

AD-A057 294

GILBERT ASSOCIATES INC READING PA

F/G 13/2

NATIONAL DAM SAFETY PROGRAM. GREEN SWAMP NUMBER 1 (NJ-00209), P--ETC(U)

JUL 78 R J WAHANK

DACW61-78-C-0114

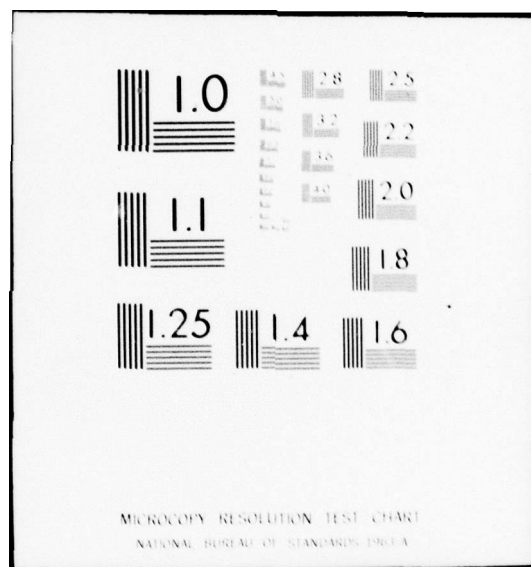
UNCLASSIFIED

NL

| of |

AD
A057 294





AD A057294

LEVEL II



PASSAIC RIVER BASIN

POST BROOK, PASSAIC COUNTY

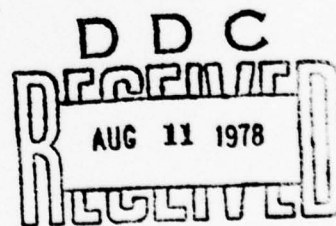
NEW JERSEY

GREEN SWAMP NO. I

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Approved for public release;
distribution unlimited

NJ 00209



DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106
JULY 1978

AU NO.
DDC FILE COPY

78 08 10 008

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NJ00209	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Green Swamp no. 1 Passaic County, N.J.		5. TYPE OF REPORT & PERIOD COVERED (9) FINAL rept.
7. AUTHOR(s) (10) Rudolph J. Wahank		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Gilbert Associates, Inc. P.O. Box 1489 Reading, Pa. 19603		8. CONTRACT OR GRANT NUMBER(s) (15) DACW61-78-C-0114
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, Pennsylvania 19106		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
12. REPORT DATE (11) Jul 1978		13. NUMBER OF PAGES 56 (12) 61 p
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (6) National Dam Safety Program. Green Swamp Number 1 (NJ-00209), Passaic River Basin, Post Brook, Passaic County, New Jersey. Phase I Inspection Report.		15. SECURITY CLASS. (of this report) Unclassified
16. DIS Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams--N.J. National Dam Safety Program Phase I Green Swamp No 1 Dam, N.J.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

DD FORM 1 JAN 73 1473

EDITION OF 1 NOV 65 IS OBSOLETE

154 850 78 08 10 008 JB
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)



DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Green Swamp No. 1, in Passaic County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on usual observation, available records, calculations and past operational performance, Green Swamp No. 1 Dam is judged to be in good condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

- a. While the Probable Maximum Flood (PMF) should not overtop the dam, the PMF and $\frac{1}{2}$ PMF will raise the reservoir level above the dam's impervious zone and concrete corewall. Therefore, engineering studies should be initiated and completed, within nine months from the date of approval of this report, to determine the effects of these flood waters upon the dam's pervious section. Any remedial measures deemed necessary as a result of these studies should be initiated within calendar year 1979.
- b. The settled upstream rip-rap slope area and the two settled upstream crest areas should be checked periodically for any possible further settlement.
- c. The tree clearing program, on the downstream embankment, currently in progress, should be continued and completed within calendar year 1979. As soon as the slopes are cleared, they should be dressed and seeded with selected grass to prevent erosion.

NAPEN-D

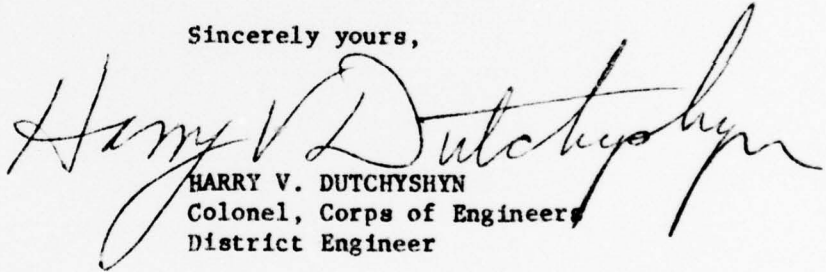
Honorable Brendan T. Byrne

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman William H. Roe of the Eighth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,



HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

LEVEL II



PHASE I REPORT NATIONAL DAM SAFETY PROGRAM

ASSESSMENTS OF GENERAL CONDITIONS

Name of Dam: Green Swamp No. 1
State: New Jersey
County: Passaic
U.S.G.S. Quad Sheet: Wanague, N.J.
Coordinates: N 41° 02' 29" E 74° 19' 23"
Stream: None (Off the Wanague River)
Date of Inspection: May 23, 1978

The dam is in good condition as defined in Appendix H. [No items requiring drastic and immediate action were observed.]

It is recommended that:

1. The effects of the PMF and 1/2 PMF on the Wanague Reservoir, which will raise the water level above the elevation of both the impervious zone and the concrete corewall of the dam, be studied in the near future.
2. The tree clearing program be continued and completed in the future; re-dressing and seeding with grass of the downstream slope to follow subsequently.
3. The settled riprap slope area and the settled crest areas be checked periodically for further settlement.



APPROVED BY	
WTS	WTS Section ☒
DN	DN Section ☐
WTS/DP	WTS/DP Section ☐
BY	
RECOMMENDATION/AVAILABILITY CODES	
SIG.	AVAIL. and/or SPECIAL
A	

Based on usual observation, available records, calculations and past operational performance, Green Swamp No. 1 Dam is judged to be in good condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. While the Probable Maximum Flood (PMF) should not overtop the dam, the PMF and $\frac{1}{2}$ PMF will raise the reservoir level above the dam's impervious zone and concrete corewall. Therefore, engineering studies should be initiated and completed, within nine months from the date of approval of this report, to determine the effects of these flood waters upon the dam's pervious section. Any remedial measures deemed necessary as a result of these studies should be initiated within calendar year 1979.

b. The settled upstream rip-rap slope area and the two settled upstream crest areas should be checked periodically for any possible further settlement.

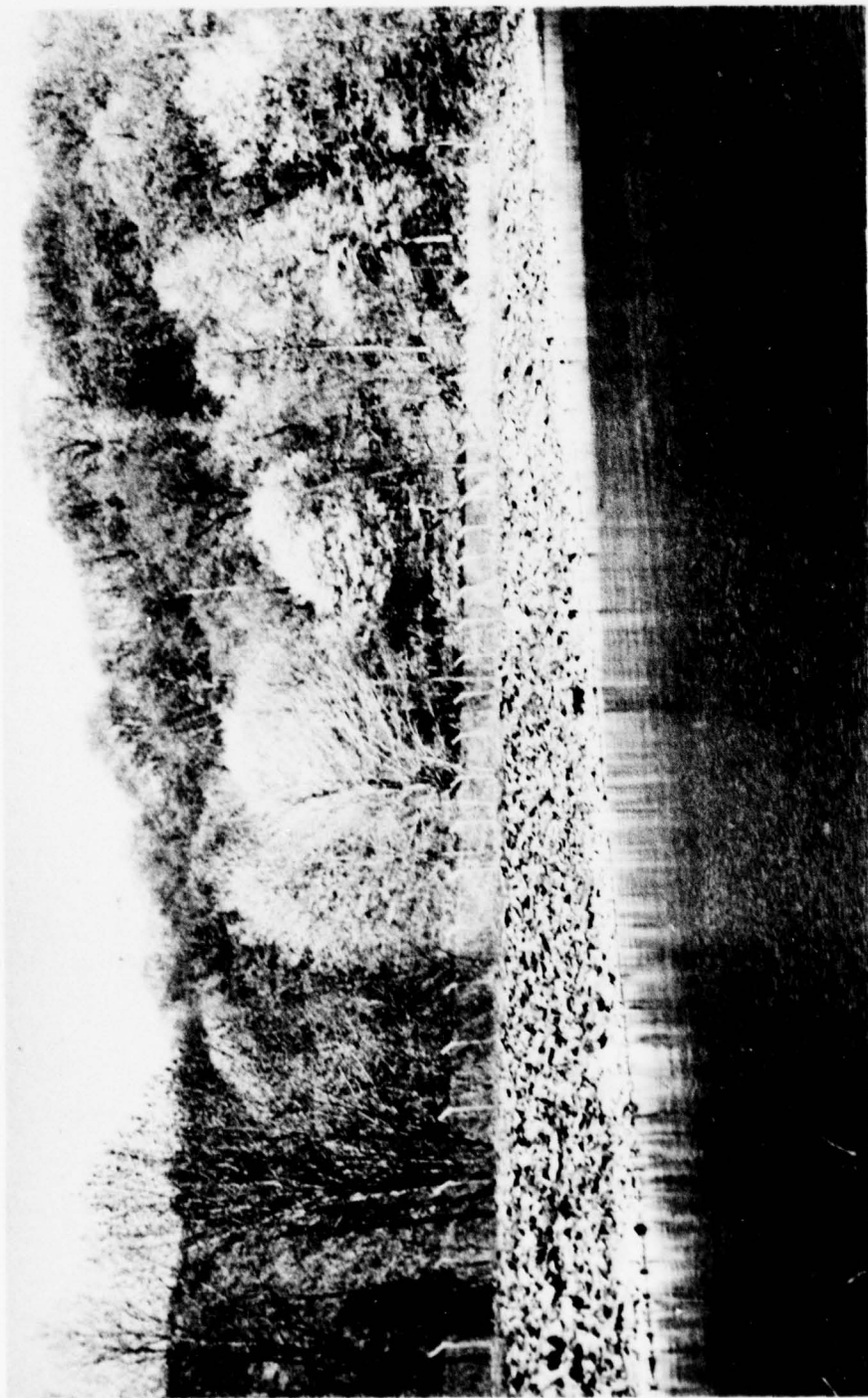
c. The tree clearing program, on the downstream embankment, currently in progress, should be continued and completed within calendar year 1979. As soon as the slopes are cleared, they should be dressed and seeded with selected grass to prevent erosion.

