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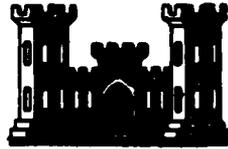
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AD-A155 478

CONNECTICUT RIVER BASIN
LUDLOW, MASSACHUSETTS

NASH HILL RESERVOIR
MA 00550

**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**



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

OCTOBER 1980

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) It is a 1900 ft. long earthfill embankment having a maximum height of 26 ft. There are deficiencies which must be corrected to assure the continued performance of the dam. The dam has been classified as small in size having a high hazard hazard potential. Repair of the existing animal burrows should be conducted immediately by the Owner.		

NASH HILL RESERVOIR

MA 00550

CONNECTICUT RIVER BASIN
LUDLOW, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
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PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00550

Name of Dam: Nash Hill Reservoir

Town: Ludlow

County and State: Hampden County, Massachusetts

Stream: Chicopee Valley Aqueduct - outlet discharges into Harris Brook, a tributary of the Chicopee River, in the Connecticut River Basin

Date of Inspection: August 22, 1980

Nash Hill Reservoir is a 25 million gallon water supply reservoir which provides storage for the City of Chicopee. Water is transmitted into and out of reservoir by the Chicopee Valley Aqueduct. The reservoir was completed in 1950 and is entirely surrounded by a 1900-foot long earthfill embankment. The maximum height of the embankment is 26 feet and the top varies from Elevation (El) 424.5 to 425.2 (National Geodetic Vertical Datum of 1929). A gatehouse on the top of the embankment contains the spillway, which is an overflow weir, and operating mechanisms on the aqueduct pipes and on the low-level outlet. The spillway is 18 feet long with the crest at El 419.60. Discharge over the spillway flows into a dry well which is drained by a 20-inch low-level outlet. An emergency spillway is located on the top of the embankment at the south end of the reservoir. The emergency spillway is 40 feet long, and the crest is at El 424.2.

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

The following deficiencies were observed at the site: animal burrows on the top and downstream slope of the embankment, cracks in the mortared stone masonry on the crest of the emergency spillway, and settlement of the retaining wall at the top of the embankment adjacent to the gatehouse.

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Based on Corps of Engineers' guidelines, the dam has been classified in the small 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 44 cfs, resulting in a reservoir level in El 422.0. The test flood would not overtop the embankment. Hydraulic analyses indicate that the spillway and emergency spillway can discharge a combined flow of 55 cfs, or 125 percent of the test flood outflow with the reservoir pool at the top of the embankment.

It is recommended that the Owner repair the deficiencies listed above, as described in Section 7.3. The Owner should also implement a program of biennial technical inspections, a plan for surveillance of the embankment during and after periods of heavy rainfall, and a plan for notifying downstream residents in the event of an emergency at the reservoir.

Repair of existing animal burrows should be conducted immediately by the Owner. The remaining measures outlined above and in Section 7 should be implemented by the Owner within a period of 2 years after receipt of this Phase I Inspection Report.



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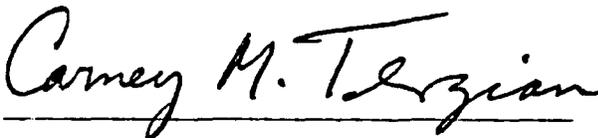


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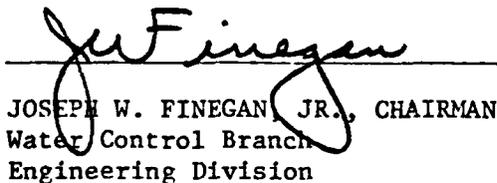
This Phase I Inspection Report on Nash Hill Reservoir (MA-00550) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.



ARAMAST MAHTESIAN, MEMBER
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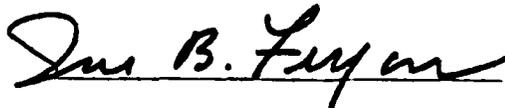


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PREFACE

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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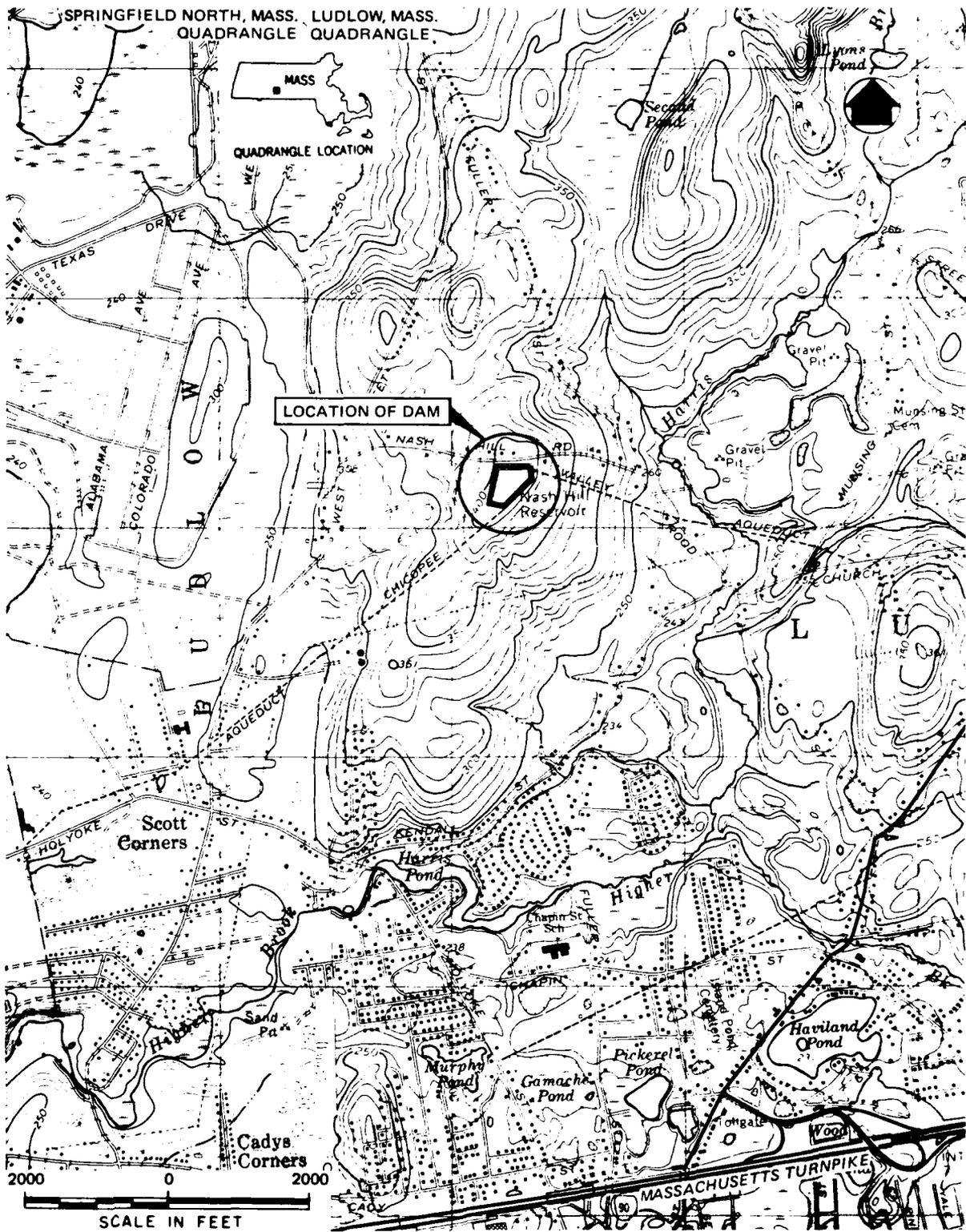
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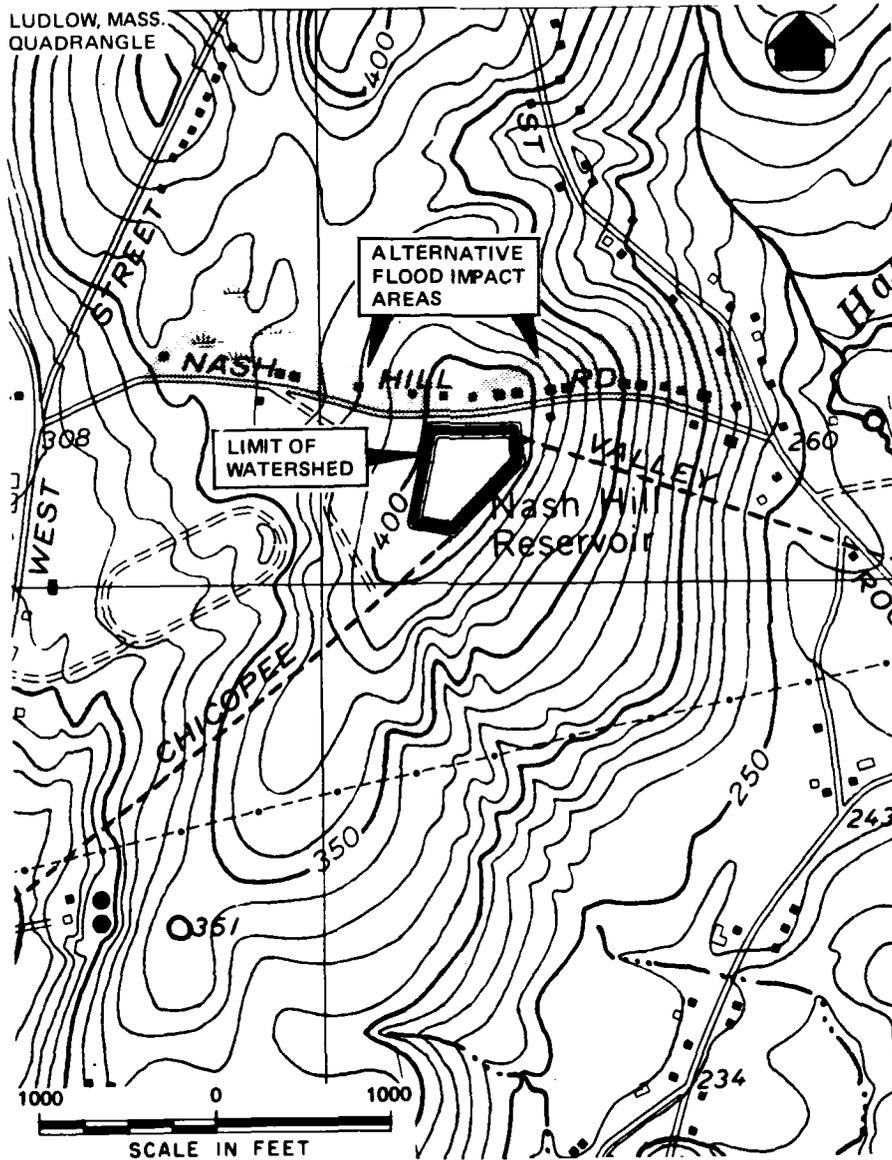
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**OVERVIEW
NASH HILL RESERVOIR
LUDLOW, MASSACHUSETTS**







MAP OF FLOOD IMPACT AREA – NASH HILL RESERVOIR

NATIONAL DAM INSPECTION PROGRAM

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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 reservoir is located on top of Nash Hill, 0.4 miles west of Harris Brook. The brook flows about 6 miles downstream to the confluence with the Chicopee River, in the Connecticut River Basin. The reservoir is in the Town of Ludlow, Hampden County, Massachusetts (see Location Map). The coordinates of this location are Latitude 42 deg. 11.7 min. north and Longitude 72 deg. 29.3 min. west.

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b. Description of Dam and Appurtenances. Nash Hill Reservoir is generally built above grade and is surrounded by a 1,900-foot long, earthfill embankment with a maximum height of 26 feet (see Plan of Dam and Sections in Appendix B and photographs in Appendix C). The top of the embankment is 12 feet wide and varies from El 424.5 to 425.2. Drawings show that the upstream slope varies from 2:1 (horizontal:vertical) near the top to 2.5:1 in the middle to 3:1 near the bottom. The upper half of the slope is covered with riprap, the upper portion of the lower half is covered with crushed stone and the lowest portion is covered with a concrete slab that also covers the bottom of the reservoir. The downstream face is a 2:1 slope covered with grass. An asphalt-paved access road is located on the downstream slope on the north side of the reservoir. Available drawings indicate that the embankment is zoned with a central core of impervious fill (see Figure B-4). The drawings also show that a cutoff trench extends to a minimum of El 394.35 which is about 8.5 feet below the base of the embankment. Information published on the design of the reservoir states that the embankment is founded on glacial till.

An emergency spillway is located on the top of the embankment at the south end of the reservoir. The crest is 40 feet long and lined with mortared stone. The central portion is at El 424.2 and the sides slope up to El 425.0. A discharge channel 110 feet long and 20 feet wide is constructed on the downstream slope and toe of the embankment. The channel is lined with mortared stone.

Water flows into and out of the reservoir through the Chicopee Valley Aqueduct. The aqueduct starts as a 48-inch steel cylinder pipe with an intake at Quabbin Reservoir. The pipe reduces to 36-inch diameter at the Swift River Crossing in Bondsville and continues to Nash Hill Reservoir, discharging into a wet well in the basement of the gatehouse (invert El 399.35). Operating mechanisms to control the gravity flow in the aqueduct are located at the Quabbin Intake and at the Swift River Crossing. A valve to shut off the inflow at Nash Hill Reservoir is located in an underground chamber at the downstream toe of the embankment near the gatehouse.

From the first wet well, water flows through two rectangular openings into a second wet well at the head of the outflow section of the aqueduct (see sections of

NASH HILL RESERVOIR

gatehouse on Figure B-6). Drawings show that the lower opening is 4 feet high by 3 feet wide with an invert at El 399.35 and the upper opening is 6 feet high by 3 feet wide with an invert at El 409.35. The outflow section of the aqueduct is a 36-inch diameter steel cylinder pipe. There is a sluice gate at the beginning of the outflow aqueduct.

Two of the concrete walls that form the first wet well extend only part way to the ceiling and form an overflow weir that serves as the main spillway for the reservoir. The weir is 18 feet long with a crest at El 419.60. Water discharging over the walls flows into a dry well which is drained by the low-level outlet for the reservoir.

The low-level outlet is a 20-inch diameter steel cylinder pipe. The first section of the outlet pipe extends from the bottom of the reservoir (invert El 397.35) to the dry well in the gatehouse. Two valves are located on this section to control flow. The second section extends from the dry well (invert El 396.60) for a distance of approximately 2,300 feet underground and discharges into Harris Brook at the bottom of Nash Hill (approximate El 230). Flow in this section is uncontrolled, and the pipe also discharges spillway flow.

- c. Size Classification. Nash Hill Reservoir has a maximum height of 26 feet and a maximum storage capacity of 102 acre-feet. The reservoir is therefore classified in the "small" size category which corresponds to a height ranging from 25 to 40 feet or a storage capacity of 50 to 1,000 acre-feet.
- d. Hazard Classification. There are 20 residences located on Nash Hill Road within 1,500 feet of the reservoir (see Flood Impact Area shown on the Location Map). The foundations of these structures are approximately at the same elevation as the slopes of the hillside. An assumed failure of the embankment on the north side of the reservoir would result in a flood wave 5 feet high across Nash Hill Road. It is possible that more than a few lives could be lost and an excessive amount of property damage could occur. Accordingly, the reservoir has been placed in the "high" hazard category.

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- e. Ownership. The reservoir is owned by the Commonwealth of Massachusetts, Metropolitan District Commission (MDC), 20 Somerset Street, Boston, Massachusetts 02108. Mr. Francis Faucher, Acting Director of the Water Division (telephone 617-727-5274) granted permission to enter the property and inspect the reservoir.
- f. Operator. The reservoir is operated by personnel from the MDC Water Division - Quabbin Reservoir Section. Mr. Henry Bedford is the foreman at the site.
- g. Purpose of the Dam. The water in Nash Hill Reservoir is currently used as a domestic water supply for the City of Chicopee, which consumes an average of 13 million gallons per day (mgd). The Towns of South Hadley and Wilbraham also draw an average of 3 mgd off the aqueduct between the Quabbin intake and Nash Hill Reservoir. However, in the event of a shut-down at the Quabbin intake, water would be pumped out of Nash Hill Reservoir to supply South Hadley and Wilbraham.
- h. Design and Construction. Nash Hill Reservoir was constructed in 1949-1950 by G. Rotondi & Sons. Drawings and specifications dated 1949 and prepared by the MDC Construction Division are available. The drawings show that the reservoir was constructed essentially as it appears today, except that the emergency spillway is located on the south side instead of the southeast side of the reservoir, and the outflow section of the aqueduct is 36 inches in diameter, not 42 inches.

Previous inspection reports indicate that since construction the reservoir has been in good condition. Repairs have been made such as backfilling animal burrows on the slopes of the embankment and repairing mortar on the crest of the emergency spillway.

- i. Normal Operating Procedures. Personnel from the MDC reportedly visit the reservoir once a day. At that time, they check the reservoir level and adjust the inflow when necessary by operating a valve on the Chicopee Valley Aqueduct in Bondsville. The chart on the water level recorder inside the gatehouse is changed once a week. The low-level outlet was last operated on August 19, 1980 to discharge debris resulting from cleaning the screens in the gatehouse. All valves and sluice gates are reportedly checked at least twice a year. The reservoir has reportedly never been completely drained.

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1.3 Pertinent Data

- a. Drainage Area. The drainage area is approximately 5.8 acres (0.01 square mile) and consists of the surface area of the reservoir and the top of the embankment (see Drainage Area shown on Map of Flood Impact Area).
- b. Discharge. Discharge from Nash Hill Reservoir normally flows by demand through a 36-inch diameter aqueduct and into the water distribution system for the City of Chicopee. At high reservoir levels, water discharges over a concrete weir inside the gatehouse and into the 20-inch diameter low-level outlet. An emergency spillway is also constructed on the top of the embankment.
 - (1) Outlet: Size - 20-inch Invert El. - 397.35.
Discharge Capacity - 45 cfs with pool at El 424.5.
 - (2) Maximum known flood at damsite: not applicable
(N/A)
 - (3) Ungated spillway capacity at top of dam: 45 cfs at
El 424.5
10 cfs at El 424.5 (emergency spillway)
 - (4) Ungated spillway capacity at test flood elevation:
44 cfs at El 422.0
 - (5) Gated spillway capacity at normal pool elevation:
(N/A)
 - (6) Gated spillway capacity at test flood elevation: N/A
 - (7) Total spillway capacity at test flood elevation: 44
cfs at El 422.0
 - (8) Total project discharge at top of dam elevation: 55
cfs at El 424.5
 - (9) Total project discharge at test flood elevation: 44
cfs at El 422.0
- c. Elevation (feet above National Geodetic Vertical Datum of 1929 (NGVD)). A benchmark was established at El 425.35 on the main floor of the gatehouse. This elevation is shown on the Contract Drawings for the reservoir.
 - (1) Streambed at toe of dam: 398.6 (low point at toe of embankment)
 - (2) Bottom of cutoff: 394.35

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- (3) Maximum tailwater: none
- (4) Normal pool: 419.60
- (5) Full flood control pool: N/A
- (6) Spillway crest: 419.60 (gatehouse)
424.20 (emergency)
- (7) Design surcharge (Original design): unknown
- (8) Top of dam: 424.5 to 425.2
- (9) Test flood surcharge: 422.0

d. Reservoir (Length in feet)

- (1) Normal pool: 750
- (2) Flood control pool: N/A
- (3) Spillway crest pool: 750
- (4) Top of dam: 750
- (5) Test flood pool: 750

e. Storage (acre-feet)

- (1) Normal Pool: 77
- (2) Flood control pool: N/A
- (3) Spillway crest pool: 77
Emergency spillway crest pool: 100
- (4) Top of dam: 102
- (5) Test flood pool: 89

f. Reservoir surface (acres)

- (1) Normal pool: 4.8
- (2) Flood-control pool: N/A
- (3) Spillway crest: 4.8
- (4) Test flood pool: 5.1

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(5) Top of dam: 5.3

g. Dam

(1) Type: earthfill

(2) Length: 1,900 feet

(3) Height: 26 feet (maximum)

(4) Top width: 12 feet

(5) Side slopes: upstream - 2:1 to 3:1
downstream - 2:1

(6) Zoning: central impervious core, intermediate semi-pervious shell, outer pervious shell

(7) Impervious core: compacted impervious fill

(8) Cutoff: trench of impervious fill extends to El 394.35

(9) Grout curtain: none

h. Diversion and Regulating Tunnel (Chicopee Valley Aqueduct)

(1) Type: 36-inch diameter steel cylinder pipe

(2) Length: 13 miles for Quabbin Reservoir to Nash Hill Reservoir
1.8 miles from Nash Hill Reservoir to Chicopee

(3) Closure: Water distribution system for City of Chicopee

(4) Access: valve chamber at toe of reservoir embankment and wet wells in gatehouse

(5) Regulating Facilities: valves at Quabbin Reservoir (intake), Swift River Crossing (Bondsville), and Nash Hill Reservoir.

i. Spillway

Gatehouse

(1) Type: concrete overflow weir

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- (2) Length of weir: 18 feet
- (3) Crest elevation: 419.60
- (4) Gates: none
- (5) Upstream channel: rectangular concrete wet well
- (6) Downstream channel: concrete dry well drained by 20-inch diameter low-level outlet

Emergency Spillway

- (1) Type: broad-crested, mortared stone masonry
- (2) Length of weir: 40 feet
- (3) Crest elevation: 424.2
- (4) Gates: none
- (5) Upstream channel: upstream slope of embankment
- (6) Downstream channel: 110 feet long, 20 feet wide channel on downstream slope and toe of embankment, lined with mortared stone masonry

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SECTION 2

ENGINEERING DATA

- 2.1 General. The engineering data available for this Phase I inspection includes contract drawings and specifications dated February 24, 1949 and prepared by the Construction Division of the Metropolitan District Commission (see Figures B-3 and B-4). The data were obtained from the MDC office at 20 Somerset Street, Boston. In addition, a description of the project is given in a publication entitled "Chicopee Valley Aqueduct" by Stanley M. Dore (Deputy Chief Engineer, Construction Division, MDC) and published in the New England Water Works Association Journal, 1949-1950. There are no as-built drawings or computations available from the Owner, State, or County agencies. Copies of previous inspection reports dated 1974 and 1976, prepared by the Massachusetts Department of Public Works are included in Appendix B.

