Lake Champlain
3-3

FLOOD PLAIN INFORMATION

WINOOSKI RIVER — STEVENS BRANCH

TOWN OF BERLIN • VERMONT

PREPARED FOR
DEPARTMENT OF WATER RESOURCES, STATE OF VERMONT
BY
DEPARTMENT OF THE ARMY, NEW YORK DISTRICT, CORPS OF ENGINEERS

Vt-w
29

Lake Champlain
RB

MARCH 1973

CONTENTS

	Page
PREFACE	i
BACKGROUND INFORMATION	1
Settlement	1
The Streams and Their Valleys	1
Stevens Branch	1
Winooski River	1
Developments in the Flood Plain	2
Stevens Branch	2
Winooski River	3
FLOOD SITUATION	4
Data Sources and Records	4
Flood Season and Flood Characteristics	5
Factors Affecting Flooding and Their Impact	5
Obstructions to Floodflows	5
Flood Damage Reduction Measure	11
Other Factors and Their Impact	12
Flood Warning and Forecasting	12
Flood Fighting and Emergency Evacuation Plans	12
Material Storage on the Flood Plain	12
PAST FLOODS	13
Summary of Historical Floods	13
Flood Records	13
Flood Description	13
FUTURE FLOODS	14
Intermediate Regional Flood	14
Winooski River at Berlin	14
Standard Project Flood	14
Flood Frequency	16
Hazards of Large Floods	16
Rates of Rise and Duration of Flooding	16
Flooded Areas and Flood Damages	19
Obstructions	19
Velocities of Flow	23
GLOSSARY	24

CONTENTS [Continued]
FIGURES

FIGURE		Page
1	Dam on the Winooski River Upstream of Stevens Branch	6
2	Debris and Silt in Pool above Dam in Figure 1	6
3	U.S. Highway 302 Bridge between Montpelier and Barre	7
4	Abandoned Railroad Bridge adjacent to U.S. Highway 302	7
5	Private Bridge to Mobile Home Park	8
6	Montpelier-Barre Railroad Bridge over Winooski River	8
7	U.S. Highway 2 Bridge over Winooski River	9
8	Shopping Center on Stevens Branch Flood Plain	9
9	Relative Flood Heights at Shopping Center	17
10	Obstructive Addition, Rear of Shopping Center	17
11	View Along Highway 302 Showing Development along Stevens Branch	18
12	Relative Flood Heights at Mobile Home Park	18
13	Relative Flood Heights, Stevens Branch Flood Plain	21
14	Relative Flood Heights, Stevens Branch Flood Plain	21
15	Relative Flood Heights, Stevens Branch Flood Plain	22
16	Relative Flood Heights, Winooski River at Berlin	22

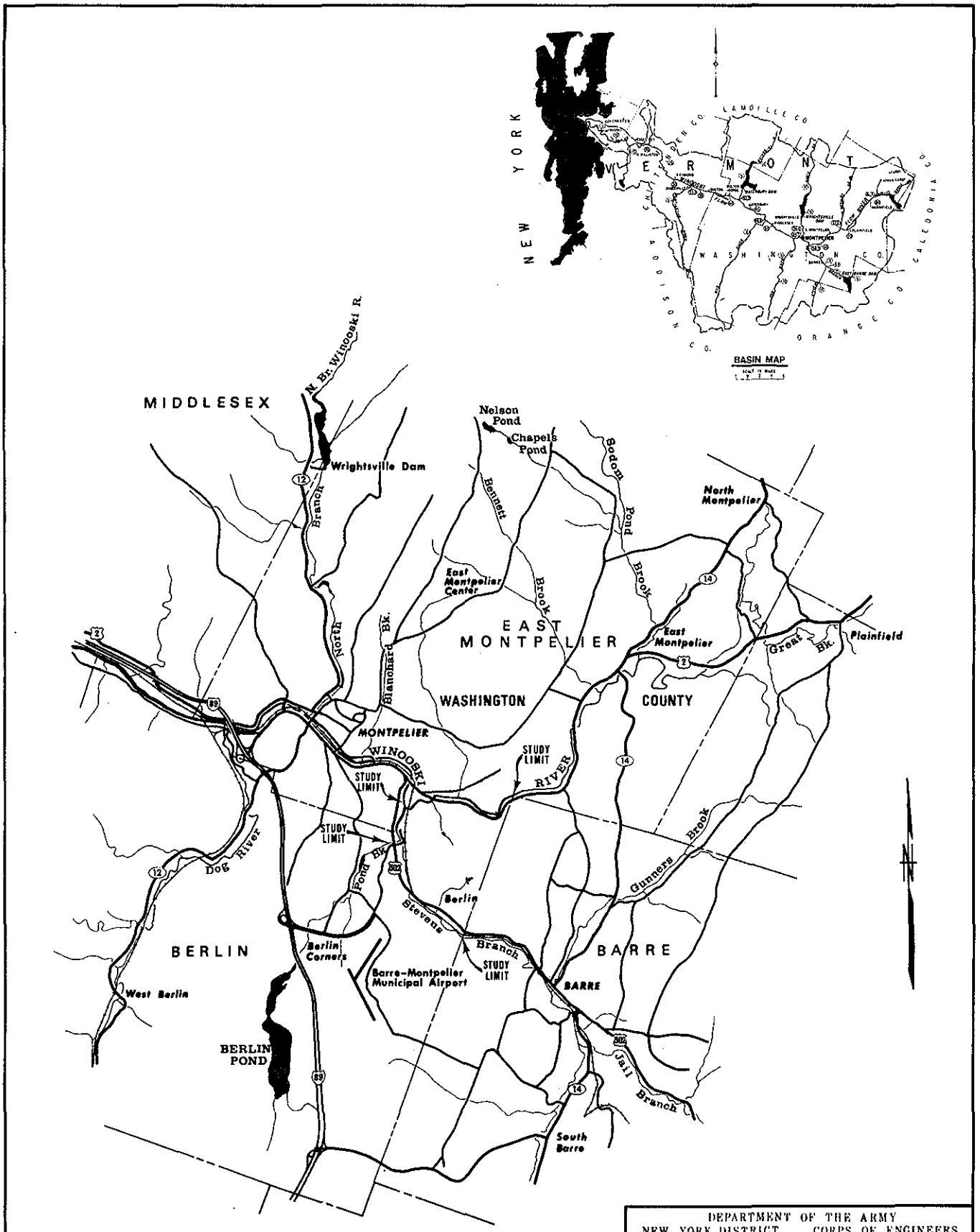
CONTENTS [Continued]

TABLES

TABLE		Page
1	Stream Gages - Winooski River Watershed	4
2	Elevation Data - Bridges Across Stevens Branch and Winooski River (Berlin Area)	10
3	Peak Flows for Intermediate Regional Flood and Standard Project Flood	15
4	Winooski River Flood Crest Elevations	20
5	Stevens Branch Flood Crest Elevations	20

PLATES

PLATE		
1	General Map - Winooski River	Opposite Page 1
2	Index Map - Flooded Areas	At end of report
3-5	Flooded Areas	At end of report
6	High Water Profiles - Winooski River and Stevens Branch	At end of report
7	Selected Cross Sections - Winooski River	At end of report
8	Selected Cross Sections - Stevens Branch	At end of report



DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

GENERAL MAP

WINOOSKI RIVER

VERMONT

1 0 1 2 MILES

MARCH 1973

PLATE 1

PREFACE

This report relates to the flood situation along the Winooski River above Stevens Branch within the Towns of Berlin and East Montpelier and the City of Montpelier, and along the Stevens Branch within the Berlin Town Limits and the City of Montpelier. The center line of the two streams forms portions of the Berlin Town Line. This report was prepared at the request of the Department of Water Resources, State of Vermont. The properties along these streams within the study are primarily commercial and residential. A number of them have been damaged by past floods.

Much of the commercial development on the flood plain of Stevens Branch along U.S. Highway 302 has taken place in recent years and, therefore, was not affected by the major floods of 1927, 1936 and 1938. However, it is evident that the recurrence of floods of the magnitude of these past floods, or the occurrence of even greater floods in the future, will result in heavy damage to and destruction of property and possible loss of life.

A somewhat similar situation exists along the Winooski River within the study area. Development is much less extensive; therefore, potential damage and destruction from future floods is somewhat less.

The report is based on information on rainfall, runoff, historical and more recent flood heights, and other technical data bearing on the frequency and magnitude of floods in the Berlin area.

The Berlin area has been studied because a knowledge of flood potential and flood hazards is important in land use planning and for management decisions concerning flood plain utilization. The report includes a history of flooding in the area and identifies those areas that are subject to possible future floods. Special emphasis is given to these possible future floods through maps, photographs, stream profiles, and cross sections.

The report does not provide solutions to flood problems; however, it does furnish a suitable basis for the adoption of land use controls to guide flood plain development and thereby prevent intensification of the loss problems. It also will aid in the identification of other flood reduction techniques such as works to modify flooding and adjustments including floodproofing which might be embodied in an overall flood plain management [FPM] program. Other FPM program studies — those of environmental attributes and the current and future land use role of the flood plain as part of its surroundings — would also profit from this information.

Under the continuing authority provided in Section 206 of the 1960 Flood Control Act as amended, this report was prepared in response to the request of the Department of Water Resources, State of Vermont, for the New York District Office of the Corps of Engineers, by Dufresne-Henry Engineering Corp., North Springfield, Vermont. The Water Resources Department will make information available to all interested agencies and individuals. Upon further request, the Corps of Engineers, New York District Office, will provide technical assistance to planning agencies in the interpretation and use of the data presented as well as planning guidance and further assistance, including the development of additional technical information.

BACKGROUND INFORMATION

Settlement

The Town of Berlin was chartered in 1763. Its population according to most recent census figures was 2,050 in 1970. Most of the residential area of the Town is on high ground, away from the Stevens Branch and the Winooski River flood plains. A large part of the commercial area is located on these flood plains, along U.S. Highways 2 and 302. Highway 302 is the main road between Barre and Montpelier and, as such, carries high density traffic of both commercial and passenger vehicles.

The Streams and Their Valleys

This report encompasses that portion of the Winooski River from the upper limit of a previous report (Flood Plain Information, Winooski River, City of Montpelier, Vermont) upstream to the Berlin-Barre Town Line (1.94 miles) and encompasses Stevens Branch from its mouth, upstream to the Berlin-Barre Line (2.43 miles), which is the downstream limit of another previous report (Flood Plain Information, Stevens Branch, City of Barre, Vermont). Both reaches of these two streams lie within the Town of Berlin, although parts of the flood plain lie within the City of Montpelier and the Town of East Montpelier.

Stevens Branch

This stream flows generally northwesterly through the Town of Berlin forming the border between Berlin and Montpelier part of the way. The streambed falls 22 feet in elevation in 2-1/2 miles, or at a rate of about 9 feet per mile, more than half of the fall being in the upper mile of the channel.

During major floods backwater from a narrowing of the Winooski River channel, within the City of Montpelier downstream from U.S. Highway 2 Bridge together with the constriction formed by the highway bridge and an adjacent railroad bridge, inundates an extensive area of the Stevens Branch flood plain which extends over a mile upstream. The upper mile of the flood plain is inundated primarily by flood water from Stevens Branch alone.

One abandoned railroad bridge and two highway bridges span Stevens Branch within the Town of Berlin, one of the highway bridges carrying heavy traffic along U.S. Highway 302 between the Cities of Montpelier and Barre. A major flood would submerge all three bridge decks and, in particular, would cause serious congestion along Highway 302. The Montpelier-Barre Railroad runs along the right bank of the Stevens Branch study reach.

Winooski River

The constrictions in the vicinity of the U.S. Highway 2 crossing in Montpelier cause backwater also to inundate the flood plain of the Winooski River to considerable depths for nearly a mile upstream, at which point the valley begins to narrow rapidly.

