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NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. GRENLOCH LAKE DAM (NJ 00402), DELA--ETC(U)
MAR 79 F KEITH JOLLS

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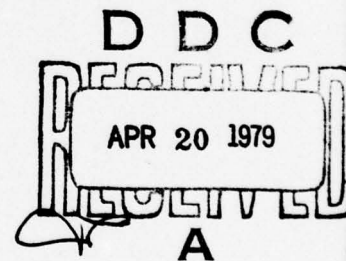
DELAWARE RIVER BASIN
SOUTH BRANCH TIMBER CREEK
GLOUCESTER AND CAMDEN COUNTIES
NEW JERSEY

LEVEL #

GRENLOCH LAKE DAM

NJ 00402

**PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM**



DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

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March, 1979

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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.		

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
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PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-D

9 APR 1979

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

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Grenloch Lake Dam in Gloucester County and Camden 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 in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Grenloch Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The spillway's capacity is considered inadequate since 44% of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The adequacy of the spillway should be determined by a qualified professional consultant, engaged by the owner, using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within twelve months of the date of approval of this report the following remedial actions should be completed:

(1) Regrade and provide slope protection for the downstream embankment areas at the bridge wingwalls and the downstream channel banks.

(2) Remove trees on the downstream embankment slopes.

NAREN-D

Honorable Brendan T. Byrne

(3) Place riprap in the downstream stilling basin to prevent scouring.

(4) Repair the spalled and deteriorated concrete surfaces of the bridge substructure.

(5) Remove debris from the spillway entrance.

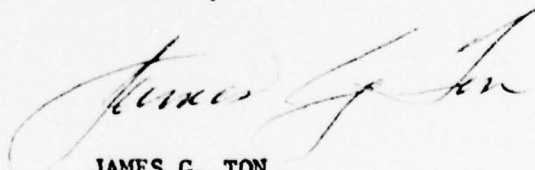
c. The owners should upgrade operation and maintenance procedures by issuing a check list for periodic inspections and institute a system of record keeping for severe storms.

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 James J. Florio of the First District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five 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,



JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

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P. O. Box CN029
Trenton, NJ 08625

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GRENLOCH LAKE DAM (NJ00402)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 6 December 1978 by Louis Berger and Associates, Inc. under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Grenloch Lake Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The spillway's capacity is considered inadequate since 44% of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The adequacy of the spillway should be determined by a qualified professional consultant, engaged by the owner, using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980.

b. Within twelve months of the date of approval of this report the following remedial actions should be completed:

(1) Regrade and provide slope protection for the downstream embankment areas at the bridge wingwalls and the downstream channel banks.

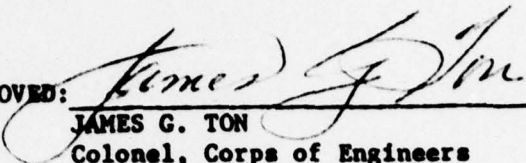
(2) Remove trees on the downstream embankment slopes.

(3) Place riprap in the downstream stilling basin to prevent scouring.

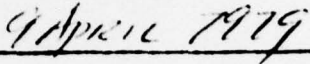
(4) Repair the spalled and deteriorated concrete surfaces of the bridge substructure.

(5) Remove debris from the spillway entrance.

c. The owners should upgrade operation and maintenance procedures by issuing a check list for periodic inspections and institute a system of record keeping for severe storms.

APPROVED: 

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

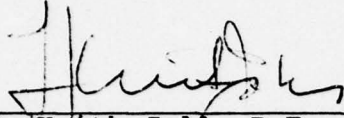
Name of Dam Grenloch Lake Dam Fed ID# NJ 00402 and
NJ ID# 533

State Located New Jersey
Counties Located Gloucester/Camden
Coordinates Lat. 3947.0 - Long. 7503.5
Stream South Branch Timber Creek
Date of Inspection 6 December 1978

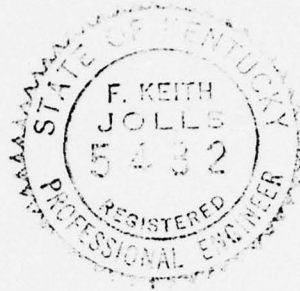
ASSESSMENT OF
GENERAL CONDITIONS

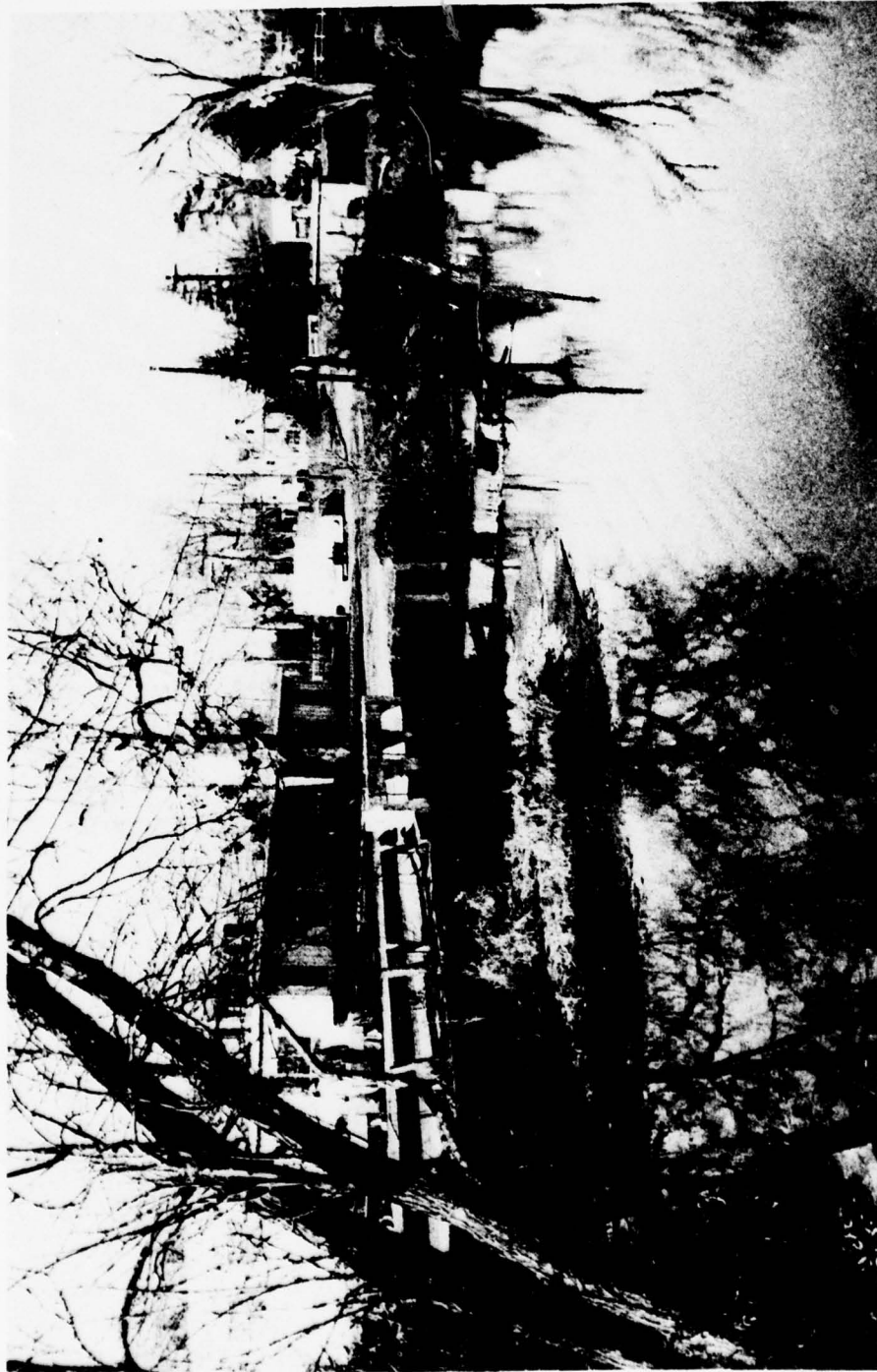
Grenloch Lake Dam is assessed to be in an overall fair structural condition and is recommended to be downgraded from a high hazard to a significant hazard category. Overtopping of the highway crossing the dam would not significantly increase the danger of loss of life or property damage as the downstream flood plain is, for the most part, uninhabited. No detrimental findings were uncovered to render a questionable judgement as to the structural stability. Remedial actions recommended to be undertaken in the future are 1) regrade and protect the downstream embankment areas at the bridge wingwalls, 2) remove root systems on the downstream embankment slopes, 3) place riprap in the downstream channel, 4) patch the concrete surfaces of the bridge substructure, and 5) remove all timber debris.

