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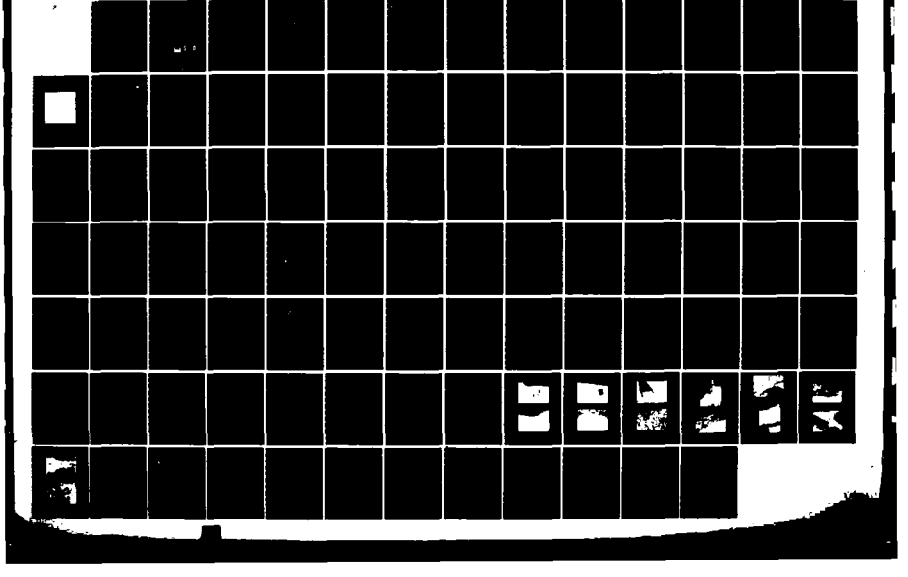

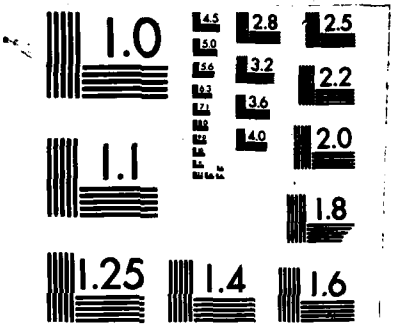

MERRIMACK RIVER BASIN
WESTMINSTER , MASSACHUSETTS

WESTMINSTER RESERVOIR DAM
MA 00639

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

JUNE 1980

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

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

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
Westminster. Massachusetts
Whitman River-tributary of the Nashua River

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

The dam is a 400 ft. long earth dam. There are deficiencies which must be corrected to assure the continued performance of the dam. Generally the dam is in fair condition. The dam has been classified as intermediete in size having a hazard potential of high.

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NEDED-E
Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, James River Massachusetts, Inc., Fitchburg, Massachusetts.

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

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDED-E

MAR 06 1981

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Westminster Reservoir Dam (MA-00639) Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The preliminary hydrologic analysis has indicated that the spillway capacity for the Westminster Reservoir Dam would likely be exceeded by floods greater than 16 percent of the Probable Maximum Flood (PMF), the test flood for spillway adequacy. Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, round-the-clock surveillance should be provided.

WESTMINSTER RESERVOIR DAM

MA 00639

MERRIMACK RIVER BASIN
WESTMINSTER, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00639

Name of Dam: Westminster Reservoir Dam

Town: Westminster

County and State: Worcester County, Massachusetts

Stream: Whitman River, tributary of the Nashua River

Date of Inspection: May 6, 1980

Westminster Reservoir Dam is a 400-foot long earth dam built in 1909 and repaired in 1939. The dam has a maximum height of 31 feet and consists of a spillway, a low level outlet, a dike, and an auxiliary dike. The top of the dam is at Elevation (El) 826. The spillway has a rounded crest weir, 49.5 feet long, and is at El 818. The outlet consists of two 30-inch diameter cast iron pipes which are controlled by gate valves. The downstream invert of the outlet is at El 795.5. The outlet works are located in a gatehouse on the upstream slope of the dam. The dam adjoins at its eastern end a 525 foot long, 3 foot high earth dike. The crest is 10 feet wide and is at El 826. East of the dike an auxiliary dike was constructed through the Salo Farm property. This auxiliary dike which is generally at elevation 825 has been modified in recent years so that it now acts as an access road.

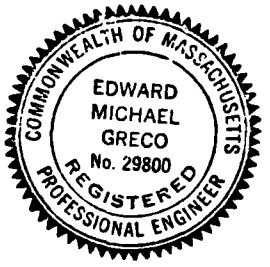
There are deficiencies which must be corrected to assure the continued performance of this dam. This conclusion is based on the visual inspection of the site and a review of the available data. Generally the dam is in fair condition.

The following deficiencies were observed at the site: extensive seepage at three locations along the downstream toe of the dam and dike; localized slumping of the upstream slope east of the gatehouse bridge; erosion of the upstream slope adjacent to the gatehouse bridge; riprap dislodged from the upstream face of the dam; cracked and spalled concrete at the downstream end of the low level outlet; mortar missing from the stone masonry sidewalls of the spillway; an accumulation of debris in the downstream channel; and a heavy growth of trees and brush on the upstream slope of the auxiliary dike.

Based on Corps of Engineers' guidelines, the dam has been classified in the intermediate size and high hazard categories. A test flood equal to the full probable maximum flood (PMF) was used to evaluate the capacity of the spillway. The test flood outflow is 11,900 cfs, without flashboards resulting in a pond level at El 827.7. With the flashboards removed, the test flood would overtop the dam by 1.9 feet. Hydraulic analyses indicate that the spillway (without flashboards) can discharge 4,200 cfs, or 35 percent of the test flood outflow before the dam is overtopped. With flashboards the spillway can discharge 1,900 cfs or 16 percent of the test flood outflow before the dam is overtopped.

It is recommended that the Owner employ a qualified registered professional engineer to conduct a more detailed hydraulic and hydrologic study of the spillway, and to evaluate the extensive seepage at the downstream toe of the dam. The owner should immediately remove the flashboards from the spillway until the detailed hydraulic/hydrologic study is completed. In addition, the Owner should repair the deficiencies listed above, as described in Section 7.3. The Owner should also implement a program of yearly technical inspections, and complete a reportedly upgraded written plan for (1) surveillance of the dam during and after periods of heavy rainfall, and (2) for notifying downstream residents in the event of an emergency at the dam.

The measures outlined above and in Section 7 should be implemented by the Owner within a period of 1 year after receipt of this Phase I Inspection Report.



Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 29800

Approved by:

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703

This Phase I Inspection Report on Westminster Reservoir 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.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. 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 investigations, 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 be any chance that unsafe conditions will 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 aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general conditions and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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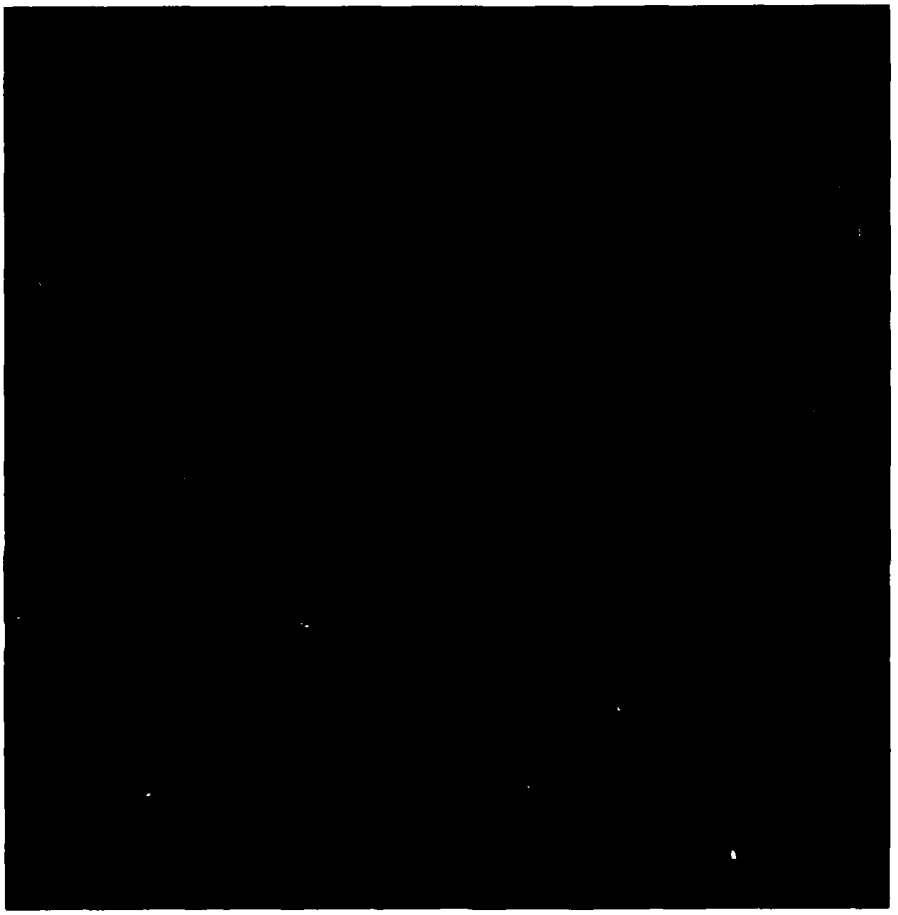
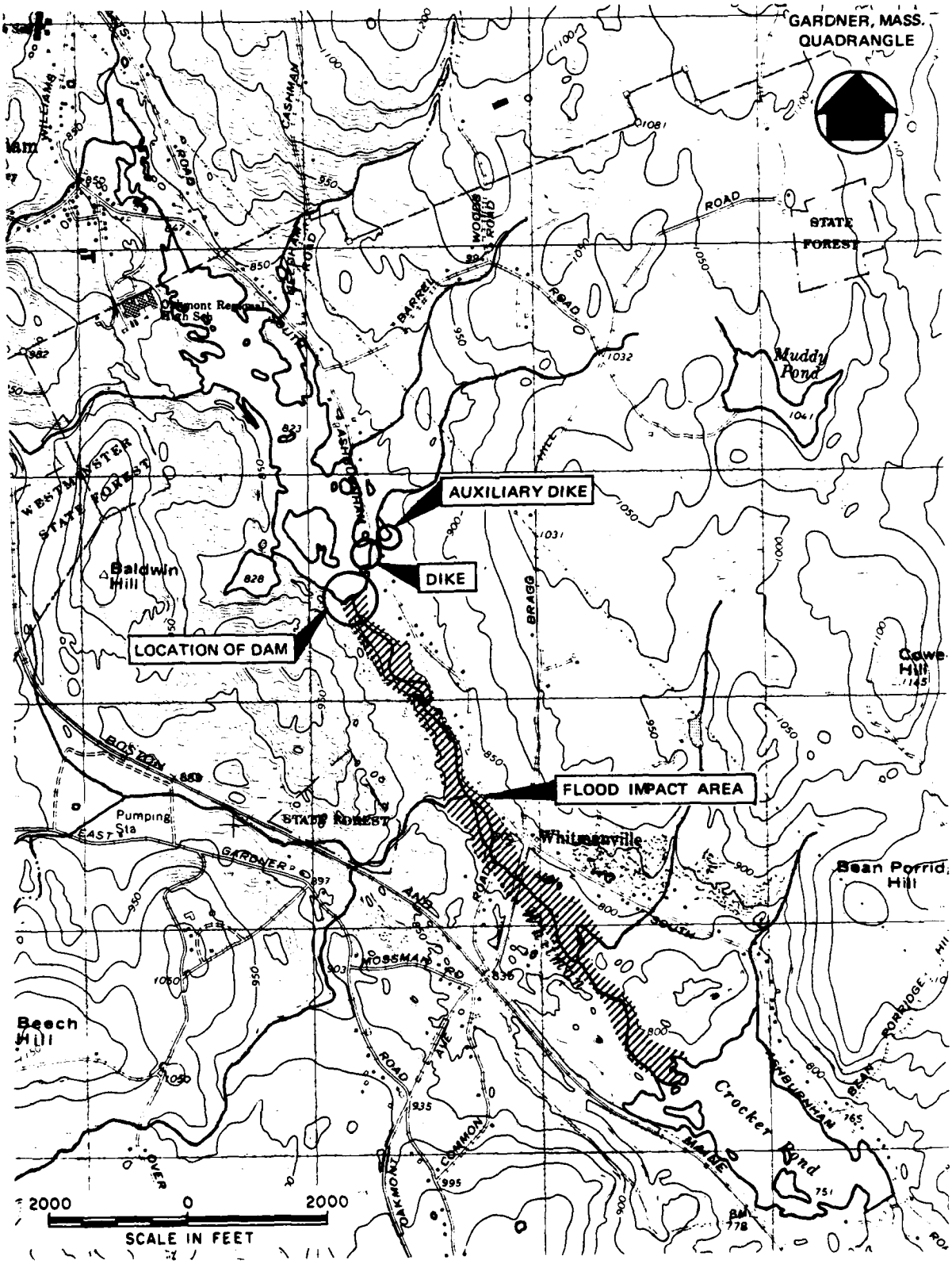
WESTMINSTER RESERVOIR DAM
WESTMINSTER, MASSACHUSETTS





LOCATION MAP – WESTMINSTER RESERVOIR DAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

WESTMINSTER 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. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Contract No. DACW 33-80-C-0054, dated April 18, 1980, has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) 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) Encourage and assist the States to quickly initiate effective dam safety programs for non-Federal dams.

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

1.2 Description of Project

a. Location. The dam is located on the Whitman River in the Town of Westminster, Worcester County, Massachusetts and in the Connecticut River Basin (see Location Map and Drainage Area Map Figure D-1). The coordinates of this location are Latitude 42 deg. 35.5 min. north and Longitude 71 deg. 54.6 min. west.

b. Description of Dam and Appurtenances. Westminster Reservoir Dam is a 400-foot long, earth dam with a maximum height of 31 feet (see Plan of Dam and Sections in Appendix B and photographs in Appendix C). The top

of the dam is 10 feet wide and varies from El 825.8 to 826.0. The upstream face is a 2:1 (horizontal to vertical) slope covered with grass and riprap. The downstream face is a 2:1 slope covered with grass. Available drawings indicate that the dam is an unzoned embankment with a concrete central core wall (see Figure B-2 and B-5). The drawings also show that beneath a section of the core wall is a cutoff wall constructed of interlocking steel sheeting that extends to an unknown depth.

The spillway, located at the west end of the dam, is a 49.5-foot long, rounded crest concrete weir. The plans indicate the approach channel consists of concrete sidewalls and a concrete floor. At the time of the inspection the floor was submerged and not visible. Wooden flashboards 2.5 feet high are mounted with steel pins on the crest of the spillway.

The crest of the spillway is at El 818, and the top of the flashboards is at El 820.5. The flashboards extend the width of the spillway.

The discharge channel below the spillway is 50 feet wide. The sides are 6-foot high concrete walls for a distance of 50 feet downstream. For another 25 feet the walls are stone masonry and for the remainder, the walls are dry stone masonry. The floor of the channel is stone masonry covered with concrete and slopes at a 20 percent grade.

The low-level outlet for the dam consists of two 30-inch diameter cast iron pipes, located 100 feet from the west end of the dam. The invert of the outlet is at El 795.5 at the downstream end. Flow into the outlet is controlled by gate valves located in the gatehouse upstream of the dam. The outlet pipes discharge in the vicinity of the downstream toe and the water flows downstream to join the spillway channel 150 feet downstream of the dam.

Connected to the dam at its eastern end is a 525 foot long, 3 foot high, earth dike. The final 120 feet extends northerly and parallels South Ashburnham road. The top of the dike varies from 9 to 10 feet in width and in elevation from El 825.7 to 826.0. The downstream face is 2:1 (horizontal to vertical) slope covered with grass. The upstream slope varies but generally is 2:1 (horizontal to vertical) and is also covered with grass. Available drawings indicate that the dike is an unzoned embankment with no core or cutoff wall.

Across the road from the dike, an auxiliary dike has been constructed through the Salo property (see Figure B-1). The auxiliary dike is intended to protect the Salo land during periods of high runoff. The dike is a 440 foot long 2 to 3 foot high earth berm that culminates in a 130 foot long 11 foot high zoned earth embankment located on the Salo farm (see Figure B-2). For the most part the elevation of the dike is El 825 but the crest of the zoned embankment is at El 826. The slopes are 2:1 (horizontal to vertical) and the crest is 10 feet wide. Subsequent to the construction of this embankment it has been modified by the addition of a new embankment upstream that acts as an access road to a house on the eastern side of the Salo property.

c. Size Classification. Westminster Reservoir Dam is classified in the "intermediate" category since it has a maximum height of 31 feet and a maximum storage capacity of 1,775 acre-feet.

d. Hazard Classification. There are 9 houses located along the stream channel starting 1,000 feet downstream of the dam (see Flood Impact Area shown on the Location Map). The foundations of these structures are approximately 15 feet above the floor of the stream channel. An assumed failure of the dam would produce a downstream flood wave ± 19 feet deep as compared to channel flow ± 7 feet deep prior to failure resulting in a possible loss of more than a few lives and a moderate amount of property damage. Accordingly, the dam has been placed in the "high" hazard category.

e. Ownership. The dam is owned by the James River - Massachusetts, Inc., P.O. Box 310, Fitchburg, Massachusetts 01420. Mr. Norman Burt (telephone 617-343-3051) granted permission to enter the property and inspect the dam.

f. Operator. The dam is operated by personnel from James River - Massachusetts, Inc.

g. Purpose of the Dam. The water in Westminster Reservoir is used as process water in the manufacture of paper by the James River - Massachusetts mill located 4.5 miles downstream.

h. Design and Construction. Construction of Westminster Reservoir Dam was completed in approximately 1909. Drawings dated 1909 and revised in 1939 are available. The drawings show that the dam was constructed essentially as it appears today, except that in 1939 the spillway was reconstructed and the crest was lowered 2 feet, the dam crest was raised one foot, and the dikes and roadway were raised.

