AD-A067 613 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 DACW61-78-C-0124

UNCLASSIFIED NL

| OF |
AD A067613

END
DATE FILMED
6-79
DDC

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

March, 1979

THIS IS THE BEST.

COPY AVAILABLE.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NJ00402
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): Phase I Inspection Report
National Dam Safety Program
Grenloch Lake Dam
Cloucester & Camden Counties, N.J.

5. TYPE OF REPORT & PERIOD COVERED: (9) FINAL Rept.

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): (10) F. Keith Jolls P.E.

8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0124

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Louis Berger & Assoc. Inc.
100Halsted Street
East Orange, N.J. → NJ State Dept. of Environ. Protection

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS:
U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

12. REPORT DATE: March 1979

13. NUMBER OF PAGES: 64

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 66p.

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(6) National Dam Safety Program. Grenloch Lake Dam (NJ ØØ4Ø2), Delaware River Basin, South Branch Timber Creek, Gloucester and Camden Counties, New Jersey. Phase I Inspection 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
Embankments
Structural Analysis
Safety
Visual Inspection
Grenlock Lake Dam

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

79 04 16 087

410 891

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
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, Grenlock 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.

NAPEN-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,

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

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.

Grenlock 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

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 9 April 1979

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

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

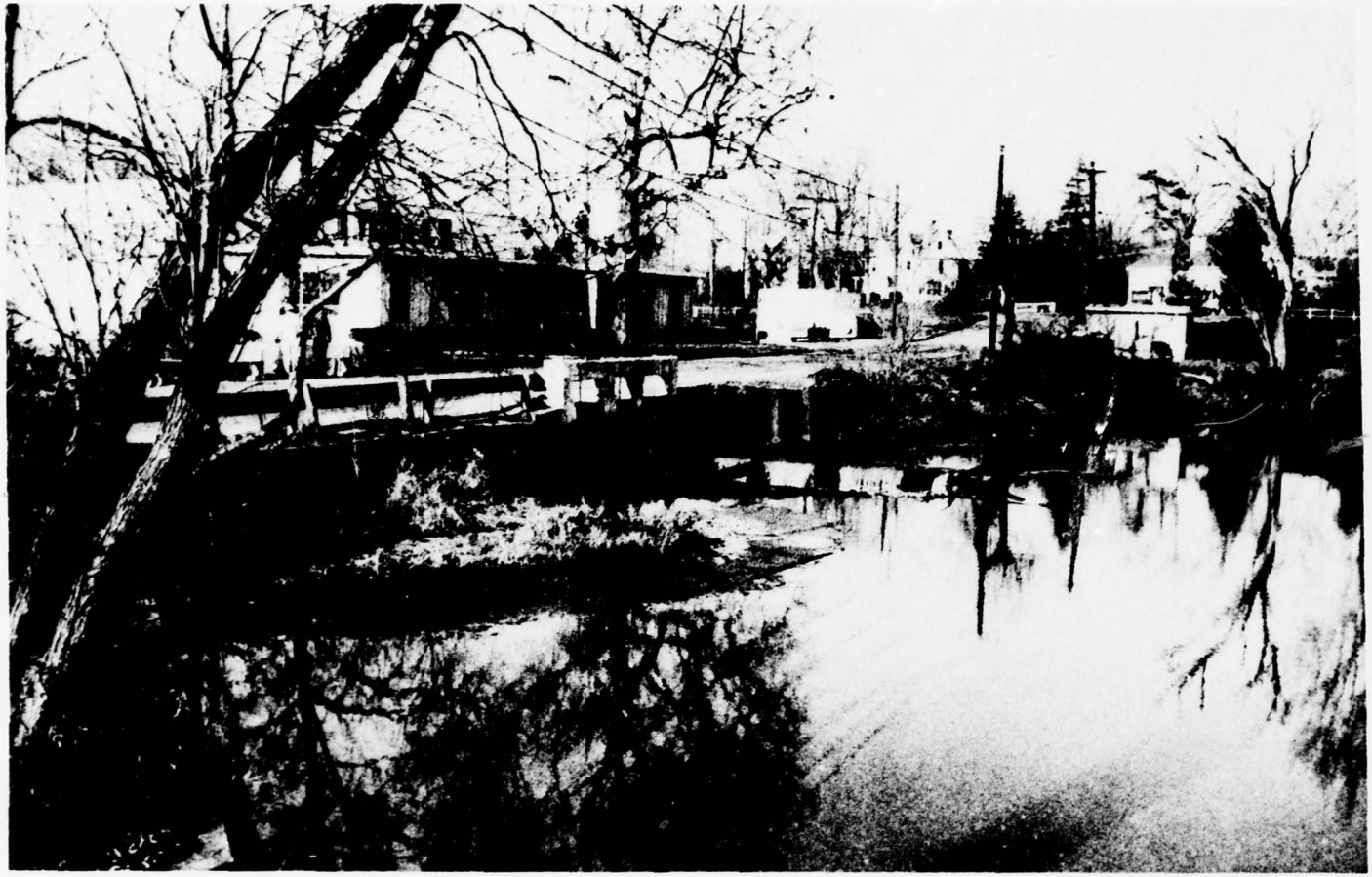
State Located New Jersey
Counties Located Gloucester/Camden
Coordinates Lat. 3947.0 - Long. 7503.5
Stream South Branch Timber Creek
Date of Inspection 6 December 1978

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

FIGURES

APPENDIX

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 bridgesstructure)
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 wing-walls 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^{o} 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 Hydrometeorlogical 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 ½ PMF design flood. The overtopping potential is considerable due to the hydraulically substandard 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 <u>significant</u>.

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.

