

SHADOW LAKE DAM GLOVER, VERMONT

DAM-BREAK FLOOD ANALYSIS

PREPARED FOR THE
U.S. ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT
AND
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DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DAM SAFETY PROGRAM

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US Army Corps
of Engineers

New York District

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DAM-BREAK FLOOD ANALYSIS

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SHADOW LAKE DAM DAM-BREAK FLOOD ANALYSIS

EXECUTIVE SUMMARY

The primary purpose of this study is to determine the downstream hazard classification of Shadow Lake for the Dam Safety Program under the jurisdiction of the State of Vermont, Department of Environmental Conservation. The secondary purpose of the study is to provide introductory information for the dam owner to develop an Emergency Action Plan (EAP) in the event of an impending dam failure.

Dam-break flood conditions are evaluated for both sunny-day and storm-day failure. The analyzed storm events include the 100-year recurrent storm and variations of the Probable Maximum Flood (PMF) (1/4, 1/2, 3/4, and full PMF).

Inflow hydrographs and spillway hydraulic capacity are developed as a basis upon which to model the breach discharge. Peak flows are routed through the reservoir using the National Weather Service Dambrk flood forecasting model. Breach discharge hydrographs for a sunny-day and a 1/2 PMF storm-day are routed through the downstream channel for a distance of approximately three miles below the dam. Limits of inundation are delineated in plan and profile view.

On the basis of the U.S. Army Corps of Engineers guidelines for safety inspection, the dam's size classification is INTERMEDIATE. On the basis of its potential to cause downstream damage, in terms of either loss of life or economic loss, Shadow Lake Dam is rated Class 2 or a SIGNIFICANT hazard category.

Four major components of an EAP are discussed: monitoring, evaluation, preventive action, and warning. Official contacts are provided in the event of an impending dam failure.

SHADOW LAKE DAM DAM-BREAK ANALYSIS

I. INTRODUCTION

A. Purpose

The primary purpose of this study is to determine the downstream hazard classification of the dam for the State of Vermont, Department of Environmental Conservation Dam Safety Program. The classification system is the one adopted by the U.S. Army Corps of Engineers and is used by the Department of Environmental Conservation to determine inspection frequency and spillway adequacy of dams under its jurisdiction. A secondary purpose is to provide information for use by the dam owner in developing an Emergency Action Plan (EAP) in the event of an impending dam failure.

The study presents the findings for various dambreak flood conditions for the Shadow Lake Dam with resulting downstream effects. These findings include development of storm inflows into the pond, mechanisms which trigger failure of the dam, resulting breach discharges, delineation of downstream flood limits (inundation mapping) and determination of downstream hazard classification. This study was not performed because of any expected dambreak at Shadow Lake Dam, but rather to investigate results of a hypothetical dambreak.

B. Downstream Hazard Classification

Dams are classified according to the potential for loss of life and property damage in the area downstream of the dam if it were to fail. The hazard classification does not refer to the condition of the dam.

The classification system used in this study has been adopted by the U.S. Army Corps of Engineers and is used by the Department of Environmental Conservation to determine inspection frequency and spillway adequacy for dams under its jurisdiction. The hazard classification is as follows:

DOWNSTREAM HAZARD CLASSIFICATION OF DAMS

<u>Class</u>	<u>Potential Hazard Category</u>	<u>Loss of Life (Extent of Development)</u>	<u>Potential Economic Loss (Extent of Development)</u>
3	Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped, occasional structures or agriculture)

2	Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry, or structures)
1	High	More than a few Excessive (Extensive community, industry, or agriculture)	

C. Authority and Acknowledgments

In March 1987, the U.S. Army Corps of Engineers, New York District, authorized the firm of DuBois & King, Inc., to conduct several dam-break flood analyses for dams located in Vermont. These analyses are the Corp's response to a request from the Vermont Department of Environmental Conservation to the Corps of Engineers for assistance in their Dam Safety Program. Mr. A. Peter Barranco, Jr., P.E., of the Department of Environmental Conservation provided important information about this dam.

II. PROJECT DESCRIPTION

A. General Description

The dam is an earthen embankment with masonry headwalls and is approximately 129 feet in length. The maximum height is 11.5 feet and the crest width is 16 feet. The principle spillway is a gatehouse with stop logs and a three foot (3) diameter drain pipe. The emergency spillway is located to the left of the gatehouse and is a 33.5 ft. long, 15 ft. wide concrete chute. The control section is set an elevation of approximately 1392.6 National Geodetic Vertical Datum (NGVD). At normal water level the lake's surface area is 188 acres. The actual date of construction is unknown, however, the year 1929 is cast in the side of the spillway. The current primary purpose of the dam is recreational.

B. Community Description

The Town of Glover is located in Orleans County, Vermont. It is bounded by the Towns of Orleans to the north, Albany to the west, Greensboro to the south, and Sheffield to the east. Glover has a population of approximately 843 and an area of 25,152 acres.¹

C. Downstream Conditions

The downstream study area for the Shadow Lake Dam is located completely within the Town of Glover and is shown on the Index Map (Plate 1). The study area of Shadow Lake is the flood plain along Shadow Lake Brook and the Barton River. It

consists of open areas and some woodland. The flood plain is generally narrow; there is some variation in width. The limit of study is approximately 16,500 feet downstream from the dam. Slope of the streambed ranges from 3.7 percent in the upper reaches to approximately 0.6 percent near the downstream limit of study. The downstream conditions discussed below and under Section V, Downstream Channel Routing, are based on a April 1990 field survey and an October 1990 field reconnaissance. Refer to Plates 3 and 4 for the following discussion of downstream conditions.

Town Highway 40 is the first downstream flow obstruction located approximately 300 feet (.06 mi.) below the dam. There is a house on the left side of the brook, however, it is well above the floodplain. A concrete bridge passes flow under the road. The first downstream habitable structure near the brook is a house located high on the left bank of Shadow Lake Brook 3,500 feet (.66 mi.) below the dam. The reach between these two areas is undeveloped, heavily wooded terrain with relatively little floodplain. The second flow obstruction is a private drive which services the house at 3,500 feet. A small wooden bridge passes flow under the road. Shadow Lake Brook joins the Barton River at approximately 5,300 feet below the dam. The third flow obstruction is another private drive located 5,900 feet downstream leading to a house and farm complex located on the river's left bank. The fourth flow obstruction is Town Highway 37 (Perron Hill Road) joining Rt. 16 from the west. A concrete bridge passes flow under the road. There is a barn and a house along the left bank; the barn is situated closer to the river than the house.

III. DAM DESCRIPTION

A. Identification

Shadow Lake Dam is identified by the Vermont Department of Environmental Conservation as #81-2. The U.S. Army Corps of Engineers identifies this dam as VT 0070. The dam is owned by the Town of Glover, Vermont.²

B. Physical Characteristics

1. Type: Earthfill with masonry headwalls
2. Length: 129 feet
3. Height: 11.5 feet
4. Top Width: approximately 16 feet
5. Side Slopes: Upstream face varies from 1V:3H * to vertical
Downstream face varies from 1V:3H to vertical

* V:H = Vertical to horizontal side slope ratio

C. Spillways

1. Principle Spillway/Gatehouse

- i). Type: 5-foot wide weir with 3 ft. diameter drain pipe
- ii). Hydraulic Capacity: 107 cfs *

2. Emergency Spillway

- i). Type: 15-foot wide concrete chute
- ii). Max. Hydraulic Capacity: 346 cfs

* cfs - Cubic feet per second. Assuming fully open gate at water elevation 1391.0. For routing analysis, this spillway is assumed to convey 20 cfs.

D. Impoundment Behind Dam

1. Surface Area

- i). At principle spillway crest: 188 acres
- ii). At top of dam: 200 acres

2. Height of Dam

- i). At principle spillway crest: 7.1 feet
- ii). At top of dam: 11.5 feet

3. Storage Volume (As computed by HEC-1 Hydrology Computer Program)

- i). At principle spillway crest: 1432 acre-feet
- ii). At top of dam: 2283 acre-feet

E. Elevations

- i). At top of dam: 1397.0 NGVD
- ii). Emergency spillway/control section: 1392.6 NGVD
- iii). Principle spillway (gatehouse with stoplogs) crest: 1391.0 NGVD
- iv). Streambed at downstream toe of slope: 1385.5 NGVD

NGVD= National Geodetic Vertical Datum

F. Watershed Area

- i). Size: 5.2 square miles (3,328 acres)
- ii). Type: Primarily woodland, steep slopes, minimal development

IV. METHOD OF ANALYSIS

This section of the report discusses the methods and assumptions used in the dam-break analysis. Results of the analysis are presented in the following Section V.

Two types of dam failures were considered in this study: "sunny-day" and "storm-day."

A sunny-day failure typically is a result of piping. Piping is internal erosion of the embankment through displacement of fines by uncontrolled seepage. Enough material is eroded so that voids are created in the embankment, which eventually collapses. The result is a breach of the embankment and formation of the breach discharge.

A storm-day failure is associated with significant inflow into the impoundment. As a result of inadequate spillway and reservoir storage capacity, overtopping of the embankment occurs. As the embankment is eroded, the ensuing breach discharge develops.

A. Hydrology

It is not the intent of this report to conduct a detailed hydrologic analysis on the lake's watershed. Numerous methods are available to generate runoff values and should be utilized when developing design flows for lakes and ponds. The results of the hydrologic procedure discussed below are intended to estimate the magnitude of stormwater runoff, and should not be interpreted as absolute values.

Inflow hydrographs for Shadow Lake Dam were developed by utilizing the U.S. Army Corps of Engineers HEC-1 Hydrology Computer Program.³ The reference flood was the Probable Maximum Flood (PMF). Various fractions of the PMF were developed. The method used in the HEC-1 program to develop the storm inflow was the SCS Unit Hydrograph. This method determined runoff discharge rates for a given drainage area or sub-drainage area over a specified duration of time.

In addition to the PMF hydrographs, a 100-year storm inflow hydrograph was developed. This inflow hydrograph was based on a 24-hour storm and had a time base of 5 minutes per ordinate. No infiltration losses were assumed in order to reflect situations that could occur during spring or fall seasons when the ground could be partially frozen or heavily saturated. The rainfall values for the 100-year storm were obtained from the National Weather Service's Rainfall Frequency Atlas of the United States Technical paper 40 and Hydro-35, 5 to 60 minute precipitation frequencies.

Information necessary for this determination included the drainage area, SCS runoff number, time of concentration, travel time to the point of interest, and rainfall depth of a design storm.⁴ The SCS Unit Hydrograph of analysis produces a runoff hydrograph representing the runoff response of a watershed to typical rainfall distributions of 24 and 48 hours in duration.

