NATIONAL PROGRAM OF INSPECTION OF NON-FEDERAL DAMS, TENNESSEE. --ETC(U)
SEP 81 6 E MOORE

UNCLASSIFIED
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**SECURITY CLASSIFICATION OF THIS PAGE (When Date Entered)**
The emergency spillway has a maximum depth of 6.1 feet and a top width of 155 feet. The dam is in the intermediate size and high hazard potential category. The reservoir has sufficient storage/spillway capacity to safely pass the full FMP. Erosion is evident in the emergency spillway channel, on the embankment abutment contracts, and on the downstream slope. Indications of dispersive soils were noted on the downstream slope. Also, the downstream slope appeared to be excessively moist and some standing water was seen. Due to these findings, Candlewood Lake Dam is considered to be "significantly deficient".
Honorable Lamar Alexander  
Governor of Tennessee  
Nashville, TN 37219

Dear Governor Alexander:

Furnished herewith is the Phase I Investigation Report on Candlewood Lake Dam near Bolivar, Tennessee. The report was prepared under the authority and provisions of PL 92-367, the National Dam Inspection Act, dated 8 August 1972.

The report presents details of the field inspection, background information, technical analyses, findings, and recommendations for improving the condition of the dam.

Based upon the inspection and subsequent evaluation, Candlewood Lake Dam is classified as significantly deficient due to excessive erosion of the embankment and emergency spillway.

We do not consider this an emergency situation at this time, but the recommendation concerning repair and stabilization of all erosion on the dam and others contained in this report should be undertaken in the near future.

Public release of the report and initiation of public statements fall within your prerogative. However, under provisions of the Freedom of Information Act, the Corps of Engineers is required to respond fully to inquiries on information contained in the report and to make it accessible for review on request.

Your assistance in keeping me informed of any further developments will be appreciated.

Sincerely,

LEE W. TUCKER  
As stated  
Colonel, Corps of Engineers  
Commander

CF:  
Mr. Robert A. Hunt, Director  
Division of Water Resources  
4721 Trousdale Drive  
Nashville, TN 37220
PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM  
TENNESSEE

Name of Dam ......................... Candlewood Lake  
County .................................. Hardeman  
Stream ................................. Trib. of East Fork of Spring Creek  
Date of Inspection ..................... January 23, 1981

This investigation and evaluation was prepared by the Tennessee Department of Conservation, Division of Water Resources.

Prepared By: ______________________  
George E. Moore  
Regional Engineer

Approved By: ______________________  
Edmond B. O'Neill  
Chief Engineer  
Safe Dams Section

Approved By: ______________________  
Robert A. Hunt, P.E.  
Director, Division of Water Resources  
Tennessee Department of Conservation
PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam ......................... Candlewood Lake
County ................................ Hardeman
Stream ............................... Trib. of East Fork of Spring Creek
Date of Inspection ............... January 23 1981

ABSTRACT

This report is based on the findings of a Phase I inspection of Candlewood Lake Dam. The zoned earthfill embankment is 43.6 feet high and 800 feet long with a crest width of 24 feet. The embankment slopes are 1V:4.3H upstream and 1V:3.4H downstream. The dam impounds 574 acre-feet at normal pool level with 298 acres of flood storage. The drainage area is 167 acres. The service spillway is a steel stand pipe connected to a 30 inch steel pipe passing under the dam. The drawdown drain is a 24 inch gate valve at the base of the riser. The emergency spillway is an earth saddle with a parabolic asphalt control section. The emergency spillway has a maximum depth of 6.1 feet and a top width of 155 feet. The dam is in the intermediate size and high hazard potential category. The reservoir has sufficient storage/spillway capacity to safely pass the full PMF. Erosion is evident in the emergency spillway channel, on the embankment abutment contacts, and on the downstream slope. Some indications of dispersive soils were noted on the downstream slope. Also, the downstream slope appeared to be excessively moist and some standing water was seen. Due to these findings, Candlewood Lake Dam is considered to be significantly deficient.
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Abstract

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SECTION 1 - GENERAL

1.1 Authority - The Phase I inspection of this dam was carried out under the authority of Tennessee Code Annotated, Sections 70-2501 to 70-2530, The Safe Dams Act of 1973, and in cooperation with the U. S. Army Corps of Engineers under the authority of Public Law 92-367, The National Dam Inspection Act.

1.2 Purpose and Scope - The purpose of a Phase I investigation is to develop an engineering assessment of the general condition of a dam with respect to safety and stability. This is accomplished by conducting a visual inspection, reviewing any available design and construction data, and performing appropriate hydraulic, hydrologic, and other analyses. A comprehensive description of the Phase I investigation program is given in Recommended Guidelines for Safety Inspection of Dams, Department of the Army, Chief of Engineers, Washington, D. C. 20314.

1.3 Past Inspections - Past inspections of Candlewood Lake Dam include a cursory inspection by George Moore and Troy Wedekind of the Tennessee Division of Water Resources on February 14, 1979. Some erosion on the downstream slope and the lack of a vegetative cover on the emergency spillway were noted at this time. Several inspections were made during the construction of the dam by Ed O'Neill also of the Tennessee Division of Water Resources.

1.4 Miscellaneous Details - The day of the inspection was clear with light breezes and an ambient temperature of about 45°F. A rainfall had occurred on February 27, 1981, three days before the inspection. The rainfall was not sufficient to raise the lake level to normal elevation but it did somewhat obscure the normal conditions on the downstream slope of the dam.

1.5 Inspection Team Members - The inspection was conducted by the following State personnel:

Ed O'Neill, Chief Engineer
George Moore, Regional Engineer
Anthony Privett, Engineering Co-op
SECTION 2 - PROJECT DESCRIPTION

2.1 Location - The project is located in Hardeman County, Tennessee, about 4 miles east of Saulsbury, Tennessee. The dam is located on the Saulsbury topographic quadrangle at 89°01'05" west longitude and 35°02'53" north latitude. Location maps are provided in Appendix B of this report. The dam intercepts an unnamed tributary about 1 mile from the east fork of Spring Creek. The east fork of Spring Creek flows 5.7 miles to its confluence with several other creeks to form the mainstem of Spring Creek.

2.2 Description

2.2.1 Embankment (Design data is shown in parenthesis) - The Candlewood Lake Dam is a zoned earth embankment dam with a straight alignment, a maximum height of 43.6 feet (35.8 feet), and a length of 800 feet (775 feet). The crest width is 24 feet (30 feet) and the crest elevation is 535 feet msl. The upstream slope is about 1V:4.3H (1V:3.1H) from the water surface to the crest. The downstream slope is about 1V:3.4H (1V:3.0H). An asphalt road runs on the crest. The upstream and downstream slopes are covered by grass. The dam is located on the Claiborne and Wilcox formation of the Mississippi Embayment Sediments. These are irregularly bedded sands of the Tertiary Period locally interbedded with lenses and beds of gray and white clay, silty clay, lignitic clay, and lignite. A hand auger sample of the embankment material is a silty clay of group CL in the Unified Soils Classification system. Embankment sketches are provided in Appendix B.