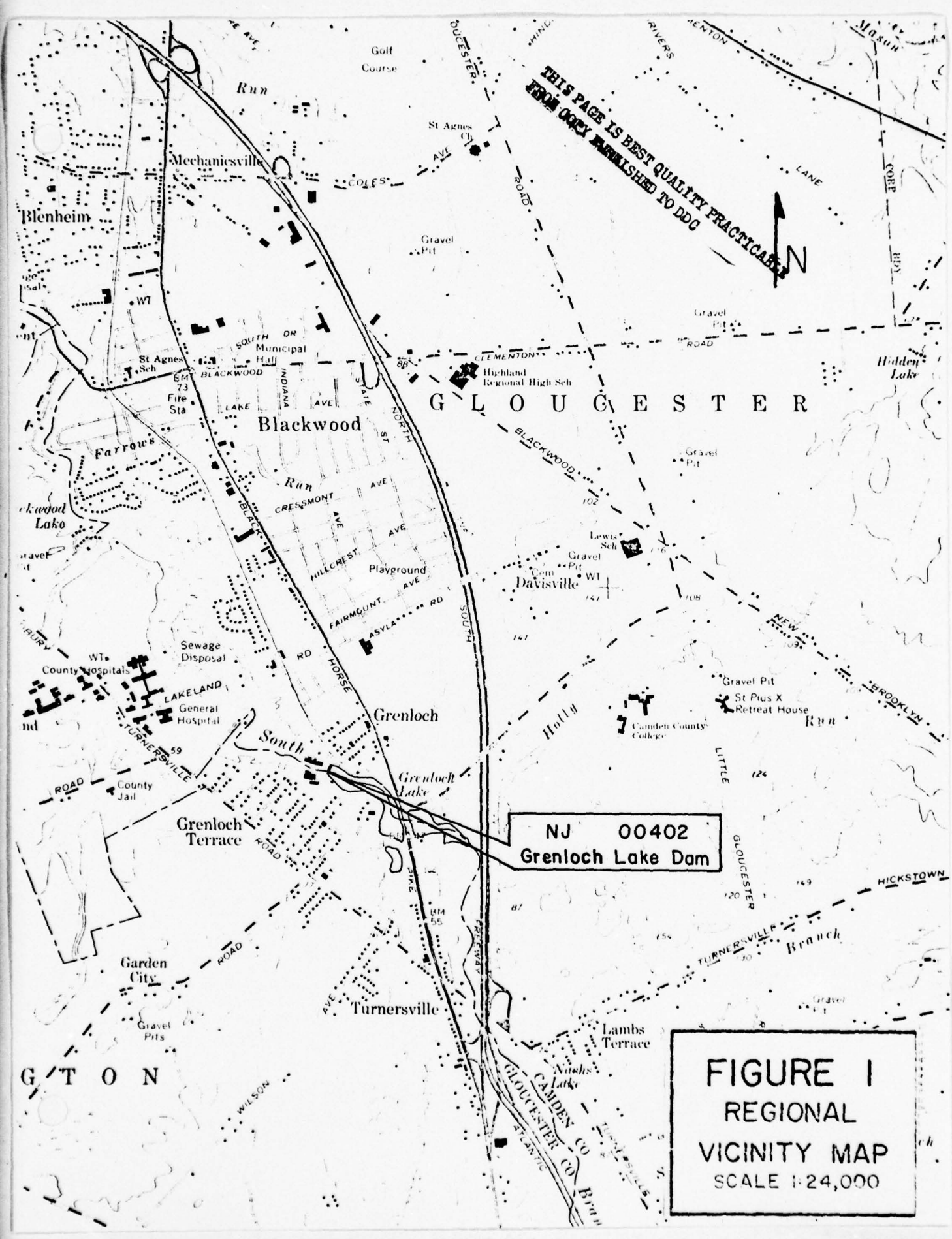
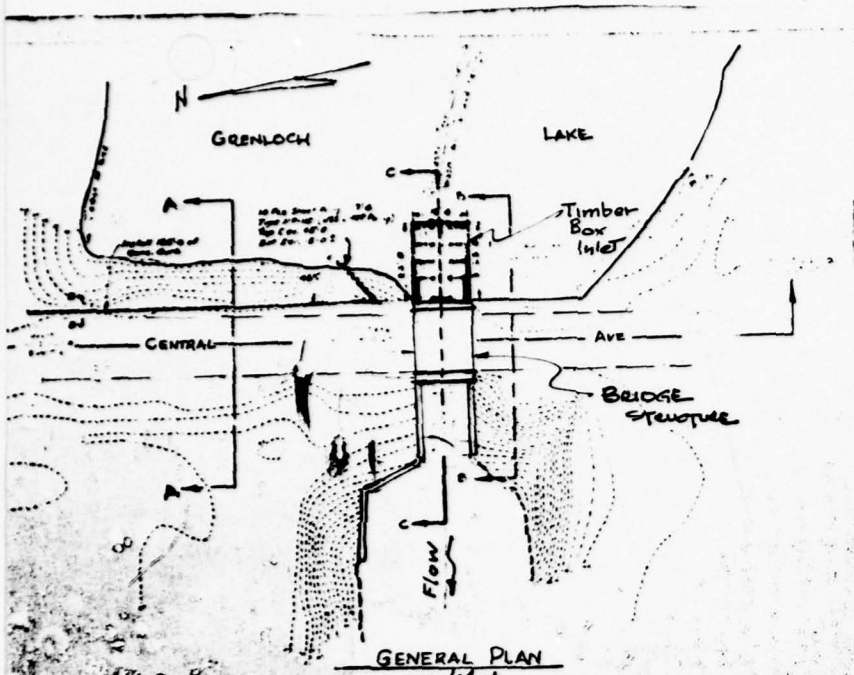
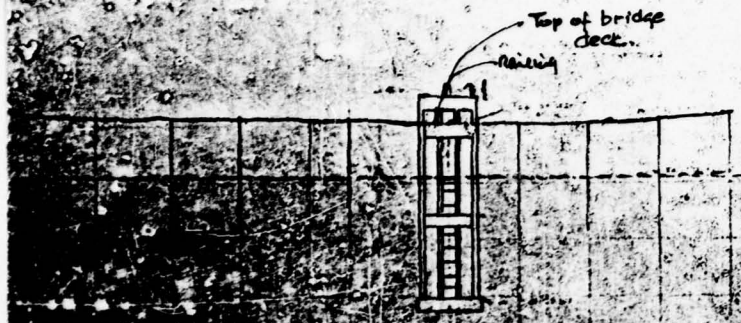


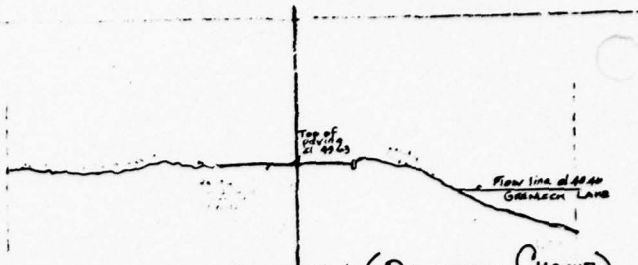
FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000



