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SOUTH BRANCH TIMBER CREEK
GLOUCESTER COUNTY
NEW JERSEY

BELLS LAKE DAM

NJ 00405

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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

March, 1979

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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)*

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Visual Inspection
Structural Analysis
Embankments
Spillways
National Dam Inspection Act Report
Bells Lake 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 records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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

IN REPLY REFER TO

NAPEN-D

24 MAY 1979

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

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Bells Lake Dam in Gloucester 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, Bells Lake 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. The dam's spillway is considered inadequate since 33 percent of the Spillway Design Flood - SDF - would overtop the dam. (The SDF, in this instance, is the 100 year flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

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

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar

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year 1980.

c. Within three months from the date of approval of this report, the following actions should be taken:

(1) Remove trees on the downstream embankment to lessen the piping potential.

(2) Place additional riprap stone at the downstream pool immediately below the culvert outlet to prevent scour.

(3) Remove the auxiliary sluiceway at the right abutment together with the grist mill debris. Safeload the existing culvert and build new embankment in the approach area and downstream power canal.

(4) Repair deteriorated concrete surfaces.

(5) Repair the hoisting device for the stoplogs.

(6) Provide slope protection for the downstream face of the embankment at the extreme low points on each side of the spillway. These could, in effect, act as auxiliary spillways to accommodate and channelize overtopping floods.

(7) The backslope areas at the ends of the bridge wingwalls should be regraded and protected with slope paving.

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. Florio of the First 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.

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NAPEN-D
Honorable Brendan T. Byrne

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 G. TON
Colonel, Corps of Engineers
for District Engineer

1 Incl
As stated

Copies furnished:
Dirk C. Hofman, P.E., Deputy Director
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

BELLS LAKE DAM (NJ00405)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 6 December 1978 by Louis Berger and Associates, Inc. under contract to the State of New Jersey. The state, under agreement with the U. S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Bells Lake 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. The dam's spillway is considered inadequate since 33 percent of the Spillway Design Flood - SDF - would overtop the dam. (The SDF, in this instance, is the 100 year flood.) To insure adequacy of the structure, the following actions, as a minimum, are recommended:

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

b. Within six months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar year 1980.

c. Within three months from the date of approval of this report, the following actions should be taken:

(1) Remove trees on the downstream embankment to lessen the piping potential.

(2) Place additional riprap stone at the downstream pool immediately below the culvert outlet to prevent scour.

(3) Remove the auxiliary sluiceway at the right abutment together with the grist mill debris. Safeload the existing culvert and build new embankment in the approach area and downstream power canal.

(4) Repair deteriorated concrete surfaces.

(5) Repair the hoisting device for the stoplogs.

(6) Provide slope protection for the downstream face of the embankment at the extreme low points on each side of the spillway. These could, in effect, act as auxiliary spillways to accommodate and channelize overtopping floods.

(7) The backslope areas at the ends of the bridge wingwalls should be regraded and protected with slope paving.

APPROVED: Joel Kollaker LTC
JAMES G. TON
Colonel, Corps of Engineers
for District Engineer

DATE: 24 May 1979

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Bells Lake Dam Fed ID# NJ 00405 and NJ ID# 368

State Located New Jersey
County Located Gloucester
Coordinates Lat. 3945.3 - Long. 7503.6
Stream South Branch Timber Creek
Date of Inspection 6 December 1978

ASSESSMENT OF GENERAL CONDITIONS

Bells Lake Dam is assessed to be in a fair overall condition but it is recommended that it be downgraded from a high hazard to a significant hazard category. Overtopping of the dam would not significantly increase the danger of loss of life as the downstream flood plain is basically uninhabited. However, a busy urban road is located immediately downstream with a hydraulically inadequate culvert. No detrimental findings were uncovered to render an imminently hazardous assessment except further studies are recommended in the future to ascertain the embankment stability and permeability. Overtopping of the dam could lead to an embankment washout. Remedial actions recommended to be undertaken in the future are 1) regrade and protect the downstream embankment areas at the bridge wingwalls, 2) remove root systems on the embankment slopes, 3) remove the abandoned sluice gate at the east end, 4) repair the spillway intake structure.

This dam has an inadequate spillway capacity, being able to accommodate only 32% of the design flood and additional hydraulic/hydrologic studies are recommended.

F. Keith Jolls P.E.
Project Manager

OVERVIEW OF BELLS LAKE DAM

JANUARY 1979

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PREFACE

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

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

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide 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 INSPECTION PROGRAM
NAME OF DAM BELLS LAKE DAM FED ID# NJ 00405

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

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

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Bells Lake Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

Bells Lake Dam is a relatively old earth highway embankment approximately 500 feet in length with a 50-year old bridge and spillway located about 150 feet from the west abutment. The embankment originally carried an early alignment of Green Tree Road across the north shore of Bells Lake to its intersection with Bells Lake Road at the site of a grist mill at the northeast corner of the lake. Bells Lake Road ran along the east shore and has long since been abandoned. The concrete spillway bridge, constructed in 1928, has a total transverse width of 43 feet face to face of parapets and the waterway opening is a 14 foot wide semicircular

arch culvert. The wingwalls are 68 feet long and parallel the axis of the dam. The spillway entrance is a three-sided concrete drop inlet structure affixed to the south bridge fascia and has two sections of removeable timber flashboards facing the reservoir. The dam embankment has back slopes of 2H:1V with numerous large trees and heavy undergrowth on both the upstream and downstream slopes. At the right abutment there is a very old, inoperable iron sluice gate that once controlled water intake for the grist mill that was located immediately below the dam. Only remnants of the mill foundation and mill raceway remain.

b. Location

Bells Lake Dam is located 600 feet south of Green Tree Road, Washington Township, Gloucester County and is built across the South Branch of Timber Creek 0.6 mile west of the intersection in Turnersville of Green Tree Road and State Highway 42.

c. Size Classification

The maximum structural height of the dam is 22 feet at the spillway and the maximum storage is estimated to be 343 acre feet. Therefore, the dam is placed in the small size category as defined by the Recommended Guidelines for Safety Inspection of Dams (storage capacity less than 1,000 acre-feet).

d. Hazard Classification

Based on the Corps of Engineers criteria and the fact that in the event of a failure, considerable damage could be inflicted on downstream property, the classification of the dam is recommended to be downgraded to significant hazard. The downstream flood plain is basically undeveloped. However, the pipe culvert at Green Tree Road, 1,000 feet downstream, is hydraulically inadequate and the roadway embankment has the potential to be breached and washed out. Green Tree Road is a busy, important urban roadway. Additionally,

there is a sewage plant facility 1,200' downstream which could be placed in jeopardy at an extreme flood stage.

e. Ownership

According to available information, there is joint ownership. The Bells Lake Community Club, P.O. Box 174, Turnersville, own the lakeside of the dam while Solar Builders Inc., 2 Laurel Lane, Blackwood, New Jersey own the downstream environs, divided approximately by the centerline axis of the dam. The demarcation is not completely clear but quite possibly the joint ownership originated and extended to the old centerline of the original road right-of-way.

f. Purpose of Dam

The dam presently impounds a recreation lake. However, evidence of an old mill exists at the right abutment where power was provided for a mill waterwheel.

g. Design and Construction History

The lower portion of the embankment was originally constructed many years ago to provide a crossing of Timber Creek west of the intersection of Green Tree Road and Bells Lake Road at the site of a grist mill (at the right abutment). The dam was then called Prossers Mill Dam. The old roads and the grist mill were relocated and/or abandoned many decades ago. In 1928, the present spillway bridge was constructed as a roadway overpass under the direction of Mr. William C. Cattell, County Engineer. A section of the embankment was reconstructed in 1941 following a 50-foot washout to the left of the bridge, at which time a timber bulkhead was constructed on either side of the spillway across the entire upstream face. Additionally, the upstream shoulder of the road was raised to an elevation about 4 feet above the spillway crest. In 1967 an inspection was performed by the Bureau of Water Control who found the dam to have several

areas of deep erosion, particularly near the right abutment. Cracks were also found in the walls of the spillway. Upon due notification, the Lake Association proceeded to fill the low spots and repair the sluice walls. In 1973 the Bureau of Water Control further directed the Bells Lake Community Club to raise the elevation of the dam to an elevation of 98.3 (approximately the present crest) and to remove the timber battens attached to the top of the spillway. In 1974, the Mayor of Washington Township requested a dam inspection by the Bureau of Water Control who found the dam in "fair to good" condition but the spillway to be inadequate. The Bureau stated that the dam could fail due to an embankment washout and recommended that the spillway capacity be increased to reduce the risk of embankment failure (the current inspection reveals that no action was taken).

h. Normal Operating Procedures

There are at present no specific operating procedures except for the periodic maintenance of the dam and spillway structure by the Bells Lake Community Club (see Section 4).

1.3 PERTINENT DATA

a. Drainage Area

The drainage area of Bells Lake Dam is 2.9 square miles.

b. Discharge of Dam Site

The spillway capacity with the reservoir at the abutment top elevation is calculated to be approximately 700 cfs. No discharge records are available at this site. However, earlier dam applications indicate design discharges between 625 cfs to 870 cfs.

c. Elevation (Above M.S.L.)

Top of dam - 98.3
Recreation Pool - 94.3 (Spillway crest)
Streambed at Center Line of Dam - 78±

d. Reservoir

Length of Recreation Pool - 2700 feet
Length of Maximum Pool - 4100 feet

e. Storage

Recreation Pool - 125 acre-ft.
Top of dam - 343 acre-ft.

f. Reservoir Surface

Top of dam - 90 acres
Recreation pool - 31 acres

g. Dam

Type - Earth embankment with concrete spillway
Length - 500 feet
Height - 22 feet (concrete bridge structure)
Freeboard between normal reservoir and top of dam - 4.0 feet
Top width - 35+ feet
Side slopes - 2H:1V
Zoning - composition and compactness unknown

h. Diversion and Regulating Tunnel

None

i. Spillway

Type - reinforced concrete frame with timber flashboards.
Effective length of weir - 29 feet
Crest Elevation - 94.3 (flashboards in place)

j. Regulating Outlets

1) Removable timber flashboards in main spillway (2 sections @ 3'-0").
Minimum invert elevation - 80.8 (flashboards removed)

2) Old Mill sluice gate (4'±) - inoperable

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The only design information available for review was one sheet of the 1928 construction plans for the spillway (included in the Appendix). The work was designed by Mr. William C. Cattell, the County Engineer, to his own County Specifications.