2.2.2 Service Spillway/Drawdown Drain - Both facilities are served by a 30" steel pipe riser and a 30" steel pipe through the dam. The crest elevation of the riser is 521.0' msl. The drawdown drain is a 24" gate valve at the base of the riser.

2.2.3 Emergency Spillway - The emergency spillway, located at the west abutment of the dam, is parabolic in shape with a maximum depth of 6.1' and a top width, at the low point of the dam, of 155'. An asphalt road covers the control section of the spillway. The entrance and exit channels have
sparse vegetation. The maximum capacity of the spillway is estimated to be 4530 cfs. The design plans call for a trapezoidal spillway with a base width of 75 feet and side slopes of 1V:3H with a maximum depth of 2 feet.

2.2.4 Reservoir and Drainage Area - The reservoir has a surface area of 43 acres at normal pool elevation with a fetch of 2000 feet. The normal impounding capacity of the reservoir is estimated to be 574 acre-feet with about 298 acre-feet of flood storage above normal pool. The drainage area is 167 acres and the predominant soils are Ruston, Lexington, and Providence. The watershed is being developed into a medium density residential subdivision.

2.2.5 Miscellaneous - The dam is currently owned by the Candlewood Lakes Property Owner's Association (W. J. Arnold, President). The dam was built in 1976 as a recreational lake for the Candlewood subdivision being developed by the Terra Aqua Corporation. The dam was designed by Ragon Engineering Company with soils testing subcontracted to Construction Materials Lab, Inc. The construction was performed by Frank Mustin of Memphis and by S & W Construction Company. The drainage filter under the toe of the dam was installed about a year after completion of the initial construction. The installation required partial excavation of the downstream slope. No other major repairs have been reported. A Certificate of operation was issued by the State in 1976. Ownership of the lake was turned over to the Property Owner's Association in 1979. No instrumentation was found.
SECTION 3 - INSPECTION FINDINGS

3.1 Specific Findings

3.1.1 Jug holes (indicative of dispersive soils) and other erosion are occurring on the downstream slope. A change in vegetation and erosion patterns occurs about halfway down the slope at the maximum section forming a horizontal line across the downstream slope. A major part of the erosion is occurring above the line which is apparently the result of repair work on the downstream slope. The lower part of the embankment has a much denser grass cover than the upper part. Some erosion is occurring near the toe but no evidence of jugging was seen. Also the entire downstream slope was wet in comparison with the upstream slope and other dams seen on the same day. One area of standing water was found about 5 feet above the toe and 100 feet left of the service spillway. No flow or evidence of the transport of embankment material was seen.

3.1.2 The emergency spillway entrance and exit channels and side slopes are almost devoid of vegetative cover. The exit channel has a relatively steep slope and some erosion gullies have formed. A large amount of material has been mechanically removed from the right edge of the downstream slope. This could possibly allow flow to impinge upon the embankment during high stages.

3.1.3 Gullies have formed on both the upstream and downstream slope on the right embankment abutment contact. The upstream gully is about 3 feet deep and the downstream gully is about 15 feet deep.

3.1.4 The upstream slope has no wave protection and some minor erosion and sloughing has occurred.

3.1.5 Standing water was seen in what appears to be a low area about 25 feet left of the channel and 50 feet downstream of the toe. No evidence of flow from the area was seen.

3.1.6 A flow of about 1 gpm was coming from the service spillway although the water level was below the spillway crest indicating a possible leak in the drawdown drain.
3.1.7 According to OCE guidelines, the dam is in the intermediate size and high hazard potential classifications. As such, the structure is required to pass the full probable maximum flood (PMF). The volume of inflow during the PMF using Antecedent Moisture Condition II (AMC II) is 381 acre-feet. Analysis indicates that the structure can safely pass the AMC II PMF with about 5 feet of freeboard. Routing of the 1-10 day 100-year storm indicates that it will pass the structure with no flow through the emergency spillway.

3.1.8 The project is located in seismic zone 2.

3.1.9 A sample of the embankment material shows a silty clay of group CL in the Unified Classification System. The sample is a shallow depth (0.5-2.0') hand auger sample taken near the crest.

3.1.10 This dam is in the high hazard potential classification as outlined in the OCE guidelines. Failure of the dam could affect the maintenance office and the guard shack for the Candlewood subdivision, a main line of Southern Railway into Memphis, and State Highway 57, all of which are located within 0.2 miles downstream of the dam.

3.1.11 The measured configuration of the dam differs considerably from the design plans. The height of the dam measured from the service spillway outlet invert is 43.6 feet whereas the design dimension is 35.8 feet. The normal pool elevations are about 2 feet higher than designed and the freeboard is 5.6 greater. The maximum depth of the emergency spillway has been increased from 2.1 feet to 6.1 feet. The design slopes of the dam are 1V:3H, the measured slopes are 4.3H:1V upstream, and 1V:3.4H downstream. The crest width was decreased from 30 feet to 24 feet.

3.2 Conclusions and Recommendations

3.2.1 Conclusions

a. Indications of the possible presence of dispersive soils were found on the embankment.

b. Erosion on the embankment and in the emergency spillway is becoming excessive.
c. The downstream slope was excessively wet. The wetness is thought to be due to repair of gullied areas with uncompacted fill.

d. The structure appears to be adequate with respect to hydraulic and hydrologic considerations. However, at high stages, flow through the emergency spillway could impinge on the embankment.

e. The seismic resistance of this structure is unknown, but under this program, dams in seismic zone 2 may be assumed to be adequate against seismic loading if judged adequate in static stability requirements.

f. Due to these conclusions, this dam is considered to have a condition classification of "significantly deficient".

3.2.2 Recommendations

a. A qualified engineer should be engaged to:

1) Check for the presence of dispersive soils and recommend and implement action as necessary to stabilize the soils.

2) Provide recommendations for repair and stabilization of all erosion on the embankment, abutments, and in the emergency spillway.

3) Provide recommendations for regrading the emergency spillway exit channel so that flow will not impinge upon the embankment.

b. A soil binding grass cover should be established on all remolded areas and the grass cover on the upper portion of the downstream slope should be improved.

c. An emergency action plan should be developed to notify downstream residents in the event of a potentially hazardous situation.

d. A program of routine maintenance and periodic inspection should be established for the dam.
SECTION 4 - REVIEW BOARD FINDINGS

The Interagency Review Board for the National Program of Inspection of Non-Federal Dams met in Nashville on 18 June 1981 to examine the technical data contained in the Phase I Investigation report on Candlewood Lake Dam. The Review Board considered the information and recommended that (1) the removal of material from the emergency spillway by mechanical means should not be allowed to continue, (2) the reason for the discontinuity on the embankment should be determined and included in the report, (3) an emergency action plan should be developed, including a warning system to alert downstream residents, in the event a serious condition develops with the project, (4) the owner should establish a regular program of inspection and maintenance to provide detection and timely correction of problem areas, and (5) the condition classification should be changed from "deficient" to "significantly deficient". They agreed with other report conclusions and recommendations. A copy of the letter report presented by the Review Board is included in Appendix F.
APPENDIX A

DATA SUMMARY
APPENDIX A
DATA SUMMARY

A.1 Dam

A.1.1 Type - Zoned earthfill, linear alignment dam with a steel pipe service spillway and drawdown drain and an earth channel emergency spillway with a paved control section.

