LEVEL II

1

DELAWARE RIVER BASIN
SHADES CREEK, LUZERNE COUNTY

PENNSYLVANIA

INDIAN LAKE DAM

NDI ID NO. PA-01041
DER ID NO. 40-143

JOHN R. LARSEN

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

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

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DELAWARE RIVER BASIN

SHADES CREEK, LUZERNE COUNTY

PENNSYLVANIA

INDIAN LAKE DAM

NDI ID No. PA-01041
DER ID No. 40-143

John R. Larsen

(6) National Dam Inspection Program. Indian Lake Dam (NDI ID Number PA-Ø1Ø41, DER ID Number 4Ø-143), Delaware River Basin, Shades Creek, Luzerne County, Pennsylvania. Phase I Inspection Report.

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

(12) 106

Prepared By:

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

(11) Apr[illegible]981

409112

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 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 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 frequent inspections can these conditions be prevented or corrected.

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.

INDIAN LAKE DAM

NDI ID No. PA-01041, DER ID No. 40-143

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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PHASE I. INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	INDIAN LAKE DAM NDI ID No. PA 01041 DER ID No. 40-143
Size:	Small (9.4 feet high; 280 acre - feet)
Hazard Classification:	Significant
Owner:	John R. Larsen Milford, Pennsylvania
State Located:	Pennsylvania
County Located:	Luzerne
Stream:	Shades Creek
Dates of Inspection:	22 October 1980 and 10 March 1981

The visual inspection and review of available design and construction information indicate that Indian Lake Dam is in fair condition. Deficiencies noted during the inspection included the reduced spillway capacity and lack of erosion protection for the embankment at the spillway and discharge channel. The Spillway Design Flood (SDF) for a dam of this size and classification is in the range of the 100 Year Flood to the 1/2 PMF. Based on the small storage and height the SDF selected was the 100 Year Flood.

INDIAN LAKE DAM

The hydrologic and hydraulic computations indicate that the combination of reservoir storage and spillway discharge capacity cannot pass the Spillway Design Flood (100 year flood) prior to overtopping the embankment. Therefore, in accordance with the criteria outlined and evaluated in Section 5.5 of this report, the spillway for Indian Lake Dam is considered to be inadequate.

It is recommended that:

a. The owner should retain a qualified professional engineer to further assess measures required to provide adequate spillway capacity for this facility. As an alternative, the removal of the telephone poles will provide adequate spillway capacity.

b. A trash rack should be provided on the intake structure and the obstruction should be removed from the discharge end of the outlet works.

c. A formal surveillance and downstream emergency warning system should be developed for use during periods of heavy or prolonged precipitation.

d. An operation and maintenance manual or plan should be prepared for use as a guide in the operation and maintenance of the dam during normal and emergency conditions.

e. A schedule of regular inspection by a qualified engineer should be developed.

Approved By:

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers

18 May 81

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

INDIAN LAKE DAM

OVERVIEW

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

INDIAN LAKE DAM

NDI ID NO. PA 01041

DER ID NO 40-143

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 non-Federal dams throughout the United States.

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

1.2 Description of Project.

a. Description of Dam and Appurtenances. Indian Lake Dam is an earthfill structure with concrete corewall approximately 9.4 feet high and 404 feet in length (including spillway). The spillway is a trapezoidal uncontrolled broad-crested weir approximately 52 feet in length and located near the right abutment. The outlet works is a 16 inch diameter pipe equipped with two gate valves.

NOTE: The U.S.G.S. 7.5 minute Quadrangle Sheet (Pleasant View Summit, PA) indicates a reservoir elevation of 1874, which is used in this report as design spillway crest elevation.

b. Location: Bucks Township, Luzerne County.

U.S.G.S. Quandrangle - Pleasant View Summit, PA.

Latitude 41° 11.6' and Longitude 75° 40.2'

Ref App E. Plates I & II.

c. Size Classification: Small: Height - 9.4 feet, Storage - 280 acre-feet.

d. Hazard Classification: Significant (Ref to Section 3.1.e).

e. Ownership: Mr. John R. Larsen.
Lake Adventure
Box 5000
Milford, Pennsylvania 18337

f. Purpose: Recreation

g. Design and Construction History: The dam was designed by Wintermute and Halsey Engineers in 1929, and construction was essentially completed in 1930. Although no formal post-construction changes have been authorized by PennDER, several modifications have been made to the spillway which have reduced its effective capacity. Refer to Section 3 for detailed discussion of these changes.

h. Normal Operationg Procedures. The reservoir is normally maintained at the crest level of the uncontrolled spillway. Inflow occuring when the lake is at or above the spillway crest is currently discharged through the uncontrolled spillway.

1.3 Pertinent Data.

a. Drainage Area (square miles)

From files:	0.30
Computed for this report:	0.27
Use:	0.27

b. Discharge at Damsite (cubic feet per second)

Maximum known flood	unknown
Outlet works with maximum pool (El. 1876.2)	17
Spillway with maximum pool (El. 1876.2)	65

c. Elevations (feet above mean sea level)

Note: All elevations are returned to a Spillway crest elevation of 1874.0 (top of corewall)

Top of Dam	
Design	1879.0
Existing	1876.2
Normal pool (Existing Spillway Crest)	1875.5
Spillway Crest	
Design	1874.0
Existing	1875.5
Outlet Works	
Upstream invert	1867.7
Downstream invert	1866.8
Streambed at toe	1866.8

d. Reservoir Length (feet)

Normal pool (El. 1875.5)	2400
Maximum pool (El. 1876.2)	2450

e. Storage (acre-feet)

Design normal pool (El. 1874.0)	190
Exist. normal pool (El. 1875.5)	240
Maximum pool (El. 1876.2)	280

f. Reservoir Surface (acres)

Normal pool (El. 1875.5)	32
Maximum pool (El. 1876.2)	35

g. Dam

Note: Refer to plates in Appendix E for plans and section

Type	earthfill w/concrete corewall
Length	404 feet, including spillway
Top Width	6 feet, average
Height	9.4 feet
Side Slopes	
Upstream	1V:5H (exist.); IV:2H (design)
Downstream	1V:5H (exist.); IV:2H (design)
Zoning	None
Cutoff	Concrete corewall
Grouting	None

h. Outlet Works.

Type:	One 16 inch pipe
Length	60 feet (estimated)
Closure:	Bronze gate valve upstream of corewall and at d/s toe.

i. Spillway (Existing Condition)

Type	Trapezodial broad-crested weir.
Location	Near right abutment.
Length	35 feet (bottom); 52 feet (top)
Crest Elevation	1875.5
Freeboard	0.7 Feet
Approach Channel	Reservoir
Downstream Channel	3 pipes immediately downstream through road embankment, then earth and rock channel.

SECTION 2

ENGINEERING DATA

2.1 Design

The available data for Indian Lake Dam consist of files provided by the Pennsylvania Department of Environmental Resources (PennDER). Information available includes PennDER inspection reports, various related correspondence, and specifications dated 28 March 1929 which provide a description of the design of the facility. Drawings dated 28 March 1929 showing plan and section views of the dam are also available. No other information concerning design of the facility is known to exist.

2.2 Construction

Information available on the original construction of the dam is generally limited to the design plans and specifications and PennDER progress reports. There were no problems noted by PennDER inspections during construction of the dam. Modifications made to the dam since its original construction include changes to the spillway, which are described in further detail in Section 3 of this report and flattening of the embankment slope as described in Section 6.

2.3 Operation

No formal records of operation or maintenance exist. Members of the Indian Lake Sports Club Association stated that they have responsibility for operation and maintenance of the facility in accordance with an agreement with the owner, Mr. Larsen. Mr. William Landmusser, (P.O. Box 87, Star Route Road, White Haven, PA 18661) is the chairman of the Board for the Association. Association members stated they check the dam periodically and during storm events. The most recent PennDER inspection report (2 June 1964) indicated that the dam was in generally fair condition.

2.4 Evaluation

a. Availability

All available written information and data were contained in the permit files provided by PennDER.

b. Adequacy

The available data, including that collected during the recent detailed visual inspection, are considered to be adequate to make a reasonable assessment of the dam.

SECTION 3

VISUAL INSPECTION

3.1 Observations.

a. General. The overall appearance and general condition of the dam and appurtenances are fair. The spillway crest has been raised and the dam crest is two feet below design elevation. These and other noteworthy deficiencies are noted below. The visual inspection checklist, field sketch and profile are provided in Appendix A. Photographs taken during the inspection are reproduced in Appendix C.

The reservoir pool was 3.5 feet below spillway crest (corewall) on the day of the initial inspection, 22 October 1980. The lake was purposely drawn down so that maintenance of the dam could be performed. On the date of the review inspection, the reservoir level was one foot above the spillway crest (corewall). Present during the initial inspection were Mr. Schall, Mr. Housenickt and Dr. Teitsworth, members of the sports club association.

b. Embankment. At the time of the initial inspection, the dam was undergoing maintenance. The embankment has been stripped of all vegetation. This apparently included trees and brush, as evidenced by the roots still projecting from the embankment. This clearing operation has exposed the top of the corewall for approximately 150 feet to the left of the spillway. Sod from the crest has been deposited along the

upstream face near the crest. Under this material it can be seen that the upper two feet of the upstream slope does not have riprap, and erosion has caused the slope to become near vertical. Below this point the slope is 1V:5H with riprap. During the review inspection, it was observed that this sod has not been removed and no riprap has been added. The downstream slope is 1V:5H and is covered with a new growth of grass. Approximately 25 feet downstream of the crest is a dirt and gravel roadway. The vertical alignment of the crest is irregular with the low spot occurring at the right abutment contact. No signs of seepage or sloughing were noted.

c. Appurtenant Structures. According to the design drawings the outlet works was to consist of a 16 inch diameter cast iron pipe encased in concrete, a concrete intake structure with trash rack and two valve boxes with the pipe ending 2 feet beyond the downstream valve box. However, the inspection revealed that the upstream and downstream ends of the conduit are 16 inch diameter vitrified clay pipe with the last section of the downstream end broken. Also, there is no trashrack on the intake structure, which is in otherwise good condition. Heavy steel plates covered the top of the valve boxes and prevented access to the valves. It was reported that the valves operated satisfactorily when the lake was recently drawn down. The area around three sides of the valve box at the crest has been excavated to a depth of about two feet. This apparently was done to permit application of a surface coat of mortar. The downstream face is the corewall. The outlet channel is

a ditch cut in earth with a 4 to 6 foot bottom width and vertical side slopes approximately 6 feet high. About ten feet downstream this channel widens slightly and the depth is one to two feet. There are no obstructions to flow.

During the review inspection, it was noted that the excavation around the upstream valve box has not been backfilled. The downstream end of the conduit could not be found. It could not be determined whether the steep side slope of the outlet ditch had collapsed or the pipe was purposely backfilled.

The spillway was originally designed as a five foot deep trapezoidal notch in the corewall with a 40 foot bottom width and 1V:1H sides. As noted in inspection reports by the State of Pennsylvania, lengths of telephone poles and timbers have been placed over and upstream of the corewall to raise the level of normal pool about ten inches above the design elevation. Those present during the initial inspection stated that maintenance was not complete and that the spillway would be cleaned out. However, on the day of the review inspection, the poles and timbers were placed neatly on edge and two high immediately upstream of the corewall. Metal rods were driven behind the corewall to restrain the poles. In addition, earth fill has been placed on the upstream side of this obstruction for a width of about five feet. This obstruction effectively raises the spillway crest level approximately 1.5 feet.

The spillway discharge channel is cut in earth the same width as the weir initially but then narrows to 25 feet wide about 25 feet downstream of the weir. At this point the flow must pass through 2-24 inch corrugated metal pipes and 1-22 inch iron pipe to cross a road. These pipes are in good condition but erosion is occurring under the pipes. However, if these pipes should fail or become obstructed, water would pond and flow over the road. This would not pose a threat to the safety of the dam. The discharge channel downstream of the pipes was recently cut in earth and has adequate dimensions. The entire spillway discharge channel and the embankment adjacent to the spillway weir are unprotected from erosion. Sufficient flows over the spillway could eventually undermine that portion of the corewall.

d. Reservoir Area. The wooded reservoir slopes are flat to moderate and appear stable. There is residential development around the entire perimeter of the lake. The lake was originally natural and sedimentation does not appear to be a problem.

e. Downstream Channel. The first two hundred feet below the dam were recently cleared. The natural channel then flows through woods in earth and rock. The stream crosses under the access road twice within one mile below the dam. The stream then crosses under Pa. Route 115 via a large concrete culvert approximately 1.4 miles downstream of the dam. Approximately 3.5 miles downstream of Indian Lake is Bear Creek Reservoir (Francis E. Walter Dam). One house with a first floor nine

feet above the streambed is located adjacent to the stream about one mile from the dam. One multi-family dwelling with the first floor nine feet above the streambed and one commercial establishment (under construction) are located adjacent to the stream bank and just upstream of Pa. Route 115. The location of these homes with respect to the streambed represents a significant hazard to the loss of a few lives and property damage should Indian Lake Dam fail. The downstream development is shown on Plate E-II.

f. Evaluation. The current maintenance being performed on the dam has both improved and worsened the condition and safety of the facility. The removal of the trees and brush from the embankment is a positive measure, although the method of removal is questioned. The embankment crest is a full two feet below design crest, which causes concern for the safety of the structure since the spillway now has 1.5 feet of fill over design crest. In addition, the lack of any erosion protection for the embankment at the spillway and the discharge channel causes concern for the safety of the structure and its ability to withstand a flood event.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Normal Operating Procedure.

The facility is essentially self regulating. Inflow normally passes through the emergency spillway located in the right portion of the dam, and through the 3 outlet pipes under the roadway located 25 feet downstream of the spillway. Large inflows in excess of the emergency spillway capacity overtop the embankment. No formal operations manual exists.

4.2 Maintenance of Dam.

The condition of the dam, as observed by the inspection team, was fair. The embankment had been recently cleared prior to the October 1980 inspection and the lake had been drawn down for work on the embankment, spillway, and outlet works. A reinspection of the site in March 1981 revealed that several modifications were made to the structure since the October 1980 inspection. The spillway had been raised approximately one foot and the upstream side of the spillway was filled in an attempt to seal the horizontal laid telephone pole weir. The telephone poles were loosely secured with metal rods; however, it appeared that during a flood of significant proportion they may float out, thereby producing a surge in downstream stages. Additionally, the downstream end of the outlet conduit could not be located. No formal maintenance manual exists.

4.3 Maintenance of Operating Facilities.

See Section 4.2 above.

4.4 Warning System.

No formal warning system exists.

4.5 Evaluation.

The raising of the spillway combined with the sudden failure potential of the telephone pole weir are a concern for a possible flood wave surge from failure of the structure. The outlet works should be free of obstructions and easily workable in an emergency condition. Formal manuals of maintenance and operations are recommended to ensure that all needed maintenance is identified and performed regularly. In addition, a formal warning system for the protection of downstream inhabitants should be developed. Included in the plan should be provisions for around-the-clock surveillance of the facility during periods of unusually heavy precipatation.

SECTION 5

HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

No formal design reports or calculations are known to exist for the facility. Drawings showing embankment, spillway, and reservoir area details are located in the PennDER files and are shown in Appendix E of this report. The elevation of the top of corewall in the spillway was assumed to be elevation 1874 and not the value shown in Appendix E. This is due to the elevation found on the U.S.G.S. quad sheet entitled Pleasant View Summit, Pa., showing 1874.0 which was assumed to be the top of corewall in the spillway.

5.2 Experience Data.

Records of reservoir levels and/or spillway discharges are not available. No records other than the recent draw down of the lake in the fall of 1980 are available.

5.3 Visual Observations.

On the date of the inspection, a condition was present that may prevent the facility from operating effectively during a flood event. The spillway level has been raised and the top of dam is lower than design. This significantly reduces the freeboard. See field sketch in

Appendix A, Exhibit A-1, for location of outlet works and outlet channel.

5.4 Method of Analysis.

The facility has been analyzed in accordance with procedures and guidelines established by the U.S. Army Corps of Engineers, Baltimore District, for Phase I hydrologic and hydraulic evaluations. This analysis has been performed using a modified version of the HEC-1 program developed by the U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California. Capabilities of the program are briefly outlined in the preface contained in Appendix D.

5.5 Summary of Analysis.

a. Spillway Design Flood (SDF). In accordance with the procedures and guidelines contained in the National Guidelines for Safety Inspection of Dams for Phase I Investigations, the SDF for Indian Lake Dam ranges between the 100 year flood and 1/2 the Probable Maximum Flood (PMF). This classification is based on the relative size of dam (small), and the potential hazard of dam failure to downstream development (significant). Due to the small storage (280 ac. ft.) and small height (9.4 feet), the SDF selected was the 100 year flood.

b. Results of the Analysis. Indian Lake Dam was evaluated under near normal operating conditions. The starting lake elevation was set at 1875.5. The top of embankment (low point) was elevation 1876.2.

The 100 year flood peak is derived by averaging the peak flow value obtained from two regression equations. The first regression equation is from Bulletin 13, Floods in Pennsylvania Water Resources Bulletin. Guidelines are provided to determine the peak value by use of regional statistical data. The second regression equation is from the Hydrologic Study, Tropical Storm Agnes, North Atlantic Division, U.S. Army Corps of Engineers, 1975. Guidelines are provided to determine the flood peak by use of map coefficients and logarithmic equations the following results are obtained.

100 year flood peak	CFS
Bulletin 13-	118
North Atlantic Division Tropical Storm Agnes	272
Average 100 year flood peak	200

To determine the adequacy of the spillway, the average value for the 100 year flood peak is compared against the maximum outflow at low point top of dam. If the maximum outflow exceeds the 100 year average peak value derived above, then the spillway is rated adequate. If

b. Results of the Analysis. Indian Lake Dam was evaluated under near normal operating conditions. The starting lake elevation was set at 1875.5. The top of embankment (low point) was elevation 1876.2.

The 100 year flood peak is derived by averaging the peak flow value obtained from two regression equations. The first regression equation is from Bulletin 13, Floods in Pennsylvania Water Resources Bulletin. Guidelines are provided to determine the peak value by use of regional statistical data. The second regression equation is from the Hydrologic Study, Tropical Storm Agnes, North Atlantic Division, U.S. Army Corps of Engineers, 1975. Guidelines are provided to determine the flood peak by use of map coefficients and logarithmic equations the following results are obtained.

100 year flood peak	CFS
Bulletin 13-	118
North Atlantic Division Tropical Storm Agnes	272
Average 100 year flood peak	200

To determine the adequacy of the spillway, the average value for the 100 year flood peak is compared against the maximum outflow at low point top of dam. If the maximum outflow exceeds the 100 year average peak value derived above, then the spillway is rated adequate. If

however, the 100 year average peak value exceeds the maximum outflow at low point top of dam, the spillway is rated inadequate. Results are as follows:

	CFS
Maximum Outflow at low point top of dam -	70
Average 100 year flood peak -	200

5.6 Spillway Adequacy.

Under existing conditions, Indian Lake Dam cannot pass the 100 year flood peak value. Since this structure cannot pass the selected SDF (100 year flood) the spillway is rated inadequate; unsafe, non-emergency.

SECTION 6

STRUCTURAL STABILITY

a. Visual Observations

(1) Embankment. Visual observations of Indian Lake Dam indicate that the dam is in fair condition. No signs of embankment distress were observed. The dam is an earthfill structure with a concrete corewall that measures 12 inches wide at the dam crest. The upstream and downstream slopes are about 5H:1V. The surface soil on the downstream slope is organic material dredged from the lake. Riprap covers the upstream slope up to the normal water line where there is a 2 foot vertical drop. This vertical drop appears to have been caused by erosion. The lake level had recently been drawn down to permit maintenance of the dam.

(2) Appurtenant Structures. These structures consist of an outlet works and a spillway. The outlet works is in good condition. It was recently operated to draw the lake down to maintain the dam, valves, and valve manholes. A trash rack is needed for protection of the outlet works. The trapezoidal broad-crested spillway is located near the right abutment. Telephone poles and timbers have been used to raise the spillway weir level about 1.5 feet.

b. Design and Construction Data

(1) Embankment. The dam was designed by Wintermute and Halsey Engineers in 1929. Additionally, specifications for construction of the dam were written concerning the type, placement, and compaction of materials. The embankment soils are not clearly specified, except that the soils on site are suitable which are sand and clay. Four test pits were dug that revealed sand and clay overlying "hard pan" soil in the center two-thirds of the dam. "Hard pan" was found in the test pits near the abutments. The corewall was founded in the hard pan for the full length of dam. The upstream and downstream embankment slopes were designed as 2H:1V, and the crest was designed to be 3 feet wide and 2 feet higher than the corewall. The embankment slopes were designed to be 2H:1V with the upstream slope covered with 12 inch riprap.

