# Phase I Inspection Report

## Beaver Dam Lake

Hudson River Basin, Orange County, New York

Inventory No. 619

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### SUPPLEMENTARY NOTES

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### KEY WORDS

- Dam Safety
- National Dam Safety Program
- Visual Inspection
- Hydrology, Structural Stability

### ABSTRACT

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Examination of available documents and a visual inspection of the dam and the appurtenant structures did not reveal conditions which constitute an immediate hazard to human life or property. However, the dam has some deficiencies which require further investigation and remedial action.

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**Security Classification of This Page:** UNCLASSIFIED
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Using Corps of Engineers screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 37 percent of Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate" spillway is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

On the basis of stability analysis performed during the investigation the structural stability of the spillway section against overturning was determined to be inadequate for all cases except the normal loading with and without earthquake. Also, the sliding stability is inadequate for all loading conditions.

It is, therefore, recommended that within three months from the date of notification to the owner, detailed hydrological hydraulic investigations of the structure should be undertaken to more accurately determine the specific characteristics of the watershed and their affect upon the overtopping potential of the dam. At the same time, further analysis of the structural stability of the spillway should be performed. Analysis should include field investigations to obtain more information regarding the extent and magnitude of uplift pressures under the base of the spillway, the quality of the foundation materials, the geometry of the spillway structure, and the condition of the masonry and concrete. Within twelve months of the date of notification to the owner, modifications to the structure, deemed necessary as a result of studies, should have been completed. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

In addition, the dam has a number of problem areas which, if left uncorrected, have the potential for the development of hazardous conditions and must be corrected within twelve months.

1. Repair and also provide controls for the reservoir drains.

2. Monitor, bi-weekly, the seepage at the downstream face of the spillway.

3. Determine the source of seepage occurring downstream of the east buttress toe. Monitor the seepage bi-weekly with the aid of weirs.

4. Repair spalled areas at the crest and downstream face of the dam.

5. Repair the upstream face of dam and spillway training walls pointing.

6. Repair the right and middle training walls.

7. Repair cracks at the right spillway training wall.

8. Remove vegetation from the crest of spillway, slope, and toe of dam. Provide a program of periodic cutting and mowing of the buttress surfaces.
HUDSON RIVER BASIN

BEAVER DAM LAKE

ORANGE COUNTY, NEW YORK

INVENTORY NO. N.Y. 619

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NEW YORK DISTRICT CORPS OF ENGINEERS

AUGUST 1980

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Hudson River Basin
National Dam Safety Program

BEAVER DAM LAKE

Orange County, New York
(INVENTORY NO. N.Y. 619)
Hudson River Basin
Orange County, New York

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DRICW51-79-C-0001

NEW YORK DISTRICT CORPS OF ENGINEERS
AUGUST 1980
This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations.Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C., 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

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

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. 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.
NATIONAL DAM SAFETY PROGRAM
BEAVER DAM LAKE
I.D. NO.: N.Y. 619
D.E.C. #502
HUDSON RIVER BASIN
ORANGE COUNTY, NEW YORK
PHASE I INSPECTION REPORT

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PHASE I REPORT
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Name of Dam: Beaver Dam Lake (I.D. No. 619)
State Located: New York
County Located: Orange
Stream: Tributary of Moodna
Basin: Hudson River
Date of Inspection: April 24, 1980

ASSESSMENT

Examination of available documents and a visual inspection of the dam and the appurtenant structures did not reveal conditions which constitute an immediate hazard to human life or property. However, the dam has some deficiencies which require further investigation and remedial action.

Using Corps of Engineers screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 37 percent of Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate" spillway is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

On the basis of stability analysis performed during the investigation the structural stability of the spillway section against overturning was determined to be inadequate for all cases except the normal loading with and without earthquake. Also, the sliding stability is inadequate for all loading conditions.

It is, therefore, recommended that within three months from the date of notification to the owner, detailed hydrological hydraulic investigations of the structure should be undertaken to more accurately determine the site specific characteristics of the watershed and their affect upon the overtopping potential of the dam. At the
same time, further analysis of the structural stability of the spillway should be performed. Analysis should include field investigations to obtain more information regarding the extent and magnitude of uplift pressures under the base of the spillway, the quality of the foundation materials, the geometry of the spillway structure, and the condition of the masonry and concrete. Within twelve months of the date of notification to the owner, modifications to the structure, deemed necessary as a result of studies, should have been completed. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

In addition, the dam has a number of problem areas which, if left uncorrected, have the potential for the development of hazardous conditions and must be corrected within twelve months.

1. Repair and also provide controls for the reservoir drains.

2. Monitor, bi-weekly, the seepage at the downstream face of the spillway.

3. Determine the source of seepage occurring downstream of the east buttress toe. Monitor the seepage bi-weekly with the aid of weirs.

4. Repair spalled areas at the crest and downstream face of the dam.

5. Repair the upstream face of dam and spillway training walls pointing.

6. Repair the right and middle training walls.

7. Repair cracks at the right spillway training wall.

8. Remove vegetation from the crest of spillway, slope, and toe of dam. Provide a program of periodic cutting and mowing of the buttress surfaces.
9. Provide a program of periodic inspection and maintenance of the dam and appurtenances, including yearly operation and lubrication of the reservoir drain systems. Document this information for future reference. The aforementioned emergency action plan should be maintained and updated periodically during the life of the structure.

Eugene O'Brien, P.E.
New York No. 29823

Col. W.M. Smith, Jr.
New York District Engineer

Date: 11 Sep 98
SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

The Phase I inspection reported herein was authorized by the State of New York, Department of Environmental Conservation, by letter dated 7 January 1980, in fulfillment of the requirements of the National Dam Inspection Act, Public Law 92-367, 8 August 1972.

b. Purpose of Inspection

This inspection was conducted to evaluate the existing conditions of the dam, to identify deficiencies and hazardous conditions, to determine if these deficiencies constitute hazards to life and property, and to recommend remedial measures where required.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam

The Beaver Dam Lake, formerly known as Salisbury Mills Dam, consists of left and right non-overflow sections with an included spillway. The dam is about 335 feet long with a maximum height of about 35 feet. The width of the wall at its top, which is also the crest of dam, varies from 3.5 feet to 3.75 feet. According to available documents, the upstream face of the wall is vertical to a depth of 8'-6" below the crest, and battered upstream at a slope of about 9.6(V) to 1(H) below. The exposed upstream face of the wall is brick faced. The crest of the earth buttress varies from 1 foot to about 6 feet below the top of the wall. The crest width of the buttress averages about 7 feet. The exposed downstream wall at both wings is vertical. The slopes of the left and right earth buttresses average about 1(V) : 1.5(H) and 1(V) : 2.0(H), respectively. In some areas the slope is protected by loosely placed stones. According to available documents, the dam is founded on a "hard pan" (glacial till).

The principal spillway is an ungated masonry and concrete gravity structure which is divided into two sections by an 8-foot wide stepped brick pier. The left and right spillway sections are about 30 feet and 35 feet long, respectively. The crest of both sections of the spillway is about 7 feet below the top of the dam; the sill of both of the sections is about 6 feet wide. Downstream of the spillway weir wall is a stepped concrete apron about 30 feet long.
The 4.5 foot wide downstream right training wall of the spillway is straight and is brick (5 steps) and concrete (1 step). The 8.0 foot-wide middle brick pier is stepped. The left training wall is constructed of stone masonry and is sloped. There are no upstream training walls.

Discharge over the spillway and concrete apron flows into a natural channel and continues under a 10-foot high by 8-foot wide roadway (Lake Road) concrete culvert located about 500 feet downstream from the dam. The channel then joins the Moodna Creek which is a tributary of the Hudson River.

At the right abutment, where the dam ends, there is an 86-foot long, 4-foot wide concrete abutment wall which is upstream and perpendicular to the axis of the dam (North-South direction). The depth of wall below ground surface is unknown. At the south end of this wall a section about 12.5 feet wide and 4.8 feet high has been removed, probably to provide access to small boats; this opening acts as an auxiliary spillway. The sill of this auxiliary spillway is concrete. Discharges from the spillway will flow along the abutment into the downstream channel. The left abutment is in natural ground.

It is reported that there are 18-inch and 24-inch diameter reservoir drains located at the right and left spillway training walls, respectively. Discharges from the 18-inch conduit are controlled by a manually operated gate valve located at the upstream face of the dam. The type of control for the 24 inch outlet pipe is unknown. The inlet and outlet elevations of both pipes are unknown. The discharges from both outlets flow into the downstream spillway channel.

b. Location
The dam is located at the south end of Beaver Dam Lake, about 900 feet north of the junction of Lake Road and State Route 94, and north of Salisbury Mills in Orange County, New York.

c. Size Classification
The dam is 35 feet high and has a storage capacity of 1440 acre-feet and is therefore classified as an intermediate dam (between 1,000 and 50,000 acre-feet).

d. Hazard Classification
The dam is in the "high" hazard potential category because the town of Salisbury Mills, including several homes and a state highway, is about 500 feet downstream from the dam.

e. Ownership
The Beaver Dam Lake is owned by the County of Orange, Goshen, New York, 10924, telephone 914-294-7951. It is reported that the dam and reservoir was acquired from the Beaver Lake Association because of tax default.

f. Purpose of Dam
The impoundment provided by the dam is used for recreational purposes.
g. **Design and Construction History**
   
   The original design and construction records are not available. The exact date of the construction of the dam and contractor's name are unknown.

h. **Normal Operational Procedures**
   
   Lake level is maintained at the crest of the right spillway section, depending upon the inflow into the lake. At present, outflow from the lake is over the ungated spillway only. The two reservoir drains are not in operating condition and reportedly have not been used for several years.

