snowmelt type which is experienced in the spring, and being the most frequent type in this watershed. The Standard Project Flood, on the other hand, is produced by a very high intensity rainstorm producing a higher peak flow but with shorter duration.

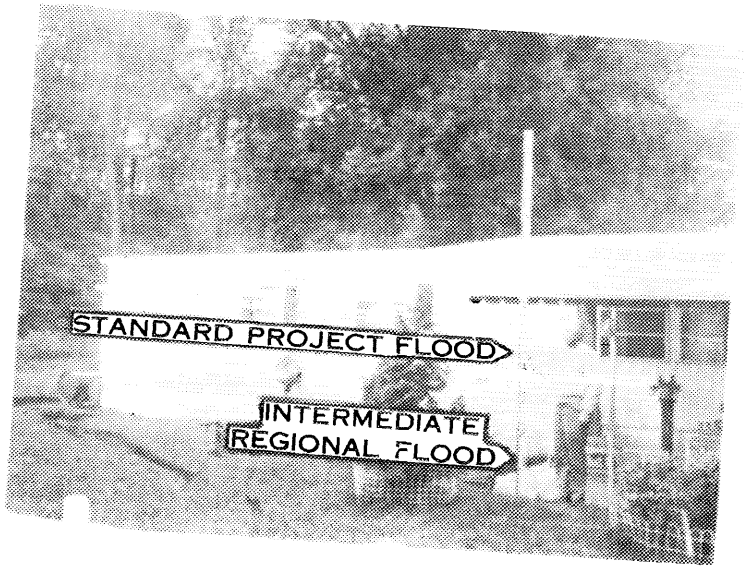
Areas Flooded and Heights of Flooding

The areas along the Connecticut, White and Mascoma Rivers flooded by the Standard Project Flood and the Intermediate Regional Flood are shown on Plates 6 through 15 for the Connecticut and White Rivers and on Plate 16 for the Mascoma River. Depths of flow can be estimated from the profiles.

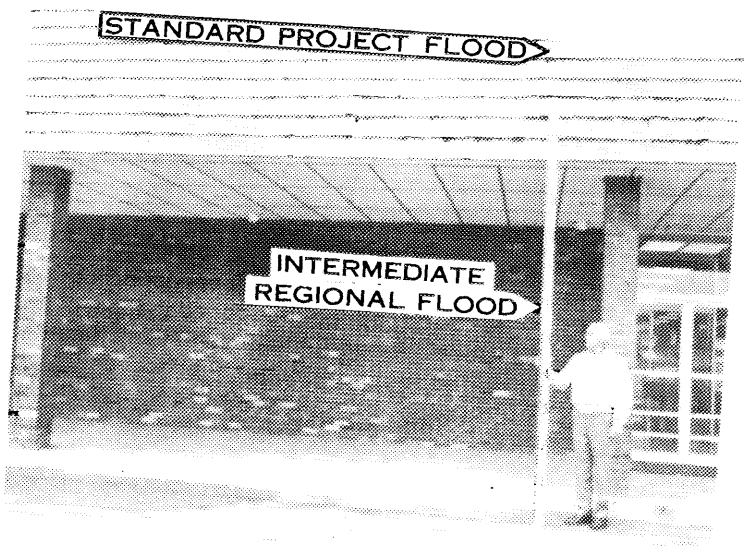
The profiles for the Connecticut and White Rivers were computed by using stream characteristics for selected reaches as determined from observed flood profiles, flood high water marks, topographic maps, and back water curves. The profiles for the Mascoma River were established by computing stages for the discharges at the dams and deriving stage relationships between the floods and the March 1936 flood. The elevations shown on the profiles and the flooded areas shown on the plans have been determined with an accuracy consistent with the purposes of this study and the accuracy of the data.

The profiles of the Standard Project Flood and the Intermediate Regional Flood depend in part upon the degree of destruction or clogging of the various bridges and dams during the flood. Because it is impossible to forecast these events, it was assumed that all structures would stand and that no clogging would occur.

Figures 9 through 15 show the heights that would be reached by the Standard Project Flood and the Intermediate Regional Flood on facilities presently existing within the floodplains in the reaches of this report.

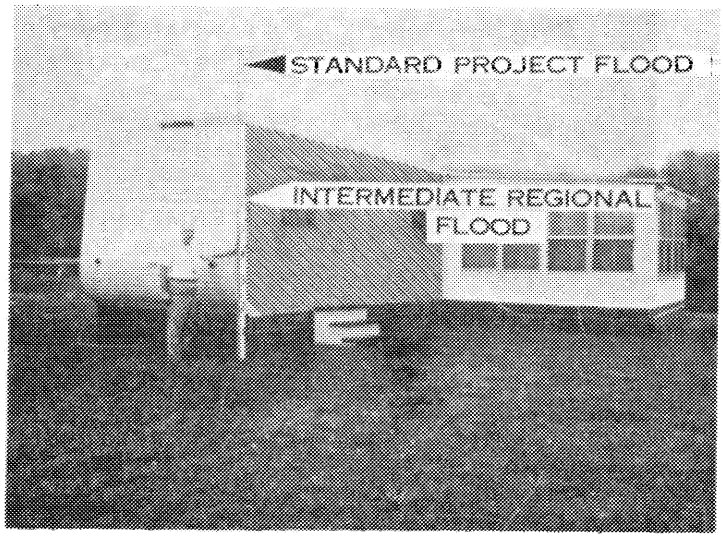


FLOOD HEIGHTS - Hartland, Vermont, Connecticut River
At Mouth of Ottauquechee River



FLOOD HEIGHTS - West Lebanon, New Hampshire
Grant's Store in Upper Valley Plaza
Connecticut River Near Mouth of Mascoma River

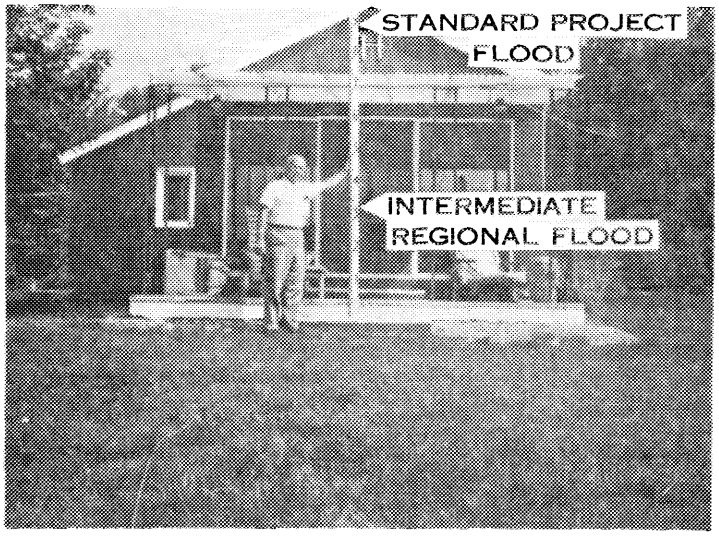
Figure 9



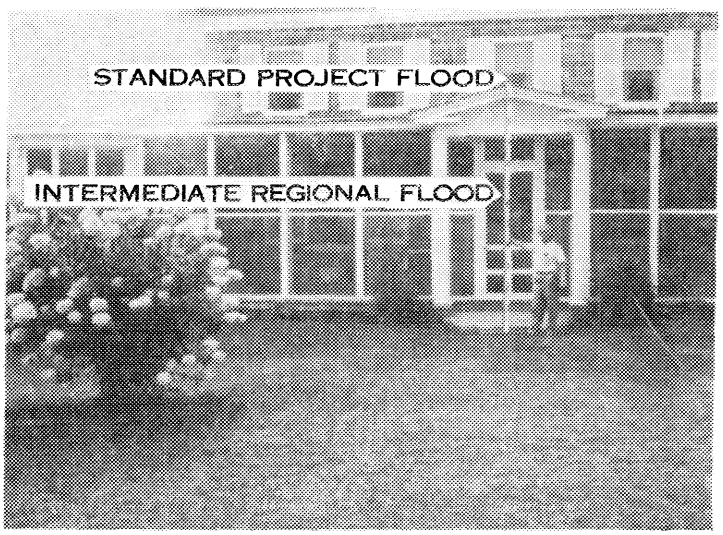
FLOOD HEIGHTS. Norwich, Vermont, Connecticut River at Pomponoosuc Village

FLOOD HEIGHTS. Connecticut River at Thetford, Vt.

Figure 10



FLOOD HEIGHTS. Connecticut River at Lyme, N.H.



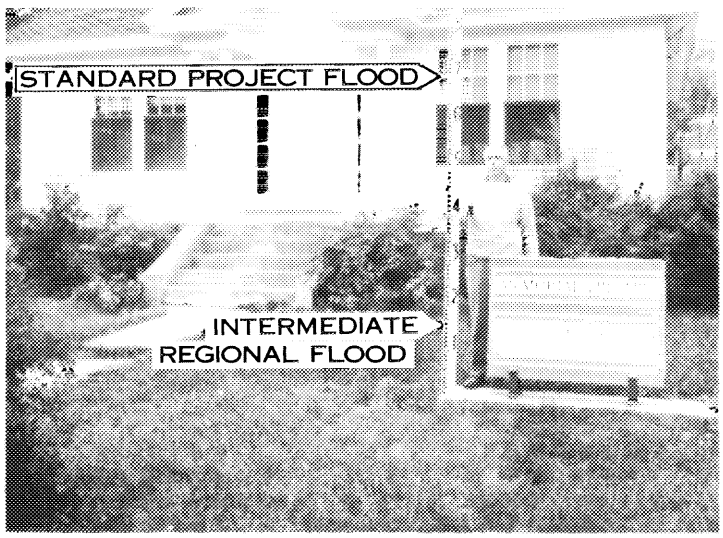
FLOOD HEIGHTS. Connecticut River at North Thetford, Vt.

Figure 11

FLOOD HEIGHTS - White River, Town Hall, Hartford, Vt.

