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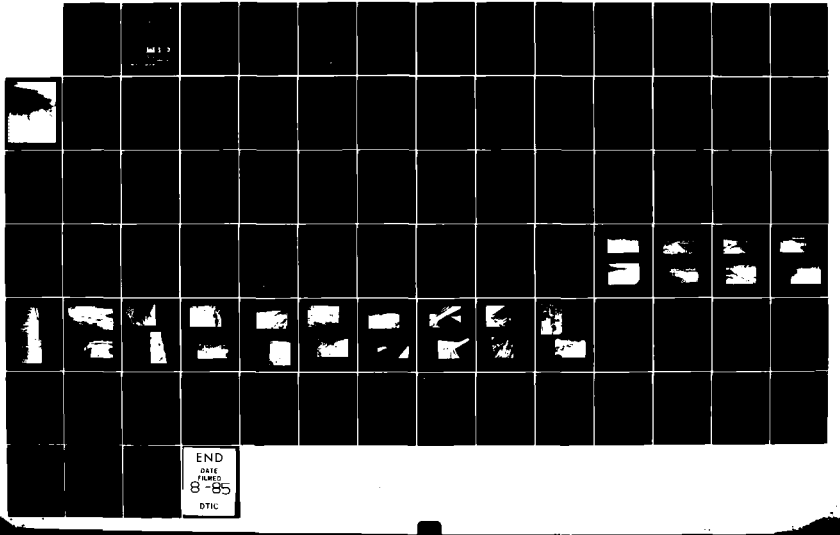

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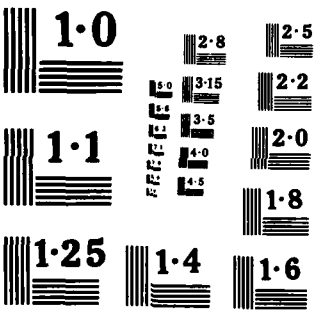
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RICHELIEU RIVER BASIN

CHITTENDEN, VERMONT

CHITTENDEN DAM

VT 00178

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JANUARY 1979

UNCLASSIFIED

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Richelieu RVver Basin
Chittenden, vT.
East Creek

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a 967 ft. long, 54 ft. high composite consisting of stone masonry, earth and rock fill. The dam is in good condition although the inspection revealed minor slumping of the riprap on the upstream slope of the dam. It is intermediate in size with a high hazard potential. There are various recommendations which should be undertaken by the owner.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

MAY 2 1979

Honorable Richard A. Snelling
Governor of the State of Vermont
State Capitol
Montpelier, Vermont 05602

Dear Governor Snelling:

I am forwarding to you a copy of the Chittenden Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Water Resources, the cooperating agency for the State of Vermont. In addition, a copy of the report has also been furnished the owner, Central Vermont Public Service Corporation, 77 Grove Street, Rutland, Vermont 05701.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Water Resources for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

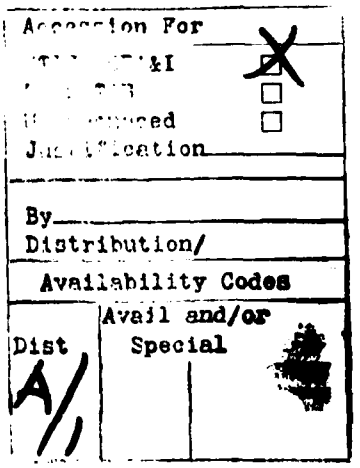
Incl
As stated

CHITTENDEN RESERVOIR

VT 00178

RICHELIEU RIVER BASIN
CHITTENDEN, VERMONT

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



LETTER OF TRANSMITTAL

FROM THE CORPS OF ENGINEERS TO THE STATE

TO BE SUPPLIED BY THE CORPS OF ENGINEERS

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: 00178

Name of Dam: Chittenden Reservoir Dam

Town: Chittenden

County and State: Rutland, Vermont

Stream: East Creek

Date of Inspection: November 9, 1978

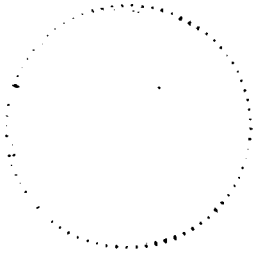
Chittenden Reservoir Dam is a 967 foot long, 54 foot high composite structure consisting of stone masonry, earth and rock fill. This dam was originally constructed in about 1901 with major reconstruction taking place in 1948. A stone masonry wall, with concrete plaster at the upstream face, ranging from 2.0 to 3.0 feet in width and 67 feet deep extends through the embankment. Steel sheeting, 25 feet deep, is located at the right abutment of the dam. The appurtenant works consist of a concrete-lined spillway, a three span truss foot bridge, spillway channel and outlet works. The outlet works is located in the original East Creek bed and consist of an outlet works conduit, a power intake conduit, gate house with electro-mechanical controls and discharge channel. Engineering data available consisted of an undated plan showing a general layout of the dam including profiles, sections and some details. No construction data or design calculations were available.

The visual inspection indicated that the dam is in good condition. The inspection revealed minor slumping of the riprap on the upstream slope of the dam and a pool of water at the base of the spillway structure which is due to seepage through or beneath the dam or around the spillway structure. Also, visual inspection revealed some cracks and efflorescence at the lower segments of the spillway and some downstream obstruction caused by overhanging trees and brush.

Based on the dam's intermediate size and high hazard classification in accordance with Corps of Engineers guidelines, the test flood is the Probable Maximum Flood (PMF). The PMF outflow overtops the dam by 1.9 feet. With the water level at the top of the dam, the spillway will pass 40 percent of the test flood outflow.

It is recommended that the owner engage a qualified engineer to investigate the seepage condition below the spillway structure and design an adequate collection and monitoring system and to further evaluate the potential for overtopping. Also, provisions should be made by the owner to improve the riprap upstream slope protection by filling deficient areas with riprap and raising the general elevation of the riprap to the top of the dam, repair the cracks on the lower section of the spillway and cut back overhanging trees along the downstream channel.

The recommendation and remedial measures are described in Section 7 and should be addressed within two years after receipt of this Phase I - Inspection Report by the owner.



Gordon H. Slaney, Jr.

Gordon H. Slaney, Jr., P.E.
Project Engineer

Howard, Needles, Tammen & Bergendoff
Boston, Massachusetts

This Phase I Inspection Report on Chittenden Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there by any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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APPENDIXES

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APPENDIX B - ENGINEERING DATA

APPENDIX C - PHOTOGRAPHS

APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS

APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure

The Chittenden Reservoir Dam is used primarily for the storage of water for the production of power by the Central Vermont Public Service Corporation. Water stored at Chittenden Reservoir is also used as a water source to Vermont Marble, as well as being used for recreation during the summer months. Under normal operation, the penstock gates are continually open and the waste gates closed. Water level is allowed to reach no higher than three (3) feet below the spillway crest elevation. Water is released from the reservoir as needed for power generation. During the fall and winter the reservoir is drawn down 19 feet below the spillway crest for storage of snowmelt and spring runoff. Water for power generation is fed through a long (greater than one-half mile) 42 inch diameter penstock.

4.2 Maintenance of Dam

This dam is visited by personnel from the Central Vermont Public Service Corporation on a daily basis. During these visits, water levels are recorded, grass is cut as necessary, painting is done as necessary and any major deficiencies that may be noted are reported. Maintenance of the dam is essentially continuous as needed.

4.3 Maintenance of Operating Facilities

Maintenance on the outlet works facilities is done on an as needed basis. The electric gate to the penstock is operated weekly for a maintenance check. The electric gate also has a manual override.

In 1973, the water supply pipe and waste pipe at the outlet works were replaced and/or repaired. All gates were also overhauled at that time.

4.4 Description of Warning Systems

A warning system plan is reportedly on file at the offices of the Central Vermont Public Service Corporation. This plan has been described to include a daily patrol of the dam site. Any dangers are reported to the dispatchers office, which in turn is to contact the Manager of Hydraulic Generation. State Police, radio and television stations are then contacted to broadcast any necessary information.

heavily wooded, with many trees overhanging the channel. Just downstream of the outlet works, the channel passes under a roadway. Several homes are located along the channel, not much above the channel elevation. The steep embankments on either side of the channel are subject to landsliding and severe erosion of the downstream channel could undermine these areas.

3.2 Evaluation

Visual examination indicates the dam is in good condition. The inspection of the dam revealed the following:

(a) Minor slumping of the riprap on the upstream slope of the dam.

(b) A pool of water at the base of the spillway structure which is due to seepage through or beneath the dam or around the spillway structure.

(c) Cracks and efflorescence at the lower segments of the spillway.

(d) Downstream channel obstruction caused by overhanging trees and brush.

The outlet works structure consists of two conduits, one for wastewater and the other for hydro-electric power generation, an intake structure (underwater) and electro-mechanically controlled gates. The control mechanism for the gates is housed in two (2) gate houses, one located at the crest of the dam, the other on the downstream toe.

The waste conduit line has two (2) manually operated gates. These gates are normally always closed. Some leakage was evident at the outlet. This leakage was reported by the owner to be intentional, in order to maintain some flow in the downstream channel. The 42 inch diameter penstock line has three (3) control gates, two manually operated and one electrically operated. The electrically controlled gate is located in the gatehouse on the downstream toe. The penstock gates are checked weekly, and appear to be in good condition.

The outlet works intake structure and conduits were not inspected as they were well below the water surface. Gate-houses housing the control mechanism were, however, inspected and were found to be in good condition. The control mechanism for all gates appeared to be in good condition. The gates themselves were not inspected as they were below water. The gates were not operated but were reported to be operational by the owner's representative.

Visual inspection of outlet works discharge channel showed it to be in generally good condition. There are few overhanging trees that would appear to obstruct free flow of the channel discharge. The spillway discharge channel, Photo 27, is a large relatively flat grassy area with roadways crossing it. The spillway discharge channel leads to the downstream channel of East Creek. The channel area is relatively clear, there are no trees that would appear to obstruct free flow of the channel discharge. A low rock wall crosses the channel but is not considered a major obstruction to flow.

d. Reservoir Area. The reservoir area consists of mountainous, wooded terrain with about 10 houses along the shore. A more detailed description of the drainage area is included in Section 1.3 of this report. The amount of siltation within the reservoir is unknown.

e. Downstream Channel. The downstream channel is steep with steep embankments on either side. The channel area is

by the Vermont Public Service Commission, dated May 12, 1953. In this report, it is stated that "minor seepage appears below the east embankment" (between the spillway and the left abutment). Based on documents in PSC case file #2377, which indicates that the present spillway structure is underlain by a 3 foot thick drainage filter and that the backfill behind the spillway training walls is pervious, it is likely that the seepage noted at the base of the spillway and east embankment is due to seepage around the spillway structure. At the time of inspection, the reservoir level was 15 feet below the crest of the dam. This places the water below or only slightly above the upstream toe of the east embankment.

c. Appurtenant Structure. Visual inspection of a concrete-lined spillway, outlet works structure, discharge channels and spillway bridge did not reveal any evidence of stability problems. The concrete surface generally appeared to be in good condition except for numerous cracks in the spillway retaining walls and concrete spillway surface. The spillway surface cracks are concentrated at the construction joints and the lower segments of the spillway. There is also evidence of efflorescence, a whitish crystalline deposit on the concrete surface, at the construction joints.

The spillway structure, shown in Photos 20 and 21, consists of two concrete retaining walls and concrete-lined spillway surface, shaped as shown on Section B-B, Figure 1 located in Appendix B. Field inspection of the training walls showed concrete surface cracks and rotational movement of some sections of these walls. These movements are about ½ inch in the right training wall and 1-1½ inches in the left training wall. (Relative movements between two lower sections of the training wall.)

The concrete spillway surface is in generally good condition, however there are numerous cracks located at the lower segments of the spillway area. These cracks are concentrated around the construction joints, as can be seen in Photos 24 and 25. There is also evidence of efflorescence, a whitish crystalline deposit on the concrete surface, at the construction joints.

The foot bridge over the spillway is a three span continuous beam structure (2-15" channel shapes). The main longitudinal beams, bearing plates, connections, railing and wooden floor are generally in good condition as shown in Photos 20, 21 and 22.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Chittenden Dam was made on November 9, 1978. The inspeation team consisted of personnel from Howard, Needles, Tammen & Bergendoff and Geotechnical Engineers, Inc. Representatives of the Central Vermont Public Service Corporation, the Vermont Public Service Board and Vermont Agency of Environmental Conservation were also present during the inspection. Inspection checklists, completed during the visual inspection are included in Appendix A. At the time of the inspection, the water level was approximately 8 feet below the permanent spillway elevation. No water was passing over the spillway. The upstream face of the dam could only be inspected above this water level.

b. Dam. Visual inspection of the dam indicated that the dam is in good condition.

Upstream Slope

The upper 15 feet of the upstream slope was visible at the time of inspection. As shown in Photos 8 and 19, the riprap slope protection has experienced minor slumping, and in some locations, is not of adequate size to protect the slope from storm waves. In Photo 18, the riprap slope protection stops about 12 feet below the crest of the dam. This may be a result of the two stage construction of the dam which resulted in the dam being raised about 10 feet ten years after initial construction.

Crest

The crest of the dam has no pavement. Photo 5 shows a typical section of the crest which has an excellent grass cover. There was no evidence of cracking or misalignment due to significant embankment movements.

Downstream Slope

The downstream slope has been covered with rock over much of its face as shown in Photos 15 and 16. The downstream face between the spillway structure and the left abutment is shown in Photo 5. Photo 10 shows a pool of clear water at the base of the spillway structure which is due to seepage through or beneath the dam or around the spillway structure. Seepage below the embankment was noted in an inspection report made

SECTION 2
ENGINEERING DATA

2.1 Design

No original design data were disclosed for Chittenden Reservoir Dam. Original construction of this dam was completed in 1901. Sheet piling was added in 1929. The dam was reconstructed in 1948 with Jackson and Moreland as engineers. The outlet pipes were replaced and/or repaired and the gates overhauled in 1973. An undated plan showing the general layout, sections and profile, as well as an area volume curve for the reservoir, were made available.