(2) Appurtenances. The outlet works designed for this dam consists of a 16 inch cast iron pipe encased in concrete and is controlled by two 16 inch brass valves, one upstream of the corewall and the other near the downstream toe. Seepage collars were to be constructed around the pipe frequently. The upstream end of the outlet works is shown to be protected by a 3 inch screen, which is not there. The outlet works pipe installed was a 16 inch vitrified clay pipe. The spillway was designed as a 40 foot long, 3 foot deep notch in the concrete corewall with the spillway channel protected by riprap.

c. Operating Records. None.

d. Post-Construction Changes. No requests for changes exist; however, changes have been made. The 3 inch screen on the outlet works was either never installed or was removed. Also, the weir elevation has been increased by about 1.5 feet through the addition of poles and timbers. In addition, the lake was reportedly deepened in one location and the dredged material, organic in nature, was dumped on the embankment. This flattened the slopes to approximately 5H:1V.

e. Seismic Stability. The dam is located in Seismic Zone 1. From visual observations, the dam is considered to be statically stable. Therefore, based on the recommended criteria for evaluation of seismic stability of dams, the structure is presumed to present no hazard from an earthquake.

SECTION 7

ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety.

The visual inspection and review of available design and construction information indicate that Indian Lake Dam is in fair condition. Deficiencies noted during the inspection included the reduced spillway capacity and lack of erosion protection for the embankment at the spillway and discharge channel.

The Spillway Design Flood (SDF) for a dam of this size and classification is in the range of the 100 year flood to the 1/2 PMF. Based on the small storage and height the SDF selected was the 100 year flood.

The hydrologic and hydraulic computations indicate that the combination of reservoir storage and spillway discharge capacity cannot pass the SDF (100 year flood) prior to overtopping the embankment. Therefore, in accordance with the criteria outlined and evaluated in Section 5.5, the spillway for Indian Lake Dam is considered to be inadequate.

b. Adequacy of Information. The design and construction data contained in PennDER files, in conjunction with data collected during the visual inspection, are considered to be adequate for making a reasonable assessment of this dam.

c. Urgency. The recommendations presented below should be implemented without delay.

d. Necessity for Additional Studies. The results of the inspection indicate a need for additional investigations to determine measures required to provide adequate spillway capacity for this facility. Alternatively, the telephone poles could be removed from the spillway, which would provide adequate capacity.

7.2 Recommendations. It is recommended that:

a. The owner should retain a qualified professional engineer to further assess measures required to provide adequate spillway capacity for this facility. As an alternative, removal of the telephone poles would provide adequate spillway capacity.

b. A trash rack should be provided on the intake structure and the obstruction should be removed from the discharge end of the outlet works.

c. A formal surveillance and downstream emergency warning system should be developed for use during periods of heavy or prolonged precipitation.

d. An operation and maintenance manual or plan should be prepared for use as a guide in the operation and maintenance of the dam during normal and emergency conditions.

e. A schedule of regular inspection by a qualified engineer should be developed.

APPENDIX A

CHECKLIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase I

Name Dam Indian Lake Dam NDI No. PA-01041 County Luzerne State Pennsylvania

Date(s) Inspection 22 Oct 80 Weather Clear Temperature 40°

Pool Elevation at Time of Inspection 1870.5 M.S.L. Tailwater at Time of Inspection --- M.S.L.

Initial Inspection Personnel:

J. Bianco (COE)
B. Cortright (COE)
J. Evans (COE)
E. Hecker (COE)
L. Reeser (COE)
Dr. Teitsworth, Indian Lake Sports Club Assoc.
Mr. Schall, Indian Lake Sports Club Assoc.
Mr. Housenickt, Indian Lake Sports Club Assoc.

E. Hecker Recorder

Review Inspection:

Date Inspection 10 Mar 81 Weather Cloudy w/snow Temperature 30's

Pool Elevation 1875.0 M.S.L Tailwater Elevation --- M.S.L.

Inspection Personnel:

J. Bianco (COE)
B. Cortright (COE)
P. Maggitti (COE)

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS
Any noticeable seepage	None
Junction of Embankment With: Abutments Spillway	Abutments - good; no erosion or settlement. Low point of dam at right abutment. Spillway - poor; no protection of embankment
Surface Cracks	None. Crest recently stripped of vegetation and topsoil.
Crest Alignment: Vertical Horizontal	Vertical - Irregular; top of corewall exposed for entire crest left of spillway. Two feet below design height. Horizontal - Good
Unusual Movement or Cracking at or Beyond the Toe	None observed

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS
Sloughing or Erosion: Embankment Crest/Slopes Abutment Slopes	None; recently regraded and seeded.
Riprap	Within 2 feet of crest; disturbed at top by grading operations
Staff Gage and Recorder	None
Instrumentation	None
Miscellaneous	Embankment recently cleared of brush and trees. Top of corewall exposed. Sod from crest along upstream slope at crest.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS
Intake Structure	Concrete headwall in good condition. No trash rack
Outlet Conduit	16" clay pipe; condition unknown except downstream end broken
Outlet Structure	None. Clay pipe ends in earth ditch 6' deep; top half of pipe broken. Review inspection - Pipe not found; buried.
Outlet Channel	Recently cut in earth; no rock protection. Begins immediately d/s of road.
Emergency Gates	Two gate valves in valve boxes; at crest and on d/s slope. Normally closed. Not operated during inspection but used to draw lake recently.

UNGATED SPILLWAY

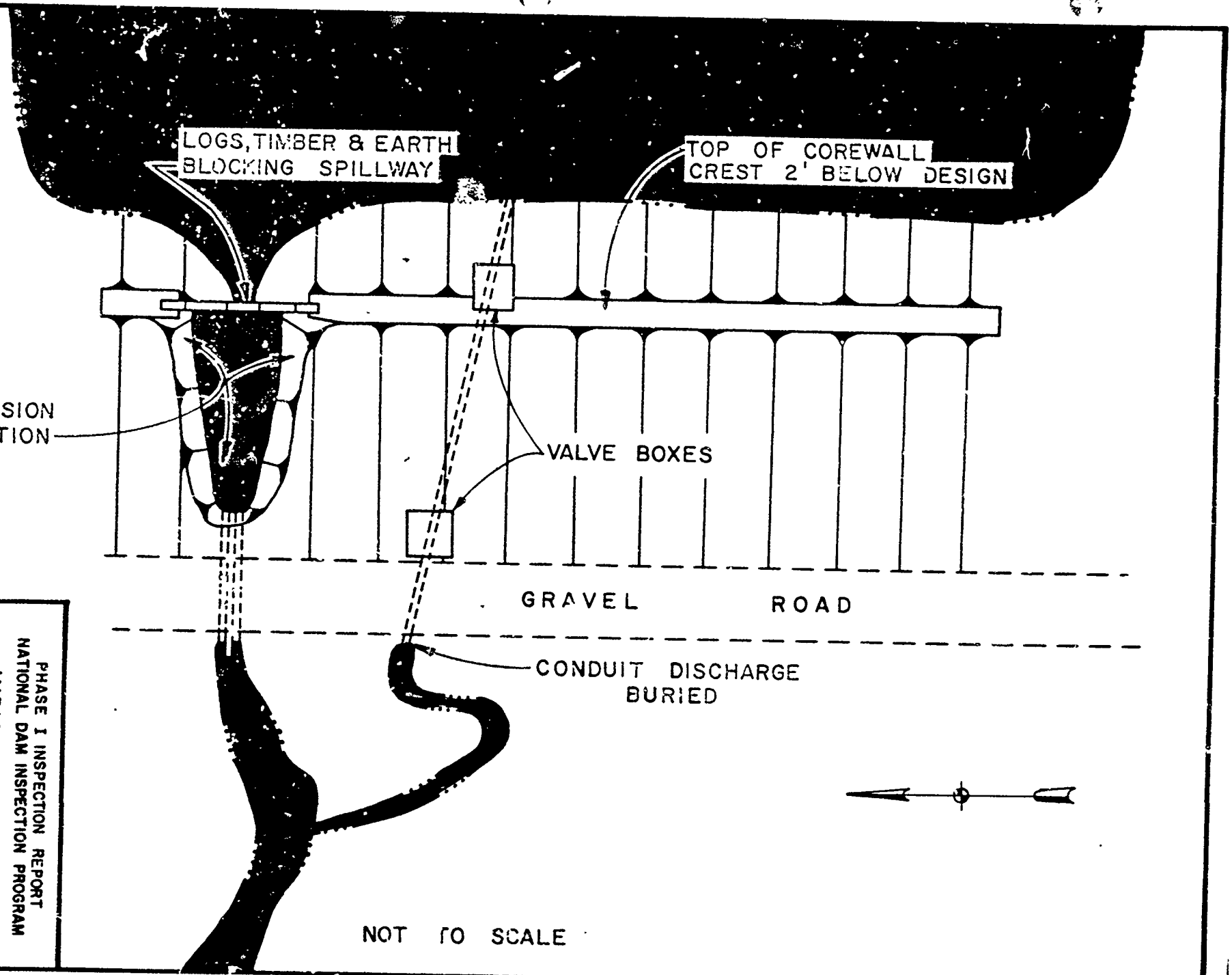
VISUAL EXAMINATION OF	OBSERVATIONS
Approach Channel	Reservoir. No obstructions
Weir Crest	12" concrete corewall covered by large sections of telephone poles in random arrangement. Concrete surface severely spalled. Review inspection - poles stacked on edge, two high, with earth fill behind. Small iron pins immed. u/s of corewall retain poles.
Bridge and Piers	None
Discharge Channel	No walls or stone protection to protect embankment or channel. 25' d/s weir are 2-24" & 1-22" dia. pipes under road. D/s of road channel recently excavated in earth and rock.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS
Slopes	Moderate; appear stable. Private residential development surrounds lake
Sedimentation	None reported; originally a natural lake

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS
Condition (Obstructions) Debris Other	First 200' recently cleared; then flows through wooded area in natural earth and rock channel. Crosses PA Route 115 1.4 miles below dam through large concrete culvert. Enters Bear Creek (Francis E. Walter Lake) about 3.5 miles d/s of dam.
Slope	Side slopes moderate. Channel slope varies from mild to moderate.
Approximate Number of Home	One house approx. 1.0 mile downstream. One multi-family dwelling and one commercial est. (under construction) 1.4 miles d/s (immed. u/s of PA Route 115).



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

INDIAN LAKE DAM

JOHN R. LARSEN

FIELD SKETCH

MAY 1981

TOP OF DAM – PROFILE

SCALE – HORIZ.: 1 IN. = 80 FT.
VERT.: 1 IN. = 4 FT.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

INDIAN LAKE DAM

JOHN R. LARSEN

PR .E

MAY 1981

EXHIBIT A-2

APPENDIX B

CHECKLIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE 1

NAME OF DAM Indian Lake Dam

ID # 40-143

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. Pleasant View Summit, Pa, Quadrangle, 7-$\frac{1}{2}$ minute quad sheet. See Appendix E, Plate E-II.
CONSTRUCTION HISTORY	PennDER inspection reports during construction.
TYPICAL SECTIONS OF DAM	Cross-section, see Appendix E.
OUTLETS - PLAN DETAILS CONSTRAINTS DISCHARGE RATINGS	Shown on cross-section.
RAINFALL/RESERVOIR RECORDS	None.

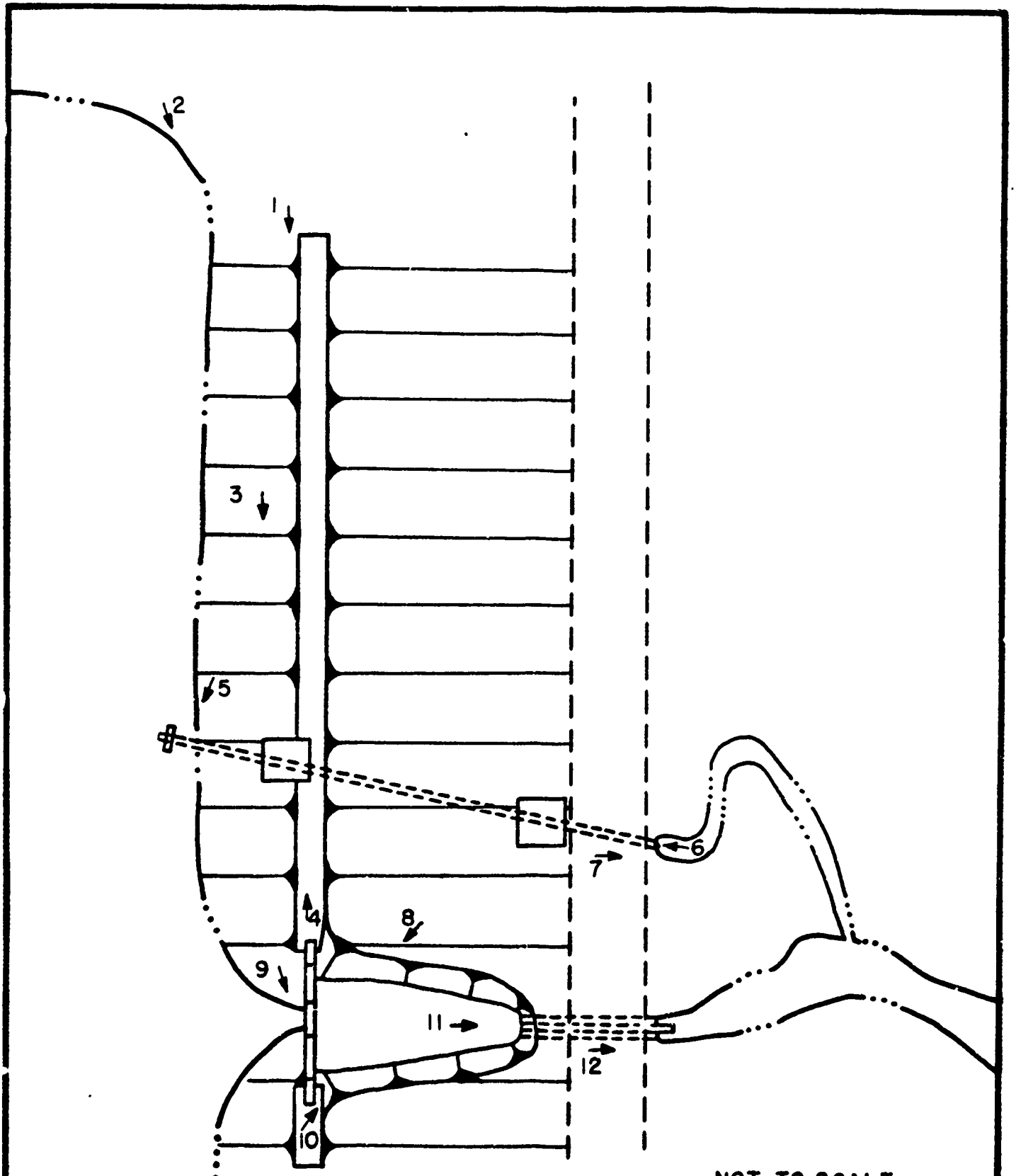
ITEM	REMARKS
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None.
POST-CONSTRUCTION SURVEYS OF DAM	None reported.
BORROW SOURCES	No data.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	Fill has been added to the downstream slope. Spillway has been raised.
HIGH POOL RECORDS	None.
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None reported.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None.
MAINTENANCE OPERATION RECORDS	None.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	Spillway section dated 1929.
OPERATING EQUIPMENT PLANS & DETAILS	Cross-section dated 1929.
SPECIFICATIONS	Specifications written by Wintermute and Halsey Engineers.
MISCELLANEOUS	None.

APPENDIX C

PHOTOGRAPHS



NOT TO SCALE

NOTE:
ALL PICTURES TAKEN
22 OCT. 80 EXCEPT
AS NOTED.

← LOCATION AND ORIENTATION OF CAMERA
5 - PHOTOGRAPH IDENTIFICATION NUMBER

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

INDIAN LAKE DAM

JOHN R. LARSEN

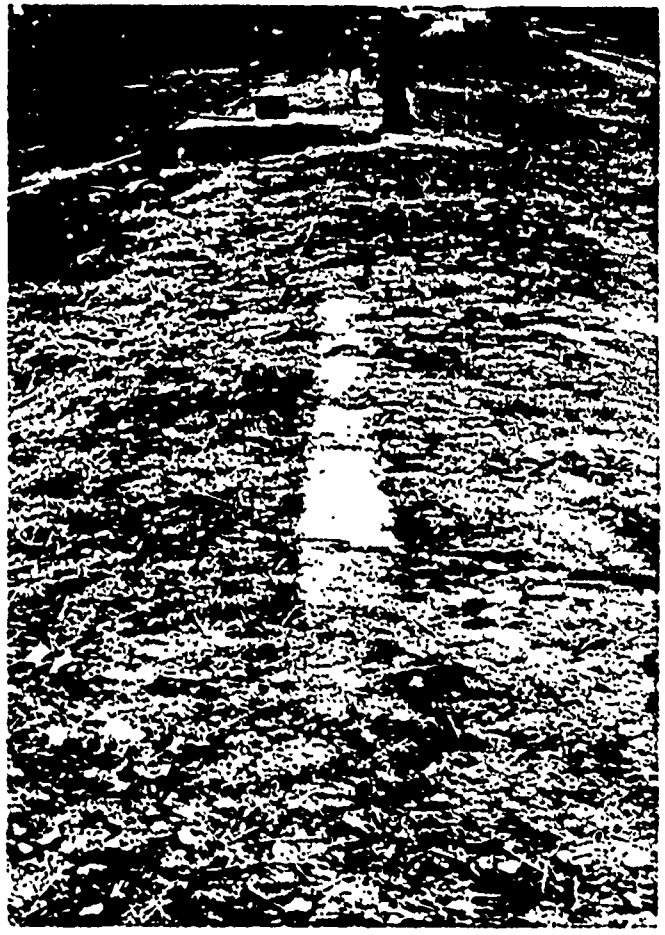
PHOTOGRAPH LOCATION PLAN

MAY 1981 EXHIBIT C-1

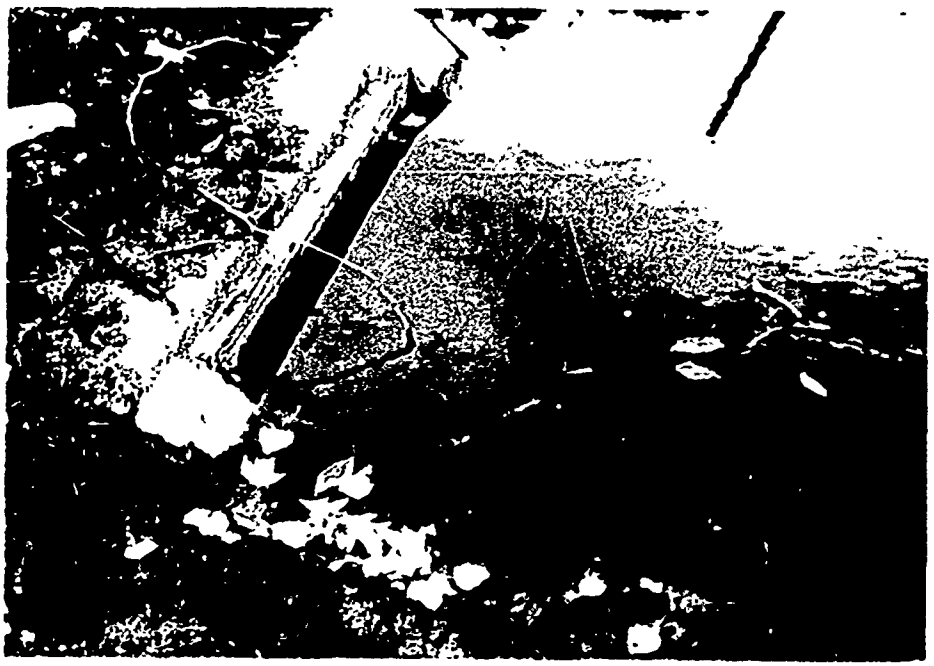
1. Crest and upstream face (22 Oct 80).