The streambed slopes 96 feet in less than two miles or at an average rate of about 50 feet per mile. Forty feet of this fall occurs in the first half mile down stream from the Town Line which includes a drop of about 24 feet over a dam and adjacent ledge outcrop (see Figure 1).

One railroad bridge and a bridge on U.S. Highway 2 span the Winooski River within the study area. Both bridge decks would be overtopped by a major flood, but since the flood plains adjacent to each bridge are wide and relatively flat, the bridge structures would cause only minor obstructions.

Developments in the Flood Plain

Stevens Branch

Commercial development along the Stevens Branch flood plain, within the Town of Berlin and the City of Montpelier, is probably more extensive and intensive than on any other flood plain in the State of Vermont. Along both sides of U.S. Highway 302, which parallels the stream and which carries heavy traffic between Barre and Montpelier, there lies an almost continuous series of shopping centers, supermarkets, restaurants, mobile home sales lots, motels, service stations, garages, warehouses, and other structures.

As of July 1, 1972, the count of completed structures was as follows:

Kind of Business	Number
Shopping Center	1
Supermarkets	2
Restaurants	8
Mobile Home Sales Lots	3
Motels	3
Service Stations	7
Garages	11
Warehouses	10
Bowling Alley	1
Residences	21
Drive-In Theater	(2 Screens) 1
Gasoline or Gas Storage Tanks	12
Miscellaneous Commercial	15

East of the stream were one mobile home park with 31 units and another smaller park with 25 units.

Some of the garage areas included used car sales lots where dozens of cars are parked on the flood plain.

All of this development is on the flood plain along less than 2-1/2 miles of stream channel.

Most of these structures would be damaged by a major flood and several would be overtopped. Mobile homes would easily be dislodged and could be floated or swept downstream and become obstructions to floodflows.

Structures not reached by the flood waters would in most cases become inaccessible because of road and highway flooding.

Winooski River

Development along the Winooski River flood plain within the study area has been only moderate. Most of the development has been along the downstream half of the two mile reach. Two bridges, one a railroad crossing, the other carrying the heavy traffic of U.S. Highway 2, span the river within the Town and City. Both bridge decks would be submerged by a major flood. Because of the extensive flood plains adjacent to the bridges, little constrictive effect exists.

The flood plain narrows significantly upstream as the Berlin-Barre Town Line is approached and development is limited to agriculture, a few residences, and scattered small commercial enterprises. Within the areas of narrow flood plain, the streambed slopes are steeper and the velocity of flood waters is high. Considerable erosion of the stream channel and banks already has taken place as evidenced by the amount of deposited material upstream from the dam that was once used to pond water for a small hydroelectric installation (see Figure 2). Future floods will cause additional erosion of the stream channel and more deposit upstream from the dam until the pond is filled completely with silt, gravel, boulders and debris.

FLOOD SITUATION

Data Sources and Records

The United States Geological Survey maintains eight stream gaging stations in the Winooski River Watershed. None of these are in the study area or on the Winooski River upstream from the Berlin Town Line. Jail Branch, a tributary to Stevens Branch, has been gaged continuously since 1933. The record at this gage site documents the runoff from about 40 square miles of watershed. The flood peaks are reduced significantly by the operation of East Barre Detention Reservoir one-half mile upstream. The maximum recorded flow rate on Jail Branch since 1933 was 634 cfs in April 1969.

TABLE 1
STREAM GAGES - WINOOSKI RIVER WATERSHED

Name of Station	Stream	Period of Record	Drainage Area [Sq. Mi.]	Maximum Discharge [C.F.S.]	Date
Essex Junction*	Winooski R.	1928-1972	1044	113,000	11/1927
Montpelier*	Winooski R.	1909-1923 1928-1972	397	57,000	11/1927
Northfield Falls	Dog River	1934-1972	76.1	9,750	9/1938
East Barre*	Jail Branch	1920-1923 1933-1972	40.4**	11,500	11/1927
Wrightsville*	North Branch	1933-1972	69.2	17,200	11/1927
Waterbury*	Little River	1935-1972	111	23,400***	11/1927
Moretown	Mad River	1928-1972	139	23,000	11/1927
Near Montpelier	Sonny Brook	1963-1972	2.3	164	5/1964

* Flow affected by upstream flood control reservoirs. The East Barre and Wrightsville Reservoirs have been in operation since 1935. The Waterbury Reservoir has been in operation since 1937.

**Includes 11.3 square miles of area diverted for East Barre Water Supply.

***No regulation

To supplement the records for this gaging station, newspaper files and historical documents and records were searched for information concerning past floods. This information has served to produce a knowledge of floods which have occurred on Stevens Branch and the Winooski River within the Towns of Berlin and East Montpelier and the City of Montpelier.

Maps included in this report were based on photogrammetry prepared in 1967 from aerial photography flown in 1958 and 1962, modified in 1972 to reflect the most recent development on the flood plains.

Cross sections of the stream valleys were surveyed in 1971 by the Vermont Department of Water Resources. Structural data on bridges and the capability of the stream channels to convey floodwaters were field checked in 1972.

Crest stages for the 1927 flood are shown in Table 5.

Flood Season and Flood Characteristics

Flooding in the upper Winooski Basin including Stevens Branch has occurred during all seasons of the year, with the greatest floodflow occurring in November 1927. Other recent floods have occurred in March 1936 and September 1938. Floodflow stages can rise from normal flow to extreme floodflow in a relatively short period of time.

The main flood season for the Winooski River is difficult to define since the rainfall is fairly uniform over the region. About 22 per cent of the total rainfall occurs in the spring (March-May), 32 per cent in the summer (June-August), 28 per cent in the fall (September-November), and 18 per cent in the winter (December-February). The majority of the storms occurring over this region are of transcontinental and coastal types. The former type, the most frequent rain producer, is most likely to occur in the winter and early spring.

The coastal type of storm, the most intense rain producer, is most likely to occur in the late summer and early fall. Of the several hundred rainstorms which have been recorded in this region since 1869, the greatest number have occurred in August. However, those producing the worst floods have occurred from September through November, such as the maximum flood of record, the November 1927 Flood.

Factors Affecting Flooding and Their Impact

Obstructions to Floodflows

Natural obstructions to floodflows include trees, brush and other vegetation growing in the stream channel or along the stream banks and on the flood plain. Man-made encroachments on or adjacent to streams such as dams, bridges and buildings also can create more extensive flooding upstream than would otherwise occur.

Representative obstructions to floodflows are shown in Figures 1 through 7.

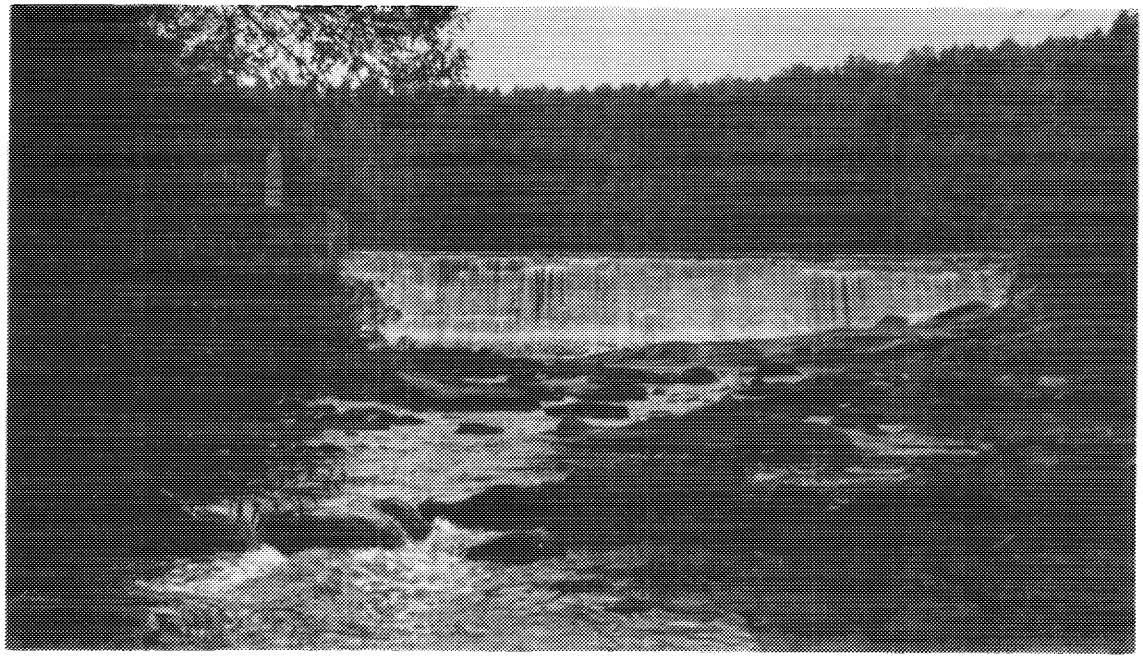


Figure 1 - Looking upstream at ledge and dam on the Winooski River 1.4 miles above Stevens Branch. Dam causes increased water surface elevations upstream.

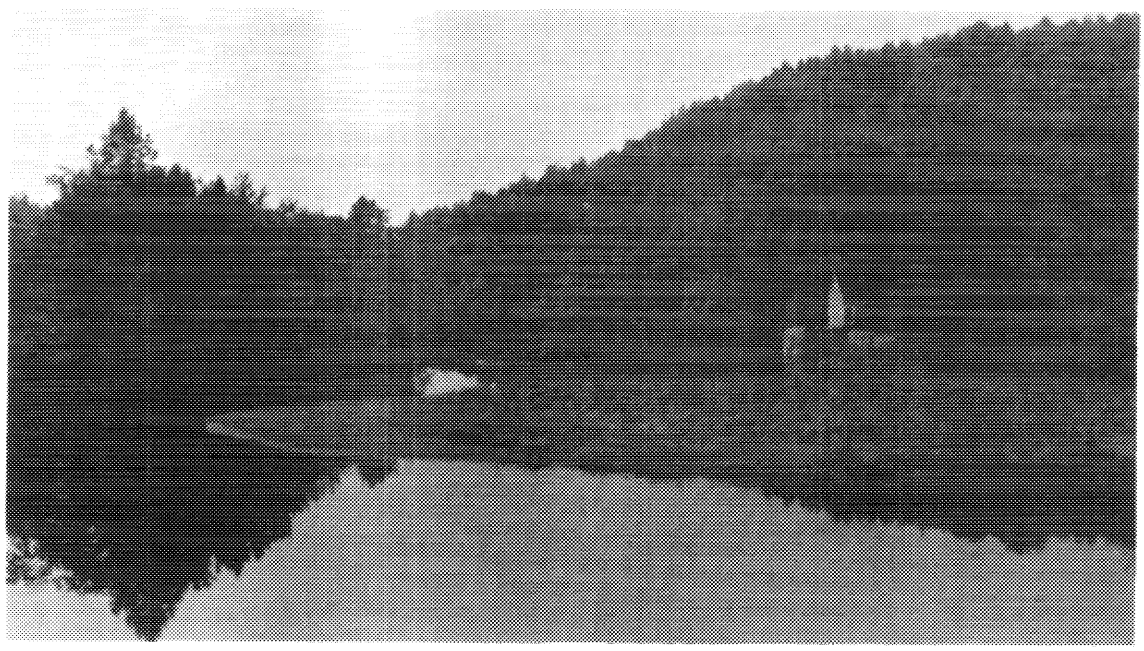


Figure 2 - Looking downstream at dam and intake structure of abandoned penstock. Note debris in pool obstructing flow of water.