2.2 Construction

No construction records were available for use in evaluating the dam.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. Engineering data available for Chittenden Reservoir Dam is limited to the plans mentioned above. These plans are on file at the Central Vermont Public Service Corporation, Rutland, Vermont.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Validity. The field investigation indicated that the external features of Chittenden Reservoir Dam substantially agree with those shown on the available plans.

(4) Gates - none.

(5) U/S Channel - none.

(6) Downstream Channel. Just downstream of the dam the channel passes under a roadway. Further downstream the channel is steep with sharply inclined embankments. The area is heavily wooded with many trees overhanging the channel.

j. Regulating Outlets. The 42 inch diameter penstock outlet for power generation is controlled by three different gates one electrically operated and the other two mechanically operated. These gates are always open. The 42 inch waste line can be used to drain the reservoir. It is controlled by two mechanically operated gates which are usually closed. The approximate invert elevation of the intakes which are located in the original East Creek river bed, is 1,451.2. The maximum outlet capacity of the 42 inch waste line, with the water surface at the top of the dam, is approximately 385 cfs.

(3) Spillway Crest Pool - 17,200.

(4) Top of Dam - 22,090.

f. Reservoir Surface (acres)

(1) Recreation Pool - 789.

(2) Flood Control Pool - 513±.

(3) Spillway Crest - 789.

(4) Test Flood Pool - 800.

(5) Top Dam - 800.

g. Dam

(1) Type - earth, rock and stone masonry.

(2) Length - 967 feet, overall.

(3) Height - 54 feet (maximum).

(4) Top Width - 15.

(5) Side Slopes - US = 2½:1; DS = 1.75:1.

(6) Zoning - unknown.

(7) Impervious core - stone masonry w/plaster.

(8) Cutoff - masonry w/grout at spillway section.

(9) Grout Curtain - unknown.

(10) Other - none.

h. Diversion and Regulating Tunnel

See Section j below.

i. Spillway

(1) Type - concrete weir.

(2) Length of Weir - 100.4 feet.

(3) Crest Elevation - 1,495.00.

(3) The spillway capacity with the water surface at the top of dam is approximately 5,590 cfs at elevation 1,501.83 feet.

(4) The spillway capacity with the water surface elevation at the test flood elevation of 1,504.22 is approximately 9,080 cfs. If, as indicated in Section 1.2i, Normal Operating Procedures, the reservoir level is three feet below the spillway crest at the beginning of the test flood inflow, the test flood elevation would be 1,503.42.

(5) The total project discharge at the test flood elevation of 1,504.22 is approximately 14,000 cfs. If the test flood elevation is 1,503.22 as noted in (4) above, the total project discharge would be approximately 12,000 cfs.

c. Elevation (feet above MSL)

(1) Streambed at centerline of dam - 1451±.

(2) Maximum tailwater - unknown.

(3) Upstream portal invert diversion tunnel - 1,451.2 (estimated).

(4) Recreation pool - 1,492.0.

(5) Full flood control pool - (See Section 1.2i) 1,476.0.

(6) Spillway crest (permanent spillway) - 1,495.0.

(7) Design surcharge - unknown

(8) Top Dam - 1,501.83 low point.

(9) Test Flood Surcharge - 1,504.22.

d. Reservoir (miles)

(1) Length of Maximum Pool - 1.6.

(2) Length of Recreational Pool - 1.6.

(3) Length of Flood Control Pool - 1.4±.

e. Storage (gross acre-feet)

(1) Recreation Pool - 14,800

(2) Flood Control Pool - 6,700±.

g. Purpose of Dam. This dam is used for storage of water for later release for power production at a downstream point by Central Vermont Public Service Corporation. Also, the dam is used as a water supply for Vermont Marble. During the summer months, the lake is used for recreational purposes. Lower reservoir levels in the winter and spring provide storage for flood runoff.

h. Design and Construction History. Original construction of this dam was completed in 1901. Sheet piling was added in 1929. The dam was reconstructed in 1948 with Jackson and Moreland as engineers. The outlet pipes were replaced and/or repaired and the gates overhauled in 1973. No in-depth design or construction data were disclosed.

i. Normal Operational Procedures. Under normal operation, the penstock gates are continually open and the waste gates closed. Water level is allowed to reach no higher than three (3) feet below the spillway crest elevation. Water is released from the reservoir as needed for power generation. During the fall and winter, the reservoir is drawn down 19 feet below the spillway crest for storage of snowmelt and spring runoff. Water for power generation is fed through a long (greater than one-half mile) 42 inch diameter penstock.

13. Pertinent Data

a. Drainage Area. The area tributary to the Chittenden Reservoir Dam consists of 15.7 square miles of heavily wooded, rolling to mountainous terrain. A large part of the watershed is in the Green Mountain National Forest and is undeveloped. Maximum elevation is 3,665 feet MSL, and the reservoir full elevation is 1,495 feet.

The area around the reservoir is steep and wooded. There are approximately 10 homes along the shoreline.

b. Discharge at Dam Site

(1) The outlet works for Chittenden Reservoir Dam consist of a 42 inch diameter penstock and a 42 inch waste line. Inverts of the lines are approximately at 1,451.2 feet. The reservoir behind the dam can be lowered about 47 feet below the dam crest elevation of 1,501.83 by opening the waste gate. This drawdown would lower the reservoir area to the original river bed elevation.

(2) There are no records available of maximum discharge at the dam site. According to CVPSC personnel, the dam spillway has been used only once, in 1951, when the flow was $\pm$2 inches over the crest.

including the spillway section is, according to existing plans, approximately 967.0 feet. The maximum structural height of the dam, according to existing plans, is about 54.0 feet. A stone masonry wall, with concrete plaster at the upstream face, ranging from 2.0 to 3.0 feet in width extends through the embankment. The maximum height of this core wall is approximately 67.0 feet and its total length is about 839 feet. Steel sheeting, 25 feet deep, is located at the right abutment of the dam as shown on Figure 1 located in Appendix B. This sheeting is approximately 210 feet in length. The upstream face of the dam has a slope of approximately 2½ feet horizontal to 1 foot vertical (2½:1) with a two foot depth of riprap placed to the crest. The downstream face has approximately a 1.75:1 slope with 30 feet of loose rock placed over the entire slope area.

The appurtenant works consist of a concrete-lined spillway, a three span truss foot bridge, spillway channel and outlet works. The outlet works is located in the original East Creek bed and consist of an outlet works conduit, a power intake conduit, gate house with electro-mechanical controls and discharge channel.

Figure 1, located in Appendix B, shows the plan of the dam and its appurtenant structures. Photographs of each structure are shown in Appendix C.

c. Size Classification. Intermediate (hydraulic height - 43 feet high, storage - 22,090 acre-feet) based on storage ($\geq$1,000 to 50,000 acre-feet) as given in Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. The dam's potential for damage rates it as a high hazard classification. Failure of the dam at maximum pool would probably result in a flood wave stage of approximately 32 feet in Chittenden, 2.1 miles downstream. Approximately 40 dwellings would probably be inundated. Valley storage between Chittenden and East Pittsford would reduce the flood wave to a 12.7 foot stage. A depth of this magnitude would probably flood an additional 20 to 30 dwellings in the East Creek flood plain. Failure of the dam would probably mean the loss of many lives in Chittenden and the upper East Creek flood plain.

e. Ownership. This dam is owned by the Central Vermont Public Service Corporation, Rutland, Vermont 05701.

f. Operator. This dam is operated by the Central Vermont Public Service Corporation, 77 Grove Street, Rutland, Vermont 05701. The Manager of Hydraulic Generation is Mr. J. Douglas Grahm. Telephone No. (802)773-2711.

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
CHITTENDEN RESERVOIR DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Howard, Needles, Tammen & Bergendoff has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Howard, Needles, Tammen & Bergendoff under a letter of October 23, 1978 from John P. Chandler, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0356 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

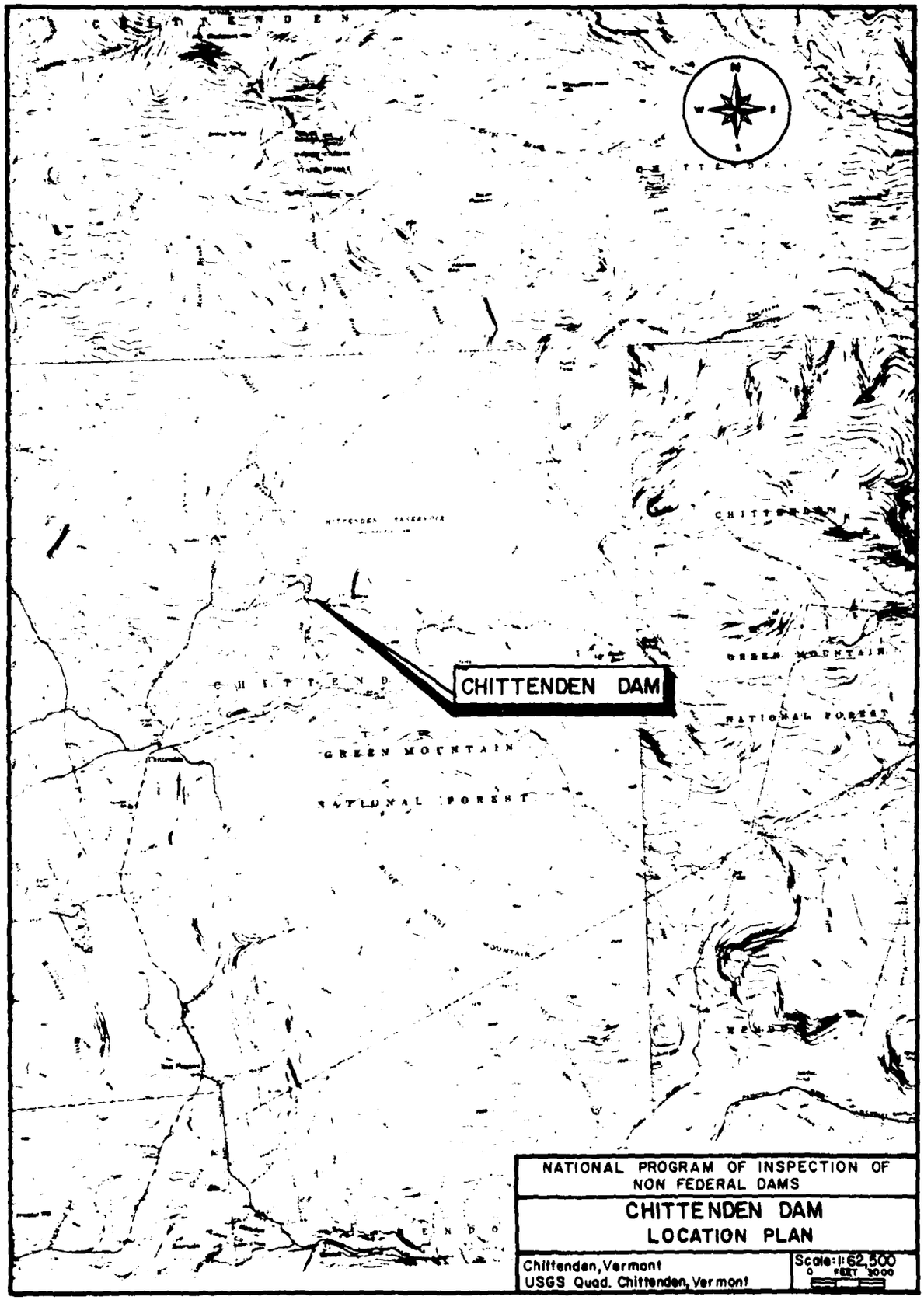
(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

