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Session B5 - Culvert Roughness Elements for Native Utah Fish Passage

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Natural Substrate Best Alternative for Native Utah Fish Passage at Culverts

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Background

• Culvert design for fish passage compares average flow velocities to fishes’ prolonged swim speeds (Hotchkiss and Frei, 2007)
• Method developed for salmonid passage
• Smaller species can take advantage of reduced velocity zones near boundaries within the culvert
• Lack of well documented data to prove it!

http://www.wildlifeandroads.org/decisionguide/2_1_1.cfm
Scope of Work

• Investigate fish passage through culverts for native Utah fishes
  – Longnose dace
  – Leatherside chub
  – Speckled dace

• Work was performed in two phases
  Phase I: Laboratory tests
  Phase II: Field tests
Phase I: Treatments

1. Smooth boundary (bare flume)
2. Cylinders on smooth boundary
3. Natural substrate boundary
Phase I: Testing

– Water velocity set between the fish’s sustained and burst swim speeds (~1 m/s)
Phase I: Velocity Measurements

- Velocities measured 1 and 5 cm above the boundary
  - 5 cm above
  - 10 cm/s contours
  - Plan view
  - Flow from right to left
Phase I: Results and Conclusions

- Energy calculations were made to more effectively compare the three treatments (Behlke)
- Substrate that scaled with fish size will allow for fish passage for native Utah fishes
- Fish were able to pass even when the velocity exceeded their prolonged swim speed
Phase II: Sites

- Corrugated metal arch culvert
- Stream site
- Double barrel concrete box culvert
- All located within 1 km of each other on Salina Creek
Phase II: Methods

• Marking
  – 3 sites
  – 4 groups at each site

• Recapture three weeks later
  – Two passes in 10-m segments
Phase II: Velocity Measurements

- Taken 2 cm above substrate
- 1-m by 1-m grid across entire area at each site
- Plan view, flow to the left
Phase II: Pebble Counts

- Zig-zag method
- Measurements taken every 0.3 m
- Performed at arch culvert and stream sites
- Box culvert was bare except for some sand

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Arch Culvert</th>
<th>Stream Site</th>
<th>Difference (arch - stream)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{16}$ (mm)</td>
<td>11</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>$D_{50}$ (mm)</td>
<td>44</td>
<td>26</td>
<td>18</td>
</tr>
<tr>
<td>$D_{84}$ (mm)</td>
<td>205</td>
<td>126</td>
<td>79</td>
</tr>
</tbody>
</table>
Phase II: Results and Conclusions

- Population densities at each site were estimated.
- Fish were able to use arch culvert site as refuge.
- Substrate should roughly scale with the size of the fish.
Recommendations

• Provide a layer of suitably scaled substrate in barrel
  – Match size distribution of adjacent reaches
  – Can follow procedures in recent FHWA publication HEC-26

• High assurance of successful fish passage, less invasive, more cost effective

• More work on substrate replenishment
Sources