Previous inspection reports indicate that since 1939 the dam has been in good condition. No repairs have been made other than replacing the stoplogs and clearing the slopes of brush.

i. Normal Operating Procedures. Personnel from James River - Massachusetts reportedly visit the dam once a month. At that time, they inspect the dam for any unusual conditions or vandalism. The flashboards are operated as necessary to maintain the flow to Crocker Pond. The low-level outlet is reportedly opened and closed every year but was last used to supply water to Crocker Pond in 1978 when the pond level was below the spillway crest.

1.3 Pertinent Data

a. Drainage Area. The approximately 7,360-acre (11.5 square mile) drainage area consists of wooded gently rolling land (see Figure D-1 in Appendix). The drainage area includes drainage from Lake Wampanoag. About 9.3 percent of the drainage area is ponds and swamps. In general, the undeveloped portions of the drainage area consist of 90 percent woodland, and 10 percent open fields. Light residential development occurs downstream of the dam and along the eastern side of the reservoir.

b. Discharge. Discharge from Westminster Reservoir Dam flows over the flashboards on the spillway and into a concrete discharge channel. Water also discharges from the low level outlet into a channel which joins the spillway discharge channel 150 downstream.

(1) Outlet: Size - 2-30 inch diameter pipes. Downstream Invert El 795.5. Combined capacity - 200 cfs.

(2) Maximum known flood at damsite: Unknown.

(3) Upgated spillway capacity at top of dam 4,200 cfs at El 825.8.

(4) Upgated spillway capacity at test flood elevation: 5,850 cfs at El 827.7.

(5) Gated spillway capacity at normal pool elevation: 1,900 cfs at El 825.8.

(6) Gated spillway capacity at test flood elevation: 3,300 cfs at El 828.2.

(7) Total spillway capacity at test flood elevation: 5,850 cfs at El 827.7.

(8) Total project discharge at test flood elevation: 6,050 cfs at El 827.7.

c. Elevation (feet above National Geodetic Vertical Datum of 1929 (NGVD)). A benchmark was established at El 818.0 at the spillway crest. This elevation was taken from a plan of changes to Westminster Dam, approved June 21, 1969 by the Worcester County Engineering Department.

(1) Streambed at toe of dam: 795.0

(2) Bottom of cutoff: unknown

(3) Maximum tailwater: unknown

(4) Normal pool: 818.0

(5) Full flood control pool: N/A

(6) Spillway crest (gated): 818.0

(7) Design surcharge (Original Design): 824.0

(8) Top of dam: 825.8

(9) Test flood surcharge: (without flashboards) 827.7

d. Reservoir (Length in feet)

(1) Normal pool: 6,000

(2) Flood control pool: N/A

(3) Spillway crest pool: 6,000

(4) Top of dam: 6,000

(5) Test flood pool: 6,000

e. Storage (acre-feet)

(1) Normal pool: 870

(2) Flood control pool: N/A

(3) Spillway crest pool: 870

(4) Top of dam: 1,775

(5) Test flood pool: 2,015

f. Reservoir Surface (acres)

*(1) Normal pool: 116

*(2) Flood control pool: N/A

(3) Spillway crest: 116

*(4) Test flood pool: 116

*(5) Top of dam: 116

g. Dam

(1) Type: earth embankment

(2) Length: 400 feet

(3) Height: 31 feet

(4) Top width: 10 feet

(5) Side slopes: 2:1 (horizontal to vertical)

(6) Zoning: None

(7) Impervious core: concrete

(8) Cutoff: partial steel sheeting

(9) Grout curtain: unknown

(10) Other: none

Dike

(1) Type: earth embankment

(2) Length: 525 feet

(3) Height: 3 feet

(4) Top Width: 9 to 10 feet

(5) Side Slopes: 2:1 (horizontal to vertical)

*Based on the assumption that the surface area will not significantly increase with changes in pool elevation from 818.0 to 825.8

(6) Zoning: none

(7) Impervious Core: none

(8) Cutoff: none

(9) Grout Curtain: none

(10) Other: none

Auxiliary Dike:

(1) Type: earth embankment

(2) Length: 400 feet

(3) Height: maximum of 11 feet

(4) Top Width: 10 feet

(5) Side Slopes: 2:1 (horizontal to vertical)

(6) Zoning: 270 feet unzoned, 130 feet zoned (swale)

(7) Impervious Core: none

(8) Cutoff: clay blanket and cutoff on upstream face in 130 foot swale section

(9) Grout Curtain: none

(10) Other: none

h. Diversion and Regulating Tunnel N/A

i. Spillway

(1) Type: rounded crest

(2) Length of weir: 49.5 feet

(3) Crest elevation: 818.0 without flashboards, 820.5 with flashboards

(4) Gates: none

(5) Upstream channel: concrete sidewalls and floor

(6) Downstream channel: concrete sidewalls for 50 feet, stone masonry for remainder, concrete covered stone masonry floor

(7) General: none

j. Regulating Outlets

(1) Invert El: 795.5 (downstream)

(2) Size: two 30-inch cast-iron pipes

(3) Description: gate valves located in gatehouse upstream of dam, hand operated

(4) Control mechanism: gate valves

(5) Other: none

SECTION 2

ENGINEERING DATA

2.1 General. The engineering data available for this Phase I inspection includes drawings dated 1909 and revised by Howard M. Turner in 1939 (see Figures B-2 through B-7). The drawings were obtained from the Worcester County Engineers Office. Computations for the redesign of the spillway are included in Appendix B. There are no other drawings, specifications, or computations available from the Owner, State, or County agencies. Copies of previous inspection reports dated 1924 to 1967, prepared by the Worcester Gouncty Engineering Department are included in Appendix B. The most recent inspection was conducted in 1976 by the Massachusetts Division of Waterways. A copy of that report is also given in Appendix B.

We acknowledge the assistance and cooperation of personnel from the Massachusetts Department of Environmental Quality Engineering, Division of Waterways; the Massachusetts Department of Public Works; and the Worcester County Engineers Office. In addition, we acknowledge the assistance of Mr. Leo Collette and Mr. Norman Burt of James River - Massachusetts, Inc., who provided information on the history and operation of the dam.

2.2 Construction Records. There are no construction records or as-built drawings available for the dam or appurtenances. Previous inspection reports by the Worcester County engineers office provided some construction information, and a summary of repairs and post-construction changes at the site.

2.3 Operating Records. No operating records are available, and there is no daily record kept of the elevation of the pool or rainfall at the dam site.

2.4 Evaluation

a. Availability. There is limited engineering data available for this dam.

b. Adequacy. The lack of detailed hydraulic, structural and construction data did not allow for a definitive review. Therefore, the evaluation of the adequacy of this dam is based on the visual inspection, past performance history, and engineering judgment.

c. Validity. Comparison of the available drawings with the field survey conducted during the Phase I inspection indicates that the available information is valid.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General. The Phase I Inspection of the dam at Westminster Rservoir was performed on May 6, 1980. A copy of the inspection checklist is included in Appendix A. Previous inspections were conducted by the Worcester County Engineers Office from 1924 to 1967, and by the Massachusetts Department of Public Works in 1972 and 1976. Copies of those reports are given in Appendix B. Selected photographs taken during our visual inspection are included in Appendix C.

b. Dam. The dam is an earthfill structure with a spillway, outlet, dike, and auxiliary dike. Evidence of extensive seepage was noted in 3 locations at the downstream toe of the dam. The seepage is indicated by marshy areas 2 to 3 feet in size and by clear streams of water flowing at approximately 1/2 gpm (see Photo No. 6).

A slump approximately 5 by 8 feet wide was observed on the upstream slope of the dam just east of the gatehouse footbridge.

The concrete on the spillway sidewalls has some minor cracks but is generally in good condition. Slight spalling has occurred on the edge of the left sidewall, as can be seen in Photo No. 10. There is minor efflorescence of the concrete along some of the cracks.

The stone masonry portion of the sidewalls is in good condition. However, where there is mortar, it is cracked in a few places. (See Photo No. 9).

Moderate erosion was noted on the upstream slope of the dam adjacent to the gatehouse footbridge. (See Photo No. 5).

A few pieces of riprap have been dislodged from the upstream face of the embankment but it is generally in good condition. Several planks are missing from the gatehouse access bridge (see Photo No. 3 and No. 5).

A small animal hole was noted on the downstream face, 100 feet west of the outlet.

c. Appurtenant Structures. The spillway is a round crested weir with flashboards. At the time of the inspection, water was discharging over the spillway, however, the weir, flashboards, and downstream toe were examined and found to be in good condition. The concrete on the crest of the spillway was in good condition with no evidence of cracking or spalling. The flashboards appeared to be sound and the retaining pins were straight. The flashboards were reportedly replaced last year and are 2.5 feet high. There is no access walkway to the flashboards which would permit removal of the boards during periods of high flow. The crest of the spillway was clear of debris.

The upstream portions of the outlet were submerged and were not visible during inspection. As shown in Photo No. 3, the gatehouse is in good condition, with minor surficial cracking on the inside walls and some staining and efflorescence on the exterior walls.

The gate valves on the outlet are reportedly in operating condition. The valves were submerged and were not visible during the inspection.

The concrete outlet structure consists of a headwall and two wingwalls that show minor cracking and associated efflorescence. The wall surfaces have suffered heavy spalling particularly adjacent to the outlet pipes (see Photo No. 7 and No. 8). The outlet was partially submerged and it was not possible to determine what, if any, was the rate of seepage. There are two drain pipes that discharge from the right sidewall. The upper one was not flowing but the lower one was discharging approximately 5 gpm of rust stained water (see Photo No. 8).

The dike section west of the highway is in good condition. The crest and slopes are clear of trees and brush and are grass covered. There is no evidence of erosion or movement of this section. The eastern section of the auxiliary dike is covered with brush and small trees along the upstream face for the first 200 feet. The top of the dike along this section is heavily rutted from vehicular traffic. The roadway dips toward the middle of the stream channel but otherwise the alignment is relatively straight. (see Photo Nos. 13 and 14). The two culvert pipes located at the low point in the roadway were submerged but appear to be open. Water passing through these pipes is ponding in a marshy area between the roadway berm and the original dike located approximately 220 feet further downstream. The original dike is in good condition and is grass covered (see overview photo).

d. Reservoir Area

The reservoir area is sparsely developed. Oakmont Regional High School is located at the northwest corner of the reservoir. Residential development is located on the north and east sides of the reservoir. Most of the land is wooded with moderately steep slopes. There is some potential that future development will occur in the reservoir area.

e. Downstream Channel. The spillway discharges into the downstream channel. The concrete and stony masonry walls that form the sides of the channel are slightly cracked and eroded, etc.) (see Photo No. 10 and No. 11). The stone masonry floor of the channel is covered with concrete. There is a slight accumulation of debris on the downstream floor of the channel (see Photograph No. 10).

Approximately 10 saplings are overhanging the right hand side of the channel.

The low level outlet discharges into a channel which joins the spillway discharge channel 150 feet downstream of the dam. The outlet channel is shallow, unlined and approximately 20 feet wide. It is clear of debris but a thick growth of brush and saplings along the banks overhang the channel.

A road embankment crosses the channel about 4,500 feet downstream of the dam. Water flows through the embankment in a 12-foot diameter corrugated metal culvert.

The village of Whitmanville is located 4,300 feet south of the reservoir.

3.2 Evaluation. The visual inspection indicates that the dam is in fair condition. The stated deficiencies which must be corrected to assure the continued performance of this dam and measures to improve this condition are outlined in Section 7.

SECTION 4

OPERATING AND MAINTENANCE PROCEDURES

4.1 Operating Procedures

a. General. According to Mr. Collette (company representative) the standard procedure for operating the dam is to visit the dam monthly to inspect the dam or more frequently as necessary to regulate the flashboards on the spillway.

b. Warning System. The Owner of the dam, in cooperation with the Office of Civil Defense, Fitchburg has devised a plan for surveillance of the embankment during and after periods of heavy rainfall, and for warning local residents in case of an emergency at the structure. This written plan is presently reportedly being upgraded.

4.2 Maintenance Procedures

a. General. The dam is generally adequately maintained. James River - Massachusetts, Inc. is responsible for maintenance of the facility. Periodic inspections by their personnel have been conducted in the past. Typical maintenance procedures have reportedly included repair of cracked or missing concrete or mortar, clearing bush and trees from the slope and discharge channels, clearing debris from the spillway and outlet intakes, and keeping the low level outlet valves in operating condition.

b. Operating Facilities. Maintenance of the operating facilities at the dam consists of a monthly inspection of the dam during which any vandalism or other damage is repaired and debris is removed from the dam and spillway. The dam is mowed and cleared of brush annually. The operating condition of the outlet works is reportedly checked periodically by the Owner. Because the auxiliary dike is on land not owned by James River - Massachusetts, the auxiliary dike is not maintained by them.

4.3 Evaluation

Evaluation. There is reportedly a program for maintaining the embankment and appurtenant structures in good operating condition. There is also a program of regular technical inspections, a plan reportedly for surveillance of the embankment during and after heavy rainfall, and reportedly an emergency warning system in effect. The latter two items are reportedly included in a written emergency preparedness plan, which is presently being upgraded. This written program should be implemented, as recommended in Section 7.3.

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

5.1 General. Westminster Reservoir Dam has a 11.5-square mile drainage area, about 9.3 percent of which is ponds and swamps (see Figure D-1, Drainage Area Map). The land is gently rolling, and lightly developed.

There is one dam upstream of Westminster Reservoir that provides additional storage within the watershed.

Westminster Reservoir has a surface area of approximately 116 acres and a maximum storage capacity of 1,775 acre-feet at El 825.8. The dam and dike section west of the roadway is of earthfill construction about 930 feet long with the top at El 825.8. The spillway consists of concrete covered stone-masonry with a rounded crest weir and discharge channel. The crest of the weir is 49.5 feet long, and at El 818.

The main outlet consists of two 30 in. diameter cast iron pipes located in the middle of the highest section of the dam. Flow through the outlet is controlled by gate valves. The outlet can discharge a flow of 200 cfs when the reservoir is at El 818.0, which is the crest of the spillway.

Starting at elevation 818.0, and assuming no inflow, the combined discharge of the outlet pipes can lower the reservoir by 1 foot in about 7 hours.

5.2 Design Data. Hydraulic computations for design of the spillway at Westminster Reservoir Dam are included in Appendix B. The spillway is designed for a maximum water surface elevation of 824 with a discharge of 2,450 cfs. The flashboards are assumed to fail at a water surface elevation of 822.5. The outlets were designed to discharge a combined maximum flow of 250 cfs.

5.3 Experience Data. There is no record of overtopping of the present dam, which was repaired in 1939. The inspection reports state that during the 1938 hurricane, water overflowed the highway onto the Salo Farm and then flowed back into Whitman Brook downstream of the dam.

5.4 Test Flood Analysis. Westminster Reservoir Dam has been classified in the "intermediate" size and "high" hazard categories. According to the Corps of Engineers guidelines, a test flood equal to the full PMF (Probable Maximum Flood) should be used to evaluate the capacity of the spillway.

The PMF rate for the Westminster Reservoir Watershed was calculated to be 1,150 cfs per square mile of drainage area. This calculation is based on the average slope of 2.4 percent in the drainage area, the pond-plus-swamp area to drainage area ratio of 9.3 percent, and the U.S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Flow Rates (dated December 1977). For this analysis the peak flow rate was estimated for topographic conditions varying between "rolling" and "flat and coastal".

Applying the full PMF rate to the 11.5 square mile drainage area results in a peak test flood inflow of 13,200 cfs. By adjusting the test flood inflow for surcharge storage, the peak test flood outflow was calculated to be 11,900 cfs (1,035 cfs per square mile, without flashboards. With flashboards to elevation 420.5 the peak test flood outflow is 12,200 cfs (1,061cfs per sq. mi.).

During the test flood, the pond level would rise to El 827.7 without flashboards. With flashboards to El 820.5, the pond would rise to El 828.2.

Hydraulic analysis indicate that the spillway without flashboards can discharge 4,200 cfs or 35 percent of the test flood outflow with the pond at El 825.8, which is the low point on top of the dam. With flashboards to El 820.5, the spillway could discharge 1,900 cfs, or 16 percent of the outflow before the dam is overtopped.

Table 5-1 below summarizes the discharge from the pond during the test flood.

TABLE 5-1.

