DELAWARE RIVER BASIN

LEHIGH RIVER, LACKAWANNA AND WAYNE COUNTIES

PENNSYLVANIA

LEVEL II

LARSEN DAM

NDI ID NO. PA-00367

DER ID NO. 35-30

BIG BASS LAKE, INC.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

JULY 1981

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DACW31-81-C-0018

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PREFACE

This report is prepared under guidance contained in 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 a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

LARSEN DAM

NDI ID No. PA-00367; DER ID No. 35-30

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

CONTENTS

APPENDICES

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Larsen Dam NDI ID No. PA-00367 DER ID No. 35-30
Size:	Small (11.7 feet high; 504 acre-ft.)
Hazard Classification:	High
Owner:	Big Bass Lake, Inc. L. Larsen, President Box 225 Gouldsboro, PA 18424
State Located:	Pennsylvania
County Located:	Lackawanna and Wayne
Stream:	Lehigh River
Date of Inspection:	2 June 1981

Based on visual inspection, available records, calculations, past operational performance, and according to criteria established for these studies, Larsen Dam is judged to be in fair condition. Based on the size and hazard classification of the dam, the Spillway Design Flood (SDF) at the dam varies between 1/2 the Probable Maximum Flood (PMF) and the PMF. Based on the downstream conditions, the selected SDF is the 1/2 PMF. Under existing conditions, the spillway will pass about 12 percent of the PMF without overtopping of the dam. If the low areas on the top of the dam were filled to the design elevation, the spillway would pass 16 percent of the PMF. It is judged that Larsen Dam could not withstand the depth and duration of overtopping that would occur during the 1/2 PMF. However, it is judged that a high hazard dam located immediately downstream would fail due to overtopping prior to the overtopping failure of Larsen Dam. Therefore, the spillway capacity of Larsen Dam is rated as inadequate.

No immediate stability problems were evident at the time of the inspection, but deficiencies do exist that could eventually affect the stability of the dam and appurtenances if they are not corrected.

Maintenance of the dam is considered inadequate.

The following studies and remedial measures are recommended to be undertaken by the Owner, in approximate order of priority, without delay:

(1) Design and construct modifications as required to provide adequate spillway capacity.

(2) If the design for spillway modifications does not include provisions for repair of the corewall and replacement of missing embankment material, separate measures should be designed and constructed to accomplish those items.

(3) Remove brush from the dam, replace missing riprap, and fill the burrowing animal hole with impervious material.

(4) Visually monitor the wet area at the toe of the dam. Take appropriate action as required if the condition worsens.

All investigations, studies, designs, and inspection of construction should be performed by a professional engineer experienced in the design and construction of dams.

In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for Larsen Dam. When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

(2) During periods of unusually heavy rains, provide round-the-clock surveillance of Larsen Dam.

(3) As presently required by the Commonwealth, institute a program of formal annual inspections by a professional engineer experienced in the design and construction of dams. Utilize the inspection results to determine if remedial measures are necessary.

(4) Expand the existing maintenance program and develop a formal maintenance manual so that all features of the dam are properly maintained.

LARSEN DAM

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.

FREDERICK FUTCHKO
Project Manager, Dam Section

Date: 7 August 1981

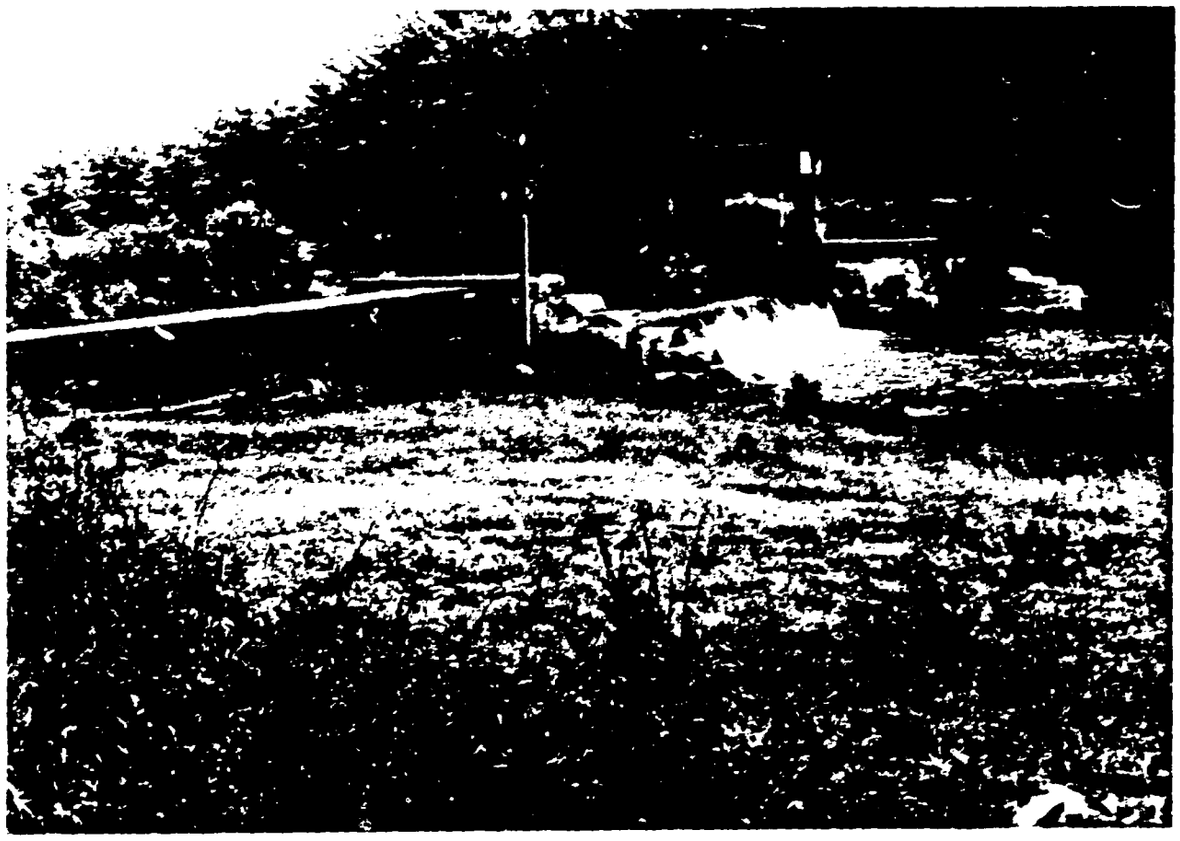
Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT,
CORPS OF ENGINEERS

JAMES W. PECK
Colonel, Corps of Engineers
Commander and District Engineer

Date: 18 Aug 81

LARSEN DAM



Overview

LARSEN DAM

NDI ID No. PA-00367; DER ID No. 35-30

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Larsen Dam consists of an embankment, an overflow spillway, and an outlet works. The embankment is earthfill and has a concrete corewall. The embankment consists of two sections, being divided by the spillway. The section to the right of the spillway is 120 feet long, and the section to the left is 75 feet long. The dam is 11.7 feet high at its highest section.

The spillway is located near the center of the dam. An approach channel leads from the reservoir to a rounded-crest, concrete weir. The weir is 70 feet long and 3.8 feet below the design level for the top of the dam. A concrete apron is located at the bottom of the weir.

The outlet works is located at the left end of the spillway. An intake structure leads from the reservoir to a pair of 24-inch diameter cast-iron pipes. Sluice gates in the intake structure can be used to prevent water from entering the conduits. There are also gate valves located further downstream that can be used to control flows.

The various features of the dam are shown on the Photographs in Appendix C and on the Plates in Appendix E. A description of the geology is included in Appendix F.

b. Location. Larsen Dam is located on the Lehigh River in Clifton Township, Lackawanna County, and Lehigh Township, Wayne County, approximately one-half mile northeast of Gouldsboro, Pennsylvania. Larsen Dam is shown on USGS Quadrangle Sterling, Pennsylvania at latitude N 41° 15' 05" and longitude W 75° 27' 30". On the USGS topographic map, Larsen Lake is shown as Johnson Pond. A location map is shown on Plate E-1.

c. Size Classification. Small (11.7 feet high, 504 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is warranted for Larsen Dam (Paragraphs 3.1e and 5.1c (5)).

e. Ownership. Big Bass Lake, Inc., L. Larsen, President, Box 225, Gouldsboro, PA 18424.

f. Purpose of Dam. Recreation.

g. Design and Construction History. Larsen Dam was constructed in 1910 by the Scranton Gas and Water Company to provide an auxiliary water supply. The dam replaced a timber crib structure that had existed at the site. The dam was designed by W.M. Marple and constructed under the supervision of H. F. Cox, both of whom were engineers for the water company. When it was constructed, the dam was known as Gouldsboro Dam. The lake was later known as Johnson Pond. The dam and lake are now known as Larsen Dam and Larsen Lake. There have been no significant modifications made to the dam since it was constructed.

h. Normal Operational Procedure. The pool is maintained at the spillway crest level with excess inflow discharging over the spillway. The outlet works is used occasionally to draw down the pool level for maintenance purposes.

1.3 Pertinent Data.

a. Drainage Area. (square miles)	15.39
b. Discharge at Damsite. (cfs)	
Maximum known flood at damsite	Unknown
Outlet works at maximum pool elevation	110
Spillway capacity at maximum pool elevation	
Design conditions	1,760
Existing conditions	1,300

c. Elevation. (feet above msl.)

Top of dam	
Design conditions	1886.4
Existing conditions	1885.7
Maximum pool	
Design conditions	1886.4
Existing conditions	1885.7
Normal pool (spillway crest)	1882.6
Upstream invert outlet works	1874.0
Downstream invert outlet works	1874.0
Streambed at toe of dam	1874.0

d. Reservoir Length. (miles)

Normal pool	0.75
Maximum pool (design)	0.80

e. Storage. (acre-feet)

Normal pool	246
Maximum pool (design)	581
Maximum pool (existing)	504

f. Reservoir Surface. (acres)

Normal pool	64
Maximum pool (design)	116
Maximum pool (existing)	105

g. Dam.

Type	Earthfill with concrete corewall
Length (feet)	195, embankment only
Height (feet)	11.7
Topwidth (feet)	
Design	8.0
Existing	Varies
Side Slopes	
Upstream	
Design	1V on 4H
Existing	1V on 4H
Downstream	
Design	1V on 3H
Existing	Varies

g.	Dam. (cont'd.)	
	Zoning	Concrete corewall; two earthen zones
	Cutoff	Cutoff trench and steel sheet piles
	Grout Curtain	None
h.	Diversion and Regulating Tunnel.	None
i.	Spillway. Type	Concrete weir
	Length of Weir (feet)	70.0
	Crest Elevation	1882.6
	Upstream Channel	Reservoir
	Downstream Channel	Concrete apron
j.	Regulating Outlets Type	Two 24-inch diameter cast-iron pipes
	Length (feet)	24
	Closure	Sluice gates at upstream end; gate valves near center
	Access	Top of dam

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. No design data are available for Larsen Dam.

b. Design Features. The project is described in Paragraph 1.2a. The various features of the dam are shown on the Photographs in Appendix C and on the Plates in Appendix E.

c. Design Considerations. Available data are not sufficient to assess the design of the dam.

2.2 Construction Data.

a. Data Available. A report on the dam was prepared in 1915 by the Pennsylvania Water Supply Commission (PWSC). The report was based on information furnished by the engineer who supervised construction of the dam. There is also a drawing prepared in 1914 that was reportedly copied from construction progress sheets. Some of the details from this drawing are shown on Plate E-2.

b. Construction Considerations. Available data indicate that the embankments are constructed of a clay-sand mixture that was obtained locally. Steel sheet piling were driven around the entire dam during construction to provide stable conditions during excavation. The tops of the sheet piles were cut off and the portions remaining were left in place. The corewall in the dam and the concrete spillway are founded on a layer of gravel and boulders that overlie bedrock at the site. A "quicksand stratum" was removed during construction. The 1915 PWSC Report indicates that construction of the dam was satisfactory.

2.3 Operation. There are no formal records of operation. No significant problems have been reported for the dam.

2.4 Evaluation.

a. Availability. Engineering data were provided by the Bureau of Dams and Waterway Management, Department of Environmental Resources, Commonwealth of Pennsylvania (PennDER). Representatives of the Owner were available for information during the visual inspection.

b. Adequacy. The type and amount of available design data and other engineering data are fair, and the assessment is based on the combination of available data, visual inspection, performance history, hydrologic assumptions and hydraulic assumptions, and calculations developed for this report.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The overall appearance of the dam is fair. Deficiencies that were observed are noted below. A sketch of the dam with the locations of deficiencies is presented on Exhibit B-1 in Appendix B. Survey information acquired for this report is summarized in Appendix B. Datum used for the survey was the spillway crest level, Elevation 1882.6, as shown on Plate E-2 in Appendix E. On the day of the inspection, the pool was at Elevation 1882.8.

b. Embankment. The survey performed for this inspection showed that the top of the dam is irregular, with the low point at Elevation 1885.7, which is 0.7 foot lower than the design level shown on Plate E-2.

Riprap on the upstream slope of the dam is generally intact but overgrown with brush (Photograph A). The upstream slope generally conforms to the slope angle shown on Plate E-2.

The portion of the embankment to the right of the spillway has the corewall exposed over a 75-foot long reach (Photograph A). The maximum exposed height of corewall is 4.5 feet (Photograph B). About 15 feet to the right of the spillway, the corewall has a 1/8-inch wide crack that extends through the corewall (Photograph C). There is no misalignment at the crack, but concrete at that location has spalled. Near the right abutment there is an area where minor surface erosion of the embankment has occurred (Photographs A and B).

The portion of the embankment to the left of the spillway is completely overgrown with brush (Photograph D). One burrowing animal hole is located on the downstream slope. There is a small wet area located near the toe adjacent to the outlet channel.

c. Appurtenant Structures. The spillway weir was submerged but no major deficiencies appear to exist (Photograph E). There is one crack in the right approach wall of the spillway, and there are numerous locations where surficial deterioration of the approach and outlet walls has occurred (Photographs E and F).

The outlet works is in fair condition. Some deterioration of the concrete intake structure has occurred. The outlet conduits were submerged and could not be inspected. The sluice gates in the intake structure and the gate valves in the outlet conduits are rusted but are reported to be functional.

d. Reservoir Area. The watershed is predominantly wooded and has gentle to moderate slopes. There are five other dams and several small ponds located within the watershed. Larsen Lake itself is segmented into three parts. The Erie-Lackawanna railroad embankment separates one small portion of the reservoir from the main body of water. There is a substantial bridge opening which allows free passage of water through the railroad embankment. There is another earthen embankment which crosses the reservoir and separates a significant portion of the lake from the main body of the reservoir. The top of the embankment is approximately 2 feet above normal pool level, and there is an opening through the embankment about 25 feet wide (Photograph G). The purpose of the embankment is unknown.

e. Downstream Conditions. Lake Lehigh Dam, DER I.D. No. 64-51, is located 0.7 mile downstream from Larsen Dam. Lake Lehigh Dam (Photograph H) was inspected in 1980 and found to be a high hazard dam. The available surcharge storage in Lake Lehigh is 31 acre-feet, compared to the 246 acre-feet of storage in Larsen Lake at normal pool level. If Larsen Dam were to fail, it could cause failure of Lake Lehigh Dam. Accordingly, Larsen Dam is a high hazard dam.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is normally maintained at spillway crest level, with excess inflow discharging over the spillway and into the Lehigh River. The outlet works is used occasionally to draw down the pool for maintenance purposes.

