Chicago Underflow Plan – CUP
McCork Reservoir Test Grout Program

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Project Description

- Flood control/CSO reservoir
- Captures CSO from Chicago and 37 suburbs
- Routed through Mainstream and Des Plaines Tunnels and Stickney Plant
- 2 Stages - 21,000 acre-ft (7B gallons)
- 300 ft deep (50 ft soil, 250 ft rock)
- Operational – 2010 (?)
- Project Completion - 2012
Project Overview
Local Sponsor - MWRDGC

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

US Army Corps of Engineers
US Army Corps of Engineers
Chicago District

Chicago Underflow Plan
CUP
Tunnel and Reservoir Project - TARP

McCook Reservoir
Thornton Reservoir

110 miles of tunnels within system beneath Chicago and surrounding suburbs
Grout Curtain Design

Design parameters under consideration:

- Drilling Method
- Hole Size
- Hole Inclination
- Hole Spacing
- Grouting Method
- Grout Mix Design
Test Grout Curtain Design

Contractual Vehicle

- Best-Value Contract – RFP
- Technical Factors Outweigh Cost

Technical Evaluation Criteria are Critical

- Too tight and no one qualifies, too vague and everyone qualifies
- Technical Approach
  - Computerized System, Drilling Approach, Grouting Approach
- Experience
- Equipment
- Safety
Test Grout Curtain Design

Contract Details

- Value Based Contract – not traditional “Low Bid”
- Contractor-Proposed methods
- Base Bid + Option (if executed)
- Base Bid – 2 parallel legs of curtain
- Option – Optional section to be drilled using one of the two methods demonstrated in Base-Bid
- Cost driven by drilling – up to 130,000 linear feet:
  - 10,000 linear feet overburden (base-bid)
  - 16,000 linear feet overburden (optional phase)
  - Appr. 50,000 linear feet rock drilling (base bid)
  - Appr. 67,000 linear feet rock drilling (optional phase)
Design Issues

- **Alignment** - *double-row curtain vs. single row*
- **Drilling Method** (Water DTH and Rotary)
- **Mix Design** - Balanced-Stabilized Grout
  - Permits high solids/water ratio with lower viscosity
  - Include demonstration of Ultra-fine/Micro-fine cement
- **Computer Control of Grouting**
Test Grout Curtain Design

- Two double row test grout curtain sections
  - 1 for testing of percussion and 1 for rotary drilling
  - “Chain link fence” or “lattice” array – rows oriented opposite each other
- Parallel sections with similar geologic and joint orientations
- Each 200-ft long, 15-ft wide
- Grout holes angled 15° from vertical, 7.5 ft from centerline of cutoff wall on each side
- Primaries 40-ft apart – split spacing down to 5-ft
Test Grout Curtain Design

Lattice Array promotes closure
Design (continued)

- Fully automated (computerized) grouting control and monitoring
- Demonstration section (10-ft rock grouting below overburden-rock interface)
- Verification boreholes (before and after)
- Rock coring
- Borehole camera logs
- Max. allowable deviation < 0.5 inch per foot (inclined) measured by precision instruments
Design (continued)

- **Primarily upstage (bottom up) grouting**
- **Downstage grouting for top 10-ft and zones of lost circulation**
- **Grout mix – balanced-stabilized mix, adjusted based on “Apparent Lugeon” value**
- **Criteria - no take for 5 min. at max. pressure**
- **Expected closure = 1 Lugeon or less**
  - (1 Lugeon = 1.4 x E-5 cm/sec)
- **Optional section (~ 800 ft)**
- **Lessons-Learned Report**
Construction

- Contractor: Advanced Construction Techniques (ACT) / Gannett-Fleming
- Started in January 2003
- Pad construction completed
- Intelligrout™ System Setup
- Drill Rig: Cubex-Wassara – Water driven, down-hole hammer
- Grout Plant: Fully automated (ACT-Thiessen)
Full-Scale Test Layout

Test Grout Curtain
200 lf each
Site Access and Curtain Alignment

Unusually good access

Contractor paved surface to assist alignment of drill rig
Drill Rigs

JKS Boyles Rig – HQ diamond tooling

Cubex-Wassara Rig – 4-inch Water-actuated down-hole-hammer
Grout Plant – ACT

Self-contained mobile plant and control center
Batching and Mixing

- Tanks designated by mixes and components
- Mixes checked for viscosity and sp. Gravity
- Flow measured by magnetic flow meters
- Mixing tanks equipped with load cells to monitor flow and supply
Pumps and Control Panel
Self-contained Mobile Grout Buggy with Flexible-Line Packer Assembly

- Constant in-line volume
- Highly portable
- Insulated lines
- Additional flow meter for Q/C at borehole
IntelliGrout System:

- Real-time monitoring and controls
- Continuous data acquisition
- Web-capable
- Computer-linked data presentation system
Summary

- **Complete Test Grout Construction in 2004**
  - Option section deleted due to funding shortfall
- **Lessons-Learned Report**
  - Combined with groundwater model for design of groundwater control system
- **Complete Design for Entire Perimeter**
  (7,500 ft Stage I and 6,000 ft Stage II) begin 2005
Summary

Lessons-Learned

- No detrimental effects on borehole quality by using down-hole water hammer
- 1.0 Lugeon achievable at the site
- Computer system grouting advantages are essential for project of this scale
- Balanced-stabilized mixes improve grout effectiveness
Summary

Lessons-Learned Report Combined with Comprehensive Groundwater Model

- Full-perimeter double-row grout curtain
- Curtain grouted to shale unit below base of reservoir
- Opposing orientation of double-rows for improved closure
- 1.0 Lugeon target closure criterion
Questions/Comments/Feedback???

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