	Flashboards in place	Flashboards removed
Maximum height of water above dam:	2.4 ft.	1.9 ft.
Discharge over spillway:	3,300 cfs	5,850 cfs
Discharge over dam:	8,900 cfs	6,050 cfs
Depth at critical flow:	1.4 ft.	1.1 ft.
Velocity at critical flow:	6.7 fps	6.0 fps

5.5 Dam Failure Analysis. The total peak discharge rate due to failure of the dam was calculated to be 35,600 cfs with the pond at El 825.8. This calculation is based on a maximum head of 30.3 feet and an assumed 112-foot wide breach occurring in the embankment. Failure of the dam would produce a downstream flood wave ±19 feet deep as compared to channel flow ±7 feet deep prior to failure. It would take about 1-1/2 hours to drain the reservoir.

There are 9 houses located along the stream channel starting 1,000 feet downstream of the dam. The foundations of these structures are approximately 15 feet above the floor of the stream channel. Due to the configuration of the channel, little attenuation of the flood flow is expected. An assumed failure of the dam could produce a flood wave that would rise above the foundation level of these houses resulting in a possible loss of more than a few lives and an excessive amount of property damage. Accordingly, the dam has been placed in the "high" hazard category.

SECTION 6

STRUCTURAL STABILITY

6.1 Visual Observations. The evaluation of the structural stability of Westminster Reservoir Dam is based on a review of previous inspection reports, a review of available drawings, and the visual inspection conducted on May 6, 1980.

As discussed in Section 3, Visual Inspection, the dam is in fair condition. Extensive seepage was observed along the downstream toe of the embankment. There is a 5 x 8 foot area on the upstream slope that has slumped. An area of erosion was observed on the upstream slope of the dam. A thick growth of trees and vegetation exists on the upstream slope of the auxiliary dike.

6.2 Design and Construction Data. Construction of Westminster Reservoir Dam was completed in 1909 and was repaired in 1939. Computations for redesign of the spillway are available and are included in Appendix B.

Drawings dated 1909 show the proposed construction of the dam (see Figures B-4 through B-7). The drawings show that the dam is an unzoned earthfill embankment founded on soil. The side slopes of the embankment are 2:1 upstream and 2:1 downstream. An impervious core wall made of concrete is located in the middle of the embankment. The earthfill is shown as selected fill on the drawings. A partial cutoff wall extends an unknown depth below the base of the dam and consists of interlocking steel sheet piling.

Specifications for construction of the dam are not available.

There is no information on the shear strength or permeability of the soil and/or rock materials of the embankment.

6.3 Post-Construction Changes. Since the original construction of the dam, several changes have been made. In 1939 the dam was reconstructed to increase the spillway capacity and stop flooding of South Ashburnham road in periods of heavy rainfall. The spillway crest was lowered 2 feet and the dam crest was raised 1 foot. The dam slopes were regraded to 2:1 (horizontal to vertical) both upstream and downstream (see Figures B-2 and B-3). The highway was raised and resurfaced between stations 46+75 and 51+50 and a connecting low earth dike crossing the Salo Farm was raised to elevation 826. Subsequent to the reconstruction, an earth dike has been constructed roughly 220 feet north of the existing Salo Dike to provide access to a house (see Photo No. B-13).

6.4 Seismic Stability. The dam is located in Seismic Zone No. 2, and in accordance with Corps of Engineers' guidelines does not warrant further seismic analysis at this time.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. As a result of the visual inspection, the review of available data, and limited information on operation and maintenance, the dam is considered to be in fair condition. The following deficiencies must be corrected to assure the continued performance of this dam: extensive seepage along the downstream toe of the embankment; slumping on the upstream slope of the dam; erosion on the upstream slope of the dam; missing riprap from the upstream slope, planks missing from the deck of the gatehouse access bridge; spalled concrete on the spillway side walls and accumulation of debris in the discharge channel.

The peak test flood (full PMF) outflow is estimated to be 11,900 cfs with the pond at El 827.7 (assuming the flashboards are removed). The test flood would overtop the low point on the dam by 1.9 feet. Hydraulic analyses indicate that the spillway (without flashboards) can discharge 4,200 cfs or 35 percent of the test flood outflow before the dam is overtopped. (With the flashboards in place, the spillway can discharge 1,900 cfs or 16 percent of the test flood outflow before the dam is overtopped).

b. Adequacy. The lack of detailed design and construction data did not allow for a definitive review. Therefore, the evaluation of this dam is based on a review of the available date, the visual inspection, past performance and engineering judgment.

c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within 1 year after receipt of this Phase I Inspection Report.

7.2 Recommendations.

It is recommended that the Owner employ a qualified registered engineer to:

a. Develop procedures for for clearing trees, brush and roots from the dam and dike for a minimum distance of 25 feet from the toe of the dam and dike embankments. All stumps and roots removed should be backfilled with select material.

b. Evaluate the significant seepage noted at the toe of the dam and dike embankment. The evaluation should be conducted after the trees and brush are cleared for a

minimum distance of 25 feet from the toe of the dam.

c. Perform a detailed hydrologic/hydraulic analysis to evaluate the discharge capability of the spillway and the overtopping potential of the dam. (Until the recommendations resulting from this investigation are implemented, the Owner should immediately remove the flashboards from the spillway.)

d. The dam and spillway should be evaluated under a no flow condition after the flashboards are removed. Consideration should be given to lowering the reservoir and examining the spillway and riprap on the upstream slope of the dam.

The Owner should implement the recommendations of the Engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. It is recommended that the Owner accomplish the following:

(1) To prevent continued erosion, fill in and re-seed eroded areas on the upstream face of the earth embankment portions of the dam.

(2) Repair all spalled and deteriorated concrete on the spillway sidewalls.

(3) Replace missing/dislodged riprap on the upstream face of the embankment.

(4) Place earthfill and re-seed eroded areas on the upstream slope.

(5) Remove all debris and loose stone in the floor of the spillway discharge channel.

(6) Fill the animal burrow at downstream toe of dam.

(7) Complete the written definite plan for surveillance of the dam and spillway during and after periods of heavy rainfall and a plan to warn people in downstream areas in the event of an emergency at the dam.

(8) Continue a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances and be supplemented by additional

inspections during and after severe storms. All repairs and maintenance should be undertaken in compliance with all applicable State Regulations. The maintenance program should include removal of any debris caught on the spillway weir to prevent clogging of the spillway.

(9) Institute a program of technical inspections to be conducted on an annual basis.

7.4 Alternatives. There are no recommended alternatives.

APPENDIX A

PERIODIC INSPECTION CHECKLIST

WESTMINSTER RESERVOIR DAM

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT WESTMINSTER RESERVOIR DAM DATE May 6, 1980

TIME 8:30 A.M.

WEATHER Clear

W.S. ELEV. 820.7 U.S. 797.0 DN.S.

PARTY:

1. W. Checci (Metcalf & Eddy - Geotechnical)
2. W. Diesl (Metcalf & Eddy - Geotechnical)
3. S. Nagel (Metcalf & Eddy - Geotechnical)
4. L. Taverna (Metcalf & Eddy - Geotechnical)
5. L. Branagan (Metcalf & Eddy - Hydraulics)

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	S. Nagel/L. Taverna	
2.	Spillway	S. Nagel/L. Taverna	
3.	Gate House	S. Nagel/L. Taverna	
4.	Access Bridge	S. Nagel/L. Taverna	
5.	Dike	S. Nagel/L. Taverna	
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE DAM NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

L/S = Left Side u/s = upstream
R/S = Right Side d/s = downstream

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	825.8
Current Pool Elevation	820.7
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible
Pavement Condition	Unpaved sodded crest-no rutting visible
Movement or Settlement of Crest	None visible
Lateral Movement	None visible
Vertical Alignment	Relatively flat
Horizontal Alignment	Good-straight
Condition at Abutment and at Concrete Structures	Left abutment ties into road, right abutment is hillside, R/H spillway wall against hill L/H wall against embankment
Indications of Movement of Structural Items on Slopes	None visible
Trespassing on Slopes	Localized rutting adjacent to gate house bridge-trees, brush and trash on d/s toe
Sloughing or Erosion of Slopes or Abutments	Sloughing of 5'x8' area next to gate house bridge
Rock Slope Protection - Riprap Failures	u/s slope riprapped from bend to spillway a few pieces missing below water line-riprap extends to water line - good condition
Unusual Movement or Cracking at or near Toes	None visible-some brush and trees encroaching at d/s toe to the left of low level outlet
Unusual Embankment or Downstream Seepage	Adjacent to outlet and 2 other large areas along d/s toe - all seepage less than 1gpm - orange staining
Piping or Boils	None visible //Animal hole @ d/s toe - 100' west of outlet
Foundation Drainage Features	None visible
Toe Drains	Toe drains exit at wall of outlet structure
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE Spillway NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	Concrete sidewalls - dry stone masonry bottom
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	1 or 2 small trees less than 6-inch diameter
Floor of Approach Channel	Loose rock-cobbles & boulders
b. Weir and Training Walls	Concrete floor & sidewalls flashboards in place
General Condition of Concrete	Good-little or no cracking-walls are straight & vertical
Rust or Staining	None visible
Spalling	Very little-most surfaces are smooth some along edge of L/H sidewall
Any Visible Reinforcing	None visible
Any Seepage or Efflorescence	No seepage-some minor efflorescence along 2 cracks
Drain Holes	9-inch drain hole in R/H d/s wall
c. Discharge Channel	Sidewalls are concrete/change to mortared stone at end of 2nd apron/dry stone at end of 3rd apron
General Condition	Good-walls straight & vertical
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Approximately 10 saplings on R/H side
Floor of Channel	Concrete to toe of dam-change to unlined stream channel
Other Obstructions	1 log & a few boulders in channel not much of an obstruction

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE Service Bridge NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	Wood plank deck spanning 2 steel I-beams - no railing
a. Super Structure	
Bearings	Cast into concrete gate house Buried in dam embankment
Anchor Bolts	N/A
Bridge Seat	N/A
Longitudinal Members	Steel I-beams - painted little rust
Under Side of Deck	Exposed
Secondary Bracing	None
Deck	2x8 boards placed across beams-several boards missing at each end
Drainage System	Uncontrolled drainage
Railings	None
Expansion Joints	None
Paint	Some paint chipped on I-beams - fair condition
b. Abutment and Piers	Abutment is u/s dam slope One concrete pier
General Condition of Concrete	Concrete good-u/s toe beginning to be undermined
Alignment of Abutment	Right angles
Approach to Bridge	From dam crest - localized erosion due to foot traffic
Condition of Seat and Backwall	Good

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE Control Tower NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	Step-tapered concrete cylinder Steel plate roof Expanded metal floor
a. Concrete and Structural	
General Condition	Good
Condition of Joints	No joints visible
Spalling	None visible
Visible Reinforcing	None
Rusting or Staining of Concrete	None visible
Any Seepage or Efflorescence	Efflorescence heavy along alligator cracking inside
Joint Alignment	N/A
Unusual Seepage or Leaks in Gate	None
Cracks	Localized alligator cracking on walls inside gate house
Rusting or Corrosion of Steel	Expanded steel deck and roof is coated with surface rust.
b. Mechanical and Electrical	-
Air Vents	-
Float Wells	-
Crane Hoist	-
Elevator	-
Hydraulic System	-
Service Gates	Submerged
Emergency Gates	-
Lightning Protection System	-
Emergency Power System	-
Wiring and Lighting System in Gate Chamber	-

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE Dike NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	825.7
Current Pool Elevation	820.7
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible
Pavement Condition	Unpaved grass covered crest
Movement or Settlement of Crest	None visible
Lateral Movement	None detectable
Vertical Alignment	Good - relatively flat
Horizontal Alignment	Good-straight along each section
Condition at Abutment and at Concrete Structures	Ties into dam on R/H side and road on L/H side
Indications of Movement of Structural Items on Slopes	N/A
Trespassing on Slopes	One small path eroded on d/s slope near junction with dam
Sloughing or Erosion of Slopes or Abutments	Minor erosion on footpath
Rock Slope Protection - Riprap Failures	N/A
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None
Piping or Boils	None
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT WESTMINSTER RESERVOIR DATE May 6, 1980

PROJECT FEATURE Auxiliary Dike NAME S. Nagel

DISCIPLINE Geotechnical NAME L. Taverna

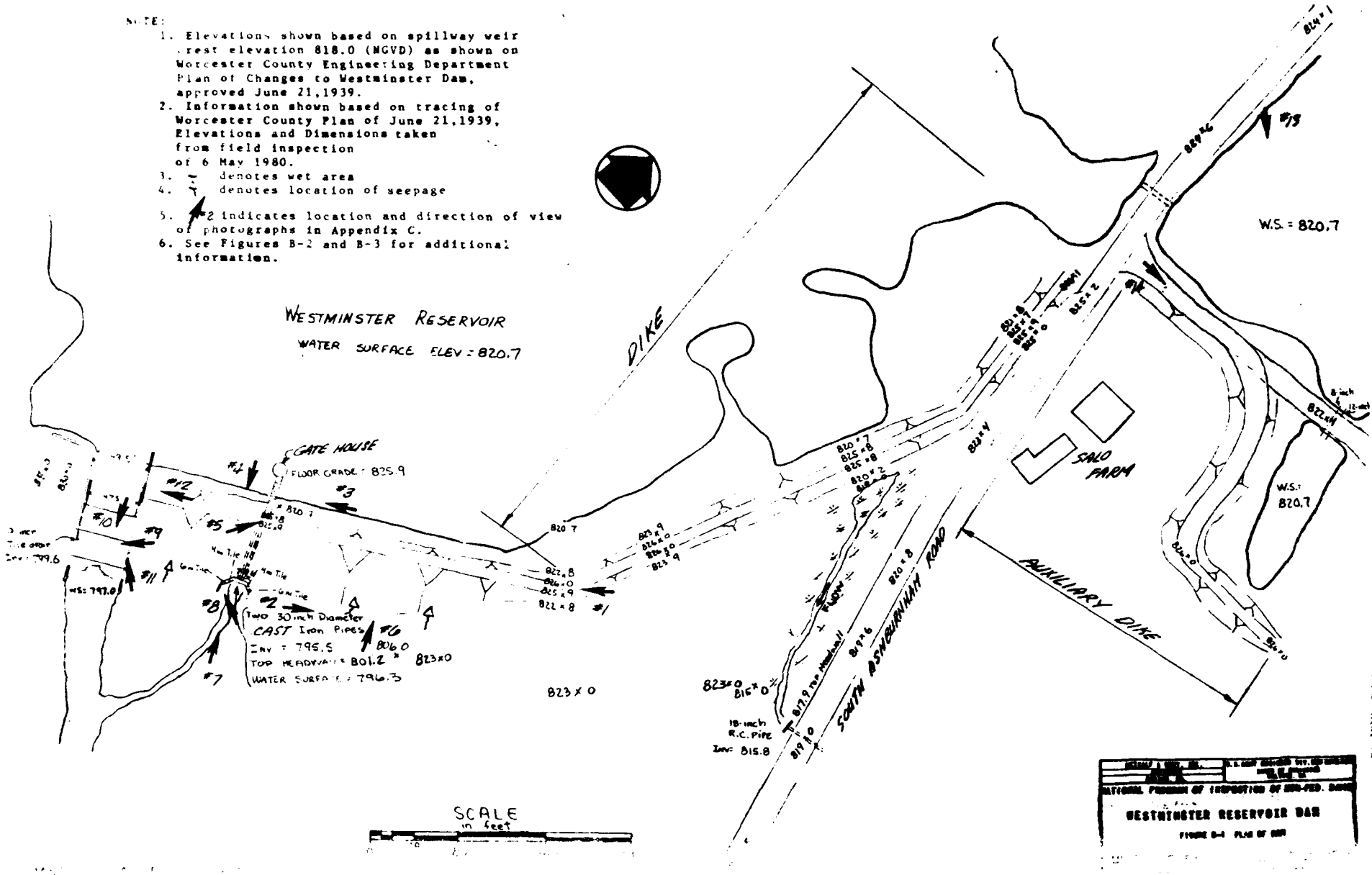
AREA EVALUATED	CONDITION
DIKE EMBANKMENT-AUXILIARY	
Crest Elevation	825.0
Current Pool Elevation	820.7
Maximum Impoundment to Date	Unknown
Surface Cracks	None visible
Pavement Condition	Unpaved dirt road on crest-rutted from vehicular traffic
Movement or Settlement of Crest	Crest dips toward stream channel
Lateral Movement	None visible
Vertical Alignment	See above
Horizontal Alignment	Crest along roadway relatively straight-remainder const. on a curve
Condition at Abutment and at Concrete Structures	Ties into road on R/H side Hillside on L/H side
Indications of Movement of Structural Items on Slopes	N/A
Trespassing on Slopes	Evidence of minor localized foot traffic on slopes
Sloughing or Erosion of Slopes or Abutments	None visible-u/s slope covered with brush & trees-d/s slope sodded
Rock Slope Protection - Riprap Failures	N/A no riprap evident
Unusual Movement or Cracking at or near Toes	None visible
Unusual Embankment or Downstream Seepage	None visible
Piping or Boils	None visible
Foundation Drainage Features	None visible
Toe Drains	None visible
Instrumentation System	None

APPENDIX B

PLANS OF DAM AND PREVIOUS
INSPECTION REPORTS

NOTE:

