Seepage Investigation and Remedial Grouting, Crafton Hills Reservoir, California

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Outline of Presentation

- Background of the dams
- Seepage History
- Geologic Investigation
- Remedial Grouting Plan
- Conclusions
Background – Site Location

California State Water Project (SWP)

East Branch Extension
Background – Site Location

Original Dam 2002

Enlargement Dam 2014
Background – Regional Geology
Seepage History – CH Reservoir

Appx seepage rate ~30 feet per day
Seepage History – CHE Reservoir

~160 ft/d
~20 ft/d
Seepage History – CHE Reservoir

So what?
Geologic Investigation – Objectives

- Determine seepage pathway(s) to develop remedial grouting plan
- Determine hydraulic properties of rock types under various pressure conditions
Geologic Investigation

Potential seepage pathways

Through outlet pipe??

Through/along dike?

Through discrete fractures?
Geologic Investigation – Methods

- Drill and install piezometers in different rock types
- Hydraulic conductivity tests
- Falling head tests
- Monitor response times to fluctuations in reservoir
- Dye tracer test
Geologic Investigation – Drilling

- 14 borings (rock coring)
- 14 piezos
- 5 VWPs
Geologic Investigation – Drilling

- Evidence of grout curtain
Geologic Investigation – K-Testing

- HCT ranged from 0 to 14 Lugeons
- Falling head tests ranged from 0.4 to 5.8 feet per day
Geologic Investigation – K-Testing

Measured permeability (cm/s)

Hydraulic conductivity test
Falling head test

- Felsic dike (~5.8 ft/d)
- Mafic dike (~2.7 ft/d)
- Meta-granitic (north)
- Meta-granitic (south)

CHE-23
CHE-29 (low)
CHE-29 (high)
CHE-30A
CHE-31 (low)
CHE-31 (high)
Geologic Investigation – Monitoring

1.2 days

4.5 days

3.3 days
Geologic Investigation – Dye Test

- Single packer set at 40 ft deep
- Applied 40 psi for 2 hours
- Monitored wells every 15 minutes
Geologic Investigation – Dye Test

Injection point

~85 feet per hour

+2 hrs

~400 feet
Geologic Investigation – Dye Test

Injection +2.5 hrs: Dye observed in CHE-20, -21, and CHE-22
Geologic Investigation – Dye Test

Injection +3.75 hrs: Dye observed in CHE-20, -21, -22, -25, -30A and CHE-31

+3.75 hrs
Geologic Investigation – Dye Test

Injection +4.5 hrs: Dye observed in CHE-20 and CHE-25
Geologic Investigation – Dye Test

Injection +6 hrs: Dye observed in CHE-25
Geologic Investigation – Dye Test

Injection +8 hrs: Dye observed in CHE-25
Geologic Investigation – Findings

- Groundwater responds differently in different materials
- Permeability testing indicated:
  - Felsic dike is more permeable under no/low pressure (up to 5.8 ft/day)
  - Meta-granitic rock is slightly more permeable under pressure (0.2 – 0.6 ft/day at 40 psi, versus 0.4 – 0.6 ft/day at no/low pressure)
- Dye test indicated:
  - a semi-impervious boundary condition along the dike
  - water moves quickly through the meta-granitic rock under pressure (85 ft/hour!)
Geologic Investigation – Findings

- Felsic dike does appear to be the primary seepage pathway:
  - Bubbling during filling
  - Not previously exposed to constant head
  - Most permeable unit tested with falling head
  - CHE-25 (screened in felsic dike) exhibits artesian pressures (>2.5 feet)
  - Seepage condition at Location B has not changed
  - CHE-25 was only downstream well where dye was observed
Remedial Grouting Plan

Phase 1

Phase 2

Phase 3
Conclusions

- The dikes seem to act both as a preferential pathway and an impediment to groundwater flow.

- The behavior of the felsic and mafic dikes vary substantially using typical grouting pressures (40-60 psi) and low/no pressure:
  - Used this information to develop a more realistic remedial grouting program.

- The calculated permeability rates are different but in the same neighborhood as the observed seepage rates.