A.1.2 Dimensions and Elevations - (Elevations taken from design plans. Field measurements, shown parenthetically if different from design plans, are referenced to the top of the service spillway headwall at elevation 496.1' msl.)

a. Crest length - 775' (800')
b. Crest width - 30' (24')
c. Height - 35.8' (43.6')
d. Crest elevation - 527.5' msl (535')
e. Service spillway elevation - 521' msl (522.9')
f. Emergency spillway elevation - 525.5' msl (528.9')
g. Embankment slope, U/S - 1V:3H (1V:4.3H)
h. Embankment slope, D/S - 1V:3H (1V:3.4H)
i. Size classification - Intermediate

A.1.3 Zones, Cutoffs, Grout Curtains

A.1.3.1 Zones (Fill material given as per Unified Classification System)

a. Core material - CL
b. Core slopes (max.) - 1V:1.4H
c. U/S zone material - random fill
d. D/S zone (1) material - random fill
e. D/S zone (1) slopes (max.) - 1V:1.4H
f. D/S zone (2) material - SP-SC

A.1.3.2 Cutoff Trench (Filled as part of core)

a. Base width - 10'
b. Side slopes - 1V:2H
c. Bottom elevation - 470' msl (approx.)

A.1.3.3 Grout Curtains - None

A.2 Reservoir and Drainage Area

A.2.1 Reservoir - (Normal pool elevation 521' msl, 6.5' below the effective crest of the dam as per design plans)
a. Surface area - 43 acres  
b. Fetch - 2000 feet  
c. Capacity (normal) - 574 acre-feet  
d. Capacity (top of dam) - 872 acre-feet

A.2.2 Drainage Area

a. Size - 167 acres  
b. Maximum relief - 100'  
c. Soil - Ruston (B), Lexington (B), Providence (B)  
d. Cover - Medium density residential  
e. Runoff (P100)(AMC III) - 65.4 acre-feet  
f. Runoff (PMF)(AMC II) - 381 acre-feet

A.3 Outlet Structures

A.3.1 Drawdown Drain - (Gate valve at base of service spillway riser)

a. Valve diameter - 24"  
b. Invert elevation - 494' msl

A.3.2 Service Spillway - (Steel pipe riser connected to steel pipe with concrete anti-seep collars)

a. Riser diameter - 30"  
b. Pipe diameter - 30"  
c. Pipe length - 240'  
d. Gradient - 1%  
e. Anti-seep collars, size - 6" x 6' x 6'  
f. Anti-seep collars, number and spacing - 12 @ 20'  
g. Spillway capacity - 135 cfs

A.3.3 Emergency Spillway - (Trapezoidal, vegetated earth saddle with paved control section through left abutment)

a. Base width - 75'  
b. Side slope - 3V:1H  
c. Control section length - 30' (24)  
d. Entrance slope - 2% (8.2%)  
e. Exit slope - 17.5% (10%)  
f. Capacity (design) - 1371 cfs

The emergency spillway was measured to be parabolic with the following dimensions:

g. Top width - 155'  
h. Maximum depth - 6.1'  
i. Capacity (measured) - 4530 cfs
A.4 Historical Data

A.4.1 Construction Date - 1976

A.4.2 Designer - Ragon Engineering Company
Bolivar, Tennessee

A.4.3 Soils Testing - Construction Materials Lab, Inc.
Jackson, Tennessee

A.4.4 Builder - S & W Construction Company
Memphis, Tennessee

A.4.5 Developer - Terra Aqua Corporation

A.4.6 Owner - Candlewood Lakes Property Owner's
Assn., W. J. Arnold, President

A.4.7 Previous Inspections - February 1979

A.4.8 Seismic Zone - 2

A.5 Downstream Hazard Data

A.5.1 Downstream Hazard Potential Classification
a. Corps of Engineers - High
b. State of Tennessee - 1

A.5.2 Persons in Probable Flood Path - variable,
generally less than 5

A.5.3 Downstream Property - US Hwy 57, mainline
Southern Railroad, maintenance office guard
shack, all within 0.2 miles of dam

A.5.4 Warning Systems - None
APPENDIX B

SKETCHES AND LOCATION MAP
EMERGENCY SPILLWAY PROFILE

SCALE: 1" = 25'

CANDLEWOOD DAM

DRAWN BY: JG
DATE: 12 MAY 81
SHEET: 4 OF 4
Photographic Record

Photo No. 1 - The upstream slope of the dam showing minor erosion apparently due to surface runoff.

Photo Nos. 2 & 3 - The downstream slope of the dam showing a discontinuity about midway down the slope.

Photo No. 4 - The left downstream embankment abutment contact. A small gully is hidden by the tall grass in the left of the photo.

Photo Nos. 5-7 - Erosion and possible jug holes on the downstream slope above the discontinuity shown in photos 2 and 3.

Photo No. 8 - The service spillway riser.

Photo No. 9 - The outlets of the service spillway and toe drains.

Photo No. 10 - The entrance channel of the emergency spillway.

Photo No. 11 - The exit channel of the emergency spillway showing erosion and sparse vegetation.

Photo No. 12 - A view of the downstream area from the top of the dam showing an area of standing water to the left of the service spillway outlet.

Photo No. 13 - Aerial view of the dam showing the erosion of the downstream slope and the emergency spillway.
APPENDIX D

CHECKLISTS - VISUAL INSPECTION,
ENGINEERING DATA, SOIL TESTS
Check List
Visual Inspection of Earth Dams
Department of Conservation
Division of Water Resources

Name of Dam: Candlewood

County: Hardeman
Date of Inspection: 1/22/01

ID # - State Federal
36-7022 7U-06020

Type of Dam: Zoned earthfill

Hazard Category: Federal State
High

Type of Dam: Zoned earthfill

Weather: Clear
Temperature: 40°F

Pool at Time of Inspection: (distance from crest)

Tailwater at Time of Inspection: (distance from stream bed)

Design/As Built Drawings Available: Yes No

Location:

Copy Obtained: Yes No
Reviewed: Yes No

Construction History Available: Yes No

Location:

Copy Obtained: Yes No
Reviewed: Yes No

Other Records and Reports Available: Yes No

Location:

Copy Obtained: Yes No
Reviewed: Yes No

Prior Incidents or Failures: Yes No

Inspection Personnel and Affiliation:

Ed O'Neill - TNR

George Moore - TNR

Anthony Privett - TNR
I. Embankment

A. Crest

**Description (1st inspection)**

Asphaltic concrete road covers crest; straight alignment; east-west orientation.

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<td>1. Longitudinal Alignment</td>
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<td>3. Transverse Surface Cracks</td>
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<td>4. General Condition of Surface</td>
<td>Good</td>
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B. Upstream Slope

1. Undesirable Growth or Debris | None |
2. Sloughing, Subsidence, or Depressions

Slight sloughing at water surface due to wave action.

