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NATIONAL DAM SAFETY PROGRAM. SPEEDWELL DAM (NJ-00359), PASSAIC --ETC(U)
MAY 79 R J MCDERMOTT, J E GRIBBIN DACW61-79-C-0011

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WHIPPANY RIVER-MORRIS COUNTY
NEW JERSEY

LEVEL II

SPEEDWELL DAM
NJ 00359

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: NJ00359

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): Phase I Inspection Report
National Dam Safety Program
Speedwell Dam
Morris County, N.J.

5. TYPE OF REPORT & PERIOD COVERED: FINAL rept.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): McDermott, Richard J. P.E.
Gribbin, John E. P.E.

8. CONTRACT OR GRANT NUMBER(s): DACW61-79-C-0011

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Storch Engineering
220 Ridgedale Ave.
Florham Park, N.J. 07932

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 98p.

11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

12. REPORT DATE: May 1979

13. NUMBER OF PAGES: 55

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Richard J. /McDermott John E. /Gribbin

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

National Dam Safety Program. Speedwell Dam (NJ-00359), Passaic River Basin, Whippany River-Morris County, New Jersey, Phase I 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)

Speedwell Dam, N.J.
Spillway
Seepage
Structural Analysis
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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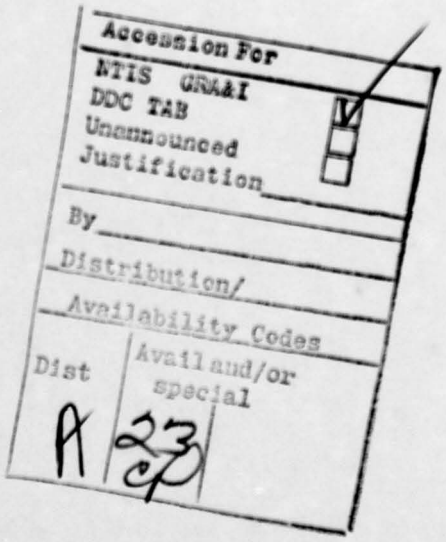

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

12 SEP 1979

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

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Speedwell Dam in Morris 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, Speedwell Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 26% of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in the instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure the following actions, as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. 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.

b. The following remedial actions should be completed within six months from the date of approval of this report:

(1) Deteriorated concrete in the spillway, outlet works and gatehouse should be thoroughly inspected and renovated. Inspect the fish screens and renovate if necessary.

(2) The gate lift stems should be replaced and the lifting mechanisms should be thoroughly inspected and renovated if necessary.

(3) The training walls along the sides of the downstream channel should be renovated to correct their undermined condition.

(4) Debris on the dam and in the downstream channel should be removed.

(5) Measures should be taken to discourage pedestrian access to the spillway crest.

c. Seepage areas should be monitored in order to determine their effect on the structural stability of the dam. If necessary, measurements should be made by the use of appropriate instrumentation.

d. The owner should upgrade the operating and maintenance procedures by issuing a manual and check list for recommended procedures. Inspection and maintenance visits should be logged. An annual site inspection should be conducted using a visual inspection check list similar to the one used in this report.

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 Congresswoman Millicent Fenwick of the Fifth 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.

NAPEN-D
Honorable Brendan T. Byrne

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,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
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Speedwell Dam (NJ00359)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 23 April 1979 by Storch Engineers 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.

Speedwell Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 26% of the Spillway Design Flood -SDF- would overtop the dam. (The SDF, in this instance, is one half of the Probable Maximum Flood.) To insure adequacy of the structure the following actions, as a minimum, are recommended.

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. 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.

b. The following remedial actions should be completed within six months from the date of approval of this report:

(1). Deteriorated concrete in the spillway, outlet works and gatehouse should be thoroughly inspected and renovated. Inspect the fish screens and renovate if necessary.

(2). The gate lift stems should be replaced and the lifting mechanisms should be thoroughly inspected and renovated if necessary.

(3). The training wall along the sides of the downstream channel should be renovated to correct their undermined condition.

(4). Debris on the dam and in the downstream channel should be removed.

(5). Measures should be taken to discourage pedestrian access to the spillway crest.

c. Seepage areas should be monitored in order to determine their effect on the structural stability of the dam. If necessary, measurements should be made by the use of appropriate instrumentation.

d. The owner should upgrade the operating and maintenance procedures by issuing a manual and check list for recommended procedures. Inspection and maintenance visits should be logged. An annual site inspection should be conducted using a visual inspection check list similar to the one used in this report.

APPROVED: Jas C Tolton LTC
JAMES C. TON
Colonel, Corps of Engineers
District Engineer

DATE: 11 October 1977

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Speedwell Dam, NJ00359
State Located:	New Jersey
County Located:	Morris
Drainage Basin:	Passaic River
Stream:	Whippany River
Date of Inspection:	April 23, 1979

Assessment of General Condition of Dam

Based on visual inspection, past operation performance and Phase I engineering analyses, the dam is assessed as being in fair overall condition.

Hydraulic and hydrologic analyses indicate that the spillway is inadequate to pass the designated spillway design flood (SDF) without an overtopping of the dam. The SDF for Speedwell Dam is equal to one-half of the Probable Maximum Flood (PMF). The spillway is capable of passing approximately 12½ percent of the PMF or 25 percent of the SDF. Therefore, the owner should engage a qualified professional engineer in the near future to perform accurate hydraulic and hydrologic analyses relating to the spillway capacity. Based on the findings of the analyses, remedial measures should be undertaken to prevent damage, especially erosion of areas adjacent to the dam, due to overtopping of the dam resulting from a storm equivalent to the spillway design flood.

Arrangements should be made in the near future to monitor the observed seepage in order to determine its effect on the structural stability of the dam. If necessary, measurements should be made by the use of appropriate instrumentation. The monitoring should be performed by a qualified professional engineer.

The spillway, outlet works and gatehouse appear to be in generally good condition. However, some of the masonry surfaces are spalled and deteriorated. With the lake drawn down, the spillway, outlet works and gatehouse should, in the near future, be renovated by sand blasting, patching, grouting and applying an epoxy preservative coating.

The gate lift stems are severely rusted at the water line and should be replaced in the near future. The gate lifting mechanisms should be thoroughly inspected in the near future and renovated if necessary.

The training walls along the sides of the downstream channel are undermined. The walls should be renovated in the near future to eliminate this condition.

Debris on the dam and in the downstream channel should be removed in the near future.

Measures should be taken to discourage pedestrian access to the spillway crest.

The owner should, in the near future, initiate a program of periodic inspection and maintenance for the dam. Repairs should be made as required and the following maintenance should be performed annually: inspect the gate operating mechanisms and perform any necessary servicing and clear the downstream channel. As part of the maintenance program, the lake should be lowered once every five years at which time the lake should be cleaned and the normally submerged portions of the dam and outlet works inspected and repaired.

Richard J. McDermott, P.E.

John E. Gribbin, P.E.

OVERVIEW - SPEEDWELL DAM

23 APRIL 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. 30214. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of 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 the 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
NATIONAL DAM SAFETY PROGRAM

SPEEDWELL DAM, I.S. NJ00359

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Speedwell Dam was made on April 23, 1979. The purpose of the inspection was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description

Speedwell Dam is a masonry overflow dam with a curved alignment and a gate house located at its center. The entire length of dam consists of two overflow sections that serve as an uncontrolled spillway and a center section containing two lift gates that serve as outlet works.

Constructed of concrete and stone, the dam is founded on rock according to construction drawings. A cyclopean masonry apron is located at the downstream toe of dam for its entire length. At the north and south ends of the dam, stone masonry retaining walls form spillway training walls and extend downstream to form the sides of the downstream channel.

The outlet works consist of two cast iron lift gates that control flow through 5-foot by 6-foot sluices in a vertical masonry wall. The sluices discharge between masonry training walls that support a masonry gatehouse. Within the gatehouse are located two manually operated gate lift mechanisms. Between the training walls, immediately upstream from the sluices, fish screens are fitted in steel slots.

The elevation of the spillway crest is 311.8 (N.G.V.D.). The tops of the spillway and outlet works training walls are set at elevation 316.5 which is the elevation of the top of dam. The ground elevation adjacent to the spillway training walls is also 316.5. An overtopping condition of the dam would be one in which discharge from the lake flowed over the center section and the ground adjacent to the spillway training

walls. The downstream channel bed elevation is 303.0. The overall length of the dam is 145 feet and the spillway crest length is 125.6 feet.

b. Location

Speedwell Dam is located in the Town of Morristown, Morris County, New Jersey. Constructed across the Whippany River, it impounds Speedwell Lake which is located in a small public park. Principal access to the dam is through a parking area which is entered from N.J. Route No. 202. Discharge from the dam flows into Pocahontas Lake located approximately 2000 feet downstream on the Whippany River.

c. Size and Hazard Classification

Size and Hazard Classification criteria presented in "Recommended Guidelines for Safety Inspection of Dams", published by the U.S. Army Corps of Engineers are as follows:

SIZE CLASSIFICATION

	Impoundment	
Category	Storage (Ac-ft)	Height (Ft)
Small	< 1000 and ≥ 50	< 40 and ≥ 25
Intermediate	≥ 1000 and $< 50{,}000$	≥ 40 and < 100
Large	$\geq 50{,}000$	≥ 100

HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life (Extent of Development)	Economic Loss (Extent of Development)
Low	None expected (no permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable agriculture, industry or structures)
High	More than few	Excessive (Extensive community, industry or agriculture)

The following characteristics relating to size and downstream hazard for Speedwell Dam have been determined for this Phase I assessment:

Height: 13.5 feet

Storage: 349 acre-feet

Potential Loss of Life:

No homes are located between Speedwell Dam and Pocahontas Lake (2000 feet downstream) in the flood plain delineated by flow resulting from dam overtopping failure. Four brick garden apartment buildings are located along Pocahontas Lake. Dam failure due to overtopping could cause inundation of one of the buildings to a depth of approximately 4 feet above first floor elevation. The other three buildings have first floor elevations at or above the estimated flood level due to dam failure.

Potential Economic Loss:

An abandoned, deteriorated stone bridge 150 feet downstream of dam would probably be washed out by dam failure outflow. Dam failure would probably cause water damage in the four garden apartment buildings at Pocahontas Lake; damage to the bridge supporting Route 202, 200 feet downstream of dam, also would be expected.

Therefore, Speedwell Dam is classified as "Small" size and "High" hazard potential.

d. Ownership

Speedwell Dam is owned and operated by the Town of Morristown, P.O. Box 709, Morristown, N. J. 07960.

e. Purpose of Dam

The purpose of the dam is the impoundment of a recreational lake facility.

f. Design and Construction History

The original dam was a timber dam constructed circa 1750 to impound a forge pond. Subsequentially, a masonry dam was constructed to replace the timber dam. Reportedly, the masonry dam was partially destroyed at a later date in order to drain the lake to reduce the potential for malaria. The dam was reconstructed in 1936-1939 at a location approximately 30 feet west of the destroyed masonry dam. The reconstructed dam, which comprises the present structure, was designed by Charles K. Fetzer (Town Engineer at that time) and built with WPA funds.

g. Normal Operational Procedures

The dam and appurtenances are operated and maintained by the Department of Parks and Grounds of the Town of Morristown. Regular maintenance consists of clearing debris from the dam and downstream channel.

The lake is not normally lowered and the gates are not opened at times of intense rain to attenuate flooding conditions.

1.3 Pertinent Data

a.	Drainage Area	25.2 square miles
b.	Discharge at Damsite	
	Maximum known flood at damsite	2122 c.f.s. (1896) NJDEP file; 2000 c.f.s. (Aug.26, 1928)-gaging station 3 miles downstream from dam
	Outlet works at normal pool elevation	813 c.f.s.
	Spillway capacity (pool elevation at top of dam)	4255 c.f.s.
c.	Elevation (Feet above MSL)	
	Top of Dam	316.5
	Maximum pool-design surcharge	321.4
	Full flood control pool	N.A.
	Recreation pool	312.1
	Spillway crest	311.8
	Stream bed at centerline of dam	303
	Maximum tailwater	314±(Estimated)
d.	Reservoir	
	Length of maximum pool	5000 feet
	Length of recreation pool	2500 feet (scaled)
	Length of flood control pool	N.A.

e. Storage (Acre-feet)

Recreation pool	77 acre-feet
Flood control pool	N.A.
Design Surcharge	1218 acre-feet
Top of dam	349 acre-feet

f. Reservoir Surface (Acres)

Top of dam	132 acres (Estimated)
Maximum pool	265 acres (Estimated)
Flood control pool	N.A.
Recreation pool	20.2 acres
Spillway crest	20.2 acres

g. Dam

Type	Masonry Gravity
Length	145 feet
Height	13.5 feet
Side slopes - Upstream	1 horiz. to 2 vert.
- Downstream	vertical
Zoning	N.A.
Impervious core	N.A.
Cutoff	N.A.
Grout curtain	N.A.
Foundation	Ledge rock (pegmatite)

h. Diversion and Regulating Tunnel N.A.

i. Spillway

Type	Uncontrolled weir
Length of weir	125.6 feet
Crest elevation	311.8
Gates	N.A.
Approach channel	N.A.
Discharge channel	Spillway discharges directly into downsteam channel

j. Regulating outlets

Two 5' x 6' sluices controlled by cast iron lift gates

SECTION 2: ENGINEERING DATA

2.1 Design

No plans or calculations pertaining to the original construction of the dam could be obtained. Engineering data relating to the reconstruction in 1939 is available. Construction drawings titled "Speedwell Dam, Morristown, Morris Co." (5 sheets) prepared by Charles K. Fetzer dated December 15, 1936 include the following:

1. Plan of dam
2. Profile of dam
3. Sections
4. Stress diagrams
5. Plan of gatehouse
6. Elevations
7. Drainage Basin Map
8. Location Map

In addition, hydraulic and structural analyses are available. The analyses were prepared by the N.J. Water Policy Commission in 1936 and are contained in the NJDEP file. The hydraulic analyses were used to evaluate the capacity at the spillway in relation to the design flood and to compute the capacity of the outlet works. The design flood was established as the mean of the North and Central Jersey Curves. Two floods of record are reported in the NJDEP file. The greater of the two occurred in 1896 and had a magnitude of 84.2 c.s.m.

