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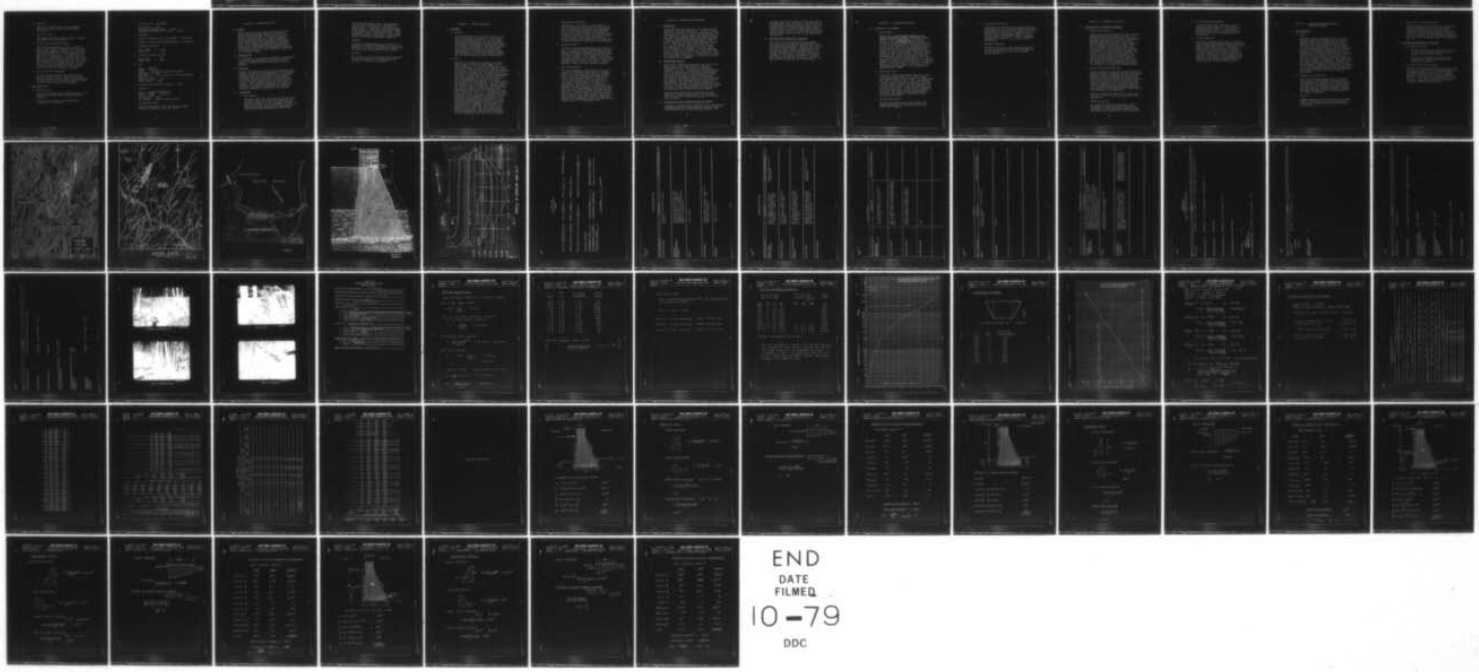

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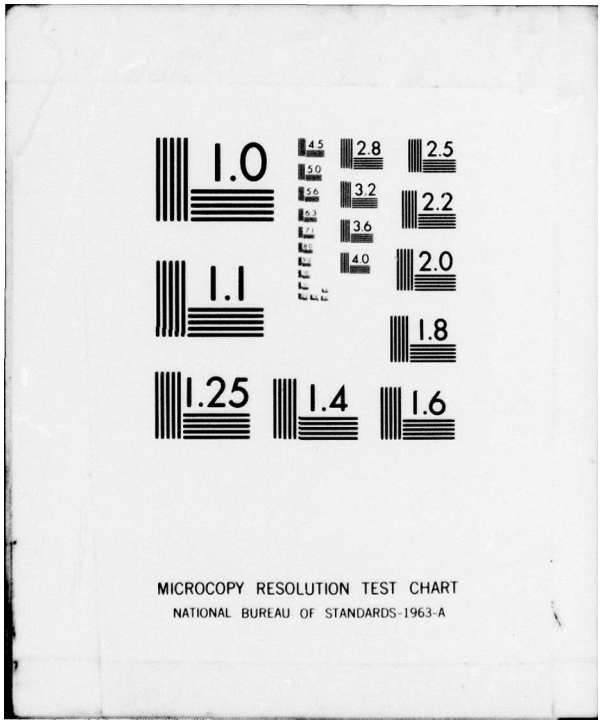
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PASSAIC RIVER BASIN
PACACK BROOK, SUSSEX COUNTY
NEW JERSEY

LEVEL II

CANISTEAR RESERVOIR DAM

NO 2

NJ 00561

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

ORIGINAL CONTAINS COLOR PLATES: ALL DDC REPRODUCTIONS WILL BE IN BLACK AND WHITE.

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

June, 1979

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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Approved for public release; distribution unlimited.

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(6) National Dam Safety Program. Canistear Reservoir Dam Number 2 (NJ-00561), Passaic River Basin, Pacack Brook, Sussex County, New Jersey. Phase 1 Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams
Embankments
Structural Analysis
Safety
Visual Inspection
National Dam Inspection Act Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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

IN REPLY REFER TO
NAPEN-D

17 SEP 1979

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

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Canistear Reservoir Dam No. 2 in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Canistear Reservoir Dam No. 2, initially listed as a high hazard potential structure but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended to be undertaken within one year from the date of approval of this report:

a. Repoint and reset all exposed stone masonry on the downstream wall and around the corners of the abutment piers.

b. Reposition the granite capstones where required and install additional rock anchors if necessary.

c. Personnel employed at the reservoir should receive additional training in the safety inspection of dams and conduct the regularly scheduled inspections of the dam.

NAPEN-D
Honorable Brendan T. Byrne

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

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

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

Sincerely,

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

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

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

CANISTEAR RESERVOIR DAM NO. 2 (NJ00561)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 10 May 1979 by Louis Berger and Associates Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Canistear Reservoir Dam No. 2, initially listed as a high hazard potential structure but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillway is considered adequate. To insure adequacy of the structure, the following actions, as a minimum, are recommended to be undertaken within one year from the date of approval of this report:

a. Repoint and reset all exposed stone masonry on the downstream wall and around the corners of the abutment piers.

b. Reposition the granite capstones where required and install additional rock anchors if necessary.

c. Personnel employed at the reservoir should receive additional training in the safety inspection of dams and conduct the regularly scheduled inspections of the dam.

APPROVED: _____

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 13 September 1979

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Canistear Reservoir Dam No. 2
Fed ID# NJ 00561

State Located New Jersey
County Located Sussex
Coordinates Lat. 4106.9 - Long. 7429.6
Stream Pacack Brook
Date of Inspection 10 May 1979

ASSESSMENT OF GENERAL CONDITIONS

Canistear Reservoir Dam No. 2 is assessed to be in a fair overall condition and it is recommended that it be downgraded to a significant hazard category. No detrimental findings were uncovered to merit further study. The spillway is adequate to accommodate the design flood. Recommended remedial actions to be undertaken in the future include repointing all exposed stone masonry and repositioning and reanchoring the spillway capstones where required.

F. Keith Jolls P.E.
Project Manager

OVERVIEW OF CANISTEAR RESERVOIR DAM NO. 2

MAY, 1979

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PREFACE

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

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an 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.

PHASE I INSPECTION REPORT
NAME OF DAM: CANISTEAR RESERVOIR DAM NO. 2
FED ID #NJ00561

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

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

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of Canistear Reservoir Dam No. 2 and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Overflow Dam No. 2 at Canistear Reservoir is a 330 foot long, stone masonry structure designed as an overflow to control the water level elevation in the reservoir. The masonry dam crestwall and abutments are founded on gneiss bedrock. The spillway is 280 feet long and has a crest width of 7 feet. The front and back slopes are 12V:1H and 12V:5H respectively. The top of the 25 foot long abutment end walls have 6 feet of freeboard above the spillway crest elevation of 1086. Spillway discharge flows down the natural channel of Pacack Brook.

This dam, together with Canistear Dam No. 1 (reported upon separately) form the major containment structures for the City of Newark Reservoir.

b. Location

Dam Site No. 2 is located at the southwestern corner of Canistear Reservoir in Hardyston Township, Sussex County, about 2 miles upstream (northeast) of New Jersey Route 23 and the town of Stockholm.

c. Size Classification

Dam No. 2 has a maximum height of 44 feet and a maximum storage capacity of 9,315 acre-feet. Accordingly, this dam is in the intermediate size category as defined by the criteria in the Recommended Guidelines for Safety Inspection of Dams (maximum storage capacity between 1,000 and 50,000 acre-feet, and a height between 40 and 100 feet).

d. Hazard Classification

The dam is located within the City of Newark Watershed which is uninhabited and undeveloped as far downstream as the village of Stockholm at Route 23. About a mile upstream from Route 23, Pacack Brook enters the flat, swampy flood plain of the Pequannock River. Development in Stockholm is generally located 20 feet or more above the flood plain and would suffer little damage from a dam break flood wave. However, the Pequannock River channel is severely constricted about 3,000 feet downstream of Stockholm. This constriction would create a backwater which could result in significant damage to homes and businesses along the edge of the flood plain and Route 23 as well as the embankment of the Susquehanna and Western Railroad. Accordingly, it is recommended that this dam be placed in the significant hazard category (the same as Dam No. 1).

e. Ownership

This dam is owned by the City of Newark, Division of Water Supply, Little Falls, New Jersey.

f. Purpose of Dam

This dam was constructed to provide a surface impoundment for water supply.

g. Design and Construction History

Both dams were designed in 1896 in order to form a water supply impoundment for the East Jersey Water Company. There are no microfilm records available at the NJDEP regarding Dam Application files, design considerations or details of construction. In 1944, plans were drawn up to refurbish the upstream face of the dam by applying a 2-inch thick layer of gunite. This work was not performed at that time but the masonry was repointed instead. In 1953, a gunite layer was applied to the upstream face of the dam as originally planned.

h. Normal Operating Procedure

The dam is maintained by personnel of the Divison of Water Supply, City of Newark who perform routine security patrols and inspection. The dam functions as an uncontrolled weir and, as such, has no regulating components.

1.3 PERTINENT DATA

a. Drainage Area

Canistear Reservoir has a drainage area of 5.32 square miles which consists of undeveloped woodlands.

b. Total spillway capacity at maximum pool elevation - 12,345 cfs

c. Elevations (ft. above MSL)

Top of dam - 1,092
Principal spillway crest - 1,086
Streambed at centerline of dam - 1,055±

d. Reservoir

Length of maximum pool (top of dam) - 9,400 feet

Length of normal pool (spillway crest) - 9,000 feet

e. Storage (acre-feet)

Top of dam - 9,315
Normal Pool - 7,400

f. Reservoir Surface (acres)

Top of dam - 336
Normal pool - 302

g. Dam

Type - Masonry
Length - 330 feet
Height - 44 feet (to bottom of footing)
Top Width - 7 feet
Side Slopes - 12V:1H upstream, 12V:5H downstream
Zoning - N/A
Impervious Core - N/A
Grout curtain - None

h. Diversion and Regulating Tunnel - None

i. Spillway

Type - Masonry overflow weir
Spillway length - 280 feet
Gates - None
U/S Channel - None
D/S Channel - Natural stream valley

j. Regulating Outlets

Two low level drains with 30 inch gate valves located at Dam No. 1 (Inv. El. 1035.5)

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

General details of the dam were obtained from a single design drawing prepared in 1896 and a repair plan dated 1944. The design and repair drawings were prepared in a manner consonant with contemporary practices and standards but contained no details or particulars of construction. While design calculations and attendant hydraulic and hydrologic design parameters are unavailable, the overall dam geometry is depicted in sufficient detail so the assessment contained herein could be made.

2.2 CONSTRUCTION

No information is available regarding the construction of the dam although field reconnaisssance reveals no deviation from the original design drawing.

2.3 OPERATION

General information pertaining to operational procedures was obtained from personnel of the Division of Water Supply and an explanation of the overall procedures for the entire water supply system, including Canistear Reservoir, is available at the Little Falls office of the Division of Water Supply. Since Canistear Reservoir functions primarily as a back-up water supply to Oak Ridge Reservoir, operational procedures are limited to daily inspections, maintenance and repairs.