We acknowledge the assistance and cooperation of personnel from the Massachusetts Department of Public Works; and Messrs. Francis Faucher and Joseph Capone of the Water and Construction Divisions of the Metropolitan District Commission. In addition, we acknowledge the assistance of Mr. Henry Bedford, foreman for the MDC who provided information on the history and operation of the reservoir.

- 2.2 Construction Records. The available construction records consist of grain size analyses and permeability tests on 22 samples of the embankment fill. These were obtained from the MDC office at Quabbin Reservoir. There are also about 50 photographs available from the MDC Construction Division. As-built drawings are not available.
- 2.3 Operating Records. A daily record is kept of the elevation of the reservoir pool, however, no measurements of rainfall are made at the site.

2.4 Evaluation

- a. Availability. The drawings, specifications, and field tests are the only engineering data available on the design and construction of the embankment.
- b. Adequacy. The lack of complete hydraulic, structural and construction data did not allow for a definitive review. Therefore, the evaluation of the adequacy of this dam is based on a limited review of the available data, the visual inspection, past performance history, and engineering judgment.

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

However, it was found that the location of the emergency spillway and the size of the outflow portion of the aqueduct are different from what is shown on the drawings.

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SECTION 3

VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I Inspection of the embankment at Nash Hill Reservoir was performed on August 22, 1980. A copy of the inspection checklist is included in Appendix A. Previous inspections were conducted by the Massachusetts Department of Public Works in 1974 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 reservoir is surrounded by an earthfill embankment with a gatehouse at the east end and an emergency spillway at the south end. No seepage or erosion was observed on the embankment. The top and slopes are clear of brush and trees and the grass is mowed. The visible portion of the riprap on the upstream slope is in excellent condition.

The most notable deficiency at the site is the presence of animal burrows on the top and downstream slope of the embankment. The burrows are 5 inches in diameter and generally about 1 foot deep, but at least two burrows are greater than 3 feet deep (see Photo No. 3). A total of 10 burrows were located, mostly on the southeast, south, and west sides of the reservoir (see Figure B-1). This condition has been cited in previous inspection reports and has reportedly been repaired in the past.

Settlement was observed in the retaining wall at the top of the embankment adjacent to the south side of the gatehouse (see Photo No. 8). A 2-inch wide, 5-foot long diagonal crack has formed in the stone masonry, and vertical displacement is visible in the capstones. However, there is no visible settlement or cracking of the earthfill at the base of the wall.

- c. Appurtenant Structures. The spillway is a concrete overflow weir inside the gatehouse. At the time of the inspection, there was no water discharging over the weir. The concrete on the crest was in good condition. There was no debris on the weir, in the wet well, or in the dry well. Access to the weir is through an opening in the floor of the gatehouse.

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The only portions of the outlet that were visible during the inspection were in the walls of the dry well and in the valve chamber. The open ends of the outlet were clear of debris, and no cracks or leaks were visible on the pipe. There was no flow through the outlet at the time of inspection. The valves on the outlet are reportedly in good operating condition. Slight corrosion was noted on the valves.

The gatehouse is constructed of cut stone masonry which is in good condition. The wood trim and gutters need to be painted. The interior of the gatehouse is well lighted and in good condition.

The crest of the emergency spillway is paved with mortared stone. A mortared stone discharge channel from the emergency spillway has been constructed on the downstream slope and toe of the embankment. There are several cracks in the mortar on the crest near the upstream edge. The cracks are oriented lengthwise, parallel to the centerline of the embankment. There is no visible sloughing of the riprap or undermining of the crest. The discharge channel is in good condition. There is a minor growth of weeds and grass in the channel below the downstream toe.

- d. Reservoir Area. The reservoir area is undeveloped except along the north side where residences have been built along Nash Hill Road. The caretaker reports that most of these homes have been built within the last 20 years. The nearest town is Ludlow located 0.8 mile south of the reservoir. Most of the land immediately surrounding the reservoir is wooded with moderate slopes. There is a good potential that future development will occur along Nash Hill Road.
- e. Downstream Channel. Both the spillway and outlet discharge into an underground pipe that discharges into Harris Brook at the bottom of Nash Hill. The brook flows through a flat, swampy area where there is a dense growth of brush and trees.

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

NASH HILL RESERVOIR

SECTION 4

OPERATING AND MAINTENANCE PROCEDURES

4.1 Operating Procedures

- a. General. Personnel from the MDC are located at a field office about 0.25 mile west of the reservoir on Nash Hill Road. According to the MDC foreman at the site, the standard procedure for operating the reservoir is to monitor the water level and adjust the inflow accordingly. The water level is monitored with a recorder inside the gatehouse. The inflow is regulated by adjusting a valve on the Chicopee Valley Aqueduct in Bondsville.
- b. Warning System. There is no warning system in effect at this dam.

4.2 Maintenance Procedures

- a. General. The embankment is generally well maintained. MDC personnel are at the site daily and are responsible for maintenance of the facility. Periodic inspections by the Massachusetts Department of Public Works have been conducted in the past. Typical maintenance procedures have included backfilling animal burrows on the slopes of the embankment, repairing stone masonry on the crest of the emergency spillway, and mowing the grass on the embankment.
- b. Operating Facilities. Under normal conditions, flow into the reservoir is regulated by operating a valve off-site, and valves and gates at the reservoir are not used. However, all the valves and gates at the reservoir are reportedly checked at least twice a year by the MDC personnel. No major repairs have been made to the gates or gatehouse, and all the facilities are reportedly operable.

- 4.3 Evaluation. There is a program for maintaining the embankment and appurtenant structures in good operating condition. However, there is no program of regular technical inspections, a plan for surveillance of the embankment during and after periods of heavy rainfall, or an emergency warning system in effect. This is undesirable, considering that the reservoir is in the high hazard category. These program should be implemented, as recommended in Section 7.3.

NASH HILL RESERVOIR

SECTION 5

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

- 5.1 General. Nash Hill Reservoir has a drainage area of 0.01 square mile which consists of the maximum surface area of the reservoir and the top of the embankment (see Drainage Area shown on Map of Flood Impact Area). The reservoir has a maximum storage capacity of 102 acre-feet.

The low-level outlet can discharge a flow of 44 cfs when the reservoir is at El 419.60 which is the crest of the spillway. At this reservoir elevation and with no additional inflow, the outlet can lower the reservoir by 1 foot in about 3 hours.

- 5.2 Design Data. There are no hydraulic or hydrologic computations available for the design of the spillway at Nash Hill Reservoir.

- 5.3 Experience Data. There are no records of discharge ever occurring over the emergency spillway.

- 5.4 Test Flood Analysis. Nash Hill Reservoir has been classified in the "small" size and "high" hazard categories. According to the Corps of Engineers guidelines, a test flood ranging from one-half the PMF (Probable Maximum) to the full PMF should be used to evaluate the capacity of the spillway. The full PMF was selected because of the proximity of the reservoir to houses along Nash Hill Road.

The test flood inflow consists of direct rainfall on the reservoir and inflow from the aqueduct. The full PMF rate consists of 19 inches of rainfall in 6 hours. Applying this rate to the 0.01 square mile drainage area results in a peak test flood inflow of 74.6 cfs. In addition, an inflow of 38 cfs was assumed to occur from the aqueduct with no outflow into the aqueduct. The reservoir pool at the start of the storm is at El 420.34 which would be due to inflow from the aqueduct and no outflow into the aqueduct. By adjusting the test flood inflow for surcharge storage, the peak test flood outflow was calculated to be 44 cfs (4,400 cfs per square mile). The reservoir pool would rise to El 422.0, which is 2.5 feet below the low point on the top of the embankment and 2.2 feet below the crest of the emergency spillway.

Hydraulic analyses indicate that the spillway and emergency spillway can discharge a combined flow of 55 cfs or 125
NASH HILL RESERVOIR

percent of the test flood outflow with the reservoir at El 424.5, which is the low point on the top of the embankment.

- 5.5 Dam Failure Analysis. The peak discharge rate due to failure of the embankment was calculated to be 5,700 cfs with the reservoir at El 422.0. This calculation is based on a maximum head of 19 feet and an assumed 58-foot wide breach occurring in the embankment on the north side of reservoir. Failure of the embankment would produce a downstream flood wave 15 feet deep flowing across Nash Hill Road.

Although failure could occur anywhere along the embankment, for the purpose of discussing the maximum downstream hazard, the primary impact areas are shown to be along Nash Hill Road (see Map of Flood Impact Area, page ix). There are 20 residences located along Nash Hill Road within 1,500 feet of the reservoir. The foundations of these structures are approximately at the same elevation as the slopes of the hillside. It is expected that the flood water would travel across the road and down the steep sides of Nash Hill. Some attenuation due to overland flow would occur, however; this would be after the water reaches some nearby residences. An assumed failure of the dam could result in a flood wave that would rise above the foundation level of these houses, resulting in the 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.

NASH HILL RESERVOIR

SECTION 6

STRUCTURAL STABILITY

- 6.1 Visual Observations. The evaluation of the structural stability of Nash Hill Reservoir is based on a review of previous inspection reports, a review of available drawings, and the visual inspection conducted on August 22, 1980.

As discussed in Section 3, Visual Inspection, the project is in good condition. No seepage was observed on the downstream slope or toe of the embankment. Settlement of the retaining wall adjacent to the south side of the gatehouse was observed, however, there is no visible cracking or settlement of the earthfill at the base of the wall. A total of ten animal burrows, two of which are greater than three feet deep, are located on the top and downstream slope of the embankment. These burrows could affect the stability of the embankment, particularly if they become more numerous or extend into the impervious core.

- 6.2 Design and Construction Data. Construction of Nash Hill Reservoir was completed in 1950. Computations for design of the dam, spillway and outlet are not available.

Drawings dated 1949 prepared by the Construction Division of the MDC show the proposed construction of the embankment (see Figure B-3). Photographs taken periodically during construction are also available. The drawings show that the embankment is a zoned earthfill section. The photographs show that the embankment is founded on a sandy, gravely soil (glacial till). An impervious core made of compacted earthfill is located in the center of the embankment. The remaining earthfill is shown as semipervious and random fill on the drawings. A cutoff trench extends to a minimum of El 394.35 which is about 8 feet below the base of the embankment. The side slopes of the embankment are 2:1 to 3:1 upstream and 2:1 downstream.

Specifications for construction of the embankment are available. They include details on the types of earth materials, riprap, and concrete used in construction. Selected portions of the specifications are given in Appendix B.

There is information on the grain size and permeability of the earthfill in the embankment. A tabulation of this data is given in Appendix B. There is no data on the shear strength of the embankment or foundation soils.

NASH HILL RESERVOIR

- 6.3 Post-Construction Changes. Since the original construction of the embankment, there have been no major changes to the facility. Repairs have been made periodically, such as the filling of animal burrows and the patching of mortar on the crest of the emergency spillway.
- 6.4 Seismic Stability. The dam is located in Seismic Zone No. 1, and in accordance with Corps of Engineers' guidelines does not warrant further seismic analysis at this time.

NASH HILL RESERVOIR

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 information on operation and maintenance, the project is considered to be in good condition. The following deficiencies must be corrected to assure the continued performance of this dam: filling of the animal burrows on the top and downstream slope of the embankment; repair of the mortar on the crest of the emergency spillway, and repair of the retaining wall adjacent to the gatehouse.

The peak test flood (full PMF) outflow is estimated to be 44 cfs with the reservoir at El 422.0. The test flood would not overtop the low point on the embankment. Hydraulic analyses indicate that the spillway and emergency spillway can discharge a combined flow of 55 cfs or 125 percent of the test flood outflow before the embankment 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 data, the visual inspection, past performance and engineering judgment.
- c. Urgency. The remedial measures outlined below should be implemented by the Owner within 2 years after receipt of this Phase I Inspection Report. However, filling of the animal burrows should be undertaken immediately and continued as a regular maintenance procedure.

7.2 Recommendations. Studies to further evaluate the condition of the embankment and appurtenances are not recommended at this time.

7.3 Remedial Measures

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

- (1) Backfill all animal burrows on the top and downstream slope of the embankment and continue this procedure on a regular basis whenever new burrows

NASH HILL RESERVOIR

appear. The Owner should consider special fencing, traps, or other means to keep the animals away from the project.

- (2) Repair cracked mortar on the crest of the emergency spillway.
- (3) Repair the stone masonry retaining wall adjacent to the south side of the gatehouse.
- (4) Institute a definite plan for surveillance of the embankment during and after periods of heavy rainfall and a plan to warn people in downstream areas in the event of an emergency at the reservoir.
- (5) Continue the program of maintenance inspections.
- (6) Institute a program of technical inspections of this embankment on a biennial basis.

7.4 Alternatives. There are no practical alternatives to the above recommendations.

NASH HILL RESERVOIR

APPENDIX A
PERIODIC INSPECTION CHECKLIST

NASH HILL RESERVOIR

PERIODIC INSPECTION CHECK LIST

PROJECT NASH HILL RESERVOIR DATE August 22, 1980
 PROJECT FEATURE Embankment NAME Sweet/Nagel
 DISCIPLINE Geotechnical NAME Greco

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	varies from 424.5 to 425.2
Current Pool Elevation	415.85 at 8 AM 415.70 at noon
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	Minor cracking in asphalt pavement on access road
Movement or Settlement of Crest	Minor irregularities in top of embankment
Lateral Movement	None visible
Vertical Alignment	Relatively flat
Horizontal Alignment	Five sides - each is straight
Condition at Abutment and at Concrete Structures	Settlement in stone masonry wall on south side of gatehouse - diagonal crack 2" wide - no cracking or settlement of adjacent earth-fill.
Indications of Movement of Structural Items on Slopes	Vertical settlement in stone masonry wall described above
Trespassing on Slopes	10 animal burrows on d/s slope on southeast, south, and west sides of reservoir-burrows 5 in. diameter, generally. 5 to 1 ft. deep, 2 are more than 3 ft. deep
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection - Riprap Failures	Dumped riprap on upstream slope in excellent condition-no failures or vegetation
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	On southeast side of reservoir-ditch along d/s toe leads to a drain away from reservoir
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT NASH HILL RESERVOIR DATE August 22, 1980
 PROJECT FEATURE Gatehouse NAME Sweet/Nagel
 DISCIPLINE Geotechnical NAME Greco

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	Exterior-granite blocks with wood trim interior-brick walls with concrete floor
a. Concrete and Structural	
General Condition	Good-trim needs paint
Condition of Joints	Good
Spalling	None
Visible Reinforcing	None
Rusting or Staining of Concrete	None
Any Seepage or Efflorescence	Minor local efflorescence
Joint Alignment	Good
Unusual Seepage or Leaks in Gate	None visible on outlet valves sluice gates are open
Cracks	Minor local cracks
Rusting or Corrosion of Steel	Minor corrosion on valve stems
b. Mechanical and Electrical	
Air Vents	None
Float Wells	Standpipe for water level recorder
Crane Hoist	4000 lb. for hoisting screens
Elevator	None
Hydraulic System	None
Service Gates	Sluice gate and valve on reservoir pipe sluice gate on outflow aqueduct
Emergency Gates	2 valves on 20-inch drain
Lightning Protection System	Ground cables on gate stems
Emergency Power System	None
Wiring and Lighting System in Gate Chamber	4 ceiling lights inside 2 floodlights outside

PERIODIC INSPECTION CHECK LIST

PROJECT NASH HILL RESERVOIR DATE August 22, 1980
 PROJECT FEATURE Spillway NAME Sweet/Nagel
 DISCIPLINE Geotechnical NAME Greco/Branagan

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	Wet well in basement of gatehouse
a. Approach Channel	
General Condition	Good-minor local efflorescence on walls
Loose Rock Overhanging Channel	N/A
Trees Overhanging Channel	N/A
Floor of Approach Channel	Submerged
b. Weir and Training Walls	Top of concrete walls
General Condition of Concrete	Good
Rust or Staining	None
Spalling	None
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None
Drain Holes	None
c. Discharge Channel	Dry well drained by outlet pipe
General Condition	Good
Loose Rock Overhanging Channel	N/A
Trees Overhanging Channel	N/A
Floor of Channel	Dry well and pipe clear of debris
Other Obstructions	None

PERIODIC INSPECTION CHECK LIST

PROJECT NASH HILL RESERVOIR DATE August 22, 1980
 PROJECT FEATURE Low-Level Outlet NAME Sweet/Nagel
 DISCIPLINE Geotechnical NAME Greco

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - TRANSITION AND CONDUIT</u>	20-inch steel lined concrete pipe
General Condition of Concrete	Good - no leaks visible
Rust or Staining on Concrete	None
Spalling	None
Erosion or Cavitation	None
Cracking	None visible
Alignment of Monoliths	N/A
Alignment of Joints	N/A
Numbering of Monoliths	N/A

Notes:

Intake structure is submerged on bottom of reservoir
 2 valves to control flow are located in basement of gatehouse
 minor corrosion noted around valves
 Outlet discharges into dry well in gatehouse
 dry well is clear of debris and walls are in good condition
 with minor cracks
 Outlet pipe leaving dry well is also clear of debris and
 other obstructions
 Outlet eventually discharges into a brook at the bottom of
 Nash Hill

