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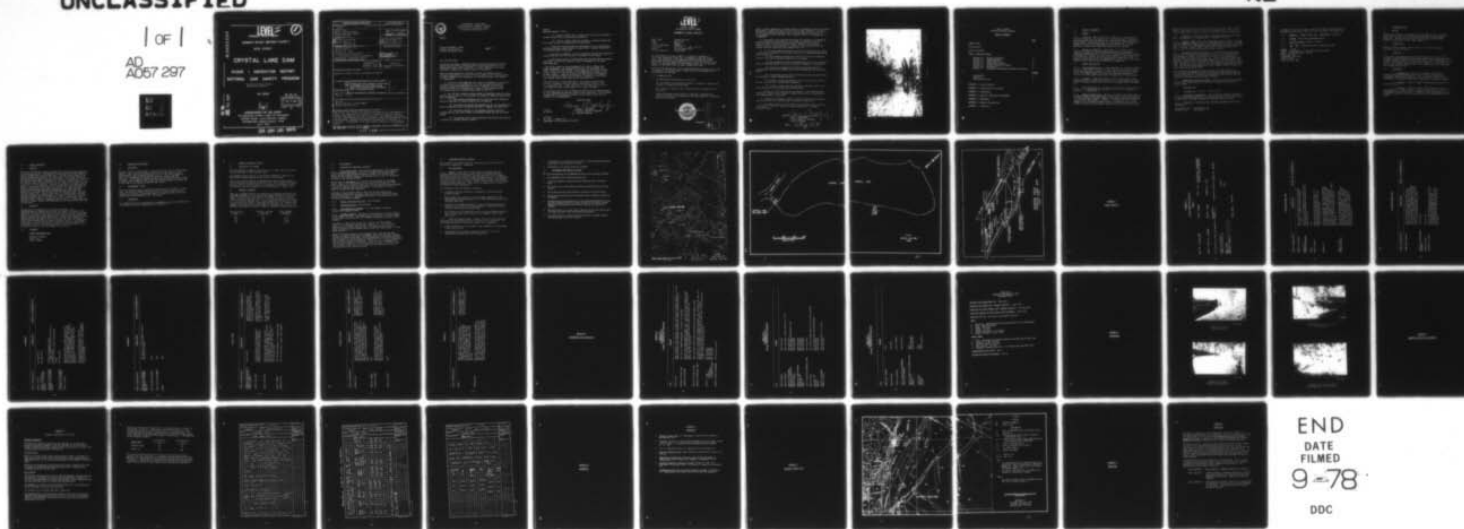
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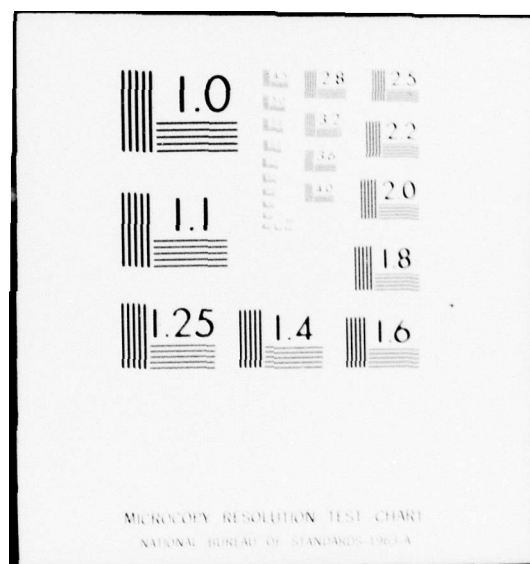
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LEVEL II



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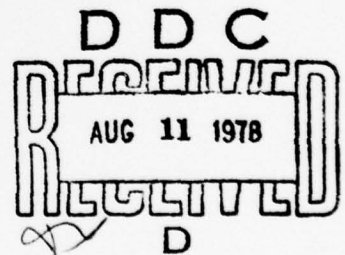
CRYSTAL LAKE DAM

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

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NJ 00217



DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

CUSTOM HOUSE - 2D & CHESTNUT STREETS

PHILADELPHIA, PENNSYLVANIA 19106

JULY 1978

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams--N.J. National Dam Safety Program Phase I The Crystal Lake Dam, N.J.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

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IN REPLY REFER TO

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

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

3 AUG 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Crystal Lake Dam in Bergen County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Crystal Lake Dam is judged to be in poor condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Engineering investigations and studies to determine the engineering properties and structural stability of the dam and spillway should be completed within nine months from the date of approval of this report. Remedial measures found necessary as a result of these investigations and studies should be initiated within calendar year 1979.

b. The following remedial actions should be initiated within six months from the date of approval of this report and should be completed within three months thereafter;

(1) The extensive undermining of the right drop apron foundation should be corrected by suitable methods such as grouting.

(2) The cracked and tilted left hardwall at the 36-inch pipe drain should be repaired before its failure obstructs or damages the outlet gate.

(3) Structural cracking in the spillway structure should be repaired and the open joint between the spillway channel and the drop apron sealed.

(4) The grouted rip-rap slope protection and channel invert should be repaired to prevent excessive erosion.

NAPEN-D

Honorable Brendan T. Byrne

(5) Install a trash rack in front of the 36-inch outlet drain to prevent the gate valve from becoming inoperative.

(6) Install a cable across the spillway to prevent boaters from being swept across the spillway onto the drop apron.

c. Within 18 months from the date of approval of the report provide additional spillway capacity and/or a saddle dike to protect properties on the southwest shore of the lake.

d. Develop and implement a periodic inspection program and maintenance manual within one year from the date of approval of this report.

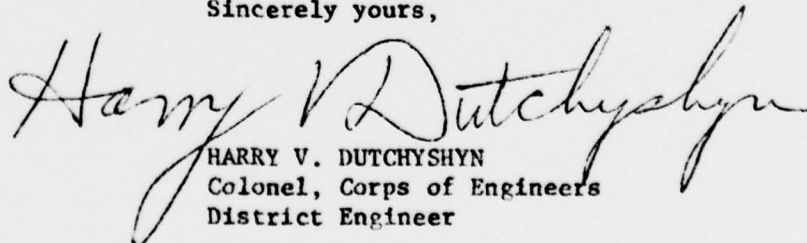
e. The hazard potential classification for this dam should be revised from "high" to "low" as a result of field investigation of the dam's downstream area.

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

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

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

Sincerely yours,


HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

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

LEVEL II

PHASE I REPORT NATIONAL DAM SAFETY PROGRAM

ASSESSMENT OF GENERAL CONDITIONS

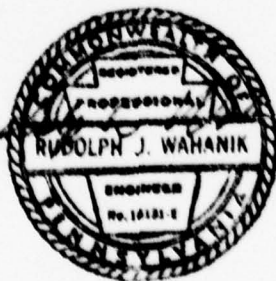
Name of Dam: Crystal Lake Dam
State: New Jersey
County: Bergen
U.S.G.S. Quad Sheet: Ramsey, N.J.
Coordinates: Lat 41°02'.0", Long. 74°14'36"
Stream: Off the Ramapo River
Date of Inspection: 30 May 1978

The dam/spillway is in poor condition, as defined in Appendix G. It can pass the 50-year flood, but is inadequate to pass the 100-year flood. The foundation of the downstream apron has been extensively undermined, which increases the possibility of structural failure of the apron. One spillway channel wall has several cracks, and the upstream headwall at the outlet drain is badly cracked and tilted.

Failure of the dam will not create a significant hazard potential as the dam is situated in a straight channel leading directly to the Ramapo River, approximately 120 feet away.

It is recommended that:

1. The undermining be halted and corrected soon.
2. The left headwall be replaced soon before it breaks off completely and obstructs or damages the outlet gate.
3. The structural cracking in the spillway structure be repaired in the near future.
4. Further investigation and studies be conducted to determine the structural stability of the dam and to delineate additional corrective measures as necessary.



