# APPENDIX 6
# Water Quality Data

## Table of Contents

# List of Figures

# LIST OF ACRONYMS AND ABBREVIATIONS

| **Abbreviation** | **Definition** |
|---|---|
| C | degrees Celsius |
| cfs | cubic feet per second |
| cft | cubic feet |
| DO | Dissolved Oxygen |
| EIS | Environmental Impact Statement |
| gpm | gallons per minute |
| kg/day | kilograms per day |
| $m^3/s$ | cubic meters per second |
| mg/l | milligrams per liter |
| µg/l | micrograms/liter |
| µS/cm | microSiemens/centimeter |
| mg/m3 | miligrams/cubic meter |
| NPDES | National Pollutant Discharge Elimination System |
| pH | $-\log_{10}[H^+]$ |
| river KM | river kilometer (distance from mouth) |
| RMS | Root Mean Square |
| SD | Standard Deviation |
| TMDL | Total Maximum Daily Load |
| TP | Total Phosphorus |
| USGS | U.S. Geological Survey |
| WDOE | Washington Department of Ecology |

# 1. Objectives

Coho salmon are being reintroduced into the Wenatchee and Methow watersheds by the Yakama Nation. Pre-smolts are proposed to be trucked to the upper areas of the watersheds for acclimation and release. Some sites will operate as spring time only facilities, with fish being reared from mid-March through April. Some sites will function as over-winter facilities from early November through April. Rearing will result in the release of some nutrients from these sites and project operation will require environmental evaluations and permits.

The main purpose of the water quality data collection effort is to develop the baseline values and active site impact data necessary to make predictions about how planned salmon acclimation and rearing facilities may affect receiving water quality.

Water quality data was collected in the Wenatchee basin throughout 2009. Nason Creek, a tributary of the Wenatchee was an important sampling target. Several currently active acclimation sites exist on Nason Creek and actual operational impacts were monitored there.

The draft Wenatchee River Watershed Dissolved Oxygen and pH Total Maximum Daily Load (Carroll and Anderson, 2009) produced by WDOE recommends that reductions in Wenatchee phosphorus loading occur to achieve water quality standards. The focus of this water quality data collection effort was, as a result, on pH, dissolved oxygen and phosphorus, with other parameters also being monitored to support various impact evaluation objectives.

## 1.1. Nason Creek

Phosphorous (P) concentrations and loads entering and leaving the acclimation ponds on Nason Creek were intensively monitored. P measurements were also made in Nason Creek just upstream and just downstream of the mouths of the creeks supplying water to the ponds and at locations farther downstream of the acclimation sites.

Another data collection objective was to measure any possible changes to DO and pH values in Nason Creek while fish were being acclimated. These parameters were measured at the acclimation study sites and at other locations in Nason Creek.

## 1.2. Wenatchee Basin

Along with the intensive Nason Creek data collection, other locations in the Wenatchee basin were also sampled. The objectives for the Wenatchee basin data included:

- To support the evaluation of impacts in the lower subbasin
- To develop baseline water quality information about receiving waters at proposed acclimation sites
- To check the Total Phosphorous (TP) mass balance in the upper Wenatchee to help better understand the dynamics of nutrients in the watershed
- To support the evaluation of general stream nutrient conditions.

# 2. Active Study Site Descriptions

## 2.1. Fish Stocking Details

The Rohlfing and Butcher coho acclimation ponds (see photos below) were in operation the spring of 2009 and 2010. This provided the opportunity to measure changes in water quality at functioning sites and in the Nason Creek receiving waters. A third acclimation site, Coulter, is located between Butcher and Rohlfing, and was also operated during the water quality study. It was not specifically targeted for direct water quality measurement.

2009 stocking details for Rohlfing:

- Fish delivery date: 3/10/09
- Number of fish released: 101,300
- Size at release: 16.2 fish/lb
- Total weight released: 6,250 lbs
- Start of exit migration (date barrier nets pulled): 5/6/09

2009 stocking details for Butcher:

- Fish delivery date: 3/10/09
- Number of fish released: 136,700
- Size at release: 16.7 fish/lb
- Total weight released: 8,190 lbs
- Start of exit migration (date barrier nets pulled): 5/7/09

2009 stocking details for Coulter:

- Fish delivery date: 4/15/09
- Number of fish released: 75,000
- Size at release: 16.7 fish/lb
- Total weight released: 4,490 lbs
- Start of exit migration (date barrier nets pulled): 5/6/09

In February, 2010, prior to acclimation, the Rohlfing pond was excavated and expanded. The pond was divided by a barrier net after the work was completed. Coho were acclimated on one side of the net and a small number of steelhead on the other.

2010 coho stocking details for Rohlfing:

- Fish delivery date: 3/22/10
- Number of fish released: 85,700
- Size at release: 16.7 fish/lb
- Total weight released: 5,130 lbs
- Start of exit migration (date barrier nets pulled): 5/7/10

2010 steelhead stocking details for Rohlfing:

- Fish delivery date: 3/25/10
- Number of fish released: 10,300
- Size at release: 7.4 fish/lb
- Total weight released: 1,390 lbs
- Start of exit migration (date barrier nets pulled): 4/22/10

2010 stocking details for Butcher:

- Fish delivery date: 3/24/10
- Number of fish released: 144,600

- Size at release: 15.7 fish/lb
- Total weight released: 9,190 lbs
- Start of exit migration (date barrier nets pulled): 5/7/10

2010 stocking details for Coulter:

- Fish delivery date: 5/6/10
- Number of fish released: 68,200
- Size at release: 17.3 fish/lb
- Total weight released: 3,930 lbs
- Start of exit migration (date barrier nets pulled): 5/7/10

**Figure 2-1. Rohlfing Coho Acclimation Pond**

**Figure 2-2. Butcher Coho Acclimation Pond**

## 2.2. Flow Dependent Parameters

Changes in the concentrations of water quality parameters are impacted by several parameters including fish biomass, the quantity of water flowing through the rearing system and the physical dimensions of the pond. The last two factors control the length of time required for the ponds to flush. A preliminary review of two flow dependent parameters are presented here as a precursor for water quality evaluations. A more detailed evaluation is provided in Appendix 7.

### 2.2.1. Flow Density

A rough approximation of relative fish biological loading is provided by flow density values, the mass of fish divided by the water flow rate. Flow density is an inexact measure of fish metabolic rates; water temperature and feed rates are other important variables. Nevertheless, it provides a useful relative measure when comparing sites with similar temperatures and feeding regimes. A comparison of fish flow densities for Rohlfing and Butcher in 2009 showed that Butcher had 60% higher flow density on average during the 2009 acclimation season.

| | 3/14 | 4/5 | 4/12 | 4/19 | 4/26 | 5/3 | 5/7 | Average |
|---|---|---|---|---|---|---|---|---|
| Rohlfing | | | | | | | | |
| Fish weight (lbs) | 4,366 | 4,626 | 5,052 | 5,597 | 5,890 | 6,253 | 6,253 | |
| Density (lbs/gpm) | 6.9 | 7.3 | 2.7 | 3.0 | 3.2 | 4.0 | 3.7 | 4.4 |
| Butcher | | | | | | | | |
| Fish weight (lbs) | 5,996 | 6,510 | 6,510 | 7,010 | 7,552 | 8,186 | 8,186 | |
| Density (lbs/gpm) | 7.8 | 8.5 | 7.6 | 8.2 | 6.7 | 6.5 | 4.7 | 7.1 |

**Figure 2-3. Fish Loading – Flow Density**

### 2.2.2. Pond Retention Time

Pond retention time is another parameter that may impact discharge water quality. Retention time is calculated by dividing the pond volume by the volumetric flow rate. It is a measure of the average time taken for water to pass through the pond. High retention time means low relative water velocities and that fish wastes have more opportunity to settle to the pond bottom. Pond nutrient assimilative capacity is presumably greater and discharge loads lower with higher retention times. The retention times for the study sites at the end of 2009 acclimation are shown in the table below.

| | Pond volume (cft) | Flow (cfs) | Retention Time (hrs) |
|---|---|---|---|
| Rohlfing | 15,000 | 3.8 | 1.1 |
| Butcher | 73,000 | 3.9 | 5.2 |

**Figure 2-4. Pond Retention Time**

The full retention time of the pond is not effective for settling wastes if the fish stay at the downstream end of the pond. This was the case at Butcher, fish were fed and the best habitat was near the pond exit.