### 1.3 PERTINENT DATA

<table>
<thead>
<tr>
<th>a. Drainage Area, square miles</th>
<th>9.25</th>
</tr>
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<tbody>
<tr>
<td>b. Discharge at Dam, cfs</td>
<td></td>
</tr>
<tr>
<td>Maximum known flood at site</td>
<td>Unknown</td>
</tr>
<tr>
<td>Ungated Spillway at Maximum Pool</td>
<td>3910</td>
</tr>
<tr>
<td>Ungated Auxiliary Spillway at Max. Pool</td>
<td>750</td>
</tr>
<tr>
<td>Regulating Outlets at Maximum Pool</td>
<td></td>
</tr>
<tr>
<td>18 Inch Diameter Pipe</td>
<td>Inoperable</td>
</tr>
<tr>
<td>24 Inch Diameter Pipe</td>
<td>Inoperable</td>
</tr>
<tr>
<td>c. Elevation (feet above MSL)</td>
<td></td>
</tr>
<tr>
<td>Top of Dam, feet</td>
<td>338.0</td>
</tr>
<tr>
<td>Spillway, feet</td>
<td>331.0</td>
</tr>
<tr>
<td>Auxiliary Spillway, feet</td>
<td>333.3</td>
</tr>
<tr>
<td>Streambed at Centerline of Dam</td>
<td>Unknown</td>
</tr>
<tr>
<td>d. Reservoir</td>
<td></td>
</tr>
<tr>
<td>Length of Normal Pool, feet</td>
<td>4200</td>
</tr>
<tr>
<td>Surface Area of Maximum Pool, acres</td>
<td>183.3</td>
</tr>
<tr>
<td>Surface Area of Normal Pool, acres</td>
<td>164.0</td>
</tr>
<tr>
<td>e. Storage, acre-feet</td>
<td></td>
</tr>
<tr>
<td>Spillway Crest</td>
<td>1440</td>
</tr>
<tr>
<td>Top of Dam</td>
<td>2644</td>
</tr>
<tr>
<td>f. Dam</td>
<td></td>
</tr>
<tr>
<td>Type: Concrete wall with Earth Buttress</td>
<td></td>
</tr>
<tr>
<td>Length: 335 feet + (140 feet left section and 195 feet right section)</td>
<td></td>
</tr>
<tr>
<td>Height: 35 feet +</td>
<td></td>
</tr>
<tr>
<td>Crest Width: Varies between 3.5 feet and 3.75 feet (concrete wall)</td>
<td></td>
</tr>
<tr>
<td>Side Slopes: Upstream: Vertical and 9.6V : 1H</td>
<td></td>
</tr>
<tr>
<td>Downstream: Vertical 1V : 1.5H (left section) and 1V : 2H (right section)</td>
<td></td>
</tr>
</tbody>
</table>
g. Spillways

Principal Spillway:
Type: uncontrolled masonry and concrete spillway
      divided into two sections, 30.0 feet and 35 feet,
      by a stepped brick pier.
Auxiliary Spillway (opening in abutment wall):
Type: uncontrolled, 12.5 feet wide and 4.8 feet high,
      opening at right abutment wall. Crest width
      4.0 feet.

h. Reservoir Drains

According to available documents the dam has two
reservoir drains; an 18 inch and a 24 inch pipe, located at the
inside face of the left and right training walls of the spill-
way, respectively. The drains have not been used for several
years and are not in operating condition. The discharge through
the 18 inch pipe is controlled by a manually operated gate valve
located at the upstream face of the right training wall of the
spillway. There exists no control for the 24 inch pipe.
SECTION 2 - ENGINEERING DATA

2.1 GEOLOGY

Beaver Dam is located in the Hudson Lowlands physiographic province of New York State. These lowland areas have gentle relief and are underlain by Ordovician shales that have been exposed by the erosion of overlying Silurian and Devonian limestones. Beaver Dam Lake lies principally in the black, Snake Hill shale of the Trenton Group. A reverse fault follows the northeast border of the lake, with the northern, upthrust block composed of undifferentiated carbonates of the Stockbridge Group. (Ref. 8).

2.2 SUBSURFACE INVESTIGATION

No subsurface investigation could be located for the project. However, surficial soils in the vicinity of the dam are of the Boynton-Albia Association (Refs. 9 and 10). These soils, found in the depressions and broad drainage channel areas of the Hudson Lowland province, are developed from till derived from slate and sandstone. The resistant sandstone persists as stones in the till.

The Boynton, making up 40 to 80% of the area, is commonly stony to very stony, deep to bedrock and poorly drained on a 0 to 3% slope. The Albia, from 0 to 50% of the area, is commonly stony, deep to bedrock, and somewhat poorly drained on a 0 to 8% slope. (Refs. 9 and 10).

2.3 DESIGN RECORDS

There are no design data, construction drawings or design memoranda available for the project features. A document dated 1912 was obtained from the New York Department of Environmental Conservation, and is given in Appendix B. The document has information regarding the dam and the spillway, and was used in determining the section of the spillway.

2.4 CONSTRUCTION RECORDS

Records of original construction are not available for the project.

2.5 OPERATION RECORDS

There are no records of operation of the dam. The regulating outlets at the dam have not been in operating condition for many years. There is no formal operation and maintenance manual for the project. No records of reservoir levels and rainfall have been kept.

2.6 EVALUATION OF DATA

Information was made available by the New York State Department of Environmental Conservation and the County of Orange, New York.

- 5 -
The information obtained from the available data, the personal interviews and the visual inspection is considered adequate for this Phase I inspection and evaluation.
SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

A visual inspection of Beaver Dam Lake was made on Thursday, April 24, 1980. At the time of inspection, the reservoir level was about El 331.5, four inches above the crest of the right spillway section. Only a small quantity of flow was trickling over the left spillway section. The weather was sunny and temperature between 65 and 70° F.

b. Dam

The dam, which consists of a concrete wall and downstream earth buttress, appears to be in generally adequate condition. There are no visible signs of distress or movement. The alignment of the crest is good. The edge of the downstream crest is heavily spalled at several locations.

The upstream brick facing is in good condition above the water line except at several locations where the mortar at the joints is loose and missing. The downstream face of the wall is heavily spalled, particularly at the east wing of the dam (See Photograph 12).

Both wings of the downstream earth buttress are in good condition and show no signs of sloughing, erosion or cracking. At about 40 feet downstream of the left wing buttress there is a saturated area caused by seepage. The source of the seepage could not be determined (See Photograph 1). Both wings of buttress are covered with vegetation including large trees, bushes, sapling and grass. (See Photographs 3 and 4).

The loose stone on the downstream face is in satisfactory condition.

c. Spillway

Visual inspection of the right section of the spillway could not be carried out because of water flowing at the time. However, it was reported that the section is in generally good condition. The left section of the spillway is in satisfactory condition. There is minor seepage through the masonry joints of the stepped face of the spillway weir. There is some vegetation including a tree at the crest and the downstream face of the weir.

At several locations at the spillway training walls there are signs of serious deteriorations due to frost action. The bricks and mortar at the masonry joints, particularly at the right and the middle training walls, are loose and missing. There are few minor cracks at the right training wall.

The emergency spillway is in good condition.
d. **Appurtenant Structures**

The 18-inch reservoir drain at the right spillway training wall could not be located, however, its regulating gate is in poor condition. The gate stem is broken and frozen into the base of the hoist support. The upper portion of the hoist is non-existent. Only the downstream end of the 24-inch reservoir drain is visible; the gate hoist for this outlet could not be located and was reported to be non-existent.

e. **Abutments**

There are no signs of seepage or other unusual conditions at both abutments. At the right abutment, natural ground downstream of the concrete wall appears to be eroded to a depth of 3 feet. This erosion could have been caused by past overtopping of the dam.

f. **Downstream Channel**

The channel downstream of the spillway is the natural streambed. Although the channel contains natural vegetation, including large trees, saplings, and grass, its present condition would not impede discharges from the spillway.

g. **Reservoir Area**

In the vicinity of the dam there is no evidence of sloughing, potentially unstable slopes or other unusual conditions which would adversely affect the dam. No evidence of excessive sedimentation was observed. The reservoir water was relatively clean.

