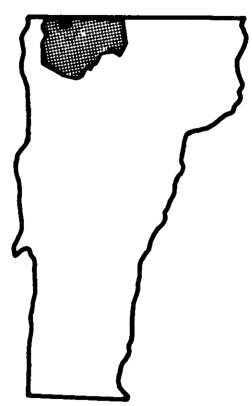
FLOOD INSURANCE STUDY

TOWN OF HIGHGATE, VERMONT
FRANKLIN COUNTY



OCTOBER 4, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER - 500055

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TOWN OF HIGHGATE, VERMONT

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Town of Highgate, Franklin County, Vermont, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Highgate to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally-supported studies are based. These criteria take precedence over the minimum federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3. In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were prepared by Dufresne-Henry Engineering Corporation for the Federal Emergency Management Agency, under Contract No. H-4751. This work was completed in January 1981.

1.3 Coordination

On April 12, 1978, areas to be studied by detailed and approximate methods were determined at an initial Consultation and Coordination Officer's (CCO) meeting attended by representatives of the FEMA, the Town of Highgate, and Dufresne-Henry Engineering Corporation (the study contractor). An announcement of the intent to perform the Flood Insurance Study for Highgate appeared in the County Courier on September 21, 1978.

The Vermont Department of Water Resources and the Franklin County Regional Planning and Development Commission were notified of the study and requested to supply pertinent information, including published and unpublished flood studies, flood plain regulations, and floodway requirements. The Vermont Department of Highways was contacted to obtain any available topographic maps of the study area. The U. S. Geological Survey (USGS) was contacted to obtain flood-prone area maps covering the study area. The community was requested to submit data concerning flood hazards, flooding experience, plans to avoid potential flood hazards, and other data deemed appropriate. Periodic contacts were made with local officials to keep them informed of the progress of the study and to solicit pertinent information.

Interviews were conducted with local residents in Highgate to obtain high-water data at sites where ice jams are known to occur. Their estimates of high water due to ice jams were field surveyed and the results were utilized to validate portions of the hydrologic and hydraulic analyses.

On May 4, 1982, the results of the study were reviewed at a final CCO meeting held with representatives of the FEMA, the town, and the study contractor.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Town of Highgate, Franklin County, Vermont. The area of study is shown on the Vicinity Map (Figure 1).

The entire length of the Missisquoi River and the Lake Champlain shoreline within the Town of Highgate were studied by detailed methods. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction for the next five years, through January 1986.

The Rock River, Kelly Brook, Saxe Brook, Carmen Brook, and Youngman Brook were studied by approximate methods. Flooding on the entire lengths of these streams, or portions of them, was found to be controlled by flooding from Lake Champlain and the Missisquoi River. Portions of Youngman Brook were found to have negligible flood hazards, therefore, no approximate flood boundaries were mapped. Cutler Pond and Proper Pond were also studied by approximate methods. Approximate methods of analysis were used to study those areas having low development potential and minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by the FEMA.

APPROXIMATE SCALE

6000 0 6000 12000 18000 FEET

VICINITY MAP

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF HIGHGATE, VT

(FRANKLIN CO.)

FIGURE 1

2.2 Community Description

The Town of Highgate is located in the northwestern portion of Franklin County in northwest Vermont. It is bordered by Lake Champlain to the west, Canada to the north, the Town of Franklin to the east, the Town of Sheldon to the southeast, and the Town of Swanton to the south.

The estimated population of 2,155 was an estimated 11-percent increase over the 1970 figure. This figure was approximately twice the average growth rate for all of Franklin County during the same period of time.

The topography of Highgate is characterized by gently rolling woodland and streams with generally steep banks that are bordered by wide flood plains. There are several stream reaches contained within narrow steep-sided gorges.

The only significant development in the study area has taken place in the Districts of Highgate Center, Highgate Falls, East Highgate, and Highgate Springs. Within Highgate, the flood plain of the Missisquoi River consists primarily of undeveloped fields used for farming, and areas of marsh and woodland.

2.3 Principal Flood Problems

Since most of the drainage area of the Missisquoi River (approximately 95 percent) lies above the study area, flooding within the study area is affected by the intensity and duration of rainfall in areas further upstream. In addition to floods caused by rainfall alone, the area is subject to flooding caused by rainfall mixed with snowmelt, ice jams, and by a combination of the three. Ice jams usually occur during the late winter and early spring, but have occurred in the early winter months. Flooding is most likely to occur during the spring when snowmelt and rainfall cause water levels to rise on the Missisquoi River.

In terms of overall property damage, the flood of November 3, 1927, is documented as the most severe flood in the study area. In addition to free-flowing flood events, there is a documented history of ice jams in the study area. The impact of ice jams is felt primarily from the downstream corporate limits to the base of the Highgate Falls dam.

From interviews with operators of the Highgate Falls hydropower station, it was determined that the March 6, 1979, ice jam event resulted in a flood elevation 3 feet above the November 3, 1927, free-flowing flood. Figure 2 shows extensive damage to the hydropower plant as a result of the March 1979 ice jam.

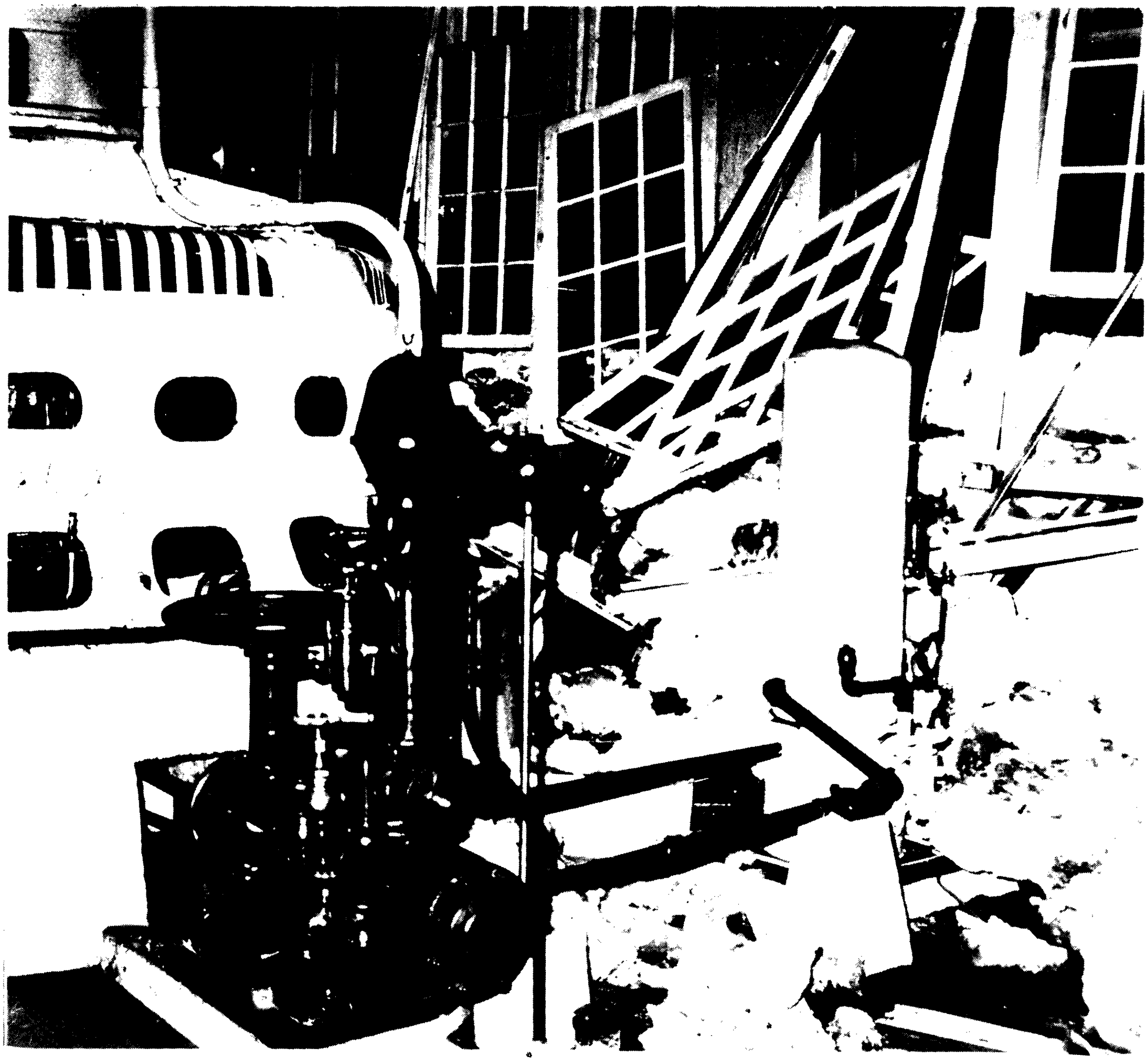


Figure 2 - Damage to Highgate Falls hydropower station during the March 6, 1979, ice jam.