Settled solids generated by fish are annually covered by material that is carried into the ponds with the inflow. These are deposited on the pond bottoms due to a slowdown in flows through the ponds. The suspended solids loading in the form of gravel, sand, and silt peak during spring snowmelt period, which occurs during and after coho have migrated. Rohlfing has more deposited material than Butcher, with several inches per year being added to the pond bottom. Periodic excavation and land disposal of accumulated silt, sand, and gravel is planned at Rohlfing.

The Rohlfing pond was excavated and expanded in 2010 to increase volume to 20,000 cft.

# 3. Data Collection Procedures

## 3.1. Methods

Collections for laboratory analysis were grab samples taken just below the water surface from the main body of flow by using an extension rod from the streambank. Sample bottles were provided by AM Test, the accredited lab that performed the measurements. Each P bottle contained ½ mg of a sulfuric acid solution, giving the sample a 28 day period over which accuracy is maintained.

EPA approved methods were used during the laboratory measurement process, which included:

| | |
|---|---|
| Chlorophyll a SM | SM1002G |
| Dissolved Organic Carbon | EPA415.1 |
| Ammonia Nitrogen | EPA350.1 |
| Nitrate/Nitrite | EPA353.2 |
| Nitrogen -Total Persulfate | OSU CCal33A.0 |
| Orthophosphate | EPA365.2 |
| Phosphorus, total low-level | SM4500-P |
| Total Organic Carbon | EPA415.1 |

**Figure 3-1. Measurement Methods**

Phosphorous samples were field replicated. Two collection bottles were filled from the same location at the same time for all P samples.

Temperature, DO, pH, and conductivity field measurements were taken with Hydrolab® Data Sonde multi-meters at the same time and location that laboratory samples were collected. The Hydrolab sondes were maintained and calibrated at the Yakama Nation Peshastin field office. Calibrations were performed before and after each sampling period and used Hydrolab recommended procedures and traceable calibration standards.

Sampling was done with a two person team and was completed over a 1 or 2 day period. All Nason Creek samples were taken on a single day. Most collections occurred between 1PM and 6PM on the first day and 10AM and 1PM on the second day. Samples were delivered to AM Test within 5 days of collection.

Flow measurements were taken at the Butcher and Rohlfing sites. Staff gauges were installed in the creeks supplying water to the ponds and flow volume measurements were taken periodically to develop a stage/discharge relationship. Other flow data in the watershed was taken from USGS and WDOE stream gauging stations.

Periphyton sampling methods and results are discussed in Appendix 7.

## 3.2. Locations

A total of 22 sites were sampled, with 11 of those being in Nason Creek. The sample site names and general location descriptions are shown in the table below.

| Active, Test Sites - Intensive P Study | | |
|---|---|---|
| Rohlfing 1 | RO1 | Rohlfing Creek, incoming water to the acclimation pond |
| Rohlfing 2 | RO2 | Rohfing Creek, outgoing water from the acclimation pond |
| Rohlfing 3 | RO3 | Nason Creek, upstream of the mouth of Rohlfing |
| Rohlfing 4 | RO4 | Nason Creek, downstream of the mouth of Rohlfing |
| Butcher 1 | BU1 | Butcher Creek, incoming water to the acclimation pond |
| Butcher 2 | BU2 | Butcher Creek, outgoing water from the acclimation pond |
| Butcher 3 | BU3 | Nason Creek, upstream of the mouth of Butcher |
| Butcher 4 | BU4 | Nason Creek, downstream of the mouth of Butcher |
| Nason Creek - Intensive P Study, DO and pH study | | |
| Boyce | BO3 | Nason, upstream of BU3 |
| Nason, Coles Corner | NCC | Nason, between Butcher and the mouth |
| Mouth of Nason | MNA | Nason, near the mouth |
| Other Sites - P Baseline Data | | |
| Tall Timber | TA4 | Napeequa, near the mouth |
| McComas 3 | MC3 | White, at the highway bridge |
| McComas 4 | MC4 | White, downstream of the proposed McComas discharge |
| Chikamin/Minnow | CM4 | Chikamin, near the mouth |
| Clear | CL1 | Clear, upstream of the acclimation pond |
| Chumstick | CH4 | Chumstick, at the highway bridge |
| Dryden | DR4 | Wenatchee, upstream of Dryden Dam |
| Wen. Basin - P mass balance | | |
| Mouth of Little Wenatchee | MLI | Little Wenatchee, at the Two Rivers Gravel mine |
| Mouth of Chiwawa | MCHI | Chiwawa, at the highway bridge |
| Mouth of Lake Wen. | MLA | Wenatchee, at the highway bridge |
| Wen. above Icicle | WIC | Wenatchee, at the highway bridge |
| General Stream Nutrient Study | | |
| White - McComas | MC4 | White, downstream of the proposed McComas discharge |
| Nason - Butcher | BU4 | Nason Creek, downstream of the mouth of Butcher |
| Dryden - Wenatchee | DR4 | Wenatchee, upstream of Dryden Dam |
| 24 Hr Nason DO and pH | | |
| Nason Trap Site | | Near mouth of Nason Creek, close to the screw trap |

**Figure 3-2. Sample Site Names**

Sample locations in the Wenatchee basin are shown in the maps below.