To model an overtopping (storm-day) failure, inflow hydrographs for the 100-year 1/4, 1/2, 3/4 and full PMF storm events were developed by using the method described above combined with the procedure outlined in Hydrometeorological Report Nos. 51 & 52.⁵ The assumptions made were that the storm's isohyetal pattern was centered over the drainage basin and that the greatest 6-hour probable maximum precipitation (PMP) increment was between the twenty-fourth and thirtieth hours into a 48-hour storm. The time base for these inflow hydrographs was 10 minutes per ordinate.

To model a piping (sunny-day) failure, a small inflow hydrograph was developed. This hydrograph represents typical sunny-day flow through the lake.

B. Reservoir Routing

If a reservoir has capacity to store water, then the inflow hydrograph should be routed through the reservoir to obtain the correct discharge. This study utilizes the HEC-1 model and the Boss Corporation's⁶ enhanced version of the National Weather Service's (NWS) "Dambrk" flood forecasting computer model⁷ to develop peak water surface information for sunny-day and storm-day failures. Both models utilize the modified Puls method of reservoir routing, which expresses the continuity equation for incremental periods of time. This method is sometimes referred to as Level Pool routing. Portions of the design plans and USGS topographic maps were verified through site investigation. Stage, surface area, and discharge relationships were then determined from this information.

C. Spillway Hydraulic Capacity

The rating curve that describes the spillway was developed by using the dam elevations and spillway geometry. Flows through the spillways and over the top of dam were computed using the weir equation. An assumption was made that the spillway would not erode when high flood flows are reached. If velocities associated with the high flood flows do erode the spillway, the dam could fail before water reaches the top of the dam. Should this circumstance occur, a smaller breach discharge than was generated in this study should be produced.

D. Breach Discharge Hydrograph

The hydrograph of the breach discharge is a function of the routed inflow hydrograph and breach parameters⁸ of a hypothetical dam failure. Figure 1 illustrates the various dam breach parameters in a typical earthen dam. Total flow out of the reservoir is a combination of weir flow through the breach and flow through the spillways. As the breach in the dam develops, so does the breach discharge.

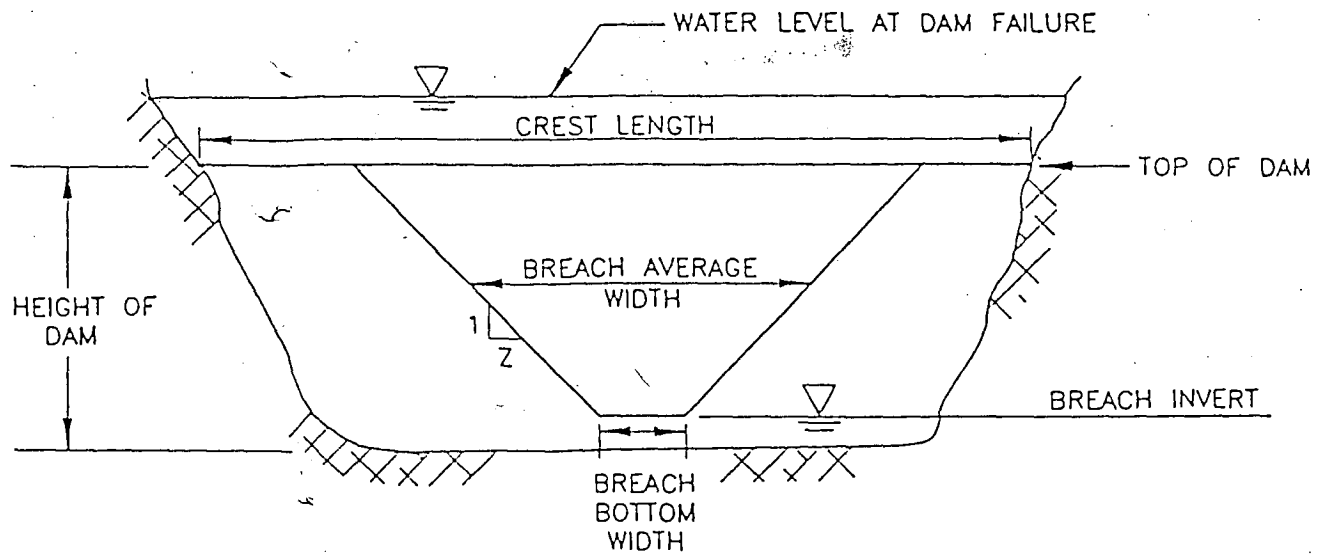


FIGURE 1: DEFINITION SKETCH OF BREACH PARAMETERS

E. Assumed Dam-Breach Parameters.

1. Assumed Piping (sunny-day) Failure Condition
 - i). Initial pool level: (Water surface prior to storm inflow hydrograph) El. 1391.0 NGVD.
 - ii). Dam failure level: (Water surface that triggers beginning of breach) El. 1391.0 NGVD.
 - iii). Breach invert: El. 1385.5 NGVD.
 - iv). Breach bottom width: 34 feet with side slopes 1V:0H (rectangle)
 - v). Time to complete formation of breach: 0.20 hours
 - vi). Downstream reach roughness (Manning's "n" value):
 - a. Channel = 0.035 to 0.055
 - b. Over-bank = .055 to .10
 - vii). Embankment Geometry
 - a. Height of dam = 11.5 feet
 - b. Crest length = 129 feet

2. Assumed Overtopping (storm-day) Failure Condition

- i). Initial pool level: El. 1391.0 NGVD.
- ii). Dam failure level: El. 1399.0 NGVD.
- iii). Breach invert: El. 1385.5 NGVD.
- iv). Breach bottom width: 50 feet with side slopes 1V:0H (rectangle).
- v). Time to complete formation of breach: 0.20 hours
- vi). Downstream reach roughness (Manning's "n" value):
 - a. Channel = 0.035 to 0.055
 - b. Over-bank = 0.055 to 0.10
- vii). Embankment Geometry
 - a. Height of Dam = 11.5 feet
 - b. Crest length = 129 feet

F. Downstream Channel Routing. A downstream channel routing analysis allows the breach discharge to be characterized at points of interest below the dam. A breach discharge is attenuated and stored through a downstream channel and flood plain in a manner similar to that by which an inflow hydrograph is routed through a reservoir. The degree to which this breach discharge is attenuated is a function of the downstream valley storage capacity and valley roughness characteristics.

1. Method: The Dynamic Wave method of channel routing is used in the NWS "Dambrk" program to route the flood wave downstream. This is a hydraulic routing method that solves complete equations of unsteady flow through a given reach. Results of this method indicate attenuation of the flood wave, resulting flood stages, and the time it takes for the wave to reach the section.

2. Typical Downstream Cross Sections: To determine valley storage capabilities, reach cross sections were obtained from field surveys and USGS maps. Manning's "n" values were assigned to the channel and over-banks on the basis of field observations and standard reference materials.⁹ These values are listed with the dam breach parameters, in Section E.

3. Downstream Flow Structures: The downstream channel routing procedure is based on the assumption that flow structures below the dam (i.e., culverts, bridges, etc.) do not become partially or fully blocked with debris. The hydraulic rating data for these structures assumes full hydraulic capacity. If structures become blocked with debris, then the peak water surface behind them could increase to stages higher than estimated.

In addition, all of the flow structures were assumed not to fail in the dambreak computer model, in order to estimate the maximum water level. However, because of the increased flood stages and velocities associated with a dam-break, failure of any or all of the flow structures is possible. This study does not attempt to estimate if any downstream structure will fail during a dambreak of Shadow Lake.

4. Antecedent Channel Flows: In order for the NWS Dambrk model to mathematically converge on initial (antecedent) channel conditions, a minimum amount of flow is required. For the sunny-day condition, initial flow was 10 cfs. Although higher than actual field conditions, this value is insignificant compared to routing of the breach discharge. For the storm-day condition, the antecedent flow is the $\frac{1}{2}$ PMF. The $\frac{1}{2}$ PMF is routed through Shadow Lake using Boss Dambrk and dam failure begins when the water reaches its maximum elevation. The resulting breach discharge hydrograph is superimposed onto the $\frac{1}{2}$ PMF hydrograph and simultaneously routed down the channel.

G. Project Mapping

The project mapping was developed by enlarging the USGS, Crystal Lake, Vt. Quadrangle, (1986, 7'-30", provisional), Vermont, 7'-30".¹⁰ Locations of structures within the inundation limits were verified through field survey and site reconnaissance. The original scale of 1:24,000 was enlarged to 1:4,800.

H. Vertical Control

Vertical control for this investigation was obtained by using a standard U.S.G.S. disk (W4 1934) located on the west end of the north abutment of a concrete bridge over the Barton River. This bridge is located near the intersection of Vt. Rt. 16 with Shadow Lake Road (S.4.2). The published elevation is 1189.122 NGVD (National Geodetic Survey, 1929)

V. RESULTS OF ANALYSIS

A. Inflow Hydrograph

As presented in Table 1, the peak inflow resulting from a 100-year storm event was 2,168 cfs and a ½ PMF resulted in a peak inflow of 6,094 cfs. Plate 8 shows that the 100-year storm inflow hydrograph peaks at 13.7 hours into a 24-hour storm. Plate 9 shows that the ½ PMF peaks at 30.2 hours into a 48-hour storm. The time base for these two graphs relate to a 24-hour clock, eg., 1100 = 11:00 AM, 1400 = 2:00 PM, and 0 = Midnight. These hydrographs were developed with the HEC-1 computer model.

B. Reservoir Storage Capacity

The maximum storage capacity at the top of dam is approximately 2,283 acre-feet. As determined from the 100-year inflow hydrograph analysis, 1,781 acre feet of water is stored behind the dam, so that the resulting maximum stage under this storm event is El. 1394.4 NGVD.

C. Spillway Hydraulic Capacity

The maximum spillway hydraulic capacity at the top of dam is approximately 346 cfs which excludes any flow from the gate house. Shadow Lake Dam does appear to have adequate storage and hydraulic spillway capacity to route and pass the 100-year and ¼ PMF storm events without overtopping the dam; no resulting failure was assumed. Peak discharges of 96 cfs from the 100-year storm and 305 cfs from the ¼ PMF storm.

D. Breach Discharge Hydrograph

Tables 2 and 3 summarize the peak discharge and the downstream channel routing results under a sunny-day and storm-day failure, respectively.

Sunny-day failure of Shadow Lake Dam resulted in a peak breach discharge of approximately 2,321 cfs. The water surface was at El. 1,391.0 NGVD when failure began, and the breach was modelled to develop fully within 12 minutes. Plates 10 and 11 shows the sunny-day breach discharge over time and distance downstream.