Figure 3 depicts the channel and hydropower station several hours after the ice jam broke. Marks on the building indicate the extent of flooding at its peak, just prior to the breaking of the ice jam. This ice jam was documented as a grounded jam. In a grounded jam, the ice forms a dam, as opposed to the more common floating jam, where water may flow beneath the ice cover.

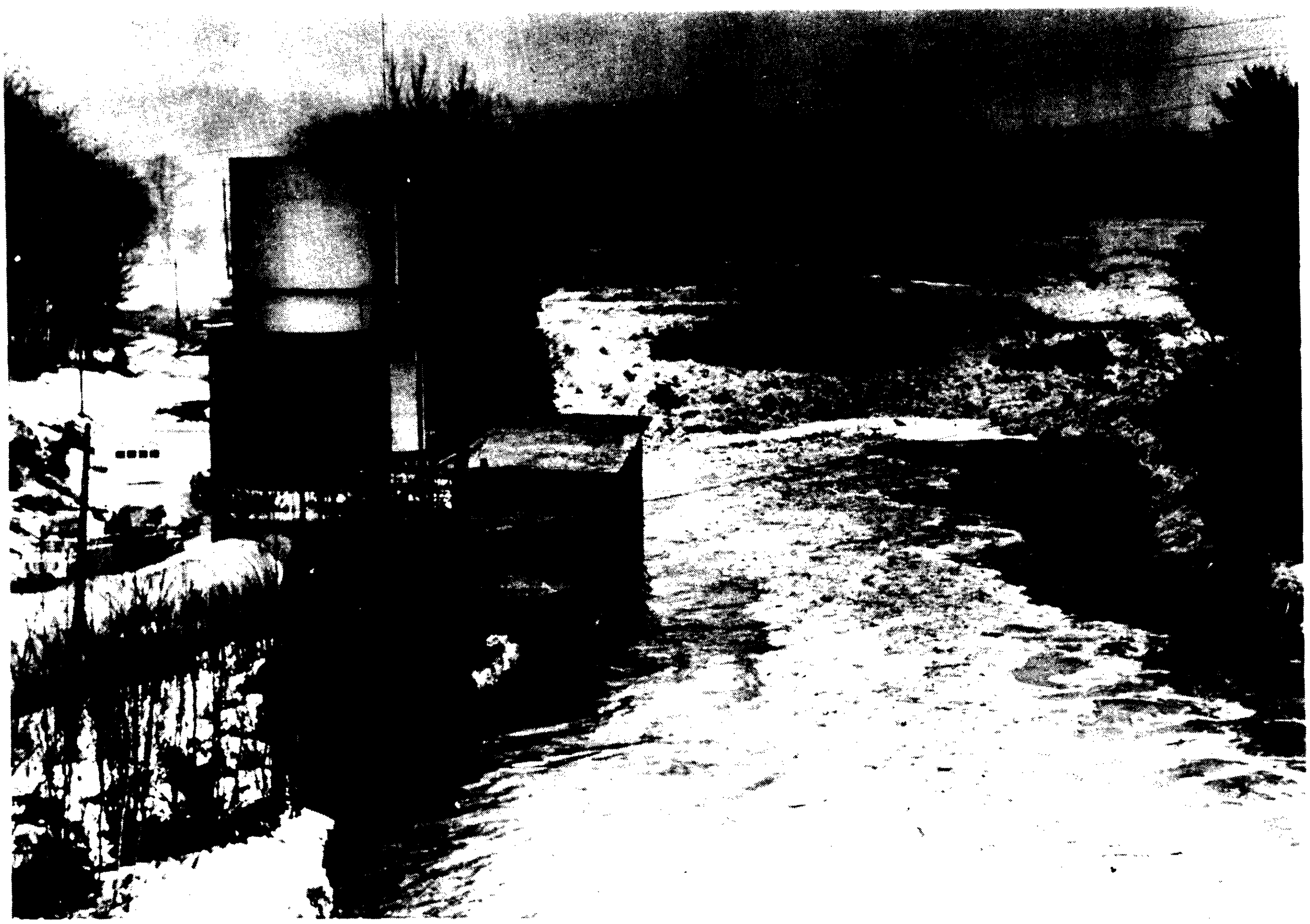


Figure 3 - March 6, 1979, ice jam at Highgate Falls hydropower station during flood recession.

At the downstream corporate limits, ice jams are frequent phenomena. Interviews with local residents indicate that flooding of the magnitude shown in Figure 4 occurs almost every year due to an ice jam at the U. S. Route 7 bridge in the Town of Swanton. Figure 4 depicts flooding at the

Bockus Farm, located at the downstream corporate limits, on March 6, 1979. Figures 3 and 4 were taken at approximately the same stage of flood recession. At its peak, the 1979 flood came above the hoods of the trucks shown in Figure 4. Although ice jams create more frequent floods and generally result in higher flood elevations, their efffects in terms of damage and losses are quite different from free-flowing floods.

Figure 4 - March 6, 1979, ice jam flood at Bockus Farm during flood recession.

The flooding on the Missisquoi River within the boundaries of the Missisquoi National Wildlife Refuge is controlled by the floodwaters of Lake Champlain. Since this area is primarily swampland, the water levels do not rise rapidly, but disperse into a wide flood plain.

Transportation facilities that parallel the Missisquoi River channel are subject to periodic flooding, such as the section of State Route 78 near East Highgate. Public utilities such as water mains and electric lines, as well as bridge crossings are also subject to damage and destruction by floodwaters.

Major floods have occurred on the Missisquoi River during all seasons of the year, except mid-winter. Even though spring is the normal period of high river flow due to snowmelt and rainfall, it is by no means the only time of the year that flooding can occur. As in most of the wooded sections of New England, the runoff potential varies greatly with the season.

The flood of November 1927 brought a total of 6.35 inches of rainfall at Enosburg Falls, Vermont, causing the river level to rise 17 feet over the Highgate Falls Dam. Several bridges along the Missisquoi River were swept away, and various businesses were damaged by the flood (Reference 1).

Potential flood heights of the 10-, 50-, 100-, and 500-year free-flowing floods at various locations along the Missisquoi River are shown in Figures 5, 6, and 7.

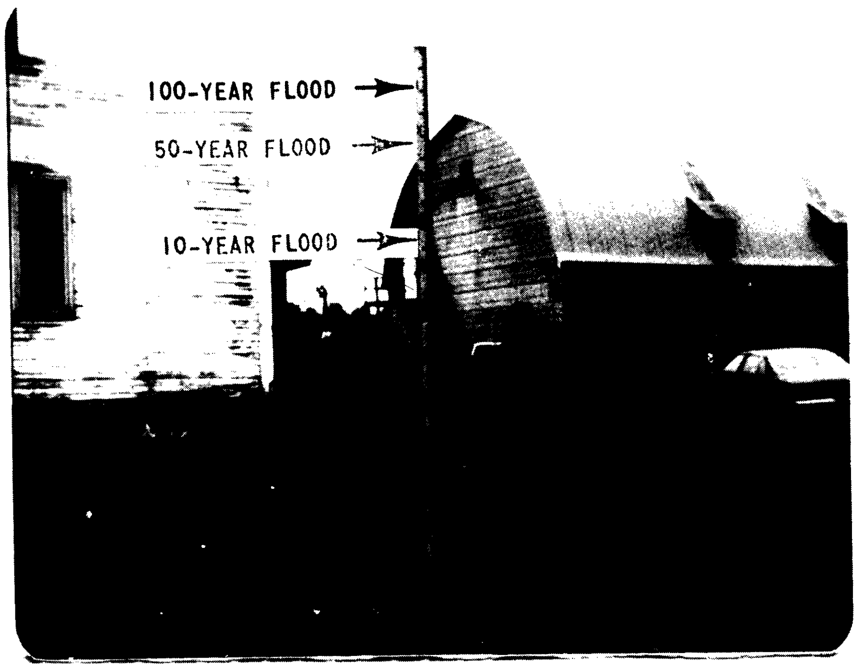


Figure 5 - Potential 10-, 50-, and 100-year flood heights at the Highgate Riverside Farm located just upstream of the Highgate-Swanton town boundary.

2.4 Flood Protection Measures

There were no flood control structures either existing or authorized in the Town of Highgate at the time of this study. There are two dams within the study area located at East Highgate and Highgate Falls. The dam at Highgate Falls is used for electrical power generation, and the dam at East Highgate has been partially destroyed by floodwaters. The Highgate Falls and East Highgate Dams have no regulatory capacity under flooding conditions.