PERIODIC INSPECTION CHECK LIST

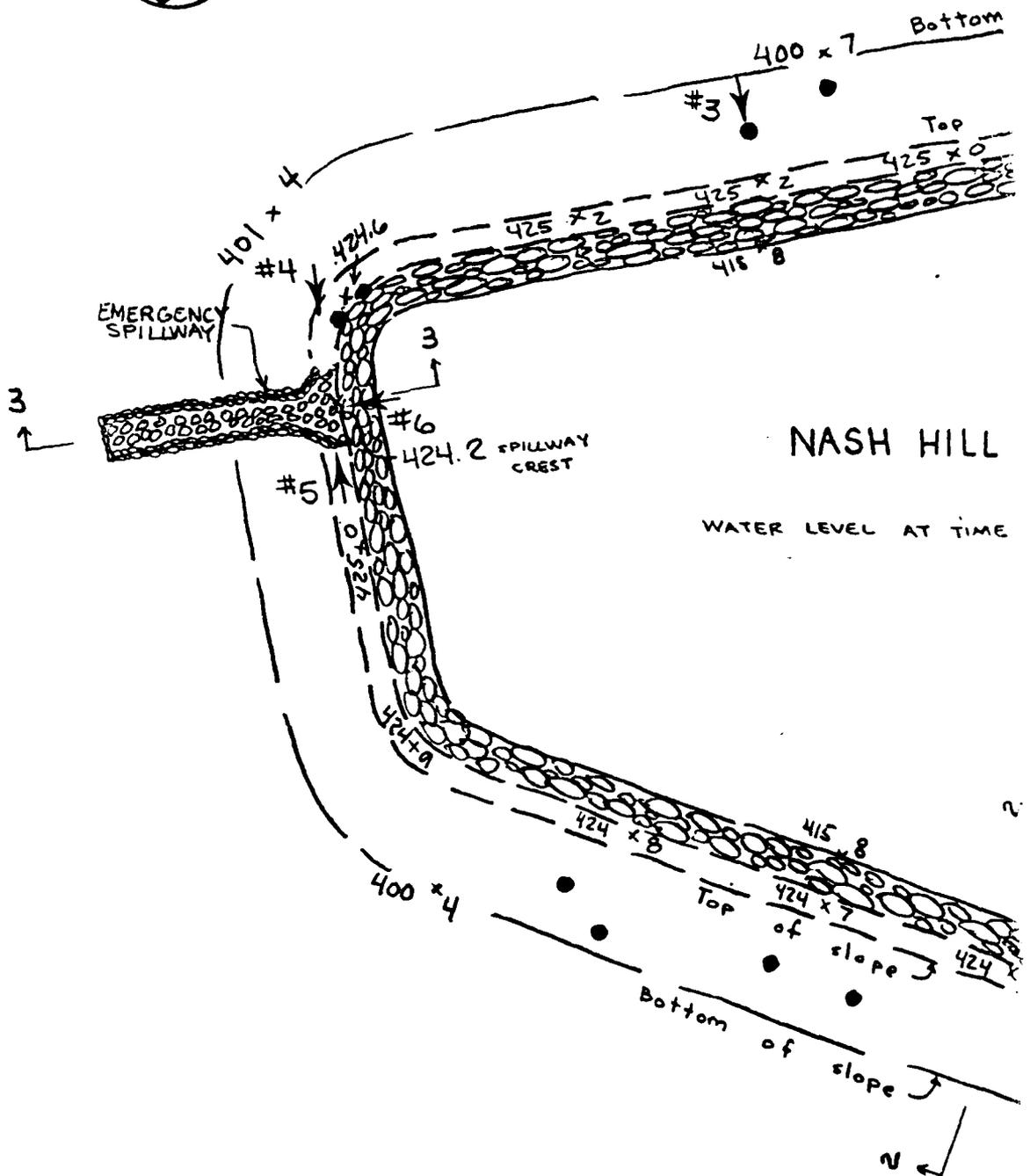
PROJECT NASH HILL RESERVOIR DATE August 22, 1980
 PROJECT FEATURE Emergency Spillway NAME Sweet/Nagel
 DISCIPLINE Geotechnical NAME Greco/Branagan

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - EMERGENCY SPILLWAY, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	2:1 slope
General Condition	Excellent-no sloughing or vegetation
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Upstream slope of embankment covered with dumped riprap
b. Weir and Training Walls	Broad crest paved with mortared stone
General Condition of Concrete	Mortar is cracked near u/s edge-repaired in past
Rust or Staining	None
Spalling	None
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None
Drain Holes	None
c. Discharge Channel	Also paved with mortared stone
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Channel	Few open and cracked joints - minor growth of grass and moss
Other Obstructions	None

APPENDIX B
PLANS OF DAM AND PREVIOUS
INSPECTION REPORTS

	<u>Page</u>
Figure B-1, Plan of Reservoir	B-1
Figure B-2, Sections through Embankment	B-2
Figure B-3, Dam of Reservoir dated 1949	B-3
Figure B-4, Typical Embankment Section, dated 1949	B-4
Figure B-5, Sections through Gatehouse, Reservoir Pipe, and Low-level Outlet dated 1949	B-5
Figure B-6, Gatehouse Sections, dated 1949	B-6
Excerpts from Specifications for Construction of Section 4 of the Chicopee Valley Aqueduct Including Nash Hill Reservoir, Contract No. 168, Dated 1949	B-7
Tabulation of Grain Size and Permeability Tests on Embankment Fill at Nash Hill Reservoir	B-13
Previous Inspection Reports by Massachusetts Department of Public Works	
Report dated June 10, 1976	B-14
Report dated April 1, 1974	B-18

NASH HILL RESERVOIR

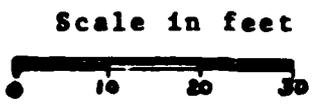
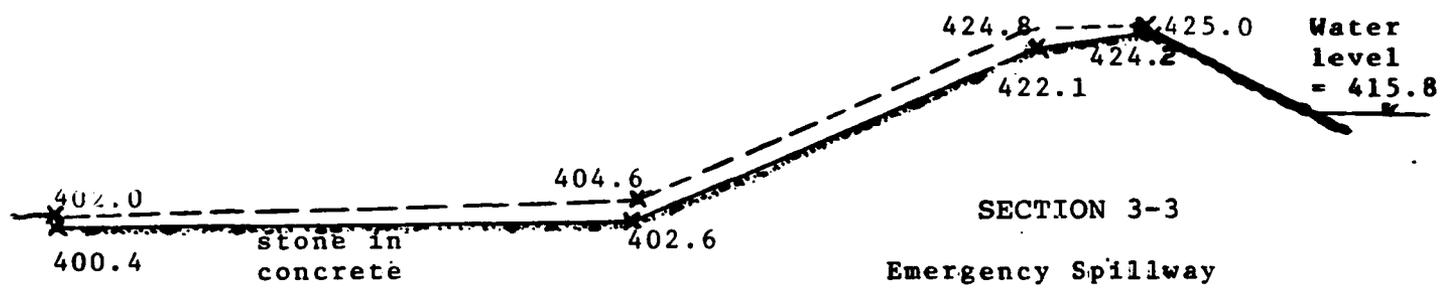
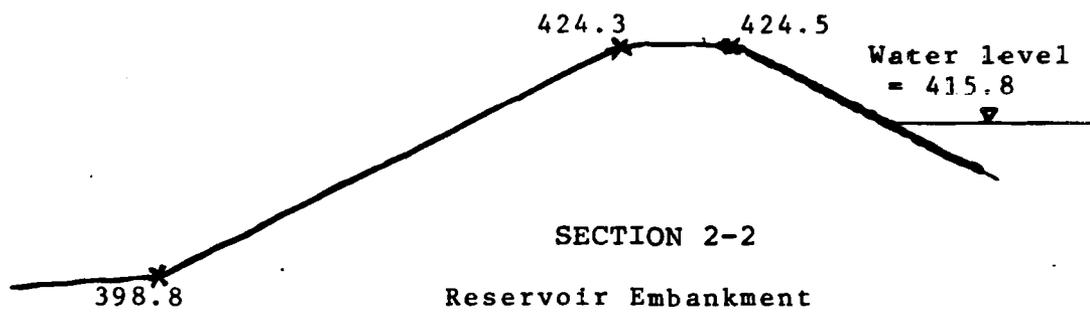
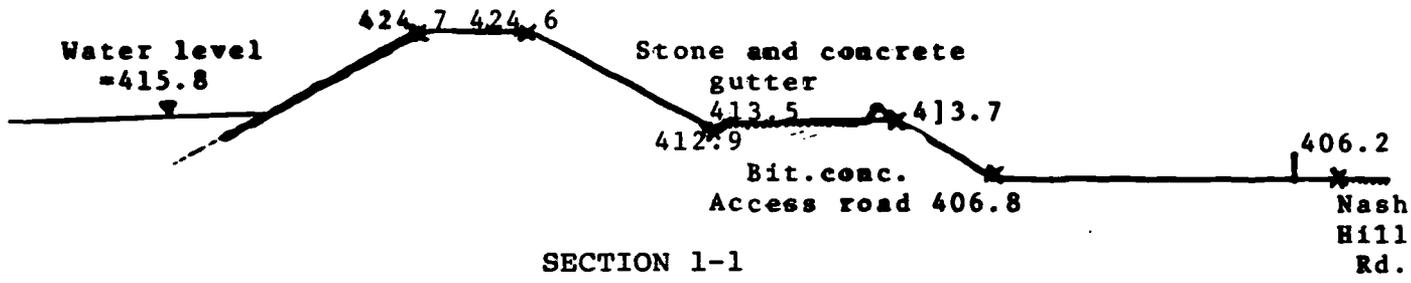


SCALE
in feet

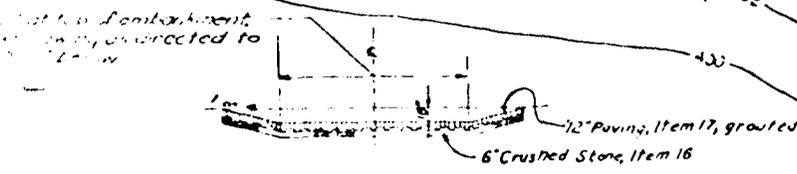
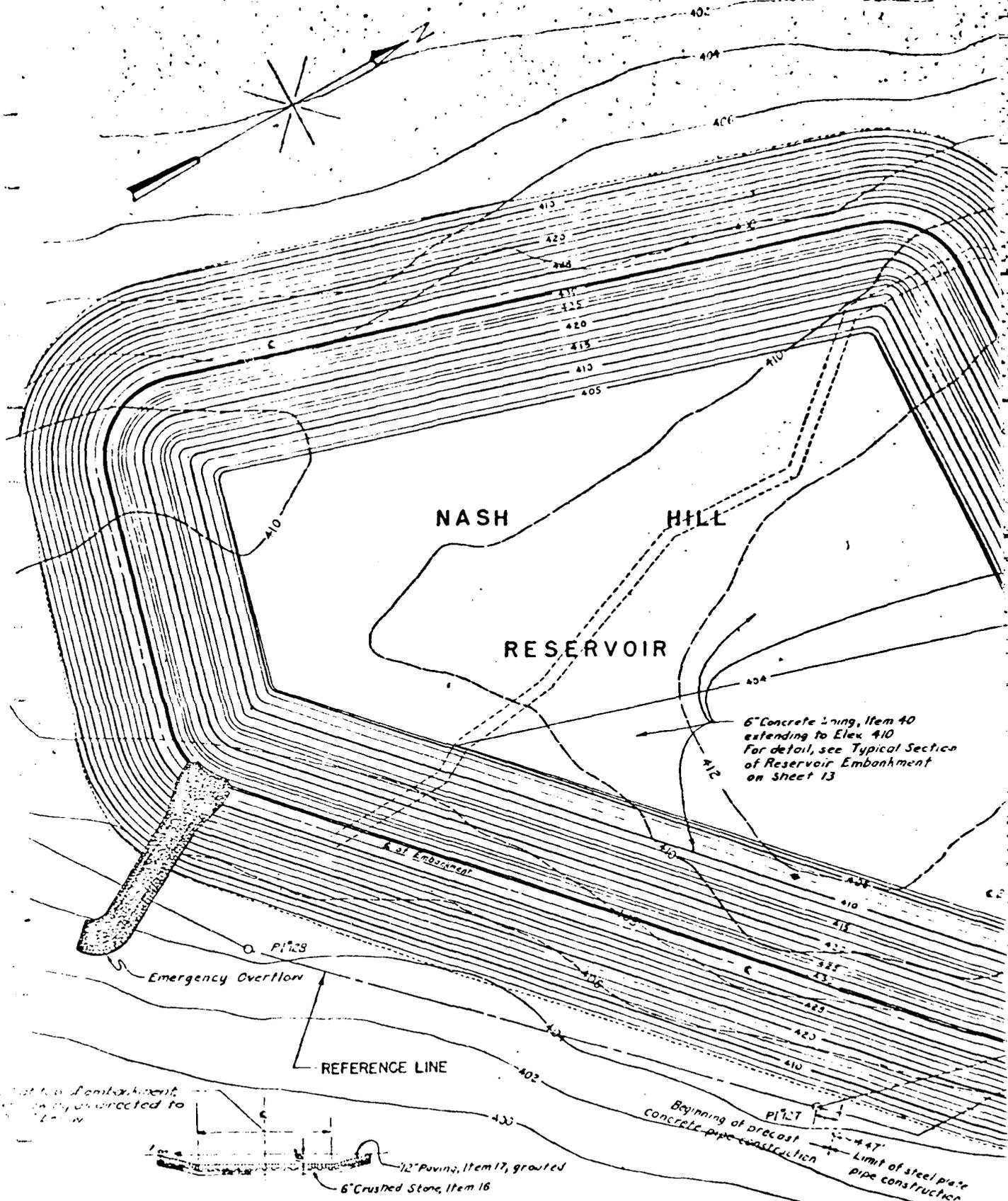


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METCALF & EDDY, INC.



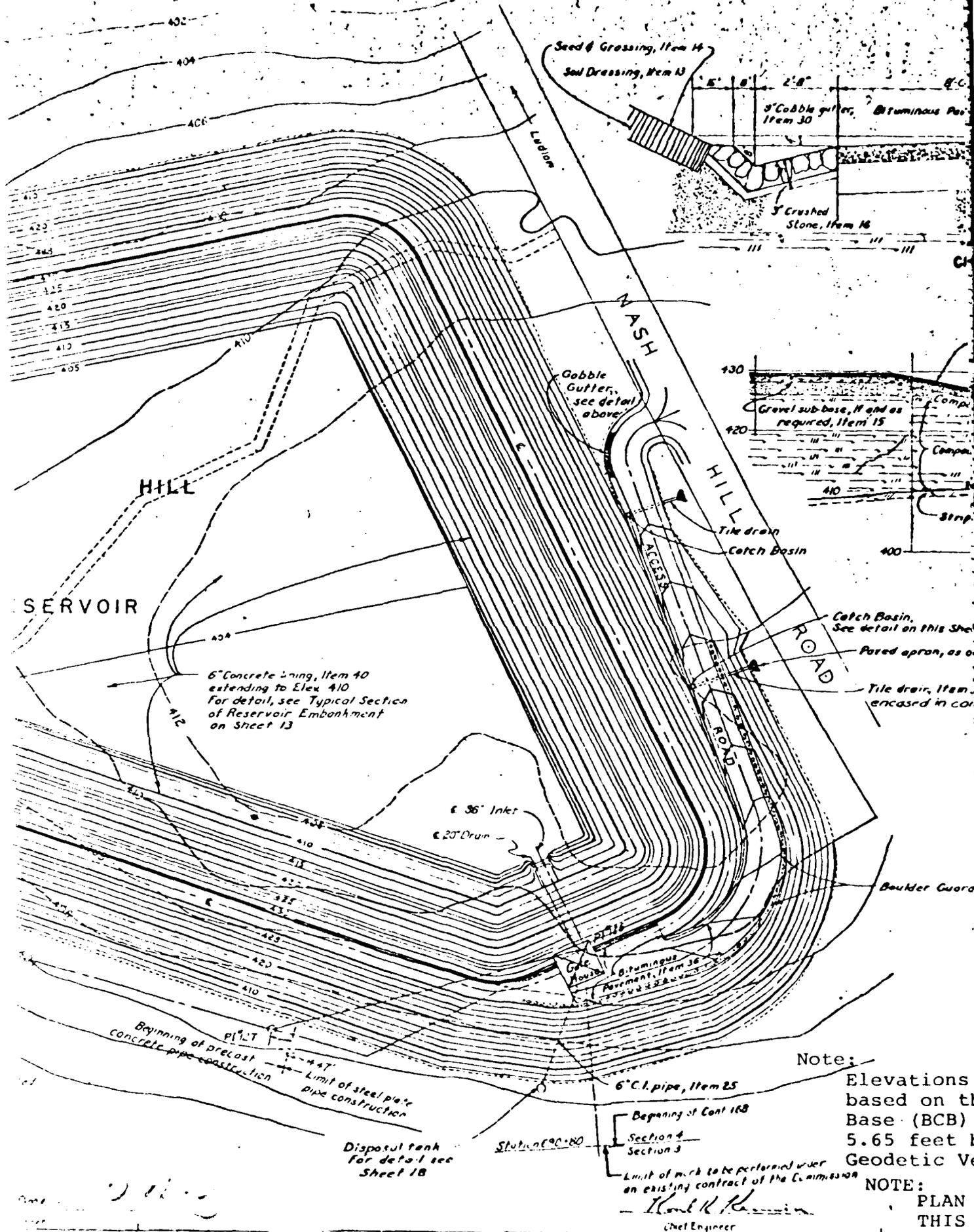
DETALP & CONF. INC. ENGINEERS BOSTON, MASS.	D.S. AND ENGINEERS DIV. GEN. EDWARDS CHIEF OF ENGINEERS BOSTON, MASS.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
MASH HILL RESERVOIR	
FIGURE 3-3 SECTIONS THROUGH EMBANKMENT	
TRIBUTARY QUICQUOZ RIVER	MASSACHUSETTS
SCALE: AS SHOWN	DATE: SEPTEMBER, 1960



EMERGENCY OVERFLOW DETAIL
0 5 10 20 FT.

Disposal tank for detail see Sheet 18

Stanley D. Dine
Deputy Chief Engineer



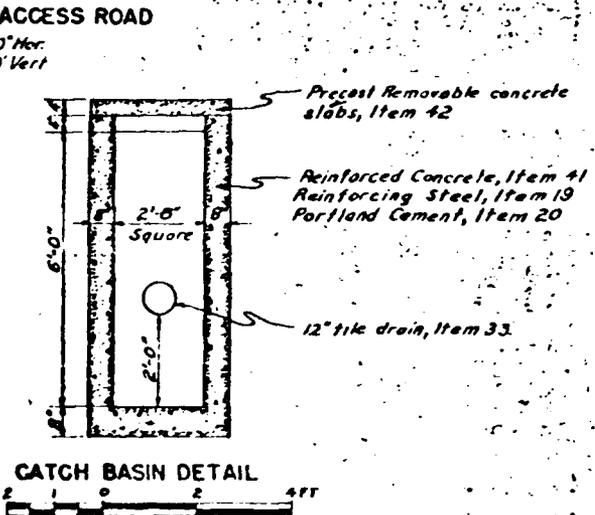
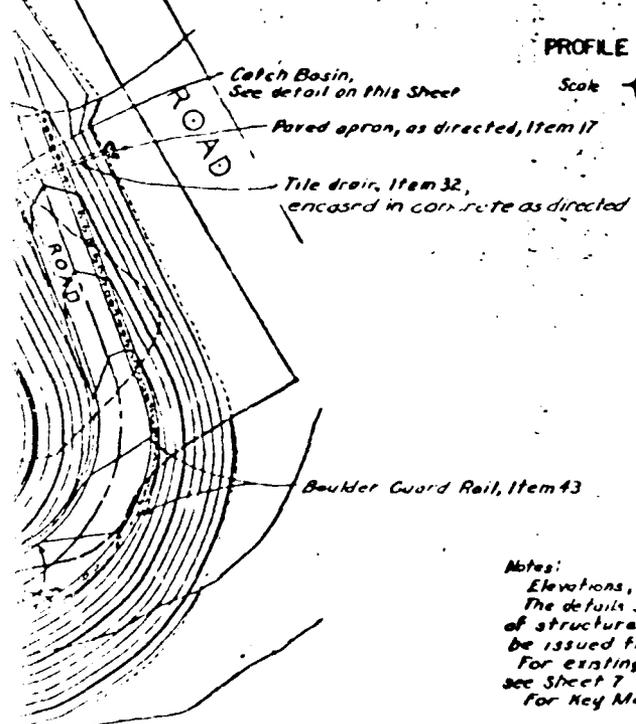
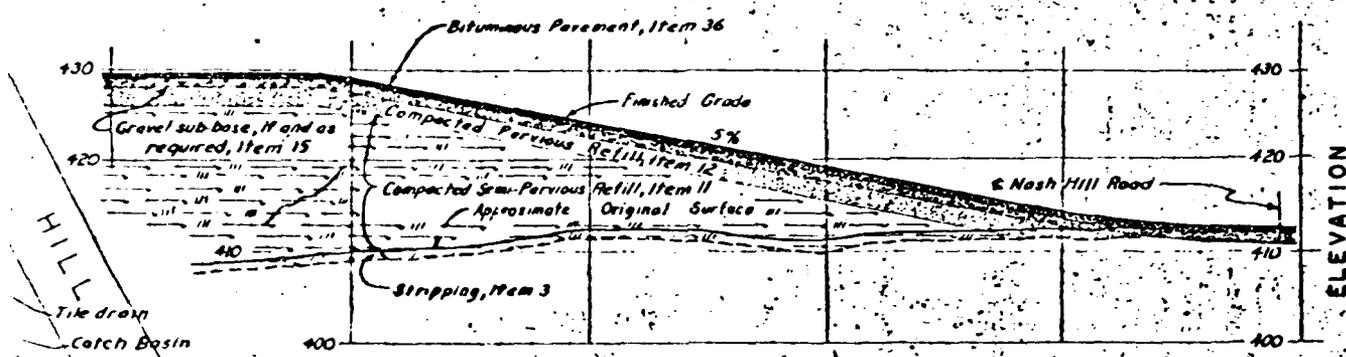
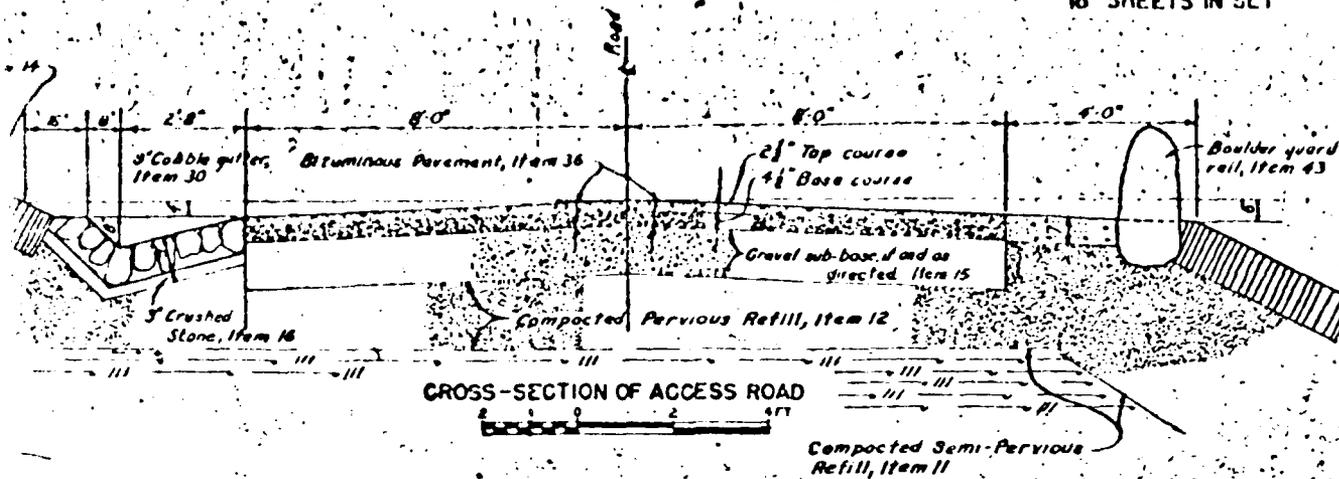
Note:
 Elevations based on the Base (BCB) 5.65 feet by Geodetic Vertical Datum
 NOTE: PLAN THIS