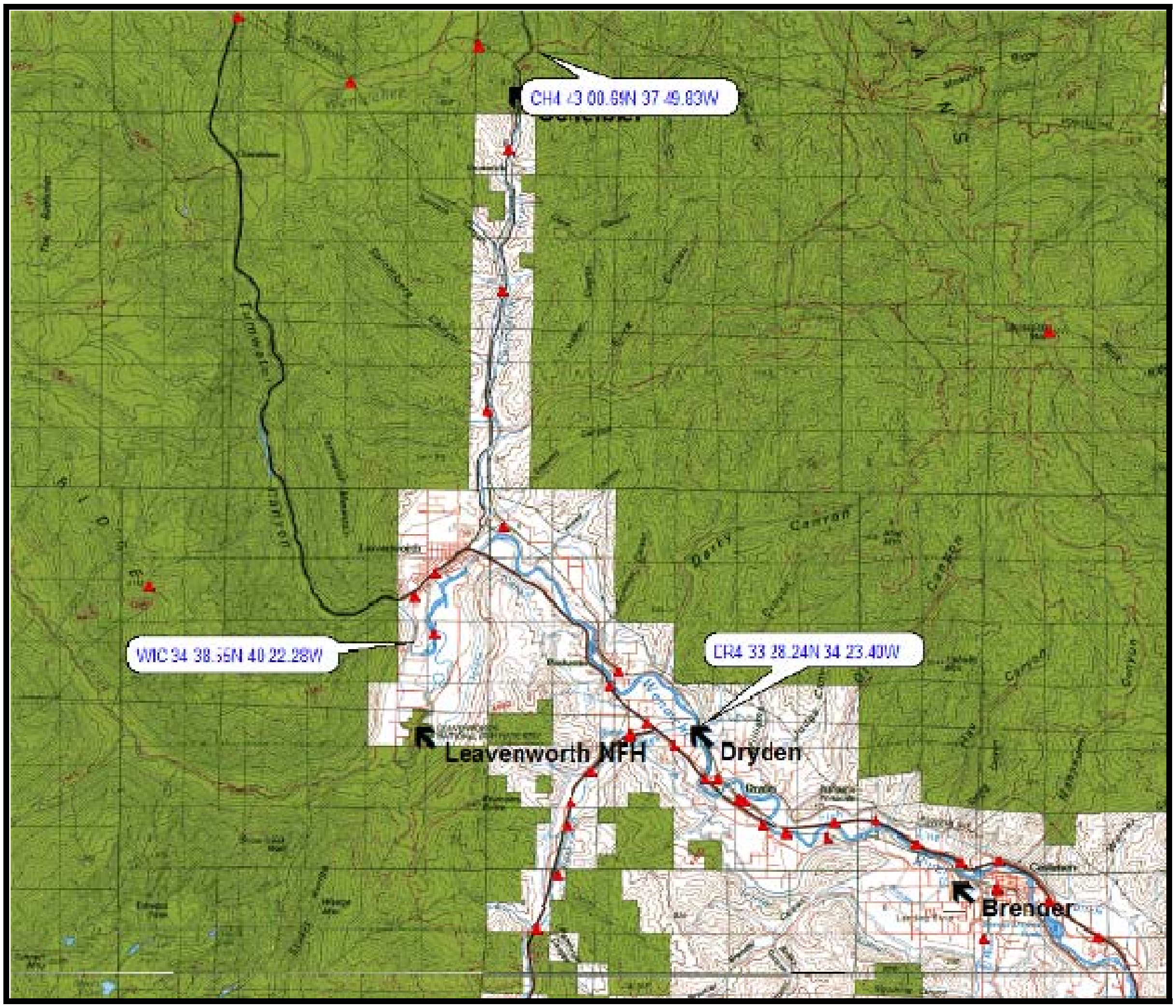



**Figure 3-3. Wenatchee Sample Sites 1**

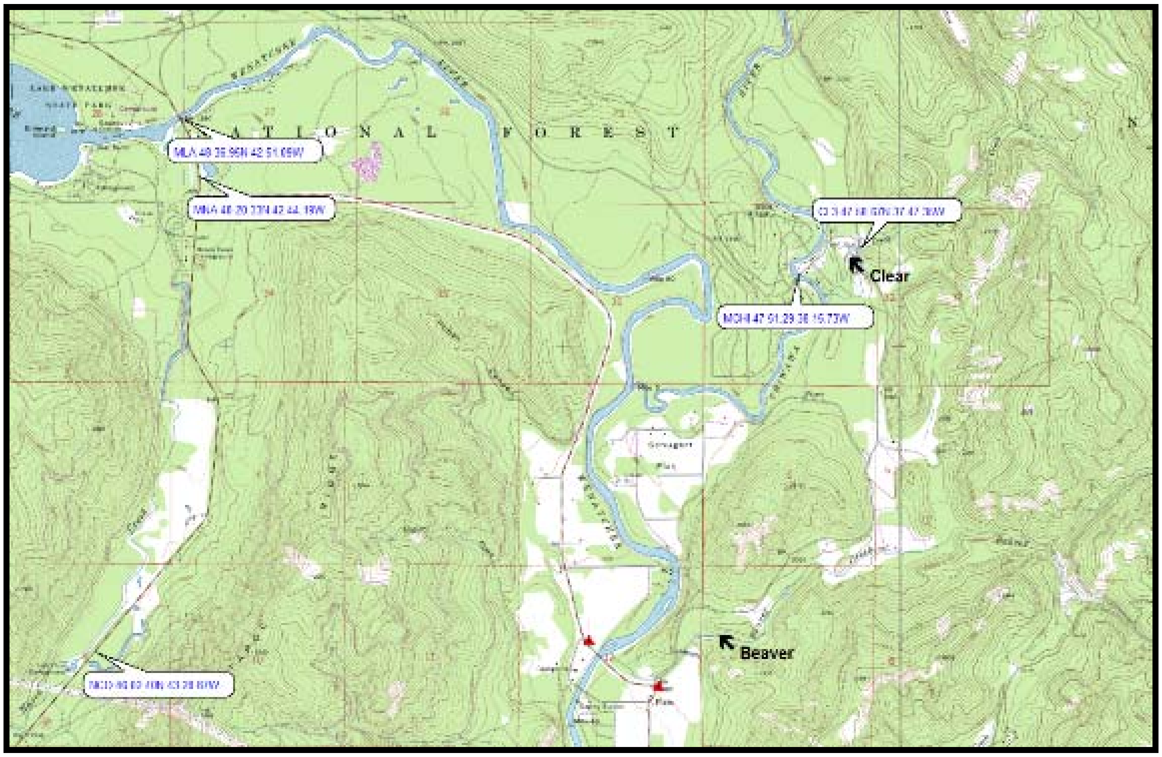



Figure 3-4.  Wenatchee Sample Sites 2


Figure 3-5.  Wenatchee Sample Sites 3

The Nason Creek active study site locations are shown in the aerials below.


**Figure 3-6. Rohlfing Sample Locations**


**Figure 3-7. Butcher Sample Locations**

## 3.3. Schedule

Water quality data was collected through all of 2009 and through the 2010 acclimation season.

Measurements made at higher frequencies during the spring acclimation periods (March-April). The full sampling schedule for is shown in the table below, with locations and numbers of samples collected.

| | 1/17/09 | 2/14/09 | 3/14/09 | 4/4/09 | 4/11/09 | 4/18/09 | 4/25/09 | 5/3/09 | 5/16/09 | 6/6/09 | 7/25/09 | 9/19/09 | 10/30/09 | 11/29/09 | 12/20/09 | 2/25/10 | 3/22/06 | 4/11/06 | 4/17/06 | 4/25/10 | 5/5/10 | 5/8/06 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nason Creek | | | | | | | | | | | | | | | | | | | | | | | |
| Rohlfing 1,2,3,4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 8 | 8 | 8 | 8 | 8 | 4 | 8 | 168 |
| Butcher 1,2,3,4 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 4 | 8 | 8 | 8 | 8 | 8 | 11 | 8 | 175 |
| Boyce (upstream) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | | 2 | 39 |
| Mouth of Nason | | | 2 | | 2 | | | 2 | | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 30 |
| Nason, Coles Corner | | | 2 | | 2 | | | 2 | | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 30 |
| Other Acclimation Sites | | | | | | | | | | | | | | | | | | | | | | | |
| McComas 3,4 | 4 | 4 | 4 | 4 | 4 | 4 | | 4 | 4 | 4 | 4 | 4 | 4 | 4 | | 4 | 3 | 2 | | | | | 61 |
| Tall Timber | 2 | 2 | 2 | | 2 | | | 2 | | 2 | 2 | 2 | | | | | | 2 | | | | | 18 |
| Clear | | 2 | 2 | | 2 | | | 2 | | 2 | 2 | 2 | | | | | | 2 | 2 | 2 | | 2 | 22 |
| Chumstick | | | | | 2 | | | 2 | | 2 | 2 | 2 | | | | | | 2 | 2 | 2 | | 2 | 18 |
| Dryden | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 42 |
| Brender | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | | 2 | 8 |
| Wenatchee Basin | | | | | | | | | | | | | | | | | | | | | | | |
| Mouth of Little Wenatchee | | | | 2 | | | 1 | | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | | 2 | 2 | 2 | | 2 | 26 |
| Mouth of Chiwawa | | | | 2 | | | | 2 | 2 | 2 | | 2 | 2 | 2 | | | | 2 | 2 | 2 | | 2 | 22 |
| Mouth of Lake Wen. | | | | 2 | | | 2 | | 2 | | 2 | 2 | 2 | 2 | | | | | | | | | 14 |
| Wen. above Icicle | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | | 2 | 39 |
| Total TP samples | 26 | 30 | 34 | 32 | 36 | 26 | 25 | 38 | 32 | 38 | 40 | 42 | 36 | 36 | 15 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 712 |
| General Stream Nutrient Study | | | | | | | | | | | | | | | | | | | | | | | |
| White - McComas | 7 | 7 | 8 | 8 | | | | 8 | | 8 | 8 | 8 | 8 | 8 | | 8 | 8 | 8 | 8 | 8 | | 8 | 126 |
| Nason - Butcher | 7 | 7 | 8 | 8 | | | | 8 | | 8 | 8 | 8 | 8 | 8 | | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 134 |
| Dryden - Wenatchee | 7 | 7 | 8 | 8 | | | | 8 | | 8 | 8 | 8 | 8 | 8 | | 8 | 8 | 8 | 8 | 8 | | 8 | 126 |
| Total water quality samples | 21 | 21 | 24 | 24 | 0 | 0 | 0 | 24 | 0 | 24 | 24 | 24 | 24 | 24 | 0 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 386 |

**Figure 3-8. Data Collection Schedule**

## 3.4. Quality Control

Quality objectives conform to those listed in the Wenatchee River Basin Dissolved Oxygen, pH, and Phosphorus Total Maximum Daily Load (TMDL) Study (Carroll et al, 2006), Table 5. Objectives for the parameters important to this plan are:

| | *Accuracy* | *Repeatability* | *Bias* | *Reporting limit* |
|---|---|---|---|---|
| Total Phosphorus | ±25% | <10% | 5% | 3 µg/l |
| Orthophosphate | ±25% | <10% | 5% | 3 µg/l |
| Nitrate-Nitrite Nitrogen | ±25% | <10% | 5% | 10 µg/l |
| Ammonia Nitrogen | ±25% | <10% | 5% | 10 µg/l |
| Disolved Oxygen | | | 5% | 1 mg/l |
| pH | .2 SU | | .1 SU | |
| Temperature | $\pm 0.2^0$ C | | | |

**Figure 3-9. Data Quality Objectives**

Accuracy and bias are expressed as deviations from true values and repeatability as the standard deviation (SD) of the data set. Values above 0.001 mg/l for phosphorous are reported in this study. Values below the 0.001 detection limit are listed at 0.0005 mg/l.