This dam has an inadequate spillway capacity, being able to accommodate only 38% of the spillway design flood.



F. Keith Jolls P.E.
Project Manager





OVERVIEW OF GRENLOCH LAKE DAM

December 1978

TABLE OF CONTENTS

	<u>Page</u>
Assessment of General Conditions	
Overall View of Dam	
Table of Contents	
Preface	
Section 1 - Project Information	1-5
Section 2 - Engineering Data	6
Section 3 - Visual Inspection	7-9
Section 4 - Operational Procedures	10
Section 5 - Hydraulic/Hydrologic	11-12
Section 6 - Structural Stability	13-14
Section 7 - Assessments/Recommendations/ Remedial Measures	15-17

FIGURES

- Figure 1 - Regional Vicinity Map
- Figure 2 - General Plan of Dam and Sections
- Figure 3 - Spillway Details

APPENDIX

- Check List - Visual Inspection
 - Check List - Engineering Data
 - Photographs
 - Check List - Hydrologic and Hydraulic Data
 - Computations
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PREFACE

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

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. 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 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. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM: GRENLOCH LAKE DAM FED ID# NJ 00402

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with Contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The State, in turn, is under agreement with the U.S. Army Engineer District, Philadelphia, to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Grenloch Lake Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Grenloch Dam is an old local street embankment approximately 250 feet long which contains a concrete spillway bridge structure and a timber box inlet on the upstream face. The embankment carries Central Avenue across the south end of the lake and has an average height of 15.7 feet adjacent to the spillway bridge. The timber box inlet is roughly 18' x 27' and discharges directly into a three celled bridge sluiceway.

b. Location

Grenloch Lake Dam is located 0.3 mile north of the intersection of Grenloch Road and the

Woodbury-Turnersville Road on Central Avenue at the Gloucester and Camden Counties boundary and is built across the South Branch of Timber Creek. It is roughly one mile north of the Atlantic Expressway (Route 42) interchange with the Black Horse Turnpike (Route 168) in Turnersville, New Jersey.

c. Size Classification

The maximum structural height of the dam is 21.2 feet at the bridge structure and the maximum storage is estimated to be 272.7 acre-ft. Therefore, the dam is placed in the small size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification

Based on the inspection criteria and the fact that in the event of a failure, the only substantial property damage that might be inflicted would be to the drainage structure at Lakeland Road (about 2000' downstream), the hazard classification is recommended to be downgraded to significant hazard. The two factory complexes each side of and just below the dam and all surrounding residential areas are above flood elevation. The downstream flood plain is basically vacant of development.

e. Ownership

As best as could be determined, the ownership of the road and bridge structure which forms the dam is jointly shared by the Boards of Chosen Freeholders of both Camden and Gloucester Counties. Dam Application No. 533 (dated 3 June 1959) indicated a certain Veselka Inc. filed the application for repairs but this firm could not be located or its prior ownership verified. The county dividing line passes through the center of the spillway bridge, and the dam embankment is a municipal street, thereby implying some form of joint ownership. The lake bottom and shores are

presently the property of the Catholic Youth Organization of the Camden Diocese, 1845 Haddon Avenue, Camden, 08103. Their representatives believe that they do not own the dam structure proper but may be responsible for the maintenance.

f. Purpose of Dam

The dam presently impounds a recreation lake. However, a water supply pump house and pressurized tank system exists near the right abutment and are the property of the A.L. Hyde Co. which is located across the street and immediately below the right abutment. In addition, there is a municipal water supply intake near the left abutment which is reportedly used as an ancillary fire protection facility.

g. Design and Construction History

Early unsubstantiated records indicate the dam was first built in 1907. It was reconstructed in 1940 after a storm washed out the right embankment and heavily damaged the left. The roadway bridge was left standing but the right bridge abutment sustained severe damage. Failure was due to a scouring out of the downstream slopes by the overtopping flow. In 1956, acting upon a complaint of a downstream property owner, the State Division of Water Policy and Supply inspected the dam and reported that the sluiceway structure was in serious condition and recommended immediate reconstruction. No action was taken until another inspection performed by Division engineers in 1958 found unapproved "premature" repairs being made to the spillway (before the hydraulic capacity for the renovations had been approved by the Division). In the following year, Veselka Inc. (then owners of the lake) entered into contract with John G. Reutter & Associates, Consulting Engineers, for the design of a new spillway. Before the approved plans went to bid, Veselka Inc. sold Grenloch Lake along with surrounding lands

to the Catholic Youth Organization of Camden. The reconstruction finally began on the new spillway in 1961. Visual inspection indicated that no major modifications have been performed since the construction of a timber box inlet in front of the highway bridge.

h. Normal Operating Procedures

No information could be obtained relating to operating procedures (see Section 4).

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of Grenloch Lake Dam is 14.6 square miles.

b. Discharge of Dam Site

The spillway capacity with the reservoir at the abutment top elevation is calculated to be 2,274 cfs. No discharge records are available at this site except earlier Division of Water Policy and Supply records which indicated a design flood of 1500 cfs (Central Jersey Curve) was employed for this site.

c. Elevation (Above M.S.L.)

Top of dam - +45.2 (Bridge deck)
Recreation Pool - +40.5
Streambed at Center Line of Dam - +29.5

d. Reservoir

Length of Maximum Pool - 4200 feet
Length of Recreation Pool - 2700 feet

e. Storage

Top of dam - 272.7 acre-ft.
Recreation Pool - 92.5 acre-ft.

f. Reservoir Surface

Top of dam - 55.8 acres
Recreation pool - 20.9 acres

g. Dam

Type - Earth embankment with timber box spillway
Length - 250 feet
Max. height - 21.2 feet (concrete bridge structure)
Effective height at spillway - 15.7
Freeboard between normal reservoir and top
of dam - 4.7 feet
Top width - 24 feet
Side slopes - 3H:1V u/s, 2H:1V d/s
Zoning - composition and compactness unknown

h. Diversion and Regulating Tunnel

None

i. Spillway

Type - timber box drop inlet (3 sided)
Length of weir - 72 feet
Crest Elevation - +40.5

j. Regulating Outlets

None

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The only information available for review were partially legible drawings of the 1960-61 reconstruction work prepared by John G. Reutter Associates which depicted, in part, the details of the timber spillway. No design or construction drawings were located for the earlier roadway or bridge work although it was recorded earlier with the State Water Quality Commission as Dam #31-30 (circa 1958).

2.2 CONSTRUCTION

No information was available except for the fact the 1960-61 repair work was done by J.D. Moore Inc. of Bridgetown.

2.3 OPERATION

See Section 4

2.4 EVALUATION

a. Availability

In view of the dam assessment and recommendations contained in Section 7, it is felt sufficient engineering data is available without recourse to obtaining additional design data on the original contract plans.

b. Adequacy

In view of the dam assessment and recommendations contained in Section 7, it is felt the field inspection provided adequate engineering data upon which to base a reliable assessment.

c. Validity

The validity of the 1960 plans is not challenged.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

The visual inspection was conducted on December 6, 1978 at which time the water level in the lake was producing a moderate flow over the inlet (which prevented close inspection of the timber spillway). The overall physical condition of the dam is fair but the embankment slopes are very poorly graded, especially at the bridge downstream wingwalls.

b. Dam

The roadway embankment, which forms the main dam structure, was assessed to be in a solid and stable condition although pavement run-off at the gutter lines causes a continual drainage problem, especially on the downstream side. The crest of the dam is an asphalt-paved two-lane street. A corrugated metal curb inlet has recently been installed just to the left of the bridge (to alleviate the run-off problem) but a considerable portion of the downstream sideslopes adjacent to the wingwalls has been washed out. There are numerous fair sized trees growing in the vicinity of the downstream wingwalls and considerable siltation was noted in the reservoir immediately upstream from the dam. The effective embankment height on both sides of the spillway bridge is extremely low as the properties on each side immediately downstream contain factory buildings and have backfilled up to within about three feet of dam crest on the left side (the H.G. Enderlein foundry) and practically at dam crest on the right (the A.C. Hyde Co.). The roadway profile is fairly level across the dam but rises on either end just past the abutments. There was no riprap protection observed at this site.

c. Appurtenant Structures

The concrete bridge which carries the Central Avenue traffic over the spillway is in poor condition. It is a rather unique three-celled culvert with 5 feet wide cells divided by solid piers and cross beams below spillway elevation. Each sluiceway originally had stoplog barriers at the fascia line but these have been completely vandalized or removed. Hoisting devices were originally installed on the parapet railings but the only equipment remaining are the torsional anchorages. The concrete is in an overall poor condition with severe spalling and cracking. At the northwest corner, there is a large piece of the concrete wingwall that has been undermined and collapsed down into the embankment toe.