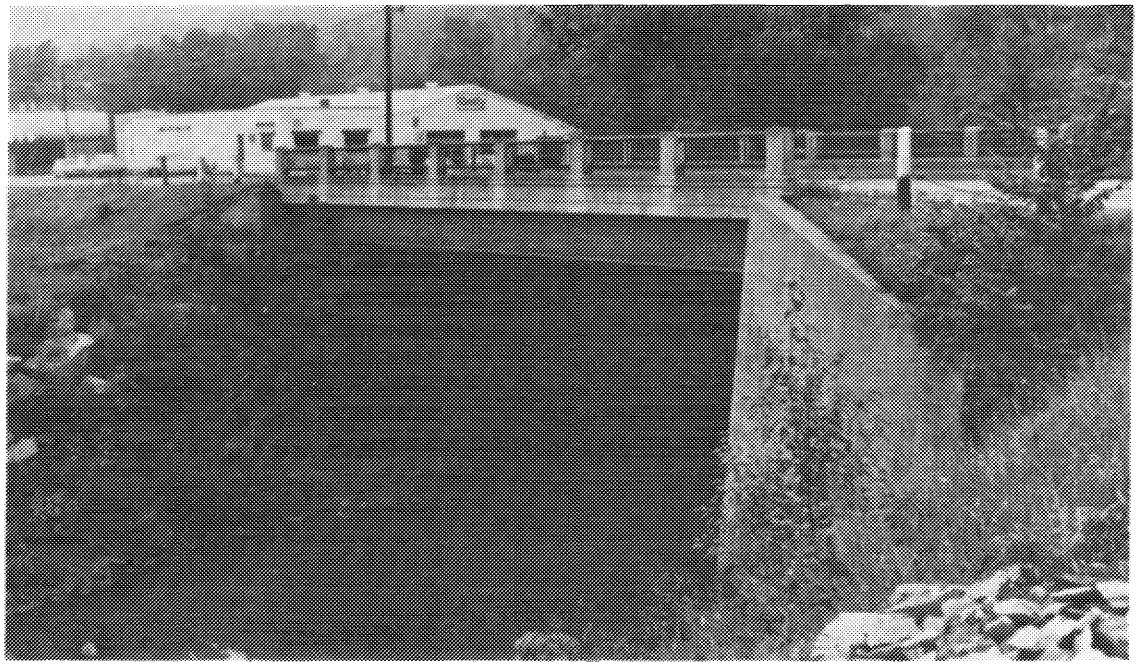


Figure 3 - Looking upstream at U.S. Highway 302 Bridge between Montpelier and Barre. Bridge would be obstructive to major floods.

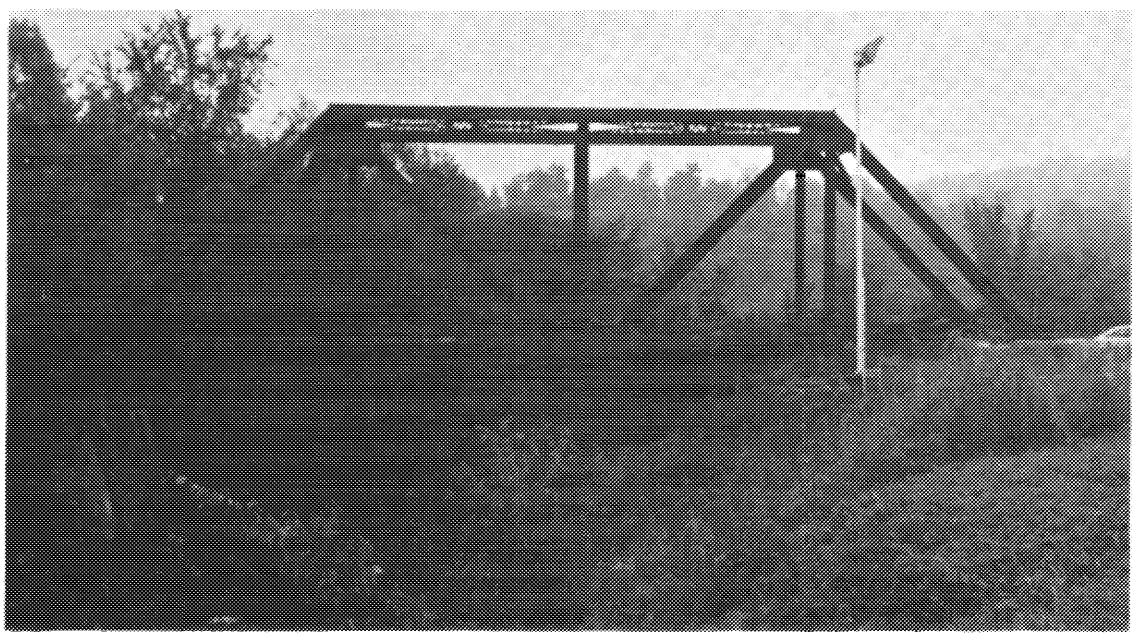


Figure 4 - Looking upstream to abandoned railroad bridge 500 ft. downstream from bridge above. Note vegetation upstream and in right foreground constricting floodflow.

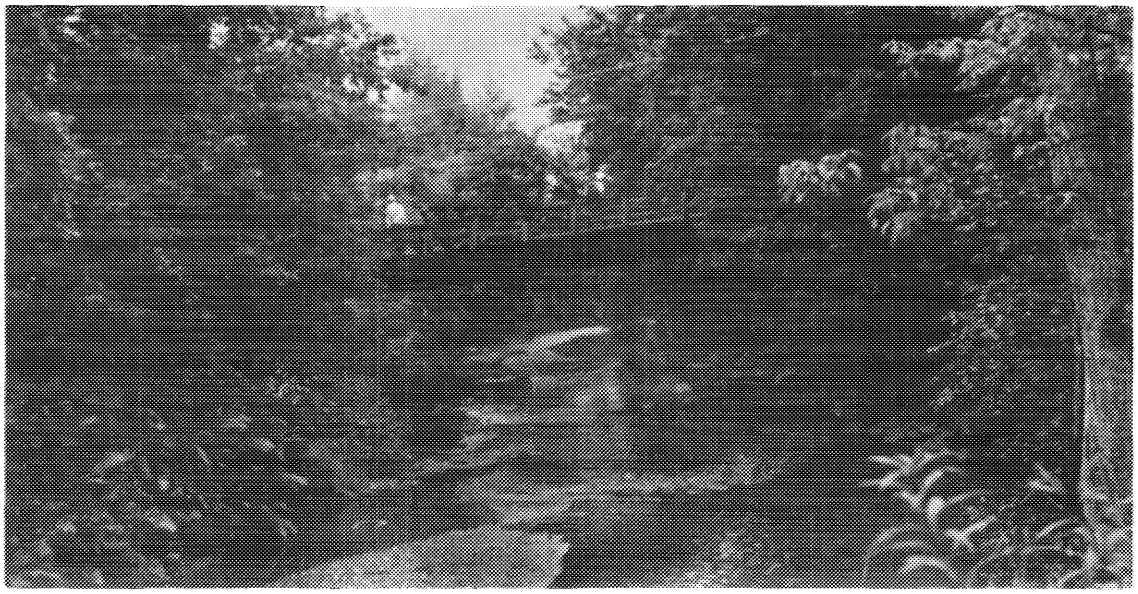


Figure 5 - Private bridge to Mobile Home Park downstream from Howard Johnson Restaurant and Motel. Note heavy vegetal growth on both banks.

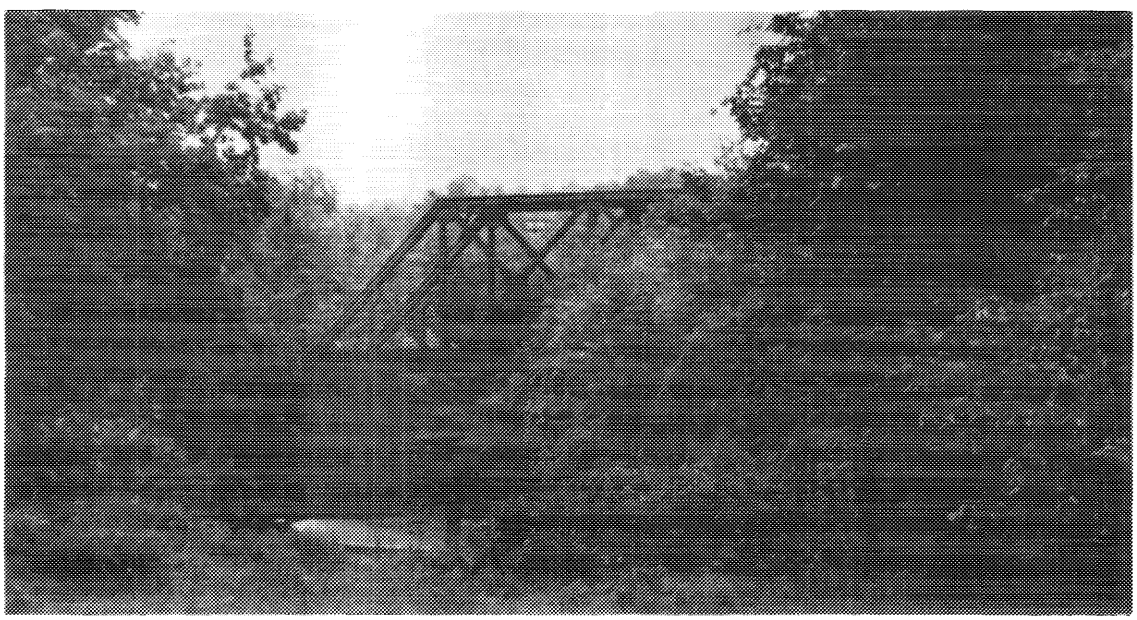


Figure 6 - Montpelier-Barre Railroad Bridge on Winooski River just upstream from mouth of Stevens Branch. Note right angle approach to bridge and heavy vegetation at right end of bridge.

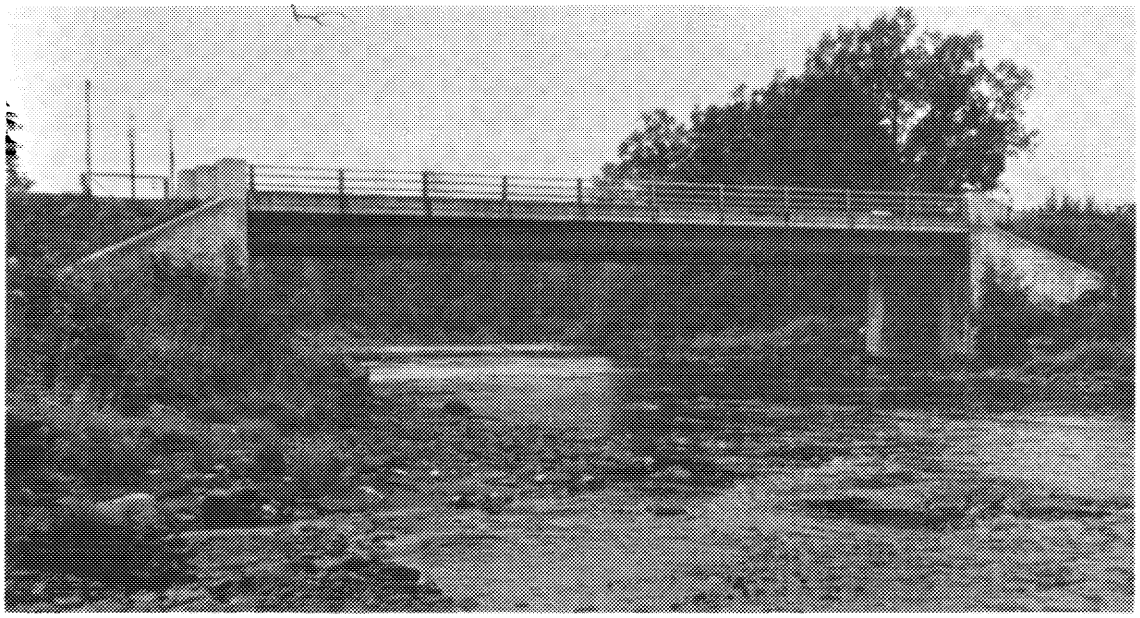


Figure 7 - Looking downstream at U.S. Highway 2 Bridge over Winooski River. Bridge is constrictive to both IRF and SPF.