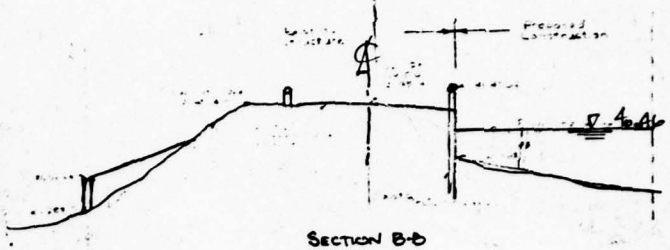
GENERAL PLAN
1/16"=1'-0"



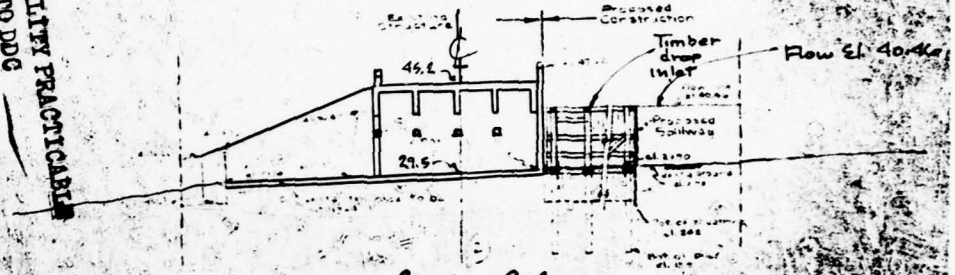
ELEVATION



SECTION A-A (DOWNSTREAM CHANNEL)



SECTION B-B



SECTION C-C

FILE

DAM APPLICATION No.

FILE

DAM APPLICATION No.

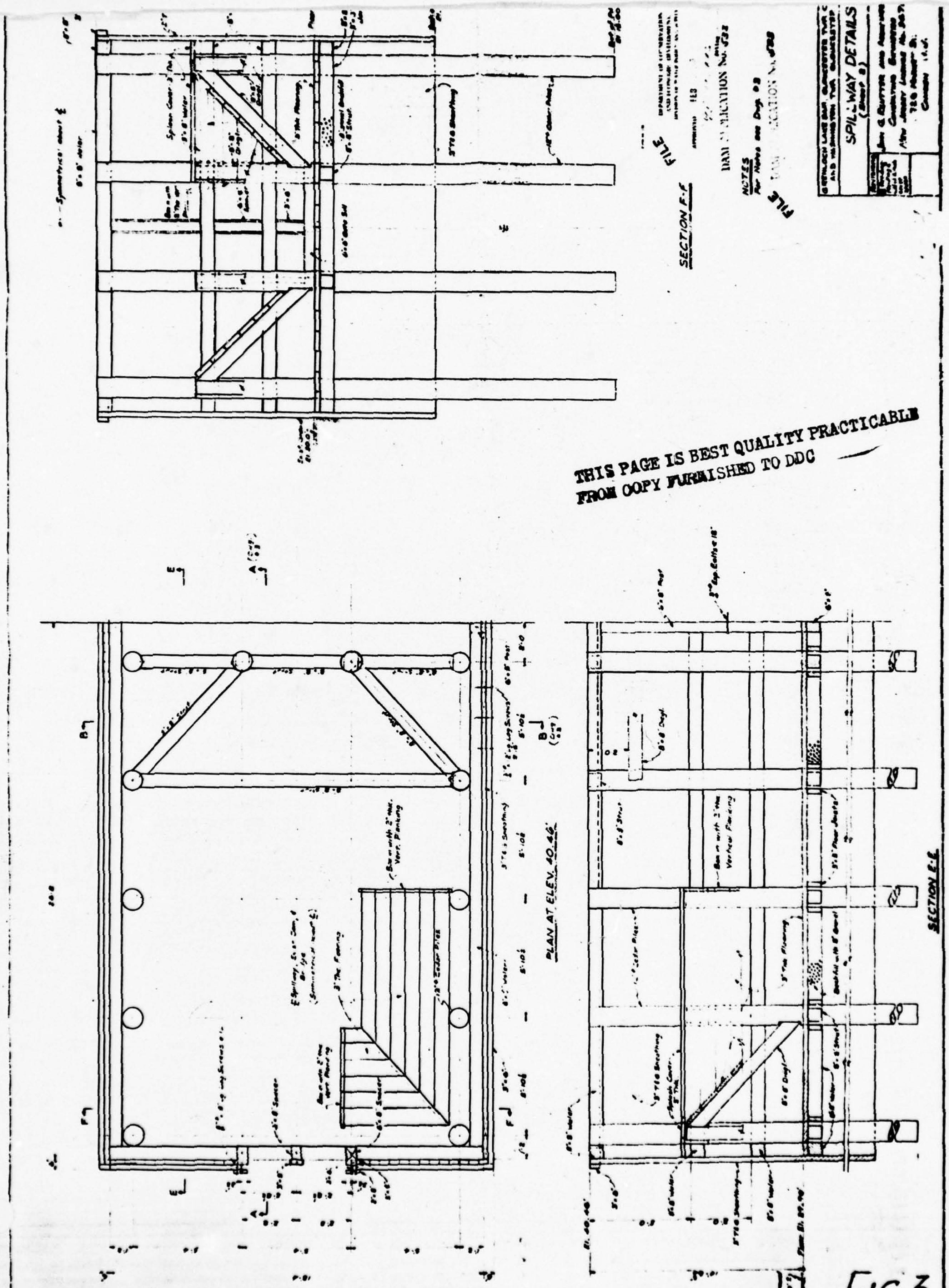


FIG. 3

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

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Satisfactory	
DRAINS	18" ø roadway catchbasin drains at NW Corner.	
WATER PASSAGES	None	
FOUNDATION	Unknown - most probably timber pilings.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
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

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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 ALINEMENT OF THE CREST	Satisfactory - dam is roadway embankment.	
RIPRAP FAILURES	NW Corner - large concrete slab collapse, down in back of wingwall.	

