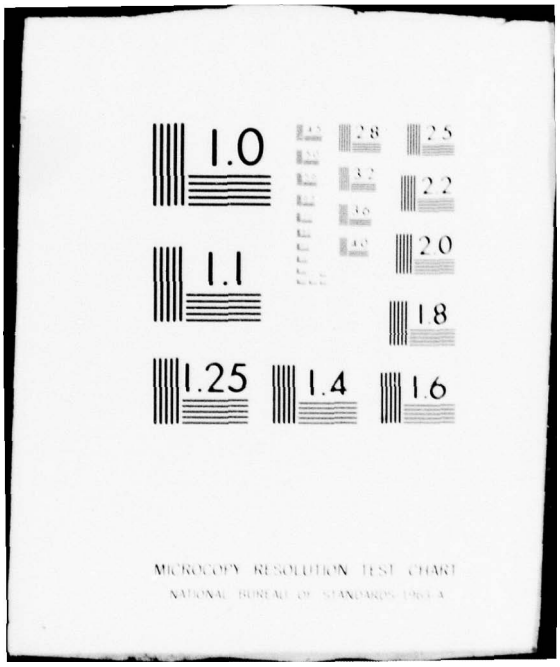
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PHASE 1 INSPECTION REPORT
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Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

March, 1979

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REPORT DOCUMENTATION PAGE

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Phase I Inspection Report National Dam Safety Program Lake Shenandoah Dam Ocean County, N.J.	5. TYPE OF REPORT & PERIOD COVERED: (9) FINAL rept.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): (10) Richard J. McDermott, P.E.	8. CONTRACT OR GRANT NUMBER(s): (15) DACW61-78-C-0124
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: (12) 98p.
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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)

Embankments	Dams
Riprap	Visual Inspection
Spillway	Structural Analysis
Silt	National Dam Inspection Act Report
	Lake Shenandoah Dam, N.J.

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

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction data 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

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

7 MAY 1979

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Lake Shenandoah Dam in Ocean 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, Lake Shenandoah Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition and the spillway is considered adequate. To assure the continued functioning of the dam and its impoundment, the following actions are recommended to be undertaken within twelve months of the date of approval of this report:

a. A program of periodic monitoring of seepage in the area adjacent to the toe of the dam should be initiated.

b. Remove silt from the downstream end of the outlet pipe.

c. Remove trees and brush on the dam's embankment.

d. Eroded areas on both sides of the dam's embankment should be filled and compacted. Before placing fill, a protective coating should be applied to the exposed steel sheet piling on each side of the spillway.

e. Riprap the upstream slope of the dam's embankment.

f. Drain the lake in order to inspect and repair the concrete spillway as necessary.

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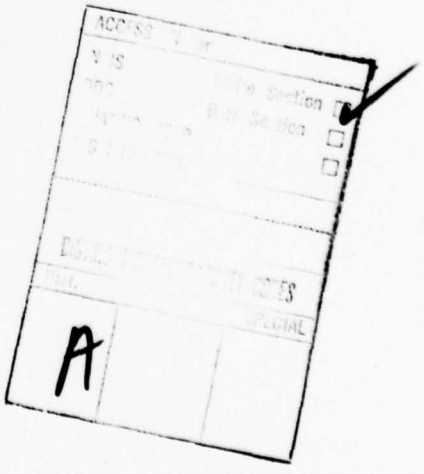
g. The owner should upgrade the operating and maintenance procedures by issuing a manual and check list for recommended procedures. Inspection and maintenance visits should be logged. Records of lake levels should be kept during routine visits and during severe storms. An annual site inspection should be conducted using a visual inspection check list similar to the one used in this report. As part of the maintenance program, the lake should be lowered at least every five years for cleaning and inspection and repair, if necessary, of the submerged portions of the dam and spillway.

h. A more extensive topographic survey of the dam and vicinity should be made.

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

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

An important aspect of the Dam Safety Program will be the implementation



of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES C. TOP
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
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Division of Water Resources
N. J. Dept. of Environmental Protection
P. O. Box CN029
Trenton, NJ 08625

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

LAKE SHENANDOAH DAM (NJ00099)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 5 December 1978 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.

Lake Shenandoah Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition and the spillway is considered adequate. To assure the continued functioning of the dam and its impoundment, the following actions are recommended to be undertaken within twelve months of the date of approval of this report:

a. A program of periodic monitoring of seepage in the area adjacent to the toe of the dam should be initiated.

b. Remove silt from the downstream end of the outlet pipe.

c. Remove trees and brush on the dam's embankment.

d. Eroded areas on both sides of the dam's embankment should be filled and compacted. Before placing fill, a protective coating should be applied to the exposed steel sheet piling on each side of the spillway.

e. Riprap the upstream slope of the dam's embankment.

f. Drain the lake in order to inspect and repair the concrete spillway as necessary.

g. 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. Records of lake levels should be kept during routine visits and during severe storms. An annual site inspection should be conducted using a visual inspection check list similar to the one used in this report. As part of the maintenance program, the lake should be lowered at least every five years for cleaning and inspection and repair, if necessary, of the submerged portions of the dam and spillway.

h. A more extensive topographic survey of the dam and vicinity should be made.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 7 May 69

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Lake Shenandoah Dam, I.D. NJ00099
State Located:	New Jersey
County Located:	Ocean
Drainage Basin:	Atlantic Coastal
Stream:	South Branch Metedeconk River
Date of Inspection:	December 5, 1978

Assessment of General Condition of Dam

Lake Shenandoah Dam is an earthfill dam with a concrete semicircular overflow spillway. The dam crest length is 375 feet and the spillway crest length is 77.4 feet. A 48-inch diameter corrugated metal pipe with gated intake, passes through the dam and outlets adjacent to the spillway.

Based on the visual inspection, available records, past operational performance and engineering analyses, the dam is judged to be in fair overall condition.

The spillway is capable of passing the spillway design flood (100-year storm) with water level at the dam crest. The capacity of the spillway is considered adequate and no remedial measures are necessary at the present time.

Two zones of seepage are present in the area adjacent to the downstream toe of the dam. Arrangements should be made immediately to observe and measure the seepage and thereafter monitor the seepage on a monthly basis.

The concrete spillway, although appearing structurally sound, contains some cracks and spalls which should be repaired in the near future.

The embankment is generally free of settlement and appears to be structurally sound. However, it contains some detrimental vegetation as well as significant erosion on its upstream and downstream faces and lacks slope protection on its upstream face. Steel sheet piling is exposed in some of the eroded areas. These conditions should be repaired in the near future and thereafter maintained. The repairs include the removal of trees and brush, the filling of eroded areas, the installation of riprap on the upstream face and the coating of exposed sheet piles before covering.

The outlet works appear to be in good condition. However, the downstream end of the outlet pipe contains a silt layer which should be cleaned in the near future.

The owner should in the near future implement a program of periodic inspection and maintenance for the dam which would include a topographic survey to provide a record of existing conditions. As a part of the maintenance program, the lake should be lowered at least every five years at which time the lake would be cleaned and submerged portions of the dam and spillway inspected and repaired.

Richard J. McDermott

Richard J. McDermott, P.E.



OVERVIEW PHOTO - LAKE SHENANDOAH DAM

5 DEC. 1978

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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

LAKE SHENANDOAH DAM, I.D. NJ00099

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 Lake Shenandoah Dam was made on December 5, 1978. 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 of Dam and Appurtenances

Lake Shenandoah Dam is an earthfill dam with an uncontrolled concrete semicircular overflow spillway and a gated corrugated metal pipe outlet. The embankment, which is sandy and grass covered, is planted with small pine trees along much of its length. Water which passes over the spillway flows through the dam via a discharge channel with timber sheeted sides. A timber bridge spanning the channel supports a paved road which traverses the entire length of the dam.

The concrete spillway is formed over a semicircular ring of steel sheet piles. The sheet piles are connected on each side of the spillway to a timber core wall within the embankment on its upstream side.

A fishway is connected to the south end of the spillway and outlets into the channel beneath the road bridge.

Having an overall length of 375 feet, the embankment has a top width of 47 feet as measured in the field, and upstream and downstream slopes of 1:1 and 2:1 respectively. The spillway has an overall crest length of 77.4 feet and an outlet channel width of 48 feet. Constructed for two staged operation, the spillway crest has a primary stage 52 feet long at elevation 24.4 and two secondary stages each of which is 12.7 feet long and at elevation 25.2. (Note: all references to the spillway crest elevation will be to the primary stage elevation of 24.4.)

The spillway crest lies 6.2 feet below the elevation of the dam crest and 10.4 feet above the elevation of the downstream channel bottom.

The outlet consists of one 48-inch corrugated metal pipe transversely penetrating the dam approximately 8 feet south of the spillway. A manually operated gate is contained in a concrete manhole located at the upstream end of the outlet pipe approximately 35 feet from the upstream face of the dam.

b. Location

Lake Shenandoah Dam is located in the Township of Lakewood, Ocean County, New Jersey. Constructed across the South Branch, Metedeconk River, it impounds Lake Shenandoah which forms the focal point of a county park area. An abandoned sewage treatment plant, now used as a sewage pump station by the Ocean County Utilities Authority, is located in the area south of the dam. Principal access to the dam is provided by a paved road which encircles the lake and intersects N.J. Route No. 88 (Ocean Avenue).

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 characteristics of Lake Shenandoah Dam are:

Storage = 617 acre-feet

Height = 17 feet

Potential Loss of Life: No inhabitable structures within 2 miles of dam in downstream flood plain as delineated by SDF outflow.

Potential Economic Loss: Bridge 1900 feet downstream of dam would be overtopped by breach outflow and probably would be washed out.

Therefore, Lake Shenandoah Dam is classified as "Small" size and "Significant" hazard potential.

d. Ownership

Lake Shenandoah Dam is owned by the County of Ocean, Court House, Toms River, N.J.08753.

e. Purpose of Dam

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

f. Design and Construction History

The earthfill embankment together with a timber spillway was constructed in 1934 with W.P.A. funds. As the lake was being filled, after completion of the dam, the timber

spillway reportedly failed. The remainder of the dam then stood unused until 1969 at which time the present spillway was constructed and the lake successfully filled. No design information nor drawings of the original dam and spillway are available. Plans for the present spillway including outlet works, embankment regrading and slope protection were prepared by Robert B. Powers, P.E., L.S. of Lakewood, N.J. and dated May, 1968.

A 24 foot wide timber bridge spanning the spillway discharge channel was constructed in conjunction with the spillway. A prefabricated Denil-type fishway was installed in 1973.

g. Normal Operational Procedures

The dam and appurtenances are maintained by the Ocean County Bridge Department. There is no fixed schedule of maintenance; rather, the Ocean County Bridge Department repairs and maintains the embankment, spillway, appurtenances and lake as needed.

The outlet pipe is used to drain the lake to facilitate repairs and sediment and debris removal. It is not used for emergency purposes during storms. The lake reportedly was drained most recently in 1977. The water level was lowered approximately to the lake bottom; this was accomplished in approximately one week.

1.3 Pertinent Data

a. Drainage Area = 29 square miles

b. Discharge at Dam site:

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N.A.
Diversion tunnel low pool outlet at pool elevation	N.A.
Diversion tunnel outlet at pool elevation	N.A.
Gated spillway capacity at pool elevation	N.A.
Gated spillway capacity at maximum pool elevation	N.A.
Ungated spillway capacity at maximum pool elevation	3680 cfs
Total spillway capacity at maximum pool elevation	3680 cfs

c. Elevation (Feet above MSL)

Top Dam	30.6
Maximum pool design surcharge	30.6
Full flood control pool	N.A.
Recreation pool	24.8
Spillway crest	24.4
Upstream portal invert diversion tunnel	N.A.
Stream bed at centerline of dam	14.0
Maximum tailwater	19± (Estimated)

d. Reservoir

Length of maximum pool	4650 feet
Length of recreation pool	4150 feet
Length of flood control pool	N.A.

e. Storage (acre-feet)

Recreation pool	111 acre-feet
Flood control pool	N.A.
Design surcharge	617 acre-feet
Top of Dam	617 acre-feet

f. Reservoir Surface (Acres)

Top of dam	120 acres
Maximum pool	120 acres
Flood control pool	N.A.
Recreation pool	44.6 acres
Spillway pool	44.6 acres

g. Dam

Type	Earthfill
Length	375 feet
Height	17 feet
Top Width	47 feet
Side Slopes - Upstream	1 horiz. to 1 vert.
Downstream	2 horiz. to 1 vert.
Zoning	Unknown
Impervious Core	Timber core wall & steel sheet piling
Cut off	None
Grout Curtain	Unknown

h. Diversions and Regulating Tunnel N.A.

i. Spillway

Type	Semicircular overflow
Length of Weir	77.4 feet
Crest elevation	24.4
Gates	N.A.
Upstream channel	N.A.
Downstream Channel	Rectangular section with timber sides through dam.

j. Regulating Outlets

48" CMP with gate in manhole

SECTION 2: ENGINEERING DATA

2.1 Design

No plans or calculations pertaining to the original construction of the dam could be obtained. However, a certain amount of information generated at the time of the spillway reconstruction in 1969 is available. As mentioned in paragraph 1.2.f., plans were prepared in 1968 including the following:

1. Plan and Profile of dam and spillway
2. Plan, elevation and section of spillway
3. Details of spillway crest and dam appurtenances
4. Logs of 8 borings made in the embankment and spillway area
5. Cross-sections of embankment
6. Location of dam

In addition, calculations pertaining to the reconstruction were obtained. These include hydraulic and hydrologic analyses as well as references to structural analyses. Construction specifications for the spillway reconstruction were also obtained.