3. Slope Protection

Has a wave protection berm which is eroding. Will need wave protection in a few years.

a. Condition of Riprap

None

b. Durability of Individual Stones

A/A

c. Adequacy of Slope Protection Against Waves and Runoff

See 1 above. As a maintenance item, stand of trees should be improved.

d. Gradation of Slope Protection - Localized Areas of Fine Material

4. Surface Cracks

None

C. Downstream Slope

1. Undesirable Growth or Debris

None
2. Sloughing, Subsidence, or Depressions; Abnormal

Bulges or Non-Uniformity Surface erosion may become the main problem. A line of erosion gullies and holes seems to be running across the dam at about mid height or slightly above. The dam, just below the erosion, has been seeded in a good stand of grass and fescue. Some holes appear to be caused by disperseive soils.

3. Surface Cracks on Face of Slope

None

4. Surface Cracks or Evidence of Heaving at Embankment Toe

None

5. Wet or Saturated Areas or Other Evidence of Seepage on Face of Slope; Evidence of "Piping" or "Boils"

The entire U/S embankment seemed extremely wet in comparison to the U/S slope and to other dams seen on the same day. The eroded areas are soft, the material appears to be gray clay. An area of standing water was seen on the embankment about 5' above the toe and 10'-15' left of the SS. No flow or evidence of the transport of embankment mud was found in the area. No other standing water was seen on the embankment. The area should be rechecked during dry weather.

6. Drainage System

Clear; was installed after dam was built.

7. Fill Contact with Outlet Structure

O.K. Some surface erosion coming into stilling basin and minor erosion around headwall.

8. Condition of Grass Slope Protection

Fair to good; needs improvement.
D. Abutments

1. Erosion of Contact of Embankment with Abutment from Surface Water Runoff, Upstream or Downstream

   Erosion gully 3' deep U/S right side.
   Erosion gully 1.5' deep D/S right side.

2. Springs or Indications of Seepage Along Contact of Embankment with the Abutments

   Soft area just U/S from toe 30' from right end; appears to be recent dumped fill; is above water line.

3. Springs or Indications of Seepage in Areas a Short Distance Downstream of Embankment - Abutment Tie-in

   None
II. Area Downstream of Embankment, Including Channel

A. Localized Subsidence, Depressions, Sinkholes, Etc. 

B. Evidence of "Piping", "Boils", or "Seepage"  

C. Unusual Presence of Lush Growth, such as Swamp Grass, etc.  

D. Unusual Muddy Water in Downstream Channel  

E. Sloughing or Erosion  

F. Surface Cracks or Evidence of Heaving Beyond Embankment Toe  

G. Stability of Channel Sideslopes  

H. Condition of Channel Slope Protection  

Notes on the condition of the channel slope protection area.
I. Adequacy of Slope Protection Against Waves, Currents, and Surface Runoff

J. Miscellaneous

K. Condition of Relief Wells, Drains, and Other Appurtenances

L. Unusual Increase or Decrease in Discharge from Relief Wells
III. Instrumentation - None

A. Monumentation/Surveys

B. Observation Wells

C. Weirs

D. Piezometers

E. Other
IV. Spillways

A. Service Spillway (Service/Emergency Combination Yes ___ No ___)

1. Intake Structure Condition Observed from waters edge. Appears o.k.

2. Outlet Structure Condition O.K.

3. Pipe Condition Appears good; observed from D/S end.

4. Evidence of Leakage or Piping None

5. General Remarks

B. Emergency Spillway

1. General Condition

2. Entrance Channel O.K.

3. Control Section O.K.
3. **Exit Channel** A large amount of rtl has been removed from the right edge of the spillway. This has apparently been due to both mechanical removal and erosion. The channel should be regraded and stabilized to assure that no flow impinges upon the embankment during high stages.

4. **Vegetative/Woody Cover** Trees were left in exit channel as energy dissipator about 150' aft of crest.

5. **Other Observations**
V. Emergency Drawdown Facilities (if part of service spillway so state) Gate valve at base of service spillway riser.

Possible 1 gpm leak.

Are Facilities Operable: Yes _____ No _____ Unknown but probable

Were Facilities Operated During Inspection: Yes _____ No _____

Date Facilities Were Last Used ____________________________
VI. Reservoir
   A. Slopes O.K.

   B. Sedimentation Minor

   C. Turbidity Clear, green; visibility about 2'

VII. Drainage Area
   Description (for hydrologic analysis) Low density
       residential development with wooded lots.

   A. Changes in Land Use
VIII. Downstream Area (Stream)

A. Condition (obstructions, debris, etc.)

Channel constructed by culvert under railroad and highway.

B. Slopes

Flat

C. Approximate No. Homes, Population, and Distance D/S

None

D. Other Hazards

Bry 27, main line Southern Railroad, 

Guard house, maintenance shack, information center

(trailer) within 0.2 miles D/S.

12
IX. Miscellaneous

Incidents/Failures

None

Observed Geology of Area
Sandy clay.

X. Conclusions

Condition satisfactory pending F & S analysis.

D/S slope indicative of dispersive soils.

D/S slope seems unusually wet compared to E/S or to other
dam inspected. E/S has been changed from original contour
both by erosion and by mechanical force.

XI. Recommendations

Establish good grass cover on D/S slope and E/S exit channel
which may require small amount of restamping.

Monitor wet areas & reinspect in dry weather (TBD).

Regrade the ES and insure the flow cannot impinge on the
dam during high flows.
## OHIO RIVER DIVISION, NASHVILLE DISTRICT
SOIL TEST DATA SUMMARY

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<th>ATTERBERG LIMITS</th>
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P.I. 39.7

*Note: The table includes data for soil testing and classification, specifically the natural water content (LL) and laboratory classification with specific gravity and dry density measurements.*

---

*Project: CANDLE WOOD
Hole: 1
Elev. Top: [Blank]
Sheet: 1
Of: 1 Sheets

*Additional notes:*
- MOTTLED EYESHIVITE CLAY (CL) 7.0
- LL 46.9, PL 16.2
- DRY HARD
- SPECIFIC GRAVITY TO 1.0
- DRIED OUT SINCE IT WAS TAXII
- P.I. 39.7
APPENDIX E

HYDRAULIC AND HYDROLOGIC DATA
Hydraulic and Hydrologic Calculations

Candlewood Lake Dam is located in Hardeman County, Tennessee. The primary land use is medium density residential development with about 26% of the area under water. The predominant soil types are Ruston (HSG B), Lexington (HSG B), and Providence (HSG C). The runoff curve number was calculated to be 83 AMC II.

The Candlewood Lake Dam is an intermediate, high hazard potential dam. As such, it is required to pass the Probable Maximum Flood (PMF) without overtopping. The PMF is derived from the Probable Maximum Precipitation (PMP). Using the U. S. Weather Service TP-40, the 6-hour PMP was estimated to be 29.7 inches yielding 27.4 inches of runoff.