The 18' x 27' timber box spillway appears to be in a satisfactory condition although the flow was quite heavy at the time of inspection (which prevented a close examination). The crest elevation and horizontal alignment are satisfactory. Although the rectangular inlet has a total drop of 10 feet, it is partially blocked with timber debris. Just to the upstream right of the spillway, there is a row of steel sheeting driven out at a 45° angle from the dam axis. This serves adequately to protect the upstream wingwall to the right of the spillway. On the left, a low concrete retaining wall extends along the dam face to the abutment.

d. Reservoir

Grenloch Lake has stable wooded banks but there is little evidence of maintenance. About 1500 feet upstream, the lake extends under Black Horse Pike in a 9x5 foot box culvert.

e. Downstream Channel

The downstream channel is well defined and flows through a basically undeveloped river valley until it passes under County Bridge BR 8C-11 at Lakeland Road (about 2000 feet to the north). Below that bridge there

is a sewage treatment plant on lower terrain. The only commercial developments that would be endangered if the dam were overtopped would be the Enderlein and Hyde factories which are immediately below the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operational procedures were not observed by the inspection team. The present owner of the lake believes they have only maintenance responsibility and know nothing of any operational procedures undertaken in the past (except for dewatering the lake several years ago).

4.2 MAINTENANCE OF DAM

Maintenance of the roadway and bridge are carried out as part of the maintenance program for the street system. There is apparently little or no continual maintenance of the timber intake.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no workable operating facilities as the stoplogs that were originally installed at the bridge fascias are all demolished.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

There is no formalized warning system in effect as the dam has not been overtopped since 1940 and it is positioned on the county boundary line which may be the cause of possible jurisdictional misunderstanding.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

Present procedures and safeguards are deemed to be adequate in view of performance record and the lack of hazards relating to the dam. However, it is felt that the ownership responsibility of maintenance should be clarified in the future by responsible authorities notwithstanding the fact that the structure is operating satisfactorily although essentially unattended.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In accordance with the criteria in the Recommended Guidelines for Safety Inspection of Dams, it has been determined that the dam at Grenloch Lake is small in size and of significant hazard. Accordingly the spillway design flood (SDF) was determined by the inspection team to be one half the probable maximum flood (PMF). The inflow hydrograph was calculated using precipitation data from Hydrometeorological Report #33. The inflow hydrograph and flood routing were performed utilizing the HEC-1 computer program. Peak inflow to the reservoir for the one-half PMF storm was 5,990 cfs and when routed, reduced insignificantly to 5,920 cfs. The spillway capacity before overtopping occurs is calculated to be 2,274 cfs. Therefore, the spillway will accommodate 38% of the SDF. This flood would cause the dam to be overtopped by approximately seven feet.

b. Experience Data

Records indicate that the dam has been overtopped and failed in the past (see paragraph 1.2.g.). In September 1940, a flood washed out the right abutment and severely undercut the left abutment. Highwater marks indicated that the floodwaters reached an elevation of roughly 4 feet above the road. There are no streamflow records available for the site.

c. Visual Observations

The timber box spillway appears to be functioning adequately except the opening is in need of cleaning. Because the terrain on either side of the spillway bridge is so close to dam crest elevation, any collapse of embankment would occur immediately to each side of the bridge wingwalls and discharge directly into the rather deep natural channel of Timber Creek.

d. Overtopping Potential

Based on the results of the hydraulic analysis, the capacity of the spillway is inadequate to accommodate the SDF. The dam has been overtopped at least once in the past and the hydraulic review indicates the potential for overtopping continues to exist although only minor downstream damage or hazardous conditions are likely to occur.

e. Drawdown Potential

At the present time, there are no facilities available to draw down the lake except to demolish part of the permanent timber box inlet.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

The concrete bridge structure, although extremely old, is in no immediate danger of collapse as long as the downstream footings are not undermined. Due to its rigid frame geometry, it has an inherently large amount of reserve strength. However, due to the constricted sluiceway channels beneath the deck, the excessive exit velocities are gradually scouring out the discharge channel and eventually could endanger the stability of the downstream wingwalls which parallel the channel banks. The dam embankment is judged to be in a satisfactory and stable condition as it is excessively wide in comparison to its height and there are no true backslopes except immediately adjacent to the wingwalls.

b. Design and Construction Data

As no design data was available relating to the concrete bridge, little can be deduced relative to its structural stability except that it exhibits only minor differential settlement or tilting and only minor structural cracking. Further in-situ knowledge of the foundation conditions would be required to verify, with any reliability, the long-term stability. The timber spillway, as long as it is buttressed into the bridge, is conservatively designed and judged to be in an adequate structural condition.

c. Operating Records

No formal operating records exist. As previously stated, the dam appears to have operated satisfactory as there is no record, according to local officials and residents, of the roadway having ever been overtopped since 1940.

d. Post Construction Changes

There have been no changes to the hydraulic elements of the dam since the 1961 installation of the timber box inlet. Highway guardrail and the CMP curb drain has been installed since then but have no effect on the dam's hydraulic capabilities. The steel sheeting was added at some unknown time prior to 1961.

e. Seismic Stability

The bridge appears to have an adequate factor of safety against static loadings and experience indicates that it will therefore have adequate stability against Zone 1 dynamic loadings. The height of the embankment is so low it will have negligible vulnerability due to any type of loading.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/
REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Subject to the inherent limitations of the Phase I visual inspection, the Grenloch Lake Dam is classified as being in a sound and overall fair condition insofar as its embankment structure is concerned but the concrete spillway bridge carrying vehicular traffic over the main discharge outlet is in need of repairs. No seriously detrimental findings were revealed in this inspection to render a questionable judgement as to the structural stability. The timber box spillway is inadequate hydraulically, being able to accommodate only 39% of the $\frac{1}{2}$ PMF design flood. The overtopping potential is considerable due to the hydraulically sub-standard spillway crest width and the ease with which the narrow sluiceway openings under the bridge can be blocked with debris. There is little that can be done to increase the present spillway capacity without undertaking major reconstruction. However, as there is only moderate downstream hazard to human life or property should the dam collapse and its hazard category is recommended to be downgraded to significant.

b. Adequacy of Information

The information gathered for the Phase I inspection is deemed to be adequate regarding the structural stability of the dam except for the lack of detailed information regarding the bridge foundations. No surveys or inspections have been recorded since 1967 and the dam has undergone deterioration since that time.

c. Urgency

No urgency is attached to implementing further studies in view of the dam hazard assessment. It is recommended that the remedial measures set forth below be taken under advisement in the near future except that the removal of debris which should be undertaken this coming spring.

d. Necessity for Further Study

Due to the downgraded significant hazard classification and the fact that only moderate downstream property damage is likely in case of a failure, further engineering studies, under the purview of the P.L. 92-367, are believed to be unnecessary.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that the ownership and responsibility for maintenance be clarified. Should anything occur at this site involving a structural collapse or personal accident, the legal ambiguities and ensuing recriminations could present an unconscionable and derisive reflection on the enforcement by the Division of Water Resources. of the State's dam safety criteria.

