Data Gaps Identified in the 2012 Chehalis River Fish Study

- Additional water quality characterizations beyond total suspended solids and BOD
- A need for improved characterization of thermal and nutrient loads from tributaries
- A need for improved characterization of groundwater’s contribution to stream temperature
- Lack of riparian shading assessment
- Meteorological data lacking in upper reaches
Water Quality Work Performed

• Continuous temperature monitoring
  – 12 locations overall
  – Covers mainstem Chehalis River and major tributaries

• Synoptic low-flow water quality surveys
  – Three surveys, 15 locations during each survey
  – Designed to measure nutrient and BOD loads

• Diurnal surveys at select locations
  – Characterizes daily fluctuations in temperature, DO, and pH

• Depth profiles of water quality parameters at select locations
Work Performed (cont.)

• Boat survey in Centralia Reach
  – Historically problematic reach with thermal stratification and low DO in summer
  – Characterization of the DO and temperature regime

• Winter water quality sampling at Pe Ell
  – To develop boundary conditions for reservoir model

• Groundwater temperature surveys
  – To provide an estimate of temperature mitigation in gaining reaches
  – Focus primarily on mainstem reach above Newaukum River confluence
Other Work Completed to Support Water Quality Modeling

• Riparian shade surveys
  – Review of existing LiDAR data to identify vegetation type and density
  – Field surveys in May 2014 to ground truth (using hemi-view) vegetation type and canopy density classifications
  – Assessments will provide inputs needed for temperature modeling
Other Work Completed to Support Water Quality Modeling (cont.)

• Adding meteorological sensors to rain gage on Chehalis River near Thrash Creek
  – Will provide wind speed and direction, dew point temperature and incident solar radiation
  – Data available to public through early warning system website

• FLIR Systems thermal imaging
Monitoring Locations

- Surface water monitoring locations
- Boat survey
- Groundwater monitoring locations
Water Quality Monitoring Results
Flows Measured During Summer Low-Flow Surveys

Long-term average flow at Doty for July, August, and September are 70, 46, and 67 cubic feet per second, respectively.
7-Day Average of Daily Maximum

Chehalis Upstream of Pe Ell (RM 107)

Elk Creek (RM 100.2)

Core Summer Salmonid Habitat

Water Quality Studies Completed in 2013-2015 Biennium
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
7-Day Average of Daily Maximum

South Fork Mouth (RM 88)

Temperature (°C)

Core Summer Salmonid Habitat

Chehalis Upstream of Newaukum Confluence (RM 75.4)

Temperature (°C)

Salmonid Spawning, Rearing, and Migration
## Temperature Exceedances

<table>
<thead>
<tr>
<th>Station ID</th>
<th>River Mile</th>
<th>Number of Days (8/1/2013 to 7/29/2014)</th>
<th>When Criteria Applies</th>
<th>Data Available over Criteria Period</th>
<th>Temperature &gt; Criteria</th>
<th>Applicable Criteria</th>
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<tbody>
<tr>
<td>CHL-PEL-US_TB</td>
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<td>84</td>
<td>Core summer salmonid habitat&lt;sup&gt;1&lt;/sup&gt;</td>
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1. Core summer salmonid habitat = 7DAD temperature shall not exceed 16 degrees Celsius from June 15 to September 15
2. Salmonid spawning, rearing, and migration = 7DAD temperature shall not exceed 17.5 degrees Celsius from September 16 to June 14
Diurnal Patterns in Temperature
Spatial Patterns in Temperature

- Open symbols shown for tributaries and filled symbols for mainstem Chehalis River.
Groundwater Temperature

- USGS Study (Ely et al. 2008) identified losing and gaining reaches
- Groundwater warmer in losing reaches (near SF confluence) and cooler in gaining reaches (near Elk Creek)
2015 Summer Temperature Snapshot
FLIR – Flown September 2013
FLIR Results at Pe Ell

- Flight September 2013

- Warming downstream

- Cooler Ground Water Inputs

- Cooler Tributary Inflows
FLIR Results: Elk Creek
FLIR Results: South Fork Chehalis

Water Quality Studies Completed in 2013-2015 Biennium
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
FLIR Results: Newaukum and Downstream Extent of Coverage

Water Quality Studies Completed in 2013-2015 Biennium
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
Diurnal Patterns in DO and pH

Core Summer Salmonid Habitat (Lowest 1-Day Min)

Core Summer Salmonid Habitat Upper Bound

Core Summer Salmonid Habitat Lower Bound
Diurnal Patterns

• Link to all figures
Low-Flow Survey: Depth Profiles of Temperature, DO, and pH

• [Link to depth profiles]
Low Flow Survey Results

Temperature Depth Profiles at Two Locations on the Mainstem Chehalis River

Dissolved Oxygen Depth Profiles at Two Location on the Mainstem Chehalis River
Low-Flow Synoptic Surveys: Spatial Patterns

- Link to field and lab parameters
Depth Profiles of Temperature in the Centralia Reach
Depth profiles were collected on 7/31/2014
Nutrient Availability

