Simulation of rivers, drains, and Lake Lowell

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Context
The modeling process

Define problem
- Literature review
- Preliminary analyses
- Data collection

Develop conceptual model
- Processes/budget
- Boundary conditions
- Hydrogeologic framework
- Data collection

Develop mathematical model
- Choose model code
- Choose how to represent processes and boundary conditions
- Construct the model

Calibration
- History matching
- Sensitivity analysis
- Data collection

Assessment of problem using model

Project completion

and objectives based on simulation results

After Reilly (2001) TWRI 3, B8
Groundwater discharges overwhelmingly to rivers and drains (much larger than pumping) 

Lowell is locally important
12. CONCLUSIONS AND RECOMMENDATIONS

A numerical model was constructed to simulate regional-scale, steady-state, ground water flow in the Treasure Valley of southwestern Idaho. Conclusions from simulations using this model consist of the following:

1. PEST-calibrated parameter values indicate relatively higher $K_A$ values in the uppermost aquifer zones, corresponding to known areas of coarser-grained sediments. PEST-calibrated parameter values also indicate relatively higher $K_A$ and $K_C$ values in areas of the eastern and central portion of the valley associated with fluvial deltaic deposition.

2. Simulated fluxes between model layers in the base calibration indicates a relatively small amount of water moving vertically between model layers, especially in the lower layers. Based on simulation results, most recharge occurring in shallow aquifer zones does not reach lower zones.

3. A 10% increase or decrease in recharge led to minimal changes in water levels or parameter value estimates. This is because shallow ground water levels in central portions of the basin are controlled, in part, by elevations of surface water channels. Decreased or increased recharge resulted in changes in the rates of water discharging to model drain, general head boundary (Lake Lowell), constant head (Snake River), and river (Boise River) cells.

4. Underflow does not appear to be consistently distributed along the Boise Front. The model experienced difficulty in applying rates as high as 8,000 ft$^3$/day/acre (similar to water budget estimates) in some model areas, especially in the far eastern portions of the model domain.

5. Simulated minimum water levels (maximum impact) indicated that some ground water level declines might occur with a 20% increase over 1096 levels. Simulated modest declines were observed in the Boise area in layers 1 and 2. Greater simulated declines were observed in the central portion of the valley (especially in the Lake Lowell area) in layers 3 and 4. Simulated water level declines and/or changes in mass balance components reflect a combination of parameter uncertainty and response to a changed hydraulic stress.

6. The simulated 20% increase in ground water withdrawals resulted in increased losses from the Boise River (23%), decreased discharges to agricultural drains (62%), and decreased discharge to the Snake River (9%). Again, simulated water level declines and/or changes in mass balance components reflect a combination of parameter uncertainty and response to a changed hydraulic stress.

7. Uncertainty in the model calibration limits a more precise description of responses to changes in recharge and/or withdrawals.

8. Changes in land use that lead to decreases in shallow-aquifer recharge may not have a substantial effect on shallow ground water levels until the water table elevations remain below those of nearby surface channels.

Additional simulations should be considered to better define aquifer system characteristics or scenario predictions. These include the following:

1. Maximum and minimum hydraulic head predictions with no changes in model stresses from the base simulation. Use the results from these simulations for comparisons in scenario predictions.

2. Increases and decreases of 30% (over 1996 levels) in aquifer recharge.

3. Across-the-board withdrawal increases and decreases in aquifer withdrawals over 1996 levels.

4. Increased local withdrawals in various locations in the valley to test responses in water levels and in recharge rates to lower model layers.

5. Simulations with reductions in recharge and increases in withdrawals to estimate at what point shallow ground water levels drop below draw elevations in the central portion of the valley.

6. Horizontal and vertical variations in underflow along the Boise Front.

7. Conduct additional simulations to refine the understanding of ground and surface water interaction in the Boise River corridor using a more refined grid than, and/or submodel of, the current model.

8. Develop response ratios for the interaction between ground water extractions and seepage from or discharge to surface channels.