The structural analyses were used to evaluate the structural stability of the spillway sections and the spillway training walls at either end of the dam. Stress diagrams contained in the plans include sections of the spillway and the outlet works training walls.

No design reports nor reports on materials investigations are available. The only available data relating to subsurface conditions at the dam site are inspection reports prepared by the N.J. Water Policy Commission during construction which indicate that the entire dam is founded on granite pegmatite.

2.2 Construction

Nine inspection reports as well as monthly progress reports written during the construction phase of the dam indicate that construction was of good quality and in conformance with the approved drawings.

2.3 Operation

One inspection report written shortly after the completion of construction indicates that the outlet works were in operation at that time and working satisfactorily. In 1944, an inspection disclosed the presence of slight seepage a short distance downstream of the south spillway training wall. The seepage was reported to be apparently travelling through the natural ground. In 1969, another inspection indicated that the dam was in good condition at that time.

2.4 Evaluation

a. Availability

Available engineering information is limited to that which is on file at the NJDEP and the Town of Morristown. The NJDEP

file contains copies of plans, specifications, calculations, correspondence and inspection reports. The file is available for inspection at the offices of the Bureau of Flood Plain Management, 1474 Prospect Street, Trenton, N.J. The Town of Morristown file contains only plans and is available for inspection at the office of the Town Engineer, 27 Dumont Place, Morristown, N. J. 07960.

b. Adequacy

Engineering data available from the NJDEP file is adequate to permit an assessment of the hydraulic capacity of the spillway and the structural stability of the dam. However, the available hydraulic and structural analyses are not adequate to be used directly for such assessments without Phase I analyses.

c. Validity

The available hydraulic analyses appear to be valid with respect to engineering practice generally accepted in 1936. However, they are not valid according to analytic procedures developed by the Corps of Engineers for the present inspection and assessment program.

The available structural analyses consist of hand written calculations and are not considered to be sufficiently detailed nor legible to be used directly for assessment of structural stability.

Most engineering data that could be verified was found to be accurate within a reasonable allowance for error. Absent data and data found in the NJDEP file that is at variance with the findings of this investigation are noted in paragraph 7.1.b.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The inspection of Speedwell Dam was performed on April 23, 1979 by staff members of Storch Engineers. A copy of the visual inspection check list is contained in Appendix 1. The following procedures were employed for the inspection:

1. The dam, appurtenant structures and adjacent areas were examined.
2. The dam and accessible appurtenant structures were measured and key elevations determined by surveyors level.
3. The dam, appurtenant structures and adjacent areas were photographed.
4. The downstream flood plain was surveyed.

b. Dam

The north and south spillway sections appeared level and horizontally aligned in agreement with the construction drawings. Most of the spillway could not be closely observed due to overflow; however, the downstream face appeared to be in good condition where it could be observed. The stone masonry wall, comprising the center section of the dam where sluices are located is severely deteriorated at the water line on the upstream side. It appears to be in good condition on the downstream side. The outlet works training walls appear to be in generally good condition; although one stone on the downstream side is displaced. The spillway training walls

appear to be in generally good condition. The upper portion of each wall appears to have been added as a pedestrian barrier with no structural function. A section of the upper portion of the south training wall is broken off.

Four areas of seepage were observed discharging from the stone training walls along the downstream channel. Two of the areas are located in the south training wall and two in the north training wall. At the south training wall, seepage was observed flowing as a trickle through the wall at one point and from its base at another point. This latter seepage flow contained orange silt. At the north training wall, the two seepage areas were manifest as wet areas with no observable flow.

The generalized soils description of the dam consists of alluvial soil composed of a wide range of grain sizes sorted into rough, intermingled layers by successive stages of water action. The alluvial soil overlies a layer of uniform deposits of silt, sand and gravel known as Wisconsin Stratified Drift. Bedrock is near the surface of the dam site and consists of granite pegmatite according to inspection reports written at the time of construction of the present dam. The dam reportedly is founded on bedrock.

According to the Geologic Map of New Jersey, the Ramapo Fault lies approximately 600 feet east of the dam and forms the contact line between Precambrian Losee Gneiss to the west and Triassic Brunswick Formation to the east.

c. Appurtenant Structures

The gatehouse walls and roof are in good condition. The concrete deck slab is in generally good condition although its

upstream end is severely spalled. No gatehouse door is in place. The two gate operating mechanisms inside the gatehouse appear to be in good condition; one is slightly rusted and the other has been painted. The two mechanisms are operated manually with a wheel or key which was not in place at the time of inspection.

The gate lift stems are severely rusted at the water line causing significant reductions in cross section. The gates could not be observed completely but appeared to be in good condition.

Steel channels in the upstream ends of the outlet works training walls used to secure fish screens are rusted but otherwise in good condition. The fish screens were submerged at the time of inspection and could not be observed.

d. Reservoir Area

Speedwell Lake is long and narrow, averaging 350 feet in width, with an overall length of approximately one-half mile. Its shores generally are wooded with steep banks ranging in slope from 7 percent to 50 percent. No structures were observed along the lake shore. Soundings in the vicinity of the dam indicate no significant accumulation of sediment.

e. Downstream Channel

The spillway discharges into the Whippany River which in the vicinity of the dam is a wide well defined stream. Immediately downstream from the dam large accumulations of rocks and small amounts of debris comprise a minor obstruction to the flow of water. Approximately 150 feet downstream an old and deteriorated

stone arch bridge spans the channel. This bridge formerly supported a road that has been relocated and now crosses the channel via a concrete bridge approximately 50 feet farther downstream.

Between the dam and the stone arch bridge the downstream channel banks are stone walls remaining from structures relating to the previous dam. They now serve as extensions of the spillway training walls. These walls generally are in good condition although they are undermined in some areas.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The level of water in Speedwell Lake is regulated naturally by discharge over the spillway of Speedwell Dam. The outlet works of the dam can be used to drain the lake or to augment the discharge capacity of the spillway. However, at the present time, no formal nor informal procedure for operating the dam and appurtenances is employed by the Town of Morristown.

The most recent drawdown of the lake occurred approximately ten years ago when water was released during a period of low flow to supply additional flow to a downstream paper mill. At that time approximately one day was required to complete the drawdown.

4.2 Maintenance of the Dam

Reportedly, the only regular maintenance performed at the dam site is the removal of debris from the dam and downstream channel. Any other maintenance is performed on an "as needed" basis. Reportedly, the most recent maintenance (other than removal of debris) was the construction of a new roof on the gatehouse approximately two years ago.

4.3 Maintenance of Operating Facilities

The outlet works for the dam are maintained on an "as needed" basis. It is not known when the outlet works was last serviced.

4.4 Description of Warning System

No warning system currently is in use for the subject dam.

4.5 Evaluation of Operational Adequacy

The operation of the dam has been successful to the extent that, reportedly, it has not been overtopped since it was constructed in 1939.

Although maintenance documentation is poor, the adequacy of the maintenance program for the dam appears to have been fair. Areas of maintenance that have not been adequately performed are:

1. Gate lift stems not replaced.
2. Some spalls and deterioration on dam not repaired.
3. Debris in downstream channel not removed.
4. Broken section of south spillway training wall not restored.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design data

The intensity of storm water runoff that the spillway should be able to handle is based on the size and hazard classification of the dam. This runoff intensity, called the spillway design flood (SDF) is described in terms of return frequency or probable maximum flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dam" published by the U.S. Army Corps of Engineers, the SDF for Speedwell Dam falls in a range of 1/2 PMF to PMF. In this case, the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low side of their respective ranges.

The SDF peak computed for Speedwell Dam is 17,623 c.f.s. This value is derived from the 1/2 PMF hydrograph computed by the use of the HEC-1-DB Flood Hydrograph Computer Program using Snyder's coefficients. Hydrologic computations and computer output are contained in Appendix 4.

The spillway discharge rates were computed by the use of a weir formula appropriate for the configuration of its overflow section.(See Appendix 4.) The spillway discharge with lake level equal to the top of dam was computed to be 4255 c.f.s.

The SDF was routed through the dam by the use of the HEC-1-DB computer program using the modified Puls method. The routing resulted in an overtopping of the center section of the dam

and the natural ground adjacent to the spillway training walls by an estimated depth of 4.9 feet. A breach analysis indicated that failure of the dam due to overtopping would not significantly increase the downstream hazard over that which would exist without dam failure. Accordingly, the subject spillway is assessed as being inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers.

b. Experience Data

Reportedly, the dam has not been overtopped since its construction in 1939. Reportedly, in 1968 a hurricane resulted in a tailwater elevation within approximately one foot of the spillway crest. At that time discharge from the dam caused damage to the stone arch bridge 150 feet downstream; but no other significant damage.

c. Visual Observations

No evidence was found at the time of inspection that would indicate that the dam had been overtopped.

d. Overtopping Potential

As indicated in paragraph 5.1.a, a storm of magnitude equivalent to the SDF would cause overtopping of the dam by a height of 4.9 feet above the top of dam. The spillway is capable of passing approximately 25 percent of the SDF with lake level equal to the top of dam.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The dam appeared, at the time of inspection, to be structurally sound with no evidence of cracks, settlement or distress. However, the visual inspection disclosed four zones of seepage discharging from the spillway training walls downstream of dam.

The seepage appears to be similar to that noted in the inspection report prepared in 1944. The severity of the seepage cannot be precisely determined within the scope of this Phase I evaluation. However, the seepage does not appear to be an indication of immediate structural instability.

b. Design and Construction Data

Both the construction drawings and inspection reports written during construction indicate that the dam is founded directly on bedrock consisting of granite pegmatite.

Structural stability computations contained in the NJDEP file are not clear enough to be used to form an assessment of the stability of the dam. Therefore, a brief stability analysis was performed as a part of this Phase I evaluation and is located in Appendix 5. The analysis does not indicate a condition of instability.

c. Operating Records

There are no operating records available for the dam. The water level of Speedwell Lake is not monitored.

d. Post Construction Changes

Since Speedwell Dam was constructed in 1939, no changes to the dam or surrounding area are known that would have significant effect on its structural integrity.

e. Seismic Stability

Speedwell Dam is located in Seismic Zone 1 as defined in "Recommended Guidelines for Safety Inspection of Dams" which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. Speedwell Dam appeared to be stable under static loading conditions at the time of inspection.

Records at the Lamont-Doherty Geological Observatory of Columbia University indicate that recent earthquakes in the Morris County area had magnitudes ranging from 0 to 3.1 (Nuttly scale).

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety

Based on hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillway of Speedwell Dam is assessed as being inadequate. The spillway is not able to pass the SDF designated for the dam without an overtopping of the center section and the natural ground adjacent to the north and south ends of the dam.

The structural integrity of the dam is considered adequate based on visual inspection and structural analysis outlined in Appendix 5. No report nor written evidence was found that would contradict that assessment.

b. Adequacy of Information

Information sources for this study include: 1) field inspection, 2) plans, correspondence and inspection reports in NJDEP file, 3) USGS quadrangle, 4) aeral photograph supplied by Morris County Planning Board, and 5) consultation with personnel of the Town of Morristown. The information obtained is sufficient to allow a Phase I assessment as outlined in "Recommended Guidelines for Safety Inspection of Dams."

Some of the absent data are as follows:

1. Stream and lake elevation gaging records.
2. Hydraulic and structural design reports.

One datum contained in the NJDEP file at variance with the findings of this report is as follows: area of Speedwell Lake, reported to be 26.5 acres, was found to be 20.2 acres.

c. Necessity for Additional Data/Evaluation

Additional evaluation is considered necessary in order to assess the effect of the observed seepage on the structural integrity of the dam. The evaluation should be based on monitoring of seepage as outlined in paragraph 7.2.c.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses outlined in paragraph 5.1.a, the spillway is assessed as being inadequate. It is therefore recommended that a qualified professional engineer be engaged in the near future to perform more accurate hydraulic and hydrologic analyses relating to the spillway capacity. The analyses should more accurately determine runoff characteristics of the watershed and should refine the discharge capacity of the spillway and the downstream channel capacity. Based on the findings of these analyses, remedial measures should be undertaken to prevent damage, especially erosion of areas adjacent to the dam due to overtopping of the dam resulting from a storm equivalent to the SDF.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future.

1. The concrete spillway, outlet works and gatehouse

should be thoroughly inspected and renovated as outlined below:

a. Drain the lake to an elevation equal to the bottom of the lift gate.
b. Thoroughly inspect and sand blast all concrete.
c. Pressure grout all major cracks and patch all spalls and deteriorated surfaces.
d. Apply an epoxy preservative coating to all surfaces.
e. Inspect the fish screens and renovate if necessary.

2. The gate lift stems should be replaced and the lifting mechanisms should be thoroughly inspected and renovated if necessary.

3. The training walls along the sides of the downstream channel should be renovated to correct their undermined condition.

4. Debris on the dam and in the downstream channel should be removed.

5. Measures should be taken to discourage pedestrian access to the spillway crest.

b. Maintenance

The owner of the dam should initiate a program of periodic inspection and maintenance in the near future, the complete records of which to be kept on file and made available to the public. A visual inspection of the dam and appurtenances by a

qualified professional engineer should be made annually and reported on a standardized check-list form. Repairs should be made as required and the following maintenance should be performed annually: inspect the gate operating mechanisms and perform any necessary servicing, and clear the the downstream channel. In addition, the lake should be lowered at least once every five years at which time the lake should be cleaned and the normally submerged portions of the dam and outlet works inspected and repaired.

c. Additional Studies

Arrangements should be made in the near future to monitor the observed seepage in order to determine its effect on the structural stability of the dam. If necessary, measurements should be made by the use of appropriate instrumentation. The monitoring should be performed by a qualified professional engineer.

