

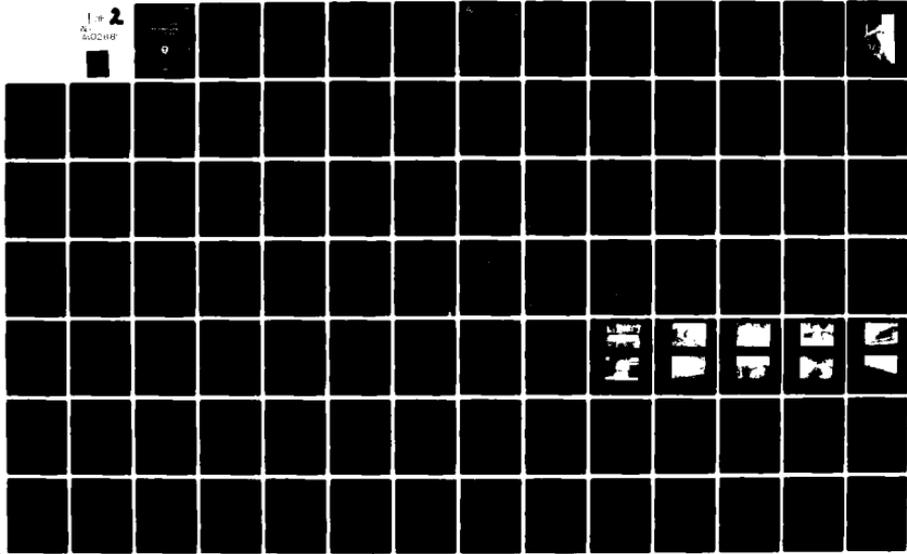
AD-A102 681

NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/8 13/13  
NATIONAL DAM SAFETY PROGRAM, SUNSET LAKE RACEWAY DAM (NJ00764),--ETC(U)  
JUL 81 R J MCDERMOTT, J E GRIBBIN DACW61-79-C-0011

DAEN/NAP-53842/NJ00764-81/ NL

UNCLASSIFIED

1 of 2  
A  
80249



DELAWARE RIVER BASIN  
COHANSEY RIVER, CUMBERLAND COUNTY  
NEW JERSEY

1

# SUNSET LAKE RACEWAY DAM NJ 00764

DTIC  
ELECTE

AUG 11 1981

AD A102681

## PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

Sunset Lake Raceway Dam (NJ00764).  
Delaware River Basin, Cohansey River,  
Cumberland County, New Jersey. Phase  
I Inspection Report.

Final rept.,

DACW61-79-C-0011



APPROVED FOR PUBLIC RELEASE;  
DISTRIBUTION UNLIMITED.

THIS DOCUMENT IS BEST QUALITY PRACTICE.  
THE COPY FURNISHED TO DDC CONTAINED A  
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.

Richard J. /McDermott  
John E. /Gribbin

DEPARTMENT OF THE ARMY

Philadelphia District  
Corps of Engineers  
Philadelphia, Pennsylvania

REPT. NO: DAEN | NAP - 53842 / NJ 00764 - 81 / 07

JUL 19 81

DTIC FILE COPY

81 8 10 103

**NOTICE**

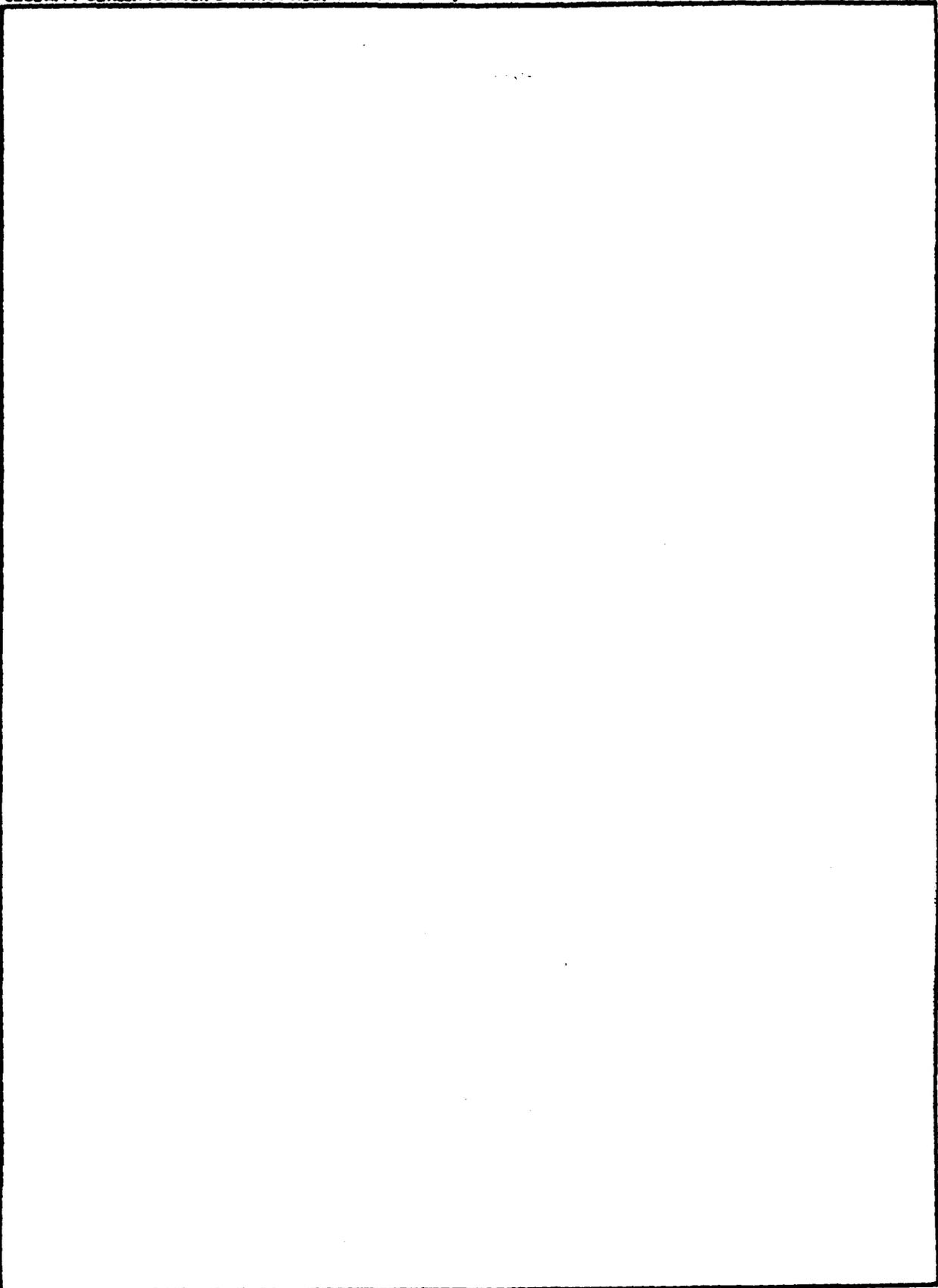
**THIS DOCUMENT HAS BEEN REPRODUCED  
FROM THE BEST COPY FURNISHED US BY  
THE SPONSORING AGENCY. ALTHOUGH IT  
IS RECOGNIZED THAT CERTAIN PORTIONS  
ARE ILLEGIBLE, IT IS BEING RELEASED  
IN THE INTEREST OF MAKING AVAILABLE  
AS MUCH INFORMATION AS POSSIBLE.**

## **DISCLAIMER NOTICE**

**THIS DOCUMENT IS BEST QUALITY  
PRACTICABLE. THE COPY FURNISHED  
TO DTIC CONTAINED A SIGNIFICANT  
NUMBER OF PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.**



**SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)**



**SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)**



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

DTIC  
 ELECTRIC  
 AUG 11 1981  
 S D

IN REPLY REFER TO  
 NAPEN-N

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	23 9

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

31 JUL 1981

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Sunset Lake Raceway Dam in Cumberland 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, Sunset Lake Raceway Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 19 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure 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. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the owner should engage a qualified professional consultant to perform the following:

(1) Prepare a design for the renovation of the embankment to bring the entire crest elevation to the level of the reconstructed portion at the upstream end, and the embankment should be renovated accordingly.

(2) The observed seepage should be monitored on a periodic basis in order to detect any changes in conditions.

APPROVED FOR PUBLIC RELEASE;  
 DISTRIBUTION UNLIMITED.

NAPEN-N

Honorable Brendan T. Byrne

c. Within six months from the date of approval of this report, the following remedial actions should be initiated:

- (1) Trees and adverse vegetation on the embankment should be removed.
- (2) Spalled and deteriorated surfaces of the spillway structure should be repaired.
- (3) The twin discharge culverts for the spillway should be renovated or replaced.
- (4) The railing along the spillway structure should be extended along the raceway to the road bridge.

d. The owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of 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 Congressman Hughes of the Second District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

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

An important aspect of the Dam Inspection 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,



ROGER L. BALDWIN  
Lieutenant Colonel, Corps of Engineers  
Commander and District Engineer

1 Incl  
As stated

**Copies furnished:**

Mr. Dirk C. Hofman, P.E., Deputy Director  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CM029  
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief  
Bureau of Flood Plain Regulation  
Division of Water Resources  
N.J. Dept. of Environmental Protection  
P.O. Box CM029  
Trenton, NJ 08625

SUNSET LAKE RACEWAY DAM (NJ00764)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 8 & 27 January 1981 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.

Sunset Lake Raceway Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 19 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure 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. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the owner should engage a qualified professional consultant to perform the following:

(1) Prepare a design for the renovation of the embankment to bring the entire crest elevation to the level of the reconstructed portion at the upstream end, and the embankment should be renovated accordingly.

(2) The observed seepage should be monitored on a periodic basis in order to detect any changes in condition.

c. Within six months from the date of approval of this report, the following remedial actions should be initiated:

(1) Trees and adverse vegetation on the embankment should be removed.

(2) Spalled and deteriorated surfaces of the spillway structure should be repaired.

(3) The twin discharge culverts for the spillway should be renovated or replaced.

(4) The railing along the spillway structure should be extended along the raceway to the road bridge.

d. The owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED:

Rog L Baldwin

ROGER L. BALDWIN

Lieutenant Colonel, Corps of Engineers  
Commander and District Engineer

DATE:

31 July 81

PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Sunset Lake Raceway Dam, I.D. NJ00764  
State Located: New Jersey  
County Located: Cumberland  
Drainage Basin: Delaware River  
Stream: Cohansey River  
Date of Inspection: January 8, 1981  
January 27, 1981

Assessment of General Condition of Dam

Based on visual inspection, past operational performance and Phase I engineering analyses, Sunset Lake Raceway Dam, a high hazard potential structure, is assessed as being in fair overall condition.

Hydraulic and hydrologic analyses indicate that the spillway is inadequate. Discharge capacity of the spillway is not sufficient to pass the designated spillway design flood (SDF) without an overtopping of the dam. (The SDF for Sunset Lake Raceway Dam is equal to one-half the probable maximum flood.) The spillway is capable of passing approximately 9 percent of the probable maximum flood or 18 percent of the SDF. Therefore, the owner should engage a professional engineer experienced in the design and construction dams in the near future to perform more accurate hydraulic and hydrologic analyses. Based on the findings of the analyses, the need for and type of remedial measures should be determined and then implemented. Consideration should be given to a regrading of the embankment to bring the entire crest elevation to the level of the reconstructed portion of the upstream end.

The owner should continue to employ the surveillance and emergency action plan currently in use.

The observed seepage should be monitored on a periodic basis by a professional engineer experienced in the design and construction of dams in order to detect any changes in condition.

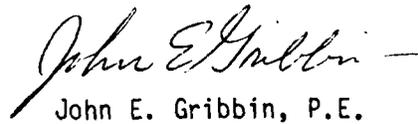
In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future:

- 1) Trees and adverse vegetation on the embankment should be removed.
- 2) Spalled and deteriorated surfaces of the spillway structure should be repaired.
- 3) The twin discharge culverts for the spillway should be renovated or replaced.
- 4) The railing along the spillway structure should be extended along the raceway to the road bridge.

In the future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

By impounding the raceway for Sunset Lake, Sunset Lake Raceway Dam also impounds the main body of Sunset Lake. The lake is also impounded by the main dam, Sunset Lake Dam. Remedial measures to correct the inadequate condition of the spillway of Sunset Lake Raceway Dam should be performed in conjunction with remedial measures for the main dam as specified in "Sunset Lake Dam, NJ00063, Phase I Inspection Report, National Dam Safety Program," dated April 1979.

  
Richard J. McDermott, P.E.

  
John E. Gribbin, P.E.



OVERVIEW - SUNSET LAKE RACEWAY DAM

31 JANUARY 1981

## TABLE OF CONTENTS

	<u>Page</u>
ASSESSMENT OF GENERAL CONDITION OF DAM	i
OVERVIEW PHOTO	iii
TABLE OF CONTENTS	iv
PREFACE	vi
SECTION 1 - PROJECT INFORMATION	1
1.1 General	
1.2 Description of Project	
1.3 Pertinent Data	
SECTION 2 - ENGINEERING DATA	7
2.1 Design	
2.2 Construction	
2.3 Operation	
2.4 Evaluation	
SECTION 3 - VISUAL INSPECTION	10
3.1 Findings	
SECTION 4 - OPERATIONAL PROCEDURES	16
4.1 Procedures	
4.2 Maintenance of Dam	
4.3 Maintenance of Operating Facilities	
4.4 Description of Warning System	
4.5 Evaluation	

TABLE OF CONTENTS (cont.)

	<u>Page</u>
SECTION 5 - HYDRAULIC/HYDROLOGIC	
5.1 Evaluation of Features	18
SECTION 6 - STRUCTURAL STABILITY	21
6.1 Evaluation of Structural Stability	
SECTION 7 - ASSESSMENT AND RECOMMENDATIONS	23
7.1 Dam Assessment	
7.2 Recommendations	
 PLATES	
1 KEY MAP	
2 VICINITY MAP	
3 SOIL MAP	
4 OVERVIEW	
5 SPILLWAY PLAN	
6 SPILLWAY PLAN AND ELEVATION	
7 PLAN - LOW LEVEL OUTLET	
8 PHOTO LOCATION PLAN	
 APPENDICES	
1 Check List - Visual Inspection	
Check List - Engineering Data	
2 Photographs	
3 Engineering Data	
4 Hydraulic/Hydrologic Computations	
5 Existing Temporary Emergency Action Plan	
6 Bibliography	

## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of 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 hydraulic and hydrologic 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 hydraulic and hydrologic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

SUNSET LAKE RACEWAY DAM, I.D. NJ00764

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 inspections of Sunset Lake Raceway Dam were made on January 8 and January 27, 1981. The purpose of the inspections 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

Sunset Lake Raceway Dam consists of an earth embankment approximately 5000 feet long impounding a raceway from Sunset Lake. The raceway, formerly used to supply water to a mill, discharges into the Cohansey River, the downstream channel for Sunset Lake. The embankment begins at the southwest corner of Sunset Lake at the Park Drive Bridge. It extends southward through the Bridgeton City Park to a concrete spillway structure at the downstream end. The spillway consists of a concrete drop inlet discharging through twin 36"x58" elliptical corrugated metal pipes.

Having an overall crest length of 5000 feet, the dam has crest elevations of 20.0, National Geodetic Vertical Datum (N.G.V.D.) for the northern or upstream end, 18.0 at the center, and 19.0 for the southern or downstream end. The overall height of the dam is 11.0 feet. The crest width is 15 feet and the downstream slope varies from 1 horizontal to 1 vertical to 2 horizontal to 1 vertical.

The spillway drop inlet contains openings with primary and secondary weir crests. The primary crest is at elevation 14.5 while the secondary crest is at elevation 16.0. Twin 36" x 58" E.C.M.P. functioning as the discharge culverts have a downstream invert of 5.0.

### b. Location

Sunset Lake Raceway Dam is located within the City of Bridgeton, Cumberland County, New Jersey. Principal access to the dam is by Mayor Aitken Drive which runs through City Park and crosses the raceway at its downstream end at a point two blocks north of N.J. Route 49.

c. Size and Hazard Classification

The dam is classified in accordance with criteria presented in "Recommended Guidelines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers. Size categories consist of Small, Intermediate and Large while hazard categories are designated as Low, Significant and High.

Size Classification: Sunset Lake Raceway Dam is classified as "Small" size since its maximum storage volume, including Sunset Lake, is 703 acre-feet (which is less than 1000 acre-feet) and its height is 11.0 feet (which is less than 40 feet).

Hazard Classification: Visual inspection of the downstream flood plain of the dam indicates that, depending upon breach location, failure of the dam could inundate public roadways, public buildings, public recreation areas and/or Bridgeton Water Works located near the downstream end of the dam. Therefore, dam failure could cause damage to a major public utility as well as loss of life. Accordingly, Sunset Lake Raceway Dam is classified as "High" hazard.

d. Ownership

Sunset Lake Raceway Dam is owned by the City of Bridgeton, City Hall, Bridgeton, New Jersey 08302.

e. Purpose of Dam

The purpose of the dam is the impoundment of a raceway formerly used to supply power to a nail mill, but now used for recreation.

f. Design and Construction History

The Sunset Lake Raceway Dam embankment was constructed in 1814 for the purpose of supplying power to a nail mill. The dam

structure for Sunset Lake, located immediately upstream, reportedly was re-built in 1938 following failure during August 1934. Reportedly, the raceway dam overtopped but did not breach during the flood of August 1934. Following this flood, the spillway configuration of upstream Sunset Lake Dam was modified and construction was completed in 1938.