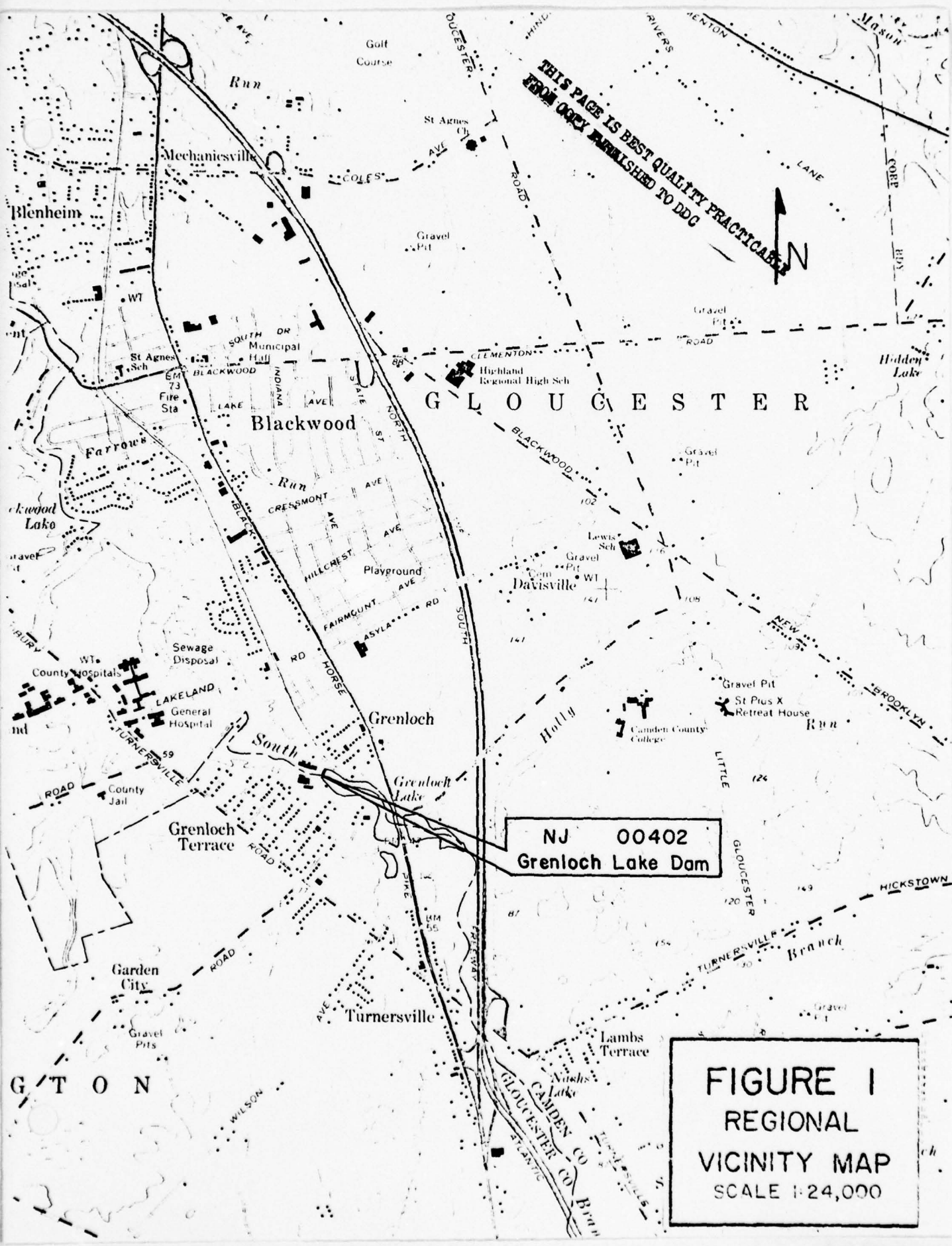
a. Alternatives

- The downstream slopes of the dam embankment in the vicinity of the bridge wingwalls should be regraded, compacted and topped with suitable slope paving and the channel banks immediately downstream should be protected with stone riprap.
- The trees should be removed from the backslopes and the disturbed areas regraded, compacted and seeded.

- The downstream stilling basin should be filled in with heavy stone to prevent continual scouring and preclude the undermining of the bridge structure.
- The timber debris should be cleared from the spillway entrance. In view of the absentee ownership, it would be advisable to clean up the fallen trees and timber drift around the lake perimeter.
- Patch the spalled and deteriorated concrete surfaces of the bridge (especially on the downstream side).

b. O&M Maintenance and Procedures

The owners should upgrade O&M procedures by issuing check lists for periodic inspections and institute a system of record keeping for severe storms.

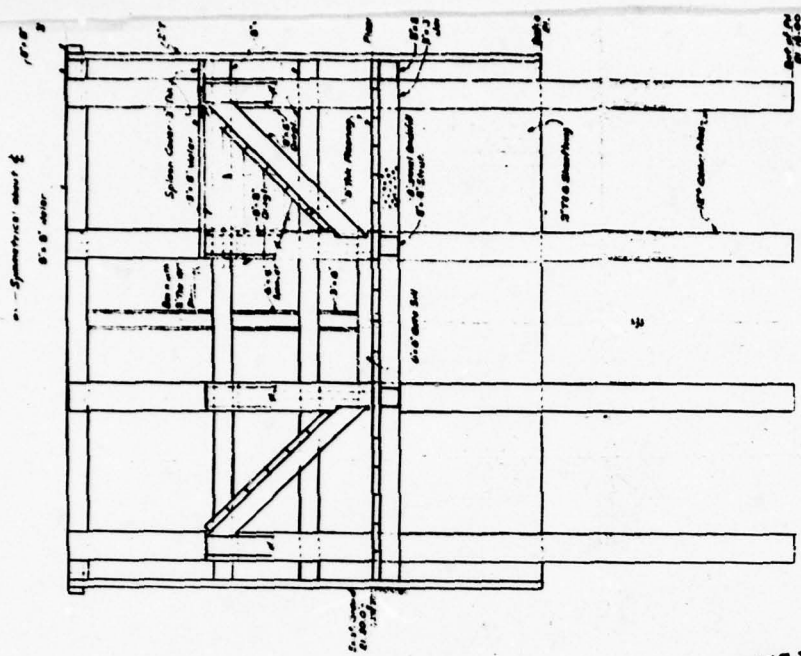
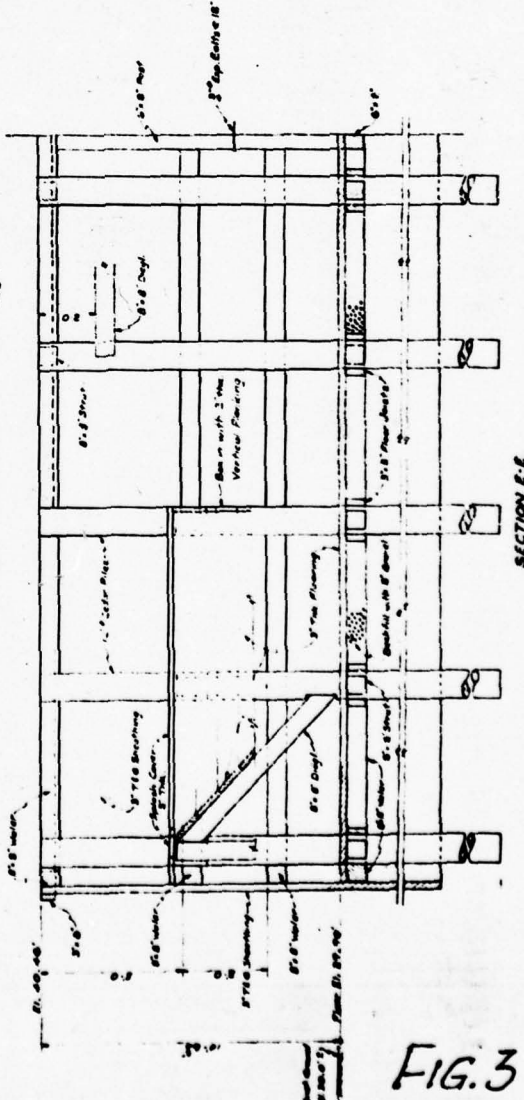
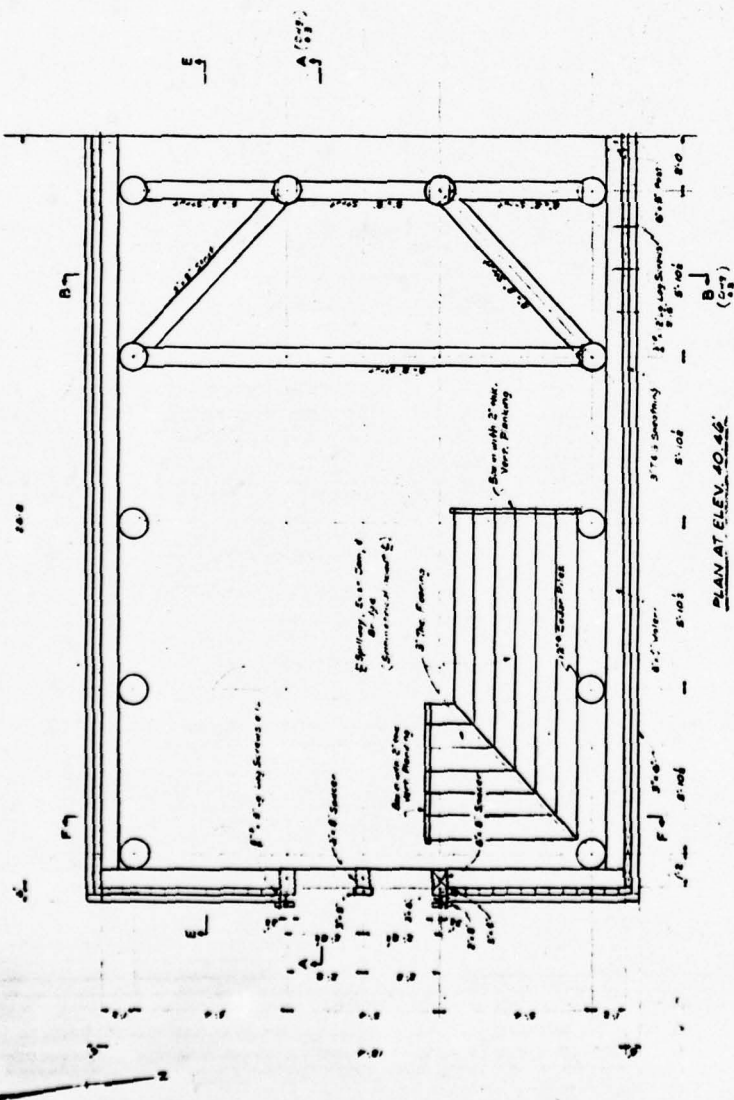