Storm-day failure results in a peak breach discharge of 8,446 cfs with the ½ PMF as the base flood. Failure begins once the water reaches maximum stage (El. 1399.3 NGVD) and the breach is assumed to develop fully within 12 minutes. Plates 12 and 13 shows the storm-day breach discharge over distance and time. Plates 10 through 13 are graphical outputs from the Boss Dambrk computer model.

TABLE 1

SHADOW LAKE DAM
GLOVER, VERMONT

100-YEAR AND PMF STORM RESERVOIR ROUTING SUMMARY

Flood Frequency	Drainage Area (acres)	Peak Inflow (cfs)	Peak * Outflow (cfs)	Maximum Lake Water Level (NGVD)	Available Freeboard ** (feet)
100-year	3328	2,168	96	1394.4	2.6
1/4 PMF	3328	2,612	305	1396.6	0.4
1/2 PMF	3328	6,094	3,571	1401.0	Overtopped
3/4 PMF	3328	9,543	7,334	1403.9	Overtopped
1 PMF	3328	12,955	10,910	1406.2	Overtopped

Values rounded to nearest significant digit.

* Discharge computed by HEC-1; non-failure of Shadow Lake Dam assumed.

** Measured from maximum lakes water level to elevation 1397.0 (assumed top of dam).

TABLE 2

SHADOW LAKE DAM
GLOVER, VERMONT

DOWNSTREAM CHANNEL ROUTING RESULTS
Sunny-Day Failure

Downstream Location	<u>Peak Water Surface</u>			
	Peak Discharge (cfs)	Elevation NGVD	Above Streambed (feet)	Time to Peak * (hours)
Shadow Lake Dam 0 Feet (0.0 mi.)	2,321	1,391.0	5.5	0.20
300 Feet (0.06 mi.) T.H. 40	2,321	1,390.0	12.0	0.66
3,500 Feet (.66 mi.) Private Drive	2,321	1,247.4	6.4	0.74
5,400 Feet (1.02 mi.) Confluence with Barton River	2,160	1,195.2	9.2	1.30
5,900 Feet (1.12 mi.) Private Drive	2,148	1,193.7	10.7	1.30
9,875 Feet (1.87 mi.)	2,121	1,176.6	7.6	1.60
16,300 Feet (3.08 mi.) Perron Hill End of Study	2,070	1,132.7	9.7	2.22

Values rounded to nearest significant digit.

* After breach initially begins to develop.

TABLE 3

SHADOW LAKE DAM
GLOVER, VERMONT

DOWNSTREAM CHANNEL ROUTING RESULTS

Storm-Day Failure

Peak Water Surface

<u>Downstream Location</u>	<u>Peak Discharge (cfs)</u>	<u>Elevation NGVD</u>	<u>Above Streambed (feet)</u>	<u>Time to Peak (hours)</u>
Shadow Lake Dam 0 Feet (0.0 mi.)	8,446	1,399.3	13.8	6.8
300 Feet (0.06 mi.) T.H. 40	8,446	1,397.1	19.1	6.9
3,500 Feet (.66 mi.) Private Drive	8,446	1,253.0	12.0	7.8
5,400 Feet (1.02 mi.) Confluence with Barton River	10,950 **	1,202.5	16.5	8.0
5,900 Feet (1.12 mi.) Private Drive	10,933	1,199.9	16.9	8.0
9,875 Feet (1.87 mi.)	10,761	1,184.5	15.5	8.4
16,300 Feet (3.08 mi.) Perron Hill End of Study	8,165	1,142.7	19.7	10.9

Values rounded to nearest significant digit.

* After breach initially begins to develop.

** Flow increases because of lateral flood inflows from Barton River.

E. Downstream Channel Routing

As shown in these breach discharge hydrographs, flows are attenuated as they are routed downstream. Plates 5, 6 and 7 show peak water surface profiles under both failure conditions at various locations downstream.

1. Sunny-day Results: The sunny-day peak breach discharge of 2,321 cfs had virtually no attenuation as it approached the confluence with the Barton River.

The peak discharge at the first downstream flow structure (Town highway 40) was 2,321 cfs. The maximum water level was El. 1390.0 NGVD, which is equal to the top of the road.

The peak discharge at the second downstream flow structure (private driveway at 3,500 feet) was 2,321 cfs. The estimated peak water level is below the driveway. The house at this driveway (third house below the dam) is located high on the left bank of Shadow Lake Brook, above the floodplain.

The peak discharge at the third downstream flow structure (private driveway, 5,900 feet) was 2,148 cfs. The estimated peak water level is El. 1193.7 NGVD, which is approximately 0.3 feet below the driveway. The house, located on the left bank of Barton River, sill El. 1200.8 NGVD is approximately 7.1 feet above the estimated peak water level.

The peak discharge at the fourth downstream flow structure (Perron Hill Road, 16,300 feet) was 2,070 cfs. The estimated peak water level is El. 1132.7 NGVD, which is approximately 1.3 feet below the road. The lowest house sill elevation next to this road, El. 1135.3 NGVD is approximately 2.6 feet above the estimated peak water level.

2. Storm-day Results: The storm-day peak breach discharge of 8,446 cfs (at the dam) had virtually no attenuation as it approached the confluence with the Barton River.

The peak discharge at the first downstream flow structure (Town highway 40) was 8,446 cfs. This peak discharge overtopped the road by approximately 7.1 feet, resulting in a maximum water level of El. 1,397.1 NGVD.

The peak discharge at the second downstream flow structure (private driveway, 3,500 feet) was 8,446 cfs. This peak discharge overtopped the driveway by approximately 3.0 feet, resulting in a peak water surface elevation of El. 1,253.0 NGVD. The house at this driveway is located high on the left bank of Shadow Lake Brook, above the floodplain.

The peak discharge at the third downstream flow structure (private driveway, 5,900 feet) was 10,933 cfs. The peak flow increased because of the lateral inflow from the Barton River. This peak discharge overtopped the driveway by approximately 5.9 feet, resulting in a peak water surface elevation of El. 1,199.9 NGVD. The house at this driveway (located on the left side of Barton River, sill El. 1200.8 NGVD) is approximately 0.9 feet above the estimated peak water surface.

The peak discharge at the fourth downstream flow structure (Perron Hill Road, 16,300 feet) was 8,165 cfs. This peak discharge overtopped the road by approximately 8.7 feet, resulting in a peak water surface elevation of El. 1,142.7 NGVD. The lowest house sill elevation next to the road, El. 1135.3 NGVD is approximately 7.4 feet below the estimated peak water surface.

F. Inundation Mapping

The limits of inundation were computed by routing the breach discharge through downstream valley cross sections and delineating the resulting maximum stages on the base map. Plates 3 and 4 show the limits of inundation over the study area. Although all structures within these limits were assumed to be inundated, certain structures may be excluded as a result of local conditions and elevations.

G. Size Classification

Shadow Lake Dam is 11.5 feet high at its maximum section. The maximum available storage behind the impoundment is 2,283 acre-feet. According to Article 2.1.1 of the Recommended Guidelines for Safety Inspection of Dams,¹¹ the dam size is "INTER-MEDIATE".

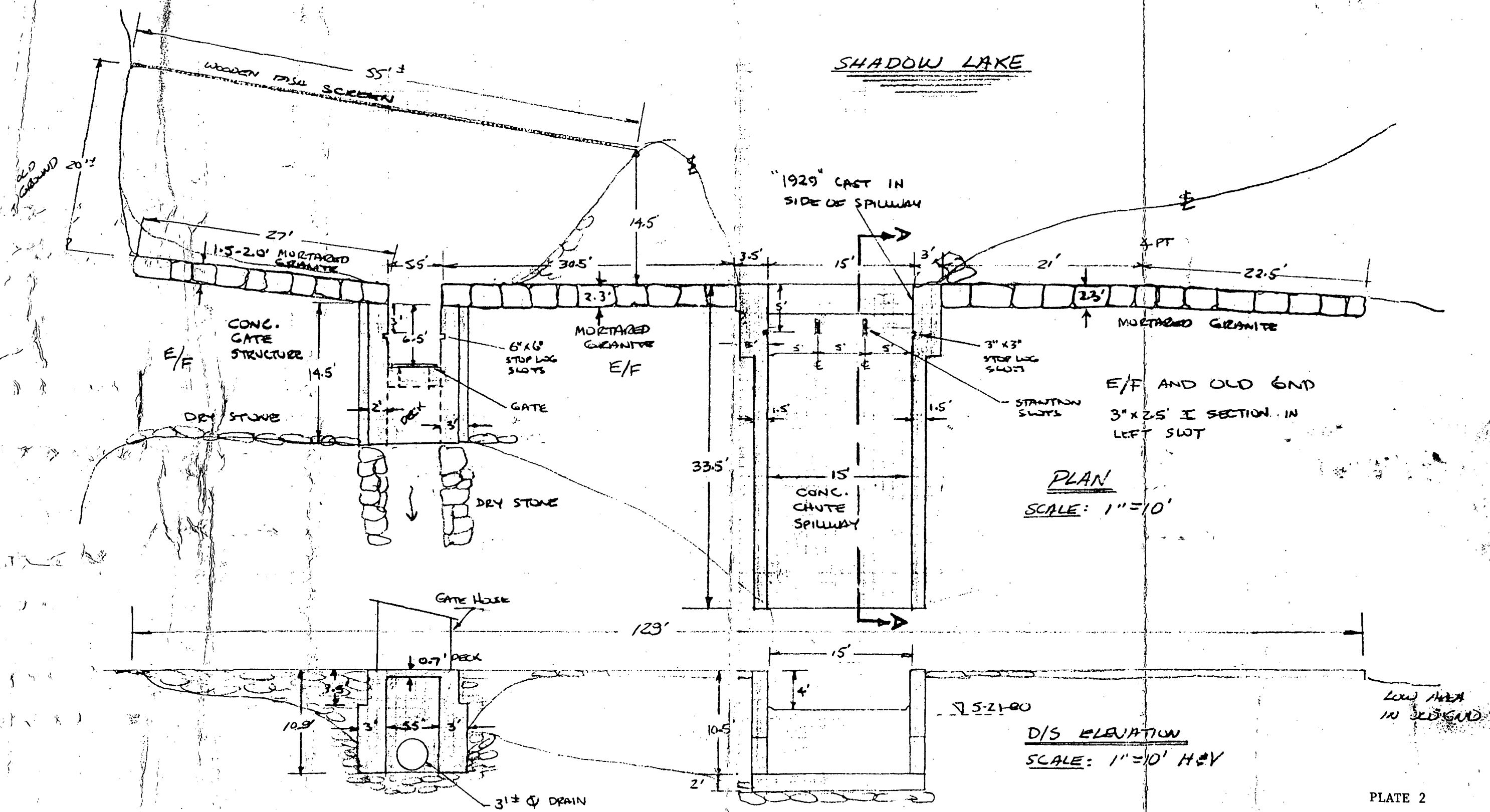
H. Hazard Classification

On the basis of its potential to cause downstream damage, the Shadow Lake Dam is given a Class 2 "SIGNIFICANT" hazard classification; refer to the Downstream Hazard Classification of Dams on page 1 of this document.