PLATES

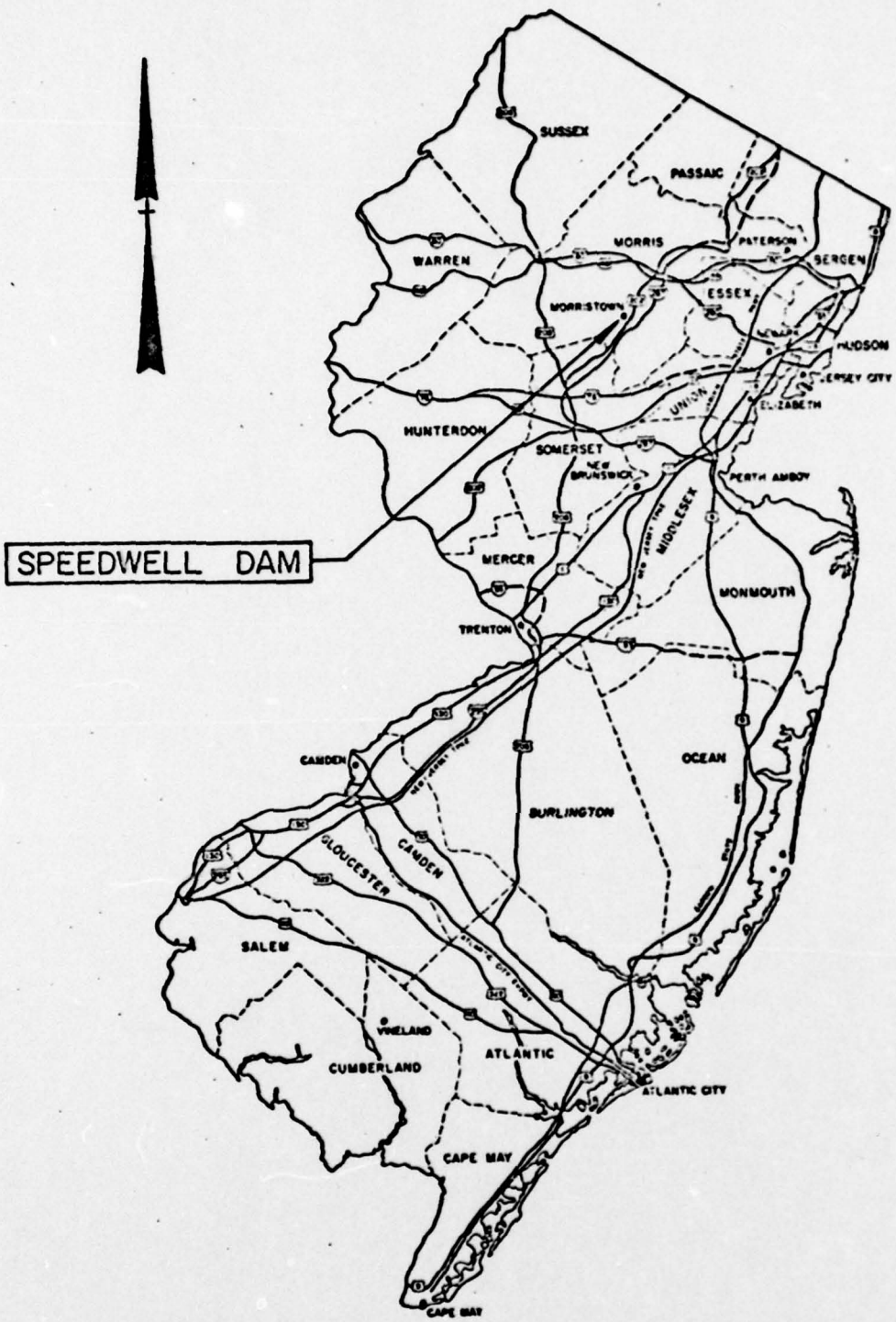


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP SPEEDWELL DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00359
	SCALE: NONE
	DATE: MAY, 1979

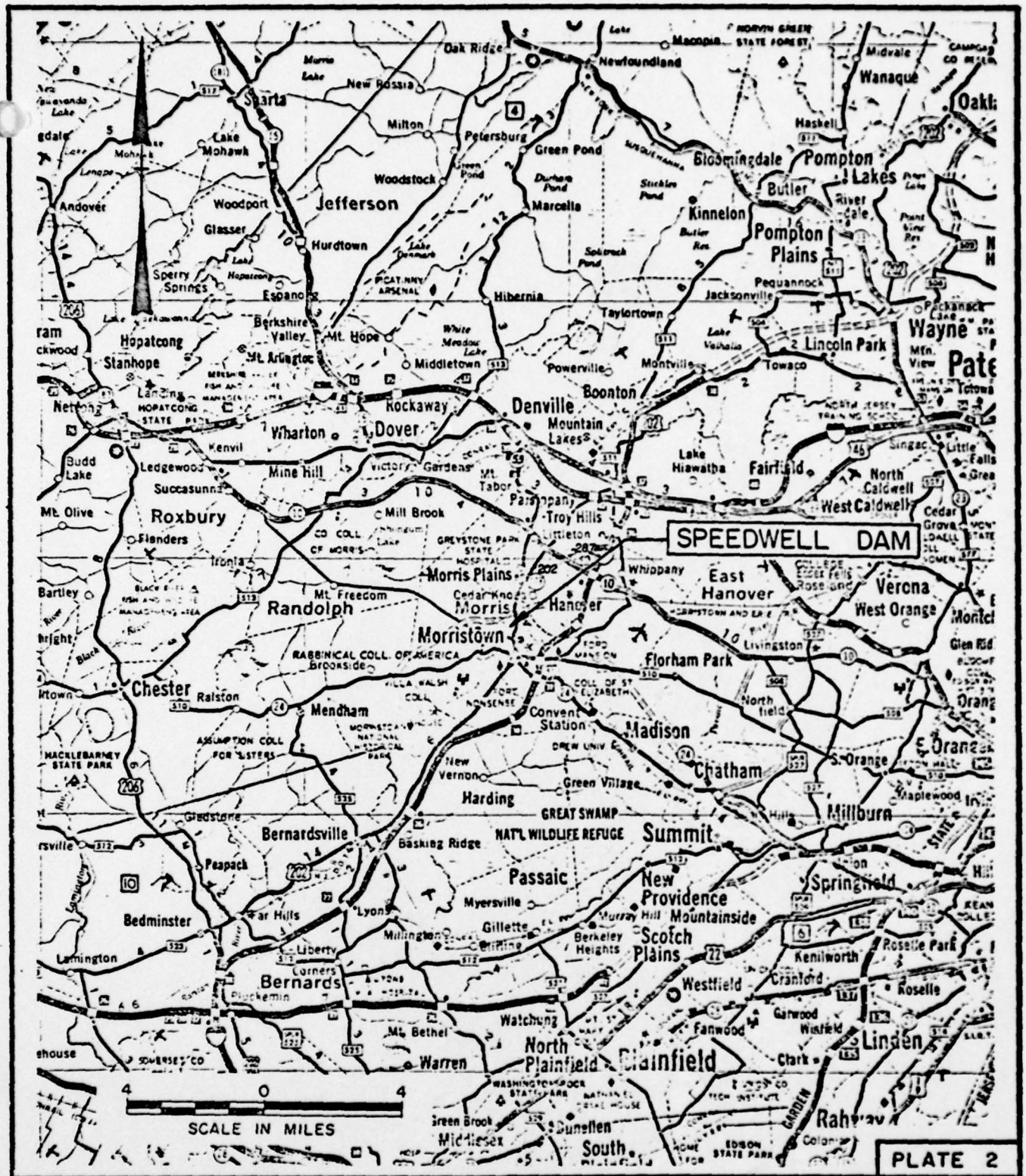


PLATE 2

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

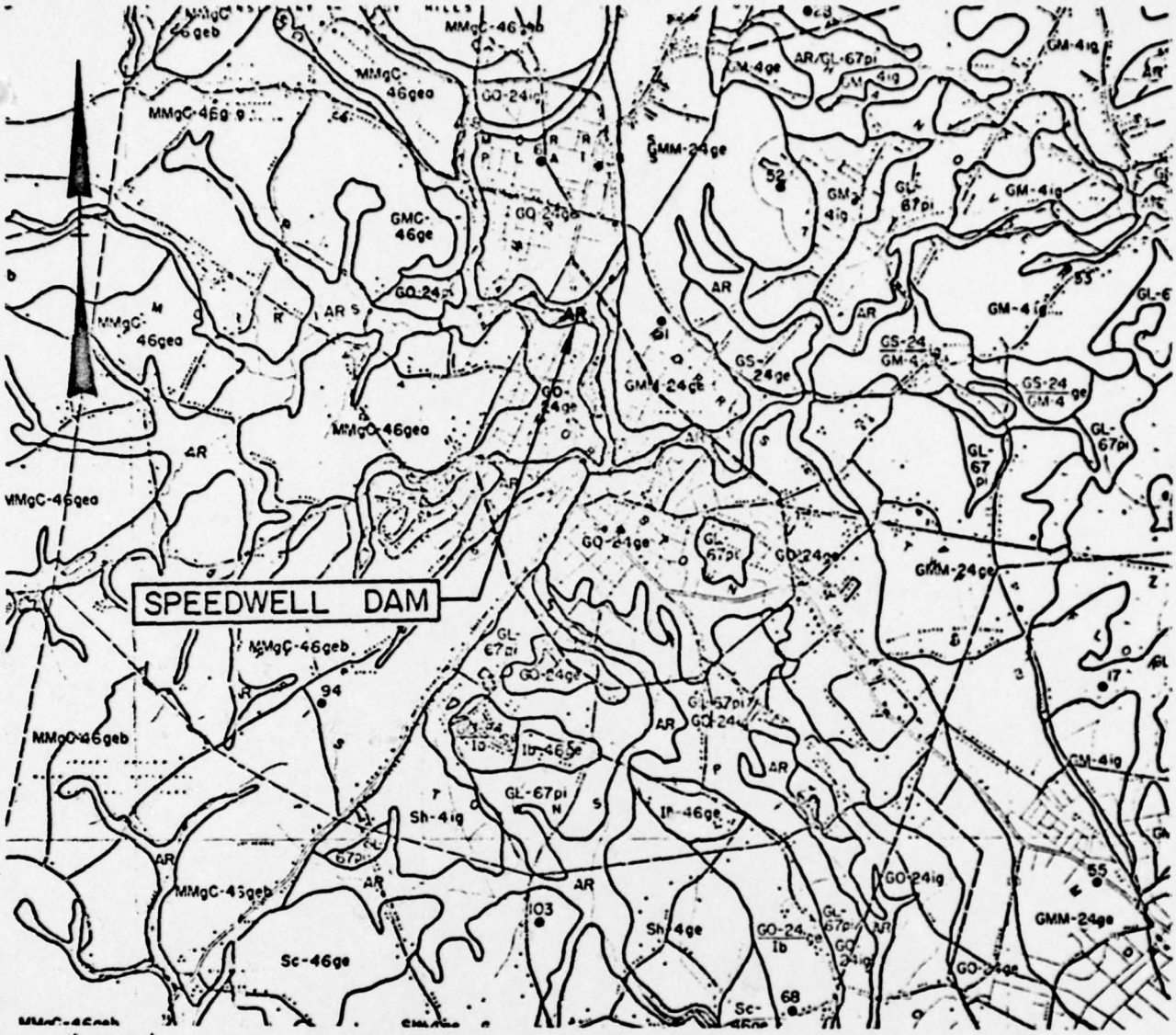
VICINITY MAP

SPEEDWELL DAM

I.D. N.J. 00359

SCALE: AS SHOWN

DATE: MAY, 1979



Legend

AR — Recent alluvium composed of statified materials deposited by streams.

GO-24 — Well-sorted, uniform deposits of silt, sand and gravel. (Wisconsin Stratified Drift)

Note: Information taken from Rutgers University Soil Survey of New Jersey, Report No. 9, Morris County, and Geologic Map of New Jersey prepared by Lewis and Kummel.