The spillway design flood intensity was computed to be 1400 cfs. The capacity of the spillway was computed to be 1434 cfs with lake stage at elevation 27.8 which allows 3.2 feet of freeboard.

2.2 Construction

No records are available pertaining to the construction of the original dam in 1934. The spillway and outlet pipe were constructed in 1969 and an Encroachment Completion Report written by Rober B. Powers, dated February 25, 1970, indicated that the reconstruction of the spillway was completed on June 3, 1969 in accordance with the approved plans. However, visual inspection on December 5, 1978 revealed no indication of riprap on the upstream face of the dam as indicated on the plans. The riprap either was never installed or it failed to remain in place subsequent to its installation. The construction of a fishway had been a condition of the Permit to reconstruct the spillway which was issued on June 27, 1968. The fishway was not included in the 1969 project but was installed in 1973 after the intervention of the Division of Fish, Game and Shell Fisheries, New Jersey Department of Environmental Protection.

2.3 Operation

No records of operation of the lake or dam are available. Likewise, no records of the original spillway failure could be found.

Three past inspection reports have been obtained. The most recent report, written on May 16, 1973 by Robert B. Powers, reported the following:

1. The dam embankment was inspected periodically and was cleared of trees and brush by county forces.
2. The spillway and appurtenances had been properly maintained and appeared to be in excellent condition.

Soundings had been taken at the cut off wall revealing no evidence of scouring or undermining.

Photographs of the dam were taken at the time of the inspections and were submitted with the inspection reports.

2.4 Evaluation

a. Availability

Engineering information is not available except that which is on file at the NJDEP. The NJDEP file contains copies of plans, specifications, calculations, correspondence and photographs available for inspection at the offices of the Bureau of Flood Plain Management, 1474 Prospect Street, Trenton, N.J.

Available from the Ocean County Engineering Department are plans of the spillway which duplicate those in the NJDEP file. In addition, plans of the timber road bridge and a table of computed flows at various points on the South Branch Metedeconk River are available from the Ocean County Engineering Department.

b. Adequacy

The available information forms a fairly complete description of subject dam with a few exceptions which are listed in paragraph 7.1.b.

c. Validity

Most information which was able to be verified was valid within a reasonable allowance for error. However, hydrologic design computations prepred in 1968 were found to be invalid in relation to criteria recently developed by the U.S. Army Corps of Engineers.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The inspection of Lake Shenandoah Dam took place on December 5, 1978 by members of the staff 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 embankment of the dam, appurtenant structures and adjacent areas were examined.
2. Areas of suspected seepage were noted and located.
3. The embankment and accessible appurtenant structures were measured and key elevations determined by hand level.
4. The embankment and appurtenant structures and adjacent areas were photographed.
5. A member of the staff of the Ocean County Engineering Department was present to assist in the inspection.

b. Dam

The dam embankment appeared to be uniformly aligned both vertically and horizontally and the paved road on the embankment was found to be in good condition.

Significant erosion was noted along most of the upstream face of the embankment and in some areas of the downstream face, especially adjacent to the spillway discharge channel. Steel sheet piling is exposed in some of the eroded areas. With the exception of the eroded areas, the grass cover on the embankment was in good condition. No riprap was found on the embankment surfaces. Considerable brush and trees were noted on the downstream face and toe of the embankment.

Two wet marshy areas were observed in the area adjacent to the downstream toe of the dam on either side of the downstream channel. The wet areas were assessed as being caused by seepage through the dam. At the time of inspection, the discharges were slight and can be described as trickling flows.

No evidence of cracking or settling was noted in the dam nor were any animal holes observed.

The generalized soils description of the dam site consists of shallow surface alluvial deposits of stratified silty sand with varying amounts of gravel deposited during the Quaternary Period and known as the Cape May Formation in the Geologic Map of New Jersey prepared by Lewis and Kummel. The shallow surface soils are underlain by stratified fine micaceous quartz sand with small amounts of silt with local thin layers of gravel and clay deposited during the Tertiary Period and known as the Kirkwood Sands. These soils are also indicated by borings performed by Jersey Boring and Drilling Corp. at the time of the spillway reconstruction. Boring logs are located in Appendix 5.

Bedrock is in excess of 100 feet below the ground surface. It is assumed that the dam is founded on the silty sands of the Cape May Formation.

c. Appurtenant Structures

The crest of the spillway appeared uniformly aligned, although a major part of it was submerged by overflow at the time of inspection. Water was flowing over the principal (elev. 24.4) part of the spillway and, therefore, the condition of much of the spillway surface was not clearly observed. In the sections of the spillway which were dry, some cracking and spalls, as well as leaching, were observed. In general, all concrete appeared to be in good condition.

Reportedly, the outlet equipment is in good working condition, although its operation was not observed at the time of inspection. The 48" diameter C.M. pipe was examined at its outlet end and appeared to be in good condition. However, a silt layer of 6 inches depth was observed at the invert of the pipe. The manhole housing the outlet gate was observed to be in good condition.

The fishway was in good condition except that slight leakage was observed at the top of the ladder where it is connected to the concrete structure on one side of the spillway.

The timber bridge over the spillway appeared to be in good condition.

d. Reservoir Area

Lake Shenandoah is long and narrow, averaging 468 feet in width with an overall length in excess of 3/4 mile. It is located in a county park and adjacent to undeveloped areas with the exception of a sewage pump station located near the south end of the dam.

The reservoir is located in a topographically flat area and consequently has gradually sloping shores. There were no structures, such as docks, observed on or near the shore.

e. Downstream Channel

The spillway conveys water into the South Branch of Metedeconk River which, in the proximity of the dam, is a shallow, wide stream. It appears to have a fairly uniform bottom and is free of weeds, pools, obstructions and debris. It has gently sloping banks and generally is wooded to its edges. A bridge crosses the stream approximately 1,900 feet downstream from the dam. There are no dwellings near the stream banks between the dam and the bridge.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The level of water in Lake Shenandoah is regulated naturally by discharge over the two stage spillway of Lake Shenandoah Dam. The two staged crest has fixed elevations. Whenever necessary for maintenance and repair the lake is lowered by opening the outlet gate of the 48-inch diameter pipe.

4.2 Maintenance of the Dam

There is no program of regular inspection and maintenance of the dam and appurtenant structures. One of the provisions of the permit for reconstruction of the spillway specified that "an annual report shall be submitted describing the existing conditions" of the dam embankment, spillway and appurtenances. However, only three of the required annual reports have been written. The last of these was completed in 1973. Maintenance is performed by the Ocean County, Bridge Department as the need arises.

At the time of the inspection, previously made repairs to some eroded areas of the embankment were observed.

4.3 Maintenance of Operating Facilities

The slide-gate and the operating mechanisms used to open and close it are maintained by the Ocean County Bridge Department as the need arises. It is not known when the outlet conduit was last maintained.

4.4 Description of any warning system in effect

There is no warning system in service now and none was utilized in the past.

4.5 Evaluation of Operational Adequacy

The operation of the spillway, since its reconstruction in 1969 has been successful to the extent that the dam has not been overtopped since then.

The maintenance program for the dam appears to have been fairly adequate. The bridge at the spillway, the roadway and the top of dam are in good condition. However, some areas of maintenance have not been adequately performed, such as the following:

1. Trees and brush allowed to grow on downstream side of the embankment.
2. Erosion of embankment not adequately treated.
3. Minor cracks and spalls on spillway not repaired.
4. Riprap on upstream face of embankment not installed or not maintained in place.

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 Gudielines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers, the SDF for Lake Shenandoah Dam falls in a range of 100-year frequency to 1/2PMF. In this case, the low end of the range, 100-year frequency, is chosen since the factors used to select size and hazard classification are on the low side of their respective ranges.

The peak 100-year flood is 3,019 cfs as calculated in accordance with analytical procedures contained in Special Report 38 published by the NJDEP.

Computations used to determine the spillway discharge capacity are contained in Appendix 4 of this report. The spillway was assumed to have outflow characteristics of a broad crested weir with breadth equal to two feet.

The spillway discharge (with water level at the dam crest) was computed to be 3680 c.f.s. Since this value is greater than the computed peak SDF (3019 c.f.s.), the spillway is considered to be adequate according to criteria developed by the U. S. Army Corps of Engineers.

b. Experience Data

No records are available that would document the proper operation of the dam and spillway since the spillway reconstruction in 1969. No records of lake levels are maintained.

c. Visual Observations

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

The difference in elevation between the dam crest and the spillway crest was measured as 6.2 feet which indicates reasonable agreement with the value of 6.6 feet used in the spillway design.

d. Overtopping Potential

As indicated in paragraph 5.1.a., the dam would not be overtopped during a storm of magnitude equivalent to the presently determined peak SDF. Detailed hydraulic and hydrologic analysis is contained in Appendix 4.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual observations

The embankment appeared, at the time of inspection, to be structurally sound with no evidence of cracks, displacement or differential settlement. However, the visual inspection disclosed two zones of seepage through the dam which were manifested as wet swampy areas adjacent to the downstream toe of dam. In one of the wet areas, located approximately 160 feet south of the spillway centerline, the water was clear while in the other area, located approximately 175 feet north of the spillway centerline, the water contained an orange colored silt.

An accurate determination of the severity of the seepage depends on several factors, one of which is periodic observation. The severity of the seepage noted at Lake Shenandoah Dam cannot be precisely determined at the present time.

b. Design and Construction Data

The analysis of structural stability and construction data for the embankment are not available. The only design and construction data available for the spillway are the drawings prepared by Robert B. Powers, P.E., L.S. of Lakewood for the reconstruction of the spillway, prepared in 1968.

In the "Report on Dam Application" by the State of New Jersey, Division of Water Policy and Supply, dated June, 1968, it is noted that "stresses in steel sheet piles due to cantilever action were checked and found within permissible limit."

c. Operating Records

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

d. Post Construction Changes

Since Lake Shenandoah Dam was reconstructed in 1969, there have been no changes to the dam or the area surrounding it that could have significant effect on its structural integrity.

e. Seismic Stability

Lake Shenandoah Dam 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 conditons if stable under static loading conditions. Lake Shenandoah Dam appears to be stable under static loading conditions at the present.

SECTION 7: ASSESSMENT, RECOMMENDATIONS, PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The SDF applicable to Lake Shenandoah Dam (100-year flood)has been calculated to have a peak magnitude of 3019 cfs. The capacity of the spillway when the lake stage equals the elevation of the dam crest is 3680 c.f.s. Thus, the spillway is considered adequate according to criteria developed by the U.S. Army Corps of Engineers.

The structural integrity of the dam appears to be adequate based on field investigations; the seepage is not considered to be an immediate indication of instability. No report nor written evidence was found that would contradict that assessment.

Therefore, based on hydraulic and structural considerations, Lake Shenandoah Dam is assessed as being satisfactory in relation to guidelines developed by the U.S. Army Corps of Engineers. Although some information has not been determined, this is not considered to have a significant effect on the overall assessment of the general condition of the dam with the exception of additional seepage studies (see paragragh 7.1.c.).

b. Adequacy of Information

Information was gathered from several sources, including: 1). field investigation, 2). plans, specifications, calculations and correspondence in NJDEP files, 3). USGS quadrangle sheet, 4). aerial photography from Ocean County, and 5). consultation with Ocean County Engineering Department. 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 gauging records.
2. Description of dam embankment fill materials.
3. As-built drawings of the dam and appurtenances.
4. Annual inspection reports subsequent to 1973.

c. Necessity for Additional Data/Evaluation

Although some data pertaining to Lake Shenandoah Dam are not available, additional data are not considered imperative for this Phase I evaluation due to the size and hazard potential classifications of the dam and its general appearance of structural integrity.

To provide an adequate record of existing conditions, a topographic survey should be undertaken as outlined in paragraph 7.2.c.

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

7.2 Recommendations

a. Remedial Measures

Based on the visual inspection of Lake Shenandoah Dam and other pertinent data obtained as part of this report, it is recommended that the following measures be undertaken by the owner in the near future:

1. Vegetation on the dam embankment, including the small pine trees adjacent to the road, should be removed. Trees should be cut at the ground surface and brush removed in a way that will cause minimal disturbance to the embankment.

2. The eroded areas on the dam embankment should be properly filled and compacted. A protective coating should be applied to the exposed steel sheet piling before placing fill. Such work should be done immediately after the vegetation has been removed.

3. Riprap should be installed as shown on the plans prepared by Robert B. Powers, P.E., L.S., on the upstream face of the dam along the entire length of the embankment.

4. The concrete spillway should be thoroughly inspected and repaired as outlined below:
    a. Drain the lake to an elevation equal to the invert of the outlet pipe.
    b. Sand blast all concrete and apply an epoxy preservative coating to all surfaces.

c. Pressure grout all major cracks and patch all spalls and eroded surfaces.

d. Seal the leak at the joint between the fishway inlet and the spillway.

5. The silt layer should be cleaned from the downstream end of the outlet pipe.

The implementation of the above measures will require proper detailed design and the obtaining of applicable NJDEP approvals.

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 when required and the following maintenance should be performed annually: remove vegetation from the embankment, repair the riprap after it is installed on the upstream dam face, fill and sod any eroded surfaces of the embankment, and clear the downstream channel. In addition, the lake should be lowered at least every five years at which time the lake should be cleaned and the submerged portions of the dam, spillway and outlet works inspected and repaired.

c. Additional Studies

Arrangements should be made immediately to monitor the seepage by visual observation. If necessary, measurements should be made by the use of appropriate instrumentation. The monitoring should be performed on a monthly basis by a qualified professional engineer.

A detailed topographic survey of the dam and area around the dam should be undertaken by a qualified licensed land surveyor or professional engineer in the near future. The survey map should be related to existing construction drawings and should become part of the permanent record mentioned in paragraph 7.2.b.