2.4 EVALUATION

a. Availability

Sufficient data was obtained from the Division of Water Supply to assess the hydrologic and hydraulic capacity of the reservoir and dam. While design data was not available, a stability analysis was done using the original design plans and general geotechnical information

obtained from geologic maps and engineering soil reports for this area. The gravity masonry wall is founded on Pre-Cambrian age Losee gneiss, a hard white granitoid basement rock prevalent in northern New Jersey. This metamorphic rock is overlaid with thin layers of glacial moraine which have no appreciable effect on the dam's structural stability.

b. Adequacy

The original design drawing and general geotechnical information available are felt to be adequate to evaluate the structural aspects of the dam within the purview of P.L. 92-367.

c. Validity

The validity of the engineering data available is not challenged and is accepted without recourse to further investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspection of Canistear Reservoir Dam No. 2 took place on May 10, 16, 1979 with engineering personnel of the City of Newark, Division of Water Supply and the New Jersey Department of Environmental Protection, Bureau of Floodplain Management. Structural aspects of the dam were discussed with the owner's representatives as were post-construction modifications and downstream channel changes. The dam appears to be in an overall satisfactory condition except as noted hereinafter.

b. Dam

The dam is a gravity-type masonry structure which closes a 330 foot wide saddle in the gneiss bedrock. The end wall abutments of the dam, which extend 6 feet higher than the crest of the weir, are keyed into the bedrock sidewalls. The bedrock footings show no visible signs of cracking or deterioration although some dampness was noted in a shallow swale which extends from the right abutment into the spillway channel. Some efflorescence was noted on the face of the end walls and spalling of mortared joints was noted on the left endwall. The cap stone on the 280 feet long overflow weir appears smooth, well joined, and in a generally good condition. The plans indicate that the capstones are mechanically fastened to the underlying masonry with a system of iron pins. Intermittant flows along the length of the weir indicates the crest alignment is not perfectly horizontal but the differential settlement is negligible. The vertical alignment of the backface of the dam appears uniform although the uneven flow down the irregular cut masonry blocks tended to accentuate the roughness. The mortar joints between some of the stone were missing and should be repointed. The entire downstream toe is concealed from view either by boulders or earth deposited along the toe of the wall.

c. Appurtenant Structures

Although the entire dam is stone masonry, a small stilling basin has been created at the toe of the dam by the piling up or accumulation of earth and boulders. The bottom of this narrow pond is lined with variable-size boulders. The outlet from the pond is located in the center of the valley although the original design plan indicates the outlet was to be positioned in front of the left abutment.

d. Reservoir Area

As part of the Newark Watershed, the reservoir area is protected against development and the lake is completely surrounded by first-growth woodland. Bedrock outcrops are numerous along the shoreline which rises abruptly from the reservoir surface. The terrain in this portion of northern New Jersey is relatively steep and irregular due in part to the massive gneiss bedrock as well as recent glacial scouring.

e. Downstream Channel

The area immediately downstream of the dam is completely overgrown while the main channel itself is lined with large diameter boulders. There is an old abandoned dam located about 300 feet downstream which is 5 feet high, 8 feet wide, 150 feet long and consists of 2 vertical masonry walls with earth fill in the middle. Saplings up to 5 inches in diameter are growing from its crest which is breached at both abutments since the discharge from the main dam bifurcates upstream of this location. The valley, which is about 400 feet wide at this point widens to over 1,000 feet before joining the outlet channel from Dam No. 1 approximately 3,000 feet further downstream. There is no development between the dam and the flood plain of the Pequannock River.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Canistear Reservoir functions as a back-up water supply for Oak Ridge Reservoir. As such, routine operations consist of continuous monitoring of the reservoir water level; repair and maintenance of the regulating appurtenances; and general groundkeeping. Each morning a security guard performs a routine patrol of the dam and takes a water level reading at the gate house standpipe at Dam No. 1. The readings and any unusual activity are reported to the Little Falls office where the information is recorded. The main purpose of the operation is to maintain a balanced water supply in all the reservoirs in the system. Thus, when Oak Ridge Reservoir is overdrafted, personnel are dispatched to Canistear to release water into the downstream impoundment.

4.2 MAINTENANCE OF DAM

Maintenance under the auspices of the Division of Water Supply is divided into two separate functioning units. As applied to Canistear Reservoir, one unit is responsible for maintenance of the operational facilities and appurtenances while the second unit is responsible for stream and reservoir sanitation and groundskeeping. Included in the second category is maintenance of the channels and areas immediately below the dams. Discussions with personnel of the Division of Water Supply indicate that manpower shortages over the last 10 years has precluded staffing the latter category of maintenance crews which accounts for the apparent lack of downstream maintenance.

During summer months when water level in the reservoir is significantly lower, the upstream face of the dam is inspected by division engineering personnel.

4.3 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

Although no formal warning system exists, established procedures have been delineated for alerting downstream communities of any impending danger. The

security guard who inspects the dam each day is equipped with a two-way radio. In the event of an emergency situation he would notify the water supply facility at Charlotteburg which would dispatch repair parties to the scene of the problem as well as alert the local and State Police and the Public Works offices of all downstream communities.

4.4 EVALUATION OF OPERATIONAL ADEQUACY

The operational and maintenance procedures applicable to this dam are satisfactory within the prescribed framework. However, only half of the maintenance procedures categorized by the Division of Water Supply are presently being implemented which will eventually result in a general deterioration of the dam's structural condition. The warning procedures in effect are considered adequate in view of the lack of development for several miles downstream.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

Based upon the Recommended Guidelines for Safety Inspection of Dams, Canistear overflow Dam No. 2 is of intermediate size and is placed in the significant hazard category. A one-half probable maximum flood was selected as the design storm by the inspecting engineer. Inflow to the reservoir was calculated using precipitation data from Hydrometeorological Report 33 by the HEC-1 computer program, which yielded a peak of 10,832 cfs. When the inflow hydrograph was routed through the reservoir, discharge was jointly controlled by both Dam No. 1 and Canistear overflow dam No. 2. Routing reduced the peak to 6,378 cfs while the spillway capacity at overtopping of either dam is approximately 12,345 cfs. Thus, the design storm is adequately accommodated, with a freeboard of approximately 2 feet.

b. Experience Data

There is a water stage gage at dam No. 1 with a period of record from 1923 to the present. The maximum stage height recorded in recent years was 1086.4 on May 25 & 26, 1978. The maximum flood of record occurred in the spring of 1903. A flood stage of 1086.7 has been estimated for the 1903 storm based on the discharge from the system at that time. Otherwise, no information was available concerning the original design criteria. The outlet pipes beneath Dam No. 1 are opened periodically, especially during periods of low flow.

c. Visual Observations

The wide spillway at this dam has more than adequate capacity to discharge excessively large storm inflows.

d. Overtopping Potential

As there are no records of the dam being overtopped and the fact that the spillway can easily accommodate the design flood, there is little potential for overtopping. Further, Dam No. 1 could sustain a considerable amount of overtopping without breaching. Hence, a damaging overtopping of dam No. 2 is a very remote possibility.

e. Drawdown Potential

Canistear reservoir would take approximately 31 days to drawdown to El. 1035.5 through the two 48" diameter cast iron pipes located within Dam No. 1.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Based upon the field inspection and a cursory static overturning analysis, Dam No. 2 is adjudged to be in a satisfactory structural condition commensurate with its age but it is believed that the jointery in the stone masonry should be repointed. The alignment of the straight wall crest displays only minor differential settlement and could be the result of a slight shifting or sliding downward of the large dimension-masonry capstones. It is quite possible that the 1" stone anchors between the capstones have rusted through (note in Figure 4 that the capstones are replaced on a 4:12 batter). Due to the continuous overflow at the time of inspection, it was impossible to observe any seepage in or around the abutment areas.

b. Design and Construction Data

Design calculations and the original stability analyses were not available but the wall section appears to have an adequate factor of safety against sliding and overturning although the continued siltation against the dam's reservoir face tends to diminish this value with time. Since the bedrock in this area exhibits high fracture permeability in the upper segments, it is possible that considerable seepage may pass through the foundation (but its durability and stability is not affected).

Nothing is known relative to the initial construction or how the work was conducted and supervised.

c. Operating Records

No records or logs are maintained at this reservoir for operations other than water consumption, water elevations and other data associated with normal water supply operation.

d. Post Construction Changes

No major changes have been made to the structural wall except for the repairing of the reservoir face. It is unknown to what depth this work was carried as its condition or extent of coverage could not be observed.

e. Seismic Stability

Experience indicates that dams in Seismic Zone 1 which have adequate factors of safety under static loads will be satisfactory under dynamic loading conditions. Additional evaluation in the future may be warranted in light of the recent seismic activity along the Ramapo fault roughly 12 miles to the east (less than 3 on the Richter scale). However, as contained in the appended calculations, the dam has adequate factors of safety against overturning and sliding.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Canistear Dam No. 2 appears to be in a fair overall condition and except for the advanced deterioration of the stone masonry joints, exhibits few signs of deterioration in spite of its 80 year old existence. Its spillway is capable of transmitting the design discharge without endangering an overtopping of Dam No. 1. However, it is noted that this dam has a very substantial structural height and the inspection team believes it prudent for the owners to continue to closely monitor the dam's condition until an in-depth inspection of the condition of the stone masonry is performed. However, within the visual inspection limitations inherent in the procedures stipulated by the Phase I criteria of the Corps of Engineers, the dam is believed to be in an adequate condition if the monitoring and remedial measures set forth below are undertaken.

b. Adequacy of Information

While the information available to evaluate the hydraulic and hydrologic capabilities of the reservoir was adequate, the lack of design and construction data precluded a definitive evaluation of the structural stability except for what could be visually observed. However, the available data is felt to be adequate for the Phase I assessment.

c. Urgency

Remedial measures described below can be undertaken in the future as part of the regular maintenance program of the Newark Division of Water Supply.

d. Necessity for Further Studies

Further studies are believed to be unnecessary under the purview of P.L. 92-367 as the Division of Water Supply has experienced engineering personnel who maintain an internal system of inspections and action plans which basically reflect, within financial limitations, the requirements mandated under the Dam Safety Act.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

a. Recommended Actions

1. Repoint and reset all exposed stone masonry on the downstream wall and around the corners of the abutment piers.

2. Reposition the granite capstones where required and install additional rock anchors if necessary.

b. O&M Maintenance and Procedures

Although present procedures are being diligently pursued in a competent, workmanlike manner, it is suggested that Division of Water Supply personnel employed at the reservoir receive additional training in the safety inspection of dams. It is further recommended that after training, these same personnel conduct the regularly scheduled inspections.