PLATE 3

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

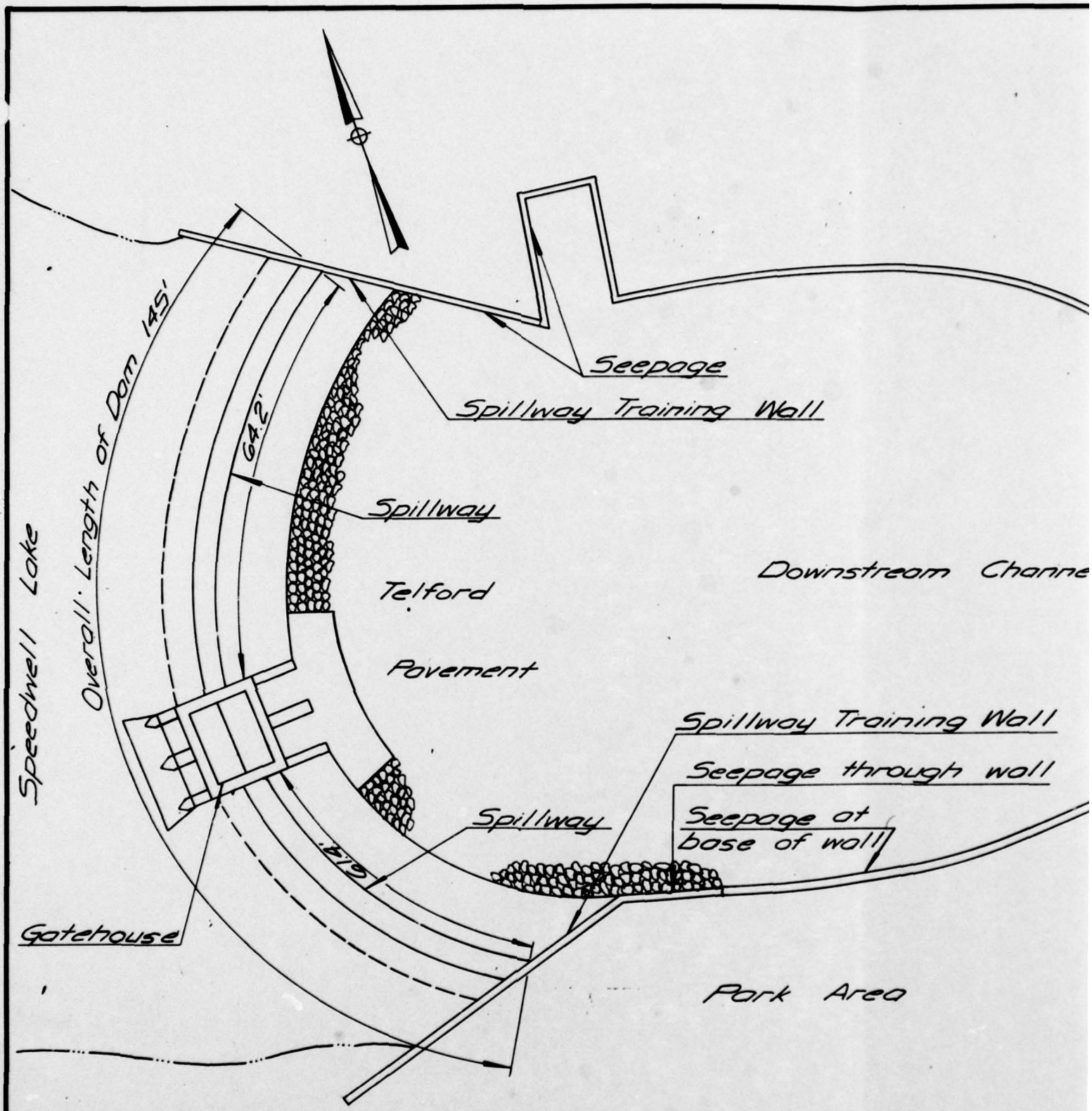
SOIL MAP

SPEEDWELL DAM

I.D. N.J. 00359

SCALE: NONE

DATE: MAY, 1979



Note: Information token from plans prepared by Charles K. Fetzer, dated December 15, 1936 and field inspection April 23, 1979.

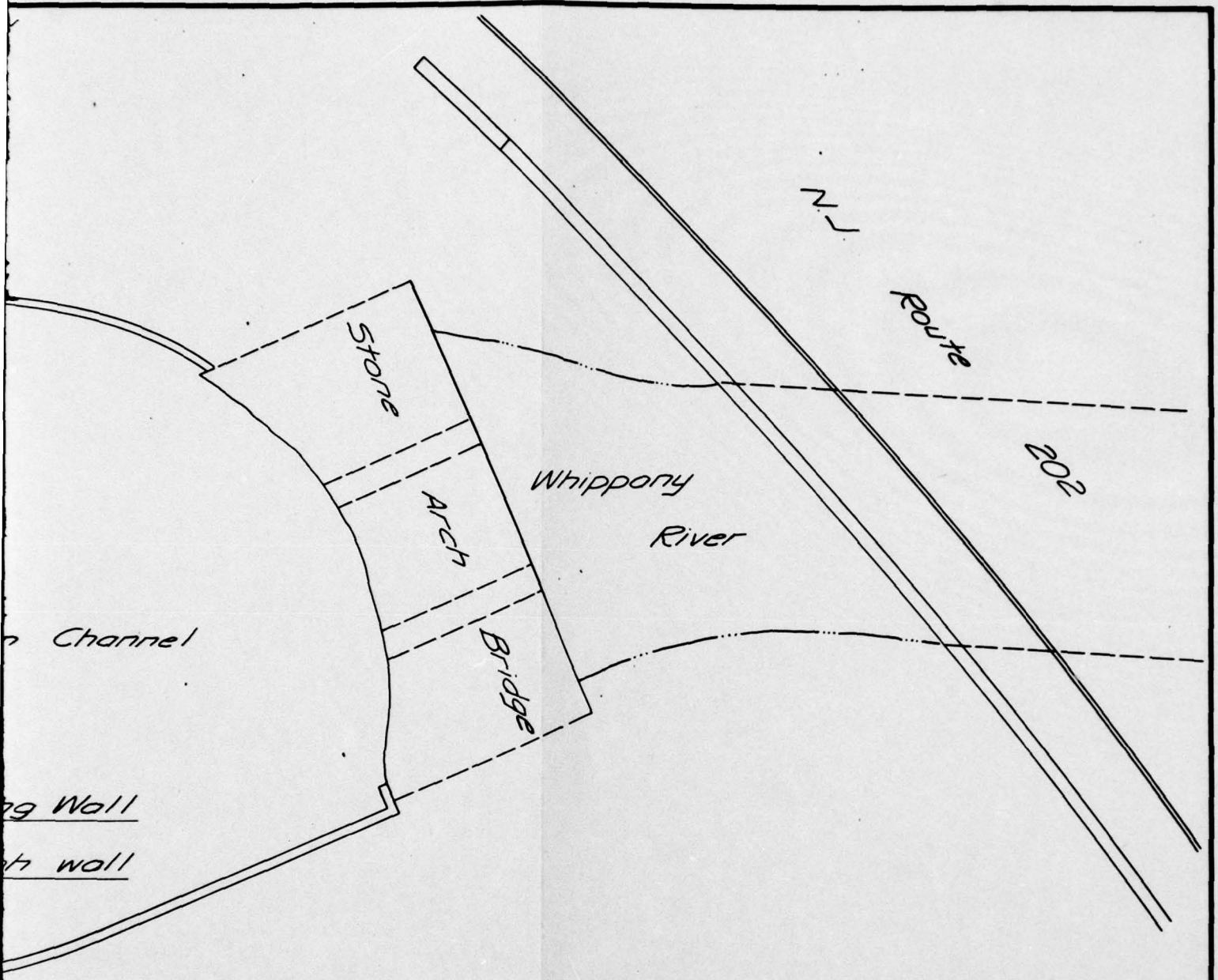


PLATE 4

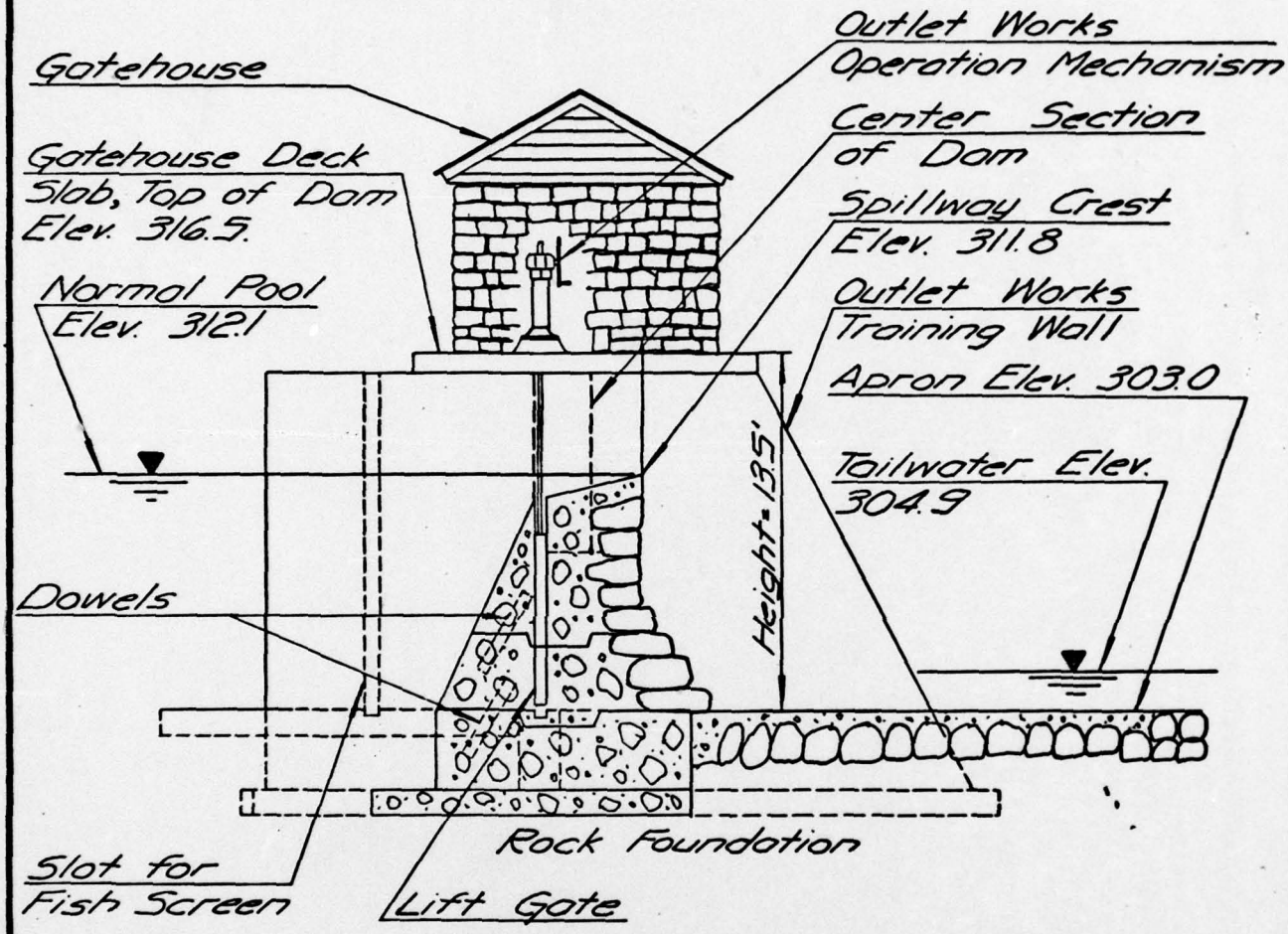
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

GENERAL PLAN

SPEEDWELL DAM

I.D. N.J. 00359	SCALE: NOT TO SCALE
	DATE: MAY, 1979



Note: Information taken from plans prepared by Charles K. Fetzer, dated December 15, 1936 and field inspection April 23, 1979.

PLATE 5

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

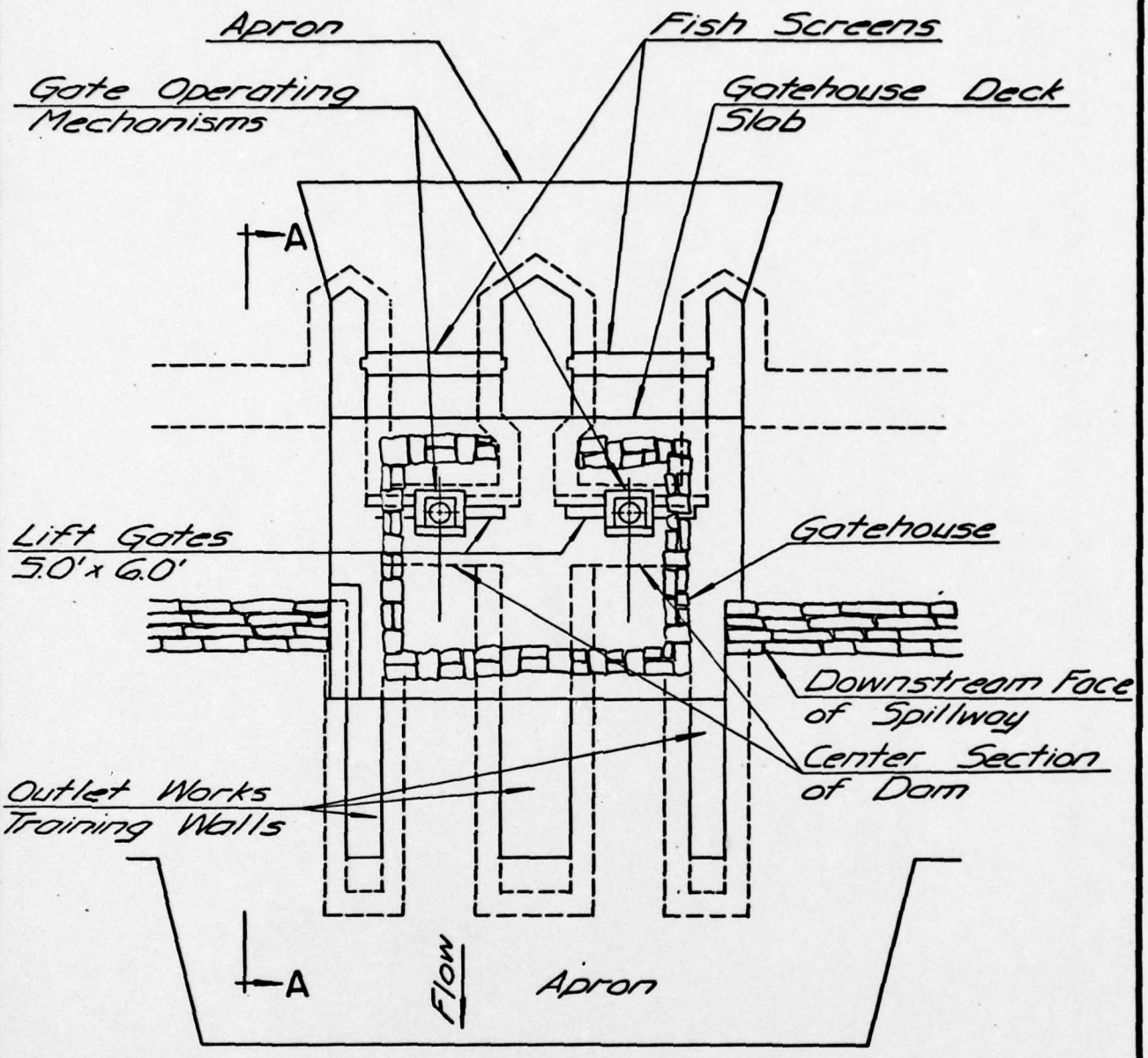
SECTION A-A

SPEEDWELL DAM

I.D. NJ.00359

SCALE: NOT TO SCALE

DATE: MAY, 1979



Note: Information taken from plans prepared by Charles K. Fetzer, dated December 15, 1936 and field inspection April 23, 1979.