4.2 Maintenance of Dam. The dam is visited at least monthly by one of the Owner's representatives. Based on the condition of the dam, it is evident that maintenance of the dam has been minimal. Formal inspections of the dam are not made.

4.3 Maintenance of Operating Facilities. The outlet works operating mechanisms are rusted but are reported to be in good working order. Maintenance is limited to checking the operation of the gate valves several times each year.

4.4 Warning Systems in Effect. There is no emergency operation and warning system.

4.5 Evaluation of Operational Adequacy. The maintenance of the dam and appurtenant works is inadequate, as evidenced by the maintenance deficiencies observed during the visual inspection. A program of formal annual inspection is necessary to detect potentially hazardous conditions. A detailed emergency operation and warning system is necessary to reduce the risk of dam failure should adverse conditions develop and to prevent loss of life should the dam fail.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. The 1915 Report by the PWSC indicated that the design capacity of the spillway was 1,650 cfs, based on a maximum available head of 3.5 feet. For this inspection it was determined that the design capacity of the spillway is 1,760 cfs, based on a maximum available head of 3.8 feet.

b. Experience Data. There are no known records of the maximum pool elevation at Larsen Dam.

c. Visual Observations.

(1) General. The visual inspection of Larsen Dam, which is described in Section 3, resulted in a number of observations relevant to hydrology and hydraulics. These observations are evaluated herein.

(2) Embankment. The top of the embankment is 0.7 foot lower than its design elevation. Accordingly, the existing spillway capacity is less than its design capacity.

Although the available records contain no reference to overtopping of the dam, the visual inspection and photographs from the records strongly suggest that the dam has been overtopped. A photograph taken in 1938 clearly shows that the entire embankment to the right of the spillway was intact and that no portions of the corewall were exposed. A photograph taken in 1957 shows the corewall exposed to approximately the same extent that exists now. Based on the visual inspection and the photographs, it is surmised that the dam was overtopped, possibly during the 1955 flood, and that the embankment suffered severe erosion.

(3) Appurtenant Structures. No deficiencies relevant to hydraulics were observed at the spillway or the outlet works.

(4) Reservoir Area. Nothing was observed in the reservoir area that would present a hazard to the dam. The segmentation of the reservoir caused by the two earthen embankments is of little significance, and the minor effects that they might have were not included in the analysis performed for this report.

There are five dams upstream from Larsen Dam, as noted in Appendix D. Phase I National Dam Inspection Reports have been prepared for four of these dams. The effects of all the dams

have been included in the analysis described hereafter. Of these five dams, only Lake Watawga Dam and Gouldsboro Dam are considered to present any noteworthy hazard to Larsen Dam. Gouldsboro Dam has an adequate spillway capacity. Lake Watawga Dam has a seriously inadequate spillway capacity.

(5) Downstream Conditions. Lake Lehigh Dam is located immediately downstream from Larsen Dam, as shown on Exhibit D-1 in Appendix D. A Phase I National Dam Inspection Report has previously been prepared for Lake Lehigh Dam, which is a small, high hazard dam with a seriously inadequate spillway capacity. Since a failure of Larsen Dam could cause a failure of Lake Lehigh Dam, a high hazard classification is warranted for Larsen Dam.

d. Overtopping Potential.

(1) Spillway Design Flood. According to the criteria established by the Office of the Chief of Engineers (OCE), the Spillway Design Flood (SDF) for the size (small) and hazard potential (high) of Larsen Dam is between one-half of the Probable Maximum Flood (PMF) and the PMF. Based on the small height of the dam and the downstream conditions, the 1/2 PMF is selected as the SDF for Larsen Dam. The watershed and reservoir were modeled with the U.S. Army Corps of Engineers HEC-1DB computer program. A description of the model is included in Appendix D. The assessment of hydrology and hydraulics is based on existing conditions, and the effects of future development are not considered.

(2) Summary of Results. Pertinent results are tabulated at the end of Appendix D. The analysis reveals that the existing Larsen Dam can pass about 12 percent of the PMF before overtopping of the dam occurs. If the low areas on the top of the dam were raised to the design elevation, the dam could pass 16 percent of the PMF. During the 1/2 PMF, the dam would be overtopped by 3.6 feet for 19 hours. This would cause the dam to fail.

(3) Spillway Adequacy. The criteria used to rate the spillway adequacy of a dam are described in Appendix D. Because Larsen Dam cannot pass the 1/2 PMF, further analysis was performed. The outflow from Larsen Dam was routed though Lake Lehigh and over Lake Lehigh Dam. Larsen Dam passes the 5 percent PMF with 1.4 feet of freeboard. The outflow from Larsen Dam during the 5 percent PMF will cause Lake Lehigh to overtop by 0.7 foot for 17.8 hours. The Phase I Report for Lake Lehigh Dam indicates that it would start failing during an overtopping of 0.5 foot. Therefore, it was judged that dwellings downstream would already be flooded by the failure of Lake Lehigh Dam before Larsen Dam started to fail. The spillway capacity of Larsen Dam is rated as inadequate.

The Commonwealth is presently reviewing plans for the rehabilitation of Lake Lehigh Dam. The plans include increasing the spillway capacity of Lake Lehigh Dam to pass the 1/2 PMF. When the rehabilitation is completed, the existing spillway capacity of Larsen Dam would pose more of a hazard to Lake Lehigh Dam and the dwellings downstream.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Larsen Dam, which is described in Section 3, resulted in a number of observations relevant to structural stability. These observations are evaluated herein for the various features.

(2) Embankment. The growth of brush on the embankment slopes will eventually create a potential hazard to the dam. The root systems create potential paths along which seepage can develop. The exposed corewall is an undesirable condition. Although the amount of exposure does not create a stability hazard under normal conditions, a small amount of overtopping would cause rapid progressive erosion that would probably result in failure of the dam. The crack in the corewall is also undesirable because of the leakage that would occur under high pool levels. The bare areas at the right abutment would allow erosion to occur rapidly if the dam were overtopped. The burrowing animal hole located on the downstream slope is minor but should be filled. The wet area at the toe to the left of the spillway is considered to be relatively minor but warrants monitoring.

(3) Appurtenant Structures. The deficiencies at the spillway, a crack in the right approach wall and surficial deterioration of the concrete, are maintenance problems that do not constitute significant hazard to the dam. Nothing was observed at the outlet works that constitutes a hazard to the dam.

b. Design and Construction Data. No stability analyses are available for the embankment or spillway. Based on review of the sections that are available, the stability of the dam is judged to be adequate for its original design conditions.

c. Operating Records. There are no formal records of operation. No stability problems are known to have occurred since the dam was constructed in 1910.

d. Post-construction Changes. There have been no post-construction changes to the dam.

e. Seismic Stability. Larsen Dam is located is Seismic Zone 1. Normally, it can be considered that if a dam in this zone has adequate factors of safety under static loading conditions, it can be assumed safe for any expected earthquake loading. Since the factors of safety are assumed to be adequate, the dam is also assumed to be stable for any expected earthquake loading.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety.

(1) Based on available records, visual inspection, calculations, and past operational performance, Larsen Dam is judged to be in fair condition. Based on the size and hazard classification of the dam, the recommended SDF varies between the 1/2 PMF and the PMF. The selected SDF for the dam is the 1/2 PMF. Based on existing conditions, the spillway will pass about 12 percent of the PMF without overtopping of the dam. If the low areas on the top of the dam were filled to the design elevation, the spillway would pass 16 percent of the PMF. It is judged that Larsen Dam could not withstand the depth and duration of overtopping that would occur during the 1/2 PMF. However, it is judged that a high hazard dam located immediately downstream would fail due to overtopping prior to the overtopping failure of Larsen Dam. Therefore, the spillway capacity of Larsen Dam is rated as inadequate.

(2) No immediate stability problems were evident at the time of the inspection, but deficiencies do exist that could eventually affect the stability of the dam and appurtenances if they are not corrected.

(3) Maintenance of the dam is considered inadequate.

(4) A summary of the features and observed deficiencies is listed below:

Feature	Observed Deficiency
Embankment:	Low areas on top; brush on slopes; surface erosion; corewall exposed and cracked; missing riprap; burrowing animal hole; wet area at toe.
Spillway:	Crack in approach wall; concrete deteriorated.
Outlet Works:	Crack in intake structure; operating mechanisms rusted.

b. Adequacy of Information. The information available is such that an assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed prior to and as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented without delay.

d. Necessity for Further Investigations. Accomplishment of the remedial measures outlined in Paragraph 7.2, will require further investigations by the Owner.

7.2 Recommendations and Remedial Measures.

a. The following studies and remedial measures are recommended to be undertaken by the Owner, in approximate order of priority, without delay:

(1) Design and construct modifications as required to provide adequate spillway capacity.

(2) If the design for spillway modifications does not include provisions for repair of the corewall and replacement of missing embankment material, separate measures should be designed and constructed to accomplish those items.

(3) Remove brush from the dam, replace missing riprap, and fill the burrowing animal hole with impervious material.

(4) Visually monitor the wet area at the toe of the dam. Take appropriate action as required if the condition worsens.

All investigations, studies, designs, and inspection of construction should be performed by a professional engineer experienced in the design and construction of dams.

b. In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for Larsen Dam. When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

(2) During periods of unusually heavy rains, provide round-the-clock surveillance of Larsen Dam.

(3) As presently required by the Commonwealth, institute a program of formal annual inspections by a professional engineer experienced in the design and construction of dams. Utilize the inspection results to determine if remedial measures are necessary.

(4) Expand the existing maintenance program and develop a formal maintenance manual so that all features of the dam are properly maintained.

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Larsen Dam

NDI ID NO.: PA-00367 DER ID NO.: 35-30

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	One drawing available in PennDER files. Pertinent sections reproduced on Plate E-2 in Appendix E.
REGIONAL VICINITY MAP	See Location Map, Plate E-1.
CONSTRUCTION HISTORY	Constructed 1910 by Scranton Gas and Water Company. Originally known as Guldsboro Dam, later as Johnson Pond Dam. No significant modifications since 1910.
TYPICAL SECTIONS OF DAM	See Plate E-2.
OUTLETS: Plan Details Constraints Discharge Ratings	See Plate E-2 for plan and details. No discharge ratings available.

A-1

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	None available.
DESIGN REPORTS	Description of design contained in 1915 report prepared by the Commonwealth.
GEOLOGY REPORTS	Geologic information contained in 1915 report and shown on Plate E-2. For general geology, see Appendix F.
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	None.
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	Described in 1915 Report.
POSTCONSTRUCTION SURVEYS OF DAM	None.

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	Borrow obtained locally.
MONITORING SYSTEMS	None.
MODIFICATIONS	None reported.
HIGH POOL RECORDS	None.
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	None reported.

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	None.
SPILLWAY: Plan Sections Details	See Plate E-2.
OPERATING EQUIPMENT: Plans Details	See Plate E-2.
PREVIOUS INSPECTIONS Dates Deficiencies	1914: Good condition. 1938: Erosion of embankment at rt. abutment. 1957: Fair condition.

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Larsen Dam **County:** Lackawanna / Wayne **State:** Pennsylvania

NDI ID No.: PA-00367 **DER ID No.:** 35-30

Type of Dam: Earthfill with concrete corewall **Hazard Category:** High

Date(s) Inspection: 2 June 1981 **Weather:** Light rain **Temperature:** 65°

Pool Elevation at Time of Inspection: 1882.8 msl/**Tailwater at Time of Inspection:** 1877.9 msl

Inspection Personnel:

A. H. Whitman (GFCC)

D. K. Ebersole (GFCC)

D. B. Wilson (GFCC) **Recorder**

EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None apparent on embankment. 1/8" wide near-vertical crack in corewall approx. 15' right of spillway.	Portions of embankment obsured by brush.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	Downstream slope: length of corewall exposed possibly due to erosion during overtopping; general surface erosion on embankment to rt. of spillway. Upstream slope: minor erosion at intake structure and at spillway.	Maximum exposed height of corewall is 4.5'. Approx. 75' length is exposed. See Sheet B-10 for section.
CREST ALIGNMENT: Vertical Horizontal	Horizontal - no deficiencies. Vertical - irregular; see Sheet B-9	
RIPRAP FAILURES	Missing riprap over 3'x2' area 20' left of intake.	

EMBANKMENT

Sheet _ _ _ 4

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: Abutment Spillway Other Features	Surface erosion at various locations as described previously.	
ANY NOTICEABLE SEEPAGE	Approx. 5' diameter wet area at toe to left of spillway.	Source indeterminate. Does not appear to be serious hazard.
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	
BRUSH / TREES / MISC.	Brush on upstream slope both sides of spillway. Brush on downstream slope left of spillway.	One burrowing animal hole on D/S slope to left of spillway.

OUTLET WORKS

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Twin 24-inch diameter cast-iron outlet conduits submerged.	
INTAKE STRUCTURE	Concrete structure; bar screen at intake; large vertical crack in intake structure.	Concrete deterrorated at upstream end of approach wall.
OUTLET STRUCTURE	Submerged.	
OUTLET CHANNEL	Stream channel; large pool at outlet area.	
EMERGENCY GATE	Two slide gates at intake structure. Two gate valves in manholes on platform.	Equipment rusty but in fair condition. Owner reported valves operated 1 week prior to inspection.

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Submerged. No readily apparent deficiencies.	
APPROACH CHANNEL	Reservoir; no obstructions. One crack in right approach wall near upstream end.	
DISCHARGE CHANNEL	Surficial deterioration of concrete outlet channel walls.	
BRIDGE AND PIERS	None.	

INSTRUMENTATION

Sheet 1 of 1

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

DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: Obstructions Debris Other	No obstructions or debris.	
SLOPES	Vary from mild to steep; brush-covered.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Lake Lehigh Dam located 0.7 mile downstream. Several dwellings 1.7 miles from dam.	Lake Lehigh Dam inspected October 1980 and classified as high hazard.