2. Upstream face (10 Mar 81).

3. Upstream face and valve box (22 Oct 80).



4. Top of corewall and valve box (22 Oct 80).



5. Outlet works intake structure (22 Oct 80).

6. Discharge of outlet works conduit (22 Oct 80).

7. Outlet works discharge channel (22 Oct 80).

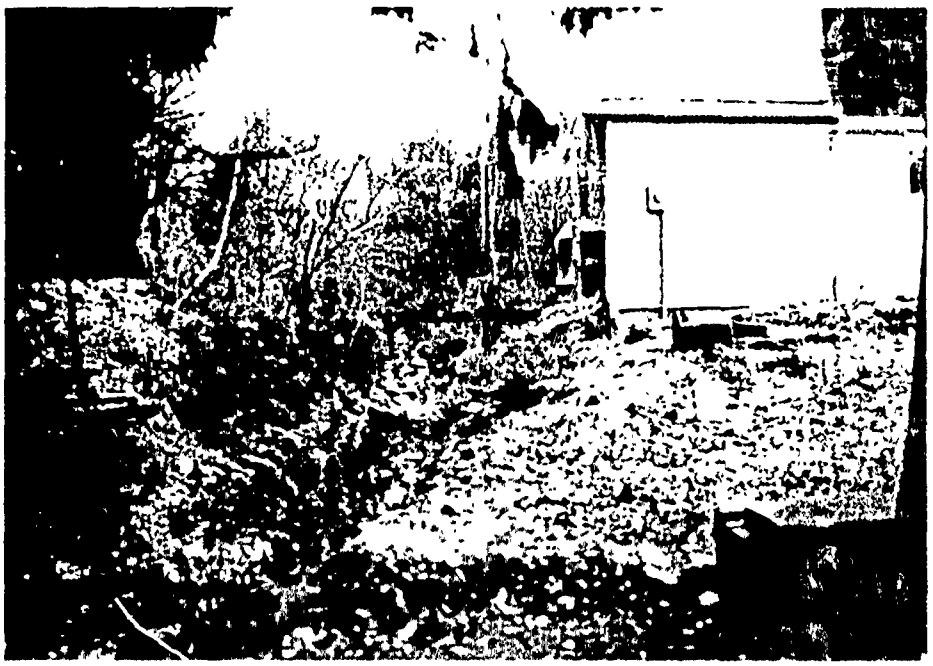
8. Spillway crest (10 Mar 81).

9. Earthfill upstream of spillway crest (10 Mar 81).

10. Spillway discharge channel immediately downstream of weir (10 Mar 81).

11. Pipes in spillway discharge channel (10 Mar 81).

12. Spillway discharge channel downstream of road (10 Mar 81).



13. Looking upstream at hazard located immediately upstream of PA Route 115.

APPENDIX D

HYDROLOGY AND HYDRAULICS

PREFACE

The modified HEC-1 program is capable of performing two basic types of hydrologic analyses: 1) the evaluation of the overtopping potential of the dam; and 2) the estimation of the downstream hydrologic-hydraulic consequences resulting from assumed structural failures of the dam. Briefly, the computational procedures typically used in the dam overtopping analysis are as follows:

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir to determine if the event(s) analyzed would overtop the dam.

c. Routing of the outflow hydrograph(s) from the reservoir to desired downstream locations. The results provide the peak discharge(s), time(s) of the peak discharge(s), and the maximum stage(s) of each routed hydrograph at the downstream end of each reach.

The evaluation of the hydrologic-hydraulic consequence resulting from an assumed structural failure (breach) of the dam is typically performed as shown below.

a. Development of an inflow hydrograph(s) to the reservoir.

b. Routing of the inflow hydrograph(s) through the reservoir.

c. Development of a failure hydrograph(s) based on specified breach criteria and normal reservoir outflow.

d. Routing of the failure hydrograph(s) to desired downstream locations. The results provide estimates of the peak discharge(s), time(s) to peak and maximum water surface elevations of failure hydrographs for each location.

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 1 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 2-18-81

DAM CLASSIFICATION:

SIZE OF DAM - SMALL
HAZARD - SIGNIFICANT
REQUIRED SDF - 100 YEAR FLOOD TO ½ PMF

DAM STATISTICS:

HEIGHT OF DAM - 9.4 FEET
STORAGE AT NORMAL POOL - 240 AC-FT.
STORAGE AT TOP OF DAM - 280 AC-FT.
DRAINAGE AREA ABOVE DAMSITE - 0.29 mi^2

ELEVATIONS: (MSL)

TOP OF DAM LOW POINT (FIELD) - 1876.2
NORMAL POOL - 1875.5 (RECENTLY RAISED POOL LEVEL)
STREAMBED AT CENTERLINE OF DAM - 1867.3
SPILLWAY CREST DESIGN - 1874.0 (TOP OF CORE WALL)
EXISTING - 1875.5 (~TOP OF TELEPHONE POLES IN SPILLWAY)
OUTLET WORKS
INVERT - 1867.1
OUTLET - 1866.8

HYDROGRAPH PARAMETERS:

RIVER BASIN - DELAWARE RIVER BASIN
ZONE - 2
SYNDER COEFFICIENTS
C_p - 0.45
C_t - 2.10
MEASURED PARAMETERS:*

L = LENGTH OF LONGEST WATERCOURSE, mi $L = 0.74$ mi
L_{CA} = LENGTH OF LONGEST WATERCOURSE TO CENTROID OF THE BASIN, mi $L_{CA} = 025$ mi

* FROM U.S.G.S. QUAD SHEET, PLEASANT VIEW SUMMIT PA. 7½ MINUTE SERIES SCALE 1:24000

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS — PAGE

SUBJECT: DAM SAFETY ANALYSIS

COMPUTATIONS: INDIAN LAKE DAM — SHEET 2 OF ____ SHEETS

COMPUTED BY: JPB — CHECKED BY: ____ — DATE: 2-18-81

NOTE: ELEVATIONS ARE REFERENCED TO U.S.G.S. QUAD SHEET ENTITLED PLEASANT VIEW SUMMIT, PA., ELEVATION GIVEN ON QUAD SHEET ASSUMED TO BE SPILLWAY CREST - TOP OF COREWALL ELEVATION 1874.0 :

t_p = SYNDERS BASIN LAG TIME TO PEAK IN HOURS

NOTE: SINCE THE CENTROID IS IN THE LAKE, THE FOLLOWING EQUATION WILL BE USED TO COMPUTE THE BASIN LAG.

$t_p = C_t (L')^{0.6}$ where L' = longest WATERCOURSE LENGTH INTO RESERVOIR

$t_p = 2.10(0.30)^{0.6} \approx 1.02$ HOURS

$L' = 1600$ FT. $= 0.30$ miles

RESERVOIR CAPACITY: NOTE: NORMAL POOL RAISED FROM 1874 TO 1875.5 IN DEC-80 TO MAR 81.

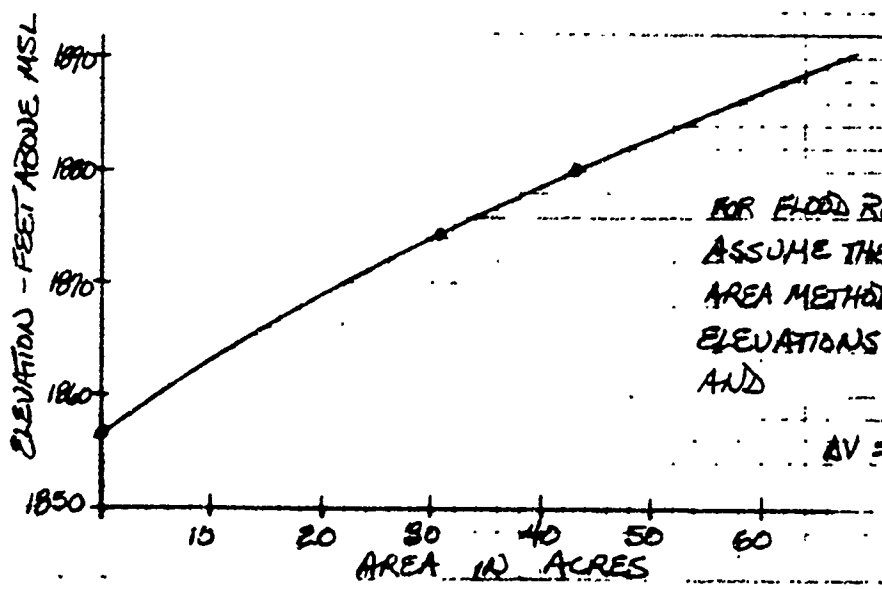
- SURFACE AREA AT ELEVATION 1874.0 - 31 ACRES
- SURFACE AREA AT ELEVATION 1880 - 43 ACRES (PLANIMETERED VALUES)

ASSUME CONICAL METHOD APPLIES TO FIND LOW POINT IN POOL, BELOW ELEVATION 1874.

$V = \frac{1}{3}AH$; $H = \frac{3V}{A} = \frac{3(190 \text{ AC-FT})}{31 \text{ AC}} = 18.4$ FEET

190 AC-FT FROM RESERVOIR FILES.

∴ ZERO STORAGE AT ELEVATION - 1855.60



FOR FLOOD ROUTING PURPOSES ASSUME THE AVERAGE END AREA METHOD IS SUITABLE TO ELEVATIONS ABOVE 1874.0 AND

$\Delta V = \left(\frac{A_1 + A_2}{2}\right)\Delta H$

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 3 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 2-20-81

ELEVATION - STORAGE TABLE:

ELEVATION (MSL)	AREA (AC)	ΔH (FT)	* INCREMENTAL VOLUME $\Delta V = (A_1+A_2)\frac{\Delta H}{2}$ (AC-FT)	CUMULATIVE VOLUME (AC-FT)
1855.60	–	–	–	0
1874.00	31	–	190	190.0
1875.50 (NORMAL POOL)	32	1.5	47.3	237.3
1876.00	34	1.0	33.0	270.3
1877.00	36	1.0	35.0	305.3
1878.00	38	1.0	37.0	342.3
1879.00	40	1.0	39.0	381.3
1880.00	43	1.0	41.5	422.8

* TO BE USED FOR VALUES ABOVE NORMAL POOL

NOTE: DRAINAGE AREA ABOVE DAM IS 0.27 mi^2

ELEVATION (MSL)	ROUNDED STORAGE (AC-FT)
1855.60	0
1874.0	190
1875.5 (NORMAL POOL)	240
1876.0	270
1877.0	310
1878.0	340
1879.0	380
1880.0	420

1876.2 (TOD) 280 AC-FT

TOD = TOP OF DAM

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 4 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 2-18-81

SDF: BASED ON THE SMALL HEIGHT OF DAM AND THE SMALL STORAGE, THE SDF SELECTED FOR THIS POND WAS THE 100 YEAR FLOOD. THIS IS IN ACCORDANCE WITH THE GUIDENCE PROVIDED.

∴ USE SDF = 100 YEAR FLOOD

PMP CALCULATIONS:

SINCE THE SDF SELECTED FOR THIS POND HAS BEEN THE 100 YEAR FLOOD, NO CALCULATIONS ARE NECESSARY TO COMPUTE THE PROBABLE MAXIMUM PRECIPATATION (PMF) OR PROBALE MAXIMUM FLOOD (PMF).

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 5 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-6-81

EMERGENCY SPILLWAY CAPACITY:

SPILLWAY IS LOCATED IN RIGHT PORTION OF DAM. SEE FIELD SKETCH IN APPENDIX A, EXHIBIT 1. DUE TO THE TRAPEZOIDAL SHAPED SPILLWAY AND UNUSUAL DOWNSTREAM CONFIGURATION IMMEDIATELY BELOW THE SPILLWAY, SKETCHS PROVIDED ON THE FOLLOWING THREE PAGES WILL ASSIST IN A BETTER UNDERSTANDING OF THE COMPUTATIONS USED TO DEVELOP THE SPILLWAY RATING CURVE.

SPILLWAY DATA:

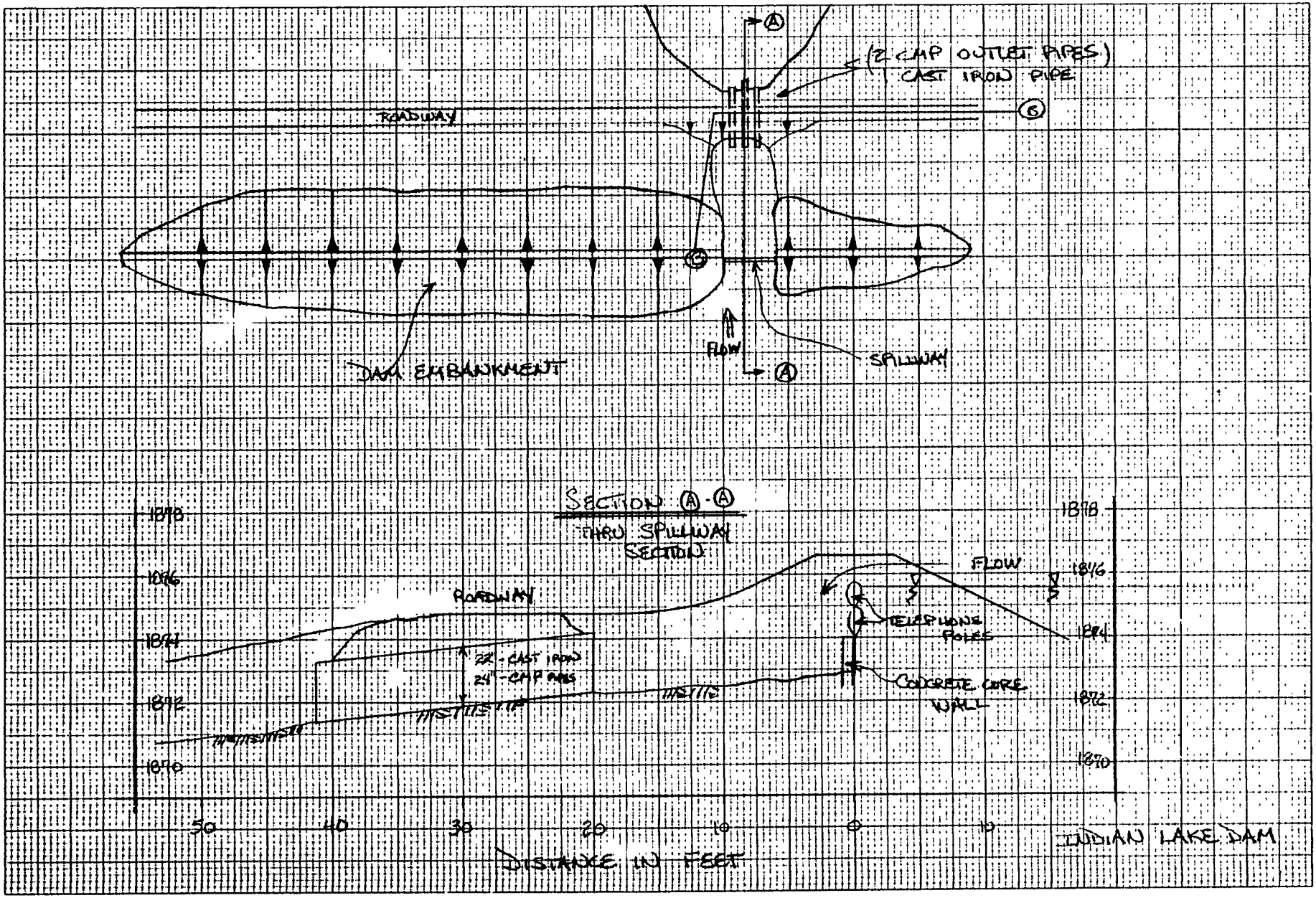
TYPE - TRAPEZOIDAL SHAPED
LENGTH - BOTTOM - 35 FEET, TOP - 52 FEET
CREST ELEVATION - AV. ~ 1875.5 (ALONG ASSUMED BOTTOM)
LOW POINT TOP OF DAM - 1876.2
SPILLWAY FREEBOARD - 0.7 FEET

C VALUE - FOR SPILLWAY - 2.85
FOR EMBANKMENT - 2.85
FOR DOWNSTREAM ROADWAY - 2.85

NOTE: THESE C VALUES WILL BE USED BASED ON LENGTHS PERPENDICULAR TO FLOW, SPILLWAY 1.0 FEET, EMBANKMENT ~ 7.0 FEET. THESE VALUES WILL BE HELD CONSTANT FOR ALL HEADS.

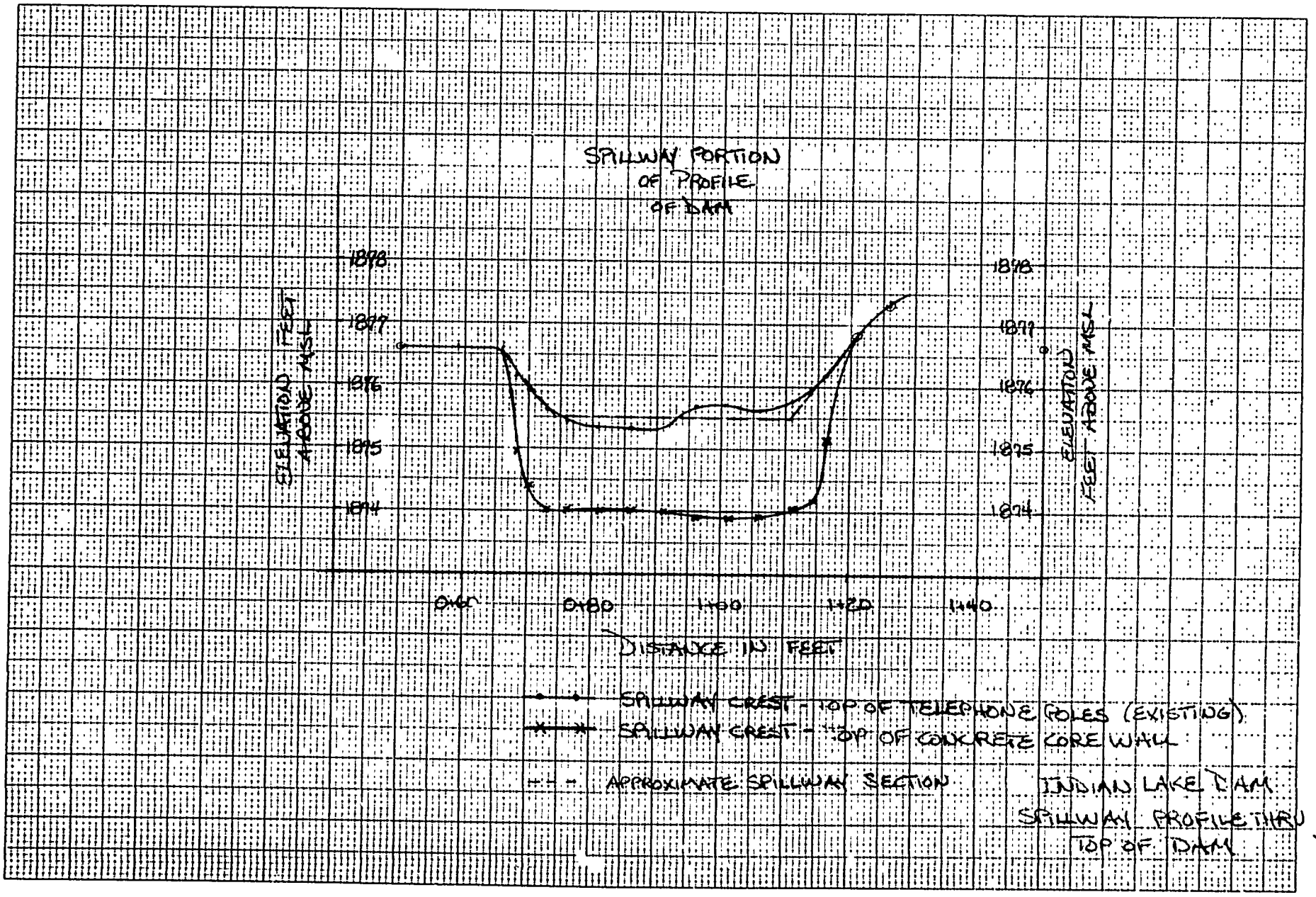
SPILLWAY SKETCH IS ON FOLLOWING PAGES.