3.2 **EVALUATION OF OBSERVATIONS**

Visual observations made during the course of the investigation reveal several deficiencies which should be corrected before further deterioration leads to a hazardous condition. The deficiencies are:

a. Both reservoir drains and its controls should be made operable.

b. Inspect on a bi-weekly interval to determine if seepage quantities are increasing through the joints at the downstream face of the spillway.

c. Determine the source of seepage occurring downstream of the east buttress toe. Monitor the seepage bi-weekly with the aid of weirs.

d. Spalled areas at the crest and the downstream face of the concrete wall should be repaired.

e. Loose and missing pointing at the upstream face of the dam and the spillway training walls should be repaired.
f. The right and the middle spillway training walls should be repaired.

g. The cracks at the right spillway training wall should be repaired.

h. The brush and trees should be removed from the crest and the downstream face of the left spillway section and from the crest, the slopes of the buttress, and the downstream toe area. Provide a program of periodic cutting and moving of the buttress surface.

i. A program of periodic inspections and maintenance of the dam and appurtenances, including yearly operation and lubrication of all gates should be established. This information should be documented for future reference. The emergency action plan described in Section 7.1d should be maintained and updated periodically during the life of the structure.
SECTION 4 - OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

There are no operating procedures for regulating the discharges. Flow is discharged over the ungated spillway. The lake is generally at the level of the spillway crest during most of the year.

The reservoir drains of the dam are inoperable and have not been operated for many years.

4.2 MAINTENANCE OF DAM AND SPILLWAYS

The presence of undesirable vegetation on the downstream face of the dam and at the spillway, inoperative reservoir drains and deterioration of spillway training walls and concrete wall of the dam indicates that no regular maintenance has been performed for many years. This was also reported by Mr. Dougherty, representative of the owner. According to available records at the New York State Department of Environmental Conservation, the dam was inspected in 1973 and 1978.

4.3 WARNING SYSTEM IN EFFECT

There is no warning system in effect or in preparation.

4.4 EVALUATION

The overall maintenance of the Beaver Dam Lake is considered to be inadequate with respect to the following areas:

a. Control of vegetation on the buttress of the dam and at the spillway.

b. Maintenance of the spillway training walls and the concrete wall of the dam.

c. Maintenance of the regulating gates and reservoir drains.
SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 DRAINAGE AREA CHARACTERISTICS

Beaver Dam Lake is located north of Salisbury Mills in Orange County, New York. (Hydrologic Unit Code 02020008). The total drainage area contributing to the lake is about 9.25 square miles, with a reservoir surface area of about 164 acres at EL 331. The drainage basin length to width ratio is approximately 5 to 1, with fairly steep slopes rising from lake EL 331 to ridges above EL 600.

5.2 ANALYSIS CRITERIA

The analysis of the spillway capacity of this dam was performed using the Corps of Engineers HEC-1 computer program for Dam Safety Investigations (Ref. 1). The Snyder's coefficients of 2.11 and 320 for Ct and 640 Cp, respectively, were obtained from a report on the Lower Hudson River Basin (Ref. 2). The Probable Maximum Precipitation (PMP) was taken from Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, U.S. East of the 105th Meridian", (Ref. 4). In accordance with the recommended guidelines (Ref. 7), the adequacy of the spillway was analyzed using the Probable Maximum Flood (PMF).

5.3 SPILLWAY CAPACITY

The principal masonry and concrete spillway is an ungated 65 foot long structure and is divided into 30 and 35 foot sections by an 8 foot wide stepped brick pier. The depth from the top of dam to the crest of both sections is about 7 feet. The sill of both sections is about 6 feet wide. Downstream portion of the spillway is a stepped concrete apron chute about 30 feet long.

The computed maximum spillway discharge at EL 338 (top of dam) is 3910 cfs. The two reservoir drains are inoperable.

5.4 RESERVOIR CAPACITY

The normal storage capacity of Beaver Dam Lake is listed as 1440 acre-feet (Ref. 5). The surcharge storage between the spillway crest, EL 331, and top of dam, EL 338, is 1204 acre-feet which is equivalent to 2.44 inches of runoff over the entire basin. The total or maximum capacity of the lake at EL 338 is 2644 acre-feet.

5.5 FLOODS OF RECORD

There are no records available of floods or maximum lake elevations.
5.6 OVERTOPPING POTENTIAL

The potential of the dam being overtopped was investigated on the basis of the spillway discharge capacity and the available surcharge storage to meet the selected design flood inflows.

The Probable Maximum Flood (PMP) routed through the lake causes the lake surface to rise to El 340.5, 2.5 feet above the top of the dam. The computed PMF peak inflow and outflow discharges were 10,600 cfs and 10,395 cfs, respectively. The one-half Probable Maximum Flood routed through the lake caused the lake surface to rise to El 338.50, 0.50 feet above top of the dam. The peak outflow discharge was 4765 cfs.

Using the Corps of Engineers Criteria the maximum spillway capacity without overtopping the dam is 37 percent of PMF peak outflow.

5.7 EVALUATION

The dam does not have sufficient spillway capacity to pass either the PMF or one-half the FMF without overtopping the dam. The overtopping could cause the failure of the dam thus significantly increasing the hazard to the loss of life downstream. Therefore, the spillway is assessed as being "seriously inadequate".
SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations
   Visual observations did not indicate either existing or potential problems with the dam and the spillway structures. The observed seepage downstream of the left buttress toe and at the spillway; and deterioration of the spillway training walls are not considered to represent an unstable or otherwise dangerous condition.

b. Design and Construction Data
   There exists no design computation or other data regarding the structural stability of the dam and the spillway. There is a document dated 1912 (See Appendix B) which shows the section of the dam, plan and section of spillway.

c. Stability Analysis
   Since there are no contract drawings or documents available showing the full geometry, the extent of the spillway section, and the foundation conditions, the primary source of structural and subsurface information used in the stability analysis is as follows:

   1. The downstream surface geometry of the exposed spillway structure was measured during the inspection using approximate methods (See sketch of spillway section given in Appendix A).

   2. The other geometry of non-exposed spillway structure and subsurface information was obtained from the documents described in Paragraph 6.1b.

The following table shows the results of the structural stability analysis of the spillway section. The computations for the stability analysis are given in Appendix F

<table>
<thead>
<tr>
<th>Case</th>
<th>Overturning</th>
<th>Sliding Factor of Safety (See Appendix F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Normal Loading with reservoir level at spillway crest; no ice load</td>
<td>Inside middle third of base</td>
<td>1.35</td>
</tr>
<tr>
<td>b. Normal Loading with reservoir level at Spillway Crest with ice load</td>
<td>1.21 feet outside middle third of base</td>
<td>1.13</td>
</tr>
<tr>
<td>c. Unusual Loading; water flowing over the spillway at depth of 7.5 feet (one-half PMF)</td>
<td>4.2 feet outside middle half of base</td>
<td>0.69</td>
</tr>
<tr>
<td>d. Extreme Loading; water flowing over the spillway at depth of 9.5 feet (PMF)</td>
<td>7.3 feet outside middle half of base</td>
<td>0.57</td>
</tr>
</tbody>
</table>
The results of the structural analysis indicates that the spillway section against overturning is inadequate for all cases except for case a and e. Also, the sliding stability is inadequate for all loading cases.

Since there is a lack of information regarding the exact geometry of the dam, foundation conditions and the extent and magnitude of the uplift pressure under the spillway, the structural stability of the spillway could not be accurately assessed with any reliability. It is, therefore, recommended that, along with the spillway adequacy studies, a more detailed structural stability analysis be performed. Field investigations should be carried out to obtain additional information regarding the uplift pressure within and under the base of the spillway; the quality of the foundation; the geometry and extent of the spillway structure; and the condition of the non-exposed masonry and concrete. The information should then be incorporated into a more detailed structural stability evaluation.

d. Operation Records
There are no records of the regulating gate operation.

e. Post-Construction Changes
There are no recorded post-construction changes.

f. Seismic Stability
The dam is located in the Seismic Zone 1 in accordance with Phase I recommended guidelines. However, based on the past earthquake experiences in the area, the New York State Geological Survey considers the area to be in the Seismic Zone 2. Based on this assessment the dam is considered in the Seismic Zone 2. The results of seismic stability are described in Section 6.1c.
SECTION 7 - ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety

Examination of the available documents and visual inspections of the Beaver Dam Lake and appurtenant structures did not reveal any conditions which are considered to be hazardous.