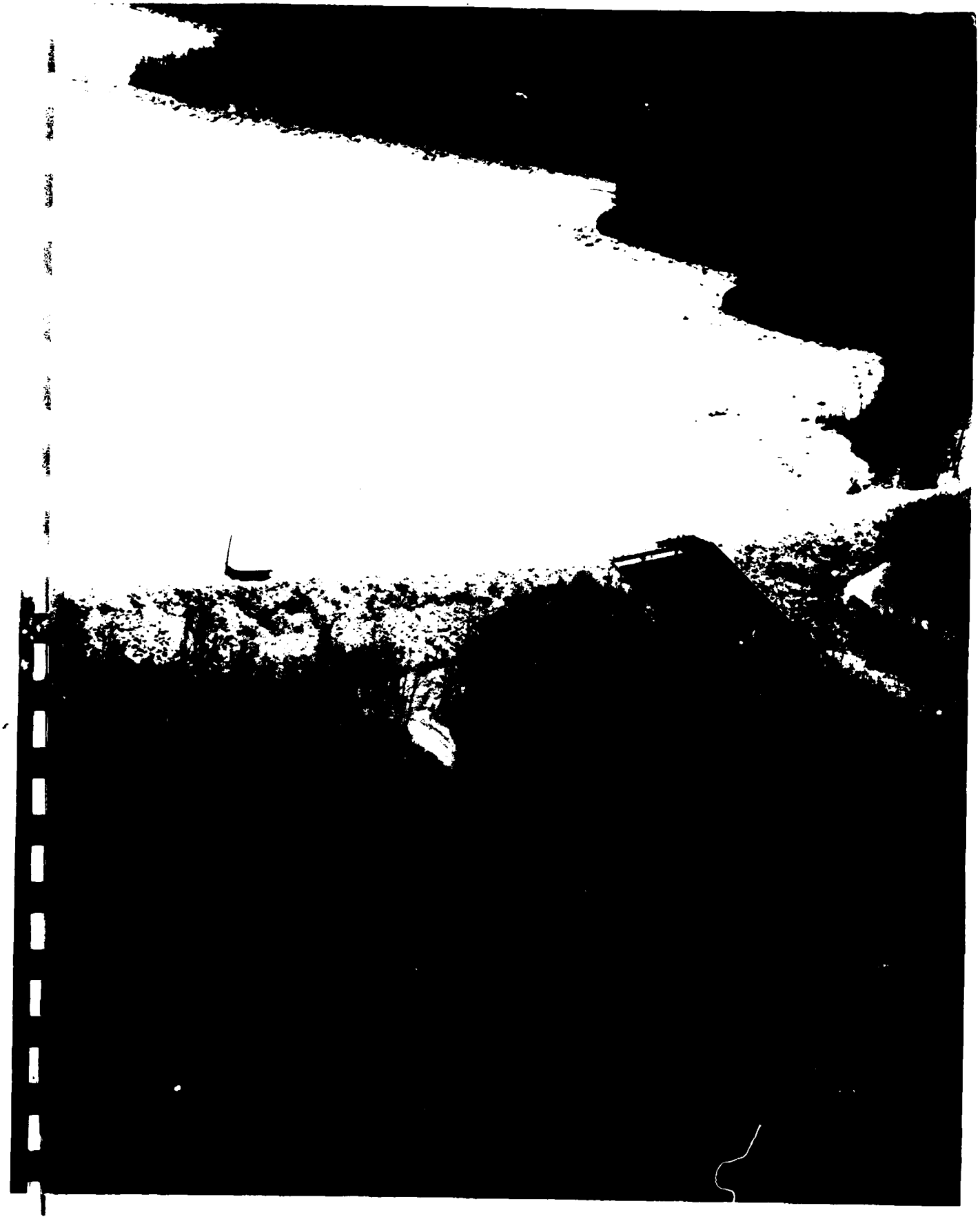
(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Chittenden Reservoir Dam is located on East Creek approximately 2 miles upstream of the center of Chittenden, in the Town of Chittenden, Vermont. The dam is shown on U.S.G.S. Quadrangle Chittenden, Vermont, with approximate coordinates of N43°43'24", W72°55'36", Rutland County, Vermont. Chittenden Reservoir Dam's location is shown on the Location Map immediately preceding this page.

b. Description of Dam and Appurtenances. Chittenden Reservoir Dam is a composite structure consisting of stone masonry, earth and rock fill. The total length of the dam,


CHITTENDEN DAM
GREEN MOUNTAIN
NATIONAL FOREST
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
CHITTENDEN DAM
LOCATION PLAN
Chittenden, Vermont
USGS Quad. Chittenden, Vermont
Scale: 1:62,500
0 FEET 3000



CHITTENDEN DAM - Overview looking upstream

4.5 Evaluation

The current operation and maintenance procedures for Chittenden Reservoir Dam appear to be adequate to insure that problems encountered can be remedied within a reasonable period of time.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. General. Chittenden Reservoir Dam is a composite structure consisting of stone masonry, earth and rock fill with a total lenth of approximately 967 feet and a maximum structural height of 54 feet. The appurtenant works consist of a 100 foot long concrete spillway, a three span truss foot bridge, spillway channel and outlet works. The outlet works is located in the original East Creek river bed and consist of a 42 inch diameter power intake conduit, a 42 inch diameter waste conduit, gate houses with both electrically and mechnically operated gates and a discharge channel.

The dam creates an impoundment of water primarily used for power production purposes by the Central Vermont Public Service Corporation. The reservoir is also used for water supply to Vermont Marble, part-time recreation and control of winter and spring snowmelt and stormwater runoff. Chittenden Reservoir Dam is classified as being intermediate in size having a maximum storage of 22,090 acre-feet.

b. Design Data. No hydrologic or hydraulic design data were disclosed for Chittenden Reservoir.

c. Experience Data. The maximum discharge at this dam site is unknown. It has been reported that since reconstruction in 1948, the spillway has only been used once, in 1951, when a 2± inch depth was observed.

d. Visual Observations. No evidence of damage to any portion of the project from overtopping was visible at the time of the inspection.

e. Overtopping Potential. As no detailed design and operational information are available, hydrologic evaluation was performed using dam information gathered by field inspection, watershed size and an estimated test flood equal to the Probable Maximum Flood (PMF) as determined by guide curves issued by the Corps of Engineers. Based on a drainage area of 15.7 square miles, it was estimated that the test flood inflow at Chittenden Reservoir Dam would be 23,600 cfs. Following the guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharge results in a test flood discharge of 14,000 cfs. As the maximum spillway capacity at the top of the dam is only 5,590 cfs (approximately 40 percent of the test flood discharge flow), the test flood will result in the dam being overtopped by approximately 1.9 feet.

As there is a high hazard to loss of life from large flows downstream of the dam (resulting from dam failure) and dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure, a review of the spillway capacity for its ability to pass ½ the PMF was made. This analysis indicates that the test flood inflow would be approximately 11,850 cfs. Following the guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharge results in a test flood discharge of 4,950 cfs. As the maximum spillway capacity at the top of the dam is 5,590 cfs, the spillway can safely pass ½ the PMF with a freeboard of approximately 0.4 feet.

f. Dam Failure Analysis. The impact of failure of the dam at maximum pool (top of dam) was assessed using the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to East Pittsford, 4.6 miles downstream. Failure of the dam at maximum pool would probably result in a flood wave stage of approximately 32 feet in Chittenden, 2.1 miles downstream. Approximately 40 dwellings would probably be inundated. Valley storage between Chittenden and East Pittsford would reduce the flood wave to a 12.7 foot stage. A depth of this magnitude would probably flood an additional 20 to 30 dwellings in the East Creek flood plain. Failure of the dam would probably mean the loss of many lives in Chittenden and the upper East Creek flood plain.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation. The visual examination did not disclose any immediate stability problems. Seepage collecting at the base of the spillway structure has been observed since the time of spillway reconstruction in 1949. This seepage is not considered to be an immediate hazard to the structural stability of the embankment.

b. Design and Construction Data. Chittenden Dam consists of an earth and rock fill embankment with a masonry core wall. The dam was built in two stages: Stage 1, built in 1901, had a crest elevation of about 1490 feet; Stage 2, built in about 1910, raised the crest about 10 feet, resulting in a dam about 40 feet high at maximum section. Detailed description of the zoning or material used in the embankment construction were not available.

An existing drawing indicates that the masonry core wall was extended below the base of the dam into the foundation. The depth of this masonry cut-off is not known along the entire axis of the dam. The masonry core wall is stopped on the right abutment and a steel sheet piling wall has been driven to extend a distance of 210 feet into the abutment. The depth of the steel sheet piling wall has been driven to extend a distance of 210 feet into the abutment. The depth of the steel sheet piling is not known.

c. Operating Records. No operating records were made available.

d. Post-Construction Changes. On June 3, 1947, the dam was badly damaged by flooding. The information available in PSC file #2377 indicates that the original spillway structure was severely damaged and required rebuilding. The present concrete spillway is the result of this rebuilding. In addition to reconstruction of the spillway, the masonry core wall between the left spillway training wall and the left abutment was investigated and repointed because leakage had been noticed in this area at high pool elevations. A section of this masonry core wall, for a distance of 50 feet from the left spillway training wall, was underpinned and deepened an unknown amount at the time of the spillway repair.

In 1973, the outlet works waste line and water supply lines were replaced and or repaired and all gates overhauled. Also at this time, a secondary berm of riprap, extending from the right abutment to the spillway, was constructed on the upstream slope of the dam.

e. Seismic Stability. The dam is located in Seismic Zone 2, and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATION AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual inspection of Chittenden Reservoir Dam indicates the dam is in good condition. The inspection revealed the following:

(1) Minor slumping of the riprap on the upstream slope of the dam.

(2) A pool of clear water at the base of the spillway structure which is due to seepage through or beneath the dam or around the spillway structure.

(3) Cracks and efflorescence at the lower segments of the spillway.

(4) Downstream channel obstruction caused by overhanging trees and brush.

The hydraulic analysis reveals that the dam cannot pass the required test flood without overtopping the dam.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. This dam is in generally good condition. The recommendations and remedial measures described in Sections 7.2 and 7.3 should be accomplished within 2 years after receipt of this Phase I Inspection Report by the owner.

d. Necessity of Additional Investigation. No additional investigation is needed to complete the Phase I inspection.

7.2 Recommendations

It is recommended that the owner engage a qualified engineer to investigate the seepage condition below the spillway structure and design an adequate collection and monitoring system and to further evalute the potential for overtopping.

7.3 Remedial Measures

(a) The riprap upstream slope protection should be improved by filling deficient areas with riprap and raising the elevation of the riprap to the top of the dam.

(b) The cracks on the lower section of the spillway should be repaired.

(c) The overhanging trees along the downstream channel should be cut back.

(d) As the discharge conduits are under hydraulic head, the operation and maintenance manual should discuss the need for monitoring the downstream outlet for possible seepage.

(e) A periodic technical inspection program should be initiated on a biennial basis.

7.4 Alternatives

There are no practical alternatives to the recommendations of Sections 7.2 and 7.3 except that on an interim basis the owner may consider operating the reservoir at a lower level throughout the year so as to provide more storage for extreme flood events.

APPENDIX A

VISUAL CHECKLIST WITH COMMENTS

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Chittenden Dam

DATE Nov. 9, 1978

TIME 1 P.M.

WEATHER Sunny & Warm

W.S. ELEV. 1487± U.S. 1452± DN.S

PARTY:

1. Gordon Slaney, HNTB
2. Stan Mazur, HNTB
3. Dan LaGatta, GEI
4. J. Peter Barranco, Jr., Vermont Dept. of Water Resources
5. Douglas Graham, CVPSC
6.
7.
8.
9.
10.

PROJECT FEATURE	INSPECTED BY	REMARKS
1. Embankment Dam	D. LaGatta	
2. Spillway, Outlet Works	S. Mazur, G. Slaney	
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam DATE Nov. 9, 1978

PROJECT FEATURE Embankment NAME D. LaGatta

DISCIPLINE Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	1501.83
Current Pool Elevation	1487.0
Maximum Impoundment to Date	1,495.2
Surface Cracks	None visible.
Pavement Condition	No pavement.
Movement or Settlement of Crest	None visible.
Lateral Movement	No misalignment observed.
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	None observed.
Trespassing on Slopes	None observed.
Sloughing or Erosion of Slopes or Abutments	None observed.
Rock Slope Protection - Riprap Failures	Local slumping of riprap and poor sizing in many locations.
Unusual Movement or Cracking at or near Toes	None observed.
Unusual Embankment or Downstream Seepage	Standing water at base of spillway appears to be seepage adjacent to spillway.
Piping or Boils	None observed.
Foundation Drainage Features	None observed.
Toe Drains	None observed.
Instrumentation System	None.
Vegetation	Good grass cover on crest.

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam DATE Nov. 9, 1978

PROJECT FEATURE Intake Channel/Structure NAME D. LaGatta

DISCIPLINE Geotechnical/Structural Engineers NAME S. Mazur

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	No approach channel visible above water level.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Intake structure was not visible above water level.
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam — DATE Nov. 9, 1978

PROJECT FEATURE Control Tower — NAME S. Mazur

DISCIPLINE Structural/Hydraulic Engineers — NAME G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural General Condition Condition of Joints Spalling Visible Reinforcing Rusting or Staining of Concrete Any Seepage or Efflorescence Joint Alignment Unusual Seepage or Leaks in Gate Chamber Cracks Rusting or Corrosion of Steel	Outlet works consist of two conduits; the wastewater conduit with two manually operated control gates, and 42"Ø penstock with three control gates, two manually operated and one electrically operated. Gates and control mechanisms appear to be in good operational condition.
b. Mechanical and Electrical Air Vents Float Wells Crane Hoist Elevator Hydraulic System Service Gates Emergency Gates Lightning Protection System Emergency Power System Wiring and Lighting System	Mechanically operated gates and electrically operated gates are housed in wooden houses. Both gate houses in good condition. Gear mechanisms of mechanically operated gates in good condition. Gates themselves were all unaccessible for inspection.

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam DATE Nov. 9, 1978

PROJECT FEATURE Outlet Work Conduit NAME S. Mazur

DISCIPLINE Structural/Hydraulic Engineers NAME G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	At the time of inspection, outlet works conduits were under water. These conduits were reported to be replaced and/or relined in 1973.
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam DATE Nov. 9, 1978

PROJECT FEATURE Outlet Structure/Channel NAME D. LaGatta

DISCIPLINE Structural/Hydraulic/Geotechnical Engineers NAME S. Mazur, G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	Good.
Rust or Staining	None observed.
Spalling	None observed.
Erosion or Cavitation	None.
Visible Reinforcing	None observed.
Any Seepage or Efflorescence	
Condition at Joints	Good.
Drain Holes	None.
Channel	None.
Loose Rock or Trees Overhanging Channel	None.
Condition of Discharge Channel	Good.

PHOTO NO. 7 - Upstream slope between spillway and right abutment.

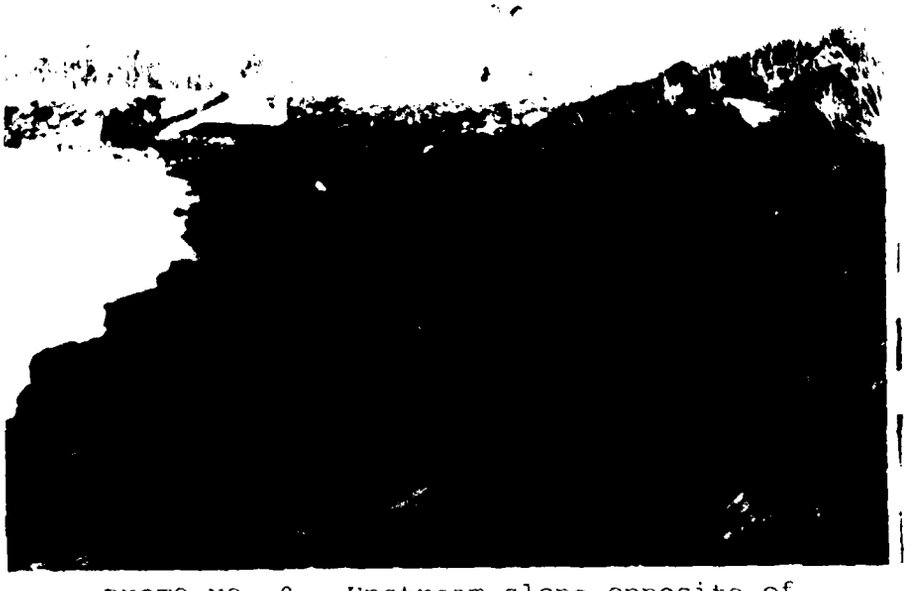


PHOTO NO. 8 - Upstream slope opposite of gatehouse. Note poor riprap sizing and minor slumping of riprap.