PLATE 6

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

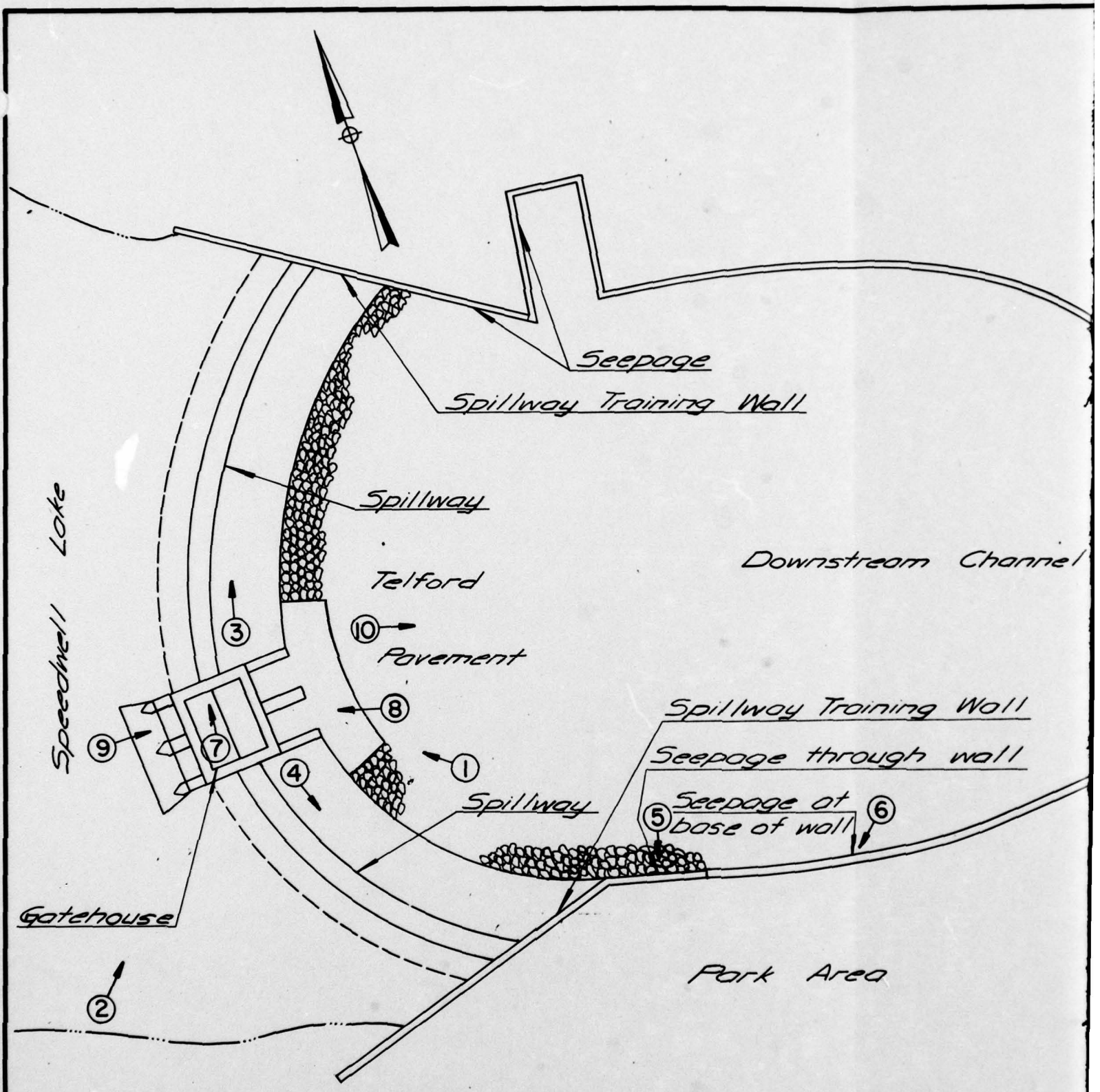
GATEHOUSE PLAN

SPEEDWELL DAM

I.D. N.J. 00359

SCALE: NOT TO SCALE

DATE: MAY, 1979



Note: Information taken from plans prepared by Charles K. Fetzer, dated December 15, 1936 and field inspection April 23, 1979.

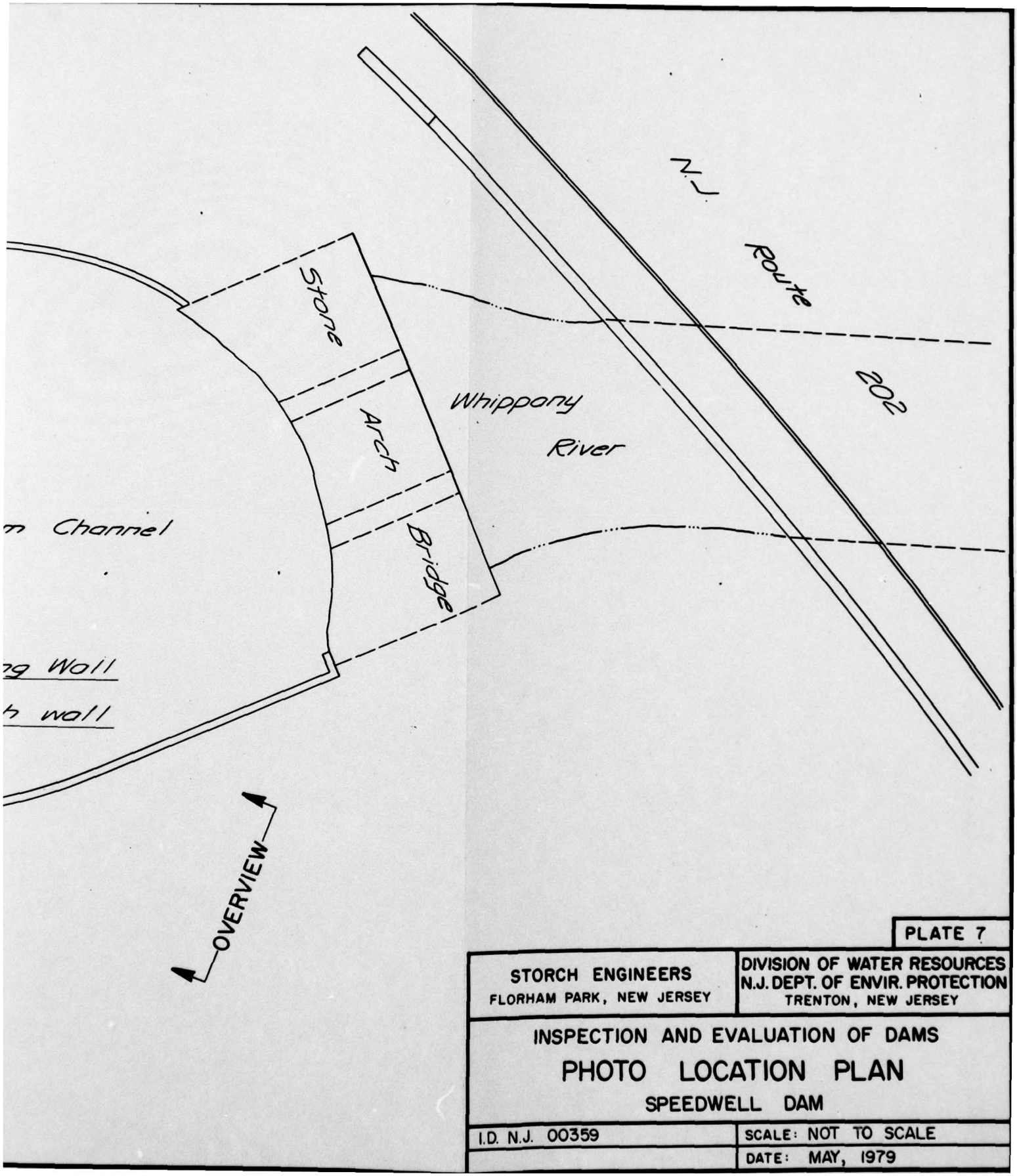


PLATE 7

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN

SPEEDWELL DAM

I.D. N.J. 00359	SCALE: NOT TO SCALE
	DATE: MAY, 1979

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List
Visual Inspection
Phase I

Name of Dam Speedwell Lake County Morris State New Jersey Coordinators NJDEP

Date(s) Inspection 4/23/79 Weather Fair Temperature 75°F

Pool Elevation at Time of Inspection 312.1 M.S.L. Tailwater at Time of Inspection 304.9 M.S.L.

Inspection Personnel:

John Gribbin David Hoyt

Ronald Lai Joseph Fox

Richard McDermott

John Gribbin Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Majority of dam is free overflow weir. Masonry training walls at each end of overflow weir comprise ends of dam. Natural ground slopes upward from training wall at each end of dam.	Upper portions of training walls appear to have been added as pedestrian barriers with no structural function. Section of upper portion of south training wall broken off.
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	No distress observed	
DRAINS	N.A.	
WATER PASSAGES	N.A.	
FOUNDATION & APRON	Apron appeared to be in good condition.	Surface obscured by discharge.
VERTICAL AND HORIZONTAL ALIGNMENT	Vertical alignment: Level Horizontal alignment: Curved	Horizontal alignment appears to be in conformance with construction drawings.

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CONCRETE/MASONRY DAMS

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
URFACE CRACKS ONCRETE SURFACES	Stone masonry center section of dam, in which gates are located, is severely deteriorated at the water line on the upstream side.	Overflow portions of dam submerged by lake and overflow. Recommend future inspection under drawn-down condition.
TRUCTURAL CRACKING	None observed	
ONSTRUCTION JOINTS	Submerged by flow	
ONOLITH JOINTS	N.A.	
EAKAGE	None observed	
EEPAGE	Four areas of seepage noted discharging from the stone masonry training walls forming the downstream channel. Two areas in the south wall were flowing as slight trickles. Two areas in north wall were manifest as wet areas.	One seepage discharge at south training wall contains orange silt.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	N.A.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	N.A.	
ANY NOTICEABLE SEEPAGE	N.A.	
STAFF GAGE AND RECORDER	N.A.	
DRAINS	N.A.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	N.A.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	N.A.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	N.A.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	N.A.	
RIPRAP FAILURES	N.A.	

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OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	N.A.	
INTAKE STRUCTURE	Masonry training walls in good condition. Steel slots for fish screen rusted but in serviceable condition.	
OUTLET STRUCTURE	Masonry training walls generally good condition; one stone displaced.	
OUTLET CHANNEL	Same as spillway outlet channel.	
GATE AND GATE HOUSING	Gates appeared to be in satisfactory condition. Lift stems are severely rusted at lake water line. Gate house in good condition. Conc. deck slab severely spalled at west edge. Operating mechanisms in good condition - one rusted, one painted.	Outlet works consists of two lift gates with operating mechanisms in masonry gate house. Gates not operated at time of inspection. Gatehouse door not in place.

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Weir in good condition.	Spillway is overflow portion of dam.
APPROACH CHANNEL	N.A.	
DISCHARGE CHANNEL	Large accumulations of rocks directly downstream. Some debris accumulated, including logs, tires, etc. The rocks and debris form a minor obstruction to flow.	Channel formed by masonry walls for 150 feet downstream.
APRON	Appeared to be in good condition.	Same as apron for dam.