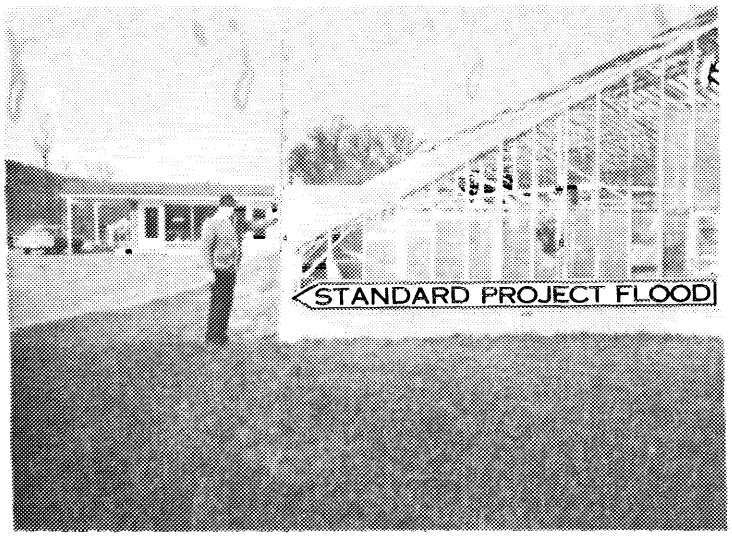
FLOOD HEIGHTS - White River, Hartford, Vt. on
Old Route 4 and 5 across from Town Hall

Figure 12



FLOOD HEIGHTS - White River, Memorial Library
West Hartford, Vermont

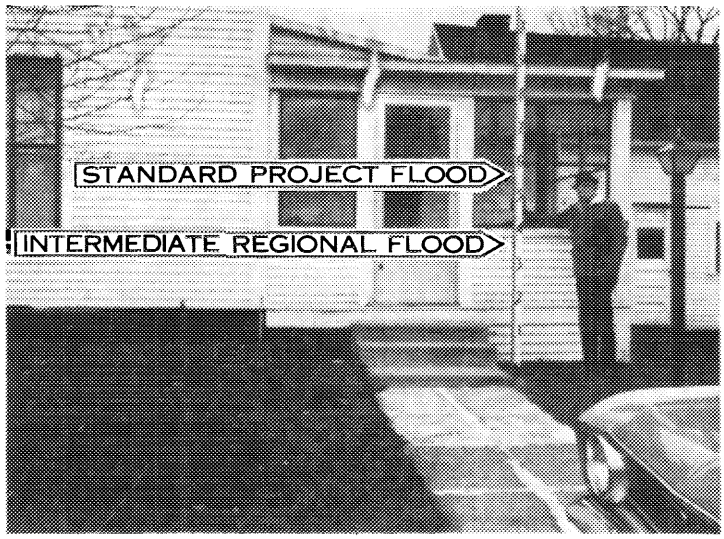
Figure 13



Spencer Gardens - 23 Spencer Street
Mascoma River

House - 21 Spencer Street
Mascoma River

Figure 14



House on Mahan Street
Mascoma River

Jenks Tool Co., Spencer Street
Mascoma River

Figure 15

GLOSSARY

Backwater. The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain. The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Hurricane. An intense cyclonic windstorm of tropical origin in which winds tend to spiral inward in a counterclockwise direction toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 miles per hour.

Hydrograph, Flood. A graph showing the stage in feet against time at a given point and the rate of rise and duration above flood stage.

Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank. The bank on the left side of a river, stream, or watercourse, looking downstream.

Right Bank. The bank on the right side of a river, stream, or watercourse, looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40-60 percent of the Probable Maximum Floods for the same basins. As used by the Corps of Engineers, Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Underclearance Elevation. The elevation at the top of the opening of a culvert, or other structure through which water may flow along a watercourse.

AUTHORITY, ACKNOWLEDGMENTS AND INTERPRETATION OF DATA

This report has been prepared in accordance with the authority granted by Section 206 of the Flood Control Act of 1960 (PL 86-645), as amended.

Assistance and cooperation of the National Weather Service, U.S. Geological Survey, Vermont and New Hampshire Water Resources Boards; towns of Hanover, Hartford, Hartland, Lebanon, Lyme, Norwich, Plainfield, Thetford, and private citizens in supplying useful data are appreciated.

This report presents the local flood situation for the above mentioned towns in New Hampshire and Vermont. The New England Division of the Corps of Engineers will provide technical assistance in application of data presented herein.

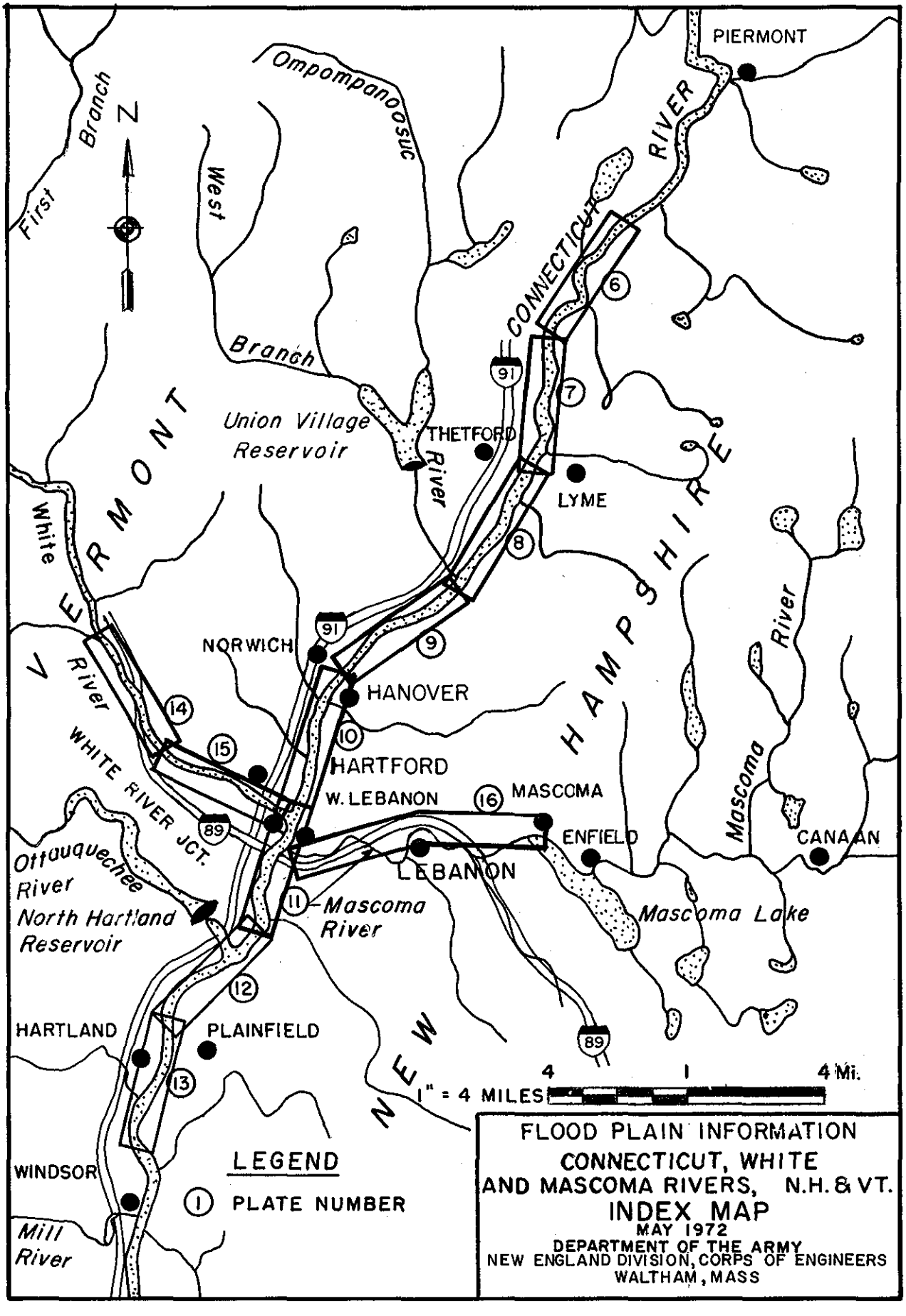
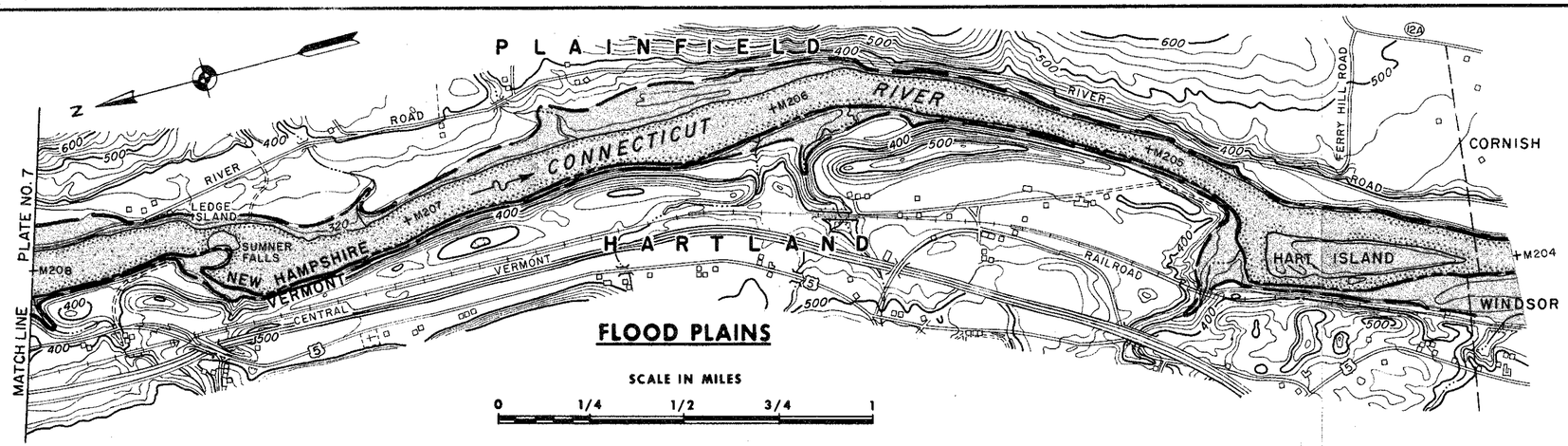
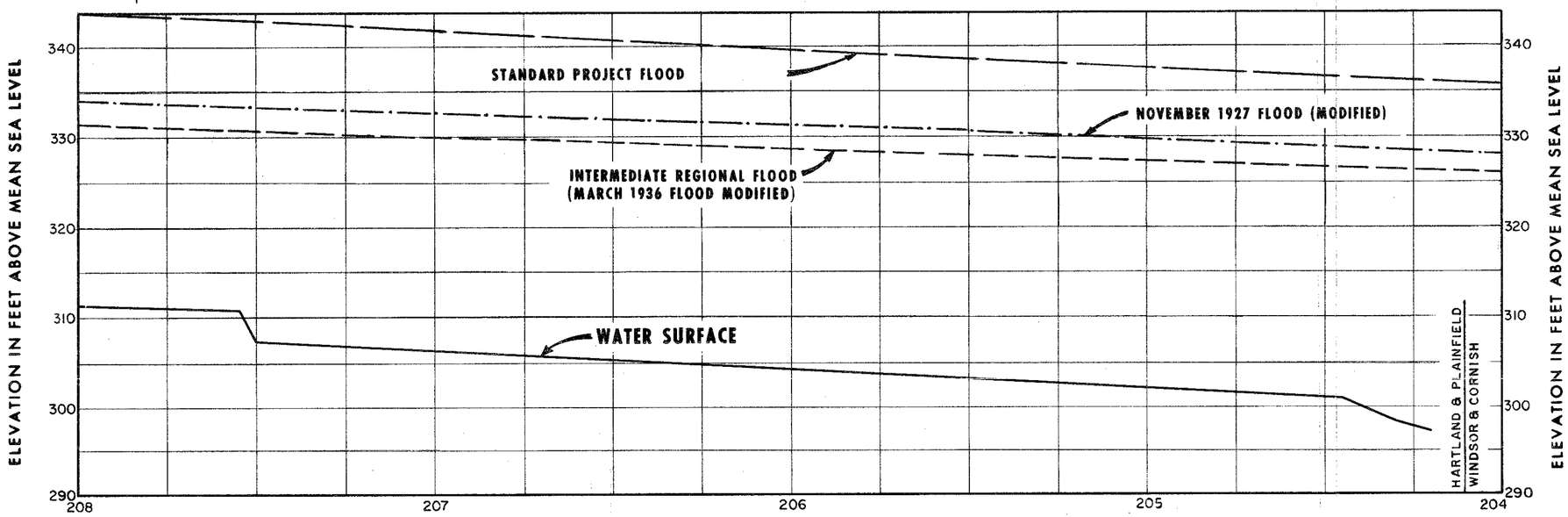

