Temperature modeling in Oregon
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WILLAMETTE RIVER AT OLD HWY 34 BR (CORVALLIS) - RM 131.4

Water Quality Standard for Temperature

- Goal: Protect aquatic organisms from adverse warming caused by anthropogenic activities.
- Water temperatures influenced:
  - solar radiation
  - stream shade
  - ambient air temperatures
  - channel morphology
  - groundwater inflows
  - stream velocity, volume, and flow
- Anthropogenic activities include:
  - discharge of heated water
  - water withdrawals
  - reduced vegetative stream shading
  - altered stream width or depth

Temperature Standard

- Biologically-based numeric criteria
  - Spawning: 13.0°C
  - Core cold water habitat: 16.0°C
  - Rearing and migration: 18.0°C
  - Migration corridors: 20.0°C
- Natural Thermal Potential (NTP)
- Human Use Allowance (HUA)
Reasons for temperature modeling

**TMDLs**
- EPA/ODEQ must develop TMDLs to address 303(d) listed waters
  - 303(d) List based on Biologically-based Numeric Criteria
  - Total Maximum Daily Loads (TMDLs)
  - TMDL = WLAs + LAEs + background
- Models needed to:
  - determine NTP temperatures
  - calculate wasteload allocations for point sources
  - evaluate impact of load allocations for non-point sources
- **NTP**
  - River restored to natural conditions and all anthropogenic heat loads eliminated
  - Natural flow, system potential shade, no point sources

**401 Water Quality Certifications**
- Determinations by DEQ that a federally licensed or permitted activity that may result in a discharge to waters of the state will not cause water quality standards violations
- The federal permit in question may not be issued without this determination in accordance with Section 401 of the CWA
- FERC relicensing of hydroelectric projects

**Reasons for temperature modeling**

**Willamette River Temperature TMDL**
Willamette River Basin, Oregon
- 13th Largest River
- Coast Range and Cascades
- TMDLs address 9 of 12 subbasins

Willamette River Basin, Oregon
- 13 Corps reservoirs
  - Flood Control
  - Navigation
  - Power

Corps Willamette Basin Project
Detroit Dam
Hydroelectric projects
Willamette Falls (PGE)
Clackamas River (PGE)

Willamette River Basin, Oregon
• 27 Major point sources, including
  • Eugene/Springfield
  • Salem
  • Portland
  • Weyerhaeuser
  • Blue Heron

303(d) Listed Reaches
### Bases for 303(d) Listings

<table>
<thead>
<tr>
<th>River Mile</th>
<th>Criteria</th>
<th>Frequency of Exceedence</th>
<th>Maximum Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.0</td>
<td>20°C</td>
<td>68% (34 of 50)</td>
<td>26°C</td>
</tr>
<tr>
<td>13.2</td>
<td>20°C</td>
<td>61% (37 of 61)</td>
<td>26°C</td>
</tr>
<tr>
<td>34.4</td>
<td>20°C</td>
<td>62% (23 of 37)</td>
<td>27°C</td>
</tr>
<tr>
<td>48.6</td>
<td>20°C</td>
<td>60% (36 of 60)</td>
<td>27°C</td>
</tr>
<tr>
<td>71.9</td>
<td>18°C</td>
<td>82% (37 of 45)</td>
<td>27°C</td>
</tr>
<tr>
<td>84.0</td>
<td>20°C</td>
<td>65% (11 of 17)</td>
<td>27.5°C</td>
</tr>
<tr>
<td>119.3</td>
<td>20°C</td>
<td>72% (41 of 57)</td>
<td>24.5°C</td>
</tr>
<tr>
<td>131.4</td>
<td>20°C</td>
<td>62% (29 of 47)</td>
<td>24°C</td>
</tr>
</tbody>
</table>

#### Beneficial uses most sensitive to temperature

- Chinook Salmon (King, Sockeye, Chum)
- Bull Trout
- Brook Trout

#### Applicable Criteria

**NTP vs. Biological Criteria**

<table>
<thead>
<tr>
<th>Year</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>2002</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
<td>34</td>
<td>36</td>
</tr>
</tbody>
</table>

**NTP Temperatures at RM 79.2 - Salem**

- Red line: NTP
- Blue line: Biological

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Willamette River System Model

Purposes:
- NTP
- Point source impacts
- Hydroelectric impacts
- Shade sensitivity
- Boundary Q and T sensitivity (reservoirs)

Willamette River System Model

- 9 CE-QUAL-W2 Models
  - Lower Willamette and Columbia
  - Middle Willamette
  - Upper Willamette
  - Coast and Middle Forks
  - McKenzie
  - Long Tom
  - Lower Clackamas
  - Santiam and N Santiam
  - S Santiam
- Calibration: '01 and '02

Willamette River System Model

W2 vs. Heat Source
Advantages of W2
- 2-Dimensional
- Stratification
- Newberg Pool and tidal reaches
- Reservoirs
- Faster (Full season)
- Branching
- Additional parameters (DO, etc.)

Advantages of HS
- Ease of use
- Integration w/Shade models (TTools)
- Stable for small streams
Analyses for Temperature TMDL

**Construct and Calibrate Model**

- Bathymetry
- Vegetation assessments
- Air temperature
- Solar radiation
- Wind speed
- Humidity
- Water temperature
- River flow and stage ht.
- Hydrodynamics

**Willamette "Mainstem" Model**
CE-QUAL-W2

**Predicted Temp.**

Inflow & temp.
- Tributaries
- Municipal
- Industry
- Withdrawals

Reservoir models:
- Bathymetry
- Flow
- Temperature
- Met data

Collaborative effort

Temperature Monitoring Stations

Channel and Riparian Vegetation Characteristics

<table>
<thead>
<tr>
<th>DOQs</th>
<th>Aerial Photos</th>
<th>Existing Layers</th>
</tr>
</thead>
</table>

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Channel and Riparian Vegetation Characteristics

Potential Vegetation Characteristics via Geomorphic Units
(for NTP)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>% Forest, Savanna, and Prairie</th>
<th>Ht (m)</th>
<th>Density (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>601</td>
<td>Quill Forest</td>
<td>52</td>
<td>21.5</td>
<td>75%</td>
</tr>
<tr>
<td>602</td>
<td>Quill Savanna</td>
<td>28</td>
<td>21.9</td>
<td>50%</td>
</tr>
<tr>
<td>603</td>
<td>Quill Prairie</td>
<td>20</td>
<td>0.9</td>
<td>75%</td>
</tr>
</tbody>
</table>

Quill – Alluvium of smaller streams

Sensitivity to Shade
Anthroprogenic Solar Radiation Load Allocation = Zero
(Vegetative Shade >= Site Potential)

Sensitivity analyses:
- Flow
- Upper boundary temperature
- Point sources
- Utilities (PGE and EWEB)
**Sensitivity to Point Sources**

**Upper Willamette**

**Mid/Lower Willamette**

**Impacts of Point Sources at WLAs**

0.23 of 0.3°C HUA allocated to point sources
Combined impact - NTP

Next steps:
- Petitions for Reconsideration
- Utilities
- Pt Sources
- Lawsuits

Next steps:
- Reserve Capacity Loans
- Heat load trading
- Reevaluate in 2012
Next steps:
• River Modeling (Corps)
• Reservoir reaches
• Determine NTP
• Reservoir Modeling (Corps)