(CONTINUED)

REVISION BY	
WIS	DATE: 6/1/78 ☒
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MINISTER	DATE: 6/1/78 ☐
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Based on visual inspection, available records, calculations and past operational performance, Crystal Lake Dam is judged to be in poor condition. The dam's spillway is considered inadequate as it will not pass the 100-year flood. To insure adequacy of the structure, the following actions, as a minimum, are recommended;

a. Engineering investigations and studies to determine the engineering properties and structural stability of the dam and spillway should be completed within nine months from the date of approval of this report. Remedial measures found necessary as a result of these investigations and studies should be initiated within calendar year 1979.

b. The following remedial actions should be initiated within six months from the date of approval of this report and should be completed within three months thereafter;

(1) The extensive undermining of the right drop apron foundation should be corrected by suitable methods such as grouting.

(2) The cracked and tilted left hardwall at the 36-inch pipe drain should be repaired before its failure obstructs or damages the outlet gate.

(3) Structural cracking in the spillway structure should be repaired and the open joint between the spillway channel and the drop apron sealed.

(4) The grouted rip-rap slope protection and channel invert should be repaired to prevent excessive erosion.

(5) Install a trash rack in front of the 36-inch outlet drain to prevent the gate valve from becoming inoperative.

(6) Install a cable across the spillway to prevent boaters from being swept across the spillway onto the drop apron.

c. Within 18 months from the date of approval of the report provide additional spillway capacity and/or a saddle dike to protect properties on the southwest shore of the lake.

d. Develop and implement a periodic inspection program and maintenance manual within one year from the date of approval of this report.

e. The hazard potential classification for this dam should be revised from "high" to "low" as a result of field investigation of the dam's downstream area.

APPROVED:

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

DATE:

3 Aug 1978



May 1978

GENERAL VIEW

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

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1.0 PROJECT INFORMATION

1.1 GENERAL

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the U.S. Corps of Engineers to initiate a national program of safety inspections of non-Federal dams throughout the United States. Gilbert Associates, Inc. has entered into a contract No. DACW61-78-C-0114 with the Philadelphia Office of the U.S. Corps of Engineers to inspect this dam, Gilbert Work Order 06-7249-000.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for the Safety Inspection of Dams (Reference 7) and contract requirements between Gilbert Associates, Inc. and the U.S. Army Corps of Engineers. The objectives are to expeditiously identify whether the dam poses an immediate threat to human life and property and to recommend future studies and/or any obvious remedial actions that may be indicated by this inspection.

1.2 PROJECT DESCRIPTION

1.2.1 Dam and Appurtenances: Crystal Lake Dam is a reinforced concrete structure, and consists of a 41-foot wide, 44-foot long spillway channel with 3-foot high walls, ending in a 5-foot deep drop apron with sloping walls. The maximum height of the structure above the stream bed is 9.5 feet. A 3-foot gated outlet drain is incorporated in the structure.

1.2.2 Location: Crystal Lake Dam is located 1,700 ft west of New Jersey Route 202 in the Borough of Oakland, N.J., and straddles the former channel of Alleman's Brook, 120 feet east of the Ramapo River (see Figure 1).

1.2.3 Size Classification: The dam is classified as a small structure because of its impoundment (approximately 400 acre-feet) according to Section 2.1.1 of Reference 7.

1.2.4 Hazard Classification: The dam is located at the lowest part of the Ramapo Mountain Lakes Development and has been classified in Reference 6 in the high hazard category. However, according to the hazard potential classification requirements of Section 2.1.2 of Reference 7, it can be changed to the low hazard category because, although the dam is located within an urban area with houses on both sides of the spillway and at the

same level, the floods that overtop the dam flow directly down a straight channel, approximately 120 feet long, into the Ramapo River. No loss of life or appreciable economic loss is anticipated from such an overtopping.

1.2.5 Ownership: The dam is owned by the Ramapo Mountain Lake Country Club. The address is 145 Hiawatha Blvd., Oakland, N.J. 07936.

1.2.6 Purpose of Dam: The Crystal Lake Dam was built as part of a lake front development to impound water to a maximum depth of 15 feet. The lake level is controlled by the ungated channel spillway which forms the visible part of the dam. A gated outlet drain is part of the structure, and is used to lower the lake during periods of heavy rainfall.

1.2.7 Design and Construction History: To date no design data have been located. According to information supplied by the Borough Engineer for Oakland, New Jersey, the developers of the lake front properties, National House and Farms Association, Inc., 230 W. 41st Street, New York, New York, filed plans with the Bergen County Clerk's Office on June 9, 1944 under file mark no. 3363. Approval for the project was received later that year. Neither the present owner of the lake, Ramapo Mountain Lakes Country Club, nor the New Jersey Department of Environmental Protection have any data regarding the dam-spillway.

A Mr. Wolf, Office Manager for National House and Farms Association, 577 7th Avenue, New York, New York, was contacted about Crystal Lake Dam and he stated that all files had been disposed off, but that the dam was approved by the New Jersey Water Resources Board.

1.2.8 Normal Operational Procedures: There is no operational procedure for this dam, except that the 36-inch gate is opened during periods of heavy rainfall.

1.3 PERTINENT DATA

1.3.1 Drainage Area: 4,300 ac. (6.48 sq. mi)

1.3.2 Discharge at the Dam Site: At the time of inspection the water was flowing over the spillway at a depth of one inch. It was not possible to observe any discharge from the fill beneath the concrete slab.

1.3.3 Elevation: (Feet above MSL) have been estimated from U.S.G.S. Quadrangle.

Top Spillway Wall: approximately 228
Spillway Crest: approximately 225

Streambed at Centerline of Dam (at edge of drop apron) approximately 215
Streambed at Centerline of Dam (30 ft away from edge of drop apron) 218

1.3.4 Reservoir: Length of max. pool - approximately 2,000 feet

1.3.5 Storage: (Acre feet) approximately 400

1.3.6 Reservoir Surface (Acres) - 26 Acres

1.3.7 Dam: Type - Concrete spillway, straight drop type.

Length: 44 feet

Height: Approximately 9.5-feet above original ground

Width: (At spillway elev.) 41 feet

Side Slopes: None

Impervious Core: None

Cut-Off: None

Grout Curtain: None

2.0 ENGINEERING DATA

2.1 DESIGN

Neither plan, profile, nor maximum section through the dam is available from either the owner or the New Jersey Department of Environmental Protection. Without any data, this review of the dam must be made primarily on the basis of the visual inspection.

2.2 CONSTRUCTION

Neither contract drawings, specifications, nor record drawings are available for this structure.

2.3 OPERATION

At the time of the inspection the 36-inch slide gate was closed. The Borough of Oakland Maintenance Department operates the 36-inch gate valve at times of heavy rainfall; the drain was stuck in the open position in the winter of 1978 when a piece of wood became lodged in it. The drain may also be used to lower the lake level; it is estimated that the lake level can be drawn down 5-6 feet.

2.4 EVALUATION

A. Availability: There is no available information on foundation exploration or design analysis. Material for the dam conceivably came from the lake area. For an accurate evaluation basic information on the subsurface and the foundations of the dam is required.

b. Adequacy: Cannot be judged considering unavailability of record drawings.

c. Validity: Cannot be judged considering unavailability of record drawings. A sketch of the concrete structure based on field measurements is shown in Figure 3. Appendix C shows photographic details of several portions of the structure described and evaluated within this report.