EMBANKMENT

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
UNCTION OF EMBANKMENT ND ABUTMENT, SPILLWAY ND DAM	Satisfactory - road embankment, asphalt paved (2 lane road).	
NY NOTICEABLE SEEPAGE	None observed.	
TAFF 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

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

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	1:1 banks 8-10' above spillway intake elevation. Banks heavily overgrown.	
SEDIMENTATION	None observed.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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	Some available
HYDROLOGY & HYDRAULICS	Some available
DAM STABILITY	None available
SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS	None available
BORING RECORDS	None available
LABORATORY	None available
FIELD	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

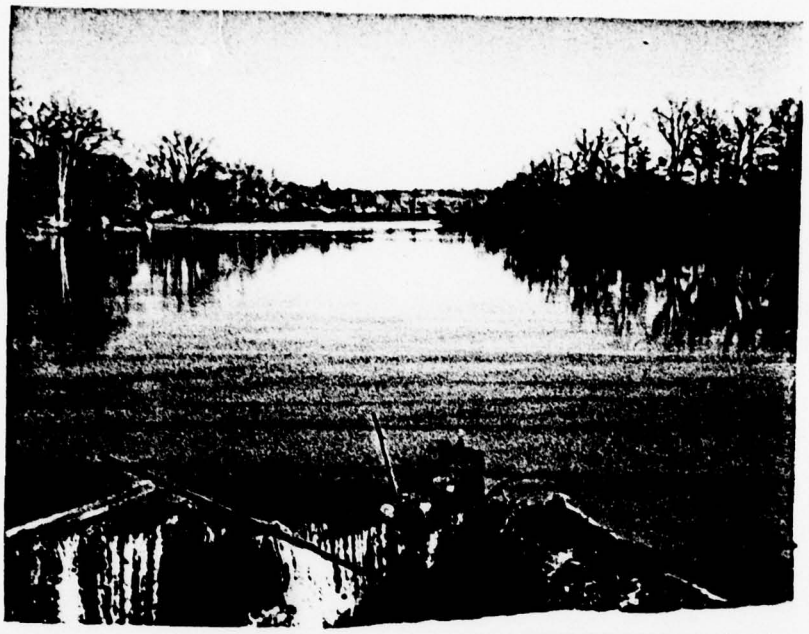
ITEM	REMARKS
SPILLWAY PLAN	Available
SECTIONS	Available
DETAILS	Available
OPERATING EQUIPMENT PLANS & DETAILS	N/A

View East along crest (Central Ave.)