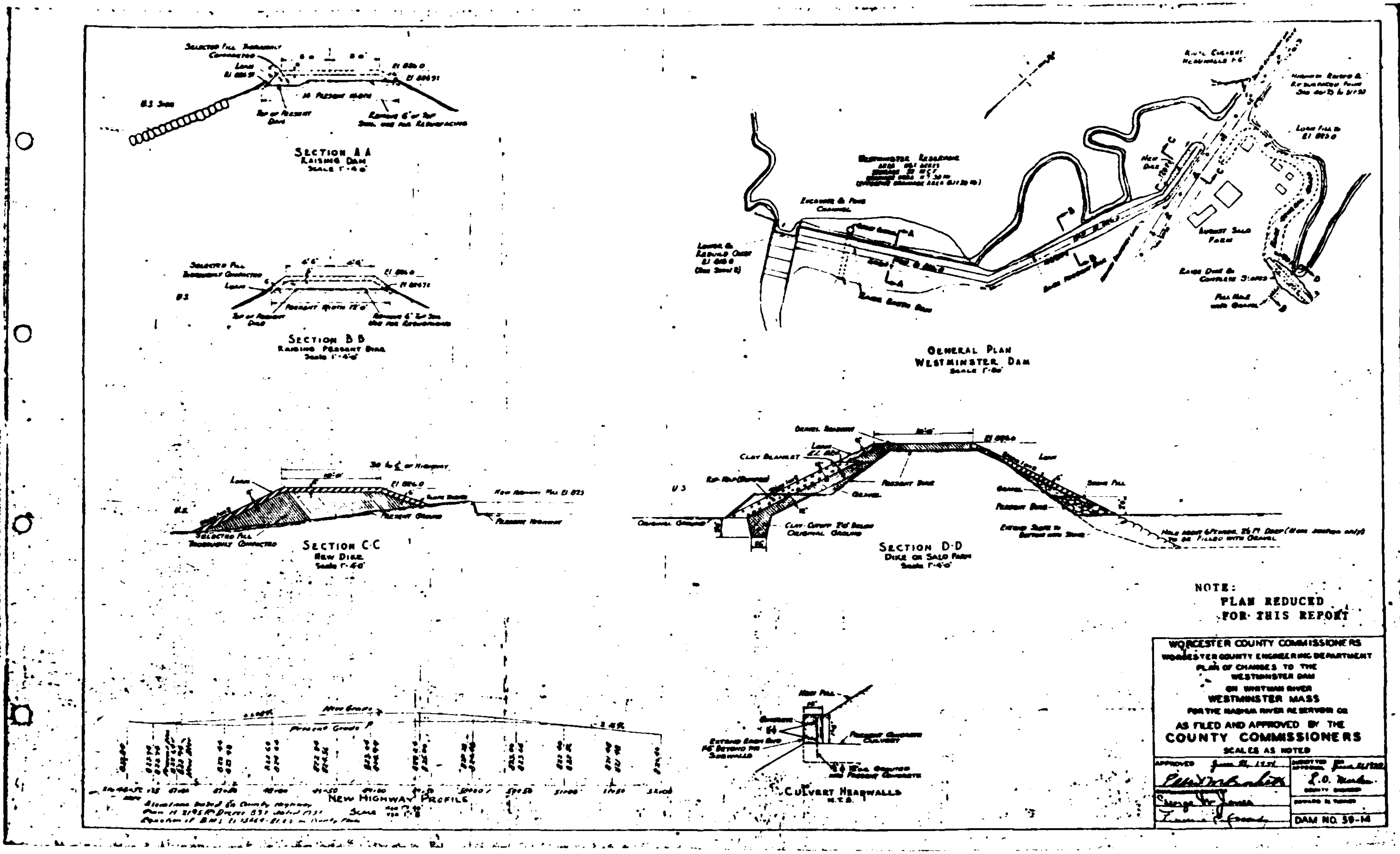
1. Elevations shown based on spillway weir crest elevation 818.0 (NGVD) as shown on Worcester County Engineering Department Plan of Changes to Westminster Dam, approved June 21,1939.
2. Information shown based on tracing of Worcester County Plan of June 21,1939, Elevations and Dimensions taken from field inspection of 6 May 1980.
3. ~ denotes wet area
4. ↓ denotes location of seepage
5. #2 indicates location and direction of view of photographs in Appendix C.
6. See Figures B-2 and B-3 for additional information.



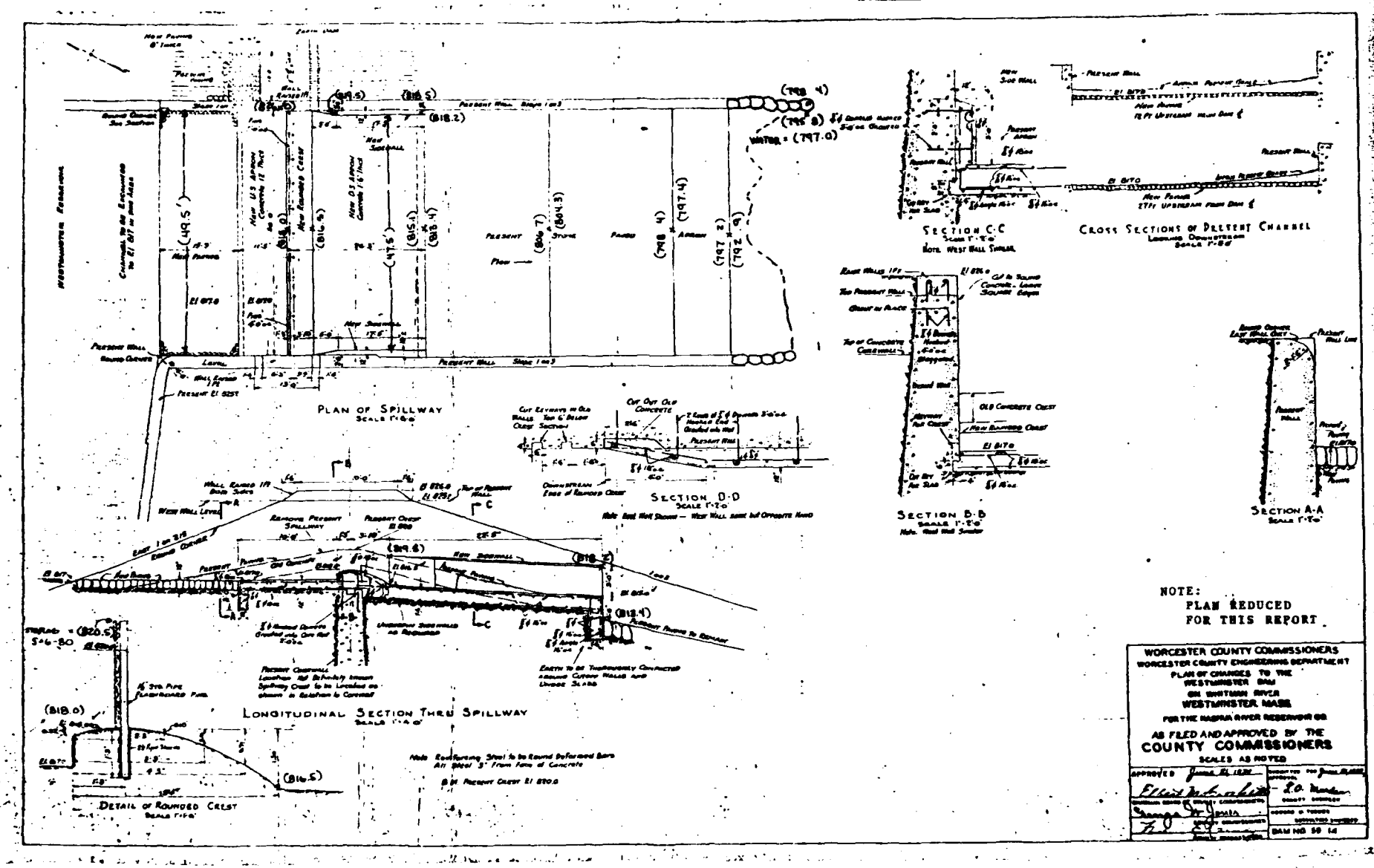
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

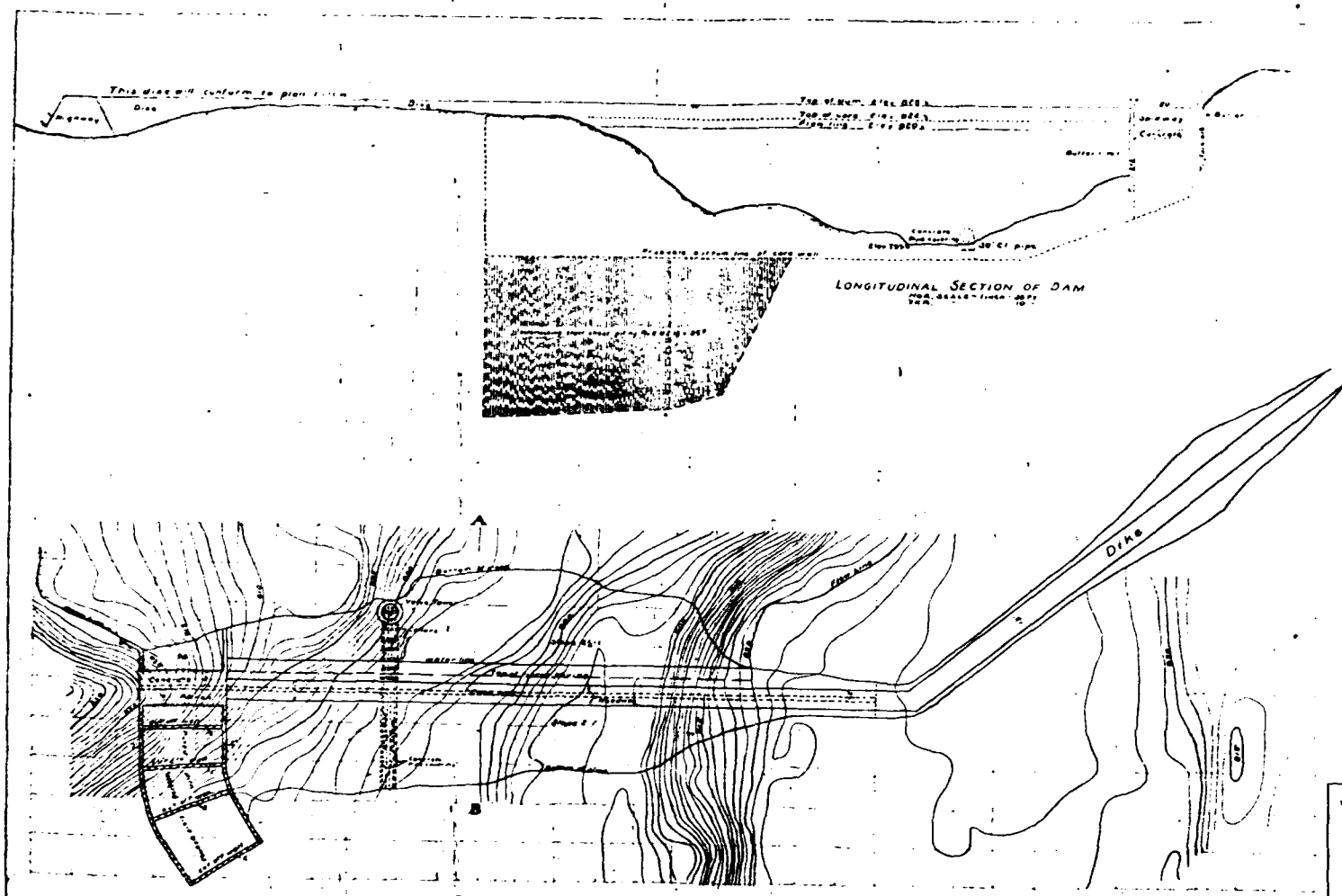
WESTMINSTER RESERVOIR DAM

FIGURE B-1 PLAN OF DAM



SECTION A-A
RAISING DAM
SECTION B-B
RAISING PRESENT DIKE
SECTION C-C
NEW DIKE
GENERAL PLAN
WESTMINSTER DAM
SECTION D-D
DIKE ON SALO FARM
NEW HIGHWAY PROFILE
CULVERT HEADWALLS
NOTE:
PLAN REDUCED
FOR THIS REPORT
WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF CHANGES TO THE
WESTMINSTER DAM
ON WHITMAN RIVER
WESTMINSTER MASS
FOR THE NASHUA RIVER RESERVOIR CO.
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
SCALES AS NOTED
DAM NO. 39-14


PLAN OF SPILLWAY
SCALE 1"=10'
LONGITUDINAL SECTION THRU SPILLWAY
SCALE 1"=4'-0"
DETAIL OF ROUNDED CREST
SCALE 1"=1'-0"
SECTION D-D
SCALE 1"=2'-0"
SECTION C-C
SCALE 1"=2'-0"
SECTION B-B
SCALE 1"=2'-0"
SECTION A-A
SCALE 1"=2'-0"
CROSS SECTIONS OF PRESENT CHANNEL
SCALE 1"=8'
NOTE:
PLAN REDUCED
FOR THIS REPORT
WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF CHANGES TO THE
WESTMINSTER DAM
ON WHITMAN RIVER
WESTMINSTER MASS.
FOR THE NASHUA RIVER RESERVOIRS
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
SCALES AS NOTED
DAM NO. 59.14



LONGITUDINAL SECTION OF DAM

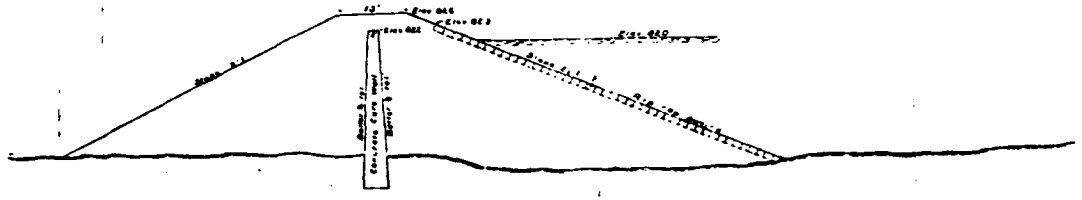
PLAN OF DAM SCALE 1-30'

NOTE:
PLAN REDUCED
FOR THIS REPORT

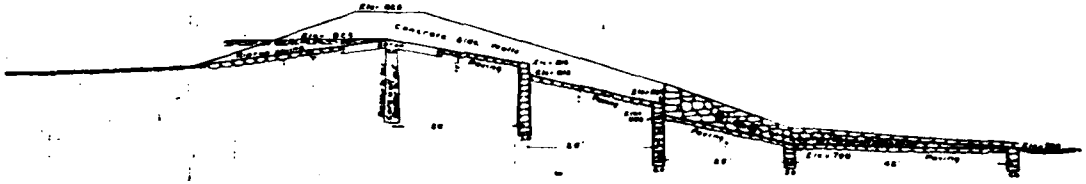
WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
DAM AND SECTION
OVER WHITMAN'S RIVER
WESTMINSTER MASS
FOR NASHUA RESERVOIR CO
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
MARCH 12 1909
DOCKET 427
SCALES AS NOTED

TRACED BY J.B.T. 1-31-39
TRACING CHECKED BY [illegible]
DAM NO. 59-14

COUNTY ENGINEER



CROSS SECTION ON A-B



LONGITUDINAL SECTION OF SPILLWAY

NOTE:
PLAN REDUCED
FOR THIS REPORT

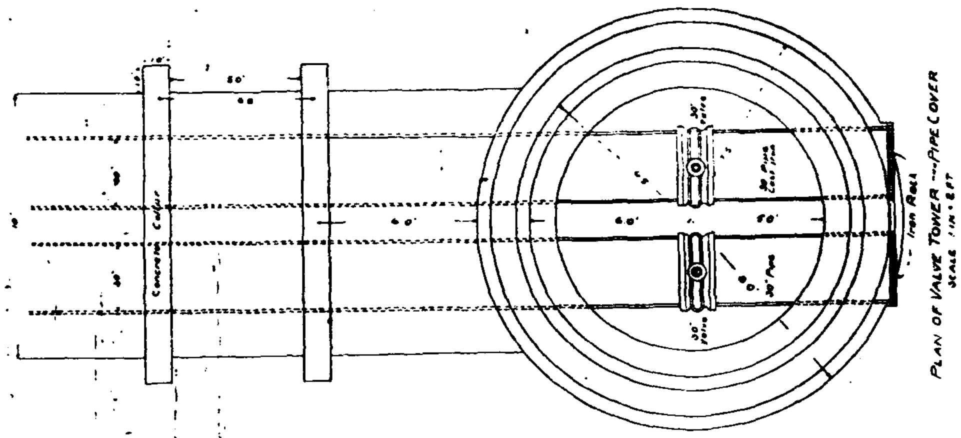
WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
DAM AND SPILLWAY SECTIONS
WHITMAN'S RIVER
WESTMINSTER, MASS
FOR THE PROPOSED RESERVOIR AS
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
MARCH 12, 1909
DOCKET 487
SCALES AS NOTED

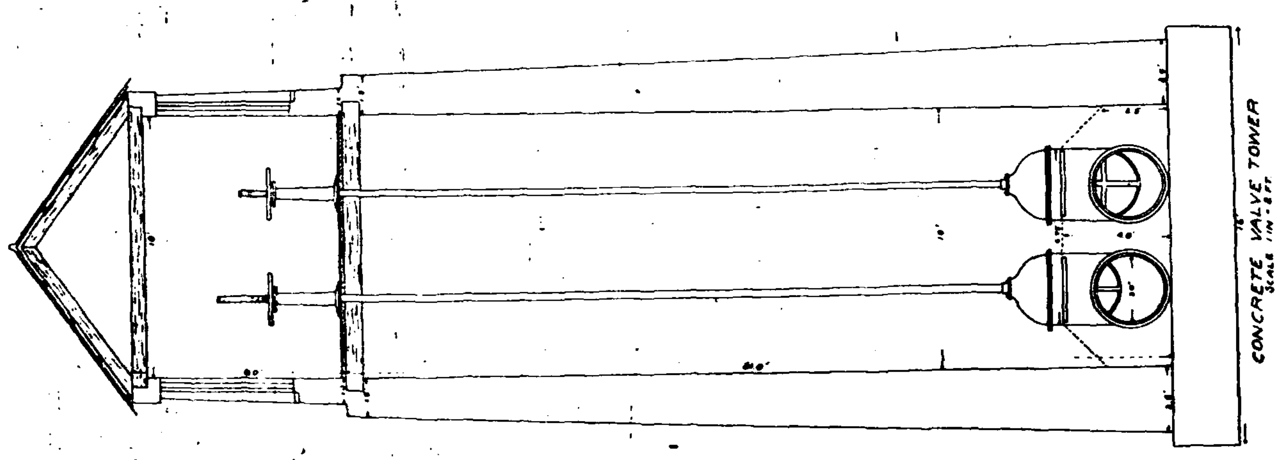
TRACED BY J.B.T. & A.M. DAM NO. 52-14
TRACING CHECKED BY J.B.T. & A.M.