PLATES

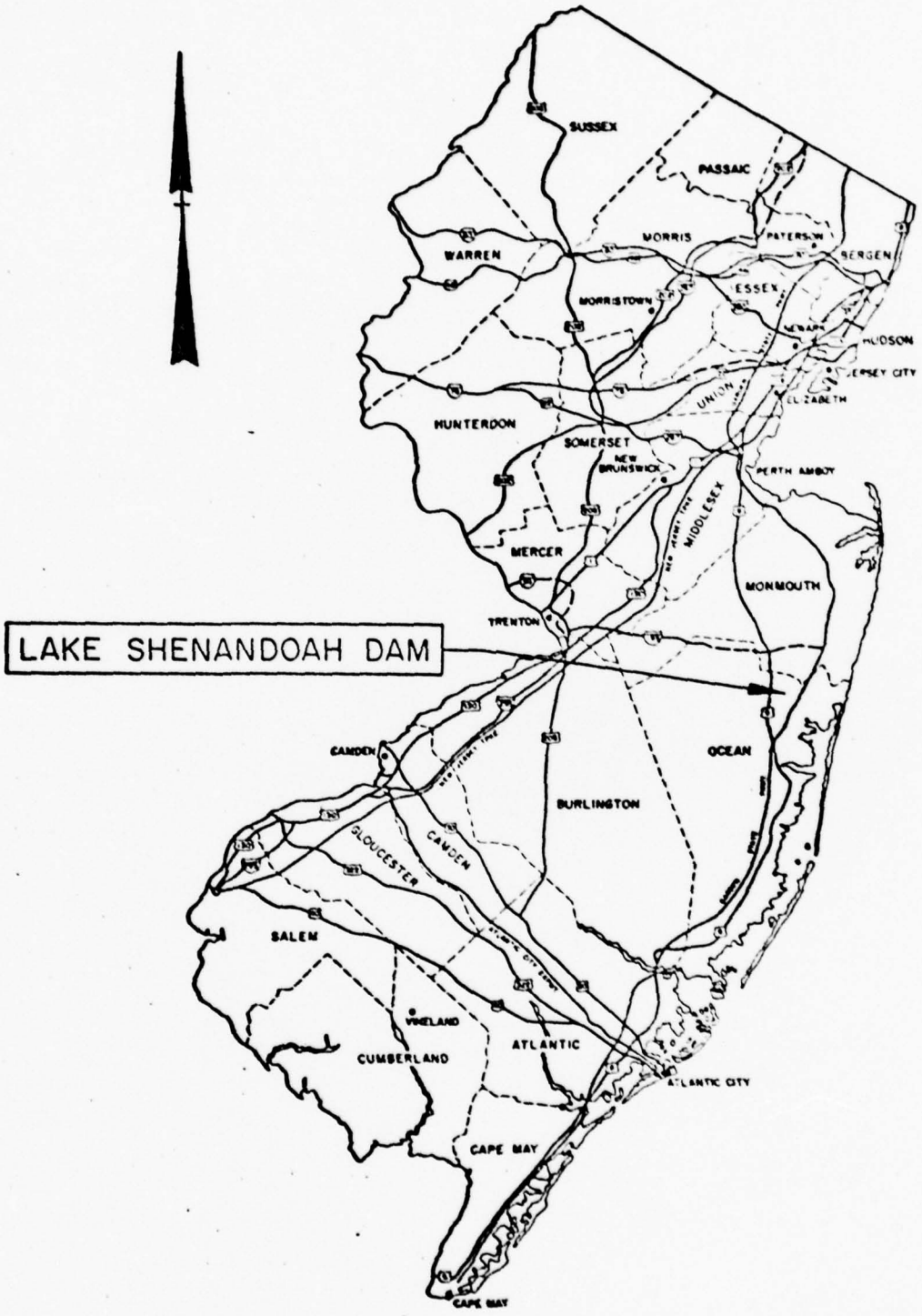
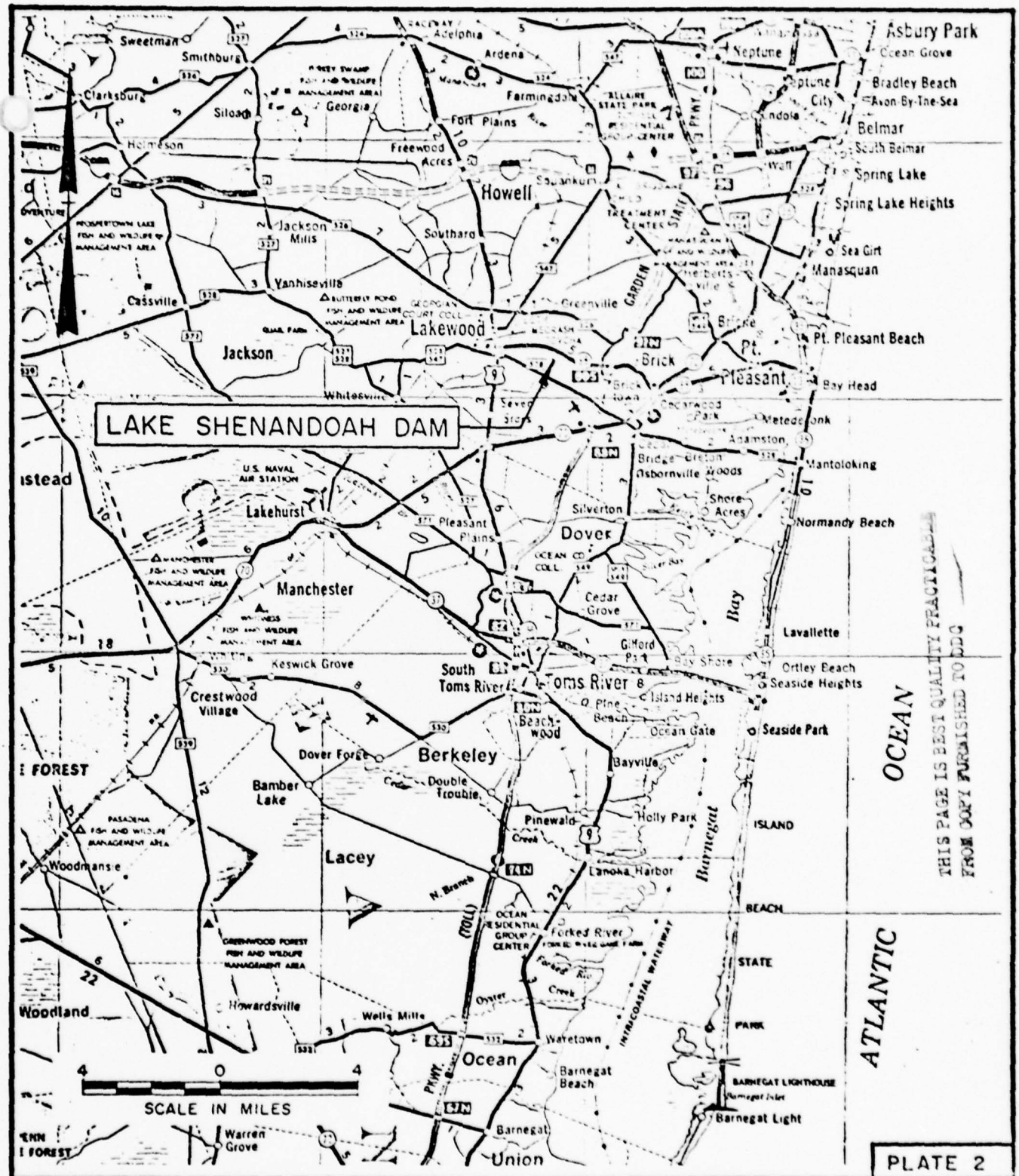


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP LAKE SHENANDOAH DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00099 / SCALE: NONE DATE: JANUARY, 1979



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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

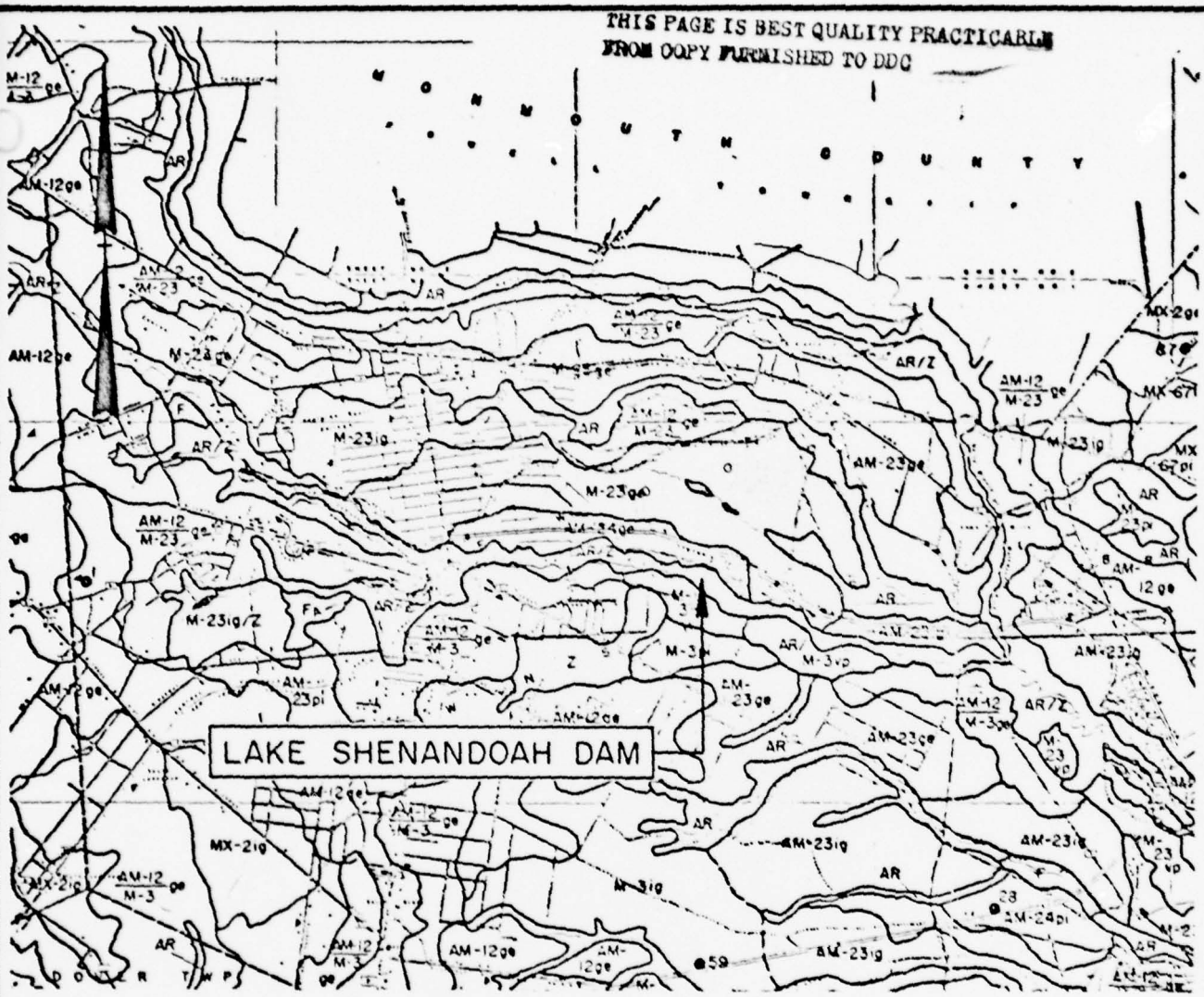
LAKE SHENANDOAH DAM

I.D. N.J. 00099

SCALE: AS SHOWN

DATE: JANUARY, 1979

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Legend

AM-24	Alluvial, stratified materials deposited during the Quarternary period. (Cape May formation.)
AR/Z	Stratified, swampy alluvium
M-3	Stratified materials deposited during Tertiary period. (Kirkwood Sand formations.)