Highgate does not have any zoning regulations concerning flood plains, but plans are being made to develop them. Under Act 250, the State of Vermont has limited regulatory control in flood hazard areas and has a

Figure 6 - Potential 10-, 50-, and 100-year flood heights at Highgate Falls Dam.

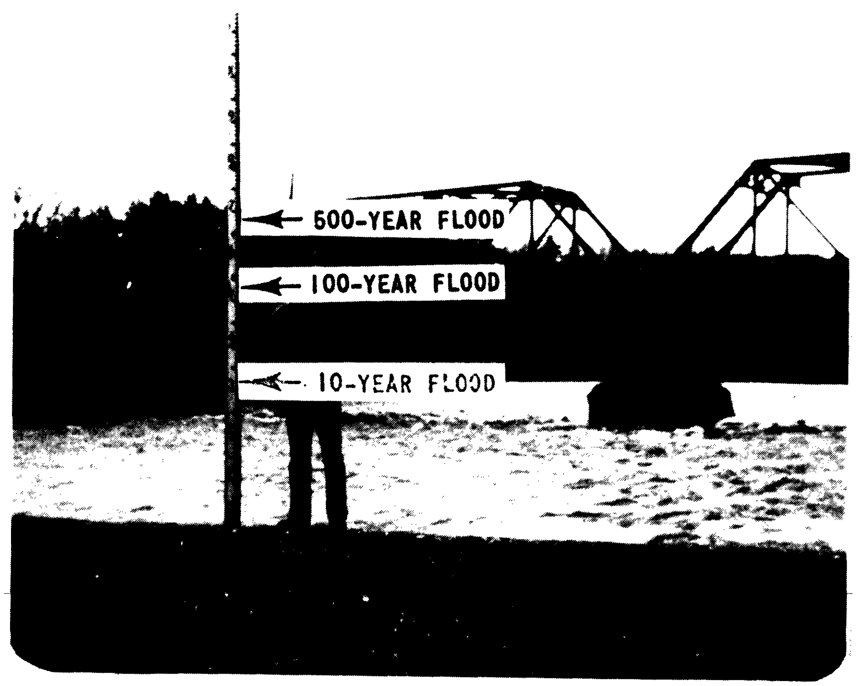


Figure 7 - Potential 10-, 100-, and 500-year flood heights at the breached dam in East Highgate.

law which requires and enables municipalities to develop local flood plain zoning regulations (Reference 2).

The National Weather Service Office (NWSO) in Burlington, Vermont, maintains year-round surveillance of weather conditions for the area of the Missisquoi River watershed. It has also established a flood warning system for all Vermont communities subject to flooding. This system is a communication network of 12 stations, selected by the NWSO, the Vermont Civil Defense Office, and the National Alarm Warning System, that warns the communities of flood hazards.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one-percent chance of annual occurrence) in any 50-year period is about 40 percent (four in ten) and, for any 90-year period, the risk increases to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals of the Missisquoi River and peak elevation-frequency relationships for floods of the selected recurrence intervals for Lake Champlain.

Hydrologic analyses were based on records of the USGS gaging station (No. 2935) located on the Missisquoi River near Richford, Vermont. A statistical analysis of the stage-discharge data from 1911 to 1923 and 1928 to 1978 was used to obtain values for the 10-, 50-, 100-, and 500-year flood discharges (Reference 3). These values were checked against regional discharge-drainage area relationships and yielded comparable results. The developed discharges for the drainage area above Richford were applied to the larger downstream watersheds by using the drainage area-discharge ratio formula:

$$Q_1/Q_2 = (A_1/A_2)^n$$

where Q_1 and Q_2 are the discharges at specific locations and A_1 and A_2 are the drainage areas at these locations, with the exponent "n" varying from 0.70 to 0.80 for the New England area. An average value of 0.75 was used for the formula (Reference 4).

A summary of drainage area-peak discharge relationships for the Missisquoi River is shown in Table 1, "Summary of Free-Flowing Discharges".

TABLE 1 - SUMMARY OF FREE-FLOWING DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
MISSISQUOI RIVER					
At the Highgate-Sheldon town boundary	809	21,500	29,000	32,600	42,000
At the confluence with Lake Champlain	855	22,400	30,200	34,000	43,800

Flooding due to ice jams is a distinctly different phenomenon than free-flowing floods. Hence, two separate hydrologic analyses were performed, one for free-flowing floods and one for ice jam events.

The discharge-frequency relationship for ice jam events is based on 45 years of winter peak discharges during the potential ice jam season (December 1 - March 31) at the USGS gage near East Berkshire, Vermont. The observed winter flow data were fit to a log-Pearson Type III distribution. The discharge-frequency relationship for winter flows in the Highgate reach was developed using the equation:

$$Q_1/Q_2 = (A_1/A_2)^n$$

A summary of peak discharges for ice jam floods on the Missisquoi River is shown in Table 2, "Summary of Ice Jam Flood Discharges".

Hydrologic analyses for Lake Champlain were based on data obtained from the Flood Insurance Study for the City of Plattsburg, New York, and a technical report of Lake Champlain and the upper Richelieu River prepared by the International Champlain-Richelieu Board (References 5 and 6).

TABLE 2 - SUMMARY OF ICE JAM FLOOD DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
MISSISQUOI RIVER					
At the confluence with Lake Champlain	855	12,921	16,362	17,493	19,571

Data used in this study were obtained from the gaging stations at Rouses Point, New York, and Burlington, Vermont.

A summary of peak elevation-frequency relationships for Lake Champlain is shown in Table 3, "Summary of Elevations".

TABLE 3 - SUMMARY OF ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
LAKE CHAMPLAIN				
Entire shoreline within the Town of Highgate	101.2	101.9	102.0	102.3

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Water-surface elevations of floods of the selected recurrence intervals were computed through the use of the U. S. Army Corps of Engineers (COE) HEC-2 step-backwater computer program (Reference 7). Starting water-surface elevations for the Missisquoi River were obtained from the Flood Insurance Study for the Town of Swanton (Reference 8).

Cross-section data were obtained by field measurement. All bridges, dams, and culverts were field surveyed to obtain elevation geometry and structural geometry in order to compute the significant backwater effects of these structures.

Roughness coefficients (Manning's "n") used in hydraulic computations were assigned on the basis of field inspection and were compared to values in published reports for reasonableness (References 9 and 10). The channel "n" values for the Missisquoi River ranged from 0.025 to 0.080, and the overbank "n" values ranged from 0.035 to 0.090.

Flooding due to ice jams is a different hydraulic phenomenon from free-flowing floods. Hence, two separate hydraulic analyses were performed, one for free-flowing floods and one for ice jams.

For ice jam floods, water-surface elevations of floods of the selected recurrence intervals were computed through the use of the COE HEC-2 step-backwater program modified to simulate both ice jam and free-flowing floods (Reference 11). The HEC-2 program was utilized to generate stage-frequency relationships for ice jam floods and free-flowing floods at each surveyed cross section. The resulting stage-frequency relationships were verified by comparison with field surveyed high-water data obtained from local residents along the study reach. Starting water-surface elevations for the ice jams were based on the results of ice cover computations and an extensive field reconnaissance effort.

A comparison of the resulting stage-frequency relationships for ice jams and free-flowing floods indicates that ice jams predominate from the downstream corporate limits to the base of the Highgate Falls dams. Using the laws of probability, the stage-frequency distribution of ice jams and free-flowing floods are combined to form a total stage-frequency distribution at each cross section. As expected, where ice jams predominate, the ice jam stage-frequency approximates the combined or total stage-frequency distribution. Similarly, where free-flowing floods predominate, the free-flowing stage-frequency distribution approximates the combined or total stage-frequency distribution.

Simulation of the flood elevations induced by ice jams requires assumptions regarding the thickness and roughness of the ice cover. From the downstream corporate limits to the Highgate Falls hydropower station, the ice cover is assumed to consist of 2-foot floating ice floes with a Manning's "n" value for the underside of the ice cover of 0.057. Since no methods are presently available for analyzing grounded jams, the HEC-2 program was calibrated to simulate the 1979 grounded jam. The results indicated that a 24-foot ice cover with a Manning's "n" of 0.100 will cause a jam such as occurred at the hydropower plant on March 6, 1979. Use of the above assumptions regarding the ice cover results in agreement with the local ice jam flood history.

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2). The labeled distance shown on the Missisquoi River profile was taken from the intersection of the National Wildlife Refuge boundary with the corporate limits.

All elevations used in this study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929. Locations of the elevation reference marks used in the study are shown on the maps.

With the exception of ice jams, the hydraulic analyses for this study are based on the effects of unobstructed flow. The flood elevations shown on the profiles are valid only if hydraulic structures remain unobstructed and do not fail.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FEMA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at scales of 1:24,000 and 1:62,500 enlarged to a scale of 1:3,000 with a contour interval of 10 feet (References 12 and 13). The 100- and 500-year boundaries for Lake Champlain were delineated using topographic maps at a scale of 1:24,000 enlarged to a scale of 1:9,600 with a contour interval of 10 feet (Reference 12). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year boundary has been shown.