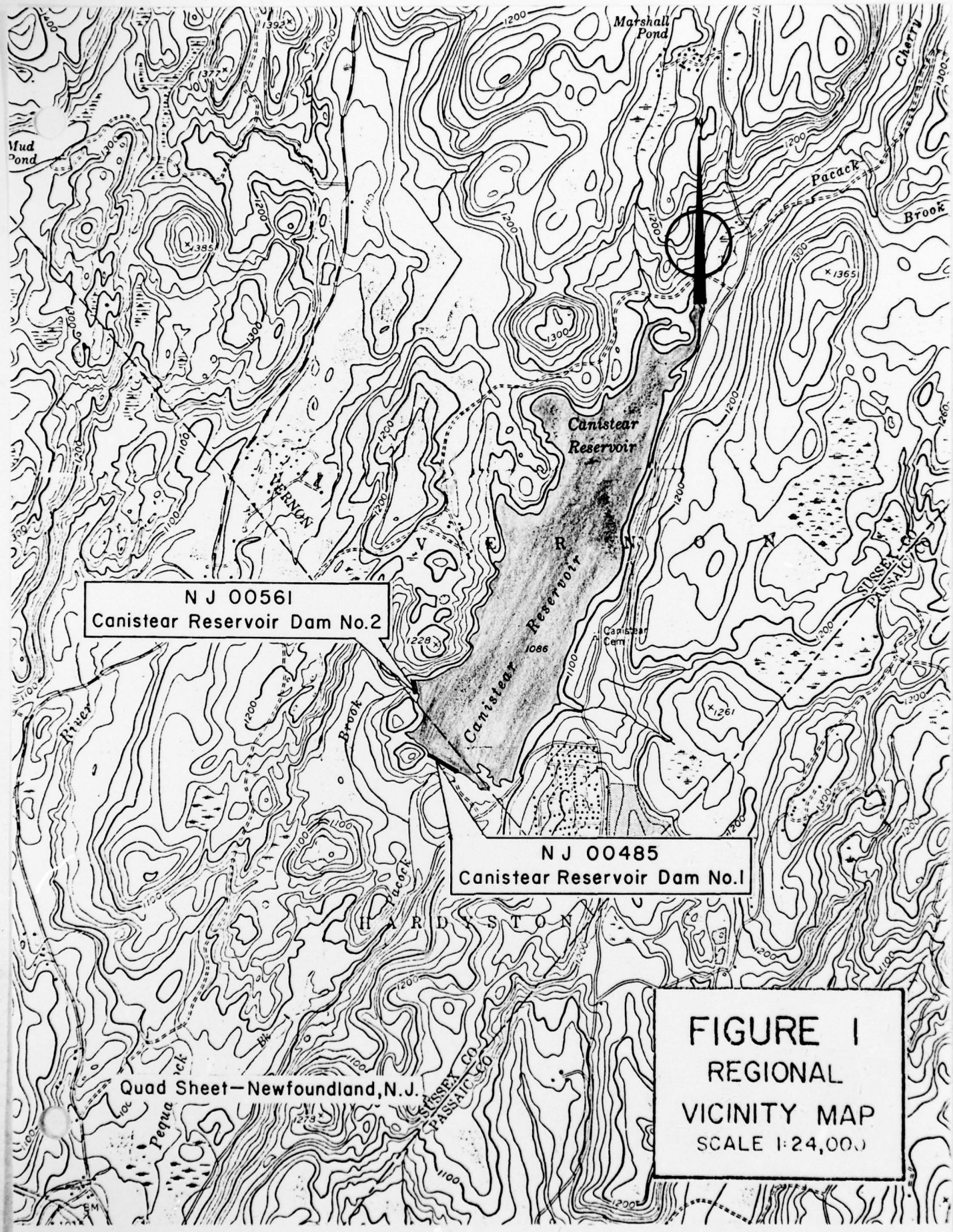
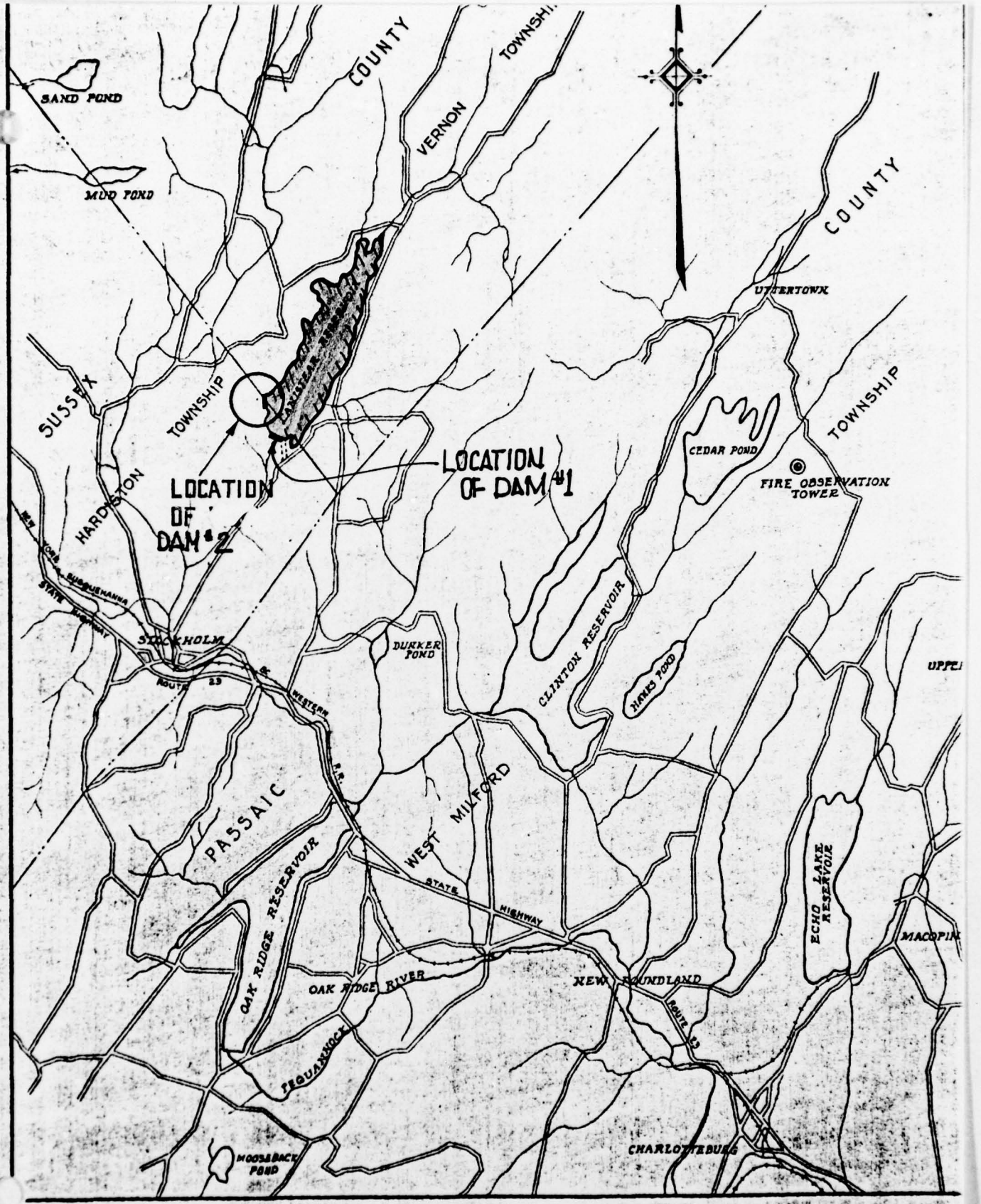


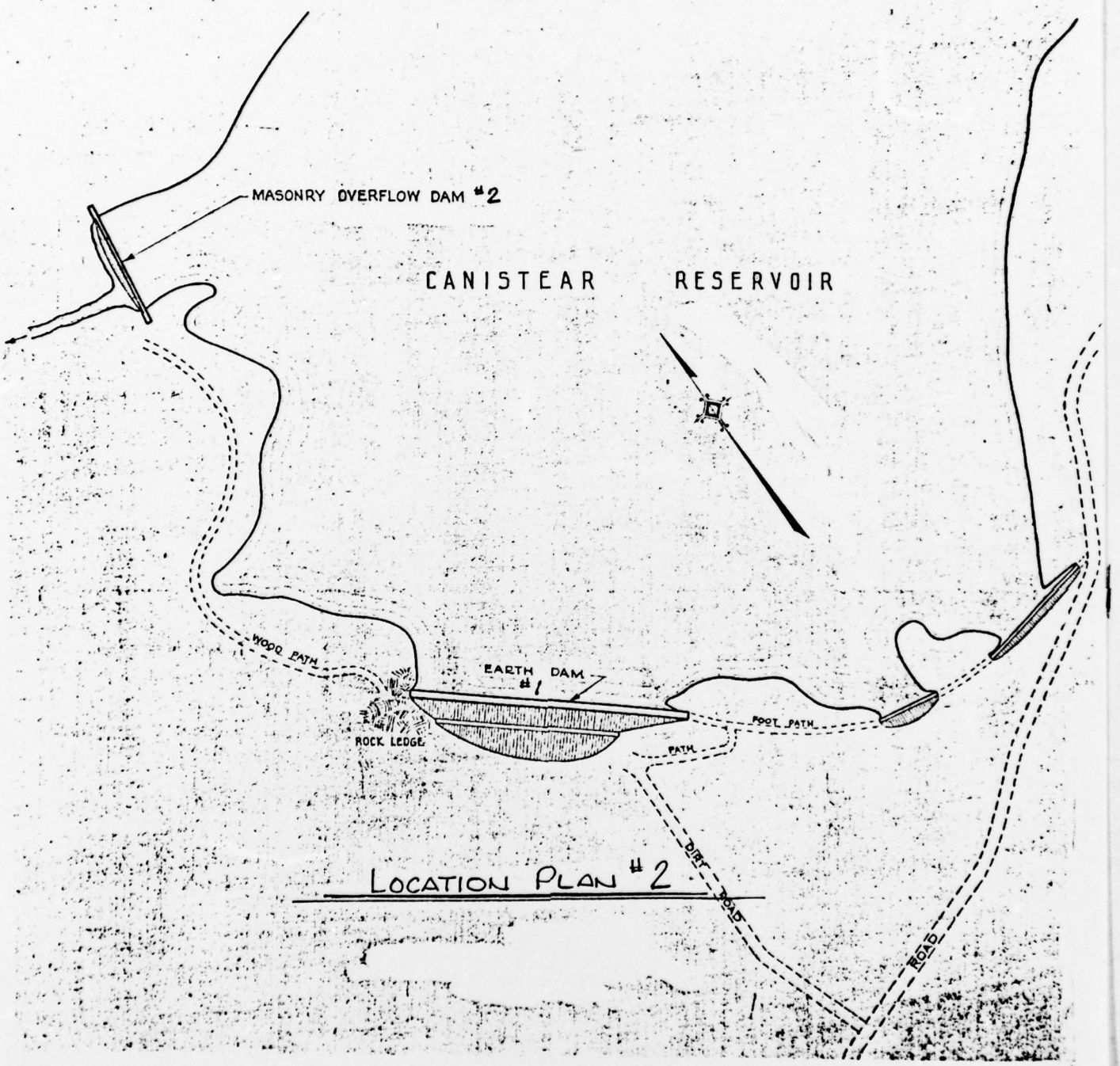
FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:24,000