Figure 8 - Obstructive shopping center on Stevens Branch. For flood depths, see Figure No. 9.

During floods, trees, brush, and other vegetation growing in the channel and floodway impede floodflows, creating backwater and increased flood heights. Trees and debris may be washed away and carried downstream to lodge at bridges and other obstructions. As the floodflow increases, masses of debris often break loose and a wall of water and debris surges downstream until another obstruction is encountered. Debris may collect against a bridge until the load exceeds the bridge's structural capacity and the bridge is damaged or destroyed. The limited capacity of obstructive bridges retards floodflows and results in increased flooding upstream, erosion of the bridge approach embankments, and possible damage to the overlying roadbed.

In general, obstructions resulting from debris further restrict floodflows and result in increased overbank flow and unpredictable areas of flooding, destruction of or damage to bridges, and an increased velocity of flow immediately downstream. It is impossible to predict the degree or location of the accumulation of debris; therefore, for the purpose of this report, it was necessary to assume in the development of the flood profiles that there would be no accumulation of debris to clog any of the bridge openings or other constrictions.

TABLE 2
ELEVATION DATA
Bridges Across Stevens Branch and the Winooski River
[Berlin Area]

			Water Surface Elevation*		
Identification	**Mileage Above Mouth**	**Under-clearance Elevation***	**Intermediate Regional Flood**	**Standard Project Flood**	**1927 Flood**
Stevens Branch					
Local Road Br.	0.63	544.4	551.3	565.6	550.0
Abandoned Railroad Br.	1.37	557.0	555.0	566.5	
U.S. Rte 302 Br.	1.46	556.6	558.0	570.0	561.0
	Mileage Above U.S.G.S. Gage at Montpelier				
Winooski River					
M & B RR. Br.	3.50	539.4	551.2	565.4	550.0
U.S. Rte 2 Br.	3.88	549.1	551.5	565.7	550.5

*Feet above mean sea level datum.

An additional factor to be recognized in Vermont is the possibility of flooding from ice jamming. Flooding of this nature often occurs when the volume of floodwater is not large. A rising stream may lift the ice cover and cause it to break up. The volume of water may not be sufficient to keep the ice cakes moving and they accumulate to form sizable barriers to the flowing water. Backwater from ice jamming is usually localized and is not readily predictable as to magnitude or location. Consequently, the effect of ice jams has not been included in this report.

The small dam on the Winooski River in the study area has no flood control capacity, nor will it seriously alter the flow characteristics of floodwaters.

Within the study area Stevens Branch is spanned by three bridges and the Winooski River by two bridges. All of these bridges are obstructive to floodflows. Pertinent information on all bridges can be found in Table 2.

Flood Damage Reduction Measures

One flood control facility consisting of a detention type dam and reservoir was completed in 1935 on Jail Branch at East Barre, a tributary to Stevens Branch. Between 1956 and 1961, the dam was modified by the Corps of Engineers to accommodate the estimated Probable Maximum Flood Runoff from 38.8 square miles of the watershed. The watershed area controlled by this structure represents 40 per cent of the Stevens Branch drainage at the Barre-Berlin line, or 30 per cent of the entire Stevens Branch Watershed. Consequently, the flood potential of the stream is reduced significantly by the reservoir.

An estimate of the flow leaving the reservoir at any time can be obtained from records at a U.S. Geological Survey gaging station on Jail Branch, 0.6 mile downstream from the dam, which has been in continuous operation since 1933. The maximum flow rate recorded on Jail Branch since completion of East Barre Reservoir was 634 cfs in April 1969. There are no other existing, authorized or proposed flood control projects planned for Stevens Branch or for the Winooski River within the study area or upstream.

Some flood peak reduction is accomplished on the Winooski River as a result of two impoundments, Peacham Pond and Mollys Falls Reservoir, which partially regulate runoff from 24 square miles of the 170 square mile Winooski River Watershed upstream from the Barre-Berlin Town Line. Only a part of their capacity would normally be available for storage of floodwaters since reservoirs for hydroelectric generation seldom are wholly depleted. It is probable, however, that some storage would be available which would help to reduce flood peaks downstream. For example, just prior to the 1927 flood, it was reported that the water in Mollys Falls Reservoir was 30 feet below the spillway and that this condition reduced by 10 per cent the maximum flow in that section of the Winooski River above Stevens Branch.

Other Factors and Their Impact

Flood Warning and Forecasting

The National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce maintains year-round surveillance of weather conditions at Montpelier, Burlington, and elsewhere in the Winooski Watershed. Flood warnings and anticipated weather conditions are issued by the National Weather Service in Burlington, Vermont, and the River Forecast Center in Hartford, Connecticut. During floods or potential flood periods, the Weather Service Office releases, at 24 hour intervals, or as may be necessary, an appropriate forecast of the high water elevations that may be expected at the stream gaging stations operated by the U.S. Geological Survey along the Winooski River and its tributaries. The National Weather Service disseminates the information to the State Police and to Civil Defense Organizations. In addition, in response to inquiries, flood forecasts are supplied to newspapers and radio and television stations which usually issue forecasts in descriptive terms, such as "Approaching bankfull" or "One or two feet above bankfull."

Flood Fighting and Emergency Evacuation Plans

Although there are no formal flood fighting or emergency evacuation plans for the Berlin area, provisions for alerting area residents and coordinating operations of town, county and State public service agencies in time of emergency are accomplished through the Montpelier Civil Defense Office.

Material Storage on the Flood Plain

Much of the development within the downstream portion of the flood plain is used for storage of equipment and materials or for agricultural purposes. Near the mouth of Stevens Branch is a building materials yard with considerable quantities of sand and gravel stored in the open. Some of this material could be washed downstream by floodwaters with the possibility of filling in the stream channel and adding to the backwater effect of existing constrictions.

PAST FLOODS

Summary of Historical Floods

Flood Records

Large floods occurred on the Winooski River in July 1830 and October 1869. These are considered the second and third largest known floods respectively, being surpassed only by the November 1927 Flood. At the Montpelier gaging station site, the elevation of the flood crest for the July 1930 Flood was estimated at 524.5 feet above mean sea level, while the flood crest for the October 1869 Flood was 522.1 feet above mean sea level. In comparison, the November 1927 Flood crested at 527.1 feet.

The greatest flood known to have occurred on Stevens Branch during the past 140 years was in November 1927 during which it is estimated that a flood stage of 570.0 feet above mean sea level occurred at the Barre-Berlin Line, the upper limit of the study area of this report. A recurrence of a flood of the magnitude of the 1927 Flood with the East Barre Dam in operation would cause an estimated flood stage at the Barre-Berlin line of 565.5 feet above mean sea level.

Another great flood, the second largest flood of recent times in the City of Barre, occurred in March 1936. During this flood, and with the East Barre and Wrightsville Dams in operation, the flood crest at the Montpelier gage was 8.2 feet lower than during the 1927 Flood.

Flood Description

Little information is available concerning the 1927 Flood in the Berlin area. From a report prepared by the War Department, Office of the Chief of Engineers, in February 1931, the following is quoted: "From Barre to Montpelier the flooded area comprised about half a square mile. Flood heights generally reached to a depth of 8 feet above the adjacent land to the junction with the main river, and to a depth of 10 feet beyond that point, to the lower dam at Montpelier. The full bank capacity of the several bridges along this reach was about half the flow. Sections of the Montpelier-Barre highway, trolley line, and railroad were flooded and considerable scouring occurred."

"Flood action on the main branch of the Winooski River above its junction with Stevens Branch was considerably ameliorated. While the peak discharge from the Kingsbury Branch was pronounced, that of the main stream was modified by the detention effect of Mollys Brook Reservoir. Fortunately, the water level was 30 feet below the spillway at this time. The maximum flow of that section of the Winooski was reduced by about 10 per cent. As the valley is narrow, with steep slopes on both sides, the rising waters were confined to a narrow course; high velocities resulted, scouring the banks and the roads built along the stream."

FUTURE FLOODS

Floods of the same or larger magnitude as those that have occurred in the past could occur in the future. Larger floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those in the study area. Similar combinations of rainfall and runoff which caused these floods could occur in the Berlin area. Therefore, to determine the flooding potential of the study area, it was necessary to consider storms and floods that have occurred in regions of like topography, watershed cover, and physical characteristics. Discussion of future floods in this report is limited to those floods that have been designated as the Intermediate Regional Flood and the Standard Project Flood. The Standard Project Flood represents a reasonable upper limit of expected flooding in the study area. The Intermediate Regional Flood may reasonably be expected to occur more frequently, although it will not be as severe as the infrequent Standard Project Flood.

Intermediate Regional Flood

A flood of this magnitude is defined as having an average frequency of occurrence of once in 100 years, although the flood may occur in any year. Such a flood also may be considered as one having a one per cent chance of being equalled or exceeded in any one year. On Stevens Branch in the study area, the Intermediate Regional Flood is equivalent to a recurrence of the November 1927 Flood under presently existing conditions.

The probability of flood occurrences is based on statistical analysis of streamflow records, when available, for the watershed under study. However, when there is a limitation on availability of such records, the flood probabilities are synthesized by analyses of rainfall and runoff characteristics in the general region.

Results of the discharge frequency analyses yield peak discharges for the various reaches along Stevens Branch. These discharges were used in the computation of the flood profiles, and are summarized in Table 3.

Winooski River at Berlin

Computations to determine the magnitude of the Intermediate Regional Flood on the Winooski River within the study area were based on statistical analyses of the floods of record on all the gaged streams in the Winooski Watershed.

Peak discharges for the estimated Intermediate Regional Flood on the Winooski River at a number of points in the study area also are included in Table 3.

Standard Project Flood

The Standard Project Flood is defined as the largest flood that can be expected from the most severe combination of meteorological and hydrologic conditions that are considered

reasonably characteristic of the geographical region involved excluding extremely rare combinations. Only in rare instances has a specific stream experienced the greatest flood that is likely to occur on it. Severe as the maximum known flood may have been on a 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 NOAA

TABLE 3
PEAK FLOWS FOR INTERMEDIATE REGIONAL FLOOD AND STANDARD PROJECT FLOOD

Location	River Mile	Drainage Area sq. mi.	Intermediate Regional Flood cfs	Standard Project Flood cfs
Winooski R. at Barre-Berlin Line	G†5.25	170	15,600	61,000
Winooski R. above Stevens Branch	G†3.50	185	17,000	66,000
Winooski R. above North Branch	G†1.0	317	31,000	118,000
North Branch Winooski R.	0.00	80	2,000	4,000
Winooski R. at Montpelier Gage	G†0.00	397	33,000	122,000
Stevens B. at Barre Line	2.43	97.4	12,800	40,000
Stevens B. above Pond Brook	0.61		14,000	45,000
Stevens B. at Mouth	0.00	129	16,000	52,000

Weather Service, has made broad and comprehensive studies and investigations based on vast records of experienced storms and floods and has evolved hydrologic procedures for estimating the flood potential of streams. These procedures have been used in computing Standard Project Floods. Peak discharges for the Standard Project Flood on both Stevens Branch and the Winooski River within the study area are shown in Table 3, where they can be compared with the Intermediate Regional Flood.

Flood Frequency

A numerical frequency or chance of occurrence or exceedence in any one year has not been assigned to the Standard Project Flood. The occurrence of such a flood would be a rare event, but such a flood could occur in any year.

Floods larger than the Standard Project Flood are possible; however, the combination of factors that would be necessary to produce such floods would rarely occur. It should not be overlooked in the study of any flood problems.