For the areas studied by approximate methods, the boundary of the 100-year flood was delineated using the Flood Hazard Boundary Map for the Town of Highgate (Reference 14).

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 2). Small areas within the flood boundaries may lie above the flood elevations and, therefore, may not be subject to flooding. Owing to limitations of the map scale and lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood can be carried without substantial increases in flood heights. Minimum standards of the FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodway in this report is presented to local agencies as a minimum standard that can be adopted or that can be used as a basis for additional studies.

The floodway presented in this study was computed on the basis of equal conveyance reduction from each side of the flood plains. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 4).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown. Portions of the floodway widths for the Missisquoi River extend beyond the corporate limits.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 8.

Near the mouth of the stream studied by detailed methods, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "With Floodway" elevations presented in Table 4 for certain downstream cross sections of the Missisquoi River are lower than the regulatory flood elevations in that area, which must take into account ice jam effects.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Missisquoi River								
A	30,575[1]	666[3]	7,443	4.6	105.9[4]	104.5	104.5	0.0
B	1,875[2]	1,379	10,555	3.2	123.7[4]	122.8	122.8	0.0
C	6,365[2]	494	6,640	5.1	123.7[4]	123.4	123.5	0.1
D	8,020[2]	1,731	21,548	1.6	136.4[4]	124.0	124.1	0.1
E	10,010[2]	134	2,182	15.6	142.2[4]	124.0	124.1	0.1
F	10,956[2]	250	3,713	9.2	153.6[4]	139.2	139.7	0.5
G	11,365[2]	401	8,345	4.1	181.2	181.2	181.2	0.0
H	11,745[2]	422	7,993	4.3	181.2	181.2	181.2	0.0
I	14,460[2]	376	7,731	4.4	181.5	181.5	181.5	0.0
J	17,565[2]	427	9,587	3.5	181.9	181.9	181.9	0.0
K	19,140[2]	412	2,426	6.9	187.0	187.0	187.0	0.0
L	21,495[2]	302	4,926	8.2	192.0	192.0	192.0	0.0
M	23,320[2]	279	4,130	8.2	192.7	192.7	192.8	0.1
N	24,765[2]	353	5,472	5.6	194.5	194.5	194.6	0.1
O	26,855[2]	354	6,018	5.6	194.5	194.5	194.6	0.1
P	28,275[2]	514	7,071	4.8	195.0	195.0	195.0	0.0
Q	29,345[2]	913	10,500	3.2	195.5	195.5	195.6	0.1

[1]Feet above confluence with Lake Champlain
[2]Feet from corporate limits
[3]This width extends beyond corporate limits
[4]Elevation computed considering ice jam effects

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF HIGHGATE, VT

(FRANKLIN CO.)

FLOODWAY DATA

MISSISQUOI RIVER

TABLE 4

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE
Missisquoi River								
R	31,365	409	3,130	10.9	198.9	198.9	198.9	0.0
S	31,685	364	2,384	14.3	199.6	199.6	199.6	0.0
T	32,365	338	3,226	10.5	203.8	203.8	203.8	0.0
U	32,995	333	4,157	8.2	211.8	211.8	212.8	1.0
V	33,445	362	4,298	7.9	212.6	212.6	213.4	0.8
W	34,835	435	5,793	5.9	214.1	214.1	214.7	0.6
X	35,315	343	4,163	8.2	214.4	214.4	214.9	0.5
Y	36,195	504	6,388	5.3	216.4	216.4	216.7	0.3
Z	36,990	493	6,216	5.5	216.9	216.9	217.2	0.3
AA	37,690	325	4,402	7.7	217.2	217.2	217.4	0.2
AB	41,190	246	4,793	7.1	218.8	218.8	219.3	0.5

[1]Feet from corporate limits

FEDERAL EMERGENCY MANAGEMENT AGENCY

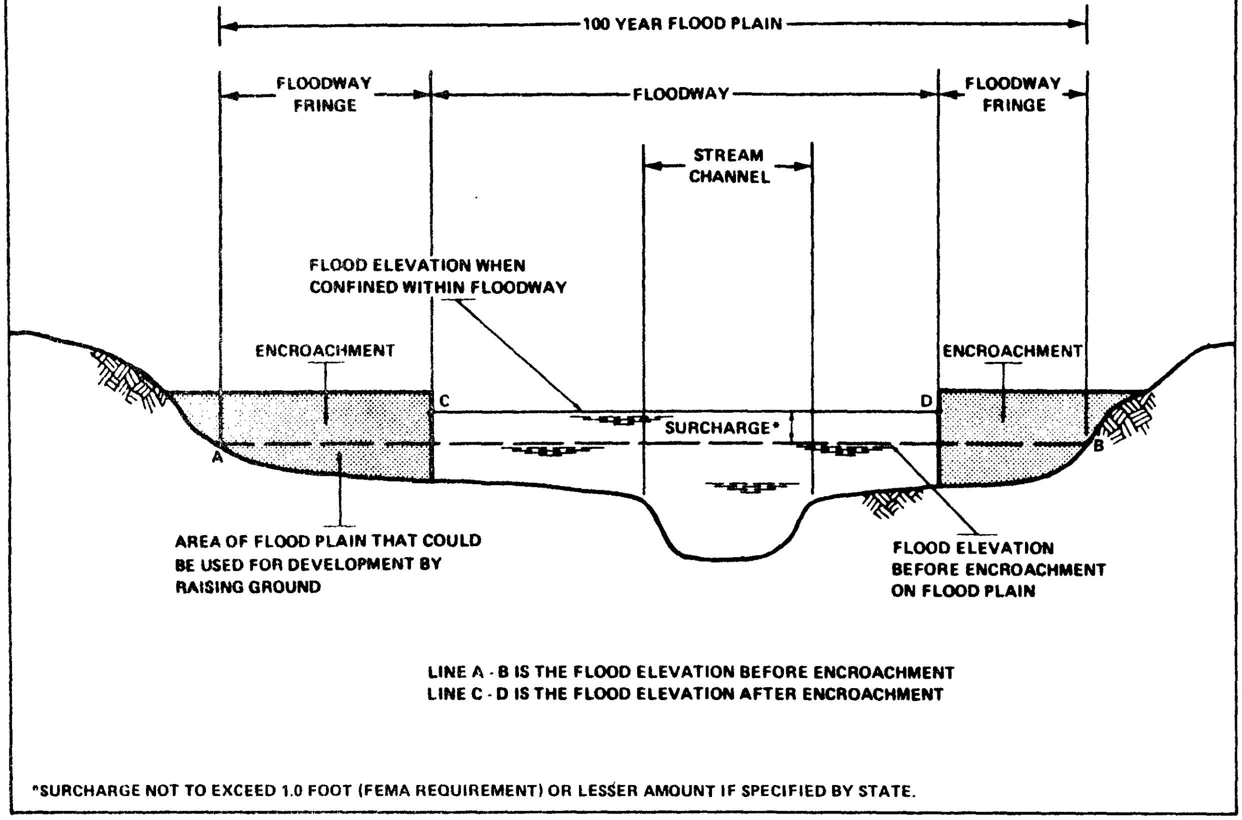
TOWN OF HIGHGATE, VT

(FRANKLIN CO.)

FLOODWAY DATA

MISSISQUOI RIVER

TABLE 4



FLOODWAY SCHEMATIC Figure 8

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source affecting the Town of Highgate.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the riverine flooding source of the Town of Highgate are shown on the Flood Profiles (Exhibit 1) and are summarized in the Flood Insurance Zone Data Table (Table 5).

In lacustrine areas, reaches are limited to the distance for which the difference between the 10- and 100-year flood elevations does not vary more than 1.0 foot. Using these criteria, the Highgate shoreline qualifies as one reach whose flooding source is Lake Champlain. The locations of these reaches are shown on the Flood Insurance Rate Map.

5.2 Flood Hazard Factors

The FHF is the FEMA device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the Town of Highgate was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zones A2, A4, and A5:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHF.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Missisquoi River							
Reach 1	15	-2.2	-0.6	+1.2	020	A4	Varies
Reach 2	15,20	-2.5	-0.7	+1.6	025	A5	Varies
Lake Champlain							
Reach 1	05,10, 15	-0.8	-0.1	+0.3	010	A2	102

[1]Flood Insurance Rate Map Panel
[2]Weighted Average
[3]Rounded to the nearest foot - see map

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FLOOD INSURANCE ZONE DATA

MISSISQUOI RIVER AND LAKE CHAMPLAIN

TABLE 5

Zone B: Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 5, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the Town of Highgate.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Town of Highgate is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FEMA.