6" C.I. pipe, Item 25
 Beginning of Cont 168
 Section 4
 Section 3
 Limit of work to be performed under an existing contract of the Commission
 - *Robert H. [Signature]*
 Chief Engineer

Disposal tank for detail see Sheet 18

Beginning of precast concrete pipe construction
 Limit of steel pipe pipe construction

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Notes:
 Elevations, Boston City Base
 The details shown on these Contract Drawings are indicative of the types of structures wanted and are subject to revision by working drawings to be issued from time to time.
 For existing topography and real estate taking at Nash Hill Reservoir Site, see Sheet 7.
 For Key Map & Locality Plan, see Sheet 1.

Note:
 Elevations shown are based on the Boston City Base (BCB) datum which is 5.65 feet below National Geodetic Vertical Datum (NGVD).

COMMONWEALTH OF MASSACHUSETTS
 METR. DISTR. COMMISSION-CONSTRUCTION DIVISION
CHICOPEE VALLEY AQUEDUCT
 SECTION 4—36 INCH CONDUIT
 NASH HILL RESERVOIR-FINAL GRADING
 ACCESS ROAD—PLAN AND PROFILE

EXCEPT AS SHOWN
 FEBRUARY 24 1949

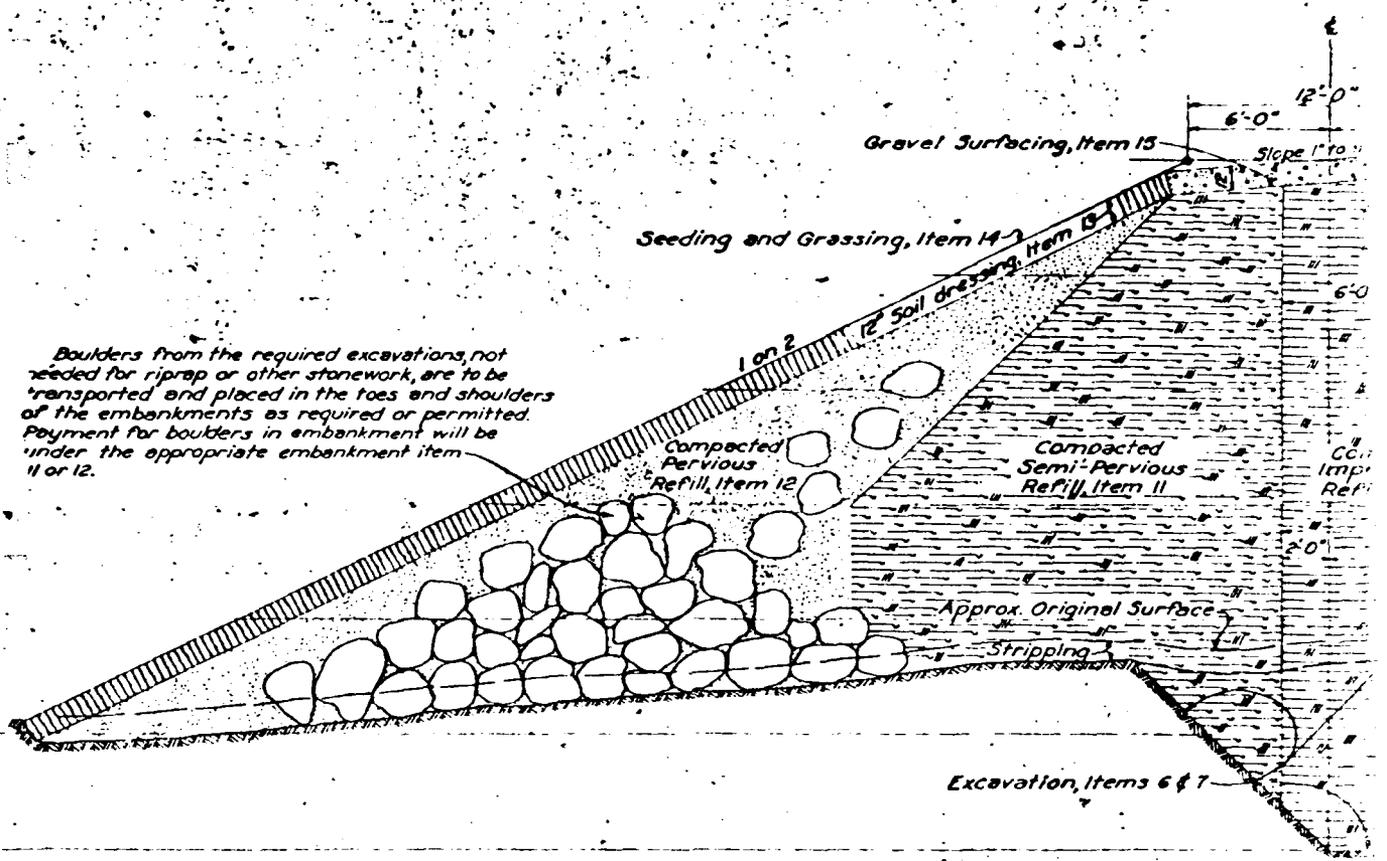
NOTE:
 PLAN REDUCED FOR
 THIS REPORT

FILE CONT. 168-32P

ACC. 51908

37

8



Boulders from the required excavations, not needed for riprap or other stonework, are to be transported and placed in the toes and shoulders of the embankments as required or permitted. Payment for boulders in embankment will be under the appropriate embankment item 11 or 12.

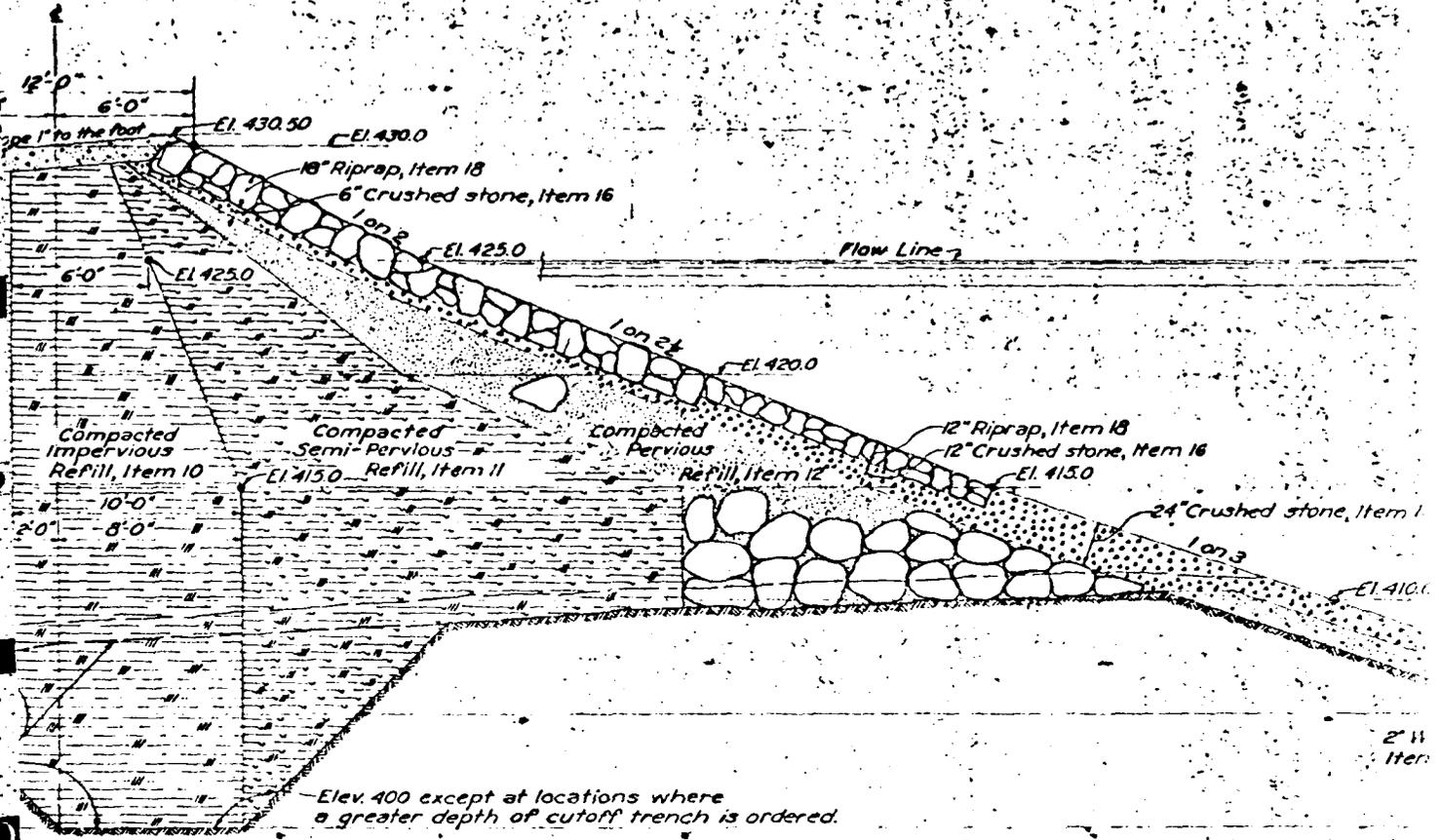
TYPICAL CROSS SECTION

NOTE: ELEVATIONS SHOWN ARE IN FEET WHICH IS 5.6 METERS

DRAWN BY
 CHECKED BY
 C. C. REDD

Stanley J. Rose
 Deputy Chief Engineer

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SECTION — RESERVOIR EMBANKMENT

Notes:
 Elevations, Boston
 The details show
 are indicative of the
 and are subject to
 to be furnished for
 For Key Map and
 For plan of res.
 Suitable pervious
 available at the site
 materials.

NOTE:
 PLAN REDUCED
 THIS REPORT

COMMONWEALTH
 METR. DISTR. COMMISSION
 CHICOPEE VALLEY
 NASH HILL
 TYPICAL CROSS SECTION

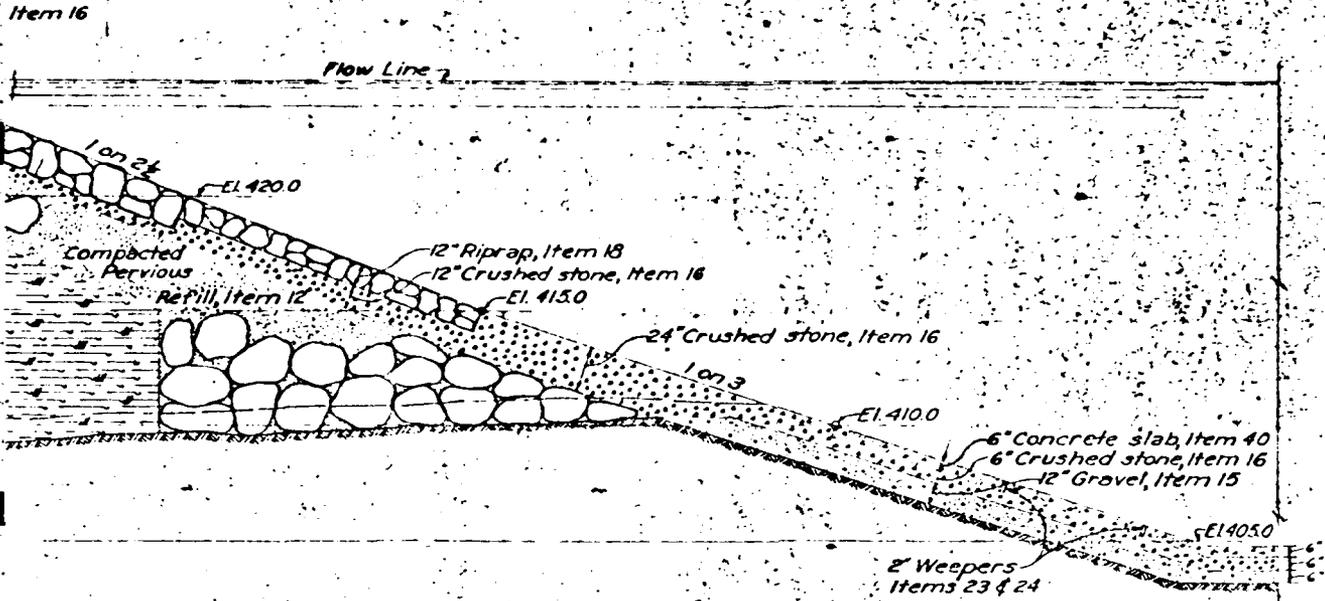
ALL ELEVATIONS SHOWN ARE BASED ON THE BOSTON CITY BASE (BCB) DATUM
 5.65 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM (NGVD).

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 Chief Engineer

16-11-1954

243

FILE CONT. 100

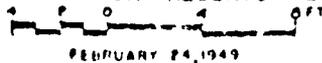


locations where
"cutoff" trench is ordered.

Notes:
Elevations, Boston City Base.
The details shown on these Contract Drawings
are indicative of the type of structures wanted
and are subject to revision by Working Drawings
to be furnished from time to time.
For Key Map and Locality Plan, see Sheet 1.
For plan of reservoir embankment, see Sheet 8.
Suitable pervious materials are probably not
available at the site. See notes on Sheet 7 regarding
materials.

NOTE:
PLAN REDUCED FOR
THIS REPORT

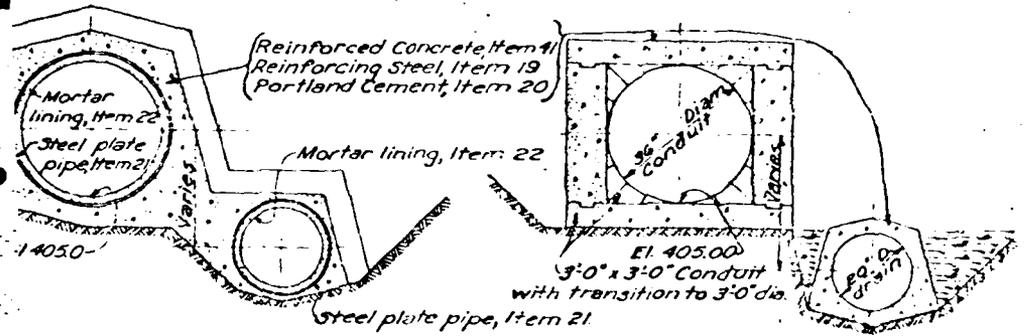
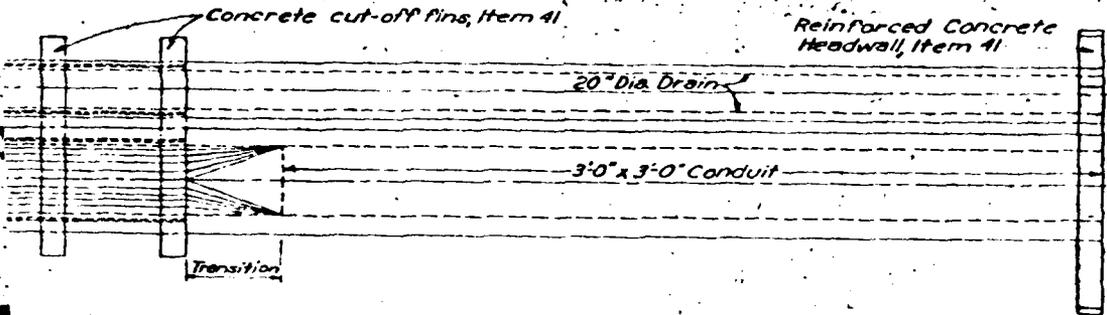
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. COMMISSION - CONSTRUCTION DIVISION
CHICOPEE VALLEY AQUEDUCT
NASH HILL RESERVOIR
TYPICAL CROSS SECTION RESERVOIR EMBANKMENT



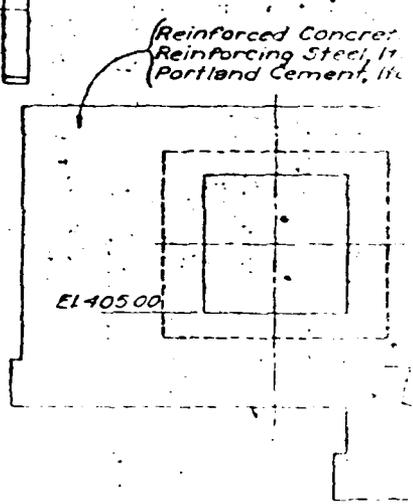
FEBRUARY 24, 1949

13

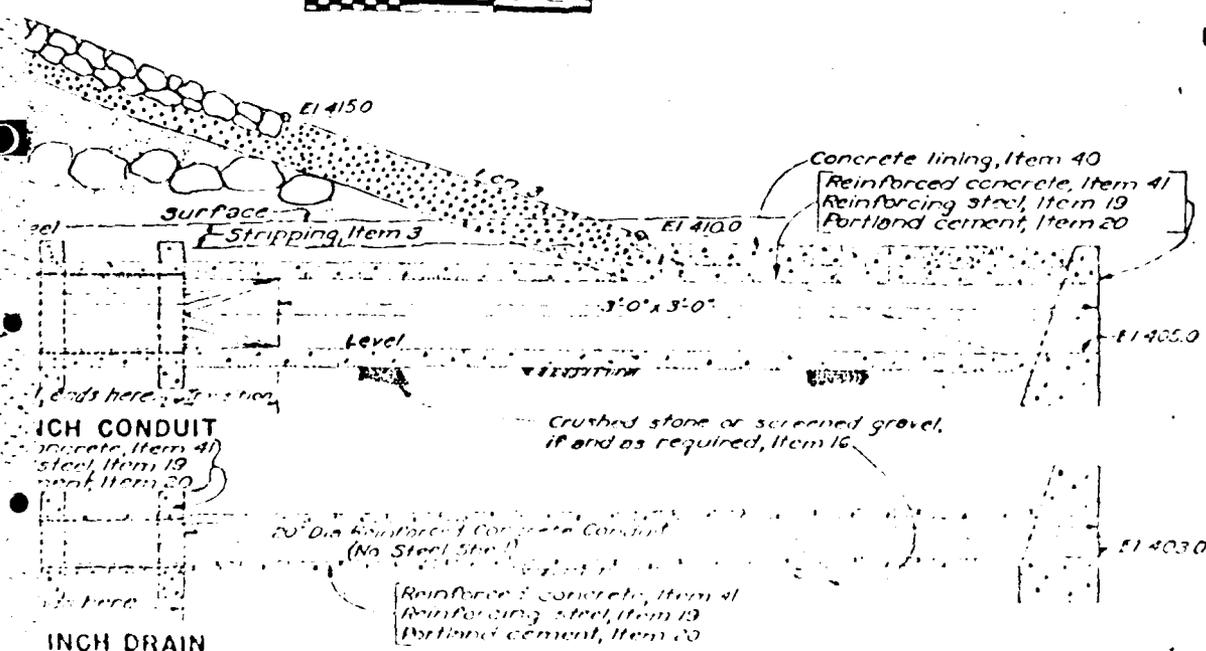
BOSTON CITY BASE (BCB) DATUM
GEODETIC VERTICAL DATUM (NGVD).



