Channel bars are a common feature in fluvial river systems. The Truckee River has 321 bars over 192 km, which cover nearly 10% of the total river surface area, and more than double the stream length. Channel bars induce near stream exchange through streamlined topography, streamlined obstructions, position in fluvial plain, hydraulic conductivity magnitude and distribution, velocity distribution in the stream channel, and stage relative to groundwater level. To date, there has been limited quantification of flow and transport through channel bar systems. The objective of this investigation was to quantify GW/SW flux differences between a channel bar, streambed, and streambank. In addition, temporal water level and heat transport dynamics were investigated to assess the effect of channel bars on long-term GW/SW exchange.

**STUDY AREA**

- Average discharge 12.5 m^3 s^-1
- Average air temperature 8.4°C
- Average precipitation 178 mm yr^-1
- 80% of the water generally losing stream.
- Streambank hydraulic gradient 0.185%
- Mixed cobble, gravel, and sand.
- 200 m long, 60 m wide average channel bar dimensions (Fig. 1).
- Stage difference across bar 0.7 m
- 30% Cottonwood, Willow, and Alder surrounding bar.

**METHODS AND EQUIPMENT**

- 11 piezometers and wells installed and monitored between 2003 and 2009.
- Multiple slug tests with variable volume injections analyzed by the Bouwer and Rice methodology.
- In-stream discharge monitored with velocity/area method and ADCP cross sections at 28 locations between 2003 and 2009. Verified by USGS gauge.
- Precipitation and other micrometeorological measurements collected nearby in Fallon, NV.
- Temperature corrected I-Button temperature dataloggers at 30- or 60-min intervals.
- Water levels/stage monitored with MicroDiver pressure transducers at 30- or 60-min intervals. Verified with manual measurements.
- Using heat as a tracer to quantify groundwater/surface water exchange.

**ANALYSES**

**3D Vertical Flux Estimates**

- Vertical hydraulic conductivity assumed constant in time and space and 10% of horizontal conductivity.
- Vertical hydraulic gradient (VHG) is used to estimate vertical seepage velocity with Darcy’s Law.
- Typically, downstream flux at head of channel bar and upward flux at tail (Fig. 2).
- Temporally variable flux based on seasonal and event-based antecedent moisture conditions and hydraulic gradient.

**RESULTS AND DISCUSSION**

**Fig. 1** – The study location is 27 km east of Reno, NV (39.5469, 119.5855). Piezometer, monitoring well, and staff-gage locations provided. Streamflow is from lower left to upper right.

**Fig. 2** – Vertical-flux time series at all three streambed locations during (a) August 2007 and (b) April 2008. Positive values indicate upward flux and negative values indicate downward flux. Discharge measured at USGS gauge 10303436. P60, P71, and P44 are located at the head, middle, and tail of the channel bar, respectively.

**Fig. 3** – Channel bar potentiometric surface and horizontal flux transects. Potentiometric surface variability through four periods. Surface flow is from lower left to upper right.

**Fig. 4** – Data flows along the streamline and flux transects. Potential surface variability through four periods. Surface flow is from lower left to upper right.

**Fig. 5** – (a) Example channel bar thermograph (P39) located at the downstream end of the channel bar. Streambed and streambank temperature boundaries (Fig. 4).

**TABLE 1** – Comparison of the median hydraulic conductivity and seepage flux for vertical 1D, horizontal 2D, and numerically-simulated 3D.

<table>
<thead>
<tr>
<th>Location</th>
<th>Conductivity (m s^-1)</th>
<th>Seepage Flux Lateral (m s^-1)</th>
<th>Seepage Flux Vertical (m s^-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Bar</td>
<td>3.36E-06</td>
<td>2.90E-07</td>
<td>1.94E-06</td>
</tr>
<tr>
<td>Streambank</td>
<td>5.68E-05</td>
<td>1.85E-06</td>
<td>2.23E-09</td>
</tr>
<tr>
<td>Streambed</td>
<td>5.34E-06</td>
<td>1.34E-06</td>
<td>1.95E-10</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

- Optimized 3D hydraulic conductivity estimates similar to field-based values (Table 1).
- Simulation results suggest that the channel bar increases fluxes six times, predominately near the edges.
- Comparison of vertical and 3D results suggests that multi-dimensional flow patterns dominate.
- Temporal vertical flux response suggests seasonal and event-based storage are important to flow patterns.
- Channel bars are an important contributor to groundwater/surface water exchange, potentially impacting several hundred cubic meters of water per day.

**Acknowledgment and Support**

- U.S. Geological Survey, Menlo Park, CA
- City of Reno Public Works Department, Reno, Nevada
- Truckee Meadows Water Authority, Reno, Nevada
- The Nature Conservancy, Reno, Nevada
- TERRECO through the German Research Foundation (DFG)

Further contact: chris.shope@uni-bayreuth.de