CLEARWATER DAM
Sinkhole Repair
Foundation Investigation and Grouting Project

Mark Harris, P.G. – USACE-SWL

One Corps Serving The Army and the Nation
Completed 1948
Crest Length 4,225 feet
Maximum Height 154 feet
Top of Conservation Pool Elevation 494 Feet
Top of Flood Pool Elevation 567 Feet
Clearwater Dam
Pool of Record – May 2002
Elevation 566.7
Clearwater Emergency Spillway
Pool of Record – May 2002
Elevation 566.7
Clearwater Dam - Sinkhole

16 January 2003
Top of dam elevation 608
Top of Sinkhole elevation 573
Pool elevation 496
Looking E from 150' U.S. of station 41 / 68: General view of cut-off trench operations.
Original Construction – STA 39+20

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.
sinkhole
COLLAPSE INTO FOUNDATION ROCK

EL 611.0 TOP DAM
EL 567 POOL OF RECORD
EL 500
EL 470
EL 435
BEDROCK
ALLUVIAL
CORE
DENTAL CONCRETE
GROUT CURTAIN
PARTIALLY FILLED JOINT
TRANSPORTED MATERIAL “SHELL”
EXIT FACE
IMP. BERM
RIVER CHANNEL EXIT FACE
EL 611.0 TOP DAM

EL 567 POOL OF RECORD

EL 500

IMP. BERM

EL 470

ALLUVIAL

EL 435

BEDROCK

PIPE THROUGH CORE

RIVER CHANNEL EXIT FACE

GROUT CURTAIN

PARTIALLY FILLED JOINT

TRANSPORTED MATERIAL “SHELL”

“PINCH POINT”
COLLAPSE AND EXIT DOWNSTREAM

EL 611.0 TOP DAM
EL 567 POOL OF RECORD
EL 500
EL 470
EL 435

IMP. BERM
CORE
DENTAL CONCRETE
GROUT CURTAIN
PARTIALLY FILLED JOINT
TRANSPORTED MATERIAL “SHELL”

RIVER CHANNEL EXIT FACE
ALLUVIAL
BEDROCK
Investigations Prior to Grouting

- Performed Geophysical Surveys
  - Kansas Geological Survey – surface wave, reflection
  - Sonic Drilling – 6 borings, 50’ into rock
  - Bureau of Reclamation – crosshole tomography
  - ERDC – SP, EM conductivity, ER

- Geotechnical Consultation
  - Dr. Steve J. Poulos - GEI
  - Analysis Assistance - ERDC

- Prepared Investigation/Grouting Contract P&S
  - computer monitored, balanced/stabilized grout
  - awarded to Advanced Construction Techniques, LTD. (ACT)
FY 04-05 Grouting Contract

• Nov 2003 - ACT/Gannett-Fleming/Boart-Longyear selected as contractor.

• Jan 2004 – begin Sonic drilling - clay core/foundation rock/dental concrete good.

• April 2004 – begin grouting.

• May 2005 – completed grouting w/ modification
Clearwater Dam

Embankment Cross Section

SINKHOLE LOCATION

CL of grout curtain
Clearwater Dam – Sonic Drilling
Clearwater Dam – Grout Line
Moderately High Lugeon

Trend Plots: Grouting Operation, Stage: AP10-7
Project Name: Clearwater Dam Sinkhole Repair
Start Time: 2004/09/13 07:36:42

Pressure vs Time
- Gauge Pressure
- Effective Pressure

Top Depth: 194.0(ft)
Bot Depth: 194.0(ft)
Top El: 399.3(ft)
Bot El: 389.6(ft)
Formation: potosi_formation
Grouting Time: 43 (min)

Flow vs Time
Flow (US Gals)

Accumulated Grout Take: 75 (US G)

Lugeon vs Time
Lugeon Value (Lu)

Water Lugeon Value: 27.0 (Lu)

Mix vs Time
Mix Legend Water=0, A=1, B=2, C=3, D=4, E=5, F=6, etc.

Mix Type

9/13/2004 08:22
Trend Plots: Grouting Operation, Stage: AP10-7
Project Name: Clearwater Dam Sinkhole Repair
Start Time: 2004/09/13 07:36:42

Pressure vs Time
- Gauge Pressure
- Effective Pressure
Top Depth: 184.0(ft)  
Bot Depth: 194.0(ft)
Top El: 399.3(ft)  
Bot El: 389.6(ft)
Formation: potosi_formation
Grouting Time: 43 (min)

Flow vs Time
Flow (US G/min)
0.0  1.0  2.0  3.0  4.0  5.0  6.0  7.0  8.0  9.0
0.0  5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 45.0 50.0
Accumulated Grout Take: 75 (US G)
High Take – No Pressure

Trend Plots: Grouting Operation, Stage: AP12-4
Project Name: Clearwater Dam Sinkhole Repair
Start Time: 2004/07/06 07:18:44

Pressure vs Time
- Gauge Pressure
- Effective Pressure
Top Depth: 152.7(ft)
Bot Depth: 165.0(ft)
Top El: 429.5(ft)
Bot El: 417.6(ft)

Flow vs Time
Flow (GPM)
Accumulated Grout Take: 2087 (US G)

Lugeon vs Time
Lugeon Value (Lu)
Water Lugeon Value: 51.0 (Lu)

Mix vs Time
Mix Legend Water=0, A=1, B=2, C=3, D=4, E=5, F=6, etc.
High Take – No Pressure

**Lugeon vs Time**

- Lugeon Value (Lu) vs Time (min)
- Water Lugeon Value: 51.0 (Lu)

**Mix vs Time**

- Mix Legend Water=0, A=1, B=2, C=3, D=4, E=5, F=6, etc.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/7/2004</td>
<td></td>
<td>Packer set at 145⁰.</td>
</tr>
<tr>
<td>7/7/2004</td>
<td></td>
<td>Stopped at approximately 2000 gallons for the day as agreed upon by ACT and COE.</td>
</tr>
<tr>
<td>7/7/2004</td>
<td></td>
<td>Stage NOT Complete.</td>
</tr>
<tr>
<td>7/7/2004</td>
<td></td>
<td>Tremied 10 gallons from time 0 to 1 minute. Inflated packer and started to Re-Grout at 2.5 minutes.</td>
</tr>
</tbody>
</table>
A - Line Closure Analysis
AP13 to AP17 - Elevation 390

Mean Water Lugeon Values Plot
Line: All, Hole Series: All, Hole ID: AP13 To AP17, Elevation: 390
A – Line Closure Analysis
AP13 to AP17 - Elevation 390

Mean Grout Take Values Plot
Line: All, Hole Series: All, Hole ID: AP13 To AP17, Elevation: 390

Hole Series
Primary
Secondary
Tertiary
Quarternary
Quinary

Grout Take (US G)
Clearwater Dam Sinkhole Repair

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Gannett Fleming

ADVANCED CONSTRUCTION TECHNIQUES

Preliminary IntelliGrout Drawings (Updated as of 09-21-04)

Notes:

1. Update drawings are not record drawings. Information shown is preliminary based on work in progress and is subject to revision.

2. Efforts will be made to provide update drawings on approximately a weekly basis.
Location of Cavity under Core Trench
Low Mobility Grout Holes
Plan View
Clearwater Dam
Major Rehabilitation Project

• PHASE I – Full length of dam, close spaced exploratory drilling and grouting.

• PHASE II – seepage cutoff wall through embankment and into rock (design dependent upon Phase I).
Little Rock District