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INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	NONE	
OBSERVATION WELLS	NONE	
WEIRS	NONE	
PIEZOMETERS	NONE	
OTHER	N.A.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Slopes range from 7% to greater than 50%. Average slope approx. 40%.	
SEDIMENTATION	No significant accumulation of sediment in the vicinity of the outlet works.	
STRUCTURES ALONG BANKS	No structures observed.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Wide, well defined stream. Rocks and debris comprise a minor obstruction.	Pocahontas Lake located approx. 2000 feet downstream of dam.
SLOPES	Slopes range from 7% to 50%. Average slope approx. 15%. Stone walls along channel are undermined.	Between dam and stone arch bridge, sides of channel are composed of stone walls which are continuations of spillway training walls.
STRUCTURES ALONG BANKS	No structures observed along banks between subject dam and Pocahontas Lake. Four brick garden apartment buildings observed along west bank of Pocahontas Lake.	
DOWNSTREAM BRIDGES	Old stone arch bridge approx. 150 feet downstream. (Openings approx. 8' high). Masonry highway bridge approx. 200 feet downstream.	Stone bridge is in deteriorated condition and usage is deterred by cross chains.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DAM - PLAN	Plans titled "Speedwell Dam, Morristown, Morris Co.," prepared by Charles K. Fetzer, dated Dec. 15, 1936. (5 sheets)
SECTIONS	
SPILLWAY - PLAN	Fetzer Plans, 1936
SECTIONS	
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Not available
OUTLETS - PLAN	Fetzer Plans. 1936
DETAILS	Fetzer Plans, 1936
CONSTRAINTS	Not available
DISCHARGE RATINGS	Available - Calculations in NJDEP file
HYDRAULIC/HYDROLOGIC DATA	Available - Floods of record (NJDEP file) Stream gauging records - USGS Station 01381500, Whippany River
RAINFALL/RESERVOIR RECORDS	Not Available
CONSTRUCTION HISTORY	Available - Photos, inspection and progress reports in NJDFP file
LOCATION MAP	Available - Fetzer Plans

ITEM	REMARKS
DESIGN REPORTS	Not available
GEOLOGY REPORTS	Not available
DESIGN COMPUTATIONS	
HYDROLOGY & HYDRAULICS	Available (N.J. State Water Policy Commission calculations in NJDEP file)
DAM STABILITY	Available (same)
SEEPAGE STUDIES	Not available
MATERIALS INVESTIGATIONS	
BORING RECORDS	Not available
LABORATORY	Not available
FIELD	Test pits at time of excavation - Inspection report in NJDEP file.
POST-CONSTRUCTION SURVEYS OF DAM	Not available
BORROW SOURCES	Not available

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

APPENDIX 2

Photographs

PHOTO 1

DOWNSTREAM FACE OF SPILLWAY AND GATEHOUSE

PHOTO 2

UPSTREAM VIEW OF GATEHOUSE

SPEEDWELL DAM
23 APRIL 1979

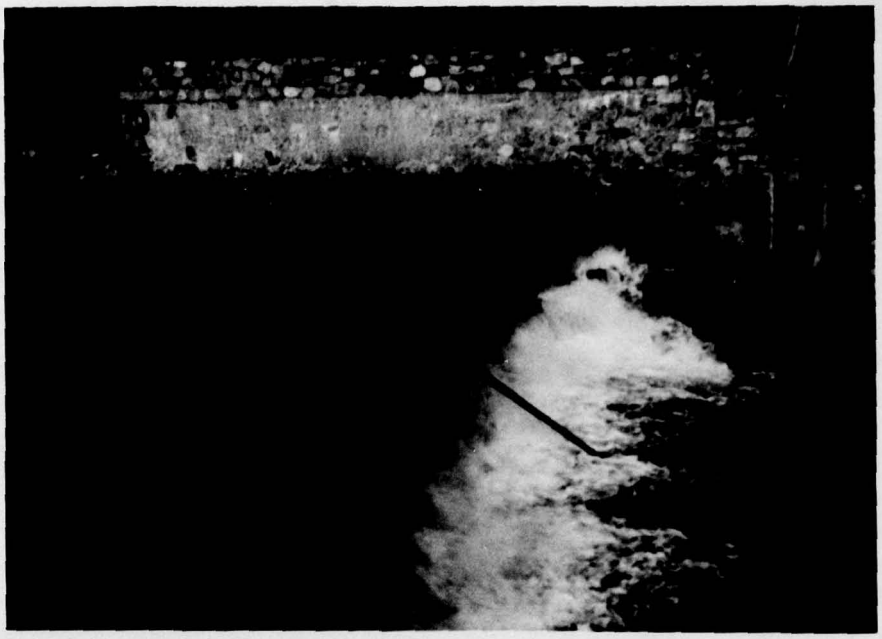


PHOTO 3

NORTH SECTION OF SPILLWAY CREST

PHOTO 4

SOUTH SECTION OF SPILLWAY CREST

SPEEDWELL DAM
23 APRIL 1979

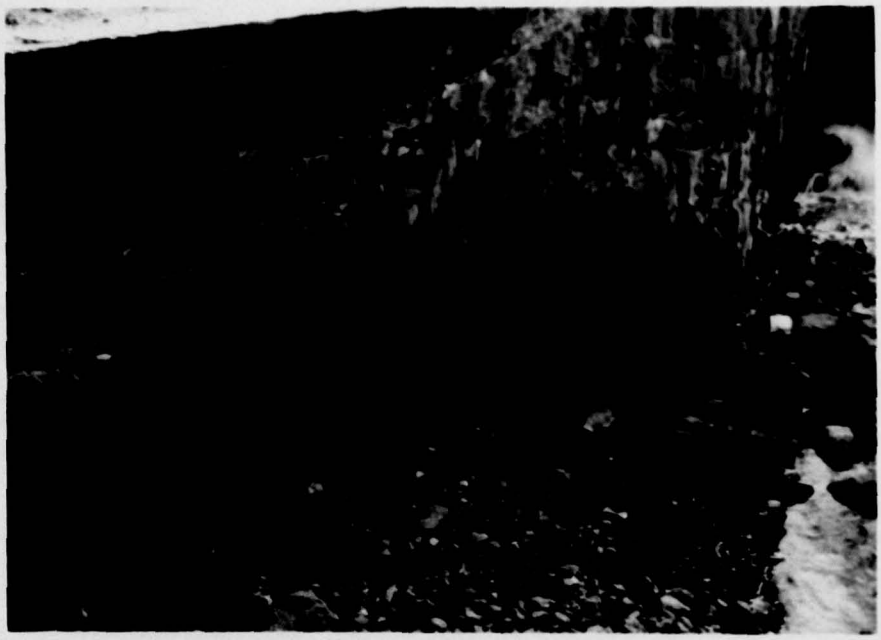


PHOTO 5

SEEPAGE THROUGH SOUTH TRAINING WALL

PHOTO 6

SEEPAGE AT BASE OF SOUTH TRAINING WALL

SPEEDWELL DAM
23 APRIL 1979

PHOTO 7

GATE OPERATING MECHANISM

PHOTO 8

DOWNSTREAM VIEW OF GATES

SPEEDWELL DAM
23 APRIL 1979

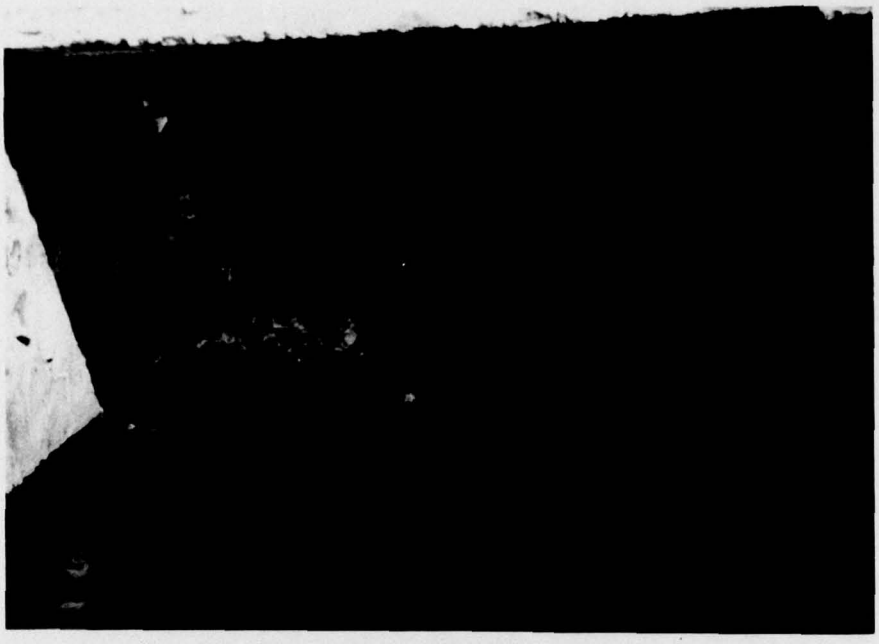


PHOTO 9

GATE LIFT STEM - RUSTED AT WATER LINE

PHOTO 10

DOWNSTREAM CHANNEL AND BRIDGES

SPEEDWELL DAM
23 APRIL 1979

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 20% developed, 80% wooded

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 312.1 (77 acre-feet)

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

ELEVATION MAXIMUM DESIGN POOL: 318.6

ELEVATION TOP DAM: 316.5

SPILLWAY CREST: Concrete Weir

a. Elevation 311.8
b. Type Uncontrolled
c. Width 4 feet
d. Length 125.6 feet
e. Location Spillover Overflow portion of dam
f. Number and Type of Gates N.A.

OUTLET WORKS: 2 - 5' x 6' sluices

a. Type Cast iron lift gates
b. Location Gatehouse at center section of dam
c. Entrance inverts 303.0
d. Exit inverts 303.0
e. Emergency draindown facilities: Raise gates

HYDROMETEOROLOGICAL GAGES: None

a. Type N.A.
b. Location N.A.
c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

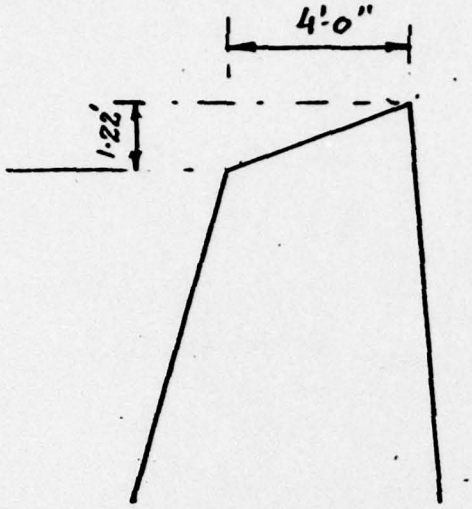
(Lake stage equal to top of dam) 4255 c.f.s.

APPENDIX 4

Hydrologic Computations

HYDRAULICS

PRINCIPAL SPILLWAY



TYPICAL SPILLWAY SECTION.

The discharge over the crest of principal spillway will be calculated by the following formula:

$$Q = C\,L\,H_e^{3/2}$$ (Ref: Design of Small Dams P. 373)

where Q = discharge
C = a variable coefficient of discharge
L = effective length of crest and
H_e = total head on the crest, including velocity of approach head, h_a

The pier and abutment effects will be accounted for by the following formula:

$$L = L' - 2(NK_p + K_a)H_e$$

(Ref: Design of Small Dams P 373)

where L = effective length of crest
L' = net length of crest
N = number of piers
K_p = pier contraction coefficient
K_a = abutment contraction coefficient and
H_e = total head on crest.

For Speedwell Lake Dam spillway,

$L' = 61'\,5'' + 15'\,4'' + 48'\,10\frac{1}{2}'' = 125'\cdot 7\frac{1}{2}''$

$= 125.625'$

N = 1
K_p = 0.02
K_a = 0.20

Coefficient of Discharge :-

Ref : Handbook of Hydraulics, King & Brater

Page 5-26.

From Table 5-12, using data for fig. 5-14 which is nearest to the Speedwell Lake Dam spillway section.

The coefficient of discharge varies from 3.38 to 3.44

Use coefficient of discharge = 3.4.

STORCH ENGINEERS

Sheet 3 of 9

Project SE # 1132B SPEEDWELL DAM

Made By DMP Date 4/30

HYDRAULICS

Chkd By JG Date 5/11

Elevation	He (Ft)	L' (Ft)	$2(NK_p + K_a)$	$L = L' - 2(NK_p + K_a)H_e$ (Ft)
311.82	0	125.625	0.44	125.625
312	0.18	125.625	0.44	125.5
313	1.18	125.625	0.44	125.1
314	2.18	125.625	0.44	124.7
315	3.18	125.625	0.44	124.2
316	4.18	125.625	0.44	123.8
316.5	4.68	125.625	0.44	123.6
317	5.18	125.625	0.44	123.3
318	6.18	125.625	0.44	122.9
319	7.18	125.625	0.44	122.5
320	8.18	125.625	0.44	122.0
325	13.18	125.625	0.44	119.8
330	18.18	125.625	0.44	117.6

Elevation	He (Ft)	L (Ft)	Q (CFS)	
311.82	0	125.6	0	
312	0.18	125.5	33	
313	1.18	125.1	545	
314	2.18	124.7	1365	
315	3.18	124.2	2395	
316	4.18	123.8	3,597	
316.5	4.68	123.6	4,255	CREST OF DAM
317	5.18	123.3	4,942	
318	6.18	122.9	6,420	
319	7.18	122.5	8,013	
320	8.18	122.0	9,704	
325	13.18	119.8	19,490	*
330	18.18	117.6	30,994	*