Using the Corps of Engineers screening criteria for review of spillway adequacy, it has been determined that the dam would be overtopped for all storms exceeding approximately 37 percent of the PMF. The overtopping of the dam could cause the erosion of the downstream face of the dam resulting in dam failure, increasing the hazard to loss of life downstream. The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe", applied to a dam because of a "seriously inadequate spillway", is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

d. Adequacy of Information

The information and data available were adequate for performance of this investigation, except as noted in Section 6.1c.

c. Need for Additional Investigations

Since the spillway is considered to be "seriously inadequate", additional hydrologic/hydraulic investigations are required to more accurately determine the site specific characteristics of the watershed. After the in-depth hydrologic/hydraulic investigations have been completed, remedial measures must be initiated to provide spillway capacity sufficient to discharge the outflow from the 1/2 PMF event. In addition, an investigation of the structural stability of the spillway portion of the dam is required.
d. **Urgency**

The additional hydrologic/hydraulic investigations and the stability investigation which are required must be initiated within 3 months from the date of notification. Within 1 year of notification, remedial measures as a result of these investigations must be initiated, with completion of these measures during the following year. In the interim, develop an emergency action plan for the notification of downstream residents and proper governmental authorities in the event of overtopping, and provide round-the-clock surveillance of the dam during periods of extreme run-off. The other problem areas listed below must be corrected within 1 year from notification.

7.2 **RECOMMENDED MEASURES**

The following are the recommended measures:

a. Both the reservoir drains and its controls should be made operable.

b. Monitor, bi-weekly, to determine if seepage quantities are increasing through the joints at the downstream face of the spillway.

c. Determine the source of seepage occurring downstream of the east buttress toe. Monitor the seepage bi-weekly with the aid of weirs.

d. Spalled areas at the crest and the downstream face of the wall should be repaired.

e. Loose and missing pointing at the upstream face of the dam and the spillway training walls should be repaired.

f. The right and middle training walls should be repaired.

g. The cracks at the right spillway training wall should be repaired.

h. The brush and trees should be removed from the crest and the downstream face of the left spillway section and the slopes of the buttress and the downstream toe area. Provide a program of periodic cutting and mowing of the buttress surface.

i. A program of periodic inspections and maintenance of the dam and appurtenances, including yearly operation and lubrication of all gates should be established. This information should be documented for future reference. The emergency action plan described in Section 7.1.d should be maintained and updated periodically during the life of the structure.
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NOTES:

1. Dimensions are based on rough measurements during inspection.

2. Depth and configuration below water line are assumed based on an available document dated 1912.
Fill out a form as complete as possible for each dam in your district and send to State Conservation Commission, Albany, N. Y.

1. Name and address of owners: J. Reynolds, Ransdell, Meadville

2. Date of construction: [illegible]

3. Uses of impounded water: [illegible]

4. Character of foundation bed: [illegible]

5. Material of waste spill: [illegible]

6. Length of waste and depth below dam: [illegible]

7. Total length of dam including waste: [illegible]

8. Material of dam: [illegible]

9. Discharges, size and location: [illegible]

Below sketch section of waste and section of dam, with greatest heights and top thickness and bottom thickness. On opposite side sketch general plan of dam and give distance from a bridge or from a tributary stream.
2. VIEWS OF UPSTREAM FACE OF DAM.
3. VIEW OF DOWNSTREAM FACE (LEFT SECTION) OF DAM. NOTE VEGETATION AT SLOPE AND SPILLWAY.

4. VIEW OF CREST AND DOWNSTREAM FACE (RIGHT SECTION) OF DAM. NOTE VEGETATION AT SLOPE.
5. VIEW OF DOWNSTREAM SPILLWAY CHANNEL. NOTE VEGETATION.

6. VIEW OF WALL AT RIGHT ABUTMENT. NOTE OPENING IN THE WALL WHICH SERVES AS AUXILIARY SPILLWAY.
7. VIEW OF DOWNSTREAM FACE OF SPILLWAY (LEFT SECTION). NOTE 24-INCH RESERVOIR DRAIN AND MINOR VEGETATION AT MIDDLE PIER.

8. VIEW OF UPPER PORTION OF THE DOWNSTREAM FACE AND LEFT BRICK PIER OF SPILLWAY. NOTE VEGETATION AND CONDITION OF MASONRY.
9. VIEW OF REGULATING CONTROL FOR 18-INCH RESERVOIR DRAIN.

10. VIEW OF DOWNSTREAM FACE OF RIGHT ABUTMENT CONCRETE WALL. NOTE EROSION OF GROUND DUE TO OVERTOPPING OF DAM IN PAST.
11. VIEW OF SEEPAGE AT DOWNSTREAM FROM THE TOE OF DAM (LEFT SECTION).

12. VIEW OF DOWNSTREAM FACE (LEFT SECTION) OF DAM. NOTE DETERIORATION OF CONCRETE.
VISUAL INSPECTION CHECKLIST

APPENDIX D
VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam BEAVER DAM LAKE
Fed. I.D. # 619 DEC Dam No. 502
River Basin HUDSON
Location: Town SALISBURY MILLS County ORANGE
Stream Name MOODNA CREEK
Tributary of HUDSON RIVER
Latitude (N) 41° 26' Longitude (W) 74° 07' 30"
Type of Dam MASONRY FACE CONCRETE AND EARTH FILL BUTTRESS
Hazard Category HIGH
Date(s) of Inspection 4-23-80
Weather Conditions SUNNY 70°F
Reservoir Level at Time of Inspection 331.5

b. Inspection Personnel TONY DOLCIMASCOLO AND JYOTINDRA PATEL

c. Persons Contacted (Including Address & Phone No.)

MR. ROBERT DOUGHERTY, PRINCIPAL ENGINEER
DEPT OF PUBLIC WORKS, ORANGE COUNTY, P.O. BOX 507,
GOSHEN NEW YORK 10924
TEL NO. (914) 294-7951

d. History:
Date Constructed UNKNOWN Date(s) Reconstructed ____________

Designer UNKNOWN
Constructed By UNKNOWN
Owner UNKNOWN

** From Available records (see Appendix) of 1912-1913 indicates it is constructed before these dates.**
2) **Embankment — Downstream of Concrete Wall**

a. Characteristics

(1) Embankment Material ____________________________________________

(2) Cutoff Type  **NONE**

(3) Impervious Core  **NONE**

(4) Internal Drainage System  **NONE**

(5) Miscellaneous ______________________________________________

b. Crest  **Top of Concrete Wall with Brick Masonary at upstream face**

(1) Vertical Alignment  **(see structural comments)**

(2) Horizontal Alignment __________________________________________

(3) Surface Cracks ________________________________________________

(4) Miscellaneous ______________________________________________

c. Upstream Slope —

(1) Slope (Estimate) (V:H) _______________________________________

(2) Undesirable Growth or Debris, Animal Burrows __________________

(3) Sloughing, Subsidence or Depressions __________________________
(4) Slope Protection

(5) Surface Cracks or Movement at Toe

---
d. Downstream Slope

(1) Slope (Estimate - V:II) $1(V):2(H)$ on Right Wing and $1(V):1.5(H)$ on Left Wing.

(2) Undesirable Growth or Debris, Animal Burrows

(3) Sloughing, Subsidence or Depressions

(4) Surface Cracks or Movement at Toe

(5) Seepage

(6) External Drainage System (Ditches, Trenches; Blanket)

(7) Condition Around Outlet Structure

(8) Seepage Beyond Toe

---
e. Abutments - Embankment Contact

LEFT ABUTMENT - NATURAL GROUND

RIGHT ABUTMENT - NATURAL GROUND RETAINED BY COMPLETE WALL
(1) Erosion at Contact: None observed.

(2) Seepage Along Contact: None observed.

3) Drainage System: None.
   a. Description of System: 
   b. Condition of System: 
   c. Discharge from Drainage System: 

4) Instrumentation (Monumentation/Surveys, Observation Wells, Weirs, Piezometers, etc.): None
5) Reservoir

a. Slopes: VISIBLY SLOPES IN VICINITY OF DAM ARE IN
   GENERALLY STABLE CONDITION

b. Sedimentation: NO EVIDENCE OF EXCESSIVE SEDIMENTATION
   OBSERVED. LAKE WATER RELATIVELY CLEAR.

c. Unusual Conditions Which Affect Dam: NONE

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.): TOWN OF SALISBURY
   MILLS, AND ST. Rt 94, (ABOUT 500 FT FROM DAM

b. Seepage, Unusual Growth: NONE OTHER OBSERVED EXCEPT
   AS NOTE IN PAR. 4D. EMPAINTMENT - SEEPAGE

c. Evidence of Movement Beyond Toe of Dam: NONE OBSERVED

d. Condition of Downstream Channel: GOOD; SEVERAL LARGE TREES, HOWEVER
   WILL NOT IMPEDE DISCHARGE. MINOR DEBRIS.

7) Spillway(s) (Including Discharge Conveyance Channel)

   a. General: SPILLWAY CROSS SECTION IS STEPPED. AT TIME OF
      INSPECTION, ABOUT 4" OF WATER WAS FLOWING OVER
      RIGHT SPILLWAY. LEFT SPILLWAY TRICKLING. PRINCIPAL
      "EMERGENCY" SPILLWAY ARE UNCONTROLLED

   b. Condition of Service Spillway: CONDITION OF RIGHT SPILLWAY
      COULD NOT BE DETERMINED BECAUSE OF DISCHARGES FLOWING
      OVER IT. LEFT SPILLWAY IS IN SATISFACTORY CONDITION.
      AT CREST &
      DOWNSTREAM FACE OF WEIR SOME VEGETATION INCLUDING
      A SMALL TREE AT THE CONTACT BETWEEN THE CREST & LEFT SPILLWAY
      TRAINING WALL; MINOR SEEPAGE FROM THE MASONRY JOINTS.
      * ALSO SPILLWAY CHANNEL
c. Condition of Auxiliary Spillway

GOOD


d. Condition of Discharge Conveyance Channel

GOOD. THERE ARE SEVERAL LARGE TREES, HOWEVER, WILL NOT IMPede DISCHARGE. EMERGENCY SPILLWAY CHANNEL IN GOOD CONDITION, EXCEPT LARGE TREES.