2.2 CONSTRUCTION

The spillway structure was built by Just F. Ericksen, General Contractor. Nothing is known about the earlier embankment construction or to what extent the embankment was modified by Ericksen.

2.3 OPERATION

Early records indicate that the 1928 bridge construction was viewed as an additional spillway to supplement the raceway sluice gate on the right abutment. The present structure appears to have operated satisfactorily as designed although the adjacent embankment washed out in 1940 (see Paragraph 5.1.b.).

2.4 EVALUATION

a. Availability

In view of the size and hazard classification it is felt that sufficient engineering data is available except for the geotechnical composition of the embankment.

b. Adequacy

The original plans reveal that the spillway arch culvert was carefully and conservatively designed and from the results of the field inspection, is built in accordance with the design plans.

c. Validity

Based on field observations, the validity of the 1928 design plans is not challenged but

further investigations would be required to assess the permeability of the embankment and to verify the phreatic water levels in the lower portions of the backslopes.

SECTION 3 - VISUAL INSPECTIONS

3.1 a. General

The visual inspection was conducted on December 6, 1978. The reservoir water level at the time of the latter inspection was above 3 inches above the top of the intake flashboards and was flowing freely.

b. Dam

The embankment portions of the dam were found to be in moderately poor condition reflecting the age and apparent lack of maintenance on the backslopes. The lake water level appears to be quite constant during most periods as the banks are well stabilized and show little evidence of sloughing at the waterline. The dam sideslopes are partially protected with natural ground cover and have many large trees growing along the sides. There is ample evidence of considerable surface run-off and erosion in numerous locations below the dam crest which have cut out rather deep erosion channels, especially at the corners of the bridge wingwalls. The flatter upstream embankment slopes are very irregular and it appears the lake has silted up considerably against the upstream face. The bulkhead constructed along the upstream face, although rebuilt in 1940, is in an extremely poor condition where it is exposed. Major portions are completely demolished. The embankment backslopes shows evidence of numerous wet areas at the lower elevations, especially at the right abutment (in the vicinity of the old grist mill raceway). As can be seen in the appended photographs, there are numerous large (24-30") trees on the slopes and the possibility of piping around the root systems is of major concern. The top of the dam is quite rough and is composed of granular material in a loose condition. It requires additional clay binder and compaction to stabilize the surface which now is very irregular as a result of vehicular traffic which trespass onto the property.

c. Appurtenant Structures

The reinforced concrete arch culvert is in moderately adequate structural condition. The wingwalls and parapets display numerous cracked and spalled areas but the structurally important zones are in an integral condition. Several horizontal construction joints in the wingwalls are eroded and separated and tierods have been installed between the west wings but whether or not these were placed during the initial construction is not known (they are not indicated on the 1928 plans). The semi-circular culvert opening has a 7-foot intrados and a clear span of 14 feet. The present headroom above the reinforced concrete invert slab is about 13 feet. The invert is founded on 8 x 8 inch timber mudsills which are supported on timber piling as are the main footings of the arch and wingwalls. Due to the depth of flow, the invert slab could not be observed. The vertical expansion joints at the corners of the wingwalls have completely disintegrated and are clogged with dirt. The vertical surfaces immediately below these joints are badly spalled and need patching. The embankment fill at each end of the downstream wingwalls is seriously eroded to a depth of 3 to 5 feet. As previously stated, there is an apparent lack of binder in the uppermost layers of embankment fill, especially near the spillway. This was further indicated by deposits of clean sand and gravel aggregate in the downstream channel (as a result of recent erosion).

The spillway inlet is a 3-sided reinforced concrete frame built monolithically into the bridge wingwalls on the south fascia. It is a type of design seen frequently in Gloucester County on roadway construction built in the 1920's and functions quite satisfactorily for the purpose intended. Two sets of timber flashboards 3 feet wide are positioned in vertical concrete slots on the upstream face and the intake frame is covered

with a concrete access slab 1'-6" above the crest. This slab provides immediate access to the removable flash boards and theoretically could act as an anti-vortex device. However, as can be seen in Section 5, it somewhat limits the hydraulic capacity of the intake for surcharges greater than the 18-inch opening. The concrete on the intake is badly chipped and spalled and the lifting devices for removal of the stoplogs are completely destroyed. A type of chain-hoist attachment on the concrete railing and shackles was attached to the stoplogs but it is completely vandalized.

The iron millrace sluice gate at the right abutment is extremely old and demolished beyond repair. However, the gate could be employed in an emergency situation, if repaired. Immediately downstream in the raceway there is considerable steel and construction debris from the old mill equipment and building foundations.

d. Downstream Channel

The South Branch of Timber Creek flows almost due north after passing the dam in a heavily wooded low marshy area between 400 to 500 feet wide. Above this undeveloped terrain, the wooded side banks gradually rise 20 to 30 feet and there are several residences constructed beyond the right abutment. The low water channel is fairly well-defined and is about 30 feet wide on the average. About 1000 feet downstream, the creek passes under Green Tree Road in a 10-foot metal culvert. The road embankment is about 20 feet above the flowline. Below Green Tree Road, the flood plain broadens out into a wider marshy uninhabited area.

e. Reservoir Area

Bells Lake has a regular well-defined shoreline that extends about 0.5 mile upstream to its headwaters at Ganttown Road. The lake is bounded on the east with residential development which includes the Bells Lake

Community Club recreation beach. It is clear of debris and there is little evidence of silting except immediately adjacent to the dam face. The maximum depth of the lake is recorded to be slightly over 13 feet.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

Operational procedures were not physically observed by the inspection team. There is little day-to-day operation and the stoplogs are infrequently adjusted.

4.2 MAINTENANCE OF DAM
4.3 MAINTENANCE OF OPERATING FACILITIES

The dam and reservoir are maintained by Bells Lake Community in a workmanlike fashion as part of their seasonal recreation program. The lake was last dewatered in 1972.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

None exists except for monitoring during heavy storms.

4.5 EVALUATION

The present operational procedures and safeguards are deemed to be adequate, in view of the position of the dam (no downstream residential areas) and the relatively small contributory area.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

The spillway is a 3-sided concrete weir with 2 sets of timber flashboards, set about 6 inches below the top of concrete crest. Eighteen inches above the spillway crest, there is a maintenance slab which restricts the inflow for greater hydraulic heads. Based on the Recommended Guidelines for Safety Inspection of Dams, a spillway design flood (SDF) of 100-year frequency was selected by the inspection team. Inflow to the reservoir for the selected 100-year storm was computed utilizing precipitation data from Technical Publication 40 and NOAA Tech. Memo NWS - Hydro 35 by the HEC-1 program which gave a peak inflow of 3,553 cfs. Routing this storm through the reservoir reduced the peak discharge to 2,160 cfs. The spillway was a calculated capacity of 695 cfs and can thus accommodate only 32% of the design flood.

b. Experience Data

There are no stream flow records available for Bells Lake Dam, but it was recorded that in October, 1940 a flood occurred and approximately 50 feet of embankment was overtopped and washed out. There is no record of the amount of rainfall which fell diving this storm. There is no evidence of recent overtoppings although the dam was reportedly to be slightly awash during a storm in 1967. This hearsay information could not be verified.

c. Visual Observations

As a result of visual inspections and in view of the small drainage area, there is little danger from overtopping except that it would occur immediately at the ends of the bridge wingwalls and would tend to concentrate flows there and at the other low spots along the irregular embankment crest.

d. Overtopping Potential

Employing the discharge and spillway capacities, overtopping would occur in the event of a 100-year frequency storm. Since the SDF greatly exceeds the spillway capacity, the overtopping potential of the SDF was determined by calculating the overbank discharge. In this manner it was determined that the SDF would overtop the dam by slightly over one foot on the average. However, as pointed out in the preceding paragraph, the overtopping flow would be concentrated at the low points on the dam crest and most probably erode the downstream face of the embankment near the end of the bridge wingwalls.

e. Drawdown

At the present time complete drawdown is not easily accommodated as there is no practical method of removing all the stoplogs. However, in an emergency with the planking removed by force, the lake would take approximately one half day to drawdown from normal pool (El. 94.3) to the base of the stop logs (El. 80.8). There is no provision to further dewater the lake.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Based upon the field inspection of existing conditions and the single 1928 design plan for the spillway culvert structure, the structural aspects of the Bells Lake Dam are deemed to be in a fair condition commensurate with its 50 years of service. Although no high hazard safety condition is foreseen, a collapse could endanger the heavily travelled Green Tree Road immediately downstream. The spillway structure is in need of superficial repair of its concrete elements but its foundation and major elements are believed to be in a sufficiently integral condition to provide many years of additional service. The auxiliary sluiceway at the right abutment is beyond repair and should be safe-loaded or sealed and the steel scrap littering the downstream raceway should be removed and the void backfilled to the normal 2:1 embankment slope (after proper foundation analysis and preparation.) There is considerable seepage in this area which should be corrected when filling in the downstream canal and rebuilding the backslope. The seepage potential and the composition of the old roadway embankment which forms the dam crest was of major concern to the inspection team. There is an apparent lack of clay binder in the most recently deposited repair fill (placed in 1974) and much of this has eroded away, especially around the ends of the spillway wingwalls. The top surface is extremely loose and badly ravelled by vehicular rutting. The shoulder zones are unstable and in a loose condition which will continually worsen and erode with time. The remaining vestiges of the timber bulkhead are beyond repair but the upstream bank appears stable enough not to dictate a replacement in kind.

b. Design and Construction Data

Although no hydraulic or structural computations were located, a review of the available plan indicates that the concrete intake and arch culvert were conservatively designed and in spite of their age, are believed to be in an adequate structural condition as long as the foundations are not undermined.

c. Operating Records

No records are available but the dam appears to be operating satisfactorily. The only known instance where overtopping caused any appreciable damage occured in 1940 and may have been the result of additional flashboards having been placed on the spillway crest at that time.

d. Post Construction Changes

The only post-construction changes have been the replacement of embankment material in 1940, 1968 and 1974 and a replacement of new timber stoplog planking and hoisting mechanism in 1967.

e. Seismic Stability

Bells Lake Dam is located in Zone 1 and due to its embankment width and spillway geometry, has negligible potential vulnerability regarding potential earthquake loadings. The depth to bedrock in the vicinity is thought to be over 100 feet and the dam is underlain with recent alluvium sands and silts with some clay (but of insufficient amounts to consider liquification a major concern). Significant amounts of organic material may be present near the surface. Experience indicates that dams in Zone 1 which have adequate stability under static conditions will have an adequate factor of safety under dynamic loading conditions.

