U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE
MANAGEMENT

NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: HYDRAULIC AND CONSERVATIVE TRACER TESTING AT C-WELLS COMPLEX

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PAHRUMP, NV JANUARY 29, 1997
Generalized geologic map showing the location of the C-hole complex and nearby boreholes (Geology modified from Day and others, in press).
Surface location and drift of boreholes UE-25c #1, UE-25c #2, and UE-25c #3 (Map referenced to Nevada State, Zone 2, coordinates)
Hydrogeologic intervals delimited by packer placement in the C-holes, June 1995 to August 1996
Hydraulic Tests

- 5/95  Open-Hole
- 6/95  Open-hole in pumping well, packed off in observation wells
- 2/96  In Bullfrog-Tram
- 5/96  In Lower Bullfrog
- 5/96  To present: Long-term test
Drawdown in the vicinity of Borehole UE-25 c#3, 14,000 minutes after pumping started, pumping test in Borehole UE-25 c#3, May-June 1995

Explanation

- Line of equal drawdown -- Interval, in meters, is variable
- BOREHOLE - Borehole numbers above line; drawdown, in meters, below line
UE-25 C#2 DRAWDOWN, MAY 1996 - JANUARY 1997
# Results of Hydraulic Testing

<table>
<thead>
<tr>
<th>Unit</th>
<th>T (ft²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calico Hills</td>
<td>200-1,000</td>
</tr>
<tr>
<td>Prow Pass</td>
<td>400-800</td>
</tr>
<tr>
<td>Upper Bullfrog</td>
<td>400-3,600</td>
</tr>
<tr>
<td>Lower Bullfrog</td>
<td>18,000-26,000</td>
</tr>
<tr>
<td>Upper Tram</td>
<td>6,000-8,000</td>
</tr>
<tr>
<td>Composite</td>
<td>18,000-32,000</td>
</tr>
</tbody>
</table>
Photograph of C-Holes Complex showing injection pipes for tracers
Tracer Tests

- 2/13/96 Test with c#3 as pumping well and iodide injected in c#2 in convergent flow field (Combined Bullfrog-Tram)

- 1/10/97 Test, similar flow field, Pyridone injected into c#1 and 2,6 di-fluoro benzoic acid (DFBA) injected into c#2 (Bullfrog)

- Planned Prow Pass test
Moench Analytic Solution to Advection Dispersion Equation

\[ \rho_E = \frac{r_L}{\alpha_L} ; \quad L_a = \pi \omega \phi \left( \frac{r_L^2 - r_w^2}{2} \right) \]

\[ \gamma (\text{GAMA}) = \gamma \left( \Delta_m, 1 - \phi, \frac{1}{C}, q_0, h, \right) \]

\[ \Gamma (\text{SIGMA}) = \Gamma \left( \frac{\phi M}{\phi_f (1 - \phi_f)} \right) \]
Blocks with Boundary Layers

Discontinuous Fractures

\[ \phi_M \bigg|_{\text{eff.}} = \frac{\sum V_B}{V} \ll \phi_M \]

\[ \phi_f \bigg|_{\text{eff.}} \gg \phi_f \]
GELHAR ET AL.: FIELD-SCALE DISPERSION IN AQUIFERS

![Graph showing field-scale dispersion in aquifers with scale and longitudinal dispersivity on a log-log scale.]

**Scale (m)**

- $19' = 5.79m$
- $100' = 30.48m$
- $23' = 7.13m$
- $281' = 85.6m$
- $8.68' = 2.65m$
- $96' = 29.26m$

**RELIABILITY**

- • low
- ○ intermediate
- ○ high

**C1**

- $19' = 5.79m$
- $23' = 7.13m$
- $100' = 30.48m$
- $281' = 85.6m$

**C2 (new)**

- $8.68' = 2.65m$
- $96' = 29.26m$
Combined UE-25 c#2 (USGS) and residual from LANL test

Time since injection of Iodide in UE-25 c#2 (USGS), in days

Concentration of Iodide, in ppb

Estimated Additional Mass due to C#2 Injection
(154 GPM rate) ~ .947 kg

PFBA inject 5-15-96 1220 hrs

UE-25 C#1 Injection

98 GPM

pump off

3-29-96

22 ppb

154 GPM

pump on

41 days

5-2-96

2-9-96

6-18-96 0800 hrs

0 20 40 60 80 100 120 140 160 180
Results of Conservative Tracer Tests

- Fracture Porosity: 0.0068 - 0.0866
- Matrix Porosity: 0.032 - 0.1895
- Longitudinal Dispersivity: 8.68 ft - 20.75 ft

- Dual-porosity medium seems to be indicated by the data
- Transport parameters less firm than hydraulic parameters
Conclusions

• High-flow zones at the C-wells complex have been successfully characterized for hydraulic and transport properties.

• Results from hydraulic testing have provided information on hydraulic parameters at a scale larger than C-wells.

• Success of testing at complex indicates that it should be used for additional testing:
  1) Low-flow zone
  2) Fault zone at bottom of complex
Planned Future Work

- Conduct hydraulic and conservative tracer testing in a low-flow zone at the C-wells complex (Prow Pass)

- Conduct hydraulic and conservative tracer testing at other locations near Yucca Mountain