RESERVOIR AND WATERSHED

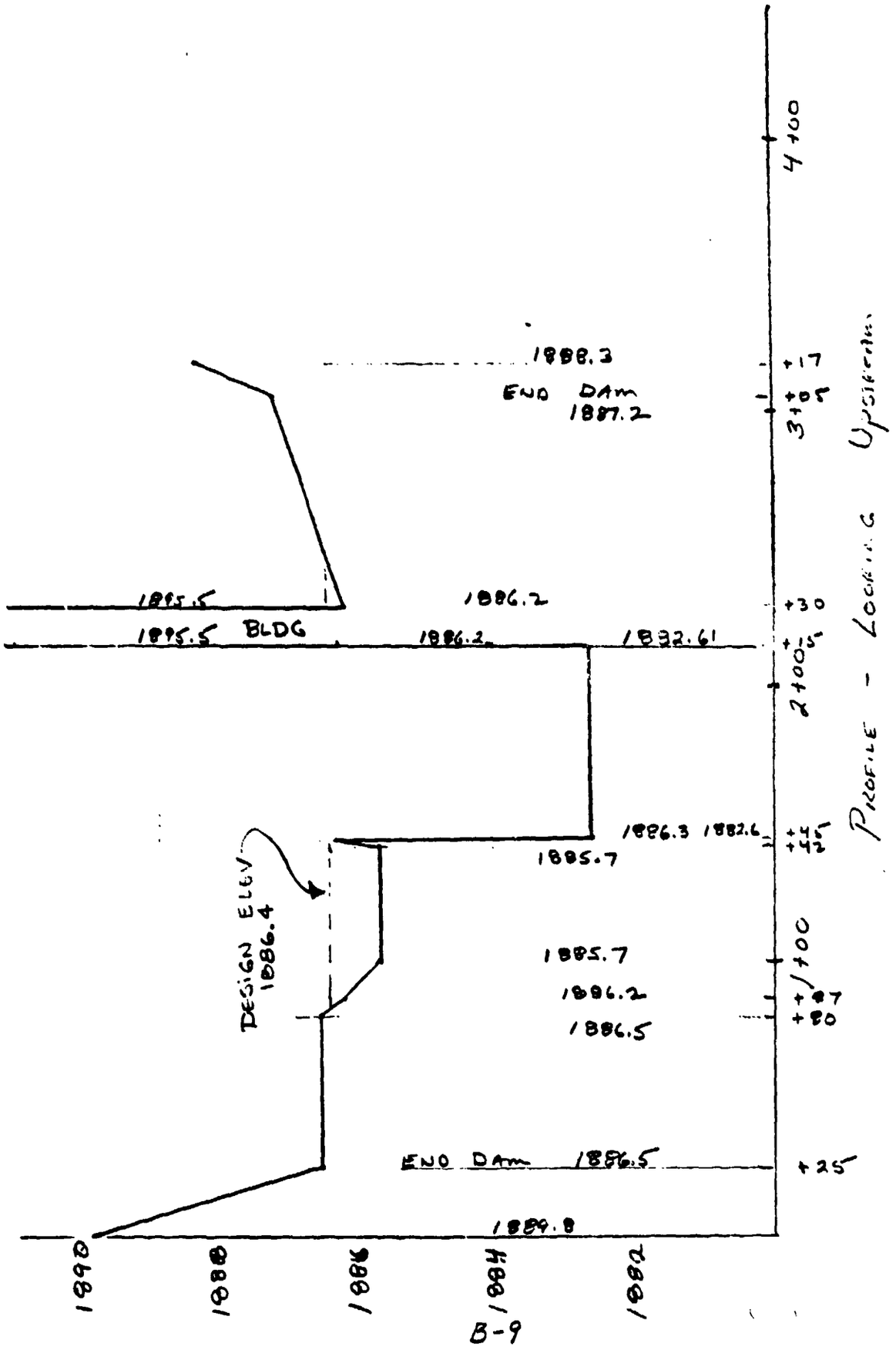
Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Mild to moderate slopes surrounding reservoir. Mostly wooded.	
SEDIMENTATION	Unknown.	
WATERSHED DESCRIPTION	Five dams and several small ponds in watershed. Watershed mostly wooded.	See Appendix D for description of upstream dams.

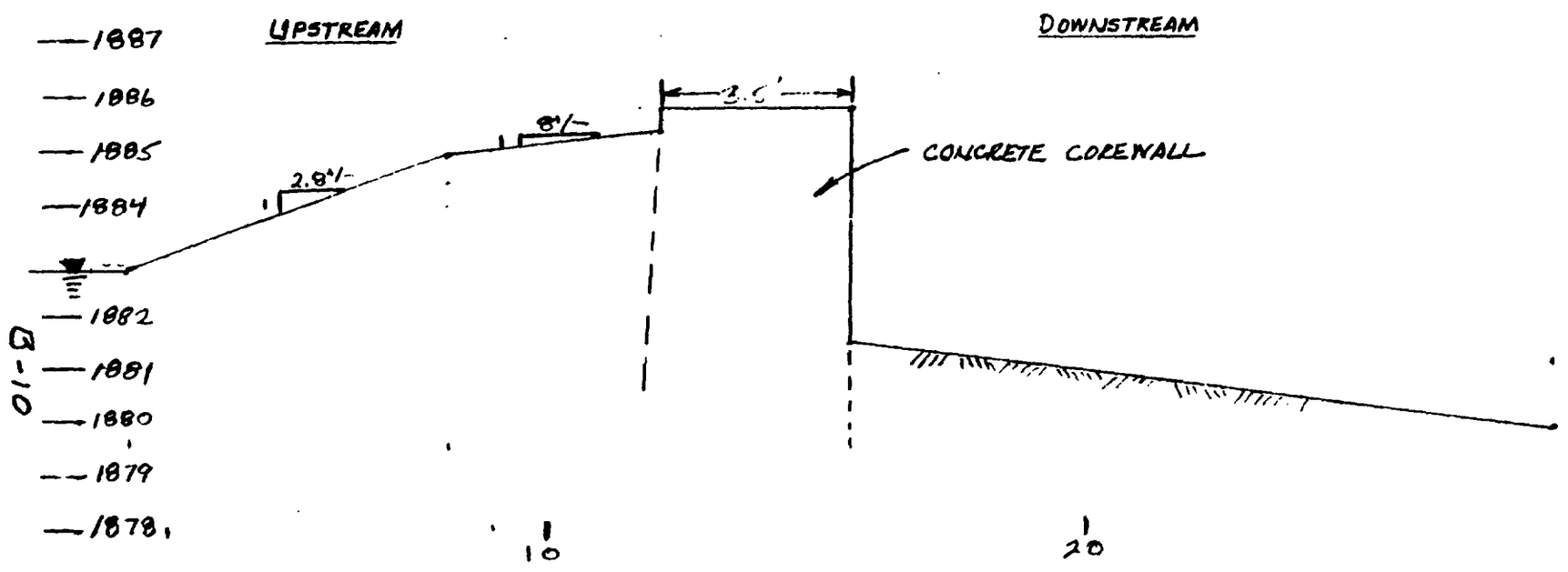
BY _____ DATE _____ SUBJECT _____ SHEET NO. _____ OF _____

CHKD BY _____ DATE _____ JOB. NO _____

LARSEN DAM



4.6

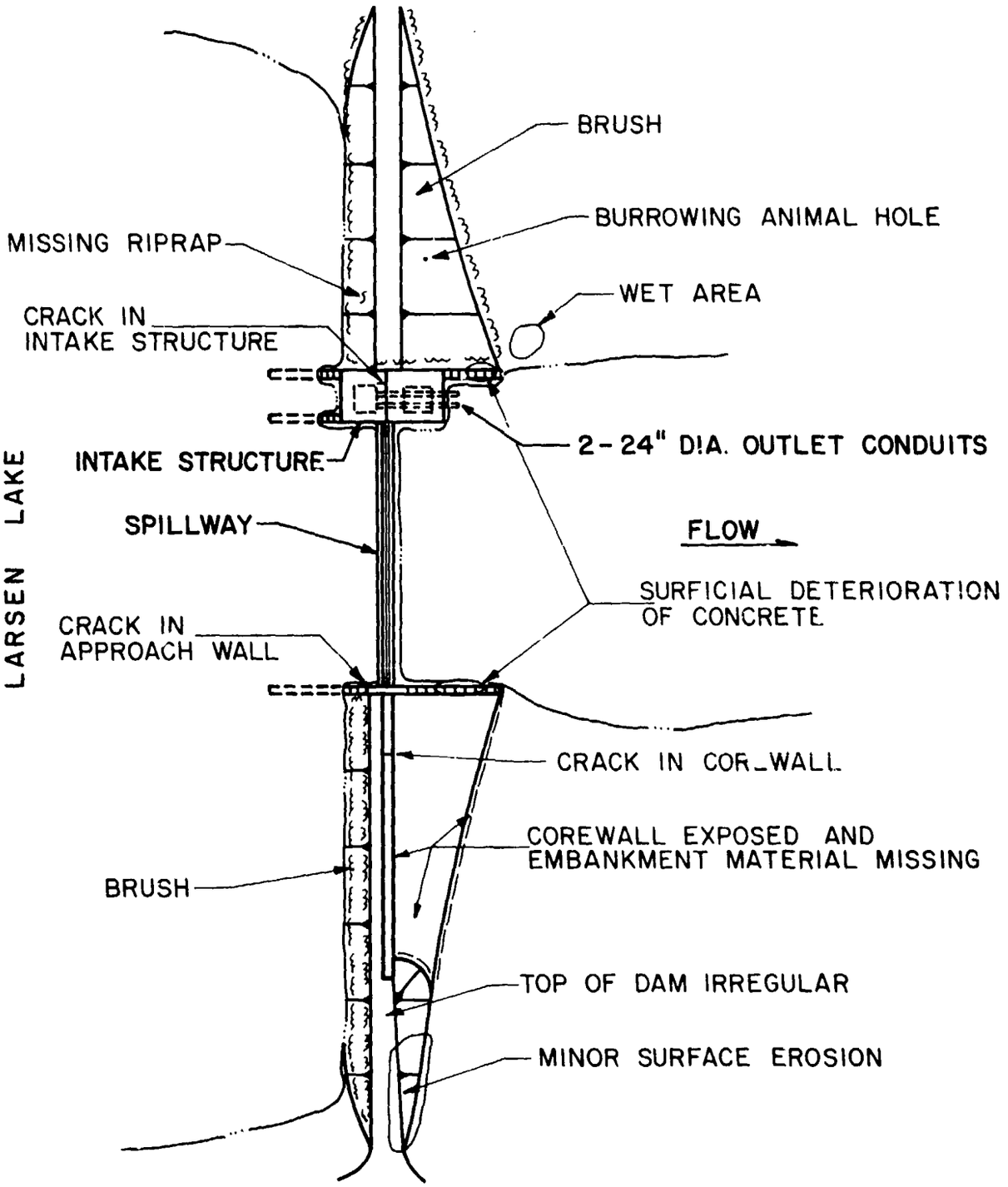


B-10

SECTION THROUGH EMBANKMENT
TO RIGHT OF SPILLWAY

BY _____ DATE _____
CHKD BY _____ DATE _____
SUBJECT LARSEN DAM
SHEET NO. _____ OF _____
JOB NO. _____

DATE OF INSPECTION: 2 JUNE 1981
POOL ELEVATION: 1882.8



NOT TO SCALE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LARSEN DAM

BIG BASS LAKE, INC.