ACCORDING TO AN AVAILABLE DOCUMENT (EXHIBIT 17) 18" φ WALLS. 24" φ OUTLET PIPE LOCATED AT EAST AND WEST SPILLWAY WALLS.

Type: Pipe    Conduit    Other

Material: Concrete    Metal    Other

Size: 18" φ & 24" φ    Lengths: Unknown

Invert Elevations: Entrance: Unknown    Exit: Unknown

Physical Condition (Describe): Unobservable

Material: 

Joints: 
Alignment

Structural Integrity:

Hydraulic Capability: CONTROL OF 24" / 18" φ   NOT VISIBLE.

OWNER DOES NOT HAVE THE OPERATING MECHANISM, THEREFORE CONDITION COULD NOT BE DETERMINED (18" φ) SEE COMMENTS [ ]

Means of Control: Gate    Valve    Uncontrolled

Operation: Operable    Inoperative    Other

Present Condition (Describe): VISIBLE SECTION A, 18" φ LINE IN FAIR CONDITION, MINOR CUSTODY.

LOCATION: OUTLET END OF 24" PIPE COULD NOT BE DETERMINED, LOCAL

LOCATION END OF 18" PIPE COULD NOT BE DETERMINED.
9) **Structural - Dam and Spillway.**

a. Concrete (Surfaces) **The brick masonry of the dam in generally good condition: minor cracks and loose mortar at joints. The complete portion (downstream face) heavily spalled particularly at the left side of the dam, some minor cracks observed. Spillway in satisfactory condition. (See comments below)**

b. Structural Cracking **No significant structural cracking visible on the dam's wall. Minor cracking at the upstream face of left training wall.**

c. Movement - Horizontal & Vertical Alignment (Settlement) **None observed.**

d. Junctions with Abutments or Embankments **Good condition.**

e. Drains - Foundation, Joint, Face **No drains.**

f. Water Passages, Conduits, Sluices **Spillway is overflow type. The condition of reservoir drain could not be determined.**

g. Seepage or Leakage **None observed.**

**The top of the spillway walls are seriously deteriorated.**
h. Joints - Construction, etc.  

SPALLING OF CONCRETE AT CONSTRUCTION JOINTS, OTHERWISE TIGHT

i. Foundation  

FOUNDATION NOT VISIBLE. HOWEVER, FROM AN AVAILABLE RECORD, THE DAM IS FOUNDED ON GLACIAL TILL (HARD PAN). SEE APPENDIX

j. Abutments  

RIGHT ABUTMENT DOWNSTREAM FACE CONCRETE WALL IS HEAVILY SPALLED.

k. Control Gates  

NO CONTROL GATES AT THE SPILLWAYS

l. Approach & Outlet Channels  

NONE

m. Energy Dissipators (Plunge Pool, etc.)  


n. Intake Structures  

NONE

o. Stability  

THERE ARE NO VISUAL INDICATIONS THAT SPILLWAY SHOWS ANY EVIDENCE OF STABILITY PROBLEMS

p. Miscellaneous  

EROSION OF FILL AT DOWNSTREAM FACE OF RIGHT ABUTMENT WALL INDICATES THAT DAM WAS OVERTOPPED. (SEE PHOTOGRAPH NO 10)
HYDROLOGIC DATA AND COMPUTATIONS

APPENDIX E
TAMS

Job No. 1551-07
Project BEAVER DAM PHASE I
Subject HYDROLOGIC/HYDRAULIC COMPUTATION

DRAINAGE BASIN AREA 2.98 SQMI
                           1907.2 Acres
LAKE AREA                0.16 SQMI
                           104.8 SQMI

INDEX RAINFALL
24 HR 200 SQMI  24.5"
6 HR 10 SQMI    26  106.1%
12 HR 10 SQMI   30  122.4%
24 HR "          33  134.7%
48 HR "          37  151.0%
## TAMS

**Job No.** 1551-07  
**Project** BEAVER DAM PHASE I INSPECTION  
**Subject** HYDROLOGIC / HYDRAULIC COMPUTATIONS

<table>
<thead>
<tr>
<th>Fl.</th>
<th>Area</th>
<th>ΔH</th>
<th>Mean Area</th>
<th>ΔVolume</th>
<th>Surcharge Storage</th>
</tr>
</thead>
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<tr>
<td>381</td>
<td>163.9</td>
<td>3.0</td>
<td>166.6</td>
<td>499.8</td>
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<tr>
<td>334</td>
<td>169.3</td>
<td>2.0</td>
<td>172.6</td>
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<td>179.6</td>
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<td>338</td>
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<td>187.4</td>
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<td>340</td>
<td>191.5</td>
<td>2.0</td>
<td>195.5</td>
<td>394.8</td>
<td>1579.0</td>
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</tbody>
</table>

---

**Surcharge Storage (Ac/ft):**

- **Axis:** Fl.
- **Surcharge Storage:**
  - **Area:**
  - **Surcharge Storage:**

---

**Graph:**

- **Fl. (Vertical):**
  - **Area (Ac):**
  - **Surcharge Storage (Ac/ft):**

---

**Legend:**

- Fl.:
- Area:
- ΔH:
- Mean Area:
- ΔVolume:
- Surcharge Storage:

---

**Sheet 2 of 5**

**Date:** May 1, 1980

**By:** DLC

**Ch'k. by:**
### Subject
Synder's Coef. obtained from WRE Inc report - Moodna Creek network. (Ref 2)

### Parameters
- \( L_{co} = 3.83 \) miles
- \( L = 7.39 \) miles
- \( D = 9.25 \) mi²
- \( \left( \frac{L}{L_{co}} \right)^{0.5} = 2.726 \)
- \( t_p = C_c \left( \frac{L}{L_{co}} \right)^{0.5} = (2.11 \times 2.726) = 5.75 \) hours
- \( t_c = \frac{5.75}{5.5} \approx 1 \) hour
- \( Q_p = \frac{640 C_p}{t_p} = \frac{320}{5.75} = 55.65 \) cfs/ft²
- \( Q_p = 515 \) cfs

### Additional Information
- From \#4 7 EM 1110-2-1405
- \( W15 = 5.5 \) hrs.
- \( W50 = 10 \) hrs
### HYDROGRAPH FOR PLAIN 1 RTIO 1

<table>
<thead>
<tr>
<th>Time (hrs)</th>
<th>Flooding</th>
<th>Peak</th>
<th>6-Hour</th>
<th>24-Hour</th>
<th>72-Hour</th>
<th>Total Volume</th>
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### HYDROGRAPH AT STA 1 FOR PLAIN 1 RTIO 2

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<td>98</td>
<td>160</td>
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</table>

### HYDROGRAPH ROUTING

**Reservoir Routing & Spillway Discharge**

<table>
<thead>
<tr>
<th>Type</th>
<th>ICOP</th>
<th>CCOP</th>
<th>ITAPE</th>
<th>JPLT</th>
<th>JPRF</th>
<th>INAME</th>
<th>ISTAT</th>
<th>IAuto</th>
</tr>
</thead>
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<td>0</td>
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</table>

**Routing Data**

<table>
<thead>
<tr>
<th>Gloss</th>
<th>CLOSS</th>
<th>AVG</th>
<th>IHS</th>
<th>ENAME</th>
<th>FDPT</th>
<th>HPRP</th>
<th>LSTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.00</td>
<td>1</td>
<td>1</td>
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**NSIP**

<table>
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<tr>
<th>NTOL</th>
<th>LAC</th>
<th>IFSK</th>
<th>X</th>
<th>TSK</th>
<th>STORM</th>
<th>ISIPAT</th>
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<tbody>
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<td>1</td>
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<td>0</td>
<td>0.00</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Other Parameters**

- IFC: 0.04
- IFF: 0.04
- IFSK: 0.04
- IFS: 0.04
- IFC: 0.04
- IFF: 0.04
- IFSK: 0.04
- IFS: 0.04
- IFC: 0.04
- IFF: 0.04
- IFSK: 0.04
- IFS: 0.04
### End-of-Period Hydrograph Ordinates