NADB FORM 1232, 28 MAR 74



L-7

Sheet 6/

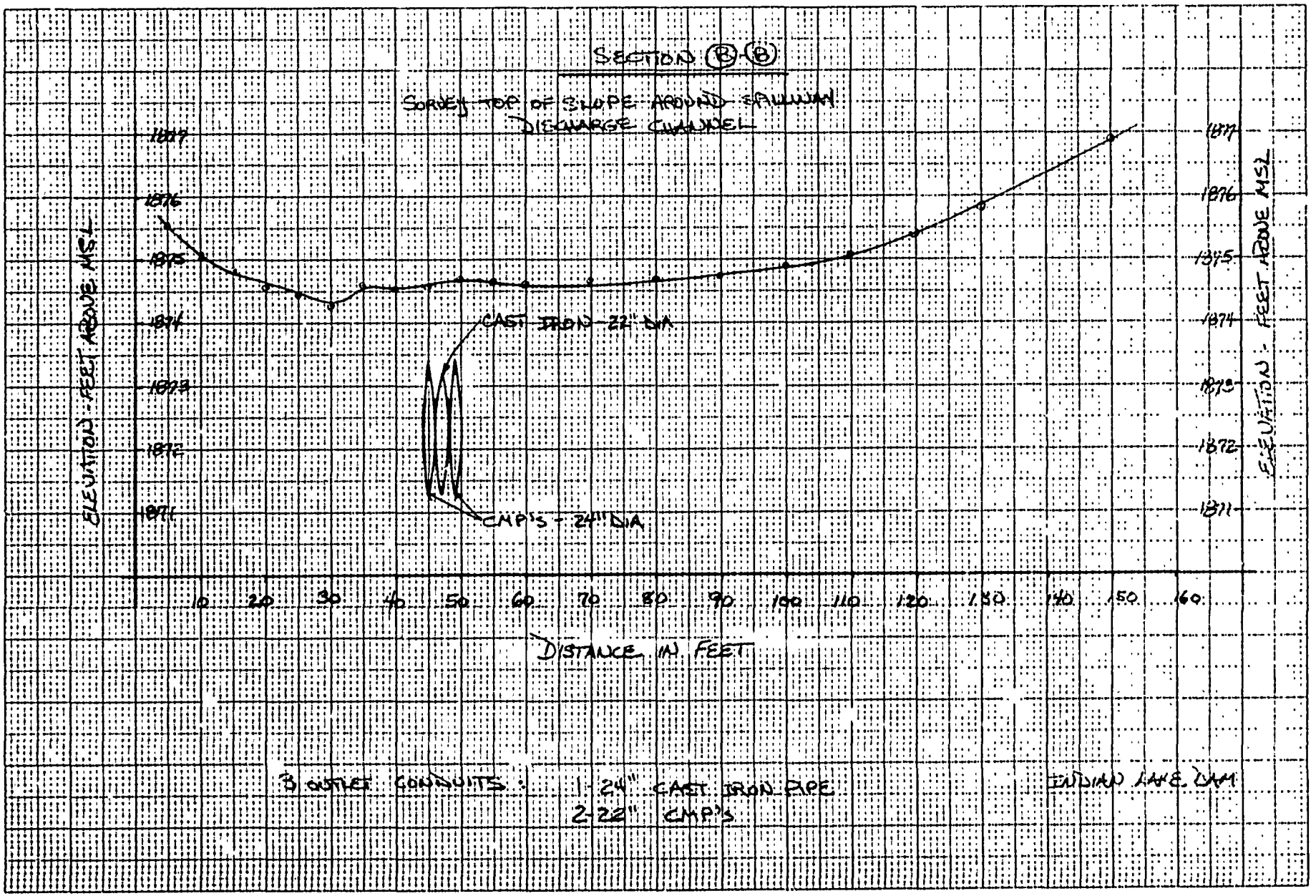


J-8

Sheet 7/

NO 340-10½ DIETZGEN GRAPH PAPER
10 X 10 PER HALF INCH

DIETZGEN CORPORATION
MADE IN U.S.A.



U-9

Sheet 8/

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 9 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-12-81

TRAPEZOIDAL SHAPED:

SPILLWAY BEHAVES AS A BROAD CRESTED WEIR.
THIS DISCHARGE CAN BE ESTIMATED AS

$Q = C L_1 H_w^{3/2}$ where: $C = 2.85$

L_1 = TOP WIDTH

H_w = WEIGHTED HEAD

SEE EMBANKMENT RATING CURVE FOR BETTER DEFINITIONS.

RESERVOIR ELEVATION (MSL)	TOP WIDTHS L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD, H_i (FT)	① INCREMENTAL FLOW AREA A_i (FT²)	TOTAL FLOW AREA (FT²)	② ③ WEIGHTED HEAD H_w (FT)	Q
1875.5	35	-	-	-	-	-	0
1875.7	39	35	0.2	7.4	7.4	0.19	9
1875.9	43	39	0.2	8.2	15.6	0.36	26
1876.1	46	43	0.2	8.9	24.5	0.53	51
1876.3	49	46	0.2	9.5	34.0	0.69	80
1876.5	52	49	0.2	10.0	44.0	0.85	116
1877.0	52	52	0.5	26.0	70.0	1.34	23
1878.0	52	52	1.0	52.0	122.0	2.34	58
1879.0	52	52	1.0	52.0	174.0	3.34	90
1880.0	52	52	1.0	52.0	226.0	4.34	134

① $A_i = H_i [(L_1 + L_2)/2]$

② $H_w = A_T / L_1$

③ $Q = C L_1 H_w^{3/2}$

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE _____

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 10 OF _____ SHEETS

COMPUTED BY JPB CHECKED BY _____ DATE 3-12-87

RESULTS OF SPILLWAY RATING:

POOL ELEVATION (MSL)	ROUNDED Q (CFS)
1875.5	0
1875.7	10
1875.9	30
1876.1	50
1876.3	80
1876.5	120
1877.0	230
1878.0	530
1879.0	910
1880.0	1340

NOW, COMPUTE THE FLOW THROUGH THE THREE PIPES PLUS OVER THE ROADWAY. THIS WILL ASSIST IN DEVELOPING THE BACKWATER EFFECTS OF THE ROADWAY IMMEDIATELY DOWNSTREAM OF THE SPILLWAY.

ASSUME INLET CONTROL DOMINATES UNTIL FLOW BEGINS TO OVERTOP THE ROADWAY EMBANKMENT, THEN OUTLET CONTROL WILL DOMINATE.

PIPE EXT INVERTS ARE AT ELEVATION 1871.3

FROM SKETCH, OVERFLOW ON THE ROADWAY BEGINS AT ELEVATION 1874.3. THEREFORE, ABOVE THIS ELEVATION ASSUME OUTLET CONTROL DOMINATES.

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS F ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 11 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-12-81

INLET CONTROL - 1-22" CAST IRON PIPE 22.5 FEET LONG
2-24" CMP 20 FEET LONG

FOR CMP ARE PROJECTING FROM FILL $K_e = 0.9$
FOR CAST IRON PIPE PROJECTING FROM FILL $K_e = 0.5$

POOL ELEV. (MSL)	HW (FT)	HW/D (FT/FT) ⊛ CAST IRON 22" = 1.83A	HW/D (FT/FT) ⊛ CMP 24" = 2A	Q ⊗ CAST IRON (CFS)	Q ⊗ 2-CMP (CFS)	TOTAL Q (CFS)
1872.3	0	—	—	—	—	0
1873.0	0.7	0.38	0.35	3	7	10
1874.0	1.7	0.93	0.85	9	18	27
1874.3 (TOP OF DAM)	2.0	1.09	1.00	12	24	36
1875.0	2.7	1.48	1.35	17	32	49
1876.0	3.7	2.02	1.85	22	44	66

NOTE: ⊛ N VALUE FOR CAST IRON PIPE (NORMAL) ~ 0.013 ■ IS VERY CLOSE TO CONCRETE PIPE $n = 0.012$ ∴ USE CONCRETE DATA PIPE VALUES ON CAST IRON PIPE.

⊗ SEE CHARTS 2 & 5 IN THIS APPENDIX FOR THESE VALUES. TAKEN FROM HYDRAULIC CHARTS FOR SELECTION OF HIGHWAY CULVERTS, U.S. DEPT. OF COMMERCE, BUREAU OF PUBLIC ROADS DEC. 1965
SEE PAGES A-25, A-26.

NOW, COMPUTE OUTLET CONTROL - ASSUME TAILWATER IS HIGH ENOUGH TO SUBMERGE ALL 3 CULVERTS.

PIPE MATERIAL	LENGTH	ENTRANCE EL.	OUTLET EL.	SLOPE
CAST IRON	22.5 FT.	1872.30	1871.30	0.045 FT/FT
CMP	20 FT.	1872.30	1871.40	0.045 FT/FT

∴ TW MUST AT LEAST AT ELEVATION 1873.40

■ - VALUE $n = 0.013$ FROM PAGE 110 OF OPEN CHANNEL HYDRAULICS, VEN CHOW, McGRAW-HILL, NEW YORK, N.Y. 1959.

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 12 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-12-81

OUTLET CONTROL:

$K_e = 0.9$ CMP L = 20 FT.
$K_e = 0.5$ CAST IRON (SEE CONCRETE DATA) L = 22.5 FT.

POOL ELEVATION (MSL)	TAILWATER ELEV (MSL)	H (FT)	Q ② 2-CMP (CFS)	Q ② CAST IRON (CFS)	TOTAL Q (CFS)
1874.3	1873.4	0.9	30	15	45
1875.0	1873.4	1.6	40	20	60
1876.0	1873.4	2.6	52	26	78
1877.0	1873.4	3.6	60	30	90
1878.0	1873.4	4.6	68	34	102
1879.0	1873.4	5.6	74	38	112
1880.0	1873.4	6.6	80	42	122

SUBMERGED OUTLET CONDUITS FLOWING FULL

② SEE CHARTS IN THIS APPENDIX, PAGES D-27, D-28.

NOTE: INLET AND OUTLET CONTROL ARE ALMOST IDENTICAL AT ELEVATION 1874.3 - 56 CFS VS. 57 CFS AND ELEVATION 1875.0 - 67 CFS VS 68 CFS.

3-PIPE RATING CURVE:

WATER SURFACE ELEVATION (MSL)	DISCHARGE CFS
1872.3	0
1873.0	10
1874.0	29
1874.3	45
1875.0	60
1876.0	78
1877.0	90
1878.0	102
1879.0	112
1880.0	122

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 13 OF SHEETS

COMPUTED BY JMB CHECKED BY DATE 3-12-81

ROADWAY RATING CURVE:

SEE EXPLANATION OF PARAMETERS AND VARIABLES UNDER EMBANKMENT RATING CURVE IN THIS APPENDIX.

$$Q = CL_1 H_w^{3/2}$$

ROADWAY INUNDATED VS. RESERVOIR ELEVATION:

ROADWAY ELEVATION (MSL)	ROADWAY LENGTH (FT)
1874.3	0
1874.5	10
1875.0	95
1875.5	116
1876.0	131
1877.0	160
1878.0	160
1879.0	160
1880.0	160

ROADWAY RATING TABLE

WATER SURFACE ELEV (MSL)	L_1 (FT)	L_2 (FT)	INCREMENTAL HEAD (FT)	① INCREMENTAL FLOW AREA, A_i (FT^2)	TOTAL FLOW AREA, A_T (FT^2)	② WEIGHTED HEAD, H_w (FT)	③ Q (CFS)
1874.3	0	–	–	–	–	–	0
1875.0	95	0	0.7	33.3	33.3	0.35	56
1876.0	131	95	1.0	113.0	146.3	1.11	436
1877.0	160	131	1.0	145.5	291.8	1.82	1119
1878.0	160	160	1.0	160.0	451.8	2.82	2159
1879.0	160	160	1.0	160.0	611.8	3.82	3404
1880.0	160	160	1.0	160.0	771.8	4.82	4825

① - $A_i = H_i[(L_1+L_2)/2]$

② $H_w = A_T/L_1$

③ $Q = CL_1 H_w^{3/2}$

recall $C = 2.85$

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 4 OF SHEETS

COMPUTED BY JJB CHECKED BY DATE 3-12-81

ROADWAY & PIPE RATING CURVE

WATER SURFACE ELEVATION (MSL)	Q 3 PIPES (CFS)	Q ROADWAY (CFS)	Q TOTAL (CFS)
1872.3	0	0	0
1873.0	10	0	10
1874.0	27	0	27
1874.3	45	0	45
1875.0	60	56	116
1876.0	78	436	514
1877.0	90	1119	1209
1878.0	102	2159	2261
1879.0	112	3404	3516
1880.0	122	4825	4947

NOW, DETERMINE THE POOL ELEVATION OF OF INDIAN LAKE V.S. THE OUTLET CAPACITY OF THE SPILLWAY OR DOWNSTREAM ROADWAY.

POOL ELEVATION (MSL)	SPILLWAY OUTFLOW (CFS)	ROADWAY & 3 PIPE OUTFLOW (CFS)	USE (CFS)
1875.5	0	350	0
1875.7	10	420	10
1875.9	30	480	30
1876.1	50	580	50
1876.3	80	750	80
1876.5	120	860	120
1877.0	230	1209	230
1878.0	530	2261	530
1879.0	910	3516	910
1880.0	1340	4947	1340

Since ROADWAY IS LOWER THAN SPILLWAY, IT CAN DISCHARGE MUCH MORE AT THE SAME ELEVATION THEN THE SPILLWAY.

NADB FORM 1232, 28 MAR 74

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SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 15 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-6-81

EMBANKMENT RATING CURVE:

THIS ANALYSIS ASSUMES THAT THE EMBANKMENT BEHAVES AS A BROAD CRESTED WEIR IF OVERTOPPING OCCURS. THIS DISCHARGE CAN BE ESTIMATED BY:

$$Q = CL_1H_W^{3/2}$$

WHERE:

Q = DISCHARGE OVER EMBANKMENT, IN CFS

L_1 = LENGTH OF EMBANKMENT, FT.

H_W = WEIGHTED HEAD, IN FEET, AVERAGE FLOW AREA WEIGHTED ABOVE LOW POINT OF DAM

C = COEFFICIENT OF DISCHARGE

LENGTH OF EMBANKMENT INNUNDATED VS. RESERVOIR ELEVATION:

RESERVOIR ELEVATION (MSL)	EMBANKMENT LENGTH (FT)
1876.2	0
1877.0	348
1878.0	348*
1879.0	348*
1880.0	348*

SEE EXHIBIT A-2, APPENDIX A FOR PROFILE OF TOP OF DAM.

* MAXIMUM LENGTH OF DAM IS 348 FEET.

NADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 16 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-6-81

EMBANKMENT RATING TABLE:

RESERVOIR ELEVATION (MSL)	L_1 (Ft)	L_2 (Ft)	INCREMENTAL HEAD, H_i (Ft)	① INCREMENTAL FLOW AREA, A_i (Ft^2)	TOTAL FLOW AREA (A_T)	② WEIGHTED HEAD, H_W (Ft)	③ Q (CFS)
1876.2	0	-	-	-	-	-	0
1877.0	248	0	0.8	99.2	99.2	0.40	174.8
1878.0	348	248	1.0	298.0	397.2	1.14	1207.2
1879.0	348	348	1.0	348.0	745.2	2.14	3104.9
1880.0	348	348	1.0	348.0	1093.2	3.14	5518.5

① $A_i = H_i [(L_1 + L_2)/2]$

② $H_W = A_T / L_1$

③ $Q = C L_1 H_W^{3/2}$

recall $C = 2.85$

TOTAL FACILITY RATING CURVE:

RESERVOIR ELEVATION (MSL)	$Q_{SPILLWAY}$ (CFS)	$Q_{EMBANKMENT}$ (CFS)	Q_{TOTAL} (CFS)
1875.5	0	0	0
1876.0	40	0	40
1876.2	70	0	70
1877.0	230	180	410
1878.0	530	1210	1740
1879.0	910	3100	4010
1880.0	1340	5520	6860

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BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 17 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 4-24-81

100 YEAR FLOOD ANALYSIS:

THE SELECTED SDF FOR INDIAN LAKE HAS BEEN THE 100 YEAR FLOOD. THIS IS BASED ON THE SIZE OF THE DAM AND THE HAZARD CATAGOREY OF THE DAM.

TO DEVELOP THE 100 YEAR FLOOD, TWO REGRESSION EQUATIONS WILL BE USED TO DETERMINE THE PEAK VALUE. THE AVERAGE OF THE TWO REGRESSION PEAKS WILL BE THE 100 YEAR FLOOD PEAK USED IN THIS ANALYSIS.

BULLENTIN 13 FLOOD PEAK:

FROM PLATE 1 - INDIAN LAKE DAM IS IN REGION 5.

∴ REGRESSION EQUATION IS -

$$Q_T = cA^x P_i^p$$

where:

Q_T = PEAK FLOW FOR RETURN PERIOD T, IN YEARS
C = REGRESSION CONSTANT
A = DRAINAGE AREA IN SQUARE MILES
X = REGRESSION COEFFICIENT
P_i = ANNUAL PRECIPITATION INDEX = AVERAGE ANNUAL EXCESS PRECIPITATION WHICH EQUALS AVERAGE ANNUAL PRECIPITATION MINUS ESTIMATED POTENTIAL ANNUAL EVAPOTRANSPIRATION
p = REGRESSION COEFFICIENT

FROM PLATE #2:

AVERAGE ANNUAL PRECIPITATION = 40 INCHES
POTENTIAL ANNUAL EVAPORTRANSPIRATION = 25 INCHES

∴ $P_i = 40 - 25 = 15$ INCHES

MADB FORM 1232, 28 MAR 74

BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 18 OF SHEETS

COMPUTED BY JAB CHECKED BY DATE 4-24-81

RECALL DRAINAGE AREA = 0.27 mi^2

FOR 100 YEAR ANALYSIS:

$C = 42.2$ $P_c = 15$

$X = 0.751$ $A = 0.27\ mi^2$

$P = 0.744$ $T = 100$

THEREFORE, $Q_T = C A^X P_c^P$

$$Q_{100} = 42.2(0.27)^{0.751}(15)^{0.744} = 118.4$$

$\therefore Q_{100} = 118.4$ CFS FROM BULLETIN 19

NOW, COMPUTE THE 100 YEAR FLOOD PEAK FROM HYDROLOGIC STUD
TROPICAL STORM AGNES, NORTH ATLANTIC DIVISION, 197

$$\log(Q_m) = C_m + 0.75 \log(A)$$

where:

C_m = a map coefficient for mean log of annual peaks

Q_m = Geometric mean of annual flood peaks, in cfs

A = drainage area in square miles

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BALTIMORE DISTRICT, CORPS OF ENGINEERS PAGE _____

SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 19 OF _____ SHEETS

COMPUTED BY JPB CHECKED BY _____ DATE 3-3-81

$LOG(Q_m) = C_m + 0.87\ LOG(A)$ recall $A = 0.27\ mi^2$

FROM FIGURE 2 $C_m = 1.70$

$\therefore LOG(Q_m) = 1.70 + 0.87\ LOG(0.27)$

$LOG(Q_m) = 1.2053$

now, compute the standard deviation

$S = C_S - 0.05\ log(A)$

where: S = standard deviation

C_S = a map coefficient for STANDARD DEVIATION

FROM FIGURE 3 $C_S = 0.405$

$S = 0.405 - 0.05\ log(0.27)$

$S = 0.4334$

now, compute the 100 YEAR FLOOD PEAK FROM THE FOLLOWING

$Log(Q_{qi}) = log(Q_m) + K(P,g)S$

where:

$log(Q_{qi})$ = log of the annual flood PEAKS FOR A GIVEN EXCEEDENCE FREQUENCY

$log(Q_m)$ = mean logarithm of annual flood peaks

$K(P,g)$ = STANDARD DEVIATE FOR A GIVEN EXCEEDENCE FREQUENCY (P) AND SKEW COEFFICIENT (g)

S = STANDARD DEVIATION, LOGS OF ANNUAL PEAKS

$\therefore$ WE NEED TO HAVE THE SKEW COEFFICIENT, FROM FIGURE 5

$g = 0.70$

BADB FORM 1232, 28 MAR 74

$K(P,g) = 2.840$

THIS IS AN INTERPOLATED VALUE FROM EXHIBIT 39 - STATISTICAL METHODS IN HYDROLOGY, LEO R BEARD - JAN 1962.