RESUTS OF VISUAL INSPECTION

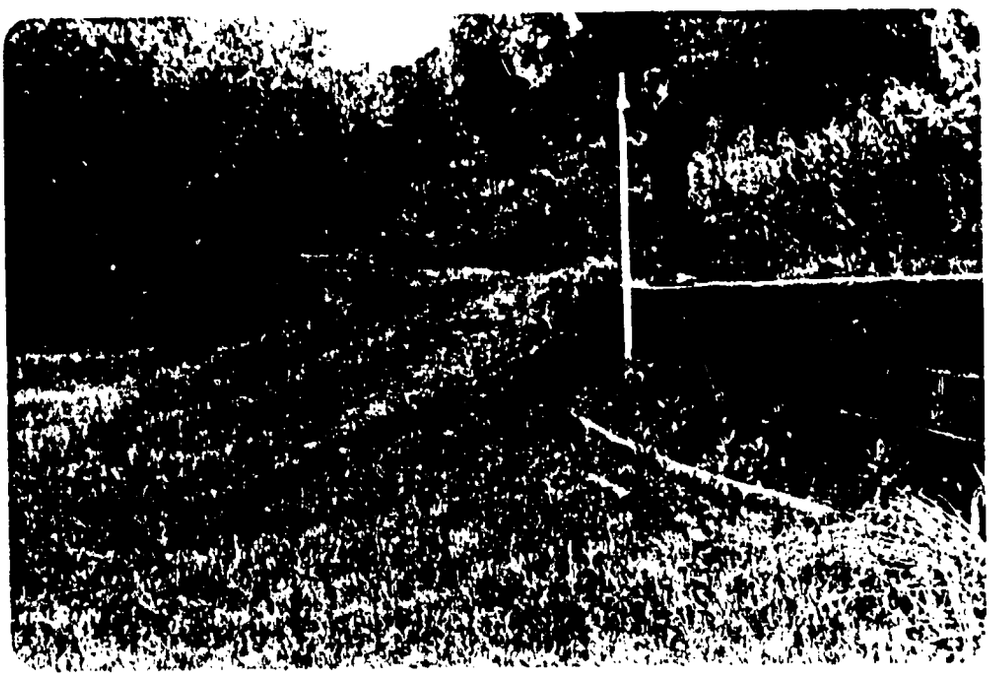
JULY 1981 EXHIBIT B-1

APPENDIX C

PHOTOGRAPHS

LARSEN DAM

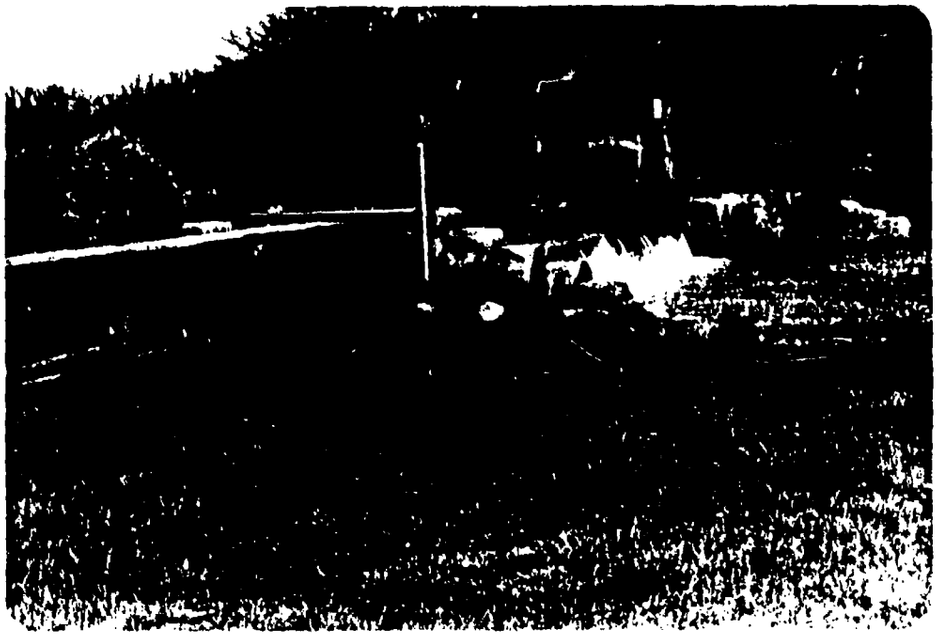
A. Embankment and Spillway



B. Exposed Corewall and Surface Erosion
Near Right Abutment

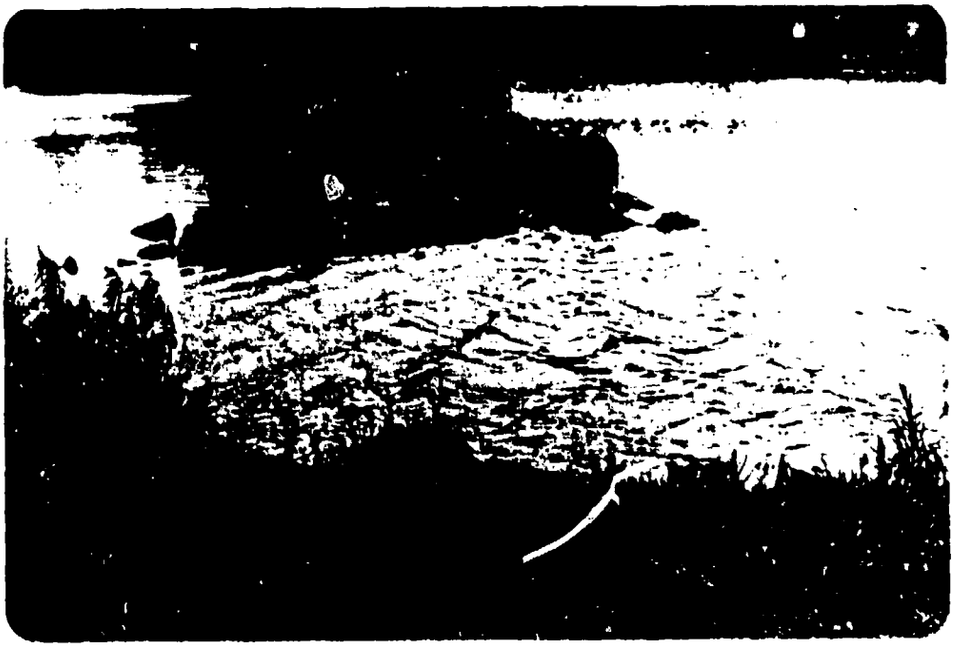
C. Crack in Corewall

D. Embankment Section to Left of Spillway



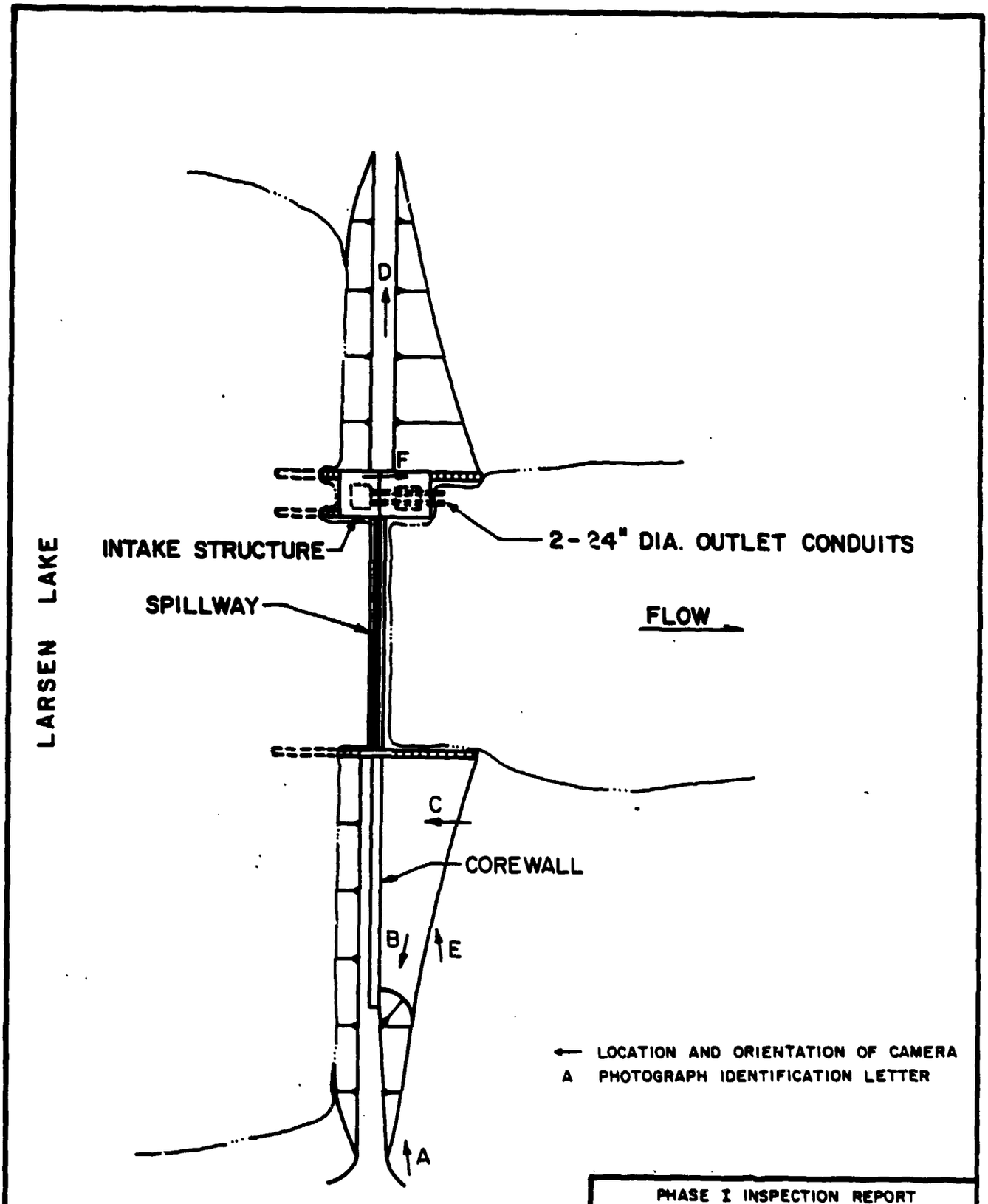
E. Spillway and Intake Structure

F. Typical Concrete Deterioration at Spillway and Outlet Works



G. Embankment in Reservoir Area

H. Lake Lehigh Dam - Located 0.7 Mile Downstream



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LARSEN DAM

BIG BASS LAKE, INC.

GUIDE TO LOCATION OF PHOTOGRAPHS

JULY 1981 EXHIBIT C-1

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D

HYDROLOGY AND HYDRAULICS

Spillway Capacity Rating:

In the recommended Guidelines for Safety Inspection of Dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended Spillway Design Flood (SDF) for the size (small, intermediate, or large) and hazard potential (low, significant, or high) classification of a dam is selected in accordance with the criteria. The SDF for those dams in the high hazard category varies between one-half of the Probable Maximum Flood (PMF) and the PMF. If the dam and spillway are not capable of passing the SDF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, or if the dam is not in the high hazard category, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

Description of Model:

If the Owner has not developed a PMF for the dam, the watershed is modeled with the HEC-1DB computer program, which was developed by the U.S. Army Corps of Engineers. The HEC-1DB computer program calculates a PMF runoff hydrograph (and percentages thereof) and routes the flows through both reservoirs and stream sections. In addition, it has the capability to simulate an overtopping dam failure. By modifying the rainfall criteria, it is also possible to model the 100-year flood with the program.

APPENDIX D

DELAWARE River Basin
Name of Stream: LEHIGH RIVER
Name of Dam: LARSEN
NDI ID No.: PA-00367
DER ID No.: 35-30
Latitude: N 41° 15.1' Longitude: W 75° 27.5'
Top of Dam Elevation: 885.7
Streambed Elevation: 1874.0 Height of Dam: 11.7 ft
Reservoir Storage at Top of Dam Elevation: 504 acre-ft
Size Category: SMALL
Hazard Category: HIGH (see Section 5)
Spillway Design Flood: VARIES 1/2 PMF TO PMF
SELECT 1/2 PMF

UPSTREAM DAMS

	Name	Distance from Dam (miles)	Height (ft)	Storage at top of Dam Elevation (acre-ft)	Remarks
★	CRYSTAL LAKE	3.8	13	755	DER ID 64-6
	UPPER KLONDIKE	0.9	14	181	DER ID 64-175
★	LOWER KLONDIKE	0.6	18	219	DER ID 64-175
★	LAKE WATAWGA	1.5	12	654	DER ID 64-38
★	GOULDSBORO	1.7	18	1500	DER ID 64-88

DOWNSTREAM DAMS

★	LAKE LEHIGH	0.7	10	163	DER ID 64-51

Except for LARSEN Dam, DATA HEREIN OBTAINED FROM PHASE I REPORTS FOR THE VARIOUS dams.

★ PHASE I REPORT PREVIOUSLY PREPARED.

DELAWARE River Basin

Name of Stream: LEHIGH RIVER

Name of Dam: LAASEN

DETERMINATION OF PMF RAINFALL & UNIT HYDROGRAPH

UNIT HYDROGRAPH DATA:

Sub-area	Drainage Area (square miles)	Cp (1)	Ct (2)	L miles (3)	L_{ca} miles (4)	L' miles (5)	Tp hours (6)	Map Area (7)	Plate (8)
A-1	2.57	0.45	2.1	2.08	0.61	N/A	2.26	2	B
A-2	3.88	0.45	2.1	N/A	N/A	2.40	3.55	2	B
A-3	0.42	0.45	2.1	1.89	0.70	N/A	2.28	2	B
A-4	0.77	0.45	2.1	N/A	N/A	0.59	1.53	2	B
A-5	4.69	0.45	2.1	3.41	2.03	N/A	3.75	2	B
A-6	0.17	0.45	2.1	N/A	N/A	0.40	1.21	2	B
A-7	2.89	0.45	2.1	2.69	1.01	N/A	2.83	2	B
Total	15.39								

(See Sketch on Sheet D-4)

(1) & (2): Snyder Unit Hydrograph coefficients supplied by Baltimore District, Corps of Engineers on maps and plates referenced in (7) & (8)

The following are measured from the outlet of the subarea:

(3): Length of main watercourse extended to divide

(4): Length of main watercourse to the centroid

The following is measured from the upstream end of the reservoir at normal pool:

(5): Length of main watercourse extended to divide

(6): $Tp=C_t \times (L \times L_{ca})^{0.3}$, except where the centroid of the subarea is located in the reservoir. Then $Tp=C_t \times (L')^{0.6}$

Initial flow is assumed at 1.5 cfs/sq. mile

Computer Data: QRCSN = -0.05 (5% of peak flow)

RTIOR = 2.0

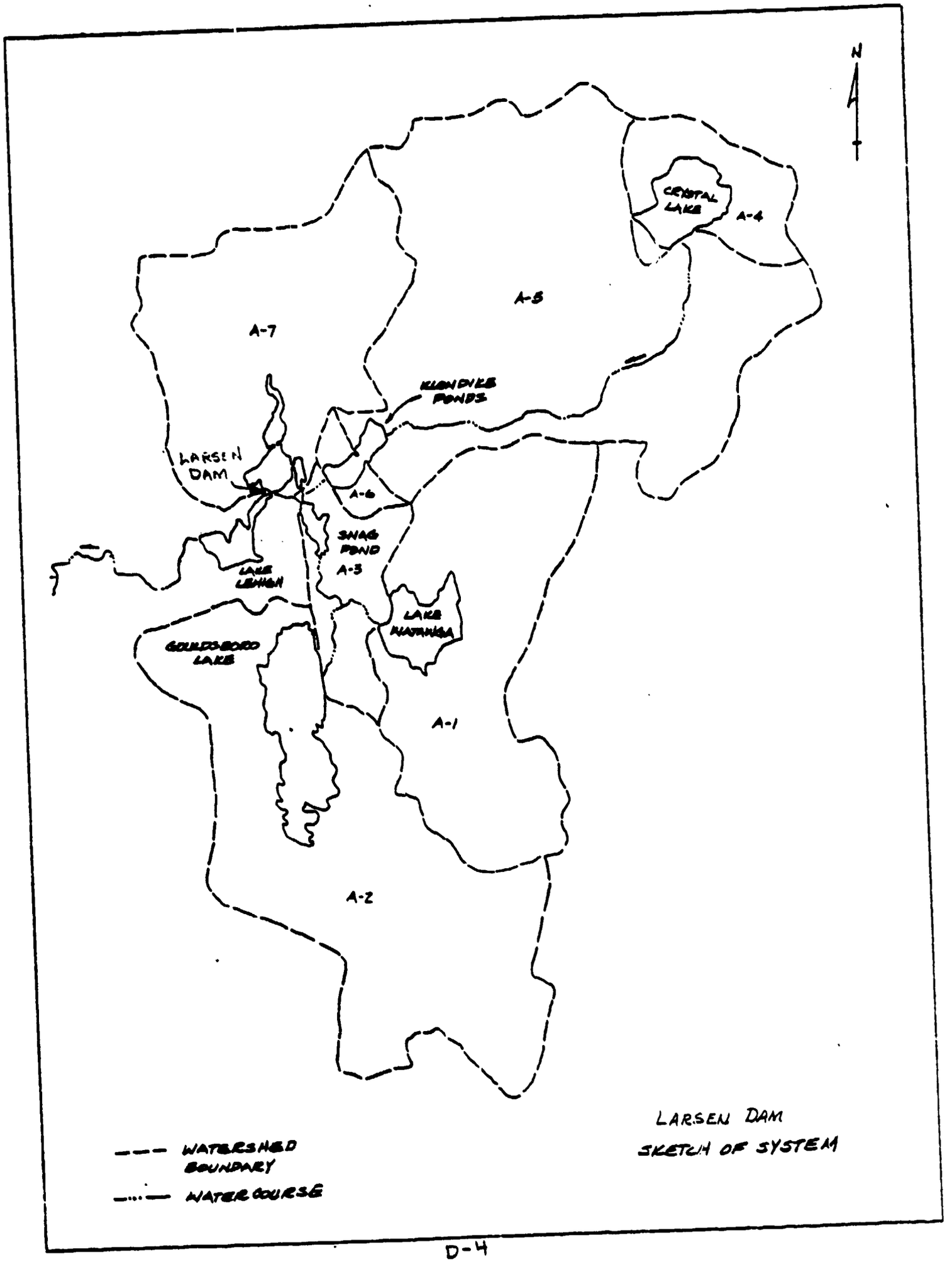
RAINFALL DATA:

PMF Rainfall Index= 21.9 in., 24 hr., 200 sq. mile

	Hydromet. 40 (Susquehanna Basin)	Hydromet. 33 (Other Basins)
Zone:	N/A	/
Geographic Adjustment Factor:	N/A	1.0
Revised Index Rainfall:	N/A	21.9

RAINFALL DISTRIBUTION (percent)

Time	Percent
6 hours	106
12 hours	119
24 hours	129
48 hours	138
72 hours	
96 hours	



LARSEN DAM
SKETCH OF SYSTEM

Data for Dam at Outlet of Subarea A-1 (See sketch on Sheet D-4)

Name of Dam: LAKE WATAUGA DAM

STORAGE DATA: TAKEN FROM PHASE I REPORT FOR LAKE WATAUGA DAM

Elevation		Area (acres)		Storage million gals	acre-ft		Remarks
1909.4	=ELEVO*	0		0	0		STREAMBED
1920.0	=ELEV1	125	=A1	144	442	=S1	NORMAL POOL
1921.6		140		213	654		TOP OF DAM
1940.0		376					

* ELEVO = ELEV1 - $(3S_1/A_1)$
** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Normal Pool is 8 percent of subarea watershed.