Hazards of Large Floods

The extent of damage caused by any flood depends on the topography of the area flooded, depth and duration of flooding, velocity of the flowing water, rate of rise and, in large part, to development on the flood plain. An Intermediate Regional Flood or Standard Project Flood on Stevens Branch and/or the Winooski River would result in inundation of commercial and residential sections in the Berlin area. Deep floodwaters flowing at high velocity and carrying floating debris and/or ice would create conditions hazardous to persons and vehicles attempting to cross flooded areas. In general, water three or more feet deep flowing at a velocity of three or more feet per second could easily sweep an adult person off his feet, thus creating certain danger of injury or drowning.

Rapidly rising and swiftly flowing floodwater may trap persons in homes or business establishments that are ultimately damaged or destroyed, or in vehicles or mobile homes that are eventually submerged or floated. Mobile homes, although usually not securely attached to a foundation, seldom can be hauled to high ground and safety within the short time between warning of an impending flood and its actual occurrence. Water lines can be ruptured by deposits of debris and the force of floodwaters, thus creating the possibility of contaminated domestic water supplies. Damaged sanitary sewer lines could result in the pollution of floodwaters creating health hazards. Isolation of areas by floodwaters could create hazards in terms of medical, fire, or law enforcement emergencies.

Rates of Rise and Duration of Flooding

Intense rains that accompany severe storm fronts usually produce the floods occurring in the Berlin area. Because of the extensive urbanization of the Stevens Branch Watershed, runoff from intense rainfall occurs rapidly and concentrates quickly into watercourses. Flash flooding frequently occurs with little advance warning that flood stages may be expected.

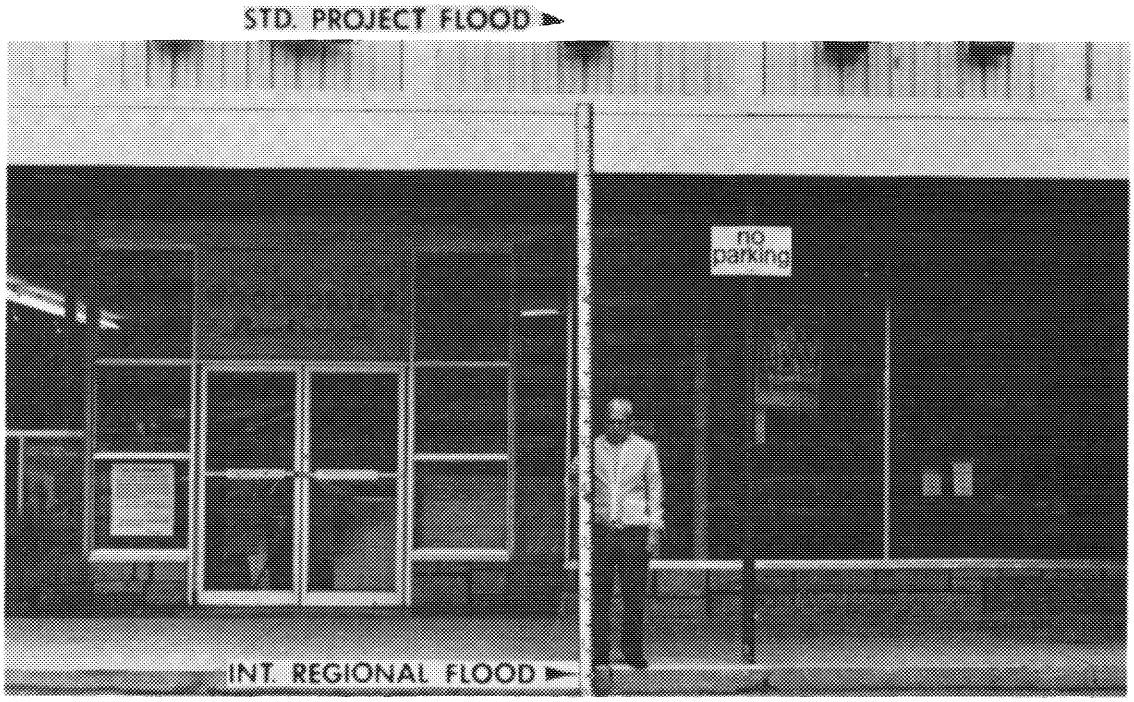


Figure 9 - Relative flood depths at Shopping Center. SPF would reach rod reading 14 ft.

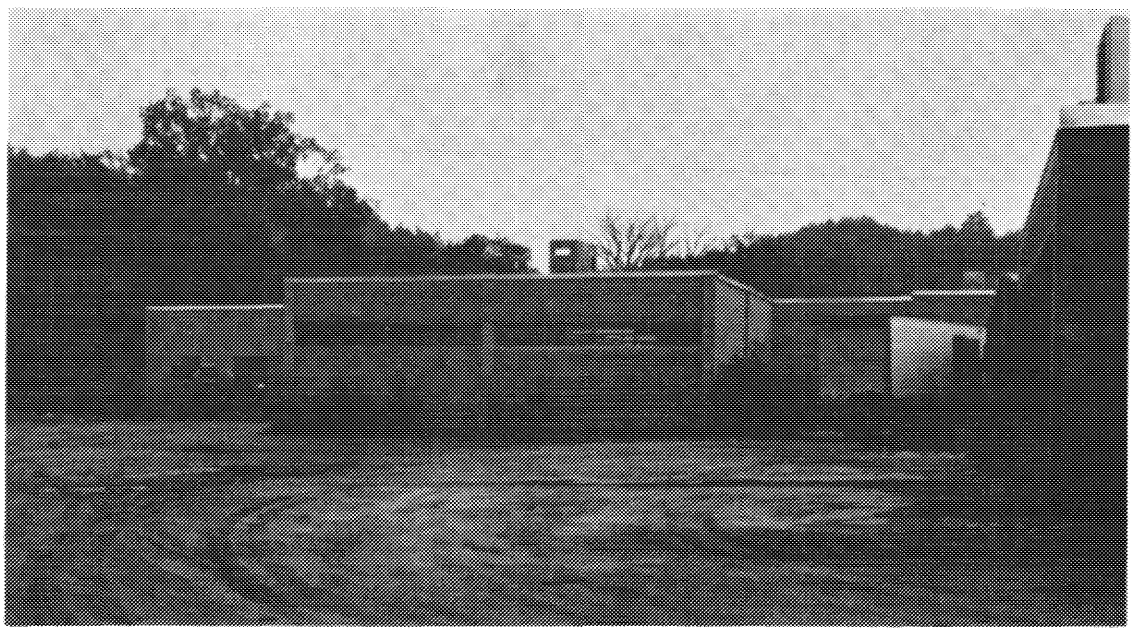


Figure 10 - Obstructive structure at rear of shopping center. Stream channel is to the left of power pole at extreme left of photograph. Floodway along left bank of stream (looking downstream) has been almost completely obstructed.

Figure 11 - View downstream along U.S. Highway 302 from vicinity of shopping center, showing some of the flood plain development along highway.

Figure 12 - Relative flood heights at Mobile Home Park on right bank downstream from Howard Johnson's. The SPF would produce a rod reading of 18 ft.

Major floods, however, are usually generated by storms of somewhat greater duration and more extensive areal extent, and flood peaks downstream from East Barre Reservoir would be reduced significantly by the operation of the reservoir. The rate of rise in stream stages usually is less rapid but the duration of flooding may be lengthened.

Warnings of flash flooding or of major flooding should be taken seriously by officials responsible for public safety and by residents whose homes or places of business may be endangered by floodwaters.

Flooded Areas and Flood Damage

The areas in the Towns of Berlin and East Montpelier and the City of Montpelier that would be flooded by the Intermediate Regional and Standard Project Floods are shown in detail on Plates 3 through 5. The actual limits of these overflow areas may vary somewhat from those shown on the maps because the 5 foot contour interval and horizontal scale of the maps do not permit precise plotting of the flooded area boundaries. As may be seen from these plates, floodflows from Stevens Branch and the Winooski River would cover large areas of highly developed land, particularly along U.S. Highways 302 and 2. The greatest depths of flooding and widest extent of overflow would occur near the mouth of Stevens Branch and upstream for as much as a mile on both streams.

Plate 6 shows water surface profiles of the Intermediate Regional and Standard Project Floods. Tables 4 and 5 summarize water surface elevations at selected valley cross sections. Depth of flow in the stream channel and on the adjacent flood plain can be estimated from these illustrations. Typical cross sections of the channel and flood plain at selected locations, together with the water surface elevation and lateral extent of the Intermediate Regional and Standard Project Floods are shown on Plates 7 and 8.

Obstructions

During floods, debris and/or floating ice collecting at bridges or other constrictions could decrease the carrying capacity of the channel and floodway and cause greater water depths (backwater effect) upstream of these points. Since the occurrence and amount of debris and/or ice are indeterminate factors, only the physical characteristics of structures and channel were considered in preparing profiles of the Intermediate Regional and Standard Project Floods. Other structures, such as ill advisedly situated buildings in the floodway, also produce backwater. The effects of such construction can only be evaluated properly by a detailed analysis of local hydraulic conditions which are beyond the scope of this report. The maps of the flooded area show the backwater effect of obstructive bridges or other constrictions, but do not reflect increased water surface elevations that could be caused by debris collecting against the structures or by deposition of silt in the stream channel under structures.

Of the five bridges crossing the streams within the study area, all are obstructive to some degree to the Intermediate Regional Flood and to the Standard Project Flood (see Table 2). Where bridges are not overtopped, damage frequently occurs to the approaches to the bridges, even though the bridge structure may remain intact.

TABLE 4
WINOOSKI RIVER FLOOD CREST ELEVATIONS

Elevations in Feet Above Mean Sea Level

Cross Section* Number	Site	Miles Above USGS Gage at Montpelier	Streambed Elevation	Inter-mediate Regional Flood	Standard Project Flood	1927 Flood
1	Downstream Limit	3.31		551.0	565.2	550.0
4	M & B RR Bridge	3.50	520.7	551.2	565.4	
8	Rte 302 Bridge	3.88	534.4	551.5	565.7	
13	Abandoned Power House	4.62	565.7	575.0	586.5	
16	Dam	4.89	610.3	619.0	621.0	
20	Town Line	5.25	617.2	626.8	636.5	

*Typical cross sections on Plate 7.