$\therefore Log(Q_{(P)}) = Log(Q_m) + K(P,g)S$

$Log(Q_{100}) = 1.2053 + 2.840(0.4394)$

$Log(Q_{100}) = 2.43616$

$Q_{100} = 272.9$

THERFORE, $Q_{100} = 272.9$ CFS FROM TROPICAL STORM AGNES REPORT, NORTH ATLANTIC DIVISION

NOW, COMPUTE THE 100 YEAR FLOOD PEAK BY AVERAGING THE TWO REGRESSION EQUATIONS.

$\therefore Q_{100} = \frac{118.4 + 272.9}{2} = 195.65$ CFS

$\therefore Q_{100} = 200$ CFS

SPILLWAY ADEQUACY:

THE SPILLWAY IS CONSIDERED ADEQUATE IF THE MAXIMUM OUTFLOW THROUGH THE SPILLWAY AT LOW POINT TOP OF DAM IS GREATER THAN THE Q_{100} PEAK CALCULATED ABOVE.

THEREFORE,

MAXIMUM OUTFLOW AT TOP OF DAM = 70 CFS
MAXIMUM INFLOW FOR 100 YEAR FLOOD = 200 CFS

SINCE THE MAXIMUM INFLOW IS GREATER THAN THE MAXIMUM OUTFLOW, THE SPILLWAY IS RATED INADEQUATE.

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SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 21 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-13-81

SPILLWAY AT ELEVATION 1874.0 - REMOVE TELEPHONE POLES FROM SPILLWAY, AND DETERMINE IF THIS WOULD MAKE THE SPILLWAY ADEQUATE.

SEE SKETCH ON PAGE D-8 OF THIS APPENDIX FOR SECTION THRU SPILLWAY.

BW = 44 FEET

ELEVATION (MSL)	TOP WIDTH (FT)
1874	44
1875	48
1876	51
1877	53
1878	53
1879	53
1880	53

MODIFIED SPILLWAY RATING CURVE:

RESERVOIR ELEVA. (MSL)	L_1 (ft)	L_2 (ft)	INCREMENTAL HEAD, H_i (ft)	① INCREMENTAL FLOW AREA, A_i (ft^2)	TOTAL FLOW AREA, A_T (ft^2)	② WEIGHTED HEAD, H_W (ft)	③ Q (CFS)
1874	44	-	-	-	-	-	0
1875	48	44	1.0	46.0	46.0	0.96	128.7
1876	51	48	1.0	49.5	95.5	1.87	372
1877	53	51	1.0	52.0	147.5	2.78	700
1878	53	53	1.0	53.0	200.5	3.78	1110
1879	53	53	1.0	53.0	253.5	4.78	1578
1880	53	53	1.0	53.0	306.5	5.78	2099

① - $A_i = H_i[(L_1+L_2)/2]$

② $H_W = A_T/L_1$

③ $Q = CL_1H_W^{3/2}$

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SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 22 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 3-13-81

COMPARISON OF MODIFIED SPILLWAY OUTFLOW VS. ROADWAY AND 3-PIPE OUTFLOW VALUES.

ELEVATION (MSL)	MODIFIED SPILLWAY (CFS)	ROADWAY & 3 PIPES (CFS)	USE Q (CFS)
1874	0	~~29~~	0
1875	~~730~~	116	116
1876	370	~~514~~	370
1877	700	~~1309~~	700
1878	1110	~~2264~~	1110
1879	1560	~~3516~~	1560
1880	2100	~~4949~~	2100

THEREFORE, ADD THE LAST COLUMN TO THE EMBANKMENT RATING TABLE AND INPUT MODIFIED SPILLWAY RATING TO A NEW RUN.

TOTAL MODIFIED FACILITY RATING CURVE:

RESERVOIR ELEVATION (MSL)	Q SPILLWAY MODIFIED (CFS)	Q EMBANKMENT (CFS)	Q TOTAL (CFS)
1874	0	0	0
1875	116	0	116
1876	370	0	370
1877	700	180	880
1878	1110	1210	2320
1879	1560	3100	4660
1880	2100	5520	7620

SINCE THE MODIFIED SPILLWAY AT TOP OF DAM (1876.2) CAPACITY EXCEEDS 200 CFS, THE MODIFIED SPILLWAY WOULD BE RATED ADEQUATE.

NADB FORM 1232, 28 MAR 74

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SUBJECT DAM SAFETY ANALYSIS

COMPUTATIONS INDIAN LAKE DAM SHEET 23 OF SHEETS

COMPUTED BY JPB CHECKED BY DATE 4-2-81

OUTLET WORKS:

THE OUTLET WORKS CONSIST OF A UPSTREAM INTAKE, 16 INCH DIAMETER VITRIFIED CLAY PIPE, AND AN OUTLET PIPE SUFFICIENTLY FAR AWAY TO LET INLET CONTROL DOMINATE. THEREFORE, THIS RATING CURVE WILL BE BASED ON AN INLET CONTROL PIPE, ASSUMING $N = 0.014$. SEE PAGE D-25 IN THIS APPENDIX FOR CHART. ASSUME THAT THIS CONCRETE PIPE CHART IS APPLICABLE

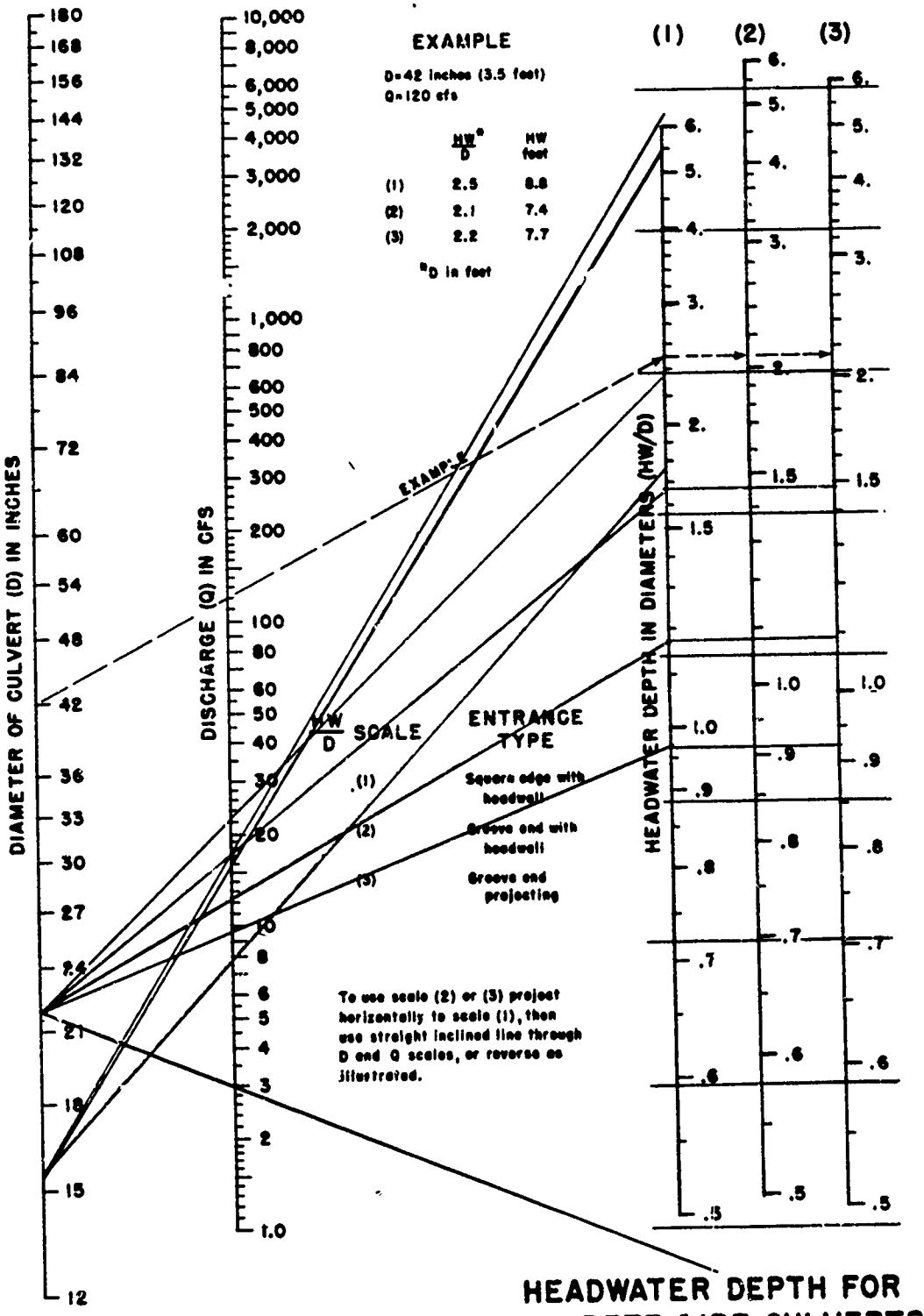
ENTRANCE: SQUARE EDGE WITH HEADWALL.

16" VITRIFIED CLAY PIPE $D = 1.33$ FT.

POOL ELEVATION (MSL)	HW (ft)	$\frac{HW}{D}$	Q (CFS)
1867.7	0	0	0
1870.0	2.3	1.96	8
1875.0	7.3	5.49	15
1876.2	8.5	6.39	17
1880.0	12.3	9.25	

NADB FORM 1232, 28 MAR 74

CHART 2



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

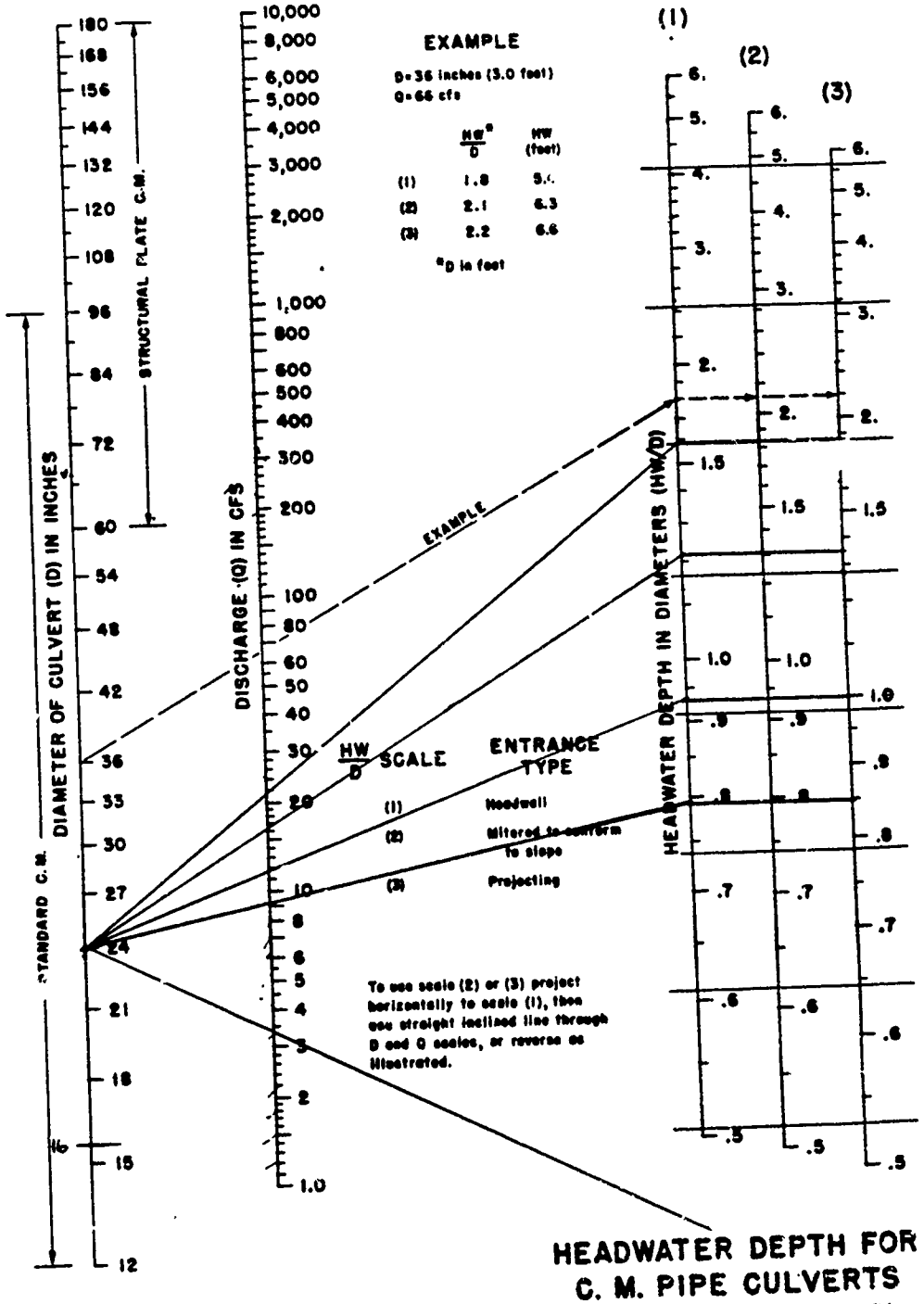
HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