The flood of September 1940 caused the raceway dam to overtop and to washout in one section. The raceway embankment reportedly breached again during a storm in 1975. The location of the breach was at the extreme upstream end of the raceway embankment immediately downstream of the Park Avenue Bridge. The 1975 breach and other embankment erosion, which resulted from the failure of Mary Elmer Dam located upstream was subsequently repaired in 1976 after being declared a disaster area by local, state, and federal governments.

g. *Normal Operational Procedures*

Reportedly, the dam and its appurtenances are operated and maintained by the City of Bridgeton. Repairs are made on an "as needed" basis. Reportedly, during periods of heavy rain, the gates at the downstream end of the raceway are raised. Also the condition of the gates are checked on a monthly basis by City personnel.

1.3 Pertinent Data

a. Drainage Area	47.7 square miles
b. Discharge at Damsite	
Maximum flood at damsite	September 1940 (Quantity of flow unknown)
Outlet Works at pool elevation	N.A.
Spillway capacity at top of dam	290 cfs



Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Unknown
h. Spillway	
Type	Concrete drop inlet with primary and secondary stages
Length of weir - Primary	9 feet
- Secondary	10 feet
Crest elevation - Primary	14.5
-Secondary	16.0
Gates	4' X 4' low level outlet gate
Approach channel	Earth raceway from Sunset Lake to spillway
Discharge channel	Twin 36" X 58" E.C.M.P.
i. Regulating outlet	4' x 4' low level outlet gate in spillway structure 4' corrugated metal pipe located approx. 200' upstream from spillway (abandoned)
j. Diversion and Regulating Tunnel	N.A.

## SECTION 2: ENGINEERING DATA

### 2.1 Design

Construction drawings titled, "Plan of Raceway Spillway for Bridgeton City Park" prepared by W.A. Kirby, City Engineer and A.L. Stubee, Consulting Engineer, dated August 19, 1947, are available in the files of the NJDEP, Division of Water Resources. These plans show a proposed spillway structure located at the southern end of the raceway. The maximum flood inflow based upon the Central Jersey Curves was found to be 325 c.f.s/sq. mi. or 490 c.f.s. These design parameters can be found in the NJDEP files.

Revisions to the August 19, 1947, plans were made to change the proposed discharge channel from a 12' x 5' wide box culvert to the twin 36" X 58" E.C.M.P. approved by NJDEP on October 30, 1953. These plans are also available in the files of the NJDEP.

In addition, a Phase I Inspection Report for Sunset Lake Dam NJ00063, prepared by the U.S. Army Corps of Engineers, dated April 1979 was available in the NJDEP files.

### 2.2 Construction

The spillway structure as it presently exists was constructed in accordance with the plans approved October 30, 1953. Reportedly, the construction was completed on September 30, 1954.

The section of the dam that breached in 1975 was subsequently reconstructed in 1976. The embankment reconstruction was performed by Don Rogers, Inc. in accordance with plans entitled "Bid -Pac-1 Storm Damage Restoration Work" dated 6/10/76 prepared by Edward H. Richardson Associates. As indicated in the contract specifications, "Borrow used for dike construction and repair shall meet the grading classification A-4 as specified by AASHTO Spec M145."

Daily inspection reports for the 1976 reconstruction are on file with the City of Bridgeton Department of Public Works.

### 2.3 Operation

Correspondence relating to the operation of the dam is available in the NJDEP file. Operation of the raceway dam has been successful to the extent that, with exception of the breach in 1975, it has not overtopped since the new spillway was completed in 1953. However, this breach reportedly resulted from the impact of the flood wave produced when Mary Elmer Lake breached.

### 2.4 Evaluation

#### a. Availability

Available engineering data is limited to that which is on file with the NJDEP and the City of Bridgeton Department of Public Works.

#### b. Adequacy

The file information was of significant assistance in the performance of a Phase I evaluation. However, complete information needed to properly evaluate the dam was not available. A list of absent information is included in paragraph 7.1.b.

#### c. Validity

The available hydraulic and hydrologic analyses in connection with the construction of the existing spillway structure appear to be invalid because of the fact that the design was based upon the drainage area of the raceway only (1.5 sq. mi.) and does not include flow transmitted through the Park Avenue Bridge (B-14) from Sunset Lake.

The hydraulic and hydrologic data made available in the Phase I Inspection Report for Sunset Lake NJ00063, dated April 1979, were found to be valid and in accordance with analytic procedures developed by the Corps of Engineers for the present inspection and assessment program.

## SECTION 3: VISUAL INSPECTION

### 3.1 Findings

#### a. General

The inspections of Sunset Lake Raceway Dam were performed on January 8 and January 27, 1981 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 embankment of the dam, appurtenant structures and adjacent areas were examined.
- 2) The dam was measured and key elevations determined with the use of a surveyor's level.
- 3) The dam embankments, appurtenant structures and adjacent areas were photographed.

#### b. Dam

The embankment forming the raceway dam extends from the Park Drive Bridge (B-14) running approximately parallel to Mayor Aitkens Drive to its terminus at the spillway structure located just south of Washington Street. Due to the extreme length of the embankment a thorough visual description of the embankment will be given referring to stations beginning at Station 0+00 (the spillway at the south end) and terminating at Station 50+00 (the Park Drive Bridge - B-14 at Sunset Lake).

Sta 0+00 to 4+00 - The crest and downstream side of embankment were generally bare probably due to pedestrian activity with the downstream slope being approximately 1.5 horiz. to 1 vert.

- Sta 4+00 to 5+00 - The downstream face of the embankment was covered with ground cover and had a slope of approximately 1.5 horiz. to 1 vert.
- Sta 5+00 to 5+25 - The downstream face appeared bare, eroded, and sloughed, probably due to pedestrian activity.
- Sta 5+25 to 6+60 - The downstream face appeared generally bare with some ground cover. A small area of erosion and sloughing was observed near Sta 6+00. Downstream slope approximately 1 to 1 to 1.5 to 1. At Sta 6+60 another area of erosion and sloughing due to pedestrian activity was observed.
- Sta 6+60 to 10+20 - The downstream face of the dam was observed to vary, with the majority being grass covered. Some bare patches were evident. The majority of the downstream slope was at a slope of approximately 2 horiz. to 1 vert.
- Sta 10+20 to 19+70 - The downstream face of the dam was observed to be generally grass covered with a few bare patches evident.
- Sta 19+70 to 22+65 - Gabion riprap slope protection was observed on the upstream embankment immediately downstream of the footbridge located at Sta 19+70. Upstream from the pedestrian footbridge the downstream face of embankment was observed to be generally covered with grass, briars,

bushes and small trees. The trees ranged in caliper from 2 inches to 12 inches. The embankment height was observed to be approx. 4.5 feet at Sta 20+75 and decrease to a height of near zero at Sta 22+65.

Sta 22+65 to 30+45 - No significant embankment was observed in the area of the Zoo. The raceway was approximately 40 feet wide with approximately 2 feet of freeboard in the channel. The embankment was observed to reappear upstream of the Zoo pedestrian bridge located at Sta 30+45.

Sta 30+45 to 45+00 - Erosion was observed on the downstream face of the dam at the footbridge located at Sta 34+30; probably caused by pedestrian activity. The erosion appeared to have exposed the roots of two large trees approximately 18 inches in diameter.

The downstream side of embankment was observed to be extremely overgrown with brushes, briars and trees. In the vicinity of Sta 38+00 a few bulges were observed on the downstream face of the embankment but they appeared to be due to the placement of fill. A bare pedestrian path was observed on the downstream embankment at Sta 38+85. Some large trees, approximately 24 inches in diameter, were observed on the downstream face in the vicinity of Sta 41+00 and 42+00.

Sta 45+0 to 50+00 (Bridge at Sunset Lake) - The embankment from Sta 45+00 to the bridge at Sunset Lake was observed to be well graded and contained a good stand of grass covering on both the upstream and downstream faces of the embankment which had slopes of approximately 2 horiz. to 1 vert.

This area of embankment appeared to be the section of embankment that breached and was repaired in 1975 and was in far better condition than the remainder of the dam.

Near the junction of the Sunset Lake and Sunset Lake Raceway embankments (Park Drive Bridge B-14) the downstream embankment was grass covered with some trees observed.

General

Grass, bushes and occasional trees were observed on the upstream side of embankment along most of its length.

c. Seepage

Evidence of possible seepage was observed in an area located approximately 100 feet south of the Bridgeton Water Works Building and approximately 150 feet downstream from the raceway embankment just east of Mayor Aitken Drive. Water flowing with a trickle and containing orange deposits was observed in a channel running from a box culvert under Mayor Aitken Drive and the Cohansey River. The culvert was at a location corresponding to the approximate position of the outlet works of the raceway; no upstream end of the culvert was observed. The origin of the flow could not be determined.

Wet areas also were observed at the toe of the dam located immediately upstream of the footbridge at the Zoo (Sta 30+45). It could not be determined if these wet areas were a result of seepage or high water table.

In addition a large pool of standing water was observed at the downstream toe of the embankment located approximately 75 feet from upstream end of the raceway (Park Drive). The pond was irregularly shaped approximately 150 feet long and 40 feet wide. Orange deposits were observed in the pool, evidently resulting from seepage.

Further conversations with the City of Bridgeton Department of Public Works revealed that the above mentioned pool of water located at the toe of the dam was created during the 1975 breach by outflow which scoured the area at the toe of the dam and now forms a low-lying depression which ponds water.

d. Appurtenant Structures

Discharge from the outlet structure located at the southerly terminus of the raceway outfalls directly into the Cohansey Rivery via twin 36" x 58" ECMP discharge pipes. These corrugated metal pipes appeared to be deteriorated at their inverts but were in generally satisfactory condition.

The concrete forming the principal intake structure appeared to be in generally satisfactory condition. The trash racks and pipe railing located on the top of the structure appeared to be in generally satisfactory condition, although the trash racks were not in proper position at the times of inspection.

The stem and wheel operating mechanism for the slide gate outlet works was observed to be rusted although it appeared to be operable.

e. Reservoir Area

The upstream embankment or west side of the raceway channel varies in slope. The upstream side of the raceway between the spillway and Eddy's Pond is wooded with very steep slopes. The remaining upstream slopes are generally flat to moderate with banks ranging from 2 to 5 feet in height.

f. Downstream Channel

The twin 36" x 58" ECMP discharge pipes outfall directly into the Cohansey River. The river varies from 50 to 100 feet in width with banks 2 to 5 feet high. The river is tidal at the outfall point and widens to a width of approximately 600 feet approximately one mile downstream.

The raceway runs approximately parallel to the Cohansey River at an average distance of about 1000 feet to the west. Between the raceway dam and the river, a flat area forms the flood plain of the dam. The area contains recreation areas, a roadway, about four public buildings and the Bridgeton Water Works.

## SECTION 4: OPERATIONAL PROCEDURES

### 4.1 Procedures

The level of water in Sunset Lake Raceway is regulated by discharge over the spillway of the dam and the spillways at Sunset Lake Dam. The low level gate in the spillway structure is reportedly opened during times of intense storms to augment the spillway capacity.

### 4.2 Maintenance of the Dam

Reportedly the dam embankment is inspected on a regular basis. Repairs are made on "as needed" basis.

### 4.3 Maintenance of Operating Facilities

Reportedly, the operation mechanism for the 4' x 4' low level outlet gate is inspected and operated once a month as part of the flood emergency program and is maintained regularly.

### 4.4 Description of Warning System

As a direct result of the 1975 flood, the City developed an extensive emergency plan to follow during flood emergencies. The emergency plan involves the Parks, Civil Defense, and Public Works Department.

Reportedly during periods of intense storms the low level outlet is opened in accordance with the emergency plan. (See Emergency Action Plan in Appendix 5.)

### 4.5 Evaluation of Operational Adequacy

The operation of the dam has been adequate to the extent that the dam reportedly has not overtopped since the adoption of the flood emergency plan.

Maintenance documentation is adequate with all visits to the raceway being logged on a maintenance sheet on file with the City of Bridgeton, Department of Public Works. However, it was observed that maintenance has been poor in the following areas:

- 1) Adverse vegetation on dam embankment has not been removed.
- 2) Eroded areas not properly stabilized.
- 3) Deteriorated spillway discharge pipes not repaired or replaced.

## SECTION 5: HYDRAULIC/HYDROLOGIC

### 5.1 Evaluation of Features

#### a. Design Data

The quantity 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 quantity, 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 Sunset Lake Raceway 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 Sunset Lake Raceway Dam is 1571 c.f.s. This value is derived from the 1/2 PMF flood hydrograph computed by combining the raceway runoff hydrograph with inflow from Sunset Lake. The runoff hydrograph was computed by the use of the HEC-1-DAM flood hydrograph computer program using the Soil Conservation Service triangular unit hydrograph with curvilinear transformation. Inflow to the raceway from Sunset Lake was computed by comparing the capacity rating of Bridge B-14 to the various lake stages occurring during the 1/2 PMF. The 1/2 PMF was routed through Sunset Lake using data contained in "Sunset Lake Dam, NJ00063, Phase I Inspection Report, National Dam Safety Program." Hydrologic computations and computer output are contained in Appendix 4.

The spillway discharge rates were computed by the use of weir formula and culvert discharge charts assuming inlet control. The total spillway discharge with raceway level equal to the

top of the dam was computed to be 290 c.f.s. The elevation of the top of dam was taken to be 18.0, N.G.V.D. The SDF was routed through the dam by use of the HEC-1-DAM computer program using the modified Puls Method. In routing the SDF, it was found that the dam crest would be overtopped by a depth of 0.5 foot. A breach analysis was then performed assuming failure of the dam, and using a trapezoidal breach section with bottom length of 100 feet and sideslopes of 1 horizontal to 1 vertical. The breach peak outflow was computed to be 2053 c.f.s. Breach computations are contained in Appendix 4. The analysis indicated that failure of Sunset Lake Raceway Dam would not significantly increase the hazard to loss of life downstream over that which would exist without 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 was overtopped once since the construction of the new spillway structure in 1953. The overtopping occurred in 1975 and resulted in a breach of the embankment near the upstream end of the raceway. The overtopping reportedly was the result of heavy rains combined with the breach of Mary Elmer Dam upstream. Reportedly, property damage was sustained by the Bridgeton Water Works and by City Park.

c. Visual Observation

No significant evidence of overtopping of the embankment was observed at the times of inspection. A renovated portion of the embankment at the upstream end of the raceway with significantly different cross section in relation to the remainder of the embankment was noted. The renovated portion appeared to correspond to the area reported to have breached in 1975.

d. Overtopping Potential

As indicated in paragraph 5.1.a. a storm of magnitude equal to the SDF would cause overtopping of the dam by a depth of 0.5 foot over the top of the dam. The spillway is capable of passing approximately 9 percent of the PMF or 18 percent of the SDF with lake level equal to the top of the dam (Elev. 18.0).

e. Drawdown Data

Assuming drawdown is accomplished by opening two 60-inch by 48-inch sluice gates at Sunset Lake (Park Avenue), the time required for drawdown is estimated to be approximately 1/2 day. The estimate is based on the drawdown estimate contained in the Phase I Report for Sunset Lake Dam.

## SECTION 6: STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability

#### a. Visual Observations

The dam appeared at the time of inspection to be outwardly structurally sound with no evidence of embankment cracks or distress. Evidence of possible seepage was observed at three locations along the dam and erosion was observed at various locations on the downstream side of embankment. The possible seepage and erosion are not considered to be indications of immediate dam instability.

#### b. Generalized Soils Description

The generalized soils description of the dam site consists of recent alluvium deposited adjacent to present stream courses overlying an irregular mantle of stratified material referred to on the Geologic Map of New Jersey as the Cape May formation.

#### c. Design and Construction Data

The analysis of structural stability and construction data for the original embankment constructed in 1814 are not available.

#### d. Operating Records

Operating records are available for the dam. Reportedly the water level of Sunset Lake Raceway is monitored visually by the City of Bridgeton and the gate in the spillway structure is opened in accordance with rainfall intensity.

e. Post-Construction Changes

Reportedly, no post-construction changes have been made since the present dam spillway was constructed in 1953 with the exception of the repair of the dam embankment completed in 1975.

f. Seismic Stability

Sunset Lake Raceway 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. Sunset Lake Raceway Dam appeared to be outwardly stable under static loading conditions at the times of inspection.

## 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 Sunset Lake Raceway Dam is assessed as being inadequate. The spillway is not able to pass the SDF without an overtopping of the dam.

The embankment of the dam exhibits areas of possible seepage as well as erosion, mostly due to pedestrian traffic, which was not considered to be evidence of immediate dam instability. The embankment appeared at the times of inspection to be generally outwardly stable.

#### b. Adequacy of Information

Information sources for this report include 1) field inspections, 2) USGS quadrangle, 3) consultation with City of Bridgeton personnel, 4) plans photographs, and inspection reports on file with the City of Bridgeton, Department of Public Works, 5) Data from the NJDEP file (Plans for present spillway, correspondence and permits), and 6) the Phase I Inspection Report for Sunset Lake Dam NJ00063, dated April 1979. 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. Structural design report.
2. Description of fill material for original embankment.
3. Soils report for the site.

c. Necessity for Additional Data/Evaluation

Although some data pertaining to Sunset Lake Raceway Dam are not available, additional data are not considered imperative for this Phase I evaluation.