The total inflow into the reservoir is about 381 acre-feet, with a peak rate of 3947 cfs. Candlewood Lake has a maximum storage above normal pool of 588 acre-feet and a maximum spillway discharge rate of 4666 cfs. The impoundment is sufficient to pass the PMF. The dam contained the storm with flows of 5.9 feet in the emergency spillway and 0.2 feet of freeboard.

Routing of a 1-10 day 100-year storm indicated that the storm would pass with no flow in the emergency spillway.

The inflow hydrograph was calculated by methods contained in Section 4, Chapter 21, of the SCS National Engineering Handbook. Hydraulic calculations were performed in accordance with King & Brater's Handbook of Hydraulics. The routings were taken from NEH-4, Chapter 17. Equation 17-11 was rearranged to the following form:

\[ I_1 + I_2 + \left( \frac{2S_1}{2r_c} - Q_1 \right) = \frac{2S}{2r_c} + O_2 \]
CANDLEWOOD LAKE

HYDROGRAPH COMPUTATION

GEM

LOCATED ON TRIBUTARY OF SPRING CREEK
DRAINAGE AREA = 167 AC = .26 MI^2
MAJOR SOIL TYPES = RUSTON, LEXINGTON, PROVIDENCE
MAJOR LAND USE = MEDIUM DENSITY RESIDENTIAL DEVELOPMENT
CN = 83 AMC II, 93 AMC III
NORMAL POOL AREA = 43 AC
D/S HAZARD - HIGH
6-HOUR PMP = 29.7 IN
6-HOUR P100 = 5.5 IN
Y = 11.97
L1 = 1400 ft

AMC II
L1 = .11 hr
Tc1 = 1.8 hr
Tc2 = .13 hr (11.97)

PMP = 29.7 IN
Q1 = 27.4 IN
HYDROGRAPH FAMILY #1
T0 = 5.8 hr
T0/Tc = 45.5
REV Tc/T0 = 50
REV T0 = .116 hr
Q0 = 1083 cfs/in
Qmax = 3947 cfs @ 2.09 hr

P100 = 5.5 IN
Q1 = 3.6 IN
HYDROGRAPH FAMILY #2
T0 = 5.1 hr
T0/Tc = 39.9
REV Tc/T0 = 36
REV T0 = 1.14 hr
Q0 = 888 cfs/in
Qmax = 3198 cfs
Qmax = 502 cfs @ 1.53 hr

AMC III
L1 = .07 hr
Tc1 = .12 hr
Tc2 = .09 hr (.067)

PMP = 29.7 IN
Q1 = 28.8 IN
HYDROGRAPH FAMILY #1
T0 = 5.9 hr
T0/Tc = 60
REV Tc/T0 = 75
REV T0 = .079 hr
Q0 = 1600 cfs/in
Qmax = 46070 cfs
Qmax = 4146 cfs @ 2.13 hr

P100 = 5.5 IN
Q1 = 4.7 IN
HYDROGRAPH FAMILY #1
T0 = 5.65 hr
T0/Tc = 64
REV Tc/T0 = 75
REV T0 = .079 hr
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Qmax = 7993 cfs
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CANDLEWOOD LAKE  |  PSH AND PSMC  |  100YR

DA = 167.6 A = .26 mi²
T = .18 hr
AVERAGE ANNUAL PRECIPITATION = 49 IN
AVERAGE ANNUAL TEMPERATURE = 67 °F
RUNOFF CN = 83
10 DAY CN = 69
10DAY Pₜₐₜ = 7.71 IN
10DAY Pₚₜₜ = 14 IN
Q₁ = 5.69 IN
Q₁₀ = 9.76 IN

Q₉₀ = .383
SERIAL NO = 5

Cᵢ = \( \frac{100 \times \text{Pₜₐₜ}}{\text{T} \times \text{A}} \) = \( \frac{100 \times 49}{83 	imes .26} \) = 1.275

MIN Qₐᵣ = 153 IN/Day = 1.07 cfs

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CANDLEWOOD LAKE
100YR. PSAMC ROUTING

STORM PASSES WITH NO
FLOW IN THE E.S.

TIME, DAYS

VOLUME IN INCHES
CANDLEWOOD LAKE ROUTING CURVE
\( \Delta t = 0.23 \text{ hr} \)

Output, cfs

\[ \begin{array}{c}
\hline
\text{Input, cfs} & \text{Output, cfs} \\
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4000 & \\
6000 & \\
8000 & \\
10000 & \\
12000 & \\
14000 & \\
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# SPILLWAY RATING +

## CANDLEWOOD LAKE

### ROUTING CURVE COMPUTATION

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### WEIR FLOW

\[ Q = \frac{CL^2}{2g} \]

### PIPE FLOW

\[ Q = \frac{Ca^2}{2g} \]

### ES.

\[ Q = 2005 \times T \]
APPENDIX F

CORRESPONDENCE
Date 2/14/79  Region West

INSPECTION REPORT

Name of Dam: Candlewood  County: Hardeman
Owner's Name: ___________  Quad: 432SE

Type Project: Application No. 76-115-0
Existing X
New Construction ___________
Repair/Alteration ___________
Removal ___________

Type Inspection:
Phase I X
Phase II ___________
Certificate X
Cursory ___________
Preliminary Site ___________
Review ___________

Damage Potential Category: One __ Two ___ Three ___ Undetermined __

Inspection by: George Moore and Troy Wedekind

Inspection Results:
The dam has numerous small erosion gullies both upstream and
downstream. The erosion gullies should be repaired along
with reseeding of the slopes to establish adequate cover to
prevent further erosion. The exit channel of the emergency
spillway has no cover. A grass cover should be established
to allow safe operation of the emergency spillway. No wetland
vegetation was observed downstream that would indicate seepage
or leaks. This report is accompanied by a photo.
Mr. Robert A. Hunt, Director
Division of Water Resources
Tennessee Department of Conservation
4721 Trousdale Drive
Nashville, Tennessee 37219

Re: Dams at Candlewood Lake, Spring Lake #2, Crystal Lake #4 and Old Hickory Lake located in Hardeman County

Dear Mr. Hunt:

Your letter of December 1, 1980 to Candlewood Lakes Inc., has been forwarded to us.

As of January 1, 1979, the ownership of the above mentioned dams was transferred to Candlewood Lakes Property Owners Association.

We were not aware of the State Safe Dams Act, but we will be glad to cooperate with you in any way possible to keep the dams safe.

Please direct all future correspondence to Candlewood Lakes Property Owners Association, P.O. Box 171321, Memphis, Tennessee 38117. The phone number is 901-685-6968.

Sincerely,

W. J. Arnold, President
Candlewood Lakes Property Owners Assn.

WJA/a
PHOTO NO. 1

14 Feb 79 Gandlewood Dam Hardeman Co.

Outlet channel of the emergency spillway showing the lack of ground cover.
October 25, 1976

Mr. Wayne L. Smith, Vice-President
Candlewood Lakes Corporation
P. O. Box 17762
Memphis, Tennessee 38117

Re: Certificate of Approval and Safety
Application No. 76-115-0, Candlewood Dam

Dear Mr. Smith:

Enclosed please find Certificate of Approval and Safety issued Candlewood Lakes Corporation for operation of the above referenced project. This Certificate is issued for a period of twelve (12) months and is due to expire on October 14, 1977.