PHOTO NO. 5 - View of dam (downstream slope) from left abutment. Note excellent grass cover at crest of the dam.

PHOTO NO. 6 - Downstream slope of dam at outlet works and power intake conduits.

PHOTO NO. 3 - View of dam (upstream slope) from left abutment.

PHOTO NO. 4 - View of dam (upstream slope) from right abutment.

PHOTO NO. 1 - General view of reservoir from foot-bridge structure.

PHOTO NO. 2 - View of reservoir and dam from foot-bridge over spillway.

APPENDIX C

PHOTOGRAPHS

FOR LOCATION OF PHOTOS, SEE FIGURE 1
LOCATED IN APPENDIX B

Dams: Hydro electric

INSPECTION REPORT
ON
Chittenden Dam

1. Date of inspection May 12, 1953 2. Water conditions Pond at Crest Level

GENERAL DATA:

3. Location of dam East Creek; town of Chittenden

4. Owner and operator Central Vermont Public Service Corp.

5. Characteristic features of dam Embankment with concrete-lined spillway on a hard pan foundation, repaired in 1948.

6. Other related data Contained in P.S.C. case file #2377

OBSERVATIONS:

7. Condition of structure Embankment - minor seepage appears belo east embankment; tree topping started; slopes remain stable.
Spillway - concrete in good condition.
Regulated outlet - remain water tight and in good condition

8. Condition of equipment In operating order

9. Operation Satisfactory

10. Maintenance Satisfactory

REMARKS:

This dam has been examined each year since its restoration five years ago. There is no significant change in its soundness.

This inspection made with R.L. Gouchoe, company engineer.

Inspected by Stephen H. Haycock

INSPECTION REPORT ON CHITTENDEN DAM

Chittenden dam has been visited periodically since its repair in 1948. Following a more recent inspection this report is submitted on the behavior of the renovated structure.

Introduction:

As is known to all concerned, this dam suffered a partial failure and was in part responsible for the June 3, 1947 flood in the Rutland area. Repairs were commenced soon after with Chas. T. Main, Inc. reviewing the drawings and supervising the reconstruction in behalf of the Commission. Details may be found in PSC case file #2377.

Review of Pertinent Data:

Owner & Operator	-	C.V.P.S.C.
Location of Dam	-	East Creek; town of Chittenden.
Purpose of Dam	-	Storage for power generation at this and down-stream sites belonging to the company.
Type of Dam	-	Embankment with stone masonry and concrete-lined chute spillway on a hard pan foundation.
Size of Pond	-	At crest level the surface area is given as 720 acres and the volume as 750 million cu. ft.
Drainage area	-	About 17 sq. mi.

Observations:

The main items of inspection which reflect the condition of the dam are noted as follows:

(a) Embankment

1. Seepage	-	insignificant amount appearing at downstream toe in one or two places.
2. Settlement	-	inappreciable
3. Slopes	-	stable
4. Foundation Condition	-	satisfactory

(b) Spillway Section:

1. Appearance	-	excellent
2. Crest	-	Free and unobstructed
3. Foundation Scour	-	inappreciable
4. Leakage	-	inappreciable

(c) Power Conduit Section:

1. Passage in Earth Section - secure
2. Equipment (gates, sluiceway, etc) - in operating order

(d) Operation: - Satisfactory

(e) Maintenance: - Good

Remarks:

With 4 years of operation the remodeled dam remains in sound condition.

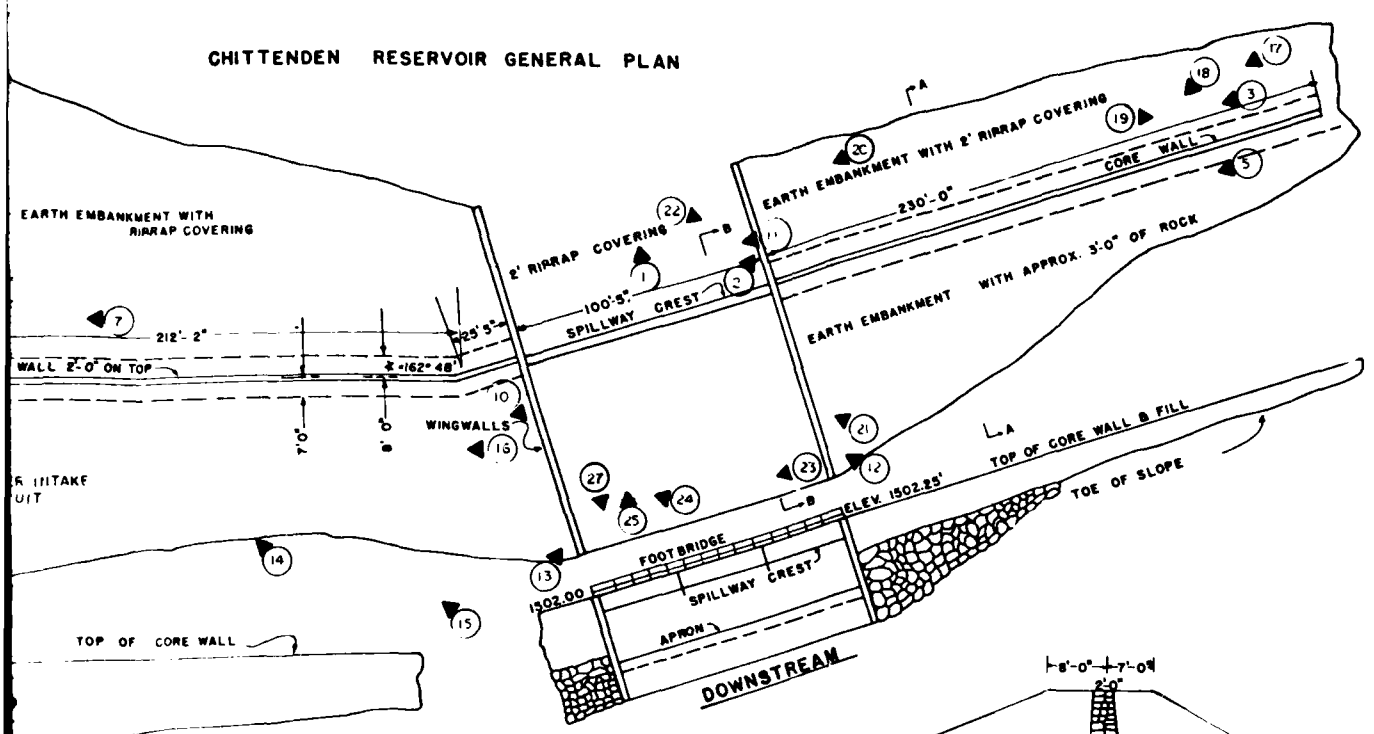
Public Service Commission
July 25, 1952

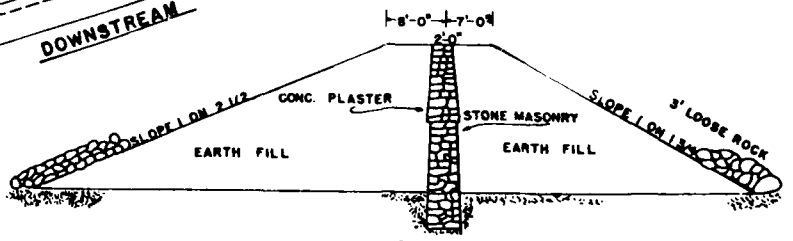
Stephen H Hayes

PAST INSPECTION REPORTS

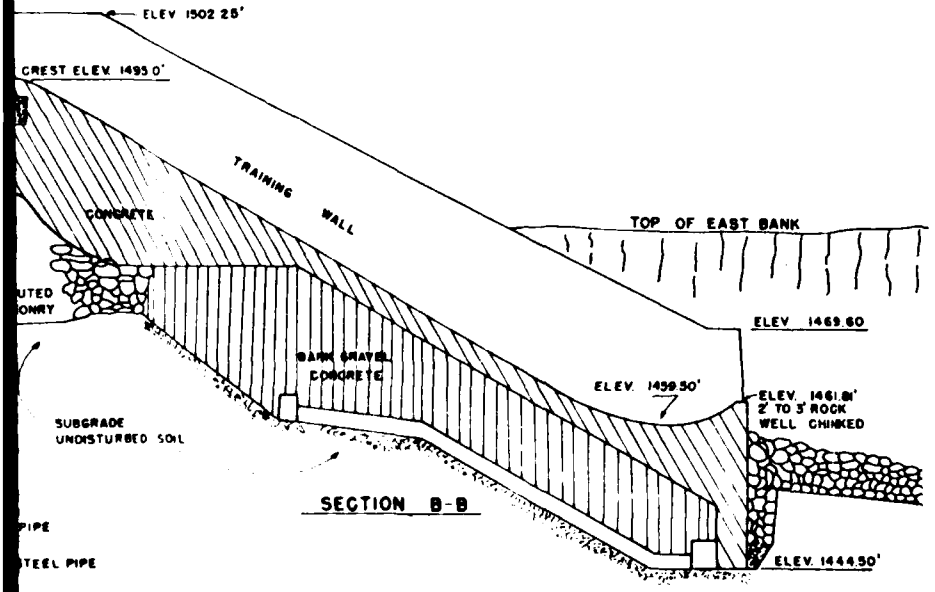
2

CHITTENDEN RESERVOIR GENERAL PLAN





SECTION A-A



SECTION B-B

NOTES

1. THIS DRAWING WAS SUPPLIED BY THE CENTRAL VERMONT PUBLIC SERVICE COMPANY. THIS INFORMATION WAS CHECKED DURING THE FIELD INSPECTION EXCEPT DIMENSIONS ON MATERIALS WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION
2. RIP-RAP PERM ON UPSTREAM FACE, CONSTRUCTED IN 1972, IS NOT SHOWN.
3. THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 1495 SHOWN ON U.S.G.S. QUADRANGLE SHEET ASSUMED TO BE FULL POOL ELEVATION AT PERMANENT SPILLWAY CREST.