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NJ 00402
Grenloch Lake Dam

FIGURE I
REGIONAL
VICINITY MAP
SCALE 1:24,000





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SECTION F-F

FILE

NOTES

See Notes on Page 93

SECTION A-A

FILE

SPILLWAY DETAILS
(Sheet 3)
J. G. Burrows and Associates
Civil Engineers
1100 Main Street, N.E.
Atlanta, Georgia 30309
Phone 462-1100

FIG. 3

Check List
Visual Inspection
Phase 1

Name Dam Grenloch Lake Dam County Gloucester/Camden State New Jersey Coordinators NJDEP

Date(s) Inspection Dec. 6, 1978 Weather Clear Temperature 45°

Pool Elevation at Time of Inspection + 41 M.S.L. Tailwater at Time of Inspection + 30 ± M.S.L.

Inspection Personnel:

K. Jolls

E. Simone

R. Lang

M. Carter

R. Lang Recorder

Dam No. 00402

CONCRETE/MASONRY DAMS

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SEE PAGE ON LEAKAGE

STRUCTURE TO
ABUTMENT/EMBANKMENT
JUNCTIONS

Satisfactory

DRAINS

18" ϕ roadway catchbasin drains at
NW Corner.

WATER PASSAGES

None

FOUNDATION

Unknown - most probably timber pilings.

CONCRETE/MASONRY DAMS

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SURFACE CRACKS
CONCRETE SURFACES

STRUCTURAL CRACKING

Very old structure with much cracking and spalling.

VERTICAL AND HORIZONTAL
ALIGNMENT

Satisfactory - dam is roadway embankment.

MONOLITH JOINTS

Satisfactory

CONSTRUCTION JOINTS

Railing is bolted and strapped to bridge superstructure.

EMBANKMENT

REMARKS OR RECOMMENDATIONS

SPECIAL EXAMINATION OF

OBSERVATIONS

SURFACE CRACKS

None observed.

UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE

None observed.

SLoughing OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES

Severe erosion at downstream corners of wingwalls.

VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST

Satisfactory - dam is roadway embankment.

PIPING FAILURES

NW Corner - large concrete slab collapse, down in back of wingwall.

EMBANKMENT

USUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
----------------------	--------------	----------------------------

FUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Satisfactory - road embankment, asphalt paved (2 lane road).	
---	---	--

ANY NOTICEABLE SEEPAGE	None observed.	
------------------------	----------------	--

STAFF GAGE AND RECORDER	None	
-------------------------	------	--

DRAINS	None	
--------	------	--

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	30' long parallel wingwalls on bridge abutments, minor cracking.	
INTAKE STRUCTURE	See concrete weir section.	
OUTLET STRUCTURE	2 - outside culverts had timber flashboards which could be raised or lowered, no flashboards were present.	
OUTLET CHANNEL	See downstream channel section.	
EMERGENCY GATE	None	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Timber box drop inlet approximately 25' x 18' 45° flashboards inside, good condition. Much debris on crest and in box structure.	
APPROACH CHANNEL	None - Grenloch Lake directly above dam and timber box inlet.	
DISCHARGE CHANNEL	Natural channel, steep banks 1:1 approximately 20-25' wide.	
BRIDGE AND PIERS	Very old roadway bridge, part of outlet structure, 2 rows of 5 supports each support deck, water passages divided into three sections each about 3½' wide, much spalling on concrete.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION			REMARKS OR RECOMMENDATIONS
VISUAL EXAMINATION MONUMENTATION/SURVEYS	OBSERVATIONS		
	None		
OBSERVATION WELLS	None		
WEIRS	None		
PIEZOMETERS	None		
OTHER	Pump house to right of spillway for factory nearby.		

RESERVOIR

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

SLOPES

1:1 banks 8-10' above spillway intake elevation.
Banks heavily overgrown.

SEDIMENTATION

None observed.

DOWNSTREAM CHANNEL

REMARKS OR RECOMMENDATIONS

OBSERVATIONS

VISUAL EXAMINATION OF

CONDITION
(OBSTRUCTIONS,
DEBRIS, ETC.)

Some debris and long on stream banks.
Generally clear and swift moving flow.

SLOPES

Steep - about 2:1, banks about 15' high just
below bridge. Large trees and heavy
undergrowth on banks.

APPROXIMATE NO.
OF HOMES AND
POPULATION

None in immediate area.
Nearest homes on much higher ground.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available
REGIONAL VICINITY MAP	Available
CONSTRUCTION HISTORY	Some known
TYPICAL SECTIONS OF DAM	Available
HYDROLOGIC/HYDRAULIC DATA	Some available
OUTLETS - PLAN	Available
- DETAILS	Available
-CONSTRAINTS	None available
-DISCHARGE RATINGS	None available
RAINFALL/RESERVOIR RECORDS	None available

ITEM	REMARKS
------	---------

DESIGN REPORTS

None available

GEOLOGY REPORTS

None available

DESIGN COMPUTATIONS
HYDROLOGY & HYDRAULICS
DAM STABILITY
SEEPAGE STUDIES

Some available
Some available
None available
None available

MATERIALS INVESTIGATIONS
BORING RECORDS
LABORATORY
FIELD

None available
None available
None available
None available

POST-CONSTRUCTION SURVEYS OF DAM

None available

BORROW SOURCES.

Unknown

ITEM	REMARKS
------	---------

MONITORING SYSTEMS

None

MODIFICATIONS

Some known

HIGH POOL RECORDS

Available

POST CONSTRUCTION ENGINEERING
STUDIES AND REPORTS

None available

PRIOR ACCIDENTS OR FAILURE OF DAM
DESCRIPTION
REPORTS

Available
Available
Available

MAINTENANCE
OPERATION
RECORDS

None available

REMARKS

ITEM

SPILLWAY PLAN

Available

SECTIONS

Available

DETAILS

Available

OPERATING EQUIPMENT
PLANS & DETAILS

N/A



View East along crest (Central Ave.)