INLET CONTROL

INDIAN LAKE DAM

CHART 5



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

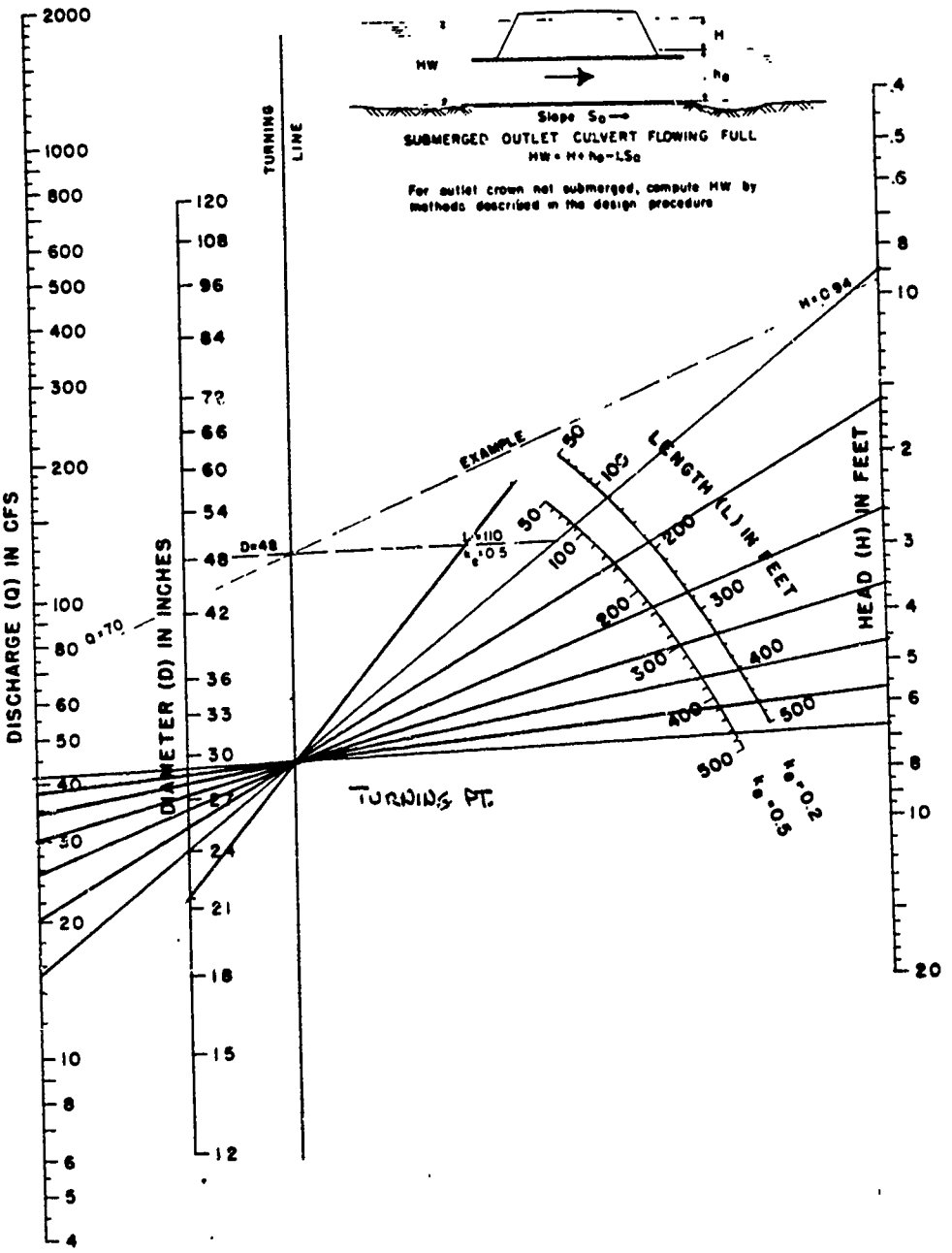
BUREAU OF PUBLIC ROADS JAN. 1963

INLET CONTROL

INDIAN LAKE DAM

INDIAN LAKE D-11

CHART 9



HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

BUREAU OF PUBLIC ROADS JAN 1963

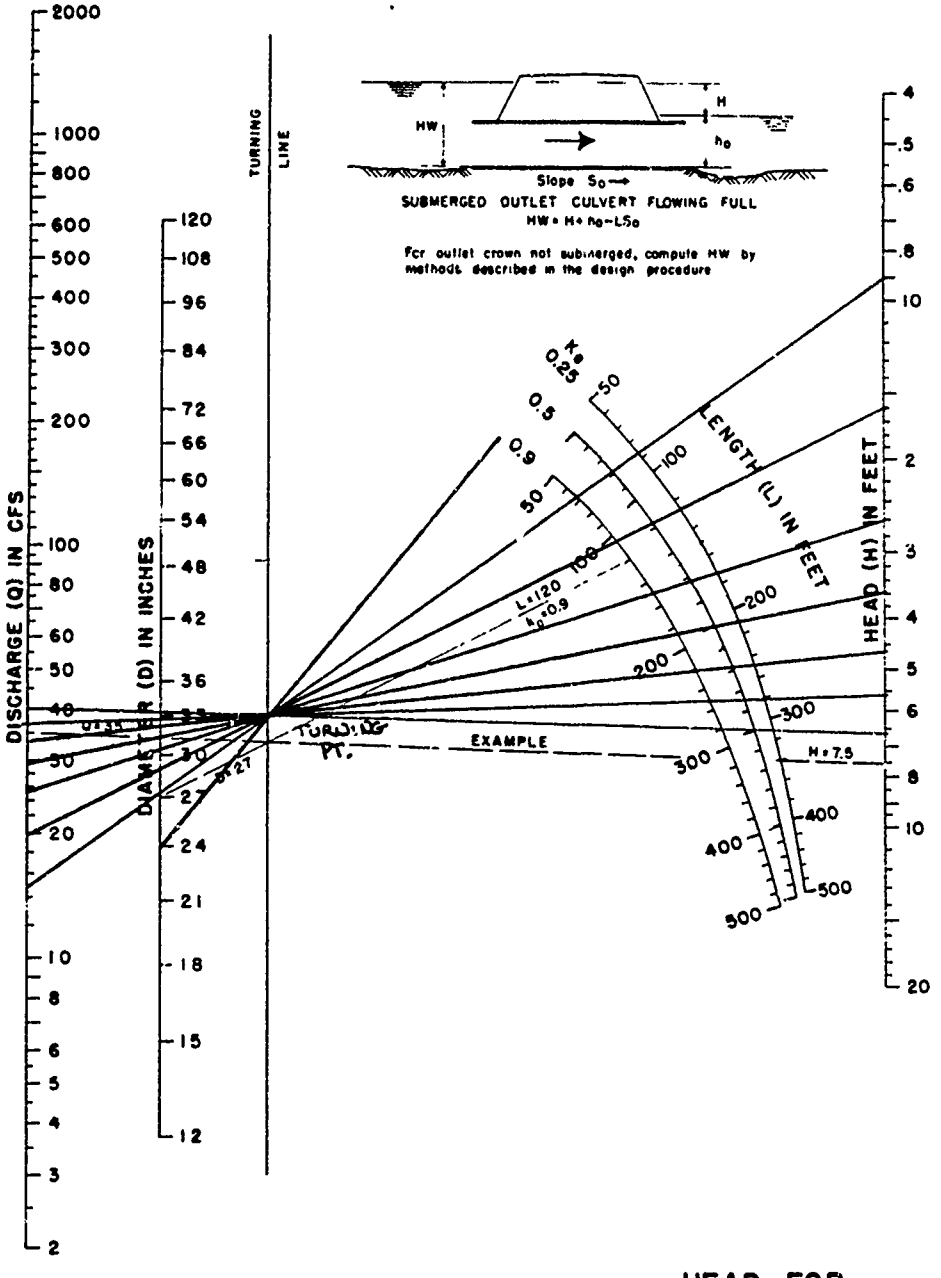
OUTLET CONTROL

INDIAN LAKE DAM

INDIAN LAKE DAM

Sheet 27

CHART II



HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

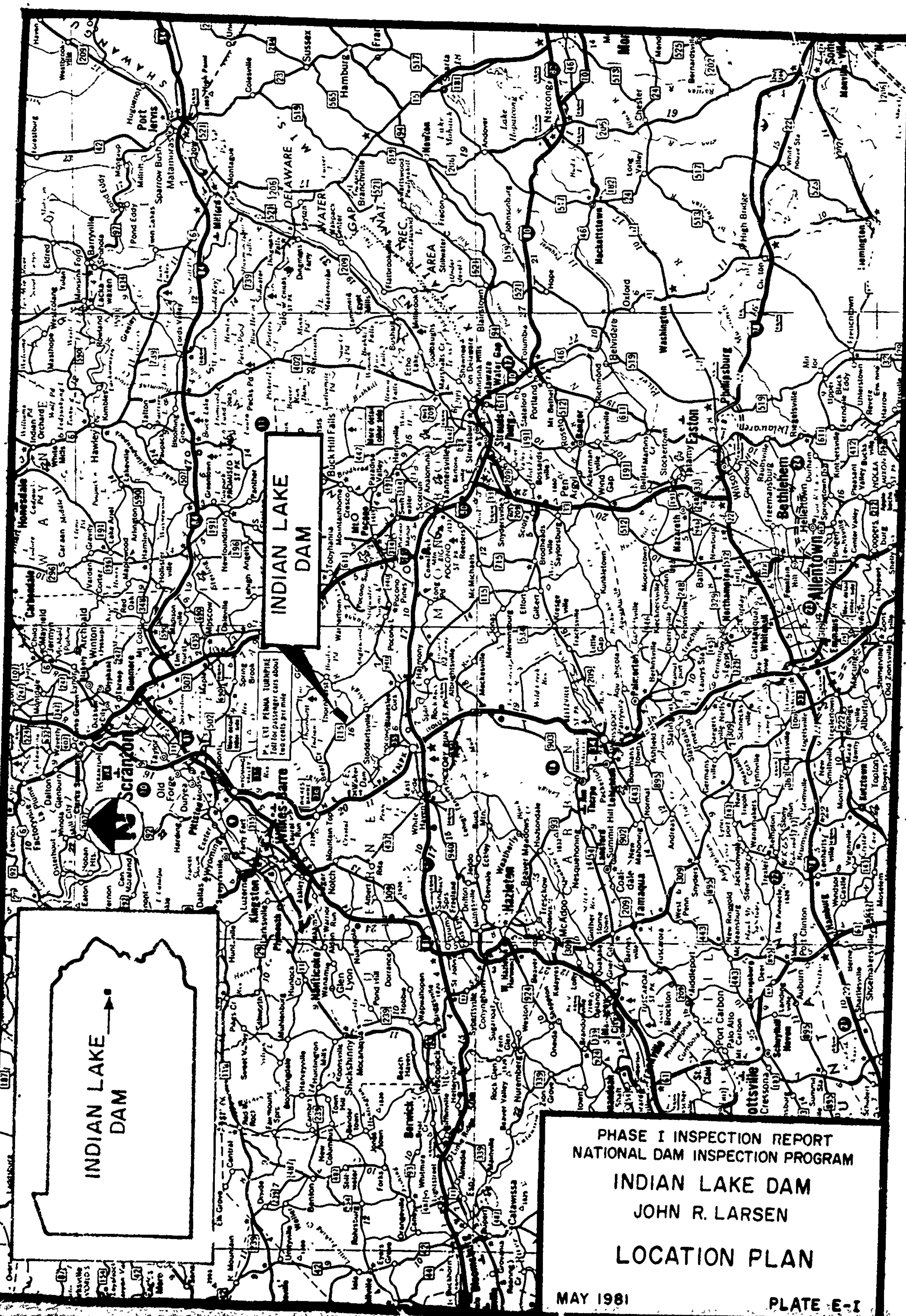
BUREAU OF PUBLIC ROADS JAN 1963

OUTLET CONTROL

INDIAN LAKE DAM

APPENDIX E

PLATES



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

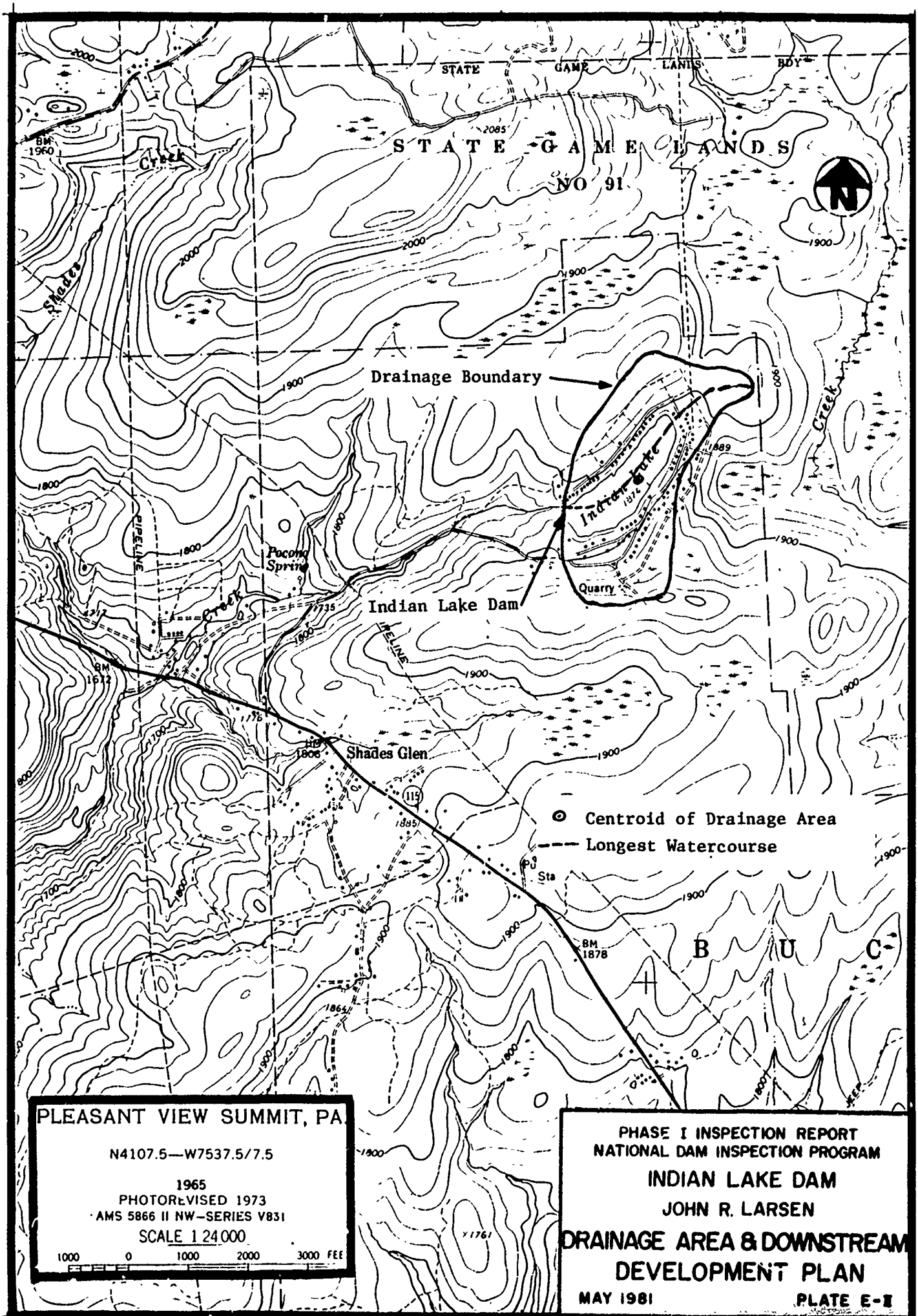
INDIAN LAKE DAM

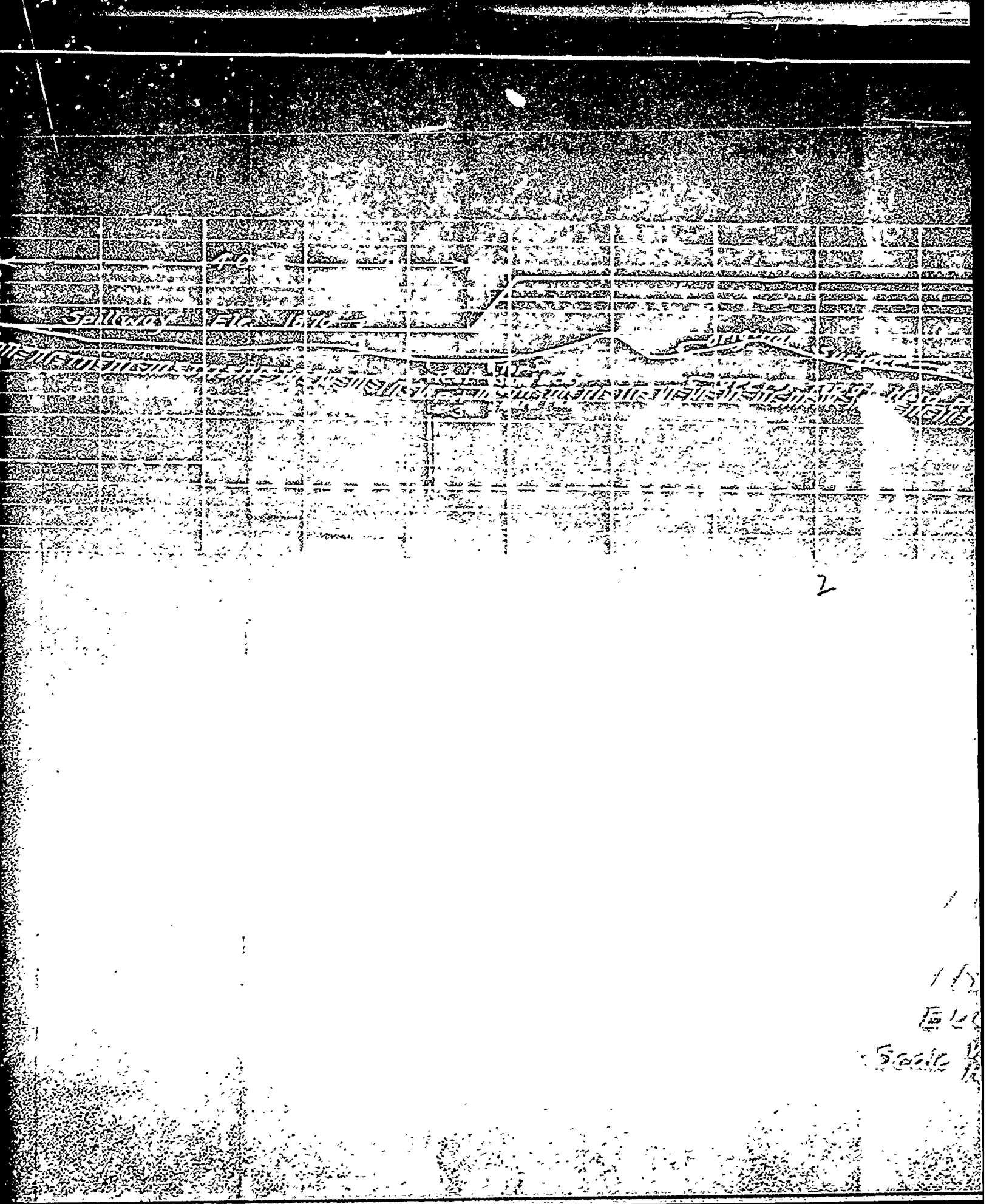
JOHN R. LARSEN

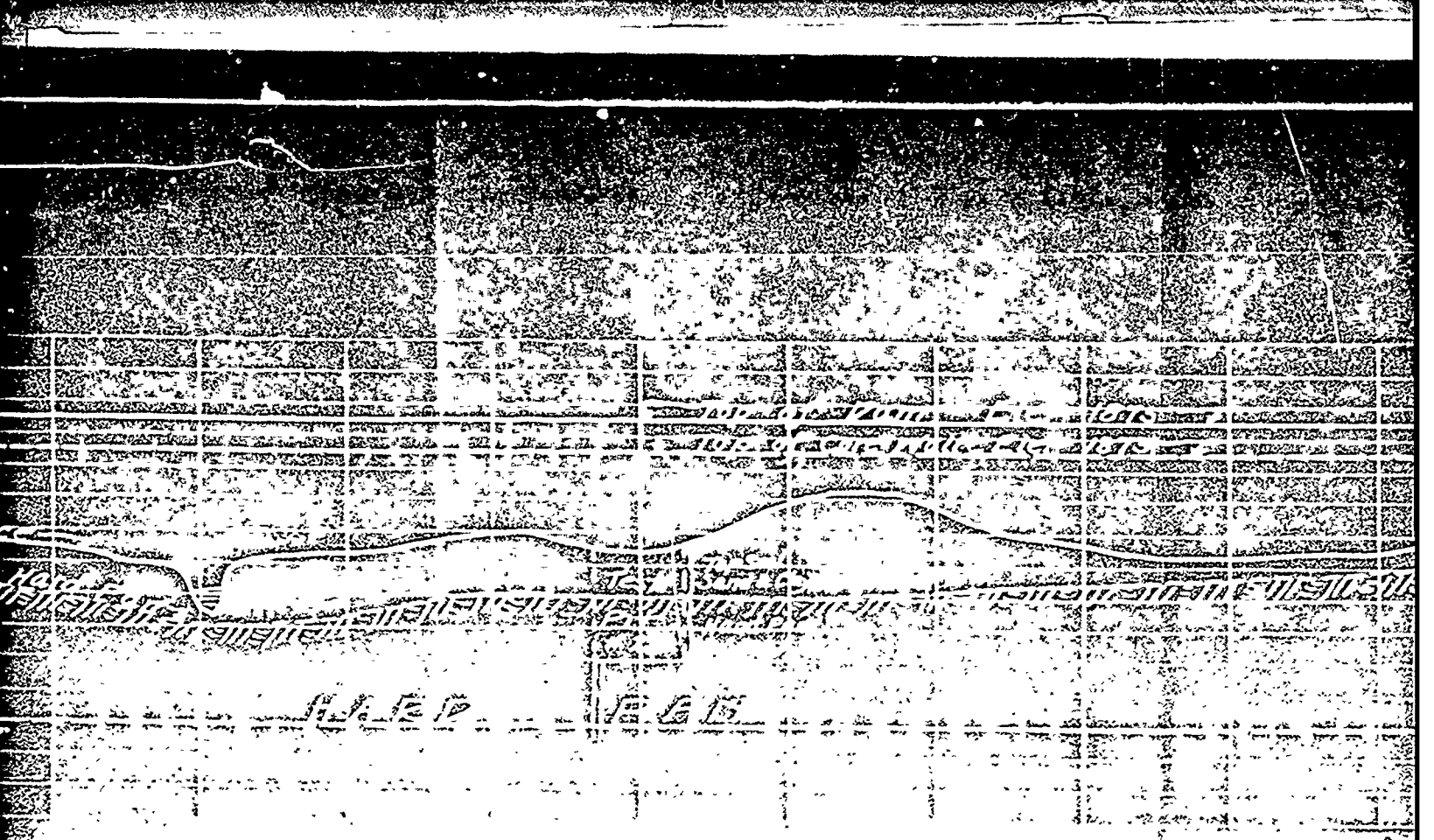
LOCATION PLAN

MAY 1981

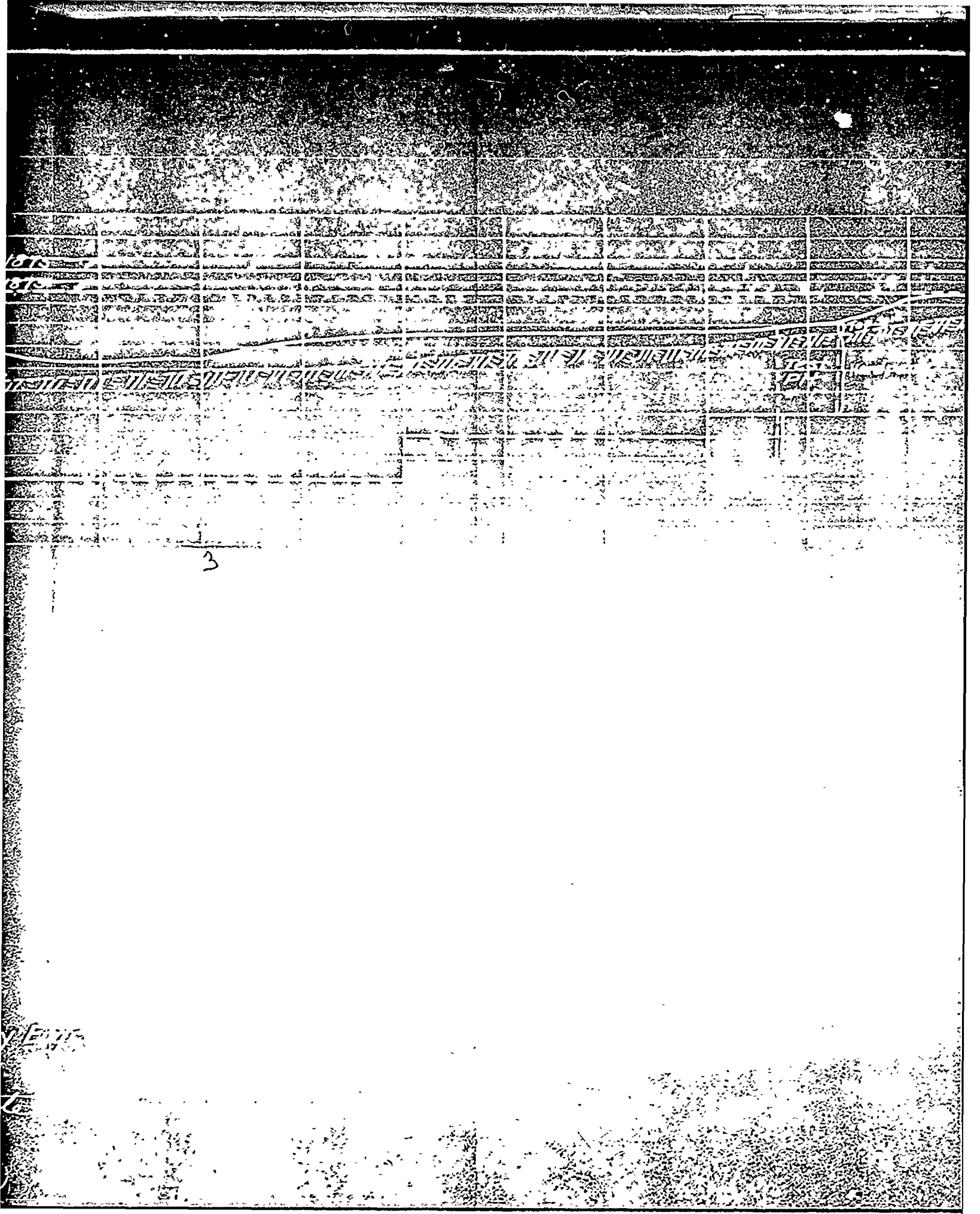
PLATE E-I