December 1978

Bridge deck and rail

December 1978



Grenloch Lake

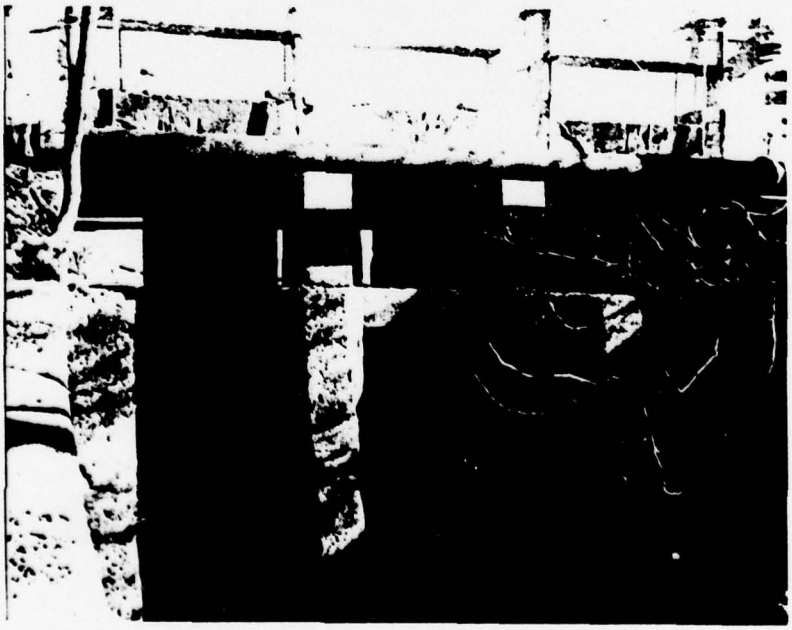
December 1978

Downstream channel

December 1978

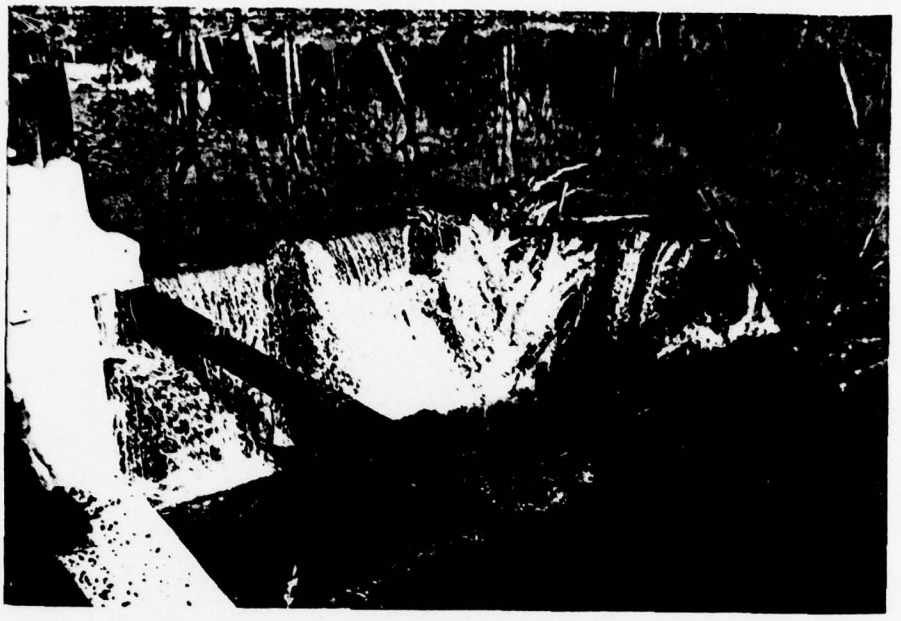
Steel sheeting

December 1978



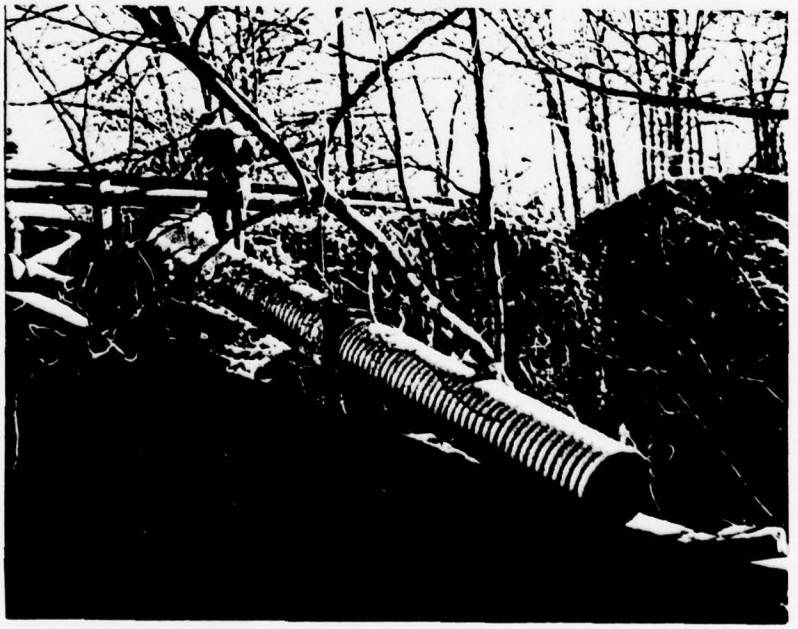
Bridge substructure

December 1978



Timber box spillway

December 1978



Surface drain pipe

December 1978

Dam No. 00402

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:

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

LOUIS BERGER & ASSOCIATES INC.
GREENLOCH LAKE DAM INSPECTION

SHEET NO. A1 OF ____
PROJECT C226

CLARK COEFFICIENTS (FROM CORPS OF ENGINEERS)

$t_c = 5.4$

$R = 12.6$

PRECIPITATION

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

Maximum 6 hour percentage = 110

" 12 " " = 120

" 24 " " = 129

Drainage area = 14.6 sq miles ✓

BY D J M DATE 1-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A2 OF...

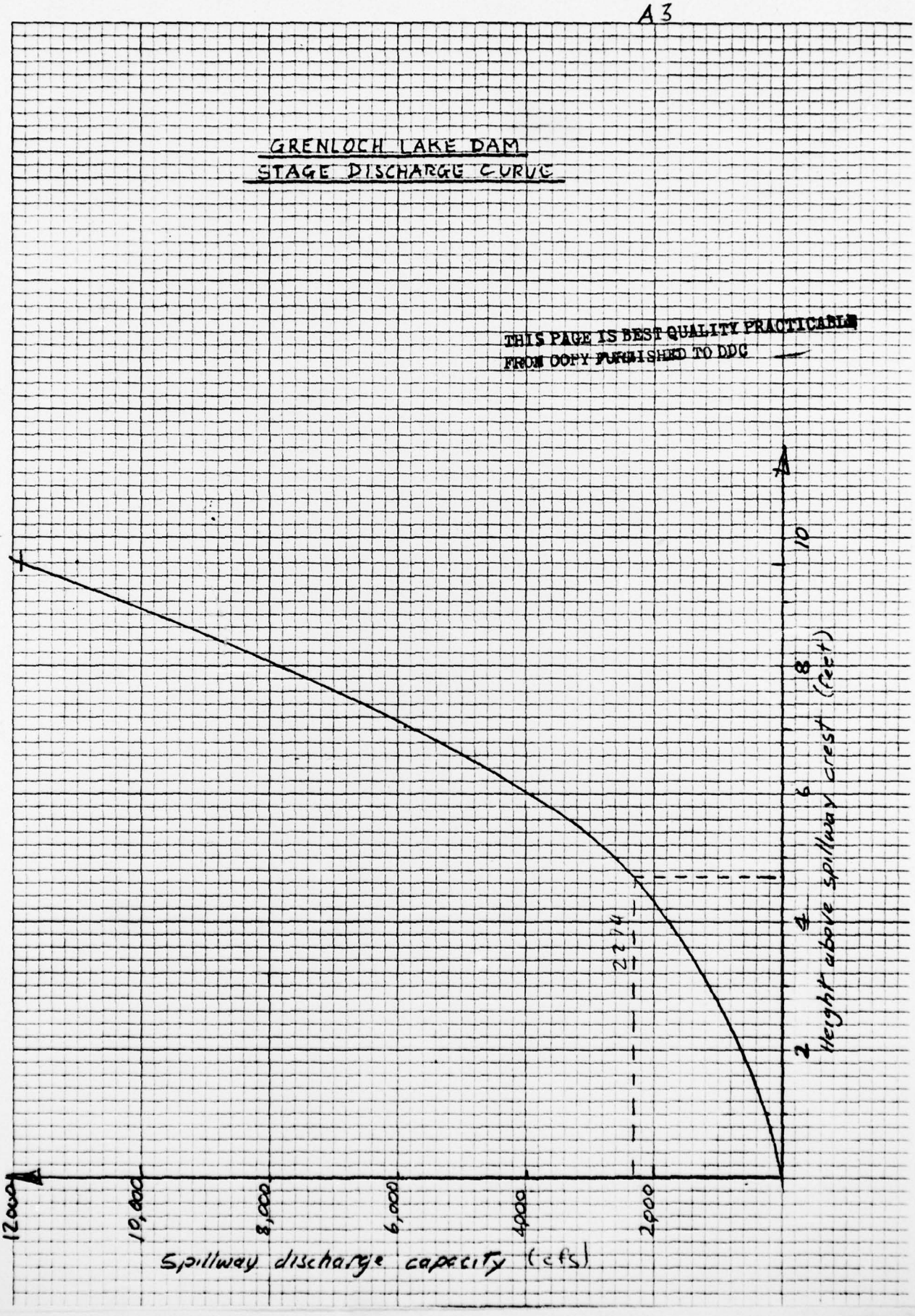
CHKD. BY...DATE... GRENLOCH LAKE DAM INSPECTION PROJECT C226

SUBJECT...