SECTION 7 - ASSESSMENTS/RECOMMENATIONS/ PROPOSED REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Subject to the inherent limitations of the Phase I visual inspection, Bells Lake Dam is classified as being in a moderately fair but sound structural condition although the spillway is incapable of passing the design flood. The dam embankment is built of unknown composition but due to its broad width to height ratio and lack of any major evidence of seepage, (except at the auxiliary spillway) is felt to be of a sufficiently impervious condition to withstand normal hydraulic heads as long as it is not overtopped. The present spillway capacity is inadequate and does not meet the requirements of the Recommended Guidelines for Safety Inspection of Dams, being able to accommodate only 32% of the design flood as calculated by Corps of Engineers criteria. The major distressed areas are at the ends of the bridge wingwalls but this is of secondary importance vis a vis the overall stability of the dam except that overtopping could tend to concentrate damaging flows in these areas. There is no economical or hydraulically feasible way to increase the present spillway's capacity without major reconstruction effort.

b. Adequacy of Information

The information gathered for the Phase I inspection is deemed to be adequate regarding the structural stability of the dam. However, no recent surveys have been made since the 1974 survey of conditions by the State Bureau of Water Control.

c. Urgency

No immediate urgency is attached to implementing further studies and it is recommended that the

remedial measures enumerated below be taken under advisement in the future.

d. Necessity for Further Study

Due to the significant hazard classification of the dam and the fact that damage to the downstream road is a possibility in case of a failure, further engineering studies are deemed necessary regarding the embankment composition (zoning and permeability) and further hydraulic/hydrologic evaluation of the spillway is recommended.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

a. Alternatives

On the basis of visual inspection, improvements to the present spillway to increase its capacity are not warranted. The exposed concrete surfaces should be sandblasted and repaired with epoxy-mortar coatings or dry-gunning and the expansion joints cleaned out and recaulked. The hoisting device for the stoplogs should be rehabilitated. The downstream face of the embankment at the extreme low points each side of the spillway could be further protected with slope paving and, in effect, act as an auxiliary spillways to accommodate and channelize overtopping floods. Additionally, the backslope areas at the ends of the bridge wingwalls should be regraded and protected with slope paving. Other remedial measures to be taken under advisement include:

1) removal of the trees on the downstream embankment to lessen the piping potential,

2) add additional riprap stone at the downstream pool immediately below the culvert outlet, and

3) remove the auxiliary sluiceway at the right abutment together with the grist mill debris. Safeload the existing culvert and build new embankment in the approach area and downstream power canal.

b. O&M Maintenance and Procedures

No additional procedures other than those presently in effect appear to be warranted in view of the above assessment.

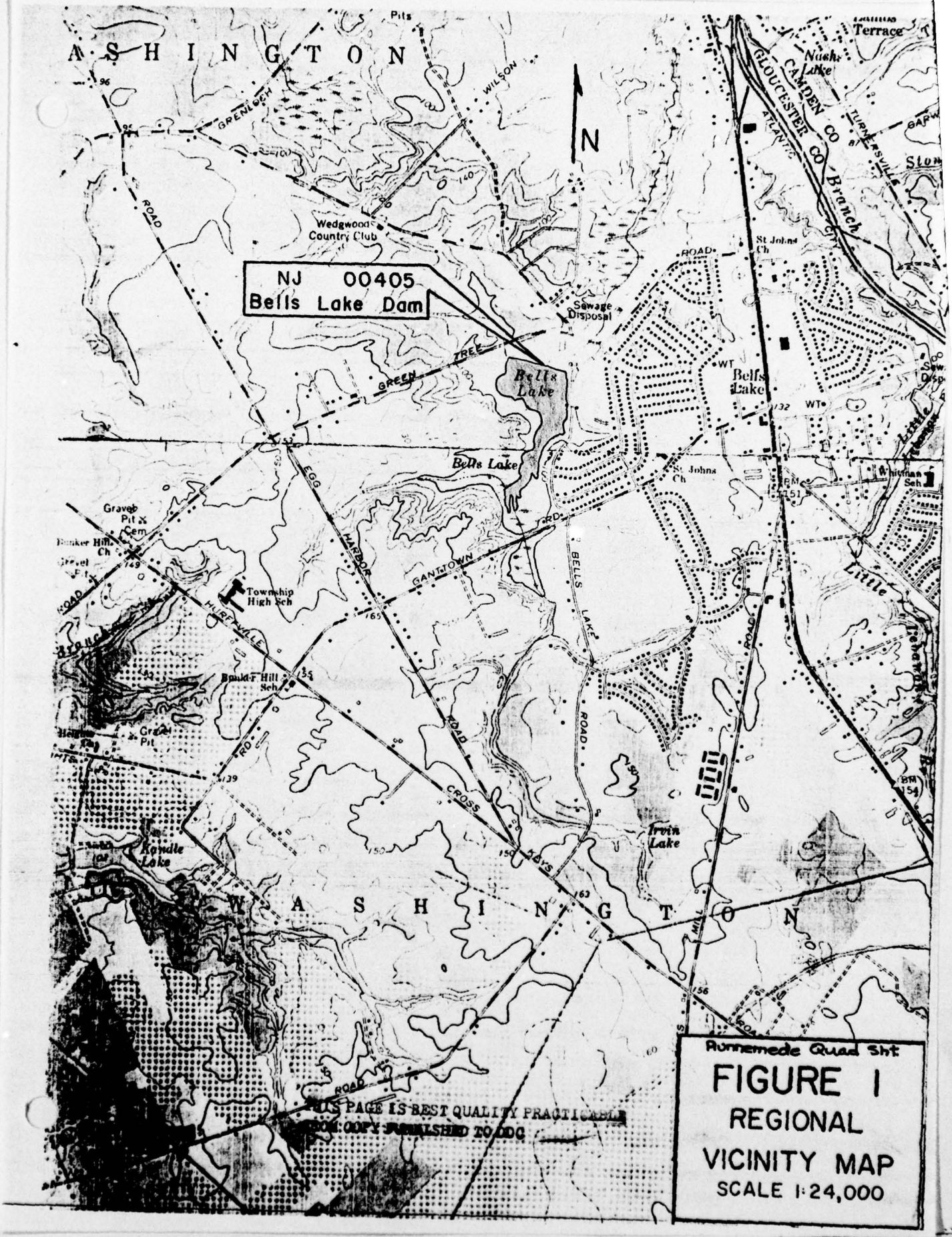

FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:24,000

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BY_____ DATE 4-79

CHKD. BY_____ DATE_____

LOUIS BERGER & ASSOCIATES INC.

