Reclamation Of The Abandoned Spenceville Copper Mine, Spenceville Wildlife Area, Nevada County, California

Presented by:
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California Geological Survey

California Department of Fish and Game
Walker and Associates
Construction Remediation Engineering
Central Valley Regional Water Quality Control Board
California Geological Survey

1 - Engineers Association of Nevada County 2002 Project of the Year;
Governor's Watershed Management Project of 2002;
California Department of Fish & Game 2002 Director's Achievement Award
The Players

DFG – Patricia Perkins, Jenny Decker
WA – William Walker, Laura Pucik, Fred Mueller
CRE – Ronald Perry
Nevada County – Elizabeth Martin
RWQCB – Robert Busby
CGS – Stephen Reynolds
Location

Formerly Camp Beale, Town Used In “Live Fire” Training For Invasion Of Germany

Transferred to State 1966, Now Part Of Spenceville Wildlife Refuge

Federal Government Retained Mineral Rights

Spenceville Circa 1947
History

• 1862 copper sulfide ore vein discovered
• Underground copper mining through 1880, when workings collapsed
• Open pit mining through 1888

• Imperial Paint Co., 1890 – 1897
• Spenceville Mineral Co. produced sulfuric acid 1904 – 1915
• 1939 Camp Beale training area
Setting

- Ecology: Blue Oak Woodland
- Hydrology: LDC Seasonal Stream augmented by Diversion from Deer Creek
- Geology: Smartville Complex
- Mining: Fifteen (15) Copper Mines within 10 miles of Spenceville
Reclamation Goals

• Improve surface- and ground-water quality
• Remove chemical hazards from site
• Remove physical hazards from site
• Restore Little Dry Creek
• Restore site for public recreational use
The Problem is Always Bigger Than You Think  Murphy
Additional Tasks

- Little Dry Creek restoration
- Historic and cultural artifacts archive
- Long term monitoring
  - ground water
  - surface water
  - vegetation
- Maintaining challenging Timeline
  - permitting
  - equipment procurement
  - mobilization
- Ability to handle contingencies
  - unknown pit features (adits, shafts, rubble)
  - historic and cultural artifacts
  - UXO
  - stream restoration
  - risk assessment results
Key Project Issues

• Project Implementation
  – Regulatory interface, multiple state agencies
  – Project financing
  – Subcontractor management
  – Suppliers
  – Time line

• Technical
  – Geochemistry
  – Engineering Geology
  – Geomorphology
Seven Million Gallon Pit “Lake” Surrounded By 66,000 Cubic Yards Of Acidic, Heavy-Metal Laden Mine Waste

Remnants of main shaft adjacent to remaining high-grade ore. Ore ranged from 3 - to 30- percent copper by weight.

Cross-cut drift along strike of main ore body

Sulfur Veins In Ore Processing Waste

Pyrite
Chalcopyrite
Chalcocite
Bornite
Sphalerite
Covellite

FeS₂
CuFeS₂
Cu₂S
Cu₅FeS₄
ZnS
CuS

FeS₂ + 15/4O₂ + 7/2H₂O = Fe(OH)₃ solid + 2SO₄²⁻ + 4H⁺
Engineering Geology

- Joint & Fracture Mapping – Slope Stability Analysis
- Selection Of Access Road Alignment
- Fill Placement & Compaction Control
- Run-on / run-off System Utilizing Wetland
### Design Parameters for Restoration of Little Dry Creek