* Submerged conditions take place above Elevation 320

STORCH ENGINEERS

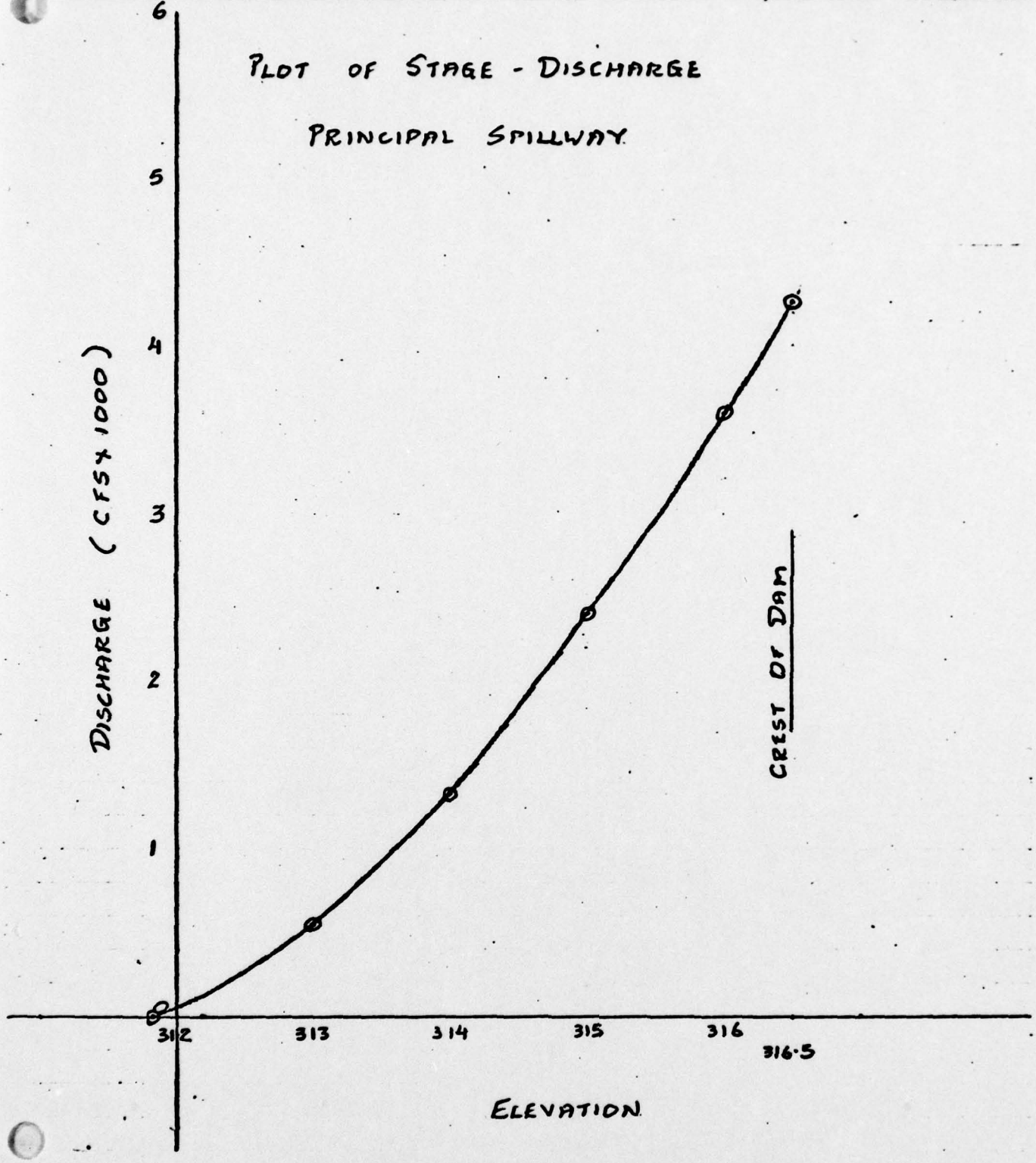
Sheet 5 of 9

Project S.E. #1132B SPEEDWELL DAM

Made By DMP Date 4/30

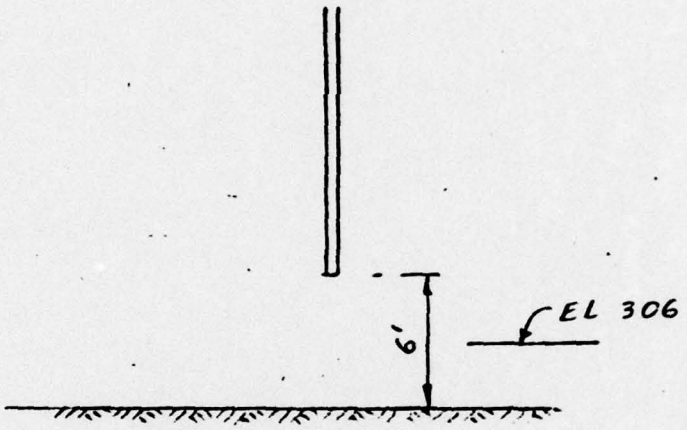
HYDRAULICS

Chkd By JG Date 5/11



Outlet Works:

The outlet works consists of two sluice gates each 5' wide x 6' high.



SECTION
SLUICE GATE

The discharge through the sluice gate openings will be calculated by the following orifice formula:-

$$Q = C a \sqrt{2gh}$$

The value of C will be taken as 0.70

$$a = 2 \times 5 \times 6 = 60 \text{ S.F.}$$

Reference: Design of Small Dams.

Page 472

STORCH ENGINEERS Sheet 7 of 9

Project S E # 1132 B SPILLWELL DAM Made By DMS Date 5/1

HYDRAULICS Chkd By JG Date 5/11

DISCHARGE - 2 GATES OPEN

Elevation	h (ft)	Q ($Ca\sqrt{2gh}$) (CFS)	
311.82	5.82	813	
312	6.00	826	
313	7.0	892	
314	8.0	953	
315	9.0	1011	
316	10.0	1066	
316.5	10.5	1092	CREST OF DAM.
317	11.0	1118	
318	12.0	1168	
319	13.0	1215	
320	14.0	1261	

HYDROLOGY

Precipitation :

Probable Maximum Precipitation
Zone 6, 25 sq. mile area
= 25.2 in

Duration (hr.)	% PMP
6	93
12	100
24	108

Infiltration :

Initial 1.0 inch

Constant 0.1 inch / hr.

Snyder's Coefficients :

$C_t = 2.0$ $C_p = 0.62$

Length of the main channel from outlet to divide L = 7.9 miles

Distance from the outlet to a point on the stream nearest the centroid of the basin L_c = 2.3 miles

$$t_p = C_t (L L_c)^{0.3}$$

$$t_p = 2.0 (7.9 \times 2.3)^{0.3} = 4.77 \text{ hrs}$$

Routing

Routing will be done by the HEC-1-DB Program. For dam overtopping analysis, the length of the dam will be taken as 177 ft. This length is due to the fact that the ground elevation adjacent to each end of dam is equal to the elevation of the top of dam. When the lake overtops the dam, water will discharge over this ground.

Stage - Area

EL. (ft.)	Surface Area (Acre)
311.8	20.2
320.0	216
340.0	909

HEC-1-DB COMPUTATIONS

```
A1                          NATIONAL DAM SAFETY PROGRAM.
A2          Speedwell ~~POCAHONTAS~~ DAM, MORRISTOWN, NEWJERSEY.
A3                          MULTI RATIO PMF ROUTING.
B     150       1       0                                  0       0       3
B1      5
J       1       5       1
J1    0.5     0.4     0.3     0.2     0.1
K       0   SPEED                       0       0       1       0
K1                  INFLOW HYDROGRAPH TO SPEEDWELL LAKE.
M       1       1    25.2            25.2       0                       1
P       0    25.2      93     100     108
T                                                     1.0    0.10
W    4.77    0.62
X    -1.0   -0.05     2.0
K       1     DAM                       0       0       1       0
K1                  ROUTE DISCHARGE THROUGH SPEEDWELL LAKE.
Y                                   1       1
Y1      1                                          -312.1      -1
Y4  311.8     312     313     314     315     316   316.5     317     318     319
Y4    320     321     322     323     324     325
Y5      0      33     545    1365    2395    3597    4255    4942    6420    8013
Y5   9704   11338   12798   14144   15457   16625
$A   20.2     216     909
$E  311.8     320     340
$$  311.8
$D  316.5    2.63     1.5     177
```

NATIONAL DAM SAFETY PROGRAM.
POCAHONTAS DAM, MORRISTOWN, NEWJERSEY.
MULTI RATIO PMF ROUTING.

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	1	0	0	0	0	0	0	3	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1

RTIOS=	.50	.40	.30	.20	.10

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO SPEEDWELL LAKE.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
SPELD	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	25.20	0.00	25.20	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.20	93.00	100.00	108.00	0.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .850

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.10	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 4.77 CP= .62 NTA= 0

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.46 AND R= 4.42 INTERVALS

UNIT HYDROGRAPH 27 END-OF-PERIOD ORDINATES, LAG= 4.78 HOURS, CP= .63 VOL= 1.00

183.	664.	1291.	1840.	2116.	2009.	1658.	1321.	1052.	838.
668.	532.	424.	337.	269.	214.	171.	136.	108.	86.
44.	55.	44.	35.	28.	22.	18.			

END-OF-PERIOD FLOW

PMF HYDROGRAPH

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	1.00	1	.11	0.00	.11	24.
1.01	2.00	2	.11	0.00	.11	22.
1.01	3.00	3	.11	0.00	.11	20.
1.01	4.00	4	.11	0.00	.11	19.
1.01	5.00	5	.11	0.00	.11	18.
1.01	6.00	6	.11	0.00	.11	17.
1.01	7.00	7	.24	0.00	.24	16.
1.01	8.00	8	.24	.09	.15	32.
1.01	9.00	9	.24	.14	.10	102.
1.01	10.00	10	.24	.14	.10	255.
1.01	11.00	11	.24	.14	.10	491.
1.01	12.00	12	.24	.14	.10	781.
1.01	13.00	13	1.95	1.85	.10	1387.
1.01	14.00	14	2.33	2.23	.10	2843.
1.01	15.00	15	2.92	2.82	.10	5612.
1.01	16.00	16	7.39	7.29	.10	10616.
1.01	17.00	17	2.72	2.62	.10	17932.
1.01	18.00	18	2.14	2.04	.10	25923.
1.01	19.00	19	.17	.07	.10	32300.
1.01	20.00	20	.17	.07	.10	35246.
1.01	21.00	21	.17	.07	.10	34053.
1.01	22.00	22	.17	.07	.10	29885.
1.01	23.00	23	.17	.07	.10	24816.
1.02	0.00	24	.17	.07	.10	20105.
1.02	1.00	25	0.00	0.00	0.00	16226.
1.02	2.00	26	0.00	0.00	0.00	13101.
1.02	3.00	27	0.00	0.00	0.00	10561.
1.02	4.00	28	0.00	0.00	0.00	8482.
1.02	5.00	29	0.00	0.00	0.00	6783.
1.02	6.00	30	0.00	0.00	0.00	5407.
1.02	7.00	31	0.00	0.00	0.00	4308.
1.02	8.00	32	0.00	0.00	0.00	3432.
1.02	9.00	33	0.00	0.00	0.00	2734.
1.02	10.00	34	0.00	0.00	0.00	2178.
1.02	11.00	35	0.00	0.00	0.00	1755.
1.02	12.00	36	0.00	0.00	0.00	1637.
1.02	13.00	37	0.00	0.00	0.00	1528.
1.02	14.00	38	0.00	0.00	0.00	1425.
1.02	15.00	39	0.00	0.00	0.00	1330.
1.02	16.00	40	0.00	0.00	0.00	1241.
1.02	17.00	41	0.00	0.00	0.00	1158.
1.02	18.00	42	0.00	0.00	0.00	1080.
1.02	19.00	43	0.00	0.00	0.00	1008.
1.02	20.00	44	0.00	0.00	0.00	940.
1.02	21.00	45	0.00	0.00	0.00	877.
1.02	22.00	46	0.00	0.00	0.00	819.
1.02	23.00	47	0.00	0.00	0.00	764.
1.03	0.00	48	0.00	0.00	0.00	713.
1.03	1.00	49	0.00	0.00	0.00	665.
1.03	2.00	50	0.00	0.00	0.00	620.
1.03	3.00	51	0.00	0.00	0.00	579.
1.03	4.00	52	0.00	0.00	0.00	540.
1.03	5.00	53	0.00	0.00	0.00	504.
1.03	6.00	54	0.00	0.00	0.00	470.
1.03	7.00	55	0.00	0.00	0.00	439.
1.03	8.00	56	0.00	0.00	0.00	409.
1.03	9.00	57	0.00	0.00	0.00	382.
1.03	10.00	58	0.00	0.00	0.00	356.
1.03	11.00	59	0.00	0.00	0.00	332.
1.03	12.00	60	0.00	0.00	0.00	310.
1.03	13.00	61	0.00	0.00	0.00	289.
1.03	14.00	62	0.00	0.00	0.00	270.
1.03	15.00	63	0.00	0.00	0.00	252.
1.03	16.00	64	0.00	0.00	0.00	235.
1.03	17.00	65	0.00	0.00	0.00	219.
1.03	18.00	66	0.00	0.00	0.00	205.
1.03	19.00	67	0.00	0.00	0.00	191.
1.03	20.00	68	0.00	0.00	0.00	178.
1.03	21.00	69	0.00	0.00	0.00	166.
1.03	22.00	70	0.00	0.00	0.00	155.
1.03	23.00	71	0.00	0.00	0.00	145.
1.04	0.00	72	0.00	0.00	0.00	135.
1.04	1.00	73	0.00	0.00	0.00	126.
1.04	2.00	74	0.00	0.00	0.00	118.
1.04	3.00	75	0.00	0.00	0.00	110.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.04	4.00	76	0.00	0.00	0.00	102.
1.04	5.00	77	0.00	0.00	0.00	95.
1.04	6.00	78	0.00	0.00	0.00	89.
1.04	7.00	79	0.00	0.00	0.00	83.
1.04	8.00	80	0.00	0.00	0.00	78.
1.04	9.00	81	0.00	0.00	0.00	72.
1.04	10.00	82	0.00	0.00	0.00	68.
1.04	11.00	83	0.00	0.00	0.00	63.
1.04	12.00	84	0.00	0.00	0.00	59.
1.04	13.00	85	0.00	0.00	0.00	55.
1.04	14.00	86	0.00	0.00	0.00	51.
1.04	15.00	87	0.00	0.00	0.00	48.
1.04	16.00	88	0.00	0.00	0.00	45.
1.04	17.00	89	0.00	0.00	0.00	42.
1.04	18.00	90	0.00	0.00	0.00	39.
1.04	19.00	91	0.00	0.00	0.00	36.
1.04	20.00	92	0.00	0.00	0.00	34.
1.04	21.00	93	0.00	0.00	0.00	31.
1.04	22.00	94	0.00	0.00	0.00	29.
1.04	23.00	95	0.00	0.00	0.00	27.
1.05	0.00	96	0.00	0.00	0.00	26.
1.05	1.00	97	0.00	0.00	0.00	24.
1.05	2.00	98	0.00	0.00	0.00	22.
1.05	3.00	99	0.00	0.00	0.00	21.
1.05	4.00	100	0.00	0.00	0.00	19.
1.05	5.00	101	0.00	0.00	0.00	18.
1.05	6.00	102	0.00	0.00	0.00	17.
1.05	7.00	103	0.00	0.00	0.00	16.
1.05	8.00	104	0.00	0.00	0.00	15.
1.05	9.00	105	0.00	0.00	0.00	14.
1.05	10.00	106	0.00	0.00	0.00	13.
1.05	11.00	107	0.00	0.00	0.00	12.
1.05	12.00	108	0.00	0.00	0.00	11.
1.05	13.00	109	0.00	0.00	0.00	10.
1.05	14.00	110	0.00	0.00	0.00	10.
1.05	15.00	111	0.00	0.00	0.00	9.
1.05	16.00	112	0.00	0.00	0.00	8.
1.05	17.00	113	0.00	0.00	0.00	8.
1.05	18.00	114	0.00	0.00	0.00	7.
1.05	19.00	115	0.00	0.00	0.00	7.
1.05	20.00	116	0.00	0.00	0.00	6.
1.05	21.00	117	0.00	0.00	0.00	6.
1.05	22.00	118	0.00	0.00	0.00	6.
1.05	23.00	119	0.00	0.00	0.00	5.
1.06	0.00	120	0.00	0.00	0.00	5.
1.06	1.00	121	0.00	0.00	0.00	5.
1.06	2.00	122	0.00	0.00	0.00	4.
1.06	3.00	123	0.00	0.00	0.00	4.
1.06	4.00	124	0.00	0.00	0.00	4.
1.06	5.00	125	0.00	0.00	0.00	3.
1.06	6.00	126	0.00	0.00	0.00	3.
1.06	7.00	127	0.00	0.00	0.00	3.
1.06	8.00	128	0.00	0.00	0.00	3.
1.06	9.00	129	0.00	0.00	0.00	3.
1.06	10.00	130	0.00	0.00	0.00	2.
1.06	11.00	131	0.00	0.00	0.00	2.
1.06	12.00	132	0.00	0.00	0.00	2.
1.06	13.00	133	0.00	0.00	0.00	2.
1.06	14.00	134	0.00	0.00	0.00	2.
1.06	15.00	135	0.00	0.00	0.00	2.
1.06	16.00	136	0.00	0.00	0.00	2.
1.06	17.00	137	0.00	0.00	0.00	1.
1.06	18.00	138	0.00	0.00	0.00	1.
1.06	19.00	139	0.00	0.00	0.00	1.
1.06	20.00	140	0.00	0.00	0.00	1.
1.06	21.00	141	0.00	0.00	0.00	1.
1.06	22.00	142	0.00	0.00	0.00	1.
1.06	23.00	143	0.00	0.00	0.00	1.
1.07	0.00	144	0.00	0.00	0.00	1.
1.07	1.00	145	0.00	0.00	0.00	1.
1.07	2.00	146	0.00	0.00	0.00	1.
1.07	3.00	147	0.00	0.00	0.00	1.
1.07	4.00	148	0.00	0.00	0.00	1.
1.07	5.00	149	0.00	0.00	0.00	1.
1.07	6.00	150	0.00	0.00	0.00	1.