Laboratory data was generated according to QA/QC procedures described in testing lab documents.  Quality Control results were provided by the lab for each sampling survey.

Several Hydrolab datasondes were used for measuring DO, pH, temperature, and conductivity. The MS5 minisonde and DS5 sondes employed have the same specifications (see Section 5.4).

# 4. Wenatchee Basin Water Data

## 4.1. Flows

### 4.1.1. Nason Creek

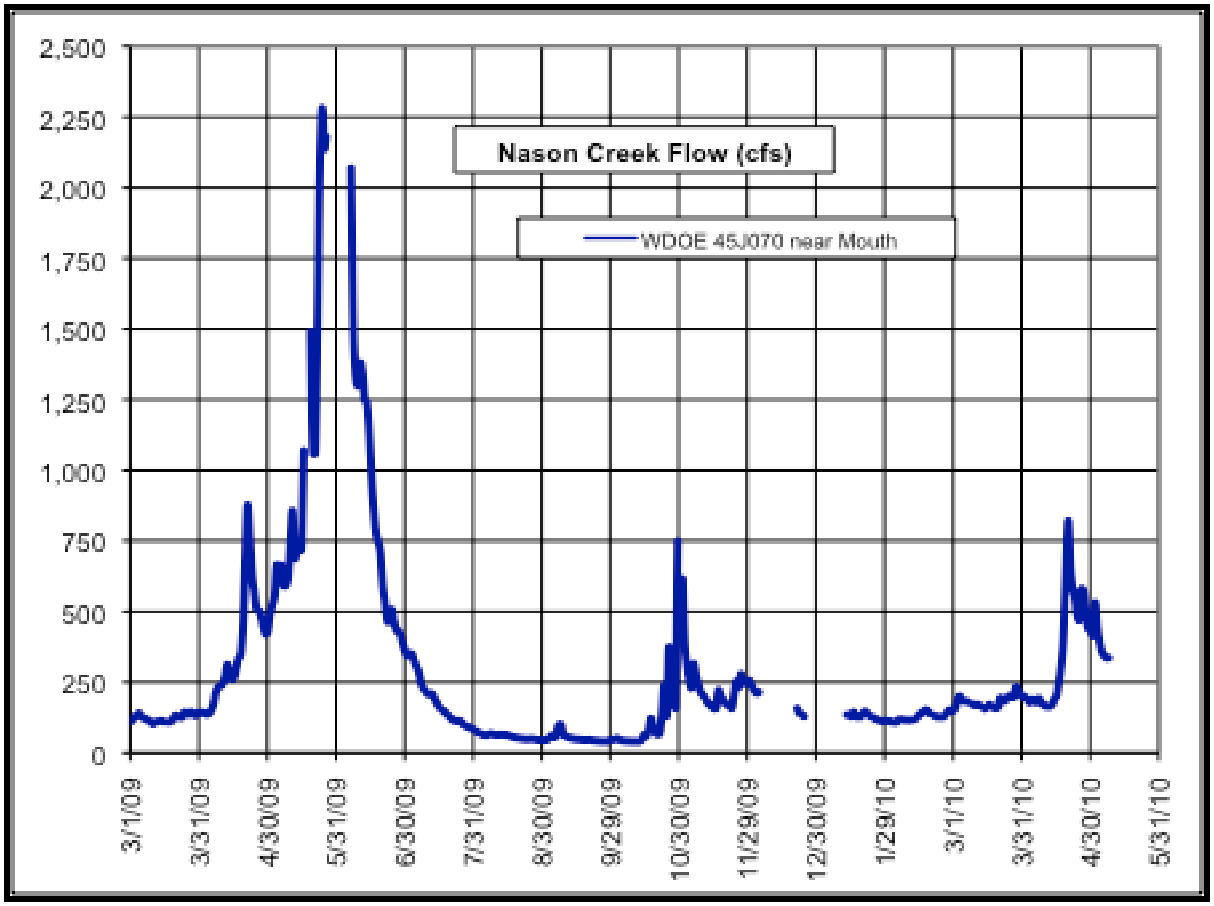
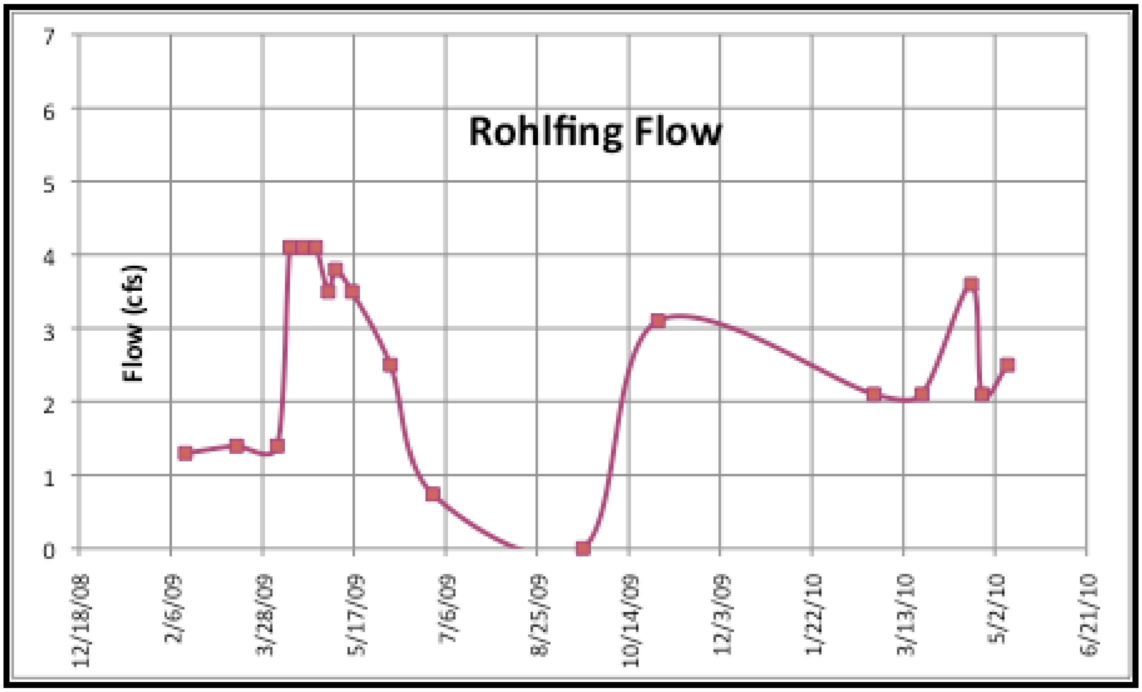



**Figure 4-1.  Nason Flow**

### 4.1.2. Active Study Sites

Rohlfing and Butcher flows showed the typical snow-melt surge in the spring, while fish were being acclimated.  Butcher baseline winter flows were slightly higher and the flow increase happened later than at Rohlfing.