PIERMONT
Ompompanoosuc
First Branch
West Branch
N
CONNECTICUT RIVER
Union Village Reservoir
THETFORD
River
LYME
VERMONT
NEW HAMPSHIRE
White River
NORWICH
HANOVER
HARTFORD
W. LEBANON
MASCOMA
ENFIELD
LEBANON
CANAAN
Mascoma River
Mascoma Lake
WHITE RIVER JCT.
Ottauquechee River
North Hartland Reservoir
Mascoma River
HARTLAND
PLAINFIELD
WINDSOR
Mill River
91
89
6
7
8
9
10
11
12
13
14
15
16
4 1 4 Mi.
1" = 4 MILES
LEGEND
1 PLATE NUMBER
FLOOD PLAIN INFORMATION
CONNECTICUT, WHITE
AND MASCOMA RIVERS, N.H. & VT.
INDEX MAP
MAY 1972
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS

PLATE NO. 5





LEGEND

NORMAL FLOW — INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

STATE LINE

NOTES

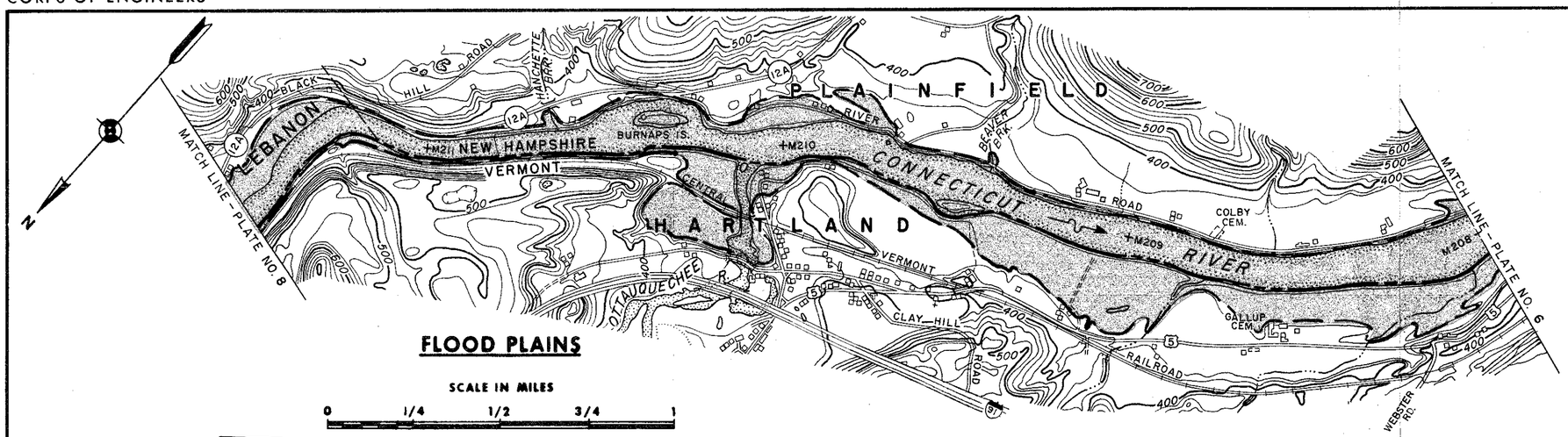
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE & NORTH HARTLAND DAMS.

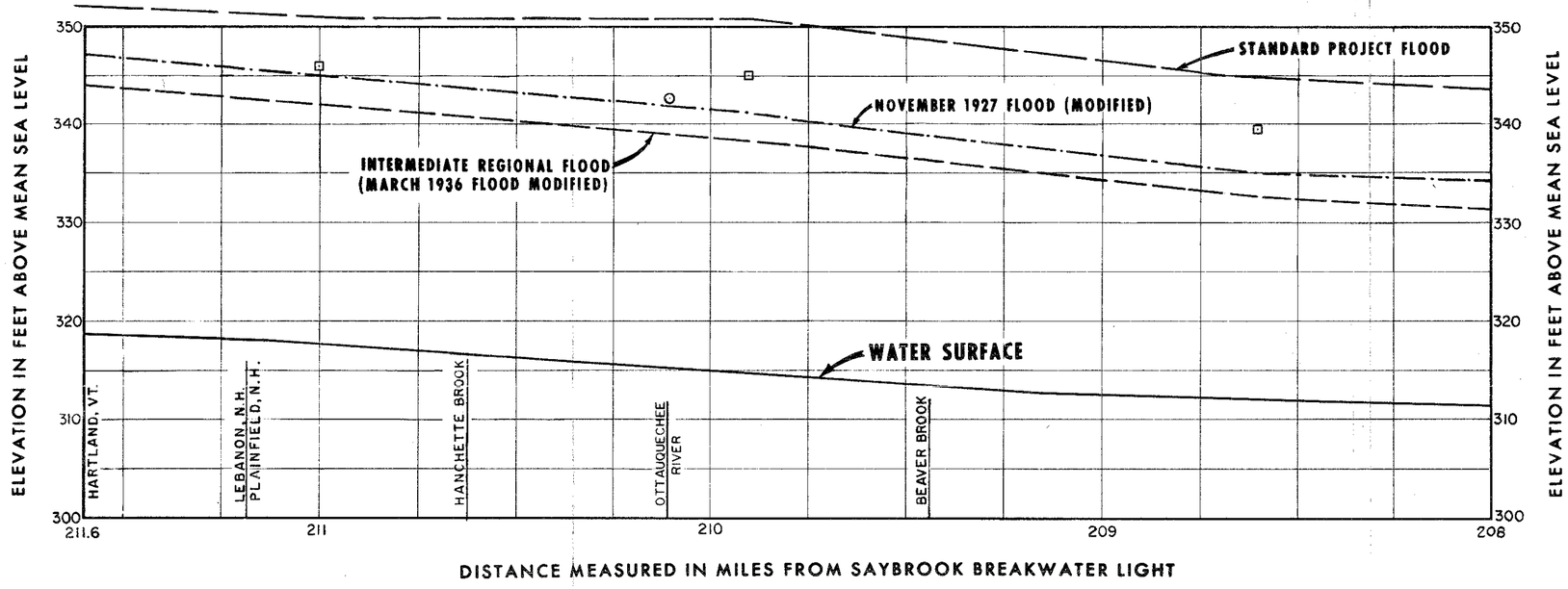
FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
PLAINFIELD, NEW HAMPSHIRE
HARTLAND, VERMONT