December 1978



Bridge deck and rail

December 1978



Grenloch Lake

December 1978



Downstream channel

December 1978



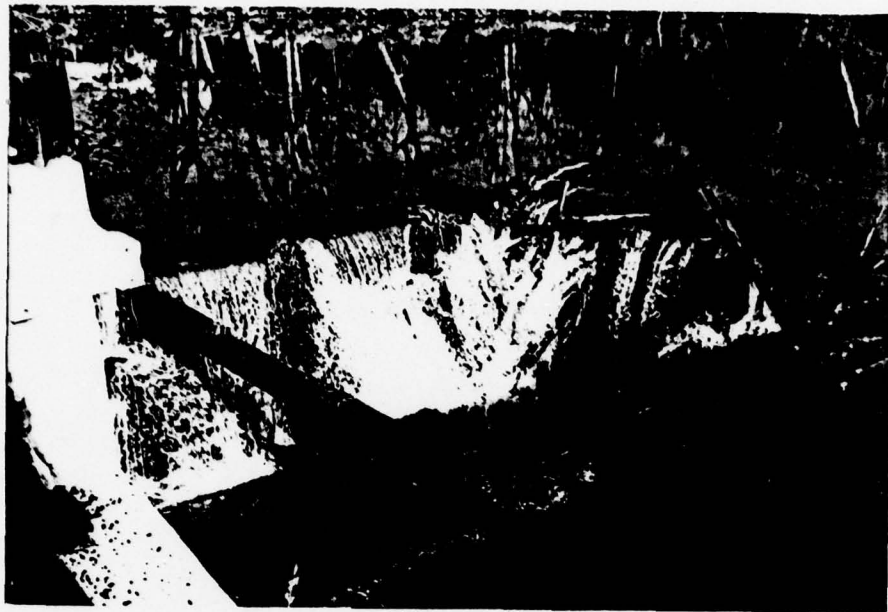
Steel sheeting

December 1978



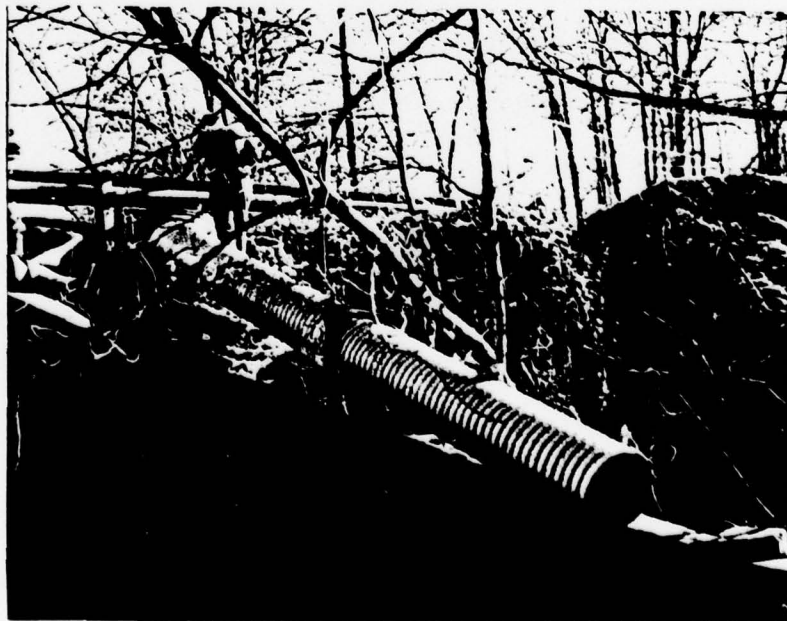
Bridge substructure

December 1978



Timber box spillway

December 1978



Surface drain pipe

December 1978

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 14.6 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 40.6 M.S.L. (acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): _____

ELEVATION MAXIMUM DESIGN POOL: _____

ELEVATION TOP DAM: 45.2 (bridge deck)

CREST: _____

- a. Elevation 40.56
- b. Type Timber box
- c. Width 8 inches
- d. Length 70' +
- e. Location Spillover 125' from right abutment
- f. Number and Type of Gates None

OUTLET WORKS: None

- a. Type _____
- b. Location _____
- c. Entrance inverts _____
- d. Exit inverts _____
- e. Emergency draindown facilities _____

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE: _____

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BY D.J.M. DATE 1-79
CHKD. BY _____ DATE _____
SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.
GREENLOCH LAKE DAM INSPECTION

SHEET NO. A1 OF _____
PROJECT C 226

CLARK COEFFICIENTS (FROM CORPS OF ENGINEERS)

$$t_c = 5.4$$

$$R = 12.6$$

PRECIPITATION

PMIF for 200 square miles & 24 hours duration = 24"

Maximum 6 hour percentage = 110

" 12 " " = 120

" 24 " " = 129

Drainage area = 14.6 sq miles ✓

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SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

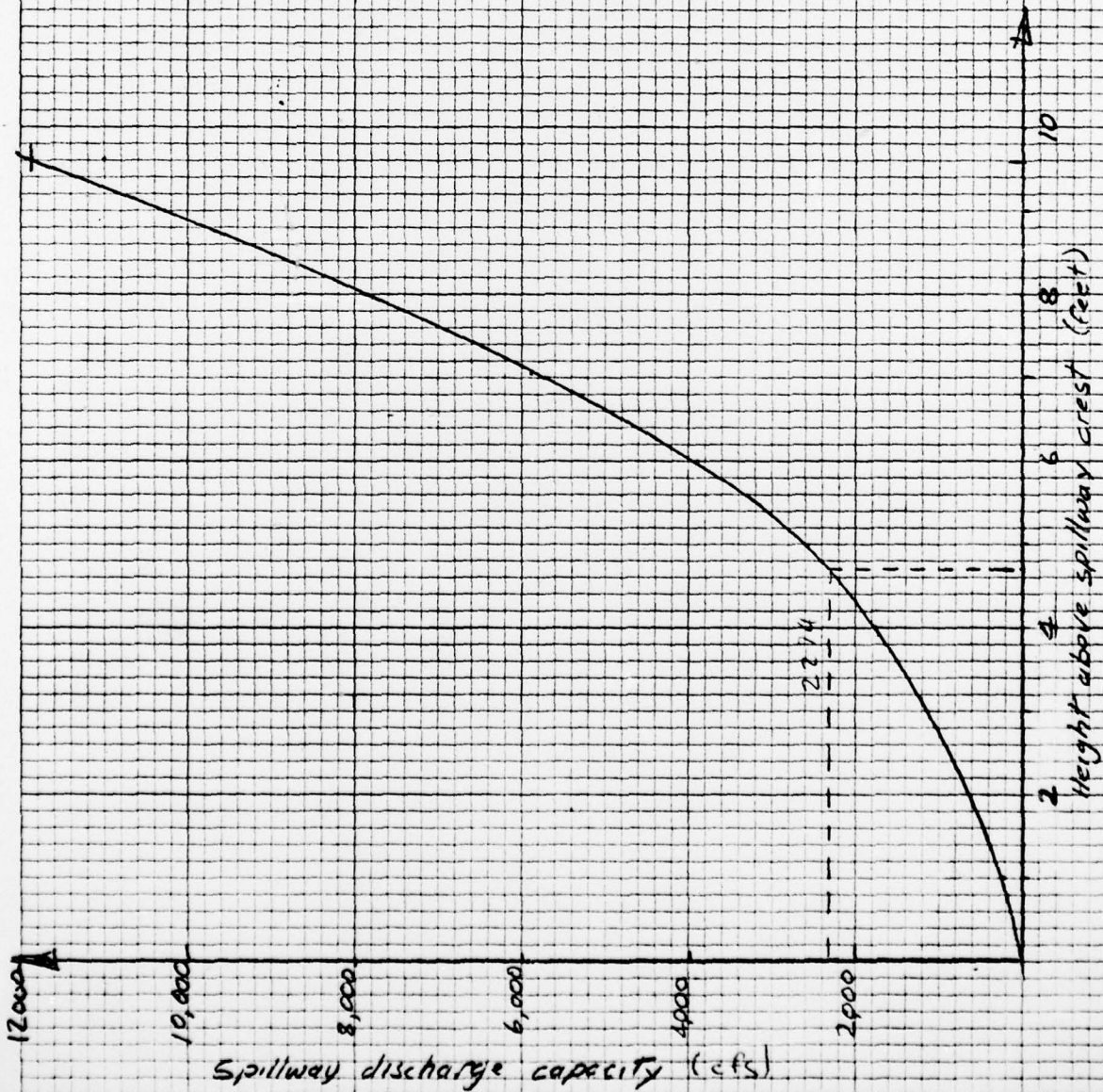
GREENLOCH LAKE DAM INSPECTIONSHEET NO. A2 OF _____PROJECT C226Spillway section effective length $\approx 72'$ @ El. 40.5Top of dam - length $\approx 250'$ @ El. 45.2

OVER SPILLWAY			OVER DAM			ΣQ
L = 72'			L = 178'			
H	C	Q	H	C	Q	
1	3.1	223				223
2	3.1	631				631
3	3.1	1160				1160
4	3.1	1786				1786
5	3.1	2495	0.30	2.8	82	2577
6	3.0	3175	1.30	2.8	739	3914
7	3.0	4000	2.30	2.8	1738	5738
8	3.0	4888	3.30	2.8	2988	7876
9	3.0	5832	4.30	2.8	4444	10276
10	3.0	6831	5.30	2.8	6081	12912

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GRENLOCH LAKE DAM
STAGE DISCHARGE CURVE

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46 0706

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
 KEUFFEL & ESSER CO. MADE IN U.S.A.