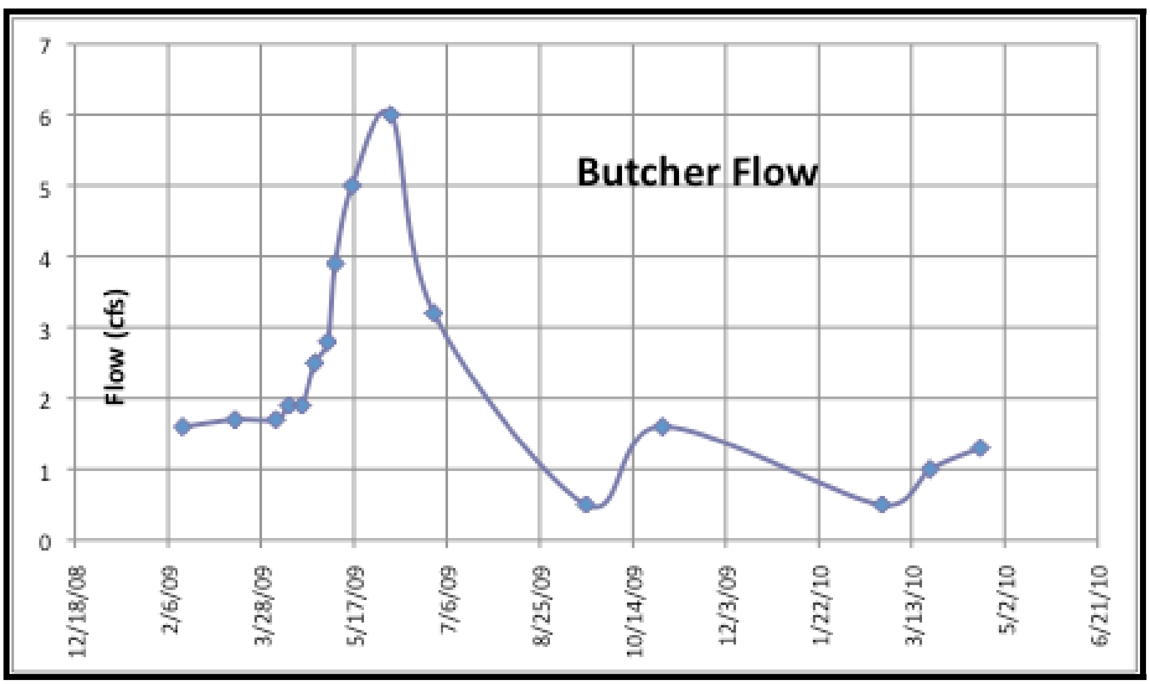




**Figure 4-2. Rohlfing and Butcher Flows**

The discharge from the ponds was diluted by large amounts after entering Nason Creek. The table below shows the ratio of pond discharge flow to Nason Creek receiving water flow during 2009 acclimation season.

| | 3/14 | 4/5 | 4/12 | 4/19 | 4/26 | 5/3 | 5/7 | **Average** |
|---|---|---|---|---|---|---|---|---|
| Rohlfing | 0.48% | 0.43% | 0.77% | 0.63% | 0.46% | 0.39% | 0.30% | **0.49%** |
| Butcher | 0.59% | 0.52% | 0.36% | 0.29% | 0.28% | 0.31% | 0.31% | **0.38%** |