PLAN & PROFILE

MAY 1972 MILE 204 TO 208

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





LEGEND

NORMAL FLOW — INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

- □ NOV. 1927 FLOOD
- ○ MAR. 1936 FLOOD

STATE LINE

NOTES

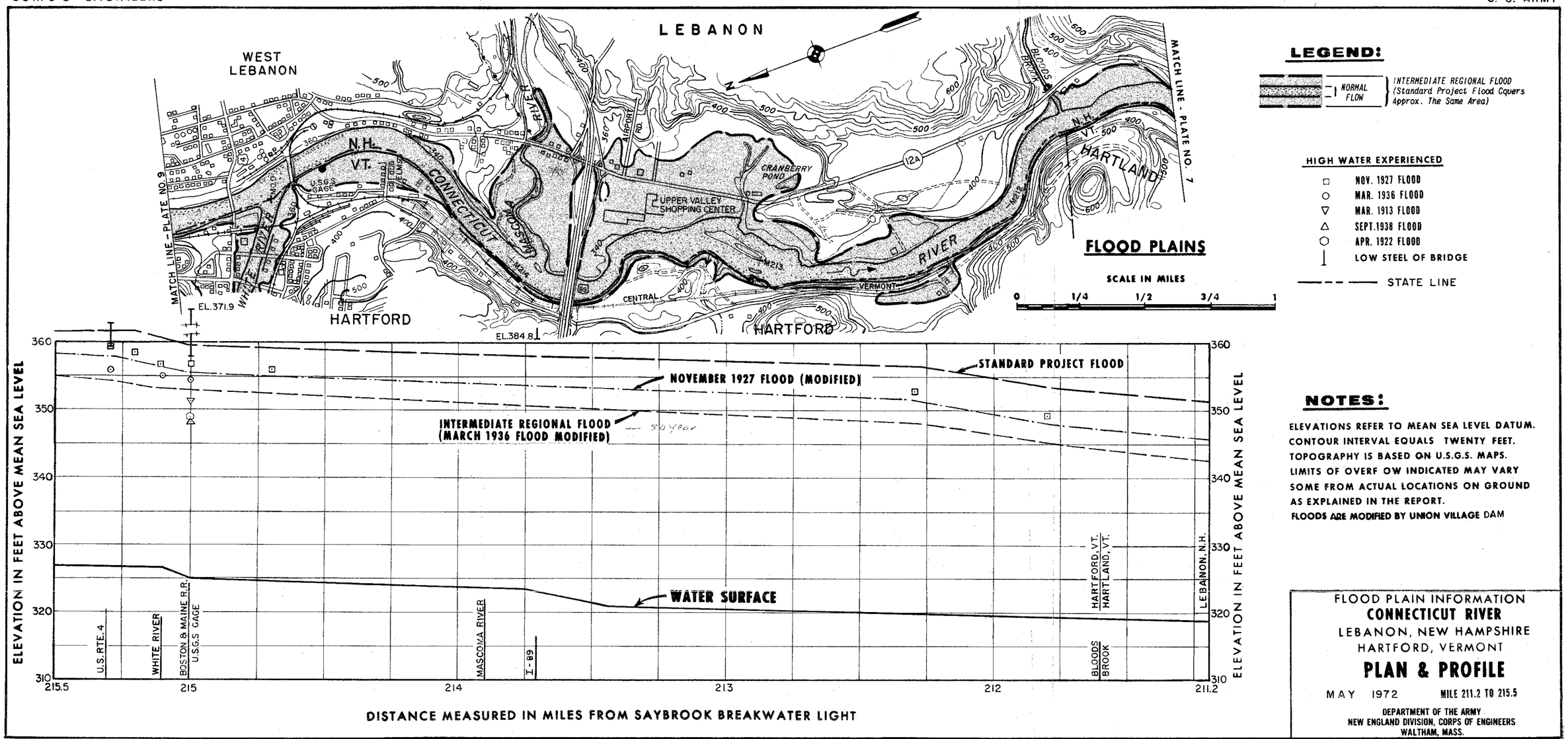
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE & NORTH HARTLAND DAMS.

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
PLAINFIELD, NEW HAMPSHIRE
HARTLAND, VERMONT

PLAN & PROFILE

MAY 1972 MILE 208 TO 211.2

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



NOTES:

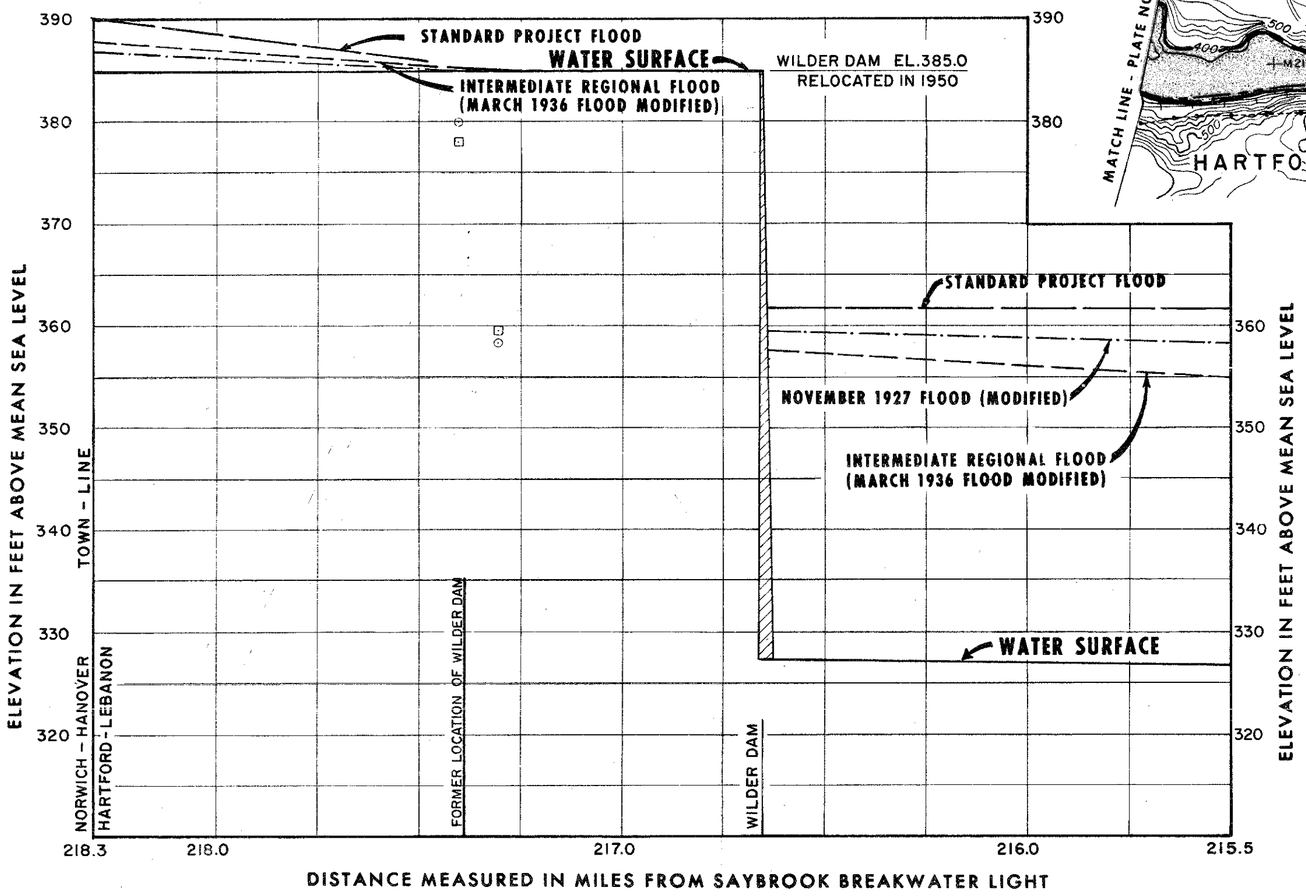
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERF OW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE DAM

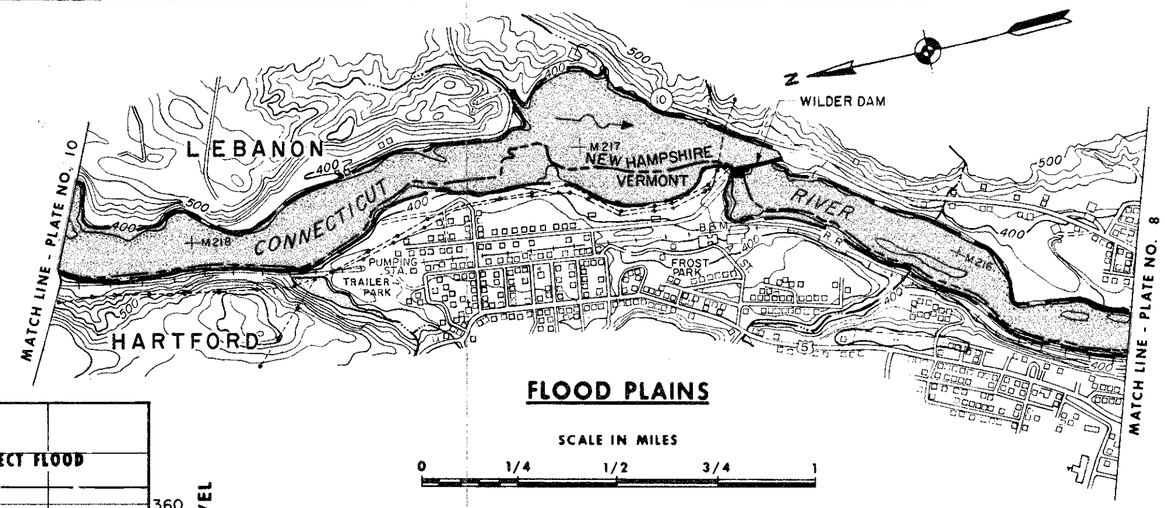
FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
LEBANON, NEW HAMPSHIRE
HARTFORD, VERMONT

PLAN & PROFILE

MAY 1972 MILE 211.2 TO 215.5

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





FLOOD PLAINS

SCALE IN MILES

0 1/4 1/2 3/4 1

LEGEND

NORMAL FLOW

INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

□ NOV. 1927 FLOOD

○ MAR. 1936 FLOOD

STATE LINE

DAM

NOTES

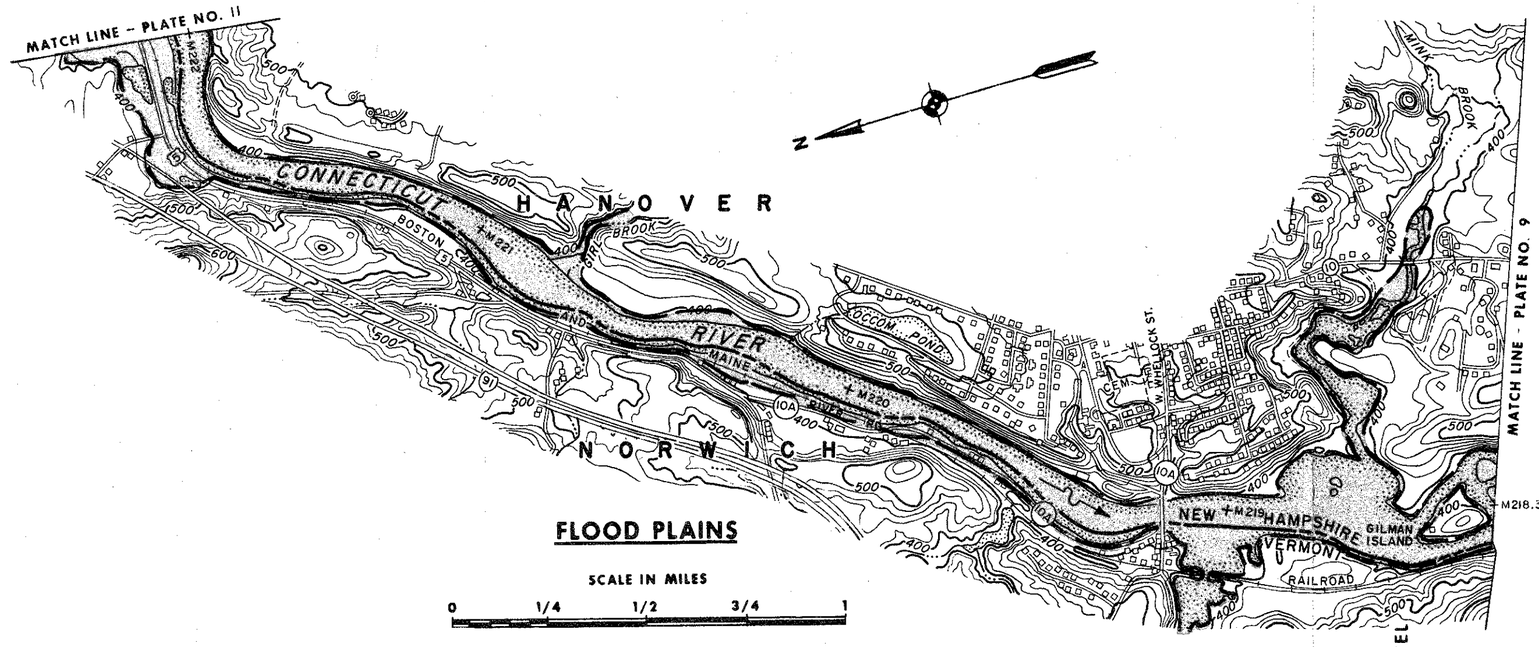
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS BELOW WILDER DAM ARE MODIFIED BY UNION VILLAGE AND NORTH HARTLAND DAMS, AND ABOVE BY UNION VILLAGE.
THE NOVEMBER 1927 AND THE MARCH 1936 FLOODS ARE ADJUSTED FOR THE INCREASE IN THE CREST AT WILDER DAM.