BELLS LAKE DAM INSPECTION

SHEET NO._____OF_____

PROJECT C 226

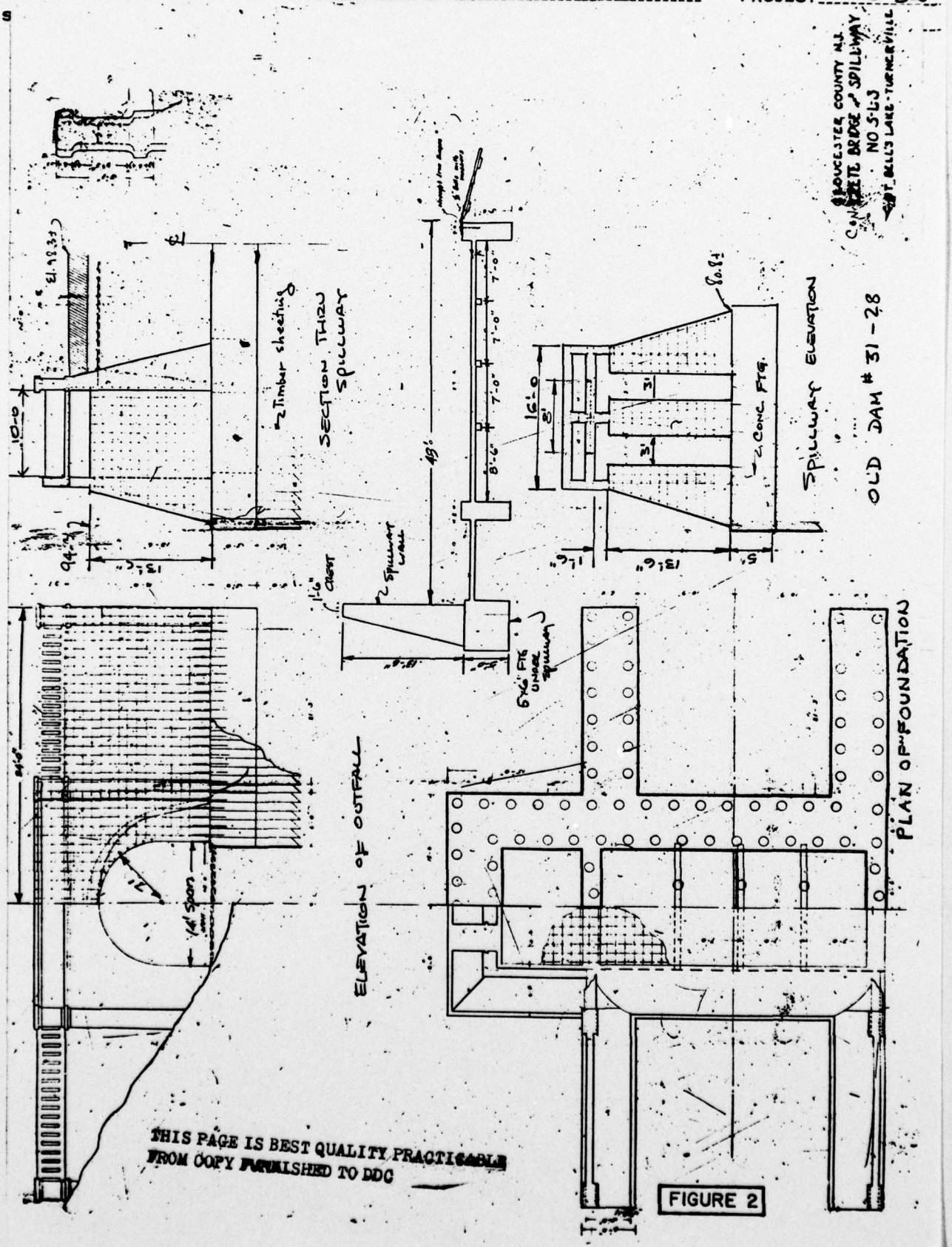

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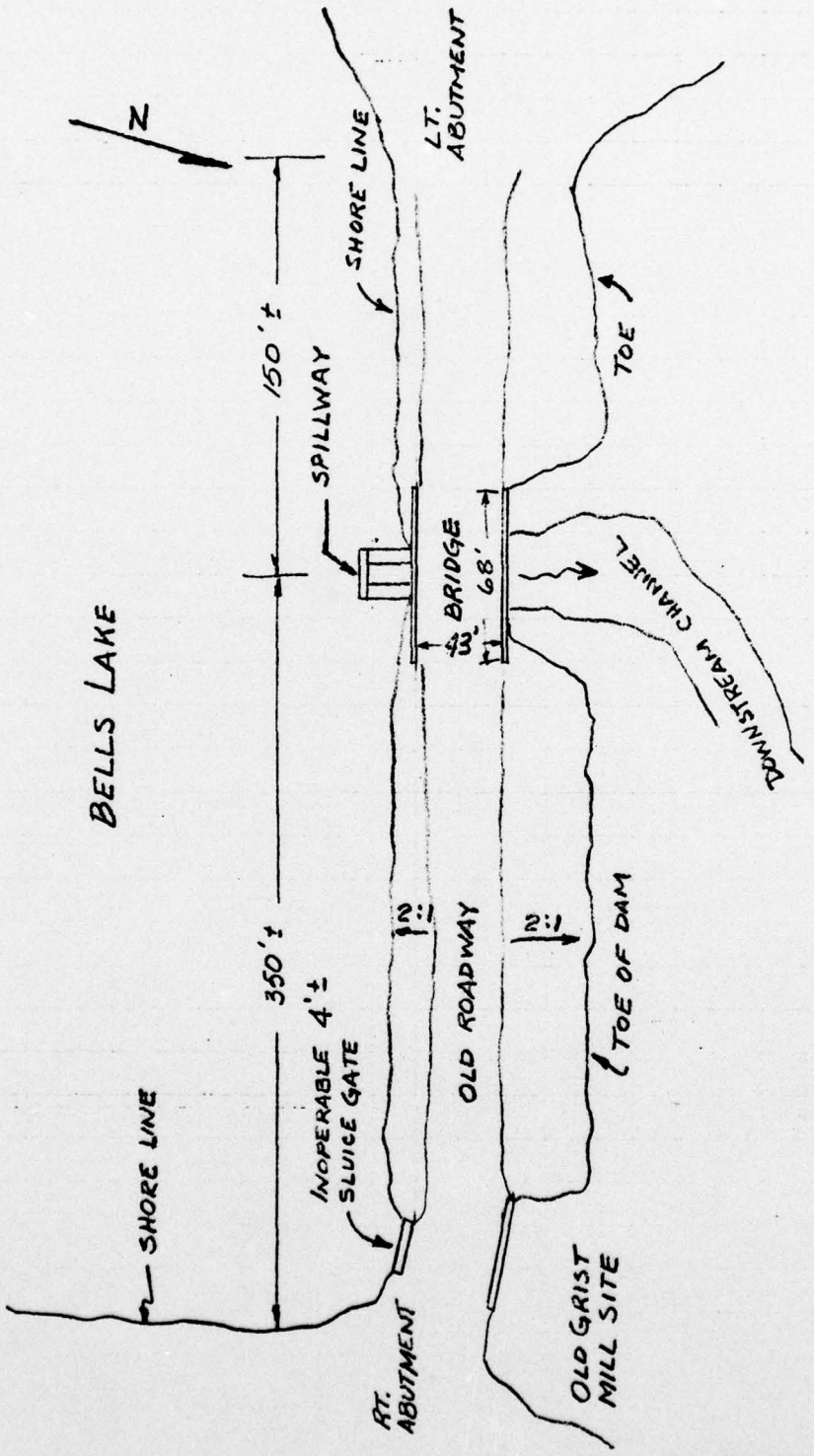
FIGURE 2

BY D.L. DATE Jan '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ BELLS LAKE DAM INSPECTION PROJECT C-226

SUBJECT GENERAL PLAN



PLAN OF DAM
FIGURE 3

Check List
Visual Inspection
Phase 1

Name Dam Bells Lake Dam County Gloucester State New Jersey Coordinators NJDEP

Date(s) Inspection Dec.6, 1978 Weather Clear Temperature 50°

Pool Elevation at Time of Inspection + 94.1 M.S.L. Tailwater at Time of Inspection + 80.0± M.S.L.

Inspection Personnel:

K. Jolls E. Simone

D. Lang

M. Carter

K. Jolls Recorder

Dam No. 00405

CONCRETE/MASONRY DAMS

SUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Satisfactory	
DRAINS	None	
WATER PASSAGES	Concrete headwall with 4' x 4' steel vertical lift gate at right abutment, totally inoperative.	
FOUNDATION	Sand embankment, bridge on timber piling.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Bridge structure apparent replacement for older intake structure at right abutment. Major cracking in bridge wingwalls. Steel tie rods added to south end of bridge.	
STRUCTURAL CRACKING	Yes - at bottom of NW wingwall.	
VERTICAL AND HORIZONTAL ALIGNMENT	Satisfactory	
MONOLITH JOINTS	None	
CONSTRUCTION JOINTS	Expansion joints at wingwall and abutment badly decomposed.	

EMBANKMENT

SUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	Very old embankment (judging from tree sizes). Predates 1928 intake bridge structure by 60-80 years. Trees upwards of 30" ø.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Downstream embankment slopes poorly defined, were originally 2:1. Upstream slopes gradually into lake, remnants of old timber cribwall (all whalers and sheeting completely gone).	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Heavy erosion at end of wingwalls.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Satisfactory - was old roadway, present condition has several low spots where overtopping flows would tend to concentrate.	
RIPRAP FAILURES	None - no riprap.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
	Visual inspection of embankment materials indicated; fine sand, trace gravel, very permeable. Dam embankment may be very porous.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Satisfactory	
ANY NOTICEABLE SEEPAGE	Yes - however, no particular locations could be found where seepage was concentrated. Swampy marsh all along toe of dam.	
STAFF GAGE AND RECORDER	None observed.	
DRAINS	None	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Concrete badly spalled in several areas. In spite of age, structure still has integrity.	
INTAKE STRUCTURE	Badly deteriorated, needs repair work. Vertical lift mechanism on timber planking is missing. Timber appears as though it could not be lifted anyway.	
OUTLET STRUCTURE	Bridge opening.	
OUTLET CHANNEL	See ungated spillway section.	
EMERGENCY GATE	None, operative gate at right abutment appears to have been used as intake for old mill site just below. Probably could be opened if necessary, little capacity though. See Water Passages.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	2-timber flashboard openings in concrete drop inlet. Concrete deteriorated.	
APPROACH CHANNEL	None - Bells Lake immediately above dam and spillway.	
DISCHARGE CHANNEL	Natural stream channel heavily wooded. Low lying area not well defined, 10'-15' wide.	
BRIDGE AND PIERS	See Concrete Dam section.	

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 observed	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Well defined shore-line wooded banks, appears to be little fluctuation in lake level.	
SEDIMENTATION	None observed.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Narrow 10-15' wide meandering natural channel, low lying, heavily wooded marshy area. Green Tree Road embankment several hundred feet downstream, elevation about same as top of dam. 12' elliptical CMP under embankment, invert about 20' below roadway.	
SLOPES	Flat floodplain.	
APPROXIMATE NO. OF HOMES AND POPULATION	None within flood plain area.	

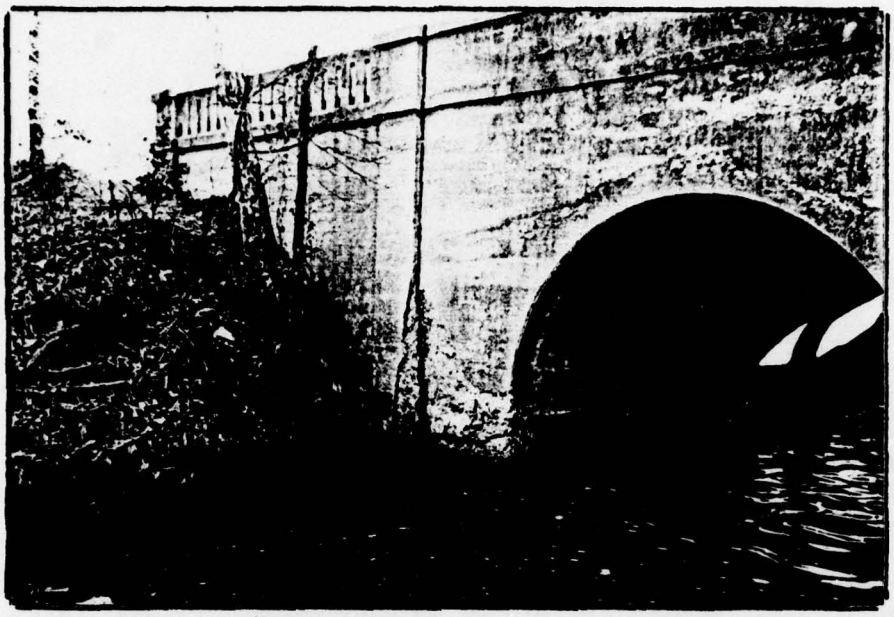
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None available
REGIONAL VICINITY MAP	Available
CONSTRUCTION HISTORY	None available
TYPICAL SECTIONS OF DAM	None available
HYDROLOGIC/HYDRAULIC DATA	None available
UTLETS - PLAN	Available (bridge plan)
- DETAILS	Available
-CONSTRAINTS	None available
-DISCHARGE RATINGS	None available
INFALL/RESERVOIR RECORDS	None available