**Figure 4-3. Dilution Ratio**

## 4.1.3. Wenatchee River

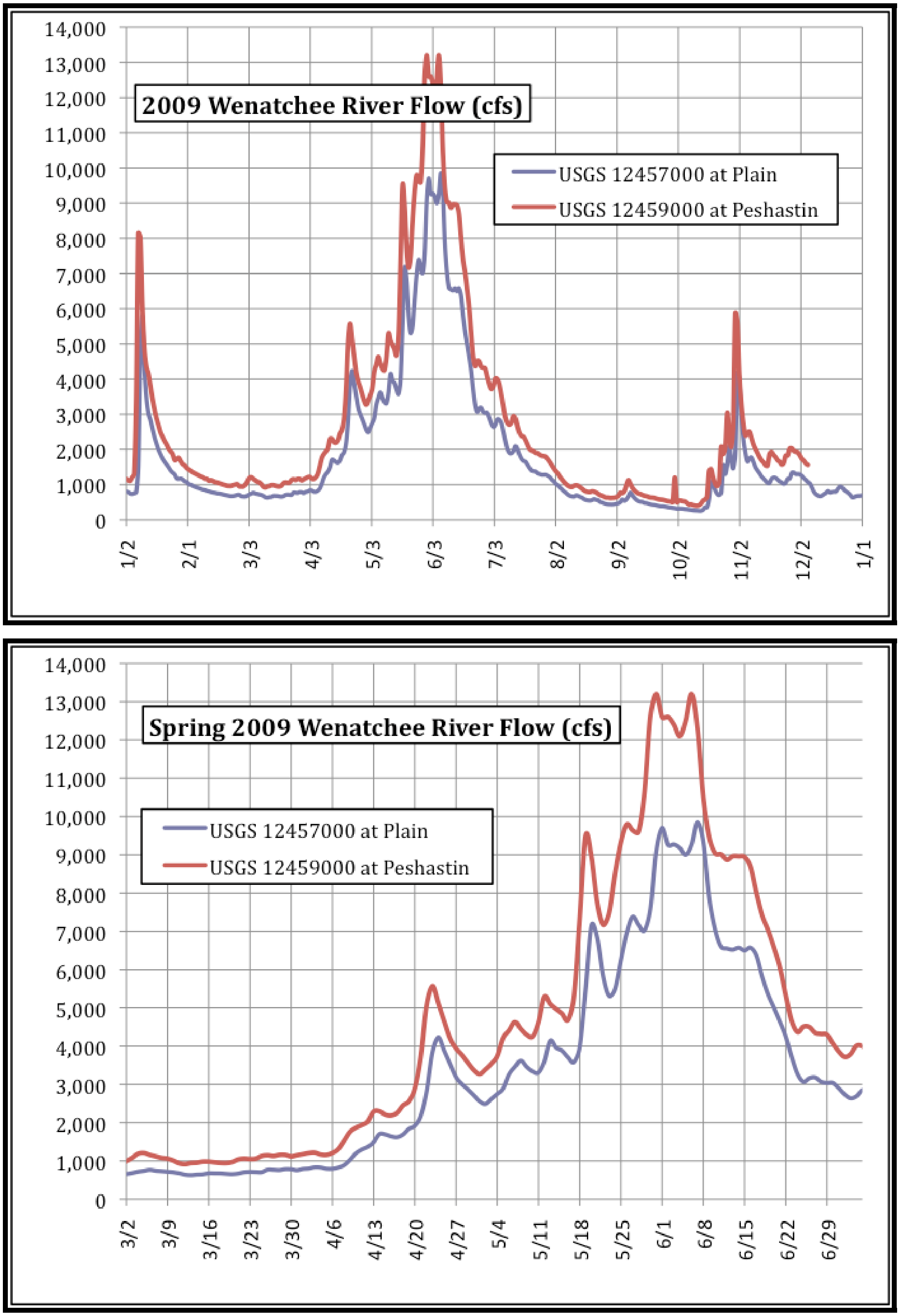



**Figure 4-4. 2009 Wenatchee Flow**

# 4.2. Active Study Sites

## 4.2.1. 2009 Water Quality Data

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Anomolous values | | | TP below detection reported at 0.0005 | | | | | | | | | | | |
| | | | | Acclimation Period | | | | | | | | | | | | | | |
| | | 1/17/09 | 2/14/09 | 3/14/09 | 4/5/09 | 4/12/09 | 4/19/09 | 4/26/09 | 5/3/09 | 5/16/09 | 6/7/09 | 7/25/09 | 9/19/09 | 10/30/09 | 11/29/09 | 12/20/09 | 2/25/10 | Units |
| Nason - Rohrfing | | | | | | | | | | | | | | | | | | |
| RO1 (Rohrfing - pond in) | Total P | 0.001 | 0.001 | 0.006 | 0.002 | 0.006 | 0.010 | 0.006 | 0.007 | 0.008 | 0.005 | 0.019 | 0.005 | 0.008 | 0.010 | 0.001 | 0.001 | mg/l |
| | Total P | 0.001 | 0.001 | 0.005 | 0.001 | 0.008 | 0.008 | | 0.007 | 0.011 | 0.002 | 0.020 | 0.005 | 0.007 | 0.009 | 0.001 | 0.001 | mg/l |
| | AVG | 0.001 | 0.001 | 0.006 | 0.002 | 0.007 | 0.009 | 0.006 | 0.007 | 0.010 | 0.004 | 0.020 | 0.005 | 0.008 | 0.010 | 0.001 | 0.001 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.001 | |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.002 | |
| | Total Dis. P | | | | | | | | | | | | | 0.005 | 0.007 | 0.002 | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.006 | 0.007 | 0.002 | 0.001 | |
| | Temp | 2.9 | 2.6 | 2.6 | 3.5 | 3.4 | 4.3 | 4.5 | 6.0 | 7.0 | 8.9 | | 11.5 | 6.5 | 5.4 | | 3.600 | °C |
| | pH | 6.5 | 7.1 | 6.5 | 6.5 | 5.5 | | 6.6 | 6.6 | 6.5 | 6.8 | | 7.0 | | 5.2 | | 5.820 | Units |
| | SpCond | 57.0 | 43.0 | 68.8 | 113.0 | 59.8 | 62.0 | 39.0 | | | 30.0 | | | | 101.5 | | 218.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.2 | 12.7 | 12.4 | 12.2 | 12.0 | 12.1 | 12.2 | 12.5 | 10.6 | 12.3 | | 10.5 | 10.4 | 11.4 | | 13.460 | mg/l |
| | DO, sat | 12.4 | 12.5 | 12.5 | 12.2 | 12.3 | 11.9 | 11.9 | 11.4 | 11.2 | 10.6 | | | | | | | mg/l |
| RO2 (Rohrfing - pond out) | Total P | 0.001 | 0.005 | 0.003 | 0.006 | 0.014 | 0.008 | 0.011 | 0.016 | 0.002 | 0.002 | 0.025 | no flow | 0.006 | 0.009 | 0.001 | 0.001 | mg/l |
| | Total P | 0.001 | 0.007 | 0.003 | 0.004 | 0.017 | 0.007 | | 0.017 | 0.002 | 0.001 | 0.025 | no flow | 0.006 | 0.002 | 0.001 | 0.001 | mg/l |
| | AVG | 0.001 | 0.006 | 0.003 | 0.005 | 0.016 | 0.008 | 0.011 | 0.017 | 0.002 | 0.002 | 0.025 | 0.000 | 0.006 | 0.006 | 0.001 | 0.001 | mg/l |
| | Otrho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.004 | |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.003 | |
| | Total Dis. P | | | | | | | | | | | | | 0.003 | 0.009 | 0.001 | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.005 | 0.005 | 0.001 | 0.001 | |
| | Temp | 2.8 | 2.3 | 2.3 | 3.3 | 3.4 | 4.3 | 4.4 | 6.0 | 7.0 | 9.3 | | | 5.8 | 5.4 | | 3.450 | °C |
| | pH | 6.5 | 6.9 | 6.4 | 6.4 | 5.7 | | 6.7 | 6.4 | 6.5 | 6.9 | | | | 5.2 | | 5.920 | Units |
| | SpCond | 58.0 | 42.7 | 69.0 | 112.8 | 60.0 | 63.0 | 39.0 | | | 30.0 | | | | 102.7 | | 215.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.3 | 12.9 | 11.7 | 11.6 | 11.7 | 11.8 | 11.7 | 12.4 | 10.6 | 12.3 | | | 10.7 | 11.3 | | 13.430 | mg/l |
| | DO, sat | 12.4 | 12.6 | 12.6 | 12.3 | 12.3 | 12.0 | 11.9 | 11.4 | 11.2 | 10.5 | | | | | | | mg/l |
| Delta P | | 0.000 | 0.006 | -0.003 | 0.004 | 0.009 | -0.002 | 0.005 | 0.010 | -0.008 | -0.002 | 0.006 | -0.005 | -0.002 | -0.004 | 0.000 | 0.000 | |
| RO3 (Rohrfing - upstream) | Total P | 0.001 | 0.003 | 0.004 | 0.002 | 0.006 | 0.007 | 0.011 | 0.006 | 0.002 | 0.006 | 0.016 | 0.003 | 0.029 | 0.007 | 0.002 | 0.001 | mg/l |
| | Total P | 0.001 | 0.000 | 0.004 | 0.001 | 0.006 | 0.008 | | 0.014 | 0.002 | 0.006 | 0.016 | 0.001 | 0.038 | 0.005 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.002 | 0.004 | 0.001 | 0.006 | 0.008 | 0.011 | 0.010 | 0.002 | 0.006 | 0.016 | 0.002 | 0.034 | 0.006 | 0.002 | 0.001 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.003 | |
| | Ortho P | | | | | | | | | | | | | 0.002 | 0.001 | | 0.002 | |
| | Total Dis. P | | | | | | | | | | | | | 0.029 | 0.003 | 0.004 | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.035 | 0.004 | | 0.001 | |
| | Temp | 1.3 | 1.3 | 0.8 | 3.2 | 2.8 | 4.2 | 3.7 | 5.1 | 5.2 | 6.3 | | 10.5 | 4.3 | 3.8 | | 2.670 | °C |
| | pH | 6.8 | 7.3 | 6.7 | 6.8 | 6.0 | | 6.5 | 6.6 | 6.6 | 6.7 | | 6.9 | | 5.5 | | 6.280 | Units |
| | SpCond | 31.2 | 33.7 | 44.0 | 57.0 | 39.0 | 47.0 | 30.0 | 224.0 | | 18.0 | | | | 40.2 | | 79.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 14.0 | 13.5 | 13.3 | 12.5 | 12.4 | 12.5 | 12.6 | | 11.4 | 13.4 | | 11.0 | 12.0 | 12.2 | | 14.140 | mg/l |
| | DO, sat | 12.9 | 12.9 | 13.1 | 12.3 | 12.4 | 12.0 | 12.1 | 11.7 | 11.7 | 11.3 | | | | | | | mg/l |
| RO4 (Rohrfing - downstream) | Total P | 0.001 | 0.001 | 0.001 | 0.001 | 0.007 | 0.006 | 0.009 | 0.004 | 0.002 | 0.006 | 0.010 | 0.003 | 0.025 | 0.009 | 0.002 | 0.001 | mg/l |
| | Total P | 0.001 | 0.001 | 0.001 | 0.003 | 0.008 | 0.006 | | 0.008 | 0.004 | 0.005 | 0.006 | 0.003 | 0.026 | 0.006 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.001 | 0.001 | 0.002 | 0.008 | 0.006 | 0.009 | 0.006 | 0.003 | 0.006 | 0.008 | 0.003 | 0.026 | 0.008 | 0.002 | 0.001 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.001 | 0.001 | 0.003 | |
| | Ortho P | | | | | | | | | | | | | 0.002 | 0.001 | | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.020 | 0.006 | 0.006 | 0.004 | |
| | Total Dis. P | | | | | | | | | | | | | 0.022 | 0.006 | | 0.001 | |
| | Temp | 1.5 | 1.5 | 1.0 | 3.5 | 3.0 | 4.5 | 4.0 | 5.2 | 5.4 | 6.4 | | 10.6 | 4.3 | 3.9 | | 2.840 | °C |
| | pH | 6.8 | 7.3 | 6.7 | 6.8 | 6.0 | | 6.7 | 6.5 | 6.6 | 6.5 | | 6.9 | | 5.5 | | 6.330 | Units |
| | SpCond | 34.0 | 34.0 | 45.0 | 61.8 | 42.0 | 45.5 | 31.0 | | | 18.3 | | | | 43.8 | | 90.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.9 | 13.4 | 13.2 | 12.4 | 12.2 | 12.3 | 12.4 | | 11.2 | 13.2 | | 11.0 | 11.9 | 12.1 | | 13.990 | mg/l |
| | DO, sat | 12.9 | 12.9 | 13.1 | 12.2 | 12.4 | 11.9 | 12.1 | 11.7 | 11.6 | 11.3 | | | | | | | mg/l |