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
LEBANON, NEW HAMPSHIRE
HARTFORD, VERMONT

PLAN & PROFILE

MAY 1972 MILE 215.5 TO 218.3

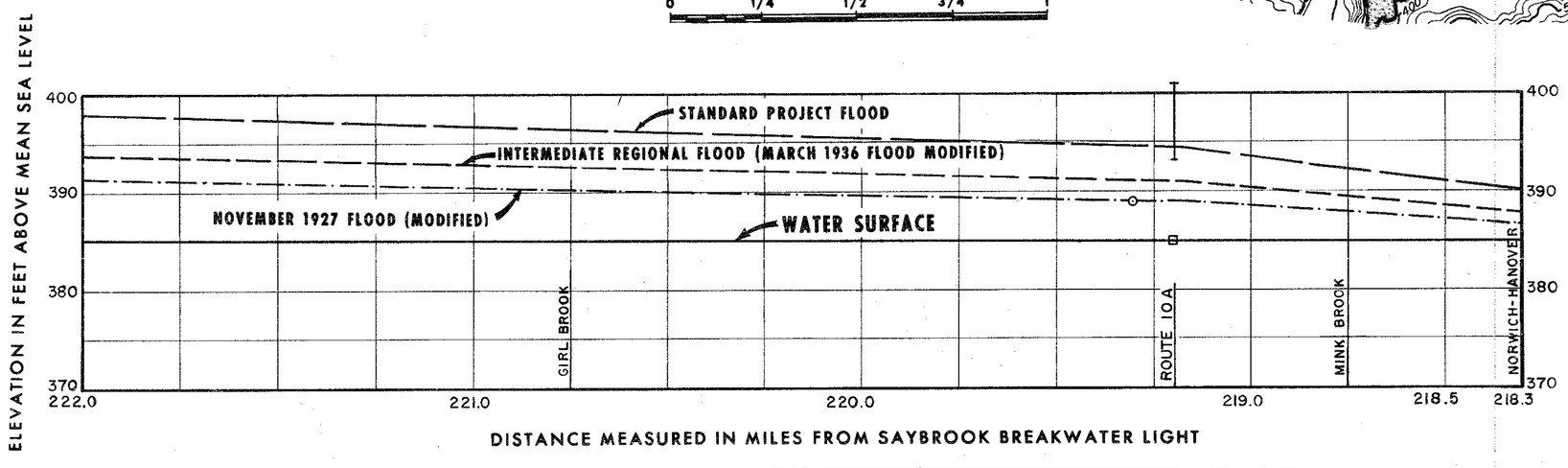
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



FLOOD PLAINS

SCALE IN MILES

0 1/4 1/2 3/4 1



LEGEND

NORMAL FLOW

INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

- □ NOV. 1927 FLOOD
- ○ MAR. 1936 FLOOD
- | LOW STEEL OF BRIDGE

— — — STATE LINE

NOTES

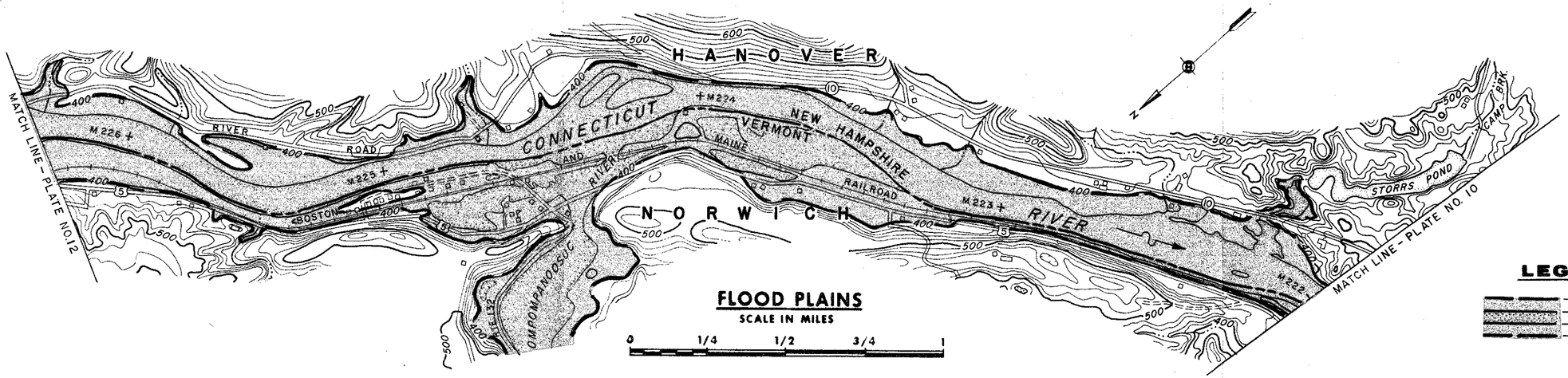
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE DAM. THE NOVEMBER 1927 AND THE MARCH 1936 FLOODS ARE ADJUSTED FOR THE INCREASE IN THE CREST AT WILDER DAM.

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
HANOVER, NEW HAMPSHIRE
NORWICH, VERMON

PLAN & PROFILE

MAY 1972 MILE 218.3 TO 222.0

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



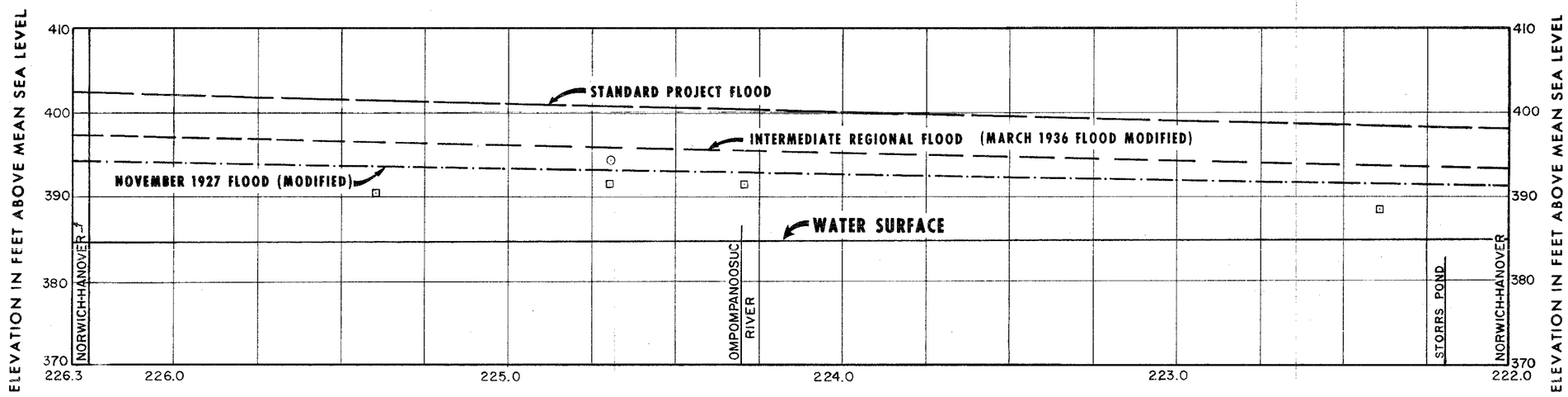
LEGEND

NORMAL FLOW — INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

- □ NOV. 1927 FLOOD
- ○ MAR. 1936 FLOOD

STATE LINE



NOTES

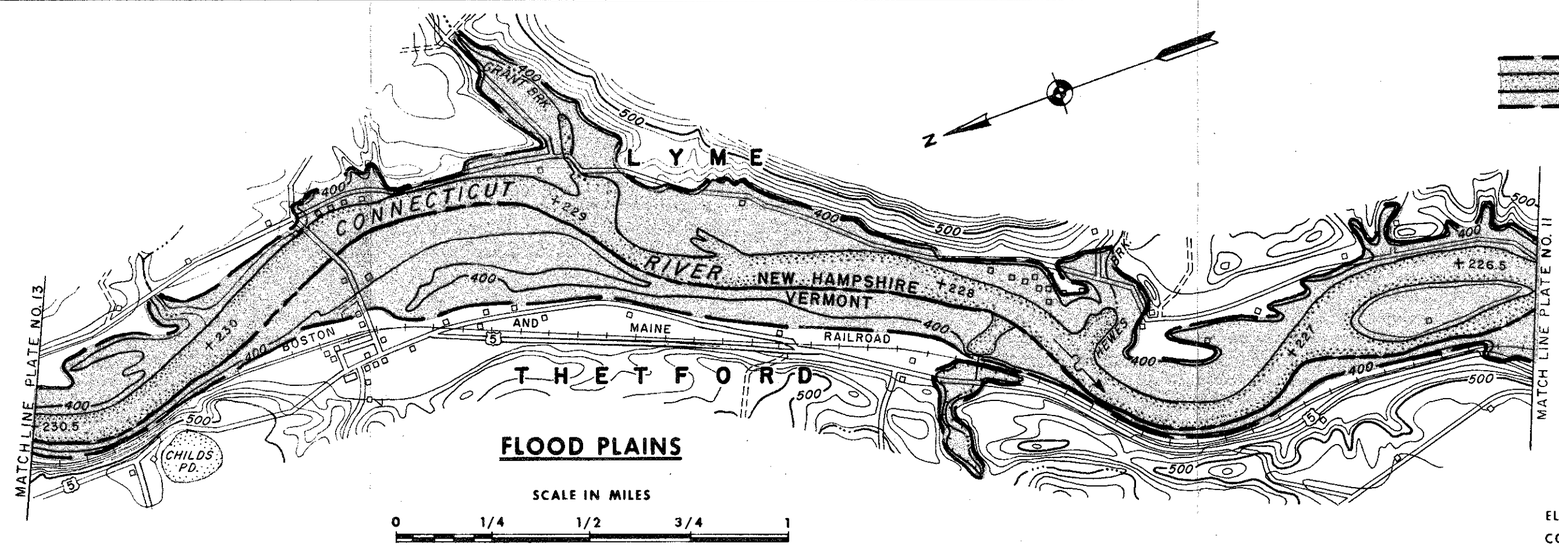
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE DAM. THE NOVEMBER 1927 AND THE MARCH 1936 FLOODS ARE ADJUSTED FOR THE INCREASE IN THE CREST AT WILDER DAM.