APPROVED:

Harry V. Dutchyshyn
HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE:

3 Aug 78



June 1978

OVERVIEW - GREEN SWAMP NO. 1

TABLE OF CONTENTS

	<u>PAGE</u>
PHASE I INSPECTION REPORT	
Section 1.0 Project Information	1
Section 2.0 Engineering Data	4
Section 3.0 Visual Inspection	5
Section 4.0 Operational Procedures	7
Section 5.0 Hydraulic/Hydrologic Design	8
Section 6.0 Dam Stability	9
Section 7.0 Assessment/Remedial Measures	10
Location Map	Fig. 1
Plan, Profile, and Section	Fig. 2
APPENDIX A - Visual Checklist	
APPENDIX B - Engineering Data Checklists	
APPENDIX C - Photographs	
APPENDIX D - Reservoir Hydrology and Drawdown	
APPENDIX E - Previous Inspection Reports	
APPENDIX F - Regional Geologic Map	
APPENDIX G - References	
APPENDIX H - Conditions	

1.0 PROJECT INFORMATION

1.1 GENERAL

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers to initiate a national program of safety inspections of non-federal dams in the United States. Gilbert Associates, Inc. has entered into a contract, No. DACW61-78-C-0114, with the Philadelphia Office of the U.S. Corps of Engineers to inspect this dam, Gilbert Work Order 06-7249-050.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the U.S. Corps of Engineers' Recommended Guideline for Safety Inspection of Dams (Reference 1), and contract requirements between Gilbert Associates, Inc. and the Corps of Engineers. The objective includes expeditiously identifying those dams which pose an immediate threat to human life or property and to recommend future studies and/or any obvious remedial actions indicated by the inspection.

1.2 PROJECT DESCRIPTION

1.2.1 Dam and Appurtenances: According to the drawings, the Greenswamp Dam #1 is a 30-foot high, 640-foot long earthfill dam with a concrete corewall extending down to a maximum final rock depth of 62 feet below the top of dam. An impervious zone located on the upstream side next to the corewall extends down to bedrock. The foundation rocks for the concrete corewall were grouted. The upstream face of the embankment has been heavily lined with riprap.

1.2.2 Location: The dam is located about 1.5 miles northwest of Haskell, N.J. and about 2.0 miles north of Bloomingdale, N.J. This dam lies on the southwest rim of the Wanaque Reservoir, at a distance of about 2.0 miles east of Raymond Dam. (See Figure 1)

Geologically, the dam is located within the physiographic province of the Precambrian Highlands, composed of biotite gneiss, amphibolite, pegmatite and metamorphosed limestone and skarn. (See Appendix F)

1.2.3 Size Classification: The dam is classified as a large structure because of its impoundment (62,000 acre feet), in accordance with Section 2.1.1 of Reference 1.

1.2.4 Hazard Classification: The dam is located 1,000 feet upstream of Lake Iosco and the moderately populated floodplain which extends down to Bloomingdale, N.J. The dam is classified as a high hazard potential based on the requirements of Section 2.1.2 of Reference 1.

1.2.5 Ownership: The dam is owned and maintained by the North Jersey District Water Supply Commission (NJDWSC), a New Jersey state commission. They have engineering and maintenance facilities located at Raymond Dam in Wanaque, N.J. The Chief Engineer of the NJDWSC in Wanaque is Mr. Dean C. Noll. The address is:

North Jersey District Water Supply Commission
Ringwood Avenue
Wanaque, N.J. 07465

1.2.6 Purpose of Dam: The Greenswamp Dam No. 1 serves as a dam which closes off low topography in the rim of the Wanaque Reservoir. The reservoir supplies water to residents of Paterson, Passaic, Clifton, Montclair, Glen Ridge, Newark, Kearny, Bloomfield and Bayonne, New Jersey.

1.2.7 Design and Construction History: This dam was constructed from July 5, 1924 to October 10, 1926 by Winston & Company, Inc. of Kingston, N.Y., as part of the total Wanaque Project. The project began in 1920 and was completed with the reservoir being filled by March 4, 1929. The original design records could not be located by the staff of the NJDWDC at Wanaque. However, publications indicate the design was performed by employees of the NJDWSC with the assistance of individual consultants. The New Jersey Department of Environmental Protection (DEP) has monthly progress inspection reports and several photographs taken during construction. There is no indication of subsequent construction other than minor maintenance.

1.2.8 Normal Operational Procedures: There is no operational procedure for this dam. Adequate freeboard is relied on to contain storm surges in the reservoir, with overflow handled by the Overflow Weir (NJ 00214). See Location Map, Figure 1.

1.3 PERTINENT DATA

1.3.1 Drainage Area: 90.4 square miles

1.3.2 Discharge at Dam Site: Not Applicable

1.3.3 Elevation: (Feet above MSL)

Top Dam - 310.0

Maximum Spillway Design Flood (SDF) Surcharge - 308.8 (See Section 5.0)

Full Flood Control Pool - Not Applicable

Recreation Pool - Not Applicable

Spillway Crest (gated) - Not Applicable

Upstream Portal Invert Diversion Tunnel - Not Applicable

Downstream Portal Invert Diversion Tunnel - Not Applicable

Streambed at Centerline of Dam - 288.0

Maximum Tailwater - None

1.3.4 Reservoir: Length of Maximum Pool - 6.1 miles

1.3.5 Storage (acre-feet):

Recreation Pool - Not Applicable
Flood Control Pool - Not Applicable
SDF Surcharge - 59,540
Top of Dam - 62,000

1.3.6 Reservoir Surface (acres):

Top of Dam - 2,620
SDF Surcharge - 2,590
Flood Control Pool - Not Applicable
Recreation Pool - Not Applicable
Spillway Crest - At Overflow Weir 2,400

1.3.7 Dam: Type - earthfill with concrete core wall and impervious zone.

Length - 640 feet
Height - 30 feet above the surface
Top Width - 15 feet
Side Slope - U/S 2(H):1(V) (top) to 3(H):1(V) (lower part)
 D/S 2(H):1(V)
Zoning - An impervious zone with side slope of 1(H):1(V) on the upstream side of the core wall; top elevation 300.3 feet.
Impervious Core - Concrete core wall with top elevation 305.0 feet extending to final rock surface. Also, see "Zoning" above.
Cutoff - A shallow cutoff in foundation rock formed by base of concrete core wall.
Grout Curtain - None (Shallow foundation grouting for concrete core wall)

1.3.8 Diversion and Regulating Tunnel: Not Applicable

1.3.9 Spillway: Not Applicable

1.3.10 Regulatory Outlet: Not Applicable

2.0 ENGINEERING DATA

2.1 DESIGN

Original design calculation data are not available for this dam. A brief description of the project design and subsurface investigation was given in the NJDWSC's 1925 report, pages 52-56 (Reference 2).

2.2 CONSTRUCTION

A set of the record drawings showing plan, cross-sections, and profiles, are available at the NJDWSC's office at Wanaque, N.J. A brief description of the construction of this dam, including foundation condition, appeared in the NJDWSC's 1925 report, pages 158-159 (Reference 2). The dam was constructed between July 5, 1924 and October 10, 1926.

2.3 OPERATION - Not Applicable

2.4 EVALUATION

2.4.1 Availability: Embankment material data and engineering design analysis data are not available.

2.4.2 Adequacy: The available design and construction data are adequate for this Phase I evaluation.

2.4.3 Validity: The record drawings appear to be consistent with observed structures, based on the visual inspection.

3.0 VISUAL INSPECTION

3.1 FINDINGS

3.1.1 General: The Phase I dam inspection was performed on May 23, 1978 by a team of Gilbert Associates, Inc. Engineers. (One previous inspection of this dam was performed on April 5, 1977 by Joseph Foley, Roscoe Jennings and Doug De Lorie of the NJDWSC. A copy of their report is attached in Appendix E.)

3.1.2 Dam: At least two local areas of the crest between Station 1+50 and Station 3+00 appeared to have settled from 4 to 6 inches. The upstream riprap slopes in these settled areas have experienced slight movement as indicated by flatter and irregular areas on the slope surface. The downstream slope was very uniform with little sloughing and erosion; the material exposed on the downstream slope was composed of silty sand and well graded gravel. Trees were cleared from the west half of the downstream slope, but standing trees remain on the east half of the slope. The east abutment rocks consist of some serpentinuous limestone or marble with a wide band of skarn mineralization (preliminarily identified as graphite and sulfide minerals) due to contact metamorphism. The rocks exposed on the west hillside are comprised chiefly of granitic gneiss, amphibolite and pegmatite. The rocks on the east abutment were observed to be broken and decomposed.

A large waterlogged or saturated area, dammed by a 5-foot high downstream dike, is located as close as four feet to the toe of the embankment. Flow from this area was estimated in the order of 15-20 gpm.

3.1.3 Appurtenant Structures: There are no flow or flood control structures at this dam.

3.1.4 Reservoir Area: The slopes of the reservoir rim near the dam site appear to be general stable, except on the right abutment where some large loose stones have fallen from the upper part of the hills apparently, due to natural erosion processes.

3.2 EVALUATION

Two slightly concave areas on the upstream side of the dam crest, along with the small disturbance of the riprap slope, indicate that non-uniform settlement took place after construction.

Except for the core, the embankment materials are reputedly composed chiefly of well-drained silty sand and gravel of low erodibility, which is a basic contributing factor to the dam stability.

The poor drainage beyond the toe of the embankment was created by a downstream cross-valley dike, built to protect the toe area against scouring and back-water encroachment from Post Brook. The amount of underseepage flow observed at the point of discharge, some 80 feet beyond the toe, was relatively small and was considered insignificant.

The complex foundation condition at this site required an extensive rock excavation and grouting program in order to provide a watertight foundation, as described in Reference 2.

In summation, the existing condition of the dam is generally good, as defined in Appendix H, although the distressed area should be checked periodically for any possible movement.

3.3 ATTENDEES

North Jersey District Water Supply Commission

Mario Di Laura

New Jersey Department of Environmental Protection

Larry Woscyna

Gilbert Associates, Inc.

Rudolph J. Wahanik
Fine T. Hsu
Rudy P. Visser

4.0 OPERATIONAL PROCEDURES

4.1 PROCEDURES

The water level in Wanaque Reservoir is contained by the Overflow Weir structure, several miles away, to a pool elevation of 302.4 feet MSL. The high water elevation recorded since October 1950 was 303.93 feet with excess flow passing over the uncontrolled weir. There is no operational procedure at Greenswamp Dam No. 1.

4.2 MAINTENANCE OF DAM

The reservoir rim is traversed daily by NJDWSC guards who report apparent maintenance problems to the Chief Engineer. In addition, periodic inspections are made by engineers and/or other personnel of the NJDWSC and reports written regarding maintenance requirements. The 1977 inspection report (Appendix E) recommended removal of trees and shrubs. The trees on the right half of the downstream slope have been removed since the inspection. The NJDWSC has foresters employed to cut trees and otherwise maintain the woodlands on their property.

4.3 MAINTENANCE OF OPERATING FACILITIES - There are no operating facilities at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

No automatic warning systems exist at this dam. A daily patrol is made by the NJDWSC security guards equipped with radios. According to NJWDSO personnel, the guards are instructed to radio the Wanaque police of any obvious, impending hazard to residents from the dams on the Wanaque Reservoir.

4.5 EVALUATION

The maintenance procedures for this dam are generally adequate. However, additional work is required to repair the settled areas of the crest and riprap. The trees remaining on the downstream slope should be removed.

5.0 HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

Other than the dam, there are no hydraulic structures or control facilities at this location. Reservoir overflow is provided by the Overflow Weir, located 2 miles to the east.

5.1.1 Design Data: The maximum pool elevation for the design discharge of 18,000 cfs is 304.3 feet. This is based on a spillway elevation of 300.3 feet plus a head of 4.0 feet, for the Overflow Weir. With the flashboards in place, the overflow functions as a sharp edged weir with an elevation of 302.4 feet, and a pool elevation of 306.6 feet with the design flow of 18,000 cfs.