Damage resulting from a sunny-day failure could include streambank erosion and overtopping of at least one road crossings within the study area. There is one habitable structure which may be subject to inundation resulting from a sunny-day failure. This is the house located adjacent to Perron Road, on the left bank of the Barton River. Discharge over Perron Road could result in inundation of the first floor of this house.

Damage resulting from a storm-day failure could include streambank erosion and overtopping of all four road crossings within the study area. Two of the identified habitable structures could be subject to be inundation by a storm-day breach discharge. These houses are located next to Perron Road, on the left bank of the Barton River.

SHADOW LAKE



PLAN
SCALE: 1"=10'

D/S ELEVATION
SCALE: 1"=10' H & V

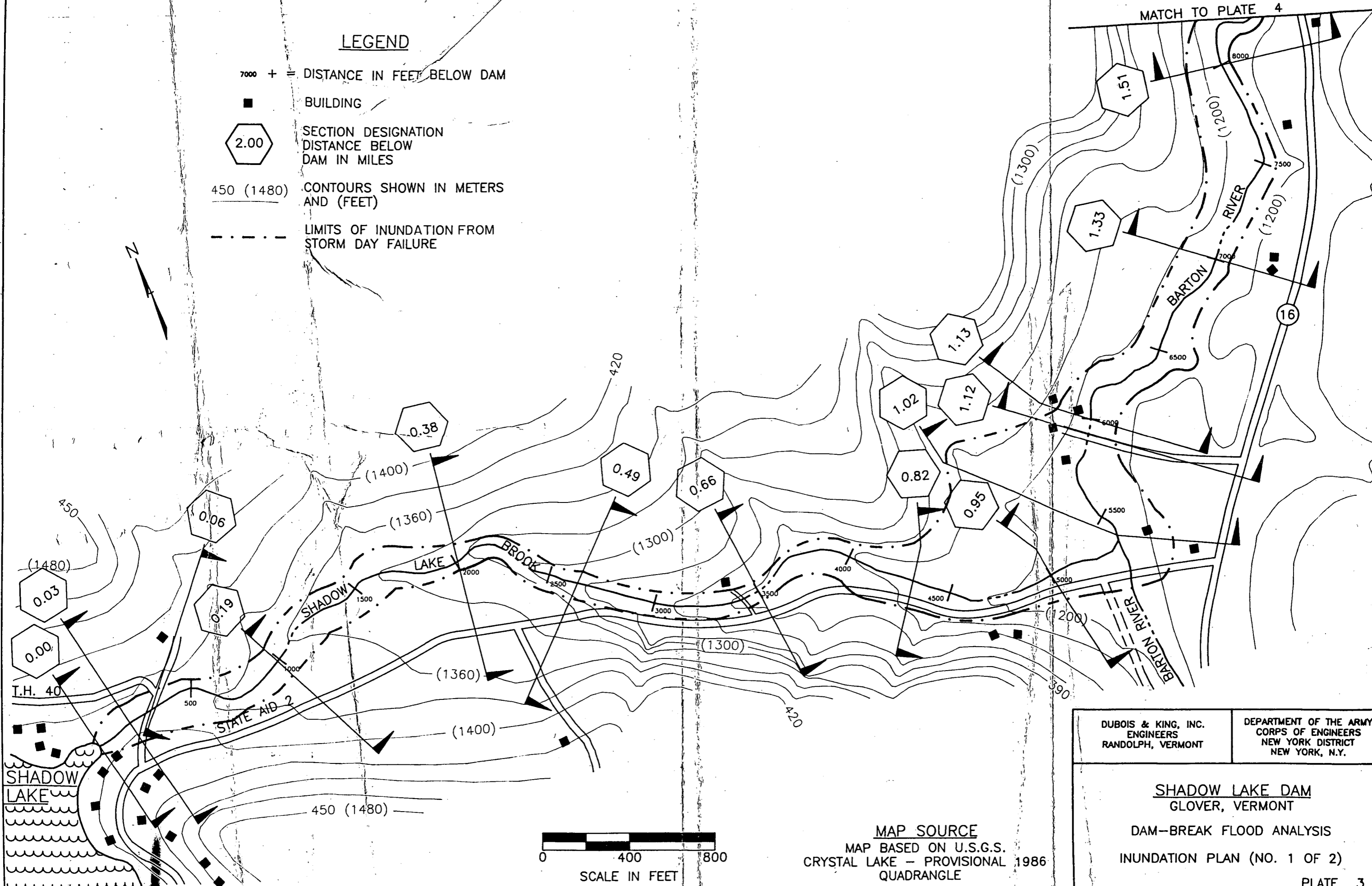
NOTE: WIDTH OF GATE STRUCTURE VARIES FROM 5.1-5.5' U/S OF GATE

∇ = WL on 5-21-80 5.0' BELOW TOP OF SPILLWAY WALL

INSPECTION / SURVEY
5-21-80 APB
CLOTH TAPE, HAND LEVEL AND 6' RULE
DRAWN
5-28-82 APB

LEGEND

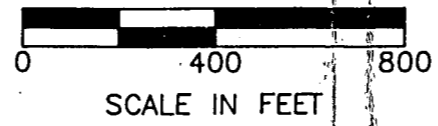
- 7000 + = DISTANCE IN FEET BELOW DAM
- BUILDING
- 2.00 SECTION DESIGNATION
DISTANCE BELOW
DAM IN MILES
- 450 (1480) CONTOURS SHOWN IN METERS
AND (FEET)
- - - - - LIMITS OF INUNDATION FROM
STORM DAY FAILURE



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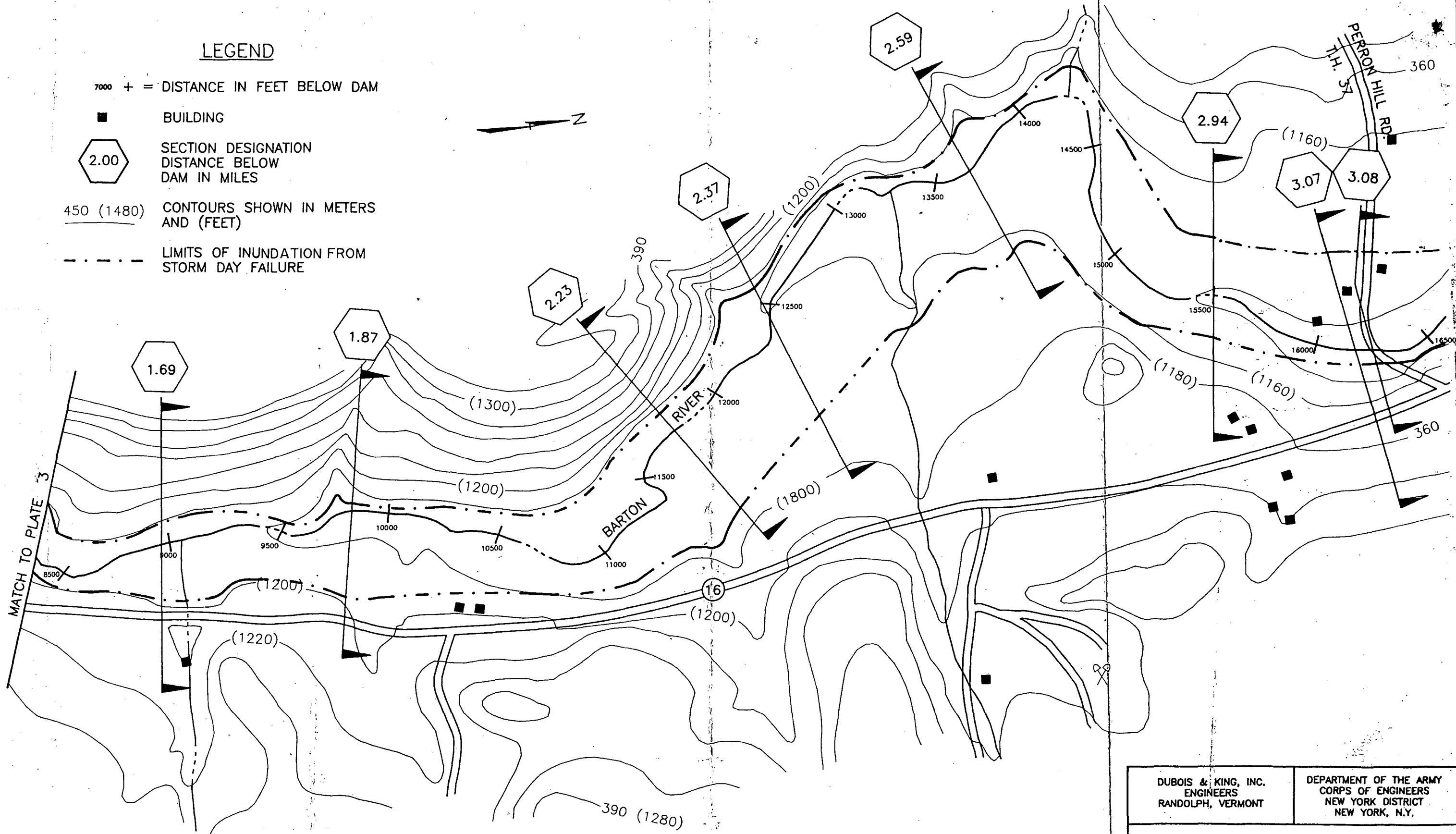
SHADOW LAKE DAM
 GLOVER, VERMONT
 DAM-BREAK FLOOD ANALYSIS
 INUNDATION PLAN (NO. 1 OF 2)
PLATE 3

MAP SOURCE
 MAP BASED ON U.S.G.S.
 CRYSTAL LAKE - PROVISIONAL 1986
 QUADRANGLE



LEGEND

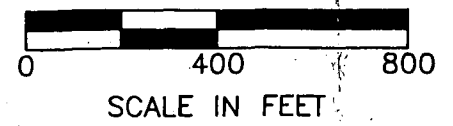
- 7000 + = DISTANCE IN FEET BELOW DAM
- BUILDING
- 2.00 SECTION DESIGNATION
DISTANCE BELOW
DAM IN MILES
- 450 (1480) CONTOURS SHOWN IN METERS
AND (FEET)
- - - - - LIMITS OF INUNDATION FROM
STORM DAY FAILURE