COUNTY ENGINEER

WESTMINSTER RESERVOIR

SHEET R-5





NOTE:
PLAN REDUCED
FOR THIS REPORT

WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
VALVE TOWER DETAILS
WHITMAN'S RIVER
WESTMINSTER, MASS.
FOR THE NASHUA RESERVOIR CO.
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
MARCH 12, 1909
DOCKET 427
SCALES AS NOTED

TRACED BY J.B.T. 6-13-29 DAM NO. 59-14
TRACING CHECKED BY L.A.M. 3-6-19

COUNTY ENGINEER

July 6, 1939

WESTMINSTER DAM

Discharge of New Rounded Crest Spillway

Data

Length of Crest	50 ft.
Top of Crest	Elev. 818
Bottom of Approach Channel	" 817

Spillway Crest Shape

Underside of nappe fits the spillway profile at H = 4.3 ft.

Determination of Crest Coefficient and Spillway Discharge

Equation of Discharge -

$$Q = CBH^{\frac{3}{2}}$$

C = Coefficient of Discharge
L = Length of Crest
H = Total Head on Crest

Basis for Determining Coefficient -

1. The coefficient of discharge for a spillway whose shape is that of the underside of nappe of a sharp crested weir, with negligble velocity of approach, is from 3.95 to 4.05 for the given head.

2. With such a shape of crest, with negligble velocity of approach, the coefficient of discharge will vary with different ratios of actual head to design head, the range being from about 3.0 to as high as 4.2 or above.

3. When velocity of approach is great, as with a low dam with high head, the coefficient of discharge for a crest fitting the underside of nappe is smaller due to the flattened trajectory of the stream.

4. The crest shape must extend downstream far enough so that changes in pressure on the face due to different heads are small. It must also extend beyond the point of critical depth, taking into account the effect of curvature, beyond which point any disturbance can have no effect on the flow over the control section of the crest.

5. The slope of the downstream apron must be sufficient to maintain flow at or below critical depth.

6. Any submergence under these circumtances (4 and 5 above) will have little effect on the discharge.

NASHUA RIVER RESERVOIR COMPANY

Westminster Reservoir

Drainage Area

Gross drainage area	11.1 sq. mi.
Nashua River drainage area (non productive of large flood flows)	3.6 "
Net Drainage Area	8.1 sq. mi.

Present Levels

Spillway crest	Elev.	820.0±
Main dam and dike	"	825.0±
Highway opposite end of main dam		823.6
Dike back of Salo's farm house		825.0±

Proposed New Levels

Spillway crest	Elev.	818.0
Crest of flashboards	"	820.0
Main dam and dike	"	826.0
Highway opposite end of main dam	"	824.6
Dike back of Salo's farm house	"	826.0

FLOOD HEIGHTS AND DISCHARGES

Dam Crest With Flashboards Out (Crest Elev. 818.0) -

W.S. Elev.	Discharge over Dam c.f.p.s.	Discharge Thru Gates c.f.p.s.	Total Discharge	Remarks
818	0	220	220	W.S. at crest of spillway
819	170	225	395	
820	470	230	700	
821	865	235	1100	
822	1330	240	1570	
822.7	1700	245	1945	
823	1860	245	2105	
824	2450	250	2700	

Dam Crest With Flashboards (Elev. 820.0)

W.S. Elev.	Discharge over Dam c.f.p.s.	Discharge Thru Gates c.f.p.s.	Total Discharge	Remarks
820	0	230	230	W.S. Top of Boards
822.5	660	245	905	5' o.c. pins ready to fail
822.5	1125	245	1370	5' o.c. pins ou
823.3	1515	245	1760	1/2 crest clear 4' o.c. pins ready to fail
823.3	2030	245	2275	Crest clear
824.0	2450	250	2700	Crest clear

Note: Tabulated discharges based on Francis Formula coefficient 3.33. A coefficient 10% higher is expected with a properly shaped crest.

The following computations are based on data compiled by Borland after a study of experiments on 78 dam crests.

H = Total Design Head = 4.3 ft.
H^p = Total Head on Rounded Crest
C_o = Theoretic Coefficient at Design Head = 4.05
C^p = Coefficient Expected
P = Height of Crest above Approach Channel = 1.0 ft.

$\frac{H_p}{H_p + P} = 0.811$ Corresponding reduction factor from Borland correcting for velocity of Approach = 0.904

Coefficient at Design Head corrected for velocity of Approach = 4.05 x 0.904 = 3.66

H_o	$\frac{H_o}{H_p}$	Correction for Head Ratio m	C = m 3.66	Expected Discharge	Approximate Pond Elev.
1	0.23	0.83	3.06	154	
2	0.46	0.90	3.28	464	
3	0.70	0.95	3.47	903	
4	0.93	0.99	3.63	1452	
4.3	1.00	1.00	3.66	1632	822.5
5	1.16	1.03	3.76	2100	
6	1.39	1.06	3.88	2850	
6.7	1.56	1.08	3.95	3420	825.0

Check from Weir Test by Schoder & Turner

Measured Head on Sharp Crest	2.0001 ft.
Discharge per foot of crest	14.434 c.f.s.
Height of Sharp Crested Weir	0.50 ft.
Calculated rise of underside of nappe	0.09 ft.
Velocity head	0.51 ft.
Total head on high point at nappe	2.42 ft.
Coefficient of Discharge of Crest just fitting underside of nappe	3.8

This shows estimated value 3.66 ft. actual crest probably on safe side.

References

Schoder & Turner - Trans. A.S.C.E. 1929
Kirschmer - Hydraulic Laboratory Practice
Randolph - Discussion, Trans. A.S.C.E. 1938
Rouse - Civil Engineering Jan. 1935
Justin & Greager - Hydro-Electric Handbook
Borland - Flew over Rounded Crest Weirs, Univ. of Colorado
Bakhmeteff - Flew in Open Channels
Model Tests at W.P.I. (not published)

TOWN OR CITY Westminster   59-14

LOCATION On road to S. Ashburnham.   C.C. DOCKET NO.

DESCRIPTION OF DAM		DESCRIPTION OF RESERVOIR & WATERSHED	
Earth Fill (Conc. Spillway - Earth Dam	El. 100'	Name of Main Stream	Whitman's River
Length	430'	" " any other Streams	
Height	45	Length of Watershed	
Thickness top abt. 12.5	Emb. 13.	Width " "	{ M - Dec 1908
" bottom spill - 115'±	" 120.	Is Watershed Cultivated	{ F. - Mar. 12, 1909
Downstream Slope	2:1	Percent in Forests	
Upstream " Riprap	2½:1	Steepness of Slope	
Length of Spillway El. El. crest 95.3	50.	Kind of Soil	
Size of Gates 2-30" gates - Conc + C.I. pipe El.		No. of Acres in Watershed	11.69 Sq. M
Location of Gates 1030 to east of spillway		" " " Reservoir	255.
Flashboards used	None	Length of Reservoir	
Width Flashboards or Gates		Width " "	
Dam designed by Parker, Bateman & Chase, C.E.		Max Flow Cu. Ft. per Sec.	{ 1938 Flood 4' over crest
" constructed by Repairs 1939		Head or Flashboards-Low Water	{ 1936 " El. 229.0 2'
Year constructed	Prob. 1909.	" " " High "	above top of spillway

GENERAL REMARKS

Owned by Nashua Res. Co.
Vol. 30, P. 309 March 12, 1909.
Interlocking sheeting used (steel.
See Dec. Mty 1908

Inspected: Sept. 29, 1924 - L.O. Marden
Second Inspection 9-10-26. "
Third " Aug. 4, 27 "
" Dec. 15, 1934 "
" 15 1928 "

GENERAL REMARKS

Inspected: Sept. 6, 1934 - L.O.M. and Ralph Mott
" : Oct. 6, 1938 - L. H. Spofford
" : Oct. 10, 1938 - L.O.M., Messrs. Crockett, Bowley
" : Oct. 17, 1938 - " M. F. Hunt
Patrol : Jan. 6, 1939 - L. H. Spofford
" : June 26 1939 - L.O.M. C.T. Crocker, H.K. Tower
" : Aug. 3, 1939 - "
1938 Flood : 4' over 1939 - L.O.M. - H.K. Tower
1936 Flood 2' El. Corcoran, Ralph Mott, B. Stubbs

Patrol - March 16, 1939 - M. F. Hunt
" " 1 " E. C. Corcoran.
Levels : Dec. 17. " F.E. Perry - M.F. Hunt - E.S. Grover - D. Doyle. Bk 155 P. 79
" Hy : " 16 1938 Hunt. Spofford. Corcoran. Field Bk 86 - Page 52
Patrol : April 1, 1940 - L.O.M. water down - no hazard
Inspected : Dec. 9, 1942 - E.C.C. (Repairs 1939 - lowered spillway 2'
" : Jan. 29, 1944 - E.C.C. raised embankment 1'
" Nov. 20, 1946 - L.O.M. new embankment along Hwy
" Dec. 21, 1948 " raising dike
" Mar. 15, 1951 "

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Aug.4,1927

Inspected by L.O.Mardan Date Sept.29,1924 Dam No. 59-14

Whitman River.

Town Westminster Location 1½ miles north Whitmanville-

Owner Nashua Reservoir Co. Use storage.

Material and Type Earth dam-paved spillway- riprap upstream.

Dam Designed by Constructed by Year

SPILLWAY-LENGTH 50'

El. top Abutment 100.- El. Crest 95.3 - El. Apron El. Streambed 70+

Width top Abutment 13.5 - Width top Crest Width bottom Spillway 115. or more.

Width Flashboards carried none Kind Flashboards

El. Flowline Cleanout Pipe prob.70. - Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition good

EMBANKMENT -LENGTH 400'

El. Top 100. El. Natural Ground Width Top 13.5

Width of Bottom 115. Upstream Slope 1½:1 Downstream Slope 2:1

Kind of Corewall Riprap rip rap

Material in Embankment Foundation

Condition good

GATES Location 175' from south end dam

Size 2-30" c.i.pipe Kind El. Flowline

Condition

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure slight leak arounf waste pipe-toe of slope.

Recent Repairs and Date none

Topography of Country below Dam wooded-medium slopes

now burned-1926

Nature of Buildings and Roads below Dam none except Mill at Whitmansville

Number Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L.O.Marden -Ralph Marble Date Sept.6,1934 Dam No. 59-14

Town Westminster Location North of Whitmanville.

Owner Crocker-Burbank Co. Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY—Length Feet. Depth Feet

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition relaid some of apron and made other repairs to abutments.

EMBANKMENT—Length overall Feet

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition

GATES Location

Size Kind El. Flowline

Condition repaired pipes from gates.

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure

Recent Repairs and Date

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number of Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

COUNTY OF WORCESTER MASSACHUSETTS

COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by L.O.Marden Date 12-15-1954 Dam No. 59-14

Town Westminster Location

Owner Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY—Length Feet. Depth Feet

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition OK

EMBANKMENT—Length overall Feet

El. Top El. Natural Ground Width Top

Width of Bottom *Upstream Slope* Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition OK

GATES Location

Size Kind El. Flowline

Condition OK

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure OK

Recent Repairs and Date repair wasteway and below outlet pipes

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number of Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by L. H. Spofford Date 10-6-48 Dam No. SP-14

Town Westminster Location Whitmanville - Whitman River

Owner Nashua River Reservoir Co. Use Impounding Reservoir

Earth Embankment - Flood height appears to have been 24 ft. over crest of spillway

SPILLWAY

El.top abutment _____ El.Crest _____ El.Apron _____ El.St.Bed _____

Width top Abut. _____ Width top Crest _____ Width bottom Sp.way _____

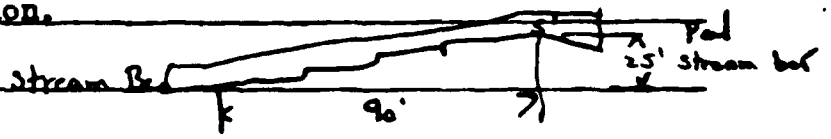
Width flashboards _____ Kind Flashboards _____

El.Flowline Cleanout Pipe _____ Size and Kind Pipe _____

Kind of Foundation under Spillway _____

Condition Concrete and grouted stone spillway 45' long with 5' concrete wings

All in good condition.



EMBANKMENT

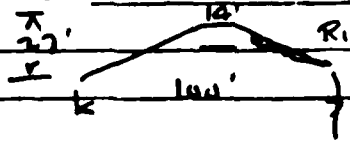
El. Top _____ El.Natural Ground _____ Width Top _____

Width of Borrom _____ Upstream Slope _____ Downstream Slope _____

Kind of Corewall _____ Riprap _____

Material in Embankment _____ Foundation _____

Condition _____



GATES In gate house, open entire flow of river going thru gate this date. Location _____

Size _____ Kind _____ El.Flowline _____

Condition _____

New concrete work on apron and wings was put in in 1936

Evidence of Leaks in Structure see other side

Recent Repairs and Date _____

Number Acres in Pond _____ Drainage Area in Sq. Miles _____

Discharge in Second Feet per Square Mile _____

Estimated Storage Million Cubic Feet _____

Conversation with Mr. Saib (adjacent farmer) reveals that flood from reservoir came 18" over road near his barn and cut down back of his buildings thus relieving pressure on the dam. Rough estimate of the flow-over indicates that 600 sq. ft. of waterway area was added to the spillway capacity in this way. Without this extra passage around his buildings the embankment would have been topped. In the event of topping the embankment, the dam would surely have gone out as the top of the embankment is sodded but has no other protection. Believe core wall is in embankment. L.D.M.

COUNTY OF WORCESTER MASSACHUSETTS
COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs.

Inspected by W. T. Hunt Date Nov 16 1939 Dam No. 59-14

Town Westminster Location Nashua Res. - Westminster

Owner Use

Material and Type

Dam Designed by Constructed by Year

SPILLWAY

El. top Abutment El. Crest El. Apron El. Streambed

Width top Abutment Width top Crest Width bottom Spillway

Width Flashboards carried Kind Flashboards

El. Flowline Cleanout Pipe Size and Kind Cleanout Pipe

Kind of Foundation under Spillway

Condition Water 2' below spillway crest. Water at 2.2 on gauge at gatehouse. Spillway elevation 25.0 Gate wide open.

EMBANKMENT

El. Top El. Natural Ground Width Top

Width of Bottom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition

GATES Location

Size Kind El. Flowline

Condition

WHEEL Kind Size Rated H. P.

Location Ave. Head

Evidence of Leaks in Structure

Recent Repairs and Date

Topography of Country below Dam

Nature of Buildings and Roads below Dam

Number Acres in Pond Drainage Area in Square Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by C.T.Crocker- H.K.Turner. H.O.Marden Date 6-22-1938 Dam No. 29-14

Town Westminster Location Ashburnham Reservoir

Owner Nashua River Res. Co. Use

SPILLWAY

El.top abutment El.Crest El.Apron El.St.Bed

Width top Abut. Width top Crest Width bottom Sp.way

Width flashboards Kind Flashboards

El.Flowline Cleanout Pipe Size and Kind Pipe

Kind of Foundation under Spillway

Condition discuss reconstruction of spillway to handle more water by lowering crest.

EMBANKMENT

El. Top El.Natural Ground Width Top

Width of Borrom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition to raise entire embankment, and main highway where embankment crosses road.

GATES Location

Size Kind El.Flowline

Condition OK

Evidence of Leaks in Structure

Recent Repairs and Date

Number Acres in Pond Drainage Area in Sq. Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs

Inspected by L. O. Marden Date [illegible] Dam No. [illegible]

Town Westminster Location Ashburnham Res.