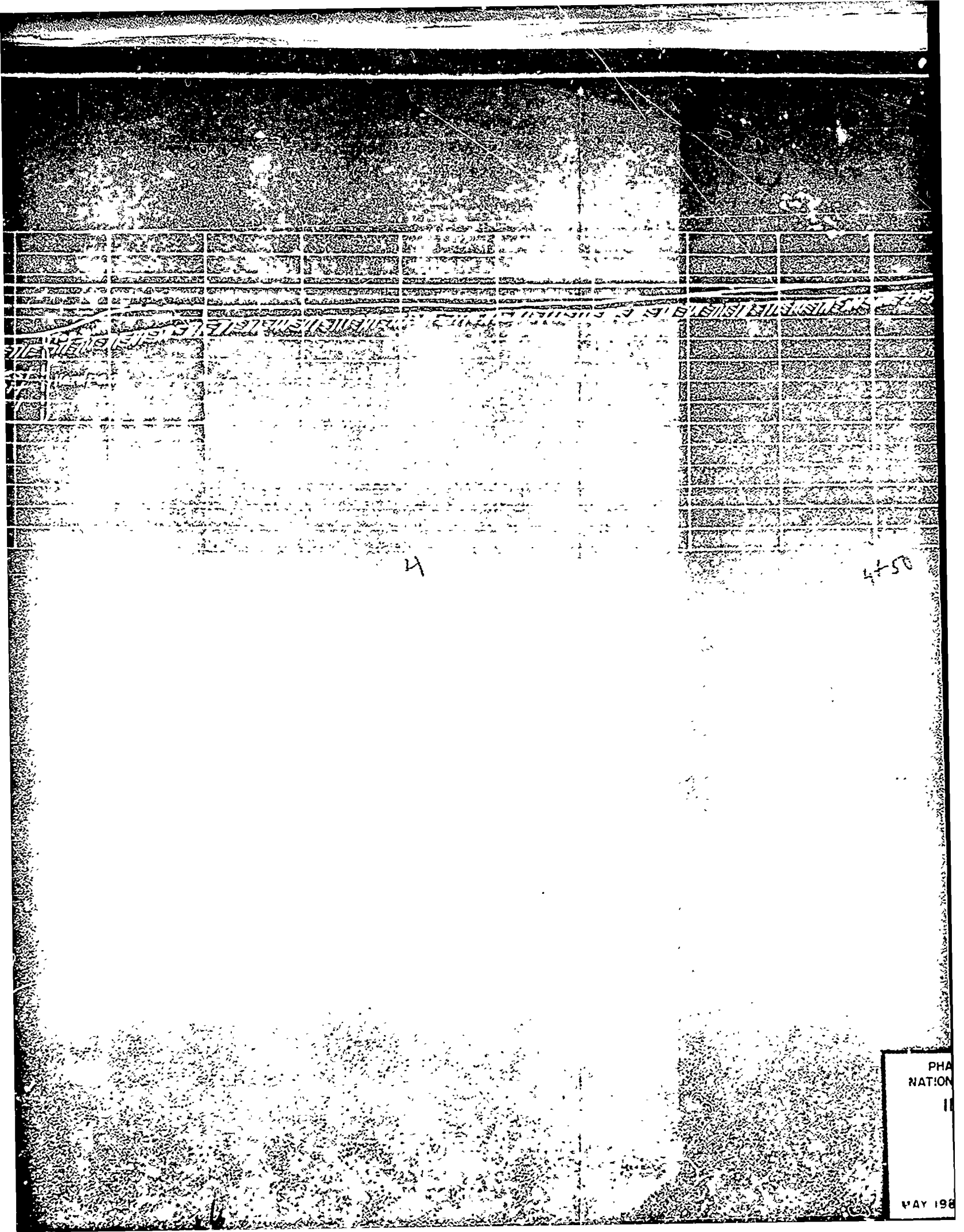

STATE GAME LANDS
NO 91
Drainage Boundary
Indian Lake Dam
Indian Lake
Quarry
Pocono Spring
Shades Glen
Shades Creek
Pipeline
Centroid of Drainage Area
Longest Watercourse
B U C
PLEASANT VIEW SUMMIT, PA.
N4107.5—W7537.5/7.5
1965
PHOTOREVISED 1973
AMS 5866 II NW—SERIES V831
SCALE 1 24000
1000 0 1000 2000 3000 FEET
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
INDIAN LAKE DAM
JOHN R. LARSEN
DRAINAGE AREA & DOWNSTREAM DEVELOPMENT PLAN
MAY 1981
PLATE E-II





3





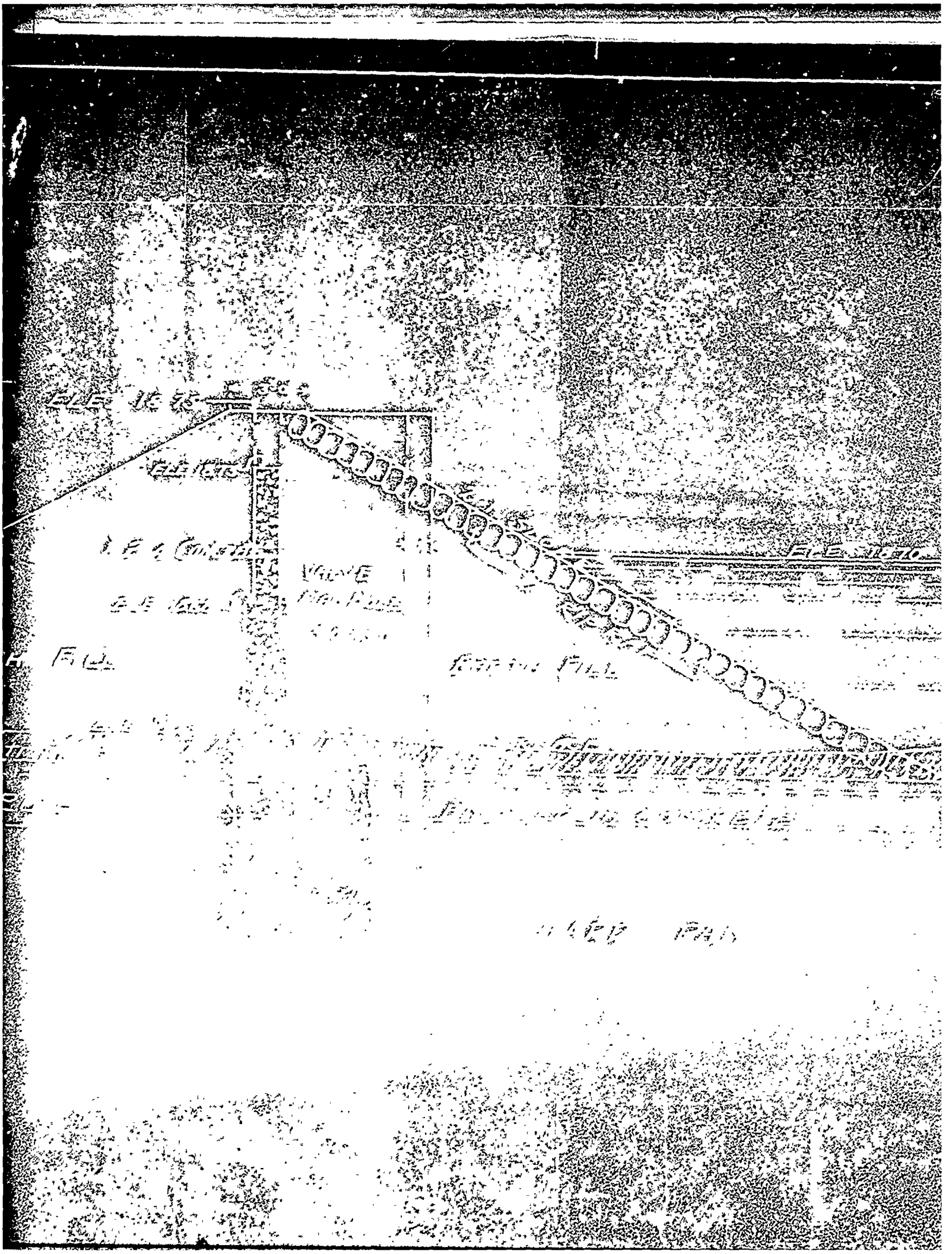
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

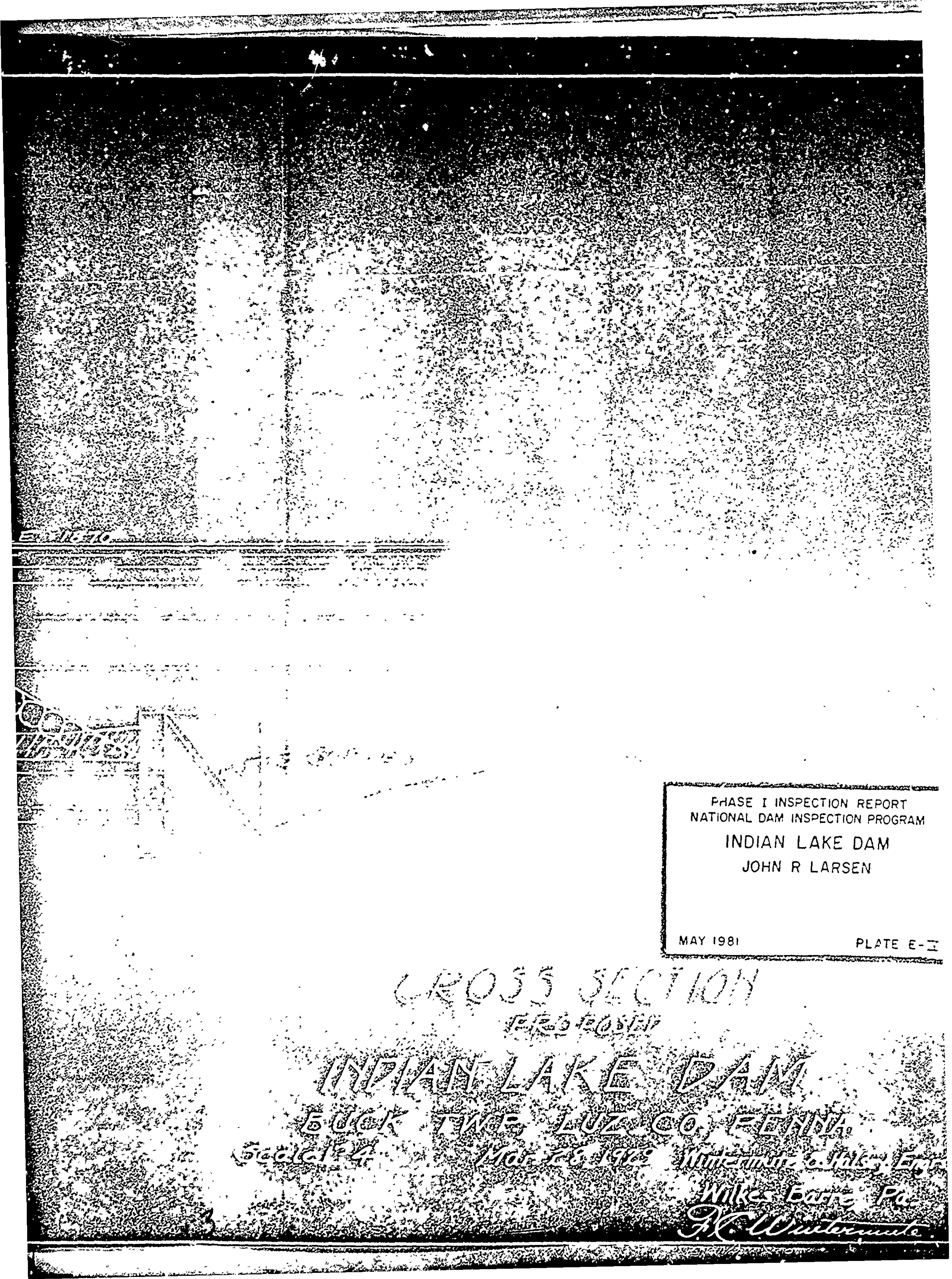
INDIAN LAKE DAM

JOHN R. LARSEN

MAY 1981

PLATE E-II

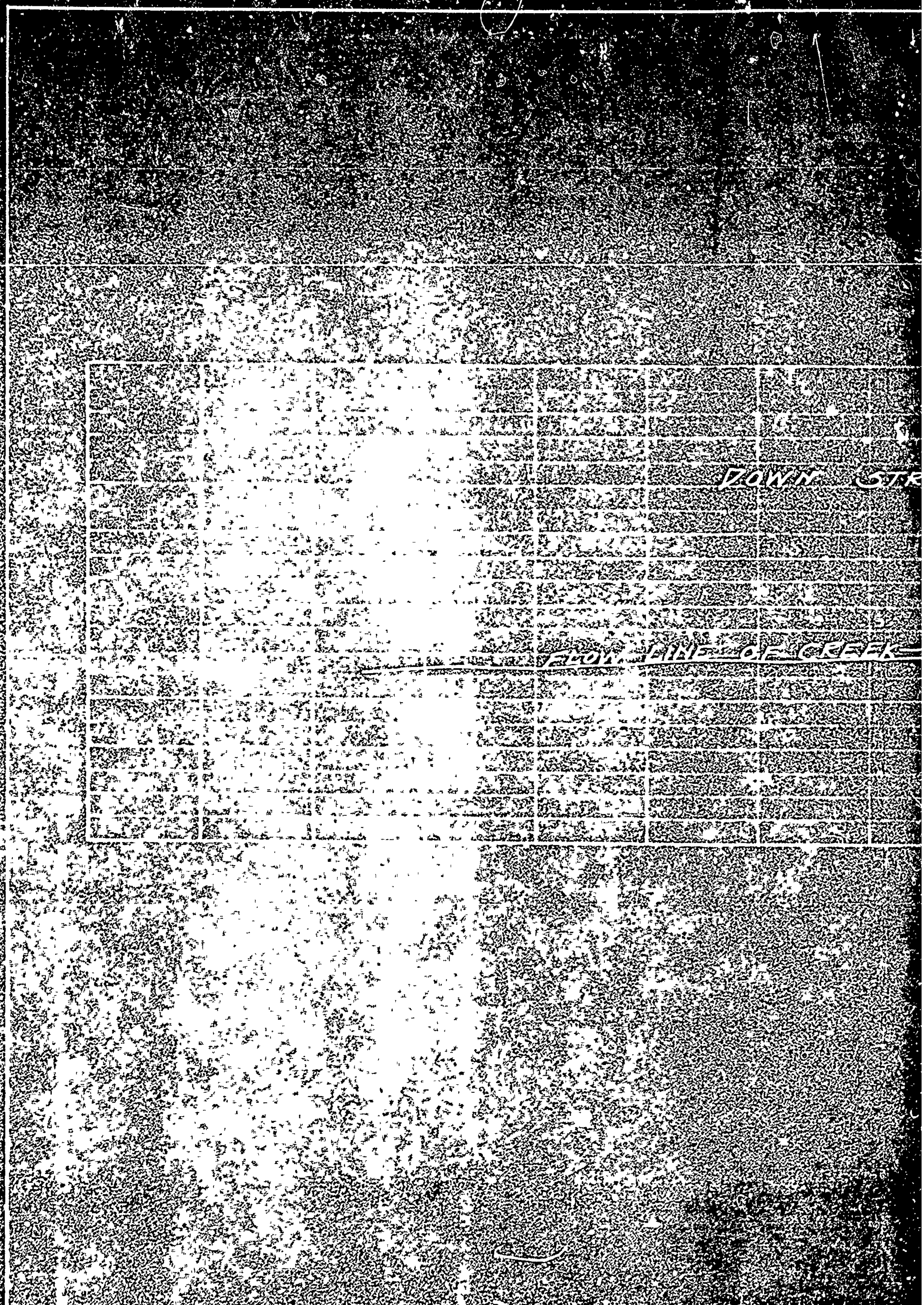


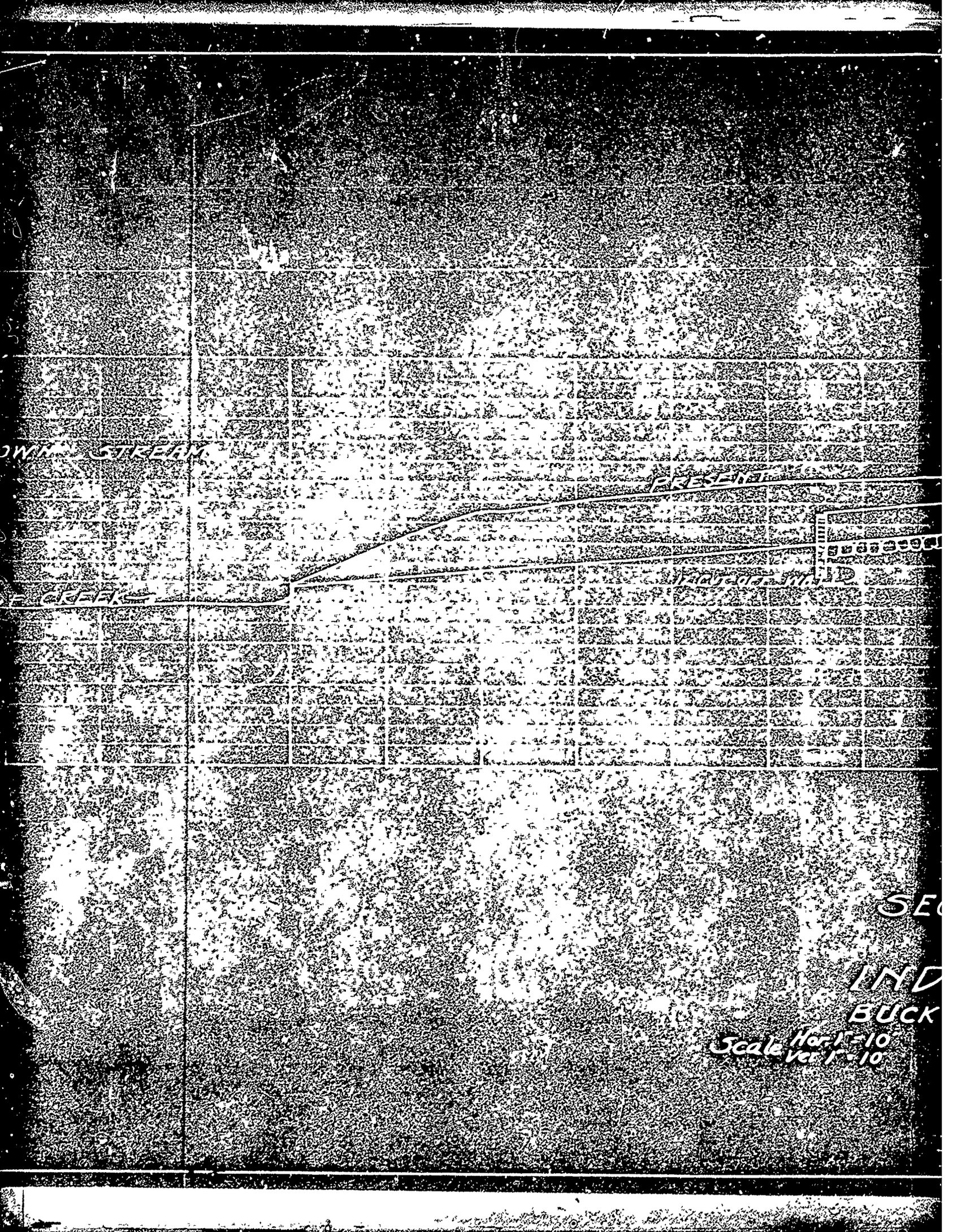


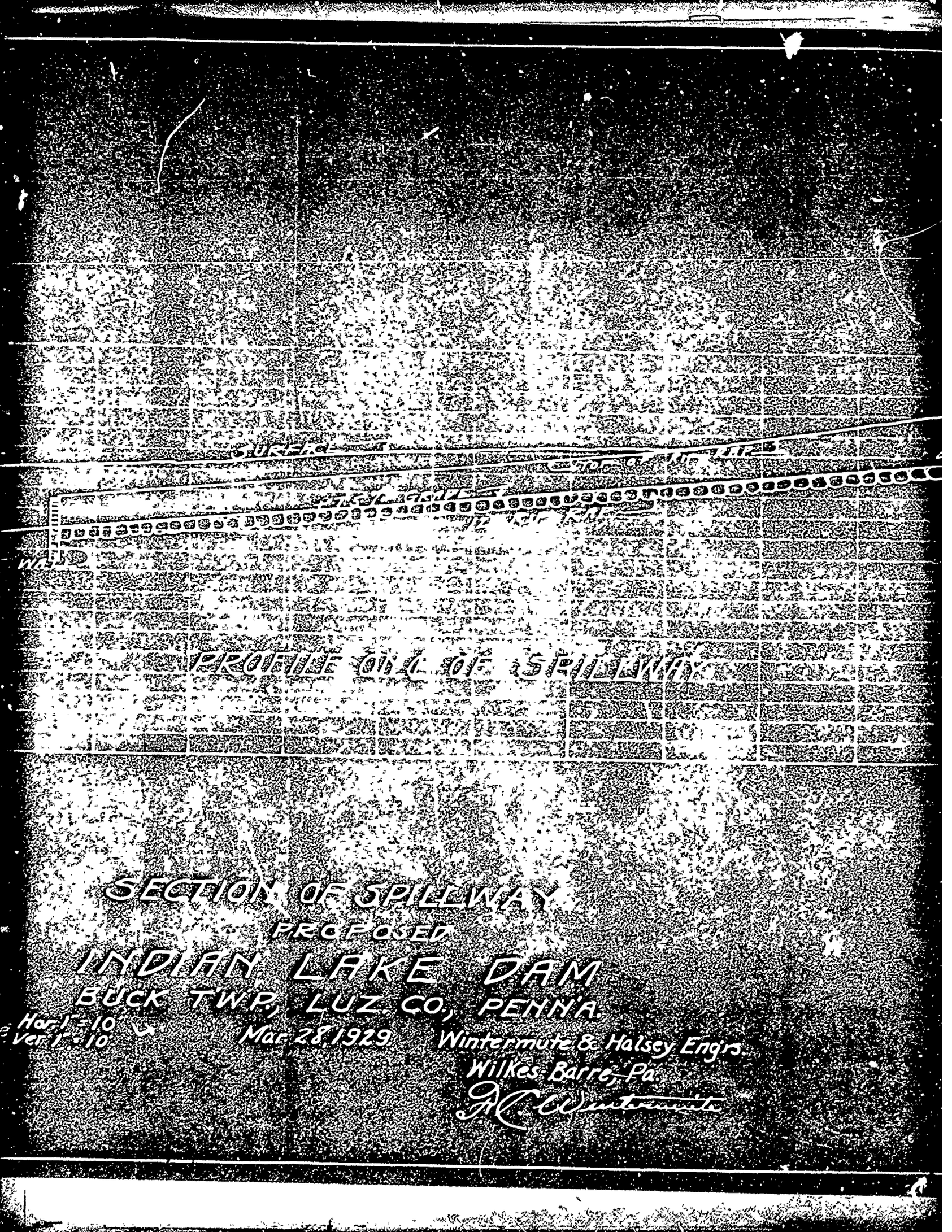
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
INDIAN LAKE DAM
JOHN R LARSEN