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 professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses related to spillway capacity. Based on the findings of these analyses, the need for and type of remedial measures should be determined and then implemented. Consideration should be given to a regrading of the embankment to bring the entire crest elevation to the level of the reconstructed portion of the upstream end.

The observed seepage should be monitored on a periodic basis by a professional engineer experienced in the design and construction of dams in order to detect any changes in condition.

The owner should continue to employ the surveillance and emergency action plan currently in use.

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

- 1) Trees and adverse vegetation on the embankment should be removed.

- 2) Spalled and deteriorated surfaces of the spillway structure should be repaired.
- 3) The twin discharge culverts for the spillway should be renovated or replaced.
- 4) The railing along the spillway structure should be extended along the raceway to the road bridge.

b. Maintenance

In the future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

PLATES

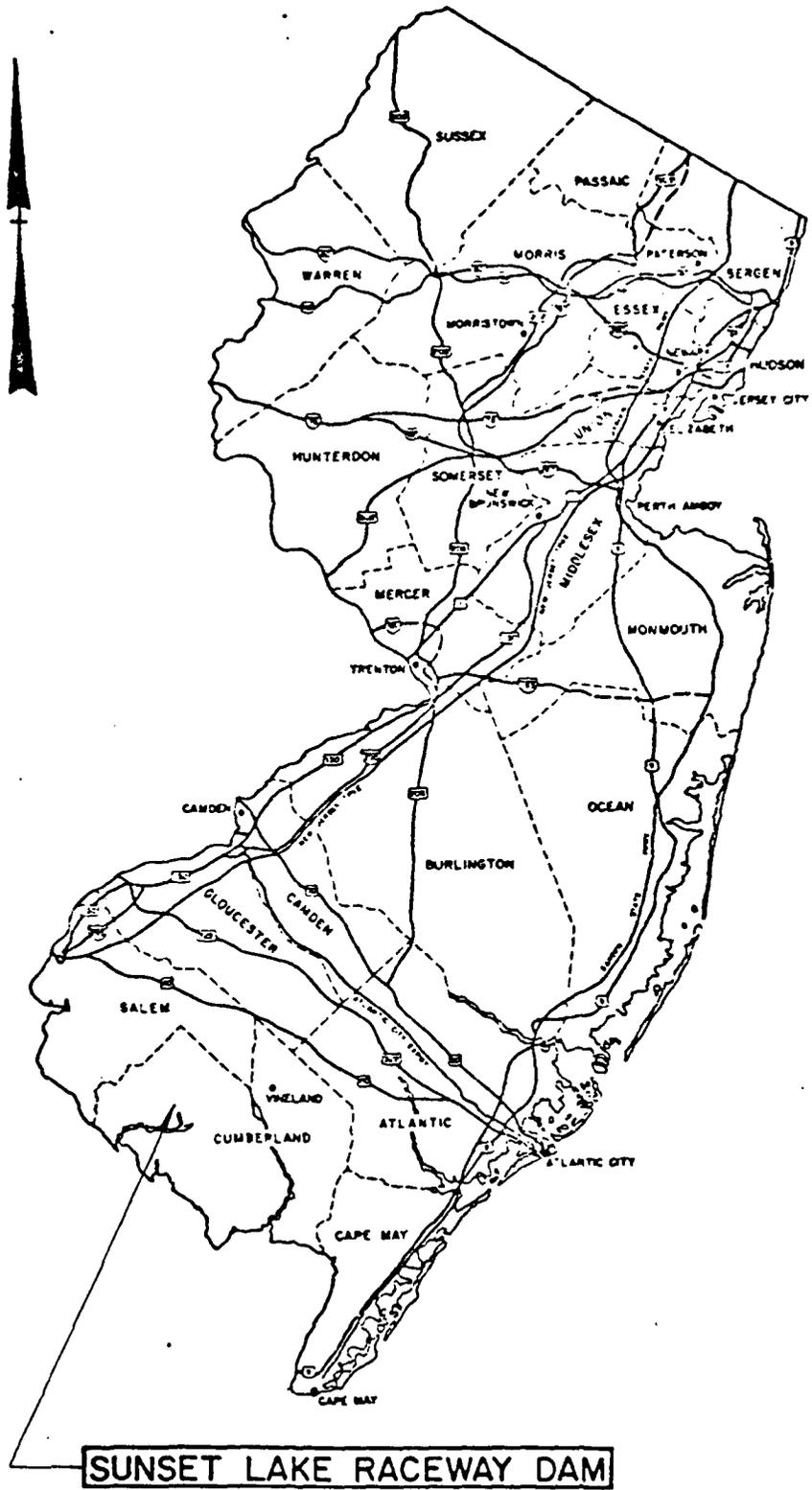


PLATE 1

STORCH ENGINEERS  
 FLORHAM PARK, NEW JERSEY

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

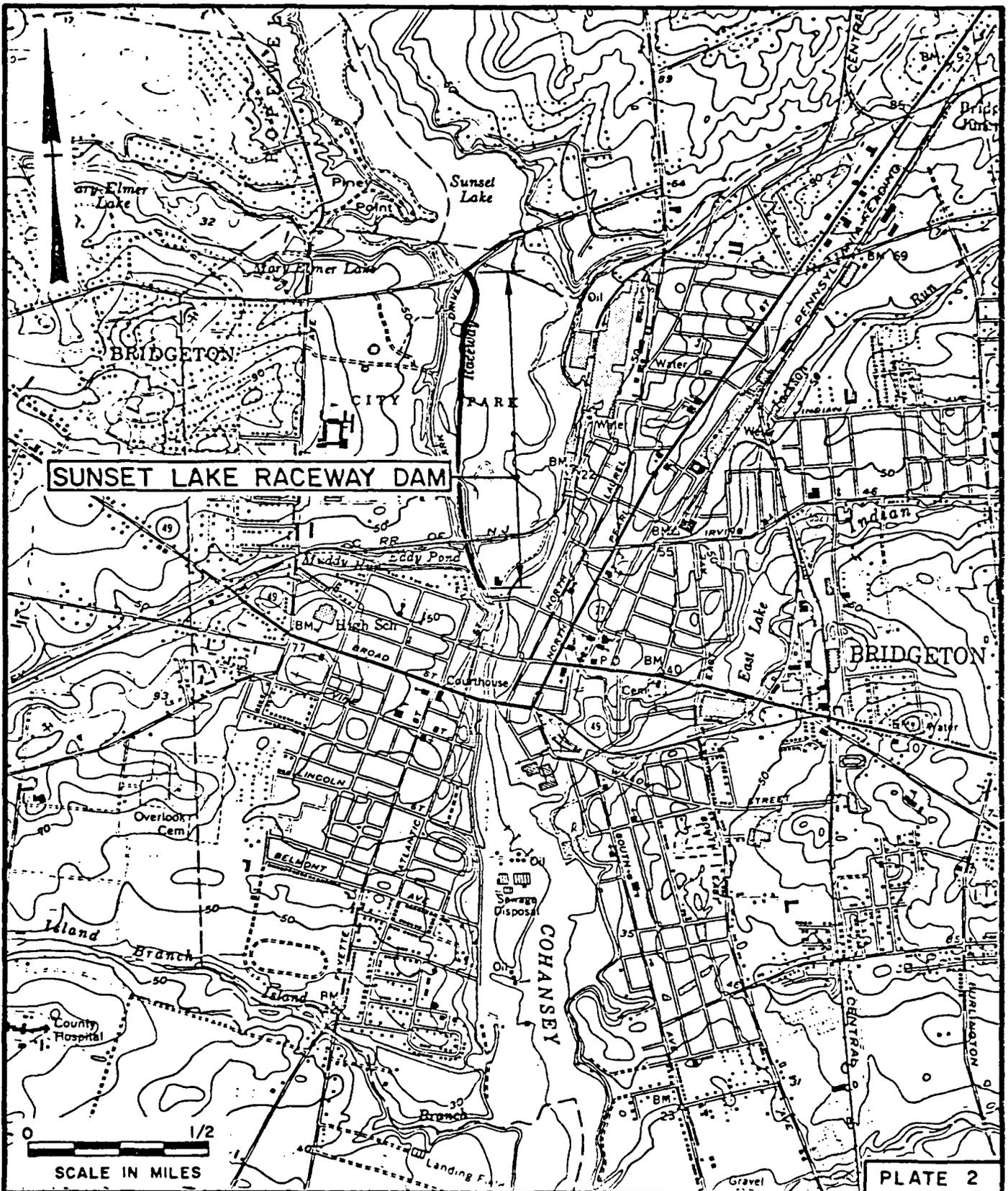
INSPECTION AND EVALUATION OF DAMS

**KEY MAP**

SUNSET LAKE RACEWAY DAM

SCALE: NONE

DATE: FEB. 1981



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  
 SUNSET LAKE RACEWAY DAM

SCALE: AS SHOWN  
 DATE: FEB. 1981



Legend

- AR Recent alluvium deposited adjacent to present stream courses.
- AR/MTM Complex intermingling of alluvium with fill, tidal marsh and swamp.
- AM-23 Irregular mantle of stratified material referred to on the Geologic Map of New Jersey as the Cape May formation.

Note: Information taken from Rutgers University, Soil Survey of New Jersey, Report No. 21, Cumberland County, June 1955 and Geologic Map of New Jersey prepared by J.V. Lewis and H. Kummel 1910-1912, revised by H.B. Kummel 1931 and M. Johnson 1950.

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**

SUNSET LAKE RACEWAY DAM

---

SCALE: NONE

DATE: FEB. 1981

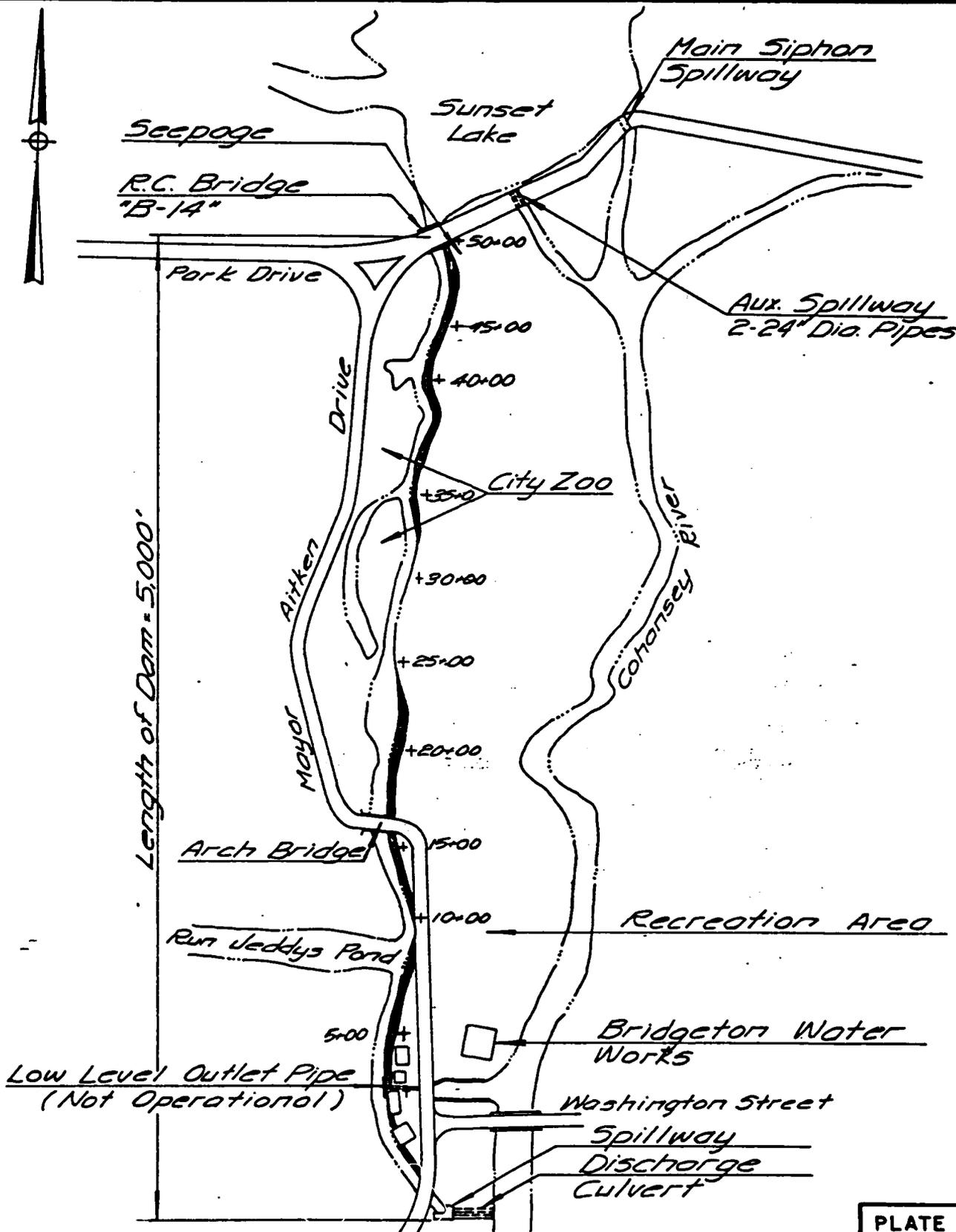
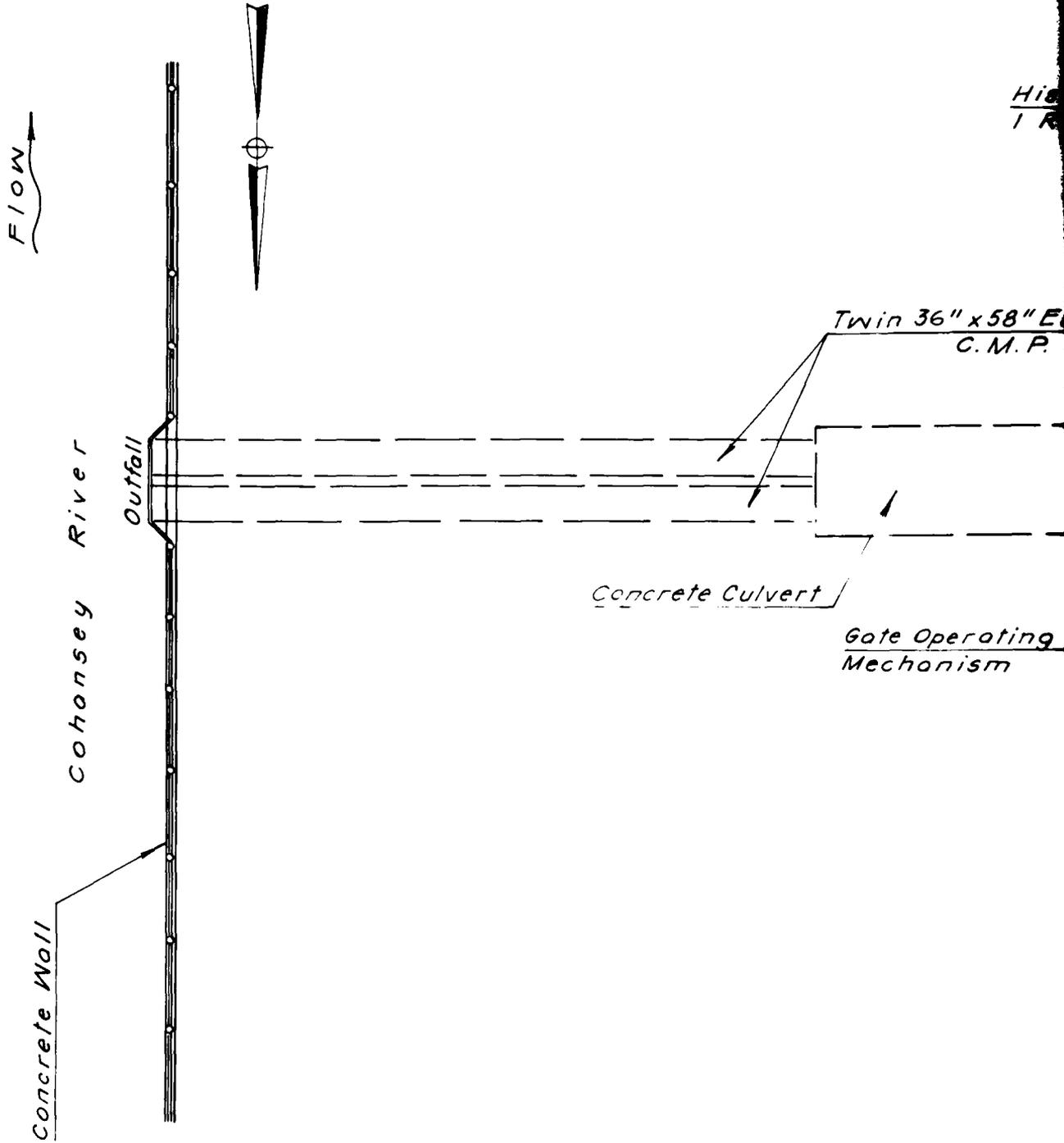


PLATE 4

<p>STORCH ENGINEERS FLORHAM PARK, NEW JERSEY</p>	<p>INSPECTION AND EVALUATION OF DAMS OVERVIEW</p>	
<p>DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY</p>	<p>SUNSET LAKE RACEWAY DAM</p>	
	<p>I.D. N.J. 00764</p>	<p>SCALE: NONE</p>
		<p>DATE: APRIL, 1981</p>