Owner Nashua River Reservoir Co. Use ____

SPILLWAY

El.top abutment ____ El.Crest ____ El.Apron ____ El.St.Bed ____

Width top Abut. ____ Width top Crest ____ Width bottom Sp.way ____

Width flashboards ____ Kind Flashboards ____

El.Flowline Cleanout Pipe ____ Size and Kind Pipe ____

Kind of Foundation under Spillway ____

Condition work commenced deepening present spillway, scarified road where grade is to be raised.

EMBANKMENT

El. Top ____ El.Natural Ground ____ Width Top ____

Width of Borrow ____ Upstream Slope ____ Downstream Slope ____

Kind of Corewall ____ Riprap ____

Material in Embankment ____ Foundation ____

Condition ____

GATES ____ Location ____

Size ____ Kind ____ El.Flowline ____

Condition ____

Evidence of Leaks in Structure ____

Recent Repairs and Date ____

Number Acres in Pond ____ Drainage Area in Sq. Miles ____

Discharge in Second Feet per Square Mile ____

Estimated Storage Million Cubic Feet ____

WORCESTER COUNTY ENGINEER

Inspection of Dams, Reservoir Dams, and Reservoirs
Ralph Marble- C.T.Crocker-B.P.St.John

Inspected by L.O.Marden-H.K.Turner Date 8-14-1939 Dam No. 59-14

Town Westminster Location Ashburnham Reservoir

Owner Nashua River Reservoir Assn. Use

SPILLWAY

El.top abutment El.Crest El.Apron El.St.Bed

Width top Abut. Width top Crest Width bottom Sp.way

Width flashboards Kind Flashboards

El.Flowline Cleanout Pipe Size and Kind Pipe

Kind of Foundation under Spillway

Condition part concrete cutoff excavated-ready to pour

EMBANKMENT

El. Top El.Natural Ground Width Top

Width of Borrom Upstream Slope Downstream Slope

Kind of Corewall Riprap

Material in Embankment Foundation

Condition ready to raise embankment. highway subgrade completed-tack coat in place.

GATES Location

Size Kind El.Flowline

Condition

Evidence of Leaks in Structure

Recent Repairs and Date

Number Acres in Pond Drainage Area in Sq. Miles

Discharge in Second Feet per Square Mile

Estimated Storage Million Cubic Feet

TOWN Westminster DAM NO. 59-19

LOCATION Westminster Res STREAM

WORCESTER COUNTY ENGINEERING DEPARTMENT

WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

OWNED BY ~~Nashua River~~ Res G PLACE Fitchburg USE Storage

INSPECTED BY LOM - Steve Foss DATE March 15, 1951

TYPE OF DAM CONDITION Good

SPILLWAY

FLASHBOARDS IN PLACE Yes RECENT REPAIRS None

CONDITION Good

REPAIRS NEEDED None

EMBANKMENT

RECENT REPAIRS Yes

CONDITION Good

REPAIRS NEEDED None Cut + grub ext brush

GATES

RECENT REPAIRS Yes

CONDITION Good

REPAIRS NEEDED None

LEAKS

HOW SERIOUS Possible Seepage

DATE 3-15-51

L.O. Marden

COUNTY ENGINEER

TOWN Westminster DAM NO. 59-14

LOCATION 600' southwesterly of South Ashburnham Rd. STREAM Whitman River "Westminster Pond"

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Weyerhaeuser Co. Inc. Place Fitchburg Use Storage Pond

Inspected by F.E.P. - W.C.G. - Tony Kubec Date Nov. 9, 1964

Type of Dam Earth, stone and concrete Condition Good

SPILLWAY

Flashboards in Place 24" boards Recent Repairs _____

Condition This concrete spillway was built in 1912.

Repairs Needed The present water level is down 12" below the spillway crest - the present capacity is about 80 M. Gals

EMBANKMENT

Recent Repairs The capacity (when full) - 360 M. Gals

Condition The area = 10.1 acres.

Repairs Needed This embankment has a clay core.

GATES

Recent Repairs _____

Condition Good condition

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Westminster DAM NO. 59.14

LOCATION South Ashburnham Rd STREAM Whitman River

"Westminster Reservoir"

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by Weyerhaeuser Co, Inc Place Fitchburg Use Storage Pond

Inspected by WCC Date Oct 26, 1967

Type of Dam Earth-Stone-Concrete Condition Good condition

SPILLWAY

Flashboards in Place 26" of 3" boards Recent Repairs _____

Condition Good condition

Repairs Needed Cemented stone crest and outlet

Pins are slightly bent. Present lakeval is below boards

EMBANKMENT

Recent Repairs _____

Condition Good condition

Repairs Needed Embankment extends 152' along railway

GATES

Recent Repairs _____

Conditions Good condition Gate is partly open

Repairs Needed Gate is located in locked gate house

LEAKS

How Serious No leaks are visible

DATE: _____ _____

County Engineer

(H)

INSPECTION REPORT & DATA FOR DAMS

Dam No. 332-14
Town: Westminster
Stream: Whitman River
Pond: Westminster Res.
Date: 2-15-72
By: Eston & Conu

Owner: Weyerhaeuser Co., Inc.
His Address: Fitchburg
Function of Dam: Storage

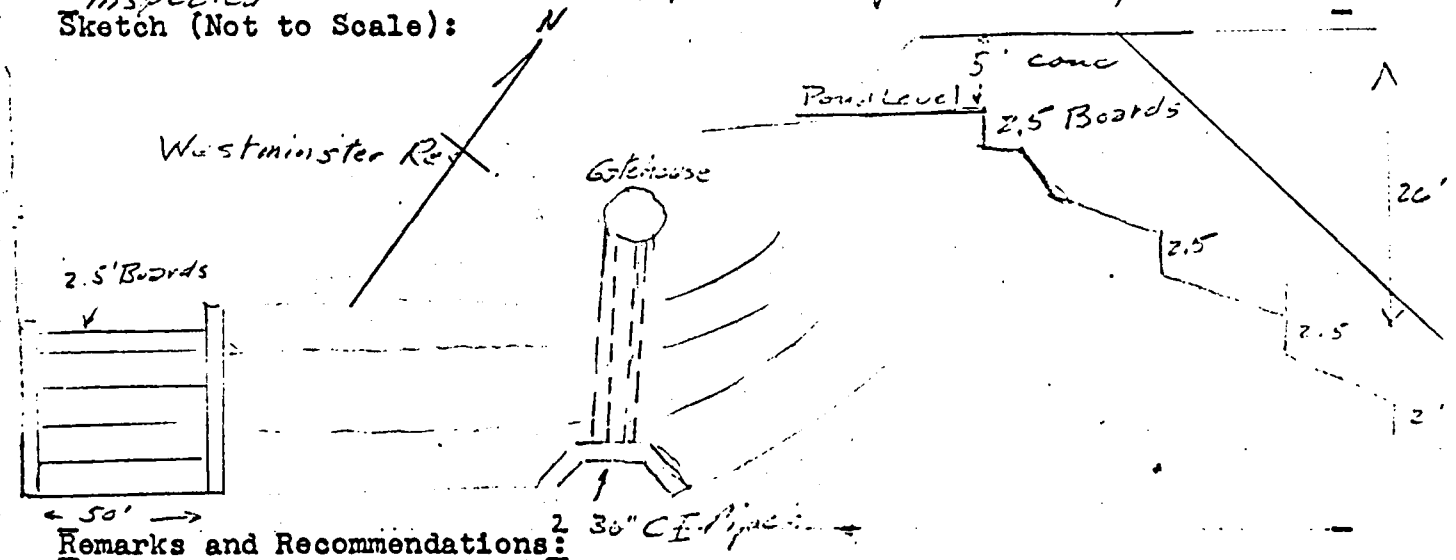
Location & Access: S.W. of Ashburnham Rd. 1.0 Mile S.E. of Ashburnham T/L
USGS Quad. Gardner Lat. 42-35-30 Long. 71-51-35
Drain.Ar.: 11.6 Sq.Mi.; Ponds: ___ ac.; Res.@dam: ___ ac.
Character of D.A.:

CONDITION RATING
Structural: Good
Hydraulic: 25 x 75
General: Good
PRIORITY:

Estimated
Discharge
Capacity:

General Description of Dam and Discharge Control:
Earth dam with stepped concrete spillway 2.5 of Boards in place which is all that is possible, Concrete gate house (Locked) houses Two gates on 30" Cast Iron pipes. One gate partially open when inspected

Sketch (Not to Scale):



Remarks and Recommendations:

Date 2-15-72 By Eston & Conu Comment

B-23 WESTMINSTER RESERVOIR DAM

Dam No. 3-14-332-14

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

October 25, 1976

Weyerhauser Co., Inc.
545 Westminster Road
Fitchburg, Massachusetts
ATT: Mr. Bill Baker

RE: Inspection Dam #3-14-332-14
Westminster
Westminster Reservoir

Gentlemen:

On April 6, 1976 , an Engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam. Our records indicate the owner to be Weyerhauser Co., Inc., Fitchburg. If this information is incorrect will you please notify this office.

The inspection was made in accordance with the provisions of Chapter 253 of the Massachusetts General Laws as amended (Dams-Safety Act). Chapter 706 of the Acts of 1975 transferred the jurisdiction of the so-called "Dams Safety Program" to the Commissioner of the Department of Environmental Quality Engineering.

The results of the inspection indicate that this dam is safe; however the following conditions were noted that require attention:

Pools 20' to 30' beyond the toe of the downstream embankment would indicate seepage. A periodic visual inspection for any increase in seepage or evidence of boil development should be made.

Any pronounced changes in this area would warrant an in-depth consultant inspection.

We call these conditions to your attention before they become serious and more expensive to correct. With any correspondence please include the number of the Dam as indicated above.

Very truly yours,

JOHN J. HANNON, P.E.
CHIEF ENGINEER

A.EC:hlb

DESCRIPTION OF DAM

DISTRICT 3

Submitted by W. REGAN Dam No. 3-14-332-14

Date 4/12/76 ~~City~~/Town WESTMINSTER

Name of Dam Westminster Reservoir

1. Location: Topo Sheet No. 19C - GARDNER QUAD

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: CIRCA 1909 Year/s of subsequent repairs ..... 1940 .....

3. Purpose of Dam: Water Supply _____ Recreational _____

Irrigation _____ Other Mill Storage

4. Drainage Area: 11.7± sq. mi. 1 acres

5. Normal Ponding Area: 255 acres; Ave. depth N/A

Impoundment: N/A gals.; N/A acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

10± Perm. Res. i.e. summer homes, etc. _____

7. Dimensions of Dam: Length Total 1000'± Max. Height 45'±
Main Dike 400'±

Slopes: Upstream Face APPROX 2½:1

Downstream Face APPROX 2:1

Width across top 10'±

8. Classification of Dam by Material:

Earth ✓ Conc. Masonry ✓ Stone Masonry _____

Timber _____ Rockfill _____ Other RIP. RAP U.S. Face No. 2 U.S. 12"x35# Interlocking Steel Sheet Piling

9. A. Description of present land usage downstream of dam:

60 % rural; 40 % urban.

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes _____ no ✓.

DAM NO. 3-14-332-14

10. Risk to life and property in event of complete failure.

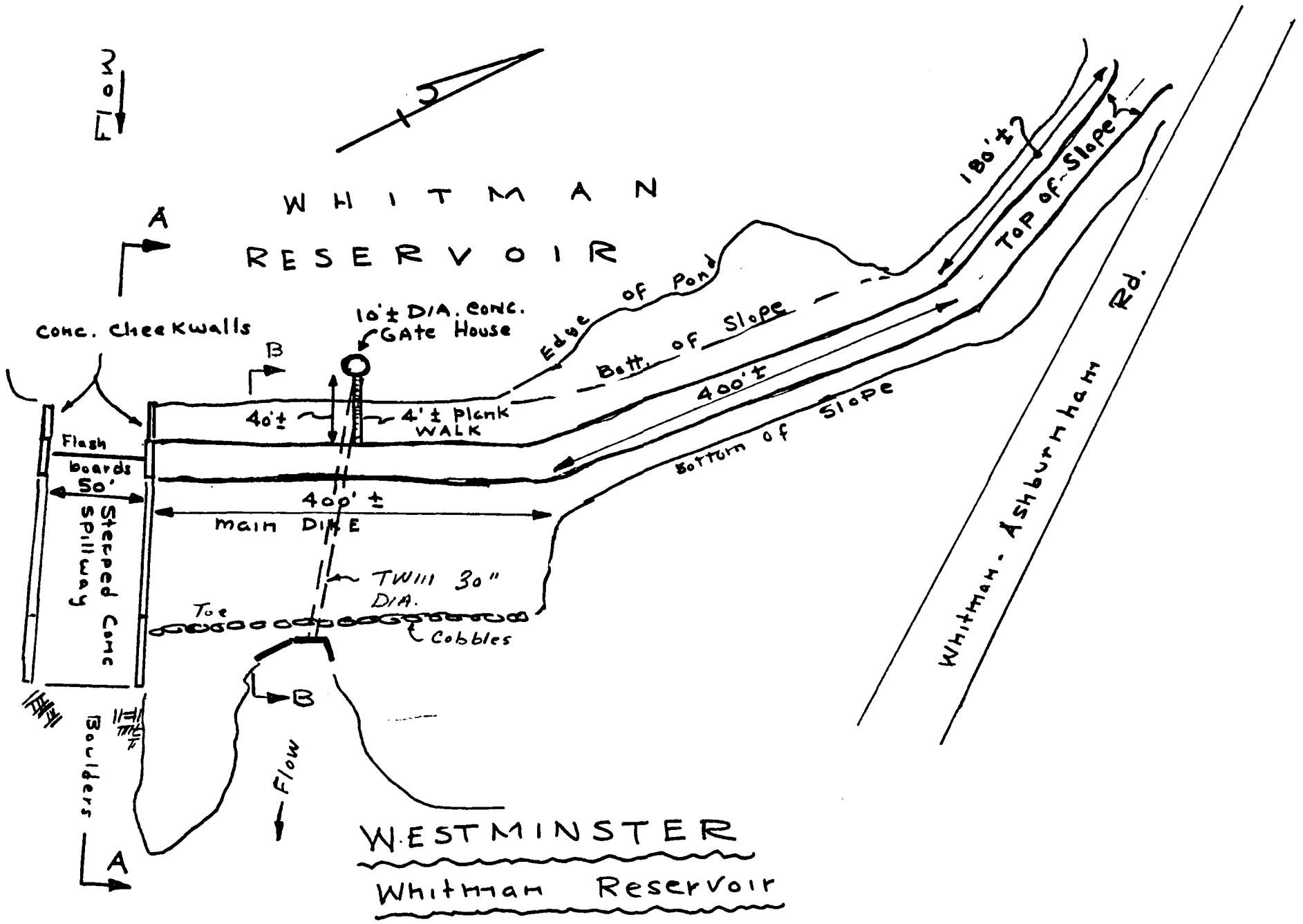
See Note Below

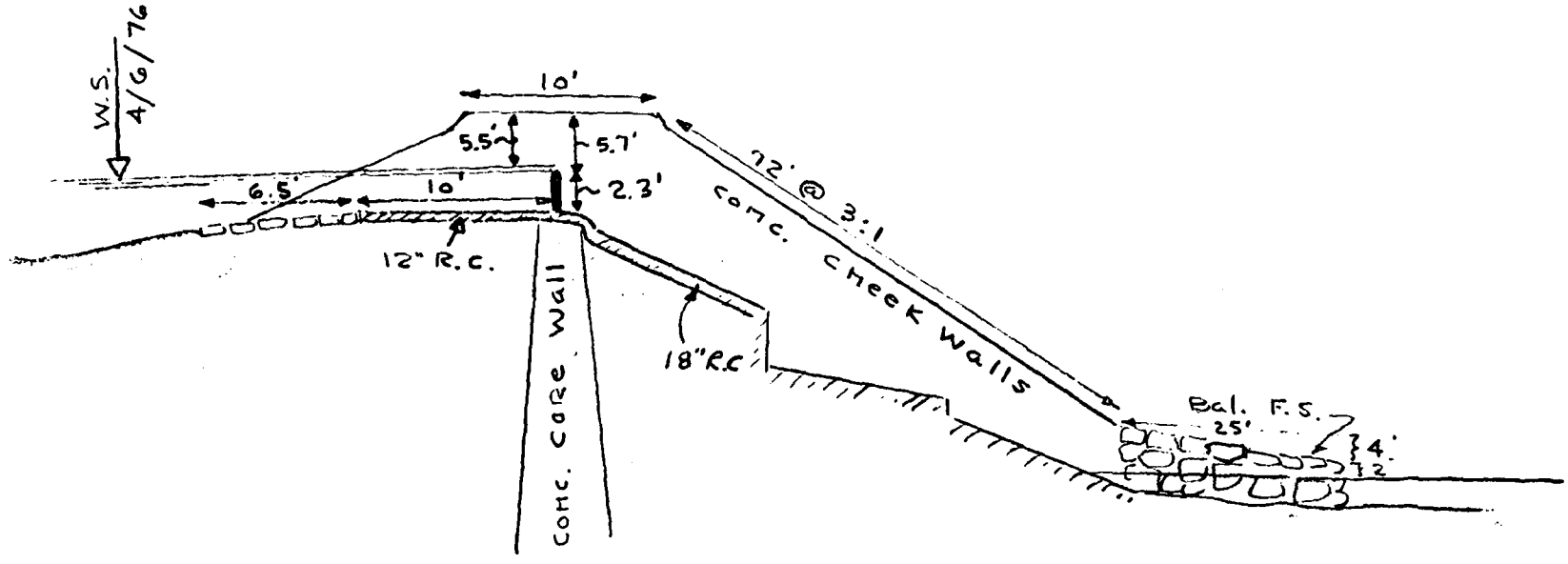
No. of people _____.
No. of homes _____.
No. of Businesses _____.
No. of industries _____. Type _____
No. of utilities _____. Type _____
Railroads _____.
Other dams _____.
Other _____.

11. Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheet.

12. How to Locate: W.B. ON Rte. 2A, TURN Rt. onto Ashburnham Rd. 0.6 ± mi. beyond Fitchburg/Westminster line. TRAVEL 3½ ± mi. to Dam LT. of Rd.

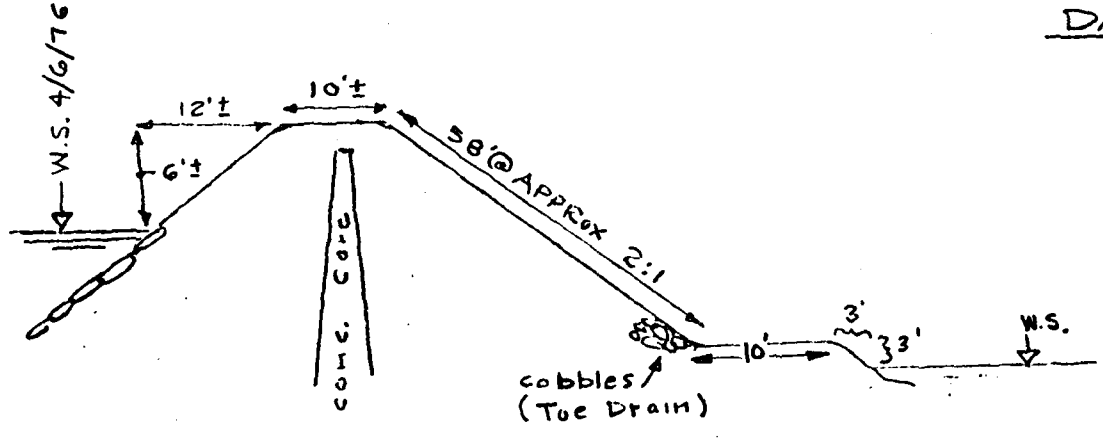
Note(10): In The Unlikely Event of Complete & Sudden failure, failure discharge Could Possibly result IN The Overtopping of Crocker Pond Dam (#11) in Spite of it's Very Large (750 ± S.F. - OGIVE - DROP) SPILLWAY CAPACITY. If failure of both Dams occured IN This MANNER, The Rte 2A Bridge Would WASH away. Among Other Results, Enormous Property damage would occur IN The Waites Corner Section of fitchburg. loss of life Could easily occur and MINOR To Moderate Property damage would occur IN D.S. Areas of The NASHUA.


N
WHITMAN
RESERVOIR
A
B
Conc. Cheekwalls
10'± DIA. Conc.
Gate House
Edge of Pond
Batt. of Slope
180'±
Top of Slope
400'±
Bottom of Slope
40'±
4'± Plank
WALK
Flash
boards
50'
Stepped Conc
Spillway
400'±
main DIKE
TWIII 30"
DIA.
Toe
Cobbles
Boulders
Flow
Whitman - Ashburnham Rd.
WESTMINSTER
Whitman Reservoir
DAM No. 3 4-332-14



SECTION A-A
(spillway)

WESTMINSTER
Whitman Reservoir
DAM No. 3-14-332-14



SECTION B-B
(Main Dike)

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: ~~City~~/Town WESTMINSTER Dam No. 3-14-332-14

Name of Dam Westminster Reservoir Inspected by Regan, Rizkalla

Date of Inspection 4/6/76

2. Owner/s: per: Assessors _____ Prev. Inspection ✓

Reg. of Deeds _____ Pers. Contact _____

1. Weyerhaeuser Co. Inc., 545 Westminster Rd. Fitchburg
Name St. & No. City/Town State Tel. No.

2. ATT: Bill Baker - Water Control Division
Name St. & No. City/Town State Tel, No.

3. _____
Name St. & No. City/Town State Tel. No.

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name: St. & No.:

City/Town: State: Tel.No.:

4. No. of Pictures taken —

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate _____

3. Severe ✓ 4. Disastrous _____

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic _____ Manual ✓

Operative ✓ yes; _____ No.

Comments:

7. Upstream Face of Dam: Condition:

1. Good ✓ 2. Minor Repairs _____

3. Major Repairs _____ 4. Urgent Repairs _____

omComments:

8. Downstream Face of Dam:

Condition: 1. Good ✓ 2. Minor Repairs ✓

3. Major Repairs ___ 4. Urgent Repairs ___

Comments: a few small animal burrows noted on D.S. face in line with The Gate House.

9. Emergency Spillway:

Condition: 1. Good ✓ 2. Minor Repairs ___

3. Major Repairs ___ 4. Urgent Repairs ___

Comments:

10. Water Level at time of inspection: 6½± ft. above ___ below ✓

top of dam Emb. principal spillway ___

other 2½'± Above Spillway Invert

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment —

Animal Burrows ~~and Washouts~~ See (8)

Damage to slopes or top of dam —

Cracked or Damaged Masonry —

Evidence of Seepage ✓ (See 12)

Evidence of Piping —

Erosion —

Leaks —

Trash and/or debis impeding flow —

Clogged or blocked spillway —

Other —

12. Remarks & Recommendations: (Fully Explain)

This dam appears To be generally well maintained and appears To be in fair T. good condition. However There are Shallow Pools several hundred Square feet in area 20' - 30' beyond The MAIN Embankment d.S. Toe. These Pools are Shallow enough To show Piping boils is They should occur. Material is being transported from The embankment; The d.S. Pool bottoms are covered with rust Colored Silt. This Coloration is Typical for dams in The Westminster Area; Emb. material has a high iron Content. Were it not for The fact That I have observed This Rust Colored Silt at about 4 other dams in The Area, I would have Suspected That The U.S. Sheet Piling was rusting out. A Consultant INSPECTION of This dam is desireable (leakage is light To moderate, but hazard rating of dam is high), and The minimum response That The owner Should make is Periodic Visual ~~Inspecting~~ INSPECTION of The leakage for IN Crease in flow or Piping Boil development. If either occurs, an IN depth Consultant Inspection is Positively WARRANTED

13. Overall Condition:

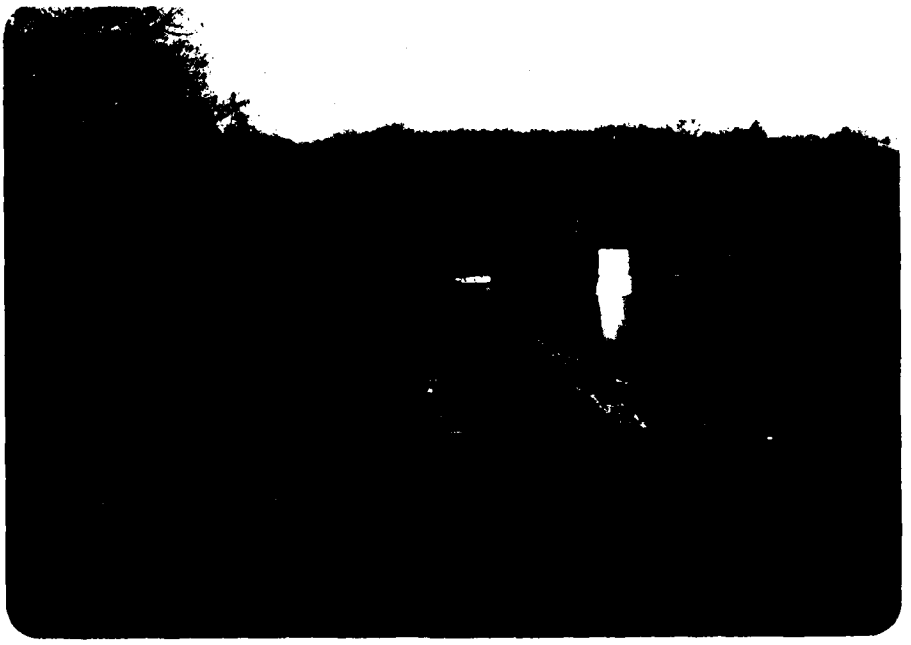
1. Safe _____
2. Minor repairs needed _____
3. Conditionally safe ~~- major repairs needed~~ ✓
   AS Per Above REMARKS
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list _____

APPENDIX C

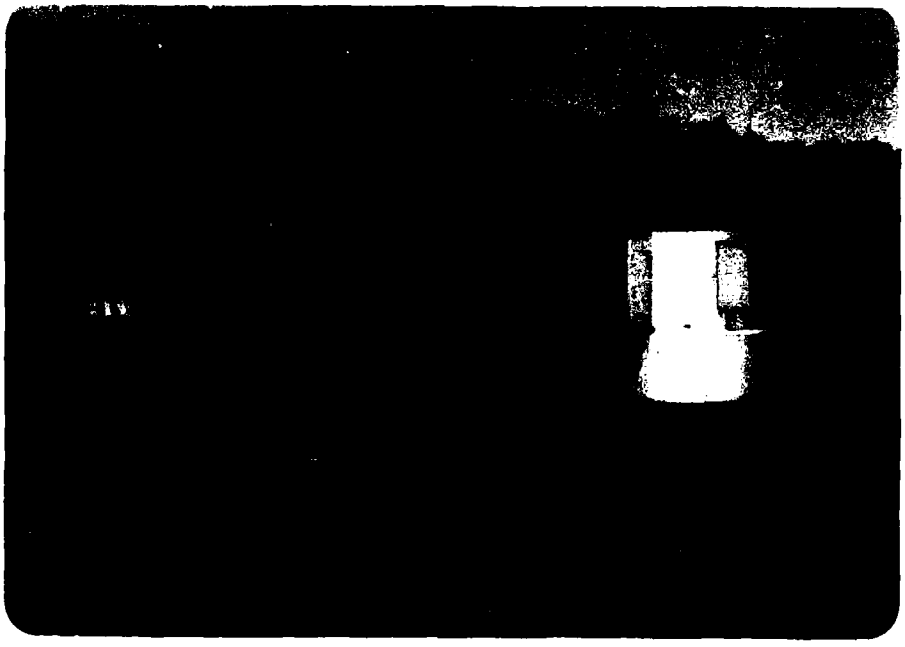
PHOTOGRAPHS

Note: Location and direction of photographs shown on Figure B-1 in Appendix B.



NO. 1 VIEW ALONG DAM CREST

NO. 2 VIEW OF DOWNSTREAM FACE OF DAM



NO. 3 VIEW OF GATEHOUSE & ACCESS BRIDGE

NO. 4 RIPRAP BELOW WATERLINE

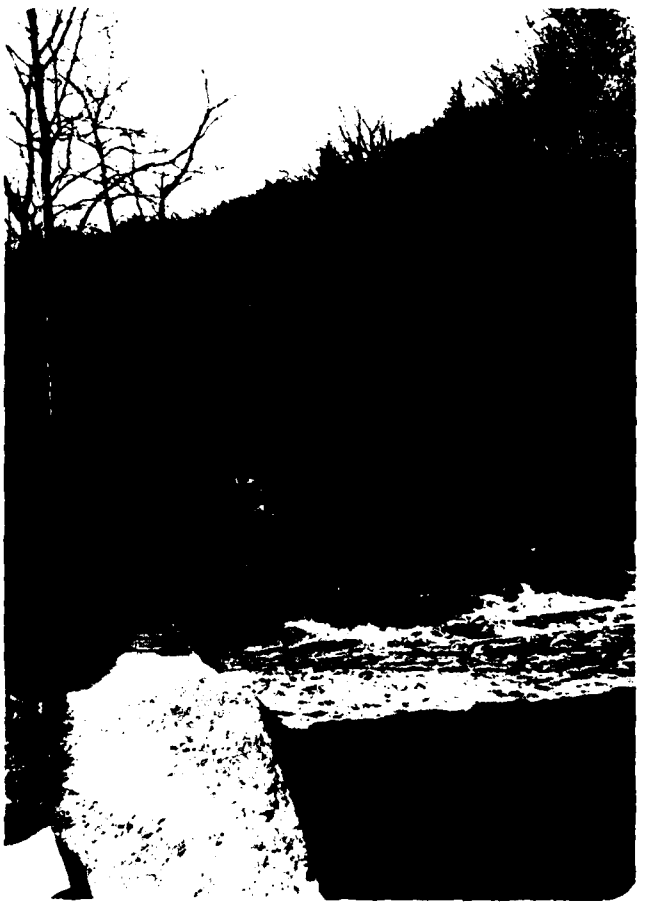
NO. 5 VIEW OF ACCESS BRIDGE & EROSION OF SLOPE

NO. 6 VIEW OF SEEPAGE AT DOWNSTREAM TOE

NO. 7 HEADWALL OF LOW LEVEL OUTLET

NO. 8 VIEW OF TOEDRAINS & DETERIORATION OF RIGHT LOW LEVEL OUTLET SIDEWALL

NO. 9 VIEW OF RIGHT SPILLWAY SIDEWALL SHOWING CHANGE FROM CONCRETE TO DRY STONE MASONRY



NO. 10 VIEW OF DOWNSTREAM CHANNEL

NO. 11 VIEW UPSTREAM OF SPILLWAY CREST

NO.12 VIEW OF FLASHBOARDS AND SPILLWAY CREST

NO. 13 UPSTREAM VIEW OF AUXILIARY DIKE

NO. 14 VIEW OF ROADWAY ALONG CREST OF AUXILIARY DIKE

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUATIONS

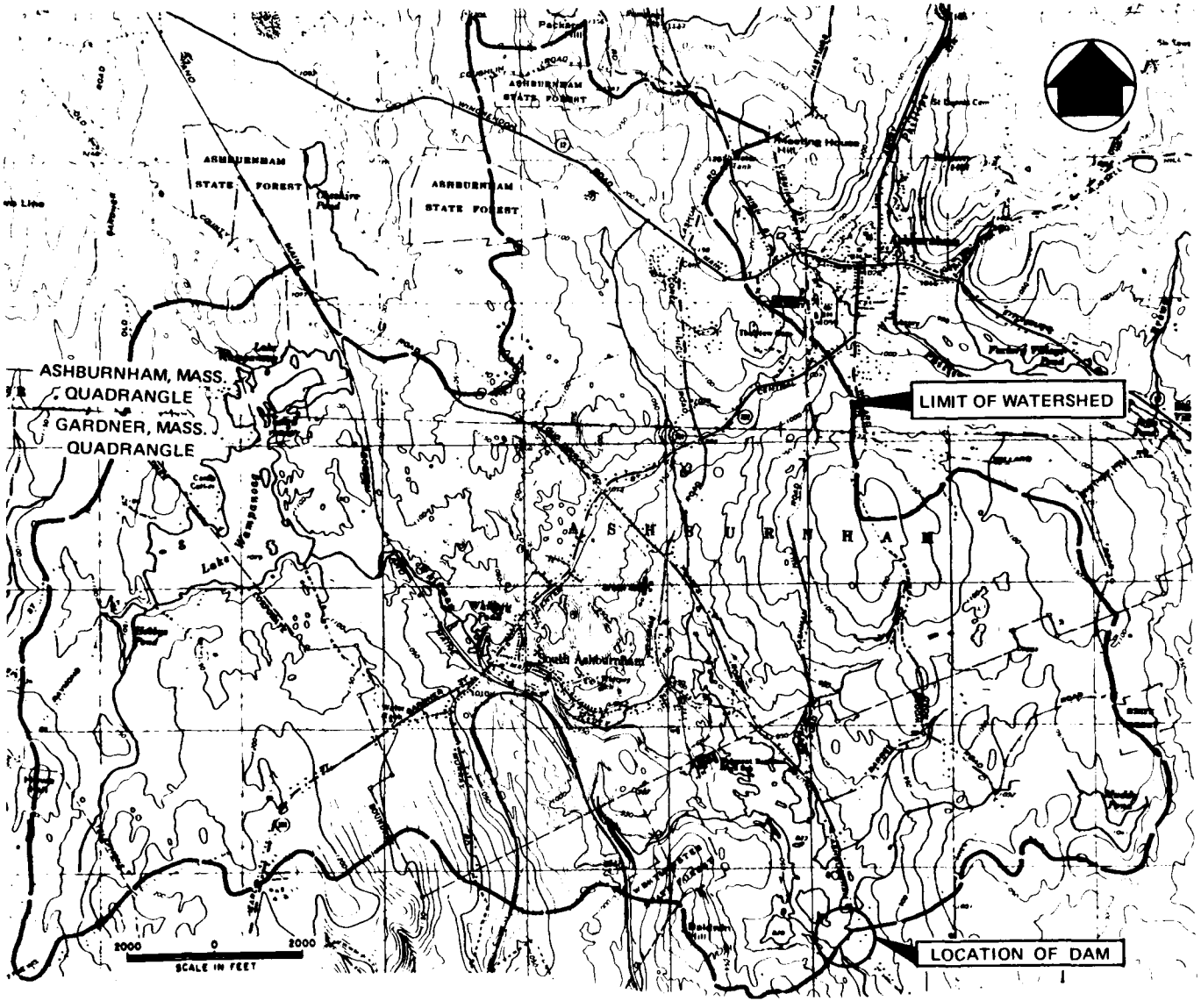


FIG. D-1 DRAINAGE AREA MAP

WESTMINSTER RESERVOIR DAM

Project Nat. Review of Non Fed. Dams Acct No 6926 Page 1 of ___
Subject Worcester County, Mass. Compld By LEB Date 6/2/80
Detail WESTMINSTER RES Ck'd By RNJ Date ___

(I) Test Flood, Storage & Storage Function

1- Total Drainage Area - 11.5 mi²

2- Pond(s) Area: 0.59 mi²
Swamp(s) Area: 0.48 "
Total Area Pond(s) & Swamp(s): 1.07 "

% Ponds & Swamps: $\frac{1.07}{11.5} = 9.3\%$

3- $\frac{1305-823}{28700} = .0168$; $\frac{1343-823}{16800} = .0309$ } Say Ave Slope = 2.4%

4- Using C. of E Curves for Peak Flow Rate & above guide values the Peak Flow Rate was estimated to be between "Rolling" and "Flat & Coastal" and taken at 1150 c.f.s./mi
Size Class: Interm.; Hazard Pot.: High; Spill. Des. Flood: Full PMF
Use: Test Flood = Full PMF

5- Test Flood Inflow = (1150) 11.5 = 13200 c.f.s.