LOCATION PLAN #1

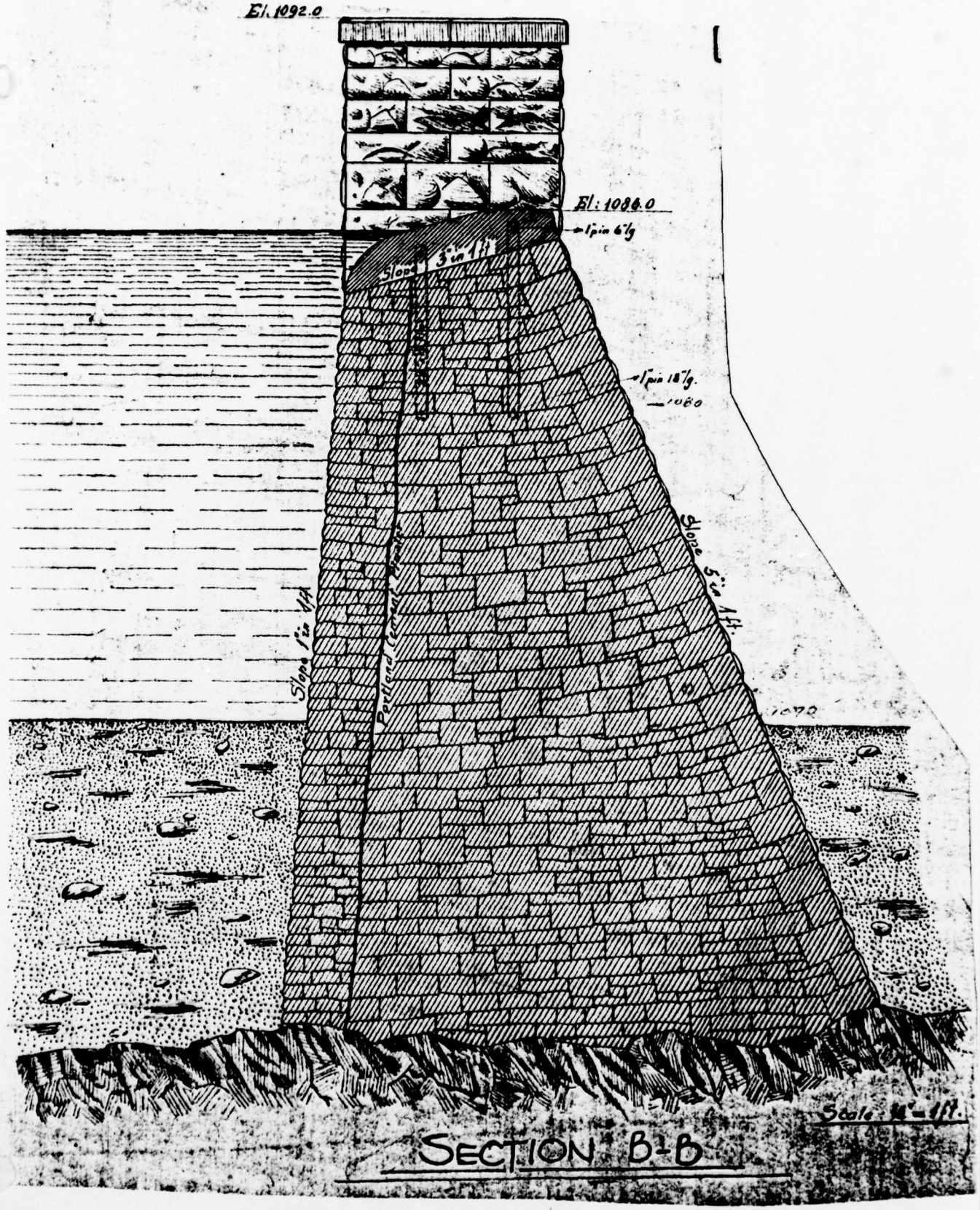
SCALE: 1" = 1 MILE

FIG. 2



LOCATION PLAN #2

FIGURE 3



Dam No. 2
FIGURE 4

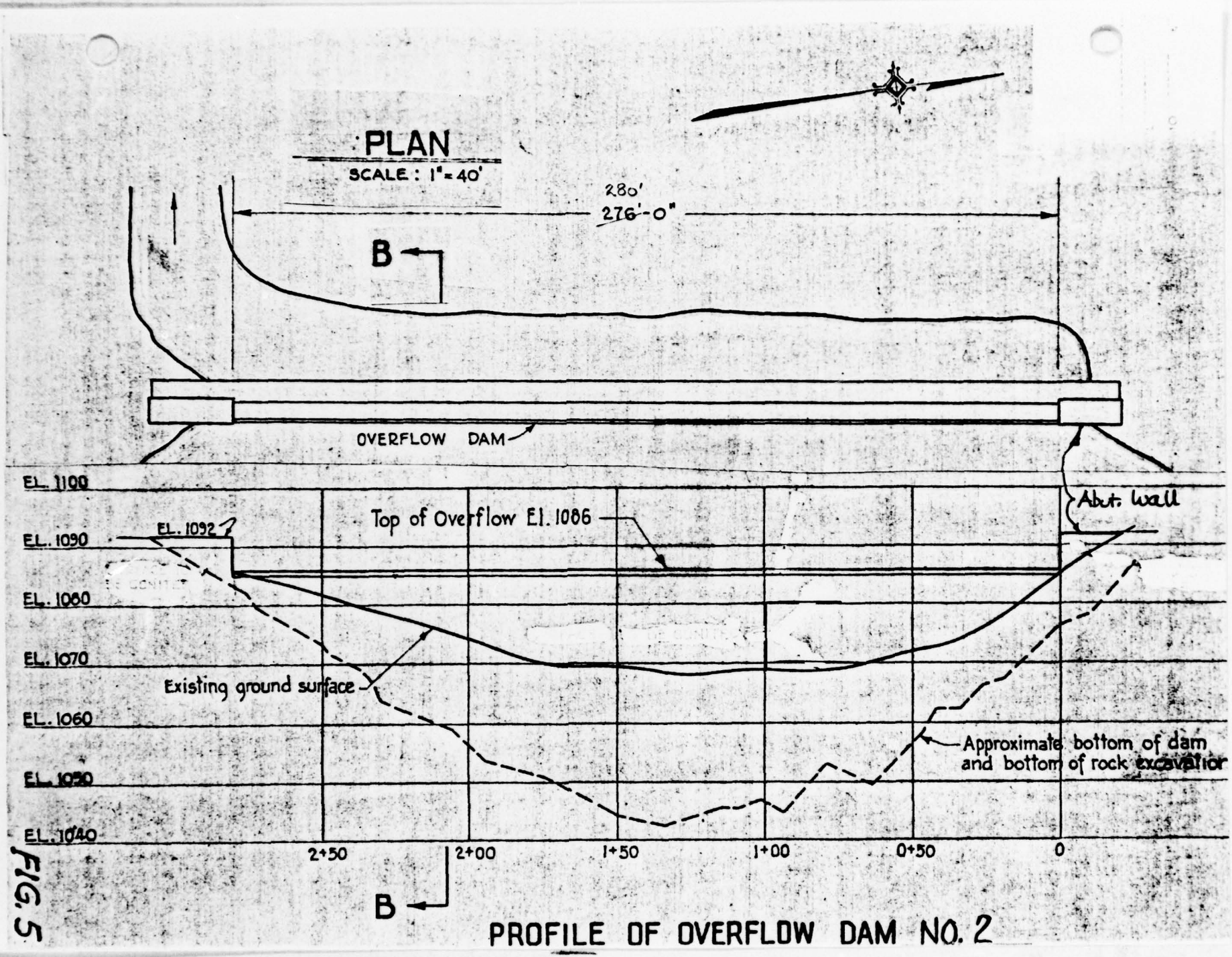


FIG. 5

PROFILE OF OVERFLOW DAM NO. 2

Check List
Visual Inspection
Phase 1

Name Dam Canistear No. 2 County Sussex State N.J. Coordinators NJDEP

Date(s) Inspection 5-10-79 Weather Clear Temperature 90°

Pool Elevation at Time of Inspection 1086.3 M.S.L. Tailwater at Time of Inspection 1055± M.S.L.

Inspection Personnel:

T. Chapter - LBA
K. Jolls - LBA
Mark Carter - (Raamott)
K. Greenfield - Raamott
Jim Conley - Newark W.S.
John Moyle - NJDEP

T. Chapter Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	Abutments and channel slopes are dry.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Granite block abutments tied to Gneiss bedrock - very firm, stable, no sign of cracking, deterioration or leakage - Junction of spillway and abutments is satisfactory.	
DRAINS	None visible	
WATER PASSAGES	Natural river channel - overgrown with large dia. trees - many scattered boulders.	
FOUNDATION	Bedrock (Gneiss)	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	None visible - some spalling where commemorative plaque was secured to granite block of abutment - plaque is gone.	Spalled areas should be resurfaced.
STRUCTURAL CRACKING	None visible - water cascading over entire length of dam spillway.	
VERTICAL AND HORIZONTAL ALIGNMENT	Very minor undulation of crest as evidenced by different rate of flow over various sections of the weir.	
MONOLITH JOINTS	Appears to be some open joints between the granite blocks but its hard to tell how far back the joints are open.	Open joints should be repointed.
CONSTRUCTION JOINTS		

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GRANITE BLOCK WEIR	Is in good condition - looks almost new although its 80 years old.	
APPROACH CHANNEL	Dam is positioned in cove on SW shoreline of Res. Weir has rounded approach lip.	
DISCHARGE CHANNEL	Natural channel; bedrock invert, heavily wooded with many boulders.	
BRIDGE AND PIERS	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	About 3:1 slopes - heavily wooded - no development.	
SEDIMENTATION	Unknown	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	An old dam is located about 300 feet downstream. It is 5' high at stream, 8' wide and about 150' long. It consists of 2 vertical masonry walls with fill in the middle. It is breached at both abutments since the discharge from the main dam bifurcates before this point.	
SLOPES	Heavily wooded, 5:1 - channel about 150-200 feet wide at bottom.	
APPROXIMATE NO. OF HOMES AND POPULATION	None until Stockholm 1.5 miles downstream. Pacack Brook flows into Pequannock River in a swampy region 2000' before reaching Rt. 23 and Stockholm.	Backwater from downstream constriction of Pequannock River could flood portions of Stockholm if dam fails.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available - City of Newark, Div. of Water Supply, Little Falls, N.J.
REGIONAL VICINITY MAP	Available - U.S.G.S. Quadrangle - Newfoundland, N.J.
CONSTRUCTION HISTORY	Unavailable
TYPICAL SECTIONS OF DAM	Available - City of Newark - D.W.S.
HYDROLOGIC/HYDRAULIC DATA	Unavailable
OUTLETS - PLAN	N/A
- DETAILS	
-CONSTRAINTS	
-DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS	Available - City of Newark - D.W.S.

ITEM	REMARKS
SPILLWAY PLAN	Available - City of Newark - D.W.S.
SECTIONS	" " " "
DETAILS	" " " "
OPERATING EQUIPMENT PLANS & DETAILS	N/A

ITEM	REMARKS
DESIGN REPORTS	Not available
GEOLOGY REPORTS	Available - State Geologic Map - Rutgers Engineering Soil Survey
DESIGN COMPUTATIONS	Not available
HYDROLOGY & HYDRAULICS	" "
DAM STABILITY	" "
SEEPAGE STUDIES	" "
MATERIALS INVESTIGATIONS	Not available
BORING RECORDS	" "
LABORATORY	" "
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	Not available
BORROW SOURCES.	Not available

ITEM	REMARKS
MONITORING SYSTEMS	Daily inspections by security personnel
MODIFICATIONS	Available - City of Newark - D.W.S.
HIGH POOL RECORDS	Available " " "
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Not available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None N/A N/A
MAINTENANCE OPERATION RECORDS	Available - City of Newark - D.W.S. " " " " " " " "

May, 1979

Canistear Reservoir Dam #2

May, 1979

View of Discharge Channel

May, 1979

View of Crest

May, 1979

View of Left Abutment

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 5.32 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1086 (7400 ± acre feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1092 (9315 acre feet)

CREST: Overflow Dam

a. Elevation 1086
b. Type Masonry w/12: 1 batter upstream face & 12:5 batter downstream
c. Width 7 feet at crest
d. Length 280 feet
e. Location Spillover center of dam
f. Number and Type of Gates None

OUTLET WORKS: (Located at Dam Site 1)

a. Type Two 42" dia. C.I. drains with four 30" valves in gate house
b. Location 537 feet from right abutment
c. Entrance inverts 1035.5
d. Exit inverts 1035.5
e. Emergency draindown facilities

HYDROMETEOROLOGICAL GAGES: (Located in gate house at Dam Site 1)

a. Type Stand pipe
b. Location Gatehouse
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 12,345 cfs.

BY D.J.M. DATE 5-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A1 OF
CHKD. BY DATE CANISTEAR RESERVOIR DAMS 1 & 2 PROJECT C.234
SUBJECT

Time of concentration :

length of longest watercourse ≈ 1.5 miles = 7920 ft.

$\Delta H \approx 1140 - 1086 = 54$ ft.

$\therefore$ Slope $= \frac{54}{7920} = 0.7\ \%$

from U.S. Navy Tech. Publication TP - PW - 5
take average velocity = 2.0 ft s^{-1}

$\therefore t_c = \frac{7920}{2 \times 60} = 66$ minutes

By California Culverts Equation :

$$t_c = \left(\frac{11.9 \times 1.5^3}{54}\right)^{0.385} = 0.89 \text{ hours} = 54 \text{ minutes}$$

By Kirpich's formula :

$$t_c = 0.00013 \times \frac{7920^{0.77}}{0.007^{0.385}} = 0.88 \text{ hours}$$

$= 53$ minutes

use t_c = 1 hour and use 1/4 hour increments

$$t_p = \frac{0.25}{2} + 0.6 \times 1 = 0.73 \text{ hours}$$

$$Q_p = \frac{484 \times 5.32}{0.73} = 3527 \text{ cfs}$$

BY D.J.M. DATE 5-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A2 OF

CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR DAMS 1 & 2 PROJECT C234

SUBJECT UNITGRAPH FOR HEC-1 PROGRAM

T hours	T/Tp	Dimensionless ordinate (DO)	Q (cfs) = Qp × DO
0.25	0.34	0.20	705
0.50	0.68	0.73	2575
0.75	1.03	0.998	3520
1.00	1.37	0.777	2740
1.25	1.71	0.47	1658
1.50	2.05	0.29	1023
1.75	2.40	0.18	635
2.00	2.74	0.107	377
2.25	3.08	0.067	236
2.50	3.42	0.04	141
2.75	3.77	0.025	88
3.00	4.11	0.016	56

Check unitgraph $\Sigma Q = 13754$

$$\frac{13754 \times 3600 \times 12}{5.32 \times 5280^2 \times 4} = 1.00155'' - \text{O.K.}$$