HOWARD NEEDLES, TAMMEN & BERGENDOFF, BOSTON, MASSACHUSETTS

US ARMY ENGINEER DIV NEW ENGLAND, CORPS OF ENGINEERS, WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

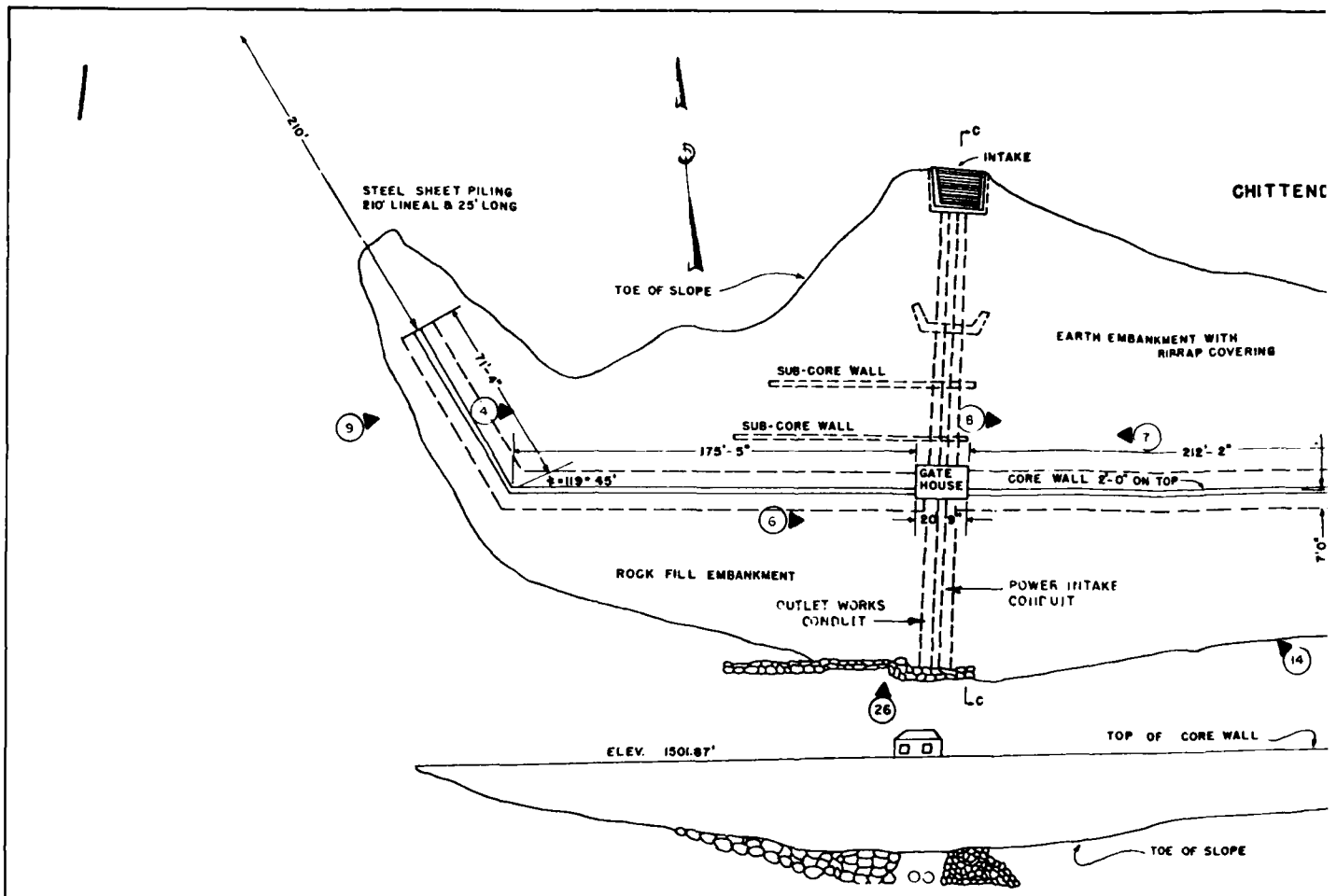
CHITTENDEN DAM

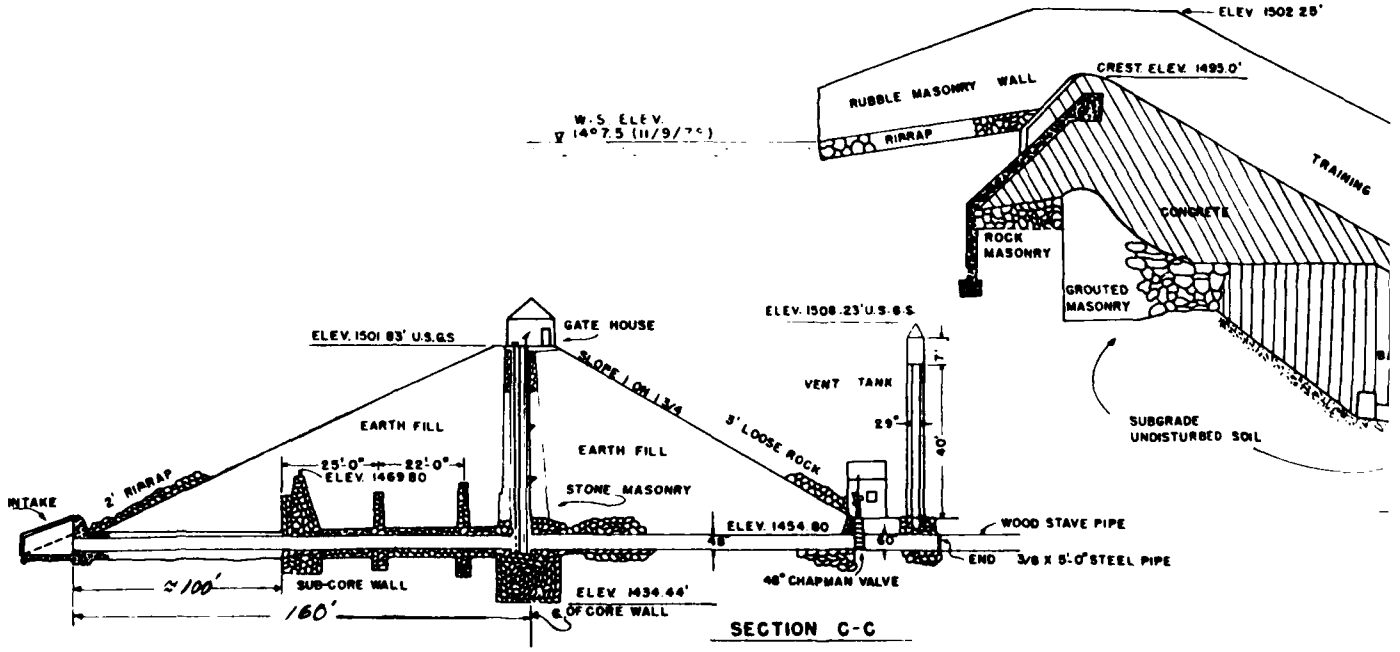
EAST CREEK — CHITTENDEN, VERMONT

SCALE

DATE

FIGURE 1





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AVAILABLE ENGINEERING DATA

The following data was found to be available at the Central Vermont Public Service Corporation, 77 Grove Street, Rutland, Vermont 05701.

1. An undated plan showing general layout of the dam including profiles, sections and some details.

2. An area-volume curve for the reservoir.

3. A plan for use during emergency situations.

APPENDIX B

1. LIST OF DESIGN, CONSTRUCTION AND MAINTENANCE RECORDS
2. PLANS AND DETAILS
3. PAST INSPECTION REPORTS

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam — DATE Nov. 9, 1978

PROJECT FEATURE Service Bridge — NAME S. Mazur

DISCIPLINE Structural Engineer — NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	
Bearings	Good.
Anchor Bolts	Good.
Bridge Seat	Bridge supports are in good condition. (Two steel columns and steel angles at training walls).
Longitudinal Members	Good condition.
Under Side of Deck	Good.
Secondary Bracing	Good.
Deck	Wooden planks, good condition.
Drainage System	None.
Railings	Steel structural shapes, good condition.
Expansion Joints	None.
Paint	Good.
b. Abutment & Piers	
General Condition of Concrete	Good.
Alignment of Abutment	Very good.
Approach to Bridge	Crest of embankment, good condition.
Condition of Seat & Backwall	Bridge is supported by steel angles connected to training walls.

PERIODIC INSPECTION CHECK LIST

PROJECT Chittenden Dam — DATE Nov. 9, 1978

PROJECT FEATURE Outlet Works - Spillway — NAME D. P. LaGatta

DISCIPLINE Structural/Hydraulic/Geotechnical Engineers — NAME S. Mazur, G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	No special approach channel visible above water line.
General Condition	
Loose Rock Overhanding Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Good.
Rust or Staining	Some at spillway bridge support.
Spalling	None.
Any Visible Reinforcing	None.
Any Seepage or Efflorescence	Efflorescence lower segments of spillway.
Drain Holes	Drains in d.s. training wall not operating during inspection.
c. Discharge Channel	
General Channel	Good.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Channel	Grassed in good condition, low rock wall crosses channel, but not a major obstruction.
Other Obstructions	

PHOTO NO. 9 - Panorama of downstream face of dike on the right abutment.

PHOTO NO. 10 - Panorama of seepage pool viewed from crest of dam.

PHOTO NO. 11 - Spillway crest viewed from left training wall. No misalignment of concrete structures due to embankment movement.

PHOTO NO. 12 - Left wing wall of spillway. The clip board, about 1 ft. below lip of spillway, marks the highest elevation of visible seepage along base of wall.

PHOTO NO. 13 - Right wing wall of spillway. The clip board, about 2 ft. below lip of spillway, marks highest elevation of visible seepage along base of wall.

PHOTO NO. 14 - Stone wall at downstream toe of the dam between right abutment and the outlet works.

PHOTO NO. 15 - Downstream face of dam between right abutment and outlet works.

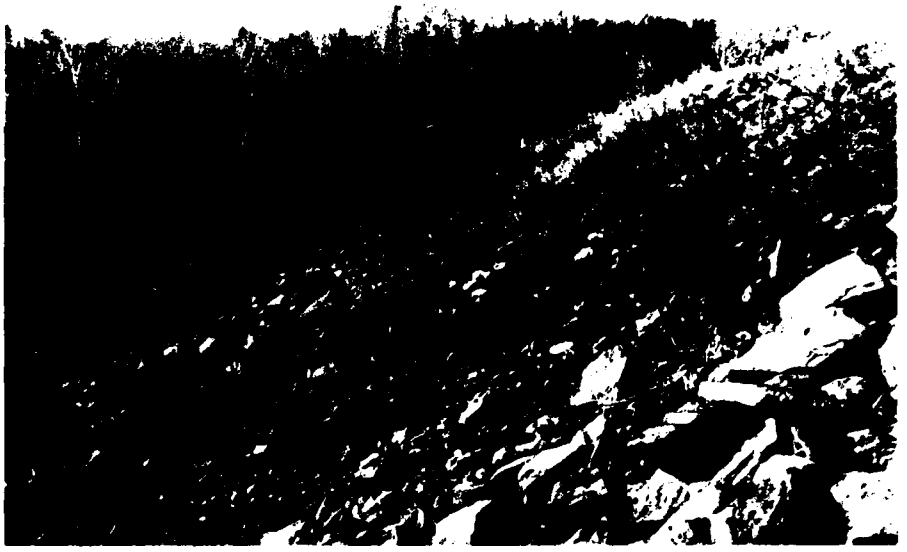


PHOTO NO. 16 - Downstream slope of dam viewed from about mid-height, adjacent to right training wall of spillway.

PHOTO NO. 17 - Upstream face of dam in vicinity of left abutment. Note that riprap is not continuous to crest of dam.

PHOTO NO. 18 - Upstream face of dam approximately 50 ft. from left abutment. Note riprap stops about 15 ft. below crest of dam.

PHOTO NO. 19 - Upstream face of dam approximately 100 ft. from left abutment. Note slumping riprap in area of 6 ft. rule.

PHOTO NO. 20 - View of spillway and foot bridge from reservoir side.

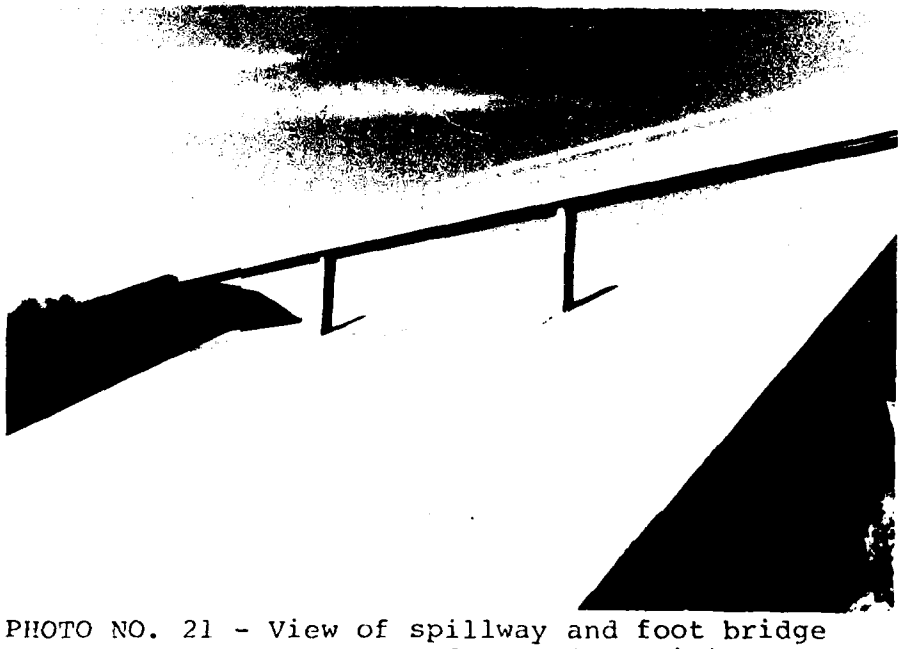


PHOTO NO. 21 - View of spillway and foot bridge structure from left training wall (downstream side).

PHOTO NO. 22 - Left training wall at spillway crest with detail of foot bridge support.

PHOTO NO. 23 - Spillway detail at discharge channel.

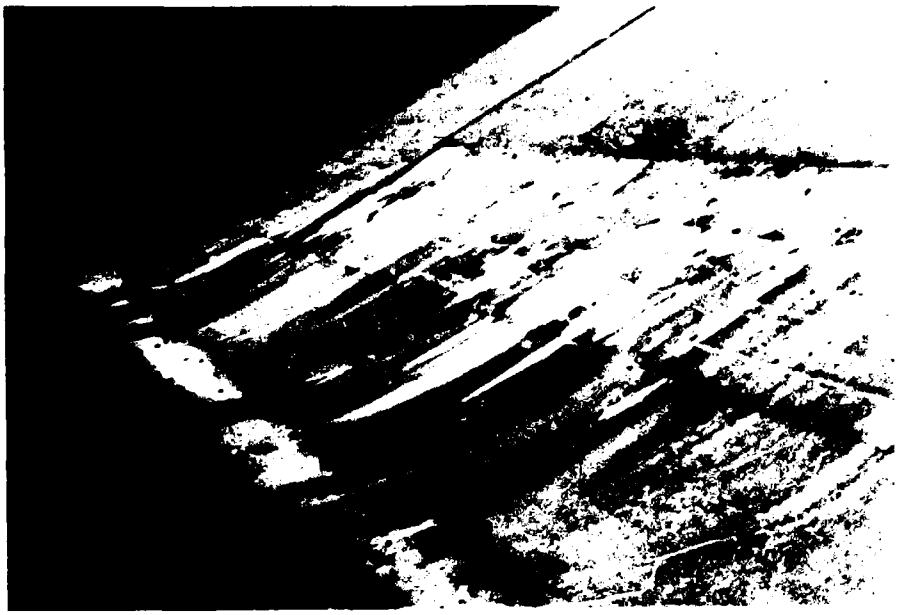


PHOTO NO. 24 - Deterioration of spillway concrete surface at lower sections of spillway structure.

PHOTO NO. 25 - Close up of spillway concrete deterioration. (Cracks with evidence of efflorescence).

PHOTO NO. 26 - Detail of outlet works structure at downstream side of dam.

PHOTO NO. 27 - View of discharge channel from spillway structure.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/28/78	Job No 5628-11-20
	Checked by	Date 1/16/79	Sheet No. 1
For Chillenden			

HYDRAULICS & HYDROLOGY

Chittenden Reservoir Dam Located across East Creek in Chittenden, Vt in the St. Lawrence River Basin.