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS	Available
HYDROLOGY & HYDRAULICS	Available
DAM STABILITY	None available
SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS	None available
BORING RECORDS	None available
LABORATORY	None available
FIELD	None available
POST-CONSTRUCTION SURVEYS OF DAM	None available
BORROW SOURCES	Not available

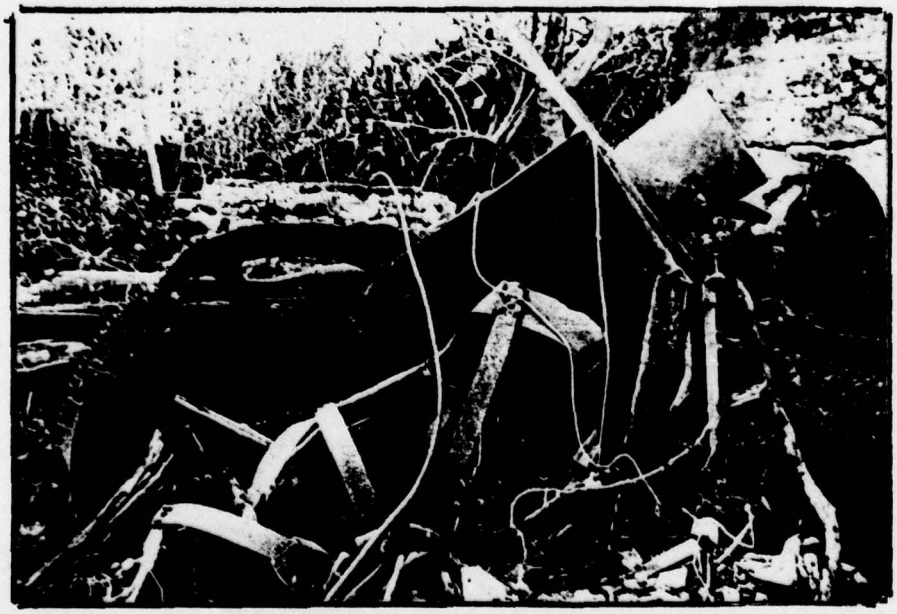
ITEM	REMARKS
MONITORING SYSTEMS	Not available
MODIFICATIONS	Available
HIGH POOL RECORDS	None available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Available
PRIOR ACCIDENTS OR FAILURE OF DAM	Available
DESCRIPTION	Available
REPORTS	Not available
MAINTENANCE	None available
OPERATION	None available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

ITEM	REMARKS
SPILLWAY PLAN	Available
SECTIONS	Available
DETAILS	Available
OPERATING EQUIPMENT PLANS & DETAILS	Not applicable