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
NORWICH, VERMONT
HANOVER, NEW HAMPSHIRE

PLAN & PROFILE

MAY 1972 MILE 222.0 TO 226.3

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



FLOOD PLAINS

SCALE IN MILES

0 1/4 1/2 3/4 1

LEGEND:

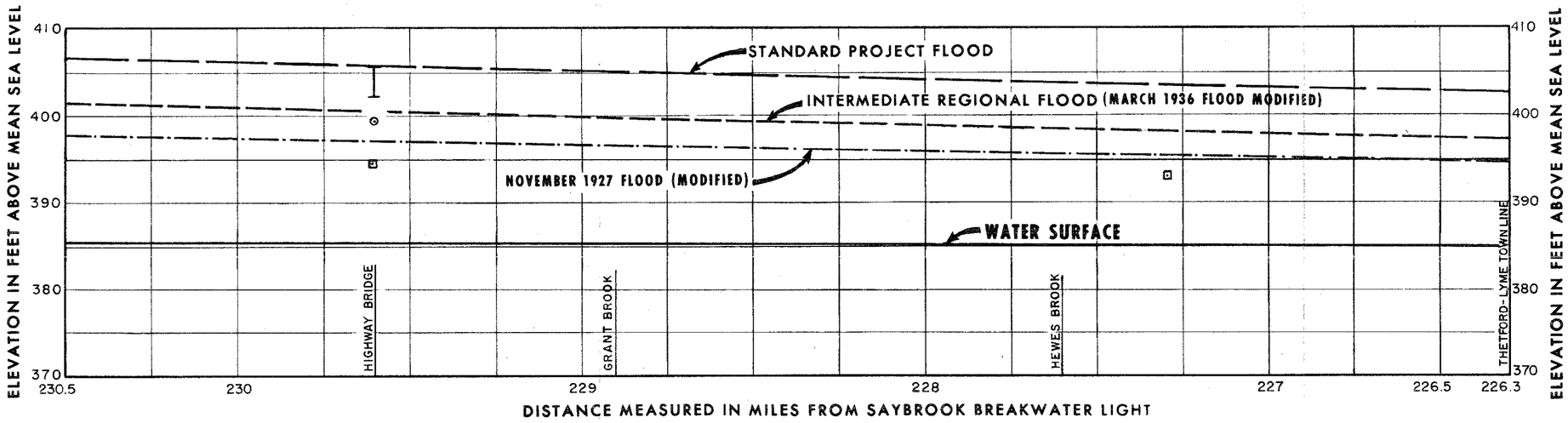
NORMAL FLOW — INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

- NOV. 1927 FLOOD
- MAR. 1936 FLOOD
- BRIDGE
- STATE LINE

NOTES:

ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE DAM.
THE NOVEMBER 1927 AND THE MARCH 1936 FLOODS ARE ADJUSTED FOR THE INCREASE IN THE CREST AT WILDER DAM.

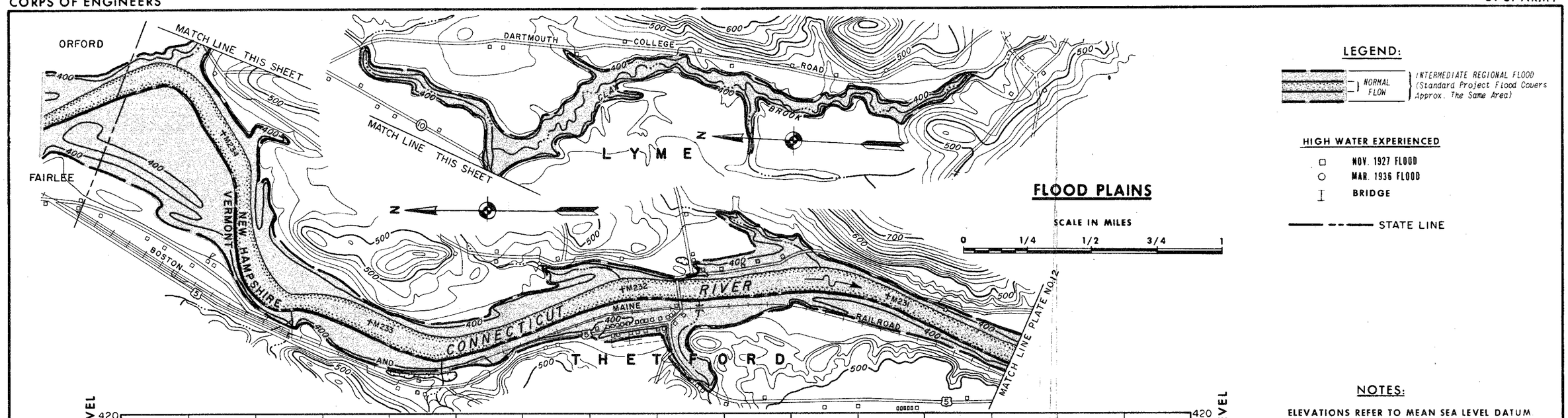


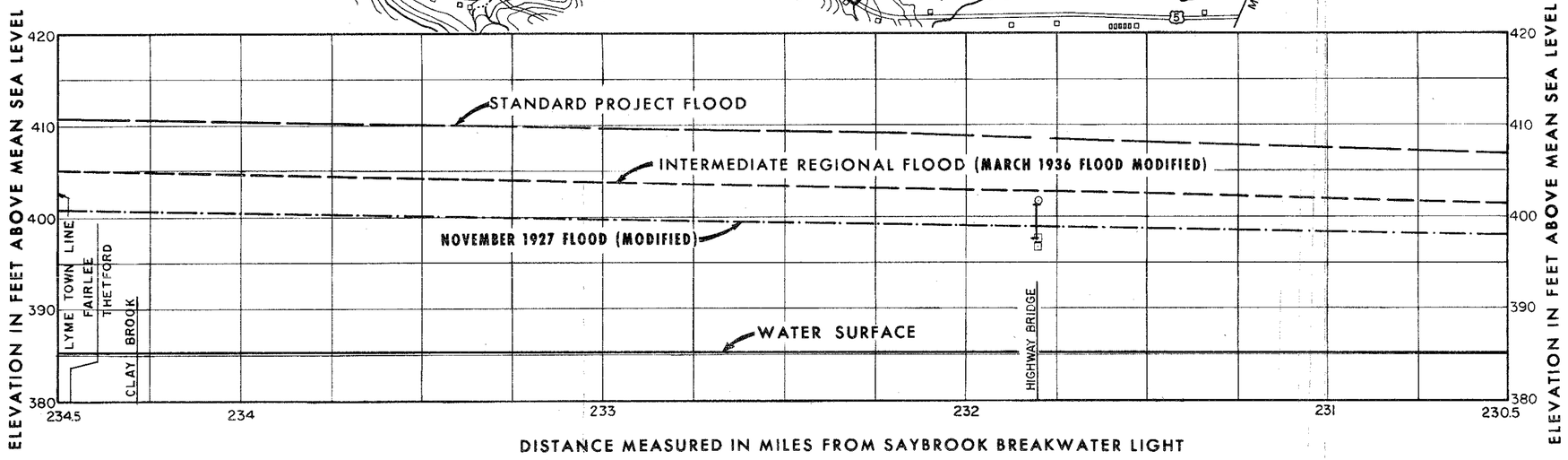
FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
THETFORD, VERMONT
LYME, NEW HAMPSHIRE