| Delta P | | 0.000 | -0.001 | -0.004 | 0.001 | 0.002 | -0.002 | -0.002 | -0.004 | 0.001 | -0.001 | -0.008 | 0.001 | -0.008 | 0.002 | 0.000 | 0.000 | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Anomolous values | | | TP below detection reported at 0.0005 | | | | | | | | | | | |
| | | | | | | Acclimation Period | | | | | | | | | | | | |
| | | 1/17/09 | 2/14/09 | 3/14/09 | 4/5/09 | 4/12/09 | 4/19/09 | 4/26/09 | 5/3/09 | 5/16/09 | 6/7/09 | 7/25/09 | 9/19/09 | 10/30/09 | 11/29/09 | 12/20/09 | 2/25/10 | Units |
| Nason - Butcher | | | | | | | | | | | | | | | | | | |
| BU1 | Total P | 0.001 | 0.003 | 0.002 | 0.004 | 0.007 | 0.009 | | 0.011 | 0.012 | 0.013 | 0.023 | 0.014 | 0.008 | 0.009 | 0.008 | 0.006 | mg/l |
| Butcher - pond in | Total P | 0.001 | 0.004 | 0.004 | 0.004 | 0.007 | 0.010 | | 0.008 | 0.012 | 0.011 | 0.019 | 0.013 | 0.007 | 0.007 | 0.009 | 0.003 | mg/l |
| | AVG | 0.001 | 0.004 | 0.003 | 0.004 | 0.007 | 0.010 | | 0.010 | 0.012 | 0.012 | 0.021 | 0.014 | 0.008 | 0.008 | 0.009 | 0.005 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.008 | 0.001 | 0.008 | |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.007 | 0.001 | 0.009 | |
| | Total Dis. P | | | | | | | | | | | | | 0.006 | 0.003 | 0.006 | 0.004 | |
| | Total Dis. P | | | | | | | | | | | | | 0.007 | 0.005 | 0.007 | 0.001 | |
| | Temp | 2.0 | 2.2 | 2.2 | 3.6 | 3.7 | 4.8 | 4.8 | 5.9 | 7.1 | 8.1 | | 10.6 | 5.9 | 4.390 | | 2.790 | °C |
| | pH | 7.3 | 7.9 | 7.2 | 7.5 | 6.8 | | 7.4 | 7.3 | 7.1 | 7.3 | | 7.2 | | 6.1 | | 6.910 | Units |
| | SpCond | 59.0 | 64.0 | 76.0 | 75.8 | 45.0 | 60.0 | 49.8 | | | 42.0 | | | | | | 91.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.8 | 13.0 | 12.7 | 12.3 | 12.0 | 12.1 | 12.0 | 12.8 | 10.7 | 12.4 | | 10.4 | 11.2 | 11.9 | | 13.950 | mg/l |
| | DO, sat | 12.8 | 12.6 | 12.7 | 12.2 | 12.2 | 11.8 | 11.8 | 11.5 | 11.2 | 10.9 | | | | | | | mg/l |
| BU2 | Total P | 0.003 | 0.004 | 0.004 | 0.017 | 0.012 | 0.014 | 0.017 | 0.031 | 0.017 | 0.005 | 0.017 | 0.015 | | 0.008 | 0.001 | 0.004 | mg/l |
| Butcher - pond out | Total P | 0.002 | 0.005 | 0.002 | 0.015 | 0.014 | 0.014 | | 0.035 | 0.021 | 0.003 | 0.020 | 0.014 | | 0.009 | | 0.001 | mg/l |
| | AVG | 0.003 | 0.005 | 0.003 | 0.016 | 0.013 | 0.014 | 0.017 | 0.033 | 0.019 | 0.004 | 0.019 | 0.015 | | 0.009 | 0.001 | 0.002 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.007 | 0.001 | 0.004 | |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.007 | | 0.002 | |
| | Total Dis. P | | | | | | | | | | | | | 0.003 | 0.007 | 0.007 | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.002 | 0.006 | | 0.001 | |
| | Temp | 1.6 | 1.7 | 1.0 | 4.2 | 4.1 | 5.6 | 5.5 | 7.6 | 8.7 | 9.7 | | 11.6 | 4.9 | 4.0 | | 2.410 | °C |
| | pH | 7.2 | 7.7 | 6.9 | 7.1 | 6.4 | | 7.0 | 6.8 | 6.9 | 7.0 | | 6.8 | | 5.9 | | 6.630 | Units |
| | SpCond | 59.0 | 64.0 | 76.0 | 77.3 | 46.8 | 62.0 | 47.8 | | | 43.8 | | | | 69.0 | | 89.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.4 | 12.8 | 11.8 | 11.2 | 10.9 | 11.2 | 11.2 | 8.8 | 10.2 | 12.3 | | 9.6 | 10.760 | 11.6 | | 12.960 | mg/l |
| | DO, sat | 12.9 | 12.8 | 13.1 | 12.0 | 12.1 | 11.6 | 11.6 | 11.0 | 10.7 | 10.5 | | | | | | | mg/l |
| Delta P | | 0.002 | 0.001 | 0.000 | 0.012 | 0.006 | 0.005 | | 0.024 | 0.007 | -0.008 | -0.003 | 0.001 | | 0.001 | -0.008 | -0.002 | |
| BU3 | Total P | 0.001 | 0.003 | 0.004 | 0.001 | 0.004 | 0.003 | 0.014 | 0.005 | 0.012 | 0.011 | 0.014 | 0.002 | 0.034 | 0.007 | 0.001 | 0.001 | mg/l |
| Butcher - upstream | Total P | 0.001 | 0.004 | 0.004 | 0.003 | 0.010 | 0.002 | | 0.008 | 0.010 | 0.011 | 0.014 | 0.002 | 0.035 | 0.006 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.004 | 0.004 | 0.002 | 0.007 | 0.003 | 0.014 | 0.007 | 0.011 | 0.011 | 0.014 | 0.002 | 0.035 | 0.007 | 0.001 | 0.001 | mg/l |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.004 | 0.001 | 0.001 | |
| | Ortho P | | | | | | | | | | | | | 0.001 | 0.003 | | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.031 | 0.004 | 0.005 | 0.006 | |
| | Total Dis. P | | | | | | | | | | | | | 0.031 | 0.006 | | 0.006 | |
| | Temp | 1.6 | 1.9 | 1.8 | 4.9 | 3.7 | 5.4 | 4.9 | 6.4 | 6.9 | 7.4 | | 11.8 | 4.4 | 4.1 | | 2.950 | °C |
| | pH | 6.6 | 7.1 | 6.6 | 6.7 | 5.9 | | 6.6 | 6.4 | 6.4 | 6.5 | | 6.4 | | 5.3 | | 6.160 | Units |
| | SpCond | 31.8 | 34.0 | 45.0 | 59.3 | 36.0 | 45.0 | 29.0 | | | 17.0 | | | | 40.0 | | 72.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.4 | 12.9 | 12.5 | 11.6 | 11.6 | 11.9 | 11.9 | 11.5 | 10.8 | 12.5 | | 10.4 | 11.7 | 11.6 | | 13.480 | mg/l |
| | DO, sat | 12.9 | 12.7 | 12.9 | 11.8 | 12.2 | 11.7 | 11.8 | 11.4 | 11.2 | 11.1 | | | | | | | mg/l |
| BU4 | Total P | 0.001 | 0.007 | 0.001 | 0.004 | 0.005 | 0.017 | 0.010 | 0.008 | 0.007 | 0.011 | 0.014 | 0.007 | 0.045 | 0.007 | 0.002 | 0.001 | mg/l |
| Butcher - downstream | Total P | 0.001 | 0.002 | 0.001 | 0.006 | 0.004 | 0.014 | | 0.011 | 0.008 | 0.012 | 0.015 | 0.007 | 0.040 | 0.007 | 0.003 | 0.007 | mg/l |
| | AVG | 0.001 | 0.005 | 0.001 | 0.005 | 0.005 | 0.016 | 0.010 | 0.010 | 0.008 | 0.012 | 0.015 | 0.007 | 0.043 | 0.007 | 0.003 | 0.004 | mg/l |
| | Ortho P | | | 0.001 | | 0.001 | | | 0.001 | 0.001 | 0.001 | | 0.001 | 0.012 | 0.001 | 0.001 | 0.001 | |
| | Ortho P | | | | | | | | | | | | | 0.012 | 0.001 | 0.001 | 0.001 | |
| | Total Dis. P | | | 0.004 | | 0.003 | | | 0.006 | 0.005 | 0.003 | | 0.001 | 0.039 | 0.003 | 0.003 | 0.001 | |
| | Total Dis. P | | | | | | | | | | | | | 0.040 | 0.005 | 0.002 | 0.003 | |
| | Temp | 1.7 | 1.9 | 1.6 | 5.0 | 3.8 | 5.4 | 4.8 | 6.6 | 7.1 | 7.4 | | 11.8 | 4.4 | 4.1 | | 2.830 | °C |
| | pH | 6.8 | 7.2 | 6.6 | 6.5 | 6.0 | | 6.7 | 6.6 | 6.5 | 6.7 | | 6.5 | | 5.6 | | 6.340 | Units |
| | SpCond | 33.6 | 38.7 | 52.0 | 54.0 | 38.0 | 48.0 | 32.7 | | | 21.0 | | | | 42.7 | | 75.000 | µS/cm |
| | Turb | | | | | | | | | | | | | | | | | |
| | LDO | 13.4 | 12.9 | 12.3 | 11.7 | 11.5 | 11.8 | 11.8 | 11.1 | 10.8 | 12.7 | | 10.1 | 11.7 | 11.7 | | 13.430 | mg/l |
| | DO, sat | 12.9 | 12.8 | 12.9 | 11.8 | 12.2 | 11.7 | 11.8 | 11.3 | | 11.1 | | | | | | | mg/l |
| Delta P | | 0.000 | 0.001 | -0.004 | 0.003 | -0.003 | 0.013 | -0.004 | 0.003 | -0.004 | 0.001 | 0.000 | 0.005 | 0.008 | 0.001 | 0.002 | 0.003 | |