BY J. J. M. DATE 5-79 | **LOUIS BERGER & ASSOCIATES INC.** | SHEET NO. A3 OF

CHKD. BY ____ DATE ____ | CANISTEAR RESERVOIR DAMS 1 & 2 | PROJECT C234

SUBJECT ____

PRECIPITATION DATA :

from Hydrometeorological Report # 33, for 200 square miles and 24 hours (in inches)

PMP in inches = 22.5

Maximum 6 hour percentage = 113 % = 25.43 inches

Maximum 12 hour percentage = 123 % = 27.68 inches

Maximum 24 hour percentage = 132 % = 29.70 inches

BY. D.J.M. DATE 5-79
CHKD. BY. DATE
SUBJECT

LOUIS BERGER & ASSOCIATES INC.
CANISTEAR RESERVOIR DAMS 1 & 2

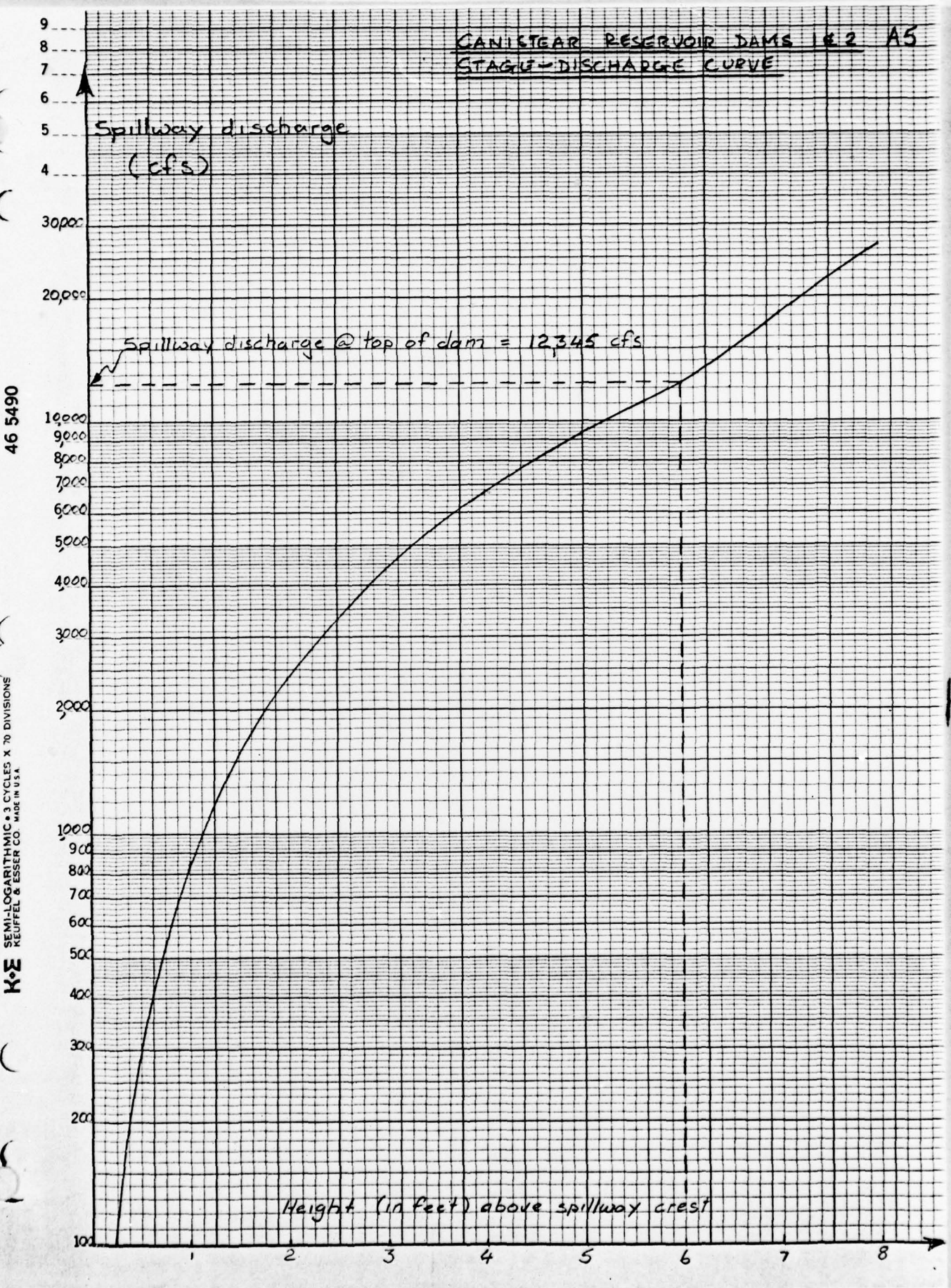
SHEET NO. A4 OF
PROJECT C234

Spillway discharge capacity:

	Over spillway crest Dam # 2 L = 280'			Over dams 1&2 Combined L: 680+330 = 1010'			Σ Q (cfs)
Elev.	H	C	Q	H	C	Q	
1086	0	0	0				0
1087	1	3.0	840				840
1088	2	3.0	2,375				2,375
1089	3	3.0	4,365				4,365
1090	4	3.0	6,720				6,720
1091	5	3.0	9,391				9,391
1092	6	3.0	12,345				12,345
1092.5*	6.5	3.0	13,920	0.5	2.7	964	14,884
1093 *	7	3.0	15,557	1.0	2.7	2727	18,284
1094 *	8	3.0	19,007	2.0	2.7	7713	26,720

* indicates overtopping of the two dams

The above calculations are based on the fact that the two dams impound the same reservoir. Dam # 1 has two low level outlets which have been neglected in the above calculations, as there is no gaurantee that they will be open under flood conditions. Therefore the spillway discharge is for dam # 2 only.

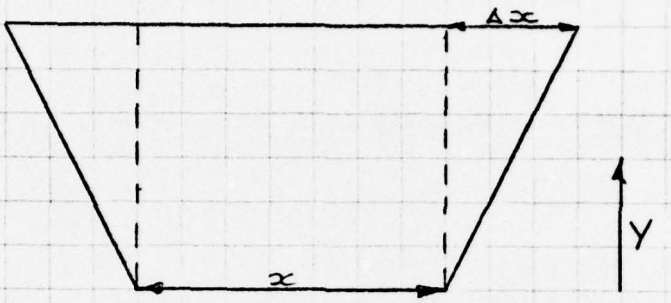

CANISTEAR RESERVOIR DAMS 1 & 2 A5
STAGE-DISCHARGE CURVE
Spillway discharge (cfs)
9
8
7
6
5
4
30,000
20,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
900
800
700
600
500
400
300
200
100
Spillway discharge @ top of dam = 12,345 cfs
Height (in feet) above spillway crest
1
2
3
4
5
6
7
8
46 5490
K•E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

BY D J M DATE 5-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A6 OF

CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR DAMS 1 & 2 PROJECT C234

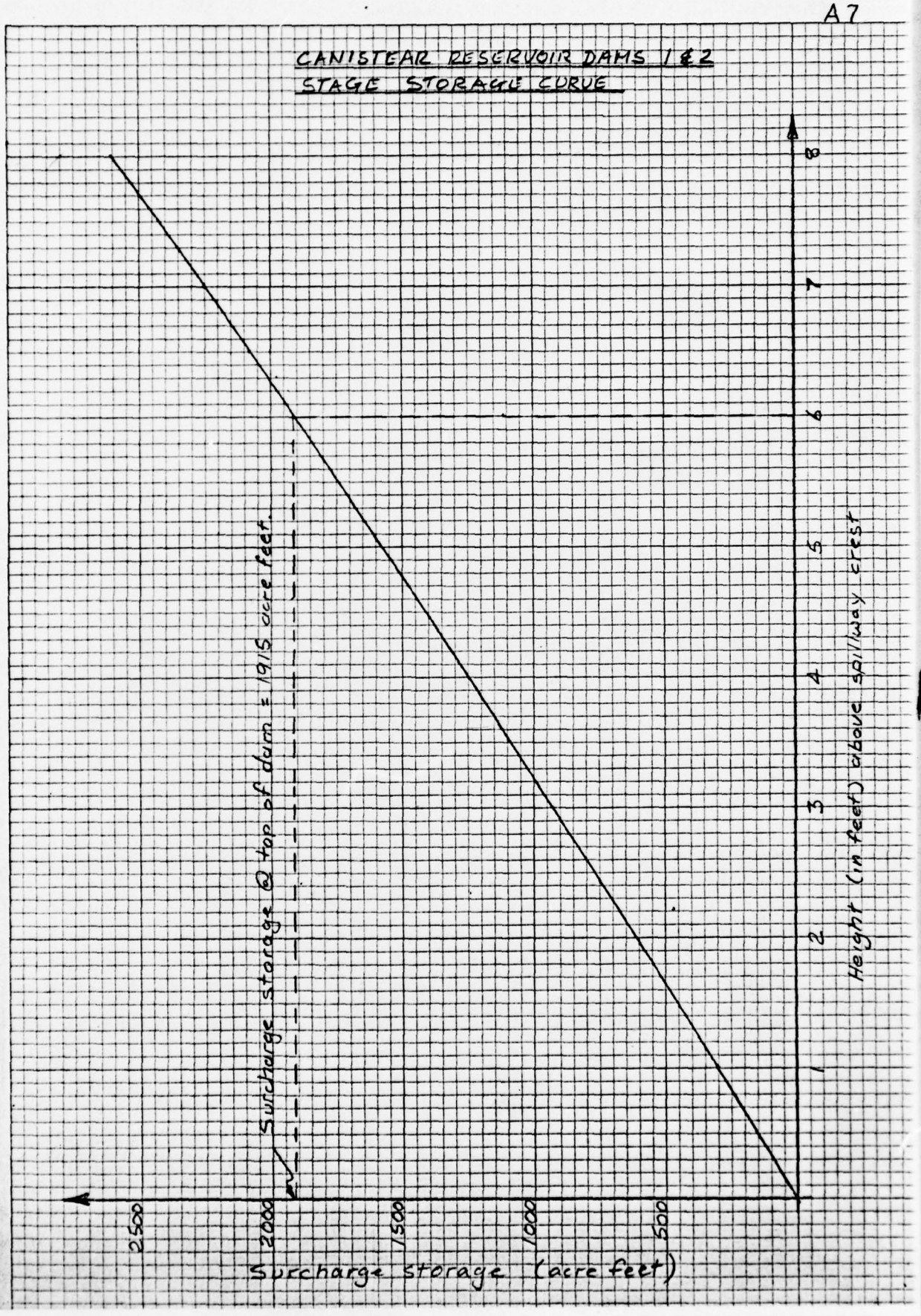
SUBJECT ____

SURCHARGE STORAGE :



Increment in Volume $\Delta V = (x + \Delta x)Y$

Elev	H (ft)	SURCHARGE STORAGE (Ac. ft.)
1086	0	0
1087	1	305
1088	2	615
1089	3	932
1090	4	1254
1091	5	1581
1092	6	1915
1092.5	6.5	2084
1093	7	2254
1094	8	2599



BY D.J.M. DATE 8-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A8 OF

CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR PROJECT C234

SUBJECT Approximate drawdown calculations

Take h from El. 1039 to El. 1086 = 47'
drawdown in 4 equal stages
assume no inflow to reservoir
Volume = 7400 acre feet.

Stage 1) $H = 41.13$ $Q = 191$ cfs

$$\text{time} = \frac{7400 \times 43560}{191 \times 4 \times 3600} = 117.2 \text{ hours}$$

Stage 2) $H = 29.38$ $Q = 162$ cfs

$$\text{time} = \frac{7400 \times 43560}{162 \times 4 \times 3600} = 138 \text{ hours}$$

Stage 3) $H = 17.63$ $Q = 125$ cfs

$$\text{time} = \frac{7400 \times 43560}{125 \times 4 \times 3600} = 179 \text{ hours}$$

Stage 4) $H = 5.88$ $Q = 72$ cfs

$$\text{time} = \frac{7400 \times 43560}{72 \times 4 \times 3600} = 311 \text{ hours}$$

$\Sigma = (311 + 179 + 138 + 117)/24 = 31.04$ Say 31 days

Q calculated by following formula.

$$Q = \sqrt{\frac{100\ H_T}{\left(\frac{2.5204\,(1+Ke)}{D^4} + \frac{466.18\,n^2 L}{D^{16/3}}\right)}}$$

Where H_T = head $L = 250$

$n = 0.02$

$Ke = 0.5$ $D = 2.5'$

BY D J M DATE 5-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A9 OF
CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR DAM # 2 PROJECT C234
SUBJECT ____

GENERAL SUMMARY OF APPENDIX:

length of dam = 330 ft.
Effective length of spillway = 280 ft. @ El. 1086±

Total spillway capacity @ top of dam = 12,345 cfs

Surcharge storage @ top of dam = 1915 ac. ft.
Storage @ normal pool = 7400 ac. ft.