TYPICAL SECTIONS
 1 0 2 4 FT



ELEVATION OF HEADWALL
 2 1 0 2



Notes:
 Elevations, Boston City Base
 The details shown are indicative of the type and are subject to revision to be furnished from the Inlet Main and 20 inch.

NOTE:
 PLAN REDUCED TO THIS REPORT

COMMONWEALTH OF MASSACHUSETTS
 METR DISTRICT COMMISSION
CHICOPEE VALLEY
 NASH HILL
 GATE HOUSE - 30 BOURNE

ELEVATIONS SHOWN ARE BASED ON THE BOSTON CITY BASE (BCB) DATUM WHICH IS 5.65 FEET BELOW NATIONAL GEODETIC VERTICAL DATUM (NGVD).

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 Chief Engineer

FILE NO. 3770

off fins, Item 41

Reinforced Concrete Headwall, Item 41

20" Dia Drain

3'-0" x 3'-0" Conduit

(Reinforced Concrete, Item 41
Reinforcing Steel, Item 19
Portland Cement, Item 20

Concrete, Item 41
Steel, Item 19
Cement, Item 20

lining, Item 22

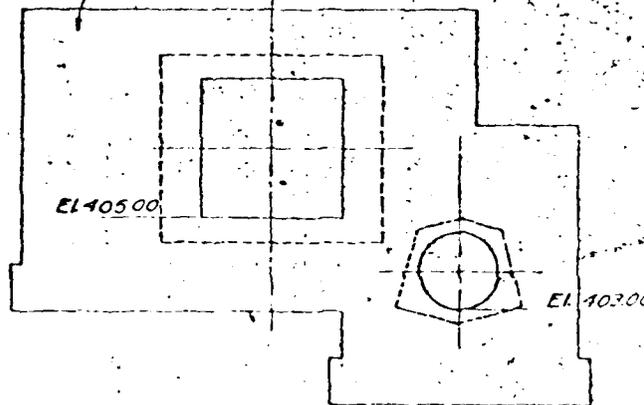
El. 405.00

3'-0" x 3'-0" Conduit
with transition to 3'-0" dia.

plate pipe, Item 21.

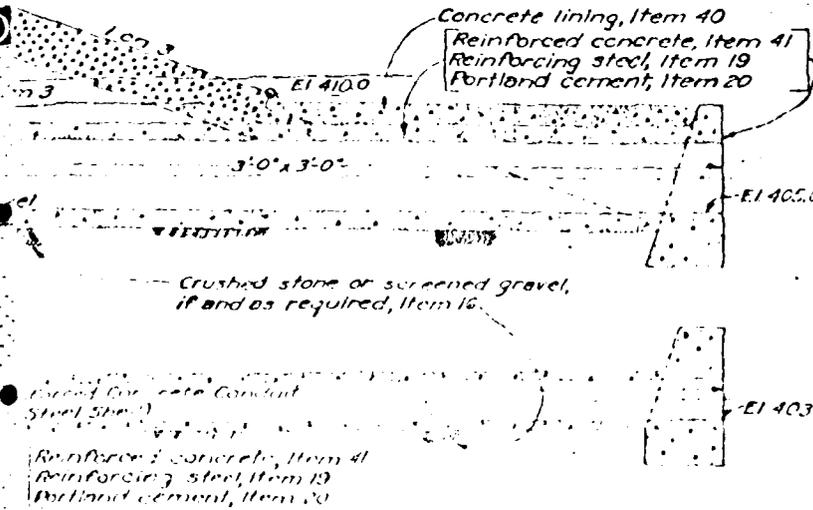
CAL SECTIONS

0 2 4 FT.



ELEVATION OF HEADWALL

2 1 0 2 4 FT.



Notes:
Elevations, Boston City Base
The details shown on these Contract Drawings are indicative of the type of structures wanted and are subject to revision by working drawings to be furnished from time to time.
For continuation of Profile through 36 inch Inlet Main and 20 inch drain, see Sheet 9.

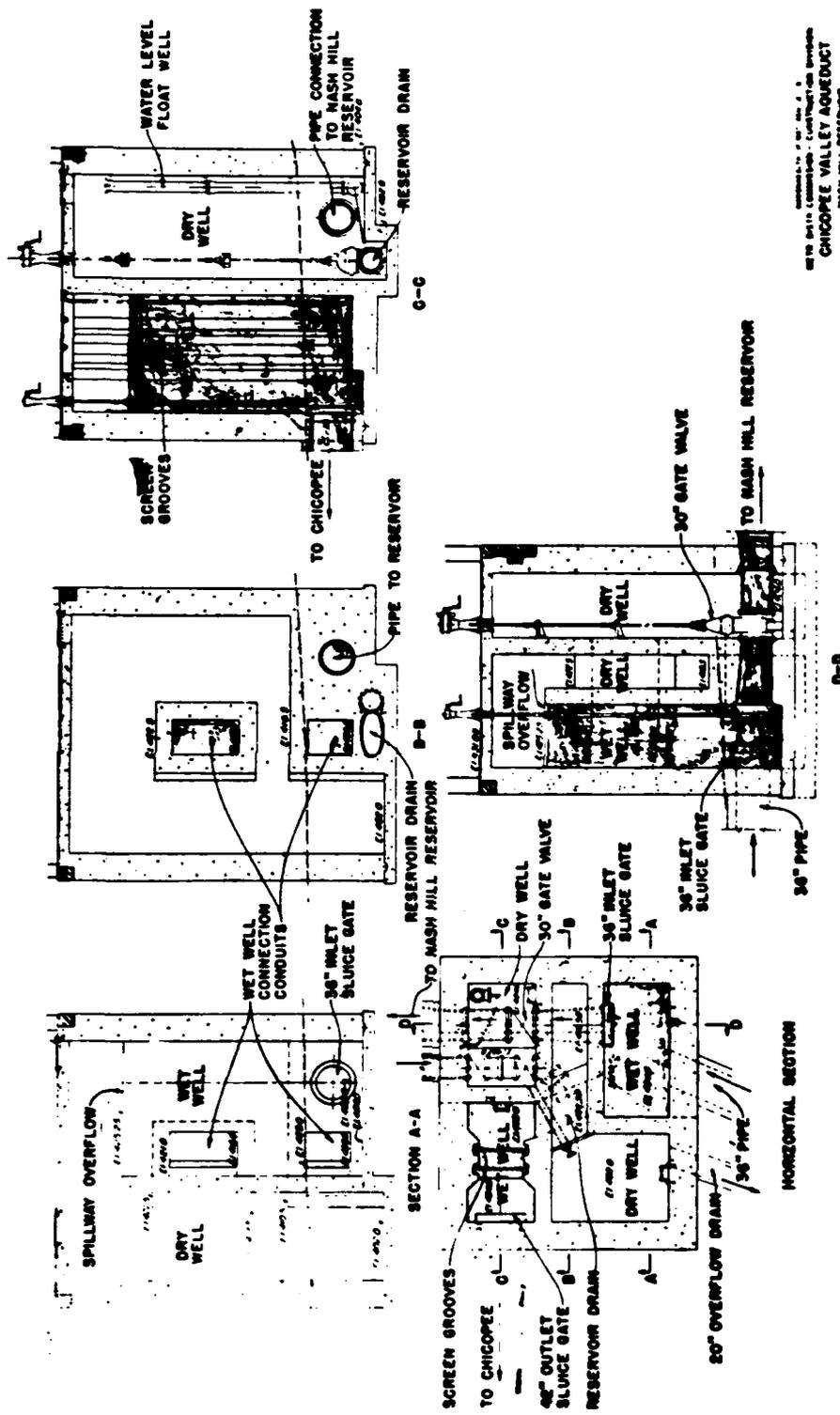
NOTE:
PLAN REDUCED FOR
THIS REPORT

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. COMMISSION - CONSTRUCTION DIVISION
CHICOPEE VALLEY AQUEDUCT
NASH HILL RESERVOIR
GATE HOUSE - 36 INCH PIPE - INLET MAIN

EXCEPT AS SHOWN
FEBRUARY 24, 1944

(10)

FILE COST \$ 322



CHICOOPEE VALLEY AQUEDUCT
 NASH HILL RESERVOIR
 SECTION A-A, B-B, C-C, D-D
 1918

J. L. ...
 Chief Engineer

...
 Chief Engineer

...
 Chief Engineer

FIG. B-6

REFILL AND EMBANKMENT FOR RESERVOIR (Items 10, 11 and 12)

Section 10.1. Work Included. Under Items 10, 11 and 12 the Contractor shall furnish, place, grade and consolidate materials required in the refills and embankments for the construction of earth dams to form the Nash Hill Reservoir, for construction of concrete-encased, mortar-lined, steel-plate pipe conduits laid in and adjacent to these dams, and for the construction of any other miscellaneous works which are a part of the Nash Hill Reservoir. Item 10 includes compacted impervious embankments, Item 11 includes compacted semi-pervious embankments and Item 12 includes compacted pervious embankments; as specified in Section 10.2.

Section 10.2. Quality. Suitable materials from the excavations shall be used for refilling and embankments placed under Items 10, 11 and 12 and additional materials, only if and as needed, may be borrowed as specified in Section 15.

Impervious Materials. Materials placed under Item 10 shall be satisfactorily impervious materials containing a sufficient proportion of acceptably fine materials. They may be, if there is a surplus of stripped materials not required for soil dressing, topsoils and subsoils satisfactorily free from vegetation, masses of roots or individual roots more than 24 inches long or one-half inch in diameter, stones over 4 inches in diameter, porous materials, or other undesirable matter. Topsoil containing an excess of organic matter or peat, silt or muck will not be acceptable. They may be materials of glacial till origin which are satisfactorily graded in sizes of particles, containing a proper proportion of fine particles to be acceptably watertight, and containing no stones larger than 4 inches in diameter.

Pervious Materials. Materials placed under Item 12 shall be acceptably coarse and pervious, shall be well graded in sizes of particles and shall contain such a small proportion of fine particles as to be satisfactorily pervious to the flow of water. They shall be composed of hard, durable stones and sands, practically free from loam and clay.

Semi-pervious Materials. Materials placed under Item 11 shall be well-graded, durable materials of glacial origin, but they do not need to be as water-tight as materials specified for Item 10 nor do they need to be as pervious as materials specified for Item 12. They shall, however, contain no stone of sizes which would prevent thorough compaction, no objectionable foreign matter such as roots and muck, or no excessive proportions of the clay, silt, or very fine sand sizes.

Boulders and Large Stones. Boulders, large stones and cobbles from the excavations, to the extent available if not required for riprap or other stonework, will be acceptable to be placed and shall be placed in the toes of the dam embankments as indicated on the plans or otherwise permitted, in lieu of the pervious or semi-pervious materials of the qualities above specified.

Section 10.3. Placing. The embankments shall be started on a firm base which shall have been cleared and stripped and from which silt, peat and perishable material shall have been removed to the extent directed. The base or other surfaces of any fill which have been allowed to weather, for periods long enough in the opinion of the Engineer to require it, shall be picked, roughened and rolled as directed to make a bond with the embankment material to be placed above.

Materials placed under Items 10, 11 and 12 shall, unless otherwise permitted or required, be deposited in approximately horizontal layers not exceeding 6 inches in thickness when compacted, and unless sufficiently moist as spread shall be wetted to the extent directed in such manner as will secure the uniform moistening of all portions of each layer. If required, the compacted surface shall be acceptably sprinkled immediately before placing each new layer. Each layer shall be rolled as directed, with an approved roller, weighted as required. For Items 10 and 11, this roller shall be of the sheep's-foot type and shall be provided with a rack for cleaning the teeth. The roller shall pass over every part of each layer that can be traversed by it. To obtain the desired compactness for the varying kinds of material used, the Engineer will prescribe the number of trips of the approved roller needed on each part of the work and the moisture content in the material being placed; but generally in the case of impervious material placed under Item 10, the moisture content of the material being placed shall not be less than 15 nor more than 22 per cent of the dry weight of the material for topsoil and subsoil, and not less than 10 nor more than 16 for glacial till materials and the number of trips shall not be less than 6 nor more than 15; in the case of pervious material placed under Item 12, the moisture content of the material being placed shall not be less than 10 per cent of the dry weight of the material and the number of trips not less than 5 nor more than 9; and in the case of semi-pervious materials placed under Item 11 the moisture content of the material being placed and the number of trips of the roller will be specified by the Engineer from time to time as the work progresses according to the character of the material being placed but the general requirements of moisture content and number of trips of the roller will be between the above stipulations for impervious materials and for pervious materials. Portions of embankments which the rollers cannot reach for any reason shall be compacted by extra-heavy pneumatic tampers, or by other means which will secure a degree of compacting equivalent to that obtained by rolling as specified. Materials placed under Item 12 may be consolidated with water at approved locations in lieu of rolling, if and as permitted, and the Engineer may require the consolidation with water of materials too coarse to be satisfactorily rolled.

Materials to be placed under Items 10 and 11 shall not be deposited when the weather conditions are such that it is impracticable to construct the embankments within the specified moisture content limitations.

No material shall be deposited under Items 10, 11 and 12 or stored in piles for future use when, in the opinion of the Engineer, cold or freezing weather will interfere with proper construction. No frozen materials shall be used in the construction, and materials shall not be deposited upon frozen surfaces or fills containing frost.

Boulders, large stones and cobbles used in lieu of pervious fill, Item 12, or semi-pervious fill, Item 11, shall be deposited in the manner directed or approved by the Engineer which will not, in his opinion, interfere with the proper consolidation of adjacent portions of the embankments.

Section 10.4. Filling Unauthorized Excavations. If the contractor excavates by permission or otherwise outside the ordered limits, he shall refill such excavations at his own expense with acceptable materials placed as approved.

Section 10.5. Measurement and Payment. Quantities to be paid for under Items 10, 11 and 12 shall be the number of cubic yards placed in accordance with orders (whether or not excavated under any excavating items) measured in position after compacting. The prices respectively stipulated shall include payment for preparing the base, borrowing, transporting and placing the materials, spreading in layers, setting, rolling, tamping, trimming to line, and all labor and materials incidental to satisfactorily completing the embankments not specifically included for payment under other items. The measurement for payment shall not include spoil banks nor refilling of unauthorized excavations nor any material placed outside of the prescribed lines even though such material may have been so placed with the permission or at the direction of the Engineer immediately adjacent to or continuous with prescribed embankments. Refilling and embanking for the cut-and-cover aqueduct construction will be included under Items 8 and 9 and not under Items 10, 11 and 12. Boulders, large stones and cobbles used in lieu of pervious fill (Item 12) and semi-pervious fill (Item 11) will be included for payment under Items 12 and 11 respectively, and not under items for riprap, paving or any other stonework item or any other embankment item. No direct payment shall be made under this or any other item for refilling and embanking of whatever nature made solely for the Contractor's plant, roads or pipe lines, or for his other requirements in carrying out the provisions of this contract, but the payment therefor is included in the prices stipulated in Items 1 to 47, inclusive.

GRAVEL (Item 15)

Section 15.1. Work Included. Under Item 15 the Contractor shall satisfactorily prepare the sub-base and furnish and place gravel of the sizes and quality specified or ordered for constructing the surface course of permanent access roads, of roadways and rights-of-way across the aqueduct line, gravel roadways ordered to be built on top of the embankments around the reservoir and over the pipe, gravel shoulders for roadways, and other ordered roadways at the site and shall furnish, place and consolidate gravel refill for constructing foundations for the aqueduct as required for certain locations where soft foundations are encountered and which, in the opinion of the Engineer, warrant the use of gravel refill in lieu of or in addition to refill under Item 8 for proper stability. Gravel surfacing for roadways will be in general about 12 inches thick and no surfacing under this item will be ordered less than 6 inches thick. Gravel in foundations shall be of the thickness directed.

Section 15.2. Material. The gravel shall be composed of hard, durable stone and coarse sand, practically free from loam and clay, and, when spread on the road or in the trench and compacted, shall present a stable foundation. The gravel particles shall be uniformly and satisfactorily graded in size. Suitable materials from the excavations under Items 4 and 6 may be used only if and as permitted.

Section 15.3. Construction Methods. Gravel shall be spread, to a depth necessary to give the thickness required after compacting, upon the sub-base satisfactorily prepared, by approved methods, care being taken to rake forward and distribute the larger stones so that they will be at the bottom of the gravel course and be evenly distributed. The gravel so placed shall be thoroughly watered and rolled with an approved self-propelled, 3-wheeled roller or otherwise satisfactorily compacted. Any depressions that appear during or after rolling shall be filled with gravel and rerolled until the surface is true and even.

Section 15.4. Maintenance. The Contractor will be permitted to use the rights-of-way and roadways surfaced under this item for the purposes of the contract and shall maintain them until the contract is completed. Final acceptance of the work under Item 15 will be withheld until completion of the contract and will be contingent upon the satisfactory maintenance of the rights-of-way and roadways.

Section 15.5. Measurement and Payment. The quantity to be paid for under Item 15 shall be the number of cubic yards of gravel furnished and satisfactorily placed in accordance with plans or orders, measured in final position within the ordered limits regardless of the quantity of material actually placed at any point. The measurement for payment shall not include any material placed outside the specified limits, either of necessity or by permission, on account of a deficiency of the subgrade or otherwise, payment for excavation and refill to the required subgrade being included under the appropriate items 4 to 12, inclusive. The yardage required within the specified lines under Item 15 shall be included in the measurement only once, regardless of the fact that additional quantities may be required for maintenance under the provisions of Section 15.4. The price stipulated shall include payment for preparation of the sub-base, for placing of the gravel and for all work directly or indirectly connected with furnishing and placing the material. Gravel used for concrete or for other purposes for which payment is provided under other items and all gravel and similar materials used for the Contractor's purposes shall not be paid for under Item 15.

CRUSHED STONE AND SCREENED GRAVEL (Item 16)

Section 16.1. Work Included. Under Item 16 the Contractor shall furnish and place on the embankments forming Nash Hill Reservoir, in the trench, under the pipe in swampy or wet locations, under paving, riprap and gutters, and elsewhere as shown on the plans or ordered, crushed stone or screened gravel of approved size and quality. Stone used in surfacing the highway under Item 36 will not be included as part of the work under Item 16.

Section 16.2. Material. Crushed stone shall consist of clean, durable crushed rock; and screened gravel shall consist of acceptably clean and coarse gravel washed or screened as required. The sizes of each shall be such that 100 per cent will pass a 4-inch ring, at least 50 per cent will be retained on a 1-inch ring and not more than 2 per cent will pass a $\frac{1}{4}$ -inch ring, and each shall be satisfactorily free from fine sand or rock flour.

Section 16.3. Measurement and Payment. The quantity to be paid for under Item 16 shall be the number of cubic yards furnished and placed, measured within the limits shown on the plans or ordered, and shall not include any material placed outside the ordered limits either of necessity or by permission, on account of a deficiency of the subgrade or otherwise.

RIPRAP (Item 18)

Section 18.1. Work Included. Under Item 18 the Contractor shall furnish all materials, equipment and labor required to construct riprap on the faces of embankments forming the Nash Hill Reservoir, at river or brook crossings, at culvert head walls or on the slopes of the aqueduct embankments needing special protection, within the limits shown on the plans or ordered, and elsewhere if and as required.