6.0 OTHER STUDIES

In 1930, the COE submitted to the U. S. House of Representatives a report on the Missisquoi River drainage basin, discussing notable historic floods and basin characteristics (Reference 1).

Flood Insurance Studies for the Towns of Swanton and Sheldon are currently being prepared (References 8 and 15). The results of those studies will be in exact agreement with the results of this study. In addition, Flood Plain Information reports are available from the COE for the Towns of Sheldon, Swanton, and Highgate (References 16 and 17).

This study is authoritative for purposes of the Flood Insurance Program, and the data presented here either supersede or are compatible with previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Insurance and Mitigation Division of the Federal Emergency Management Agency, Regional Director, Region I Office, J. W. McCormack Post Office and Courthouse Building, Room 462, Boston, Massachusetts 02109.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U. S. House of Representatives, 71st Congress, 2nd Session, House Document 496, Missisquoi River Report, prepared by the U. S. Army Corps of Engineers, Washington, D. C., 1930.

2. Richard Vogel, Project Engineer, Dufresne-Henry Engineering Corporation, Personal Communication, November 28, 1979.

3. Water Resources Council, "Guidelines for Determining Flood Flow Frequency", Bulletin 17A, Washington, D. C., June 1977.

4. Johnstone, D. C., Elements of Applied Hydrology, New York, Ronald Press, 1949.

5. U. S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Plattsburg, Clinton County, New York, Washington, D. C., April 1978.

6. International Champlain-Richelieu Board, Technical Report of Physical Aspects Committee, Technical Report of Net Benefits Committee, Report of Environmental Impact Committee, in Regulation of Lake Champlain Upper Richelieu River, Ottawa, Canada, December 1977.

7. U. S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, Davis, California, November 1976.

8. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Town of Swanton, Franklin County, Vermont (Unpublished).

9. U. S. Department of the Interior, Geological Survey, Water-Supply Paper 1849, Roughness Characteristics of Natural Channels by Harry H. Barnes, Jr., Washington, D. C., 1967.

10. U. S. Department of Commerce, Bureau of Public Roads, Hydraulic Design Series, No. 4, Design of Roadside Drainage Channels, Washington, D. C., U. S. Government Printing Office, May 1965.

11. U. S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, Davis, California, November 1976 (Updated 1980 - Experimental Modification 99.4 for Ice Cover Analysis).

12. U. S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 10 Feet: East Alburg, Vermont, 1964; Highgate Center, Vermont, 1964, Photorevised 1972.

13. U. S. Department of the Interior, Geological Survey, 15-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 10 Feet: Enosburg Falls, Vermont, 1953.

14. U. S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, Town of Highgate, Franklin County, Vermont, May 31, 1974, Revised August 13, 1976.

15. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Town of Sheldon, Franklin County, Vermont, (Unpublished).

16. U. S. Army Corps of Engineers, New York District, Flood Plain Information, Sheldon, Vermont, New York, July 1978.

17. U. S. Army Corps of Engineers, New York District, Flood Plain Information, Swanton and Highgate, Vermont, New York, September 1978.

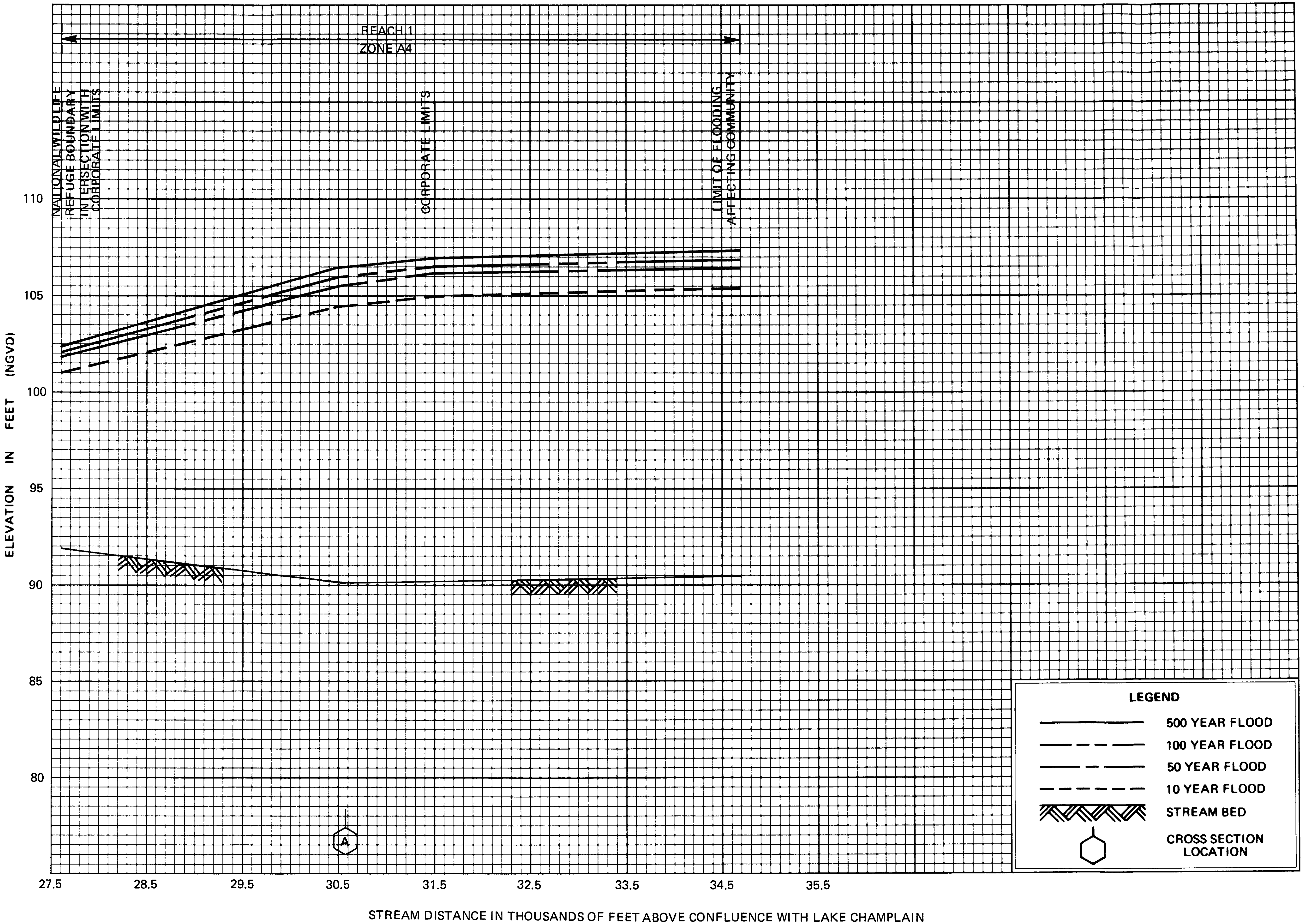
American Society of Civil Engineers, Reprint 2559, Approximate Method for Quick Flood Plain Mapping by R. F. Powell, L. D. James and E. D. Jones, New York, November 1975.

Brater, Ernest F., and Horace Williams King, Handbook of Hydraulics, 5th Edition, New York, McGraw-Hill, 1963.

Chow, Ven Te, Open-Channel Hydraulics, New York, McGraw-Hill, 1959.

U. S. Department of the Interior, Fish and Wildlife Service, Photogrammetric Mapping of Lake Champlain and Missisquoi River, Franklin County, Vermont, Sheet Identification Numbers 01-1001-1, through 01-1001-16.

U. S. Department of the Interior, Geological Survey, Open-File Report, Flood Magnitude and Frequency of Vermont Streams by C. G. Johnson and G. D. Tasker, Washington, D. C., March 1974.



FLOOD PROFILES

MISSISQUOI RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF HIGHGATE, VT
(FRANKLIN CO.)