High  
1 R



*Note*

*Information taken from "Plan of Raceway  
Spillway for Bridgeton City Park" prepared  
by W.A. Kirby, City Engr, 1947 and field  
inspections January 8 and 27, 1981*



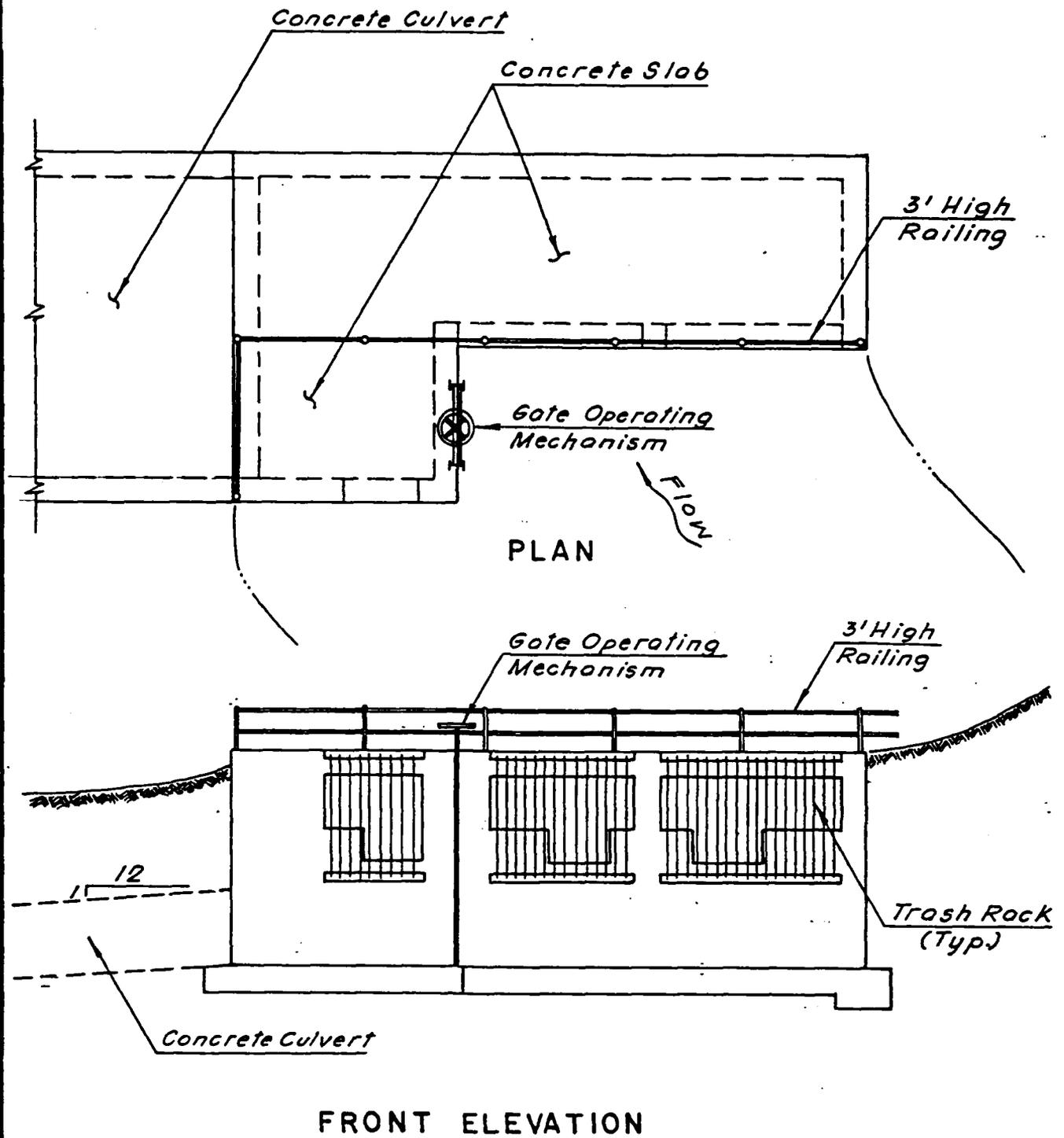


PLATE 6

<p>STORCH ENGINEERS FLORHAM PARK, NEW JERSEY</p>	<p>INSPECTION AND EVALUATION OF DAMS SPILLWAY PLAN &amp; ELEVATION SUNSET LAKE RACEWAY DAM</p>	
<p>DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY</p>		<p>SCALE: NONE DATE: FEB. 1981</p>

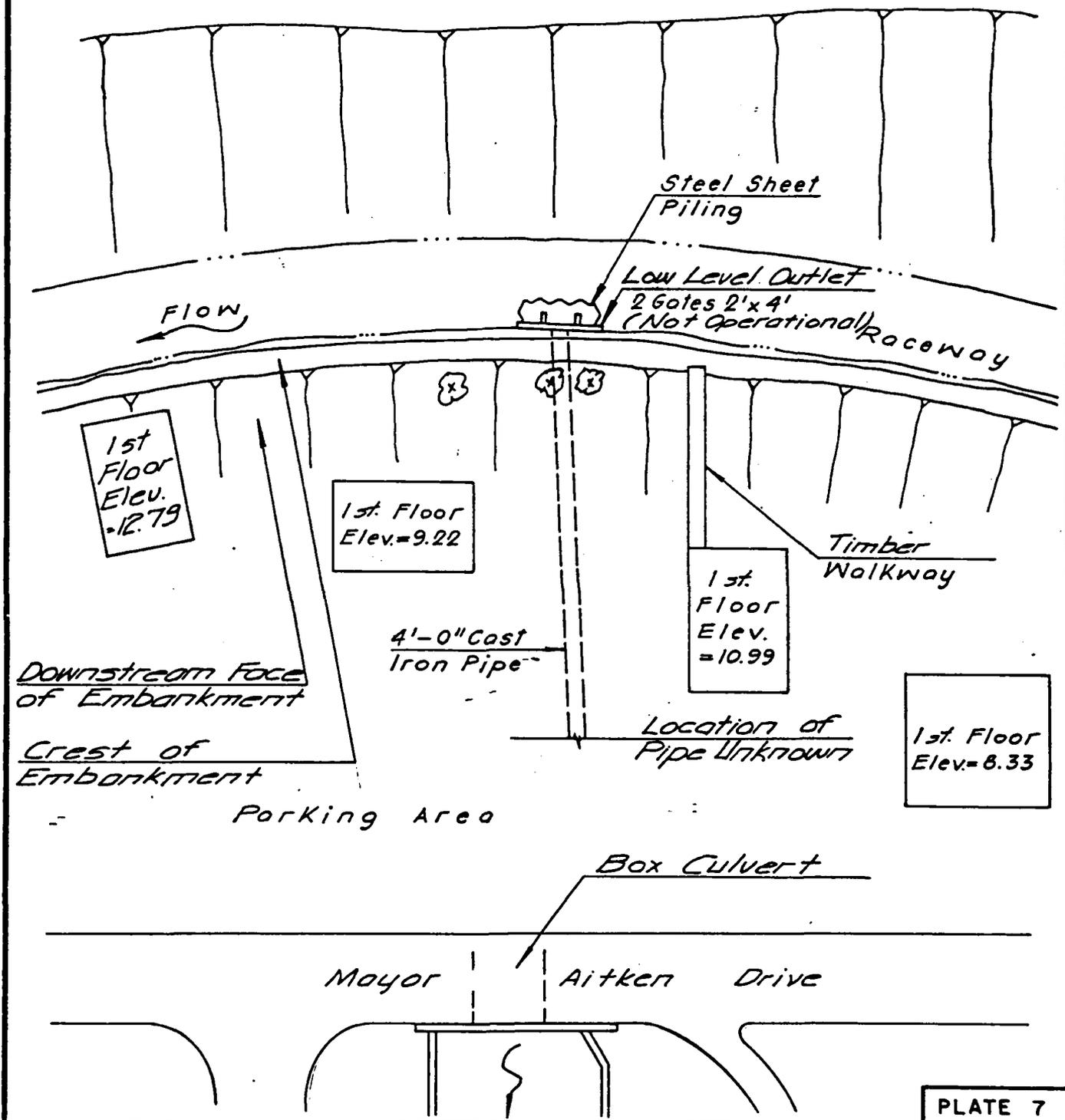
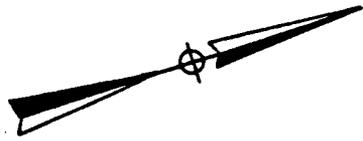


PLATE 7

<p>STORCH ENGINEERS FLORHAM PARK, NEW JERSEY</p>	<p>INSPECTION AND EVALUATION OF DAMS PLAN - LOW LEVEL OUTLET SUNSET LAKE RACEWAY DAM</p>	
<p>DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY</p>	<p>I.D. N.J. 00764</p>	<p>SCALE: NONE DATE: FEB, 1981.</p>

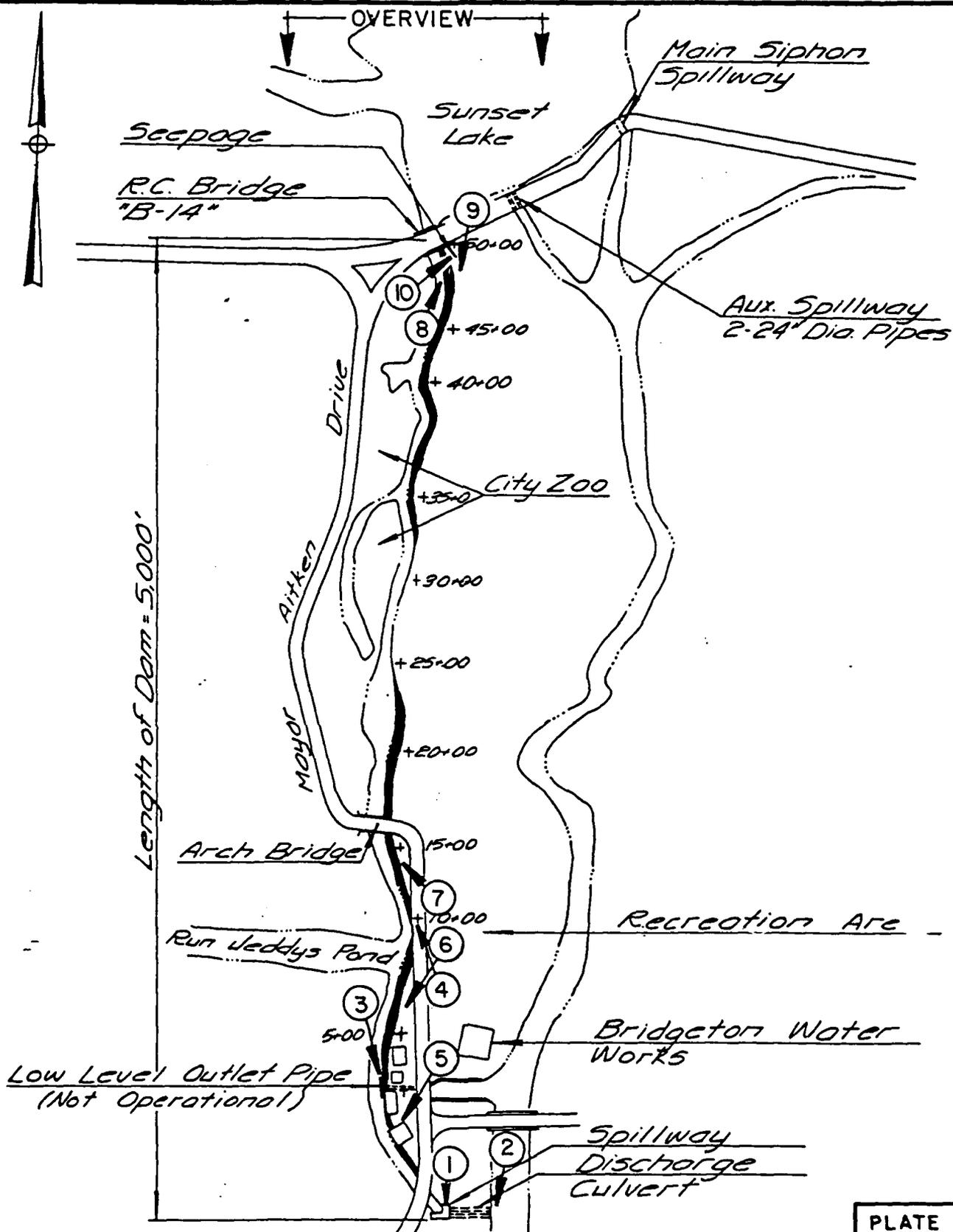


PLATE 8

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  
 SUNSET LAKE RACEWAY DAM

---

I.D. N.J. 00764	SCALE: NONE
	DATE: APRIL, 1981

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List

Visual Inspection

Phase I

Name of Dam Sunset Lake Raceway Dam County Cumberland State N.J. Coordinators NJDEP

Date(s) Inspection 1/8/81, 1/27/81 Weather Sunny, Cloudy Temperature 15° F., 35° F.

Pool Elevation at time of Inspection 16.0 M.S.L. Tailwater at Time of Inspection 3.5 M.S.L.

Inspection Personnel:

<u>John Gribbin</u>	<u>Mark Brady</u>	<u>Richard McDermott</u>
<u>Charles Osterkorn</u>	<u>John Powanda</u>	
<u>Daniel Buckelew</u>		

John Gribbin Recorder

Present: Mr. Russ Davis, Assistant to Bridgeton City Engineer.

Note: Stations begin at spillway (0 + 0) and end at Sunset Lake (50 + 0).

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Condition of embankment varied. Some area grass covered, some areas bare, some areas overgrown with briars, bushes and trees (2" to 24").	Trees should be removed. Surfaces should be stabilized.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appeared sound.	
ANY NOTICEABLE SEEPAGE	<ol style="list-style-type: none"> <li>1. Pool of standing water noted at toe about 75' from up-stream end. Pool contained orange colored deposits.</li> <li>2. Wet area (flowing with a trickle) in channel leading away from box culvert under road about 150' from toe at approx. location of outlet works. Orange deposits in water.</li> <li>3. Wet areas at toe in the vicinity of Sta 30 + 45.</li> </ol>	Seepage should be monitored. Origin of water in #2 could not be assessed.
TAFF GAGE AND RECORDER	None observed.	
RAINS	None observed.	

EMBANKMENT

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	About 3 areas of erosion and minor sloughing noted on downstream side between Sta 5 + 00 and Sta 7 + 00, apparently due to pedestrain activity. A few other areas of erosion were noted along the embankment.	Eroded areas on the embankment should be stabilized.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical: varies by approx. 2' Horizontal: follows course of raceway Downstream face generally uniformly aligned with a few areas where the surface was bulged, apparently due to the addition of extra fill.	
RIPRAP	One area of gabion slope protection noted on upstream face at approx. Sta 20 + 00. No other riprap observed.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	Not observed.	
INTAKE STRUCTURE	Concrete headwall with steel sheet piling noted on up-stream side of embankment at approx. location of outlet works. Majority of structure submerged.	
OUTLET STRUCTURE	Not observed.	
OUTLET CHANNEL	Point of discharge for outlet works not observed. However, outlet channel appeared to be channel leading away from box culvert under Mayor Aitken Dr. Channel, lined with stone walls, runs from road to Cohansey River.	
GATE AND GATE HOUSING	None observed.	

SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
DROP INLET	Most surfaces of enclosed concrete chamber appeared to be in satisfactory condition. A portion of the structure adjacent to the left opening was spalled with a maximum depth of about 3".	Spalled concrete surfaces should be repaired.
RAILING	Steel pipe railing was in satisfactory condition.	Railing should be extended along a portion of raceway to provide proper safety protection.
GATE	Gate was submerged. Operating mechanism appeared to be in satisfactory condition. Stem was rusted at the water line but appeared functional.	
DISCHARGE CULVERTS	Discharge ends of twin elliptical corrugated metal discharge culverts were in generally satisfactory condition although they were deteriorated along their inverts.	Culverts should be repaired or replaced.
TRASH RACKS	Trash racks were rusted but in generally sound condition. Two trash racks were not in proper position at the times of inspection.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed.	
OBSERVATION WELLS	None observed.	
WEIRS	None observed.	
PIEZOMETERS	None observed.	
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Bank slopes along raceway opposite dam vary from steep and wooded with rock outcrops along the downstream portion to flat and moderate and grassy along the upstream portion.	
SEDIMENTATION	Unknown	
STRUCTURES ALONG BANKS	Concrete abutments and pier for abandoned bridge located at Sta 10 + 00. Road bridge over raceway located at Sta 19 + 00. Structures associated with City Zoo located in vicinity of Sta 35 + 00. Pedestrian bridges across raceway at various locations. Road bridge over raceway at connection with Sunset Lake (Sta 50 + 00).	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
<p>CONDITION (OBSTRUCTION, DEBRIS, ETC.)</p>	<p>Spillway discharge culverts discharge directly into Cohansey River. No significant obstruction observed.</p>	
<p>SLOPES</p>	<p>Flood plain of Cohansey River as well as downstream area between Raceway and River generally flat.</p>	
<p>STRUCTURES ALONG BANKS</p>	<p>Paved roadway (Mayor Aitken Dr.) located along toe of dam from Sta 1 + 00 to Sta 19 + 00. Recreation area including tennis courts and baseball fields located downstream in vicinity of Sta 10 + 00. Four park buildings located at toe of dam in vicinity of Sta 4 + 00.</p>	

CHECK LIST  
ENGINEERING DATA  
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
DAM - PLAN	Available: Plans entitled "Plan of Raceway Spillway for Bridgeton City Park, prepared by W. A. Kirby, City Engineer and A. L. Stuber, Consulting Engineer, dated August 1947 in NJDEP file.
SPILLWAY - PLAN	Available: Kirby & Stuber Plans also 1976 reconstructed section shown on plans entitled "Bid Pac-1 Storm Damage Restoration Work" prepared by Edward H. Richardson Associates, dated 6/10/76. In City of Bridgeton D.P.W. files. Available: Kirby and Stuber Plans
SECTIONS	
OPERATING EQUIPMENT PLANS & DETAILS	Available: Kirby & Stuber Plans
OUTLETS - PLAN	Available: Kirby & Stuber Plans
DETAILS	Available: Kirby & Stuber Plans
CONSTRAINTS	Not Available
DISCHARGE RATINGS	Available in NJDEP files
HYDRAULIC/HYDROLOGIC DATA	Available in NJDEP files
RAINFALL/RESERVOIR RECORDS	Not Available
CONSTRUCTION HISTORY	Available: Phase I Inspection Report for Sunset Lake Dam, NJ00063, issued by U.S. Army Corps of Engineers, dated April 1979.
LOCATION MAP	Available: Phase I Inspection Report for Sunset Lake Dam, NJ00063.