3.0 VISUAL INSPECTION

3.1 FINDINGS

The dam is a reinforced concrete spillway with a vertical drop at the end of the spillway section. The properties adjoining the spillway channel are heavily shrubbed and contain mature trees. The only slope visible is the grouted riprap approach apron. The side slopes of the outlet channel to the Ramapo River originally may have been about 1.5 horizontal to 1 vertical but are now steeper than 1 horizontal to 1 vertical, because nearly all of the grouted riprap slope protection along the right side has been lost; the left side is in fair condition. Erosion at the edge of the drop apron has gouged a 42-inch depression deep in the streambed; 30 feet downstream the debris is deposited to above the water surface. The right drop apron foundation has undergone extensive undermining and a 2-inch gap has opened up on the lower right spillway slab and drop apron wall. The left spillway channel wall, as well as the slab, is cracked in several places. Surficial cracking with efflorescence is visible in both walls. The left upstream headwalls over the 36-inch outlet pipe is cracked and tilted towards the lake. There is no physical barrier such as a cable across the spillway to prevent boaters from being swept across the spillway crest onto the drop apron.

3.2 ELEVATION

The spillway still functions in the present condition. The foundation material beneath the concrete slab cannot be evaluated. The undermined areas should be filled in soon to prevent collapse of the drop apron; all structural cracks should be repaired and the joint between the spillway channel and the drop apron sealed. Larger riprap should be placed immediately below the edge of the vertical drop apron and the grouted riprap slopes reconstructed to prevent excessive erosion. If overtopping does result, structural failure due to erosion of the soils around and downstream of the structure would be possible. The tilted headwall should be replaced before it falls and damages the slide gate.

3.3 ATTENDEES

Gilbert Associates, Inc.

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

4.0 OPERATIONAL PROCEDURES

4.1 PROCEDURES

The water level in Crystal Lake is controlled by the crest of the spillway channel. Peak flows from Alleman's Brook will raise the water level approximately 3 feet causing flooding of the low lake front properties. There is no documented operational procedure for Crystal Lake Dam available. The Borough of Oakland operates the 36-inch gate valve in time of heavy rains to keep the water level from flooding lake front properties. At the time of the inspection the gate was closed.

4.2 MAINTENANCE OF DAM

There has evidently been no maintenance performed on this dam for a long time. The spillway channel and drop apron are in poor condition (see Appendix G) and need a considerable amount of remedial work, as does the cracked and tilted headwall at the 36-inch pipe.

4.3 EVALUATION

The remedial work as outlined should be implemented as soon as possible and in accordance with the recommendations of Section 7.0.

5.0 HYDRAULIC/HYDROLOGIC DESIGN

5.1 EVALUATION OF FEATURES

The only hydraulic feature at this structure is a gate valve on a 36-inch outlet drain used to lower the lake level.

The maximum spillway capacity of the dam was estimated at about 625 cfs with 3 feet of water passing over the crest of the spillway.

From the evaluation presented in Appendix D, the Crystal Lake spillway is able to pass only the 50-year flood of 634 cfs. This dam has a low hazard potential and its spillway capacity is considered to be adequate to pass the 50-year flood, but inadequate to pass the 100-year or larger flood.

5.2 RESERVOIR DRAWDOWN

There are no volume curves for the reservoir in existence and the U.S.G.S. Quadrangle (Reference 3) does not provide enough information to calculate them. To calculate the time required to drawdown 312 acre-ft from the Crystal Lake from elevation 225 ft to 215 ft plus the inflow contribution of 13 cfs from the drainage area, it was assumed that the reservoir volume varies with the third power of the depth and that the 54-ft long, 36-inch diameter reinforced concrete drain pipe had a Manning's "n" = 0.018. The drawdown times when the reservoir volume is evacuated through the pipe are:

<u>Water Elevation</u> <u>Feet</u>	<u>Reservoir Storage</u> <u>Acre-feet</u>	<u>Total Drawdown</u> <u>Time-Hours</u>
225	312	0
221	92	28.81
217	12	42.63
213	0	46.31

6.0 DAM STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

6.1.1 Visual Observations: The extensive undermining of the downstream vertical concrete drop apron, structural cracking of the spillway channel walls, and the unknown foundation material on which the spillway rests warrant further in-depth studies and investigations in order to analyze the stability of the dam and spillway.

The dam and its impoundment are located in the floodplain of the Ramapo River. There is no rock exposure in the vicinity of the dam site. The surficial materials consist of sandy silt and silty sand with variable amounts of gravel as exposed along the river banks. Its geological location is shown on the geologic map, Appendix F.

The banks of the discharge channel, where the grouted riprap slope protection has been lost, shows the in-situ soil to be a brown silty fine sand to fine sandy silt. Presumably this material has been used to build the dam in the former streambed.

6.1.2 Design and Construction Data: Not Available

6.1.3 Operating Records: Not Available

6.1.4 Post-Construction Changes: It is not known if any post-construction changes were made.

6.1.5 Seismic Stability: The dam is located within or in the vicinity of the Ramapo Fault Zone. The Ramapo Fault is the major structural element in this region, which separates the Precambrian Highlands from the Triassic Lowlands.

According to a news report dated July 4, 1978 in the "Philadelphia Inquirer," an earthquake with measured intensity of 2.5 to 3.0 on the Richter scale occurred on June 30, 1978. The quake was the largest of nearly 20 tremors along the Ramapo Fault in the last several years. A 1976 quake measured 2.6.

Based on the above geological and earthquake data, some concerns have arisen with regard to the long term dynamic stability of the dam, although the dam is located within Zone 1 on the Algermissen's Risk Map (1969 edition). Static stability of the dam cannot be analyzed now due to lack of engineering data including foundation information. Therefore, it is recommended that the structural stability of this dam should be analyzed in the near future with a seismic coefficient of 0.05, when required subsurface information and substructure data become available.

7.0 ASSESSMENT/REMEDIAL MEASURES

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

7.1 DAM ASSESSMENT

7.1.1 Safety: On the basis of the visual field inspection, the spillway which forms the dam on Crystal Lake has undergone extensive undermining, which with time might cause the structure to fail; however, this failure should not create a significant hazard potential. No conditions have been found to indicate that an imminent hazard exists. The spillway cannot pass floods with a recurrence interval of more than 50 years without flooding adjacent properties. Most of this flooding would occur even if the dam did not exist (Appendix D).

The following conditions should be considered:

- a. Flooding of adjacent properties is expected to continue with the present spillway.
- b. The flooding will continue to erode the banks downstream of the dam/spillway causing increasing loss of slope protection (particularly along the right side).
- c. Erosion of the foundation materials of the spillway drop apron will continue even without any flooding conditions, causing the eventual failure of this section of the spillway.
- d. The cracked and tilted head wall at the 36-inch pipe might eventually drop into the lake with the possibility of damage to the 36-inch outlet drain.

7.1.2 Need for Further Studies: Design, construction and subsurface data needed for assessing the safety of the dam are not available. The following investigation, studies and analysis are recommended:

- a. A detailed survey as to the extent of the undermined area and damage to the concrete walls.
- b. A determination of essential dimensions and qualities of the substructure through subsurface investigations.

- c. A determination of foundation conditions of the dam through subsurface investigations and laboratory testing.
- d. Performance of structural stability analyses.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The following measures are recommended because of the aforesaid concerns:

- a. The undermined area should be grouted soon.
- b. A key wall should be constructed soon along the edge of the drop apron.
- c. The cracked and tilted headwall should be reconstructed in the near future.
- d. The cracked spillway works should be repaired in the near future.
- e. The grouted slope protection and channel invert should be repaired in the future.
- f. Classification and determination of the engineering properties of the spillway foundation materials should be made in the future through subsurface investigations and laboratory testing for stability analysis.
- g. The installation of a trash rack in front of the 36-inch outlet drain to prevent the gate valve from becoming inoperative.
- h. The installation of a cable across the spillway to prevent boaters from being swept across the spillway.

