Wolf Creek Dam
Foundation Remediation

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Project Location

Wolf Creek Dam
**Lake Cumberland**

- **Flood Control**
  - $34 million/yr

- **Hydropower**
  - $77 million/yr

- **Recreation**
  - 5 million visitors per year
  - $129 million impact on local economy

- **Water Supply**
  - Between 100k and 200k Users

- **Water Quality**
  - Whole Cumberland River System Relies on Wolf Creek for Cool, Oxygenated Water
  - USFWS Trout Hatchery Downstream over $1 million per year
Site Stratigraphy

Limestone Foundation

Ft Payne LS. (MISS.)
Chattanooga Shale (MISS-DEV)
Cumberland LS. (ORD)
Leipers LS. (ORD)
Catheys LS. (ORD)

Overburden

Top of Dam El. 773
Solution Features Intercepting Cutoff Trench
“Overhangs and loose rock will be removed only where they cross the lines of the trench, since the earthfill in the sides of the trench will have the function only of stability and not of an absolutely uniform tight contact with the trench walls.”
1960’s Problem Areas

- Wet Areas Starting in 1964
- Sinkholes
- Muddy Flow 1967
1968 Sinkhole

Note the body language
1960’s and 70’s Remedial Features

- Embankment Wall
- Switchyard Wall
- Diaphragm Wall
- Grout Lines
- Concrete Dam
- Powerhouse
- Switchyard
- Switchyard Wall
Post Construction Distress Indicators

WET AREAS

ICOS Diaphragm Walls
Post Construction Distress Indicators
Post Construction Distress Indicators

- Headwater
  - D-323A – 586.10
  - VWP1-1 – 596.8
  - VWP1-2 – 571.8
  - D-268A – 568.3
- WA-59R – 502.8
  - VWP1-3 – 551.8
  - VWP1-4 – 536.6
- Tailwater

BUILDING STRONG®
Potential Failure Mode & Ongoing Foundation Remediation

- Elev. 773
- Elev. 750
- Elev. 680
- Elev. 495
- Elev. 475 Base of New Wall
- Elev. 425 Bottom of Grout
- Piezometer
- Existing Wall
- TOR Elev. 570±
Instrumentation

- 200+ Piezometers
- 50 Inclinometers
- 11 Extensometers
- 101 Surface Monuments
- 32 Crack Pins
Foundation Remediation Contract

- Two Phase Approach
  - Phase 1: Grouting
  - Phase 2: Barrier Wall Construction
Foundation Grouting Contract

- Advanced Construction Techniques
- Low Bid Contract
- 1300 Holes
- 900,000 gallons of grout
- $70 million
- Completed September 2008

Dual Line Grout Curtain
Overburden Drilling & Casing Installation – Rotosonic Drilling
Rock Drilling with a Cubex Rig
Wash Borehole Before Grouting
Optical Televiewer
Grout Hole Imagery
Grout Hole Imagery

Before Washing

After Washing
Grout Cart Injection System

Radio Tower

Packer

Grout & Return Hose
Schematic of Grout Injection System

NOTE: Water Pressure Testing and Grouting uses the same equipment
Grouting Results – Trend Plots

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<th>Date:</th>
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<td>Job Location:</td>
<td>Jamestown, KY</td>
<td>Start Time:</td>
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<td>Total Grout Volume (gal)</td>
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![Graphs showing grouting results](image)

- **Pressure (psi)**: Blue line represents Gauge Pressure, Red line represents Effective Pressure.
- **Flow (gpm)**: Graph showing flow over time.
- **Target Pressure (psi)**: 97 psi
Grouting Results
Pre-Con Site Characterization

- **EMBANKMENT**
  - Mineralogy
  - Gradation
  - Atterberg Limits
  - Hydrometer Analysis

- **BEDROCK**
  - Point Load Test
  - Unconfined Compression
  - Cerchar Abrasiveness Index
  - Rock Structure
  - Discontinuities
  - Bedding Heterogeneity
Barrier Wall Contract

- Contractor: Treviicos – Soletanche JV
- Best Value - Request for Proposals
- 4000-ft Concrete Barrier Wall
- Approx. 210,000 cyds of Concrete
- $340 Million
Barrier Wall Construction

- Guidewall Construction
- Pre-Excavation
- Encasement Wall
- Pilot / Exploratory Holes
- Construction Techniques
  - Combination Barrier Wall (CBW)
  - Pile Barrier Wall (PBW)
  - Slot Pile System (SPS)
- Assessing Wall Continuity at Depth
  - Instrumented Equipment
Pre-Excavation - Clamshell

PLAN

PROFILE

BUILDING STRONG®

9’-2”

4 ft

~170-ft
Encasement Wall - Hydromill

- 5" min overlap
- 9'-2"
- 6 ft

**PLAN**

- Embankment
- Alluvium
- Rock

**PROFILE**

- P
- S
- P

BUILDING STRONG®
Encasement Wall Verticality

- X → +X
  +Y
  -Y

0.25% Tolerance
Theoretical (Vertical)
Actual Deviation

Section Cut @ 120-ft

Section Cut @ 166-ft
Encasement Wall Verticality

1.0 m | Sensor: P2 | 1.0 m

0.96 m + 0.87 m = 6.0 ft

Y' = Upstream
Y = Downstream

(-) X'  (0)  P2  (+) Y

(-) Y'  (0)  P1  (+) X

Sensor Unit

25°
Concrete Placement
Pilot Hole Verticality

- **PARATRACK 2**
  - Tri-Axial Accelerometers & Magnetometers
- **Inclinometer**
  - Inserted Inside Drill Casing
Pile Barrier Wall - PBW

Min. 2’ Wall Thickness

31”

Embarkment

Alluvium

Rock
PBW Verticality

- Biaxial Inclinometer
  - Multiple Shots to Reduce Error
- KODEN
  - Dimensions of Final Excavation

0.25% Tolerance
Theoretical (Vertical)
Actual Deviation

6.7-in
Concrete Placement
Combined Barrier Wall

Embankment

Alluvium

Rock

10'-6"

2'-7"
Slot Pile System - SPS

Completed Segment

31"

Embankment

Alluvium

Rock
Consistency of Multiple Surveys

Reading (Inches)
Left (-) / Right (+)

Depth (Ft.)

Wirth Center
Paratrack
Inclinometer
Koden 'Center'
Tolerance

Reading (Inches)
Upstream (-) / Downstream (+)

Depth (Ft.)
Assessing Wall Continuity at Depth

150-FT

- WIRTH/Secant Inclinometer
- Pilot Hole PARATRACK
- Pilot Hole Inclinometer
- 0.25% Tolerance / Theoretical
- Primary Panel
- Secondary Panel

BUILDING STRONG®
Assessing Wall Continuity at Depth

250-FT

270-FT

- WIRTH/Secant Inclinometer
- Pilot Hole PARATRACK
- Pilot Hole Inclinometer
- 0.25 % Tolerance / Theoretical
QUESTIONS