Spillway section effective length = 72' @ El. 40.5

Top of dam - length = 250' @ El. 45.2

	OVER SPILLWAY L = 72'		OVER DAM L = 178'			ΣQ
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

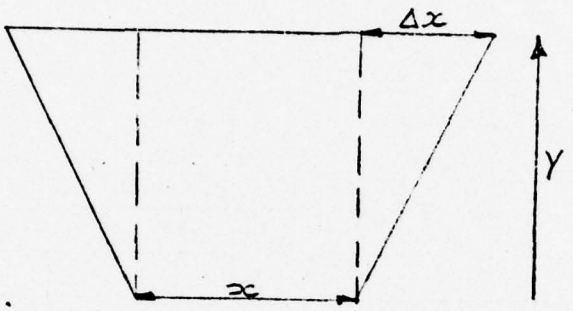


BY D.J.M. DATE 1-79
CHKD. BY ____ DATE ____
SUBJECT ____

LOUIS BERGER & ASSOCIATES INC.
GRENLOCH LAKE DAM INSPECTION

SHEET NO. A4 OF ____
PROJECT C226

Area of lake @ El. 40.46 ≈ 20.9 acres
Area of contour @ El. 50.00 ≈ 91.7 acres



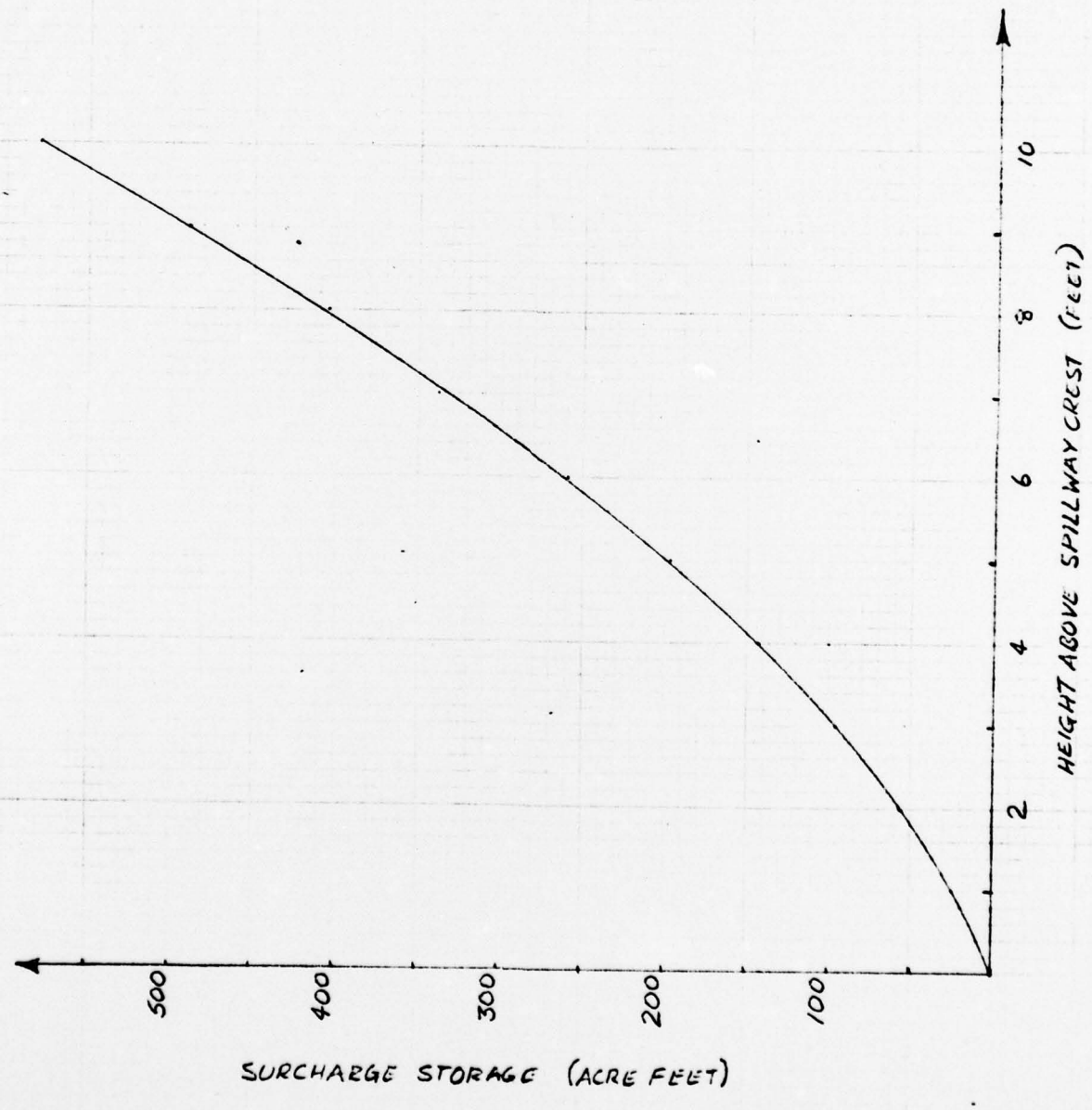
Increment in volume $\Delta V = (x+\Delta x)y$

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

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

SUBJECT STAGE STORAGE CURVE
GRENLOCH LAKE DAM INSPECTION

SHEET NO. A5 OF .....
JOB NO. C226



HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
****

FOR FINAL REPORT

GREYLOCH LAKE DAM INSPECTION SOUTH GROUP C226
BY D.J.MULLIGAN
JANUARY 1979

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	1	0	0	0	0	0	0	0	0

JOPER	NWT
5	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS= 1.00 0.50 0.40 0.20 0.10

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
10	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	0	14.60	0.0	14.60	0.0	0.0	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	24.00	110.00	120.00	129.00	0.0	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.813

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.50	0.10	0.0	0.0

UNIT HYDROGRAPH DATA
TC= 5.40 R= 12.60 NTA= 0

RECESSION DATA
STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00

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

41.	152.	309.	463.	568.	592.	557.	514.	475.	439.
405.	374.	346.	319.	295.	272.	252.	232.	215.	198.
183.	169.	156.	144.	133.	123.	114.	105.	97.	90.
83.	76.	71.	65.	60.	56.	51.	47.	44.	41.
37.	35.	32.	29.	27.	25.	23.	21.	20.	18.
17.	16.	14.	13.	12.	11.	11.	10.	9.	8.
8.	7.	7.	6.	6.	5.	5.	4.	4.	4.

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

BY D.J.M DATE 3-79 LOUIS BERGER & ASSOCIATES INC. SHEET NO. A6 OF
CHKD. BY DATE GREYLOCH LAKE DAM PROJECT
SUBJECT

BY D.J.M. DATE 3-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A7 OF

CHKD. BY _____ DATE _____ GRENLOCH LAKE DAM PROJECT _____

SUBJECT _____

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 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A8 OF

CHKD. BY_____DATE_____ GREENLOCH LAKE DAM PROJECT_____

SUBJECT_____

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.