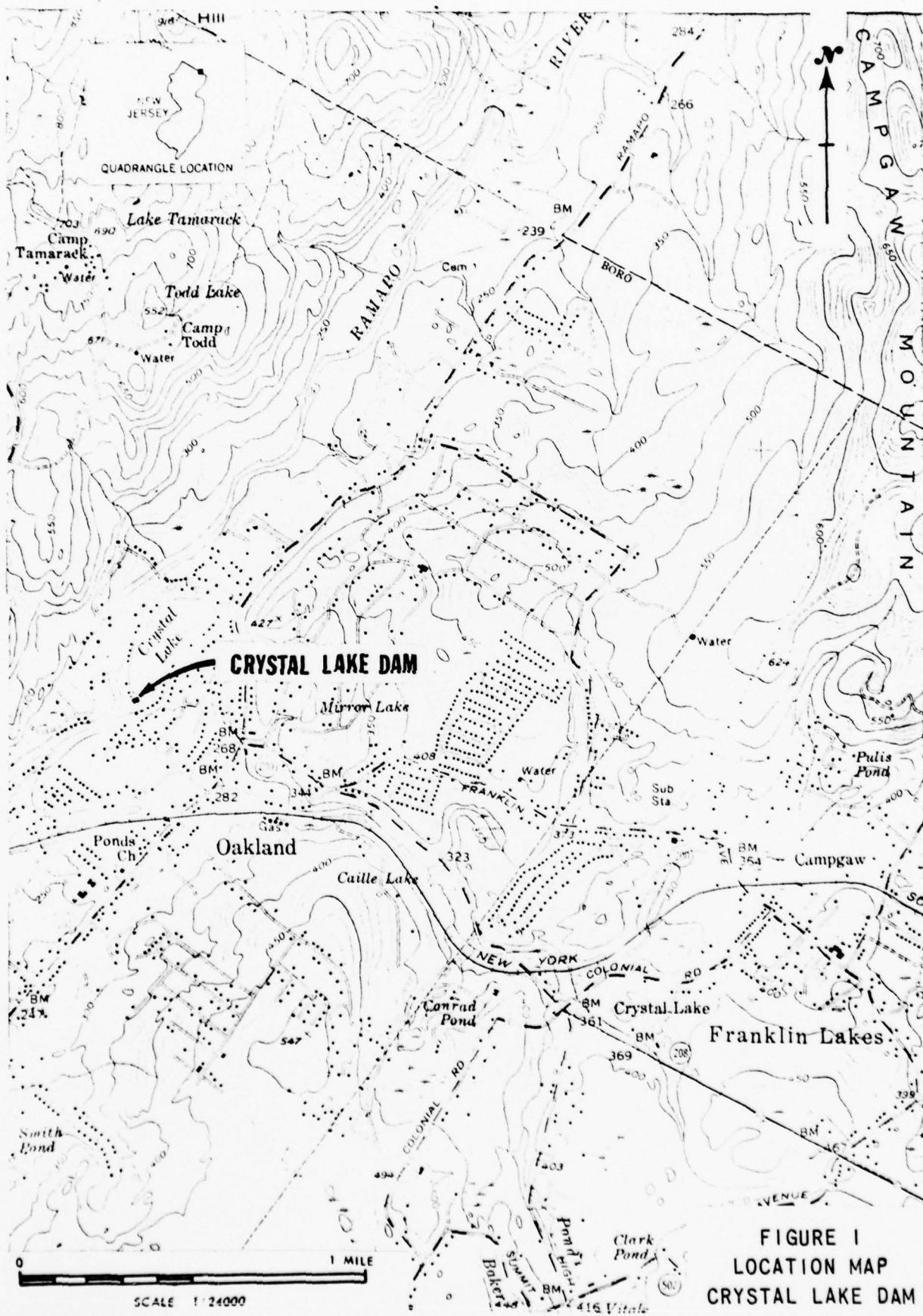
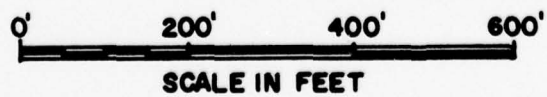
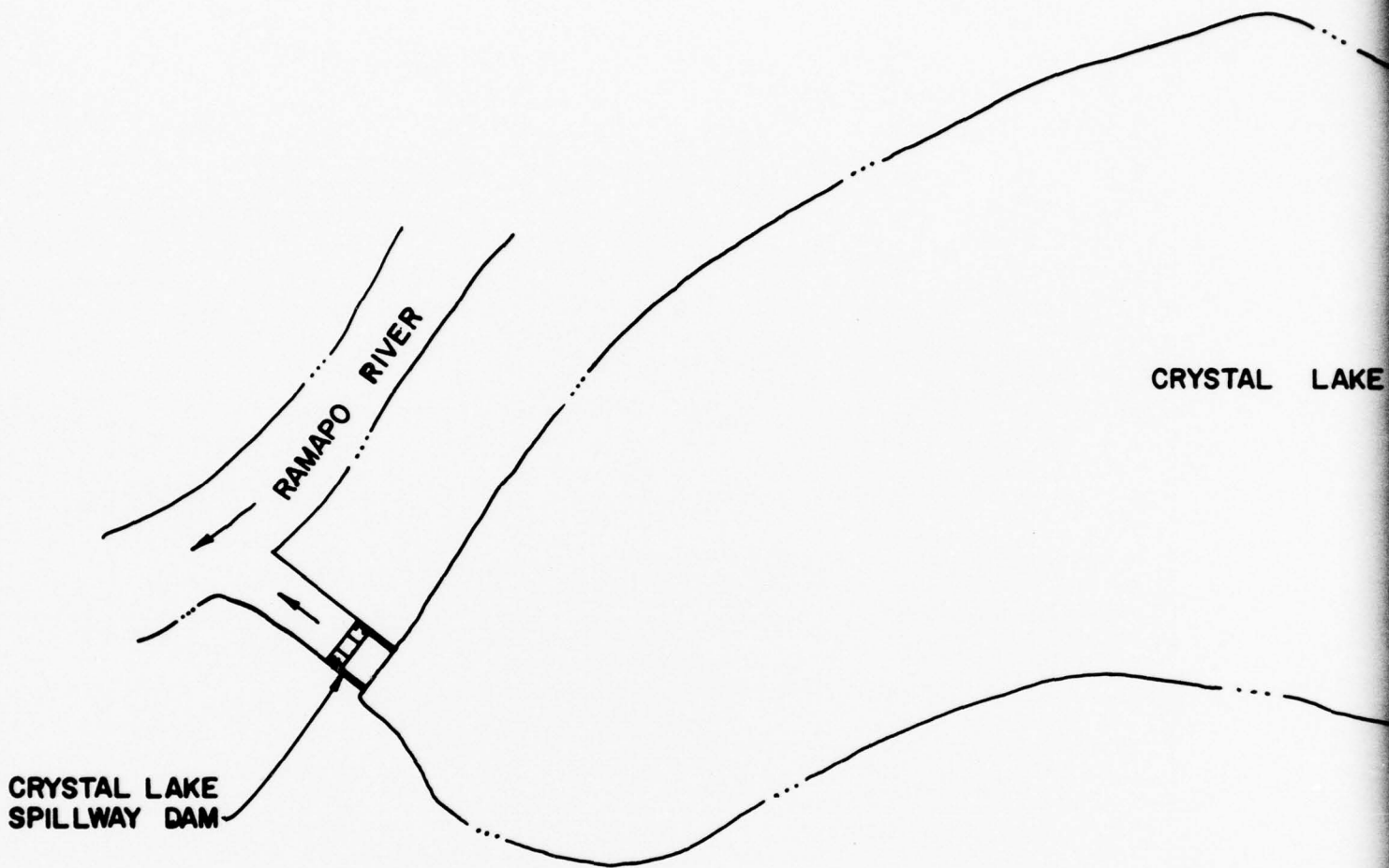