TABLE 5
STEVENS BRANCH FLOOD CREST ELEVATIONS

Elevations in Feet Above Mean Sea Level

Cross Section Number		Miles Above Mouth	Streambed Elevation	Inter-mediate Regional Flood	Standard Project Flood	1927 Flood
1	Mouth	0.05	526.9	551.0	565.2	550.0
8	Farm Road Bridge	0.63	530.6	551.3	565.6	
12	Rte 302 Bridge	0.91	531.3	551.8	565.8	
28	Town Line	2.43	549.2	565.5	574.1	570.0

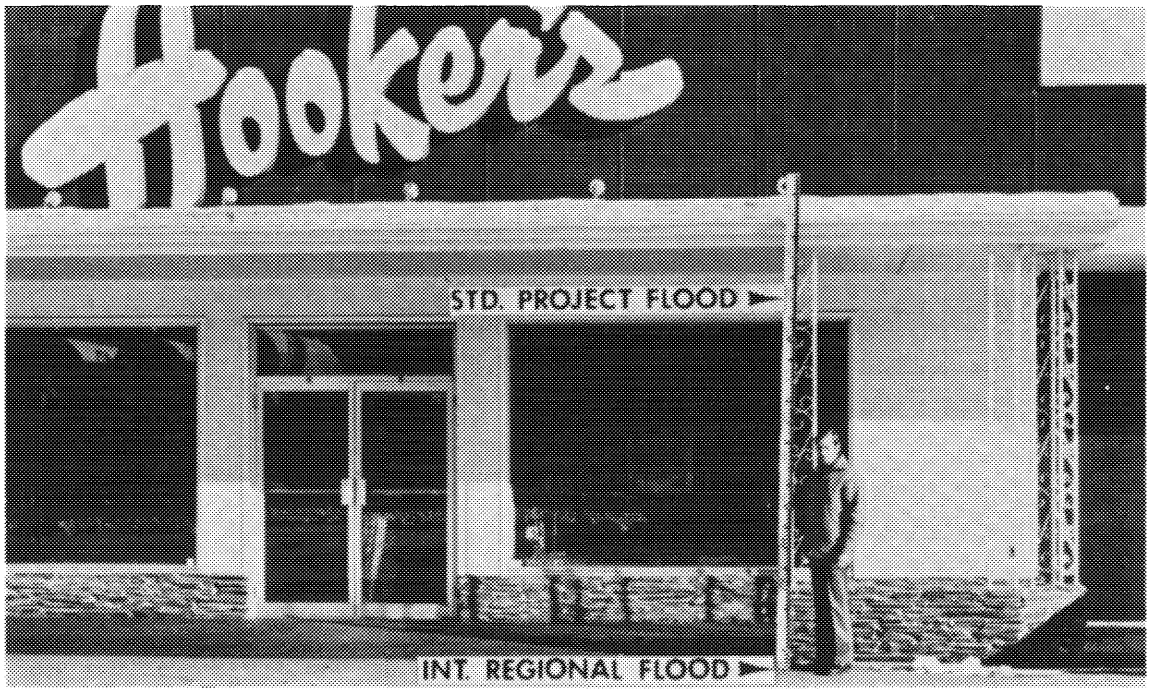


Figure 13 - Relative flood heights, Stevens Branch Flood Plain at Hooker's Furniture Store.

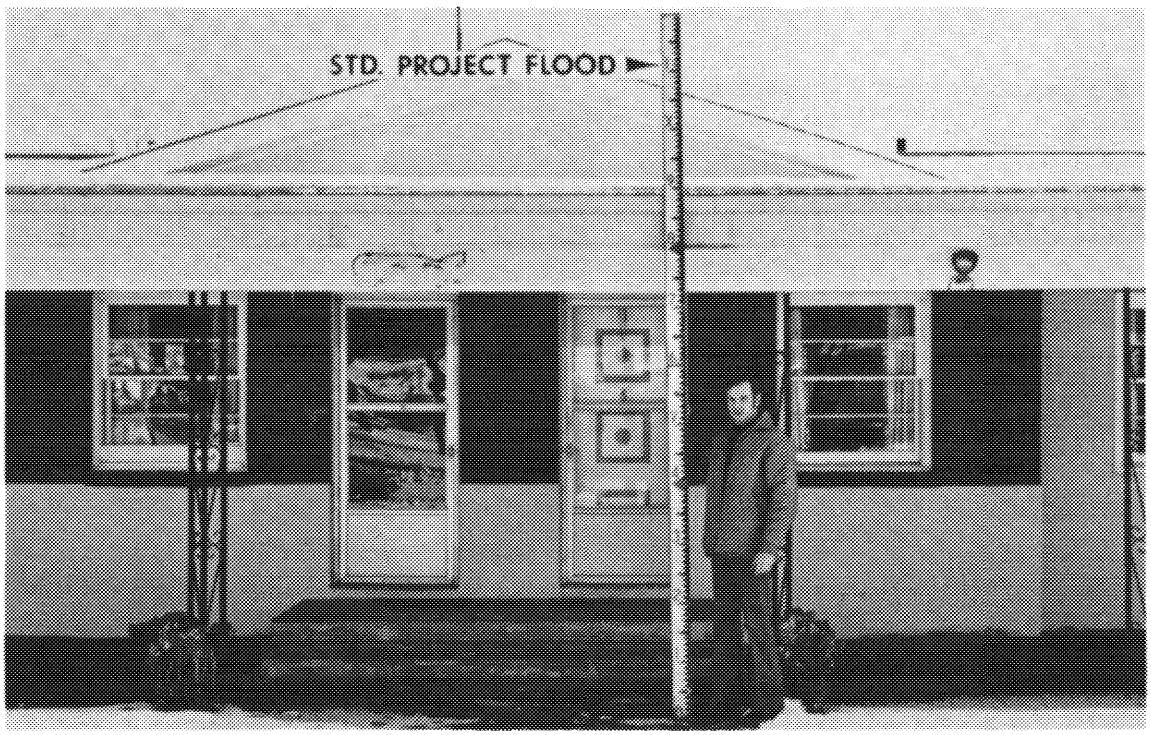


Figure 14 - Relative flood height, Stevens Branch Flood Plain at Vermonter Motel. The IRF would be 14 ft. lower than the SPF.

Figure 15 - Relative flood heights, Stevens Branch Flood Plain downstream from Pond Brook.

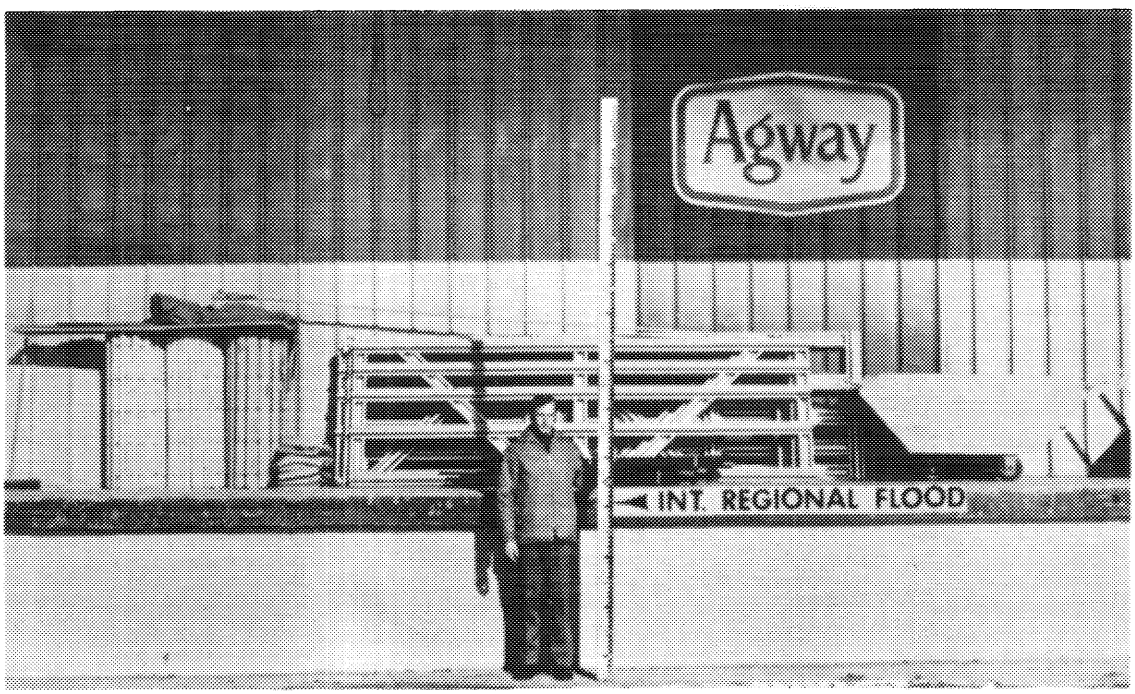


Figure 16 - Relative flood heights, Winooski River flood plain upstream from U.S. Highway 2 Bridge. The SPF would be 14 ft. higher than the IRF.

Velocities of Flow

Water velocities during floods depend largely on the magnitude of the flood peak, the size and shape of the valley cross sections, conditions of the stream, and the bed slope, all of which vary on different streams, at different locations on the same stream, and throughout each cross section. During an Intermediate Regional Flood, velocities of main channel flow in the upper reaches of the streams in the study area would be as much as 10 feet per second (Stevens Branch) and 20 feet per second (Winooski River). Water flowing at these rates is capable of causing severe erosion to stream banks and channels and to fill around bridge abutments, and of transporting large objects. In the lower reaches of both streams, because of the large amount of backwater effect from downstream, the velocities would be much lower, averaging only one to three feet per second. It is expected that velocity of flow during a Standard Project Flood would be somewhat greater than during an Intermediate Regional Flood. Overbank flow in the Berlin area would be at a somewhat slower velocity than main channel flow except for the upper reach of the Winooski River where high overbank flow velocities would continue to prevail due to the steep channel slope and narrow flood plain.

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.

Floodway. That portion of the channel and flood plain which is covered by flowing water during a flood as contrasted to that portion of the flood plain where water is ponded with no appreciable velocity of flow.

Hydrograph. A graph showing flow values against time at a given point, usually measured in cubic feet per second. The area under the curve indicates total volume of flow.

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, or watercourse, looking downstream.

Probable Maximum Flood. The flood that may be expected from the most severe combination of conditions that are reasonably possible in the region.

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 discharge for this flood is generally about 40-60 per cent of the Probable Maximum Flood for the basin. 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.