123	0.0	0.0	0.
124	0.0	0.0	0.
125	0.0	0.0	0.
126	0.0	0.0	0.
127	0.0	0.0	0.
128	0.0	0.0	0.
129	0.0	0.0	0.
130	0.0	0.0	0.
131	0.0	0.0	0.
132	0.0	0.0	0.
133	0.0	0.0	0.
134	0.0	0.0	0.
135	0.0	0.0	0.
136	0.0	0.0	0.
137	0.0	0.0	0.
138	0.0	0.0	0.
139	0.0	0.0	0.
140	0.0	0.0	0.
141	0.0	0.0	0.
142	0.0	0.0	0.
143	0.0	0.0	0.
144	0.0	0.0	0.
145	0.0	0.0	0.
146	0.0	0.0	0.
147	0.0	0.0	0.
148	0.0	0.0	0.
149	0.0	0.0	0.
150	0.0	0.0	0.
SUM	25.25	22.76	212695.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11980.	11060.	7099.	2947.	212695.
INCHES		7.05	18.09	22.53	22.59
AC-FT		5487.	14088.	17543.	17587.

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	1.	3.	16.	54.	128.	234.
362.	494.	692.	1101.	1860.	3231.	5295.	7712.	9931.	11447.
11980.	11898.	11035.	10269.	9537.	8851.	8205.	7596.	7022.	6486.
5991.	5534.	5111.	4721.	4361.	4028.	3720.	3436.	3174.	2932.
2708.	2501.	2310.	2134.	1971.	1821.	1682.	1553.	1435.	1325.
1224.	1131.	1044.	965.	891.	823.	760.	702.	648.	599.
553.	511.	472.	436.	403.	372.	344.	317.	293.	271.
250.	231.	213.	197.	182.	168.	154.	142.	130.	120.
110.	100.	86.	71.	54.	22.	11.	2.	2.	1.
1.	1.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11980.	11060.	7099.	2947.	212695.
INCHES		7.05	18.09	22.53	22.59
AC-FT		5487.	14088.	17543.	17587.

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	1.	8.	27.	64.	117.
181.	247.	346.	550.	930.	1616.	2647.	3856.	4966.	5724.

0.	0.	0.	0.	0.	0.	1.	4.	10.	18.
27.	37.	49.	69.	105.	172.	265.	360.	444.	508.
541.	543.	525.	500.	474.	449.	426.	404.	383.	363.
345.	328.	312.	296.	282.	269.	257.	244.	232.	220.
209.	199.	188.	177.	165.	154.	144.	134.	125.	116.
108.	100.	93.	87.	81.	76.	71.	66.	62.	58.
54.	51.	48.	44.	42.	39.	37.	34.	32.	30.
29.	27.	26.	24.	23.	22.	21.	20.	19.	18.
17.	16.	15.	14.	13.	11.	10.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11843.	11038.	7086.	2946.	212604.
INCHES		7.03	18.06	22.52	22.58
AC-FT		5476.	14063.	17539.	17580.

STATION 110, PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	47.
117.	184.	262.	390.	632.	1092.	1834.	2985.	4374.	5387.
5881.	5922.	5668.	5311.	4936.	4582.	4250.	3937.	3668.	3394.
3135.	2896.	2675.	2492.	2325.	2153.	1990.	1839.	1704.	1578.
1459.	1348.	1245.	1150.	1061.	980.	905.	836.	772.	713.
659.	609.	564.	521.	482.	445.	411.	380.	351.	324.
299.	276.	255.	236.	218.	201.	186.	172.	158.	146.
135.	125.	115.	107.	96.	91.	84.	77.	71.	65.
60.	55.	49.	42.	35.	24.	13.	6.	3.	1.
1.	1.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	0.	0.	0.	0.	0.	2.	6.	11.
17.	22.	28.	38.	57.	91.	146.	216.	276.	315.
337.	335.	325.	312.	298.	284.	272.	260.	248.	235.
223.	212.	202.	191.	180.	168.	157.	147.	137.	127.
118.	110.	102.	95.	89.	83.	77.	72.	67.	63.
59.	55.	52.	48.	45.	42.	40.	37.	35.	33.
31.	29.	28.	26.	25.	23.	22.	21.	20.	19.
18.	17.	17.	16.	15.	15.	14.	14.	13.	13.
12.	12.	11.	11.	10.	9.	9.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5922.	5518.	3538.	1473.	106256.
INCHES		3.52	9.02	11.26	11.28
AC-FT		2737.	7021.	8768.	8786.

STATION 110, PLAN 1, RTIO 3

BY. D.J.M. DATE 2-79

CHKD. BY _____ DATE _____

SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

GREENWOOD LAKE DAM

SHEET NO. ALL OF _____

PROJECT _____

5990.	5849.	5517.	5135.	4768.	4426.	4103.	3798.	3511.	3243.
2996.	2757.	2556.	2361.	2180.	2014.	1860.	1718.	1587.	1466.
1354.	1251.	1155.	1067.	986.	910.	841.	777.	717.	663.
613.	567.	522.	482.	445.	411.	380.	351.	324.	299.
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.	5.	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.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5990.	5530.	3549.	1473.	106346.
INCHES		3.52	9.05	11.26	11.29
AC-FT		2744.	7044.	8771.	8793.

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 3

0.	0.	0.	0.	0.	1.	6.	22.	51.	94.
145.	198.	277.	440.	744.	1293.	2118.	3085.	3973.	4579.
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.	189.	174.	161.	149.	137.	127.	117.	108.
100.	92.	85.	79.	73.	67.	62.	57.	52.	48.
44.	40.	34.	28.	22.	9.	4.	1.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4792.	4424.	2840.	1179.	85077.
INCHES		2.82	7.24	9.01	9.03
AC-FT		2195.	5635.	7017.	7035.

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 4

0.	0.	0.	0.	0.	1.	3.	11.	26.	47.
72.	99.	138.	220.	372.	646.	1059.	1542.	1986.	2289.
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.	209.	193.	178.	165.	152.	140.	130.	120.
111.	102.	94.	87.	81.	74.	69.	63.	59.	54.
50.	46.	43.	39.	36.	34.	31.	28.	26.	24.
22.	20.	17.	14.	11.	4.	2.	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	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2396.	2212.	1420.	589.	42539.
INCHES		1.41	3.62	4.51	4.52

AC-FT			1097.	2818.	3509.		3517.			