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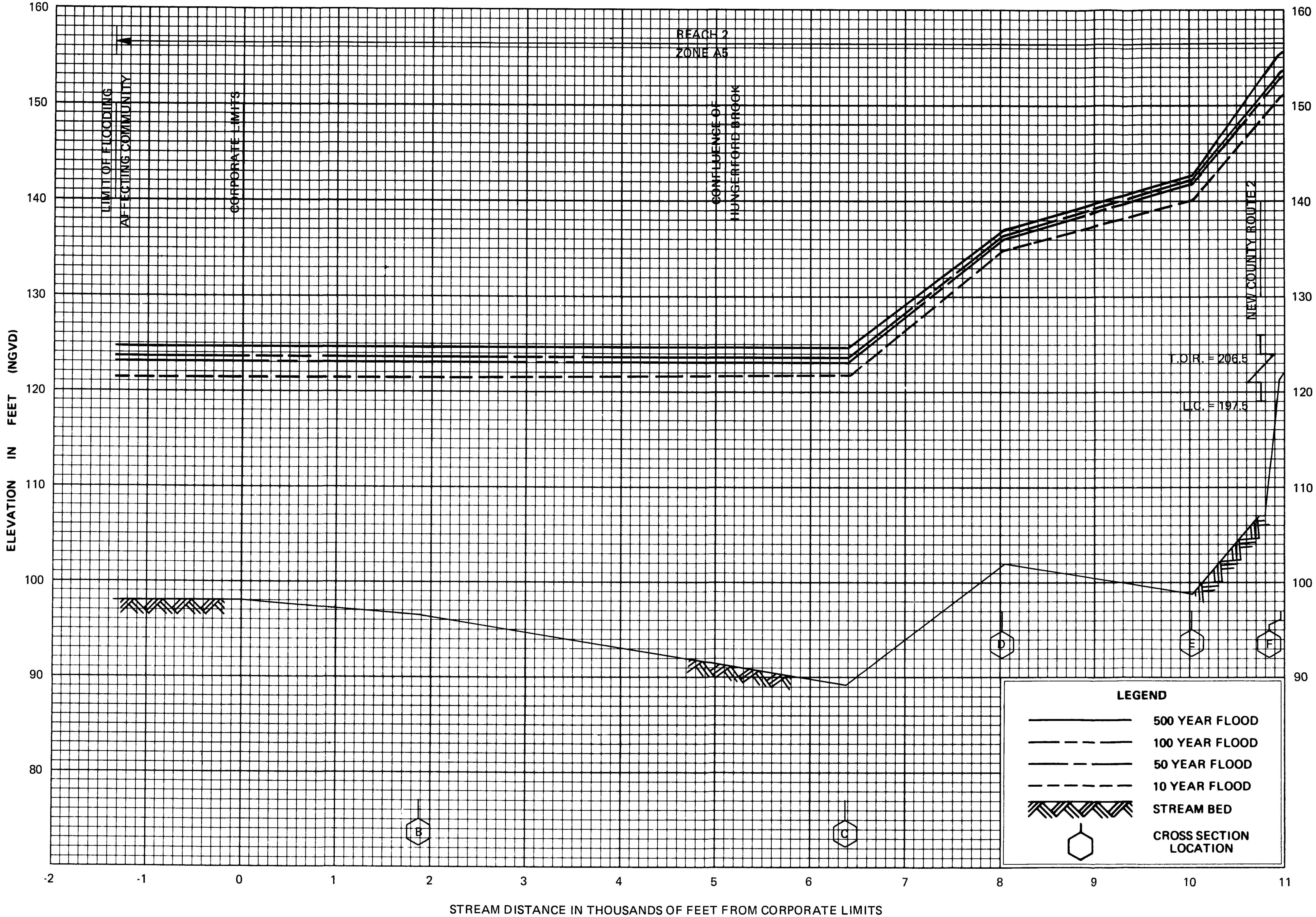

FLOOD PROFILES

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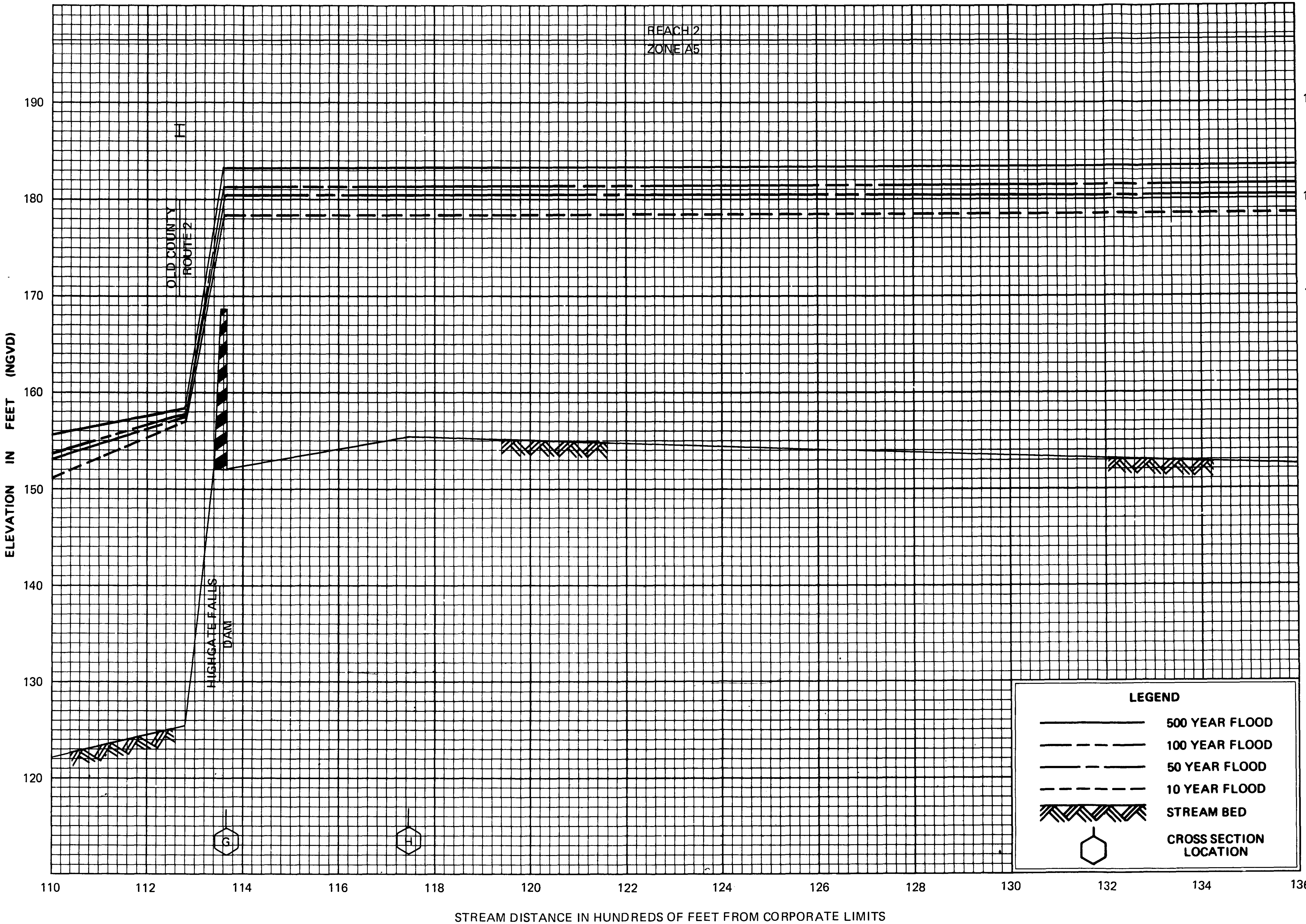

FLOOD PROFILES

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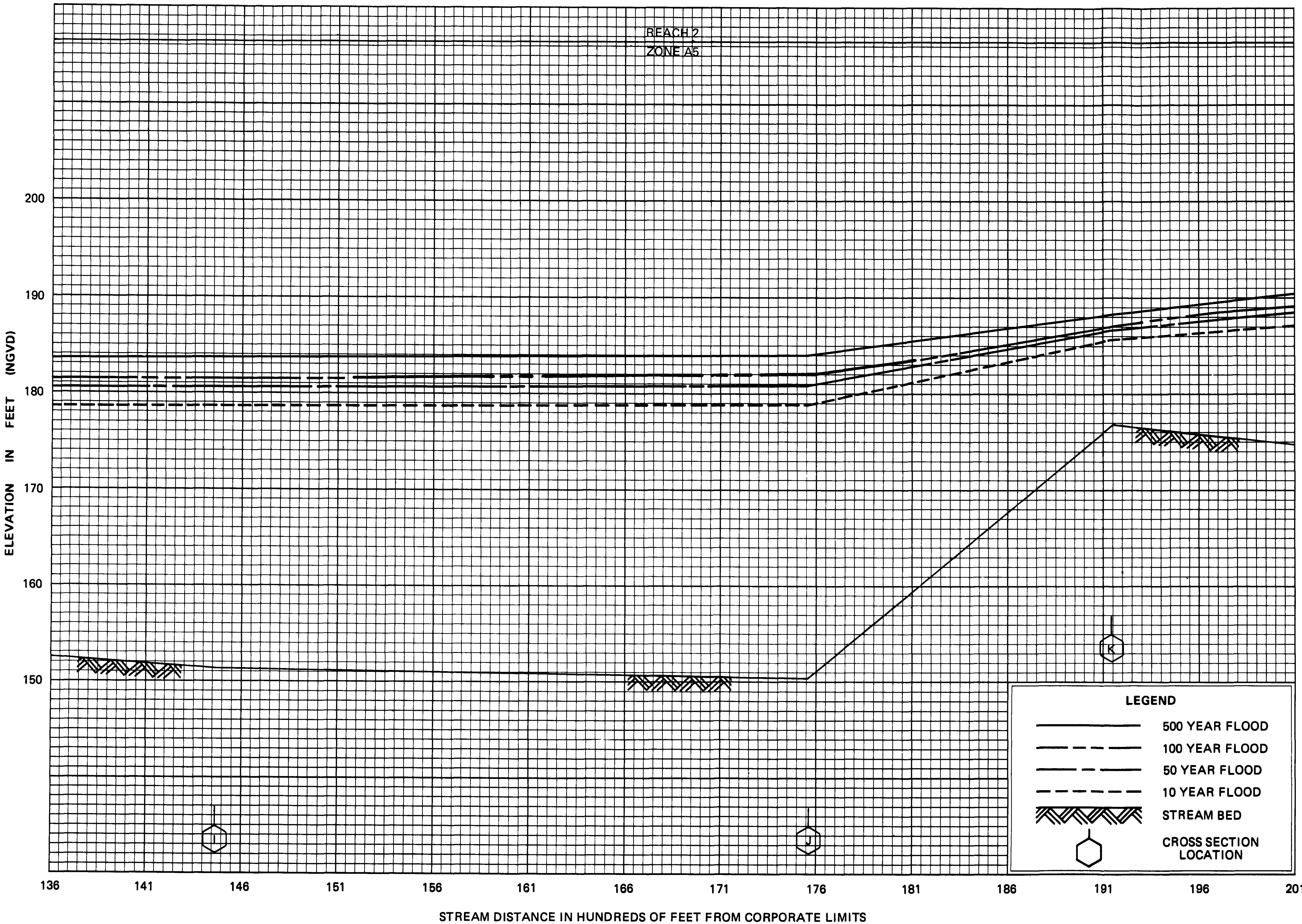