<table>
<thead>
<tr>
<th>Date</th>
<th>1st Hour</th>
<th>2nd Hour</th>
<th>3rd Hour</th>
<th>4th Hour</th>
<th>5th Hour</th>
<th>6th Hour</th>
<th>7th Hour</th>
<th>8th Hour</th>
<th>9th Hour</th>
<th>10th Hour</th>
<th>11th Hour</th>
<th>12th Hour</th>
<th>13th Hour</th>
<th>14th Hour</th>
<th>15th Hour</th>
<th>16th Hour</th>
<th>17th Hour</th>
<th>18th Hour</th>
<th>19th Hour</th>
<th>20th Hour</th>
<th>21st Hour</th>
<th>22nd Hour</th>
<th>23rd Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/12</td>
<td>241.66</td>
<td>553.87</td>
<td>635.61</td>
<td>634.85</td>
<td>621.38</td>
<td>605.62</td>
<td>600.24</td>
<td>602.35</td>
<td>605.87</td>
<td>609.38</td>
<td>612.87</td>
<td>616.38</td>
<td>619.87</td>
<td>623.38</td>
<td>626.87</td>
<td>629.87</td>
<td>632.87</td>
<td>635.87</td>
<td>638.87</td>
<td>641.87</td>
<td>644.87</td>
<td>647.87</td>
<td>650.87</td>
</tr>
</tbody>
</table>

### Pea Outflow Is 476°C At Time 41.0 Hours

<table>
<thead>
<tr>
<th>CFS</th>
<th>476.0</th>
<th>477.0</th>
<th>478.0</th>
<th>479.0</th>
<th>480.0</th>
<th>481.0</th>
<th>482.0</th>
<th>483.0</th>
<th>484.0</th>
<th>485.0</th>
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<th>489.0</th>
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<th>497.0</th>
<th>498.0</th>
<th>499.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFS</td>
<td>476.0</td>
<td>477.0</td>
<td>478.0</td>
<td>479.0</td>
<td>480.0</td>
<td>481.0</td>
<td>482.0</td>
<td>483.0</td>
<td>484.0</td>
<td>485.0</td>
<td>486.0</td>
<td>487.0</td>
<td>488.0</td>
<td>489.0</td>
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<td>491.0</td>
<td>492.0</td>
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<td>495.0</td>
<td>496.0</td>
<td>497.0</td>
<td>498.0</td>
<td>499.0</td>
</tr>
</tbody>
</table>

### Hydrograph Routing

| Start | 0:00  | 1:00  | 2:00  | 3:00  | 4:00  | 5:00  | 6:00  | 7:00  | 8:00  | 9:00  | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Water | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
### CHANNEL ROUTING REACH: 0:00 TO 24:00

<table>
<thead>
<tr>
<th>STAGE</th>
<th>ICOMP</th>
<th>IECOM</th>
<th>ITAFF</th>
<th>JPPY</th>
<th>JPPY</th>
<th>INAME</th>
<th>ISTAGE</th>
<th>IAUTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLOSS</td>
<td>CLOSE</td>
<td>AVG</td>
<td>IRES</td>
<td>ISAME</td>
<td>IOPT</td>
<td>IPPY</td>
<td>LSTR</td>
<td></td>
</tr>
<tr>
<td>RSTAS</td>
<td>NSTD.</td>
<td>LAG</td>
<td>APSKK</td>
<td>X</td>
<td>TSK</td>
<td>STOR.</td>
<td>ISPRAT</td>
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</table>

### CROSS SECTION TERMINATES:
- STA=66.00 STA=66.00 STA=66.00

<table>
<thead>
<tr>
<th>STAGE</th>
<th>FLAT</th>
<th>FLON</th>
<th>FLON</th>
<th>FLAT</th>
<th>FLON</th>
<th>FLAT</th>
<th>FLON</th>
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<tbody>
<tr>
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<td>98.4</td>
<td>98.1</td>
<td>98.4</td>
<td>98.1</td>
<td>98.4</td>
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</table>

### OUTFLOW

<table>
<thead>
<tr>
<th>STATION</th>
<th>3 PLAN TIME</th>
<th>9:00</th>
<th>10:00</th>
<th>11:00</th>
<th>12:00</th>
<th>13:00</th>
<th>14:00</th>
<th>15:00</th>
<th>16:00</th>
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<td>98.1</td>
<td>98.4</td>
<td>98.1</td>
<td>98.4</td>
<td>98.1</td>
<td>98.4</td>
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</tbody>
</table>

### TOTAL VOLUME

<table>
<thead>
<tr>
<th>PEAK</th>
<th>24-HOUR</th>
<th>72-HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.1</td>
<td>98.4</td>
<td>98.1</td>
</tr>
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### STATION DATA

- STA=66.00 STA=66.00 STA=66.00

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<th>98.4</th>
<th>98.1</th>
<th>98.4</th>
<th>98.1</th>
<th>98.4</th>
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<tr>
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<td>98.4</td>
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</tbody>
</table>
### Table: Stage and Volume Data

<table>
<thead>
<tr>
<th>Station</th>
<th>Stage</th>
<th>Phillips 6-Hour</th>
<th>Phillips 72-Hour</th>
<th>Phillips 77-Hour</th>
<th>Total Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.1</td>
<td>1.167</td>
<td>8.17</td>
<td>8.20</td>
<td>14980</td>
</tr>
<tr>
<td>24</td>
<td>2.4</td>
<td>8.17</td>
<td>26.53</td>
<td>26.52</td>
<td>21807</td>
</tr>
<tr>
<td>32</td>
<td>2.1</td>
<td>26.53</td>
<td>40.50</td>
<td>40.51</td>
<td>6668</td>
</tr>
</tbody>
</table>

### Maximum Stage

- **Stage**: 10.6
- **Volume**: 15229

### Maximum Staging

- **Volume**: 15249

### Station 4, Plan 1, Ratio 2

<table>
<thead>
<tr>
<th>Station</th>
<th>Stage</th>
<th>Phillips 6-Hour</th>
<th>Phillips 72-Hour</th>
<th>Phillips 77-Hour</th>
<th>Total Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.1</td>
<td>1.167</td>
<td>8.17</td>
<td>8.20</td>
<td>14980</td>
</tr>
<tr>
<td>24</td>
<td>2.4</td>
<td>8.17</td>
<td>26.53</td>
<td>26.52</td>
<td>21807</td>
</tr>
<tr>
<td>32</td>
<td>2.1</td>
<td>26.53</td>
<td>40.50</td>
<td>40.51</td>
<td>6668</td>
</tr>
</tbody>
</table>

### Outflow

- **Volume**: 15229

### Stop

- **Volume**: 15249
<table>
<thead>
<tr>
<th>Definition</th>
<th>Site/Type</th>
<th>Area</th>
<th>Plan</th>
<th>Ratio 1</th>
<th>Ratio 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2492.5%</td>
<td>(25.0%)</td>
<td>10497</td>
<td>4765.5</td>
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</tr>
<tr>
<td>River 18</td>
<td>1</td>
<td>21.2%</td>
<td>10497</td>
<td>4765.5</td>
<td></td>
</tr>
<tr>
<td>River 15</td>
<td>3.7%</td>
<td>97095</td>
<td>4767.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>River 14</td>
<td>4.7%</td>
<td>(205.4%)</td>
<td>10497</td>
<td>4774.4</td>
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</tr>
<tr>
<td>River 13</td>
<td>6.7%</td>
<td>(295.4%)</td>
<td>10497</td>
<td>4774.4</td>
<td></td>
</tr>
</tbody>
</table>
### Summary of Dam Safety Analysis

#### Plan 1

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Stillwater Crest</th>
<th>Top of Dam</th>
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</thead>
<tbody>
<tr>
<td>1440</td>
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<td>2640</td>
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</tbody>
</table>

#### Ratio of Water Storage and Outflow

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Maximum</th>
<th>Duration</th>
<th>Time of Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depth</td>
<td>Stage</td>
<td>Storage</td>
<td>Outflow</td>
<td>Over Top</td>
<td>Max Outflow</td>
</tr>
<tr>
<td></td>
<td>W.S.</td>
<td>F.S.</td>
<td>F.S.</td>
<td>F.S.</td>
<td>F.S.</td>
<td>F.S.</td>
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<tr>
<td>1.</td>
<td>4.42</td>
<td>7.40</td>
<td>3.75</td>
<td>10197</td>
<td>16.00</td>
<td>46.00</td>
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<tr>
<td>1.5</td>
<td>13.10</td>
<td>7.40</td>
<td>2720</td>
<td>4755</td>
<td>5.00</td>
<td>48.00</td>
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</table>

#### Plan 1 Station 3

<table>
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<tr>
<th>Ratio</th>
<th>Maximum Flow (C.F.S)</th>
<th>Maximum Stage (F.T)</th>
<th>Time (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>16195</td>
<td>305.0</td>
<td>46.00</td>
</tr>
<tr>
<td>0.50</td>
<td>4767</td>
<td>303.2</td>
<td>48.00</td>
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</tbody>
</table>

#### Plan 1 Station 4

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Maximum Flow (C.F.S)</th>
<th>Maximum Stage (F.T)</th>
<th>Time (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>16619</td>
<td>302.1</td>
<td>47.00</td>
</tr>
<tr>
<td>0.50</td>
<td>4774</td>
<td>301.1</td>
<td>48.00</td>
</tr>
</tbody>
</table>
STABILITY ANALYSIS
Assumptions:

1. See Notes on the Sketch.
2. Since Spillway is masonry (brick & stone) & concrete, the unit weight is assumed as 105 lbs/cuft.
3. During overturning, it is assume that toe of Spillway is about 28 ft from upstream face.
4. Frictional Resistance is assumed to develop at the entire base i.e. 31 feet.
5. Internal Resistance of Glacial Till is equal to angle of repose which is about 35°.