The project will be scheduled for a safety inspection by our Division at a time interval of approximately one year. You will be further notified prior to the inspection.

Enclosed for your information is a pamphlet regarding inspection and maintenance of privately owned dams. You are requested to properly maintain the structure and periodically perform routine inspection in accordance with the guidelines furnished in the pamphlet. Should a problem develop please notify our office immediately.

Your cooperation with the safe dams program is appreciated. If we can be of assistance at any time, please let us know.

Very truly yours,

Robert A. Hunt
Director

copy to: Ragon Engineering Company

Edmond B. O'Neill, Regional Engr.
Division of Water Resources

Encl. (2)
August 16, 1976

Mr. Robert A. Hunt
Tennessee Department of Conservation
Division of Water Resources
6213 Charlotte Ave.
General Care Bldg., Suite #107
Nashville, Tennessee 37209

Re: Candlewood Subdivision
Candlewood Lake (Lake #1)

Dear Mr. Hunt:

The Construction of Candlewood Lake has been completed
and was done in substantial conformity with the approved
plans and specifications as prepared by Ragon Engineering
Company.

Yours truly,

[Signature]

James H. Ragon, P.E.

JHR/ct

Enc.

cc:
Mr. Edmond B. O'Neill
Regional Engineer
S & W Construction Company
Memphis, Tennessee
1. The Interagency Review Board, appointed by the Commander on 8 October 1980, presents the following recommendations after meeting on 18 June 1981 to consider the Phase I investigation report on Candlewood Lake Dam inspected by the Tennessee Department of Conservation.

2. The condition classification should be changed from "deficient" to "significantly deficient."

3. Removal of material in the emergency spillway by mechanical means should not be allowed to continue.

4. The reason for the discontinuity on the embankment slope should be determined and included in the report.

5. An emergency action plan should be developed, including a warning system to alert downstream residents, in the event a serious condition develops with the project.

6. The owner should establish a regular program of inspection and maintenance to provide detection and timely correction of problem areas.

7. The Board is in agreement with other report conclusions and recommendations following minor revisions.

HERMAN GRAY
Chief, Design Branch
Alternate Chairman

BOBBY J. MOORE
Assistant State Conservation Engineer
Alternate, Soil Conservation Service

ROBERT A. HUNT
Director, Division of Water Resources
State of Tennessee

THOMAS N. PORTER
Hydraulic Engineer
Alternate, Hydrology and Hydraulics Branch

EDWARD B. BOYD
Hydrologic Technician
Alternate, US Geological Survey

TIMOTHY MCCLESKEY
Chief, Instrumentation and Inspection Section
Alternate, Geotechnical Branch
APPENDIX G

DESIGN AND CONSTRUCTION DATA
CANDLEWOOD LAKE (LAKE NO. I)

HARDEMAN COUNTY, TENNESSEE

CANDLEWOOD LAKES INCORPORATED

RANDOLPH & WILLIAMS

DEVELOPER

RACON ENGINEERING COMPANY

SADLER, TENNESSEE

LOCATION MAP
# Analyses of Moisture Density Test of Compacted Fill

**Contractor:**

**Project:**

**Report to:** Mr. Randy Holt; Mr. Ed O'Neil

**Date:** September 19, 1974

**Lab. No.:** 24534

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**Location of Tests:**

1. 50' L. in Center of Dam
ANALYSES OF MOISTURE DENSITY TEST OF COMPACTED FILL

Contractor: Randy Holt
Project: CANDLE NO1

Report to: Mr. Randy Holt; Mr. Ed O'Neil
Date: September 17, 1974
Lab. No. 24504

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Location of Tests

1 Center of Dam, 100' E. from Ditch
## Analysis: MOISTURE DENSITY TEST (Proctor)

**From:**

**Contractor:**

**Producer:**

**Report To:** Mr. Randy Holt; Mr. Ed O'Neil

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<td>148.5</td>
<td>143.9</td>
<td>138.3</td>
</tr>
<tr>
<td>Moisture Content % Dry Soil</td>
<td>11.0%</td>
<td>14.5%</td>
<td>18.7%</td>
</tr>
<tr>
<td>Density Dry Soil lbs./cu. ft.</td>
<td>106.2</td>
<td>112.4</td>
<td>105.9</td>
</tr>
</tbody>
</table>

**Remarks:** Light-loam Sandy Silt

---

**Maximum Density, Dry Soil (Lbs./cu.ft.)** 112.5

**Optimum Moisture Content (% of Dry Weight)** 14.6%

**Location of Tests:** Taken from the core area

---

40 OLD HICKORY COVE  
JACKSON, TENNESSEE 38301  
(901) 424-7646
ANALYSES OF MOISTURE DENSITY TEST OF COMPACTED FILL

Contractor: CANDLEWOOD DEVELOPMENT

Report to: Mr. Randy Holt; Mr. Ed O'Neil

Date: October 10, 1974

Lab. No.: 24762

<table>
<thead>
<tr>
<th>Test No.</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of Sand (lbs./cu. ft.)</td>
<td>98.0</td>
<td>98.0</td>
</tr>
<tr>
<td>Wgt. of Jar &amp; Sand (before test)</td>
<td>7.80</td>
<td>7.59</td>
</tr>
<tr>
<td>Wgt. of Jar &amp; Sand (after test)</td>
<td>3.42</td>
<td>3.22</td>
</tr>
<tr>
<td>Wgt. of Sand in Hole &amp; Funnel</td>
<td>4.38</td>
<td>4.37</td>
</tr>
<tr>
<td>Wgt. of Sand in Funnel</td>
<td>1.90</td>
<td>1.90</td>
</tr>
<tr>
<td>Wgt. of Sand in Hole</td>
<td>2.48</td>
<td>2.47</td>
</tr>
<tr>
<td>Volume of Hole (cu. ft.)</td>
<td>0.0253</td>
<td>0.0252</td>
</tr>
<tr>
<td>Wgt. of Wet Soil</td>
<td>3.27</td>
<td>3.32</td>
</tr>
<tr>
<td>Wgt. of Dry Soil</td>
<td>2.78</td>
<td>2.83</td>
</tr>
<tr>
<td>Wgt. of Water</td>
<td>.49</td>
<td>.49</td>
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<tr>
<td>Moisture Content (% of Dry Wgt.)</td>
<td>17.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Density, Dry Soil (lbs./cu. ft.)</td>
<td>109.9</td>
<td>112.3</td>
</tr>
<tr>
<td>% Required Density</td>
<td>97.7</td>
<td>99.8</td>
</tr>
<tr>
<td>Required Density (lbs./cu. ft.)</td>
<td>112.5</td>
<td>112.5</td>
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<tr>
<td>Optimum Moisture (% of Dry Wgt.)</td>
<td>14.6</td>
<td>14.6</td>
</tr>
<tr>
<td>Stone, % by Wgt.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Location of Tests:
1 350' W. in Center of Dam
2 250' W. in Center of Dam