ITEM

REMARKS

DESIGN REPORTS

Not Available

GEOLOGY REPORTS

Not Available

DESIGN COMPUTATIONS  
HYDROLOGY & HYDRAULICS  
DAM INSTABILITY  
SEEPAGE STUDIES

Available: Handwritten calculations in NJDEP files. Also Phase I Inspection Report for Sunset Lake Dam, NJ00063, in NJDEP files.

Not Available  
Not Available

MATERIALS INVESTIGATIONS  
BORING RECORDS  
LABORATORY  
FIELD

Not Available

POST-CONSTRUCTION SURVEYS OF DAM

Available: Damage Survey Report (DSR-3-4-21) from the U.S. Dept. H.U.D. in City of Bridgeton D.P.W. files.

BORROW SOURCES

Available: Specification for borrow used in 1976 Embankment Reconstruction in City of Bridgeton D.P.W. files.

ITEM

REMARKS

MONITORING SYSTEMS

Available: Visual monitoring as indicated per City of Bridgeton "Temporary Operating Procedure for Flood Gates at Sunset Lake and South End of Raceway" dated January 12, 1977 in City of Bridgeton D.P.W. files. (See Appendix 5)

MODIFICATIONS

Available: Kirby and Stuber Plans, Edward H. Richardson Plans

HIGH POOL RECORDS

Not Available

POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS

Available: Phase I Inspection Report for Sunset Lake Dam NJ00063 in NJDEP files.

PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS

Available: NJDEP and City of Bridgeton D.P.W. files.

MAINTENANCE OPERATION RECORDS

Available: City of Bridgeton D.P.W. files.

APPENDIX 2

Photographs



PHOTO 1  
SPILLWAY AT DOWNSTREAM END OF RACEWAY (STA 0+0)



PHOTO 2  
OUTFALL FROM SPILLWAY INTO COHANSEY RIVER

SUNSET LAKE RACEWAY DAM  
8 JANUARY 1981



PHOTO 3  
HEADWALL AT LOCATION OF LOW LEVEL OUTLET

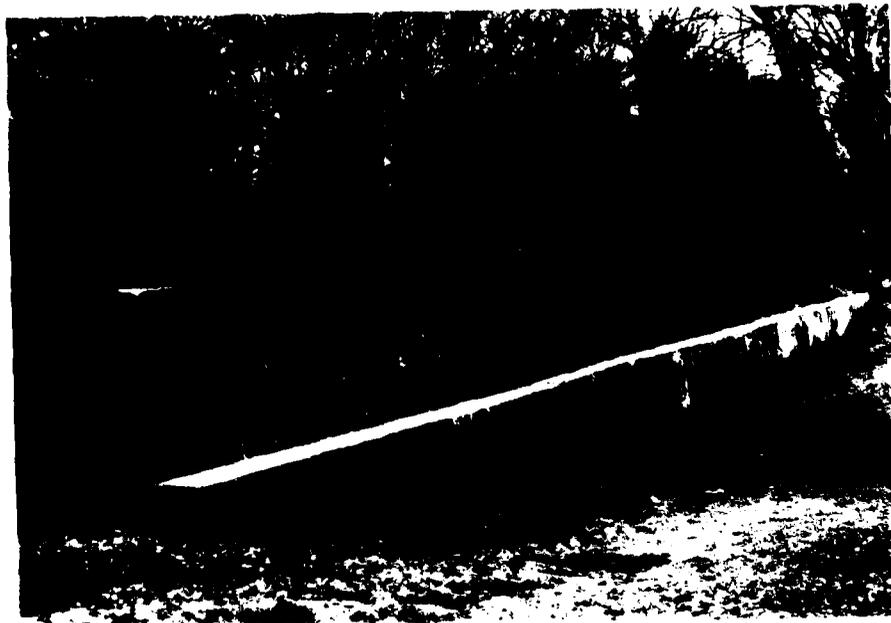


PHOTO 4  
CONCRETE WALL AT LOCATION OF ABANDONED BRIDGE PIER  
(APPROX. STA 10+0)

SUNSET LAKE RACEWAY DAM  
27 JANUARY 1981

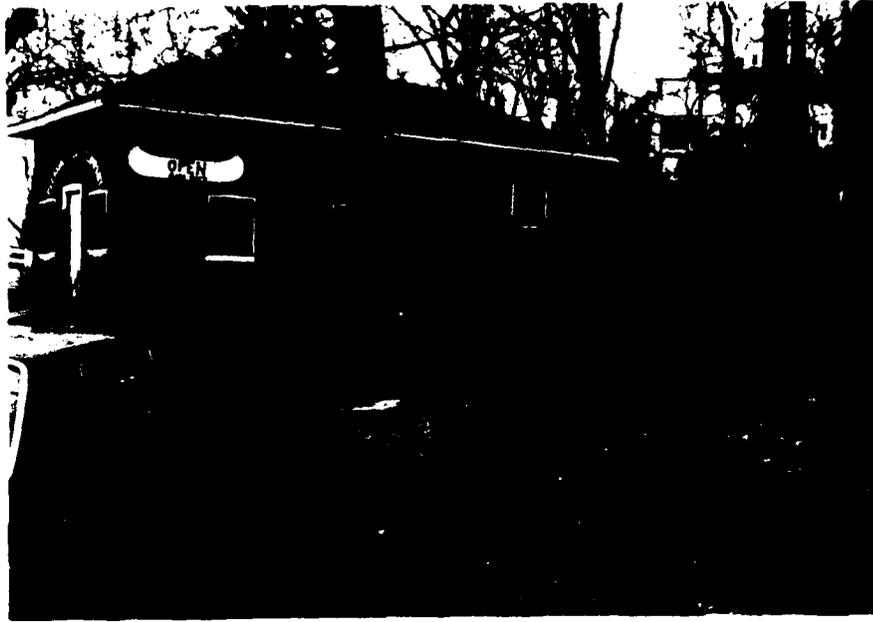


PHOTO 5  
DOWNSTREAM FACE OF EMBANKMENT AT PARK BUILDING  
(APPROX. STA 1+0)



PHOTO 6  
DOWNSTREAM FACE OF EMBANKMENT (APPROX. STA 8+0)

SUNSET LAKE RACEWAY DAM  
27 JANUARY 1981



PHOTO 7  
DOWNSTREAM FACE OF EMBANKMENT (APPROX. STA 11+0)



PHOTO 8  
UPSTREAM FACE OF EMBANKMENT IN VICINITY OF ENTRANCE  
FROM SUNSET LAKE

SUNSET LAKE RACEWAY DAM  
27 JANUARY 1981



PHOTO 9  
DOWNSTREAM FACE OF EMBANKMENT IN VICINITY OF ENTRANCE  
FROM SUNSET LAKE



PHOTO 10  
STANDING WATER AT TOE OF EMBANKMENT (APPROX. STA 48+65)

SUNSET LAKE RACEWAY DAM  
27 JANUARY 1981

APPENDIX 3

Engineering Data

CHECK LIST  
HYDROLOGIC AND HYDRAULIC DATA  
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Wooded and residential with Sunset Lake upstream.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 16.0 (417 acre-feet)

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

ELEVATION MAXIMUM DESIGN POOL: 18.5

ELEVATION TOP DAM: 18.0

SPILLWAY CREST: \_\_\_\_\_

- a. Elevation 14.5 (Primary), 16.0 (Secondary)
- b. Type Concrete drop inlet with primary and secondary stages
- c. Width 1.0 foot
- d. Length 9 feet (Primary), 10 feet (Secondary)
- e. Location Spillover Downstream end of raceway
- f. Number and Type of Gates One 4' x 4' slide gate

OUTLET WORKS: \_\_\_\_\_

- a. Type Gated 4' corrugated metal pipe
- b. Location Approx. 200' upstream from spillway
- c. Entrance Invert Unknown
- d. Exit Invert Unknown
- e. Emergency Draindown Facilities: Open slide gate in spillway  
(Outlet works abandoned)

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) 290 c.f.s.

APPENDIX 4

Hydraulic/Hydrologic Computations

HYDROLOGY

THE INFLOW HYDROGRAPH FOR SUNSET LAKE RACEWAY DAM WILL BE DEVELOPED AS A COMBINED HYDROGRAPH BY THE ADDITION OF THE OUTFLOW HYDROGRAPH FOR SUNSET LAKE AND RUNOFF HYDROGRAPH FOR THE RACEWAY. THE OUTFLOW HYDROGRAPH FOR SUNSET LAKE WILL BE BASED ON THE FLOW VOLUME THRU BRIDGE "B14" AT THE UPSTREAM END OF THE RACEWAY.

CAPACITY OF BRIDGE B14 WILL BE TAKEN FROM "Sunset Lake Dam, N.J. 00063, Phase I Inspection Report" dated April 1979.

Project 1132-06 SUNSET LAKE RACEWAY DAM Made By J.H.G. Date 3-30-81  
(SUNSET LAKE) Chkd By JG Date 4/3/81HYDROLOGIC ANALYSIS SUNSET LAKE :

THE INFLOW HYDROGRAPH FOR  
SUNSET LAKE DAM WILL BE  
DEVELOPED BY HEC-1-DAM COMPUTER  
PROGRAM USING THE SNYDERS SYNTHETIC  
UNIT HYDROGRAPH. APPLICABLE DATA  
WILL BE TAKEN FROM "SUNSET LAKE DAM, N.J. 00063,  
Phase I Inspection Report" dated April 1979.

DRAINAGE AREA = 45.7 SQ MI

INFILTRATION DATA

INITIAL INFILTRATION = 1.5 IN

CONSTANT INFILTRATION = 0.15 IN/HOUR

TIME OF CONCENTRATION

[by Snyder's Introduction to hydrology, p 125]

$$t_1 = C_t (L LCA)^{.3} \quad t_1 = \text{LAG Time} \quad [\text{Hr}]$$

$$t_1 = 4.51 (8.7 \times 3.6)^{.3} \quad C_t = \text{coefficient for slopes \& storage}$$

$$\underline{t_1 = 12.6 \text{ Hr.}}$$

$$C_t = 4.51$$

(supplied by Corps of Engineers)

$L$  = length of longest water course  
[MI]

$LCA$  = length to centroid along  
the main channel [MI]

COMPUTER INPUT

$$\text{LAG Time} = 12.6 \text{ Hr}$$

$$C_p = 0.7 \quad (\text{supplied by Corps of Engineers})$$

Project 1132 -06

SUNSET LAKE RACEWAY DAM

Made By Ji Ha Date 3-20-81

(SUNSET LAKE)

Chkd By JG Date 4/3/81

PRECIPITATION :

Probable maximum precipitation for 200 SQMI

for 24 hours duration = 24 inches

Percentage of PMP for 45.7 Sqmi

DURATION [hr]

% PMP

6

98

12

107

24

117

SCALE 4:1 TO THE INCH

Project 1132 - 06 SUNSET LAKE RACEWAY DAM  
(SUNSET LAKE)

Made By JHG Date 9-30-81

Chkd By JG Date 4/3/81

LAKE STORAGE VOLUME.

H. S. ELEV. [FEET]

AREA [Acres]

3.20

0

16.0

93.4

20.0

168.7

30.0

389.8

HEC-1-DAM PROGRAM WILL DEVELOP

STORAGE CAPACITY FROM SURFACE

AREAS & ELEVATIONS.

INFORMATION TAKEN FROM PHASE I REPORT

FOR SUNSET LAKE DAM

SCALE  
4 IN = 1 FT

TO THE INCH  
4 X 4  
SQUARE

HYDROLOGIC ANALYSIS FOR RACEWAY :

THE RUNOFF HYDROGRAPH FOR THE

RACEWAY WILL BE DEVELOPED BY

HEC-1-DAM PROGRAM USING THE

SCS - METHOD WITH CURVILINEAR

TRANSFORMATION.

DRAINAGE AREA - 2.0 SQMI

INFILTRATION DATA

INITIAL INFILTRATION - 1.5 IN

CONSTANT INFILTRATION - 0.15 IN/HOUR

TIME OF CONCENTRATION

1. [by SCS - TR 55]

OVERLAND FLOW:

LENGTH = 4000 [FE]

AVE. SLOPE = 0.8 [%]

$\Delta H = 112' - 80' = 32'$

AVE. VELOCITY = 0.25 [Fps]

CHANNEL FLOW:

LENGTH = 10000 [FE]

AVE. SLOPE = 0.64 [%]

$\Delta H = 80' - 16' = 64'$

AVE. VELOCITY = 2.83 [Fps]

$$T_c = \left( \frac{4000}{.25} \right) + \left( \frac{10000}{2.83} \right) \frac{1}{3600} = 4.4 + 1.0 = \underline{5.4 \text{ Hr}}$$

2. [Handbook of hydrology by Chow, Pg 14-26]

$$T_c = \frac{2.14}{\sqrt{s}} \sqrt{\frac{2}{3} L \eta}$$

$T_c$  = time of concentration [min]

$s$  = slope [%]

$\eta$  = 0.4 roughness coefficient

$L$  = length of overland flow [FE]

$$T_c = \frac{2.14}{\sqrt{0.008}} \sqrt{\frac{2}{3} \times 4000 \times 0.4}$$

$$T_c = 80 \text{ min} = 1.3 + 1.0 = \underline{2.3 \text{ Hr}}$$

3. ['Design of small dams' pg 71]

$$T_c = \left( \frac{11.9(L)^3}{H} \right)^{.385}$$

 $T_c$  = time of concentration [Hr]

 $L$  = longest water course [Mi]

 $H$  = elev. difference [FL]

$$T_c = \left( \frac{11.9 \times 2.65^3}{96} \right)^{.385}$$

$L = 2.65 \text{ [Mi]}$

$H = 96 \text{ [FL]}$

$$\underline{T_c = 1.4 \text{ Hr}}$$

### COMPUTER INPUT

$T_c = 3.9 \text{ Hr}$

$LAG = 60\%$

$$\underline{LAG \text{ Time} = 2.4 \text{ Hr.}}$$

SQUARE 4 X 4 TO THE INCH

PRECIPITATION

PROBABLE MAXIMUM PRECIPITATION = 27 INCHES

FOR 6 HOURS DURATION AND 10 SQMI

DURATION [HR]

% PMP

6

100

12

109

24

117

Project 1132-06

SUNSET LAKE RACEWAY DAM

Made By \_\_\_\_\_

Date \_\_\_\_\_

Chkd By JG

Date 4/3/81

SQUARE 4 X 4 TO THE INCH

LAKE STORAGE VOLUME

W.S. ELEV. [FE]

AREA [Acres]

10.0

0

16.0

9.2

20.0

31.0

30.0

48.0

HEC-1-DAM COMPUTER PROGRAM WILL

DEVELOP STORAGE CAPACITY FROM

WATER SURFACE AREAS & ELEVATIONS.

INFORMATION TAKEN U.S.G.S. QUADRANGLE

Shiloh & Bridgeton, N.J.

HYDROLOGIC ANALYSISSEQUENCE OF COMPUTATION:

1. ROUTE  $\frac{1}{2}$  PMF THRU SUNSET LAKE USING HEC-1-DAM COMPUTER PROGRAM AND DATA FROM PHASE 1 REPORT.
2. FROM ABOVE ROUTING, DETERMINE HYDROGRAPH OUTFLOWING THRU BRIDGE "B14" INTO RACEWAY.
3. COMPUTE RUNOFF HYDROGRAPH TO RACEWAY USING HEC-1-DAM COMPUTER PROGRAM AND DATA FROM USGS QUADRANGLES.
4. COMBINE HYDROGRAPHS FROM NOS. 2 & 3 ABOVE TO DETERMINE COMPLETE INFLOW HYDROGRAPH TO RACEWAY.
5. ROUTE HYDROGRAPH FROM NO. 4 ABOVE THRU RACEWAY USING HEC-1-DAM COMPUTER PROGRAM.