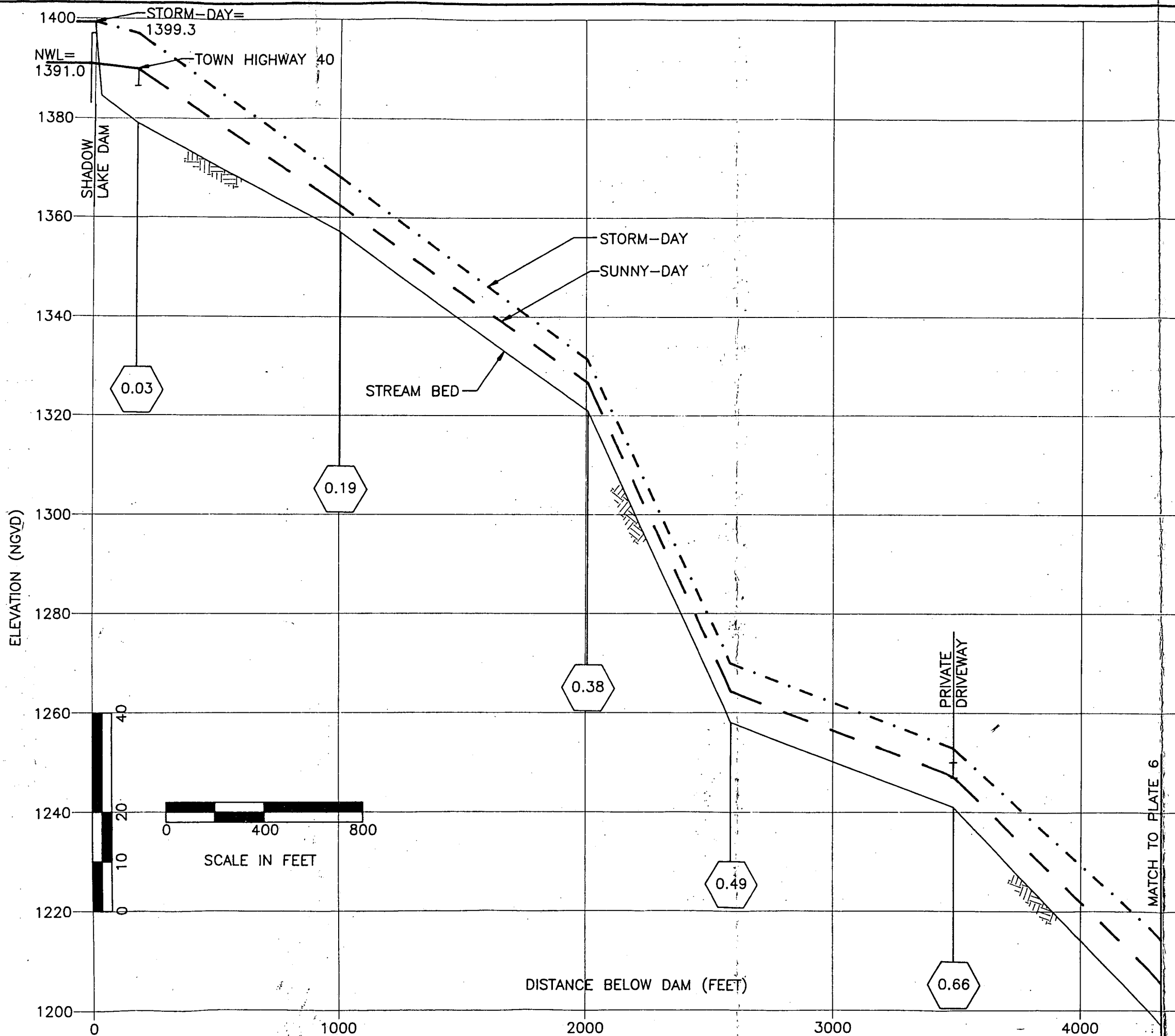


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SHADOW LAKE DAM
 GLOVER, VERMONT
 DAM-BREAK FLOOD ANALYSIS
 INUNDATION PLAN (NO. 2 OF 2)
 PLATE 4

MAP SOURCE
 MAP BASED ON U.S.G.S.
 CRYSTAL LAKE - PROVISIONAL 1986
 QUADRANGLE





0.77

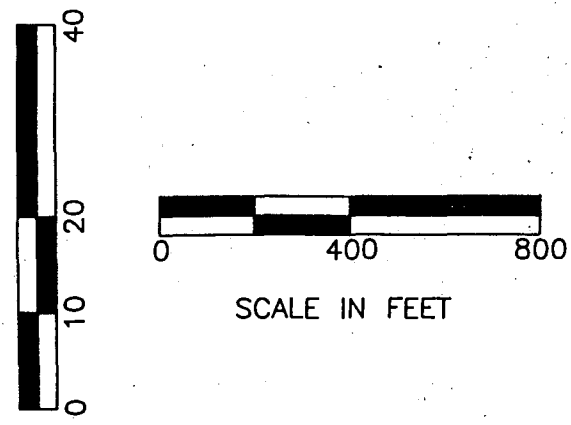
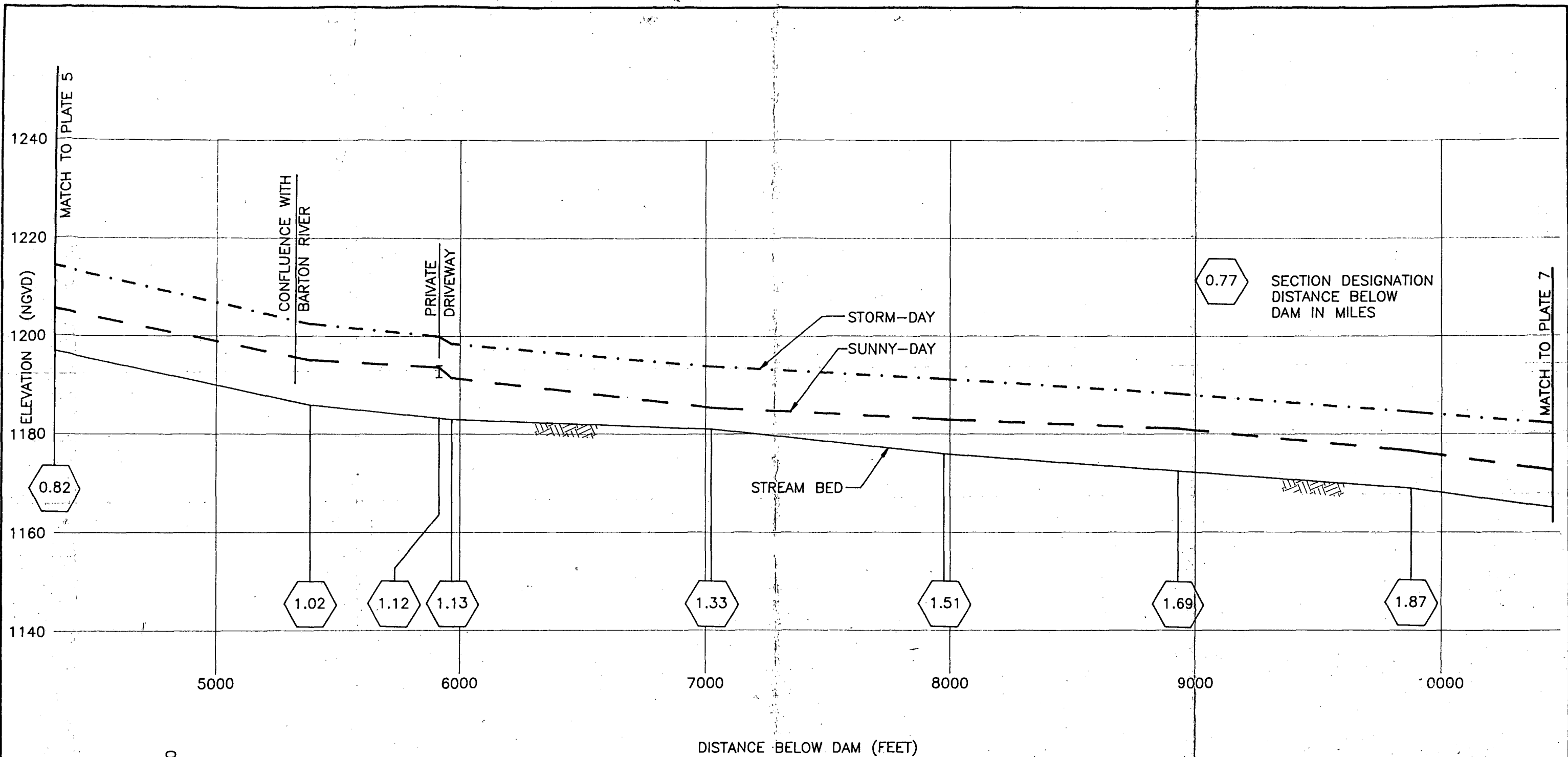
SECTION DESIGNATION
DISTANCE BELOW
DAM IN MILES

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SHADOW LAKE DAM
GLOVER, VERMONT