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

HYDROGRAPH ROUTING

ROUTE DISCHARGE THROUGH SPEEDWELL LAKE.

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-312.	-1

STAGE	311.80	312.00	313.00	314.00	315.00	316.00	316.50	317.00	318.00	319.00
	320.00	321.00	322.00	323.00	324.00	325.00				
FLOW	0.00	33.00	545.00	1365.00	2395.00	3597.00	4255.00	4942.00	6420.00	8013.00
	9704.00	11330.00	12798.00	14144.00	15457.00	16625.00				

SURFACE AREA=	20.	216.	909.
CAPACITY=	0.	826.	11280.
ELEVATION=	312.	320.	340.

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPI
311.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
316.5	2.6	1.5	177.

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

½ PMF

Route Discharge thru Speedwell Lake

OUTFLOW

24.	18.	14.	13.	11.	10.	9.	10.	21.	74.
176.	360.	494.	999.	1936.	3545.	6288.	9969.	13390.	15860.
16843.	16271.	14467.	12138.	9820.	7878.	6314.	5064.	4126.	3366.
2665.	2094.	1692.	1288.	1036.	872.	799.	743.	693.	646.
602.	561.	528.	497.	464.	433.	403.	376.	350.	326.
304.	284.	264.	246.	230.	215.	200.	187.	174.	162.
151.	141.	132.	123.	115.	107.	100.	93.	87.	81.
75.	70.	66.	61.	57.	53.	50.	46.	43.	40.
38.	35.	33.	32.	31.	29.	27.	26.	24.	22.
21.	20.	18.	17.	16.	15.	14.	13.	12.	11.
10.	10.	9.	8.	8.	7.	7.	6.	6.	6.
5.	5.	5.	4.	4.	4.	3.	3.	3.	3.
3.	2.	2.	2.	2.	2.	2.	2.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	0.	0.	0.	0.	0.	0.

STORAGE

3.	2.	2.	2.	1.	1.	1.	1.	3.	6.
11.	18.	30.	55.	109.	218.	401.	635.	873.	1060.
1141.	1094.	954.	782.	626.	500.	403.	326.	262.	204.
155.	119.	92.	72.	57.	49.	45.	42.	40.	38.
36.	34.	32.	30.	28.	26.	24.	22.	21.	19.
18.	17.	16.	15.	14.	13.	12.	12.	11.	10.
10.	9.	9.	8.	8.	8.	7.	7.	7.	6.
6.	6.	6.	6.	6.	5.	5.	5.	5.	5.
4.	4.	4.	4.	4.	4.	4.	3.	3.	3.
3.	2.	2.	2.	2.	2.	2.	2.	2.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STAGE

311.9	311.9	311.9	311.9	311.9	311.9	311.9	311.9	311.9	312.1
312.3	312.5	312.9	313.6	314.6	316.0	317.6	319.0	320.2	321.0
321.4	321.2	320.6	319.8	319.0	318.2	317.6	317.0	316.4	315.8
315.2	314.7	314.3	313.9	313.6	313.4	313.3	313.2	313.2	313.1
313.1	313.0	313.0	312.9	312.8	312.8	312.7	312.7	312.6	312.6
312.5	312.5	312.5	312.4	312.4	312.4	312.3	312.3	312.3	312.3
312.2	312.2	312.2	312.2	312.2	312.1	312.1	312.1	312.1	312.1
312.1	312.1	312.1	312.1	312.0	312.0	312.0	312.0	312.0	312.0
312.0	312.0	312.0	312.0	312.0	312.0	312.0	312.0	311.9	311.9
311.9	311.9	311.9	311.9	311.9	311.9	311.9	311.9	311.9	311.9
311.9	311.9	311.9	311.9	311.8	311.8	311.8	311.8	311.8	311.8
311.8	311.9	311.8	311.8	311.8	311.8	311.8	311.8	311.8	311.8
311.8	311.9	311.8	311.8	311.8	311.8	311.8	311.8	311.8	311.8
311.8	311.9	311.8	311.8	311.8	311.8	311.8	311.8	311.8	311.8

PEAK OUTFLOW IS 16843. AT TIME 21.00 HOURS

Speedwell Dam

SUMMARY OF DAM SAFETY ANALYSIS

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	312.10	311.50	316.50
STORAGE	7.	0.	272.
OUTFLOW	84.	0.	4255.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	321.36	4.86	1141.	16843.	12.00	21.00	0.00
.40	320.28	3.78	886.	13568.	11.00	21.00	0.00
.30	319.14	2.64	653.	10237.	9.00	21.00	0.00
.20	317.81	1.31	435.	6808.	6.00	21.00	0.00
.10	315.83	0.00	206.	3395.	0.00	21.00	0.00

APPENDIX 5

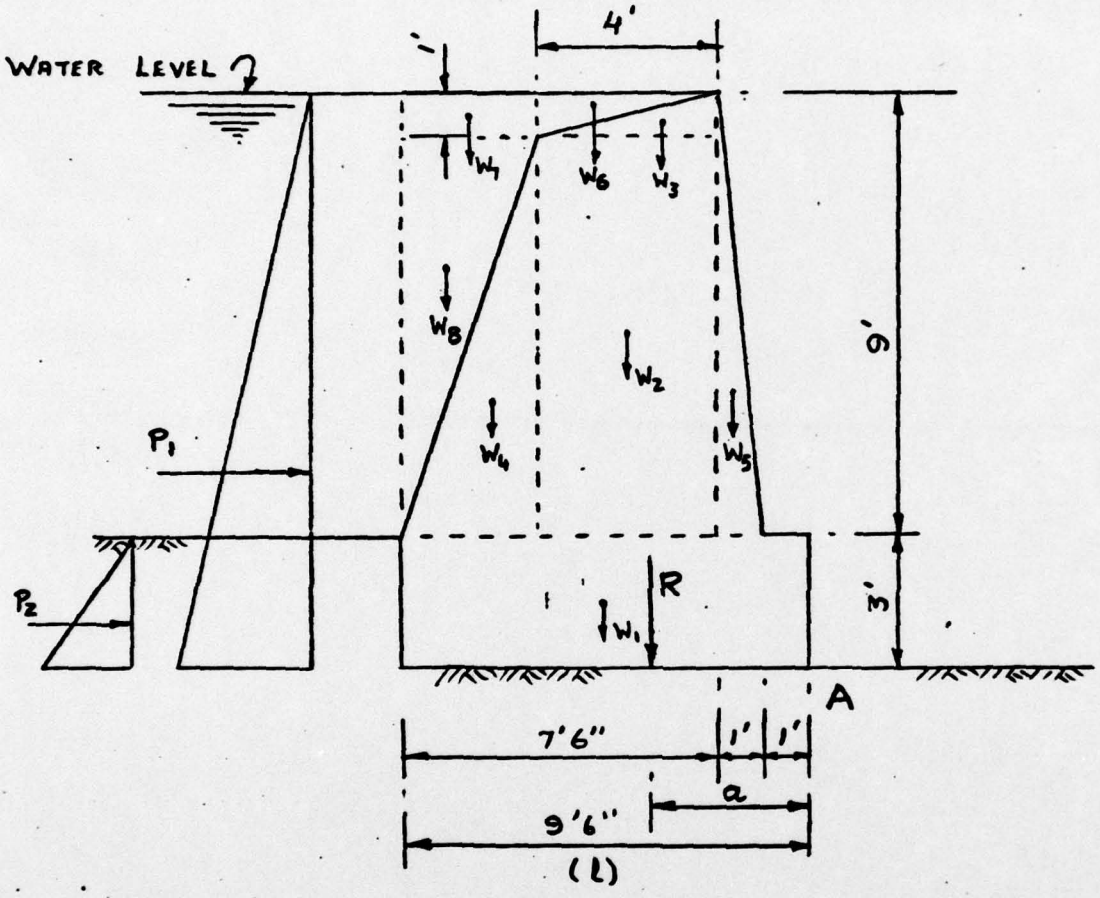
Structural Computations

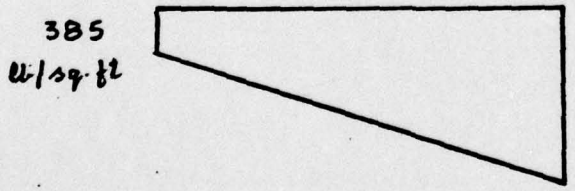
Project S.E. #1132B SPEEDWELL DAM Made By DMP Date 5/15

STABILITY ANALYSIS Chkd By RM Date 5/15

STABILITY ANALYSIS

SPILLWAY WALL





Bearing Pressure

$P_1 = \frac{1}{2}(62.4)(12)(12) = 4,492.8$ lb

$P_2 = \frac{1}{2}(0.333)(120)(3)(3) = 179.8$ lb

Overturning Moment about A = $4492.8 \times 4 + 179.8 \times 1$

= 18151 Ft. lb.

Computation of restoring moment about A

	W, lb	x, ft	$M_r = xW$ ft-lb
W_1: $9.5 \times 3 \times 150$	4275	4.75	20,306
W_2: $4 \times 8 \times 150$	4800	4.0	19,200
W_3: $\frac{1}{2} \times 4 \times 1 \times 150$	300	3.33	999
W_4: $\frac{1}{2} \times 3.5 \times 8 \times 150$	2100	7.17	15,057
W_5: $\frac{1}{2} \times 1 \times 9 \times 150$	675	1.67	1,127
W_6: $\frac{1}{2} \times 1 \times 4 \times 62.4$	124.8	4.67	583
W_7: $3.5 \times 1 \times 62.4$	218.4	7.75	1.693
W_8: $\frac{1}{2} \times 3.5 \times 8 \times 62.4$	873.6	8.33	7,277
Total	13,367		66,242

Distance of the resultant from point A (a) $= \frac{66.242 - 18,151}{13,367}$

$= 3 \cdot 60$ Ft.

Third of the base $= \frac{9.5}{3} = 3 \cdot 2$ Ft

Therefore, the resultant is in the middle-third of the base.

Maximum bearing pressure $= (4l - 6a)\frac{R}{l^2}$

$= \{(4 \times 9 \cdot 5) - (6 \times 3 \cdot 6)\}\frac{13,367}{9 \cdot 5^2}$

$= 2,429$ lb per sq. ft. O.K.

Minimum bearing pressure $= (6a - 2l)\frac{R}{l^2}$

$= \{(6 \times 3 \cdot 6) - (2 \times 9 \cdot 5)\}\frac{13,367}{9 \cdot 5^2}$

$= 385$ lb per sq. ft. O.K.

Friction Force $= 0 \cdot 5 \times 13367$

$= 6683 \cdot 5$ lb

Total Horizontal Thrust $= 4,492 \cdot 8 + 179 \cdot 8$

$= 4,672 \cdot 6$ lb

The factor of safety against sliding $= \frac{6683 \cdot 5}{4,672 \cdot 6} = 1 \cdot 43$ O.K.

The factor of safety against overturning $= \frac{66.242}{18.151} = 3.65$ O.K.

The Speedwell Dam is constructed as an arch between two abutments. The arch effect improves the factors of safety calculated above.

Reference: Design of Concrete Structures

Urquhart, O'Rourke & Winter

Sixth Edition

Article 9.6.

AD-A073 979 NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. SPEEDWELL DAM (NJ-00359), PASSAIC --ETC(U)
MAY 79 R J MCDERMOTT, J E GRIBBIN DACW61-79-C-0011

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2 OF 2
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APPENDIX 6

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