∴ Total storage @ top of dam = 9315 ac. ft.

Lake area @ normal pool = 302 acres
Lake area @ top of dam = 336 acres

CANNISTEAR DAMS 1&2 INSPECTION
BY LINDA J. BAINES
JUNE 14 1979

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	0	15	0	0	0	0	0	0	0

JOPER	NWT
3	0

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

SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

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

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	-1	5.32	0.0	5.32	0.0	0.500	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	22.50	113.00	123.00	132.00	0.0	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.776

LOSS DATA

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

GIVEN UNIT GRAPH, NUFGG= 12

705.	2573.	3520.	2740.	1658.	1023.	635.	377.	236.	141.
88.	56.								

UNIT GRAPH TOTALS 13752. CFS OR 1.00 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q
1	0.03	0.00	0.
2	0.03	0.00	0.
3	0.03	0.00	0.
4	0.03	0.00	0.
5	0.03	0.00	0.
6	0.03	0.00	0.
7	0.03	0.00	0.
8	0.03	0.00	0.
9	0.03	0.00	0.
10	0.03	0.00	0.
11	0.03	0.00	0.
12	0.03	0.0	0.

LOUIS BERGER & ASSOCIATES INC.

CANISTEAR RESERVOIR #1E7

13	0.03	0.00	0.
14	0.03	0.00	0.
15	0.03	0.00	0.
16	0.03	0.00	0.
17	0.03	0.00	0.
18	0.03	0.00	0.
19	0.03	0.00	0.
20	0.03	0.00	1.
21	0.03	0.00	4.
22	0.03	0.00	8.
23	0.03	0.00	11.
24	0.03	0.00	13.
25	0.07	0.05	47.
26	0.07	0.05	168.
27	0.07	0.05	332.
28	0.07	0.05	460.
29	0.07	0.05	538.
30	0.07	0.05	586.
31	0.07	0.05	615.
32	0.07	0.05	633.
33	0.07	0.05	644.
34	0.07	0.05	650.
35	0.07	0.05	654.
36	0.07	0.05	657.
37	0.07	0.05	657.
38	0.07	0.05	657.
39	0.07	0.05	657.
40	0.07	0.05	657.
41	0.07	0.05	657.
42	0.07	0.05	657.
43	0.07	0.05	657.
44	0.07	0.05	657.
45	0.07	0.05	657.
46	0.07	0.05	657.
47	0.07	0.05	657.
48	0.07	0.05	657.
49	0.49	0.47	954.
50	0.49	0.47	2036.
51	0.49	0.47	3517.
52	0.49	0.47	4669.
53	0.59	0.57	5436.
54	0.59	0.57	6121.
55	0.59	0.57	6735.
56	0.59	0.57	7164.
57	0.74	0.72	7531.
58	0.74	0.72	8072.
59	0.74	0.72	8693.
60	0.74	0.72	9160.
61	1.88	1.85	10228.
62	1.88	1.85	13314.
63	1.88	1.85	17411.
64	1.88	1.85	20582.
65	0.69	0.67	21664.
66	0.69	0.67	19799.
67	0.69	0.67	16364.
68	0.69	0.67	13555.
69	0.54	0.52	11755.
70	0.54	0.52	10323.
71	0.54	0.52	9150.
72	0.54	0.52	8361.
73	0.04	0.01	7481.

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CANISTEAR RESERVOIR #1 & 2

74	0.04	0.01	5868.
75	0.04	0.01	3897.
76	0.04	0.01	2395.
77	0.04	0.01	1526.
78	0.04	0.01	990.
79	0.04	0.01	657.
80	0.04	0.01	459.
81	0.04	0.01	340.
82	0.04	0.01	269.
83	0.04	0.01	225.
84	0.04	0.01	197.
85	0.04	0.01	197.
86	0.04	0.01	197.
87	0.04	0.01	197.
88	0.04	0.01	197.
89	0.04	0.01	197.
90	0.04	0.01	197.
91	0.04	0.01	197.
92	0.04	0.01	197.
93	0.04	0.01	197.
94	0.04	0.01	197.
95	0.04	0.01	197.
96	0.04	0.01	197.
97	0.0	0.0	187.
98	0.0	0.0	150.
99	0.0	0.0	99.
100	0.0	0.0	60.
SUM	23.08	20.64	283663.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	21664.	10556.	2955.	2837.	283661.
INCHES		18.46	20.67	20.67	20.67
AC-FT		5237.	5864.	5864.	5864.

RUNOFF MULTIPLIED BY 0.50

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	4.	6.	7.	24.	84.	166.	230.	269.	293.
308.	316.	322.	325.	327.	329.	329.	329.	329.	329.
329.	329.	329.	329.	329.	329.	329.	329.	477.	1018.
1758.	2335.	2718.	3060.	3368.	3582.	3766.	4036.	4347.	4580.
5114.	6657.	8706.	10291.	10832.	9899.	8182.	6778.	5878.	5162.
4575.	4181.	3741.	2934.	1949.	1198.	763.	495.	329.	229.
170.	135.	112.	98.	98.	98.	98.	98.	98.	98.
98.	98.	98.	98.	98.	98.	93.	75.	50.	30.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10832.	5278.	1477.	1418.	141830.
INCHES		9.23	10.33	10.33	10.33
AC-FT		2618.	2932.	2932.	2932.

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

HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
11	1	0	0	0	0	1

OGILVIE PRESS Buffalo, New York Printed in U.S.A. 450

BY LJB DATE 6-79 LOUIS BERGER & ASSOCIATES INC. SHEET NO. A13 OF
CHKD. BY DATE CANISTEAR RESERVOIR NO. 1 & 2 PROJECT C-234
SUBJECT

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

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

STORAGE=	0.	305.	615.	932.	1254.	1581.	1915.	2084.	2254.	2599.
OUTFLOW=	0.	840.	2375.	4365.	6720.	9391.	12345.	14884.	18284.	26720.

TIME	EOP STOR	AVG IN	EOP OUT
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.
11	0.	0.	0.
12	0.	0.	0.
13	0.	0.	0.
14	0.	0.	0.
15	0.	0.	0.
16	0.	0.	0.
17	0.	0.	0.
18	0.	0.	0.
19	0.	0.	0.
20	0.	0.	0.
21	0.	1.	0.
22	0.	3.	0.
23	0.	5.	0.
24	0.	6.	1.
25	1.	15.	2.
26	2.	54.	4.
27	4.	125.	11.
28	8.	198.	22.
29	12.	250.	34.
30	17.	281.	48.
31	22.	300.	62.
32	27.	312.	76.
33	32.	319.	89.
34	37.	324.	102.
35	42.	326.	114.
36	46.	328.	126.
37	50.	329.	137.
38	54.	329.	148.

BY. L.B DATE 6-79

CHKD. BY DATE

SUBJECT

LOUIS BERGER & ASSOCIATES INC.

CANISTEAR RESERVOIR #182

SHEET NO. A14 OF

PROJECT C-234

39	57.	329.	158.
40	61.	329.	167.
41	64.	329.	176.
42	67.	329.	185.
43	70.	329.	193.
44	73.	329.	200.
45	75.	329.	207.
46	78.	329.	214.
47	80.	329.	220.
48	82.	329.	226.
49	86.	403.	236.
50	96.	747.	264.
51	119.	1388.	327.
52	153.	2046.	422.
53	195.	2526.	538.
54	243.	2889.	668.
55	294.	3214.	809.
56	346.	3475.	1045.
57	398.	3674.	1301.
58	449.	3901.	1554.
59	501.	4191.	1811.
60	553.	4463.	2069.
61	608.	4847.	2339.
62	677.	5886.	2762.
63	772.	7681.	3361.
64	891.	9493.	4109.
65	1016.	10562.	4976.
66	1119.	10366.	5733.
67	1183.	9041.	6198.
68	1207.	7480.	6378.
69	1206.	6328.	6371.
70	1190.	5520.	6251.
71	1163.	4868.	6057.
72	1131.	4378.	5821.
73	1095.	3961.	5560.
74	1053.	3337.	5248.
75	999.	2441.	4853.
76	936.	1573.	4392.
77	870.	980.	3973.
78	805.	629.	3566.
79	743.	412.	3182.
80	687.	279.	2828.
81	636.	200.	2508.
82	590.	152.	2252.
83	548.	124.	2045.
84	510.	105.	1856.
85	476.	98.	1685.
86	444.	98.	1531.
87	416.	98.	1391.
88	391.	98.	1265.
89	368.	98.	1152.
90	347.	98.	1049.
91	329.	98.	957.
92	312.	98.	873.
93	296.	98.	816.
94	282.	98.	776.
95	268.	98.	739.
96	255.	98.	703.
97	243.	96.	670.
98	231.	84.	637.
99	220.	62.	605.
100	208.	40.	574.
SUM			132011.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6378.	4285.	1375.	1320.	132011.
INCHES		7.49	9.62	9.62	9.62
AC-FT		2126.	2729.	2729.	2729.

RUNOFF SUMMARY. AVERAGE FLOW

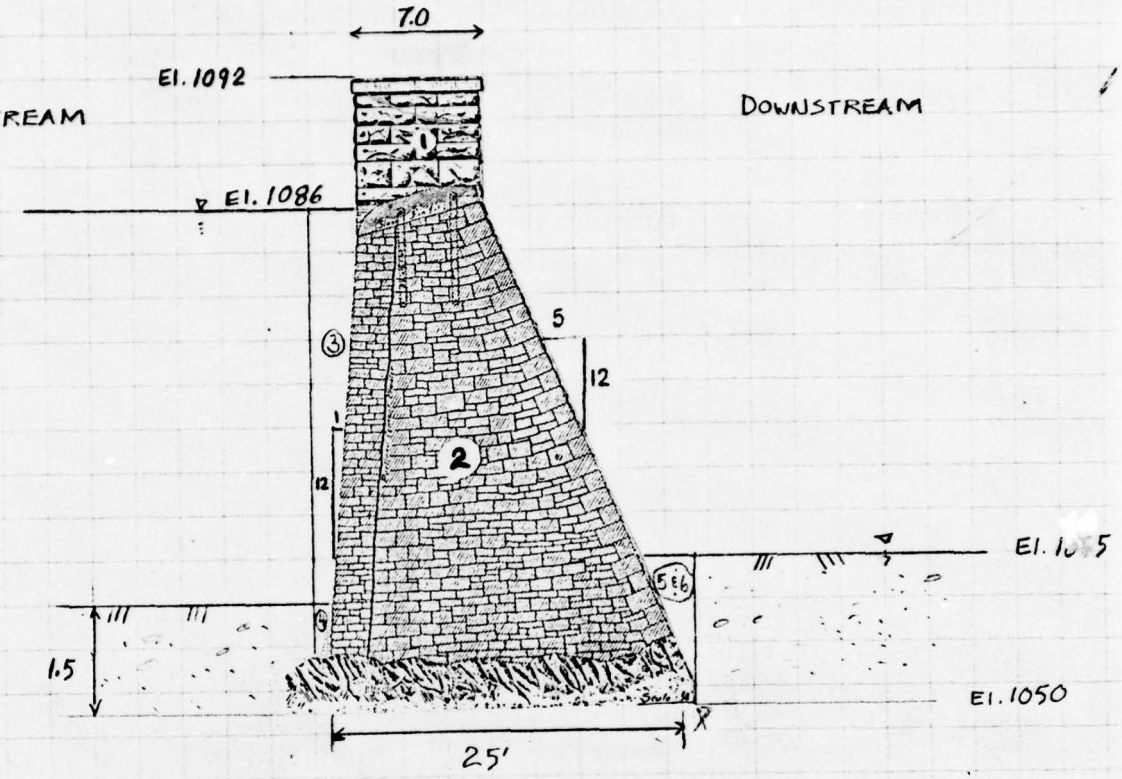
		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	10832.	5278.	1477.	1418.	5.32
ROUTED TO	11	6378.	4285.	1375.	1320.	5.32

STABILITY COMPUTATIONS

BY L.B. DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B1 OF

CHKD. BY H.M. DATE AUG '79 CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS



CONSIDER ALL FORCES PER FOOT OF DAM

①	$6' \times 7' \times 1' \times 160\ \#/cf$ =	6720 #
②	$\frac{1}{2}(36)'(7'+25') \times 1' \times 160\ \#/cf$	92,160 #
③	$62.4\ \#/cf \times 36' \times \frac{1}{2} \times 3'$	3,370 #
④	$1.5 \times 110\ \#/cf \times \frac{1}{2} \times .125$	10 #
⑤	$5 \times 110\ \#/cf \times \frac{1}{2} \times 2.08$	572 #
⑥	$5 \times 62.4\ \#/cf \times \frac{1}{2} \times 2.08$	324 #
		103,156 # /

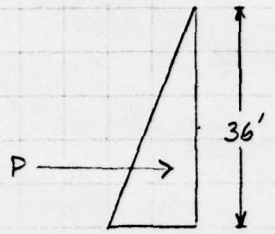
BY L.B. DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B2 OF

CHKD. BY H.W. DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

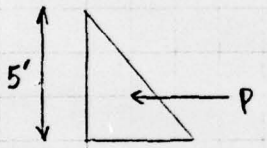
HORIZONTAL FORCES

WATER (UPSTREAM)



$$P = \frac{36^2 \times 62.4\#/cf}{2} = 40,435\#$$

WATER (DOWNSTREAM)



$$P = \frac{5^2 \times 62.4\#/cf}{2} = 780\#$$

ACTIVE EARTH PRESSURE $\phi = 33°$ $K_p = 0.2948$

$$= \frac{.6(110)(.2948)(1.5)^2(1)}{2}$$

$$= 22\#$$

PASSIVE EARTH PRESSURE $\phi = 33°$ $K_p = 3.39$

$$= \frac{.6(110)(5)^2(1)(3.39)(1)}{2}$$

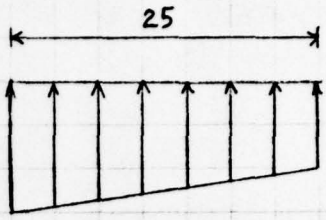
$$= 2797\#$$

BY L.B. DATE Aug. '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B3 OF

CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

UPLIFT PRESSURE



$$\text{TOTAL Uplift} = \left(\frac{2246.4 + 312}{2}\right)25$$

$$31{,}980\ \#$$

FACTOR OF SAFETY AGAINST SLIDING ASSUMING COEFF. OF FRICTION = 0.75 See page 24 DESIGN OF SMALL DAM

$$= \frac{0.75(103.2 - 31.98)}{40.44 - .78 + .022 - 2.8}$$

$$= 1.5 \quad \text{ok}$$

BY L.B. DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B4 OF
CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-234
SUBJECT STABILITY COMPUTATIONS

FACTOR OF SAFETY AGAINST OVERTURNING

TAKE MOMENTS ABOUT 'x'

	LOAD	ARM	MOMENT
SECTION ①	6.72 ^{k}	18.5	124.32
SECTION ②	92.16 ^{k}	14.94	1,376.87
SECTION ③	3.37 ^{k}	24	80.88
SECTION ④	.01 ^{k}	24.96	.25
SECTION ⑤	.57 ^{k}	.69	.39
SECTION ⑥	.324	.69	.22
$H_2O_{upstream}$	40.44	12	- 485.28
$H_2O_{downstream}$	.78	1.67	1.30
ACTIVE EARTH	.022	0.5	- .01
PASSIVE Earth	2.8	1.67	4.68
Uplift	31.98	15.65	- 501

OVERTURNING MOMENT = 986.3

STABILIZING MOMENT = 1588.91

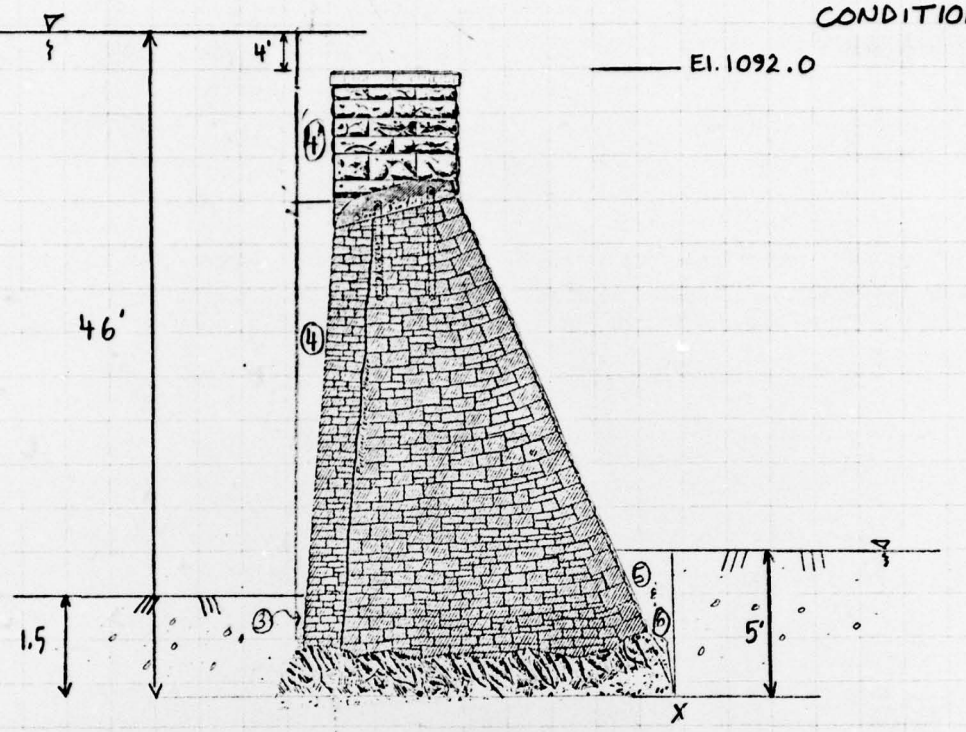
$$F.S. = \frac{1588.91}{986.3} = 1.61 > 1.5 \quad \text{ok}$$

BY L.B DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B5 OF

CHKD. BY H.M DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

CONDITION # 2



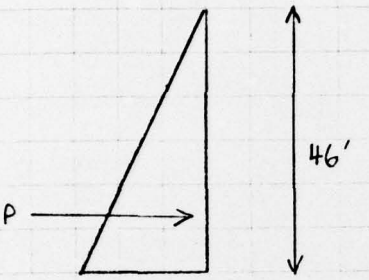
CONSIDER ALL FORCES PER FOOT OF DAM

SECTION ①		6720 #
SECTION ②		92,160 #
SECTION ③	1.5 x 110 #/cf x ½ x .125	10 #
SECTION ④	36 x 62.4 x ½ x 3	3,370
SECTION ④'	10 x 3 x 62.4	1,872
SECTION ⑤	5 x 110 x ½ x 2.08	572
SECTION ⑥	5 x 62.4 x ½ x 2.08	324
		105,028

BY L.B. DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B6 OF.
CHKD. BY H.M. DATE CANISTEAR RESERVOIR #2 PROJECT C-234
SUBJECT STABILITY COMPUTATIONS

HORIZONTAL FORCES

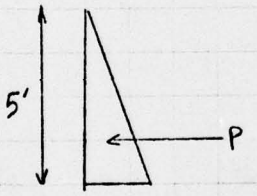
WATER (UPSTREAM)



$$P = \frac{46^2 \times 62.4\#/cf}{2}$$

$$= 66{,}019\#$$

WATER (DOWNSTREAM



$$P = \frac{5^2 \times 62.4\#/cf}{2}$$

$$= 780\#$$

ACTIVE EARTH PRESSURE

$$\frac{.2948(.6)(110)(1.5)^2}{2}$$

$$= 22\#$$

PASSIVE EARTH PRESSURE

$$= \frac{.6(110)(5)^2(3.39)}{2}$$

$$= 2797\#$$

BY L.B. DATE AUG '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 87 OF

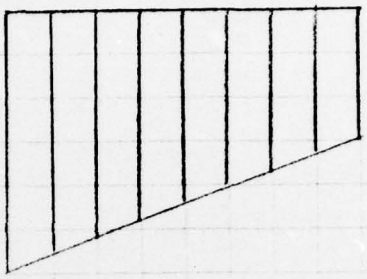
CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

UPLIFT PRESSURE

UPSTREAM

$46' \times 62.4 = 2870\ \#/ft^2$



DOWNSTREAM

$5 \times 62.4 = 312$

TOTAL UPLIFT PRESSURE $= \left(\frac{2870+312}{2}\right) 25$

$= 39,775\ \#$

FACTOR OF SAFETY AGAINST SLIDING

$$= \frac{0.75\ (105 - 39.8)}{66 - .78 + .022 - 2.8}$$

$= .78$ N.G.

BY L.B. DATE AUG '79 | **LOUIS BERGER & ASSOCIATES INC.** | SHEET NO. B8 OF.
CHKD. BY H.M. DATE | CANISTEAR RESERVOIR #2 | PROJECT C-234
SUBJECT STABILITY COMPUTATIONS

FACTOR OF SAFETY AGAINST OVERTURNING

TAKE MOMENTS ABOUT 'x'

LOAD		ARM	MOMENT
SECTION ①	6.720 K	18.5	124.32
SECTION ②	92.16 K	14.94	1,376.87
SECTION ③	.010 K	24.96	.25
SECTION ④	3.370 K	24	80.9
SECTION ④'	1.87 K	23.5	43.9
SECTION ⑤	.57 K	.69	.39
SECTION ⑥	.324 K	.69	.22
H_2O UPSTREAM	66.019 K	15.33	- 1012
H_2O DOWNSTREAM	.780 K	1.67	1.3
ACTIVE EARTH	.022	0.5	- 0.01
PASSIVE EARTH	2.8	1.67	4.68
UPLIFT PRESSURE	39.8	15.85	- 631

OVERTURNING MOMENT = 1643

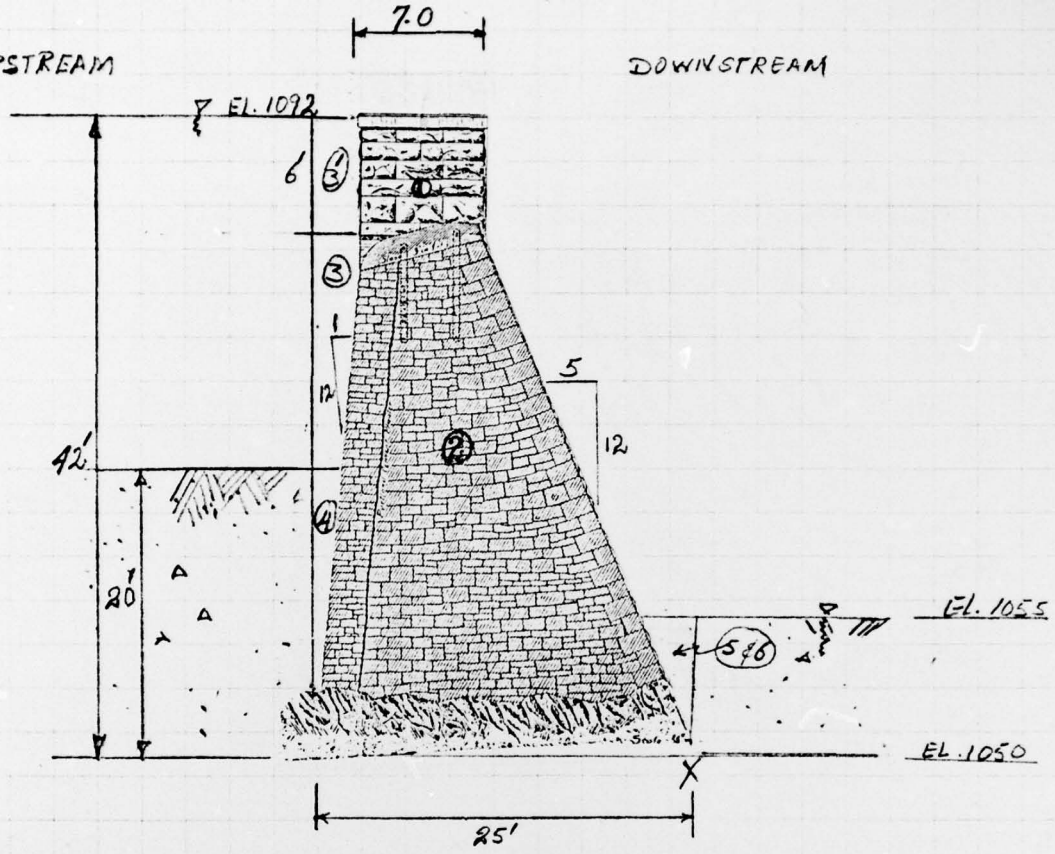
STABILIZING MOMENT 1633

F.S. = 1633/1643 = .99 N.G.