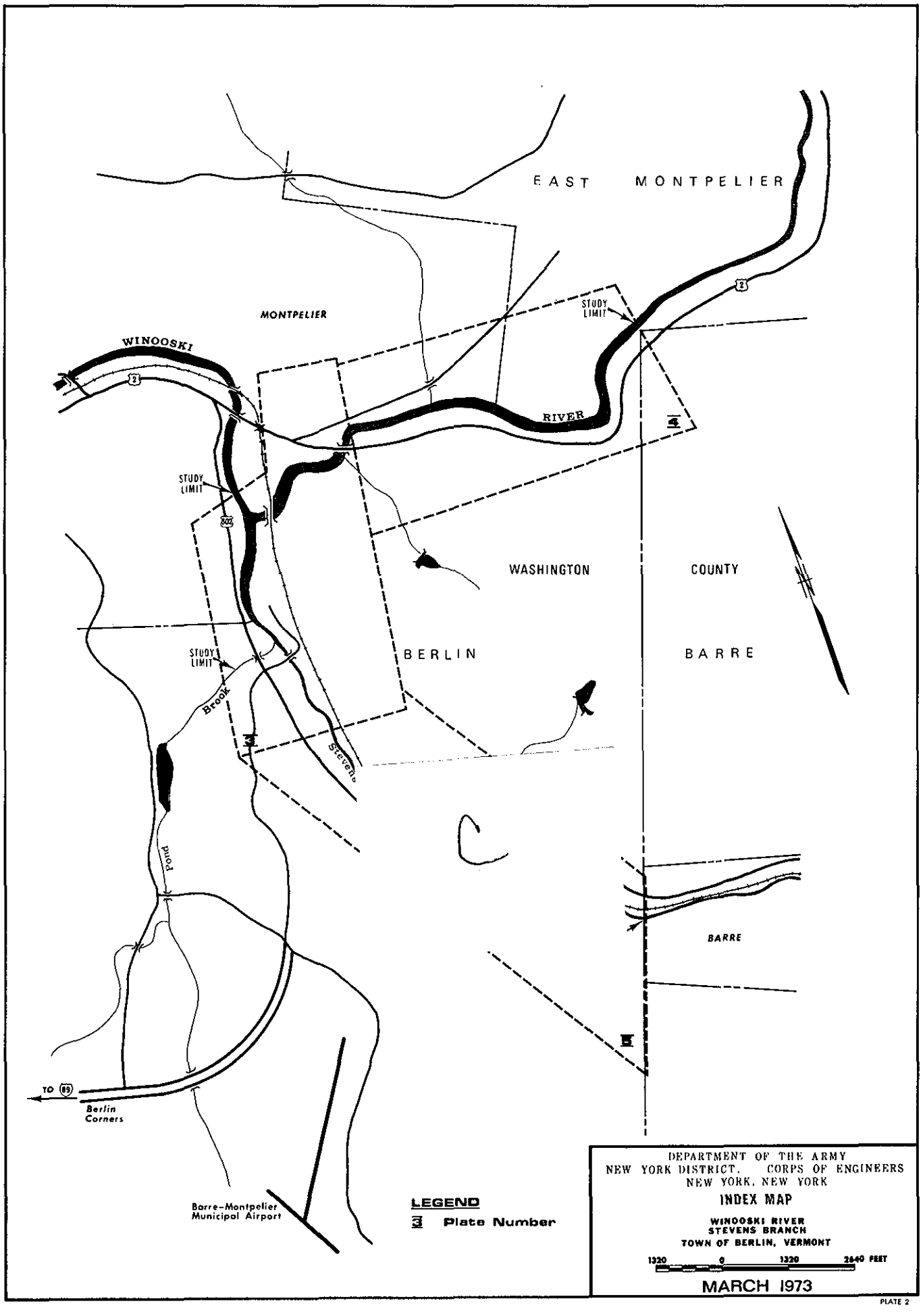
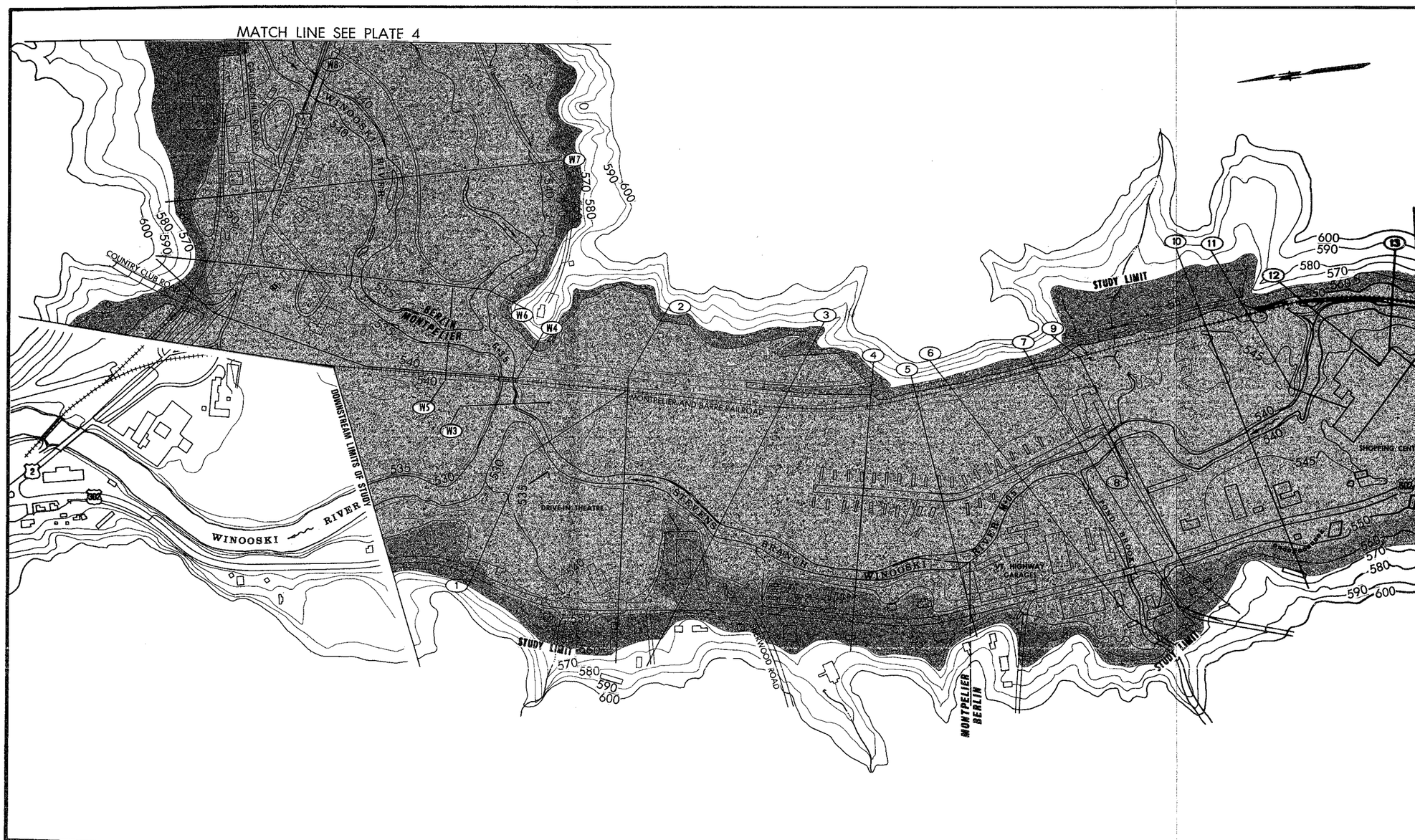

EAST MONTPELIER
MONTPELIER
WINOOSKI
RIVER
STUDY LIMIT
STUDY LIMIT
STUDY LIMIT
WASHINGTON COUNTY
BERLIN
BARRE
BARRE
Brook
Stevens
Pond
TO 89
Berlin Corners
Barre-Montpelier Municipal Airport
LEGEND
Plate Number
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK
INDEX MAP
WINOOSKI RIVER
STEVENS BRANCH
TOWN OF BERLIN, VERMONT
1320 0 1320 2640 FEET
MARCH 1973

PLATE 2



LEGEND

CHANNEL — INTERMEDIATE REGIONAL FLOOD — STANDARD PROJECT FLOOD

M+2.5 MILES ABOVE MOUTH

G+4.0 MILES ABOVE U.S.G.S. GAGE

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

NOTES:

1. MAP IS BASED ON PHOTOGRAMMETRY, V.S.H.D. PLANS, AND FIELD SURVEYS BY V.S.D.W.R.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOODWAY MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. CONTOUR INTERVAL IS AS SHOWN

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

FLOODED AREAS

WINOOSKI RIVER

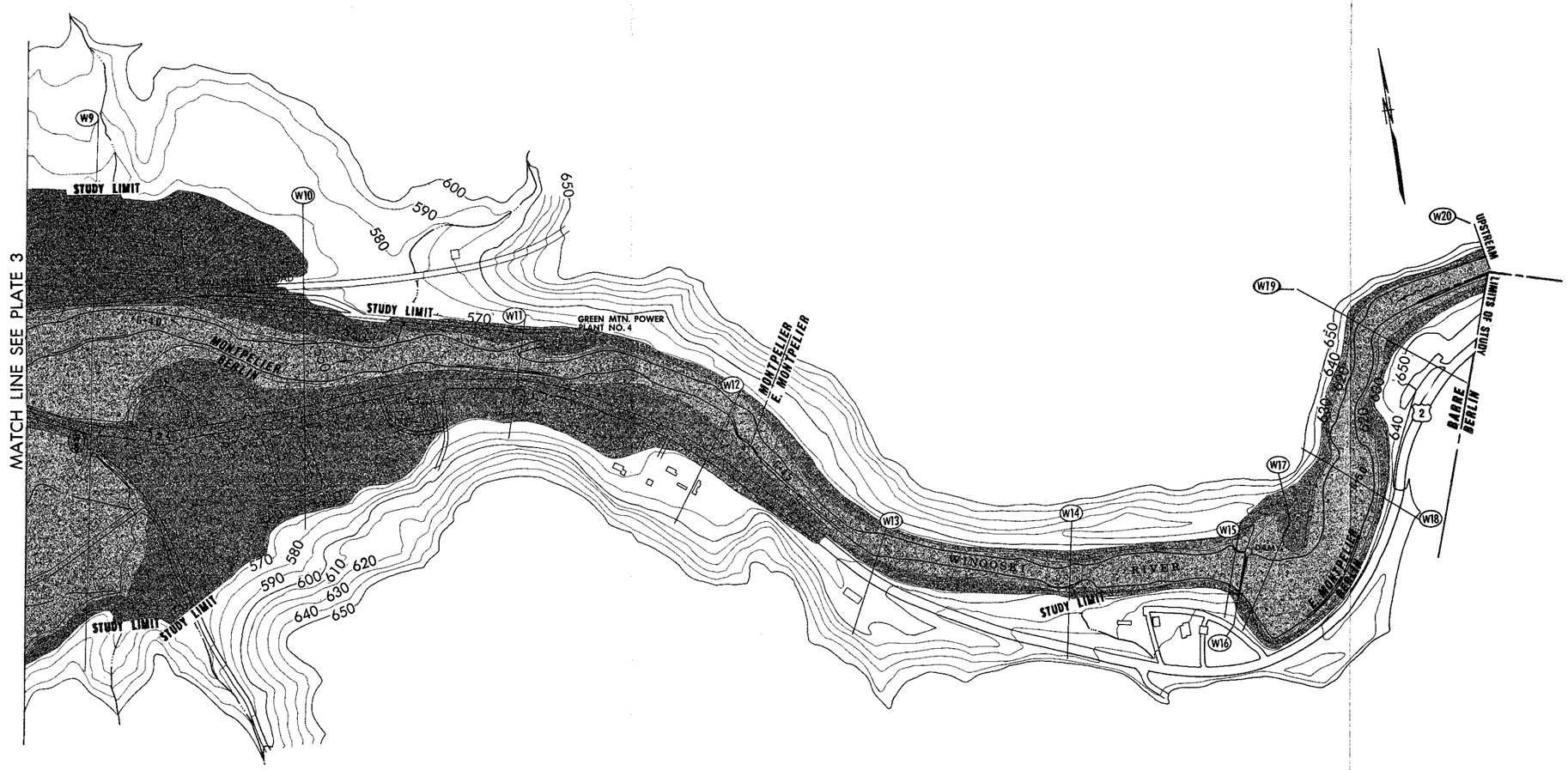
STEVENS BRANCH

TOWN OF BERLIN, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973



LEGEND

CHANNEL → INTERMEDIATE REGIONAL FLOOD → STANDARD PROJECT FLOOD

6+4.0 MILES ABOVE U.S.G.S. GAGE

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

NOTES:

1. MAP IS BASED ON PHOTOGRAMMETRY, V.S.H.D. PLANS, AND FIELD SURVEYS BY V.S.D.W.R.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOODWAY MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. CONTOUR INTERVAL IS AS SHOWN

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

FLOODED AREAS

WINOOSKI RIVER
TOWN OF BERLIN, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973

LEGEND

CHANNEL > INTERMEDIATE REGIONAL FLOOD > STANDARD PROJECT FLOOD

M+2.5 MILES ABOVE MOUTH

(6) CROSS SECTION

525 GROUND ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

NOTES:

1. MAP IS BASED ON PHOTOGRAMMETRY, V.S.H.D. PLANS, AND FIELD SURVEYS BY V.S.D.W.R.
2. LIMITS OF OVERFLOW SHOWN MAY VARY FROM ACTUAL LOCATION ON GROUND AS EXPLAINED IN THE REPORT.
3. AREAS OUTSIDE THE FLOODWAY MAY BE SUBJECT TO FLOODING FROM LOCAL RUNOFF.
4. CONTOUR INTERVAL IS AS SHOWN