CASES - LOADING CONDITIONS

CASE I: Normal Loading Condition; Normal Lake level without ice load.
CASE II: Normal Loading Condition; Normal Lake level with ice load.
CASE III: Unusual Loading Condition; Reservoir level equal to ½ PMF.
CASE IV: Extreme Loading Condition; Reservoir level equal to PMF.
CASE V: Unusual Loading Condition; Normal Lake level without ice load and earthquake.

STABILITY CRITERIA:

The stability criteria against overturning and sliding were evaluated as follows.

Overturning - Stability is considered adequate if the resultant of all forces falls within the middle third of the base under the normal loading condition and within middle half of the base under the unusual and extreme loading conditions.

Sliding - Stability along the base of the structure is evaluated using the friction factor of safety (FFS) which is equal to $V \tan \phi / H$, where $V$ is the sum of vertical forces acting on the base, $H$ is the sum of all horizontal forces and $\tan \phi$ is Friction Factor. The stability with respect to sliding is considered adequate if the FFS exceeds 1.50 under normal loading conditions, 1.25 under unusual loading conditions and 1.1 under extreme loading conditions.
NOTES:
1. Dimensions are based on rough measurements during inspection.
2. Depth and configuration below water line are assumed based on an available document dated 1942.

Toe of spillway is estimated at about 28' from upstream face.
## A. DEAD LOADS

<table>
<thead>
<tr>
<th>Load Description</th>
<th>F&lt;sub&gt;V&lt;/sub&gt; (kips)</th>
<th>( \text{Mr}_\text{KF} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( W_1 ) = 0.145 \times 28 \times 6.3</td>
<td>25.58 \times 24.85 = 635.66</td>
<td></td>
</tr>
<tr>
<td>( W_2 ) = 0.145 \times 22 \times 0.7</td>
<td>2.23 \times 21.35 = 47.61</td>
<td></td>
</tr>
<tr>
<td>( W_{2A} ) = 0.145 \times \frac{1}{2} \times 2.5 \times 0.7</td>
<td>0.13 \times 14.7 = 2.79</td>
<td></td>
</tr>
<tr>
<td>( W_3 ) = 0.145 \times 22 \times 1.0</td>
<td>3.19 \times 20.5 = 61.50</td>
<td></td>
</tr>
<tr>
<td>( W_4 ) = 0.145 \times 20 \times 1.0</td>
<td>2.90 \times 19.5 = 56.55</td>
<td></td>
</tr>
<tr>
<td>( W_5 ) = 0.145 \times 18 \times 1.0</td>
<td>2.61 \times 18.5 = 48.29</td>
<td></td>
</tr>
<tr>
<td>( W_6 ) = 0.145 \times 15 \times 1.0</td>
<td>2.18 \times 17.5 = 38.15</td>
<td></td>
</tr>
<tr>
<td>( W_7 ) = 0.145 \times 11.0 \times 1.0</td>
<td>15.95 \times 12.0 = 191.40</td>
<td></td>
</tr>
<tr>
<td>( W_{7A} ) = 0.145 \times \frac{1}{2} \times 10 \times 13</td>
<td>2.15 \times 13.67 = 29.73</td>
<td></td>
</tr>
<tr>
<td>( W_8 ) = 0.145 \times \frac{1}{2} \times 7 \times 1.75</td>
<td>0.89 \times 4.67 = 4.15</td>
<td></td>
</tr>
<tr>
<td>( W_9 ) = 0.145 \times \frac{1}{2} \times 5.25 \times 7</td>
<td>5.32 \times 3.50 = 18.65</td>
<td></td>
</tr>
</tbody>
</table>

\[ \Sigma F_V = 63.15 \text{ kips}, \quad EM_K = 1137.58 \]

\[ \text{\textit{E}} = \frac{1137.58}{63.15} = 18.01 \text{ ft} \]

During the sliding, additional vertical load \((W_{10})\) would act. (See Note 4).

\[ W_{10} = 0.145 \times \frac{1}{2} \times 23 \times 5.25 = 8.75 \text{ kips} \]
8. Hydrostatic Forces

\[ P = \frac{1}{2} \times 1.75 \times 28 = 24.5 \times 9.33 = 228.59 \text{ kips} \]

\[ U = \frac{1}{2} \times 1.75 \times 28 = 24.5 \times 18.67 = 457.42 \text{ kips} \]

\[ E = M @ \text{TOE} \text{ kips/ft} \]

\[ 0.0624 \times 28 = 1.75 \text{ kips/ft} \]
TAMS

Project: PHASE 1 INSPECTION — BEAVER DAM LAKE
Subject: DAM STABILITY ANALYSIS

BEAVER DAM LAKE

Job No. 1555-07

Date 5/9/80

Sheet 4 of 11

By JP

Ch'k. by AD

C. ICE FORCES

a) According to Corps criteria ice pressure of 500 lbs./ft²

b) Ice thickness 1 feet

\[
\text{EM @ toe} = KF \times 5.0 \times 1 \times 27.5 = 137.50 \, \text{ft}
\]

CASE 1. NORMAL OPERATING CONDITION — WITHOUT ICE.

A. Dead Load

<table>
<thead>
<tr>
<th>( F_U )</th>
<th>( F_H )</th>
<th>( M_U )</th>
<th>( M_H )</th>
</tr>
</thead>
<tbody>
<tr>
<td>63.16</td>
<td>0</td>
<td>113.6</td>
<td>0</td>
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</tbody>
</table>

B. Hydrostatic

<table>
<thead>
<tr>
<th>( F_U )</th>
<th>( F_H )</th>
<th>( M_U )</th>
<th>( M_H )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-24.50</td>
<td>24.5</td>
<td>0</td>
<td>686.0</td>
</tr>
</tbody>
</table>

Dead Load

\[
\frac{63.16 - 24.50}{38.66} = 113.6 - 686.0 = 451.60 \, \text{ft}
\]

Resultant location:

\[
\text{Resultant location} = \frac{451.60}{38.66} = \frac{28.0}{3} = 2.35 \, \text{ft inside middle third}
\]

\[
\bar{z} = \frac{28.0}{2} - \frac{451.60}{38.66} = 2.32 \, \text{ft downstream from base}
\]

\[
P = \frac{38.66}{28} \left( 1 + \frac{6 \times 2.32}{28.0} \right) \times 1000 = 10 + 5 = \{15.0 \, \text{psi} @ \text{Toe}, 5.0 \, \text{psi} @ \text{heel}\}
\]

GUIDING FACTOR

Friction factor of Safety Considered

\[
\text{FFS} = \frac{47.41 + \tan 35^\circ}{24.5} = \frac{47.41}{24.5} = 1.95 < 1.50
\]
CASE II  NORMAL OPERATING CONDITION - WITH ICE LOAD

A. Dead Load  
\[
\begin{align*}
F_v & = 63.16 \\
F_h & = 0.0 \\
M_r & = 113.6 \\
M_o & = 0
\end{align*}
\]

B. Hydrostatic  
\[
\begin{align*}
F_v & = 24.50 \\
F_h & = 24.5 \\
M_r & = 0 \\
M_o & = 680.0 \uparrow
\end{align*}
\]

C. Ice Load  
\[
\begin{align*}
F_v & = 38.66 \\
F_h & = 29.5 \\
M_r & = 113.6 \uparrow \\
M_o & = 823.5 \uparrow \text{(Overturning)}
\end{align*}
\]
\[
\frac{38.66}{47.41} \text{(see note 4)}
\]

\[\Sigma M = 113.6 - 823.5 = 314.10 \text{ @ toe}\]

Resultant location  
\[
\frac{314.10 - 28.0 \uparrow}{38.66} = -1.21 \text{ ft outside middle third (d/s)}
\]

\[\bar{e} = \frac{28.0}{2} - \frac{314.10}{38.66} = 5.87 \text{ downstream from top of base}\]

\[p = \frac{38.66 \left(1 + \left(\frac{6 \times 5.87}{28.0}\right) \times \frac{1000}{144}\right)}{28} = 10^{+}13; \frac{230 \text{ psi}}{\text{@ toe}}\]
\[\frac{-2.5 \text{ psi}}{\text{@ heel}}\]

SLIDING FACTOR

Fraction factor of safety considered  
\[F_F S = \frac{47.41 \tan 35^\circ}{29.5} = 1.13 < 1.5\]
CASE III $\frac{1}{2}$ PMF (El. 338.5)

0.0624 x 7.5 = 0.468 ksf

0.0624 x 35.5 = 2.21 ksf

0.32 ksf

Fy = 63.16  EM 1137.58

b. Hydrostatic loads.