DAM-BREAK FLOOD ANALYSIS
PEAK WATER SURFACE PROFILE

PLATE 5

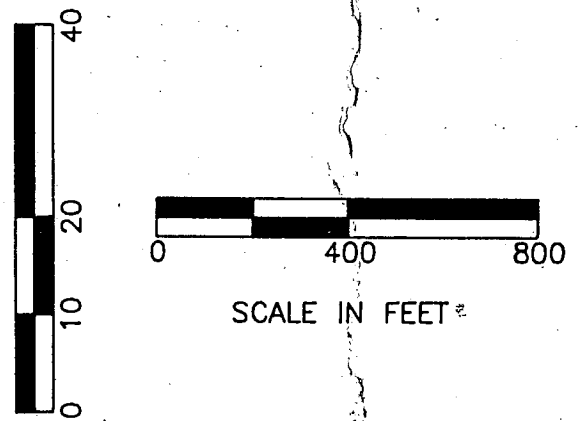
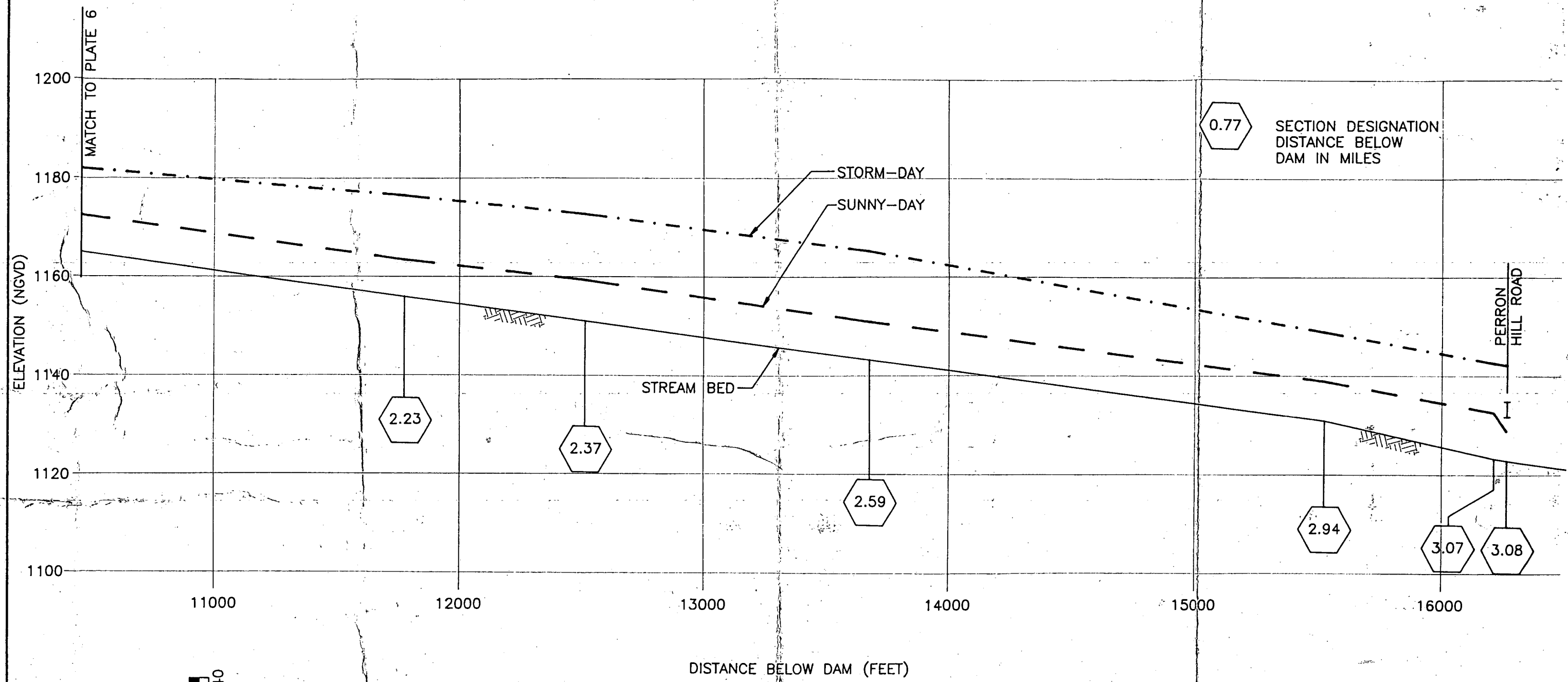


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SHADOW LAKE DAM
 GLOVER, VERMONT

 DAM-BREAK FLOOD ANALYSIS
 PEAK WATER SURFACE PROFILE

 PLATE 6



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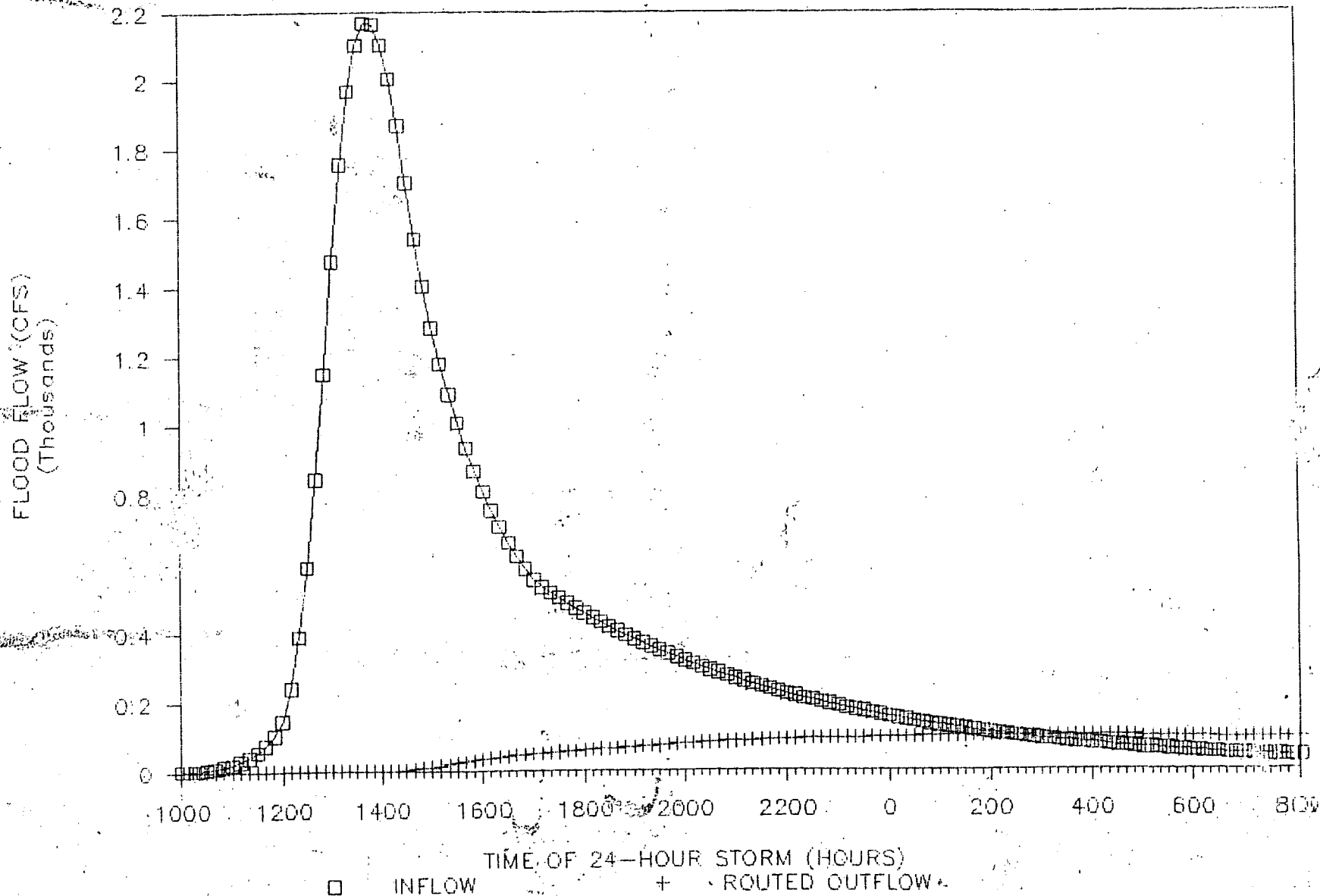
SHADOW LAKE DAM
 GLOVER, VERMONT