CLASSIFICATION SIZE: Intermediate
HAZARD: HIGH

Basic DATA D.A. = 15.7 sq mi HNTB calculation
Upstream Basin: Rolling

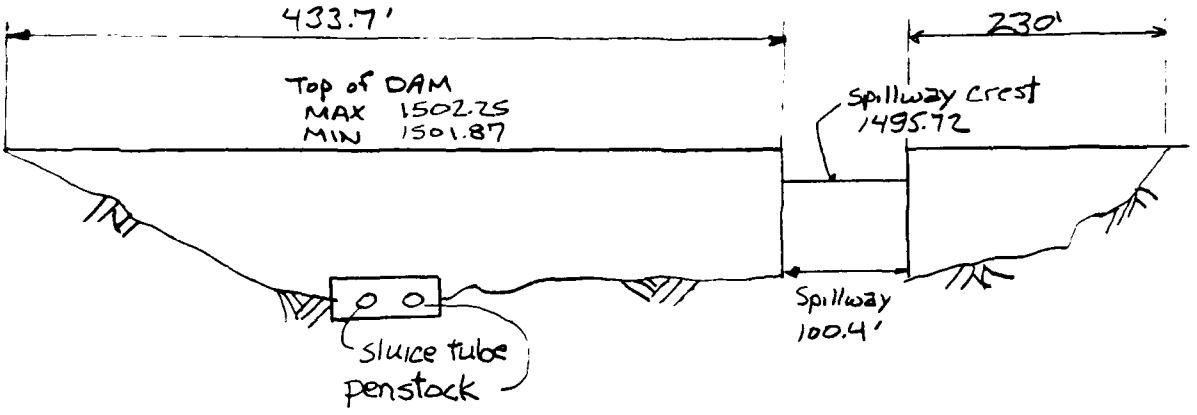
Reservoir: Normal Pool elev. 1495.72
Storage 17,200 acre-ft
Max. Pool elev. 1501.87
Storage 22090 acre-ft
Surface Area Normal 795 acres
Max 800 acres

Dam: Earth w/ Rip-Rap Cover &
Concrete Core
40 ft high
738.7' long

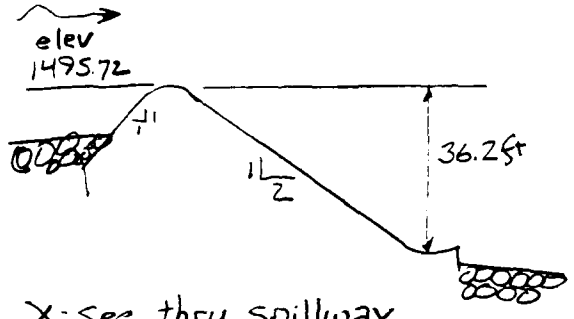
Spillway: Concrete weir
Crest @ elev 1495.72
Length - 100.4 ft

Outlet: Sluice Tube 42" dia
Penstock 42" dia

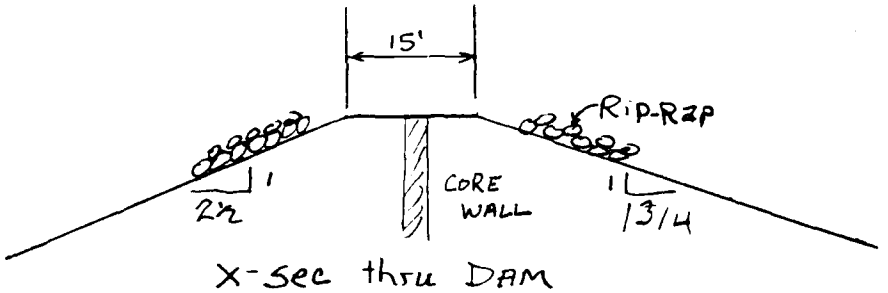
HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/29/78	Job No 5628-11-20
	Checked by MWD	Date 1/16/79	Sheet No. 2
For Chittenden Res.			



LONGITUDAL X-SECTION THRU DAM



X-sec thru spillway



X-sec thru DAM

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/29/78	Job No 5628-11-20
	Checked by RWB	Date 1/16/79	Sheet No 3
For Chittenden Res.			

Step 1 Calculation of Spillway Design Flood

Classification size: Intermediate
hazard: high

Hydrologic Evaluation Guideline Recommends

PMF for SDF

PMF = 1510 cfs/mi² × 15.7 sq.mi. = 23707 cfs

Use PMF: 23,700 cfs.

Step 2 Calculation of Surcharge by PMF

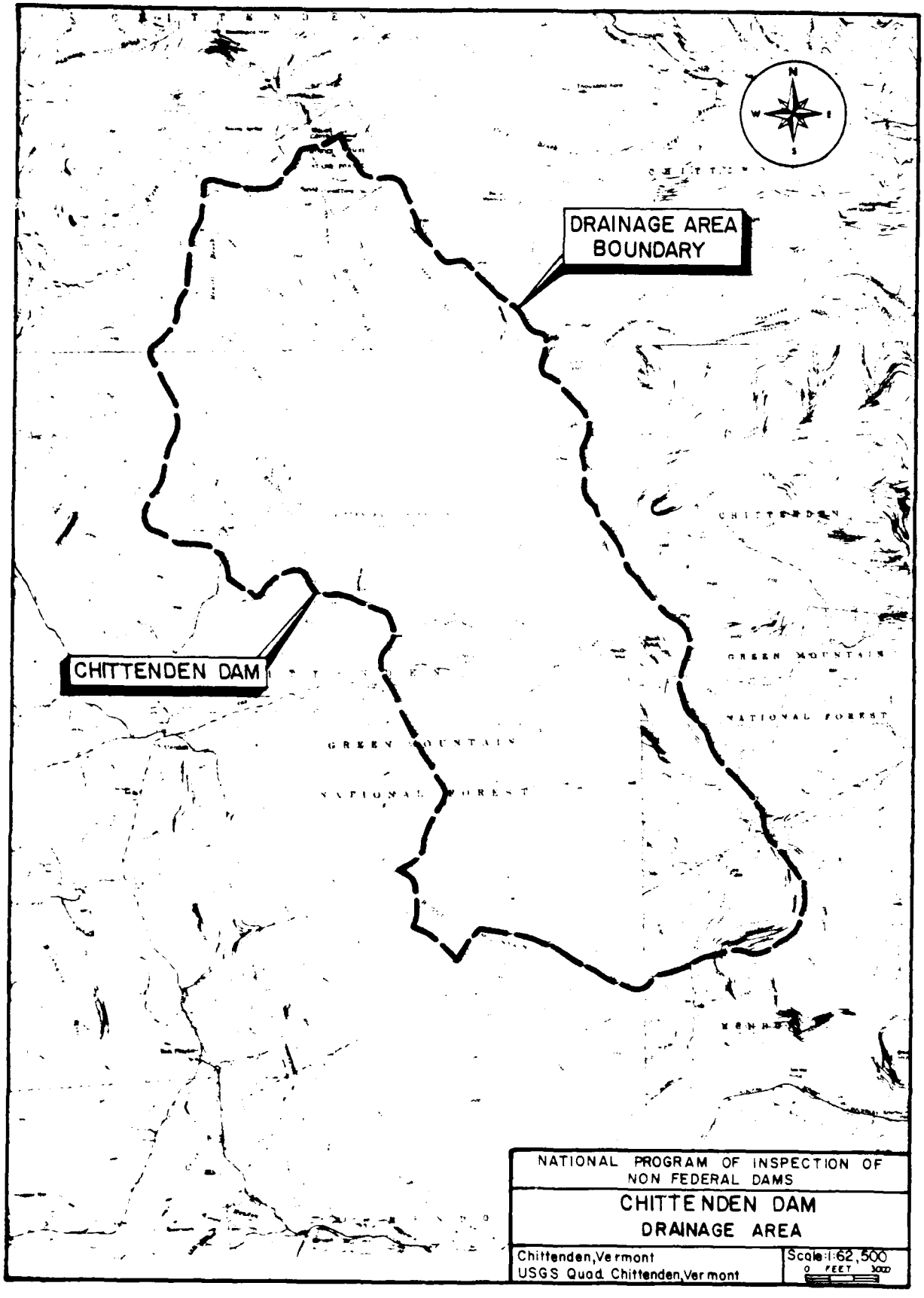
Spillway Design Flood = 23,700 cfs.

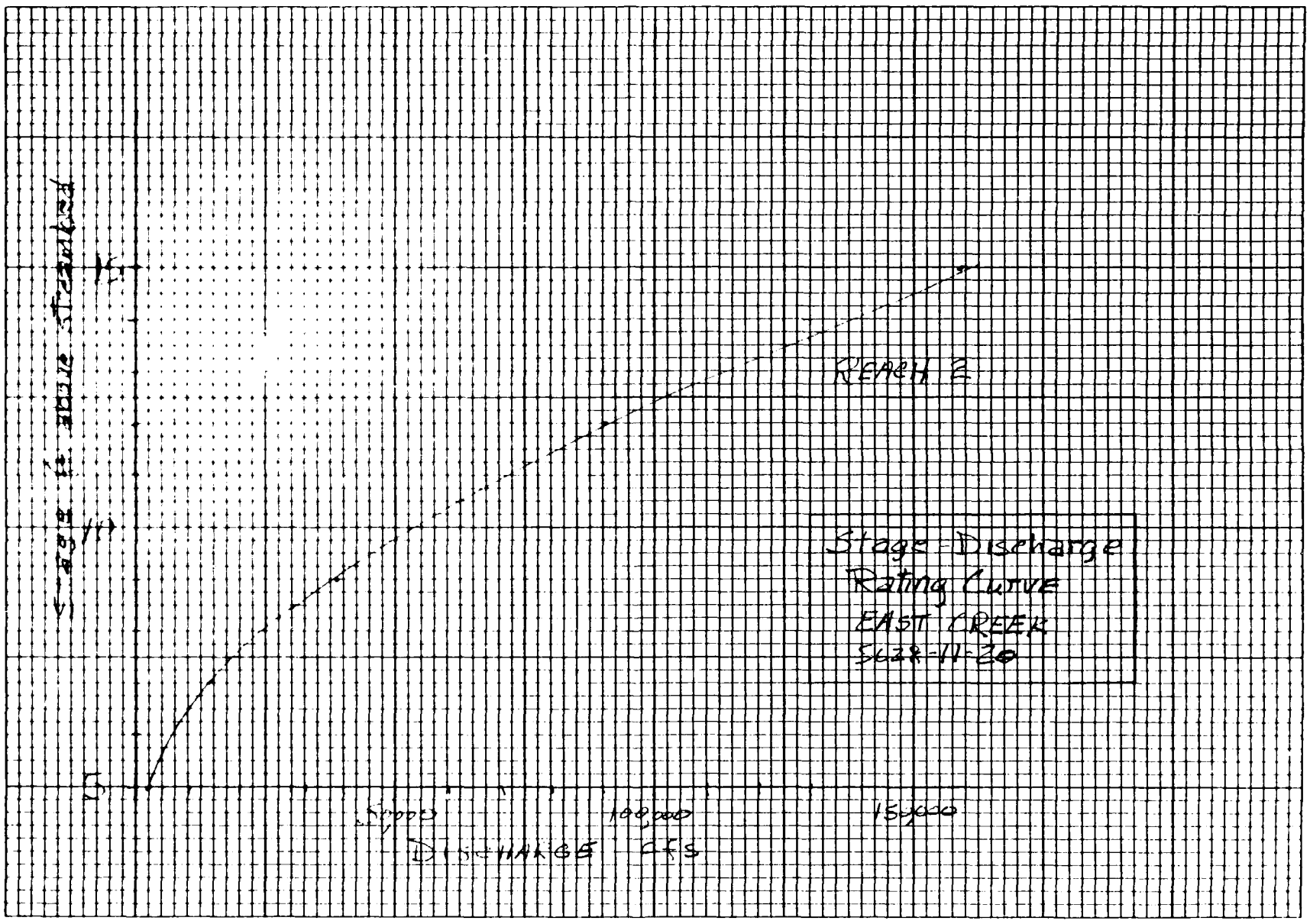
Consider: sluice tube closed
penstock closed