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankfull Q</td>
<td>644 cfs</td>
</tr>
<tr>
<td>Slope</td>
<td>0.017</td>
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<tr>
<td>Bankfull Width</td>
<td>65 ft</td>
</tr>
<tr>
<td>Width Flood-Peak Area</td>
<td>175 ft</td>
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<tr>
<td>Bankfull Max Depth</td>
<td>4.2 ft</td>
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<tr>
<td>Bankfull Mean Depth</td>
<td>2.0 ft</td>
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<tr>
<td>Bankfull Area</td>
<td>140 sq ft</td>
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<tr>
<td>Entrainment Ratio</td>
<td>2.9</td>
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<tr>
<td>Width - Depth Ratio</td>
<td>15.5</td>
</tr>
<tr>
<td>D50</td>
<td>18 mm</td>
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<tr>
<td>Sinuosity</td>
<td>1.6</td>
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<td>Meander - Width Ratio</td>
<td>3</td>
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<tr>
<td>Riffle-pool spacing</td>
<td>300</td>
</tr>
<tr>
<td>Meander Length</td>
<td>796 ft</td>
</tr>
<tr>
<td>Radius of curvature</td>
<td>300 ft</td>
</tr>
<tr>
<td>Rosgen Classification</td>
<td>C4</td>
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</table>

#### Using Reference Reach As Starting Point – Integrate Regional and Local Hydrologic Data To Design Replacement Channel

- **Watershed Parameters**
  - Peak flow: 644 cfs
  - Area: 10 to 20 square miles

- **Watershed Area**
  - Peak year: 1996
  - Peak year 1: 1991
  - Peak year 2: 1992
  - Peak year 3: 1993

- **Channel**
  - Peak flow: 644 cfs
  - Area: 10 to 20 square miles

- **Peak Q vs. Watershed Area for California Watersheds 10 to 20 Square Miles**

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**Hydrogeology & Fluvial Geomorphology**

**Reference Reach – Existing Natural Analog From Upper LDC and Local Streams**

**Channel Pebble Count**

**Cumulative %**

<table>
<thead>
<tr>
<th>Particle Size (mm)</th>
<th>Cumulative %</th>
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<tr>
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<td>4</td>
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<td>6</td>
<td>60</td>
</tr>
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<td>8</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>

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**DMG**

**Notes**

- Elevation in feet
- 327.2
- 330.0
- 331.0
- 332.0

**Cut to 331.4 OR DAYLIGHT; CONTOUR TO O.G.**

**Peak Q vs. Watershed Area for California Watersheds 10 to 20 Square Miles**

<table>
<thead>
<tr>
<th>Area in Square Miles</th>
<th>Peak Q (cfs)</th>
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<tbody>
<tr>
<td>10</td>
<td>1000</td>
</tr>
<tr>
<td>12</td>
<td>1100</td>
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<tr>
<td>14</td>
<td>1200</td>
</tr>
<tr>
<td>16</td>
<td>1300</td>
</tr>
<tr>
<td>18</td>
<td>1400</td>
</tr>
<tr>
<td>20</td>
<td>1500</td>
</tr>
</tbody>
</table>
AMD Treatment Plant

• Single phase neutralization
  – 150 GPM
  – 24/7 operation
  – Influent pumped and mixed from 3 depth pit to obtain average input of ~9000 ppm TDS
  – gravity flow through plant
  – 7.3 million gallons treated
  – 25,000 cu ft sludge generated
  – On-site process and effluent monitoring

• Effluent used to irrigate wildlife fodder
Tailings Treatment

- Liming agent: sugar beet waste
  - long term buffering, pH control
  - hematite: 10% by volume amendment
  - jarosite: 30% by volume amendment

- Pit backfilled with treated material
  - layer of limestone rock lining the pit
  - 90% compaction of treated materials
  - excess of material will result in mound

- Pit covered with native soils and revegetated with native species

- Final cover land form based upon geomorphic analysis
  - Integrated into broader landscape
Treated Water Irrigating Wildlife Forage

Removal & Treatment Of Acidic Mine-Pit Water

Backfilling Dewatered Mine Pit With Stabilized Waste
Site Reclamation
Restoration Of Little Dry Creek
Bird’s-Eye View

Then

1993

Now

2010

Then 2010

A
Keys to Success

• Risk Sharing
  – Contractors and State
• Real-Time Decisions
  – Issue change orders on site
• Daily QA/QC Review
  – What’s working-What’s not – What needs to change
  – Critical path management
• Unified Technical and Financial Control
  – The buck stops here