Additional recommendations include the following:

1. Expand monitoring in areas showing recent ground water level declines.

2. Consider incorporating new monitoring data into the model as they become available.

3. Better define discharge rates to surface water channels to allow more constraint on simulated discharge.


5. Refine model based on newly compiled diversion and return data.

6. Install additional multi-completion monitoring wells to expand vertical and/or horizontal data.

7. Search for opportunities to enhance ground water level monitoring in portions of the valley with relatively few current data.
Drains in Treasure Valley
Example
Areal Extent
Measured Drains

EXPLANATION
- City or community
- Stream or river
- Reservoir
- Approximate model extent
- Streamgage
- Streamgage (drain), new
- Streamgage (drain)
- Measurement site (drain)
- IPCO streamgage

User Name: ybarst
Date Saved: 6/5/2017 8:18:35 AM
Document Name: TV_37_Streamgages
Measured Drains

13206400 - Eagle Drain
13210980 - Fifteenmile Creek nr Midland Blvd nr Middleton
13210980 - Mason Creek at Caldwell
Measured Drains

13210840-N. Middleton Drain
13210831-S. Middleton Drain
Measured Drains

132109867-E. Hartley Abv Backwater nr Wilder
13210986-W. Hartley Gulch nr Caldwell
Measured Drains

13212549 - Conway Gulch Below 1st St. at Notus
13212890 - Dixie Drain nr Wilder
13213072 - Sand Run Gulch nr Parma
Measured Drains

13173635-Ross Drain
13173630-S. Boise Drain
13173632-N. Alkali Drain
Drain boundaries in MODFLOW
MODFLOW Drain Package

Water only exits

Not a source of recharge

Flow proportional to head difference when head above a certain elevation; Zero flow when below

\[ Q_{out_{nb}} = CDRN_{nb} (h_n - HDRN_{nb}), \]
\[ Q_{out_{nb}} = 0, \]

\[ h_n > HDRN_{nb} \]
\[ h_n \leq HDRN_{nb}, \]
Implementation
Drain Discharge
### Discharge Data

**USGS 13210824 N MIDDLETON DRAIN (MILL SLOUGH) AT MIDDLETON ID**

- **Canyon County, Idaho**
- **Hydrologic Unit Code**: 17050114
- **Latitude**: 43°42'23.58", **Longitude**: 116°37'05.49" NAD83
- **Drainage area**: 63 square miles
- **Gage datum**: 2,390 feet above NAVD88

#### Output formats
- HTML table of all data
- Tab-separated data
- Reselect output format

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**00060, Discharge, cubic feet per second**

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</tr>
</tbody>
</table>

**Mean of monthly Discharge**

| Mean of monthly Discharge | 24 | 29 | 25 | 32 | 39 | 41 | 38 | 42 | 41 | 35 | 31 | 28 |

*No Incomplete data have been used for statistical calculation*
Rivers
Rivers
Boise & Payette

Water can flow either way

Recharge and discharge

Flow proportional to head difference when head above a certain elevation; Flow is constant when below

\[
Q_{RIV_{nb}} = CRI_{V_{nb}} (HRIV_{nb} - h_{n}), \quad h_{n} > RBOT_{nb}
\]
\[
Q_{RIV_{nb}} = CRI_{V_{nb}} (HRIV_{nb} - RBOT_{nb}), \quad h_{n} \leq RBOT_{nb}
\]
Rivers

USGS
science for a changing world
Lake Lowell
Lowell
Lowell

**General Head Boundary**

\[ Q = -C(H - H_{\text{ref}}) \]

- **H**: groundwater head
- **H_{\text{ref}}**: lake stage
- **C**: lakebed conductance
Lowell

\(H\): groundwater head

\(H_{ref}\): lake stage

\(C\): lakebed conductance

\[C = \text{multi}_{area} \times C_{base}\]

\[\frac{Q}{A} = K \frac{\Delta H}{L}\]

\[C = \frac{KA}{L}\]

\[Q(t) = -C(t) \times (H - H_{ref}(t))\]
Thanks for listening!