$P_f = \frac{1}{2} [2.21 + 0.47] 28 = 31.52 \times 10.97 = 441.59$ k

$P_T = \frac{1}{2} \times [0.32 x 5.2] 0.6 = 0.50 \times 1.73 = 0.87$ k

$U = \frac{1}{2} x [2.21 + 0.32] 25 = 35.42 \times 17.48 = 619.14$ k
TAMS

Job No. 1551-07
Project PHASE 1 INSPECTION
Subject DAM STABILITY ANALYSIS

BEAVER DAM LAKE

Fv  Fh  Mr  Mo

Dead Load  63.16  0  1137.58  c

Hydrostatic  -35.42  37.02  1.07  1060.73
27.74  37.02  1138.45  1060.73
6.75  36.99 (sliding case)

RESULTANT LOCATION

\[ E_M = E_{Mr} - M_o = 1138.45 - 1060.73 = 77.72 \, \text{kF}. \]

Resultant location: \[ \frac{77.72 - \frac{28.0}{3}}{27.74} = 2.8 - 9.3 = -6.5 \, \text{ft} \, \text{outside} \, \text{downstream} \, \text{middle} \, \text{third}. \]

\[ e = \frac{28}{2} - \frac{77.72}{27.74} = 14 - 2.8 = 11.2 \, \text{downstream from base}. \]

\[ P = \frac{27.74}{28} \left( 1 + \frac{6}{28} \right) \frac{10.00}{144} = 7 \pm 17 \, \% \, \text{against}. \]

SLIDING FACTOR

\[ FFS = \frac{36.99 \tan 35^\circ}{37.02} = 0.69 \, < 1.25 \]
CASE IV

PMF (EL.340.5)

0.0624 x 37.5 = 2.34 k/sf

0.44 k/sf

2.34 k/sf

9.5 x 0.0624
= 0.59 k/sf

\[ P_n = \frac{1}{2} \left[ 2.34 + 0.61 \right] \times 28 = 41.80 \times 11.2 = 462.56 \text{ k/sf} \]

\[ P_T = \frac{1}{2} \times 0.44 \times 7.0 \times 0.6 = 0.92 \times 2.33 = 2.14 \text{ k/sf} \]

\[ U = \frac{1}{2} \left[ 2.34 + 0.44 \right] \times 28 = 38.92 \times 17.19 = 669.03 \text{ k/sf} \]

a. Dead load (See Computation Sheet #2)

\[ F_v = 63.16 \text{ k/sf} \]

b. Hydrostatic loads

PMF (EL.340.5)
Job No. 1551-07
Project PHASE I INSPECTION
Subject DAM STABILITY ANALYSIS
BEAVER DAM LAKE

Dead load: 63.16 0 1131.88 0

Hydrostatic: -35.92 40.38 2.14 1131.59

\[
\begin{array}{llll}
24.24 & 40.38 & 1139.72 & 1131.59 \\
\hline
1.75 \\
\end{array}
\]

\[E_f v = 32.99 \text{ (Sliding Case)}\]

RESULTANT LOCATION

\[E M = E M_v - M_0 = 1139.72 - 1131.59 = -8.13\]

Resultant location: \(-8.13, -0.3, 9.3\) ft outside
downstream middle

\[e = \frac{2B}{2} - \left( -\frac{6.13}{24.24} \right) = 14.03\] ft downstream
from base

\[p = \frac{24.24}{21.58} \left( 1 + \frac{6 \times 14.3}{28} \right) \frac{1000}{144} = 8 \pm 2.5 = \left( -33 \text{ psi} \right)\]

SLIDING FACTOR

\[FFS = \frac{32.99 \tan 35^\circ}{40.38} = 0.57 < 1.1\]
TAMS

Job No. 1551-11
Project Beaver Dam Lake
Subject Dynamic Stability

BEAVER DAM LAKE

CASE IV. NORMAL OPERATING CONDITION - WITH EARTHQUAKE LOAD

A. LOCATE CENTER OF GRAVITY OF WALL

<table>
<thead>
<tr>
<th>Sections</th>
<th>Area (ft²)</th>
<th>X (ft from toe)</th>
<th>y (ft from toe)</th>
<th>Ax (ft³)</th>
<th>Ay (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>176.4</td>
<td>24.85</td>
<td>14.0</td>
<td>4383.5</td>
<td>2469.1</td>
</tr>
<tr>
<td>1</td>
<td>15.4</td>
<td>21.35</td>
<td>11.0</td>
<td>328.8</td>
<td>169.4</td>
</tr>
<tr>
<td>2</td>
<td>22.0</td>
<td>21.47</td>
<td>22.83</td>
<td>19.3</td>
<td>20.5</td>
</tr>
<tr>
<td>3</td>
<td>20.0</td>
<td>20.5</td>
<td>11.0</td>
<td>451.6</td>
<td>242.0</td>
</tr>
<tr>
<td>4</td>
<td>20.0</td>
<td>19.5</td>
<td>10.0</td>
<td>390.0</td>
<td>200.0</td>
</tr>
<tr>
<td>5</td>
<td>19.0</td>
<td>18.5</td>
<td>9.0</td>
<td>333.1</td>
<td>162.5</td>
</tr>
<tr>
<td>6</td>
<td>15.0</td>
<td>17.5</td>
<td>7.5</td>
<td>262.5</td>
<td>112.5</td>
</tr>
<tr>
<td>7</td>
<td>100.0</td>
<td>12.0</td>
<td>5.5</td>
<td>1320.0</td>
<td>605.0</td>
</tr>
<tr>
<td>7</td>
<td>15.0</td>
<td>13.7</td>
<td>12.0</td>
<td>205.5</td>
<td>180.0</td>
</tr>
<tr>
<td>8</td>
<td>6.1</td>
<td>4.7</td>
<td>5.83</td>
<td>28.7</td>
<td>35.6</td>
</tr>
<tr>
<td>9</td>
<td>36.7</td>
<td>3.5</td>
<td>2.63</td>
<td>1288.0</td>
<td>96.8</td>
</tr>
<tr>
<td>Total</td>
<td>435.7</td>
<td></td>
<td></td>
<td>7851.1</td>
<td>4293.1</td>
</tr>
</tbody>
</table>

\[ \bar{x} = 18.1 \text{ ft} \quad \bar{y} = 9.85 \text{ ft} \]

8. FORCES

<table>
<thead>
<tr>
<th>Forces</th>
<th>F₁ (K)</th>
<th>F₂ (K)</th>
<th>Mx (KF)</th>
<th>My (KF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead Load</td>
<td>63.16</td>
<td>0</td>
<td>1137.6</td>
<td>0</td>
</tr>
<tr>
<td>Hydrostatic Uplift</td>
<td>24.5</td>
<td>0</td>
<td>0</td>
<td>457.4</td>
</tr>
<tr>
<td>Hydrodynamic (1)</td>
<td>1.78</td>
<td>0</td>
<td>0</td>
<td>19.9</td>
</tr>
<tr>
<td>Earthquake Force (2)</td>
<td>3.16</td>
<td>0</td>
<td>0</td>
<td>31/13</td>
</tr>
<tr>
<td>Hydrostatic Pressure</td>
<td>0</td>
<td>24.5</td>
<td>0</td>
<td>28.6</td>
</tr>
<tr>
<td>Dead Load (3)</td>
<td>8.75</td>
<td>0</td>
<td>1138.0</td>
<td>73.7%</td>
</tr>
</tbody>
</table>

Note: See note 4
CASE III Continued

(1) Hydrodynamic Forces & Moments:

Zangene Method: \[ P = (C) \cdot W \cdot h^2 \] where \( C = 0.726 \) when \( \theta = 0^\circ \)

\[ P = 0.726 \cdot (0.05) \cdot (0.624) \cdot (28)^2 \approx 1.78 \cdot \frac{K}{f} \]

Zone 2

\[ M_p = 1.78 \cdot (0.4) \cdot (28) \Rightarrow 19.9 \text{ K-ft.} \]

(2) Dynamic Forces and Moments:

Zone 2 \( \Rightarrow n = 0.05 \)

\[ W_0 = 0.05 \cdot (63.16) = 3.16 \text{ K} \rightarrow \]

\[ M_{w0} = 3.16 \cdot \bar{y} = 3.16 \cdot (9.8) = 31.13 \text{ K-ft} \]

Location of Resistant:

\[ X_R = \frac{1188 \cdot 737.0}{38.7} = 10.4 \text{ ft. (Positive, therefore okay)} \]

Sloping Factor of Safety:

\[ FFS = \frac{\sigma_y}{\sigma_f} \cdot \frac{tan 35^\circ}{29.4} = 1.13 < 1.25 \]
References


5. "National Program of Inspection of Dams", Vol. 3, Department of the Army, Office of the Chief of Engineers, 1975


7. "Recommended Guidelines for Safety Inspection of Dams", Department of the Army, Office of the Chief of Engineers, Appendix D