40 OLD HICKORY COVE
JACKSON, TENNESSEE 38301
(901) 424-2545
**MOISTURE DENSITY TEST (Proctor)**

**Project:** CANDIWOOD DEVELOPMENT  
**Date:** October 15, 1974  
**Lab. No.:** 24812

<table>
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<tr>
<th>Test No.</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. of Mold</td>
<td>4.40</td>
<td>4.90</td>
<td>4.40</td>
<td>4.40</td>
<td>4.40</td>
</tr>
<tr>
<td>Wt. Mold &amp; Wet Soil</td>
<td>8.00</td>
<td>8.80</td>
<td>8.80</td>
<td>8.80</td>
<td>8.80</td>
</tr>
<tr>
<td>Wt. Wet Soil</td>
<td>3.97</td>
<td>4.07</td>
<td>4.10</td>
<td>4.00</td>
<td>3.97</td>
</tr>
<tr>
<td>Density Wet Soil lbs./cu. ft.</td>
<td>119.4</td>
<td>119.4</td>
<td>119.4</td>
<td>121.1</td>
<td>122.4</td>
</tr>
<tr>
<td>Wt. Pan &amp; Wet Soil</td>
<td>150.0</td>
<td>150.0</td>
<td>150.0</td>
<td>150.0</td>
<td>150.0</td>
</tr>
<tr>
<td>Wt. Pan &amp; Dry Soil</td>
<td>141.7</td>
<td>144.9</td>
<td>160.7</td>
<td>177.2</td>
<td>192.6</td>
</tr>
<tr>
<td>Wt. of Water</td>
<td>13.3</td>
<td>15.1</td>
<td>19.3</td>
<td>24.0</td>
<td>27.4</td>
</tr>
<tr>
<td>Wt. Pan</td>
<td>17.6</td>
<td>15.1</td>
<td>15.8</td>
<td>15.8</td>
<td>15.5</td>
</tr>
<tr>
<td>Wt. of Dry Soil</td>
<td>33.1</td>
<td>149.0</td>
<td>149.0</td>
<td>159.4</td>
<td>177.1</td>
</tr>
<tr>
<td>Moisture Content % Dry Soil</td>
<td>17.1</td>
<td>19.1</td>
<td>17.2</td>
<td>17.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Density Dry Soil lbs./cu. ft.</td>
<td>107.4</td>
<td>111.8</td>
<td>107.0</td>
<td>106.5</td>
<td>102.6</td>
</tr>
</tbody>
</table>

**Remarks:**  
Clayey silt

**Maximum Density, Dry soil (Lbs./cu.ft.)**  
108.7

**Optimum Moisture Content (% of Dry Weight)**  
14.0%

**Location of Tests:**  
taken from core fill

---

**40 OLD HICKORY COVE  
JACKSON, TENNESSEE 38301  
(901) 424-2646**
### Construction Materials Laboratory

**DAVID M. EVANS, P.E.**

---

**Analysis of Soil Classification**

**Received from Contractor:**

**Producer:**

**Reported To:** Mr. Randy Holt; Mr. Ed O'Neil

**Sample:** Silty Clay with Fine Sand

**Location:** West Core

<table>
<thead>
<tr>
<th>Size</th>
<th>Retained On</th>
<th>Percent</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>5&quot;</td>
<td>No. 10</td>
<td>0.0</td>
<td>Gravel</td>
</tr>
<tr>
<td>No. 10</td>
<td>No. 40</td>
<td>1.5</td>
<td>Coarse Sand</td>
</tr>
<tr>
<td>No. 40</td>
<td>No. 200</td>
<td>63.3</td>
<td>Fine Sand</td>
</tr>
<tr>
<td>No. 200</td>
<td>Pan</td>
<td>35.2</td>
<td>Combination Silt &amp; Clay</td>
</tr>
</tbody>
</table>

**Liquid Limit:** 33

**Plastic Limit:** 23

**P. L.: 10**

**Classification:** CL

**NOTE:** Material should be satisfactory for cut-off as long as sand content does not increase.
ANALYSES OF MOISTURE DENSITY TEST OF COMPACTED FILL

Contractor: Project:

Report to: Mr. Randy Holt; Mr. Ed O'Neil Date: October 28, 1974

Lab. No. 24961

<table>
<thead>
<tr>
<th>Test No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of Sand (lbs./cu. ft.)</td>
<td>98.0</td>
<td>98.0</td>
<td>98.0</td>
</tr>
<tr>
<td>Wgt. of Jar &amp; Sand (before test)</td>
<td>7.77</td>
<td>7.70</td>
<td>7.63</td>
</tr>
<tr>
<td>Wgt. of Jar &amp; Sand (after test)</td>
<td>3.58</td>
<td>3.69</td>
<td>3.68</td>
</tr>
<tr>
<td>Wgt. of Sand in Hole &amp; Funnel</td>
<td>4.19</td>
<td>4.01</td>
<td>3.95</td>
</tr>
<tr>
<td>Wgt. of Sand in Funnel</td>
<td>1.90</td>
<td>1.90</td>
<td>1.90</td>
</tr>
<tr>
<td>Wgt. of Sand in Hole</td>
<td>2.29</td>
<td>2.11</td>
<td>2.05</td>
</tr>
<tr>
<td>Volume of Hole (cu. ft.)</td>
<td>0.0257</td>
<td>0.0215</td>
<td>0.0209</td>
</tr>
<tr>
<td>Wgt. of Wet Soil</td>
<td>2.93</td>
<td>2.91</td>
<td>2.89</td>
</tr>
<tr>
<td>Wgt. of Dry Soil</td>
<td>2.63</td>
<td>2.60</td>
<td>2.57</td>
</tr>
<tr>
<td>Wgt. of Water</td>
<td>.30</td>
<td>.31</td>
<td>.32</td>
</tr>
<tr>
<td>Moisture Content (% of Dry Wgt.)</td>
<td>11.4</td>
<td>11.9</td>
<td>12.5</td>
</tr>
<tr>
<td>Density, Dry Soil (lbs./cu. ft.)</td>
<td>112.6</td>
<td>120.9</td>
<td>125.0</td>
</tr>
<tr>
<td>% Required Density</td>
<td>100.0</td>
<td>96.0</td>
<td>97.7</td>
</tr>
<tr>
<td>Required Density (lbs./cu. ft.)</td>
<td>112.5</td>
<td>125.9</td>
<td>125.9</td>
</tr>
<tr>
<td>Optimum Moisture (% of Dry Wgt.)</td>
<td>14.6</td>
<td>8.6</td>
<td>8.6</td>
</tr>
</tbody>
</table>

Location of Tests
1. 25' N. in Center of Dam
2. 25' W. off Center of Dam, 275' N.
3. 225' N. in Center of Dam

40 OLD HICKORY COVE JACKSON, TENNESSEE 38301
(901) 424-2546
Flood Routing

A.