BY D.J.M. DATE 1-79

CHKD. BY _____ DATE _____

SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

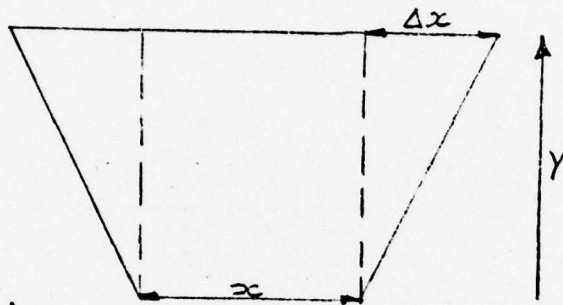
GRENOCH LAKE DAM INSPECTION

SHEET NO. A4 OF _____

PROJECT C 226

Area of lake @ El. 40.46 $\approx$ 20.9 acres

Area of contour @ El. 50.00 $\approx$ 91.7 acres



Increment in volume $\Delta V = (x + \Delta x)y$

HEIGHT ABOVE
CREST (feet)

STORAGE
(acre feet)

1	25
2	57
3	96
4	143
5	197
6	259
7	328
8	405
9	489
10	580

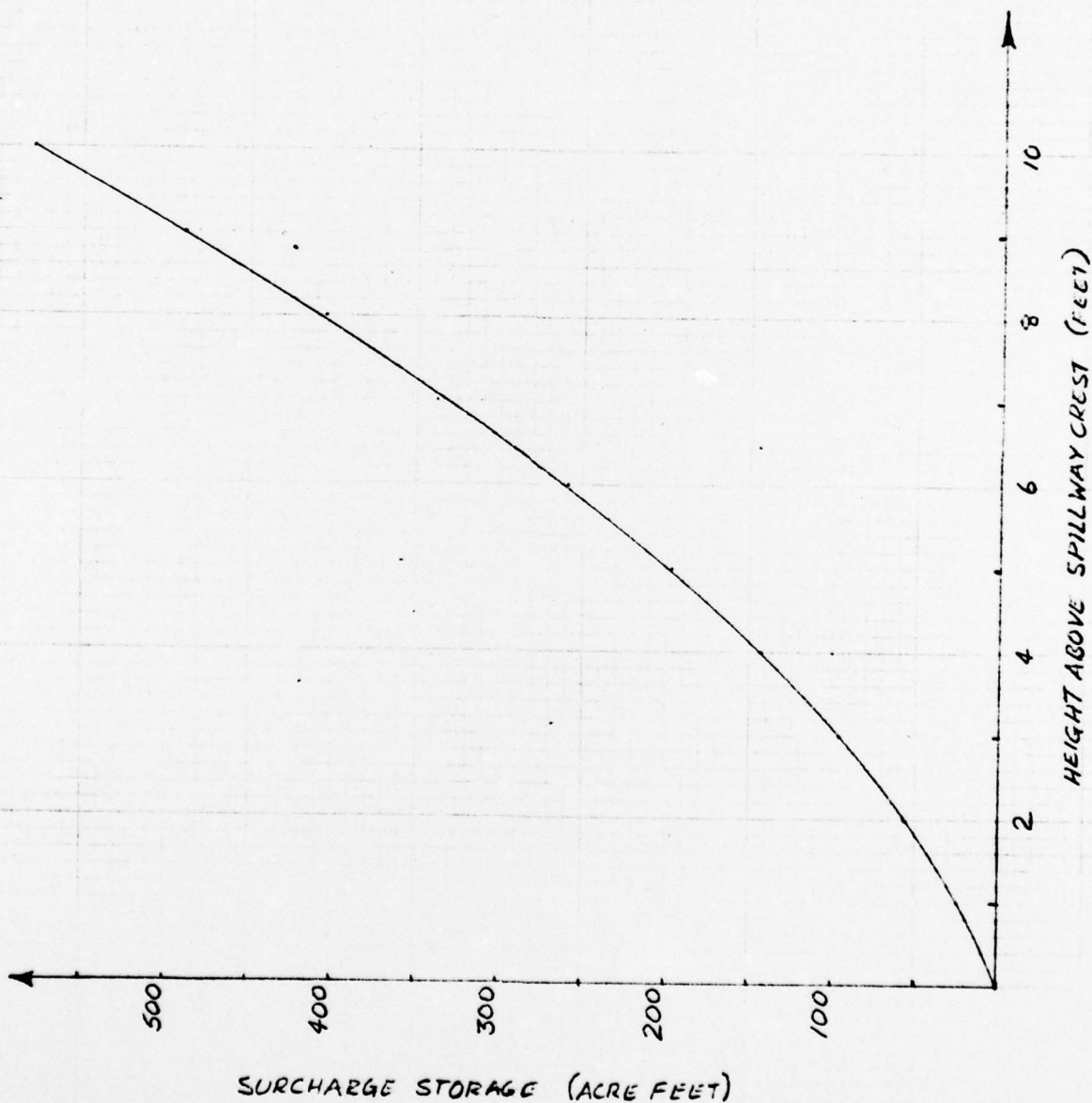
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BY DJM DATE 1-79
CHKD. BY _____ DATE _____

SUBJECT STAGE STORAGE CURVE
GRENOCH LAKE DAM INSPECTION

SHEET NO. A5 OF _____
JOB NO. C226

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LOUIS BERGER & ASSOCIATES INC.
GRENLOCH LAKE DAM

SHEET NO. A6 OF _____
PROJECT _____

HFC-1 VERSION: DATE: JAN 1977

IN THE SUPREME COURT OF THE UNITED STATES

GFFWILCH LARK DA
BY D.J. MULLIGAN
JANUARY 1979

JOB: SPECIFICATION										
NO	NHR	NMIN	IDAY	IHR	IWIN	MEIRC	IPLT	IPRT	NSTAN	
50	1	0	0	0	0	0	0	0	0	
			JOPER		NWT					
			5		0					

MULTI-PLAN ANALYSES TO BE PERFORMED

```

PLAN=1 NRTIO=5 LRTIO=1
RTIOS= 1.00 0.50 0.40 0.20 0.10

```

新加坡中華總商會

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

◆ ◆ ◆ ◆ ◆

★★★★★★★★★★

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SUB-AREA RUNOFF COMPUTATION

INFLUENCE OF HYDROGRAPH

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HYDROGRAPH DATA									
IMYDG	IUNG	TAREA	SNAP	TRSCP	RATIO	ISNOW	ISAME	LOCAL	
1	0	14.60	0.0	14.60	0.0	0	1	0	

PRECIP DATA

SPCL	PMS	R6	R12	R24
0.0	24.00	110.00	120.00	129.00

TRDPS COMPUTED BY THE PROGRAM IS 0.817

	LOSS DATA								
	DLTGP	RTIOL	ERAIN	STRKS	RITOK	STRTL	CNSTL	ALSMX	RTIMP
1-6	0-0	1-00	0-0	0-0	1-00	0-50	0-0	0-0	0-0

UNIT HYDROGRAPH DATA

TC=	5.40	R=	12.60	NIA=	0
-----	------	----	-------	------	---

REFLECTION DATA

```

ACCESSION DATA
STRTQ= 0.0  GRCSN= 0.0  RTORS= 0.00

```

UNIT HYDROGRAPH 70 END-OF-PERIOD ORDINATES. LAG= 5.33 HOURS. CP= 0.34 VOL= 1.00

Year	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404
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TIME	RAIN	EXCS	COMP G
END-OF-PERIOD FLOW			

BY DJM DATE 3-79
CHKD. BY _____ DATE _____
SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.
GRENOCH LAKE DAM