FLOOD PROFILES

MISSISQUOI RIVER

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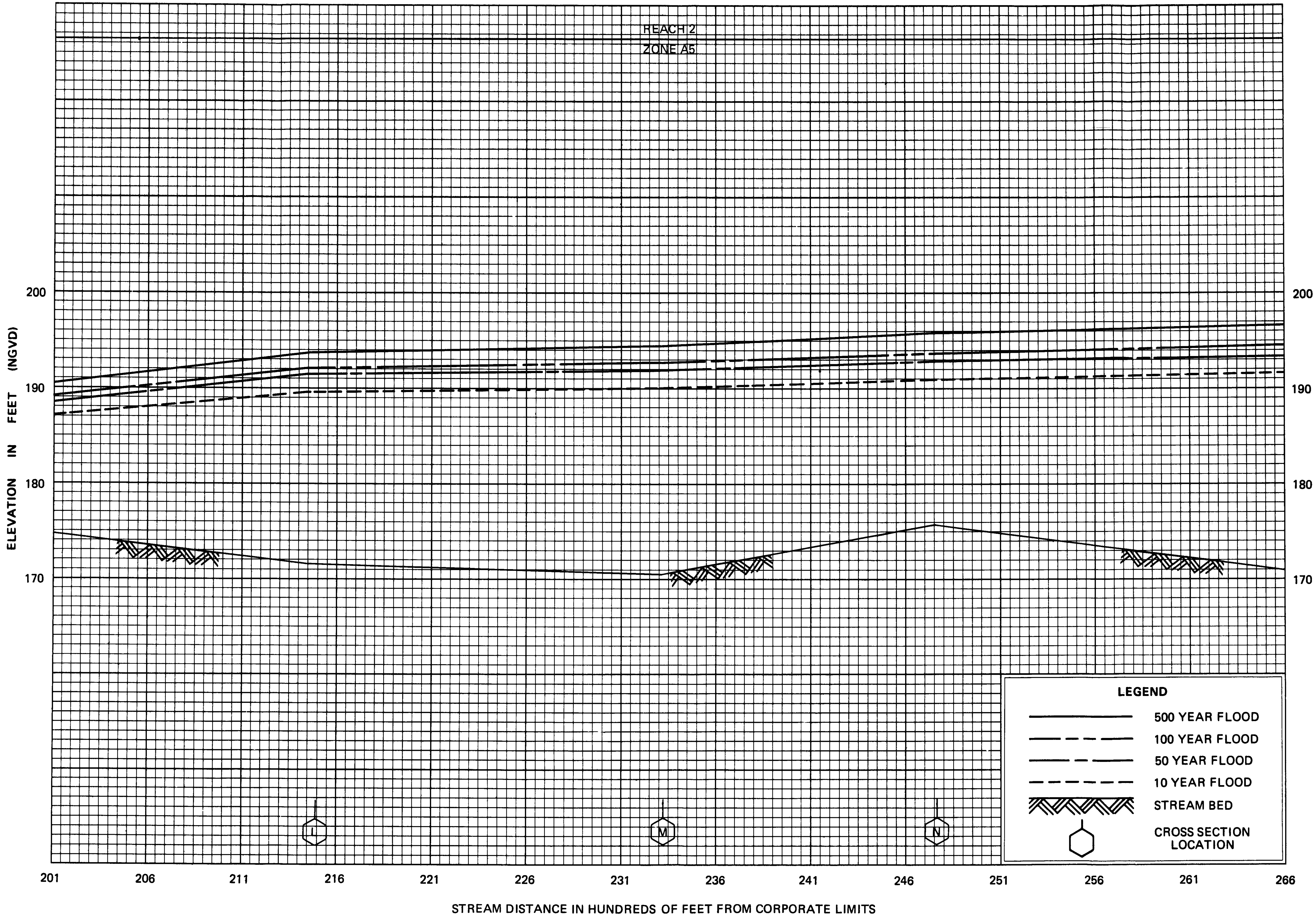

FLOOD PROFILES

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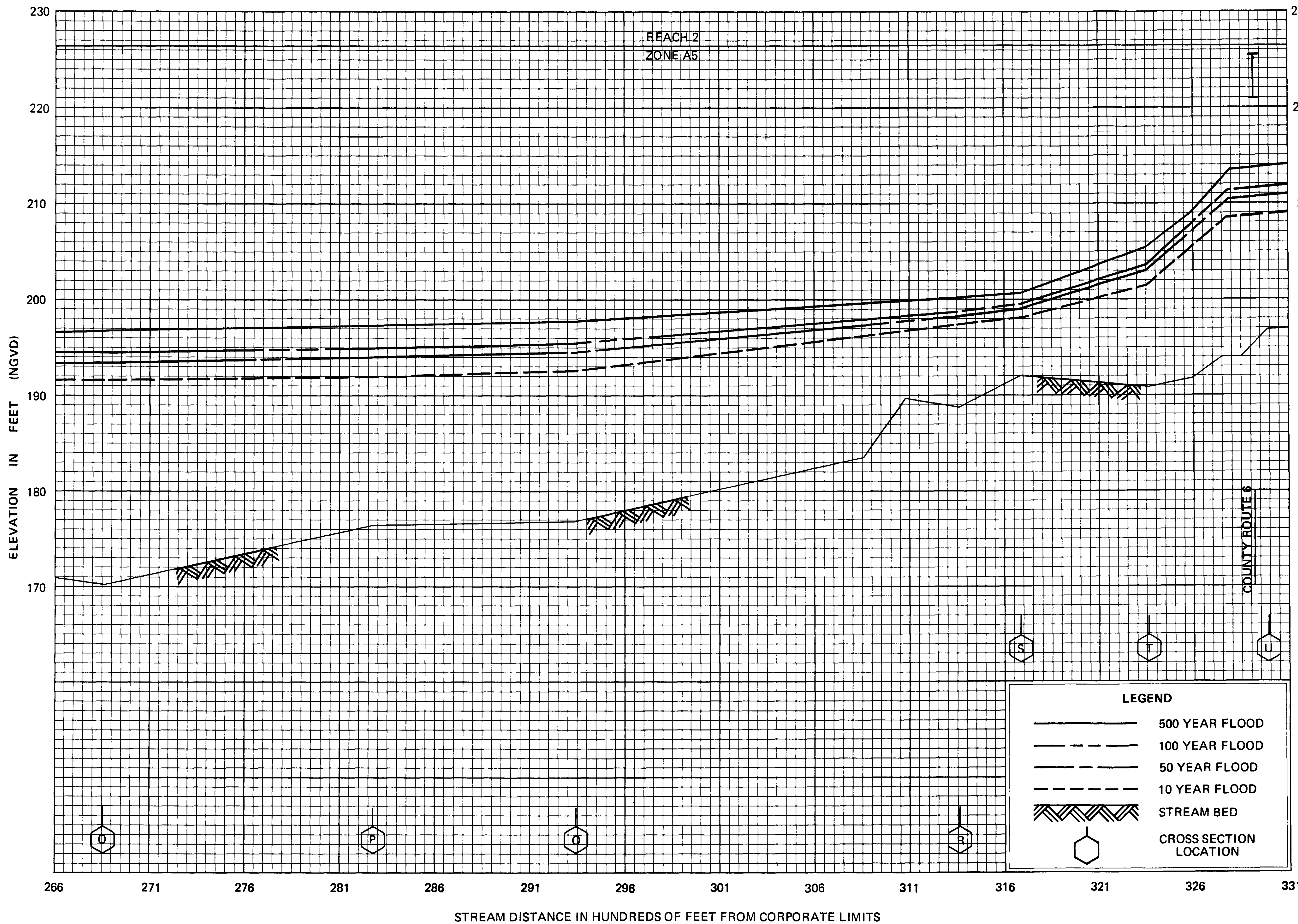

