Rethinking Rivers: (re)integrating channels and floodplains in fluvial ecosystems

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An Ecohydraulics Perspective

• Large projects on King County rivers are becoming more common
  – On the order of a mile or more in length
  – Setback or remove hardened banks
  – Changes channel/ floodplain dynamics

• How do we monitor these projects?
  – Adapt our approaches
  – Make sure the technology works for us
Getting the river into the floodplain

• Primary objectives are:
  – Store floodwater
  – Create aquatic habitat

• What else happens?
  – Stage-dependent channels form in the floodplain that *convey water, sediment, and wood*
  – Habitat volumes change too
Quantifying the response

• Highly precise tools used to measure the physical template
  – LiDAR
  – SONAR
  – More conventional direct measurements

• Facilitates highly precise spatially explicit analyses
  – Geostatistical refinements
  – Ecohydraulics
Technical Considerations

• Data
  – Scale
    • Space
    • Time
    • Radiometry
  – Statistics
    • How do we meet assumptions?

• Phenomena under investigation
  – Ecohydraulics
To what end?

• Understand the new hydraulic regime (changes in effective discharge ($\Delta Q_e$))

• *Parts of the floodplain become conveyance channels*

• Effective discharge
  – How does $\Delta Q_e$ affect flood storage?
  – How does $\Delta Q_e$ affect habitat forming processes (and ultimately habitat volumes)?
Planning for a discharge

Recurrence interval and exceedance probability

- Recurrence interval $T = \frac{n+1}{m}$
- Exceedance probability $P = \frac{1}{T}$

<table>
<thead>
<tr>
<th>Flow (cfs)</th>
<th>Rank</th>
<th>$T$</th>
<th>$P$</th>
</tr>
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<tr>
<td>864</td>
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<td>62.00</td>
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<tr>
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<td>2.21</td>
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<td>1.48</td>
<td>0.68</td>
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<td>76</td>
<td>56</td>
<td>1.11</td>
<td>0.90</td>
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</tbody>
</table>
Cross-section Hydraulic Geometry

Legend
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation
- U.S. Department of the Interior
- Ground
- Bank Sta

Nelson 24

Station (ft)
Profile Hydraulic Geometry

Legend
- WS: ximum Daily Mean
- WS: Mean Annual Flood
- WS: Median Daily Mean
- WS: Minimum Daily Mean

Similkameen Existing Ground
Plan Hydraulic Geometry

Legend

WS Minimum Daily Mean
WS Median Daily Mean
WS mean Annual Flood
WS ximum Daily Mean
Ground
Bank S
\[ Q = v \times A \]
Ecohydraulics examples from Jorde et al. 2001

Unregulated River

Regulated River

Fig. 2: Distribution of water depths and local flow velocities in two structurally different river reaches for various discharges
Naturally dynamic channel/ floodplain

\[ Q_{bf} \]
Ecohydraulic habitat suitability generated with CASiMir (Jorde et al. 2001)

Fig. 4: Habitat suitability maps for brown trout (*Salmo trutta*) in Loderio Floodplain and Loderio Channel, 5200 l/s, derived by preference functions
Spatial statistics underpinnings

- Semivariance and Covariance
- Used to determine lag distance ($h$)
- Informs the sampling density necessary to support a desired spatial resolution

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{n(h)} (x_i - y_i)^2$$
What’s it all mean?

- Supply and transport of sediment and wood are related to stochastic processes (i.e., flooding).

- Connectivity between channels and floodplains is necessary for the creation and destruction of geomorphic features which in turn is governed by river management (i.e. bank hardening).

- Unhardening alluvial river banks changes wood and sediment dynamics that affect patch dynamics and habitat heterogeneity – locally and in downstream reaches.