DAM-BREAK FLOOD ANALYSIS
 PEAK WATER SURFACE PROFILE

PLATE 7

SHADOW LAKE DAM : GLOVER, VERMONT

100-YEAR STORM HYDROGRAPH ANALYSIS



SHADOW LAKE DAM : GLOVER, VERMONT

1/2 PMF STORM HYDROGRAPH ANALYSIS

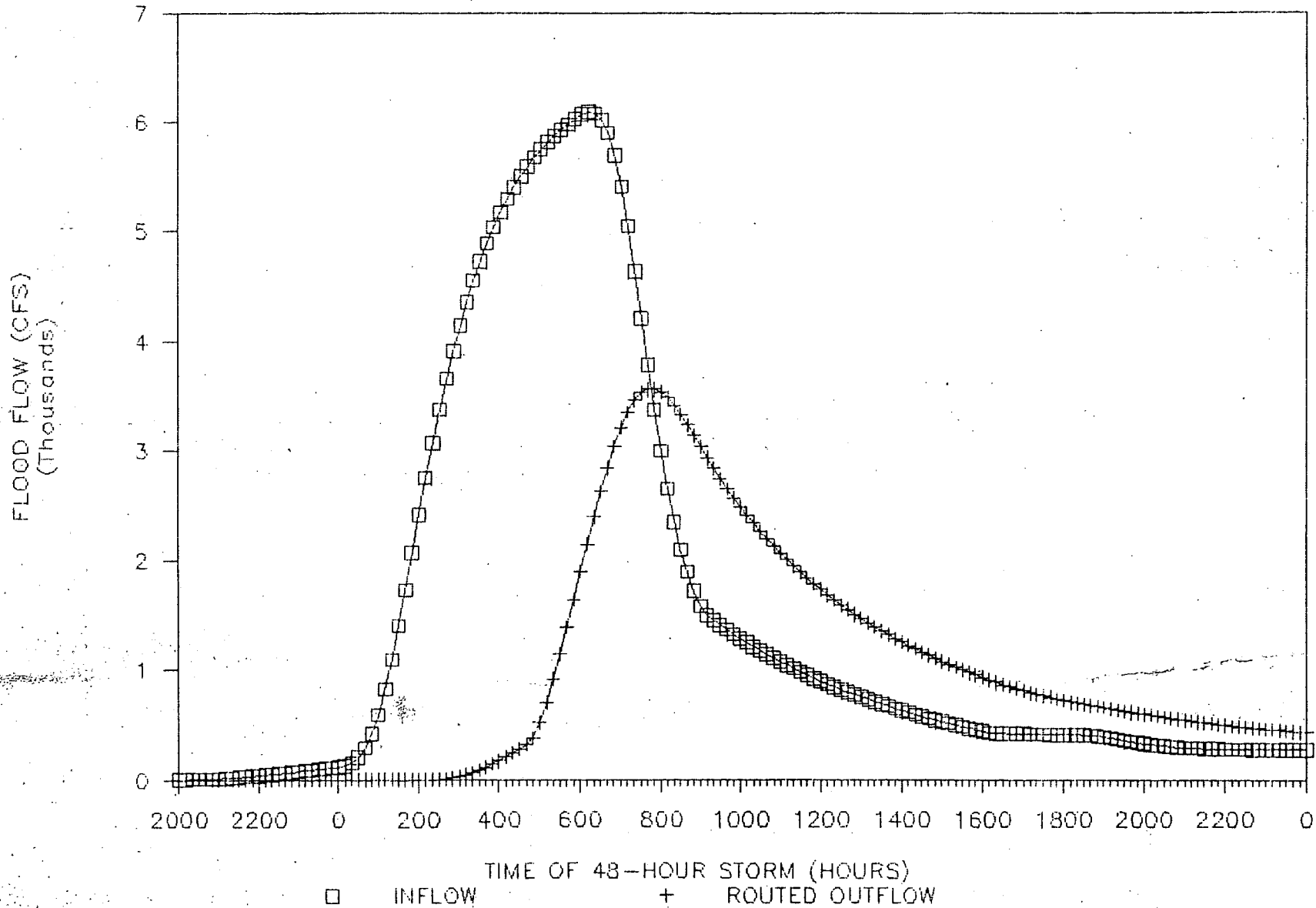
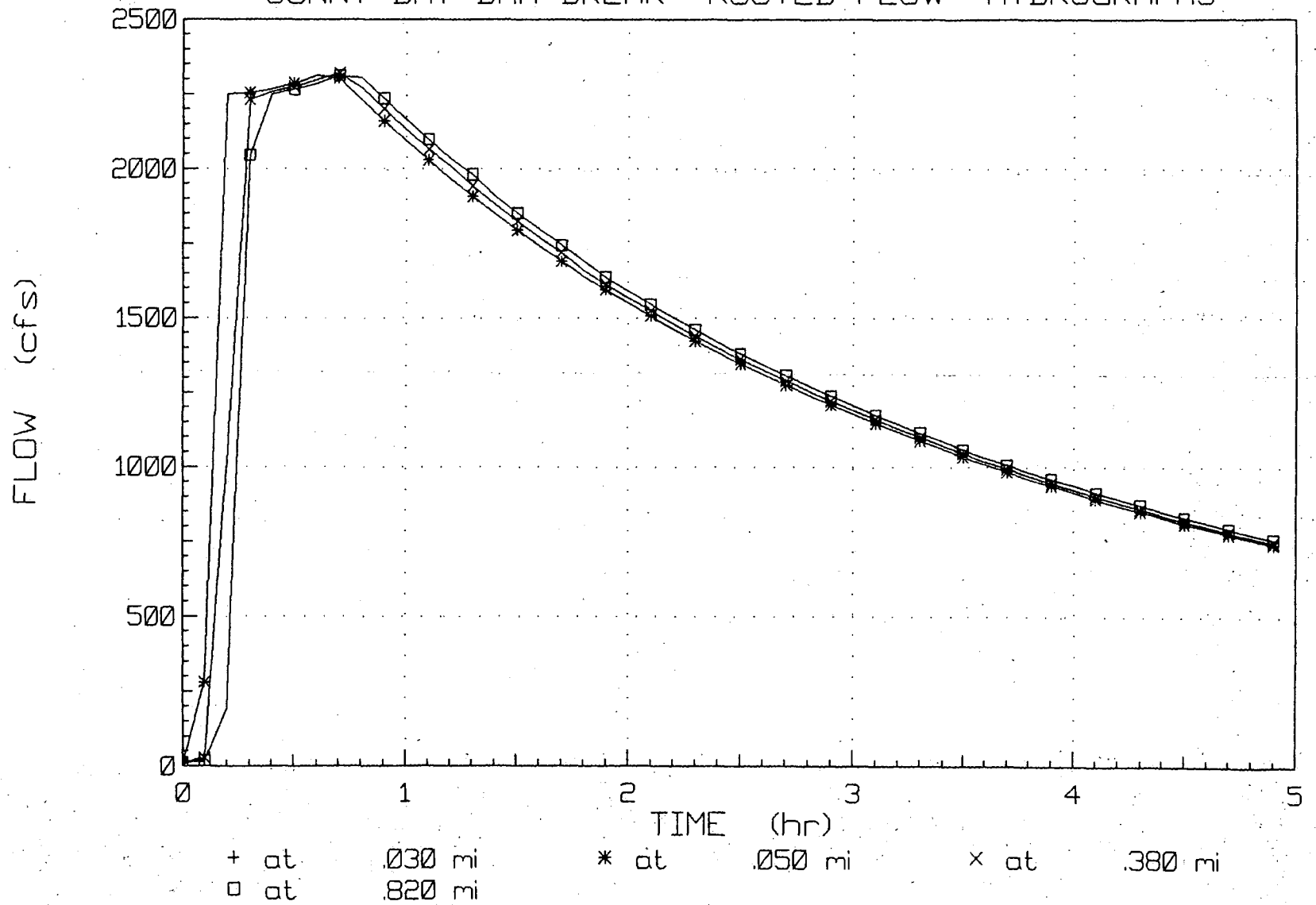