Spillway: $Q_S = C L H_S^{3/2}$

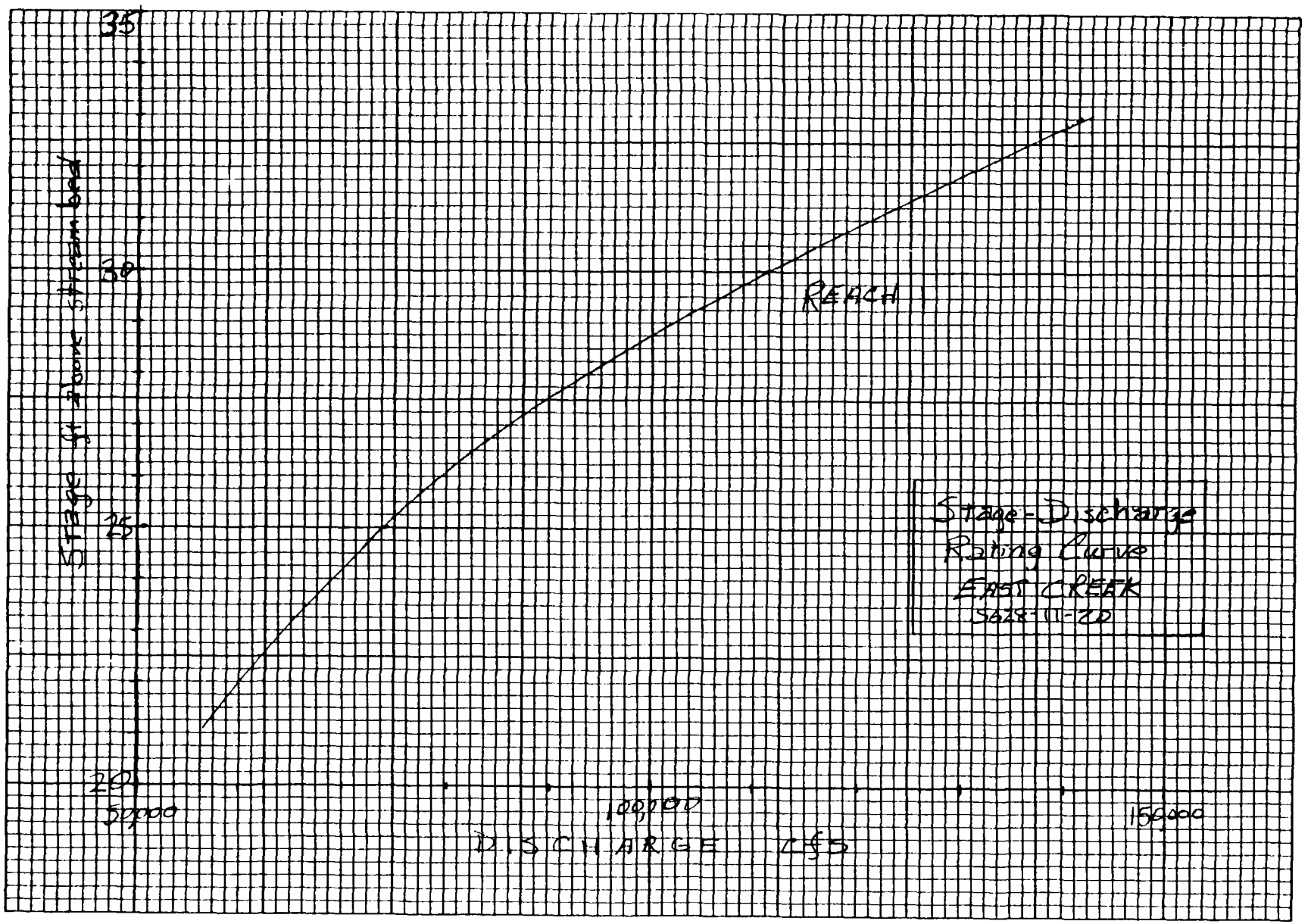
$C = 3.65$
$L = 100.4$ ft
$Q_S = 3.65(100.4) H_S^{3/2}$
$Q_S = 366.5 H_S^{3/2}$

DAM CREST
$Q_D = C L H_D^{3/2}$
$C = 3.08$
$L = 663.7$ ft
$Q_D = 3.06(663.7) H_D^{3/2}$
$Q_D = 2031 H_D^{3/2}$


DRAINAGE AREA BOUNDARY
CHITTENDEN DAM
N
W
E
S
GREEN MOUNTAIN NATIONAL FOREST
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
CHITTENDEN DAM
DRAINAGE AREA
Chittenden, Vermont
USGS Quad. Chittenden, Vermont
Scale 1:62,500
0 FEET 3000


KEPEH 2
Stage Discharge
Rating Curve
EAST CREEK
SU28-11-20
50000
100,000
150,000
DISCHARGE CFS

10x10 TO THE INCH



HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/28/78	Job No SC28-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No 9
For Chittenden Res.			

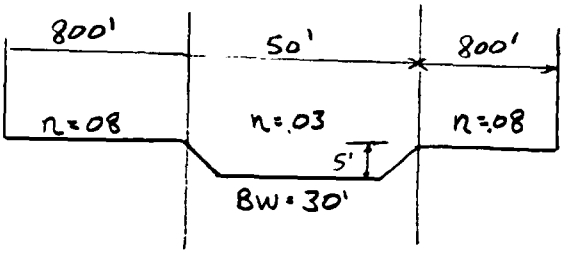
Downstream Damage Summary

End of Reach	Stage	DISCHARGE
At dam	32.9 ft	140,000 cfs
11,000 ft. ds. at Chittendon	32.1	132,000
24,500 ft ds at Pittsford	12.7	106,800

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/28/78	Job No. 5628-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No. 8
For Chittenden Res			

Step 5

Reach 2



Characteristics

$L = 13500'$

$S = 0.0103$

$n = .030$ channel

$.080$ overbank

Stage	Discharge
5	2450
7	14,400
9	38,100
12	90,400
15	159,600

$Qp_1 = 132{,}000$ cfs

$Stage_1 = 13.65'$ $\quad Area_1 = 14{,}472\ \square'$

$$V_1 = \frac{14472 \times 13500}{43560} = 4485 \text{ acre-ft} < \frac{22090}{2}$$

$$Qp_{2\,TRIAL} = 132000\left(1 - \frac{4485}{22090}\right) = 105{,}200 \text{ cfs}$$

$Stage_2 = 12.6$ ft $\quad Area_2 = 12{,}740\ \square'$

$$V_2 = \frac{12740 \times 13{,}500}{43560} = 3948 \text{ acre-ft}$$

$$V_{AVG} = \frac{V_1 + V_2}{2} = \frac{4485 + 3948}{2} = 4217 \text{ acre-ft}$$

$$Qp_2 = 132{,}000\left(1 - \frac{4217}{22090}\right) = 106{,}800 \text{ cfs}$$

Reach Outflow = 106,800 cfs

Stage = 12.7 ft

Stage	Discharge
5 ft	1990 cfs
25	72,800
30	113,000
33	142,600

Step 4 Flood Wave Routing

$Qp_1 = 140{,}000$ cfs $Stage_1 = 32.9$ ft

$Area_1 = 5158$ sq ft

$$Vol_1 = \frac{5158 \times 11{,}000}{43560} = 1302 \text{ acre-ft} < \frac{22090}{2}$$

Reach length O.K.

$$Q_{P_2\,TRIAL} = Q_{P_1}\left(1 - \frac{V_1}{S}\right) = 140000\left(1 - \frac{1302}{22090}\right) = 131{,}750 \text{ cfs}$$

$Stage_2 = 32.0$ ft $Area_2 = 4875$ sq ft

$$V_2 = \frac{4875 \times 11{,}000}{43{,}560} = 1231 \text{ acre ft}$$

$$V_{AVE} = \frac{V_1 + V_2}{2} = \frac{1302 + 1231}{2} = 1266 \text{ acre-ft}$$

$$Q_{P2} = Q_{P_1}\left(1 - \frac{V_{AVE}}{S}\right) = 140{,}000\left(1 - \frac{1266}{22090}\right) = 132{,}000 \text{ cfs}$$

Reach Outflow 132,000 cfs

Stage = 32.1 ft

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/28/78	Job No. 5628-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No. 6
For Chittenden Res.			

Estimate of Downstream Damage

Step 1 Reservoir Capacity

Normal Storage 17200 acre-ft.
@ elev. 1495.72 Crest of spillway

Max. storage 22,090 acre-ft
@ elev. 1501.87 top of dam

Step 2 Peak Failure Outflow

$$Q_{P_1} = 8/27 \sqrt{g}\, W_b\, Y_o^{3/2}$$

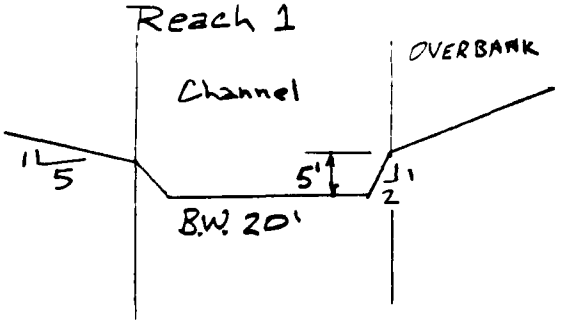
W_b = 40% of dam length = 40% (764.1)

Y_o = height - streambed to max pool elev.
1501.87 - 1460.± = 41.87 use 42 ft.

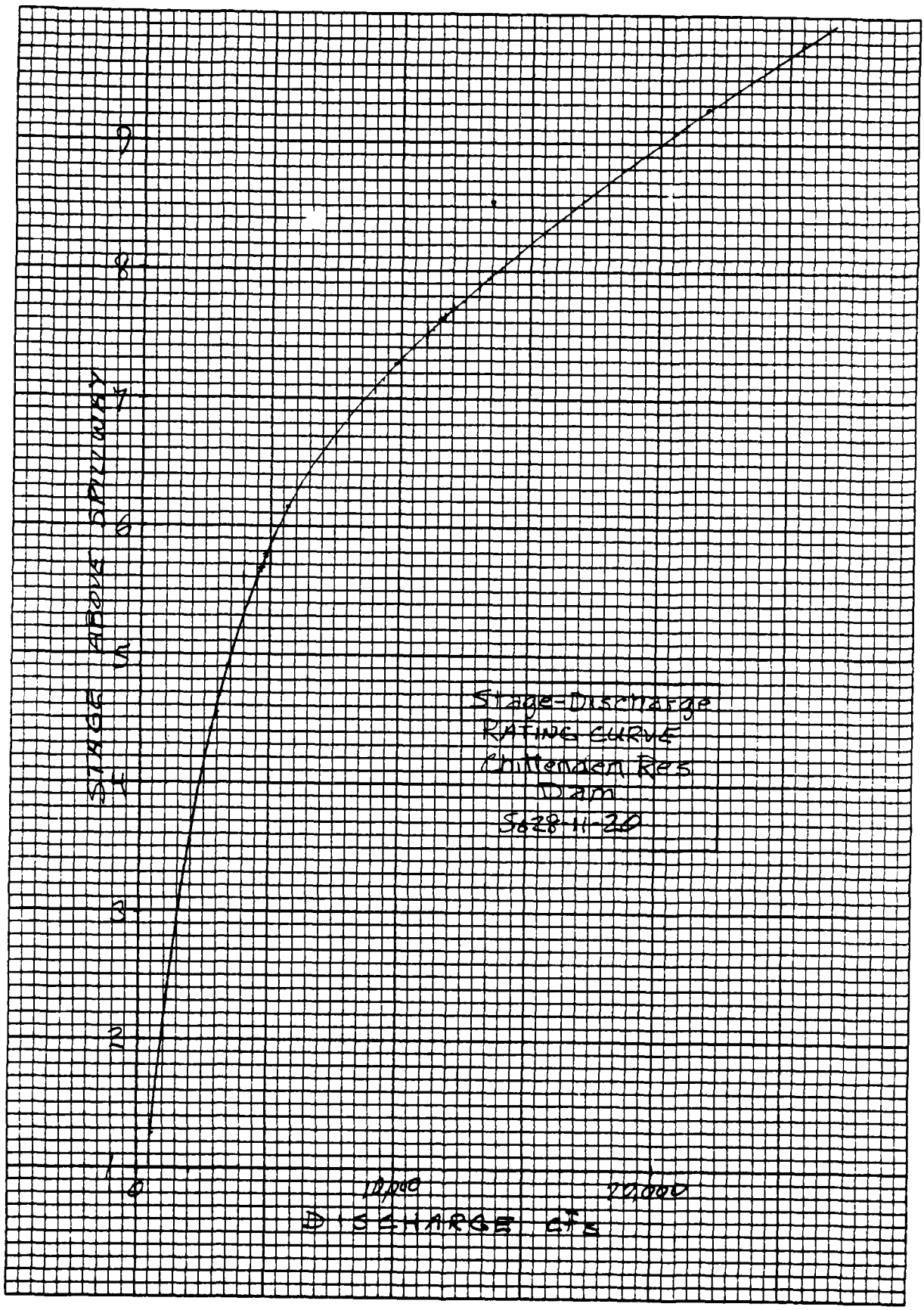
$$Q_{P_1} = 8/27 \sqrt{g}\,(.40)(764.1)(42)^{3/2} = 140{,}000 \text{ cfs.}$$

Q_{P_1} = 140,000 cfs.

Step 3 Stage - Discharge Curve



Reach Characteristics
L = 11,000
S = 0.03
n = .045 channel
.08 overbank


STAGE ABOVE SPILLWAY
0
1
2
3
4
5
6
7
8
9
10,000
20,000
DISCHARGE CFS
Stage-Discharge
Rating Curve
Chittenden Res
Dam
5628 11-20
10X10 TO THE INCH

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 1/15/79	Job No 5628-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No.
For Chittenden			

$$Q_{P4} = Q_{P1}\left(1 - \frac{Stor_{AVE2}}{9.5}\right) = 11850\left(1 - \frac{5.59}{9.5}\right) = 4880 \text{ cfs}$$

$Surcharge_4 = 5.77 \text{ ft}$

$Stor_4 = 5.77(.955) = 5.51 \text{ in}$

$$Stor_{AVE_3} = \frac{5.51 + 5.59}{2} = 5.55 \text{ in}$$

Stor values close to within 1% use Q_{P5} as outflow

$$Q_{P5} = Q_{P1}\left(1 - \frac{Stor_{AVE3}}{9.5}\right) = 11850\left(1 - \frac{5.55}{9.5}\right) = 4940 \text{ cfs.}$$

½ PMF outflow = 4930 cfs.

Stage 5.78' above spillway elev = 1501.5 ft

Top of Dam = 1501.87

Spillway will safely pass ½ PMF ✓

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 1/15/79	Job No 5628-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No
For Chittenden Res.			

Supplementry Cals. Surcharge storage with 1/2 PMF

PMF = 23,700 cfs

1/2 PMF = 11,850 cfs

Effect of Surcharge Storage on 1/2 PMF

Q_{P_1} = 11850 cfs R.O. 9.5 in

$Surcharge_1$ = 7.65 ft

$$Stor_1 = \frac{7.65\ ft \times 12\ in/ft \times 800\ acres}{15.7\ sq\ mi \times 640\ acres/mi^2} = 7.65(.955) = 7.30\ in$$

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{Stor}{9.5}\right) = 11850\left(1 - \frac{7.30}{9.5}\right) = 2740\ cfs$$

$Surcharge_2$ = 4.42 ft

$Stor_2 = 4.42(.955) = 4.22\ in$

$$Stor_{Ave_1} = \frac{7.30 \times 4.22}{2} = 5.76\ in$$

$$Q_{P_3} = Q_{P_1}\left(1 - \frac{Stor_{Ave}}{9.5}\right) = 11850\left(1 - \frac{5.76}{9.5}\right) = 4665\ cfs$$

$Surcharge_3$ = 5.68 ft

$Stor_3 = 5.68 \times (.955) = 5.42\ in$

$$Stor_{Ave_2} = \frac{5.42 + 5.76}{2} = 5.59\ in$$

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by	Date 12/13/78	Job No. 5628-11-20
	Checked by	Date 1/16/79	Sheet No.
For Chittenden			

$Qp_3 = 23{,}700\left(1 - \frac{7.96}{15}\right) = 11{,}120$ cfs

surcharge$_3$ = 7.54 feet

Stor$_3$ = 7.54 × .955 = 7.20 inches

Stor ave$_2$ = $\frac{7.20 + 7.96}{2}$ = 7.58 in

$Qp_4 = 23{,}700\left(1 - \frac{7.58}{15}\right) = 11{,}720$ cfs.