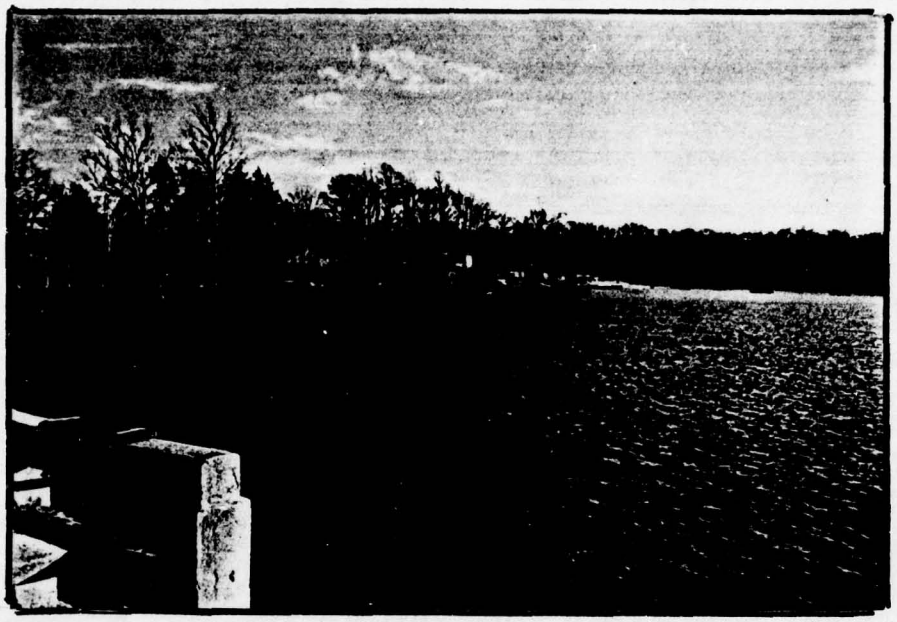
Downstream bridge opening

December 1978



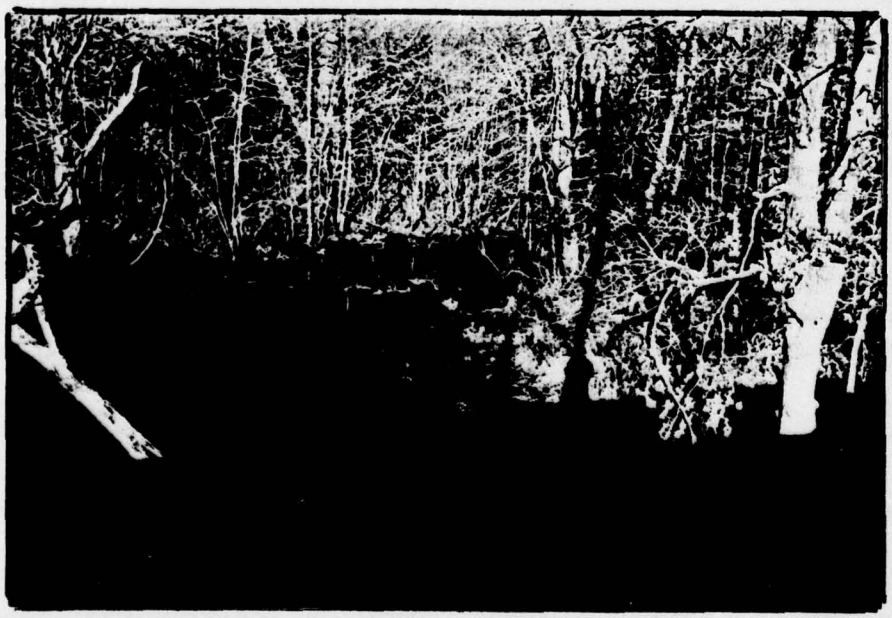
Remains of old mill

December 1978



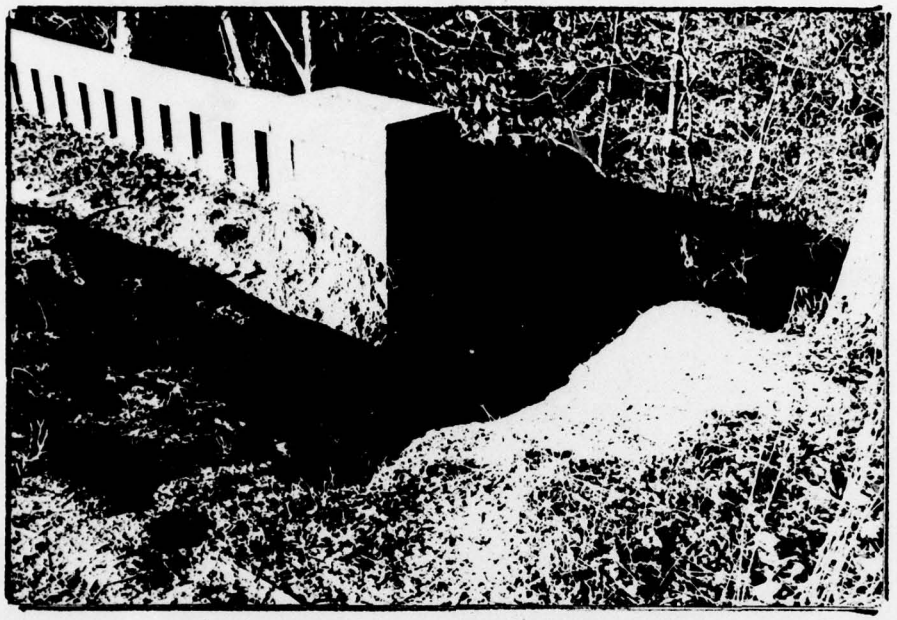
Bells Lake

December 1978



Downstream channel

December 1978

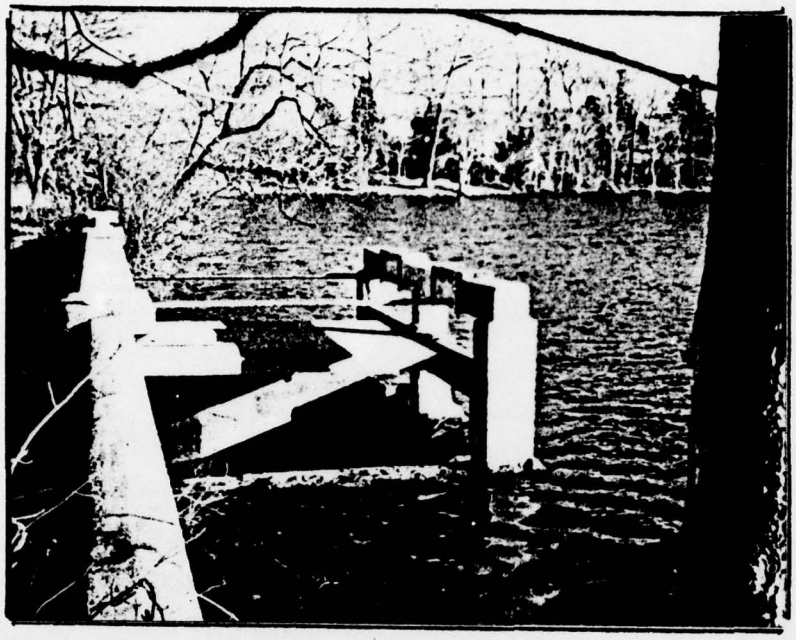


Erosion at NE wingwall

December 1978

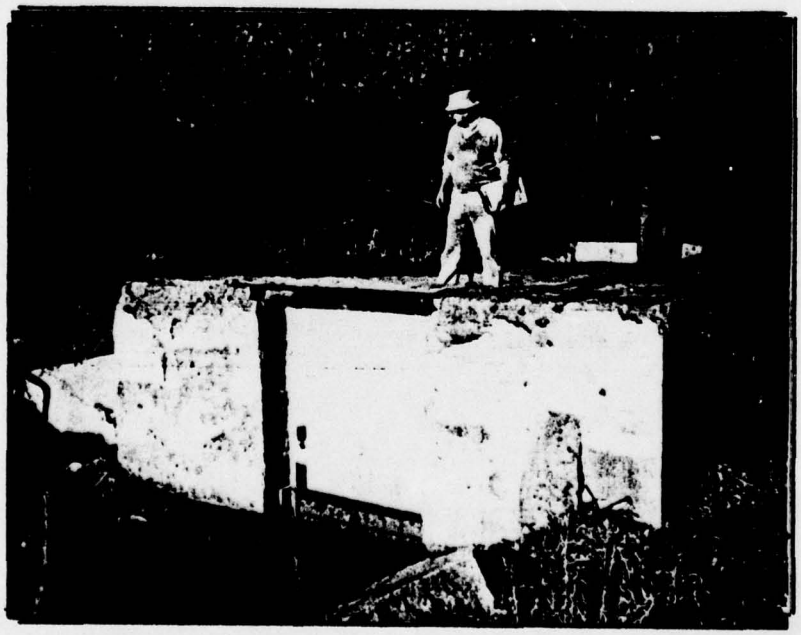
View East along dam crest

December 1978



Spillway

December 1978



Inoperative sluicegate

December 1978

Dam No. 00405

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2.9 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): + 94.3 M.S.L. (125 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): + 98.3 M.S.L. (343 acre-feet)

ELEVATION MAXIMUM DESIGN POOL:

ELEVATION TOP DAM: +98.3 M.S.L.

CREST:

a. Elevation + 95.8 ±
b. Type Sharp crested weir (3 sided)
c. Width 1'-6"
d. Length 29 feet
e. Location Spillover 300' ± from right abutment.
f. Number and Type of Gates 2'-3' wide stoplogs

OUTLET WORKS:

a. Type Vertical lift
b. Location Left abutment
c. Entrance inverts 90.5 ±
d. Exit inverts Unknown
e. Emergency draindown facilities None

HYDROMETEOROLOGICAL GAGES: None

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 695 cfs

BY D. L. DATE Jan 79 | **LOUIS BERGER & ASSOCIATES INC.** | SHEET NO. A1 OF.
CHKD. BY DATE | BELLS LAKE DAM INSPECTION | PROJECT C-226
SUBJECT

CALCULATION OF T_c :

U.S. NAVY & TEXAS HIGHWAY DEPARTMENT METHOD

Channel Length - 11,700'
Elev. Diff. - 46'
Slope - 46/11,700 = 0.39 % T_1 = 1.63
assume vel. - 2 f/s in channel

Overland flow:
Length - 1000'
Elev. diff. - 16'
Slope - 1.6 %
use vel. - 1.0 f/s $T = .28$

$\Sigma T = T_c = 1.91$

CALIFORNIA CULVERTS METHOD

L = 2.22 miles
H = 46'

$$T_c = \left[\frac{11.9 \times (2.22)^3}{46}\right]^{0.385} = 1.49 \text{ hours}$$

Use value of 1.91

$$T_p = \frac{0.25}{2} + (0.6 \times 1.91) = 1.27 \text{ hours}$$

$$Q_p = \frac{484 \times 2.9 \times 1}{1.27} = 1105 \text{ cfs.}$$

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BELLS LAKE DAM INSPECTION

SHEET NO. A2 OF.
PROJECT C-226

TIME (T)	T/T_p	Dimensionless Ordinate (DO)	$Q_p \times DO = Q$
0.25	0.20	.075	83
0.50	0.39	.268	296
0.75	0.59	.560	619
1.00	0.79	.870	961
1.25	0.98	.980	1083
1.50	1.18	.920	1017
1.75	1.38	.768	849
2.00	1.57	.590	652
2.25	1.77	.420	464
2.50	1.97	.335	370
2.75	2.17	.250	276
3.00	2.36	.180	199
3.25	2.56	.140	155
3.50	2.76	.100	111
3.75	2.95	.081	90
4.00	3.15	.06	66
4.25	3.35	.0477	53
4.50	3.54	.030	33
4.75	3.74	.0065	7
5.00	3.94	.004	4
			7388

Obtained from pg. 74 'Design of Small Dams'
assumed straight lines between points on curve
except on points of inflection

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SUBJECT_____

Precipitation data from T.P. 40 & NOAA Technical Memorandum NWS HYDRO-35 (See depth duration curve over leaf)

Time	Precipitation	Δ	Rearrange Δ
0.25	1.7	1.7	0.06
0.50	2.4	0.7	0.06
0.75	2.8	0.4	0.06
1.00	3.1	0.3	0.07
1.25	3.4	0.3	0.08
1.50	3.7	0.3	0.09
1.75	3.86	0.16	0.11
2.00	4.00	0.14	0.14
2.25	4.11	0.11	0.30
2.50	4.22	0.11	0.30
2.75	4.31	0.09	0.70
3.00	4.40	0.09	1.70
3.25	4.49	0.09	0.40
3.50	4.57	0.08	0.30
3.75	4.64	0.07	0.16
4.00	4.71	0.07	0.11
4.25	4.78	0.07	0.09
4.50	4.84	0.06	0.09
4.75	4.90	0.06	0.07
5.00	4.96	0.06	0.07
5.25	5.02	0.06	0.06
5.50	5.08	0.06	0.06
5.75	5.14	0.06	0.06
6.00	5.20	0.06	0.06

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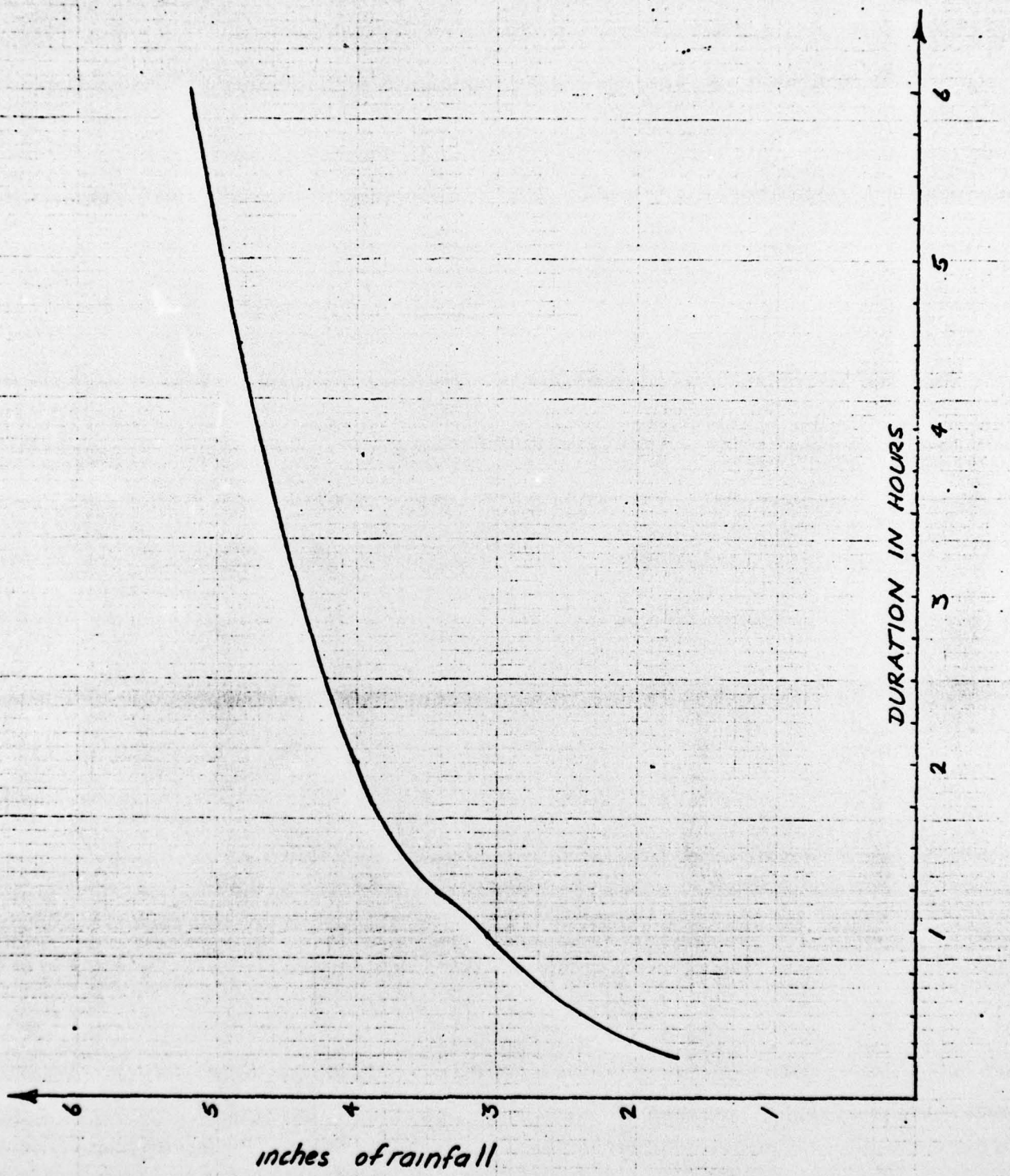
BY D.J.M DATE 1-79 SUBJECT SHEET NO. A4 OF

