High Resolution Groundwater Models of the San Joaquin River Riparian Zone for Evaluation of Surface Water/Groundwater Interactions under Alternate River Flow Regimes

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Project Study Area:

Friant Dam to the Merced River
Model Capabilities

• Characterize
  • Near-river groundwater elevations
  • River seepage losses
  • Boundary flux (regional/local interface)

• As function of
  • River stage
  • River extent
  • Regional groundwater boundary conditions
  • Antecedent flow conditions and resulting groundwater condition
Model History - 1

- **1999-2000**: For SJ RRHRP (USBR contract)
  - **Domain**: Extent of mapped riparian vegetation, 5 reaches
  - **Resolution**: 300 x 50 ft model cells, 5 to 13 model layers
  - **Parameterization**: Soil texture analysis, 300+ logs; calibration
  - **Calibration**: Reach 1 & 2 only, shallow piezometer data
  - **River boundary**: HEC-2 models (MEI, 2000), 3 flow exceedence levels
  - **Code**: MODFLOW, with custom package for 2-D unsaturated flow
  - **ET**: variable by plant group and time of year
  - **Applications**: Sensitivity analyses illustrating dynamic nature of surface water/groundwater conditions
Model Input: Land Surface and River Bottom Elevations, Reach 2
Distribution of Wells Providing Lithologic and Water-Level Data

- San Joaquin River

Depth of Well
- Unknown
- Less Than 100 Feet
- Greater Than 100 Feet

3 0 3 6 Miles

N
River Cell Coverage under Alternate Discharge Profiles
Original Model Calibration in Reach 2 using data from 1999 pilot releases

b) River MP 220, Model Row 140

<table>
<thead>
<tr>
<th>Date</th>
<th>Measured Depth to Water (feet below measuring point)</th>
<th>Simulated Water Level Change (feet from starting elevation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/29/1999</td>
<td>-10</td>
<td>Model Cell near River (row 140, column 129)</td>
</tr>
<tr>
<td>8/9/1999</td>
<td>-8</td>
<td></td>
</tr>
<tr>
<td>9/20/1999</td>
<td>-6</td>
<td></td>
</tr>
<tr>
<td>11/1/1999</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>12/13/1999</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>1/24/2000</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3/5/2000</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4/16/2000</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>4/16/2000</td>
<td>6</td>
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</table>
Example Sensitivity Analysis: Steady State Depth to Water under Alternate River Flow Conditions

**DEPTH TO WATER**
- **Red** = 52 – 60 ft
- **Yellow** = 44 – 50 ft
- **Green** = 20 – 44 ft
- **Blue** = 0 – 20 ft

**High River Stage**

**Base Case**

**Low River Stage**
Model History - 2

• 2005: Model Update and Assessment of Proposed Restoration Hydrographs
  • **Domain:** Unchanged
  • **Resolution:** 300 x 50 ft model cells, 3 model layers
  • **Parameterization:** Updated, new monitoring data
  • **Calibration:** Reach 1 & 2, seepage losses and groundwater elevations
  • **River boundary:** Updated HEC-2 models (MEI ’05), 6 RIV Pkgs
  • **ET:** variable by plant group and time of year
  • **Applications:** Evaluation of seepage losses and groundwater conditions with alternate restoration hydrographs
Updated Model Calibration, Spring 2005 Flood Release
River Coverage in Reach 2 for RIV Pkg at 500, 2,000 and 8,000 cfs
Updated Model Calibration, Simulated and Observed Groundwater Levels
Updated Model Calibration, Spring 2005, River Seepage Targets

Friant Dam to Gravelly Ford (Reach 1)
Gravelly Ford to Bifurcation Structure (Reach 2a)

Note: Reach 1 losses include river diversions. Reach 2 losses include levee seepage.
Simulated Groundwater Elevation before and after 2005 Peak Flow, Reach 2
Example Restoration Hydrograph and Simulated Reach Losses

### Normal Condition Hydrograph

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow (cfs)</th>
<th>Reach 1a</th>
<th>Reach 1b</th>
<th>Reach 2a</th>
<th>Reach 2b</th>
<th>Total, cfs</th>
<th>Total acre-ft</th>
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</thead>
<tbody>
<tr>
<td>10/1-1/31</td>
<td>500</td>
<td>46</td>
<td>30</td>
<td>166</td>
<td>3</td>
<td>245</td>
<td>59,772</td>
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<tr>
<td>2/1-2/25</td>
<td>1,000</td>
<td>77</td>
<td>53</td>
<td>96</td>
<td>279</td>
<td>505</td>
<td>25,041</td>
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<td>2/26-4/6</td>
<td>2,000</td>
<td>89</td>
<td>57</td>
<td>83</td>
<td>81</td>
<td>310</td>
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<tr>
<td>4/7-5/3</td>
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<td>88</td>
<td>100</td>
<td>86</td>
<td>429</td>
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<td>5/14-7/22</td>
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<td>-4</td>
<td>29</td>
<td>-8</td>
<td>13</td>
<td>1,805</td>
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<td>7/23-9/30</td>
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<td>29</td>
<td>16</td>
<td>37</td>
<td>2</td>
<td>84</td>
<td>11,663</td>
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</tbody>
</table>

### Reach 1 and 2 Annual Seepage Loss, acre feet

| Reach 1 and 2 Annual Seepage Loss, acre feet | 144,085 |
Simulated Groundwater Elevation, under Restoration Hydrograph for “Normal” Year, Reach 2, after “Dry” Year

Left: before 4,000 cfs peak
Right: after 4,000 cfs peak
Observations

• River seepage losses are dynamic:
  • Non-linear dependency on river flow
  • Dependent on past year’s flow history
  • Dependent on regional groundwater levels
  • Not all losses will return as bank storage.

• Groundwater elevations are dynamic:
  • Dependent on river flows
  • Dependent on pumping in near and distant regions
  • Impacted by vegetation and stream bed
Implications

• River losses will vary substantially throughout a season;

• Losses in any given year will likely vary from those seen in a prior year.

• Making most efficient use of available water to meet river restoration goals will require sophisticated understanding of groundwater conditions impacting river seepage losses.
Improving Model Reliability

- DATA, DATA, DATA…
  - Groundwater piezometers
  - Well logs
  - Hydraulic testing
  - Land surface and river bed elevation data
  - Flow data

- CALIBRATE, VERIFY, CALIBRATE, VERIFY. CALIBRATE……
  - Restoration program data can be used to refine tools and improve their value to the program in meeting water management and restoration goals.
Questions?