PLAN & PROFILE

MAY 1972 MILE 226.3 TO 230.5

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



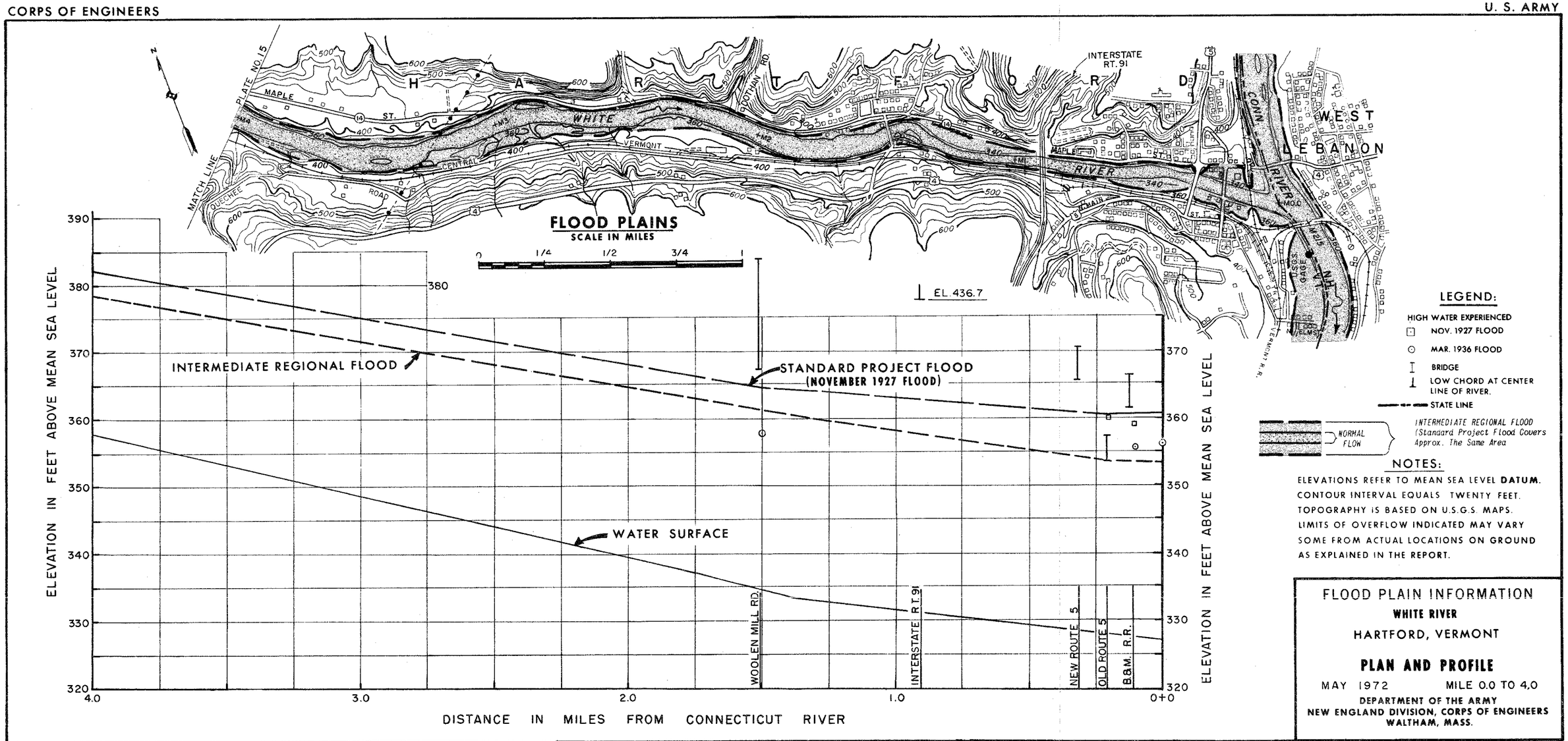


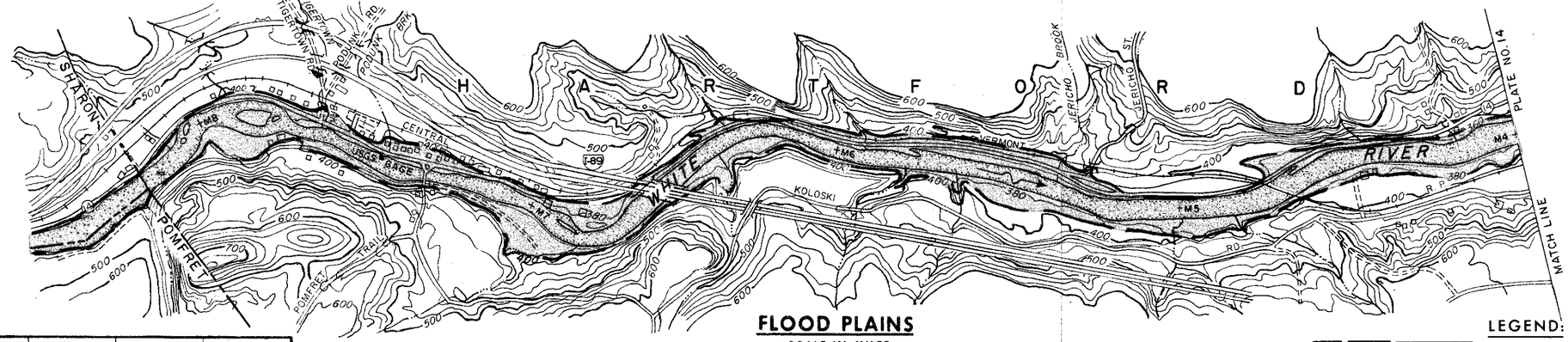
NOTES:

ELEVATIONS REFER TO MEAN SEA LEVEL DATUM
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOODS ARE MODIFIED BY UNION VILLAGE DAM.
THE NOVEMBER 1927 AND THE MARCH 1936 FLOODS ARE ADJUSTED FOR THE INCREASE IN THE CREST AT WILDER DAM.

FLOOD PLAIN INFORMATION
CONNECTICUT RIVER
THETFORD, VERMONT
LYME, NEW HAMPSHIRE
PLAN & PROFILE
MAY 1972 MILE 230.5 TO 234.5

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

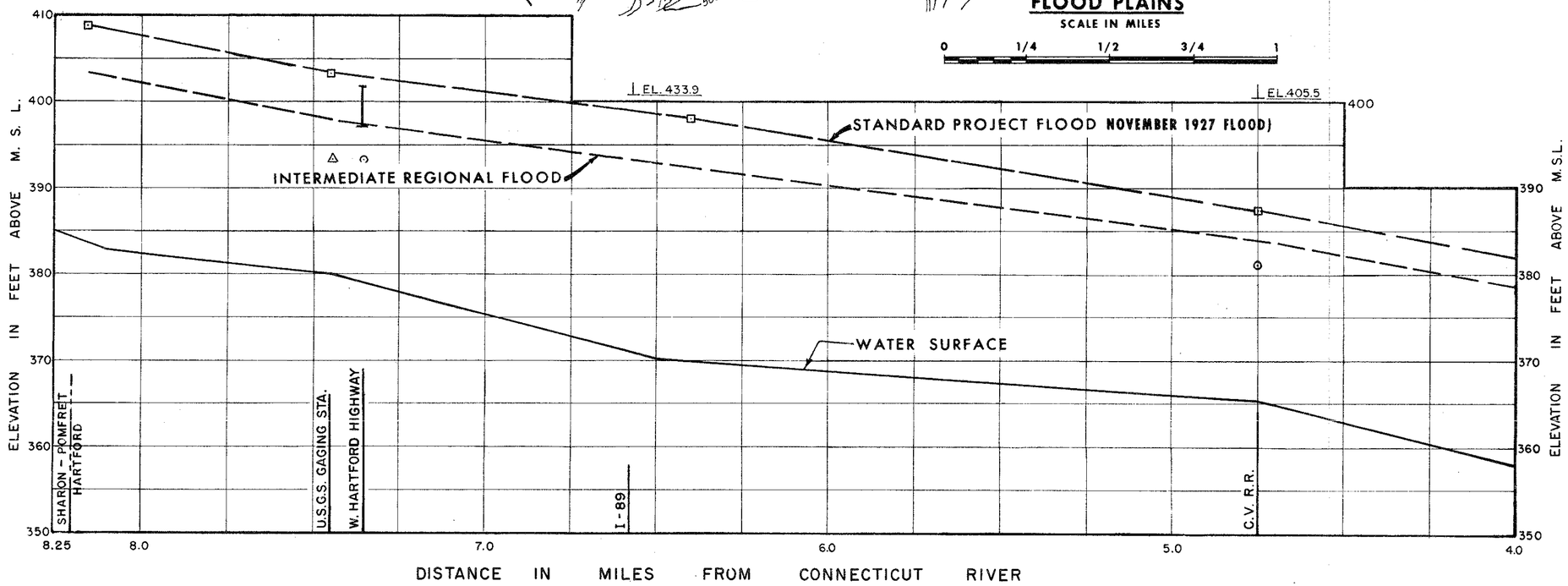

FLOOD PLAINS
SCALE IN MILES
0 1/4 1/2 3/4 1
PLATE NO. 15
MATCH LINE
MAPLE ST.
WHITE RIVER
VERMONT CENTRAL
QUECHEE ROAD
DOTHAN RD.
INTERSTATE RT. 91
MAIN ST.
CONN. RIVER
WEST LEBANON
N.H.
EL. 436.7
INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD
(NOVEMBER 1927 FLOOD)
WATER SURFACE
WOOLEN MILL RD.
INTERSTATE R.T. 91
NEW ROUTE 5
OLD ROUTE 5
B.&M. R.R.
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM CONNECTICUT RIVER
LEGEND:
HIGH WATER EXPERIENCED
NOV. 1927 FLOOD
MAR. 1936 FLOOD
BRIDGE
LOW CHORD AT CENTER LINE OF RIVER.
STATE LINE
NORMAL FLOW
INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area
NOTES:
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.
FLOOD PLAIN INFORMATION
WHITE RIVER
HARTFORD, VERMONT
PLAN AND PROFILE
MAY 1972
MILE 0.0 TO 4.0
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



FLOOD PLAINS

SCALE IN MILES

0 1/4 1/2 3/4 1



LEGEND:

NORMAL FLOW

INTERMEDIATE REGIONAL FLOOD (Standard Project Flood Covers Approx. The Same Area)

HIGH WATER EXPERIENCED

- NOV. 1927 FLOOD
- MAR. 1936 FLOOD
- SEP. 1938 FLOOD
- BRIDGE
- LOW CHORD

NOTES:

ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.