NOTE: Information taken from Rutgers University Soil Survey of New Jersey, Report No. 8 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

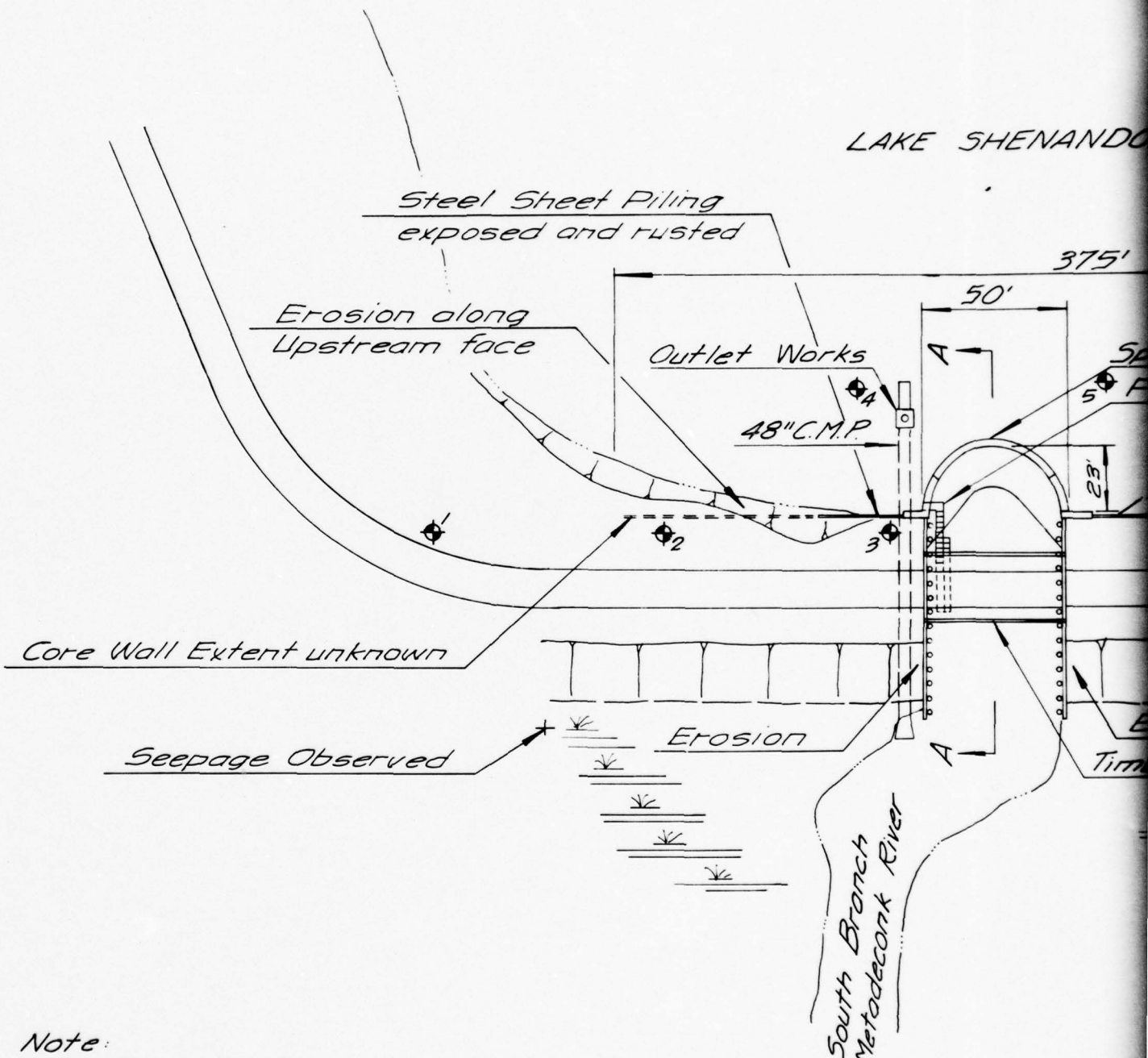
SOIL MAP

LAKE SHENANDOAH DAM

I.D. N.J. 00099

SCALE: NONE

DATE: JANUARY, 1979



Note:

1. Information taken from plan by Robert B. Powers, P.E. 1968, and field inspection December 5, 1978.
2. ⊕ Boring Locations

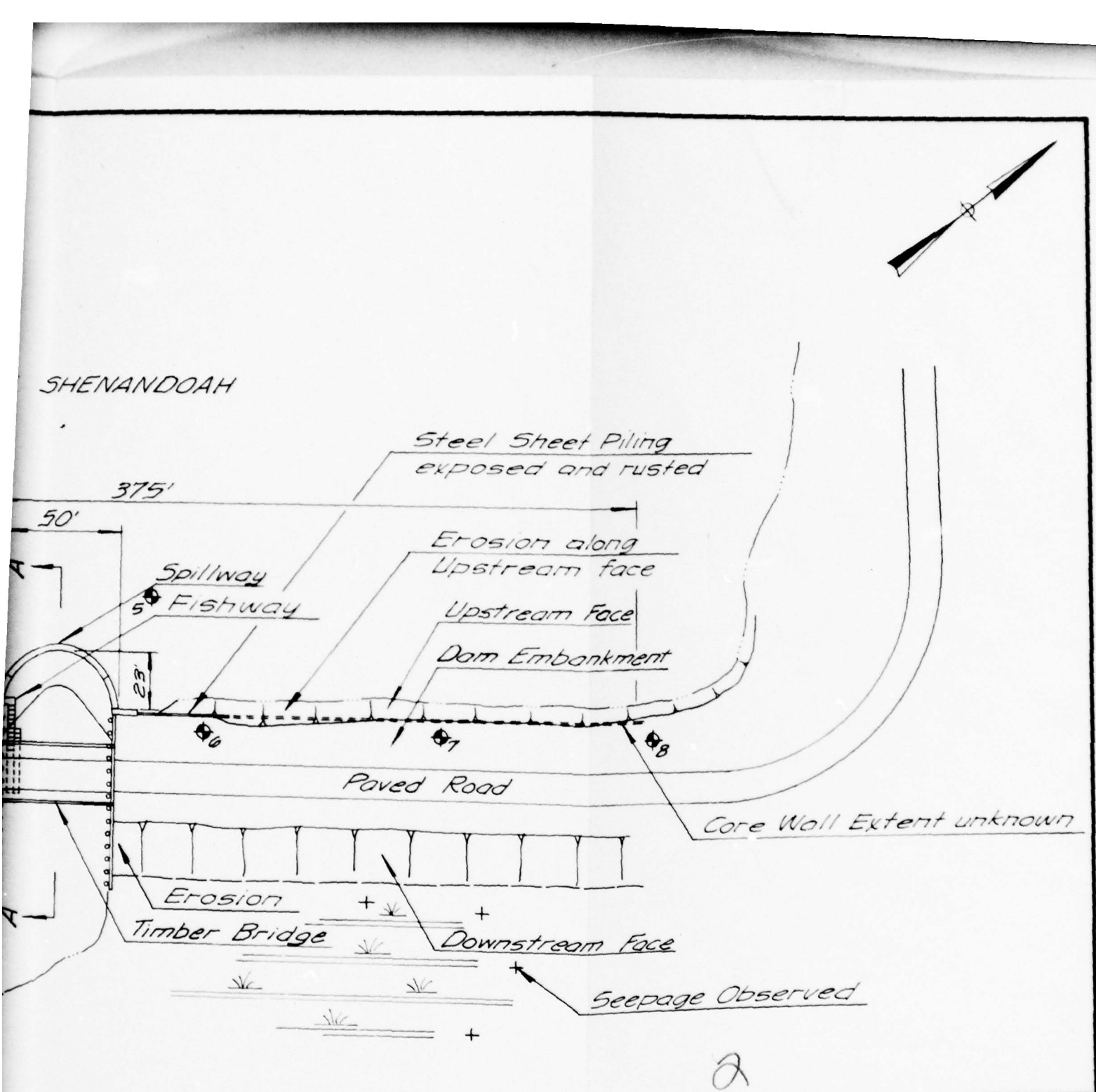


PLATE 4

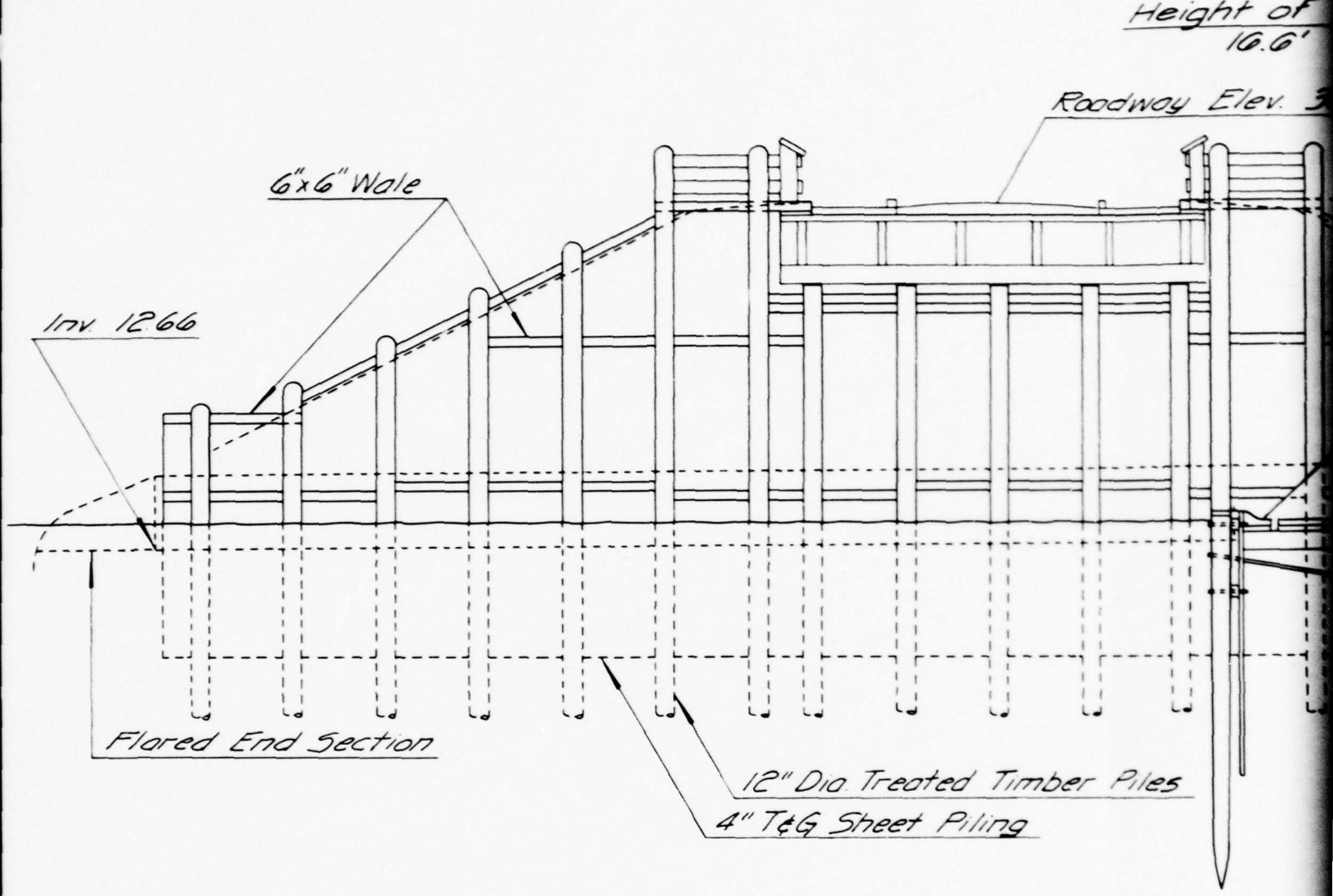
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

GENERAL PLAN

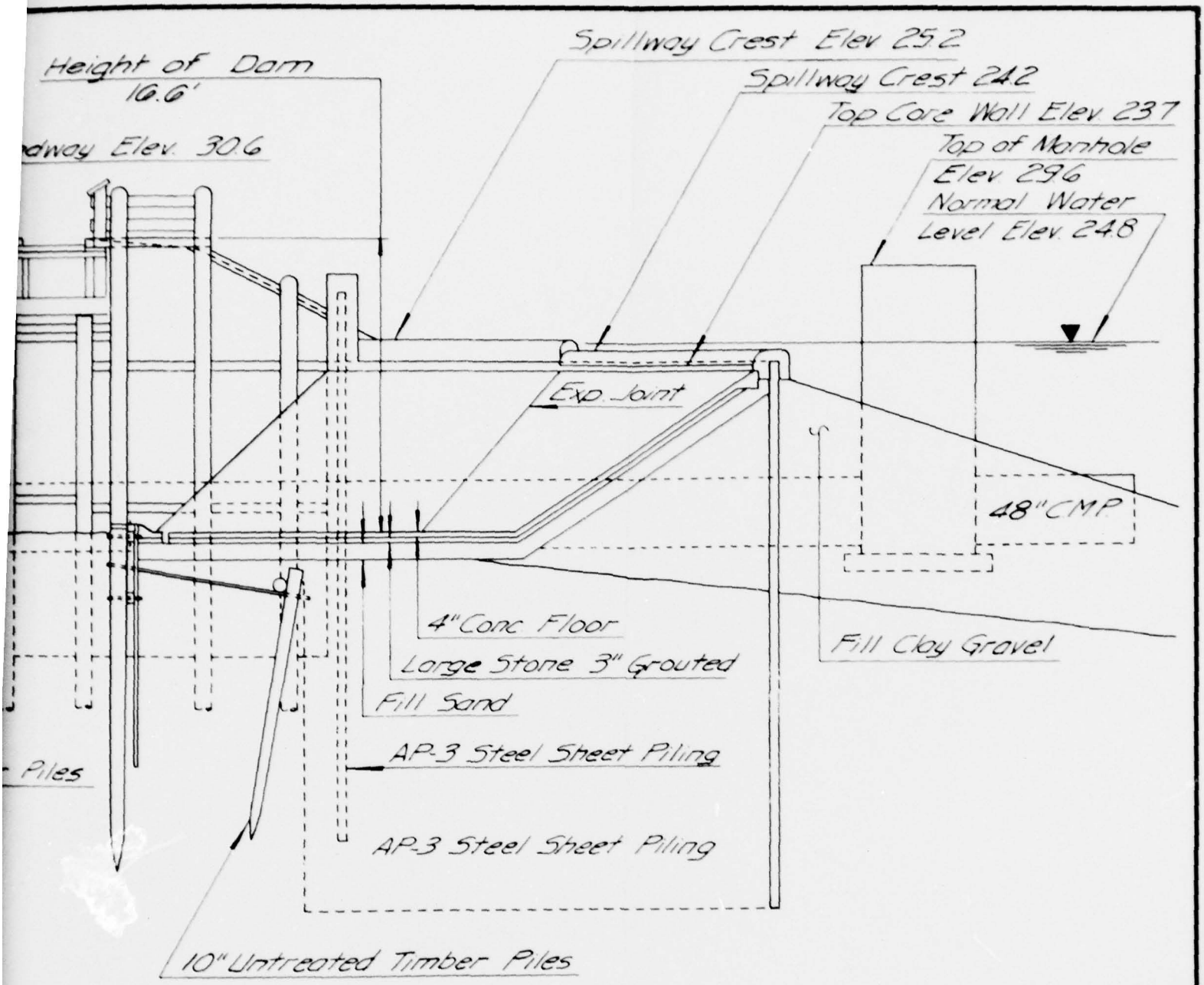
LAKE SHENANDOAH DAM

I.D. N.J. 00099	SCALE: NOT TO SCALE
	DATE: JANUARY, 1979



SECTION A-A

Note:
Information taken from plan by Robert B. Powers, P.E., 1968 and field inspection December 5, 1978.