- Chehalis River is moderately P-limiting
- Low turbidity and chlorophyll-a indicates no light limitation almost throughout the river
- Low-flow or quiescent conditions could promote (attached) algal activity
Centralia Reach Boat Survey

- Link to Field Parameter Depth Profiles
Summary
Temperature Summary

• Upper reaches consistently showed exceedances over criterion
  – Temperature at tributary mouths also warm
  – Data indicates that thermal refuge available to aquatic species is limited in the upper watershed
  – Riparian study indicates only limited shading available in upper reaches (consistent with Ecology’s TMDL, which calls for more shading)

• Conditions in fall generally below applicable criterion

• Thermal stratification observed in Centralia Reach
Exceedances in Other Parameters

• DO potentially problematic in upper reaches in summer
  – Evidence of (attached) algal activity
  – pH swings correspond to DO swings, but no excursions noted during study

• DO very low in lower waters of stratified portions of Centralia Reach
  – Particularly from River Miles 68 to 70
  – SOD is likely cause
  – pH also affected in bottom waters, likely from sediment redox activity

• No excursions in turbidity
Conclusion

• Water quality study has collected data consistent with the objectives
  – Establishes baseline conditions
  – Data sets for developing temperature and water quality models

• Continued data collection will help establish inter-annual trends
  – Data set collected is over 12-month period covering two summers and one winter
Figure 1

Proposed Flow Measurement, Water Quality Sampling, and Temperature Probe Locations

Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
Figure 2
Water Quality Depth Profiling and Sampling Locations in the Centralia Reach Boat Survey
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species

- Water Quality Sampling and Depth Profiling
- Water Quality Depth Profiling Only
- Chehalis River

NOTE:
Depth profiling was performed at all sampling stations.
Figure 3
Groundwater Monitoring Locations
Water Quality Studies
Chehalis Basin Strategy: Reducing Flood Damage and Enhancing Aquatic Species
Figure 9

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax
Figure 9 (continued)

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax
Figure 9 (continued)

Temporal Trends in Temperature in the Chehalis River and its Major Tributaries

Tidbit data measured every 30 minutes and shown as 7DADmax
Diurnal Trends in Temperature Recorded at Three Locations on the Mainstem Chehalis River
Figure 13

Diurnal Trends in Dissolved Oxygen Recorded at Three Locations on the Mainstem Chehalis River

Sept. data calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg
Figure 14

Diurnal Trends in pH Recorded at Three Locations on the Mainstem Chehalis River
Diurnal Trends in Turbidity Recorded at Three Locations on the Mainstem Chehalis River
Figure 16
Diurnal Trends in Chlorophyll-a Recorded at Three Locations on the Mainstem Chehalis River
Figure 17

Temperature Depth Profiles at Two Locations on the Mainstem Chehalis River
Figure 18

Dissolved Oxygen Depth Profiles at Two Locations on the Mainstem Chehalis River
Figure 19

pH Depth Profiles at Two Locations on the Mainstem Chehalis River
Figure 20

Turbidity Depth Profiles at Two Locations on the Mainstem Chehalis River
Figure 21
Chlorophyll-a Depth Profiles at Two Locations on the Mainstem Chehalis River
Figure 22

Spatial Patterns in Dissolved Oxygen in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries. Sept. measurements flagged with * signs were calibrated from raw measurements at 637 mmHg to values shown at 750 mmHg.
Figure 23
Spatial Patterns in pH in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries.
Spatial Patterns in Turbidity in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Ecology criteria shown and labeled. Crosses shown when the criteria apply to tributaries.
Figure 25

Spatial Patterns in Total Suspended Solids in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

Lab - ARI
Lab - Dragon
Figure 26

Spatial Patterns in Chlorophyll-a in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River

Field
Lab - Dragon
Figure 27

Spatial Patterns in 5-Day Biochemical Oxygen Demand in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits
Figure 28
Spatial Patterns in Ammonia in the Mainstem Chehalis River and its Tributaries
during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

Lab - ARI
Lab - Dragon
Figure 29

Spatial Patterns in Nitrite plus Nitrate in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Non-detected or J-flagged results shown in black

Lab - ARI
Lab - Dragon
Figure 30

Spatial Patterns in Total Kjeldahl Nitrogen in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits

Note:
Open symbols shown for tributaries and filled symbols for mainstem Chehalis River
Figure 31

Spatial Patterns in Orthophosphate in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits
Spatial Patterns in Total Dissolved Phosphorus in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits
Figure 33

Spatial Patterns in Total Phosphorus in the Mainstem Chehalis River and its Tributaries during the Summer Low-Flow Surveys

Non-detects set to half of reporting limits
Figure 34

Depth Profiles of Temperature in the Centralia Reach

Depth profiles were collected on 7/31/2014
Figure 35

Depth Profiles of Dissolved Oxygen in the Centralia Reach

Depth profiles were collected on 7/31/2014
Figure 36
Depth Profiles of pH in the Centralia Reach

Depth profiles were collected on 7/31/2014
Figure 37

Depth Profiles of Turbidity in the Centralia Reach

Depth profiles were collected on 7/31/2014
Figure 38

Depth Profiles of Chlorophyll-a in the Centralia Reach

Depth profiles were collected on 7/31/2014