SELECTION OF TUNNEL METHODS

By: Dr. Gary S. Brierley
Successful Tunnel “Design”

Produce a satisfactory finished facility for no more money and in no more time than is required for the existing ground conditions.
Tunnels are Different than Above-Ground Structures

- Entirely within the ground.
- The ground cannot be specified.
- The ground can be changed.
- Serial Construction Schedule.
Tunnels are Different than Above-Ground Structures

- Work from inside/out.
- The ground requires temporary support.
- Lots of third party impacts.
- Land not owned by project.
Building a Tunnel

- **Excavate** the ground
- **Control** the ground during the process of excavation.
- **Support** the ground as the tunnel is advanced.
- **Install** the final lining.
Evaluating Tunneling Issues

Diagram:

- Project Layout
- Subsurface Conditions

Ground Behavior / Ground Control

- Construction Methods
- Third Party Impacts
- Design Criteria

Contract Documents
Risk Management

✓ The Geotech
✓ The Designer
✓ The Contractor
✓ The Owner
✓ Third Parties
✓ Insurers, etc.
Case Histories
Phoenix Casa Grande Highway
Geotechnical Investigation

- Tunnel Alignments
  - Public ROW Roadways
  - Creek / Easement Parallel Existing Trunk Sewer

- Test Hole Locations
  - 15 Total Test Holes
    - Spatial Variation
    - Representative Mix
    - Based on Alignments
South Austin Regional Wastewater Treatment Plant

Tunneling Through Backfill and Lift Station Walls Without Disturbing Plant Operations

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Project Background

- SARWWTP receives flow from the south half of Austin (SAR Service Area)
- PER confirmed flow from service area
- Flow from two separate service areas is delivered to the site via two tunnels
- Tunnels terminate in two separate lift stations approximately 90 feet deep
- No definition of division of flow
Tunnel Route

- Avoid Damage to Operating Facilities
- Minimize Interruptions of Plant Operations
- Tunnel Must be Constructible
Tunnels Between Access Shafts No. 2

- Access Shaft 1 to Access Shaft 2 – 768 ft
- Decker Model 70 TBM – 5.75 ft dia
- Hobas Pipe – 63 in.
- Downhill - 0.2%
- Taylor Shale
Backfill of Existing Lift Stations

- Probing Operations
- Compaction Grouting
Saguaro Ranch Tunnel
Portal Cut
Horizontal Boring
Pilot Tunnel
Shotcrete
Top Heading
Final Tunnel
Grand & Bates Sewer Relief Tunnel
Tunnel Alignment

Grand & Bates / Plan View
Subsurface Conditions

- **Overburden Soil**
  - 25 to 75 ft. fill/loess/alluvial soils
  - Rubble fill (rip rap) at Outfall Structure

- **Highly Weathered Limestone**
  - Low quality fractured zones with shale seams
  - Pinnacled surface/karst potential
  - $k = 2.5 \times 10^{-3} \text{ cm/sec}$

- **Unweathered St. Louis Limestone**
  - White-light Gray, thin-massive bedding
  - Chert lenses and nodules
  - $k = 1.5 \times 10^{-5} \text{ cm/sec}$
VE Proposed Alternative Alignment

Simplified Alignment Reduces Construction Time, Effort, and Cost
Increased Tunnel Diameter

132-in Precast Concrete Liner Pipe increases storage volume by over 40%
Limited Use of Drill & Blast

Drill-Blast Starter Tunnel Used to Permit Assembly of TBM
Simplified Ground Support

5.5 ft. #8 Resin Grouted Rock dowels and WWF Provide Primary Crown Support

8 x 11.5 in. Channel Crown Sets at Railroad & Highway Crossings
Montreal
New Crystal Springs Bypass (Polhemus) Tunnel

City And County Of San Francisco Public Utilities Commission
San Francisco Water Department
SFPUC
Water Supply Improvement Program
Need for the Project
Project Location

North Shaft
Landslide area
New Tunnel
South Shaft Area
Ground Conditions
Ground Conditions

Sandstone

Mélange Matrix
Tunnel Boring Machine
Temporary Tunnel Lining
Crossing San Mateo Creek
A Final Recommendation: THINK! THINK! THINK! THINK!