6. Pond Storage
The pond area is 0.18 sq. mi. at elev.
Based on a const. area, storage increases at 116 ac. feet per foot of depth increase.

7- Spillway crest elev. is 818.0 (820.5 with flashboards)

8- Storage Functions are based on $Q_{out} = Q_{in}\left[1 - \frac{S_{out}}{R}\right]$
S_{out} = Storage Vol. in Reservoir related to final Q_{out} in terms of inches of rain over the drainage area

S(in Inches) $= 12\,D\left(\frac{0.18}{11.5}\right) = 0.188\,D$; R = 6hr rain of Storm
D = Storage depth in feet above spillway crest in reservoir

9- Storage Functions: (Test Flood & ½ PMF - if needed)

F_{TF} = 13200 − 695	S = 13200 − 130 D
$F_{½\,PMF}$ = 6600 − 695	S = 6600 − 130 D

(II) Discharge Relations

1- Spillway

Round crest, 48.5' effective width, use $q = 4H^{1.5}$ for no flashboards & Williams & Hagen "Hyd. Tables" with flashbds

a). No Flashboards (Crest el. 818.0)

Pond El.	819	820	822	824	825	826	827	828	827.5
q	4	11.3	32	58.8	74.1	90.5	108	126.5	117.1
Q_{1a}	190	550	1550	2850	3590	4390	5240	6130	5680

b) With Flashboards (@ el. 820.5)

Pond El.	821	822	824	825	826	827	828	826.5	827.5	828.5
q	1.2	6.1	21.6	31.5	42.6	52.7	64.5	48.7	60.5	72.2
Q_{1b}	60	300	1040	1530	2077	2560	3130	2360	2930	3500

2- Crest Flow

Unit flow: $q = 2.5\,h^{1.5}$, Crest consists of: 156' @ el. 825.5; 494' @ el. 825.9; 421' @ 826.0

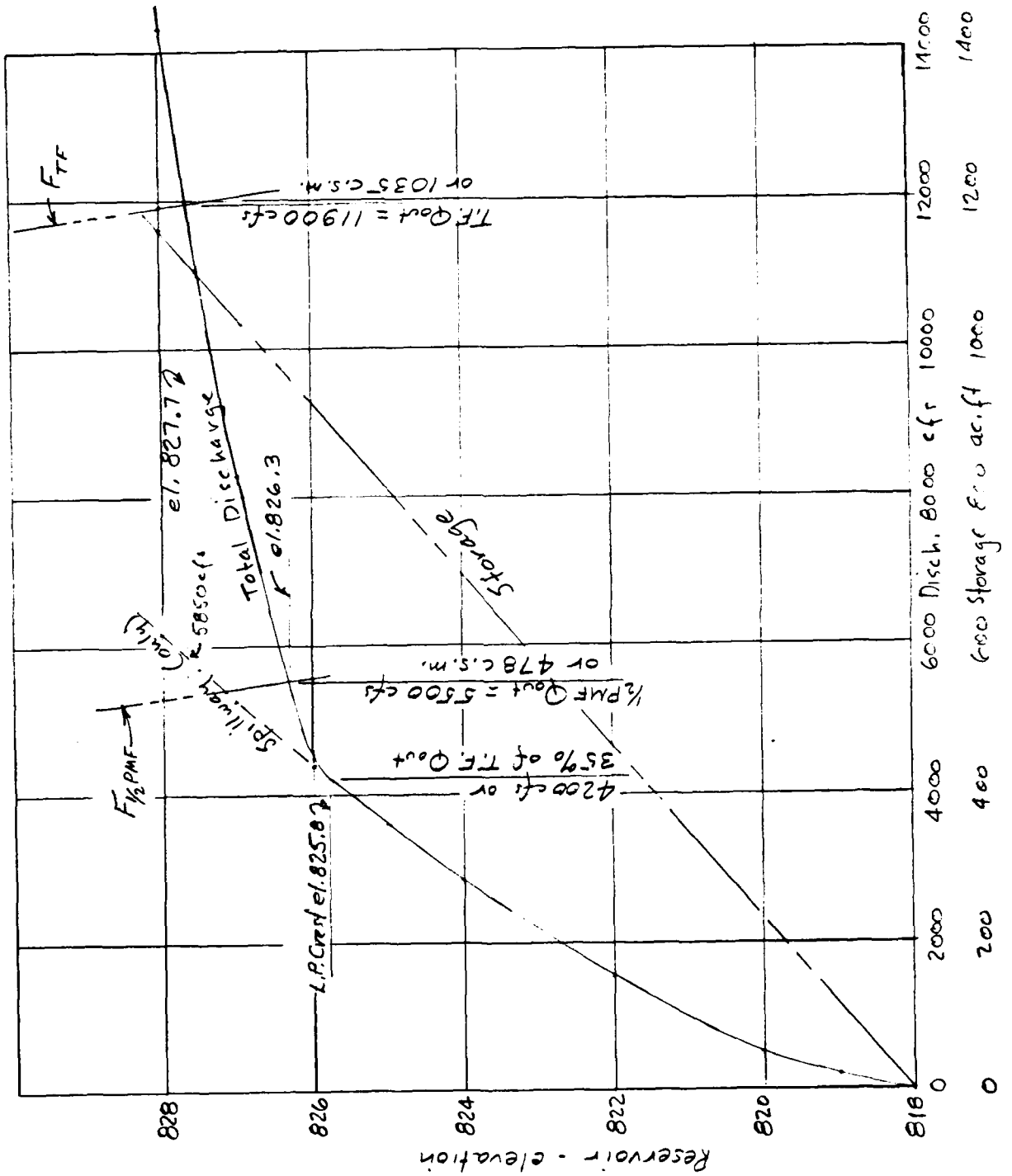
Pond El.	826.0	826.5	827	827.5	828	828.5
Q_A	40	230	520	880	1300	1760
Q_B	40	590	1450	2550	3830	5280
Q_C	—	380	1070	1970	3040	4240
ΣQ_2	80	1200	3040	5400	8170	11280

Project Nat Review of Non Federal Dams Acct. No. 6926 Page 3 of 4

Subject Worcester County, Mass Compld. By LEB Date 6/3/80

Detail WESTMINSTER RES Ck'd By [illegible] Date [illegible]

(III) Discharge, Storage & Storage Funct. vs Res. Elev. — NO STOPLOGS



METCALF & EDDY, ENGINEERS

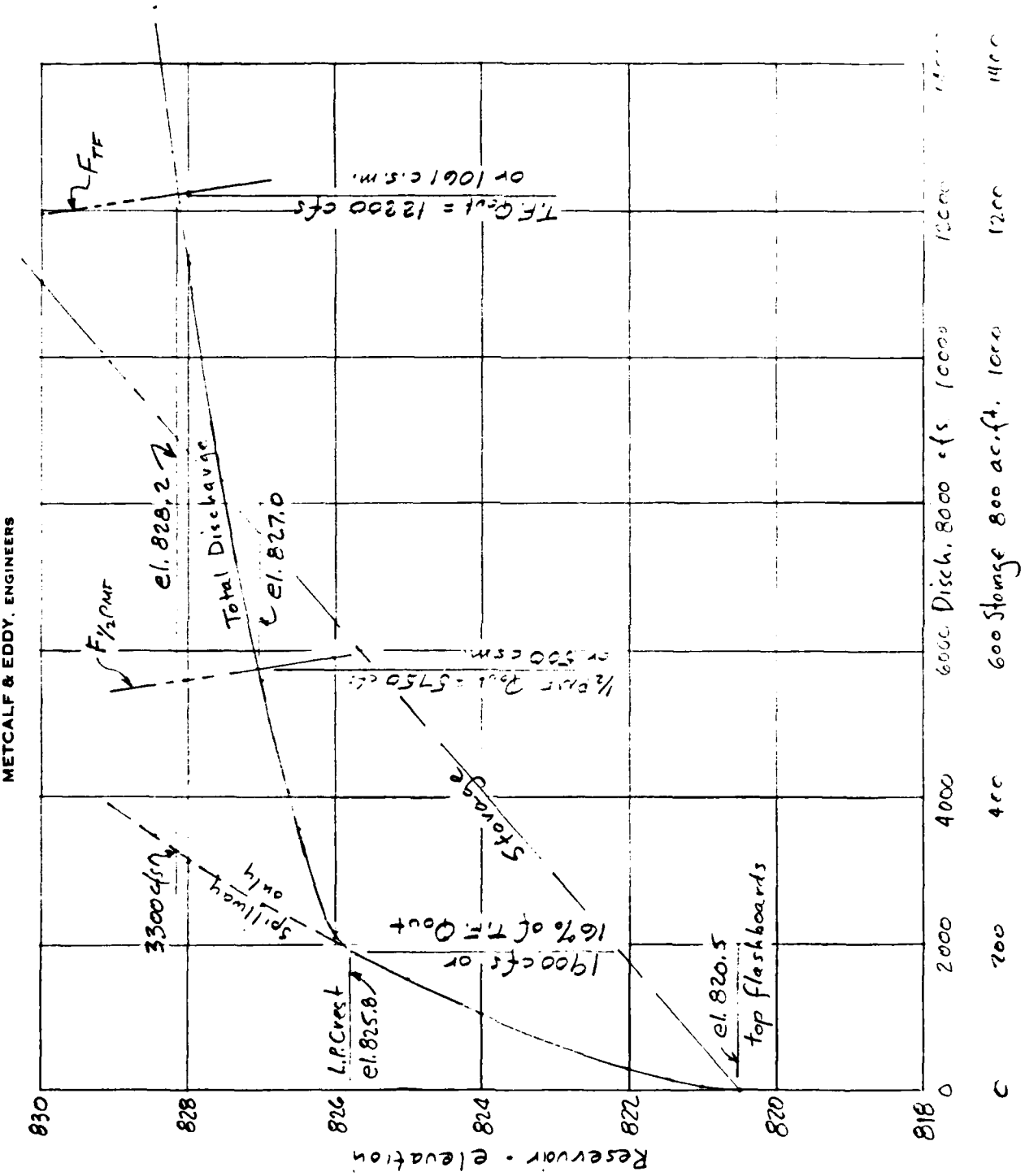
NONREPRODUCIBLE GRID FORM 145

Project Nat. Review of Non Federa Dams Acct No 6926 Page 4 of 6

Subject Worcester County, Mass Compld By [illegible] Date 6/7/80

Detail WESTMINSTER RES. Ck'd By [illegible] Date

(IV) Discharge, Storage & Storage Funct. vs Res. Elev - WITH STOPLOGS



METCALF & EDDY, ENGINEERS

NONREPRODUCIBLE GRID FORM 145

V, Low Level Outlet

Two 30 ϕ pipes - ℄ outlet 796.6± - losses: ent C.E, exit 1.0, valves 0.5, Friction 1.0 , Vel. = $4.42\sqrt{h}$, $Q = 43.4\sqrt{h}$

Res El	817	818	819.5	820.5
h	20.2	21.2	22.7	23.7
Q	195	201	207	211
$\bar{Q}$	197 NO F.B.		209 WITH F.B.	

Time to Lower Res. 1 foot:

No Flashboards - $\frac{116(43560)}{197(3600)} = 7.1$ hours = 427 min

with Flashboards - $\frac{116(43560)}{209(3600)} = 6.7$ hours = 403 min

VI Test Flood Crest Discharge

A. No Flashboards

Max. head = 827.7 - 825.8 = 1.9 feet

$q = 6.68$ cfs/ft. , $y_c = 1.1$ ft. ; $V_c = 6.0$ fps.

B. With Flashboards

Max. head = 828.2 - 825.8 = 2.4 feet

$q = 9.48$ cfs/ft ; $y_c = 1.4$ ft. ; $V_c = 6.7$ fps.

(VII) Failure of Dam (NO FLASHBOARDS)

Peak Failure Flow:

Pond Elevation - 825.8 (L.P. Crest)
Toe Elevation — 795.5
Y_o = 30.3'

Dam Length Subject to Breaching = 280'
$W_o = 40\%(280) = 112'$

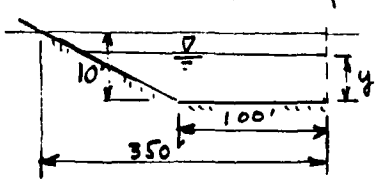
$Q_{P_i} = 1.68\, W_o (Y_o)^{1.5} = 1.68(112)(30.3)^{1.5} = 31400$ cfs

Spillway disch. 4200 cfs.; Total disch. 35600 cfs.

Storage Volume Released:

Storage Above Spillway	7.8(116)	= 905 ac.ft.
Storage Below Spillway	22.5(116)⅓	= 870 " "
S = Total Storage =		1775 " "

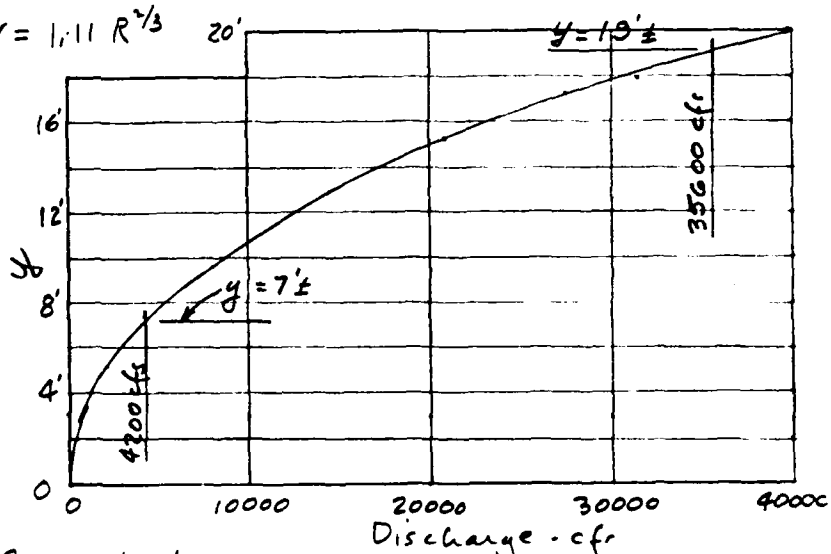
Channel Hydraulics:



$S = \frac{20}{3600}$, $n = 0.10$, $A = 100y + 12.5y^2$, $P = 100 + 25y$

$V = 1.11\, R^{2/3}$

y	A	P	V	Q
2	250	150	1.56	390
5	812	225	2.61	2120
10	2250	350	3.84	8635
15	4312	475	4.83	20828
17	5312	525	5.19	27583
18	5850	550	5.37	31407
20	7000	600	5.71	39968



Depth of flow rises from 7'± to 19'±

Time to Drain:

$$\frac{43560\ (1775)}{3600(\frac{1}{2})(31400)} = 1.37 \text{ Hours} = 82 \text{ Minutes}$$

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST.	STATE	COUNTY	CONGR DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY | MO | YR
MA	459	NED	25	027	04				WESTMINSTER RESERVOIR DAM	4235.5	7154.6	11JUN80

POPULAR NAME	NAME OF IMPOUNDMENT
	WESTMINSTER RESERVOIR

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	04	WHITMAN RIVER	WESTMINSTER	3	4525

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)
EPRD	1909	S0	31	31	1775	970

DIST	OWN	FED R	PRV/FED	SCS E	STATE
NED	N	N	N		

REMARKS
P3-INDUSTRIAL

D/S HAS	SPILLWAY CREST LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
Y	400		50	4200	19000											

OWNER	ENGINEERING BY	CONSTRUCTION BY
JAMES RIVER MASS INC	HOWARD M TURNER	UNKNOWN

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY | MO | YR	AUTHORITY FOR INSPECTION
METCALF + EDDY INC	00MAY80	PL 92-367

REMARKS
30 DIKE LENGTH 525 FEET AUXILIARY DIKE LENGTH 440 FEET

END

FILMED

8-85

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