Section 18.2. Specifications. Riprap shall be composed of durable stone of acceptable sizes. Suitable boulders and large cobbles from the required excavations may be used. The riprap shall be constructed of the thickness and the extent shown on the plans or directed. The average surface of the riprap shall satisfactorily approximate the required theoretical. The Contractor will not be required to place riprap by hand except to rearrange surface stones as necessary to fill unsatisfactory depressions in the surface below the required grades. Riprap shall have no broken stone or gravel small enough to pass a 4-inch ring and at least 50 per cent of the volume shall consist of stones exceeding one-half cubic foot, and in the case of riprap more than 12 inches in ordered thickness, at least 20 per cent exceeding one cubic foot; and the boulders and large cobbles used shall contain a sufficient number of large angular stones to give stability to the entire mass.

Section 18.3. Measurement and Payment. The quantities to be paid for under Item 18 shall be the number of cubic yards of riprap satisfactorily placed in the completed work, measured to the ordered theoretical surfaces regardless of the quantities of riprap projecting beyond such surfaces and with no deduction for the voids. The price stipulated shall include payment for all work directly or indirectly connected with furnishing, placing and trimming the riprap.

TABULATION OF GRAIN SIZE AND PERMEABILITY TESTS ON EMBANKMENT FILL
AT NASH HILL RESERVOIR (OBTAINED FROM FILES AT QUABBIN RESERVOIR OFFICE)

Type of fill	Sample	Unit weight (lbs/cu. ft.)	Moisture content (%)	% Passing # 200 sieve	Uniformity coefficient	Effective size	Maximum size	Permeability gal/acre/day
pervious	Couture's Pit	125	1.4	0.78	11.4	.18	2"	1,547,910
pervious	Gate's Pit	130	1.2	-	15.1	1.10	3"	863,258
pervious	-	-	-	-	12.2	.30	-	1,101,000
semi-pervious	Gate's Pit	126.9	0.5	0.56	12.0	.46	1"	672,774
semi-pervious	168-1A	118.2	4.2	7.28	14.6	.105	3"	4,961
semi-pervious	168-2A	117.1	4.6	6.5	24.3	.103	3"	11,907
semi-pervious	168-3A	121.0	5.2	9.6	32.5	.080	3"	15,082
semi-pervious	168-4A	118.0	7.2	11.1	38.7	.053	3"	27,386
semi-pervious	168-6	125.4	0.6	3.98	13.5	.133	2"	15,479
semi-pervious	168-8	129.7	1.7	10.26	-	-	3"	6,350
semi-pervious	168-10	127.2	1.5	11.0	35.4	.065	3"	6,450
semi-pervious	168-11	126.1	2.9	11.8	22.2	.063	2.5"	12,606
semi-pervious	168-12	127.4	2.3	9.16	17.1	.07	2.5"	10,626
semi-pervious	168-14	128.0	2.1	11.57	11.9	.067	2.5"	9,402
impervious	168-1	115.0	7.0	16.5	56.7	.0215	1.5"	10,170
impervious	168-2	110.0	7.7	17.3	32.0	.0281	1.5"	37,209
impervious	168-3	106.6	9.52	16.0	19.5	.042	1.5"	30,759
impervious	168-4	106.6	7.3	31.78	30.0	.0155	1.5"	50,604
impervious	168-5	122.3	3.0	11.2	19.8	.058	2"	21,996
impervious	168-7	128.7	2.5	8.8	35.7	.084	2"	10,748
impervious	168-9	123.0	2.5	12.9	22.9	.045	2"	10,915
impervious	168-13	125.5	2.0	11.4	22.2	.054	2"	12,320

INSPECTION REPORT - DAMS AND RESERVOIRS

1. LOCATION:

City/Town Ludlow . County Hampden . Dam No. 2-7-151-11 .

Name of Dam Nash Hill Reservoir .

Mass. Rect.

Topo Sheet No. 15A . Coordinates: N 437,000 , E 331,300 .

Inspected by: Harold T. Shumway , On June 10, 1976 . Date 4/1/74 . Last Inspection

2. OWNER/S: AS of 6/10/76

per: Assessors _____, Reg. of Deeds _____, Prev. Insp. x, Per. Contact x .

M.D.C., Winsor Dam Hdqtrs.
 1. Attn: Mr. John W. Capithorne, Supt., Winsor Dam, Ware Rd., Belchertown, Mass.
 Name St. & No. City/Town State Tel. No.

2. _____
 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.

Mr. Henry Befford,
M.D.C., Winsor Dam Hdqtrs., Winsor Dam, Ware Rd., Belchertown, Mass.
 Name St. & No. City/Town State Tel. No.

4. DATA:

No. of Pictures Taken None , Sketches See description of Dam.
 Plans, Where At Quabbin Reservoir office of MDC - File #168-3-2, Contract 168
 13th St

5. DEGREE OF HAZARD: (if dam should fail completely)*

- 1. Minor _____
- 2. Moderate x _____
- 3. Severe _____
- 4. Disastrous _____

Comments: Approximately 26 million gallons capacity - could flood houses on hillside below.

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

6. OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: In Gatehouse - 36" pipe line to Chicopee and South Hadley.

Controls yes, TYPE: Screw operated gate valves.

Automatic . Manual X. Operative Yes X, No .

Comments: All controls and machinery in gatehouse in good operating condition.

No. 2 Location and Type: In gatehouse - 20" overflow or waste pipe-empties into brook

Controls yes, Type: Double gate valves and hand stands.

Automatic . Manual X. Operative Yes X, No .

Comments: See comments above.

No. 3 Location and Type: Southwesterly corner of reservoir-emergency overflow spillway
20' wide x 1 1/2' high grouted stone masonry crest and outlet channel.

Controls None, Type:

Automatic . Manual . Operative Yes , No .

Comments: Crest and upper end has been recently regrouted.

Drawdown present Yes X, No . Operative Yes X, No .

Comments: See No. 2 above.

7. DAM UPSTREAM FACE: Slope 2 1/2:1, Depth Water at Dam 20'

Material: Turf . Brush & Trees . Rock fill X. Masonry . Wood

Other 18" riprap on 6" crushed stone base.

Condition: 1. Good X. 3. Major Repairs .

2. Minor Repairs . 4. Urgent Repairs .

Comments:

8. DAM DOWNSTREAM FACE: Slope 2:1

Material: Turf X. Brush & Trees . Rock Fill . Masonry . Wood

Other

Condition: 1. Good . 3. Major Repairs .

2. Minor Repairs X. 4. Urgent Repairs .

Comments: Three open animal burrows found which caretaker said he would have
refilled and tamped in immediately.

9. EMERGENCY SPILLWAY: Available yes. Needed _____.

Height Above Normal Water: 3 1/2 Ft.

Width 20 Ft. Height 1 1/2 Ft. Material grouted stone masonry.

Condition: 1. Good x. 3. Major Repairs _____.

2. Minor Repairs _____ 4. Urgent Repairs _____.

Comments: _____

10. WATER LEVEL AT TIME OF INSPECTION: 11 Ft. Above _____ Below x _____.

Top Dam x F.L. Principal Spillway _____.

Other _____.

Normal Freeboard 5 Ft. when reservoir is full.

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment None.

Animal Burrows and Washouts 3 animal burrows.

Damage to Slopes or Top of Dam See above.

Cracked or Damaged Masonry None found.

Evidence of Seepage Wetness of ground noted in 30'+ long area on south slope toe.

Evidence of Piping None found.

Leaks None found.

Erosion None found.

Trash and/or Debris Impeding Flow None found.

Clogged or Blocked Spillway None found.

Other _____.

⑫

OVERALL CONDITION:

1. Safe _____.
2. Minor repairs needed x _____.
3. Conditionally safe - major repairs needed _____.
4. Unsafe _____.
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____.

⑬

REMARKS AND RECOMMENDATIONS: (Fully Explain)

This is an open reservoir formed by an earthen embankment located on Nash Hill and is a part of the MDC Quabbin system. The entire installation is very well maintained. Top and slopes are well turfed and mowed over. The three woodchuck holes located on downstream south slope were new burrows and Caretaker said he would have animals removed and holes refilled immediately. A slight wetness of ground surface at toe of south slope in one area was noted. Caretaker stated that this dries up completely in summer months. Dam appears to be sound and safe at present time.

HTS/fc

6. OUTLETS: OUTLET CONTROLS AND DRAWDOWN

No. 1 Location and Type: In gate house - 36" pipe line to Chicopee and South Hadley.

Controls Yes, TYPE: Screw operated gate valves.

Automatic . Manual X. Operative Yes X, No .

Comments: All operating machinery in gate house in good operating condition.

No. 2 Location and Type: In gate house - 20" overflow or waste pipe empties into brook.

Controls Yes, Type:

Automatic . Manual X. Operative Yes X, No .

Comments: See above

No. 3 Location and Type: at southwesterly corner of reservoir - emergency overflow spillway. Chute 3½' above flow line - 18'H.-20'W. narrowing to 10' on slope.

Controls No, Type:

Automatic . Manual . Operative Yes , No .

Comments: Grouted stone bottom and sides - grout broken away at upper end.

Drawdown present Yes X, No . Operative Yes X, No .

Comments: See No. 2 Above.

7. DAM UPSTREAM FACE: Slope 2½:1, Depth Water at Dam 20'

Material: Turf . Brush & Trees . Rock fill X. Masonry . Wood .

Other 18" rip rap on 6" crushed stone base

Condition: 1. Good X. 3. Major Repairs .

2. Minor Repairs . 4. Urgent Repairs .

Comments:

8. DAM DOWNSTREAM FACE: Slope 2:1

Material: Turf X. Brush & Trees . Rock Fill . Masonry . Wood .

Other

Condition: 1. Good . 3. Major Repairs .

2. Minor Repairs X. 4. Urgent Repairs .

Comments: On south slope grass is somewhat sparse.

9. EMERGENCY SPILLWAY: Available Yes . Needed _____.

Height Above Normal Water 3 1/2 Ft.

Width 20 Ft. Height 1 1/2 Ft. Material Grouted stone .

Condition: 1. Good _____ . 3. Major Repairs _____ .
 2. Minor Repairs X . 4. Urgent Repairs _____ .

Comments: Grout has cracked away on upstream end chute.

10. WATER LEVEL AT TIME OF INSPECTION: 6 Ft. above _____ . Below X _____ .

Top Dam X _____ F.L. Principal Spillway _____ .

Other _____ .

Normal Freeboard 5 Ft. when reservoir is full

11. SUMMARY OF DEFICIENCIES NOTED:

Growth (Trees and Brush) on Embankment None _____ .

Animal Burrows and Washouts Several wood chuck holes which had been filled by _____ .
Maintenance Personnel noted.

Damage to Slopes or Top of Dam None noted _____ .

Cracked or Damaged Masonry Some open joints in grouted stone emergency spillway. _____ .

Evidence of Seepage None seen _____ .

Evidence of Piping None seen _____ .

Leaks None seen _____ .

Erosion None _____ .

Trash and/or Debris Impeding Flow None _____ .

Clogged or Blocked Spillway _____ .

Other _____ .

12.

OVERALL CONDITION:

1. Safe X
2. Minor repairs needed _____.
3. Conditionally safe - major repairs needed _____.
4. Unsafe _____.
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list _____.

13.

REMARKS AND RECOMMENDATIONS: (Fully Explain)

This is a distributing reservoir of the I.D.C. built at the same time as the Chicopee Aqueduct and serves South Hadley and Chicopee. It is a open reservoir formed by earth embankment located on Nash Hill.

The entire installation is well maintained. The Maintenance Foreman responsible for the reservoir accompanied us on the inspection and we were able to enter the gatehouse and view the valve-operating mechanism which is maintained in excellent condition. Because of possible vandalism the gatehouse is equipped with secure shutters and illuminated at night by flood lights.

The embankments are generally in good condition with well established turf, well mowed, over most of the top and downstream slopes. On the southeasterly slope in many areas the grass has almost disappeared and some extra care is probably needed to reestablish the turf here. Quite a few woodchuck holes were noted but all had been filled with tamped earth by the maintenance force. The riprap surface of the upstream slopes is in excellent condition.

The grouted stone paving of the emergency overflow spillway has several open joints on the upstream end where frost action or earth movement has cracked the grouted stone paving. This should be repaired before it progresses further.

RCS/js/rt

DESCRIPTION OF DAM

DISTRICT 2.Submitted by R. C. Salls, P.E. Dam No. 2-7-161-11Date April 1, 1974 ~~City~~/Town LudlowName of Dam Nash Hill Reservoir

1. Location: Topo Sheet No. 15A Mass. Rect. Coordinates N 437,000 E 331,800
Provide $8\frac{1}{2}$ " x 11" in clear copy of topo map with location of Dam clearly indicated.
On Nash Hill south of Nash Street about 2500 feet easterly from West Street or 1500 feet westerly from Fuller Street.
2. Year built 1950[†] Year/s of subsequent repairs UNK.
3. Purpose of Dam: Water Supply X Recreational _____
Flood Control _____ Irrigation _____ Other _____
Distribution Reservoir _____
4. Drainage Area: N/A sq. mi. _____ acres.
Type: City, Bus. & Ind. _____ Dense Res. _____ Suburban _____ Rural, Farm
Wood & Scrub Land _____ Slope: Steep _____ Med. _____ Slight _____
All inflow through aqueduct from Quabbin
5. Normal Ponding Area: 4 Acres; Ave. Depth 20'
Impoundment: 26 Million gals.; 80 acre ft.
Silted in: Yes _____ No X Approx. Amount Storage Area _____
6. No. and type of dwellings located adjacent to pond or reservoir _____
i.e. summer homes etc. No houses
7. Dimensions of Dam: Length 1400'± * Max. Height 25.5
Freeboard 5.5 From flow link to top
Slopes: Upstream Face 2 1/6 to 1
Downstream Face 2:to 1
Width across top 12' wide top sloping 1' in 12' Toward
* Sum of lengths of four side of Reservoir. downstream slope.

8. Classification of Dam by Material:

Earth X Conc. Masonry _____ Stone Masonry _____
Timber _____ Rockfill _____ Other _____

8A. Dam Type: Gravity X Straight _____ Curved, Arched _____ Other Embankment
Overflow _____ Non-overflow X
Encloses Reservoir _____

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

100 % rural; _____ % urban

B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of a complete dam failure? Yes X No _____

C. Character Downstream Valley: Narrow _____ Wide X Developed _____
Rural X Urban _____

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

No. of people 12⁺

No. of homes 12⁺

No. of businesses None

No. of industries None Type _____

No. of utilities 6 Type Jet Lines oil pipe line plus water, gas, electric & telephone distribution line

Railroads None

Other dams None

Other This is a holding reservoir on a hill top.

11. Attach Sketch of dam to this form showing section and plan on 8 1/2" x 11" sheet.

RCS/vk/rt
Attachments
Locus Plan
Sketches

APPENDIX C

PHOTOGRAPHS

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

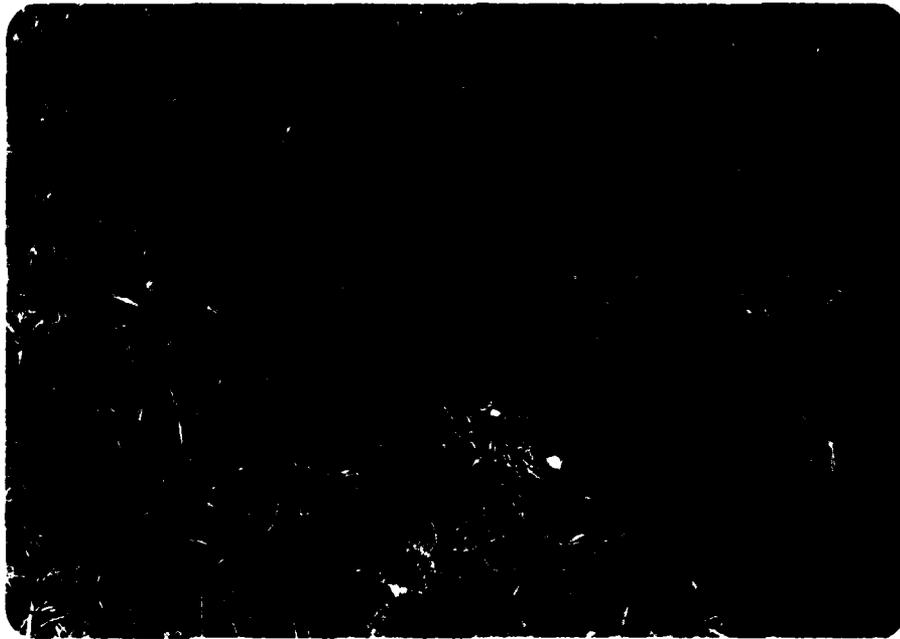
NASH HILL RESERVOIR



**NO. 1 ACCESS ROAD AND DOWNSTREAM SLOPE OF
EMBANKMENT ON NORTH SIDE OF RESERVOIR**



**NO. 2 TOP AND DOWNSTREAM SLOPE OF EMBANKMENT
ON SOUTHEAST SIDE OF RESERVOIR**



**NO. 3 TYPICAL ANIMAL BURROW ON DOWNSTREAM
SLOPE OF EMBANKMENT**



**NO. 4 TOP OF EMBANKMENT AND CREST OF EMERGENCY
SPILLWAY ON SOUTH SIDE OF RESERVOIR**



NO. 5 REPAIRED AND CRACKED MORTAR ON CREST OF EMERGENCY SPILLWAY



NO. 6 DISCHARGE CHANNEL BELOW EMERGENCY SPILLWAY



**NO. 7 GATEHOUSE AND UPSTREAM SLOPE OF
EMBANKMENT ON EAST SIDE OF RESERVOIR**



**NO. 8 SETTLEMENT IN RETAINING WALL ADJACENT TO
GATEHOUSE**

APPENDIX D
HYDROLOGIC AND HYDRAULIC
COMPUTATIONS

	<u>Page</u>
Hydrologic and Hydraulic Computations	D-1

NASH HILL RESERVOIR

I Test Flood; Reservoir Conditions; & Storage Function

1- Size Test Flood

Res. Size - Small ; Hazard Class - High

Use Test Flood = Full PMF

2- Reservoir Conditions

The test flood will be applied to the reservoir under the following coincident conditions:

Condition
Used in
Report

a - Reservoir full to crest of overflow spillway. No net flow in/out other than test flood inflow

b - Max. inflow from Quabbin. No service pipe out flow. Initial res. level set by disch. from Quabbin to overflow spillway.

c - Reservoir full to crest of emergency spillway. No net flow in/out other than test flood.

Also, as a test of the emergency spillway, the following will be investigated without any test flood:

d - Reservoir at crest of emergency spillway, max. inflow from Quabbin and no outflow via service pipe or overflow spillway.

3 - Storage Functions

From C. of E. guidelines: "Est. Effect of Surch. Storage on Max. Prob. Discharges": $Q_{out} = Q_{in} (1 - \frac{S}{R})$

S = Storage in terms of inches of rain on drainage area

R = Total inches of rain in test rain fall = 19"

$Q_{in} = 74.6$ cfs, max. inflow rate - See II

$Q_{out} = 74.6 - 3.93 S$; 'S' to be evaluated from storage

② Maximum Inflow

Quabbin - Nash Hill supply line consists of 24000' of 48" ϕ pipe, followed by 45000' of 36" ϕ pipe.

Use $C = 140$ & ignore minor losses.

$$12.56 V_4 = 7.07 V_3 \quad ; \quad V_3 = 1.7765 V_4$$

$$V_4 = 140(1)(1.3183) \left(\frac{h_{L4}}{24000} \right)^{0.54} \quad ; \quad h_{L4} = 1.5264 V_4^{1.852}$$

$$V_3 = 140(0.83423)(1.3183) \left(\frac{h_{L3}}{45000} \right)^{0.54} \quad ; \quad h_{L3} = 4.003 V_3^{1.852} = 11.6 V_4^{1.852}$$

$$H = h_{L4} + h_{L3} = 13.129 V_4^{1.852} = 0.121 Q^{1.852}$$

$$\text{or } Q = 3.127 H^{0.54}$$

Quabbin - max el. 524.35 (NGVD)

Nash Hill Full - el. 419.6 (NGVD) then $H = 104.75$; $Q = 38.5 \text{ cfs}$

Nash Hill @ Emer. Spill. - el. 424.2 (NGVD) " $H = 100.15$; $Q = 37.6 \text{ cfs}$

Nash Hill @ el. 424.6 (NGVD) " $H = 99.75$; $Q = 37.5 \text{ cfs}$

③ Crest Flow

The test flood under reservoir condition "C" results in a 0.2 ft. depth above the low point on the crest as shown on ④.