\[ P = 29.5 \quad Q = 26 \]

\[ DA = 17.14 \times 0.267 \times 1 \]

\[ T_e = \left[ \frac{12.9(1.2)}{102} \right]^{0.335} = 0.116 \]

Family = 1

\[ T_o = 5.71 \text{ hr} \]

\[ T_p = 0.7 \text{ T_e} = 0.081 \]

\[ T_{P/2} = \frac{5.71}{0.081} = 70.5 \]

\[ T_p (Rev.) = 75 \]

\[ T_p (Rev.) = \frac{5.71}{0.076} = 0.076 \text{ hr} \]

\[ Q_p = \frac{1701.52}{12.94(0.267)} = 1701.52 \text{ ft}^3/\text{sec} \]

\[ Q_p = Q \times Q_p = 26(1701.52) = 44241 \text{ ft}^3/\text{sec} \]

\[ Q_1 = 0.09 (44241) = 3982 \text{ ft}^3/\text{sec} \]

\[ V = 53.33(26)(0.267) = 370.2 \text{ Apr. 16.13 x 10}^6 \text{ ft}^3 \]

\[ L_e = 525.4 \]

\[ V_{of} = 25 \times 10^6 \text{ ft}^3 \]

\[ V_{of} = V_{eo} - V_{of} = (34 - 25) \times 10^6 = 9 \times 10^6 \text{ ft}^3 \]

\[ V_{eo} = \frac{9 \times 10^6}{16.13 \times 4} = 0.56 \]

B.

\[ P = 12 \quad Q = 9.5 \]

\[ N_p = 521 \]

\[ V_{of} = 25 \times 10^6 \text{ ft}^3 \]

\[ V_{eo} = 135 \times 5.8 \times 10^6 \text{ ft}^3 \]

\[ V_{eo} = 31.9 \times 10^6 \text{ ft}^3 \]

\[ V_{eo} = 625.4 \times 521 \]

C.

\[ P = 5.5 \quad Q = 3.3 \quad \text{100 yr storm} \]

\[ 171(23.56)^2 = 2.05 \times 10^6 \text{ ft}^3 \]
IVI 4-2-0.4

\[ t_1 = \frac{484.4 - 484(0.267)}{0.076} = 1701.52 \text{ ft/sec/m} \]

12. \[ Q = Q_0 = 26(1701.52) = 44241 \text{ ft}^3/\text{sec} \]

13. \[ Q_i = 0.09(44241) = 3982 \text{ ft}^3/\text{sec} \]

14. \[ V_i = \frac{53.33(260.267)}{1370.2} = 16.13 \times 10^6 \text{ ft}^3 \]

\[ L_{60} = 525.4' \]

15. \[ V_{60} = 25 \times 10^6 \text{ ft}^3 \]

16. \[ V_{sp} = V_{60} - V_{6f} = (34 - 25)0^6 = 9 \times 10^6 \text{ ft}^3 \]

17. \[ V_{6f} = 16.13 \times 10^6 \quad \text{ft}^3 \]

\[ Q = 9.5'' \]

18. \[ N_0 = 521 \]

19. \[ V_{sp} = 25 \times 10^6 \text{ ft}^3 \]

20. \[ V_{60} = 135 \times 5.9 \times 10^6 \]

21. \[ V_{min} = 34.9 \times 10^6 \text{ ft}^3 \]

22. \[ E_{min} = 525.4 - 524 \]

23. \[ Q = 3.3 \text{ ft}^3 \]

24. \[ 17(43580)^{0.33} = 2.05 \times 10^6 \text{ ft}^3 \]

25. \[ V_{opt} = 2.05 \times 10^6 \]

26. \[ V_{min} = 27.05 \times 10^6 \text{ ft}^3 \]

27. \[ E_{min} = 522 \]

DEPT. OF CONSERVATION
WATER RESOURCES

RECEIVED APR 8 1974
d. Compute the available flood storage at $E_B$

$$V_{st} = V_{th} - V_{uf}$$

e. Follow steps 1 through 5 of the procedure given under principal spillway corrections for two stage structures

4. Principal Spillway System Calculations:

<table>
<thead>
<tr>
<th>$E_e$</th>
<th>$L$</th>
<th>$V_{sp/N_I}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>525.4</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>$V_t$</td>
<td>$Q_o$</td>
<td>$V_{sp/N_I}$</td>
</tr>
<tr>
<td>534/10^6</td>
<td>102</td>
<td>0.50</td>
</tr>
<tr>
<td>$V_{sp}$</td>
<td>$Q_{ph}$</td>
<td>$V_{sp/N_I}$</td>
</tr>
<tr>
<td>2X10^6</td>
<td>113</td>
<td>0.020</td>
</tr>
</tbody>
</table>

a. Select an elevation of emergency spillway crest, $E_e$
b. Read the total storage at $E_e$ from the stage-storage curve, this is $V_{te}$
c. Compute the available flood storage at $E_e$

$$V_{sp} = V_{te} - V_{uf}$$
d. Obtain principal spillway discharge at $E_e$, this is $Q_{ph}$
e. Compute the average high stage release rate, this is $Q_o$
f. Follow the procedure given for single stage structures, or steps 6 through 10 for two stage structures, principal spillway corrections
g. Compute the principal spillway correction

$$V_{op/N_I} = V_{sp/N_I} - V_{sp/N_I}$$
h. Obtain from the emergency spillway layout data

(1) Entrance Length, $L$
(2) Profile use
(3) Slope, $S_o$
(4) $Q_o = 3982 \text{ cfs}$

5. $Q_o = 3982 \text{ cfs}$

<table>
<thead>
<tr>
<th>$E_e$</th>
<th>$V_{tw}$</th>
<th>$V_{sw}$</th>
<th>$V_{sw/N_I}$</th>
<th>$V_{op/N_I}$</th>
<th>$Q_{4}/Q_o$</th>
<th>$Q_{4}/Q_o$</th>
<th>$z_2$</th>
<th>$Q_{2}/Q_o$</th>
<th>$b$</th>
<th>$V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ft</td>
<td>ft</td>
<td>ft</td>
<td>ft</td>
<td>ft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>525.9</td>
<td>35.2</td>
<td>10.2</td>
<td>0.772</td>
<td>0.832</td>
<td>0.1</td>
<td>2822</td>
<td>0.5</td>
<td>0.53</td>
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<td>526.4</td>
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<td>11.4</td>
<td>0.863</td>
<td>0.922</td>
<td>0.05</td>
<td>399</td>
<td>0.86</td>
<td>1.94</td>
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<td>526.9</td>
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<td>0.916</td>
<td>0.976</td>
<td>0.01</td>
<td>40</td>
<td>0.73</td>
<td>1.5</td>
<td>3.92</td>
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<tr>
<td>526.2</td>
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</tbody>
</table>
METHO
0V
RESERVOIR-FLOOD-ROUTING CHARTS

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Prepared by
REGIONAL TECHNICAL SERVICE CENTER
UPPER DARBY, PENNSYLVANIA

STANDARD PUBLICATION
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DATE: November, 1963