CHKD. BY DATE DEPTH DURATION CURVE JOB NO. C227

T.P. 40 & NOAA Tech. Memo NWS - HYRO 35



BY D.L. DATE Jan '79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A5 OF
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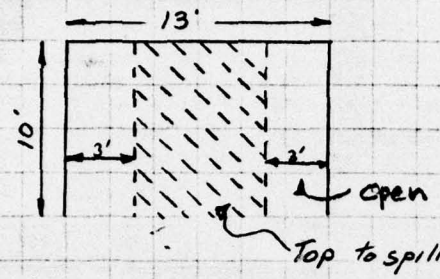
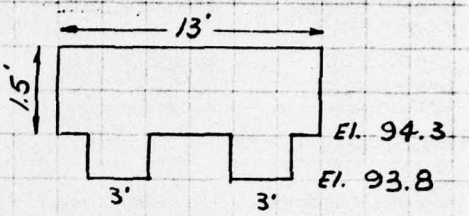
SUBJECT

PLAN OF SPILLWAY



EL. OF SPILLWAY



Assume control at inlet and that spillway acts as weir for 1.5' then as culvert

Discharge over crest L = 27'

H	C	Q
1	3.0	81
1.5	3.0	223

Disch. over flashboards L = 6'

H	C	Q
1.5	3.0	50
2.0	3.0	102

Over dam L = 500'

H	C	Q

use formula $Q = CA\sqrt{2gH}$

A ≅ 70 ft² C = 0.5

2		397
3		487
(ABUT. TOP) 4		562
5		628
6		688
7		743
8		794

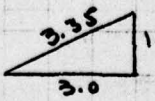
C = 0.65, A = 12

2.5		99
3.5		117
4.5		133
5.5		147
6.5		159
7.5		171
8.5		182

1	2.8	1400
2	2.8	3960
3	2.8	7275
4	2.8	11,200

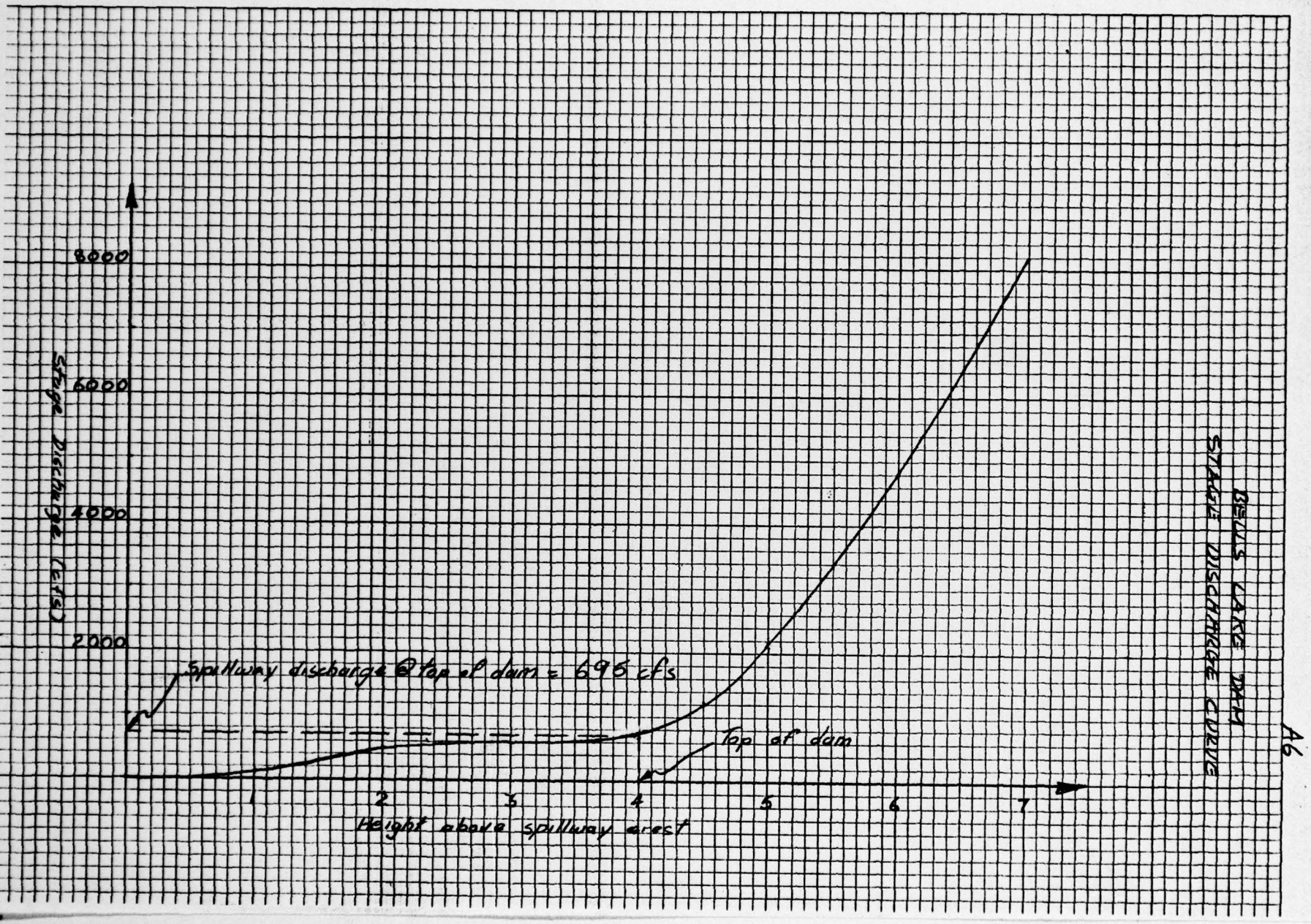
H	ΣQ
1	131
2	496
3	604
4	695
5	2175
6	4807
7	8189
8	12176

Three sided culvert



A = 10 × 3.35 × 2
= 67.0 say 70 ft²

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



A6

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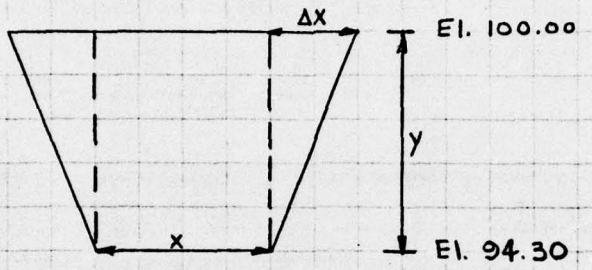
SUBJECT

STAGE STORAGE DATA:

Area of lake at El. 94.30 ≈ 31.7 acres
Area of contour at El. 100 ≈ 96.4 acres



Formula for each increment of storage

Volume = $(x + \Delta x)y$

HEIGHT (ft.)	STORAGE (acre-ft)
1	37
2	86
3	146
4	218
5	300
6	395
7	500
8	617
9	745

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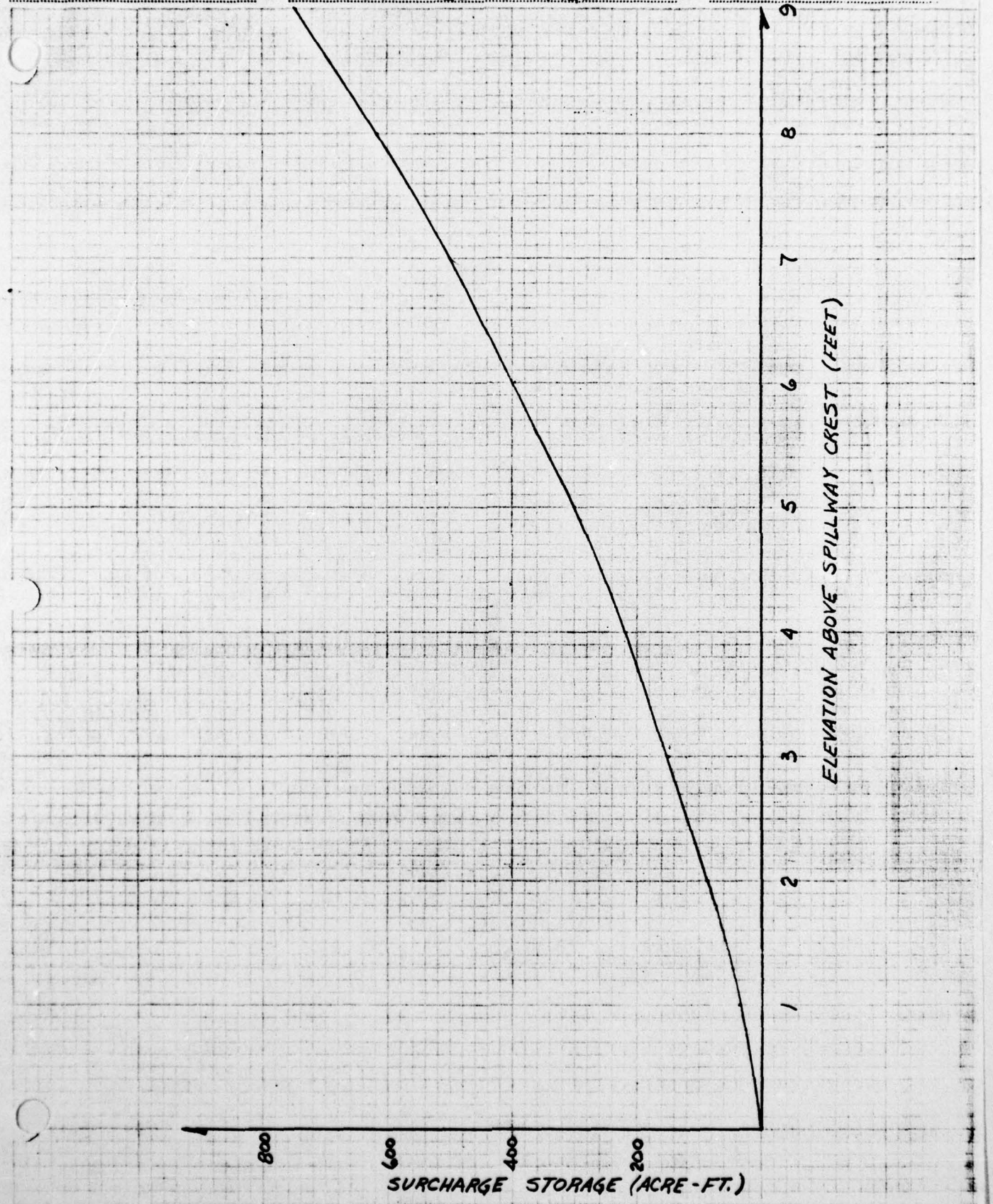
BY DL DATE Jan '79 SUBJECT BELLS LAKE DAM INSPECTION SHEET NO. A8 OF

CHKD. BY DATE SURCHARGE - STORAGE JOB NO. C-226



BY D.J.M DATE 4-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A9 OF...

