Little Rock District

Clearwater Dam
Major Rehab Project

Bobby Van Cleave, P.E.
Geotechnical & Civil Section - Design Branch
Little Rock District Corps of Engineers

✉️ E-Mail bobby.e.vanclave@swl02.usace.army.mil
☎️ TEL (501) 324-5055 Ext. 1420
Fax (501) 324-5265
What’s the problem(s)?
Significant Deficiencies

• **Long-Term Seepage**
  - Seepage has been observed at and around the downstream left abutment since first filling.
  - Several remediation attempts have been accomplished over the past 60 years.
  - A sinkhole appeared on the upstream face of the embankment in 2003.

• **Seismic**
  - Clearwater is located in the New Madrid Seismic Zone.
  - Some of the alluvial soils beneath the structure may be susceptible to liquifaction under certain earthquake events.

• **Spillway**
  - There is currently material located within the spillway that should be removed to allow for the PMF event.
What can happen?
Consequences

- In the event of a dam breach caused by seepage or seismic
  - Total damages: $168,520,000
  - Total loss of life: 340
When were seepage problems first observed?
Looking E from 150' U.S. of station 41+68; General view of cut-off trench operations.
Looking S from 175' US of station 39 + 20: Open joint in cut-off trench foundation.
Original Construction – STA 40+15

Looking NW from 35° U.S. of station 40+15: Open joint in cut-off trench foundation.
Top of dam elevation 608
Top of parapet wall 611
Pool elevation 494
CLEARWATER DAM
POOL OF RECORD – MAY 2002
ELEVATION 566.7
POOL OF RECORD – MAY 2002
LOOKING TOWARDS LEFT ABUTMENT
POOL OF RECORD – MAY 2002
EMERGENCY SPILLWAY
LOOKING TOWARDS NORTHEAST
CLEARWATER DAM
DISCHARGE IMPACTS

Black River Stage @ Popular Bluff, MO (ft.)
Clearwater Dam – Sinkhole Investigation
15 January 2003
Clearwater Dam – Sinkhole Investigation
16 January 2003
Clearwater Dam – Sinkhole Investigation
16 January 2003
Final excavation at 25 feet deep
Geophysical and Subsurface Investigations
• Kansas Geological Survey – surface wave, reflection
• Sonic Drilling – 6 borings, 50’ into rock
• Bureau of Reclamation – crosshole tomography
• ERDC – SP, EM conductivity, ER
KANSAS GEOLOGICAL SURVEY
Sinkhole boring SH-1A
9 April 2003
Bureau of Reclamation – June 2003
What information was gained from these investigations?
PLAN VIEW OF CORE TRENCH

CROSS-SECTION OF CORE TRENCH

sinkhole
PDT arrived at two primary structural alternatives (out of 10 measures evaluated) that address the Clearwater seepage problems.

- Report submitted June 04.
- Approved by SWD 6 August 04.
- Receive CG Wedge Funds from HQ 13 Aug 04.
MAJOR REHAB
PROJECT SUMMARY

- Design/Const schedule developed Oct 04
- New survey initiated in Oct 04, complete Feb 05
- Seepage consultants on board Feb 05
  - Bruce, Silva, Poulos
- Cutoff wall through the centerline of the dam was approved. Wall location has been moved to centerline of clay core by SWL and Consultants with approval by SWD and HQ.
What immediate remediation efforts need to be performed?
Foundation Drilling and Grouting – Sinkhole Repair Project
Location of Sinkhole and Grouting Project
Clearwater Dam

Embankment Cross Section

SINKHOLE LOCATION

CL of grout curtain
Clearwater Dam – Sonic Drilling
LOW MOBILITY GROUT HOLES – PLAN VIEW

Upstream

Core Trench

Downstream

LMG C-line

Grout A-line

LMG B-line

Solution Joint (cavity)

Upstream
FY 04-05 Grouting Contract Summary

- November 2003 – ACT/Gannett-Fleming
- December 2003 – NTP
- April 2004 – grouting began in rock
- August 2004 – grouting 75% complete; discovery of unknown cavity
- November 2004 – modify contract for low mobility grout (LMG)
- April 2005 – complete LMG
- May 2005 – contractor demob
Will seismic issues affect seepage remediation?
SEISMIC STUDY EFFORTS

• Hired FMSM to perform parametric seismic analysis.
• Obtained services of seismic consultants – Seed, Castro, Lorig, Hempen.
• Performed additional SPT for limited seismic investigation requested by consultants to verify historical drilling data.
Drilling and Sampling Photos

Instrumented Drill Rod to Measure Hammer Energy
Drilling and Sampling Photos

SPT Analyzer Readout Terminal
Drilling and Sampling Photos

Disturbed Tube Sample
Slope stability and FLAC analyses indicate no slope failure under current OBE assigned by ERDC.

SPT samples were relatively consistent with historical data.

The cutoff wall should incorporate a plastic concrete to match the strengths of the embankment materials.

FMSM to finalize data and report in July.

Continue seismic analysis through DSAP (FY06-FY08).
MAJOR REHAB PROJECT STATUS

- Phase I – exploratory drilling/grouting along full length of dam. (early FY06)

- Phase II – construction of work platform, Cutoff wall construction and seepage blanket extension. (late FY06)
PROPOSED CUTOFF WALL
• DEPTH INTO ROCK: 60 FT+/-
• TOTAL DEPTH: 200 FT+/-
• LENGTH: 4,300 FT+/-

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DRAWING NOT TO SCALE
CRITICAL INFORMATION NEEDED FOR CUTOFF WALL DESIGN

- Depth of rock embedment.

- Permeability of existing soils and rock.

- Method of construction:
  - Rock mill or Secant pile

- The presence of any other large cavities/features.
MAJOR REHAB AND DAM SAFETY PROJECT FUNDING

- **FY05**
  - **$1.05M CG** – detailed design for MRP
  - Per direction from HQ/SWD, utilized $350k for limited seismic deformation and stability analysis

- **FY06**
  - **$22M CG** – Phase I construction (exploratory drilling/grouting)
  - Complete design and initiate Phase II construction (work platform, cutoff wall)
  - **$245k O&M** – Seismic Intensity for MCE, Borings and Testing

- **FY07**
  - **$23M CG** – Phase II construction (work platform, cutoff wall)
  - **$260k O&M** – Seismic Analysis Phase I and II
MAJOR REHAB AND DAM SAFETY PROJECT FUNDING

- **FY08**
  - $23M CG – Phase II construction (cutoff wall)
  - $300k O&M – Seismic Evaluation Report

- **FY09**
  - $21.1M CG – Phase II construction (cutoff wall)

- **FY10**
  - $23M CG – Phase II construction (work platform, cutoff wall)