BREACH DATA: BREACH ANALYSIS NOT REQUIRED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL= _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-1

Name of Dam: LAKE WATAWGA DAM

SPILLWAY DATA: FROM PHASE I REPORT FOR LAKE WATAWGA DAM (1980)

	Existing Conditions	Design Conditions
Top of Dam Elevation	1921.6	(N/A)
Spillway Crest Elevation	1920.0	
Spillway Head Available (ft)	1.6	
Type Spillway	CONCRETE WEIR-FREE OVERFALL	
"C" Value - Spillway	3.1	
Crest Length - Spillway (ft)	51.0	
Spillway Peak Discharge (cfs)	320	
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway		
"C" Value - Auxiliary Spill. (ft)	N/A	
Crest Length - Auxil. Spill. (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve: $Q = CLH^{1.5} = 158\,H^{1.5}$

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:

	Outlet 1	Outlet 2	Outlet 3
	(NO OUTLET WORKS)		
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction=$29.1 N^2 L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5} = C$			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$ (cfs)			
Q Combined (cfs)			

Data for Dam at Outlet of Subarea A-2 (See sketch on Sheet D-4)

Name of Dam: GOULDSBORO DAM

STORAGE DATA: FROM PHASE I REPORT FOR GOULDSBORO DAM

Elevation		Area (acres)		Storage million gals	Storage acre-ft		Remarks
	=ELEVO	0		0	0		
1894.0	=ELEV1	260	=A1	355	1089	=S1	NORMAL POOL
1900.0				1829	5601		
1910.0				3046	9348		

* ELEVO = ELEV1 - $(3S_1/A_1)$
** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Normal Pool is 10 percent of subarea watershed.

BREACH DATA: BREACH ANALYSIS NOT REQUIRED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL= _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-2

Name of Dam: GOULDSBORO DAM

SPILLWAY DATA: FROM PHASE I REPORT FOR GOULDSBORO DAM - JULY 1979

	Existing Conditions	Design Conditions
		(N/A)
Top of Dam Elevation	1901.7	
Spillway Crest Elevation	1894.0	
Spillway Head Available (ft)	7.7	
Type Spillway	CONCRETE DROP INLET	
"C" Value - Spillway	2.85	
Crest Length - Spillway (ft)	13.25 (INSIDE LENGTH OF WEIR)	
Spillway Peak Discharge (cfs)	149 *	
Auxiliary Spillway Crest Elev.	1895.5	
Auxiliary Spill. Head Avail. (ft)	6.2	
Type Auxiliary Spillway	OPEN CHANNEL	
"C" Value - Auxiliary Spill. (ft)	N/A	
Crest Length - Auxil. Spill. (ft)	130 (BOTTOM WIDTH)	
Auxiliary Spillway Peak Discharge (cfs)	2970	
Combined Spillway Discharge (cfs)	3119	

* ASSUMED CONSTANT FOR HEADS ABOVE 25 FEET

Spillway Rating Curve: (SEE BELOW)

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)
1894.0			0
1895.0			38
1895.5			69
1896.5			290
1897.5			596
1898.5			1029
1899.5			1570

OUTLET WORKS RATING:	Outlet 1	Outlet 2	Outlet 3
	(N/A)	(N/A)	(N/A)
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction=$29.1_N{}^2L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5}$ = C			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$(cfs)			
Q Combined (cfs)			

Data for Dam at Outlet of Subarea A-4 (See sketch on Sheet D-4)

Name of Dam: CRYSTAL LAKE DAM

STORAGE DATA: TAKEN FROM PHASE I REPORT FOR CRYSTAL LAKE DAM

Elevation		Area (acres)		Storage million gals	acre-ft		Remarks
2046.9	=ELEVO*	0		0	0		
2055.9	=ELEV1	133	=A1	130	399	=S1	NORMAL POOL
2058.4		132		246	754		TOP OF DAM
2060.0		164		328	1007		
20800	**	259		1694	5200		

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Normal Pool is 27 percent of subarea watershed.

BREACH DATA: BREACH ANALYSIS NOT REQUIRED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL = _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-4

Name of Dam: CRYSTAL LAKE DAM

SPILLWAY DATA: FROM PHASE I REPORT FOR CRYSTAL LAKE DAM (1981)

	Existing Conditions	Design Conditions
		(N/A)
Top of Dam Elevation	2058.4	
Spillway Crest Elevation	2055.9	
Spillway Head Available (ft)	2.5	
Type Spillway	BROAD-CRESTED CONCRETE	
"C" Value - Spillway	2.7	
Crest Length - Spillway (ft)	29.5	
Spillway Peak Discharge (cfs)	315	
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway		
"C" Value - Auxiliary Spill. (ft)	N/A	
Crest Length - Auxil. Spill. (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve: $Q = CLH^{1.5} = 79.7\,H^{1.5}$

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:	Outlet 1	Outlet 2	Outlet 3
	(N/A)		
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction $=29.1 n^2 L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5} = C$			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$ (cfs)			
Q Combined (cfs)			

Data for Dam at Outlet of Subarea A-5 (See sketch on Sheet D-4)

Name of Dam: UPPER KLONDIKE DAM

STORAGE DATA: FROM PHASE I REPORT FOR LOWER KLONDIKE DAM

Elevation		Area (acres)		Storage million gals	acre-ft		Remarks
1892.6	=ELEVO*	0		0	0		STREAMBED
1902.0	=ELEV1	20	=A1	20	63	=S1	***
1906.6		32		59	181		TOP OF DAM
1920.0	**	81		297	910		

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour at least 10 feet above top of dam

*** From Design Drawings

Reservoir Area at Normal Pool is 1 percent of subarea watershed.

BREACH DATA: BREACH ANALYSIS NOT REQUIRED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL= _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-5

Name of Dam: UPPER KLONDIKE DAM

SPILLWAY DATA: FROM PHASE I REPORT FOR LOWER KLONDIKE DAM (1980)

	Existing Conditions	Design Conditions
		(N/A)
Top of Dam Elevation	1906.6	
Spillway Crest Elevation	1902.0	
Spillway Head Available (ft)	4.6	
Type Spillway	BROAD-CRESTED CONCRETE	
"C" Value - Spillway	2.7	
Crest Length - Spillway (ft)	140.0	
Spillway Peak Discharge (cfs)	5729	
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway	N/A	
"C" Value - Auxiliary Spill. (ft)		
Crest Length - Auxil. Spill. (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve: $Q = CLH^{1.5} = 378H^{1.5}$

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:	Outlet 1	Outlet 2	Outlet 3
	(N/A)		
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction=$29.1_N{}^2L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5} = C$			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$ (cfs)			
Combined (cfs)			

Data for Dam at Outlet of Subarea A-6 (See sketch on Sheet D-4)

Name of Dam: LOWER KLONDIKE DAM

STORAGE DATA: FROM PHASE I REPORT FOR LOWER KLONDIKE DAM

Elevation		Area (acres)		Storage million gals	acre-ft		Remarks
1882.3	=ELEVO*	0		0	0		
1895.1	=ELEV1	22	=A1	31	94	=S1	A1 FROM DESIGN DRAWINGS
1899.6		34		71	218		TOP OF DAM
1900.0		35		76	233		DESIGN TOP OF DAM
1920.0	**	150		635	1949		

* ELEVO = ELEV1 - $(3S_1/A_1)$
** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Normal Pool is 20 percent of subarea watershed.

BREACH DATA: BREACH ANALYSIS NOT REQUIRED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL= _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-6

Name of Dam: LOWER KLONDIKE DAM

SPILLWAY DATA: FROM PHASE I REPORT FOR LOWER KLONDIKE DAM

	Existing Conditions	Design Conditions
Top of Dam Elevation	1899.6	1900.0
Spillway Crest Elevation	1895.1	1895.0
Spillway Head Available (ft)	4.5	5.0
Type Spillway	BROAD-CRESTED CONCRETE	
"C" Value - Spillway	2.7	2.7
Crest Length - Spillway (ft)	138	138
Spillway Peak Discharge (cfs)	3337	4165
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway		
"C" Value - Auxiliary Spill. (ft)		
Crest Length - Auxil. Spill. (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve: $Q = CLH^{1.5} = 373\,H^{1.5}$

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:	Outlet 1 (N/A)	Outlet 2	Outlet 3
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction $=29.1N^2L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5} = C$			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$ (cfs)			
Q Combined (cfs)			

Data for Dam at Outlet of Subarea A-7 (See sketch on Sheet D-4)

Name of Dam: LARSEN

STORAGE DATA:

Elevation		Area (acres)		Storage million gals	Storage acre-ft		Remarks
1871.0	=ELEVO*	0		0	0		
1882.6	=ELEV1	63.5	=A1	80.2896	246.[illegible]	=S1	OWNERS DATA
1885.7		105			504		Top Dam
1886.4		116			591		
1890.0		180					

* ELEVO = ELEV1 - $(3S_1/A_1)$

** Planimetered contour ~~as least 10 feet~~ (INTERPOLATED) above top of dam

Reservoir Area at Normal Pool is 3 percent of subarea watershed.

BREACH DATA: NOT USED

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAI' _____ mins = _____ hrs (time for breach to develop)

Data for Dam at Outlet of Subarea A-7

Name of Dam: LARSEN

SPILLWAY DATA: $Q = C L H^{1.5}$

	Existing Conditions	Design Conditions
Top of Dam Elevation	1885.7	1886.4
Spillway Crest Elevation	1882.6	1882.6
Spillway Head Available (ft)	3.1	3.8
Type Spillway	CONCRETE GRAVITY W/ ROUND CREST	
"C" Value - Spillway	3.4	3.4 *
Crest Length - Spillway (ft)	70.0	70.0
Spillway Peak Discharge (cfs)	1,299	1,763
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway		
"C" Value - Auxiliary Spill. (ft)		
Crest Length - Auxil. Spill. (ft)		
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)	1,299	1,763

* KINGS HANDBOOK FIG 71

Spillway Rating Curve:

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:

	Outlet 1	Outlet 2	Outlet 3
Invert of Outlet	1874.0	1874.0	
Invert of Inlet	1874±	1874±	
Type	CIP	CIP	
Diameter (ft) = D	2	2	
Length (ft) = L	24	24	
Area (sq. ft) = A	3.14	3.14	
N	.014	.014	
K Entrance	0.5	0.5	
K Exit	1.0	1.0	
K Friction=$29.1 N^2 L/R^{4/3}$	.34	.34	
Sum of K	1.84	1.84	
$(1/K)^{0.5} = C$	.74	.74	
Maximum Head (ft) = HM	8+/-	8+/-	
$Q = CA\sqrt{2g(HM)}$ (cfs)	53	53	
Q Combined (cfs)	106		
	≈ 110		

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1                A1                        NATIONAL DAM INSPECTION PROGRAM
    2                A2                          LEHIGH RIVER
    3                A3                          LARSEN DAM
    4                B    300       0      15       0       0       0       0       0      -6       0
    5                B1     5
    6                J      1       8       1
    7                J1     1      .5      .3      .25      .2      .15      .1      .05
    8                K      0       1                                        1
    9                K1       INFLOW TO LAKE WATAUGA DAM
   10                M      1       1    2.57              15.39                                   1
   11                P              21.9     106     119     129     138
   12                T                                                       1.0    0.05             0.06
   13                M   2.26    0.45
   14                X   -1.5   -0.05     2.0
   15                K      1       1                                        1
   16                K1       ROUTE THROUGH LAKE WATAUGA DAM
   17                Y                                      1       0
   18                Y1     1                                        -1920.0
   19                SA     0     125     140     376
   20                SE1909.4  1920.0  1921.6  1940.0
   21                SS1920.0    51.0     3.1     1.5
   22                SD1921.6
   23                SL  89.5     126     212     295     379     450     730     730
   24                SV1921.6  1921.7  1921.8  1922.0  1922.2  1922.5  1923.0  1925.0
   25                K      0       2                                        1
   26                K1       INFLOW TO GOULDSBORO DAM
   27                M      1       1    3.88              15.39                                   1
   28                P              21.9     106     119     129     138
   29                T                                                       1.0    0.05             0.10
   30                M   3.55    0.45
   31                X   -1.5   -0.05     2.0
   32                K      1       2                                        1
   33                K1       ROUTE THROUGH GOULDSBORO DAM
   34                Y                                      1       0
   35                Y1     1                                        -1896      -1
   36                Y41894.0  1895.0  1895.5  1896.5  1897.5  1898.5  1899.5
   37                Y5     0      38      69     290     596    1029    1570
   38                SS  1089    5601    9350
   39                SE  1894    1900    1910
   40                SS  1894
   41                SD1901.7     2.5     1.5    1000
   42                K      2       A                                        1
   43                K1       COMBINE OUTFLOWS FROM LAKE WATAUGA AND GOULDSBORO DAM
   44                K      1       3                                        1
   45                K1       ROUTE DOWNSTREAM TO SNAG POND
   46                Y                                      1       0
   47                Y1     1                                        -1
   48                Y6   0.1    0.07     0.1    1878    1900    3300   0.010
   49                Y7     0    1900     150    1890     300    1880     300    1878     310    1878
   50                Y7   310    1880     410    1890     510    1900
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D-17

existing

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K       0       3                                               1
K1       SUB-AREA RUNOFF BELOW WATAUGA GOULDSBORO JOHNSON (SNAG POND)
M       1       1    0.42            15.39                                      1
P            21.9     106     119     129     138
T                                                               1.0    0.05             .07
W    2.28    0.45
X    -1.5   -0.05     2.0
K       2       3                                               1
K1       COMBINE SUB-AREA SNAG POND WITH WATAUGA GOULDSBORO OUTFLOW
K       0       4                                               1
K1       INFLOW TO CRYSTAL LAKE
M       1       1    0.77            15.39                                      1
P            21.9     106     119     129     138
T                                                               1.0    0.05            0.27
W    1.53    0.45
X    -1.5   -0.05     2.0
K       1       4                                               1
K1       ROUTE THROUGH CRYSTAL LAKE
Y                               1       0
Y1      1                                                 -2055.9
SA      0     133     152     166     259
SE2046.9   2055.9  2058.4  2060.0  2080.0
SS2055.9     29.5     2.7     1.5
SD2058.4
SL      0      60     845     895     910
SV2058.4   2058.5  2059.0  2059.5  2060.0
K       1       5                                               1
K1       ROUTE DOWNSTREAM TO KLONDIKE POND-STREAM SECTION 1
Y                               1       0
Y1      1                                                      -1
Y6    0.1    0.07     0.1  2017.0  2040.0    3300   0.004
Y7      0    2060     250    2020     495    2019     496    2017     504    2017
Y7    505    2019     850    2020    1000    2060
K       1       6                                               1
K1       ROUTE DOWNSTREAM TO KLONDIKE POND-STREAM SECTION 2
Y                               1       0
Y1      1                                                      -1
Y6    0.1    0.07     0.1  2000.0  2030.0    4000   0.004
Y7      0    2030     250    2020    1195    2002    1196    2000    1204    2000
Y7   1205    2002    1820    2020    2000    2030
K       1       7                                               1
K1       ROUTE DOWNSTREAM TO KLONDIKE POND-STREAM SECTION 3
Y                               1       0
Y1      1                                                      -1
Y6    0.1    0.07     0.1  1943.0  1980.0    7600   0.007
Y7      0    1980     300    1960     545    1945     546    1943     554    1943
Y7    555    1945     820    1960    1050    1980
K       0       8                                               1
K1       INFLOW TO UPPER KLONDIKE POND
M       1       1    4.69            15.39                                      1
```