5.1.2 Experience Data: The maximum recorded reservoir level since October, 1950 is 303.9 feet, (Reference 6 and 7), 6.1 feet lower than the crest of Greenswamp Dam No. 1. This level was reached in March, 1951.

5.1.3 Visual Observations: There is no visual evidence to indicate the dam has ever been overtopped.

5.1.4 Overtopping Potential: The PMF, when developed as described in Appendix D and with the flashboards on the Overflow Weir, results in a reservoir elevation of 308.8 feet. One-half of the PMF results in a reservoir elevation of 306.0 feet, with the flashboard in place.

Details on the methodology used and the hydrologic results are presented in Appendix D.

5.1.5 Reservoir Drawdown: The existing emergency drawdown facilities installed in the several dams of the Wanaque Reservoir are not adequate to lower the water level of the reservoir in a short period of time. It is recommended that the Owner design and later construct water release structures that will allow lowering of the water level within an acceptable period of time. A preliminary evaluation of the performance of the existing drawdown facilities is given in Appendix D. The time required to drawdown the Reservoir to the bottom surface level of Greenswamp Dam No. 1 (280 feet) using the existing facilities at Raymond Dam is:

<u>System in Use</u>	<u>Time in Days</u>
Aerator System	98
36-inch Diameter Blowoff	310
Aerator and Blowoff	75

6.0 DAM STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

6.1.1 Visual Observations: The local and minor movement of the upstream riprap and associated non-uniform settlements of the dam crest do not appear to affect the overall stability of the dam, as the area of concern appears to have been stabilized. A periodic check on further settlement activity in the affected area is needed.

6.1.2 Design and Construction Data: The NJDWSC's 1925 report (Reference 2, page 54) states that the geologic investigations during the initial phases of this project disclosed very complex underground conditions that required special treatment. Structural stability analysis for the dam's concrete core wall or embankment were not available and is not known to have been performed.

6.1.3 Operating Records: Not Applicable

6.1.4 Post Construction Changes: None

6.1.5 Seismic Stability: The dam is located within Zone 1 on the Algermissen's Seismic Risk Map of the United States (1969 Edition).

The static stability of the dam appears to be satisfactory and conventional safety margins appear to exist; therefore, in accordance with paragraph 3.6.4 of Reference 1, the dam may be assumed to present no hazard due to earthquakes.

7.0 ASSESSMENT/REMEDIAL MEASURES

The assessment and remedial measures contained herein are based on the provisions of Appendix H, Conditions.

7.1 DAM ASSESSMENT

7.1.1 Safety: On the basis of visual inspection, the general condition of the dam is good, except in two local areas where the embankment has experienced minor non-uniform settlements. The dam is founded on a complex of fractured rock which required extensive treatment to achieve water tightness and stability. According to Reference 2, page 54, such conditions were encountered and required considerable over-excavation and grouting.

7.1.2 Adequacy of Information: Most of the design and construction information obtained from the NJDWSC's 1925 report (Reference 2) is adequate for this Phase I evaluation; however, test boring and embankment material data are insufficient.

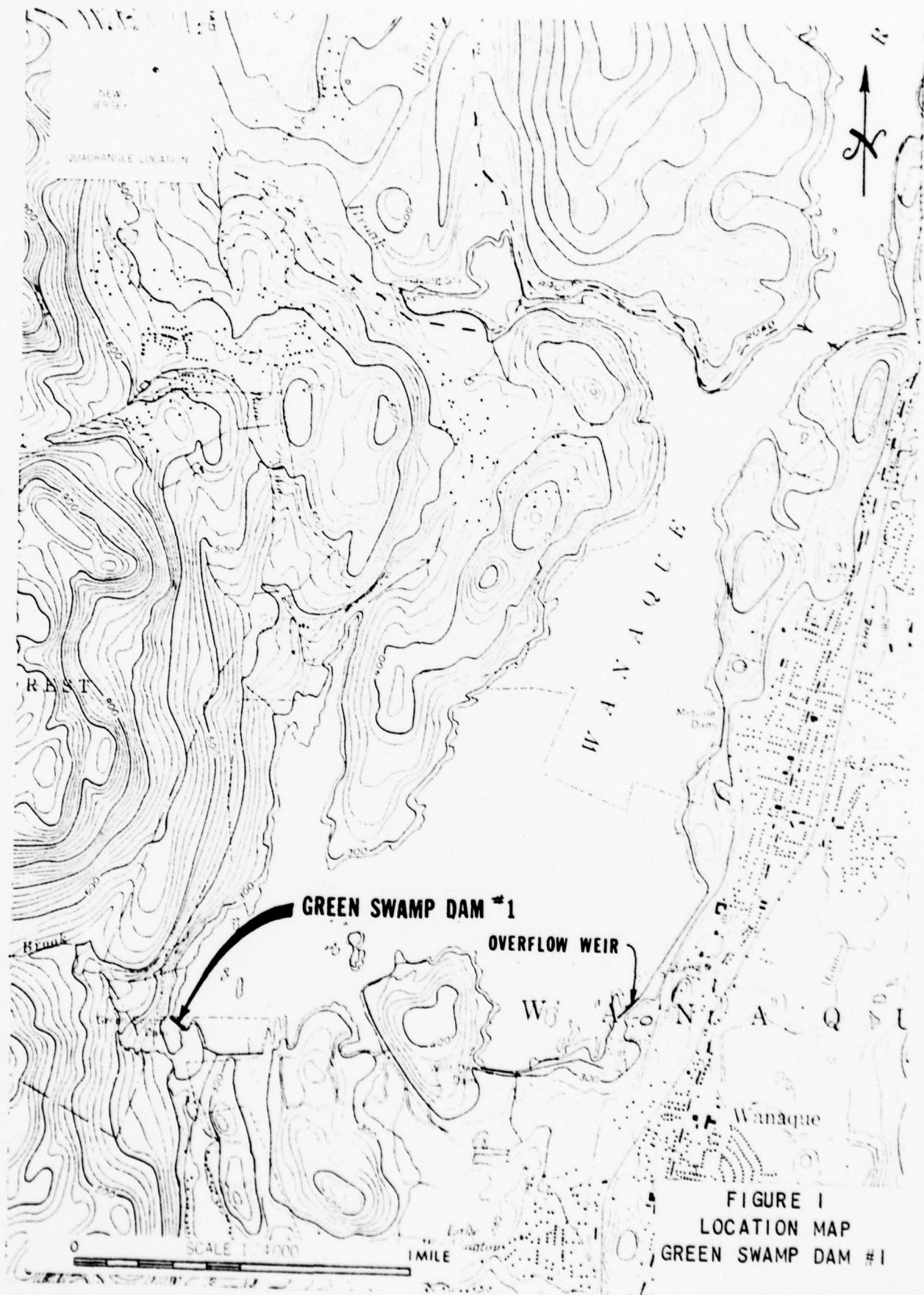
7.1.3 Urgency: Actions needed are summarized on the Assessments of General Conditions sheet of this report.

7.1.4 Necessity for Further Studies: It is necessary to further study the potential hazardous condition if the pool level of the Wanaque Reservoir exceeds elevation 305 feet, the top of the concrete corewall (PMF at elevation 308.8 feet and 1/2 PMF at elevation 306.0 feet), and if water is allowed to percolate through the pervious section of the dam under variable hydrostatic heads.

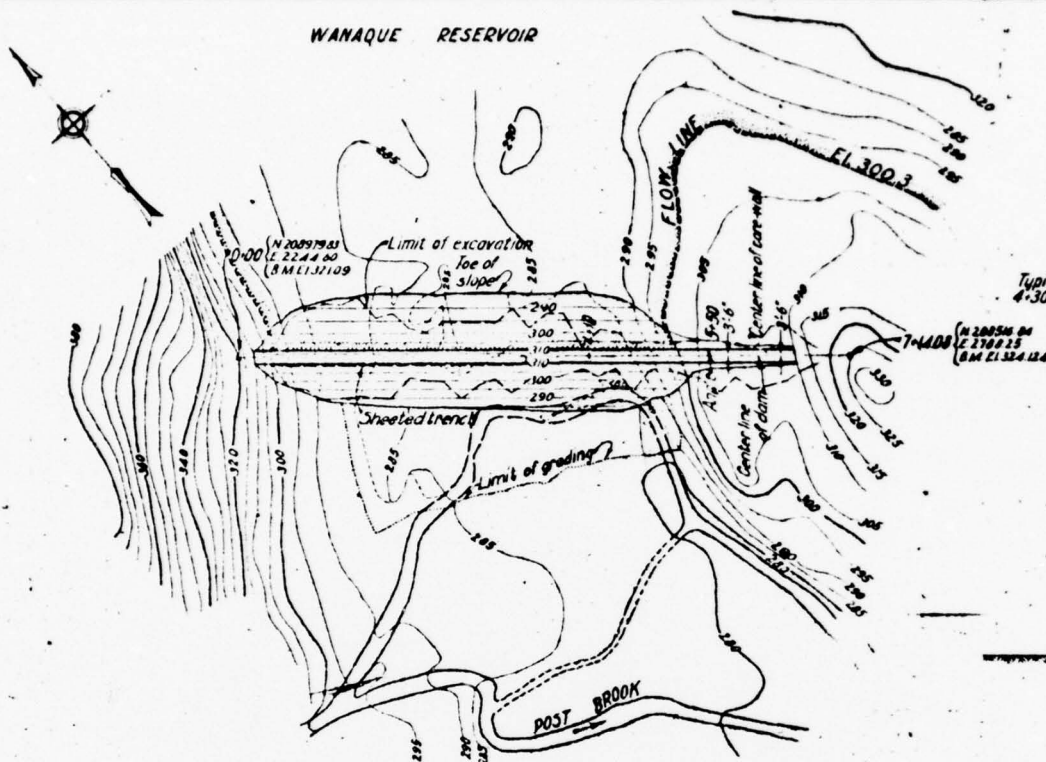
7.2 REMEDIAL MEASURES

7.2.1 Alternatives: The partially settled ground and disturbed riprap between Station 1+50 and Station 3+00 should be checked periodically for any possible further movement.

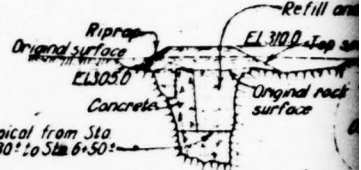
7.2.2 Operational/Maintenance Procedures: Clearing and prevention of tree growth on the east side of the downstream embankment should be continued. The cleared embankment slope should be redressed and seeded with selected grass.