INFLOW HYDROGRAPH TO RACEWAY

SQUARE 4 X 4 TO THE INCH

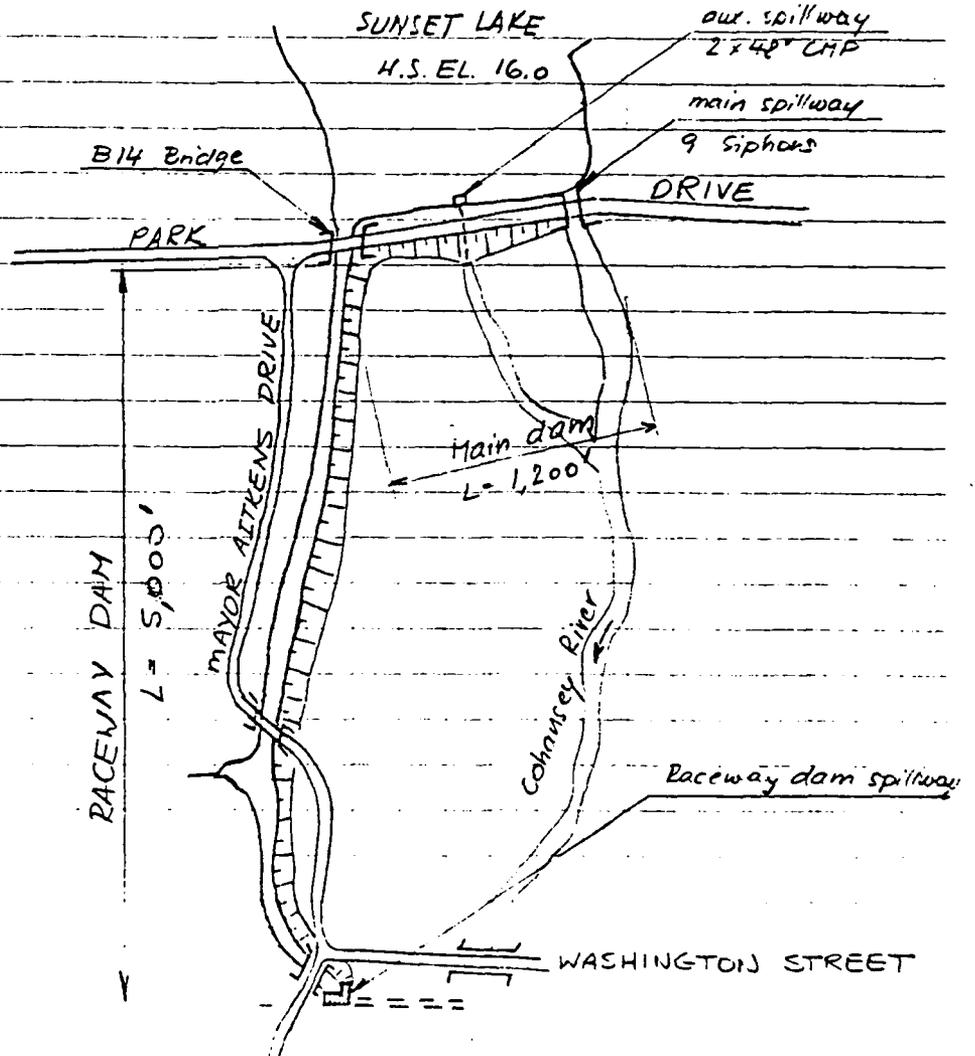
Time Period	Hours	Inflow Q [cfs]	Time Period	Hours	Inflow Q [cfs]	Time Period	Hours	Inflow Q [cfs]
1	1	55	31	7	2489	61	13	272
2	2	55	32	8	2446	62	14	259
3	3	55	33	9	2404	63	15	246
4	4	55	34	10	2362	64	16	233
5	5	55	35	11	2319	65	17	220
6	6	55	36	12	2249	66	18	207
7	7	55	37	13	2180	67	19	194
8	8	55	38	14	2111	68	20	181
9	9	57	39	15	2042	69	21	168
10	10	71	40	16	1974	70	22	155
11	11	100	41	17	1833			
12	12	129	42	18	1615			
13	13	210	43	19	1397			
14	14	481	44	20	978			
15	15	955	45	21	559			
16	16	1525	46	22	508			
17	17	2465	47	23	457			
18	18	3065	48	0	444			
19	19	2925	49	1	431			
20	20	3066	50	2	419			
21	21	3141	51	3	406			
22	22	2884	52	4	402			
23	23	2717	53	5	379			
24	0	2659	54	6	366			
25	1	2625	55	7	353			
26	2	2767	56	8	339			
27	3	2826	57	9	326			
28	4	2812	58	10	313			
29	5	2729	59	11	300			
30	6	2532	60	12	287			

HYDRAULICS

SPILLWAY DISCHARGE:

THE SPILLWAY AT SUNSET LAKE RACENAY DAM IS A CONCRETE BOX DROP INLET WITH A PRIMARY CREST AT ELEV. 14.5 FEET AND A SECONDARY CREST AT ELEV. 16.0 FEET

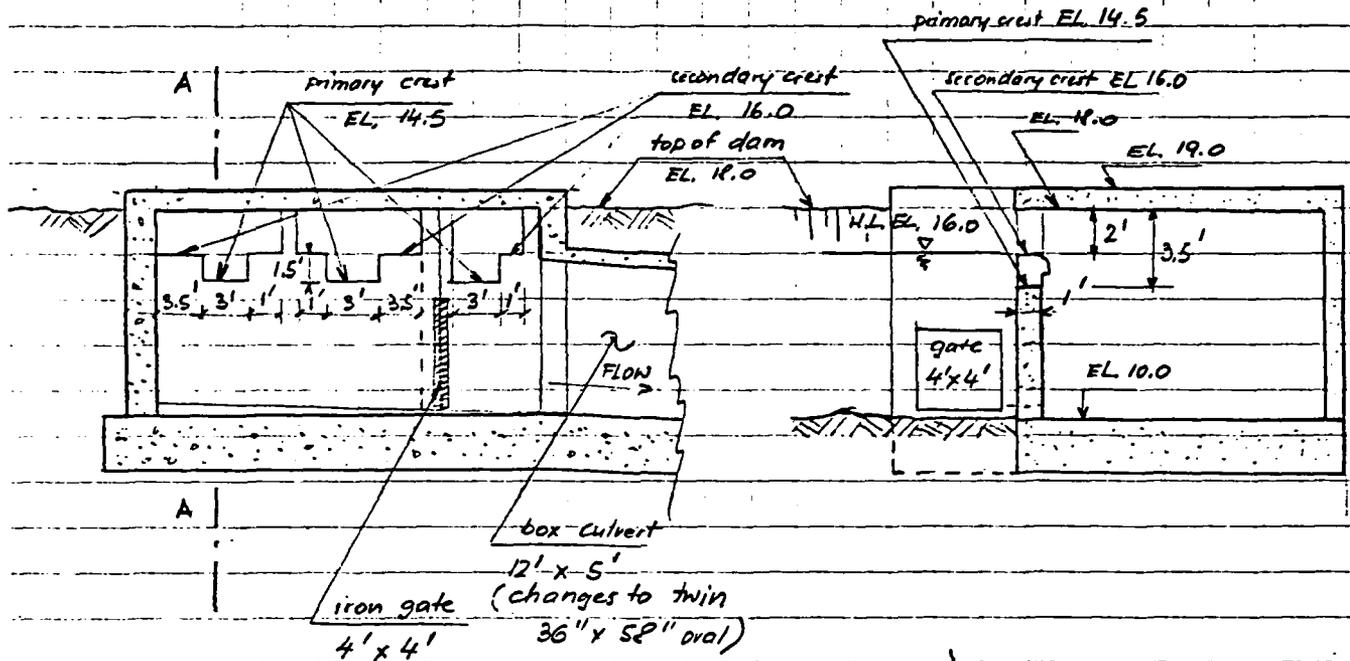
PLAN:



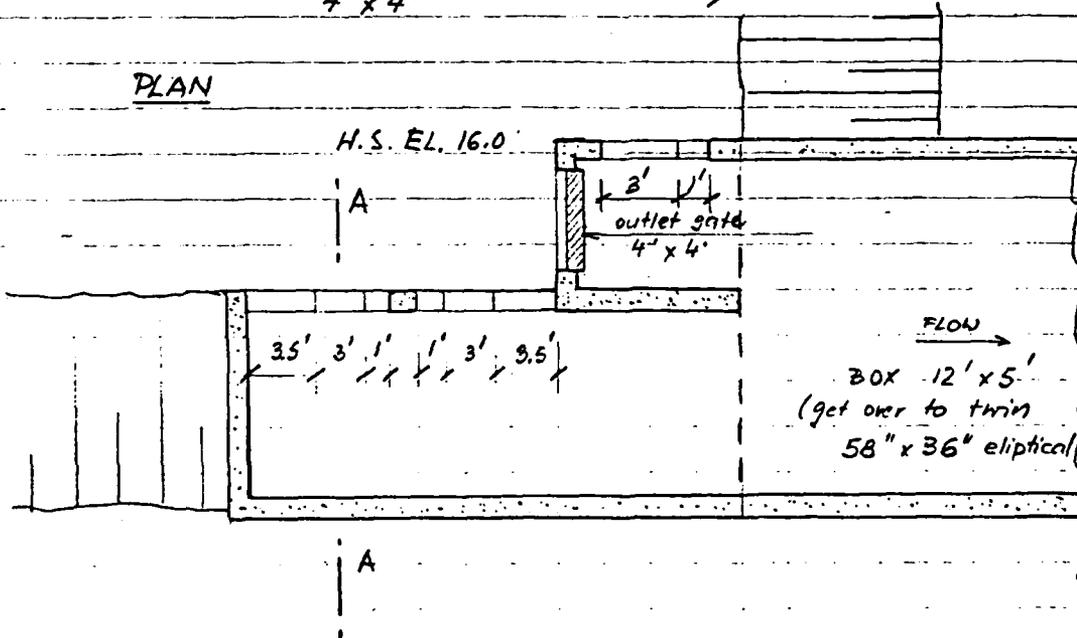
DISCHARGE CALCULATION

ELEVATION

SECTION A-A



PLAN



Project 1132-06 SUNSET LAKE RACEWAY DAM

Made By \_\_\_\_\_ Date \_\_\_\_\_

Chkd By JG Date 4/3/81THE DISCHARGE OF PRIMARY CREST

WILL BE CALCULATED FROM EL. 14.5 FEET

TO EL. 18.0 FEET FOR A SHARP CRESTED

WEIR, FROM EL. 18.0 FEET &amp; ABOVE

FOR A RECTANGULAR ORIFICE.

THE DISCHARGE OF SECONDARY CREST

WILL BE CALCULATED FROM EL. 16.0 FEET

TO EL. 18.0 FEET FOR A SHARP CRESTED

WEIR, FROM EL. 18.0 FEET &amp; ABOVE

FOR A RECTANGULAR ORIFICE.

[Handbook of hydraulics, Pg 5-9]

[Handbook of hydraulics, Pg 4-11]

## FORMULA FOR SHARP CRESTED WEIR

## FORMULA FOR ORIFICES

$$Q = CLH^{3/2}$$

$$Q = Ca\sqrt{2gh}$$

- $Q$  = discharge [cfs]  
 $C$  = 3.33 coefficient  
 $L$  = length of spillway [ft]  
 $H$  = head on spillway [ft]

- $Q$  = discharge [cfs]  
 $C$  = .6 coefficient  
 $a$  = area of discharge [ft<sup>2</sup>]  
 $g$  = 32.2  
 $h$  = head to centroid [ft]

SQUARE  
4 X 4  
TO THE INCH

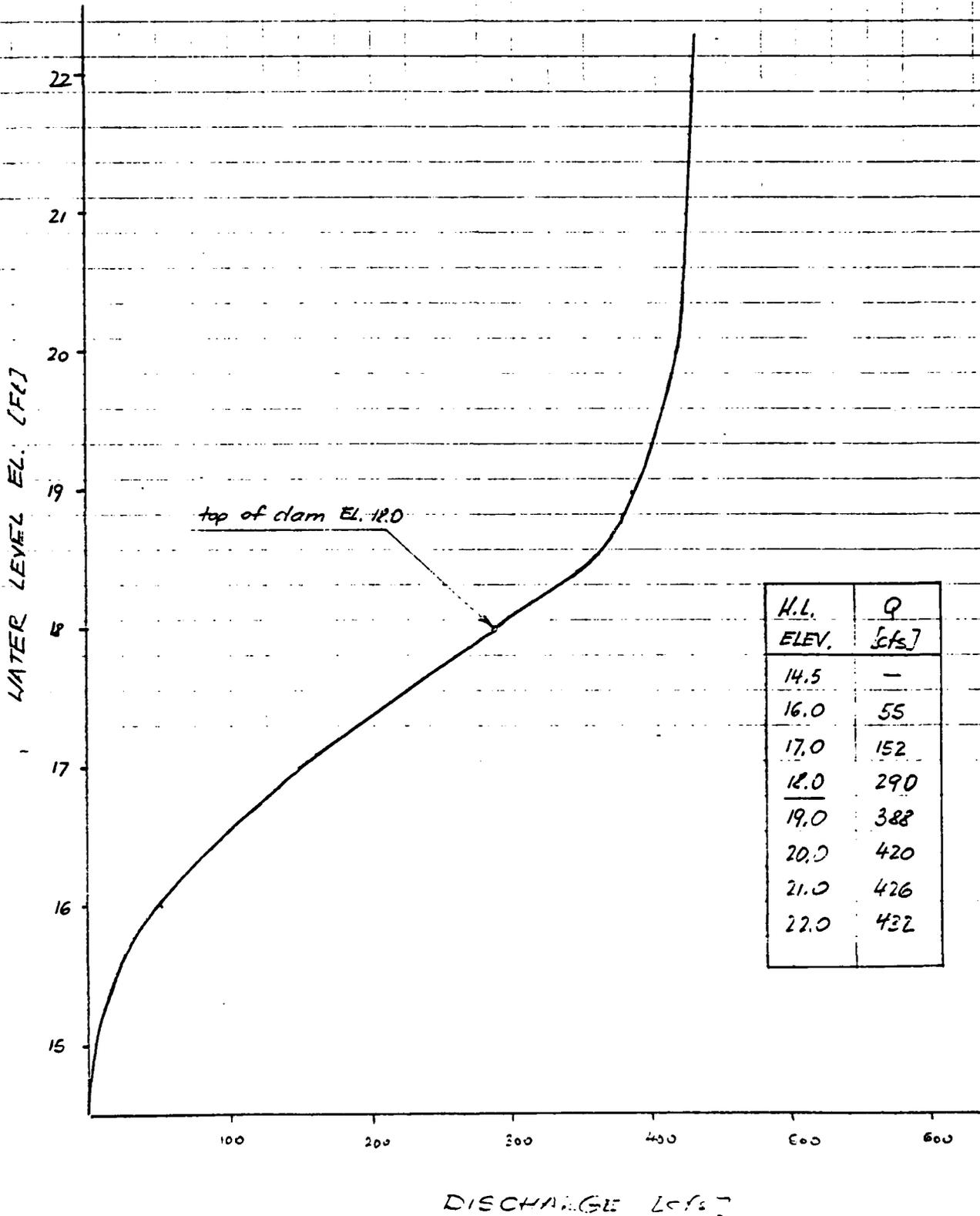
THE DISCHARGE CAPACITY FOR THE TWIN  
36" x 58" elliptical pipes, WILL BE BASED ON  
HYDRAULIC CHARTS FOR THE SELECTION  
OF HIGHWAY CULVERTS, ASSUMING INLET  
CONTROL. SPILLWAY DISCHARGE SHALL  
BE TAKEN AS WEIR/ ORIFICE FLOW  
OR CULVERT FLOW, WHICHEVER CONTROLS.

