Surface Discharges and Injection of Produced Geothermal Water

Geothermal Resources Council
Portland, Oregon
September 27, 2014
Presented by Scott Nichols, Manager of Permitting & Lands
Power Plants, Cooling Options and Water Reuse

- Raft River, Idaho
  - Water Cooled
  - Geothermal Injection
  - Agricultural Re-use & Infiltration

- Neal Hot Springs, Oregon
  - Air Cooled
  - Geothermal Injection

- San Emidio, Nevada
  - Water Cooled
  - Geothermal Injection
  - Surface Discharge
Raft River Project Site
Raft River Pre-Project Site Conditions

- Beneficial use designation: cold water biota, salmonid spawning, and primary contact recreation.
- 303 (d) listed; 2004 TMDL limits established temperature, bacteria and sediment.
- Represents the last segment (2 miles) of riparian system on Raft River.
- Intermittent stream flow and an “at-risk” riparian system.
- 20 – 90 feet to ground water.
- Geothermal springs and wells throughout valley.
General Permit
Considerations & Conditions

• Non-Contact Cooling Water is Not Wastewater
• Surface Water Quality Rules – Require Evaluation of Recharge Water
• Ground Water Quality Rule – Require Assessment of Potential GW Impacts

• Primary Purpose of Permit is Ground Water Quality Protection

• Ground Water Quality
  • Fluoride exceed GW quality standards in domestic wells.
  • GW quality standards for TDS, Fe, Mn, Cl exceeded in most wells.
  • Baseline TDS of all local cold water wells approximately 2000 mg/l.
  • Baseline TDS in irrigation wells – 1237 mg/l.
  • 7 shallow & intermediate depth monitoring wells.
  • Project does not increase the constituent load, only the concentration.
Operational Parameters

- Three “Fluid” Cycles
  - Geothermal – Closed System 100% Injection
    - +/- 5000 gpm at 280° from wells RRG-1,2,4,7
    - +/- 5000 gpm injected at 133° at wells RRG-3,6,11
  - Cooling Water – Reuse and Irrigation
    - Average 500 gpm from three wells
    - 60% evaporative loss (app. 300 gpm)
    - 40% reuse and irrigation (app. 200 gpm)
  - Iso-Pentane
Cooling Water Reuse

• Utilized existing water rights for the property
• Soils are silt loam +/- 60 inches
• Agricultural water right converted to an industrial water right (IDWR)
• 30% percent reduction due to higher consumptive & year round use

• Pre-project Irrigation
  • 940 acres irrigated cropland
  • Average TDS concentration – +1250 mg/l
  • Average TDS load - 4.6 tons/acre/year

• Post Construction Reuse and Irrigation
  • 113 acres irrigated pasture and infiltration area (3 acres)
  • Average TDS concentration < 2000 mg/l
  • Average load – 7-9 tons/acre/year
Irrigation and Wastewater Management
Monitoring Network and Schedule

- **Three Monitoring Components**
  - Non-Contact Cooling Water (1 site)
    - Continuous, Monthly, Quarterly
    - Composite and Grab samples
    - TDS, EC, pH, As, Cl, Pb, F, N, P, Fe, Mn
  - Groundwater Wells
    - 5 upgradient, 7 downgradient
    - First Year - Quarterly
    - Semi-Annual thereafter
  - Soils (Infiltration Basins)
    - Annually (3 monitoring units)
    - SAR, pH, EC, Mn, Fe, Cl, P, Na
Background & Monitored Groundwater Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Background Groundwater mg/l</th>
<th>Monitoring Results mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS</td>
<td>2214</td>
<td>1555</td>
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<tr>
<td>Chloride</td>
<td>953</td>
<td>716</td>
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<tr>
<td>Manganese</td>
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<tr>
<td>Fluoride</td>
<td>3.6</td>
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<tr>
<td>Arsenic</td>
<td>&lt;.05</td>
<td>&lt;.05</td>
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<tr>
<td>Iron</td>
<td>4.2</td>
<td>3.0</td>
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<tr>
<td>Lead</td>
<td>&lt;.005</td>
<td>&lt;.005</td>
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</table>
# Background & Monitored Soil Conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline Soil mg/l</th>
<th>Monitoring Results mg/l</th>
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<tbody>
<tr>
<td>SAR</td>
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<td>.62</td>
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<tr>
<td>Chloride</td>
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<td>Manganese</td>
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<tr>
<td>Sodium</td>
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<tr>
<td>Potassium</td>
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<tr>
<td>Iron</td>
<td>5.33</td>
<td>4.26</td>
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Center Pivot Operations
April 15 – October 31
Infiltration Area Operations
November 1 – April 14