CHKD. BY..... DATE..... BELLS LAKE DAM INSPECTION PROJECT C.226

SUBJECT..... Approximate drawdown calculation

Volume of lake = 125 acre feet

drawdown possible to El. 80.8

$\therefore h = 13.5'$

Assume drawdown in two stages ; ½ volume under head of 10.13' & ½ volume under head of 3.38'

Assume inflow of 6 cfs (= 2cfs/sq mile)

i) $h = 10.13'$

$Q = 3.0 \times 6 \times 10.13^{1.5} - 6 = 574$ cfs

$$\text{time} = \frac{125 \times 43560}{2 \times 574 \times 3600} = 1.32 \text{ hours}$$

ii) $h = 3.38'$

$Q = 3.0 \times 6 \times 3.38^{1.5} - 6 = 106$ cfs

$$\text{time} = \frac{125 \times 43560}{2 \times 106 \times 3600} = 7.13 \text{ hours}$$

Σ time = 8.5 hours

Say ½ day

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BY RGL DATE 4-79 | **LOUIS BERGER & ASSOCIATES INC.** | SHEET NO. A10 OF

CHKD. BY DATE | BELLS LAKE DAM INSP. | PROJECT C226

SUBJECT HEC-1

PELLS LAKE DAM INSPECTION SOUTH GROUP C226
BY D.J.MULLIGAN
JANUARY 1979

JOB SPECIFICATION

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

JOPER 3 NWT 0

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

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
9	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	-1	2.90	0.0	2.90	0.0	0.0	0	0	0

PRECIP DATA

NP	STORM	DAJ	CAK
24	0.0	0.0	0.0

PRECIP PATTERN

0.06	0.06	0.06	0.07	0.08	0.09	0.11	0.14	0.30	0.30
0.70	1.70	0.40	0.30	0.16	0.11	0.09	0.09	0.07	0.07
0.06	0.06	0.06	0.06						

LOSS DATA

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

GIVEN UNIT GRAPH, NUHGQ= 20

83.	296.	619.	961.	1083.	1017.	849.	652.	464.	370.
276.	194.	155.	111.	90.	66.	53.	33.	7.	4.

UNIT GRAPH TOTALS 7383. CFS OR 0.99 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q
1	0.06	0.00	0.
2	0.06	0.00	0.
3	0.06	0.00	0.
4	0.07	0.00	0.
5	0.08	0.00	0.
6	0.09	0.00	0.
7	0.11	0.02	2.
8	0.14	0.11	16.
9	0.30	0.27	71.

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BY RGL DATE 4-79
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SUBJECT _____

LOUIS BERGER & ASSOCIATES INC.

Bells Lake Dam Insp.
HEC-1

SHEET NO A 11 OF _____
PROJECT C226

10	0.30	0.27	198.
11	0.70	0.67	443.
12	1.70	1.67	921.
13	0.40	0.37	1643.
14	0.30	0.27	2510.
15	0.16	0.13	3264.
16	0.11	0.08	3553.
17	0.09	0.06	3417.
18	0.09	0.06	3014.
19	0.07	0.05	2498.
20	0.07	0.05	2004.
21	0.06	0.04	1648.
22	0.06	0.04	1326.
23	0.06	0.04	1065.
24	0.06	0.04	883.
25	0.0	0.0	724.
26	0.0	0.0	604.
27	0.0	0.0	489.
28	0.0	0.0	386.
29	0.0	0.0	277.
30	0.0	0.0	178.
31	0.0	0.0	122.
32	0.0	0.0	80.
33	0.0	0.0	56.
34	0.0	0.0	40.
35	0.0	0.0	28.
36	0.0	0.0	19.
37	0.0	0.0	13.
38	0.0	0.0	9.
39	0.0	0.0	6.
40	0.0	0.0	3.
41	0.0	0.0	2.
42	0.0	0.0	0.
43	0.0	0.0	0.
44	0.0	0.0	0.
45	0.0	0.0	0.
46	0.0	0.0	0.
47	0.0	0.0	0.
48	0.0	0.0	0.
49	0.0	0.0	0.
50	0.0	0.0	0.
51	0.0	0.0	0.
52	0.0	0.0	0.
53	0.0	0.0	0.
54	0.0	0.0	0.
55	0.0	0.0	0.
56	0.0	0.0	0.
57	0.0	0.0	0.
58	0.0	0.0	0.
59	0.0	0.0	0.
60	0.0	0.0	0.
61	0.0	0.0	0.
62	0.0	0.0	0.
63	0.0	0.0	0.
64	0.0	0.0	0.
65	0.0	0.0	0.
66	0.0	0.0	0.
67	0.0	0.0	0.
68	0.0	0.0	0.
69	0.0	0.0	0.
70	0.0	0.0	0.

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71	0.0	0.0	0.
72	0.0	0.0	0.
73	0.0	0.0	0.
74	0.0	0.0	0.
75	0.0	0.0	0.
76	0.0	0.0	0.
77	0.0	0.0	0.
78	0.0	0.0	0.
79	0.0	0.0	0.
80	0.0	0.0	0.
81	0.0	0.0	0.
82	0.0	0.0	0.
83	0.0	0.0	0.
84	0.0	0.0	0.
85	0.0	0.0	0.
86	0.0	0.0	0.
87	0.0	0.0	0.
88	0.0	0.0	0.
89	0.0	0.0	0.
90	0.0	0.0	0.
91	0.0	0.0	0.
92	0.0	0.0	0.
93	0.0	0.0	0.
94	0.0	0.0	0.
95	0.0	0.0	0.
96	0.0	0.0	0.
97	0.0	0.0	0.
98	0.0	0.0	0.
99	0.0	0.0	0.
100	0.0	0.0	0.
SUM	5.20	4.24	31512.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3553.	1305.	328.	315.	31512.
INCHES		4.19	4.21	4.21	4.21
AC-FT		647.	651.	651.	651.

HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
99	1	0	0	0	0	1

ROUTING DATA

GLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

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

STORAGE=	0.	37.	86.	146.	218.	259.	300.	395.	500.	617.
OUTFLOW=	0.	131.	496.	604.	695.	1330.	2175.	4807.	8189.	12176.

TIME	EOP STOR	AVG IN	EOP OUT
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.

BY RGL DATE 4-79

CHKD. BY ____ DATE ____

SUBJECT ____

LOUIS BERGER & ASSOCIATES INC.

Bells Lake Dam Insp.

HEC-1

SHEET NO. A13 OF ____

PROJECT C226

4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	1.	0.
8	0.	9.	1.
9	1.	44.	4.
10	4.	134.	13.
11	10.	320.	35.
12	23.	682.	80.
13	46.	1282.	200.
14	82.	2077.	468.
15	131.	2887.	577.
16	189.	3409.	658.
17	243.	3485.	1080.
18	280.	3215.	1761.
19	297.	2756.	2111.
20	299.	2251.	2160.
21	294.	1826.	2043.
22	284.	1487.	1848.
23	273.	1195.	1619.
24	262.	974.	1392.
25	252.	803.	1216.
26	242.	664.	1064.
27	233.	546.	921.
28	224.	437.	788.
29	216.	331.	692.
30	206.	227.	680.
31	195.	150.	666.
32	184.	101.	652.
33	172.	68.	637.
34	160.	48.	621.
35	148.	34.	606.
36	136.	23.	586.
37	124.	16.	565.
38	113.	11.	545.
39	102.	7.	525.
40	92.	5.	506.
41	82.	2.	464.
42	73.	1.	398.
43	65.	0.	341.
44	59.	0.	293.
45	53.	0.	251.
46	48.	0.	215.
47	44.	0.	184.
48	41.	0.	158.
49	38.	0.	135.
50	35.	0.	124.
51	32.	0.	115.
52	30.	0.	107.
53	28.	0.	99.
54	26.	0.	92.
55	24.	0.	86.
56	23.	0.	80.
57	21.	0.	74.
58	19.	0.	69.
59	18.	0.	64.
60	17.	0.	59.
61	16.	0.	55.
62	15.	0.	51.
63	13.	0.	48.
64	13.	0.	44.
65	12.	0.	41.
66	11.	0.	38.
67	10.	0.	36.
68	9.	0.	33.
69	9.	0.	31.
70	8.	0.	29.
71	8.	0.	27.
72	7.	0.	25.
73	6.	0.	23.
74	6.	0.	21.
75	6.	0.	20.
76	5.	0.	18.
77	5.	0.	17.
78	4.	0.	16.
79	4.	0.	15.
80	4.	0.	14.
81	4.	0.	13.
82	3.	0.	12.
83	3.	0.	11.
84	3.	0.	10.
85	3.	0.	10.
86	3.	0.	9.
87	2.	0.	8.
88	2.	0.	8.
89	2.	0.	7.
90	2.	0.	7.
91	2.	0.	6.
92	2.	0.	6.
93	2.	0.	5.
94	1.	0.	5.
95	1.	0.	5.
96	1.	0.	4.
97	1.	0.	4.
98	1.	0.	4.
99	1.	0.	3.
100	1.	0.	3.
SUM			31470.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2160.	1062.	328.	315.	31470.
INCHES		3.41	4.21	4.21	4.21
AC-FT		527.	651.	651.	651.

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	9	3553.	1305.	328.	315.	2.90
ROUTED TO	99	2160.	1062.	328.	315.	2.90

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