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

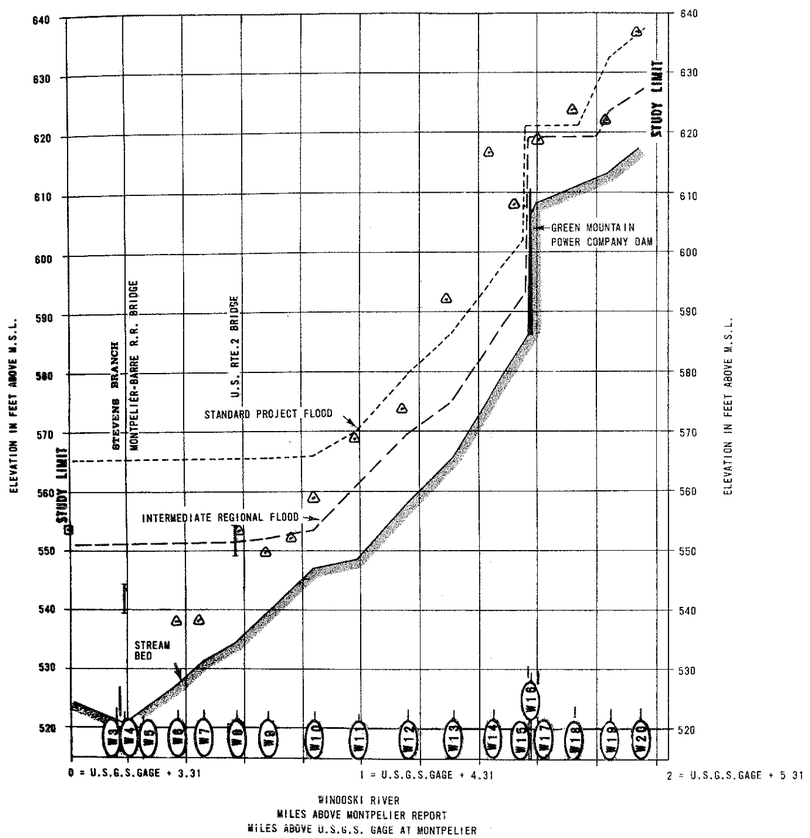
FLOODED AREAS

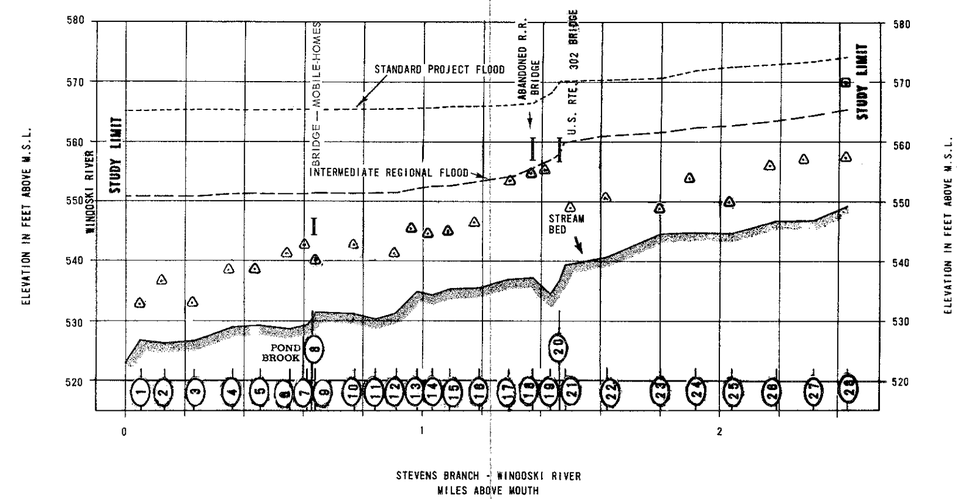
STEVENS BRANCH
TOWN OF BERLIN, VERMONT

SCALE IN FEET

200 0 200 400 600

MARCH 1973





LEGEND

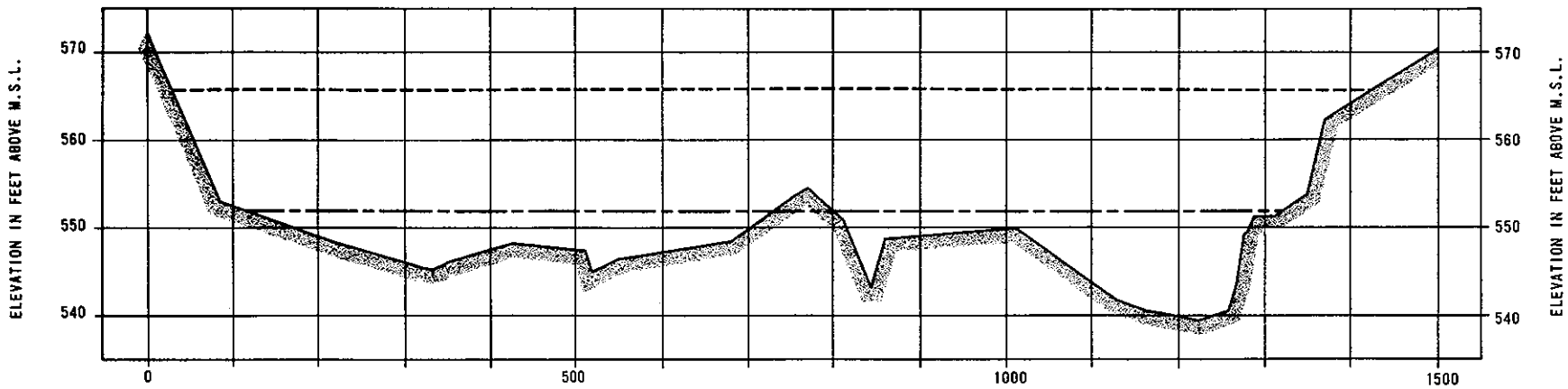
- STANDARD PROJECT FLOOD
- INTERMEDIATE REGIONAL FLOOD
- STREAM BED
- (3) CROSS SECTION
- △ TOP OF LOW BANK
- ⊡ 1927 FLOOD ELEVATION
- I BRIDGE DECK
- I UNDERCLEARANCE

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

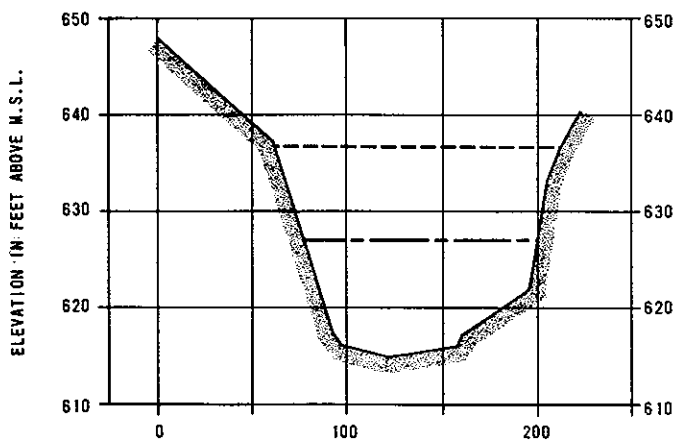
HIGH WATER PROFILES

WINOOSKI RIVER
STEVENS BRANCH
TOWN OF BERLIN, VERMONT

MARCH 1973



CROSS SECTION NO. 9 - MILE G + 3.99



CROSS SECTION NO. 20 - MILE G + 5.25

LEGEND

- STANDARD PROJECT FLOOD
- INTERMEDIATE REGIONAL FLOOD
- GROUND LINE

NOTES:

1. SECTIONS TAKEN LOOKING DOWNSTREAM.
2. ELEVATIONS REFER TO MEAN SEA LEVEL DATUM.
3. HORIZONTAL DISTANCES ARE IN FEET
4. G = U.S.G.S. GAGE AT MONTPELIER

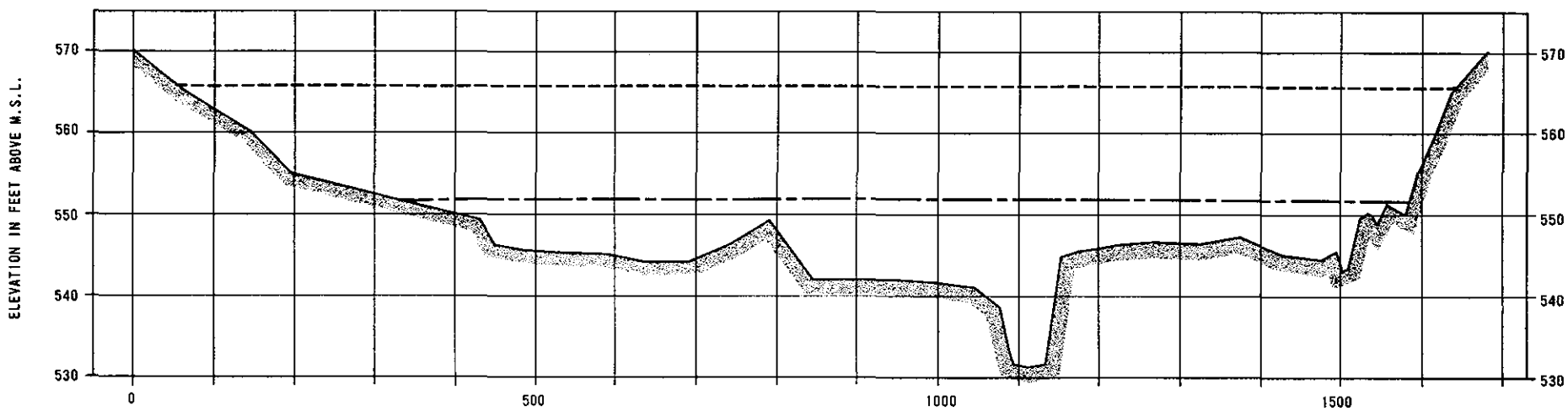
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

SELECTED CROSS SECTIONS

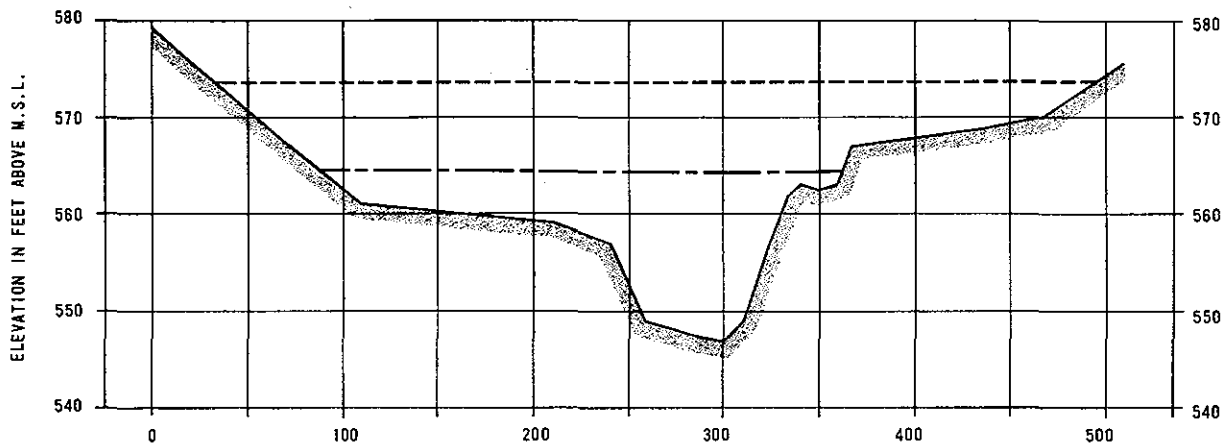
WINOOSKI RIVER

TOWN OF BERLIN, VERMONT

MARCH 1973



CROSS SECTION NO. 9
RIVER MILE 0 + 64



CROSS SECTION NO. 27
RIVER MILE 2 + 32

LEGEND

- STANDARD PROJECT FLOOD
- INTERMEDIATE REGIONAL FLOOD
- GROUND LINE

NOTES:

1. SECTIONS TAKEN LOOKING DOWNSTREAM.
2. ELEVATIONS REFER TO MEAN SEA LEVEL DATUM
3. HORIZONTAL DISTANCES ARE IN FEET.

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT. CORPS OF ENGINEERS
NEW YORK, NEW YORK

SELECTED CROSS SECTIONS

STEVENS BRANCH

TOWN OF BERLIN, VERMONT

MARCH 1973