SHEET NO. A7 OF _____
PROJECT _____

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1	0.12	0.00	0.
2	0.12	0.00	0.
3	0.12	0.00	0.
4	0.12	0.00	0.
5	0.12	0.01	1.
6	0.12	0.02	3.
7	0.33	0.23	16.
8	0.33	0.23	54.
9	0.33	0.23	128.
10	0.33	0.23	234.
11	0.33	0.23	362.
12	0.33	0.23	494.
13	2.15	2.05	692.
14	2.58	2.48	1101.
15	3.22	3.12	1860.
16	8.16	8.06	3231.
17	3.00	2.90	5295.
18	2.36	2.26	7712.
19	0.18	0.08	9931.
20	0.18	0.08	11447.
21	0.18	0.08	11980.
22	0.18	0.08	11698.
23	0.18	0.08	11035.
24	0.18	0.08	10269.
25	0.0	0.0	9537.
26	0.0	0.0	8851.
27	0.0	0.0	8205.
28	0.0	0.0	7596.
29	0.0	0.0	7022.
30	0.0	0.0	6486.
31	0.0	0.0	5991.
32	0.0	0.0	5534.
33	0.0	0.0	5111.
34	0.0	0.0	4721.
35	0.0	0.0	4361.
36	0.0	0.0	4028.
37	0.0	0.0	3720.
38	0.0	0.0	3436.
39	0.0	0.0	3174.
40	0.0	0.0	2932.
41	0.0	0.0	2708.
42	0.0	0.0	2501.
43	0.0	0.0	2310.
44	0.0	0.0	2134.
45	0.0	0.0	1971.
46	0.0	0.0	1821.
47	0.0	0.0	1682.
48	0.0	0.0	1553.
49	0.0	0.0	1435.
50	0.0	0.0	1325.
51	0.0	0.0	1224.
52	0.0	0.0	1131.
53	0.0	0.0	1044.
54	0.0	0.0	965.
55	0.0	0.0	891.
56	0.0	0.0	823.
57	0.0	0.0	760.
58	0.0	0.0	702.
59	0.0	0.0	648.
60	0.0	0.0	599.
61	0.0	0.0	553.

BY D J M DATE 3-79

CHKD. BY _____ DATE _____

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LOUIS BERGER & ASSOCIATES INC.

GRENOCH LAKE DAMSHEET NO. A8 OF _____

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62	0.0	0.0	511.
63	0.0	0.0	472.
64	0.0	0.0	436.
65	0.0	0.0	403.
66	0.0	0.0	372.
67	0.0	0.0	344.
68	0.0	0.0	317.
69	0.0	0.0	293.
70	0.0	0.0	271.
71	0.0	0.0	250.
72	0.0	0.0	231.
73	0.0	0.0	213.
74	0.0	0.0	197.
75	0.0	0.0	182.
76	0.0	0.0	168.
77	0.0	0.0	154.
78	0.0	0.0	142.
79	0.0	0.0	130.
80	0.0	0.0	120.
81	0.0	0.0	110.
82	0.0	0.0	100.
83	0.0	0.0	86.
84	0.0	0.0	71.
85	0.0	0.0	54.
86	0.0	0.0	22.
87	0.0	0.0	11.
88	0.0	0.0	2.
89	0.0	0.0	2.
90	0.0	0.0	1.
91	0.0	0.0	1.
92	0.0	0.0	1.
93	0.0	0.0	0.
94	0.0	0.0	0.
95	0.0	0.0	0.
96	0.0	0.0	0.
97	0.0	0.0	0.
98	0.0	0.0	0.
99	0.0	0.0	0.
100	0.0	0.0	0.
101	0.0	0.0	0.
102	0.0	0.0	0.
103	0.0	0.0	0.
104	0.0	0.0	0.
105	0.0	0.0	0.
106	0.0	0.0	0.
107	0.0	0.0	0.
108	0.0	0.0	0.
109	0.0	0.0	0.
110	0.0	0.0	0.
111	0.0	0.0	0.
112	0.0	0.0	0.
113	0.0	0.0	0.
114	0.0	0.0	0.
115	0.0	0.0	0.
116	0.0	0.0	0.
117	0.0	0.0	0.
118	0.0	0.0	0.
119	0.0	0.0	0.
120	0.0	0.0	0.
121	0.0	0.0	0.
122	0.0	0.0	0.

LOUIS BERGER & ASSOCIATES INC.
GREENLOCH LAKE DAM

SHEET NO. A9 OF
PROJECT _____

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123	0.0	0.0	0.0	0.0	0.0
124	0.0	0.0	0.0	0.0	0.0
125	0.0	0.0	0.0	0.0	0.0
126	0.0	0.0	0.0	0.0	0.0
127	0.0	0.0	0.0	0.0	0.0
128	0.0	0.0	0.0	0.0	0.0
129	0.0	0.0	0.0	0.0	0.0
130	0.0	0.0	0.0	0.0	0.0
131	0.0	0.0	0.0	0.0	0.0
132	0.0	0.0	0.0	0.0	0.0
133	0.0	0.0	0.0	0.0	0.0
134	0.0	0.0	0.0	0.0	0.0
135	0.0	0.0	0.0	0.0	0.0
136	0.0	0.0	0.0	0.0	0.0
137	0.0	0.0	0.0	0.0	0.0
138	0.0	0.0	0.0	0.0	0.0
139	0.0	0.0	0.0	0.0	0.0
140	0.0	0.0	0.0	0.0	0.0
141	0.0	0.0	0.0	0.0	0.0
142	0.0	0.0	0.0	0.0	0.0
143	0.0	0.0	0.0	0.0	0.0
144	0.0	0.0	0.0	0.0	0.0
145	0.0	0.0	0.0	0.0	0.0
146	0.0	0.0	0.0	0.0	0.0
147	0.0	0.0	0.0	0.0	0.0
148	0.0	0.0	0.0	0.0	0.0
149	0.0	0.0	0.0	0.0	0.0
150	0.0	0.0	0.0	0.0	0.0
SUM	25.25	22.76	212695.		

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 1									
INCHES	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME	INCHES	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
0.	0.	1.	3.	16.	0.	0.	1.	3.	16.
162.	492.	1101.	1860.	5231.	5295.	7712.	9931.	11447.	234.
1180.	11060.	7099.	2947.	212695.	1180.	11060.	7099.	2947.	212695.
AC-FT	5487.	14088.	17543.	17587.	AC-FT	5487.	14088.	17543.	17587.

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GRENOCH LAKE DAM

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5990.	5849.	5517.	5135.	4768.	4426.	4103.	3798.	3511.	3243.
2996.	2767.	2556.	2361.	2180.	2014.	1860.	1718.	1587.	1466.
1354.	1251.	1155.	1067.	986.	910.	841.	777.	717.	663.
517.	457.	422.	382.	345.	311.	280.	251.	224.	200.
277.	256.	236.	218.	201.	186.	172.	159.	147.	135.
125.	115.	107.	99.	91.	84.	77.	71.	65.	60.
55.	50.	45.	35.	27.	11.	3.	1.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK 5990. 5530. 3549. 1473. 106346.
 CFS 3.52 9.05 11.29
 INCHES 2744. 7044. 8771.
 AC-FT

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 3

145.	149.	277.	440.	744.	1293.	2118.	3085.	51.	94.
4792.	4679.	4414.	4108.	3815.	3541.	3282.	3038.	2809.	2595.
2396.	2214.	2045.	1889.	1744.	1611.	1488.	1375.	1270.	1173.
1083.	1001.	924.	854.	788.	728.	673.	621.	574.	530.
490.	452.	418.	386.	356.	329.	304.	281.	259.	240.
221.	204.	185.	174.	161.	149.	137.	127.	117.	108.
100.	92.	85.	79.	73.	67.	62.	57.	52.	48.
44.	40.	34.	28.	22.	17.	14.	11.	9.	8.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK 4792. 4424. 2840. 1179. 85077.
 CFS 2.82 7.24 9.01
 INCHES 2195. 5635. 7017.
 AC-FT

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 4

72.	89.	136.	220.	372.	646.	1059.	1542.	26.	47.
2396.	2340.	2207.	2054.	1907.	1770.	1641.	1519.	1404.	1297.
1198.	1107.	1022.	944.	872.	806.	744.	687.	635.	586.
542.	500.	462.	427.	394.	364.	336.	311.	287.	265.
245.	226.	205.	193.	178.	165.	152.	140.	130.	120.
111.	102.	94.	87.	81.	74.	67.	63.	59.	54.
50.	46.	42.	39.	36.	34.	31.	28.	26.	24.
22.	20.	17.	14.	11.	9.	8.	7.	6.	5.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK 2396. 2212. 1420. 589. 42539.
 CFS 1.41 3.62 4.51
 INCHES

SUBJECT.....

GREAT LAKES DAM

PROJECT_____

1

HYDROGRAPH ROUTING

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10

STOR

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OPERATION	STATION	PLAN	RATIOS APPLIED TO FLOWS				
			1.00	0.50	0.40	0.20	0.10
HYDROGRAPH AT ROUTED TO	110	1	11980.	5990.	4792.	2396.	1198.
		2	8.....		0.	0.	1.
		1	11943.	5922.	4737.	2341.	1166.
		2	8.....		0.	0.	1.