Surcharge$_4$ = 7.63 ft

Stor$_4$ = 7.63 × .955 = 7.29 inches

Stor ave$_3$ = $\frac{7.29 + 7.58}{2}$ = 7.43 in

$Qp_5 = 23{,}700\left(1 - \frac{7.43}{15}\right) = 11960$ cfs

Outflow with 3 feet of Storage in reservoir 12,000 cfs

Stage 7.7 feet

Dam will be overtopped by 1.55 feet

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 12/13/78	Job No. 5628-11-20
	Checked by [illegible]	Date 1/16/79	Sheet No
For Chittenden Res.			

Supplementry surcharge storage calculations

Normally maximum reservoir elevation is three feet below the spillway crest. Therefore this volume is available for storage of the PMF runoff.

Reservoir Vol full at 1495.72 = 786×10^6 cu.ft.

at 1492.72 = 643×10^6 cu.ft.

Vol available for PMF Storage 143×10^6 cu.ft.

Res storage below crest = 3283 acre-ft

PMF runoff $\frac{19''}{12''/ft} \times 15.7 \times 640 = 15910$ acre-ft

$\frac{3283}{15910} \times 19'' = 3.92$ inches reduction of PMF runoff due to storage below spillway crest

Use 4.0

Test Flood Inflow 23,700 cfs = Q_{P_1}

Surcharge = 9.51 ft

$$Stor_1 = \frac{9.51 \times 12 \times 800}{15.7 \times 640} = 9.09 \text{ in}$$

$$Q_{P_1} = 23{,}700\left(1 - \frac{9.09}{15}\right) = 9340 \text{ cfs}$$

Surcharge$_2$ = 7.15 ft

$$Stor_2 = 7.15 \times .955 = 6.83 \text{ in}$$

$$Stor_{ave} = \frac{9.09 + 6.83}{2} = 7.96 \text{ in}$$

$Stor_3 = 7.95(.955) = 7.59$ inches

$Stor_{AVE_2} = \frac{Stor_{AVE_1} + Stor_3}{2} = \frac{8.25 + 7.59}{2} = 7.92$ in.

$Q_{P_4} = Q_{P_1}\left(1 - \frac{Stor_{AVE_2}}{19}\right) = 23{,}700\left(1 - \frac{7.92}{19}\right) = 13{,}820$ cfs

$Surcharge_4 = 8.02$ ft

$Stor_4 = 8.02(.955) = 7.65$ inches

$Stor_{AVE_3} = \frac{Stor_{AVE_2} + Stor_4}{2} = \frac{7.92 + 7.65}{2} = 7.79$ in.

$Stor_{AVE}$ closing to within 2% use Q_{P_5}

$Q_{P_5} = Q_{P_1}\left(1 - \frac{Stor_{AVE_3}}{19}\right) = 23{,}700\left(1 - \frac{7.79}{19}\right) = 13983$ cfs

Reservoir Outflow 14,000 cfs.
Stage. 8.05 ft
Elevation 1503.77

Conclusions

1. Reservoir Storage reduces the SDF from 23,700 cfs to 14,000 cfs or by 41%.
2. The spillway & storage capacity can safely pass 40% of the test flood.
3. At the test discharge of 14,000 cfs the dam crest will be overtopped by 1.90 ft.

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/29/78	Job No 5628-11-20
	Checked by MWM	Date 1/16/79	Sheet No 4
For Chittendon Res			

Stage - Discharge (Fig 1)

Pool Elev	Spillway H_S	Spillway Q_S	DAM H_D	DAM Q_D	Q_{Total}
1497.0	1.28 ft.	530 cfs	-	-	530 cfs
1501.87	6.15	5590	-	-	5590
1503.0	7.28	7200	1.13 ft	2440 cfs	9640
1505.0	9.28	10,360	3.13	11,250	21,610
1505.5	9.78	11,210	3.63	14,050	25,260

Step 4 Effect of Surcharge on PMF

$Q_{P_1} = 23{,}700$ cfs

$Surcharge_1 = 9.51$ ft.

$$Stor_1 = \frac{9.51\text{ ft} \times 12\text{ in/ft} \times 800\text{ acres}}{15.7\text{ sq mi} \times 640\text{ acres/mi}^2} = 9.09\text{ in}$$

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{Stor_1}{19"}\right) = 23{,}700\left(1 - \frac{9.09}{19}\right) = 12{,}361\text{ cfs}$$

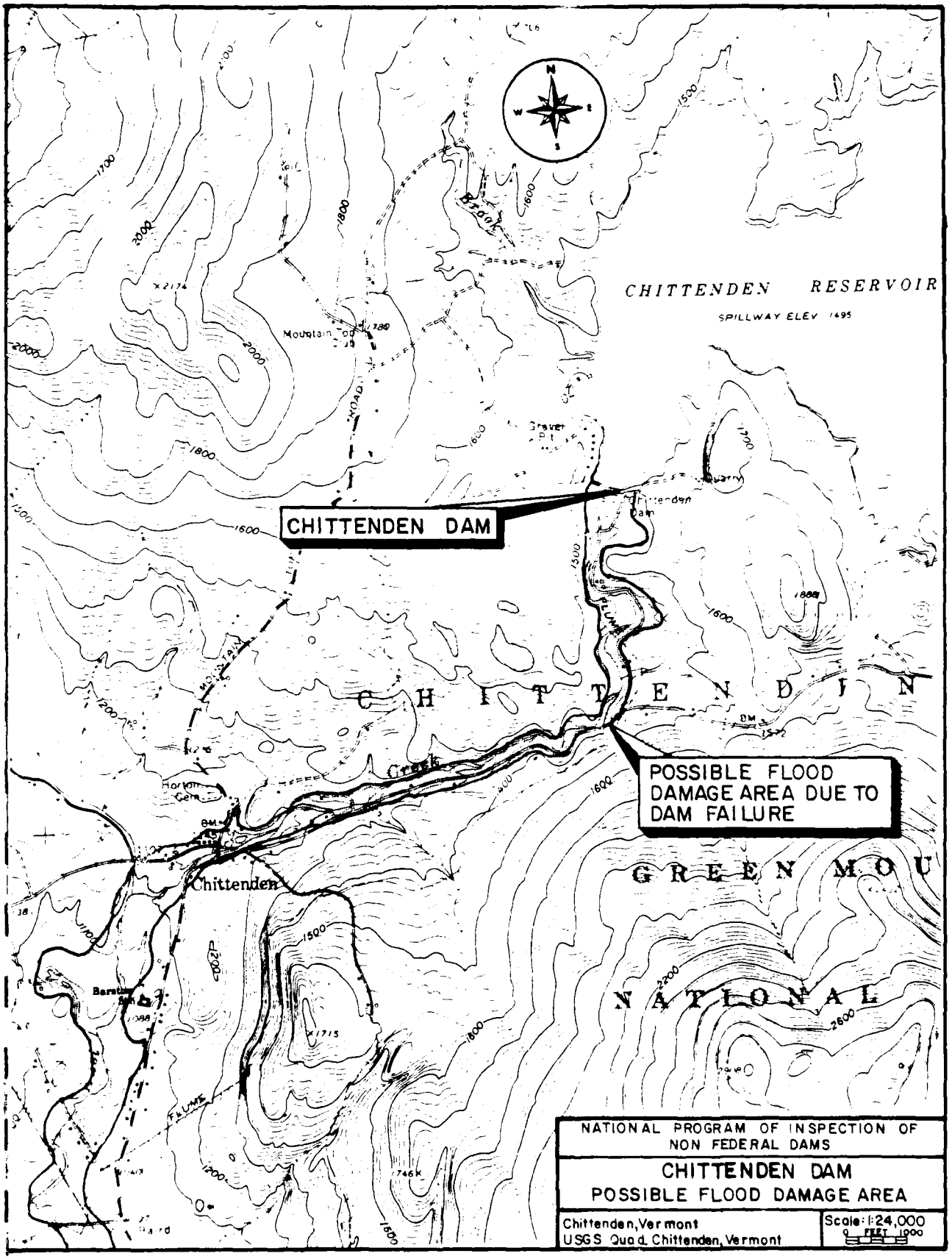
$Surcharge_2 = 7.76$ ft

$$Stor_2 = \frac{7.76 \times 12 \times 800}{15.7 \times 640} = 7.76(.955) = 7.41\text{ inches}$$

$$Stor_{AVE_1} = \frac{Stor_1 + Stor_2}{2} = \frac{9.09 + 7.41}{2} = 8.25\text{ in}$$

$$Q_{P_3} = Q_{P_1}\left(1 - \frac{Stor_{AVE}}{19}\right) = 23{,}700\left(1 - \frac{8.25}{19}\right) = 13400\text{ cfs.}$$

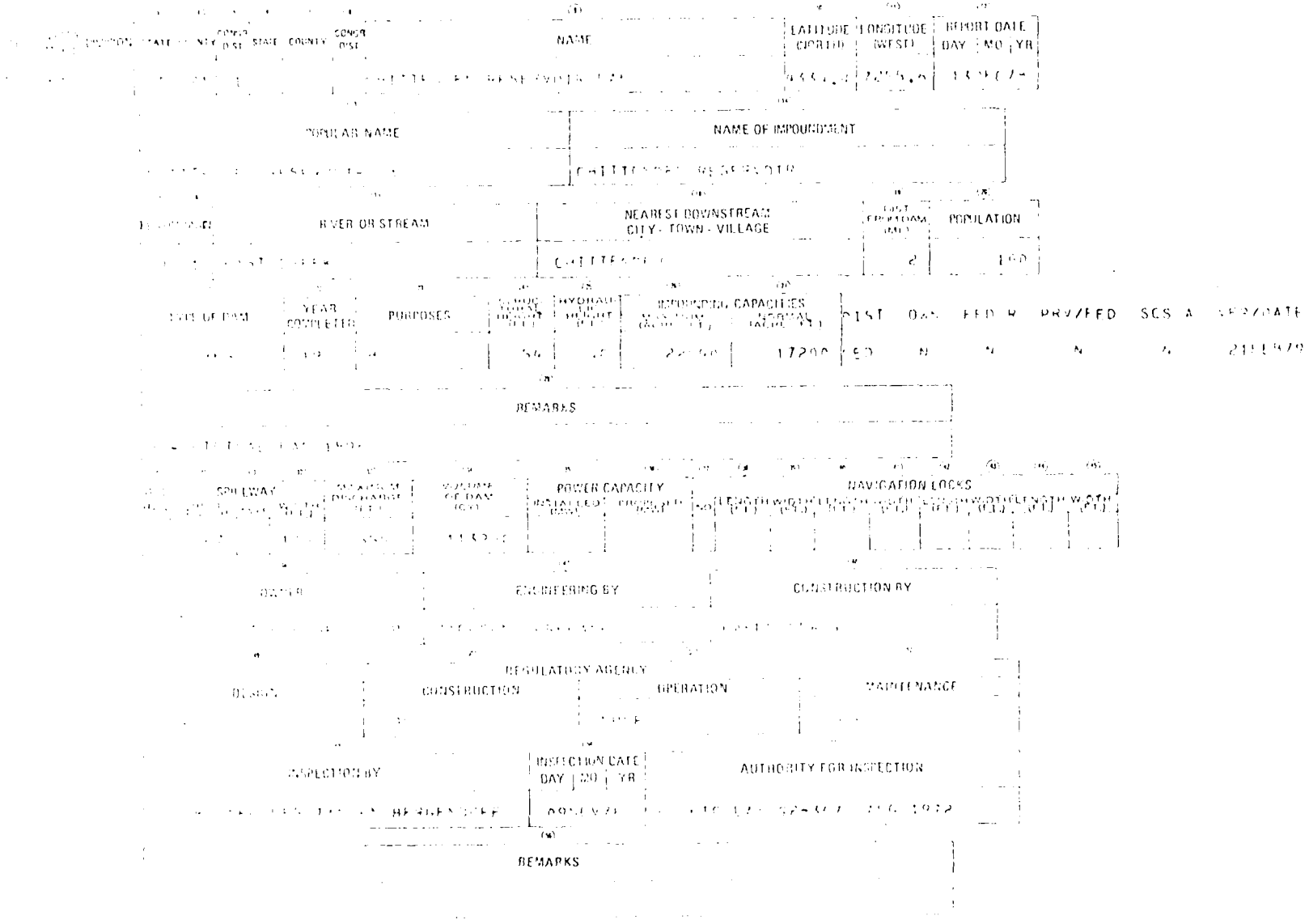
$Surcharge_3 = 7.95$ ft


CHITTENDEN RESERVOIR
SPILLWAY ELEV 1495
CHITTENDEN DAM
POSSIBLE FLOOD DAMAGE AREA DUE TO DAM FAILURE
Chittenden
GREEN MOU
NATIONAL
Creek
FLUME
NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS
CHITTENDEN DAM
POSSIBLE FLOOD DAMAGE AREA
Chittenden, Vermont
USGS Quad. Chittenden, Vermont
Scale: 1:24,000
FEET 1000

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES




DAT
FILM