BY HLM DATE 8/29 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 29 OF

CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS



CONSIDER ALL FORCES PER FOOT OF DAM.

① $6' \times 7' \times 160^{\#/CF}$ = 6720#

② $\frac{1}{2}(36')(25+7.0') \times 1' \times 160^{\#/CF}$ = 92,160#

③ $\frac{1}{2}(36') \times 62.4^{\#/CF} \times 3'$ = 3370#

④ $6' \times 3' \times 62.4^{\#/CF}$ = 1123#

⑤ $20' \times 110^{\#/CF} \times \frac{1}{2} \times 1.66$ = 1826#

⑥ $5' \times 110^{\#/CF} \times \frac{1}{2} \times 2.08$ = 572#

⑥ $5' \times 62.4^{\#/CF} \times \frac{1}{2} \times 2.08$ = 324#

106,095#

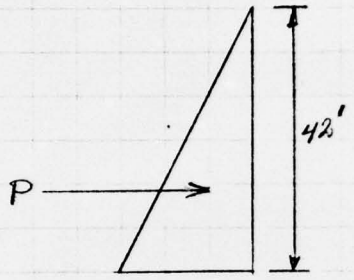
BY H.M. DATE 8/17 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B-10 OF

CHKD. BY L.B. DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

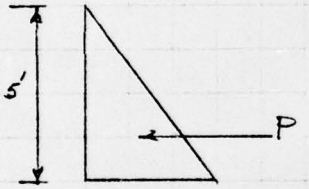
HORIZONTAL FORCES

WATER (UPSTREAM)



$$P = \frac{42^2 \times 62.4^{\#/CF}}{2} = 55{,}037^{\#}$$

WATER (DOWNSTREAM)



$$P = \frac{5^2 \times 62.4^{\#/CF}}{2} = 780^{\#}$$

ACTIVE EARTH PRESSURE

$\phi = 33^\circ \quad K_p = 0.2948$

$$\frac{.6(110)(.2948)(20)^2(1)}{2} = 3{,}891^{\#}$$

PASSIVE EARTH PRESSURE

$\phi = 33^\circ \quad K_p = 3.39$

$$\frac{.6(110)(5)^2(1)(3.39)}{2} = 2797^{\#}$$

BY H.III DATE 8/79

CHKD. BY _____ DATE _____

SUBJECT STABILITY COMPUTATIONS

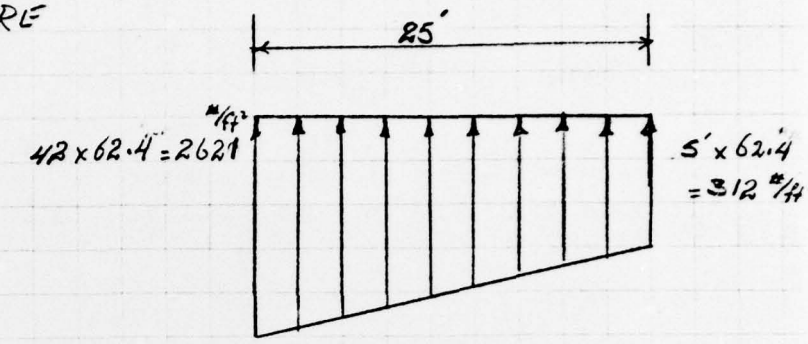
LOUIS BERGER & ASSOCIATES INC.

CANISTEAR RESERVOIR #2

SHEET NO. B-11 OF _____

PROJECT C-234

UPLIFT PRESSURE



TOTAL UPLIFT

$$= \left(\frac{2621 + 312}{2}\right) 25 = 36662^{\#}$$

FACTOR OF SAFETY AGAINST SLIDING

ASSUMING COEFF. OF FRICTION = 0.75 see page 240 small dams.

$$\frac{0.75(106.1 - 36.7)}{55 - .78 + 3.89 - 2.8}$$

$$= .94 \text{ N.G.}$$

BY H.M. DATE 8/79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B12 OF

CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

FACTOR OF SAFETY AGAINST OVERTURNING

TAKE MOMENTS ABOUT 'X'

	LOAD	ARM	MOMENT
SECTION ①	6.72^k	18.5	124.32
SECTION ②	92.16^k	14.94	1376.87
SECTION ③	3.37^k	24.00	80.90
SECTION ④	1.12^k	23.5	26.32
SECTION ⑤	1.83^k	24.5	44.65
SECTION ⑥	.57^k	.69	.40
	.324^k	.69	.22
H_2O UPSTREAM	55.04^k	14.00	-770.56
H_2O DOWNSTREAM	.78^k	1.67	1.30
ACTIVE EARTH	3.9^k	6.67	-26.01
PASSIVE EARTH	2.8^k	1.67	4.67
UPLIFT	36.7	15.78	-579.13

OVERTURNING MOMENT = 1376

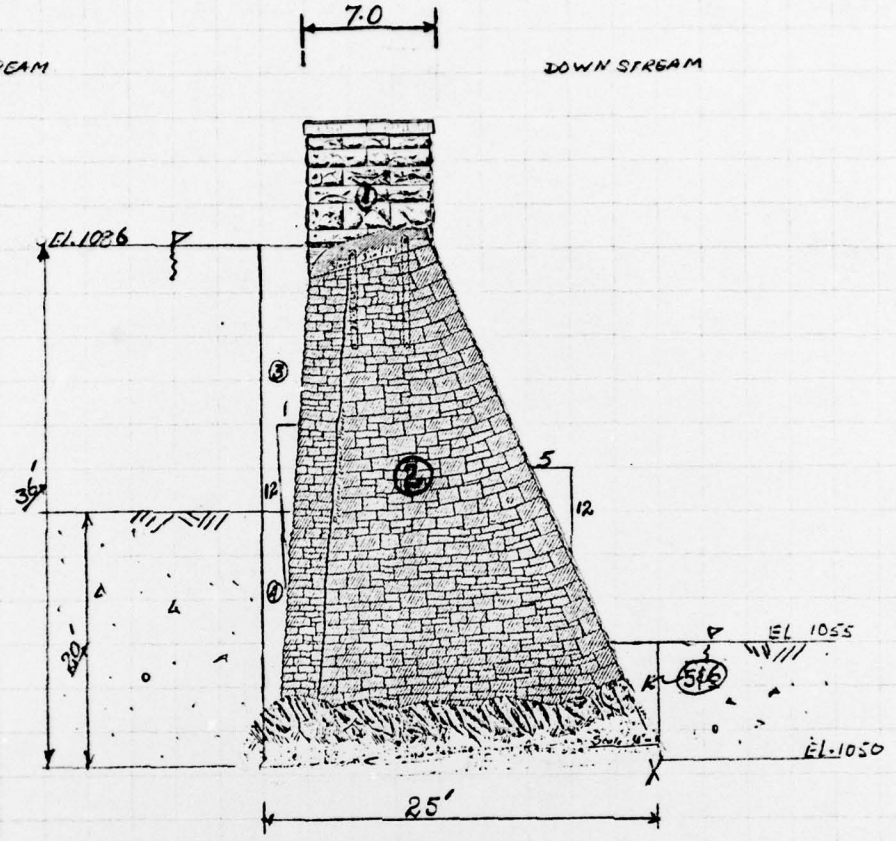
STABILIZING MOMENT = 1660

$F.S = \frac{1660}{1376} = 1.21$ N.G.

BY. H.M. DATE 8/79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 013 OF.

CHKD. BY L.G. DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS



CONSIDER ALL FORCES PER FOOT OF DAM

①	$6' \times 7' \times 160^{\#/CF}$	$= 6720^{\#}$
②	$\frac{1}{2}(36')(25'+7') \times 1' \times 160^{\#/CF}$	$= 92{,}160^{\#}$
③	$\frac{1}{2}(36') \times 62.4^{\#/CF} \times 3'$	$= 3370^{\#}$
④	$20' \times 110^{\#/CF} \times \frac{1}{2} \times 1.66$	$= 1826^{\#}$
⑤	$5' \times 110^{\#/CF} \times \frac{1}{2} \times 2.08$	$= 572^{\#}$
⑥	$5' \times 62.4^{\#/CF} \times \frac{1}{2} \times 2.08$	$= 324^{\#}$
		$104{,}972.^{\#}$

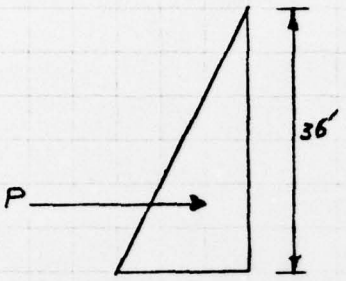
BY H.A. DATE 8/24 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. B14 OF

CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-23A

SUBJECT STABILITY COMPUTATIONS

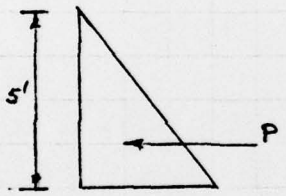
HORIZONTAL FORCES

WATER (UPSTREAM)



$$P = \frac{36^2 \times 62.4^{\#/CF}}{2} = 40,435.^{\#}$$

WATER (DOWNSTREAM)



$$P = \frac{5^2 \times 62.4^{\#/CF}}{2} = 780^{\#}$$

ACTIVE EARTH PRESSURE.

$\phi = 35^\circ \qquad K_p = 0.2948$

$$\frac{.6(110)(0.2948)(20)^2(1)}{2} = 3891^{\#}$$

PASSIVE EARTH PRESSURE.

$\phi = 35^\circ \qquad K_p = 3.39$

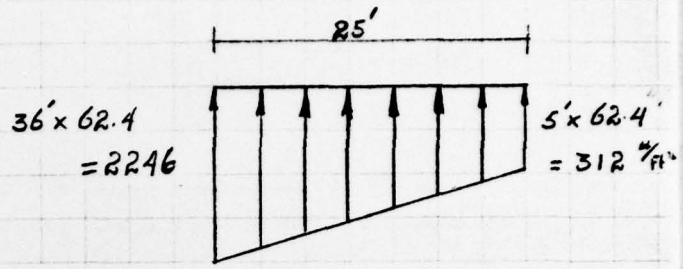
$$\frac{.6(110)(5)^2(3.39)(1)}{2} = 2797^{\#}$$

BY H. M. DATE 8/29 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 215 OF

CHKD. BY DATE CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

UPLIFT PRESSURE



TOTAL UPLIFT

$$= \frac{(2246 + 312)}{2} 25 = 31975^{\#}$$

FACTOR OF SAFETY AGAINST SLIDING

ASSUMING COEFF. OF FRICTION = 0.75 see page 240 small dams.

$$\frac{.75(105 - 32.0)}{40.43 - .78 + 3.89 - 2.8}$$

$$= 1.34 \text{ N.G.}$$

BY H.M. DATE 8/79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. 8/6 OF

CHKD. BY ____ DATE ____ CANISTEAR RESERVOIR #2 PROJECT C-234

SUBJECT STABILITY COMPUTATIONS

FACTOR OF SAFETY AGAINST OVERTURNING

TAKE MOMENTS ABOUT 'X'

	LOAD	ARM	MOMENT
SECTION ①	6.72^k	18.5	124.32
SECTION ②	92.16^k	14.94	1376.87
SECTION ③	3.37^k	24.00	80.90
SECTION ④	1.83^k	24.4	44.65
SECTION ⑤	.57^k	.69	.40
SECTION ⑥	.324^k	.69	.22
H_2O UPSTREAM	40.43^k	12.00	−485.16
H_2O DOWNSTREAM	.78^k	1.67	1.30
ACTIVE EARTH	3.9^k	6.67	−26.01
PASSIVE EARTH	2.8^k	1.67	4.67
UPLIFT	31.97^k	15.64	−500.01

OVERTURNING MOMENT = 1011.2

STABILIZING MOMENT = 1653.33

$$F.S = \frac{1633.33}{1011.2} = 1.62 \quad O.K$$