```
P           21.9      106      119      129      138
T                                                         1.0     0.05              0.01
W    3.75    0.45
X    -1.5   -0.05     2.0
K       2       8                                         1
K1      COMBINE FLOWS FROM CRYSTAL LAKE AND UPPER KLONDIKE SUB-AREA
K       1       8                                         1
K       ROUTE THROUGH UPPER KLONDIKE LAKE
Y                                  1        0
Y1      1                                            -1902.0
SA      0      20       32       81
$E1892.6  1902.0  1906.6  1920.0
$$1902.0     140     2.7     1.5
$D1906.6
SL      1     160      365      733      765      765
$V1906.6  1906.9  1907.0  1907.5  1908.0  1910.0
K       0       9                                         1
K1      SUB-AREA RUNOFF LOWER KLONDIKE DAM
M       1       1     0.17              15.39                               1
P           21.9      106      119      129      138
T                                                         1.0     0.05              0.20
W    1.21    0.45
X    -1.5   -0.05     2.0
K       2       9                                         1
K1      COMBINE OUTFLOW FROM UPPER KLONDIKE WITH LOWER KLONDIKE SUB-AREA
K       1       9                                         1
K1      ROUTE THROUGH LOWER KLONDIKE LAKE
Y                                  1        0
Y1      1                                            -1895.1
SA      0      22       34       35      150
$E1882.3  1895.1  1899.6  1900.0  1920.0
$$1895.1     138     2.7     1.5
$D1899.6
SL      1     840     1180     1380
$V1899.6  1900.0  1900.5  1902.0
K       2      10                                         1
K1      COMBINE OUTFLOWS FROM KLONDIKE WATANGA & GOULDSBORO AT JOHNSON POND
K       0      10                                         1
K1      SUB-AREA RUNOFF JOHNSON POND
M       1       1     2.89              15.39                               1
P           21.9      106      119      129      138
T                                                         1.0     0.05              0.04
W    2.83    0.45
X    -1.5   -0.05     2.0
K       2      10                                         1
K1      TOTAL INFLOW TO JOHNSON POND
K       1      10                                         1
K1      ROUTE THROUGH LARSEN DAM
Y                                  1        1
Y1      1                                            -1882.6
```

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151   SA     0    63.5    180
152   SE  1871  1882.6   1890
153   SS1882.6      70    3.4     1.5
154   SD1885.7
155   SL    42      57     90     145     200     222     235
156   SV1885.7  1886.2 1886.5 1886.51  1887.2  1888.3    1890
157   K      1      11                                      1
158   K1      ROUTE THROUGH LAKE LEHIGH
159   Y                              1       0
160   Y1     1                                          -1873
161   SA     0      44     48
162   SE1864.0    1873   1880
163   SS1873.0      88    3.1     1.5
164   SD1873.7
165   SL     0      26    115     186     248     278     278
166   SV1873.7  1874.0 1874.5  1875.0  1875.5  1876.0  1876.5
167   K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALC'ILATIONS

RUNOFF HYDROGRAPH AT	1	
ROUTE HYDROGRAPH TO	1	LAKE WATAUGA
RUNOFF HYDROGRAPH AT	2	
ROUTE HYDROGRAPH TO	2	GOULDSBORO DAM
COMBINE 2 HYDROGRAPHS AT	1	
ROUTE HYDROGRAPH TO	3	
RUNOFF HYDROGRAPH AT	3	
COMBINE 2 HYDROGRAPHS AT	3	
RUNOFF HYDROGRAPH AT	4	
ROUTE HYDROGRAPH TO	4	CRYSTAL LAKE
ROUTE HYDROGRAPH TO	5	
ROUTE HYDROGRAPH TO	6	
ROUTE HYDROGRAPH TO	7	
RUNOFF HYDROGRAPH AT	8	
COMBINE 2 HYDROGRAPHS AT	8	
ROUTE HYDROGRAPH TO	8	UPPER ONDIKE DAM
RUNOFF HYDROGRAPH AT	9	
COMBINE 2 HYDROGRAPHS AT	9	
ROUTE HYDROGRAPH TO	9	LOWER KLONDIKE DAM
COMBINE 2 HYDROGRAPHS AT	10	
RUNOFF HYDROGRAPH AT	10	
COMBINE 2 HYDROGRAPHS AT	10	
ROUTE HYDROGRAPH TO	10	LARSEN DAM
ROUTE HYDROGRAPH TO	11	LAKE LEHIGH
END OF NETWORK		

D

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00	RATIO 2 .50	RATIO 3 .30	RATIO 4 .25	RATIO 5 .20	RATIO 6 .15	RATIO 7 .10	RATIO 8 .05	
HYDROGRAPH AT	1	2.57	1	4625.	2313.	1388.	1156.	925.	694.	463.	231.	
	(	6.66)	(	130.98)(	65.49)(	39.29)(	32.74)(	26.20)(	19.65)(	13.10)(	6.55)(	
ROUTED TO	1	2.57	1	4484.	2119.	1103.	839.	577.	368.	210.	89.	LAKE WATANGA
	(	6.66)	(	126.98)(	59.99)(	31.23)(	23.76)(	16.33)(	9.85)(	5.96)(	2.53)(	
HYDROGRAPH AT	2	3.88	1	5252.	2626.	1575.	1313.	1050.	788.	525.	263.	
	(	10.05)	(	148.71)(	74.35)(	44.61)(	37.18)(	29.74)(	22.31)(	14.87)(	7.44)(	
ROUTED TO	2	3.88	1	1064.	306.	101.	62.	45.	32.	21.	11.	GOULDSBORO DAM
	(	10.05)	(	30.12)(	8.66)(	2.86)(	1.76)(	1.29)(	.91)(	.60)(	.30)(	
2 COMBINED	4	6.45	1	4638.	2159.	1131.	865.	599.	368.	224.	97.	
	(	16.71)	(	131.34)(	61.13)(	32.04)(	24.51)(	16.98)(	10.41)(	6.35)(	2.76)(	
ROUTED TO	3	6.45	1	4625.	2153.	1124.	860.	596.	366.	224.	97.	
	(	16.71)	(	130.97)(	60.95)(	31.84)(	24.37)(	16.89)(	10.38)(	6.34)(	2.73)(	