Apply 63 feet of reuse water or approximately 41 million gallons each winter.
## Predicted & Monitored Cooling Water Quality

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Predicted Cooling WQ</th>
<th>Monitoring Results</th>
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<tbody>
<tr>
<td>TDS</td>
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<td>2483</td>
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<tr>
<td>Chloride</td>
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<td>Nitrogen</td>
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<tr>
<td>Fluoride</td>
<td>4.8</td>
<td>2.54</td>
</tr>
<tr>
<td>Arsenic</td>
<td>not predicted</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Iron</td>
<td>not predicted</td>
<td>.2</td>
</tr>
<tr>
<td>Lead</td>
<td>not predicted</td>
<td>&lt;.005</td>
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<tr>
<td>Ortho- Phos as P</td>
<td>3.3</td>
<td>.5</td>
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<tr>
<td>Manganese</td>
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<tr>
<td>Magnesium</td>
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<tr>
<td>Sodium</td>
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<td>375</td>
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Raft River Summary

- There is no significant change in water quality or water quality trends in the project area from 1979 through 2014.
- Annual fluctuations in ground water elevation are consistent with those observed in the Geoscience Study (1981) and EG&G (1979). Depth to ground water is not changing.
- TDS and chloride concentrations in ground water show no upward trend.
- Actual cooling water reuse is approximately 30% lower than estimated.
- TDS concentrations are approximately 29% lower than originally modeled.
- Reuse water volume does not meet irrigation - demand 3-5 inch irrigation deficit.
- No runoff to Raft River.
- No impacts to groundwater.
- Significant riparian improvement.
- Year round stream flow
Neal Hot Springs Site
Neal Hot Springs
Pre-Project Site Conditions

- Beneficial use designation: cold water biota, primary contact recreation.
- 303 (d) listed; TMDL limits established for temperature and bacteria.
- Marginally functioning riparian system.
- Intermittent stream flows, riparian system in decline.
- 0-20 feet to groundwater.
- Geothermal springs mix with surface water.
General Permit Considerations & Conditions

• Required baseline hydrologic and geologic assessment.
• Primary Purpose of Permit is Ground Water Quality Protection.
• Ground Water Quality
  • Geothermal influenced ground water quality standards exceeded for TDS, Chloride & Silica.
    • 3 domestic well monitoring points in shallow aquifer.
• Surface water shows no geothermal influence.
• Monitor spring and fall for elevated constituents of interest.
  • (TDS, Chloride & Silica)
• Annual water assessment.
San Emidio Site
San Emidio Site Conditions

- No Surface Water.
- No Ground Water.
- No Natural Riparian System.
- 0-100 feet to Geothermal Fluid.
- Elevated Ground Surface Temperatures.
- Playa discharges 40 inches water annually.
- Long History of Discharge to Retention Ponds & Playa.
San Emidio Reporting

- Monthly Reporting
  - Bureau of Land Management & Division of Minerals
    » geothermal fluid production, injection, temperature & pressure.
  - Division of Water Resources
    » geothermal fluid production & injection; water & blowdown.

- Quarterly Reporting
  - Division of Environmental Protection (NDEP) for Surface Discharge
    » Daily average & maximum blowdown; TDS, pH, Profile 1

- Semi-Annual Reporting
  - NDEP - Underground Injection Control
    » Average discharge & total geothermal fluid & blowdown
Summary

1. Start baseline surface and ground water monitoring early.
2. Become the expert on local hydrology & geothermal fluid behavior.
3. Know your neighbors, understand their concerns, build confidence.
4. Collaborate and build agency support during well permitting.
5. Work within the local hydrologic and soil conditions.
6. Good data = streamlined permitting