FLOOD PROFILES

MISSISQUOI RIVER

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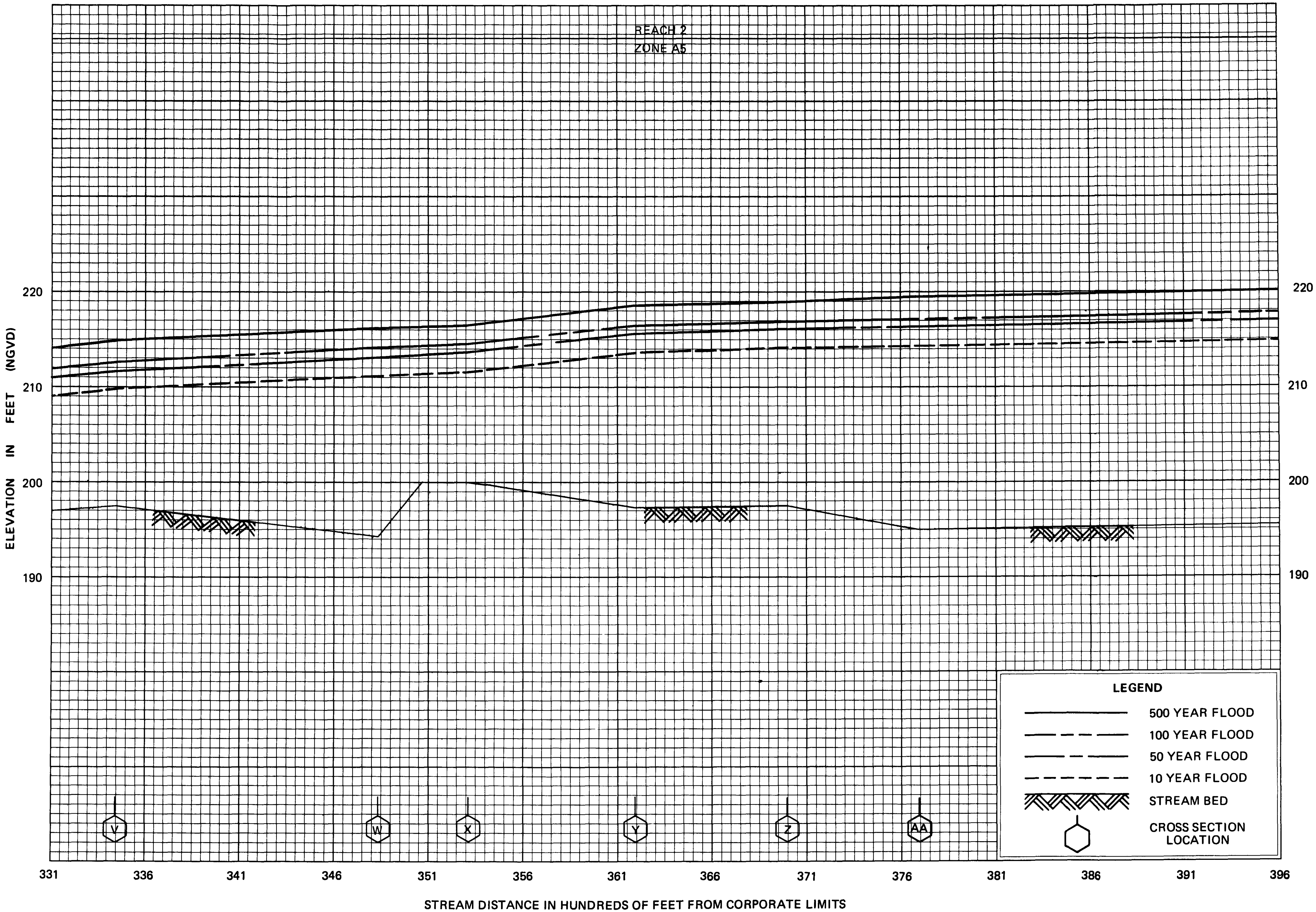

FLOOD PROFILES

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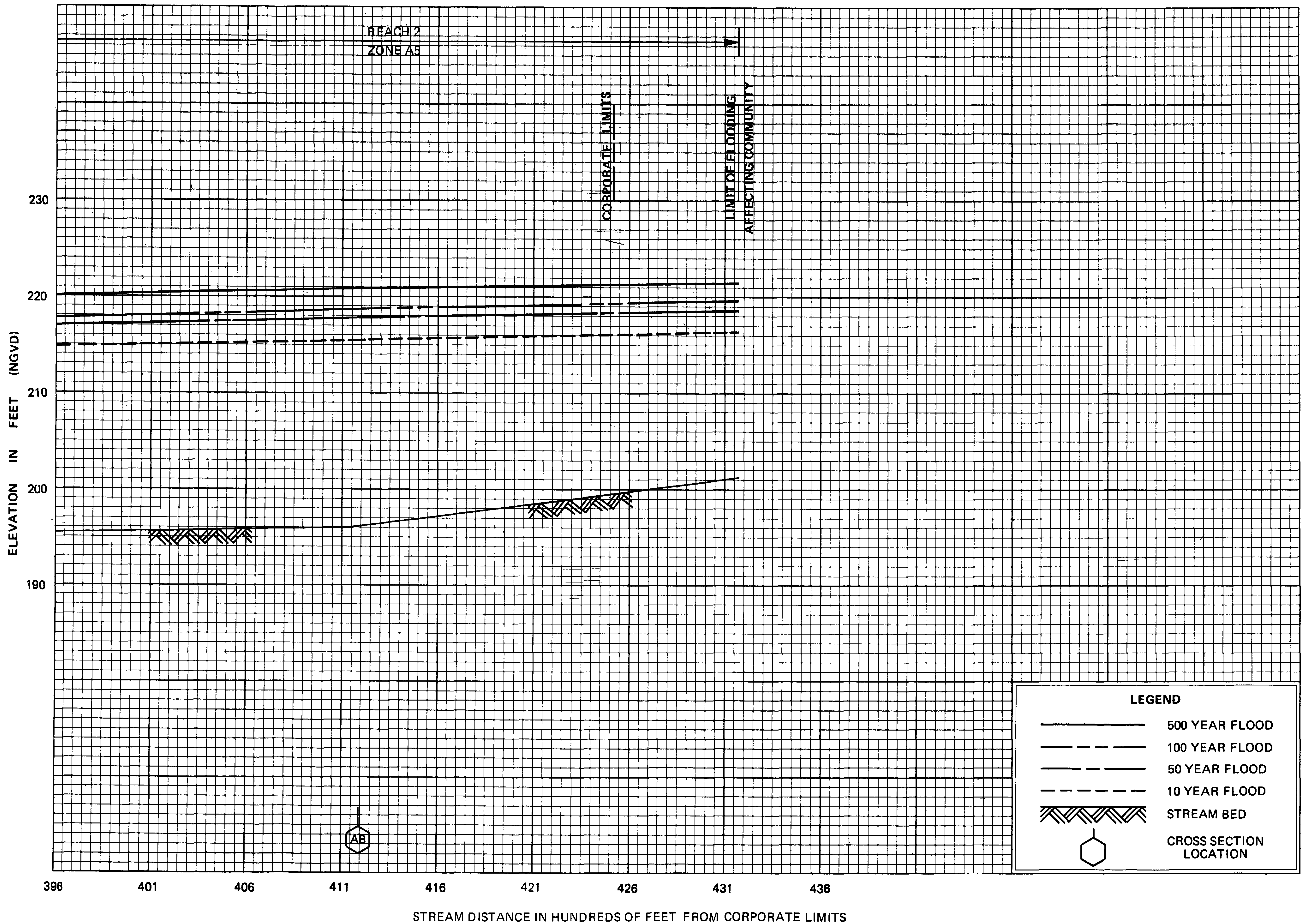

FLOOD PROFILES

MISSISQUOI RIVER

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