A-A

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PLATE 5

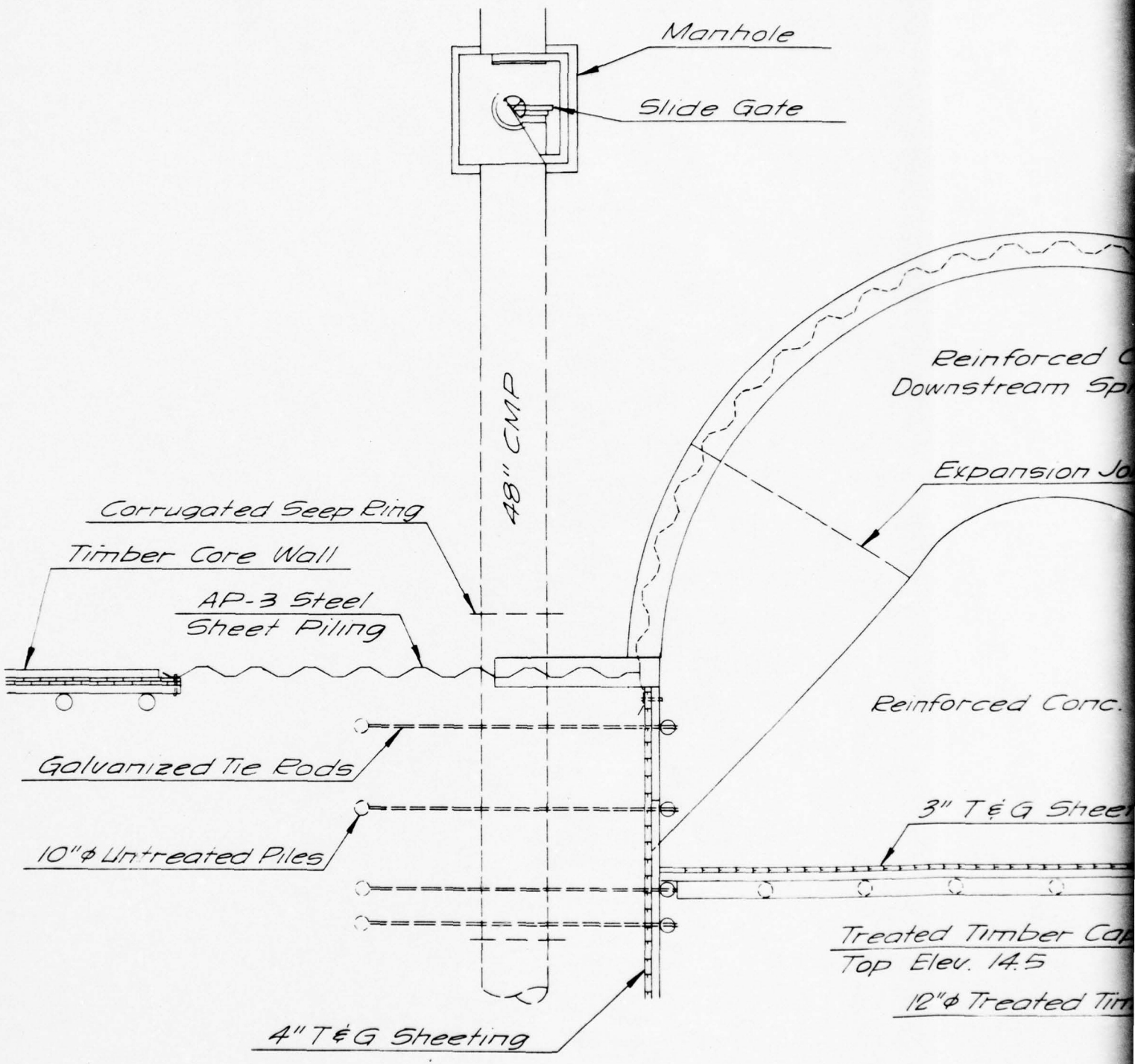
STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

SECTION A-A

LAKE SHENANDOAH DAM

I.D. NJ 00099	SCALE: NOT TO SCALE
	DATE: JANUARY, 1979



Note:
Information taken from plan by
Robert B. Powers, P.E. 1968, and
field inspection December 5, 1978.

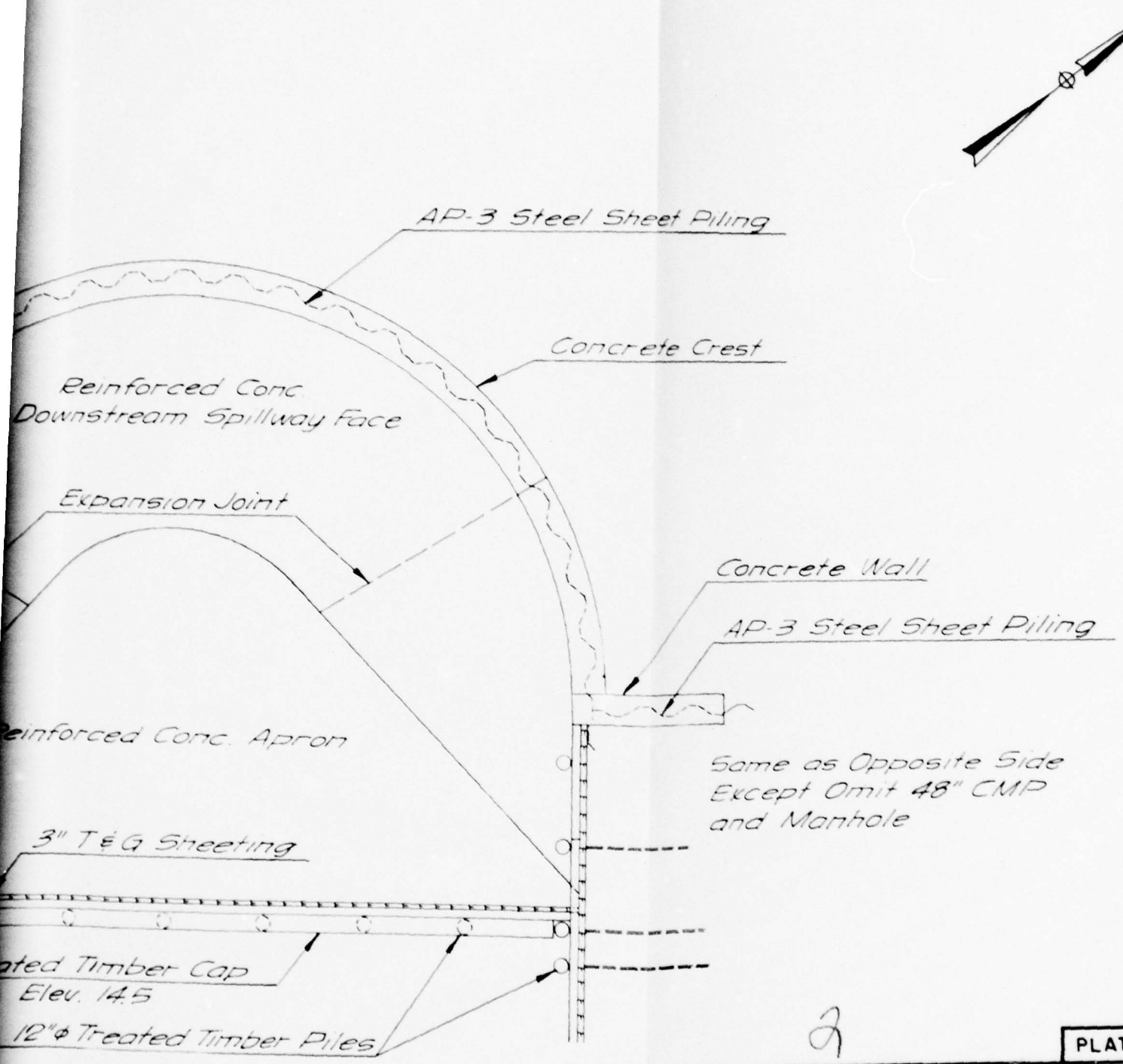


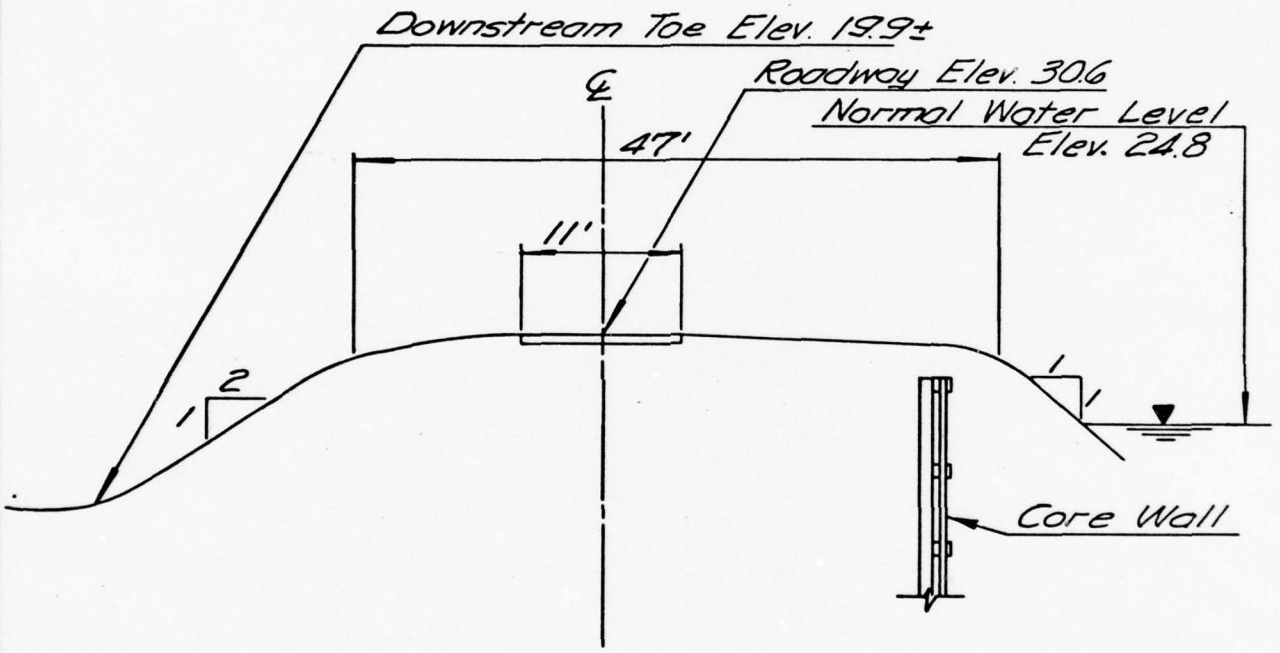
PLATE 6

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

INSPECTION AND EVALUATION OF DAMS

SPILLWAY PLAN
LAKE SHENANDOAH DAM

I.D. N.J. 00099	SCALE: NOT TO SCALE
	DATE: JANUARY, 1979

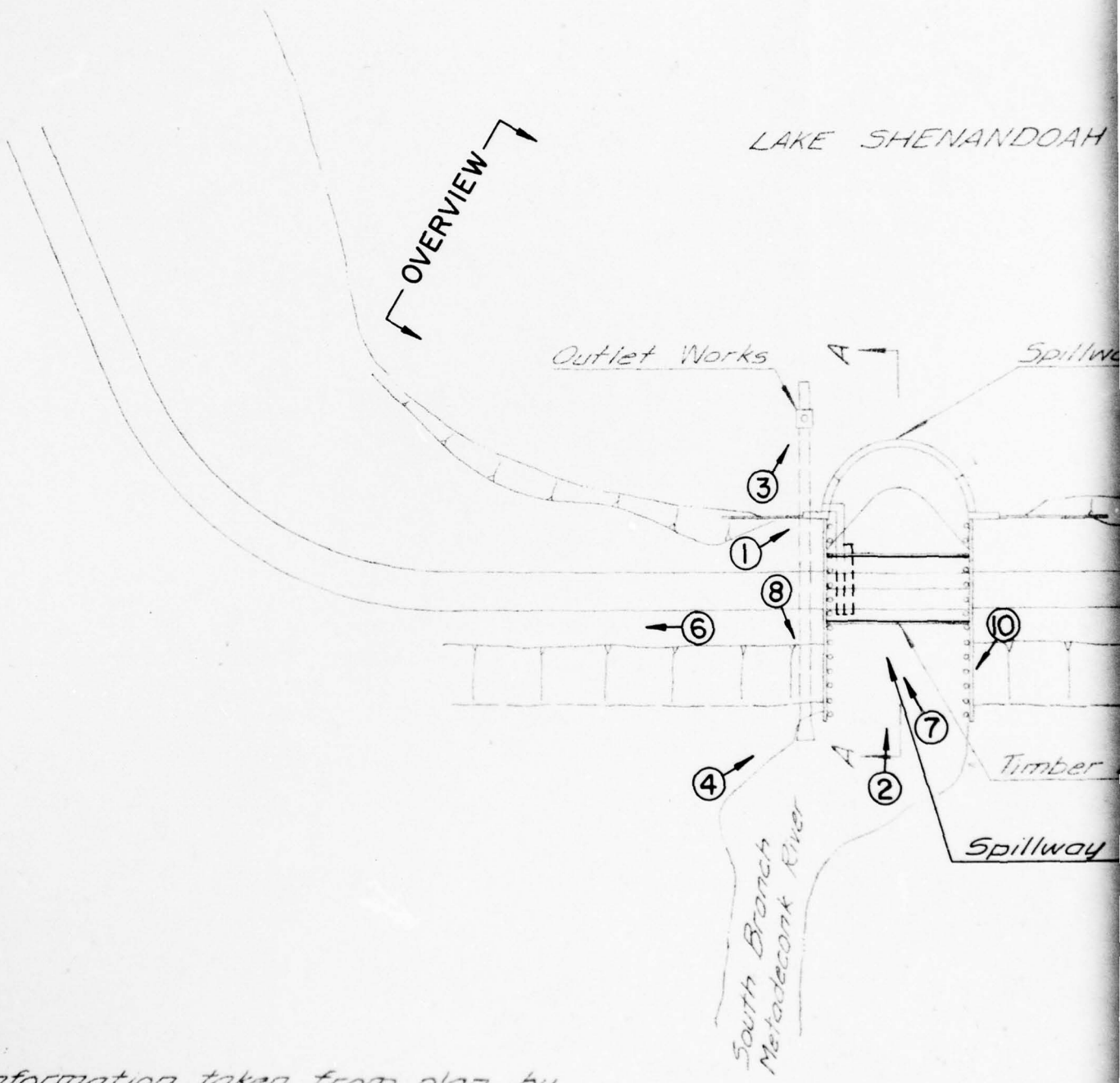


DAM SECTION

NOTE:
Information taken from plan by Robert B. Powers, P.E., 1968 and field inspection December 5, 1978.