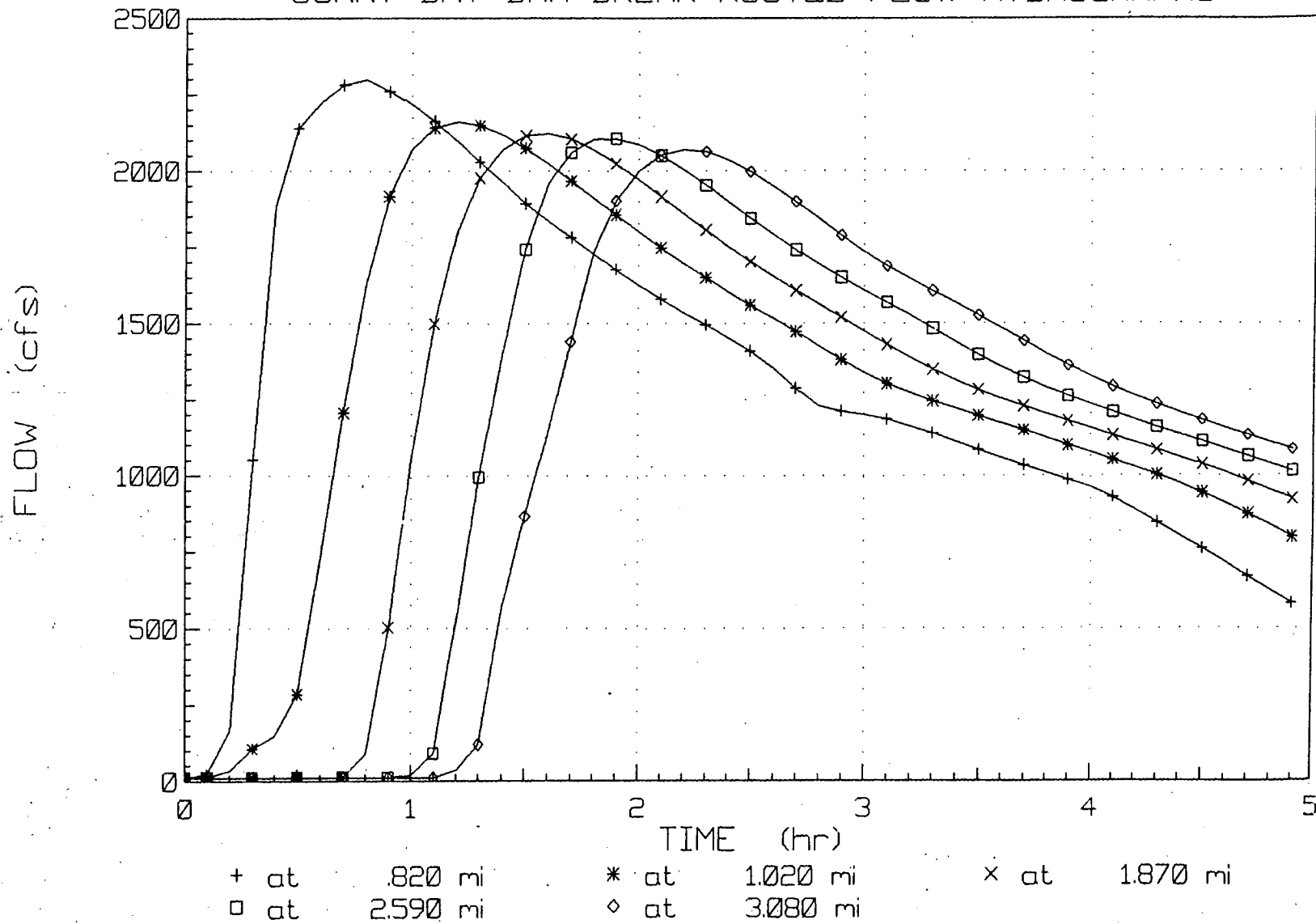
PLATE 9

SHADOW LAKE DAM : GLOVER, VERMONT
SUNNY-DAY DAM-BREAK ROUTED FLOW HYDROGRAPHS

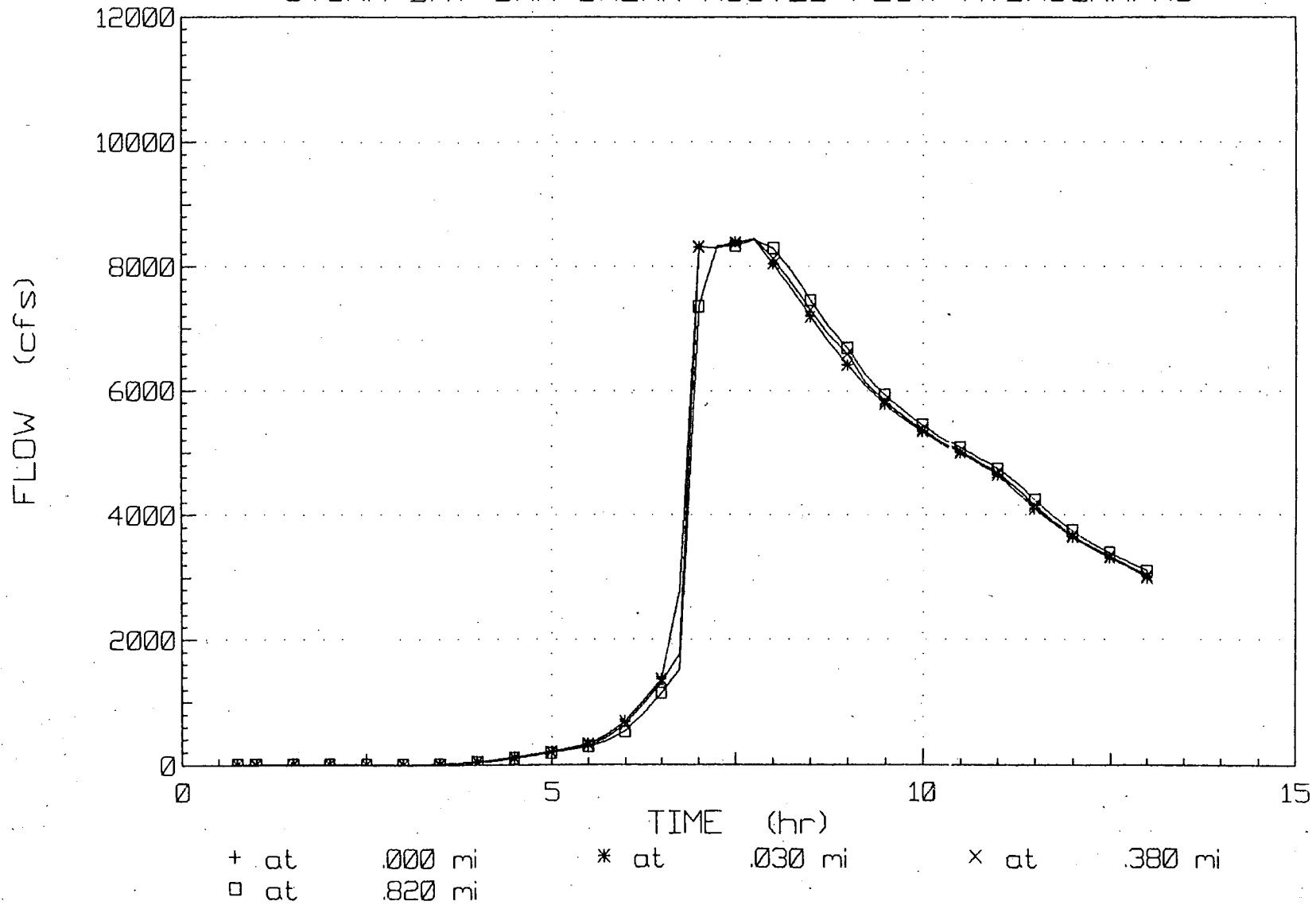


SHADOW LAKE DAM : GLOVER, VERMONT

SUNNY-DAY DAM-BREAK ROUTED FLOW HYDROGRAPHS

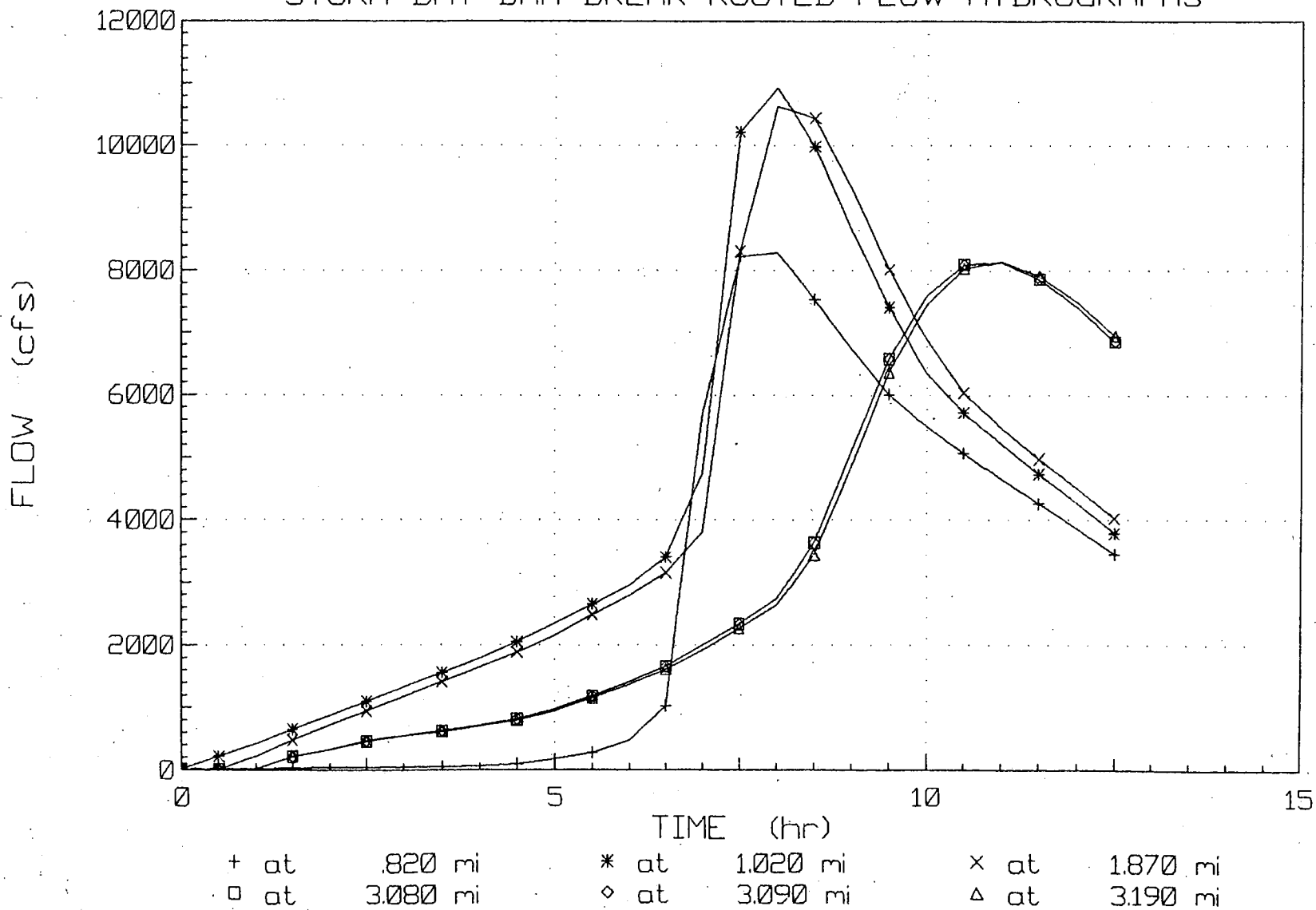


SHADOW LAKE DAM : GLOVER, VERMONT
 STORM-DAY DAM-BREAK ROUTED FLOW HYDROGRAPHS



SHADOW LAKE DAM : GLOVER, VERMONT

STORM-DAY DAM-BREAK Routed FLOW HYDROGRAPHS



EMERGENCY ACTION PLAN
for
SHADOW LAKE DAM

I. INTRODUCTION

A. Purpose

This Emergency Action Plan (EAP) is a suggested procedural outline¹² indicating appropriate steps to be taken in the event of an impending failure of the Shadow Lake Dam. Also, this EAP lists phone numbers of certain local and state officials to contact in case of an emergency.

B. Items in the EAP

The following are major items which should be addressed by the owner of the dam:

1. Monitoring
2. Evaluation
3. Preventive Action
4. Warning

II. MONITORING

A. Purpose

Having a person monitor the dam in the event of an impending dam failure is the first step in implementing the EAP. During periods of heavy precipitation, flooding or any unusual hydrologic events that might cause structural damage to the dam, the owner should have qualified personnel monitor the dam. The owner should assume responsibility for having the monitor at the dam within a reasonable time and for providing an adequate communication system between the monitor and local officials.

B. The designated monitor is:

1. Name: Mr. John H. Doe
2. Address: Main Street
Glover, Vermont
3. Phone: Home: (802) 222-2222
Work: (802) 222-2222

C. Type of Training

The owner should provide proper training such that the monitor will have sufficient ability to recognize the condition of the dam and be able to identify and evaluate specific problem areas. This training should be extensive enough to allow the monitor to describe condition to local officials.

D. Communication System

The owner should provide primary and secondary communication systems between the dam monitor and local officials.

1. Primary System: Normal telephone communication. The monitor should have access to the nearest available telephone and should have on his person the phone numbers of all appropriate necessary local officials.
2. Secondary System: Shortwave radio. If the phone system is out of order, the monitor should have access to a shortwave radio that can be monitored by local officials with scanners.

As an alternative to this system, if any local officials live within a short of the dam, the monitor could drive to one of their residences if the roads are passable.

III. EVALUATION

A. Purpose In conjunction with the ability to assess the condition of the dam, the monitor should have the ability to determine and evaluate the nature of any existing problem. This evaluation is a crucial step, because failure to accurately and promptly identify a problem may adversely affect the EAP warning system.

B. Following is a check list of items that the monitor should use for assistance in preparing a safety assessment of the dam.

1. Water Surface Level:
 - i). Elevation
 - a. Normal
 - b. High (If so, how high, with respect to the top top of dam?)

2. Principle Spillway:
 - i). Condition upon arrival
 - a. Clear
 - b. Blocked (If so, to what extent?)
3. Emergency Spillway:
 - i). Condition upon arrival
 - a. Clear
 - b. Blocked (If so, to what extent?)
4. Top of Dam Crest
 - i). Condition upon arrival:
 - a. Cover
 - b. Erosion
5. Down-Stream Face:
 - i). Condition upon arrival:
 - a. Cover
 - b. Erosion
 - c. Evidence of piping

IV. PREVENTIVE ACTION

A. Purpose

This section addresses actions that the monitor can take to help prevent an overtopping failure of Shadow Lake Dam.

B. The monitor should ensure that the principle and emergency spillways are kept clear of debris during normal conditions. In the event of flood conditions, the monitor should also take reasonable steps to ensure that the spillways do not become blocked with debris so that they can carry their full capacity. The monitor's safety should not be jeopardized.

V. WARNING

A. Purpose

If the monitor feels that possible failure of the Shadow Lake Dam is imminent, he should immediately notify the designated parties by utilizing previously established communication systems. The monitor should notify the following officials and the downstream residents. Others can be contacted if determined necessary by the monitor.

B. Officials to Contact (as of February 1991)

1. Mr. Dean Bailey
Administrative Assistant to Selectmen
Home: (802) 525-3760
2. Mr. Lawrence White
Chairman - Town of Glover Selectmen
Home: (802) 525-6286
3. Mr. David Perron
Constable
Town of Glover
Home: (802) 525-3895
4. Mr. Alton Brooks
Fire Chief
Town of Glover
Home: (802) 525-3612
5. Mr. David Perron
Civil Defense
Town of Glover
Home: (802) 525-3895
6. Vermont Emergency Management Agency
24 Hour Duty Officer
1-800-422-8606
(802) 244-8721
7. Town of Glover
Owner of Dam
Glover, Vermont
Town Clerk Office: (802) 525-6227

Officials at the Vermont Emergency Management office can be reached (24) hours a day. During normal business hours, the receptionist at the office will locate the current duty officer. During all other hours the phone connects to the Vermont State Police Department in Waterbury, Vermont, which will locate the duty officer. In the event that the phone system has failed, any Vermont State Police barracks or cruiser can reach the duty officer through its radio system. Any available shortwave radio or CB radio could be utilized to contact the nearest police barracks.

C. Downstream Residents

(To Be Filled Out and Periodically Updated by Dam Owner)

<u>Name</u>	<u>Phone Number</u>
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APPENDIX A

REFERENCES

REFERENCES

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