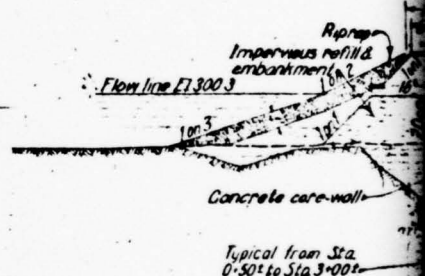
WANAQUE RESERVOIR



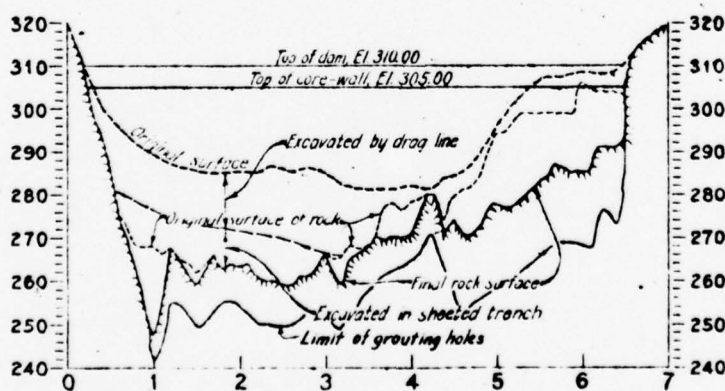
PLAN



STATION 6+10
DAM NO. 1



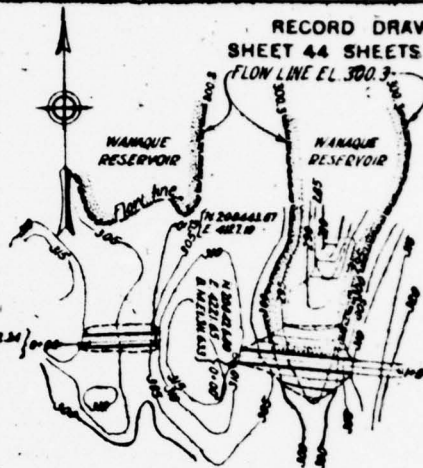
STATION
DAM



PROFILE
DAM NO 1

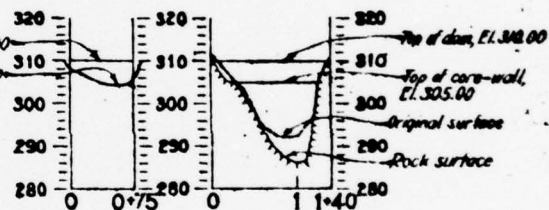
NOTE: Bench marks

RECORD DRAWING
SHEET 44 SHEETS IN SET 61
FLOW LINE EL. 300.3



PLAN

100 0 100 200ft



PROFILES

STATION 1+00
DAM NO. 1

DAM NO. 2 A

DAM NO. 3

Note: Holes drilled to depth of 10 ft.
but no grout necessary at dam no. 3

CONSTRUCTION RECORD

Dam No. 1 built July 5, 1924, to Oct. 10, 1926.
Dam No. 2A built Sept. 2, 1927, to Sept. 16, 1927.
Dam No. 3 built July 24, 1924, to Nov. 20, 1926
under Contract 7, Clifford F. Mac Evoy Co.,
Newark, N.J., Contractor, in accordance with
this record drawing.

Engineer in charge
NORTH JERSEY DISTRICT
WATER SUPPLY COMMISSION

WANAQUE RESERVOIR

GREEN SWAMP DAMS

NUMBERS 1, 2 A AND 3

PLAN, PROFILES AND SECTIONS

APRIL 30, 1931

FIGURE 2

NOTE: Bench marks are 1/2 brass rods caulked into ledge rock.

Asst. Chief Engineer

CASE

DP

File-3420g Rev. 3244

2

APPENDIX A
VISUAL CHECKLIST

Check List
Visual Inspection
Phase 1

Green Swamp
Name Dam: Dam No. 1 County: Passaic State: New Jersey Coordinators: Philadelphia District Corps of Engineers

Date(s) Inspection: May 23, 1978 Weather: Clear Temperature: 76°F

Pool Elevation at Time of Inspection: 302.7* MSL Tailwater at Time of Inspection: Not Available

Gilbert Associates, Inc.
Inspection Personnel: New Jersey Department of Environmental Protection North Jersey District Water Supply Commission

Rudolph J. Wahanik Mario DiLaura
Fine T. Hsu

Rudi P. Visser

Fine T. Hsu - Recorder

*Recorded this date at the Gaging Station at Raymond Dam.

EMBANKMENT

Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Physical cracks were not observed on the embankment itself	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No significant unusual movement or cracking at or beyond the toe was observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	The downstream embankment slopes were relatively uniform with little sloughing or erosion. Erosion at the abutment was not apparent except for some large rock debris from a rock fall. The upstream slopes have experienced slight movement, indicated by flatter and irregular slope surface.	Trees were removed along the downstream slope in the western half embankment area. Trees could be cut and removed in the eastern half of the embankment area.
VERTICAL AND HORIZONTAL	Portions of the crest had settled variably (from approximately 4-inches to 6-inches) between Station 1+50 and 3+00 on the upstream side.	
RIPRAP FAILURES	Portions of the upstream riprap slope between Station 1+50 and 3+00 may have moved slightly as indicated by local flatter slopes (between 2-1/2(H):1(V) and 2(H):1(V) and surface irregularity at Station 4+65.	

EMBANKMENT

Sheet 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The contact of embankment and abutment appears to be in good condition and watertight.	East abutment rocks consist some serpentinuous limestone. West abutment is formed by gneiss rock.
ANY NOTICEABLE SEEPAGE	A large waterlogged or saturated zone as close as 4 feet to the toe of the embankment was observed. A flow of 15-20 gpm was estimated at the point of discharge located at approximately 80 feet beyond the toe near the left abutment.	A large flow of Post Brook was fed from a natural waterfall located some 600 feet beyond the embankment toe. A 5 feet high dike, aligned parallel to the dam, was built at a distance of approximately 80 feet beyond the toe.
STAFF GAGE AND RECORDER	None.	
DRAINS	No pipe drains or filter drains were observed along the toe area.	

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None was observed.	
OBSERVATION WELLS	None was observed.	
WEIRS	None was observed.	
PIEZOMETERS	None was observed.	
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	A continuous exposure of bedrock along the right rim of reservoir around the dam has formed a steep and relatively stable slope. There are a few large loose rock blocks along the toe of the slopes, apparently the results of a rockfall.	
SEDIMENTATION	No sediments were observed in the reservoir near the dam. The rock slope and good vegetation cover near the dam site protects the area from excessive erosion and formation of sediment.	

APPENDIX B

ENGINEERING DATA CHECKLISTS

APPENDIX B
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	A tracing of the record drawing is available at the NJDWSC office in Wanaque, N.J. (hereafter referred to as NJDWSC-W).
REGIONAL VICINITY MAP	The USGS Wanaque, N.J. 7-1/2 min. quadrangle map is available.
CONSTRUCTION HISTORY	The 1925 Commissioner's Report (Reference 2) is available at NJDWSC-W, pages 158-159, detail construction of this dam. There is also a 1930 and a 1931 Commissioner's report at NJDWSC-W, an article on the construction was printed in the N.E.W.A. Journal (Reference 3) during construction. Some photos are available in the NJDWSC-W and the N.J. Department of Environmental Protection offices in Trenton, N.J. (DEP).
TYPICAL SECTIONS OF DAM	A section through the dam is shown on record drawing No. 44 of 61 which is available at NJDWSC-W (see page 13 of this report).
HYDROLOGIC/HYDRAULIC DATA	Records are available at NJDWSC-W and some are printed in USGS reports.
OUTLETS - PLAN	Not Applicable
- DETAILS	Not Applicable
- CONSTRAINTS	Not Applicable
- DISCHARGE RATINGS	Not Applicable
RAINFALL/RESERVOIR RECORDS	Excellent records are available from the USGS and NJDWSC from the time of construction of this dam.

APPENDIX B (Continued)

ITEM	REMARKS
DESIGN REPORTS	Design reports are not available; however, a brief description of the dam design can be found in the North Jersey District Water Supply Commission's Report 1925. (Reference 2, page 158-159)
GEOLOGY REPORTS	Geologic reports of this dam site were described by Prof. C. P. Berkey on Page 54 of the North Jersey District Water Supply Commissions' 1925 Report (Reference 2).
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Design calculations, dam stability, or seepage studies were not available at NJDWSC-W. Complete original design calculations for this dam do not appear to be in the DEP files.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Impervious borrow materials for the Wanaque reservoir project were investigated as shown on drawings Contract 7, sheet 3, Contract 2A, sheet 7, including test boring data available at the NJDWSC-W. Test borings at foundation area of the dam were not available. Foundation grouting records were shown in Drawing sheet 47 in set 61. Laboratory tests were not reported.
POST-CONSTRUCTION SURVEYS OF DAM	See Record Drawing Sheet 44 in set 61 showing as-built section, profile, and plan (See Figure 2 of this report).
BORROW SOURCES	All impervious materials required for constructing the impervious layer upstream apparently came from borrow area "A", shown in Drawing Sheet 3 in Set 31, Contract 7.
SPILLWAY PLAN	Not Applicable
SECTIONS	Not Applicable
DETAILS	Not Applicable

APPENDIX B (Continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS & DETAILS	Not Applicable
MONITORING SYSTEMS	None observed.
MODIFICATIONS	No modifications from the design of the dam were observed.
HIGH POOL RECORDS	Records exist at the NJDWSC-W and USGS publications.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Annual reports for certain years are in dam file No. 32 of DEP.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported.
MAINTENANCE OPERATION RECORDS	Operational levels of the reservoir are available from NJDWSC-W.

APPENDIX B (Continued)

CHECK LIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC DATA

DRAINAGE AREA CHARACTERISTICS: Densely forrested, few homes, very hilly with minimal cover on bedrock.
ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 302.4 (44.350 acre-feet)
ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Not Applicable
ELEVATION MAXIMUM SPILLWAY DESIGN FLOOD POOL: 308.8
ELEVATION TOP DAM: 310.00

CREST: Unpaved roadway

- a. Elevation: 310.0
- b. Type: Non-overflow
- c. Width: 15 feet (measured)
- d. Length: 640 feet (measured)
- e. Location Spillover: Not Applicable
- f. Number and Type of Gates: Not Applicable

OUTLET WORKS: None

- a. Type: Not Applicable
- b. Location: Not Applicable
- c. Entrance Inverts: Not Applicable
- d. Exit Inverts: Not Applicable
- e. Emergency Draindown Facilities: Not Applicable

HYDROMETEOROLOGICAL GAGES:

- a. Type: Rainfall recording charg, 24 hour precipitation can, and maximum and minimum temperature recorder. Float type continuous stream level recorder with drum chart.
- b. Location: Raymond Dam in Wanaque, New Jersey.
- c. Records: Weather data published as climatological Data-Wanaque-Raymond Dam by the National Oceanic and Atmospheric Administration. Streamflow data is recorded by the U.S.G.S.

MAXIMUM NON-DAMAGING DISCHARGE: Non-overflow dam.

APPENDIX C

PHOTOGRAPHS



June 1978

LOOKING WEST ALONG CREST

PARTIALLY CLEARED DOWNSTREAM
SLOPE LOOKING TOWARDS LEFT ABUTMENT



June 1978

APPENDIX D

RESERVOIR HYDROLOGY AND DRAWDOWN

APPENDIX D

RESERVOIR HYDROLOGY AND DRAWDOWN

Reservoir Hydrology

The hydrologic analysis presented in this Report and in the Appendix pertains to present hydrologic conditions and does not consider future changes produced by uncertain conditions such as urbanization, forest fires, or other modifications within the watershed.