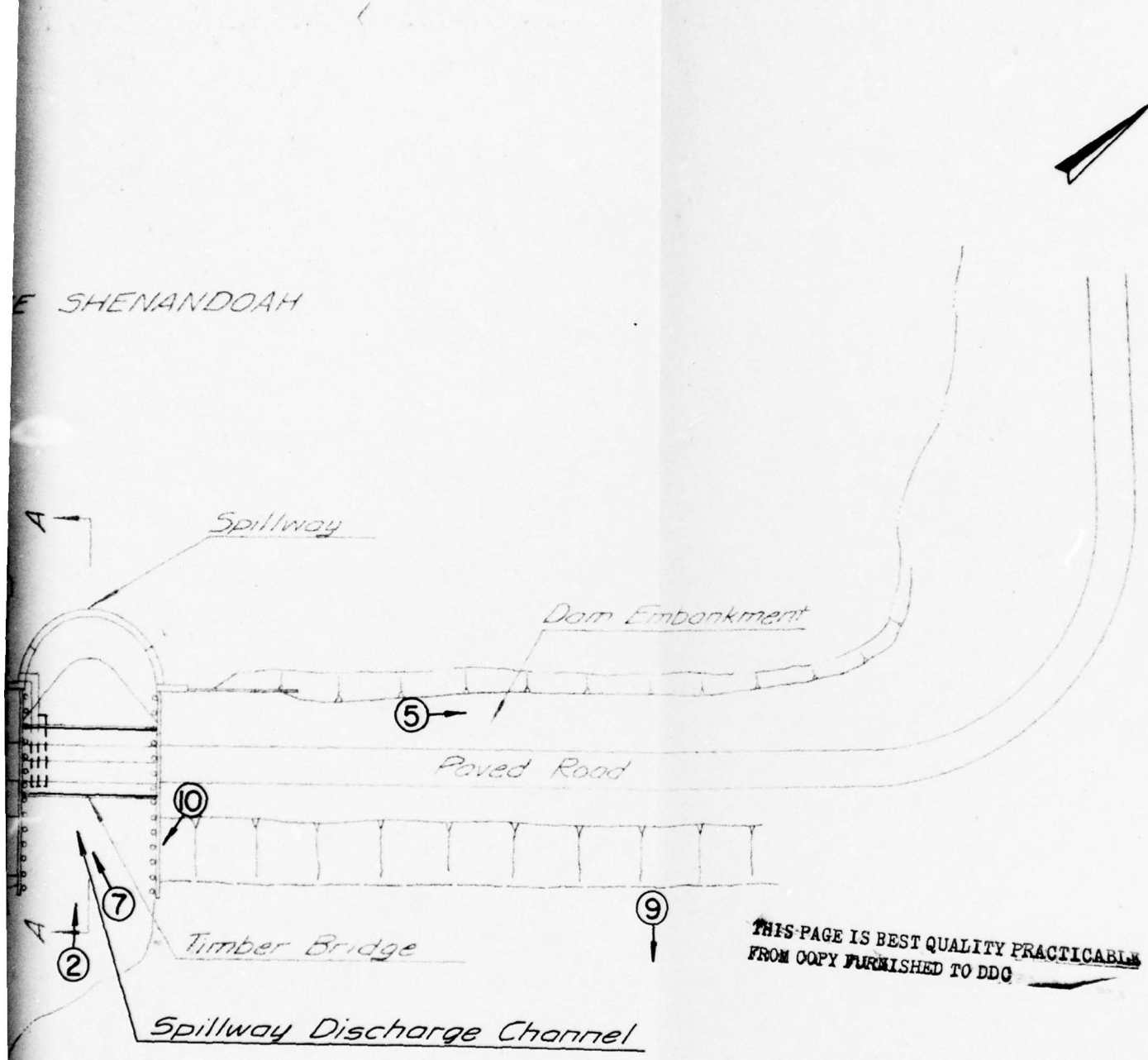
PLATE 7

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS DAM SECTION LAKE SHENANDOAH DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. NJ00099 / SCALE: NOT TO SCALE DATE: JANUARY, 1979



Note:
1. Information taken from plan by Robert B. Powers, P.E. 1968, and field inspection December 5, 1978.

E SHENANDOAH



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PLATE 8

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

LAKE SHENANDOAH DAM

I.D. N.J. 00099	SCALE: NOT TO SCALE
	DATE: JANUARY, 1979

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List
Visual Inspection
Phase 1

Name Dam Lake Shenandoah County Ocean State N.J. Coordinators NJDEP

Date(s) Inspection 12/5/78 Weather Partly Cloudy Temperature 59°F

Pool Elevation at Time of Inspection 24.8 M.S.L. Tailwater at Time of Inspection 16.3 M.S.L.

Inspection Personnel:

Richard McDermott Miron Petrovski

John Gribbin

Dinesh Patel

J.G. Recorder

Present: Louise McCarthy, Ocean County Eng. Dept.

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE	N/A	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	N/A	
DRAINS	N/A	
WATER PASSAGES	N/A	
FOUNDATION	N/A	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	N/A	
STRUCTURAL CRACKING	N/A	
VERTICAL AND HORIZONTAL ALIGNMENT	N/A	
MONOLITH JOINTS	N/A	
CONSTRUCTION JOINTS	N/A	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Upstream embankment significantly eroded along majority of face. Downstream embankment severely eroded adjacent to spillway discharge channel.	Steel sheet piling adjacent to spillway on both sides had become exposed and rusted. Timber core wall not visible.
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Good	
RIPRAP FAILURES	Riprap protection on the upstream slope not in accordance with plan construction. (apparently washed away).	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Embankment is sandy with grass covering most surfaces (except where eroded). Small pine trees planted along the crest.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Considerable Erosion.	It appears that the remedy has been to dump sand in the eroded areas. The remedy has been insufficient.
ANY NOTICEABLE SEEPAGE	Wet spongy areas with slight seepage at downstream toe 175' North of ℄ of spillway 160' South of ℄ of spillway.	Seepage north of spillway contained orange colored silt.
STAFF GAGE AND RECORDER	---	
DRAINS	N/A	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	Gated intake in conc. box manhole approximately 35' from edge of lake.	
OUTLET STRUCTURE	48" Corrugated metal pipe. Invert 42" below stilling pool elevation. 6" silt layer on bottom of pipe.	
OUTLET CHANNEL	N/A	
EMERGENCY GATE	NONE	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A	
APPROACH CHANNEL	N/A	
DISCHARGE CHANNEL	N/A	
BRIDGE AND PIERS	N/A	
GATES AND OPERATION EQUIPMENT	N/A	

INSTRUMENTATION

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

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Slopes range from 1% to 3%.	Land around lake varies: sand, grass, woods.
SEDIMENTATION	NOT KNOWN	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No obstructions. Wide shallow stream.	
SLOPES	Stream is in low swampy area immediately downstream of dam.	
APPROXIMATE NO. OF HOMES AND POPULATION	None in the vicinity of the dam.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Plans of Proposed Spillway by Robert B. Powers, P.E., L.S. of Lakewood, N.J.; dated May, 1968. Plans of earth embankment construction not available.
REGIONAL VICINITY MAP	Available.
CONSTRUCTION HISTORY	Earth embankment & timber spillway first built in 1934. Failure of the spillway, date not available. Spillway reconstructed; completed in June 1969.
TYPICAL SECTIONS OF DAM	Available (Plans by Robert B. Powers).
HYDROLOGIC/HYDRAULIC DATA	Available (Plans by Robert B. Powers).
OUTLETS - PLAN	Available (Plans by Robert B. Powers).
- DETAILS -CONSTRAINTS -DISCHARGE RATINGS	Not Available.
RAINFALL/RESERVOIR RECORDS	Not Available.

ITEM	REMARKS
DESIGN REPORTS	Not Available.
GEOLOGY REPORTS	Not Available.
DESIGN COMPUTATIONS	Not Available.
HYDROLOGY & HYDRAULICS	Available.
DAM STABILITY	Not Available.
SEEPAGE STUDIES	Not Available.
MATERIALS INVESTIGATIONS	Not Available.
BORING RECORDS	Available for those made in 1968.
LABORATORY	Not Available.
FIELD	Not Available.
POST-CONSTRUCTION SURVEYS OF DAM	Not Available.
BORROW SOURCES	Not Available.

ITEM	REMARKS
MONITORING SYSTEMS	NONE
MODIFICATIONS	Fishway constructed after the reconstruction of the spillway.
HIGH POOL RECORDS	Not Available.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Some of the annual inspection reports available.
PRIOR ACCIDENTS OR FAILURE OF DAM	Failure of Original Timber Spillway.
DESCRIPTION	Not Available.
REPORTS	Not Available.
MAINTENANCE OPERATION RECORDS	Not Available.

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	See Powers plans referenced above.
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Available for 48" dia CM outlet pipe.