FIGURE 1
LOCATION MAP
CRYSTAL LAKE DAM



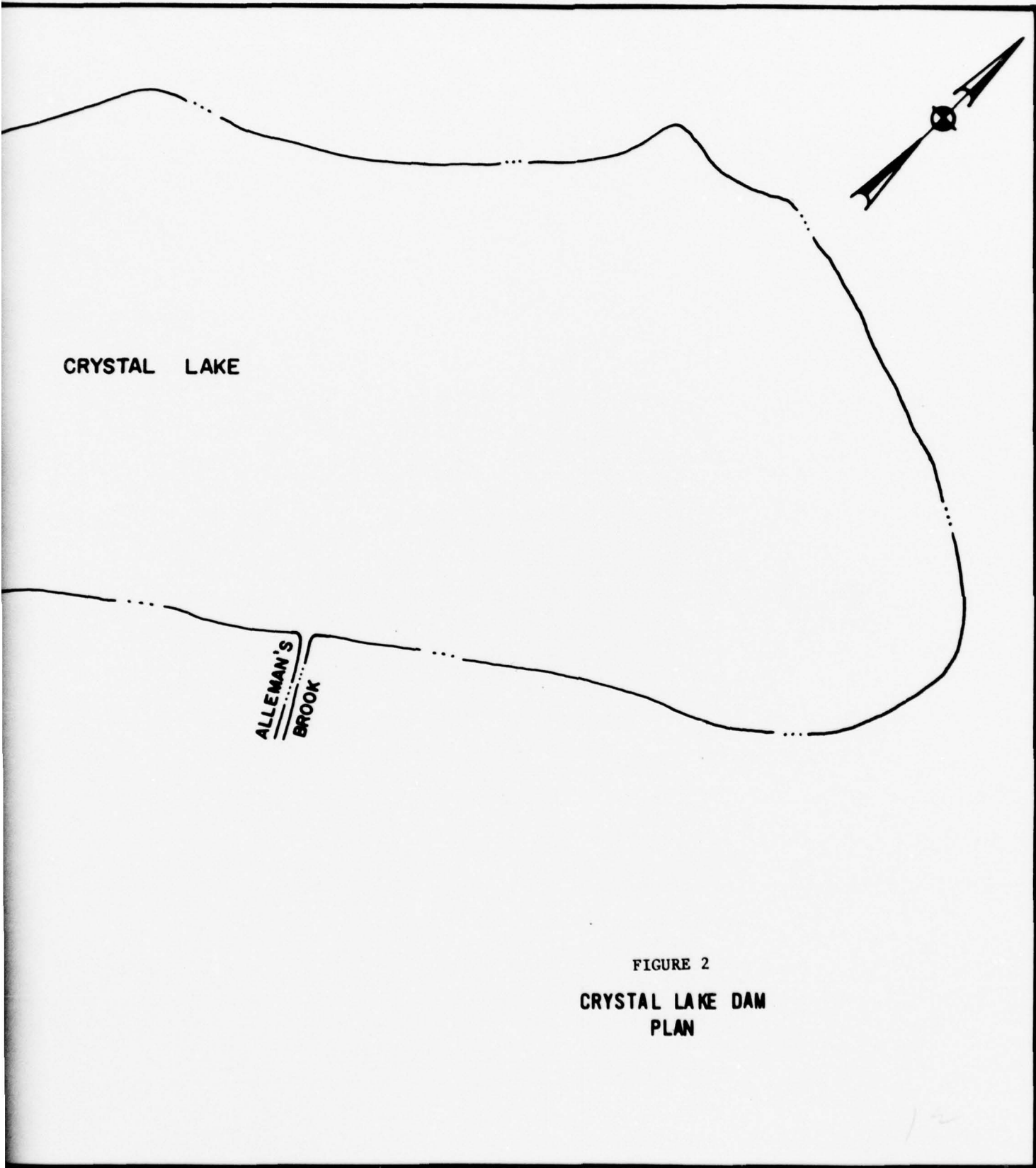
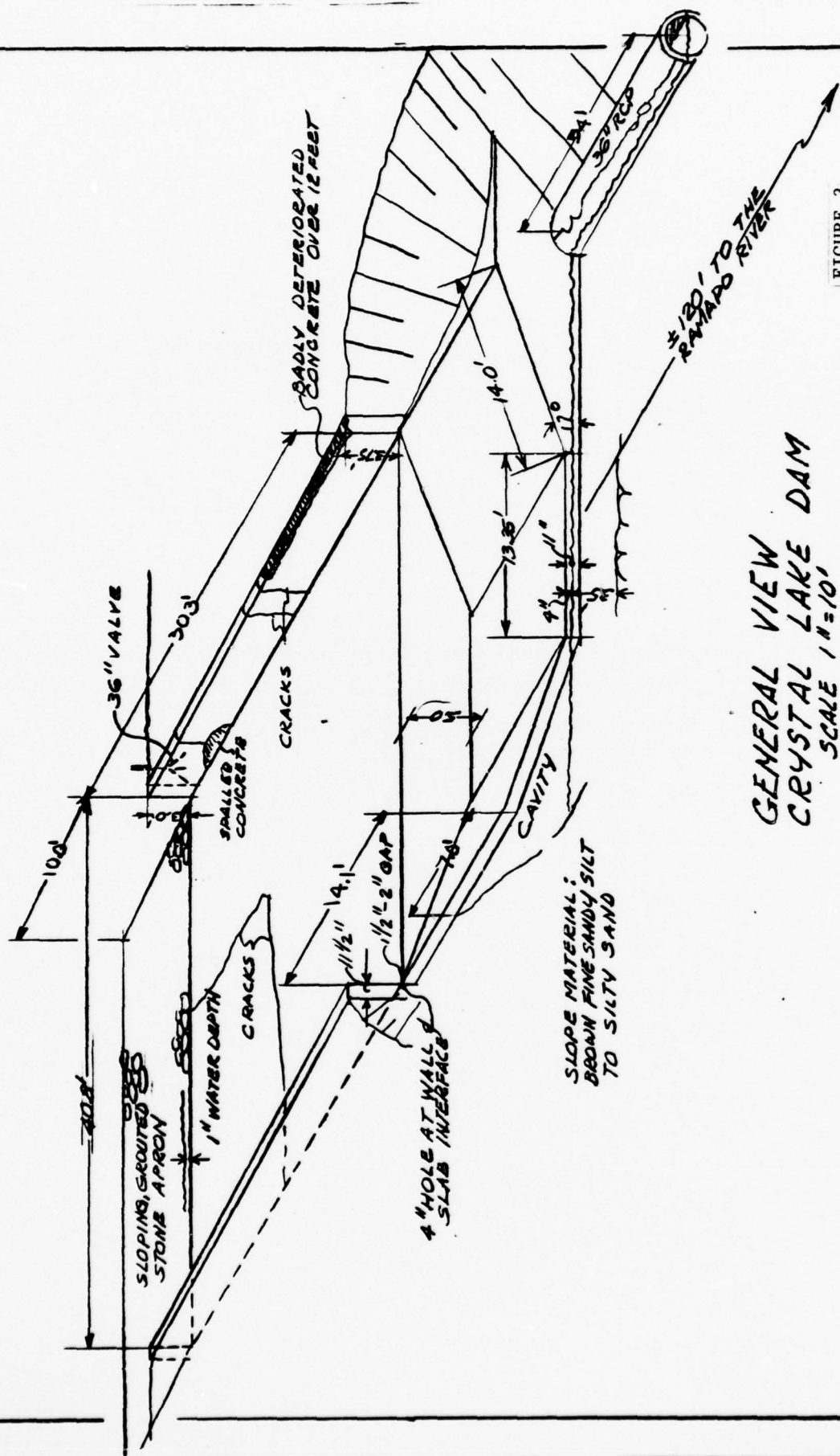


FIGURE 2
CRYSTAL LAKE DAM
PLAN



GENERAL VIEW
CRYSTAL LAKE DAM
SCALE 1"=10'

FIGURE 3

APPENDIX A
VISUAL CHECKLIST

APPENDIX A

Visual Inspection Checklist

Phase 1

Name Dam: Crystal Lake County: Bergen State: N.J. Coordinators: Philadelphia District Corps of Engineers

Date(s) Inspection: 5/30/78 Weather: Clear Temperature: 68°F

Pool Elevation at Time of Inspection: approximately 625 MSL Tailwater at Time of Inspection: 620 MSL

Inspection Personnel:
Gilbert Associates, Inc.