HYDROGRAPH AT	3	.42	1	755.	378.	227.	189.	151.	113.	76.	38.	
	(	1.09)	(	21.38)(	10.69)(	6.41)(	5.35)(	4.28)(	3.21)(	2.14)(	1.07)(	
2 COMBINED	3	6.87	1	5342.	2491.	1299.	992.	686.	422.	258.	111.	
	(	17.79)	(	151.27)(	70.54)(	36.78)(	28.08)(	19.42)(	11.94)(	7.31)(	3.15)(	
HYDROGRAPH AT	4	.77	1	1730.	865.	519.	433.	346.	260.	173.	87.	CRYSTAL LAKE
	(	1.99)	(	49.00)(	24.50)(	14.70)(	12.25)(	9.80)(	7.35)(	4.90)(	2.45)(	
ROUTED TO	4	.77	1	1201.	257.	134.	105.	78.	54.	31.	12.	
	(	1.99)	(	34.02)(	7.28)(	3.78)(	2.98)(	2.22)(	1.52)(	.88)(	.34)(	
ROUTED TO	5	.77	1	1125.	254.	132.	104.	78.	52.	30.	12.	
	(	1.99)	(	31.85)(	7.18)(	3.74)(	2.95)(	2.20)(	1.48)(	.86)(	.34)(	
ROUTED TO	6	.77	1	1046.	251.	131.	103.	76.	52.	30.	12.	
	(	1.99)	(	29.62)(	7.10)(	3.70)(	2.91)(	2.17)(	1.47)(	.86)(	.34)(	
ROUTED TO	7	.77	1	966.	247.	128.	101.	75.	51.	30.	12.	
	(	1.99)	(	27.36)(	7.00)(	3.63)(	2.86)(	2.13)(	1.45)(	.85)(	.33)(	
HYDROGRAPH AT	8	4.69	1	6113.	3057.	1834.	1528.	1223.	917.	611.	306.	
	(	12.15)	(	173.11)(	86.56)(	51.93)(	43.28)(	34.62)(	25.97)(	17.31)(	8.66)(	
2 COMBINED	8	5.46	1	6624.	3164.	1883.	1566.	1251.	937.	624.	310.	UPPER KLONDIKE
	(	14.14)	(	187.56)(	89.59)(	53.33)(	44.35)(	35.42)(	26.53)(	17.66)(	8.79)(	
ROUTED TO	8	5.46	1	6622.	3138.	1866.	1551.	1238.	926.	614.	304.	
	(	14.14)	(	187.53)(	88.86)(	52.85)(	43.93)(	35.06)(	26.21)(	17.39)(	8.61)(	

D-22

HYDROGRAPH AT	9	.17	1	430.	215.	129.	108.	86.	65.	43.	22.	
	(	.44)	(	12.19)(	6.09)(	3.66)(	3.05)(	2.44)(	1.83)(	1.22)(	.61)(	
2 COMBINED	9	5.63	1	6791.	3232.	1923.	1599.	1276.	954.	633.	313.	LOWER KLONDIKE
	(	14.58)	(	192.31)(	91.53)(	54.45)(	45.27)(	36.13)(	27.01)(	17.93)(	8.85)(	
ROUTED TO	9	5.63	1	6792.	3205.	1904.	1582.	1261.	942.	624.	306.	
	(	14.58)	(	192.34)(	90.76)(	53.92)(	44.79)(	35.71)(	26.68)(	17.66)(	8.68)(	
2 COMBINED	10	12.50	1	11893.	5610.	3203.	2573.	1933.	1349.	875.	414.	
	(	32.37)	(	336.76)(	158.86)(	90.70)(	72.85)(	54.73)(	38.20)(	24.78)(	11.73)(	
HYDROGRAPH AT	10	2.89	1	4553.	2277.	1366.	1138.	911.	683.	455.	228.	
	(	7.49)	(	128.93)(	64.47)(	38.68)(	32.23)(	25.79)(	19.34)(	12.89)(	6.45)(	
2 COMBINED	10	15.39	1	16278.	7745.	4427.	3564.	2706.	1944.	1267.	607.	LARSEN DAM
	(	39.86)	(	460.95)(	219.32)(	125.37)(	100.91)(	76.63)(	55.05)(	35.88)(	17.18)(	
ROUTED TO	10	15.39	1	15702.	7418.	4166.	3326.	2484.	1715.	1091.	511.	
	(	39.86)	(	444.64)(	210.06)(	117.96)(	94.19)(	70.33)(	48.56)(	30.90)(	14.47)(	
ROUTED TO	11	15.39	1	15673.	7400.	4151.	3314.	2472.	1707.	1086.	500.	LAKE LEHIGH
	(	39.86)	(	443.80)(	209.53)(	117.55)(	93.83)(	70.01)(	48.35)(	30.75)(	14.14)(	

SUMMARY OF DAM SAFETY ANALYSIS

LARSEN DAM

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1882.60	1882.60	1885.70
STORAGE	246.	246.	506.
OUTFLOW	0.	0.	1299.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1891.94	6.24	1497.	15702.	28.75	44.00	0.00
.50	1889.31	3.61	990.	7418.	19.00	44.25	0.00
.30	1887.92	2.22	777.	4166.	13.50	44.75	0.00
.25	1887.48	1.78	716.	3326.	11.75	45.00	0.00
.20	1886.94	1.24	646.	2484.	9.75	45.25	0.00
.15	1886.24	.54	564.	1715.	6.50	45.75	0.00
.10	1885.36	0.00	469.	1091.	0.00	46.00	0.00
.05	1884.26	0.00	368.	511.	0.00	46.25	0.00

SUMMARY OF DAM SAFETY ANALYSIS

LAKE LEHIGH

PLAN 1 ..... ELEVATION STORAGE OUTFLOW

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	1873.00	1873.00	1873.70
	132.	132.	163.
	0.	0.	160.

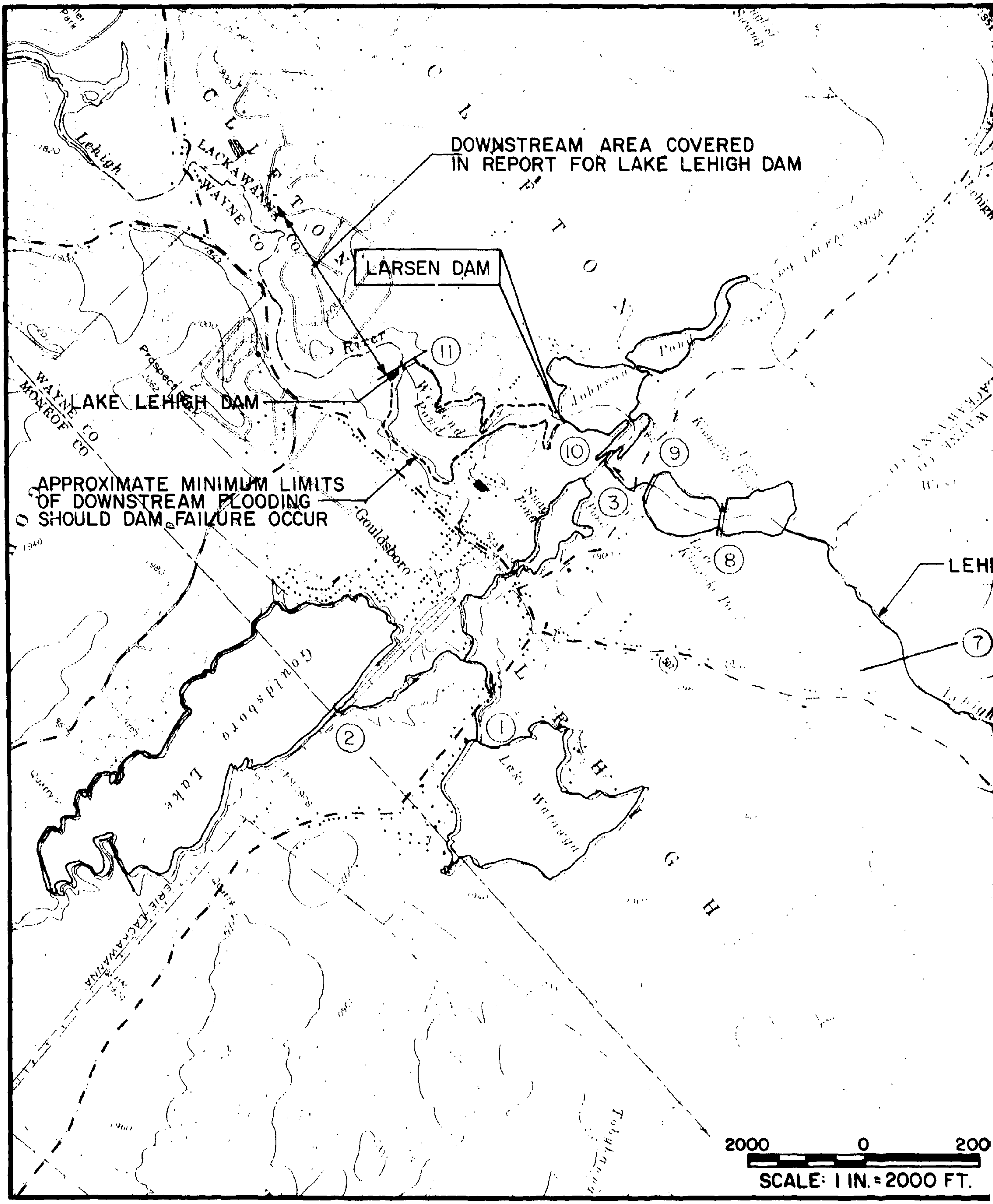
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1880.04	6.34	456.	15673.	51.75	44.00	0.00
.50	1877.75	4.05	347.	7400.	41.25	44.50	0.00
.30	1876.60	2.90	294.	4151.	38.75	45.00	0.00
.25	1876.26	2.56	278.	3316.	37.75	45.25	0.00
.20	1875.86	2.16	260.	2472.	33.75	45.75	0.00
.15	1875.44	1.74	241.	1707.	30.25	46.00	0.00
.10	1875.00	1.30	221.	1084.	25.50	46.50	0.00
.05	1874.39	.69	194.	500.	17.75	47.25	0.00

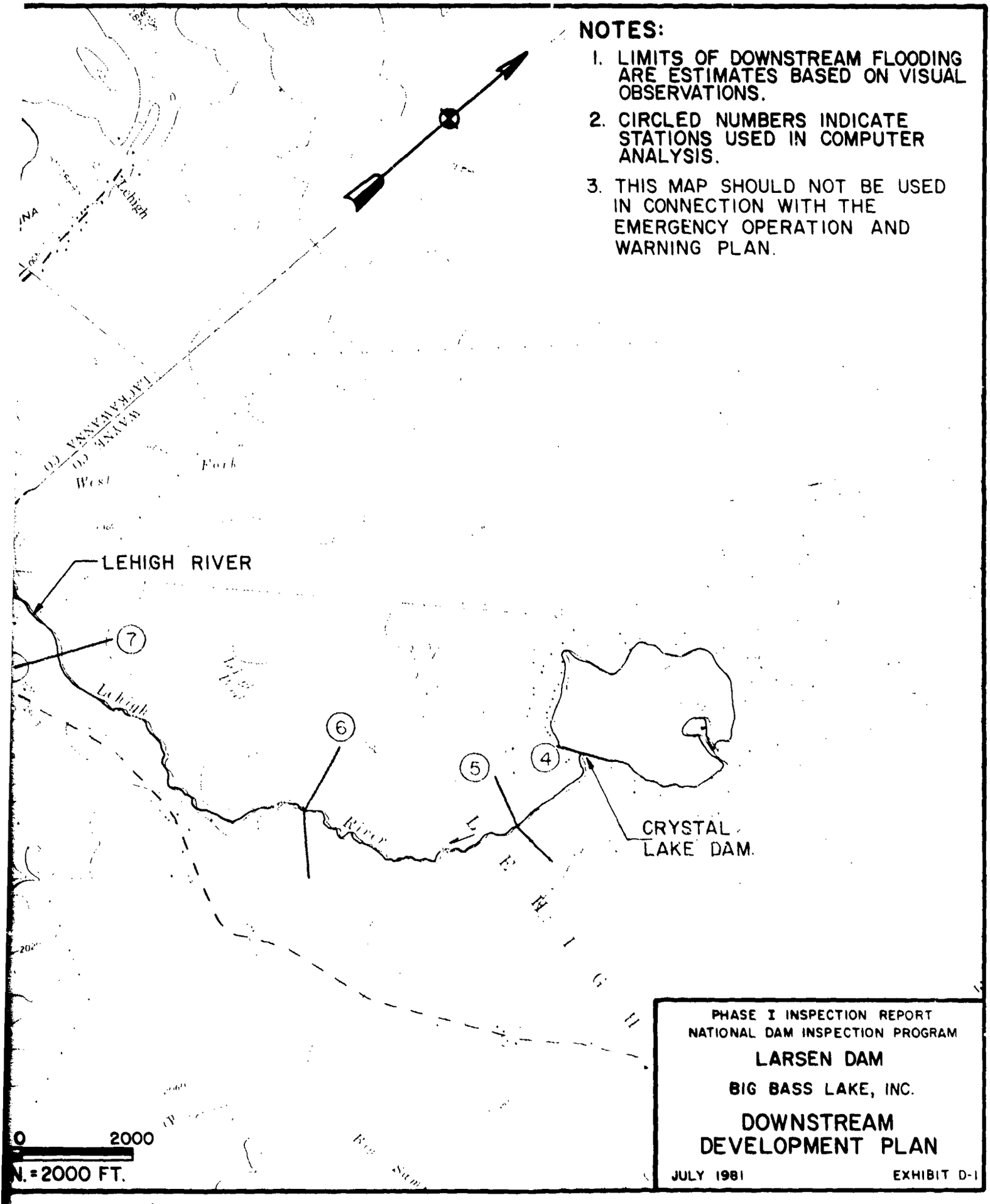
BY _____ DATE _____ SUBJECT _____ SHEET NO. _____ OF _____

CHKD. BY _____ DATE _____ JOB. NO _____

Summary of Pertinent Results

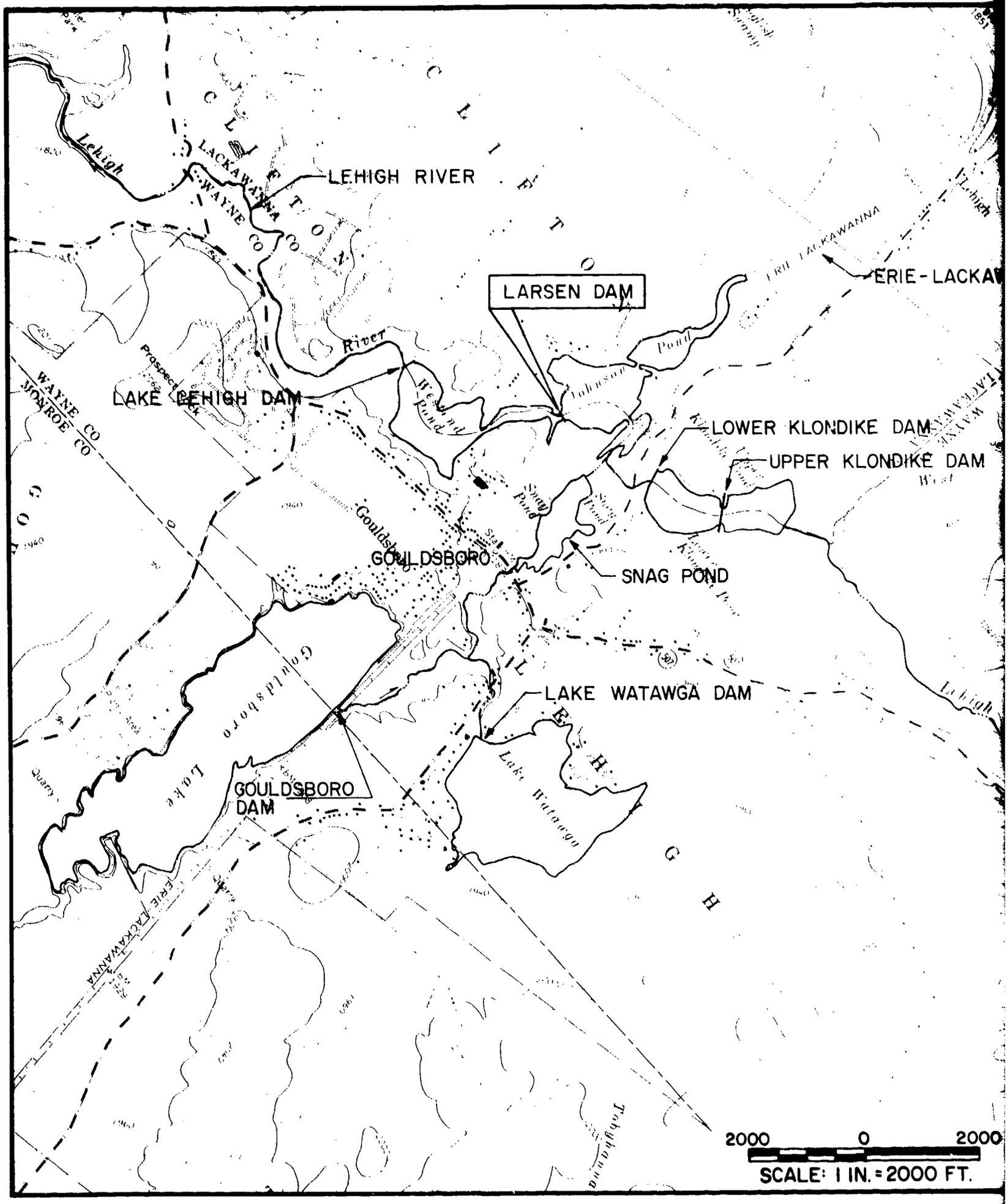
	PMF	½ PMF = SDF
Rainfall (inches)	24.62	-
Larsen Dam (assuming dam remains intact)		
Runoff - approx. (inches)	22.39	11.19
Inflow (cfs)	16,278	7,745
Outflow (cfs)	15,702	7,418
Depth Overtopping (ft)	6.24	3.61
Duration Overtopping (hrs)	28.75	19.00
Existing Lake Lehigh (assuming dam remains intact)		
Inflow (cfs)	15,702	7,418
Outflow (cfs)	15,673	7,400
Depth Overtopping (ft)	6.34	4.05
Duration Overtopping (hrs)	51.75	41.25

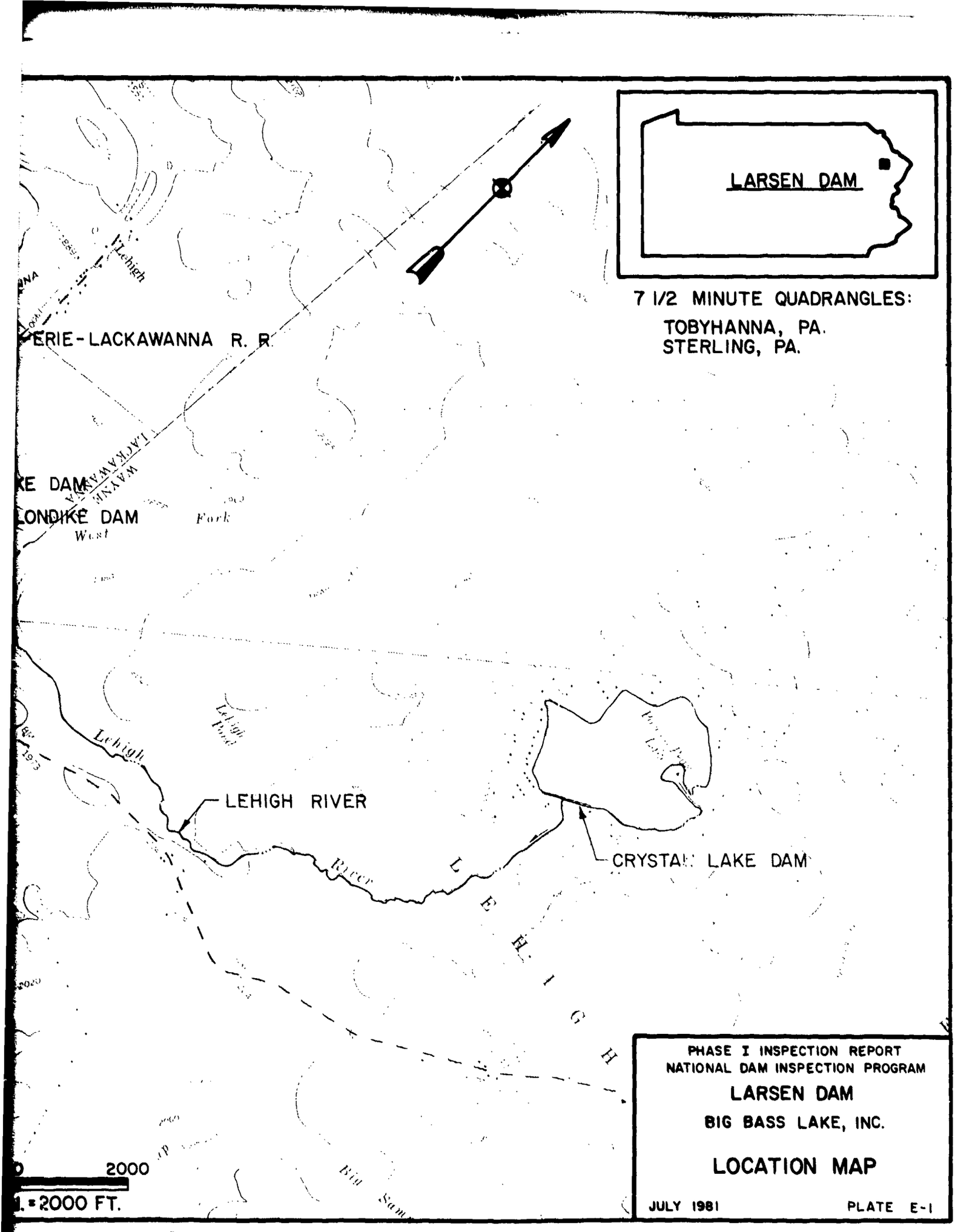

DOWNSTREAM AREA COVERED
IN REPORT FOR LAKE LEHIGH DAM
LARSEN DAM
LAKE LEHIGH DAM
APPROXIMATE MINIMUM LIMITS
OF DOWNSTREAM FLOODING
SHOULD DAM FAILURE OCCUR
WAYNE CO
MONROE CO
LACKAWANNA CO.
WAYNE CO
Gouldsboro
Gouldsboro
Lake
Lake
2000 0 200
SCALE: 1 IN.=2000 FT.


NOTES:
1. LIMITS OF DOWNSTREAM FLOODING ARE ESTIMATES BASED ON VISUAL OBSERVATIONS.
2. CIRCLED NUMBERS INDICATE STATIONS USED IN COMPUTER ANALYSIS.
3. THIS MAP SHOULD NOT BE USED IN CONNECTION WITH THE EMERGENCY OPERATION AND WARNING PLAN.