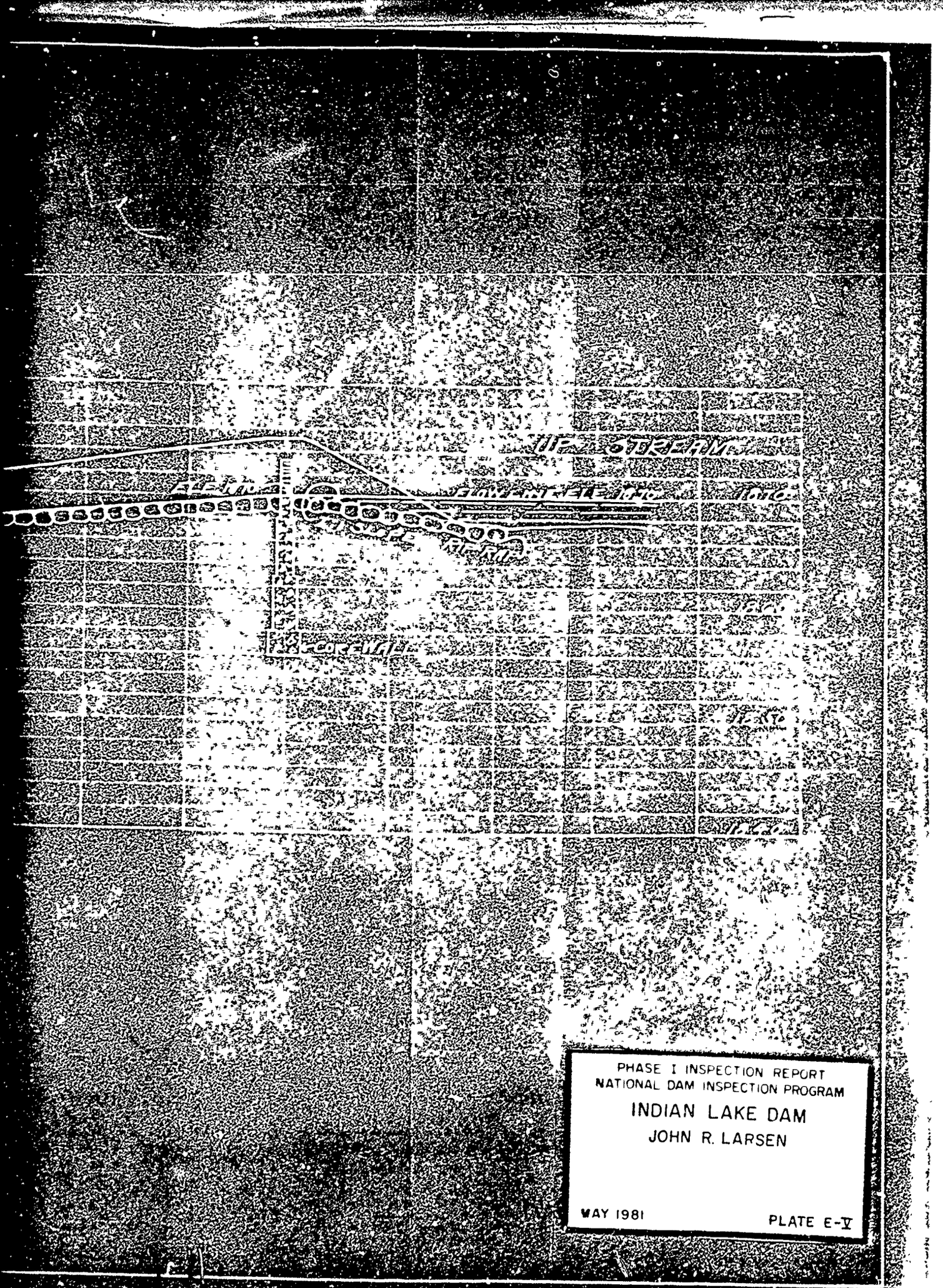
MAY 1981

PLATE E-II


DOWN STR
FLOW LINE OF CREEK


STREAM
CREEK
SEC
LYD
BUCK
Scale Hor. 1"=10'
Ver. 1"=10'


PROFILE OF C. OF SPILLWAY
SECTION OF SPILLWAY
PROPOSED
INDIAN LAKE DAM
BUCK TWP., LUZ. CO., PENN'A.
Hor. 1" = 10'
Ver. 1" = 10'
Mar. 28, 1929
Wintermute & Halsey Engrs.
Wilkes Barre, Pa.



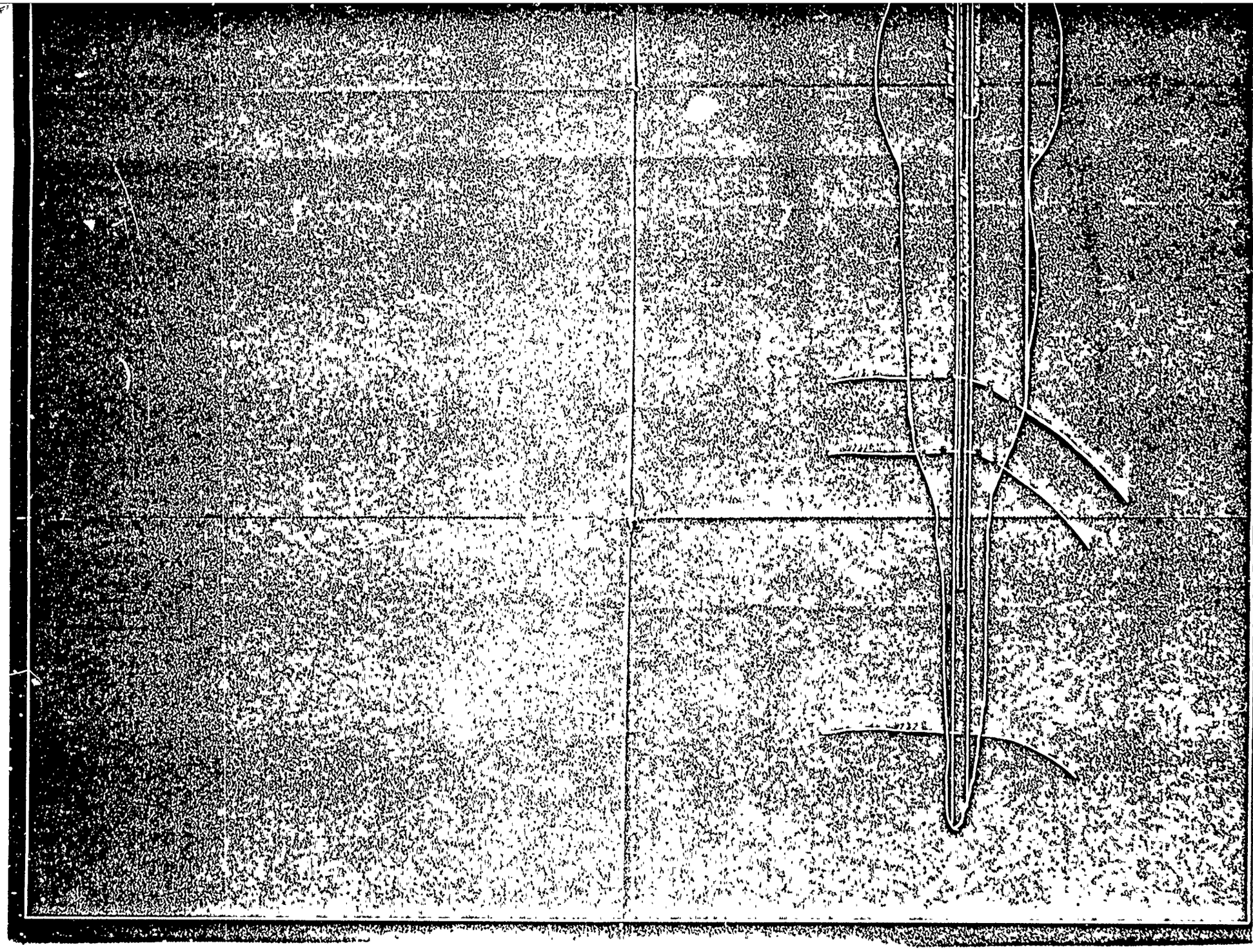
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

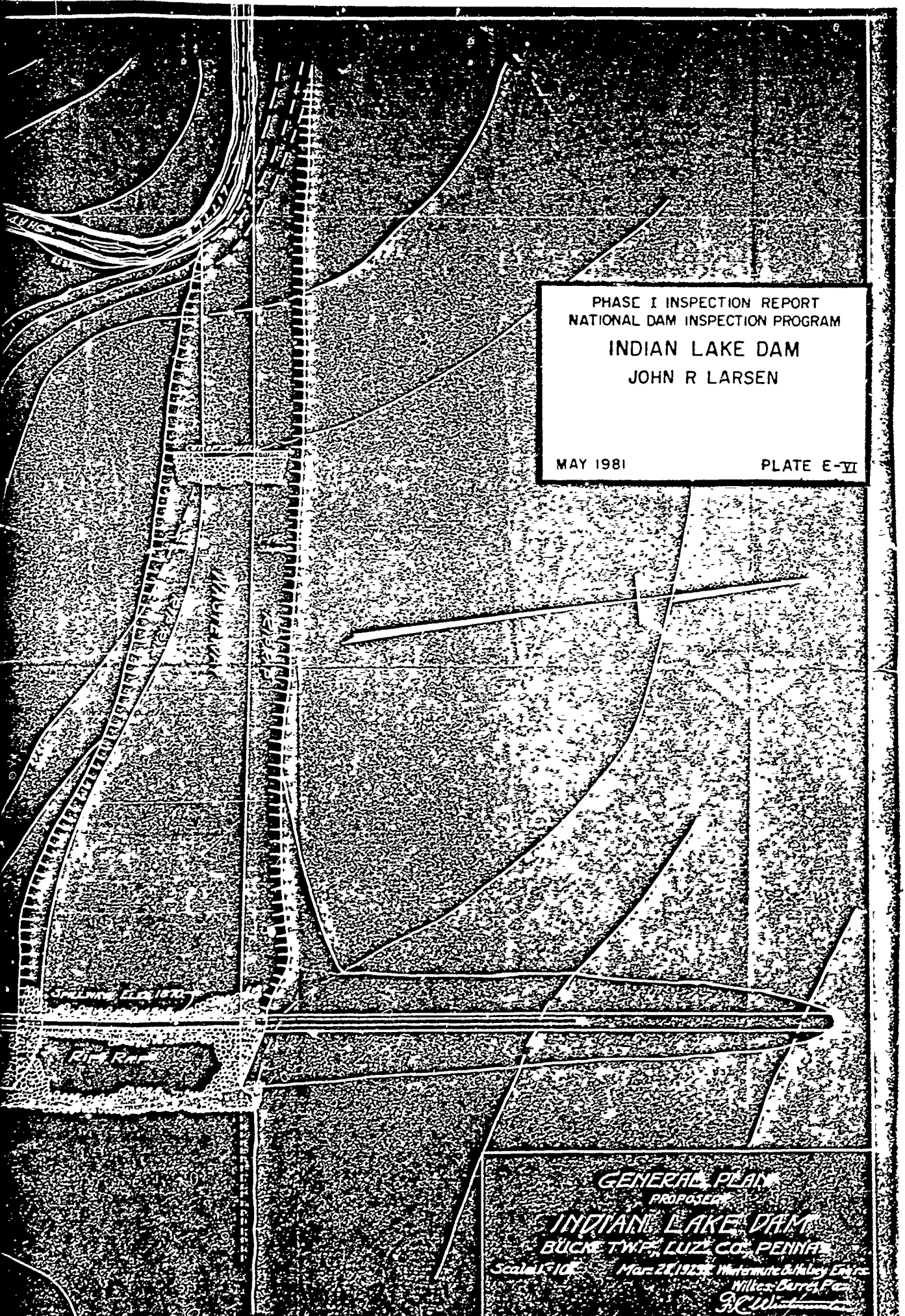
INDIAN LAKE DAM

JOHN R. LARSEN

MAY 1981

PLATE E-V




PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
INDIAN LAKE DAM
JOHN R LARSEN
MAY 1981
PLATE E-VI
GENERAL PLAN
PROPOSED
INDIAN LAKE DAM
BUCK TWP. LUZ. CO. PENNA.
Scale 1"=10'
Rip Rap

APPENDIX A

CHECKLIST - VISUAL INSPECTION

APPENDIX F

GEOLOGY

GENERAL GEOLOGY

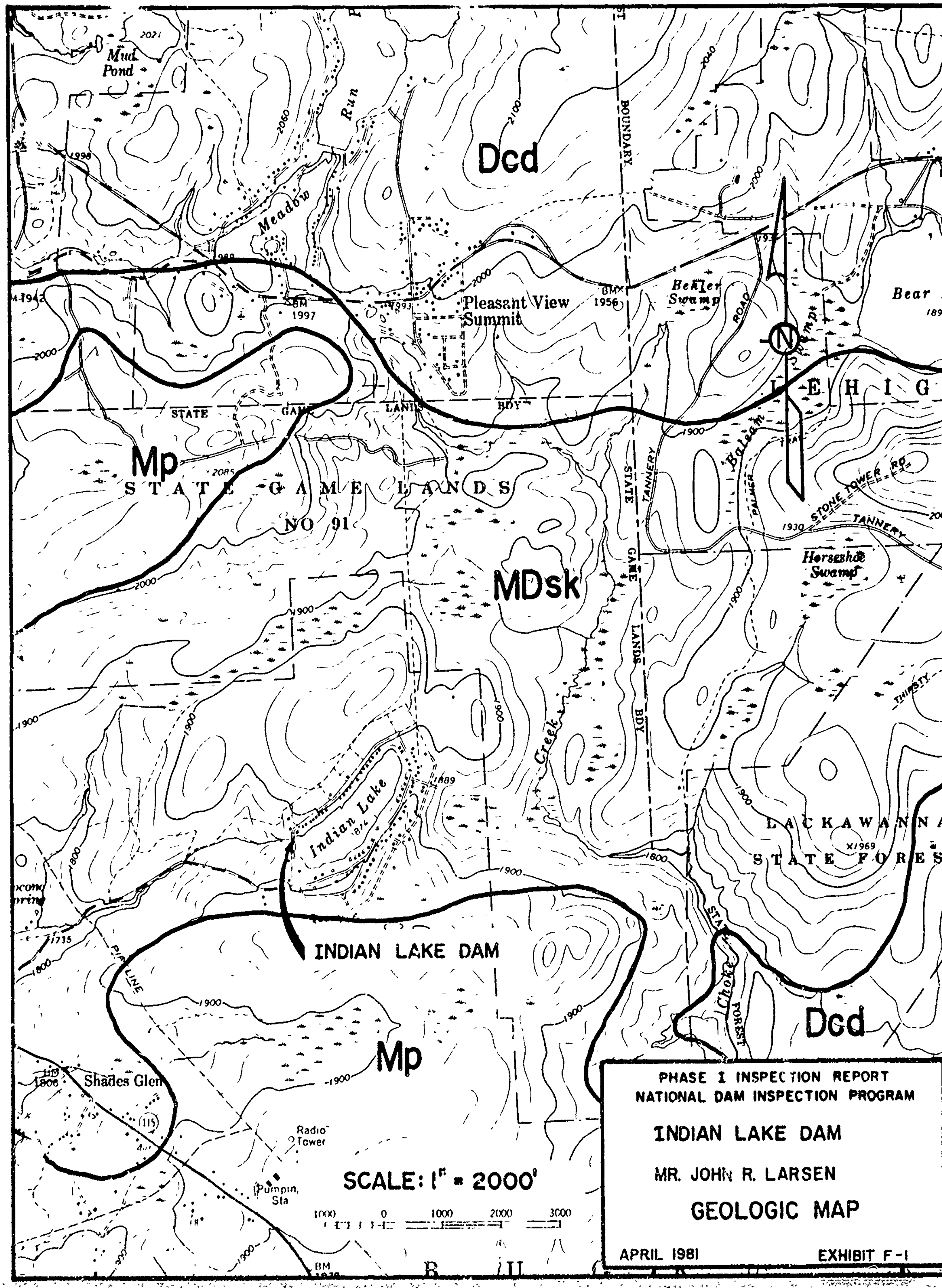
The bedrock at Indian Lake Dam is the Spechty Kopf Formation. This formation consists of fine to medium-grained, crossbedded sandstone, siltstone, and pebbly mudstone. There may be some Late Wisconsian drift, probably till, in the area. The drift is probably less than 2m thick and locally may be totally absent.

Legend
(Bedrock)

Dcd DUNCANNON MEMBER, CATSKILL FORMATION - Interbedded red and gray sandstone, red siltstone and red mudstone. The sandstone is fine and very-fine grained, silty, poorly sorted, micaceous, and locally conglomeratic.

Mp POCONO FORMATION - Light-gray to buff or light-olive-gray, medium-grained, crossbedded sandstone and minor siltstone, commonly conglomeratic at base and in middle; medial conglomerate, where present, is used to divide into Mount Carbon and Beckville Members; equivalent to Burgoon Sandstone of Allegheny Plateau.

MDsk SPECHTY KOPF FORMATION - Light- to olive-gray, fine- to medium-grained, crossbedded sandstone, siltstone, and local polymictic diamictite, pebbly mudstone, and laminate; sometimes arranged in crude fining-upward cycles; locally has grayish-red shale near top and conglomerate at base and in middle.


Mud Pond
Meadow Run
Dcd
BOUNDARY
Pleasant View Summit
Bekler Swamp
Bear
LEHIGH
STATE GAME LANDS BDY
Mp
STATE GAME LANDS
NO 91
TANNERY
STATE GAME LANDS BDY
Balsam Swamp
PALMER
STONE TOWER RD
TANNERY
Horseshoe Swamp
MDsk
THIRSTY
Creek
Indian Lake
LACKAWANNA STATE FOREST
INDIAN LAKE DAM
PIPE LINE
Choke
STATE FOREST
Dcd
Mp
Shades Glen
Radio Tower
Pumpin Sta
SCALE: 1" = 2000'
1000 0 1000 2000 3000
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

INDIAN LAKE DAM

MR. JOHN R. LARSEN

GEOLOGIC MAP

APRIL 1981

EXHIBIT F-1