Fine T. Hsu
Rudi Visser
Rudolph J. Wahanik

Others:
None

Fine T. Hsu - Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Due to the flow of water over the spillway no seepage or leakage could be detected.	
STRUCTURE TO ABUTMENT/EMBANKMENT	The walls of the spillway are in contact with soil backfill; the abutments appeared to be in normal condition.	
DRAINS	None.	
WATER PASSAGES	Some surface cracks had developed on the concrete surface of the weir. Some longitudinal and deep cracks were found at the retaining wall face.	
FOUNDATION	A portion of spillway drop apron foundation was badly undermined. This caused a 2" gap to open up at the drop apron-spillway slab interface. No bedrock is exposed in the vicinity of the dam. Surficial material consists of sandy silt, silty sand with variable amounts of gravel as exposed along the river banks.	
SURFACE CRACKS CONCRETE SURFACES	The slab is cracked roughly down middle starting at the intake edge, ±15 feet long, then turning to the right wall. The left wall is badly deteriorated over a 12-foot length. Some spalling of this wall has occurred near slab (up to 1 inch deep). Both walls have extensive cracking with efflorescence.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
STRUCTURAL CRACKING	The left wing wall, at the intake side, has a 45° crack running from top of wall to top of 36-inch outlet pipe. The top of this concrete wall is badly deteriorated and the wall is tilted towards lake. The left wall has two vertical cracks, 3 feet apart, 12 feet from downstream edge of wall.	
VERTICAL AND HORIZONTAL ALIGNMENT	Fairly good.	
MONOLITH JOINTS	None visible.	
CONSTRUCTION JOINTS	At the right downstream corner of the wall and the slab a 4-inch gap was found. A 2-inch gap exists between the slab and downstream drop apron; a 4-inch void was found below the right downstream wall and slab.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Not Applicable	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Not Applicable	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Downstream embankment slopes: a. Right - Badly eroded due to failure of grouted riprap. b. Left - In fair shape, some missing riprap.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Not Applicable	
RIPRAP FAILURES	Approximately 800 to 1,000 square feet of grouted stone riprap has disappeared from the right embankment, and about 400 square feet from the left embankment. If the pool bottom were originally ripped, then approximately 2,000 square feet may have been lost. The surrounding high ground forms the embankments for the spillway outlet channel. No other embankment exists. Both embankments are heavily wooded.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	The junction of the embankment and the spillway is eroding.	
ANY NOTICEABLE SEEPAGE	None.	
STAFF GAGE AND RECORDER	None	
DRAINS	None	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	None visible	Examination for cracking and spalling should be done when water is not passing the spillway or outlet works.
INTAKE STRUCTURE	A small portion of the hand-operated stem was above the pool level; the remainder of the gate was submerged.	Examination for damage, siltation and debris at the structure should be done when water in the pool is low.
OUTLET STRUCTURE	The 36-inch concrete outlet conduit underlying the left abutment was extended 16 feet beyond the spillway edge. The connections of the conduit pipes were very poor and in many cases they were left open and loose.	As scouring was extensive and evident, the condition of the conduit support was in doubt.
OUTLET CHANNEL	See "Discharge Channel" on subsequent page.	
EMERGENCY GATE	36-inch slide gate on upper right headwall.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Several surface cracks had developed on the concrete surface of the spillway. At least three longitudinal and extensive cracks were visible on the left retaining wall face. The right downstream apron was severely undermined. Portions of the stilling basin concrete structure may have been washed away.	The concrete spillway should be examined for seepage, undermining, and cracks when there is no water passing over the crest of the weir.
APPROACH CHANNEL	None.	
DISCHARGE CHANNEL	Downcutting and lateral erosion of the discharge channel has been in progress; part of the channel lining is lost. The discharge channel extends for 120 feet before joining the Ramapo River.	Continuous downcutting or undermining immediately below the apron will eventually damage the substructure and lead to a total collapse of the weir.
BRIDGE AND PIERS	None.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The slopes around the lake area vary from gentle natural slopes to vertical bulkheads. There is a low area located in the southwest shore of the lake and on the bank of the Ramapo River, where flooding occurred several times in the past due to inadequate capacity of the spillway.	Unless an adequate spillway is constructed and/or a levee is built, property in the low area will not be protected.
SEDIMENTATION	The lake receives its water from Alleman's Brook which empties into the eastside of the lake. As the brook traverses wooded areas with steep slopes and little soil cover, and the properties around the lake are vegetated, little sedimentation is expected to take place.	

APPENDIX B

ENGINEERING DATA CHECKLISTS

APPENDIX B

CHECK LIST

ENGINEERING DATA DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None available of the spillway. Neither the Borough of Oakland Engineer, nor the Ramapo Mountain Lakes Country Club which owns Crystal Lake have any plans.
REGIONAL VICINITY MAP	The U.S.G.S. Ramsey Quadrangle, 7 1/2 min. is available.
CONSTRUCTION HISTORY	The plan for Ramapo Mountain Lakes, Sec. I was filed with the Bergen County Clerk's Office on 6-9-44, mark No. 3363. The tract of land, including the lake, was owned by the National House & Farms Association, Inc. 230 W. 41st St., N.Y., N.Y.
TYPICAL SECTIONS OF DAM	None available; sketch plan reconstructed from measurements taken.
HYDROLOGIC/HYDRAULIC DATA	According to the Borough of Oakland's Engineer, Mr. Yuracheck, the lake area measures 26.6 acres with a drainage area of 4,300 AC.; a flow on Alleman's Brook of 2440 cfs will raise the lake level 3 feet, encroaching on some of the lake front properties.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	Not Available Not Available Not Available Not Available
RAINFALL/RESERVOIR RECORDS	No reservoir records.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DESIGN REPORTS	None Available
GEOLOGY REPORTS	None available, except from U.S.G.S. data.
DESIGN COMPUTATIONS	None Available
HYDROLOGY & HYDRAULICS	See Hydrology and Hydraulic data.
DAM STABILITY	None Available
SEEPAGE STUDIES	None Available
MATERIALS INVESTIGATIONS	None Available
BORING RECORDS	None Available
LABORATORY	None Available
FIELD	None Available
POST-CONSTRUCTION SURVEYS OF DAM	None Available
BORROW SOURCES	Not needed, minimal amount of fill under spillway.
SPILLWAY PLAN	Reconstructed from Field Measurements
SECTIONS	None Available
DETAILS	None Available
OPERATING EQUIPMENT	A 36-inch slab gate is in place.
PLANS & DETAILS	None Available

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	Not Known
HIGH POOL RECORDS	None Available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None Available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None. None Available None Available
MAINTENANCE OPERATION RECORDS	None. None. None Available

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2600 Acres

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 225.00 feet

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): Not Available

ELEVATION MAXIMUM SPILLWAY DESIGN FLOOD SURCHARGE: 228.00 feet

ELEVATION TOP DAM: Not known, approximately 228 feet

CREST:

- a. Elevation: approximately 225 (Estimated from U.S.G.S. Quadrangle)
- b. Type: Ungated spillway
- c. Width: 40.8 feet
- d. Length: 44 feet
- e. Location Spillover: at entrance
- f. Number and Type of Gates: None

OUTLET WORKS:

- a. Type: Slide gate on 36-inch reinforced concrete pipe 54 feet long
- b. Location: Along left wall
- c. Entrance inverts: 213 feet
- d. Exit inverts: 213 feet
- e. Emergency drawdown facilities: the 36-inch pipe described above

HYDROMETEOROLOGICAL GAGES: None

MAXIMUM NON-DAMAGING DISCHARGE: 625 cfs

APPENDIX C

PHOTOGRAPHS



May 1978

UPSTREAM LEFT ABUTMENT
HEAD WALL DAMAGE



May 1978

UPSTREAM LEFT ABUTMENT
NOTICE TILTED HEAD WALL



May 1978

DOWNSTREAM DROP SPILLWAY APRON
RIGHT ABUTMENT



May 1978

DOWNSTREAM DROP SPILLWAY APRON
LEFT ABUTMENT AND 36 INCH DRAIN PIPE

APPENDIX D

RESERVOIR HYDROLOGY AND DRAWDOWN

APPENDIX D

Reservoir Hydrology and Drawdown

RESERVOIR HYDROLOGY

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

Available Plans

There are no plans of the Crystal Lake Spillway and Dam, or hydraulic or hydrologic data available either from the present owner, Ramapo Mountain Lakes County Club, or the New Jersey Department of Environmental Protection (DEP).

Therefore, the dimensions obtained during the visual inspection were used to determine the appropriate discharge coefficients in computing the discharge capacity of the spillway.

Major Floods

Information concerning major floods or peak discharges at the dam site were not available. Property owners along the West Lake Shore, immediately north of the dam/spillway, do suffer some flooding of their properties when the lake level has risen to 3.0 above the spillway crest.

The abutments on either side of the spillway walls are in good shape and display no signs of erosion along the walls.

The drainage area of Crystal Lake Dam is 4300 acres.

The maximum capacity of the existing spillway is 630 cfs and the lake is separated from the Ramapo River by a narrow strip of land, approximately 1000 ft long by 200 feet wide forming a natural earth dike at elevation approximately 228 feet.

Because the dam has been classified as a low hazard potential under the requirements of Table 3 of Reference 7, the spillway capacity will be reviewed against floods with a return period of 50 and 100 years. The floods were evaluated using a Regional Study for the Upper Delaware River Basin (Reference 4) and the Special Report 38 (Reference 5). The magnitude of the resultant floods is:

<u>Method Used</u>	<u>50 Year Flood cfs</u>	<u>100 Year Flood cfs</u>
Regional Study	634	758
Report 38	468	580

For evaluation purposes, the 634 cfs flood with a 50-year recurrence interval that was calculated in accordance with the method described in Reference 4 is considered to be an appropriate design flood for this type of structure. Notice that the 50-year flood resulting from this method is larger than the 100-year flood evaluated with the method of Reference 5.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT	C. O. E.		FILING CODE
	PROJECT	Dam Safety		W.O. 7249 PAGE 1 OF 3
SYSTEM	Crystal Lake			ORIGINATOR WARANIK
CALCULATION FOR	Lake Drawdown			DATE July 27/78
to calculate the time required to drawdown 312 Acres-ft from elevation 225 ft to elevation 213 ft it was assumed that the reservoir volume varies with the third power of the depth and that the 54 foot long 36 inch diameter pipe had a Manning's $n = 0.018$, the flow that can be pushed through the pipe was calculated with the equation $Q_{\text{eff}} = a \sqrt{\frac{2gh}{1 + K_m + K_p L}}$ where: $a = \text{pipe area} = 7.07 \text{ Sq. Ft.}$ $K_m = \text{minor losses summation} = 2.00$ $K_p = 0.0139 *$ $L = 54 \text{ Ft of length}$ $Q = 7.07 \sqrt{\frac{2 \times 32.2 \times h}{1 + 2 + (0.0139 \times 54)}} = 7.07 \sqrt{\frac{64.4}{3.751}} h$ $Q = 29.299 \sqrt{h}$ $h = \text{head differential in ft}$ * Exhibit (3-4) Soil Conservation Service - Engineering Field Manual - Chapter 3 Hydraulics - US Govt 1959				REVIEWER
				DATE
				RESULTS

GAI 350 REV 10-72

Drawdown without inflow considerations.

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.		CLIENT <u>C. of E.</u>		FILING CODE	
PROJECT <u>Dam Safety</u>		W.O. <u>06-7249</u>		PAGE 2 OF 3	
SYSTEM <u>Crystal Lake</u>		ORIGINATOR <u>W. L. ...</u>		DATE <u>July 20/78</u>	
CALCULATION FOR <u>Draw down.</u>		REVIEWER		DATE	
RESULTS					

Water level ft.	Depth H ft.	Reservoir Area-ft	Volume ft ³	Volume Difference ft ³	Water level center of Gravity of layer of water ft.	Available Head h in ft	Partial Time Q hours
225	12	312*	13590720	9563840	223	10	92.65
221	8	92	402680	3523520	219	6	71.77
217	4	12	503360	503360	215	2	41.44
213	0	0	0				337

* 312 Area-ft = 26 Acres x 12 ft depth.; Volume ft³ = (19.88686 H)³

** Q₁₃ = 29.289 ft³/hr

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.		CLIENT COE	FILING CODE																															
PROJECT Dam Safety		NO. 7247	PAGE 3 OF 3																															
SYSTEM Crystal Lake		ORIGINATOR Whelan																																
CALCULATION FOR Drawdown		DATE July 20/78																																
		REVIEWER																																
		DATE																																
		RESULTS																																
Since there is an inflow of 2 cfs/sq. mi., the 6.48 sq. mi. will contribute $2 \times 6.48 = 12.96 \text{ cfs} \approx 13 \text{ cfs}$ and the drawdown times will be increased by $13 \times 3600 / Q = \frac{46800 \text{ cu. ft.}}{Q \text{ cfs}}$ <table border="1"> <thead> <tr> <th>Available h ft.</th> <th>Q cfs.</th> <th>$\frac{46800}{Q}$ Hours</th> <th>Hours</th> <th>Accum. Total Hours used in Rptmt</th> <th>Water level</th> </tr> </thead> <tbody> <tr> <td>10</td> <td>92.65</td> <td>0.14</td> <td>28.81</td> <td>0</td> <td>225</td> </tr> <tr> <td>6</td> <td>71.77</td> <td>0.18</td> <td>13.82</td> <td>28.81</td> <td>221</td> </tr> <tr> <td>2</td> <td>41.44</td> <td>0.31</td> <td>3.68</td> <td>42.63</td> <td>217</td> </tr> <tr> <td></td> <td></td> <td></td> <td></td> <td>46.31</td> <td>213</td> </tr> </tbody> </table>					Available h ft.	Q cfs.	$\frac{46800}{Q}$ Hours	Hours	Accum. Total Hours used in Rptmt	Water level	10	92.65	0.14	28.81	0	225	6	71.77	0.18	13.82	28.81	221	2	41.44	0.31	3.68	42.63	217					46.31	213
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2	41.44	0.31	3.68	42.63	217																													
				46.31	213																													