HYDROGRAPH AT STA 10 FOR PLAN 1, RTIO 5

0.	0.	0.	0.	0.	0.	2.	5.	13.	23.
36.	49.	69.	110.	186.	323.	529.	771.	993.	1145.
1198.	1170.	1103.	1027.	954.	885.	821.	760.	702.	649.
599.	553.	511.	472.	436.	403.	372.	344.	317.	293.
271.	250.	231.	213.	197.	182.	168.	155.	143.	133.
122.	113.	104.	96.	89.	82.	76.	70.	65.	60.
55.	51.	47.	44.	40.	37.	34.	32.	29.	27.
25.	23.	21.	20.	18.	17.	15.	14.	13.	12.
11.	10.	9.	7.	5.	2.	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.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1198.	1106.	710.	295.	21270.
INCHES		0.70	1.81	2.25	2.25
AC-FT		549.	1409.	1754.	1759.

HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
110	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE=	25.	57.	96.	143.	197.	259.	328.	405.	489.	580.
OUTFLOW=	223.	631.	1160.	1786.	2577.	3914.	5738.	7876.	10276.	12912.

STATION 110, PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	32.	135.
247.	372.	525.	787.	1284.	2204.	4066.	6632.	8987.	10834.
11792.	11843.	11324.	10592.	9844.	9140.	8478.	7853.	7271.	6718.
6206.	5732.	5305.	4899.	4525.	4180.	3866.	3595.	3322.	3068.
2834.	2618.	2450.	2278.	2108.	1948.	1800.	1669.	1545.	1428.
1319.	1218.	1125.	1038.	959.	886.	818.	756.	698.	645.
597.	552.	510.	471.	435.	402.	372.	343.	317.	293.
270.	250.	231.	213.	197.	182.	168.	154.	142.	130.
119.	109.	98.	84.	69.	48.	26.	13.	5.	3.
2.	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.

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	25.
90.	146.	209.	312.	505.	869.	1466.	2302.	3390.	4258.
4704.	4737.	4536.	4249.	3948.	3690.	3427.	3176.	2938.	2715.
2522.	2358.	2185.	2020.	1867.	1728.	1601.	1481.	1368.	1264.
1167.	1077.	995.	919.	849.	784.	724.	669.	618.	572.
529.	489.	452.	417.	385.	356.	329.	304.	281.	259.
239.	221.	204.	189.	174.	161.	149.	137.	127.	117.
109.	100.	92.	85.	79.	73.	67.	62.	57.	52.
49.	44.	39.	34.	28.	19.	11.	5.	2.	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.

STOR

0.	0.	0.	0.	0.	0.	0.	2.	5.	9.
15.	19.	24.	32.	47.	75.	119.	178.	235.	272.
289.	290.	283.	272.	260.	249.	236.	225.	214.	203.
193.	182.	170.	159.	148.	139.	129.	120.	112.	104.
97.	90.	84.	78.	73.	68.	64.	60.	56.	52.
49.	46.	43.	40.	38.	35.	33.	31.	30.	28.
26.	25.	24.	22.	21.	20.	19.	18.	17.	17.
16.	16.	15.	14.	14.	13.	13.	12.	12.	12.
11.	11.	11.	10.	10.	9.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4737.	4406.	2831.	1178.	84986.
INCHES		2.81	7.21	9.01	9.02
AC-FT		2186.	5617.	7014.	7027.

STATION 110, PLAN 1, RTIO 4

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22.	66.	102.	155.	253.	430.	725.	1139.	1583.	1989.
2256.	2340.	2290.	2170.	2027.	1885.	1752.	1630.	1510.	1397.
1291.	1193.	1101.	1016.	939.	867.	801.	740.	683.	631.
585.	541.	500.	462.	426.	394.	364.	336.	310.	287.
265.	245.	226.	209.	193.	178.	164.	152.	140.	130.
120.	111.	102.	94.	87.	80.	74.	69.	63.	59.
54.	50.	46.	43.	39.	36.	34.	31.	28.	26.
24.	22.	20.	17.	14.	10.	5.	3.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	0.	0.	0.	0.	0.	1.	2.	5.
9.	13.	16.	20.	27.	41.	64.	9[illegible].	128.	157.
175.	181.	177.	169.	159.	150.	140.	131.	122.	114.
106.	98.	92.	85.	80.	74.	70.	65.	61.	57.
53.	50.	47.	44.	41.	38.	36.	34.	32.	30.

28.	27.	25.	24.	23.	21.	20.	19.	19.	18.
17.	16.	16.	15.	14.	14.	13.	13.	12.	12.
12.	11.	11.	11.	11.	10.	10.	10.	10.	10.
9.	9.	9.	9.	9.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2340.	2179.	1415.	589.	42448.
INCHES		1.39	3.61	4.50	4.51
AC-FT		1081.	2808.	3504.	3510.

STATION 110, PLAN 1, RTIO 5

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8.	9.	44.	75.	126.	215.	361.	561.	789.	990.
1120.	1166.	1145.	1088.	1018.	947.	879.	815.	755.	698.
645.	597.	552.	510.	472.	436.	402.	372.	343.	317.
293.	271.	256.	231.	213.	197.	182.	168.	155.	143.
132.	122.	113.	104.	96.	89.	82.	76.	70.	65.
60.	55.	51.	47.	44.	40.	37.	34.	32.	29.
27.	25.	23.	21.	20.	18.	17.	15.	14.	13.
12.	11.	10.	8.	7.	5.	3.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	0.	0.	0.	0.	0.	0.	1.	3.
5.	8.	11.	13.	17.	24.	36.	51.	69.	83.
93.	98.	95.	91.	86.	80.	75.	71.	66.	62.
58.	54.	51.	48.	44.	42.	39.	37.	34.	32.
30.	29.	27.	26.	24.	23.	22.	21.	20.	19.
18.	17.	16.	15.	15.	14.	14.	13.	13.	13.
12.	12.	12.	11.	11.	11.	10.	10.	10.	10.
10.	9.	9.	9.	9.	9.	9.	9.	9.	9.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	8.	8.	8.	8.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1166.	1088.	707.	294.	21179.
INCHES		0.69	1.80	2.25	2.25
AC-FT		540.	1404.	1749.	1751.

OPERATION	STATION	PLAN	RATIOS APPLIED TO FLOWS 1.00	0.50	0.40	0.20	0.10
HYDROGRAPH AT	10	1	11980.	5990.	4792.	2396.	1198.
		2	8.**********		0.	0.	1.
ROUTED TO	110	1	11843.	5922.	4737.	2340.	1166.
		2	8.**********		0.	0.	1.