SCALE 4 X 4 TO THE INCH

SPILLWAY STAGE DISCHARGE TABULATION

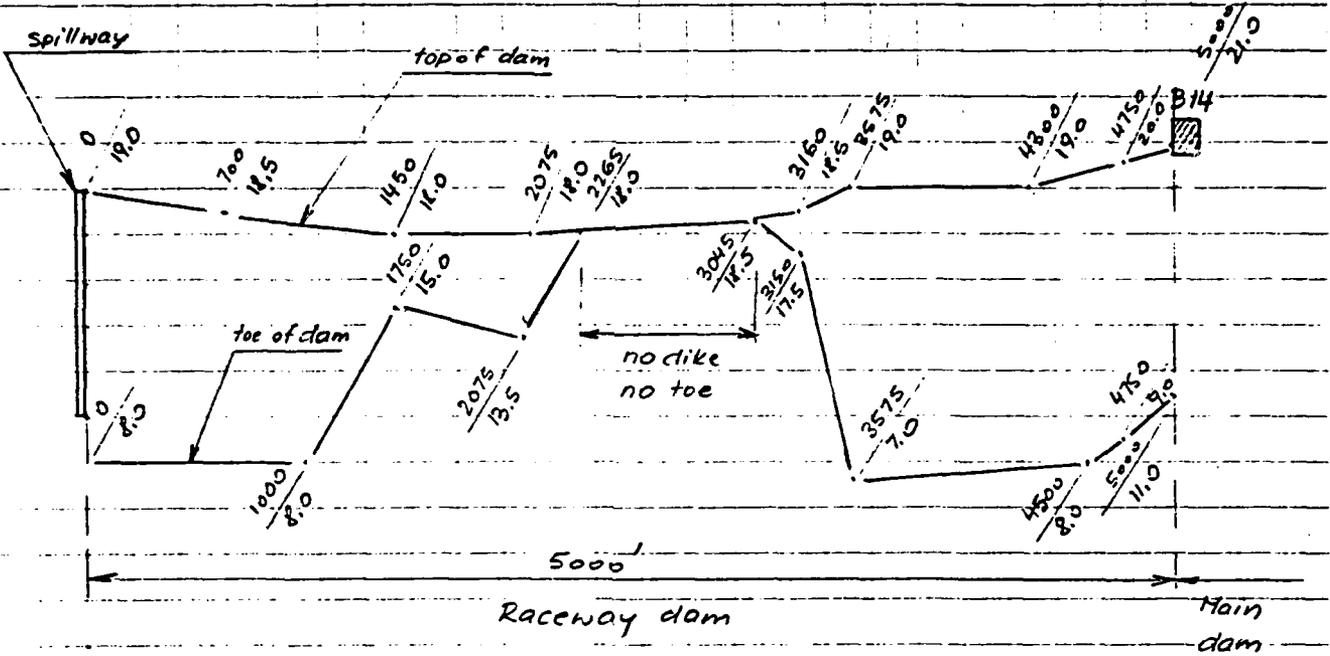
H.L. ELEV. [FT]		RACEWAY DAM SPILLWAY												Total Q [cfs]	
		PRIMARY CREST EL. 14.5				SECONDARY CREST EL. 16.0				ORIFICE FLOW Q = 20 FT <sup>2</sup>		CHRT 6 EL. 5.0			
		NEIR FLOW L = 9'	ORIFICES FLOW a = 31.5 FT <sup>2</sup>		NEIR FLOW L = 10'	ORIFICE FLOW a = 20 FT <sup>2</sup>		HW [FT]	Q [cfs]						
H [FT]	C [cfs]	h [FT]	C [cfs]	H [FT]	C [cfs]	h [FT]	C [cfs]	Q [cfs]	Q [cfs]	Q [cfs]	Q [cfs]				
14.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16.0	1.5	333	55	-	-	-	-	-	-	-	55	11.0	360	55	55
17.0	2.5	333	119	1.0	333	33	-	-	-	-	152	12.0	380	152	152
<u>18.0</u>	3.5	333	196	2.0	333	94	.6	.6	.6	.6	290	13.0	400	290	290
19.0				2.75	.6	252	.6	.6	.6	.6	388	14.0	410	388	388
20.0				3.75	.6	294	.6	.6	.6	.6	461	15.0	420	420	420
21.0				4.75	.6	331	.6	.6	.6	.6	524	16.0	426	424	424
22.0				5.75	.6	364	.6	.6	.6	.6	579	17.0	432	432	432

STAGE DISCHARGE CURVE



BREACH ANALYSIS:

SOURCE 4.1.4 TO THE RIVER



BREACH CONDITIONS:

BOTTOM OF BREACH	EFF. LENGTH	=	100	[FT]
	ELEV.	=	10.0	[FT]
SIDE SLOPE OF BREACH		=	1:1	
W.L. ELEV.		=	16.0	[FT]
W.L. ELEV. WHICH WILL CAUSE DAM TO FAIL		=	18.0	[FT]
TIME TO DEVELOP BREACH TO MAX. SIZE		=	1.0	[HR]

BREACH RESULTS:

MAX. OUTFLOW = 2053 c.f.s.

HEC-1-DAM PRINTOUT

Routing thru Sunset Lake



NATIONAL DAM SAFETY PROGRAM  
 SUNSET LAKE RACEWAY DAM  
 MULTI RATIO ROUTING

NO	MHR	MMIN	IDAY	JOB SPECIFICATION										
				IHR	IWIN	METRC	IPLT	IFRT	NSTAN	JOPER	LBPT	IRACE		
200	0	30	0	0	0	0	0	0	0	4	0	5	0	0

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

RIIOS= .50

\*\*\*\*\*

SUR-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO SUNSET LAKE/DAM

ISTAD	ICOMP	IECON	ITAFE	JFLT	JFRT	INOME	ISTADE	IAUTO
LAKE	0	0	0	0	0	1	0	0

INHYDG	IUNG	TAREA	SNAP	TRSDA	TRSFC	RATIO	ISNOW	ISAME	LOCAL
1	1	45.70	0.00	45.70	0.00	0.000	0	1	0

PRECIP DATA

SEEF	FMS	R6	R12	R24	RAB	R72	R96
0.00	24.00	98.00	107.00	117.00	0.00	0.00	0.00

TRSFSC COMPUTED BY THE PROGRAM IS .847

LOSS DATA

LROPT	STKR	DLTKR	RTIOL	ERAIN	STKRS	RTIOK	STRIL	CNSTL	ALSHX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA

IP= 12.60 CP= .70 NTA= 0

RECESSION DATA

SIRIO= -1.00 ORCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH100	END-OF-PERIOD	ORDINATES,	LAG=	12.52	HOURS,	CP=	.69	VOL=	.99
14.	54.	112.	180.	257.	339.	427.	518.	613.	710.
809.	910.	1011.	1114.	1215.	1307.	1393.	1466.	1528.	1581.
1624.	1656.	1679.	1692.	1694.	1686.	1665.	1629.	1569.	1492.
1414.	1340.	1270.	1203.	1140.	1080.	1024.	970.	920.	871.
826.	783.	742.	703.	666.	631.	598.	567.	537.	509.
482.	457.	433.	410.	389.	369.	349.	331.	314.	297.
282.	267.	253.	240.	227.	215.	204.	193.	183.	174.
165.	156.	148.	140.	133.	126.	119.	113.	107.	101.
96.	91.	86.	82.	78.	73.	70.	66.	63.	59.
56.	53.	50.	48.	45.	43.	41.	39.	37.	35.

END-OF-PERIOD FLOW

MO,DA	HR,MM	PERIOD	RAIN	EXCS	LOSS	COMP	MO,DA	HR,MM	PERIOD	RAIN	EXCS	LOSS	COMP							
0																				
SUM													23.79	19.93	3.86	1170986.				
													(	601.)	(	506.)	(	98.)	(	33158.63)

## STATION IN-DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES							
MO. DA	HR. MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	1.30	1	1.50	21.	55.	397.	16.0
1.01	1.00	2	1.00	20.	55.	396.	16.0
1.01	1.30	3	1.50	19.	55.	395.	16.0
1.01	2.00	4	2.00	17.	55.	394.	15.9
1.01	2.30	5	2.50	16.	55.	393.	15.9
1.01	3.00	6	3.00	15.	55.	391.	15.9
1.01	3.30	7	3.50	14.	55.	390.	15.9
1.01	4.00	8	4.00	13.	55.	388.	15.9
1.01	4.30	9	4.50	12.	55.	387.	15.9
1.01	5.00	10	5.00	11.	55.	386.	15.9
1.01	5.30	11	5.50	11.	55.	384.	15.8
1.01	6.00	12	6.00	10.	55.	383.	15.8
1.01	6.30	13	6.50	9.	55.	381.	15.8
1.01	7.00	14	7.00	9.	55.	379.	15.8
1.01	7.30	15	7.50	8.	55.	377.	15.8
1.01	8.00	16	8.00	8.	55.	375.	15.7
1.01	8.30	17	8.50	7.	55.	373.	15.7
1.01	9.00	18	9.00	8.	55.	371.	15.7
1.01	9.30	19	9.50	11.	55.	369.	15.7
1.01	10.00	20	10.00	16.	55.	368.	15.7
1.01	10.30	21	10.50	24.	55.	366.	15.6
1.01	11.00	22	11.00	35.	55.	366.	15.6
1.01	11.30	23	11.50	50.	55.	365.	15.6
1.01	12.00	24	12.00	68.	55.	365.	15.6
1.01	12.30	25	12.50	96.	55.	366.	15.6
1.01	13.00	26	13.00	144.	55.	369.	15.7
1.01	13.30	27	13.50	222.	55.	374.	15.7
1.01	14.00	28	14.00	336.	55.	383.	15.8
1.01	14.30	29	14.50	494.	55.	398.	16.0
1.01	15.00	30	15.00	705.	505.	411.	16.1
1.01	15.30	31	15.50	974.	782.	420.	16.2
1.01	16.00	32	16.00	1339.	1089.	429.	16.3
1.01	16.30	33	16.50	1825.	1489.	441.	16.4
1.01	17.00	34	17.00	2412.	1993.	456.	16.6
1.01	17.30	35	17.50	3087.	2589.	475.	16.8
1.01	18.00	36	18.00	3838.	3264.	498.	17.0
1.01	18.30	37	18.50	4653.	3427.	535.	17.3
1.01	19.00	38	19.00	5514.	3575.	600.	17.8
1.01	19.30	39	19.50	6407.	4126.	687.	18.5
1.01	20.00	40	20.00	7323.	4762.	787.	19.2
1.01	20.30	41	20.50	8249.	5287.	901.	19.9
1.01	21.00	42	21.00	9175.	6947.	1009.	20.5
1.01	21.30	43	21.50	10091.	8831.	1081.	20.9
1.01	22.00	44	22.00	10987.	10122.	1125.	21.2
1.01	22.30	45	22.50	11853.	11138.	1157.	21.3
1.01	23.00	46	23.00	12674.	12040.	1185.	21.5
1.01	23.30	47	23.50	13429.	12865.	1210.	21.6
1.02	0.00	48	24.00	14104.	13610.	1232.	21.7
1.02	.30	49	24.50	14691.	14267.	1251.	21.8
1.02	1.00	50	25.00	15185.	14829.	1267.	21.9
1.02	1.30	51	25.50	15581.	15296.	1280.	22.0
1.02	2.00	52	26.00	15877.	15663.	1290.	22.0
1.02	2.30	53	26.50	16067.	15925.	1297.	22.0
1.02	3.00	54	27.00	16148.	16080.	1302.	22.1
1.02	3.30	55	27.50	16122.	16127.	1303.	22.1
1.02	4.00	56	28.00	15993.	16068.	1301.	22.1
1.02	4.30	57	28.50	15765.	15908.	1297.	22.0
1.02	5.00	58	29.00	15440.	15649.	1290.	22.0
1.02	5.30	59	29.50	15021.	15295.	1280.	22.0
1.02	6.00	60	30.00	14499.	14844.	1267.	21.9
1.02	6.30	61	30.50	13901.	14302.	1252.	21.8
1.02	7.00	62	31.00	13274.	13705.	1235.	21.7
1.02	7.30	63	31.50	12640.	13085.	1216.	21.6
1.02	8.00	64	32.00	12012.	12463.	1198.	21.5
1.02	8.30	65	32.50	11401.	11850.	1179.	21.5
1.02	9.00	66	33.00	10818.	11257.	1161.	21.4
1.02	9.30	67	33.50	10264.	10691.	1143.	21.3
1.02	10.00	68	34.00	9737.	10154.	1126.	21.2
1.02	10.30	69	34.50	9236.	9643.	1109.	21.1
1.02	11.00	70	35.00	8759.	9157.	1092.	21.0
1.02	11.30	71	35.50	8307.	8692.	1076.	20.9
1.02	12.00	72	36.00	7876.	8254.	1060.	20.8
1.02	12.30	73	36.50	7467.	7839.	1045.	20.7
1.02	13.00	74	37.00	7078.	7446.	1029.	20.7
1.02	13.30	75	37.50	6708.	7075.	1014.	20.6

HEC-1-DAM PRINTOUT

Runoff Hydrograph to Raceway

AD-A102 681

NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/6 13/13  
NATIONAL DAM SAFETY PROGRAM, SUNSET LAKE RACEWAY DAM (NJ00764).--ETC(U)  
JUL 81 R J McDERMOTT, J E GRIBBIN DACW61-79-C-0011

UNCLASSIFIED

DAEN/NAP-53842/NJ00764-81/ ML

2x2  
A  
MOTER



END  
DATE  
FILMED  
9-81  
DTIC



NATIONAL DAM SAFETY PROGRAM  
 SUNSET LAKE RACEWAY DAM  
 MULTI-RATIO ROUTING

NO NHR NMIN IDAY IHR IKIN MEIRC JFLT IFRT MSION  
 100 0 30 0 0 0 0 0 4 0  
 JOFER NMT LROPT TRACE  
 5 0 0 0

JOB SPECIFICATION

MULTI-PLAN ANALYSES TO BE PERFORMED

NPLAN= 1 NRATIO= 1 LRTIO= 1

RTIOS= .50

\*\*\*\*\* \*\*\*\*\* \*\*\*\*\* \*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO RACEWAY DAM

ISTAO ICOMP IECON ITAFC JFLT JFRT INAME ISTAGE IAUTO  
 LAKE 0 0 0 0 0 0 1 0 0

HYDROGRAPH DATA

IHYD0 IUHQ IAREA ITRSDA ITRSFC RATIO ISNDW ISAME LOCAL  
 1 2 2.00 0.00 2.00 0.00 0.000 0 1 0

PRECIP DATA

SPFE PMS R6 R12 R24 R48 R72 R96  
 0.00 27.00 100.00 109.00 117.00 0.00 0.00 0.00

TRSF0 COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT STRKR BLTKR RTIOL ERAIN STRKS RTIOK STRIL CNSIL ALSX RTIMP  
 0 0.00 0.00 1.00 0.00 0.00 1.00 1.50 .15 0.00 0.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAB= 2.40

RECESSION DATA

STRIO= -1.00 CRCSN= -.05 RTIOR= 2.00

END-OF-PERIOD FLOW

NO.DA HR.MM PERIOD RAIN EXCS LOSS COMP 0 NO.DA HR.MM PERIOD RAIN EXCS LOSS COMP 0

SUM 25.27 21.45 3.83 58162.  
 ( 642.)( 545.)( 97.)( 1646.96)

## STATION RA-DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES							
MO. DA	HR. MN	PERIOD	HOURS	INFLOW	OUTFLOW	STORAGE	STAGE
1.01	.30	1	.50	1.	0.	18.	16.0
1.01	1.00	2	1.00	1.	1.	18.	16.0
1.01	1.30	3	1.50	1.	1.	18.	16.0
1.01	2.00	4	2.00	1.	1.	18.	16.0
1.01	2.30	5	2.50	1.	1.	18.	16.0
1.01	3.00	6	3.00	1.	1.	18.	16.0
1.01	3.30	7	3.50	1.	1.	18.	16.0
1.01	4.00	8	4.00	1.	1.	18.	16.0
1.01	4.30	9	4.50	1.	1.	18.	16.0
1.01	5.00	10	5.00	0.	1.	18.	16.0
1.01	5.30	11	5.50	0.	1.	18.	16.0
1.01	6.00	12	6.00	0.	0.	18.	16.0
1.01	6.30	13	6.50	0.	0.	18.	16.0
1.01	7.00	14	7.00	0.	0.	18.	16.0
1.01	7.30	15	7.50	0.	0.	18.	16.0
1.01	8.00	16	8.00	0.	0.	18.	16.0
1.01	8.30	17	8.50	0.	0.	18.	16.0
1.01	9.00	18	9.00	2.	1.	18.	16.0
1.01	9.30	19	9.50	6.	2.	19.	16.0
1.01	10.00	20	10.00	16.	7.	19.	16.0
1.01	10.30	21	10.50	30.	15.	19.	16.1
1.01	11.00	22	11.00	45.	26.	20.	16.2
1.01	11.30	23	11.50	61.	39.	21.	16.3
1.01	12.00	24	12.00	74.	52.	22.	16.3
1.01	12.30	25	12.50	100.	68.	23.	16.4
1.01	13.00	26	13.00	155.	94.	25.	16.6
1.01	13.30	27	13.50	263.	140.	29.	16.9
1.01	14.00	28	14.00	426.	209.	36.	17.4
1.01	14.30	29	14.50	624.	318.	46.	18.0
1.01	15.00	30	15.00	840.	895.	52.	18.3
1.01	15.30	31	15.50	1063.	985.	52.	18.3
1.01	16.00	32	16.00	1356.	1351.	54.	18.4
1.01	16.30	33	16.50	1705.	1652.	55.	18.5
1.01	17.00	34	17.00	2122.	2099.	57.	18.6
1.01	17.30	35	17.50	2462.	2435.	58.	18.6
1.01	18.00	36	18.00	2608.	2611.	58.	18.6
1.01	18.30	37	18.50	2567.	2578.	58.	18.6
1.01	19.00	38	19.00	2365.	2381.	58.	18.6
1.01	19.30	39	19.50	2042.	2072.	57.	18.5
1.01	20.00	40	20.00	1637.	1671.	55.	18.5
1.01	20.30	41	20.50	1286.	1318.	54.	18.4
1.01	21.00	42	21.00	982.	1018.	52.	18.3
1.01	21.30	43	21.50	732.	766.	51.	18.3
1.01	22.00	44	22.00	536.	570.	49.	18.2
1.01	22.30	45	22.50	399.	429.	48.	18.1
1.01	23.00	46	23.00	297.	333.	47.	18.1
1.01	23.30	47	23.50	222.	284.	45.	18.0
1.02	0.00	48	24.00	167.	259.	42.	17.8
1.02	.30	49	24.50	130.	227.	38.	17.5
1.02	1.00	50	25.00	121.	195.	34.	17.3
1.02	1.30	51	25.50	113.	170.	31.	17.1
1.02	2.00	52	26.00	105.	148.	29.	17.0
1.02	2.30	53	26.50	98.	130.	28.	16.9
1.02	3.00	54	27.00	92.	116.	27.	16.8
1.02	3.30	55	27.50	85.	105.	26.	16.7
1.02	4.00	56	28.00	80.	96.	25.	16.6
1.02	4.30	57	28.50	74.	88.	24.	16.6
1.02	5.00	58	29.00	69.	81.	24.	16.5
1.02	5.30	59	29.50	65.	75.	23.	16.5
1.02	6.00	60	30.00	60.	70.	23.	16.5
1.02	6.30	61	30.50	56.	65.	23.	16.4
1.02	7.00	62	31.00	53.	60.	22.	16.4
1.02	7.30	63	31.50	49.	56.	22.	16.4
1.02	8.00	64	32.00	46.	52.	22.	16.3
1.02	8.30	65	32.50	43.	49.	22.	16.3
1.02	9.00	66	33.00	40.	45.	21.	16.3
1.02	9.30	67	33.50	37.	42.	21.	16.3
1.02	10.00	68	34.00	35.	39.	21.	16.3
1.02	10.30	69	34.50	32.	37.	21.	16.2
1.02	11.00	70	35.00	30.	34.	21.	16.2
1.02	11.30	71	35.50	28.	32.	20.	16.2
1.02	12.00	72	36.00	26.	30.	20.	16.2
1.02	12.30	73	36.50	25.	28.	20.	16.2
1.02	13.00	74	37.00	23.	26.	20.	16.2
1.02	13.30	75	37.50	21.	24.	20.	16.2