GAI 150 REV. 10-72

APPENDIX E

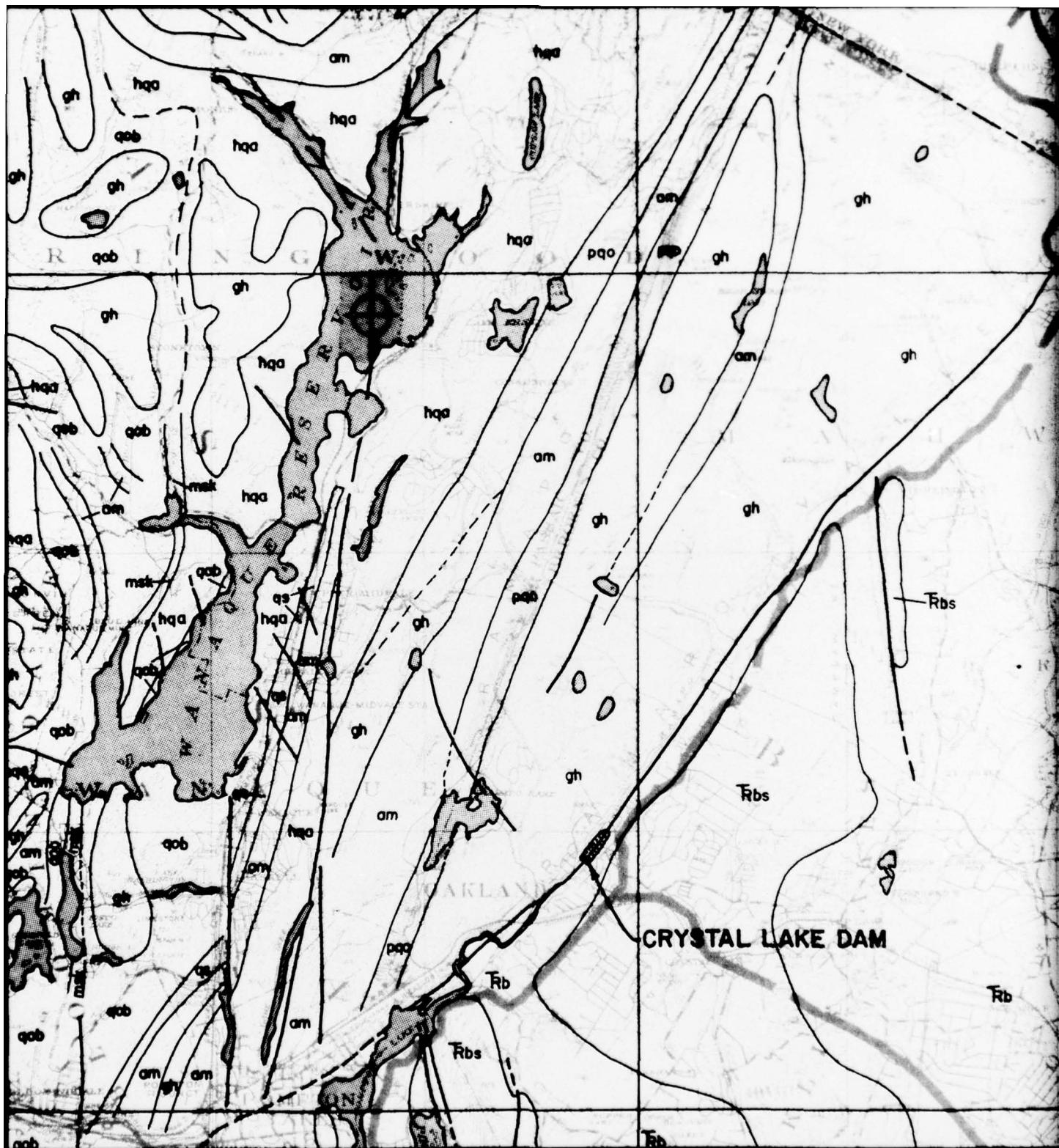
REFERENCES

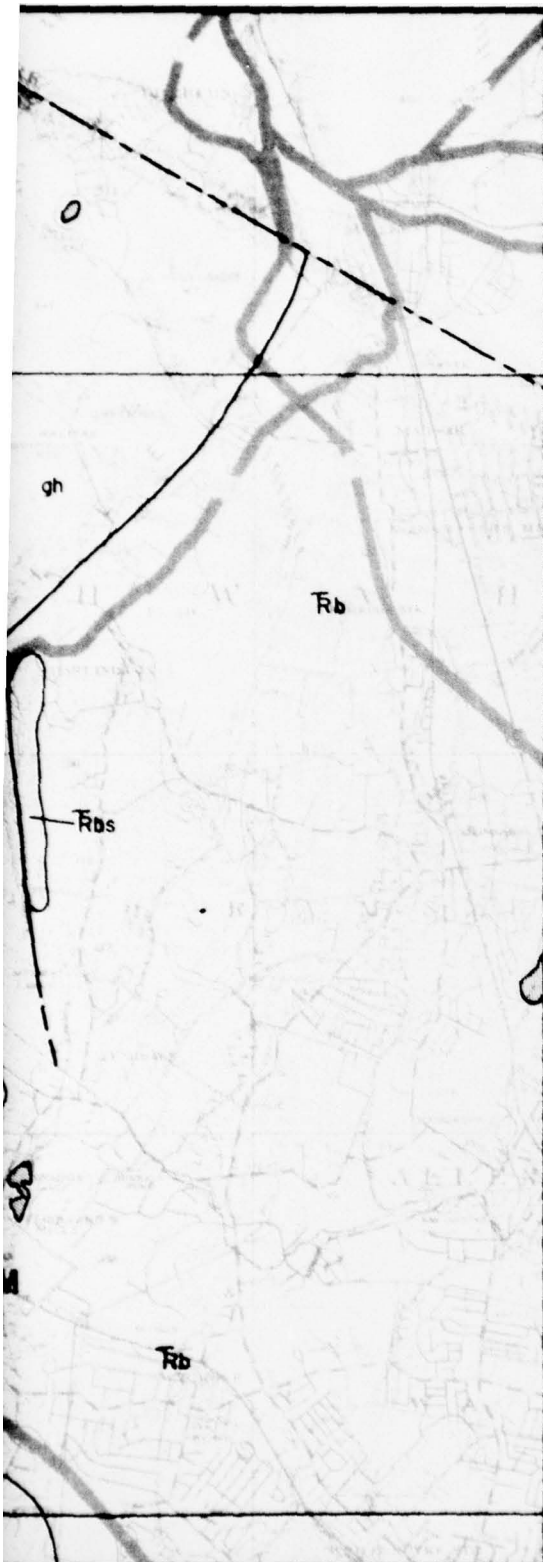
APPENDIX E

REFERENCES

1. Design of Small Dams, U.S. Department of the Interior, Bureau of Reclamation, 1973.
2. "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian," U.S. Weather Bureau Hydrometeorological Report No. 33, 1956.
3. U.S.G.S. Quadrangle Sheets for Ramsey New Jersey and New York.
4. Regional Frequency Study, Upper Delaware and Hudson River Basins, N.Y. District.
5. Magnitude and Frequency of Floods in New Jersey with Effect of Urbanization, Special Report 38, Stephen J. Stankowski U.S.G.S.
6. National Program of Inspection of Dams, Volume III, May 1975 - Department of the Army, Office of the Chief of Engineers, Washington, D.C.
7. Recommended Guidelines for Safety Inspection of Dams, (Washington, D.C., Department of the Army, Office of the Chief of Engineers).

APPENDIX F
REGIONAL GEOLOGIC MAP





LEGEND

TRIASSIC

Tb BRUNSWICK FORMATION
Tbs BASALT FLOWS

PRECAMBRIAN

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

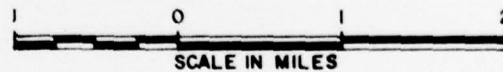
— CONTACT LINE
— FAULT LINE

NOTES

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

SOURCE

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



APPENDIX F REGIONAL GEOLOGIC MAP SHOWING DAM LOCATION

APPENDIX G

CONDITIONS

APPENDIX G

CONDITIONS

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

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

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

"good condition" - minor studies or remedial measures are required.

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

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