FLOOD PLAIN INFORMATION

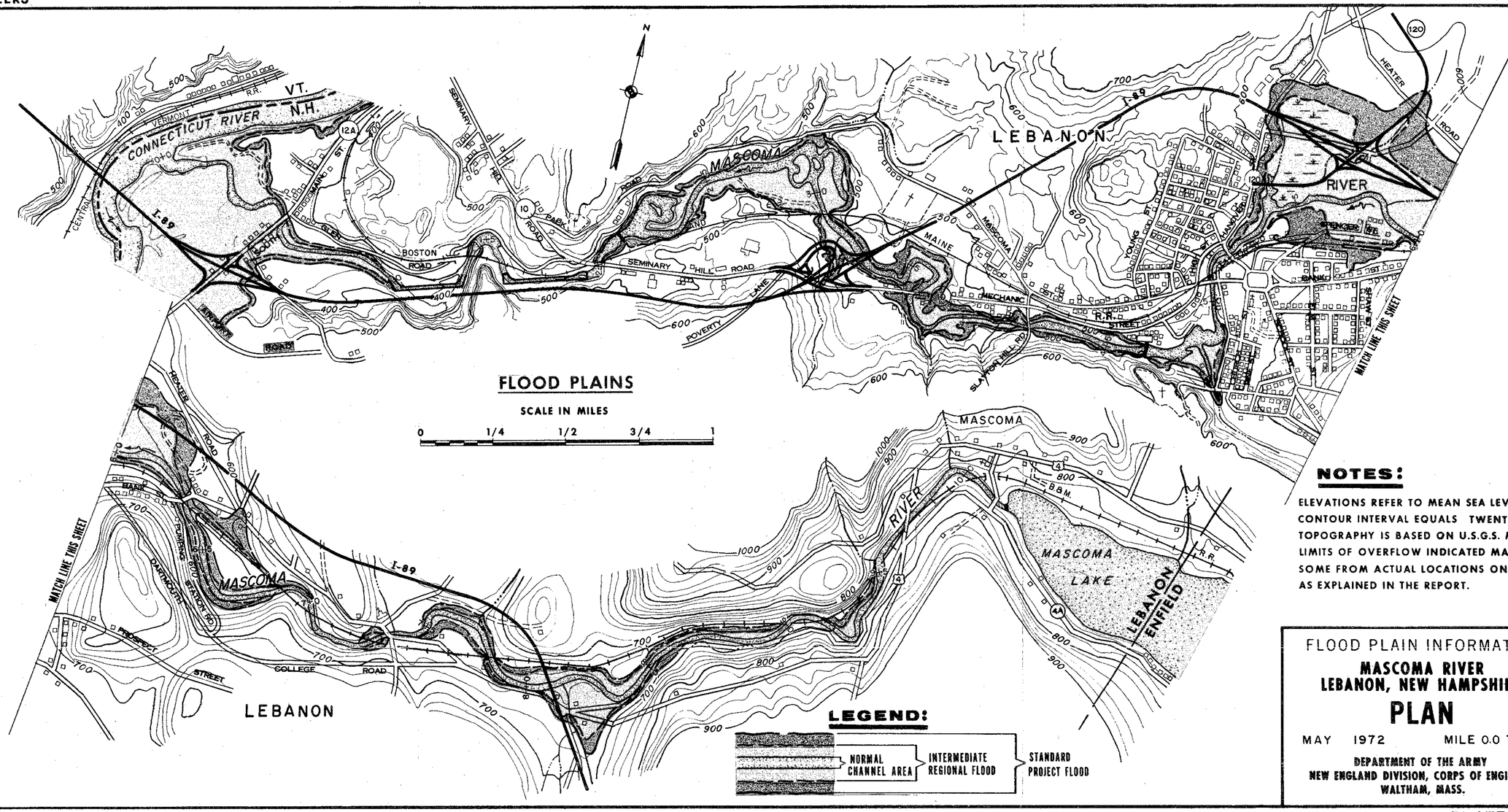
WHITE RIVER

HARTFORD, VERMONT

PLAN AND PROFILE

MAY 1972 MILE 4.0 TO 8.25

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



NOTES:

ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
CONTOUR INTERVAL EQUALS TWENTY FEET.
TOPOGRAPHY IS BASED ON U.S.G.S. MAPS.
LIMITS OF OVERFLOW INDICATED MAY VARY SOME FROM ACTUAL LOCATIONS ON GROUND AS EXPLAINED IN THE REPORT.

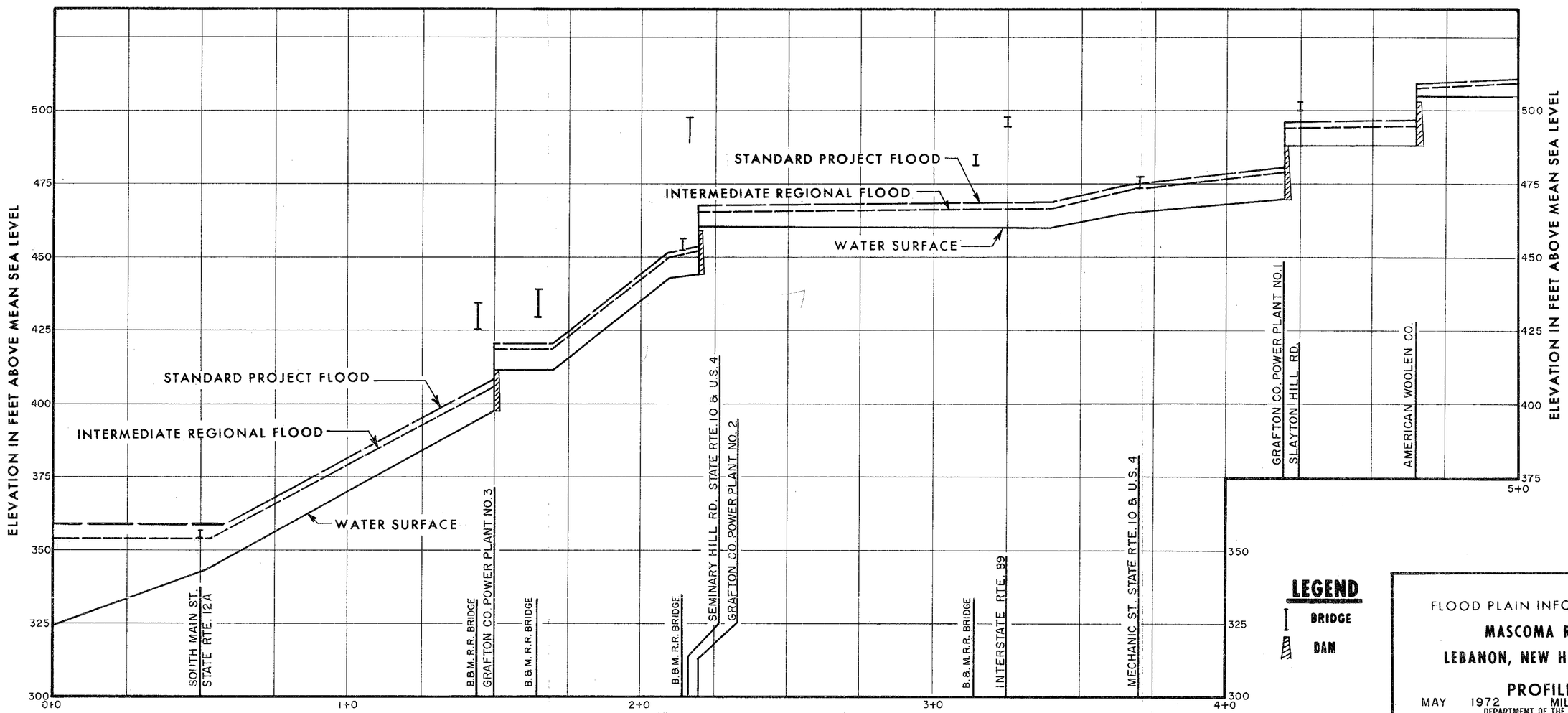
FLOOD PLAIN INFORMATION

MASCOMA RIVER
LEBANON, NEW HAMPSHIRE

PLAN

MAY 1972 MILE 0.0 TO 10.8

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



FLOOD PLAIN INFORMATION

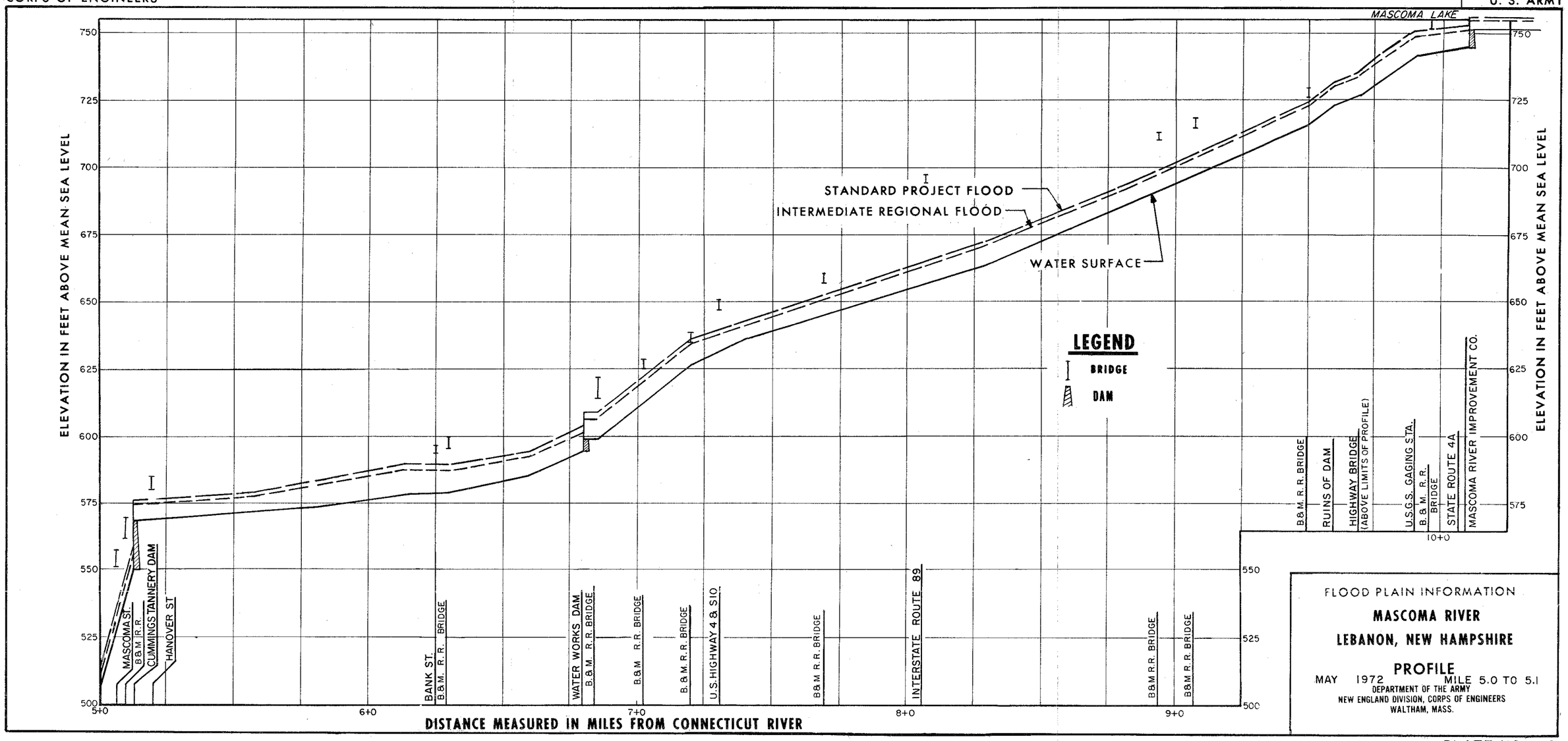
MASCOMA RIVER

LEBANON, NEW HAMPSHIRE

PROFILE

MAY 1972 MILE 0.0 TO 5.0

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



FLOOD PLAIN INFORMATION

MASCOMA RIVER

LEBANON, NEW HAMPSHIRE

PROFILE

MAY 1972 MILE 5.0 TO 5.1

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