The inflow Probable Maximum Flood (PMF) Hydrograph for Wanaque Reservoir was supplied by the Philadelphia Office of the Corps of Engineers (Reference 8) and is shown in Figure D-1. This hydrograph has a peak flow rate of 33,500 cfs occurring 50 hours after its start. The total runoff volume is 94,500 acre-feet, over a time span of 140 hours. The HEC-1 Computer Program (Reference 5) was used to route this hydrograph through the reservoir. The main discharge structure for Wanaque Reservoir is a 520-feet long Overflow Weir about 1.34 miles east of Green Swamp Dam No. 1, which has had permanent flashboards in place since 1934. The storage volume-spillway outflow relation was determined assuming that the initial water surface elevation was at the top of the flashboards (302.4) and the structure functions as a sharp-crested weir.

Since the flashboards are not designed to break away, the spillway discharge and the reservoir storage/spillway outflow relationships used in HEC-1 for routing the PMF and one-half PMF through the reservoir assume the flashboards are in place. These relationships are in Figure D-2.

<u>Water Elevation</u> <u>ft.</u>	<u>Spillway Discharge</u> <u>cfs</u>	<u>Reservoir Storage</u> <u>Acre-ft.</u>
302.4	0	0
303	820	1381
304	3760	3530
305	8410	5678
306	14210	7765
307	18640	9822
308	23700	12431
309	28900	14270
310	35300	16418

The surface area and storage of the Wanaque Reservoir at different water levels (Reference 2) are shown in Figure D-3. Their values are:

<u>Water Elevation ft.</u>	<u>Surface Area Acre</u>	<u>Storage Acre-ft.</u>
215	0	0
220	40	153
230	190	1228
240	370	4910
250	790	9820
260	1070	19027
270	1300	31303
280	1630	45420
290	1960	63326
300	2310	84701
310*	2620	106183
312*	2680	110480

*Values extrapolated from elevation 305.00-feet. (Reference 2)

Results of this routing procedure indicate that the PMF would raise the pool elevation to about 308.8 feet. Routing one-half the PMF (16,750 cfs) through Wanaque Reservoir raises the pool elevation to about 306.0 feet, 4 feet below the crest of Greenswamp Dam No. 1.

Flood routing was also performed assuming that the flashboards were removed. In this case, the storage volume-outflow relation was determined with the starting water surface elevation at the top of the spillway crest (300.3 feet) and the Overflow Weir discharging as an uncontrolled ogee crest spillway. HEC-1 results indicate that the PMF would raise the pool elevation to 306.9 feet. The reservoir was designed to safely discharge 18,000 cfs (slightly larger than 1/2 of the PMF) without the flashboards in place. Graphs of pool elevation versus time for the PMF and 1/2 PMF routing, with and without flashboards, are found in Figures D-4 and D-5.

Reservoir Drawdown

If an emergency condition that affects the stability of one of several dams that form the Wanaque Reservoir or of the outlet and control works of the Raymond Dam develops, then a fast drawdown of the reservoir to a lower water level will be required. The lower water level depends on the location and nature of the hazardous condition. Figure D-6 shows graphically the times required to lower the reservoir level with the existing facilities.

The water level in the Wanaque Reservoir can be lowered by means of:

- a. The Wanaque Aqueduct System.
- b. The existing aerator system.
- c. A 36-inch diameter blowoff.
- d. The blowoff and the aerator together.
- e. Other blowoff lines.

All drawdown times were computed considering that the minimum inflow of 2 cfs/square mile into the reservoir was equalized by the system demand and other water losses.

A. The Wanaque Aqueduct

The potential of the Wanaque Aqueduct to lower the water level in the reservoir during an emergency condition is non-existent because a minimum inflow of 2 cfs/sq. mile, which is equivalent to 117 MGD, will supply the average daily demand of the distribution system. Table 1 gives the average water consumption during the last ten years.

Table 1

<u>Year</u>	<u>Demand (MGD)</u>
1967	95.37
1968	106.92
1969	111.17
1970	113.45
1971	112.88
1972	112.17
1973	103.09
1974	98.90
1975	92.07
1976	90.58
1977	107.90

B. Aerator System

Operation of the existing aerator system will drawdown the reservoir water level between the crest of the overflow weir at elevation 302.4 feet and the top of the aeration nozzles at elevation 240.5 feet in the following times:

<u>Water Level (Feet)</u>	<u>Total Time (Days)</u>
302.4	0
300	10.39
290	55.42
280	98.03
270	135.76
260	174.69
250	212.65
240.5	253.65

C. 36-Inch Diameter Blowoff

The 36-inch diameter blowoff installed at the bottom of the Raymond Dam in the stream control conduits can be used to lower the reservoir level to an elevation of 222.00 which corresponds to the entrance intake sill of the lower conduit. The blowoff discharge is located at centerline elevation 213.38 feet. The times in days required by the blowoff line operating alone to lower the reservoir water level are:

<u>Water Level (Feet)</u>	<u>Total Time (Days)</u>
302.4	0
300	33.18
290	177.59
280	309.41
270	420.21
260	525.48
250	613.40
240	677.29
230	713.89
222	728.79

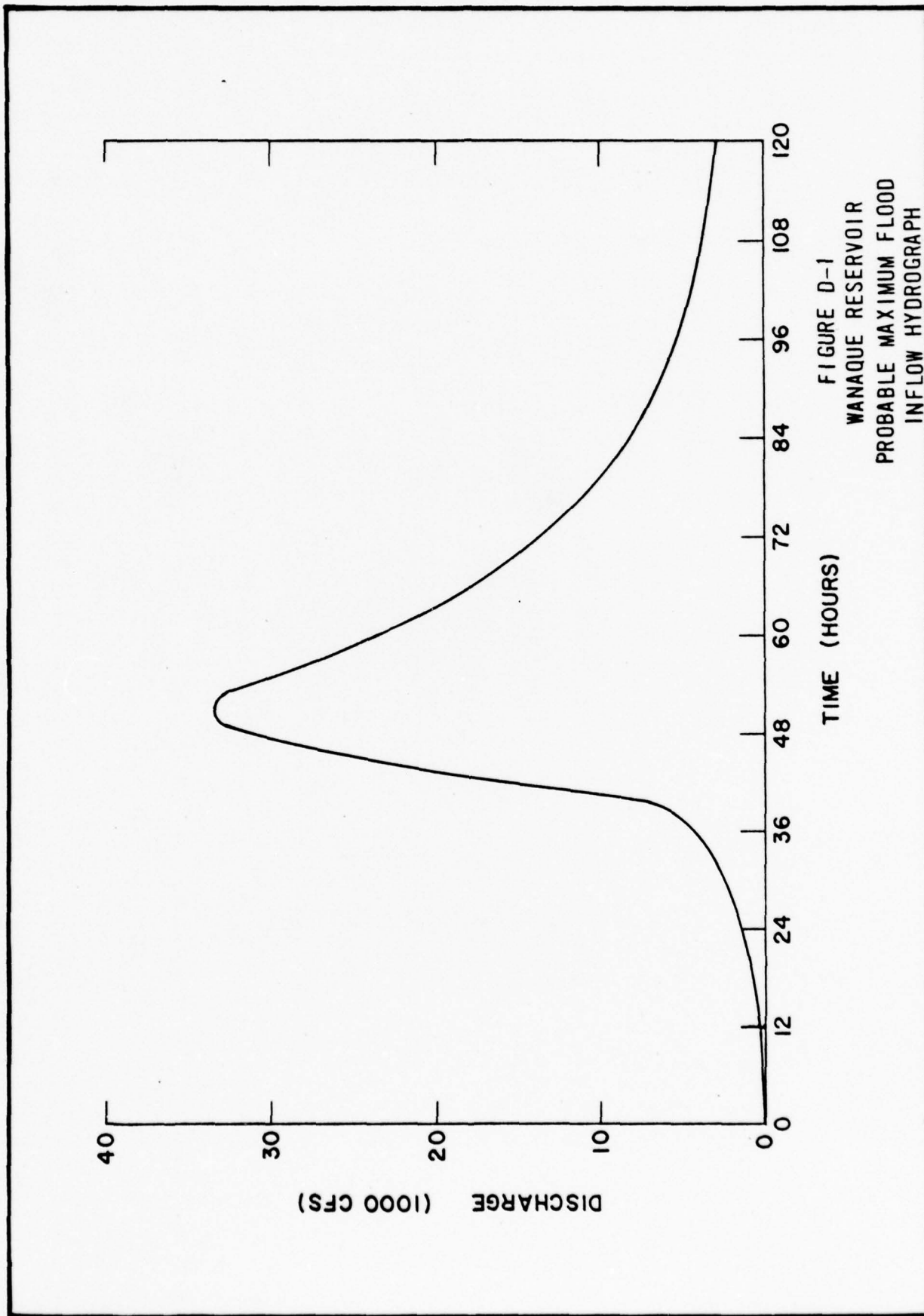
D. Blowoff and Aerator

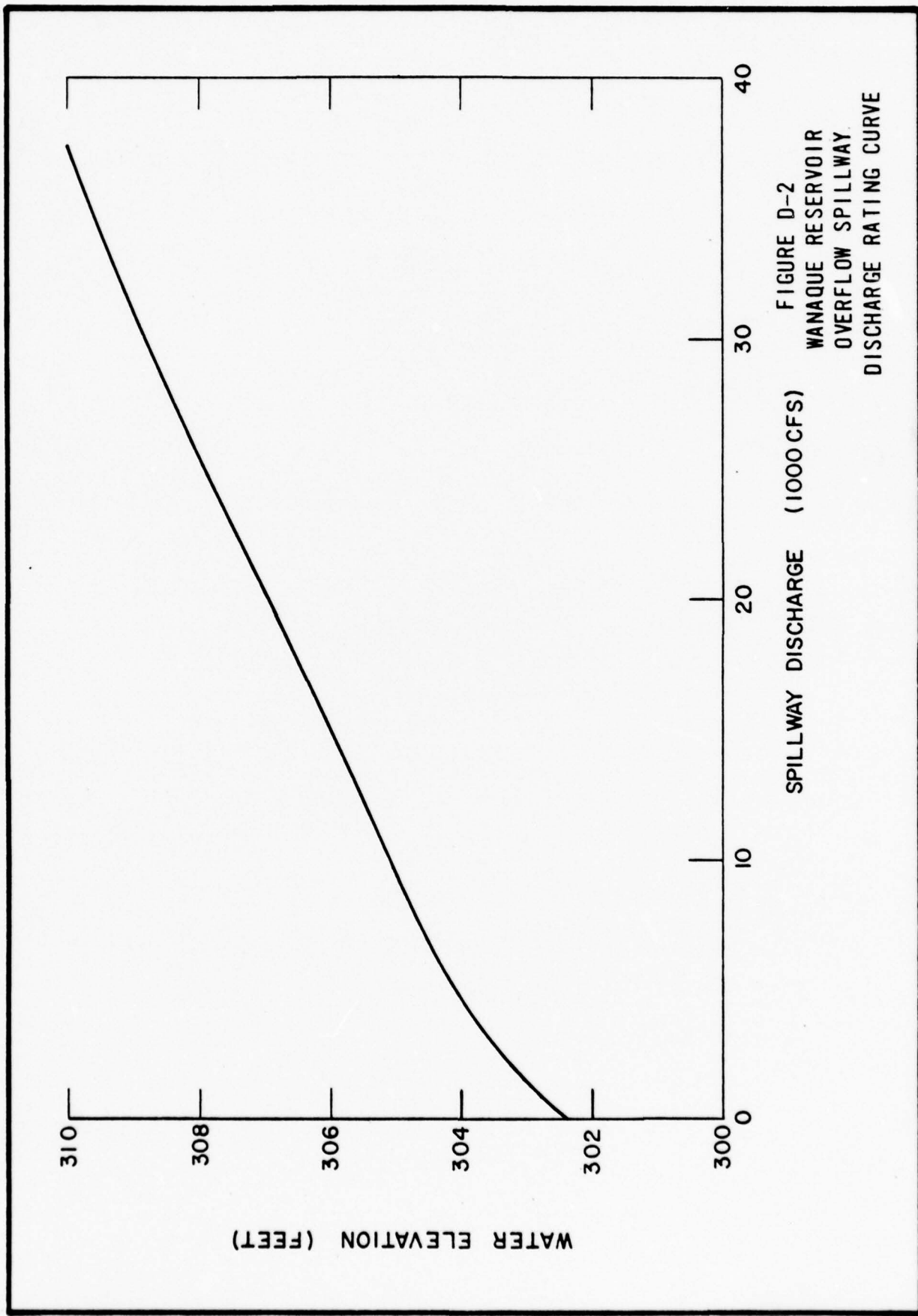
Simultaneous operation of the 36-inch diameter blowoff pipe in conjunction with the aerator system will lower the reservoir water level in the following times:

<u>Water Level (Feet)</u>	<u>Total Time (Days)</u>
302.4	0
300	7.94
295	42.29
280	74.48
270	102.63
260	131.05
250	157.55
240	181.98
230	218.58
222	233.48

E. Other Blowoff Lines

Smaller diameter blowoff lines installed in several of the dams around the Wanaque Reservoir are not known to be in operable condition because, since its installation in 1925, the lines have not been inspected, operated, or maintained.





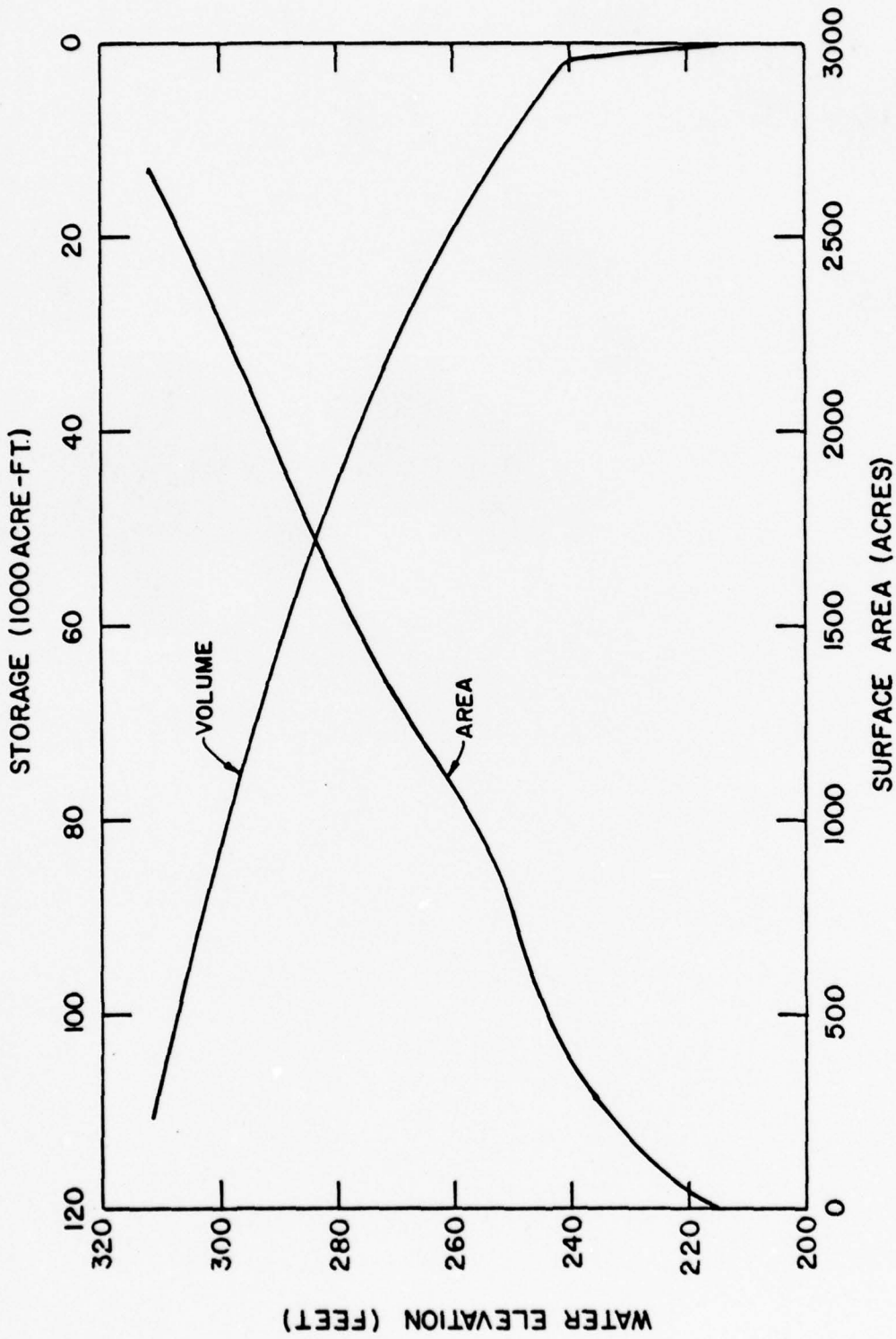


FIGURE D-3
WANAQUE RESERVOIR
AREA - CAPACITY CURVES

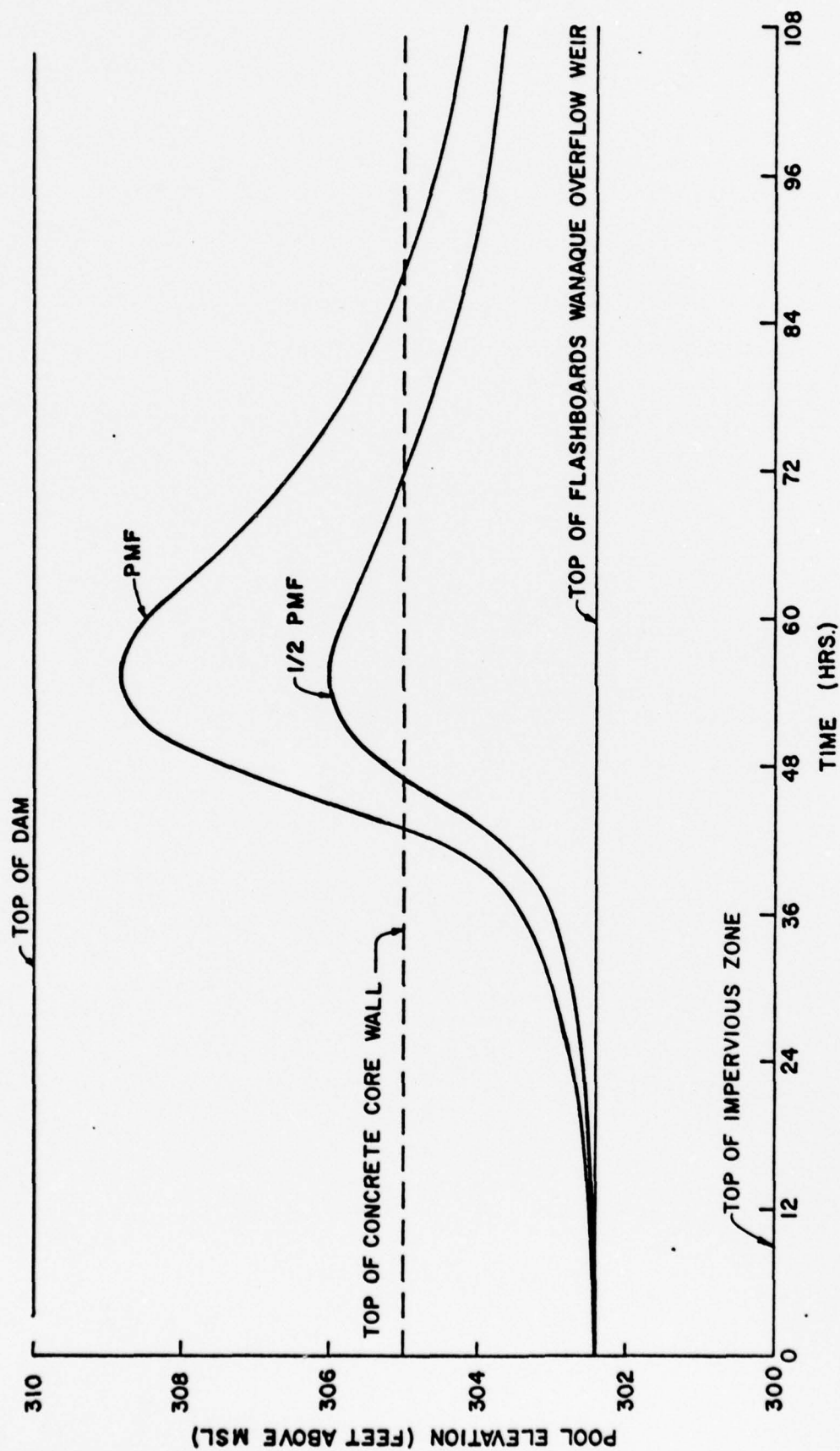


FIGURE D-4
FLOOD ROUTING THROUGH
WANAQUE RESERVOIR WITH
FLASHBOARDS IN PLACE
GREEN SWAMP DAM #1

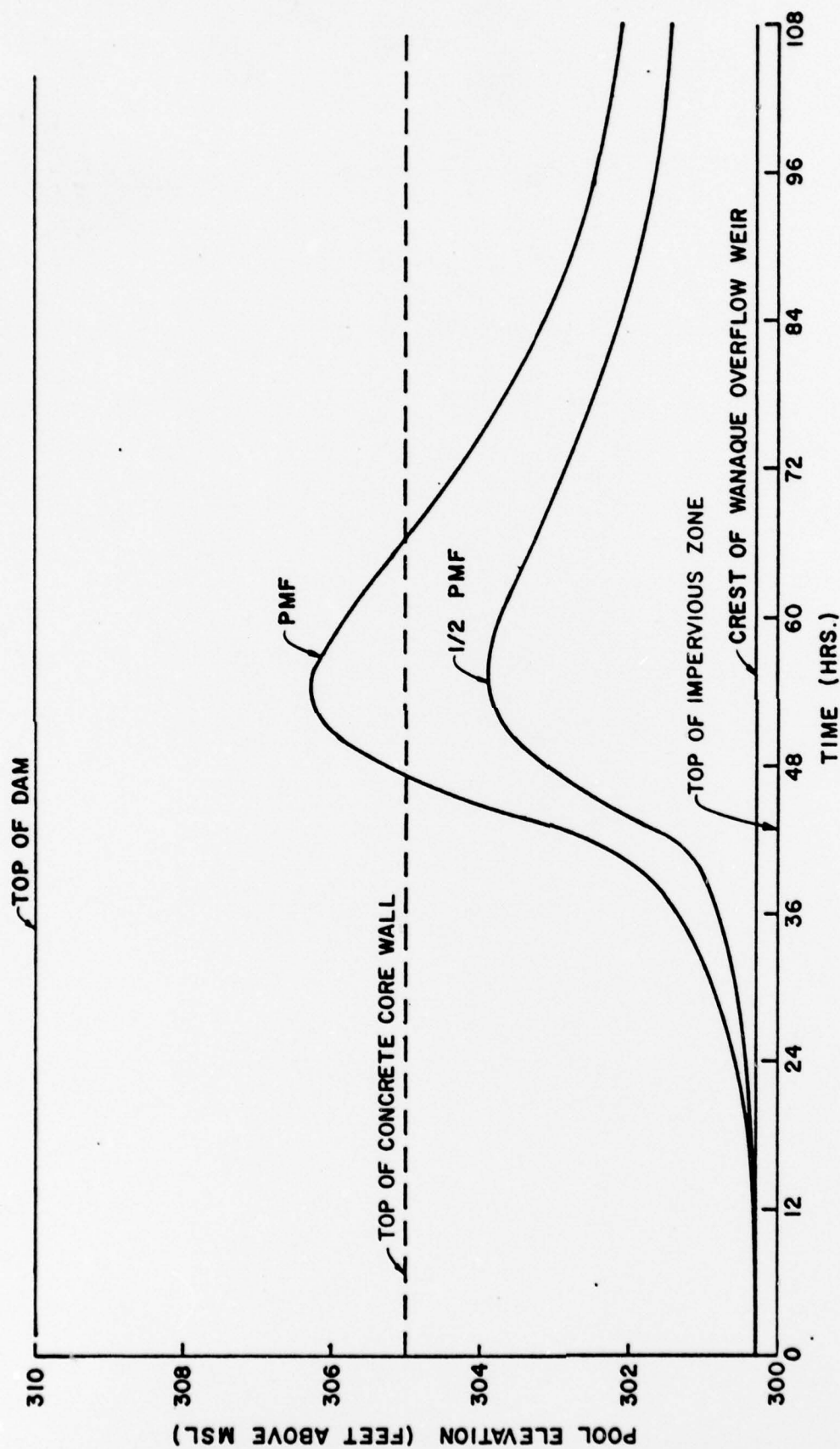


FIGURE D-5
FLOOD ROUTING THROUGH
WANAQUE RESERVOIR WITHOUT
FLASHBOARDS IN PLACE
GREEN SWAMP DAM #1

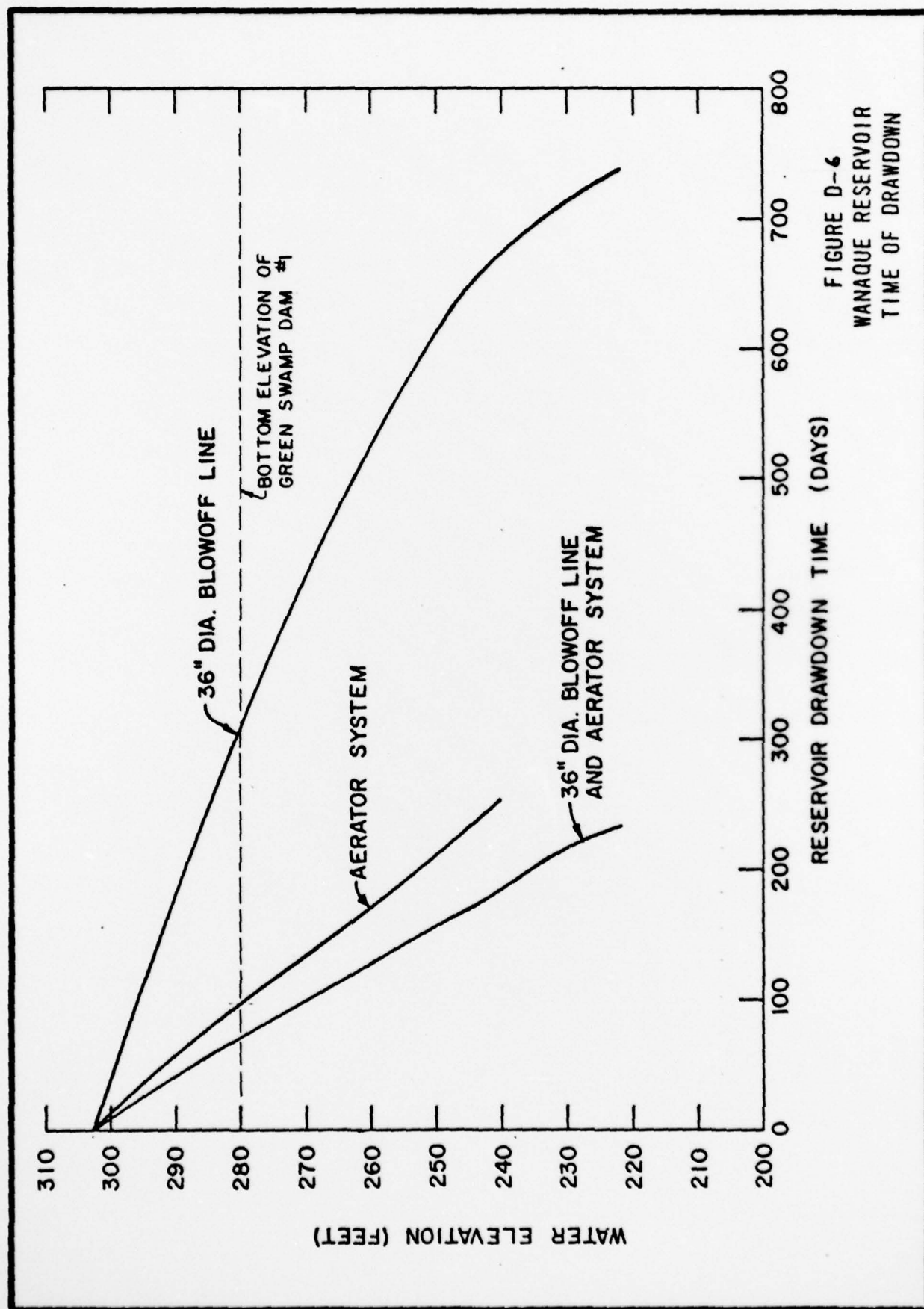


FIGURE D-6
WANAQUE RESERVOIR
TIME OF DRAWDOWN

APPENDIX E

PREVIOUS INSPECTION REPORTS

(The North Jersey District Water Supply Commission provided the inspection reports contained herein.)

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION

M E M O R A N D U M

TO: Dam Inspection File

FROM: Joseph Foley, Engineer

DATE: April 5, 1977

On March 31, 1977 Roscoe Jennings, Doug De Lorie and I inspected the dams at the Wanaque Reservoir; the following is a report on their conditions and recommendations on maintenance of same.

FURNACE ROAD DAM

Condition: There are trees and brush on the wet and dry sides of the dam and also a small swamp of apparently trapped water behind the dam.

Recommendations: The trees should be killed and removed using poison suitable for potable water.

MIDVALE DAM

Condition: Some trees are growing on the wet and dry sides of the dam. There is a small spring flowing from the foot of the dam at the north end. Wet spots and soft wet sand are also apparent at the foot of the dam. No sink holes or other indications of dam failure were apparent at this location. A sample of water from this spring and a sample from the reservoir were taken and analyzed, the results are as follows:

Spring Water:	Specific conductivity	68
	pH	6.3
Reservoir Water:	Specific conductivity	102
	pH	6.9

The results indicate that this water is more likely to be ground water than reservoir water. (For additional information, please refer to a memo from Bob Wieland to George Destito dated May 3, 1976).

Recommendations: The trees on the dam should be killed and removed. The dam should also be checked periodically to be sure the spring is not a leak in the dam.

RAYMOND DAM

Condition: Excellent

SPILLWAY

Condition: Good, except that it was indicated by Ernie Restaino that there is a small leak in the spillway. I did not observe it because of the overflow. I will check it again when the reservoir goes down.

Recommendations: The leak in the spillway should be fixed when the reservoir goes down.

WOLF DEN DAM

Condition: There are trees and shrubs on both the wet and dry sides. There are small springs flowing from the low sections behind the dam. Some samples were also taken here and the results were that the water had a specific conductivity of 90 and a pH of 6.3, so this water is most likely ground water also.