LEHIGH RIVER
7
6
5
4
CRYSTAL LAKE DAM.
0 2000
N. = 2000 FT.
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LARSEN DAM
BIG BASS LAKE, INC.
DOWNSTREAM DEVELOPMENT PLAN
JULY 1981
EXHIBIT D-1

APPENDIX E

PLATES


LEHIGH RIVER
LARSEN DAM
LAKE LEHIGH DAM
LOWER KLONDIKE DAM
UPPER KLONDIKE DAM
GOULDSBORO
SNAG POND
LAKE WATAWGA DAM
GOULDSBORO DAM
2000 0 2000
SCALE: 1 IN. = 2000 FT.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

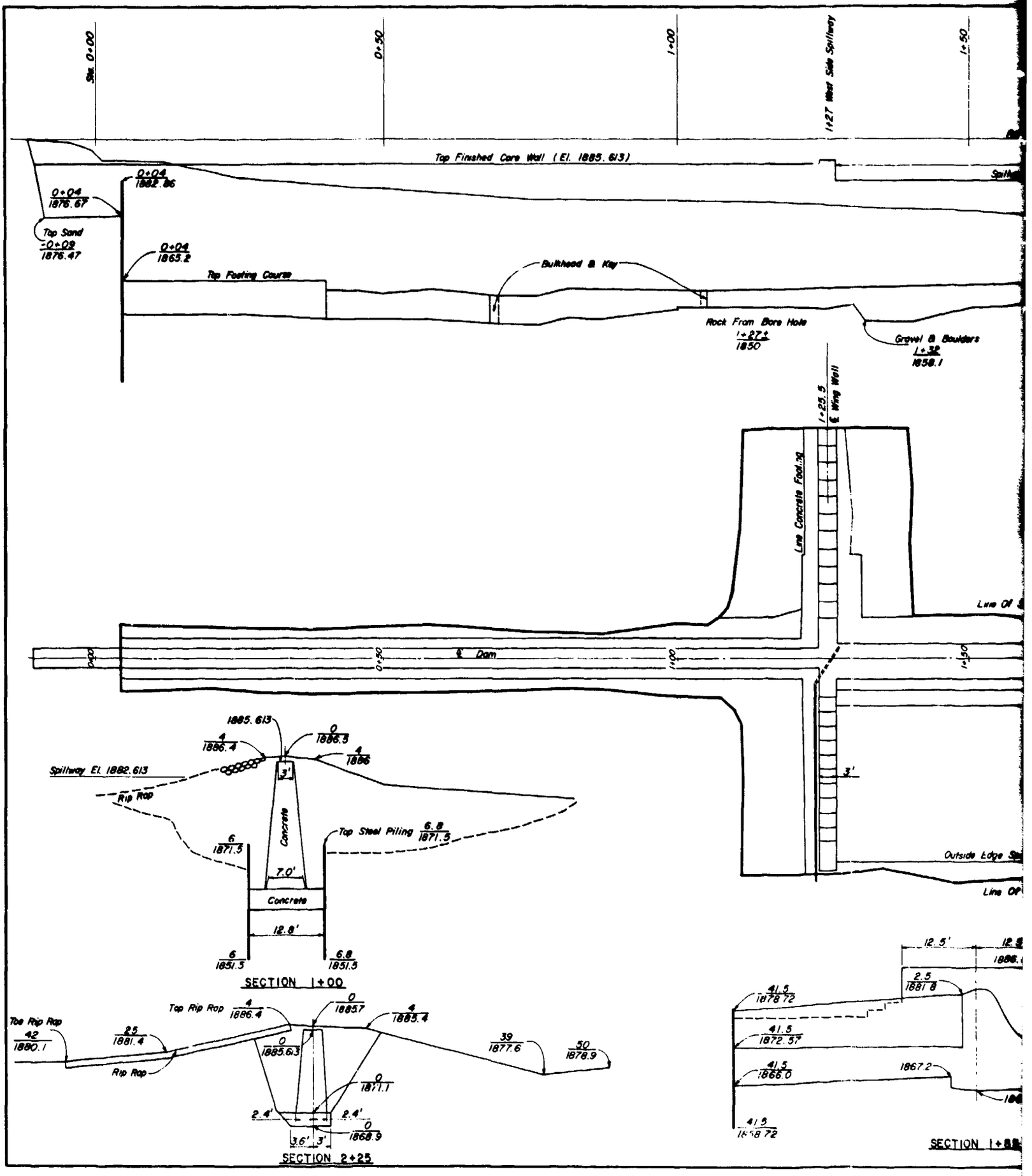
LARSEN DAM

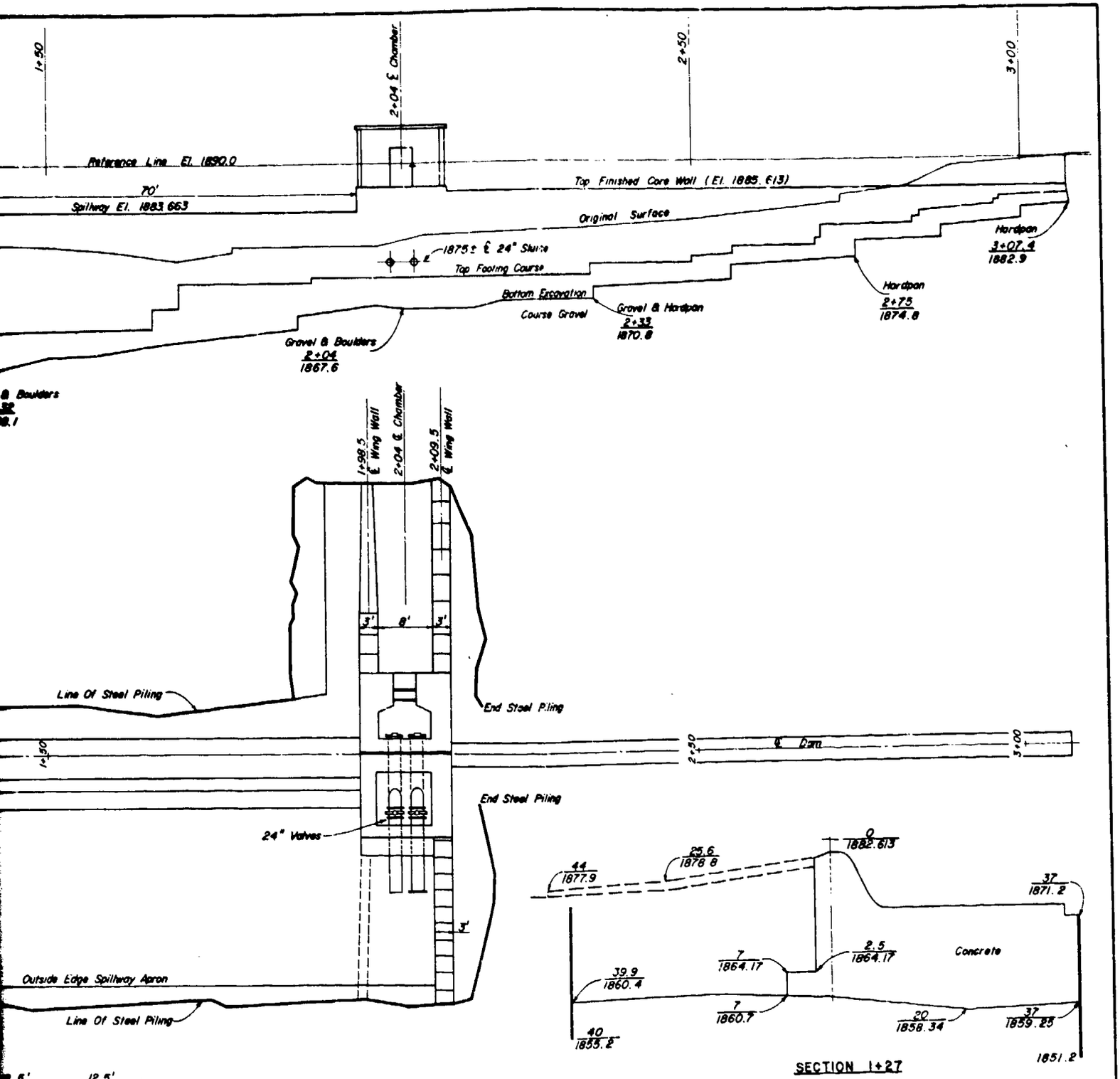
BIG BASS LAKE, INC.

LOCATION MAP

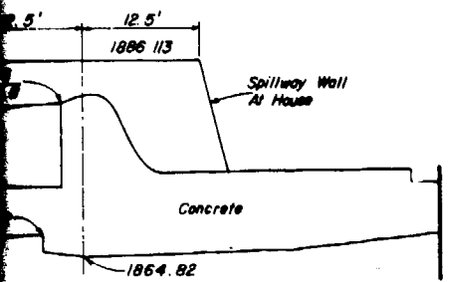
JULY 1981 PLATE E-1

1 2


Sta. 0+00
0+50
1+00
1127 West Side Spillway
1+50
Top Finished Core Wall (El. 1885.613)
0+04
1882.86
0+04
1876.67
Top Sand
=0+09
1876.47
0+04
1865.2
Top Footing Course
Bulkhead & Key
Rock From Bore Hole
1+27±
1850
Gravel & Boulders
1+38
1858.1
1+25.5
℄ Wing Wall
Line Concrete Footing
Line Of
℄ Dam
0+00
0+50
1+00
1+50
1885.613
4
1886.4
0
1886.5
4
1886
Spillway El. 1882.613
Rip Rap
3'
Concrete
Top Steel Piling
6.8
1871.5
6
1871.5
7.0'
Concrete
12.8'
6
1851.5
6.8
1851.5
3'
Outside Edge
Line Of
SECTION 1+00
Toe Rip Rap
42
1890.1
2.5
1881.4
Top Rip Rap
4
1886.4
0
1885.7
4
1885.4
0
1885.613
39
1877.6
50
1878.9
Rip Rap
0
1871.1
2.4'
2.4'
3.6'
3'
0
1868.9
SECTION 2+25
12.5'
2.5
1881.8
41.5
1878.72
41.5
1872.5?
41.5
1866.0
1867.2
41.5
1858.72
SECTION 1+8



SECTION 1+27



SECTION 1+85

NOTE

THIS PLATE WAS TRACED FROM A DRAWING IN PENNDER FILES TITLED

"S G & W. CO.
GOULDSBORO DAM
COPIED FROM PROGRESS SHEETS
NOV. 11 1914"

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LARSEN DAM

BIG BASS LAKE, INC.

PLAN PROFILE AND DETAILS

JULY 1981

EXHIBIT E-2

12

APPENDIX F

GEOLOGY

LAKE LEHIGH DAM

APPENDIX F

GEOLOGY

Larsen Dam is located in Wayne County within the Appalachian Plateau Physiographic Province. The most pronounced topographic feature in the area is Camelback Mountain, which is part of the Pocono Plateau Escarpment. This escarpment has a well defined, southwestward trend from Camelback Mountain, but is irregular between Camelback Mountain and Mt. Pocono, which lies to the north. Streams east of the escarpment drain directly to the Delaware River, while those to the west drain to the Lehigh River.

The Pocono Plateau Section lies to the west of the escarpment. This area is relatively flat, with local relief seldom exceeding 100 feet. The topography has been greatly influenced by continental glaciation. Many features were created by deposition of glacial materials. The entire plateau lacks well-developed drainage.

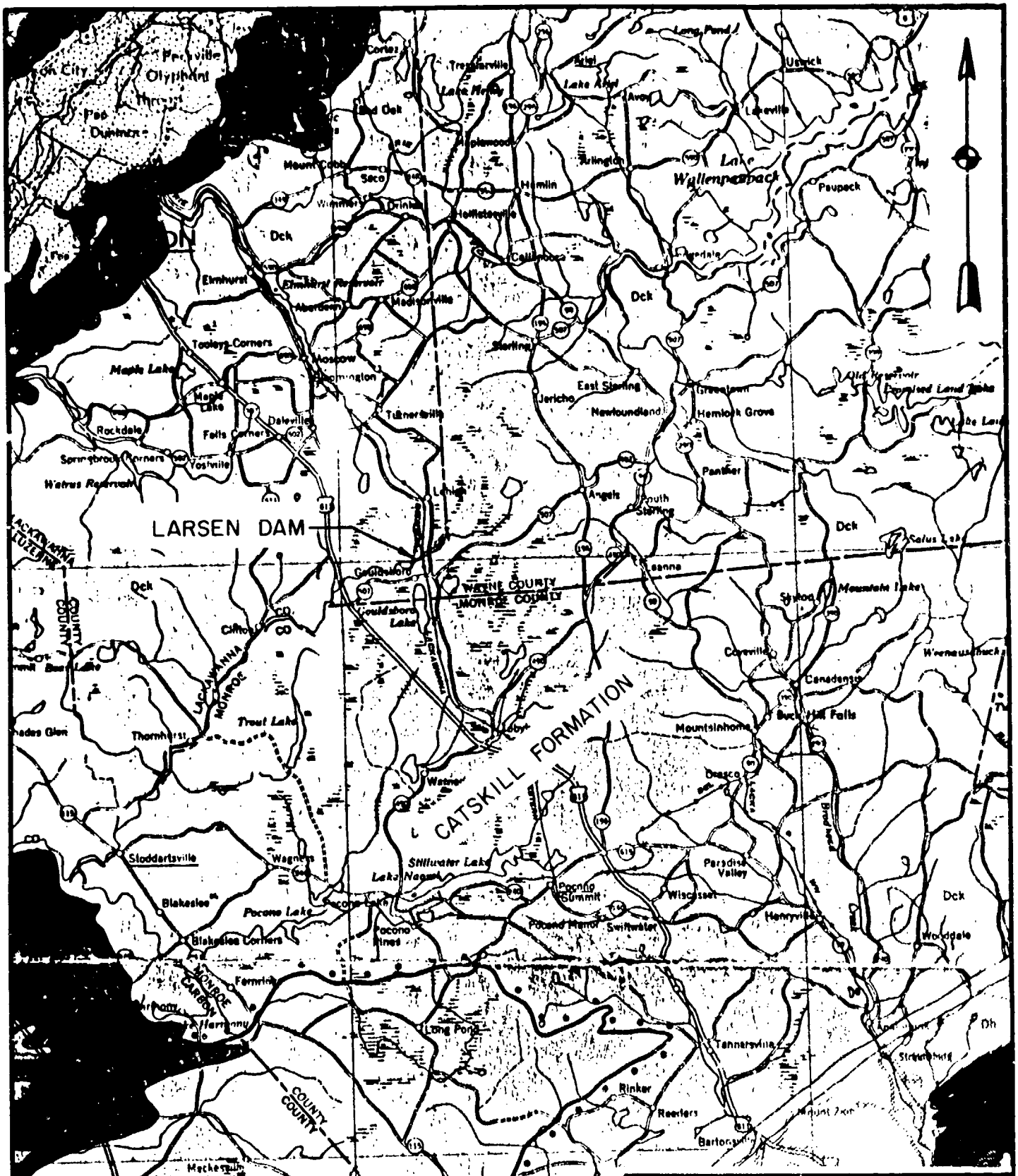
East of the escarpment is the Glaciated Low Plateaus Section of the province. This area is characterized by pre-glacial erosional topography with locally thick glacial deposits. Local relief is generally 100 to 300 feet.

Bedrock units of the sections described above are the lithified sediments of offshore marine, marginal marine, deltaic and fluvial environments associated with the Devonian Period. These units include siltstones of the Mahantango Formation, siltstones and shales of the Trimmers Rock Formation, and seven mapped members of the Catskill Formation. These members include sandstones, siltstones, and shales of the Towamensing Member; sandstone, siltstone and shales of the Walcksville Member; sandstones, siltstones, and shale of the Beaverdam Run Member; sandstone and shale of the Long Run Member; sandstones and conglomerates in the Packerton Member; sandstone and some conglomerates in the Poplar Gap Member; and sandstones and conglomerates in the Duncannon Member.

Larsen Dam in underlain by the Duncannon Member of the Catskill Formation. The Duncannon Member is predominantly a conglomerate and sandstone unit with some red siltstone and shale. Conglomerates present are generally thick-bedded with subangular to well-rounded quartz pebbles in a coarse-grained sandstone matrix. They are very well indurated and have low porosity due to silica cementation. The sandstones are predominantly fine- to medium-grained, thin- to thick-bedded and well-indurated with a clay and silica cement. Red

sandstones near the top of the unit grade into red siltstone and shale, marking the content with the Spechty Kopf Formation. The Duncannon Member maintains very steep cut slopes and is reported to be an excellent foundation for heavy structures.

Bedrock is almost entirely overlain by glacial till of Late Wisconsin Age. This till is basically an unsorted mixture of clay, silt, sand, and gravel. It is moderately cohesive and is generally derived locally from the sandstones of the Catskill Formation. Thickness of the till varies from 3 to 100 feet, with an average thickness of 45 feet. Available information indicates that the dam is probably founded on this till.



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LARSEN DAM

BIG BASS LAKE, INC

GEOLOGIC MAP