The unit flow at that point is:

$$q = 2.55 (0.2)^{1.5} = 0.23 \text{ cfs/ft}$$

As critical flow:

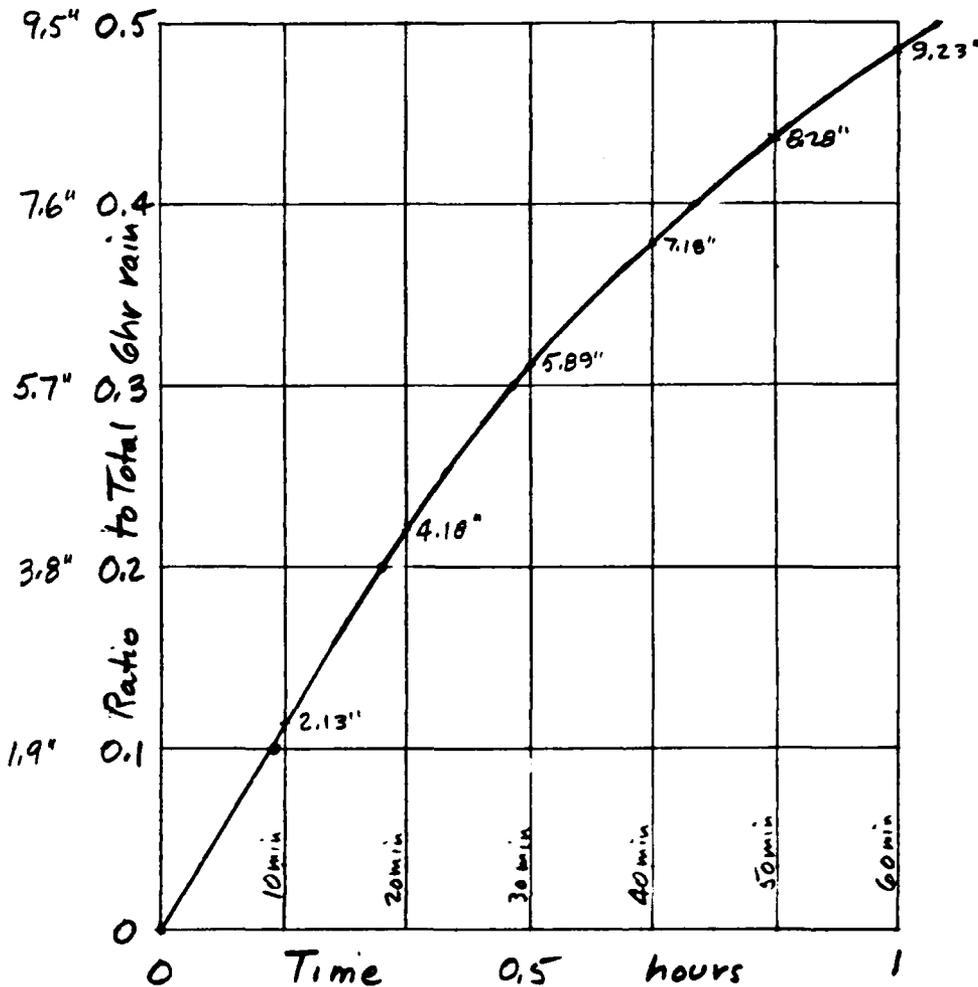
$$y_c = 0.12 \text{ ft} \quad ; \quad V_c = 1.9 \text{ fps.}$$

IV

Peak Hour Rainfall

Taken from USBR "Des. of Sm. Dams" Second Ed., Fig 18

Inches of rainfall based on P.M.P. rain of 1.9"
 Assume rain directly converts to runoff with no losses & $E \approx 0$



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10min period	Incr. rain	cfs. for 5.79 acres	Incr. Vol.
1 st	2.13"	74.6	1.03 ac. ft
2 nd	2.05"	71.8	0.99 " "
3 rd	1.71 "	59.9	0.82 " "
4 th	1.29 "	45.2	0.62 " "
5 th	1.10 "	38.5	0.53 " "
6 th	0.95 "	33.3	0.46 " "
Total	9.40 in		4.45 " "

Max Inflow Rate (10min period) = 74.6 cfs.

(V) Drainage Area

All of dam crest (width ± 12') will be included - much may slope away from res.

Tributary Rain Area - el. 424.35 ± (NGVD)

$$A = 110,122 + 1501[65+12] + \pi(77)^2$$

$$A = 252326 \text{ ft}^2 = 5.79 \text{ acres}$$

(VI) Storage Function Values of Test Flood (Elevs are NGVD)

1 - Res. Condition "a" $\left[S = \frac{\text{Net Storage (12)}}{5.79} \right]$

Res El.	Net Storage	"S"	Q _{out}
419.6	0	0	74.6
420.0	1.9	3.9	59.1
420.5	4.4	9.1	38.9
421.0	6.7	13.9	20.0

2 - Res. Condition "b"

Res. El.	Net Storage	"S"	T.F. Q _{out}	* Total Q _{out}
420.34	0	0	74.6	113.1
421.50	5.8	12.0	27.5	66.0
422.00	8.3	17.2	7.1	45.6
422.20	9.3	19.3	(-1.2)	37.3

* Incl. Quabbin inflow of ± 38.5 cfs.

3 - Res. Condition "c"

Res El.	Net Storage	"S"	Q _{out}
424.2	0	0	74.6
424.4	1.1	2.3	65.6
424.6	2.1	4.4	57.5
424.8	3.2	6.6	48.5
425.0	4.2	8.7	40.4

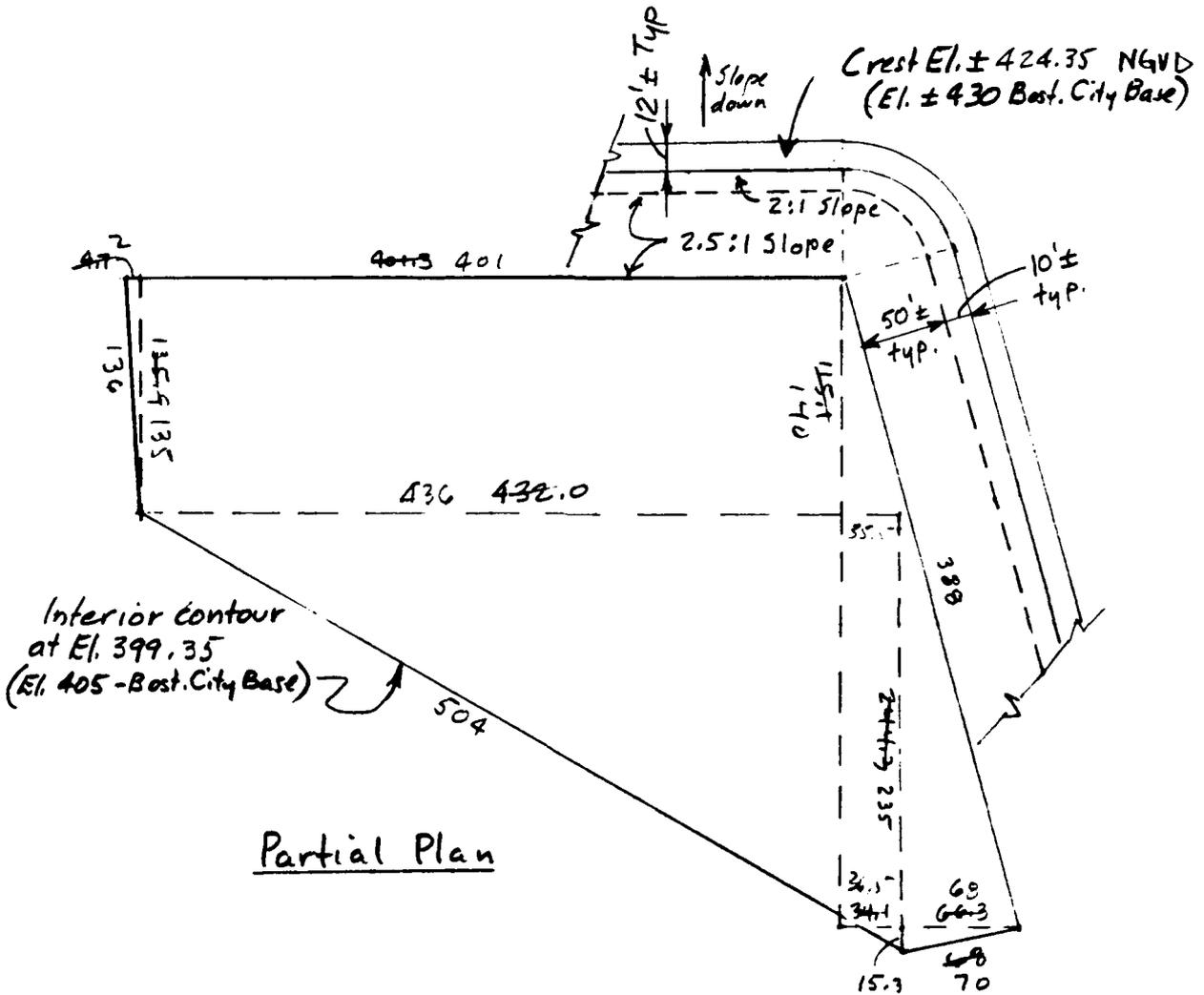
NONREPRODUCIBLE GRID FORM 145

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Storage Volume

1- Area of bottom of Reservoir



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Partial Plan

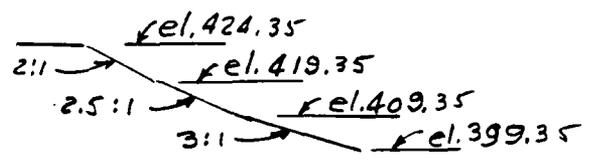
Area @ el. 339.35 (NGVD)

$$\begin{aligned}
 & 137.5(400.75) + \frac{1}{2} 2(135) + 375(104.5) \frac{1}{2} + 436(235) \frac{1}{2} + 15.3(68) \frac{1}{2} - 36(235) = \\
 & = 55103 + 135 + 19594 + 51230 + 520 - 8460 = \\
 & = 118,122 \text{ ft}^2 = 2.712 \text{ acres}
 \end{aligned}$$

Below el. 399.35, bottom slopes down ±2' to 20" φ Drain
 However, 3' φ inlet/outlet has invert at el. 399.35,
 so all storage below that level is dead storage.

VIII Storage Volume - Cont.

2 - Area at Critical Elevations



Nominal Interior Slopes

Area el. 409.35
 $A_2 = 118,122 + 1501(30) + \pi(30)^2 = 165,979 \text{ ft}^3 = 3.8104 \text{ acres}$

Area el. 419.35
 $A_3 = 118,122 + 1501(55) + \pi(55)^2 = 210,180 \text{ ft}^3 = 4.8251 \text{ acres}$

Area el. 424.35
 $A_4 = 118,122 + 1501(65) + \pi(65)^2 = 228,960 \text{ ft}^2 = 5.2562 \text{ acres}$

3 - Volume at Critical Elevations (above el. 399.35)

Elev.	Area	Depth	$\Delta \text{Vol.}$	$\Sigma \Delta \text{Vol. (acft.)}$
399.35	2.7117 ac.			0
		10'	32.61	
409.35	3.8104 "			32.61
		10'	43.18	
419.35	4.8251 "			75.79
		5'	25.20	
424.35	5.2562 "			100.99

4 - Volume below El. 399.35

Bottom slopes from el. 399.35 down to el. 397.35 at 20" ϕ drain.

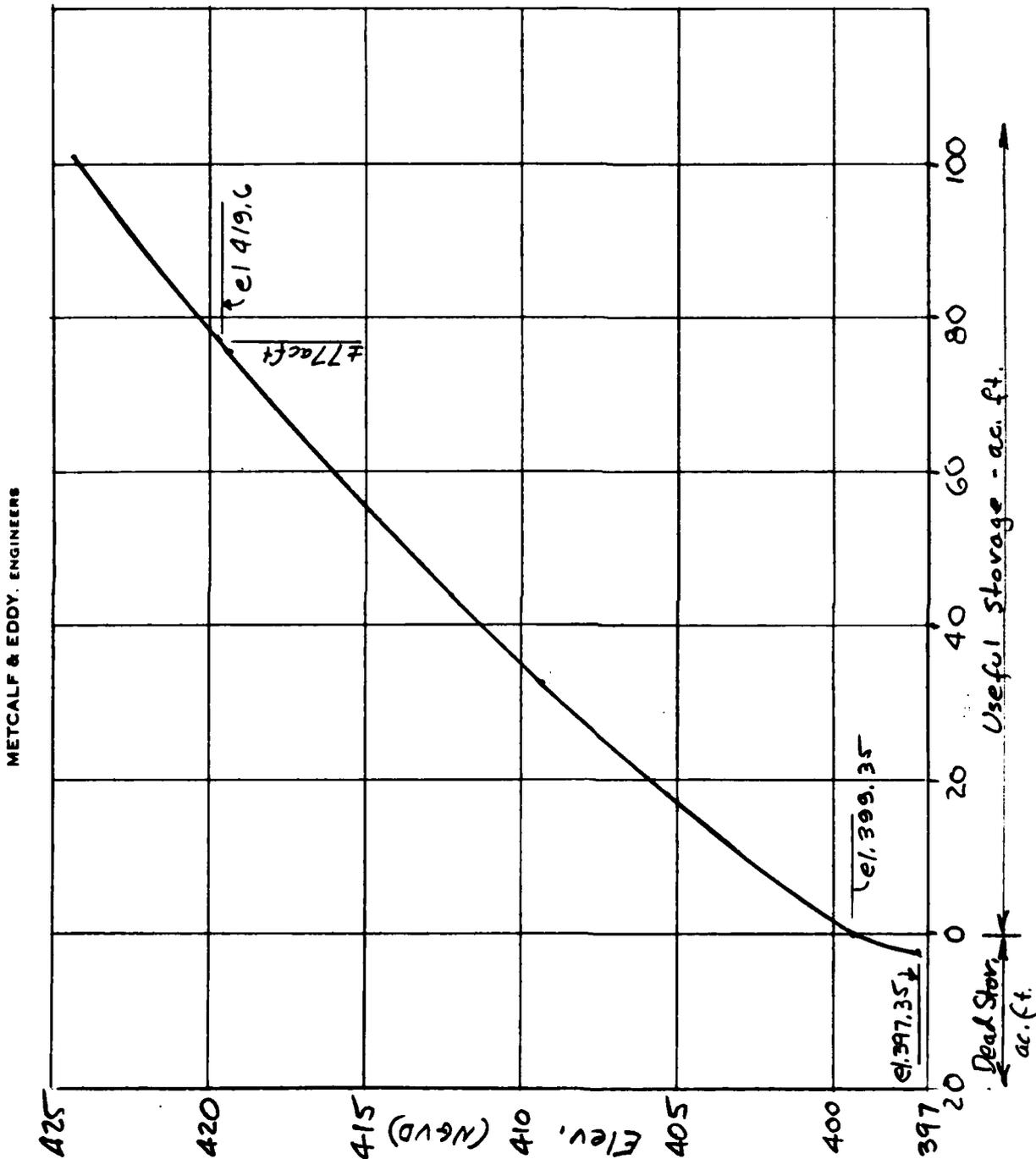
$$V_0 \approx \frac{1}{2} \left[\left(\frac{403+436}{2} \right) 135 + \left(\frac{436+348}{2} \right) 60 \right] + \frac{1}{2} \left(\frac{348+70}{2} \right) 190$$

$$V_0 \approx 40076 + 59565 = 99641 \text{ ft}^3 = 2.29 \text{ ac. ft.}$$

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Ⓐ Storage Volume - Cont.



(X) Detailed Storage Volume

1- Areas above el. 419.35

$E1.419.6 - A = 118122 + 1501(55.5) + \pi(55.5)^2 = 211,104 \text{ ft}^2 = 4.8463 \text{ ac.}$

$E1.420.35 - A = 118122 + 1501(57) + \pi(57)^2 = 213,886 \text{ ft}^2 = 4.9101 \text{ ac.}$

$E1.422.35 - A = 118122 + 1501(61) + \pi(61)^2 = 221,372 \text{ ft}^2 = 5.0820 \text{ "}$

$E1.423.35 - A = 118122 + 1501(63) + \pi(63)^2 = 225,154 \text{ ft}^2 = 5.1688 \text{ "}$

$E1.423.85 - A = 118122 + 1501(64) + \pi(64)^2 = 227,054 \text{ ft}^2 = 5.2124 \text{ "}$

$E1.424.85 - A = 118122 + 1501(66) + \pi(66)^2 = 230,873 \text{ ft}^2 = 5.3001 \text{ "}$

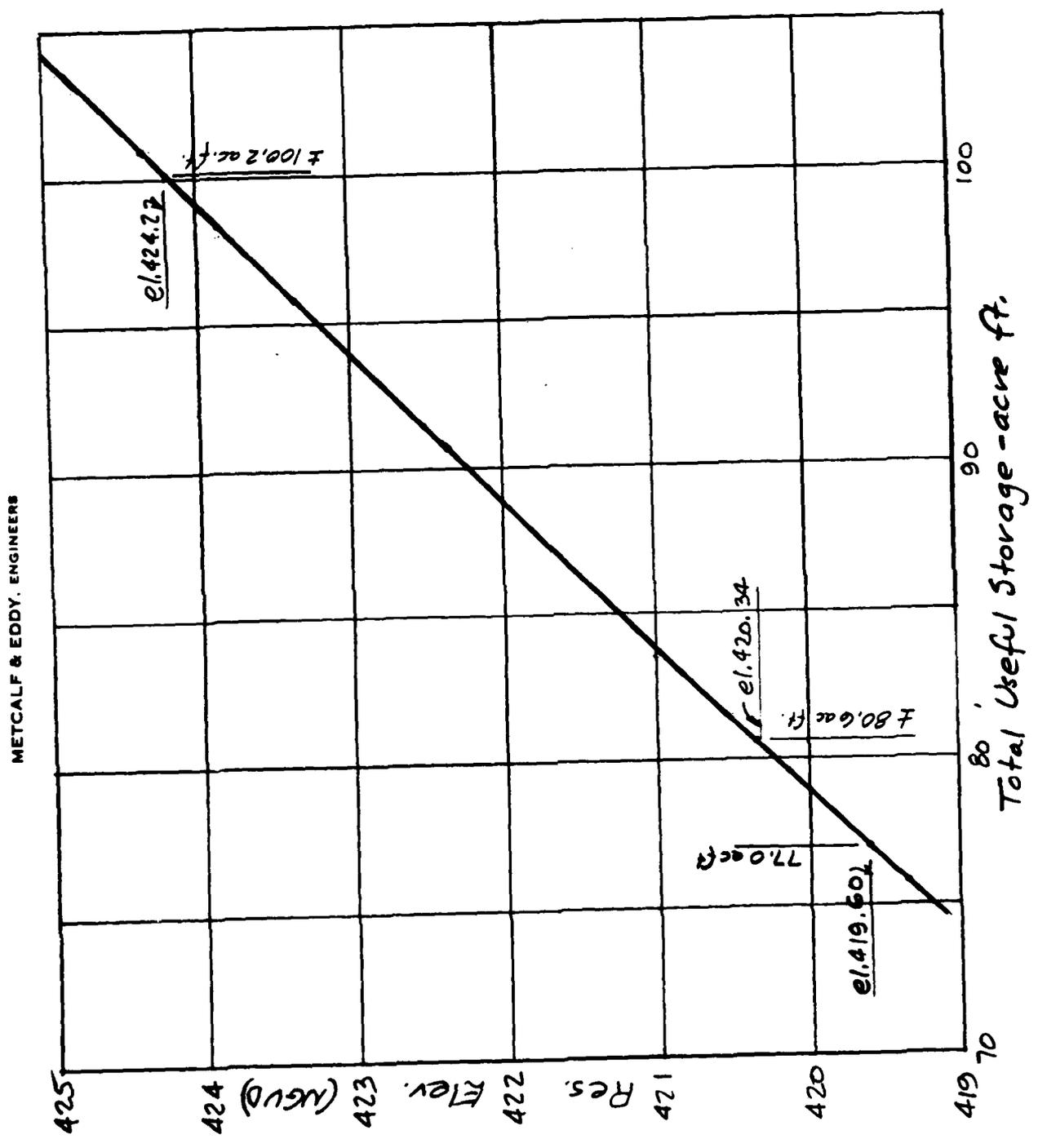
2- Volume above el. 419.35

Elev.	Area	Depth	Δ Vol.	Σ Vol.
419.35	4.8251 ac.			75.79 ac.ft.
419.60	4.8463 "	0.25'	1.21	77.00
420.35	4.9101 "	0.75'	3.66	80.66
422.35	5.0820 "	2.00'	9.99	90.65
423.35	5.1688 "	1.00'	5.12	95.77
423.85	5.2124 "	0.50'	2.60	98.37
424.35	5.2562 "	0.50'	2.62	100.99
424.85	5.3001 "	0.50'	2.64	103.63

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(XI) Detailed Storage Volume - Cont.