Recommendations: I recommend that the trees and shrubs be removed.

GREEN SWAMP

#4 Dam

Condition: The general condition of the dam is good, although sections of the gunite surfacing are cracked and have fallen off (especially near the expansion joints), due to moisture that found its way under the gunite. There was water running out of the drain but this flow was not excessive.

Recommendations: The cracked and loose gunite should be chipped away and replaced and at the expansion joints, the gunite should be chipped and tar poured in to allow expansion of the concrete.

#3 and #2A Dams

Condition: Both small dams are heavily wooded and there is a small swamp behind the #3 dam.

Recommendations: The only recommendation for these dams is that the trees be removed from both sides of the dams.

#2 Dam

Condition: This dam is in excellent condition, except around the expansion joints where the gunite is cracked due to the fact that no allowance was made for expansion when the gunite was applied to the dam. There is also a swamp behind this dam, but this looks like a natural swamp.

Recommendations: The gunite at the expansion joints should be chipped away and tar poured in to allow expansion and any other cracks in the gunite should be chipped and repaired.

#1 Dam

Condition: There are trees and shrubs on both wet and dry sides of this dam. There is also a swamp behind the dam.

Recommendations: The dam should be cleared of trees and shrubs.

As a result of my research, so far on dam inspection, I received a booklet, "Supervision of Dams by State Authorities" published by the United States Committee on large dams, July 1966. This publication had little information on the actual inspection of dams but it did have some useful information such as: the function of dam supervision in New Jersey is performed by the Chief Engineer, Division of Water Policy and Supply, Department of Conservation and Economic development. Inspection of dams is done by the State at the State's own expense on the complaint of potential failure.

Additional information on dam inspection is also coming from the Corps of Engineers and the United States Committee on Large Dams.

JF:lk

cc: Dean C. Noll
Robert G. Wieland

Report on Dam Inspection

YANAGUE PROJECT

Application No. 32.

Location 23.31.5.4.8 and nearby.

On March 23, 1928, the gates in the main dam were closed except for the passage of 27 m. g. d. through the blow-off, and on March 29, 1928, the water in the reservoir had risen 7 feet.

On March 29, 1928, in company with Mr. H. T. Critchlow, inspection was made of all of the dams in the Yanague project.

Furnace Road dam was found to be about 50 per cent complete.

Post Rock Diversion dam, weir and control house were complete except for closing a small breach which was left in the dam for stream control, and installation of recording gage in the control house.