APPENDIX 2

Photographs

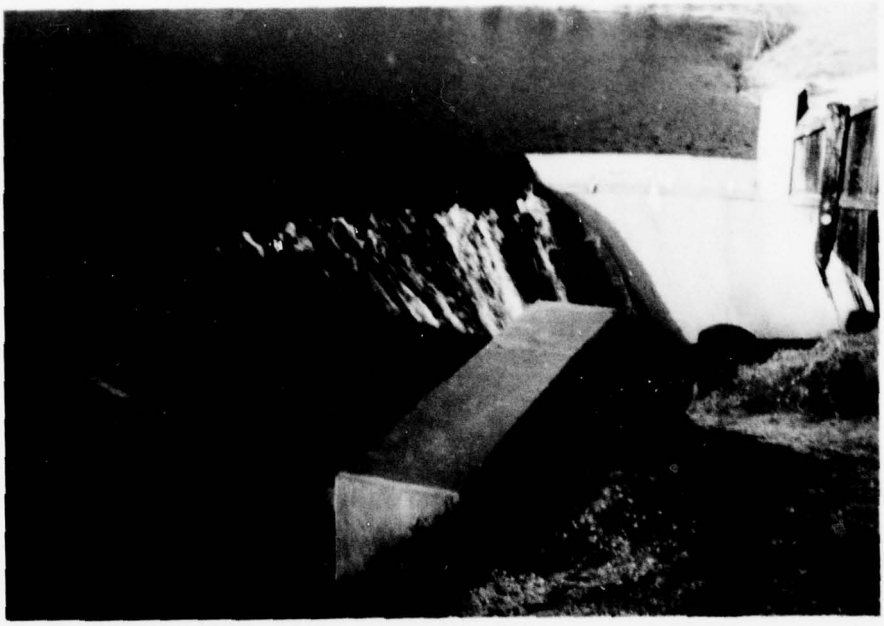


PHOTO 1

SPILLWAY

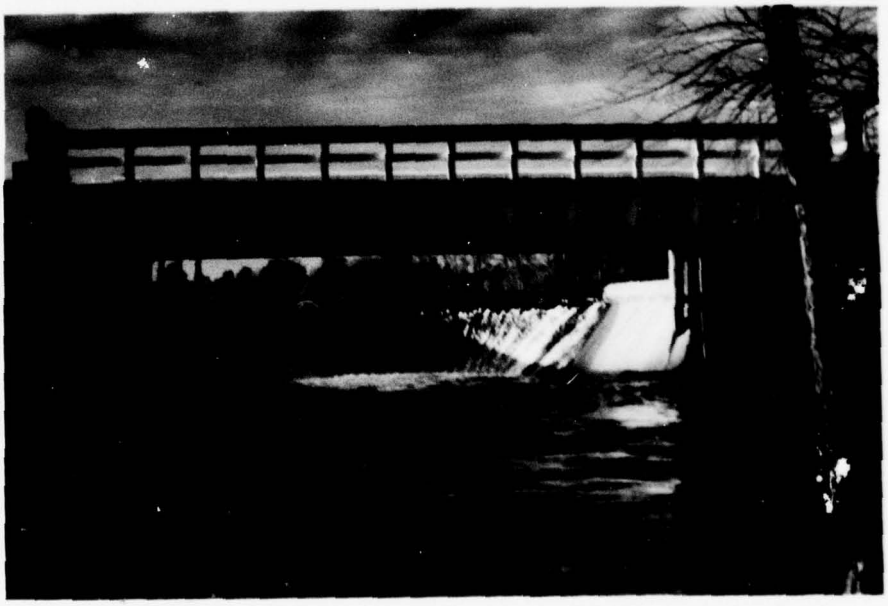


PHOTO 2

ROAD BRIDGE OVER SPILLWAY DISCHARGE CHANNEL

5 DEC. 1978

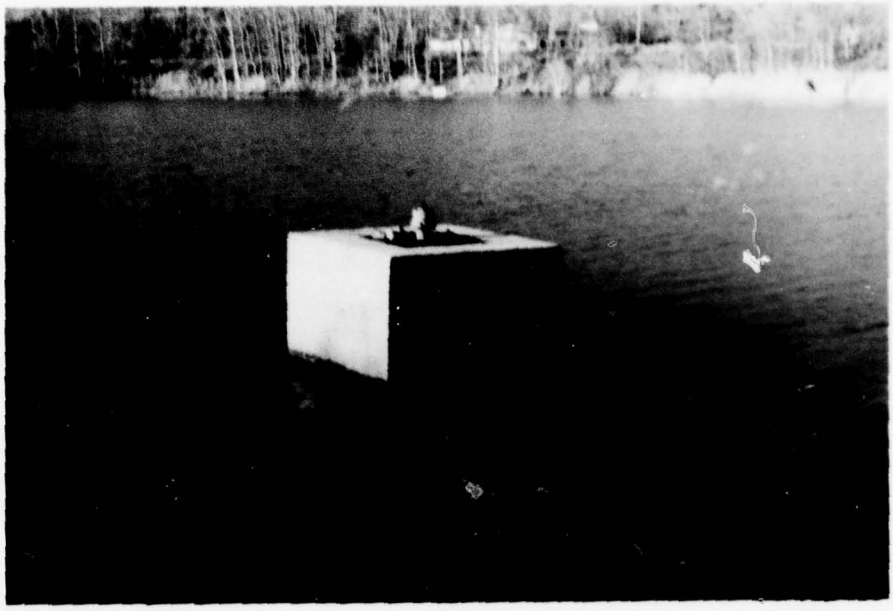


PHOTO 3

OUTLET WORKS MANHOLE

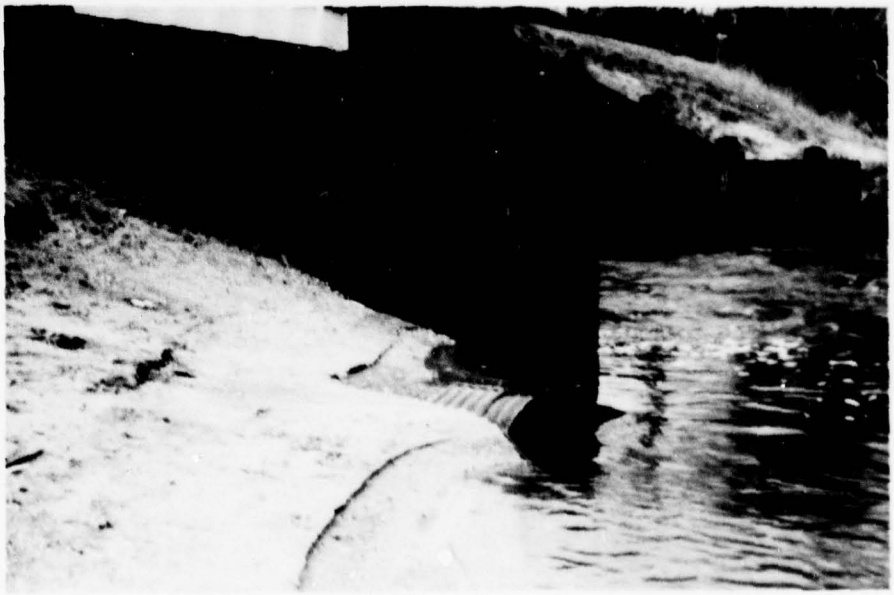


PHOTO 4

TIMBER SHEETING FORMING SPILLWAY DISCHARGE CHANNEL
CORRUGATED METAL OUTLET PIPE

5 DEC. 1978



PHOTO 5

UPSTREAM FACE OF DAM



PHOTO 6

DOWNSTREAM FACE OF DAM

5 DEC. 1978

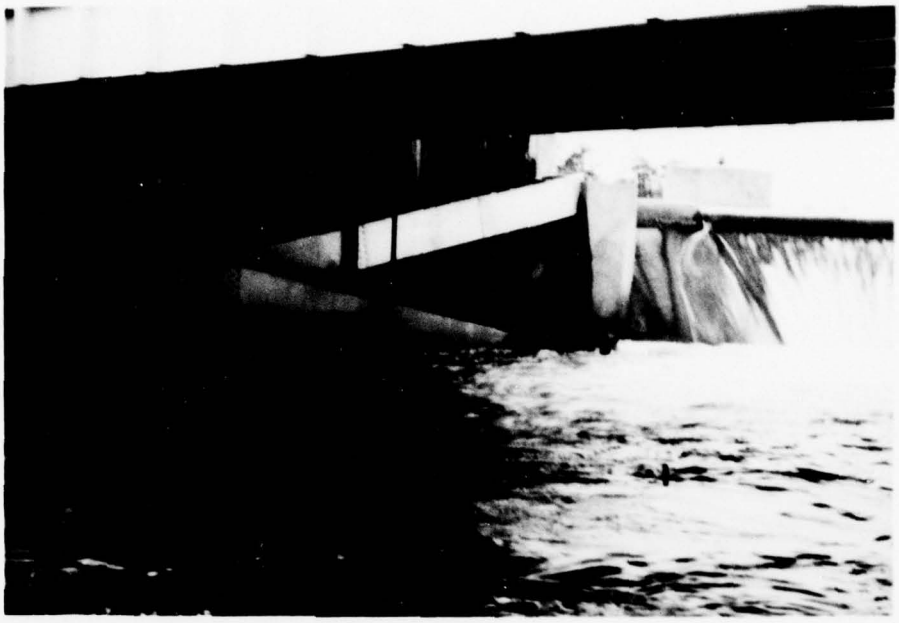


PHOTO 7

FISHWAY

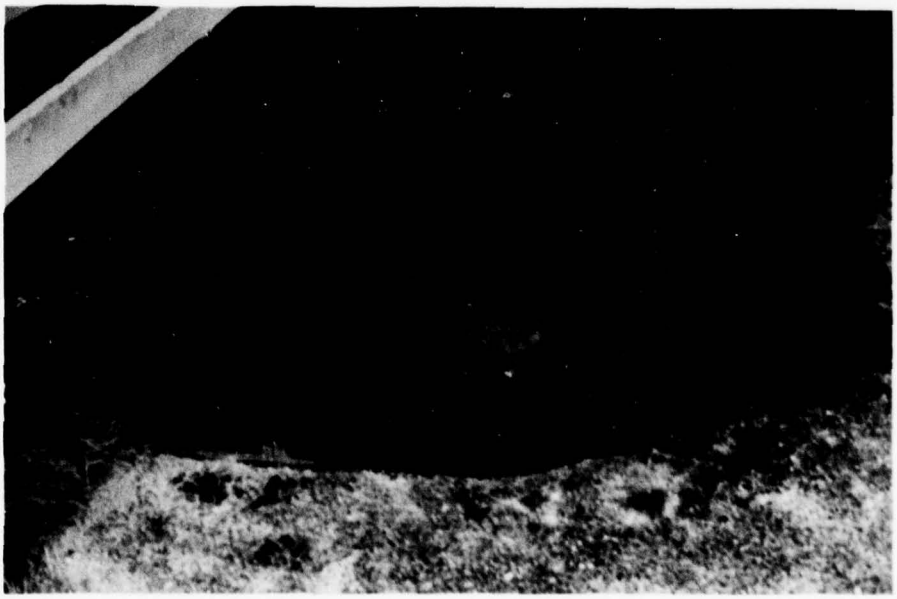


PHOTO 8

EROSION ADJACENT TO DOWNSTREAM TIMBER SHEETING

5 DEC. 1978



PHOTO 9

SEEPAGE AT NORTH DOWNSTREAM TOE OF DAM



PHOTO 10

DOWNSTREAM CHANNEL

5 DEC. 1978

APPENDIX 3

Engineering Data

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Generally wooded, partly developed

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 24.8 (111 acre-feet)

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

ELEVATION MAXIMUM DESIGN POOL: 30.6

ELEVATION TOP DAM: 30.6

SPILLWAY CREST: Semicircular reinforced concrete

- **a. Elevation** 25.2(Secondary crest, length 25.4 ft.) 24.4(Primary crest, length 52 ft.)
- **b. Type** uncontrolled overflow
- **c. Width** 25"
- **d. Length** 77.4 ft. (total)
- **e. Location Spillover** entire length of spillway
- **f. Number and Type of Gates** None

OUTLET WORKS: 1 - 48" Diam. pipe

- **a. Type** Corrugated Metal Pipe
- **b. Location** Approx. 8ft. south of spillway
- **c. Entrance inverts** 13.36 (Plans)
- **d. Exit inverts** 12.8 (Field measured)
- **e. Emergency draindown facilities:** Slide gate in manhole

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) 3680 cfs

APPENDIX 4

Hydrologic Computations

STORCH ENGINEERS

Sheet 1 of 7

Project #1132

Made By DMP Date 1/11/79

– 9KE SHENANDOAH DAM

Chkd By JG Date 1/15/79

100 YEAR FLOOD - PEAK DISCHARGE

From Special Report #38

$$Q_{100} = 136\, A^{0.84}\, S^{0.26}\, S_t^{-0.51}\, I^{0.14}$$

1 Drainage Area A = 29 Sq. Mi.

2 Main Channel Slope (S) :-

Length of main-channel = 10.4 Mi

10% of stream length = 1.04 Mi

85% of stream length = 8.84 Mi

Elevation at 10.4 Mi upstream from Dam } = 75

Elevation at 1.04 Mi upstream from Dam } = 24.4

$$S = \frac{75 - 24.4}{8.84 - 1.04} = \frac{50.6}{7.8} = 6.5 \text{ Ft/Mi}$$

3 Surface Storage Index (S_t) :-

Area of lakes and swamps as measured from geological swamp maps } = 0.562 Sq. Mi

$$S_t = \frac{0.562}{29} \times 100 + 1 = 2.94\ \%$$

4. Manmade - impervious cover index I :
Total population of Township of Lakewood = 38,000

Approximate population in the drainage area } = 19,000

Population density = $\frac{19,000}{29}$ = 655 Persons / Sq Mi

Impervious Cover Index = 9.7

Use the value given by Ocean County of I = 10.82

5 100 year flood - peak discharge Q_{100} :-

$$Q_{100} = 136\ (29)^{0.84}\ (6.5)^{0.26}\ (2.94)^{-0.51}\ (10.8)^{0.14}$$

$$= 136 \times 16.92 \times 1.63 \times 0.577 \times 1.395$$

$$= \underline{\underline{3,019\ \text{CFS}}}$$

SPILLWAY DISCHARGE

The discharge over the spillway will be calculated by Francis Weir Formula:

$$Q = Cl\left[(h+h_v)^{3/2} - h_v^{3/2}\right]$$

where Q = discharge. CFS
l = effective length of crest, ft
h = measured head on crest, ft, upstream from weir beyond beginning of surface curve
h_v = velocity of approach
C = coefficient
Francis's value $C = 3.33$
(C varies for small values of h. For $h > 3.5'$ c approaches 3.33.)

For complete end contractions:

$$l = l' - 0.1nh$$

where l' = total measured length on crest
n = number of end contractions

Length of spillway at elev. 24.40 = 52'

Length of spillway at elev. 25.20 = 52 + 2 (12.7)

= 77.4'

For Lake Shenandoah Dam, h_v is small as compared to h, and, therefore, will be taken as zero.

The effect of the fishway will be neglected.