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(XII) Discharge Relations

1- Overflow Spillway (inside gate house)

$L = 18 \pm$, Crest el. 419.6 (NGVD)

$Q_1 = 3.33(18) H_1^{1.5} = 59.94 H_1^{1.5}$ or $H_1 = 0.06529 Q_1^{2/3}$

Q_1	20	38.5	40	60	80	100	120
H_1	0.48	0.74	0.76	1.00	1.21	1.41	1.59
Water El.	420.08	420.34	420.36	420.60	420.81	421.01	421.19

2- 20" ϕ Drain to Brook

* $L = 2800 \pm$; ϕ outlet el. ± 228 (NGVD); no valves, etc.; $A = 2.18 \text{ ft}^2$

* Based on oral information & U.S.G.S. Topo Map

$H_2 = \frac{V^2}{2g} \left[0.5 + 1.0 \frac{h_f}{h_c} + 0.17 \frac{2800}{1.67} \right] = 30 \frac{V^2}{2g}$

$V_2 = 1.465 \sqrt{H_2}$; $Q_2 = 3.19 \sqrt{H_2}$

H_2	50	100	150	180	190	192	194	195	196.5
Water Elev.	278	328	378	408	418	420	422	423	424.5
Q_2	22	32	39	43	44	44	44	44.5	44.7

3- Emergency Spillway

"Sharp" crest @ el 424.2 ; Width = $\pm 20'$, $Q_3 = 3.0(20) H_3^{1.5}$

Water Elev.	424.3	424.4	424.5	424.6	424.7	424.8
H_3	0.1	0.2	0.3	0.4	0.5	0.6
Q_3	2	5	10	15	21	28

4- Crest Flow

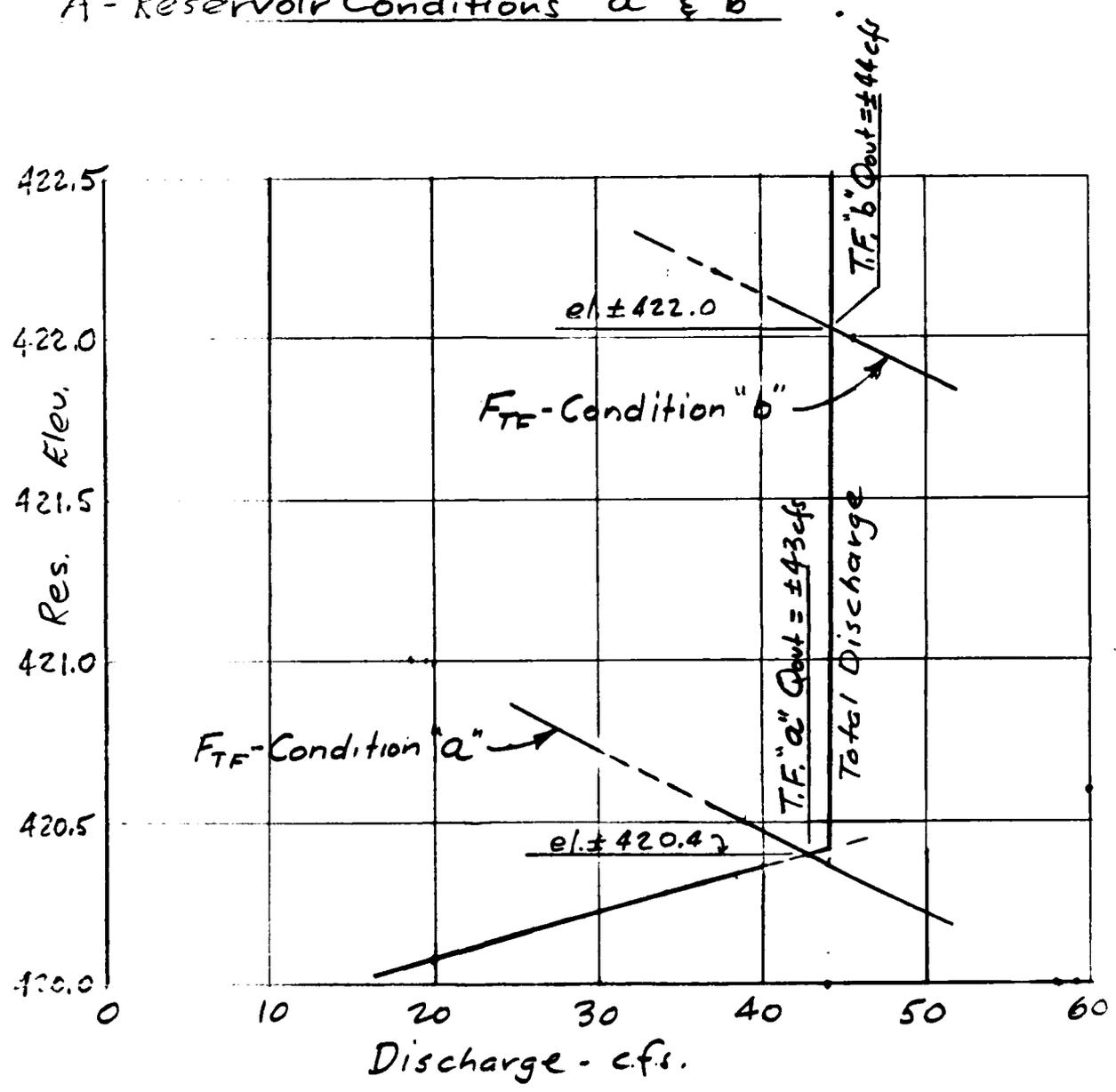
Lowest elev. : $\pm 100'$ @ 424.5 ; $\pm 130'$ @ 424.6 ; $\pm 220'$ @ 424.7 ; Use $g = 2.55 H_4^{1.5}$
 $\pm 110'$ @ 424.8

Water Elev.	424.6	424.7	424.8	424.9
Q_A	8	23	42	64
Q_B	—	10	30	54
Q_C	—	—	18	50
Q_D	—	—	—	9
ΣQ_4	8	33	90	177

(XIII) Discharge & Storage Function vs Res. Elev.

A - Reservoir Conditions "a" & "b"

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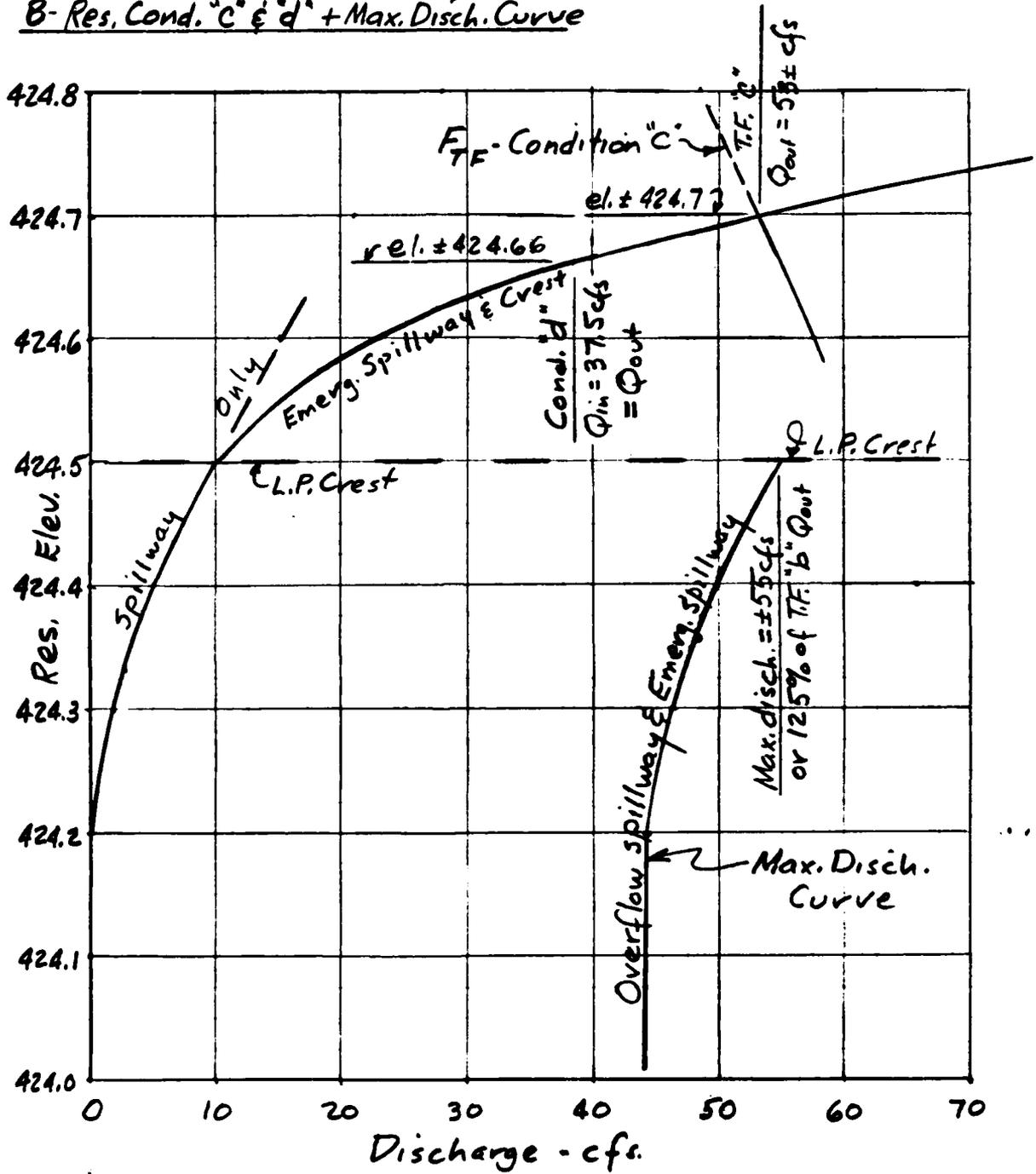


THE LOWER RESERVOIR ONE FOOT FROM EL. 419.60

at 419.60 77 ac-ft
 418.60 66 ac-ft

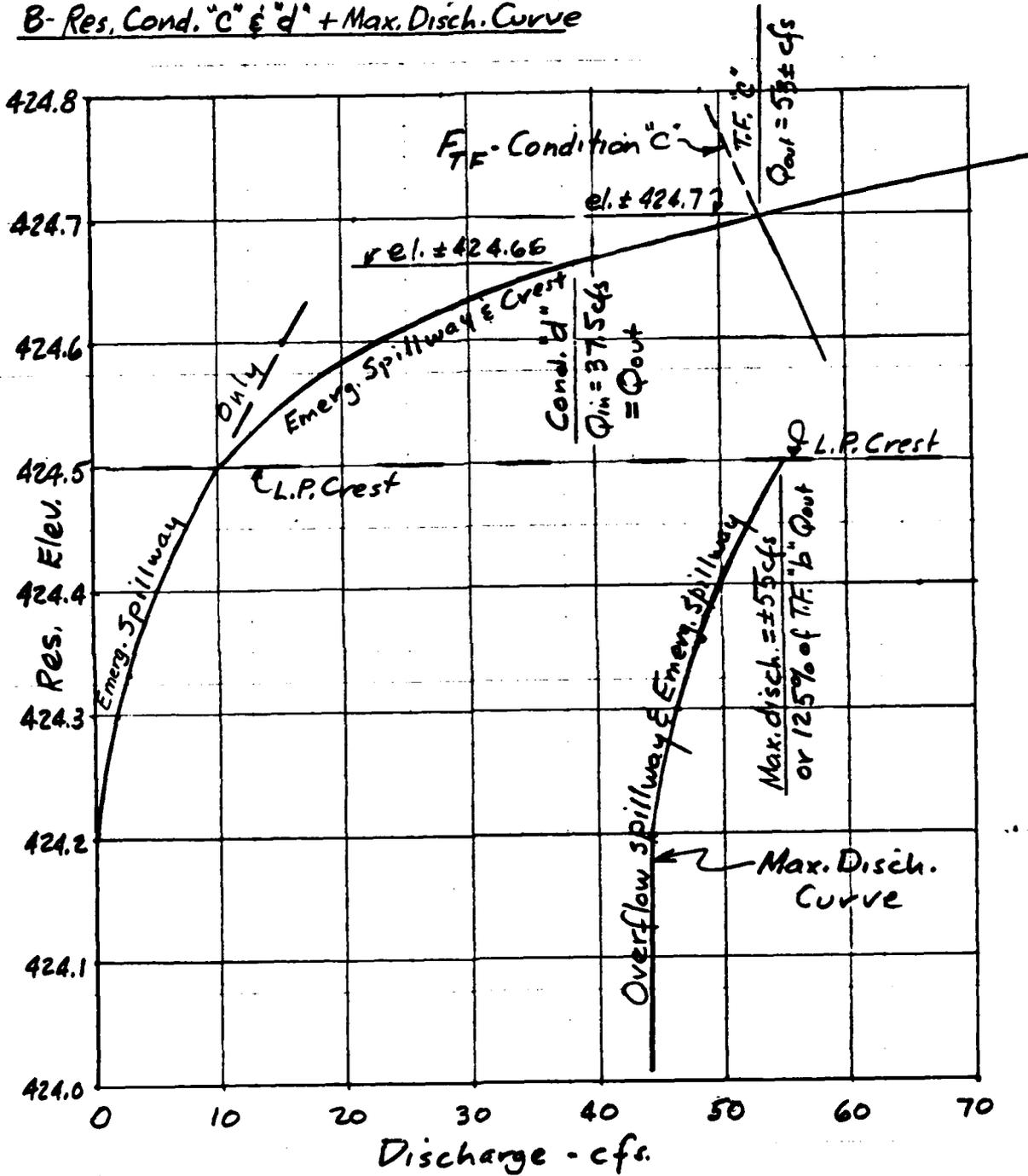
$$\frac{11 \text{ ac-ft (43560)}}{44 \text{ cfs (3600)}} = 3.03 \text{ hrs}$$

(XIV) Discharge & Storage Function vs Res. Elev. - Cont.
B- Res. Cond. "c" & "d" + Max. Disch. Curve



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(XIV) Discharge & Storage Function vs Res. Elev. - Cont.
B- Res. Cond. "c" & "d" + Max. Disch. Curve



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(XV)

Failure of Dam - Southeast or West Sides

Peak Failure Flow:

Pond Elevation - 422.00
 Toe Elevation - 397.35
 $Y_0 = 24.65$

Dam Length Subject to Breaching = $3 \times 24.65 \approx 74'$



$Q_p = 1.68 W_0 (Y_0)^{1.5} = 1.68 (74) (24.65)^{1.5} \approx 15,200 \text{ cfs}$

Continuing Spill. Disch.: —
 Peak Failure Flow: 15,200 cfs

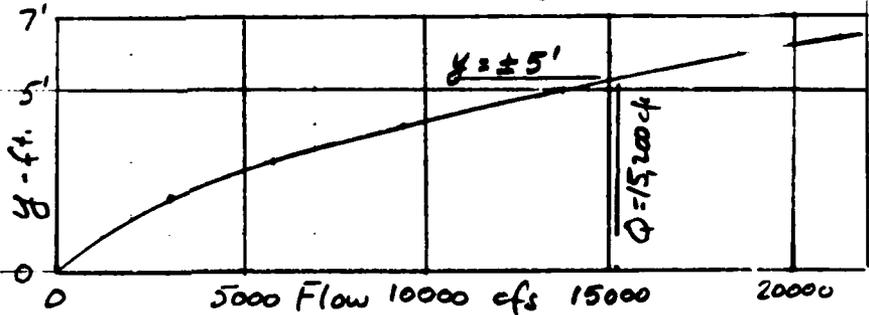
Storage Volume Released:

Storage Above ~~spillway~~ el. 399.35 : 101.5 ac ft
 Storage Below ~~spillway~~ el. 399.35 : 2.3 " "
 Total Storage 99.2 ac ft

Channel Hydraulics: (Southeasterly slope - no channel)

Assume flow width = 2 (breach width) = 164'
 $S = \frac{150}{1600}$; $n = .08$; $A = 164 y$; $R \approx y$; $V = 5.7 y^{2/3}$

y	V	Q
2	9.05	3000
4	14.36	9400
6	18.82	18500
6.5	19.85	21200



As overland, no channel, flow depth is $\pm 5'$ at a width equal to twice the breach width. This would vary as the flow spread, or concentrated in some undefined gully, etc.

NONREPRODUCIBLE GRID FORM 143

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(XVII) Failure of Dam - North Side (beyond access road)

Peak Failure Flow:

Pond Elevation - 422.00 T.F. max el.
 Toe Elevation - 405.35 L.P. ± Ground north side
 $Y_0 = 16.65$

Dam Length Subject to Breaching = $3 \times 16.65 \approx 50'$

$W_0 = 40\% \times Y = 7$

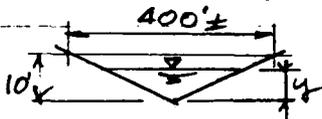
$Q_P = 1.68 W_0 (Y_0)^{1.5} = 1.68 (50) (16.65)^{1.5} \approx 5700 \text{ cfs}$

Continuing Spill. Disch.: —
 Peak Failure Flow: 5700 cfs

Storage Volume Released:

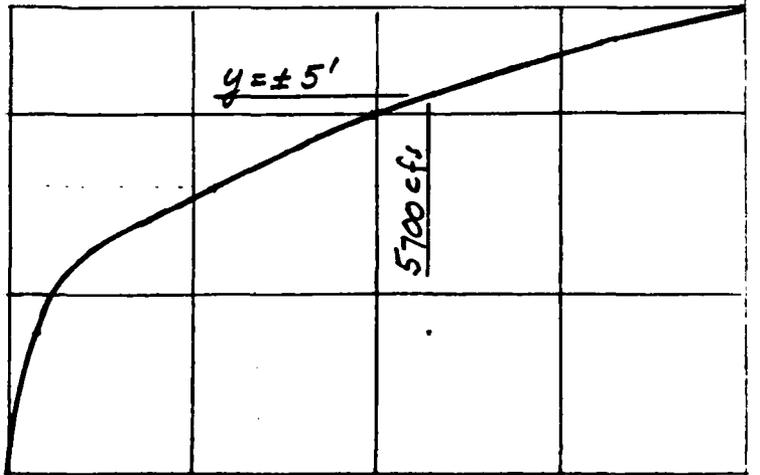
Storage Above Spillway at el. 424.5: 101.8 ac ft
 Storage Below Spillway at el. 405.35: 18.0 " "
 Total Storage Released: 83.8 " "

Channel Hydraulics: (for Northerly gully)



$S \approx \frac{50}{600}$; $n = 0.08$, $R \approx K_y$, $A = 20y^2$, $V = 3,387 y^{2/3}$

Depth (y)	Area (A)	Velocity (V)	Flow (Q)
2.0	80	5.38	430
5	500	9.90	4950
10	2000	15.72	31440
7	980	12.39	12150
6	720	11.18	8050
6.5	845	11.80	9970
4	320	8.53	2730
1	20	3.39	70



Flow $\approx \frac{2}{3} (16.65) \approx 11'$ deep across Nash Hill Rd @ $\frac{5700}{50(11)} \approx 10 \text{ fps}$

Flow approaches Fuller Road with max. depth of $\pm 5'$ at $\pm 10 \text{ fps}$

APPENDIX E
INFORMATION AS CONTAINED IN THE
NATIONAL INVENTORY OF DAMS

NASH HILL RESERVOIR

NOT AVAILABLE AT THIS TIME

END

FILMED

7-85

DTIC