HEC - 1 - DAM PRINTOUT

Overtopping Analysis



NATIONAL DAM SAFETY PROGRAM  
 SUNSET LAKE RACEWAY DAM, NEW JERSEY  
 MULTI RATIO ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
70	1	0	0	0	0	0	0	4	0
			JOPER	MUT	LROPT	TRACE			
			5	0	0	0			

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

RTIOS= .50

\*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO SUNSET LAKE RACEWAY DAM

ISTAD	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUMG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.00	0.00	0.00	0.00	0.000	0	1	0

\*\*\*\*\*

\*\*\*\*\*

\*\*\*\*\*

\*\*\*\*\*

\*\*\*\*\*

\*\*\*\*\*

HYDROGRAPH ROUTING

ROUTE DISCHARGE THRU RACEWAY DAM

ISTAQ	ICONF	IECON	ITAPE	JFLT	JPRT	INAME	ISTAGE	IAUTO
RA-DAM	1	0	0	0	0	0	0	0
ROUTING DATA								
QLOSS	AVG	IRES	ISAME	IOFT	IFMP	LSTR		
0.0	0.000	1	1	0	0	0		
NSIFS	NSIDL	LAG	ANSKK	X	TSK	STORA	ISPRAT	
1	0	0	0.000	0.000	0.000	-16.	-1	
STAGE	14.50	16.00	17.00	18.00	19.00	20.00	21.00	22.00
FLOW	0.00	55.00	152.00	290.00	388.00	420.00	426.00	432.00
SURFACE AREA=	0.	9.	31.	48.				
CAPACITY=	0.	18.	95.	486.				
ELEVATION=	10.	16.	20.	30.				

CREL	SPWID	COOW	EXFW	ELEVL	COOL	CAREA	EXPL
14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA			
TOPEL	COOD	EXFD	DAMWID
18.0	2.6	1.5	625.

CREST LENGTH 625. 2450. 4300. 4500. 4750. 5000.  
 AT OR BELOW ELEVATION 18.0 18.5 19.0 19.5 20.0 21.0

PEAK OUTFLOW IS 1563. AT TIME 21.00 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION STATION AREA PLAN RATIO 1  
 .50

HYDROGRAPH AT LAKE 0.00 1 1571.  
 ( 0.00) ( 44.47)

ROUTED TO RA-DAM 0.00 1 1563.  
 ( 0.00) ( 44.27)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... ELEVATION INITIAL VALUE SPILLWAY CREST TOP OF DAM  
 STORAGE 14.00 1A.50 1B.00  
 OUTFLOW 18. 8. 46.  
 55. 0. 290.

RATIO OF PHF .50 MAXIMUM RESERVOIR W.S.ELEV 18.46 MAXIMUM STORAGE AC-FT 55. MAXIMUM DUEFLOW CFS 1563. DURATION OVER TOP HOURS 30.00 TIME OF FAILURE HOURS 21.00 0.00

HEC - 1 - DAM PRINTOUT

Breach Analysis



NATIONAL DAM SAFETY PROGRAM  
 SUNSET LAKE RACEWAY DAM, NEW JERSEY  
 MULTI RATIO ROUTING

JOB SPECIFICATION										
NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IFRT	NSTAN	
70	1	0	0	0	0	0	0	0	0	0
				JOPER	NWT	LROFT	TRACE			
				5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED  
 NPLAN= 1 NRTO= 1 LRTO= 1

RTIOS= .50

\*\*\*\*\*

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO SUNSET LAKE RACEWAY DAM

HYDROGRAPH DATA										
ISTAD	ICOMP	IECON	ITAPE	JFLT	JFRT	INAME	ISTAGE	IAUTO		
LAKE	0	0	0	0	0	1	0	0		
IHYDG	IWHG	IAREA	SNAP	IRSDA	IRSEC	RATIO	ISNOW	ISAME	LOCAL	
-1	0	0.00	0.00	0.00	0.00	0.000	0	1	0	

\*\*\*\*\*

HYDROGRAPH ROUTING

ROUTE DISCHARGE\_IHRL\_RACEWAY DAM

ISTAD ICOMP IECON ITAPE JPLY JFRT INAME ISTAGE IAUTO  
 RA-DAM 1 0 0 0 0 0 0 0  
 OLOBS CLOSS AVB IRES ISAME IOFT IFMP LSTR  
 0.0 0.000 0.00 1 1 0 0 0  
 NSTPS NSTDL LAB ANSKK X TSK STORA ISPRAT  
 1 0 0 0.000 0.000 0.000 16.1

STAGE 14.50 16.00 17.00 18.00 19.00 20.00 21.00 22.00  
 FLOW 0.00 55.00 152.00 290.00 388.00 420.00 426.00 432.00

SURFACE AREA= 0. 9. 31. 48.

CAPACITY= 0. 18. 95. 486.

ELEVATION= 10. 16. 20. 30.

CREL SEWID COOW EXPW ELEV COOL CAREA EXEL  
 14.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0

DAM DATA  
 TDFEL COOD EXPB DAMWID  
 18.0 2.6 1.5 625.

CREST LENGTH 625. 2450. 4300. 4500. 4750. 5000.  
 AT OR BELOW ELEVATION 18.0 18.5 19.0 19.5 20.0 21.0

DAM BREACH DATA  
 BRWID 100. 1.00 10.00 1.00 16.00 18.00  
 Z ELBH JFAIL WSEL FAIL

BEGIN DAM FAILURE AT 16.00 HOURS

PEAK OUTFLOW IS 2053. AT TIME 16.60 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN RATIO 1
HYDROGRAPH AT LAKE		0.00 ( 0.00)	1 ( 44.47)
ROUTED TO RA-DAM		0.00 ( 0.00)	1 ( 44.80)

SUMMARY OF DAM SAFETY ANALYSIS

FLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	16.00	14.50	18.00
STORAGE	18.	8.	46.
OUTFLOW	55.	0.	290.

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	18.27	.27	51.	2053.	1.28	16.60	16.00

APPENDIX 5

Existing Temporary Emergency Action Plan



THE CITY OF BRIDGETON

BRIDGETON, NEW JERSEY 08302  
**RECEIVED**

January 12, 1977

APR 20 1981

ALBERT A. FRALINGER, JR.  
Director of Public Works  
City Engineer

**STORCH ENGINEERS**

Temporary Operating Procedure for Flood Gates at Sunset Lake and South End of Raceway

**Subject:** The subject of this order and procedure is to set forth a temporary agreement for the operation, control delegation of duties and responsibilities of the flood control gates on Sunset Lake and the Raceway.

**Purpose:** The purpose of this agreement is to set forth a procedure to be followed by various departments of the city that are responsible for the health, safety and welfare of the public in time of emergency and to further set forth practices to be followed that will eliminate or help reduce to a minimum, damages to public property during time of flooding or severe weather.

**Jurisdiction:** According to the revised ordinances of the City of Bridgeton, the Department of Public Works is responsible for the proper and efficient conduct of all public works functions of the city government. It shall further administer and control functions, and the construction, operation and maintenance of public works improvements, facilities and services relating to rivers, streams, waterfronts and flood damage control and reduction.

**Normal Operation:** In that the subject structures are located within the limits of the City Park, the Director of the Department of Parks and Recreation shall assume the responsibility for the normal operation of the flood gates. He shall be responsible for assigning personnel within his department to periodically inspect, perform normal maintenance activities, clean and keep free of debris the flood gates, siphons and all equipment related thereto. He shall set forth a schedule for periodic inspections of the facilities at such time a representative of the Department of Public Works shall be present to witness the raising and lowering of the gates and to offer technical advice to the Department of Parks and Recreation as the need may be, at the same time, the Civil Defense Director shall be contacted in order for him to be present.

Location of Flood Gates

The flood gates referred to in this order shall be (a) two (2) flood gates located at the southeast end of Sunset Lake on Park Drive adjacent to siphon structure (b) flood gate on the center spillway on Park Drive at the southerly end of Sunset Lake and (c) flood gates at the southerly end of the raceway adjacent to Mayor Aitken Drive in Morningside Park. (See attached map for location of structures).

Location of Cranks or Keys for Operation of Flood Gates

There shall be three (3) sets of duplicate cranks or keys stored at three (3) locations in the City of Bridgeton. The original set shall be located at the Park Office in Morningside Park, a duplicate set shall be located at the City Engineer's Office, Florida Avenue, and a duplicate set shall be stored at Police Headquarters in City Hall, East Commerce Street.

Each set of cranks shall be properly tagged for identification to the particular flood gate it controls. (See attached map for crank location).

The gate at the south end of the raceway is operated by a permanent crank which is chained and secured by a padlock. The keys to the lock are also stored at the above three locations.

#### Procedure To Be Followed During Times of Inclement Weather or Notice of Severe Storm Conditions

The Division of Engineering shall establish a suitable flood guage at each location of the gates as above identified. A procedure for reading the guages and an appropriate standard report form shall be prepared. The Director of Parks and Recreation shall assign personnel to periodically read the guages and maintain the report form, a copy of which shall be forwarded to the City Engineer on a monthly basis.

The purpose for this procedure is to establish a record of flow of the control area and to establish a record log to help determine a procedure for opening the gates at the proper time to eliminate flooding conditions.

At this time, an exact procedure has not been determined in that further coordination is needed with the County Engineer's office for the control of the lakes north of the city which all flow into Sunset Lake.

At this time, until a coordinated procedure has been established by the necessary governmental agencies, the Director of Parks and Recreation, or designee, shall notify the Director of Public Works, or his designee, of any substantial changes in the height of the lake or raceway and measures shall be taken to start lowering the water level to help control flooding. It is important that the Department of Parks and Recreation keep a watchful eye with regard to weather reports or change in flow at the control areas well in advance of the approach of a major storm to allow for the gates to be adjusted in time.

#### EMERGENCY CONDITIONS

In case of an emergency involving the entire water shed area the flood gates should be raised in the following order:

1. Gate "C" -- South end of Raceway
2. Gate "A" -- Southeast end of Sunset Lake on Park Drive
3. Gate "B" -- Center spillway on south end of Sunset Lake on Park Drive

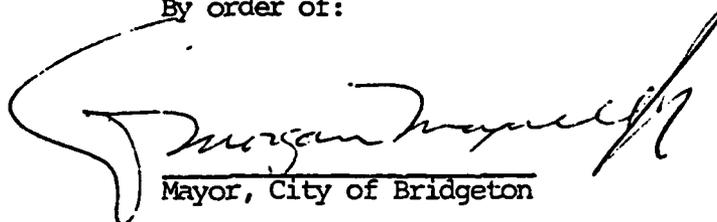
In case of minor problems, the gate which would give the required relief should be opened first.

At the first sign of an emergency condition, where probable flooding may occur, the Director of Parks and Recreation, or his designee, shall notify the following officials in the order listed.

1. Director of Public Works and Supervisor of Streets and Roads Division
2. Director of Police and Fire
3. City Civil Defense Director
4. Mayor
5. Business Administrator
6. City Council President

Until a more exact procedure has been established, the Department of Parks and Recreation and Department of Public Works shall work together to coordinate a suitable working program of inspection and control.

By order of:

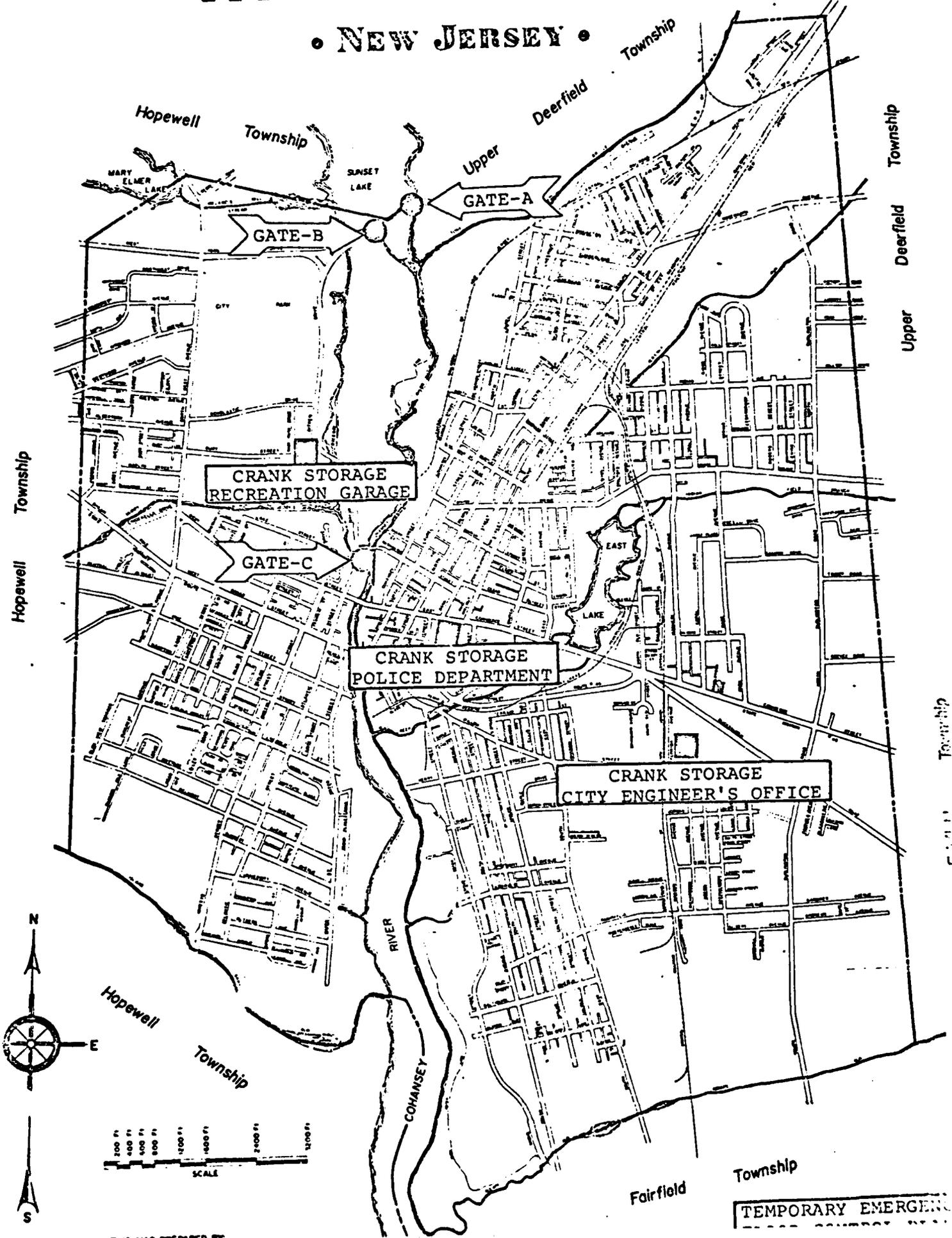


Mayor, City of Bridgeton

Date: 4-1-77

Attachment

• NEW JERSEY •



APPENDIX 6

**Bibliography**

1. "Recommended Guidelines for Safety Inspection of Dams," Department of the Army, Office of the Chief of Engineers, Washington, D.C. 20314.
2. Design of Small Dams, Second Edition, United States Department of the Interior, Bureau of Reclamation, United States Government Printing Office, Washington, D.C., 1973.
3. Holman, William W. and Jumikis, Alfreds R., Engineering Soil Survey of New Jersey, Report No. 21, Cumberland County, Rutgers University, New Brunswick, N.J. 1953.
4. "Geologic Map of New Jersey, " prepared by J. Volney Lewis and Henry B. Kummel, Dated 1910-1912, revised by H.B. Kummel, 1931 and M. Johnson, 1950.
5. Chow, Ven Te., Ed., Handbook of Applied Hydrology, McGraw-Hill Book Company, 1964.
6. Herr, Lester A., Hydraulic Charts for the Selection of Highway Culverts, U.S. Department of Transportation, Federal Highway Administration, 1965.
7. Safety of Small Dams, Proceedings of the Engineering Foundation Conference, American Society of Civil Engineers, 1974.
8. King, Horace Williams and Brater, Ernest F., Handbook of Hydraulics, Fifth Edition, McGraw-Hill Book Company, 1963.
9. Urban Hydrology for Small Watersheds, Technical Release No. 55, Engineering Division, Soil Conservation Service, U.S. Department of Agriculture, January 1975.
10. Sunset Lake Dam NJ00063 - Phase I Inspection Report, U.S. Army Corps of Engineers, April 1979.