STORCH ENGINEERS

Sheet 4 of 7

Project # 1132

Made By DMP Date 1/9/79

LAKE SHENANDOAH DAM

Chkd By JG Date 1/15/79

EFFECTIVE LENGTH OF CREST

Elevation	h	l'	$0.1nh$ $(n=2)$	l $(=l'-0.1nh)$
24.40	0	52	0	52
25.00	0.6	52	0.12	51.88
25.20	0.8	52	0.16	51.84
25.50	0.3	77.4	0.06	77.34
26.00	0.8	77.4	0.16	77.24
26.50	1.3	77.4	0.26	77.14
27.00	1.8	77.4	0.36	77.04
27.50	2.3	77.4	0.46	76.94
28.00	2.8	77.4	0.56	76.84
28.50	3.3	77.4	0.66	76.74
29.00	3.8	77.4	0.76	76.64
29.50	4.3	77.4	0.86	76.54
30.00	4.8	77.4	0.96	76.44
30.50	5.3	77.4	1.06	76.34
31.00	5.8	77.4	1.16	76.24
31.12	5.92	77.4	1.184	76.212

STORCH ENGINEERS

Sheet 5 of 7

Project # 1132

Made By DMF Date 1/10/79

LAKE SHENANDOAH DAM

Chkd By JG Date 1/15/79

DISCHARGE OVER SPILLWAY

Elevation	h_1 Ft	ℓ_1 Ft	Q_1 $(3.33 \ell_1 h_1^{3/2})$ CFS	h_2 Ft	ℓ_2 $(\ell - \ell_1)$ Ft	Q_2 $(3.33 \ell_2 h_2^{3/2})$ CFS	Q $(Q_1 + Q_2)$ CFS
24.40	0	52	0	0	0	0	0
25.00	0.6	51.88	80.3	0	0	0	80.3
25.20	0.8	51.84	123.5	0	0	0	123.5
25.50	1.1	52	200	0.3	25.34	14	214
26.00	1.6	52	350	0.8	25.24	60	410
26.50	2.1	52	527	1.3	25.14	124	651
27.00	2.6	52	726	1.8	25.04	201	927
27.50	3.1	52	945	2.3	24.94	290	1.235
28.00	3.6	52	1,183	2.8	24.84	388	1571
28.50	4.1	52	1,438	3.3	24.74	494	1932
29.00	4.6	52	1,708	3.8	24.64	608	2316
29.50	5.1	52	1.994	4.3	24.54	729	2.723
30.00	5.6	52	2.295	4.8	24.44	856	3.151
30.50	6.1	52	2,609	5.3	24.34	989	3598
31.00	6.6	52	2,936	5.8	24.24	1,128	4064
31.12	6.72	52	3,016	5.92	24.212	1,161	4,177

STORCH ENGINEERS

Sheet 6 of 7

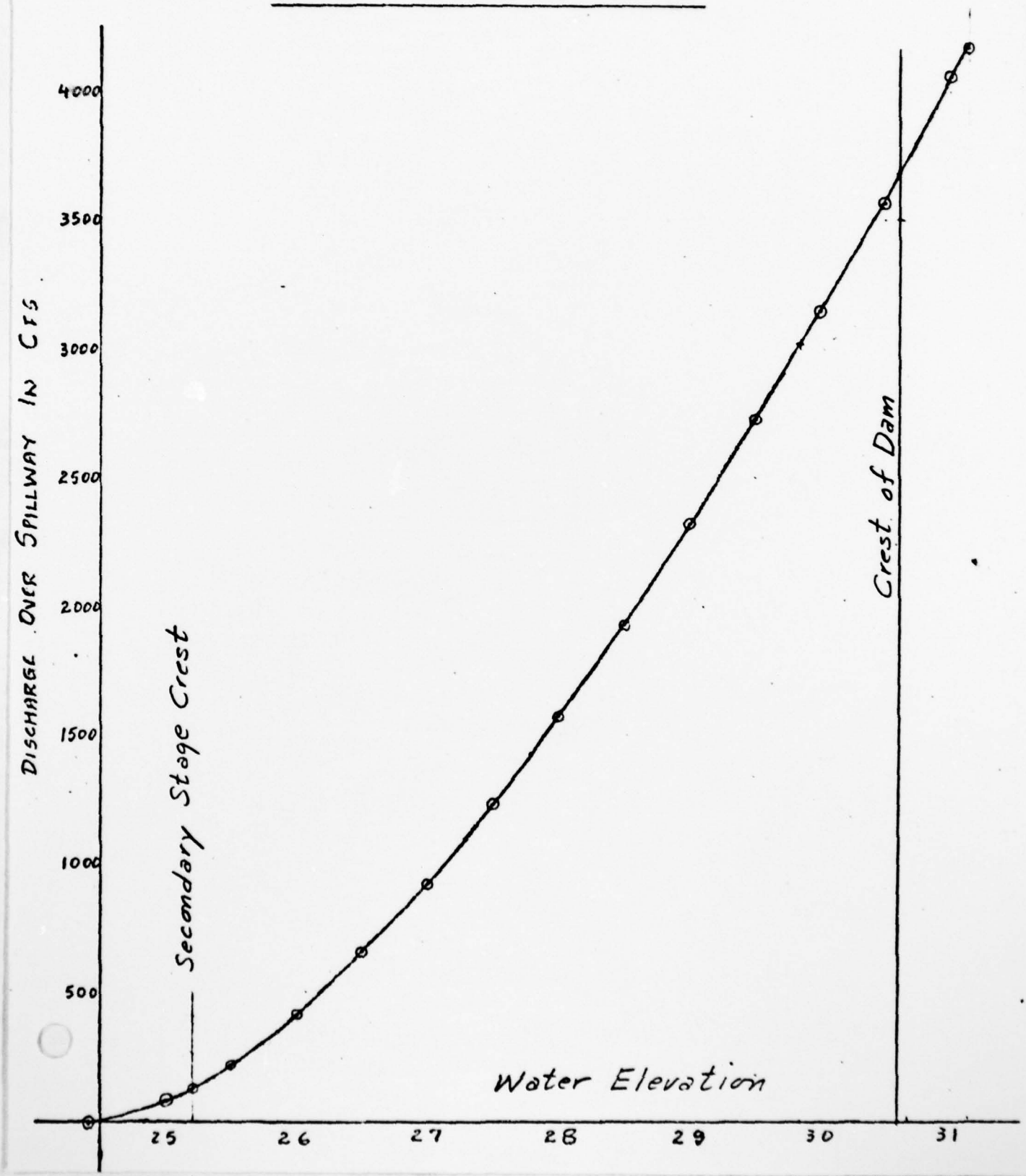
Project # 1132

Made By DMP Date 1/10/79

- KE SHENANDOAH DAM

Chkd By JG Date 1/15/79

STAGE - DISCHARGE CURVE



CAPACITY OF OUTLET WORKS

Outlet works 48" Diam C.M. Pipe
Length = 102 Ft
Slope 13.28 - 12.66 = 0.62 Ft
k_e (Outlet Control) = 0.5
n (-do.) = 0.024.
Invert Elevation at Inlet = 13.28

1.	Water Elevation	24.40	31.12
2	H_W	11.12 Ft	17.84 Ft
3	h_o	4 Ft	4 Ft
4	$L S_o$	0.62 Ft	0.62 Ft
5	$H = H_W - h_o + L S_o$	7.74 Ft	14.46 Ft
6	For Outlet Control Q	150 CFS	210 CFS
7	$\frac{H_W}{D}$	2.78	4.46
8	For Inlet Control Q	182 CFS	250 CFS

OUTLET CONTROL GOVERNS

Flow at water elevation 24.40 = 150 CFS

Flow at water elevation 31.12 = 250 CFS

APPENDIX 5

Boring Logs

LAKE SHENANDOAH DAM
BORING LOG INFORMATION

1. Boring Log information taken from drawing titled "Proposed Spillway at Lake Shenandoah" prepared by Robert B. Powers, P.E., L.S., dated May, 1968.

2. NOTES ON DRAWING

Borings made by:

JERSEY BORING & DRILLING CORP.
NEWARK, N. J.

BORING LOG PRESENTATION

Col. A. denotes depth below existing ground surface.

Col. B. denotes a visual classification of materials sampled.

Col. C. denotes sample numbers at appropriate depths.

Col. D. denotes blows per 6" on a 2" o.d. sampler with a 140 lb. hammer falling 30".

Col. E. denotes blows per 1' on a 2-1/2" dia. casing with a 250 lb. hammer falling 24".

Water readings were taken inside the casing at the time the borings were made. Soil porosity, site topography, recent rainfall, casing wash water, etc. may cause changes in fluctuation or inaccuracies in the water reading.

NOTE: Borings made at locations indicated in the field by stakes placed by the clients representative.

BORING 1

TYPE DR YE
WATER 25-6
SURFACE EL. 2.2 DATE: 1-25-6x

A	B	C	D	E
5'	Brn fine sand, trace silt	1	7 6	2 5 0 16
10'	Brn med fine sand, little silt	2	17	24 8 22 35
15'	Brn fine sand, trace silt	3	17	54 1 36 50 50
20'	Gray, med fine sand, trace silt	4	5 15	44 36
25'	Yellow fine sand, trace silt	5	7 5	30 30 31
30'	Gray fine sand, trace silt	6	3 8	

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BORING 2

TYPE [illegible]
WATER [illegible]
SURFACE EL [illegible] DATE [illegible]

A	B	C	D	E
5'	Gray fine sand, some trace rock chips	1	1, 2	5, 5, 5, 5, 4, 2, 5, 8, 8
10'	Gray, coarse to fine trace organic silt	2	1, 3, 1	5, 1, 5, 8, [illegible]
15'	Yellow [illegible] fine sand, trace silt	3	2, 4, 3	[illegible], 18, 16, 21
20'	Gray fine sand trace silt	4	5, 6, [illegible]	19, 27, [illegible], 20
25'	Yellow [illegible] fine sand, trace silt	5	6, 6, [illegible]	40, 45, 27, 16, 25, 33
30'	Gray fine sand, trace silt [illegible]	6	[illegible], 7, 11	21

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BORING 3

TYPE DRIVE
WATER 3[illegible]
SURFACE EL 170' DATE 8 [illegible] 66

A	B	C	D	E
5'	Br[illegible] fine sand, trace gravel	1	[illegible]	2 2 5 18 47
10'	Yellow brn fine sand, trace silt	2	3 4 5	135 30 32 43 56
15'	Tan fine sand, trace silt	3	5 4 4	51 45 [illegible] 50 50
20'	Gray fine sand, trace silt	4	8 13 9	5 53 63
25'	[illegible]	5	3 27 20	[illegible] 00 [illegible] 190 204
30'	[illegible]	6	1 6 1	218
35'	Gray silt, trace fine sand	7	[illegible]	
40'	Gray fine sand trace silt	8	[illegible]	

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BORING 4

TYPE DRIVE
WATER DRY
SURFACE EL. 18.2 DATE 8-3-66

A	B	C	D	E
				2
5'	Yellow brn med to	1	1 2	25
	fine sand, trace silt			
				39
				32
				4
10'	Yellow brn fine sand,	2	1 3	69
	trace silt			31
				41
				5
				50
15'	Gray fine sand,	3	4 5	6
	trace silt			
				75
				114
20'	"	4	"	
				97

				97
				90
25'		5	10 22	
				103
30'		6	1 4	200
35'		7	6 7	
40'	Gray, fine sand	8	6	
	little fine grave			

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BORING 5

TYPE CR-E
WATER Dry
SURFACE EL 17.2 DATE 8-5-66

A	B	C	D	E
5'	Tan coarse to fine sand, trace silt	1	2 3 1	13 27
10'	Tan fine sand, trace silt, trace grave	2	3 5 7	36 27
15'	Tan fine sand, trace silt	3	5 6 4	44 31
20'	Gray fine sand, trace silt	4	4 10 7	100 90 94
25'		5	9 20 10	103 102 109 115 119
30'		6	2 5 1	125
35'		7	0 2	
40'		8	3 4	

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BORING 6

TYPE DRIVE
WATER DRY
SURFACE EL. 28.5' DATE 4-8 EL

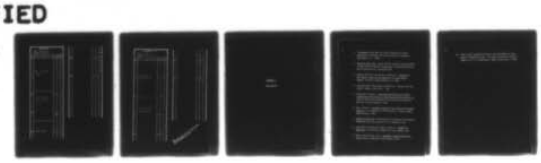
A	B	C	D	E
5'	Brn fine sand trace silt	1	1 2 3	1 2 2 2 2 5 6
10'	Gray fine sand and organic silt	2	1 3 4	4 6 11 10 8
15'		3	2 9 5	8 1 7
20'	Gray fine sand and yellow fine sand, trace silt	4	17 21 8	18 18 21 23 26
25'	Brn fine sand little silt	5	7 6	26 16 20 13 19 16 9
30'	Gray fine sand, trace silt	6	10 9 11	

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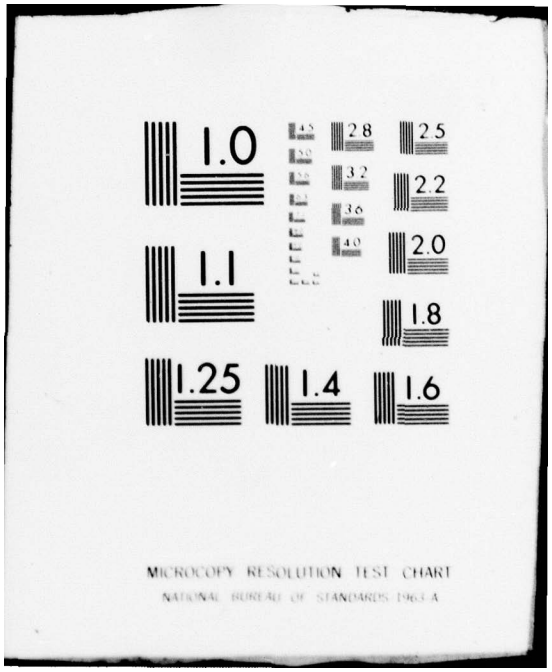
AD-A068 649 NEW JERSEY STATE DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/G 13/2
NATIONAL DAM SAFETY PROGRAM. LAKE SHENANDOAH DAM (NJ-00099), AT--ETC(U)
MAR 79 R J MCDERMOTT DACW61-78-C-0124

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2 OF 2
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DATE FILMED
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1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

BORING 7

TYPE DRIVE
WATER DRY
SURFACE EL 30.0' DATE 7-28-66

A	B	C	D	E
5'	Brn fine sand, trace silt	1	1, 2, 1	1, 2, 2, 3, 5, 1, 2, 2, 4
10'	Gray med fine sand, trace gravel and silt	2	1, 2, 1	2, 5, 3, 1, 6
15'		3	4, 5	24, 5, 9, 14, 14
20'	Gray [illegible] fine sand, trace silt	4	4, 5	15, 25, 25
25'		5	6, 8	31, 29, 23, 25, 30, 31, 15
30'		6	7, 10	

BORING 8

TYPE DRIVE
WATER DRY
SURFACE EL. 32.2 DATE 1-12-68

A	B	C	D	E
5'	Brn med fine sand, trace silt	1	7, 3, 5	4
10'		2	10, 10, 12	10
15'	Yellow brn fine sand, trace silt	3	4, 5, 7	10
20'		4	5, 8, 8	15
25'		5	10, 13, 12	25
30'		6	7, 5, 9	14

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APPENDIX 5

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