Yanague Main dam.

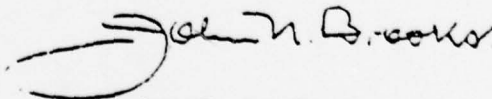
Midvale Dam.

Overflow Weir.

Wolf Den Dam, and

Green Swamp Dams Nos. 1, 2, 3 and 4 were complete and were given final inspection.

The construction of all dams has been done in accordance with the approved plans and in a thoroughly workmanlike and satisfactory manner.



John H. Brooks
Hydraulic Engineer.

C 7/30
Trenton, N. J.

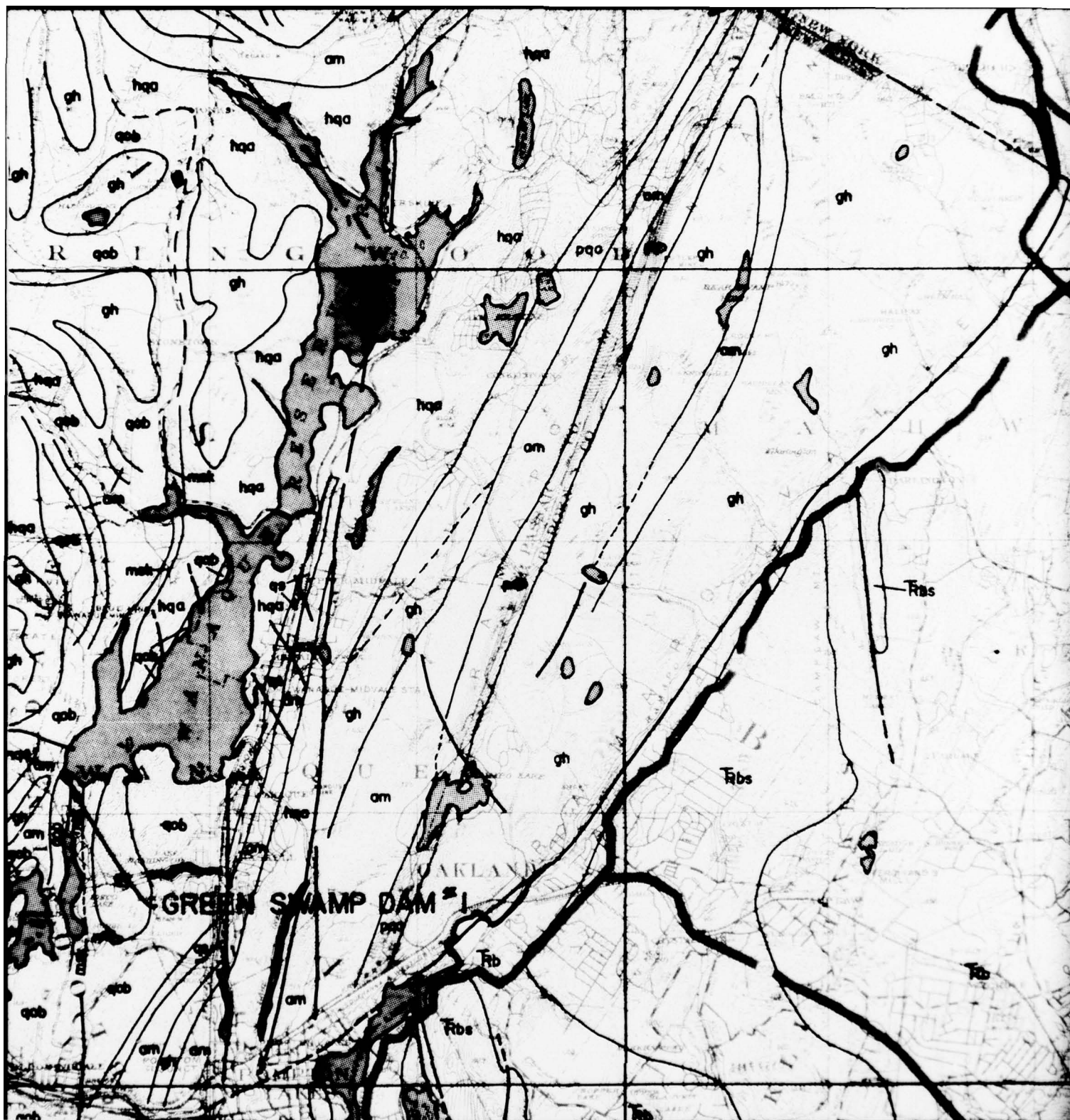
March 30, 1928.

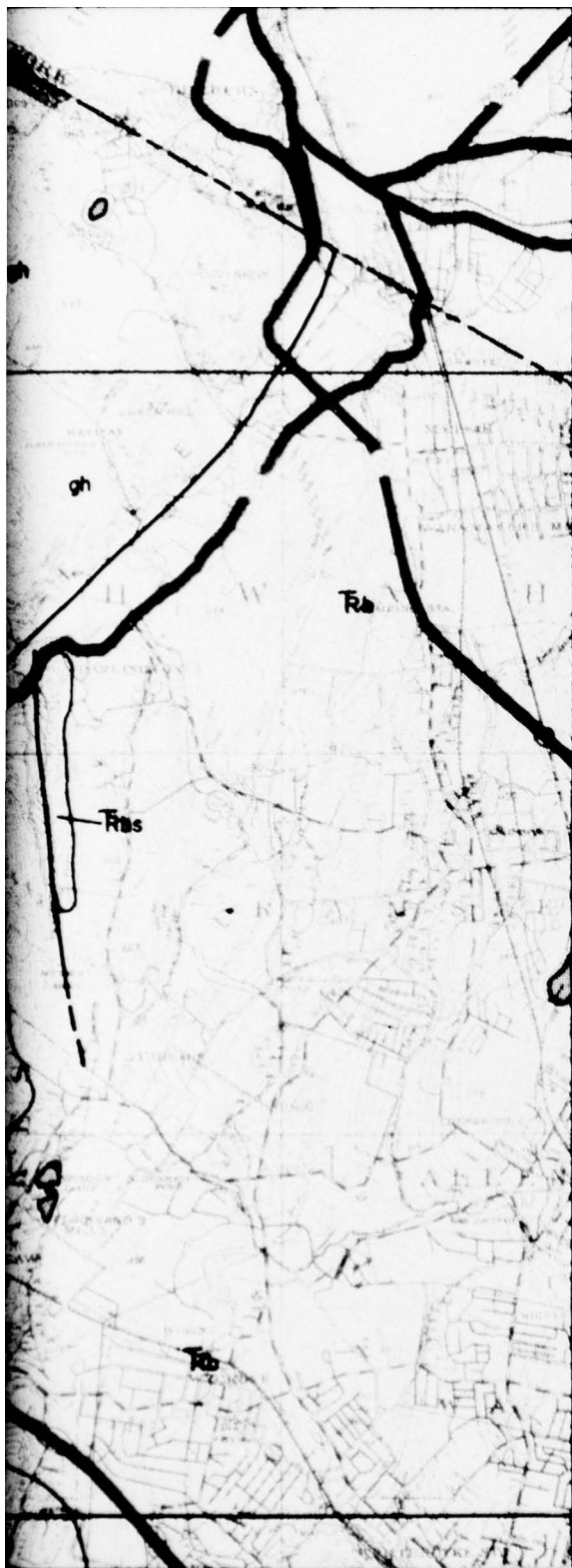
(New Jersey - Dept. of Environmental Protection)

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDG

APPENDIX F

REGIONAL GEOLOGIC MAP





LEGEND

TRIASSIC

Tbb BRUNSWICK FORMATION
Tbs BASALT FLOWS

PRECAMBRIAN

gh MOSTLY HORNBLLENDE GRANITE AND GRANITE GNEISS
am AMPHIBOLITE
pqo PYROXENE GNEISS; MAINLY QUARTZ-OLIGOCLEASE -
CLINOPYROXENE GNEISS
hqa PYROXENE GNEISS; MAINLY QUARTZ-ANDESINE GNEISS
WITH BOTH ORTHO-AND CLINOPYROXENE
qo QUARTZ-OLIGOCLEASE-GNEISS
qob QUARTZ-OLIGOCLEASE-BIOTITE GNEISS
qs SILLIMANITE GNEISS
msk MARBLE AND SKARN

——— CONTACT LINE
- - - - - FAULT LINE

NOTES:

1. THE PRECAMBRIAN MAP UNITS REPRESENT GENERALIZED GROUPINGS OF ROCK TYPES BASED MAINLY ON MINERAL COMPOSITION. THERE IS MUCH LOCAL VARIATION IN THE MINERAL COMPOSITION.
2. THE CONTACT LINES AND FAULT LINE SHOWN ON THE DRAWING ARE DASHED WHERE INFERRED.

SOURCE:

NEW JERSEY GEOLOGICAL SURVEY TOPOGRAPHIC SERIES
AND GEOLOGIC OVERLAY SHEETS 23.



APPENDIX F REGIONAL GEOLOGIC MAP SHOWING DAM LOCATION

APPENDIX G

REFERENCES

APPENDIX G

REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Appendix D, (Washington, D.C., Department of the Army, Office of the Chief of Engineers).
2. North Jersey District Water Supply Commission - Report 1925, (Newark, N.J., Office of the Commission), 1925.
3. Public Works, Vol. 54, No. 5, May 1923.
4. Water Resources Data for New Jersey, Part 1, Surface Water Records, United States Department of the Interior, Geologic Survey.
5. HEC-1 Flood Hydrograph Package, Hydrologic Engineering Center, Corps of Engineers, January, 1973.
6. Daily Reservoir Water Level and Discharge Record Files from October 1950 to date, owned by the NJDWSC.
7. Water Resources Data for New Jersey, Part 1, Surface Water Records, USGS, Department of the Interior.
8. "Passaic River Basin - New Jersey and New York Survey Report for Water Resources," New York District Corps of Engineers, June 1972.

APPENDIX H

CONDITIONS

APPENDIX H

CONDITIONS

This report is based on a visual inspection of the dam, a review of available engineering data, and a hydrologic analysis performed during Phase I investigation as set forth in the Recommended Guidelines for Safety Inspection of Dams, as modified by the contract between the U.S. Corps of Engineers and Gilbert Associates, Inc., Contract No. DACW61-78-C-0114.

The foregoing review, inspection, and analysis are by their nature limited in scope. It is possible that hazardous conditions exist and that conditions exist which with time might develop into safety hazards and that these conditions are not detectable by means of the aforesaid review, inspection, and analysis. Accordingly Gilbert Associates, Inc. cannot and does not warrant or represent that conditions which are hazardous do not exist, or that conditions do not exist which with time might develop into safety hazards.

As required by the Corps of Engineers, the terms "good", "fair", "poor", "condition" have been used in this report to characterize the information obtained from the aforesaid review, inspection, and analysis. The definitions of these terms as used are:

- "good condition" - minor studies or remedial measures are required.
- "fair condition" - sizeable studies or remedial measures are required due to the deficiencies which could be hazardous depending on conditions. Immediate attention is required.
- "poor condition" - major studies or remedial measures are required due to deficiencies which could be hazardous depending on conditions. Immediate studies or corrective action is required.