**Figure 4-5. Active Site Water Quality**

# 4.2.2. 2010 Water Quality Data

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Anomolous values | TP below detection reported at 0.0005 | | | | | |
| | | | Acclimation Period | | | | | | |
| | | 2/25/10 | 3/23/10 | 4/12/10 | 4/18/10 | 4/25/10 | 5/5/10 | 5/9/10 | Units |
| Nason - Rohling | | | | | | | | | |
| RO1 | Total P | 0.001 | 0.001 | 0.003 | 0.002 | 0.005 | 0.018 | 0.001 | mg/l |
| Rohling - pond in | Total P | 0.001 | 0.001 | 0.002 | 0.001 | 0.003 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.001 | 0.003 | 0.002 | 0.004 | 0.018 | 0.001 | mg/l |
| | Ortho P | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | |
| | Ortho P | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.005 | 0.002 | 0.001 | 0.016 | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.001 | 0.002 | 0.003 | | 0.001 | |
| | Temp | 3.600 | 4.320 | 3.870 | 5.670 | 5.690 | 5.110 | 6.570 | °C |
| | pH | 5.820 | 6.680 | 6.910 | 6.580 | 7.160 | 6.900 | 6.790 | Units |
| | SpCond | 218.000 | 129.400 | 88.500 | 91.400 | 72.000 | 70.200 | 68.800 | µS/cm |
| | TSS | | | 1.000 | 0.500 | 0.500 | 1.000 | 2.500 | |
| | LDO | 13.460 | 11.540 | 12.700 | 11.800 | 12.070 | 11.750 | 11.610 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| RO2 | Total P | 0.001 | 0.004 | 0.010 | 0.007 | 0.012 | | 0.001 | mg/l |
| Rohling - pond out | Total P | 0.001 | 0.001 | 0.010 | 0.014 | 0.014 | 0.027 | 0.001 | mg/l |
| | AVG | 0.001 | 0.002 | 0.010 | 0.011 | 0.013 | 0.027 | 0.001 | mg/l |
| | Ortho P | 0.004 | 0.001 | 0.002 | 0.003 | 0.008 | | 0.001 | |
| | Ortho P | 0.003 | 0.001 | 0.002 | 0.003 | 0.008 | 0.001 | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.009 | 0.006 | 0.005 | | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.008 | 0.009 | 0.008 | 0.016 | 0.001 | |
| | Temp | 3.450 | 4.290 | 3.560 | 5.440 | 5.570 | 5.350 | 6.610 | °C |
| | pH | 5.920 | 6.670 | 6.460 | 6.550 | 7.030 | 6.900 | 6.440 | Units |
| | SpCond | 215.000 | 128.400 | 87.900 | 92.100 | 72.400 | 71.100 | 69.900 | µS/cm |
| | TSS | | | 1.000 | 0.500 | 1.000 | 0.500 | 3.500 | |
| | LDO | 13.430 | 11.460 | 12.010 | 10.980 | 11.210 | 10.910 | 10.810 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| Delta P | | 0.000 | 0.002 | 0.008 | 0.009 | 0.009 | 0.009 | 0.000 | |
| RO3 | Total P | 0.001 | 0.001 | 0.004 | 0.002 | 0.004 | 0.017 | 0.001 | mg/l |
| Rohling - upstream | Total P | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.001 | 0.003 | 0.002 | 0.003 | 0.017 | 0.001 | mg/l |
| | Ortho P | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | |
| | Ortho P | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.001 | 0.003 | 0.002 | 0.019 | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.001 | 0.003 | 0.001 | | 0.001 | |
| | Temp | 2.670 | 4.480 | 3.180 | 4.720 | 4.480 | 4.470 | 5.840 | °C |
| | pH | 6.280 | 6.940 | 6.940 | 6.850 | 7.340 | 7.090 | 6.560 | Units |
| | SpCond | 79.000 | 72.700 | 45.000 | 46.300 | 37.000 | 40.500 | 39.000 | µS/cm |
| | TSS | | | 0.500 | 0.500 | 0.500 | 0.500 | 3.000 | |
| | LDO | 14.140 | 11.760 | 13.170 | 12.380 | 12.660 | 12.150 | 12.020 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| RO4 | Total P | 0.001 | 0.001 | 0.002 | 0.003 | 0.002 | 0.015 | 0.001 | mg/l |
| Rohling - downstream | Total P | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.001 | 0.002 | 0.003 | 0.002 | 0.015 | 0.001 | mg/l |
| | Ortho P | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | |
| | Ortho P | 0.001 | 0.004 | 0.001 | 0.001 | 0.001 | | 0.001 | |
| | Total Dis. P | 0.004 | 0.001 | 0.001 | 0.003 | 0.001 | 0.012 | 0.001 | |
| | Total Dis. P | 0.001 | 0.001 | 0.001 | 0.003 | 0.004 | | 0.001 | |
| | Temp | 2.840 | 4.580 | 3.250 | 4.940 | 4.620 | 4.500 | 5.960 | °C |
| | pH | 6.330 | 6.840 | 6.880 | 7.000 | 7.220 | 7.090 | 6.570 | Units |
| | SpCond | 80.000 | 77.400 | 50.000 | 48.900 | 38.700 | 42.400 | 40.700 | µS/cm |
| | TSS | | | 0.500 | 0.500 | 2.500 | 0.500 | 0.500 | |
| | LDO | 13.990 | 11.660 | 13.030 | 12.210 | 12.570 | 12.100 | 11.930 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| Delta P | | 0.000 | 0.000 | -0.001 | 0.001 | -0.001 | -0.002 | 0.000 | |
| Nason - Butcher | | | | | | | | | |
| BU1 | Total P | 0.006 | 0.004 | 0.006 | 0.012 | 0.012 | 0.001 | 0.001 | mg/l |
| Butcher - pond in | Total P | 0.003 | 0.005 | 0.011 | 0.009 | 0.012 | | 0.001 | mg/l |
| | AVG | 0.005 | 0.005 | 0.009 | 0.011 | 0.012 | 0.001 | 0.001 | mg/l |
| | Ortho P | 0.008 | 0.005 | 0.006 | 0.002 | 0.012 | 0.001 | 0.001 | |
| | Ortho P | 0.009 | 0.006 | 0.001 | 0.002 | 0.012 | | 0.001 | |
| | Total Dis. P | 0.004 | 0.004 | 0.006 | 0.007 | 0.010 | 0.001 | 0.001 | |
| | Total Dis. P | 0.001 | 0.005 | 0.007 | 0.007 | 0.011 | | 0.001 | |
| | Temp | 2.790 | 4.430 | 3.130 | 6.000 | 5.490 | 4.390 | 8.100 | °C |
| | pH | 6.910 | 7.460 | 7.550 | 7.710 | 7.670 | 7.640 | 7.030 | Units |
| | SpCond | 91.000 | 87.200 | 61.500 | 66.600 | 60.600 | 63.300 | 63.200 | µS/cm |
| | TSS | | | 1.000 | 2.500 | 6.500 | 3.000 | 7.000 | |
| | LDO | 13.950 | 11.680 | 12.990 | 11.790 | 9.960 | 12.060 | 11.800 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| BU2 | Total P | 0.004 | 0.002 | 0.022 | 0.017 | 0.017 | 0.016 | 0.001 | mg/l |
| Butcher - pond out | Total P | 0.001 | 0.006 | 0.025 | 0.018 | 0.020 | | 0.001 | mg/l |
| | AVG | 0.002 | 0.004 | 0.024 | 0.018 | 0.019 | 0.016 | 0.001 | mg/l |
| | Ortho P | 0.004 | 0.006 | 0.018 | 0.011 | 0.027 | 0.011 | 0.001 | |
| | Ortho P | 0.002 | 0.001 | 0.020 | 0.010 | 0.026 | | 0.001 | |
| | Total Dis. P | 0.001 | 0.004 | 0.022 | 0.014 | 0.016 | 0.012 | 0.001 | |
| | Total Dis. P | 0.001 | 0.004 | 0.022 | 0.019 | 0.017 | | 0.001 | |
| | Temp | 2.410 | 5.560 | 3.210 | 8.500 | 8.050 | 7.400 | 10.230 | °C |
| | pH | 6.630 | 7.350 | 6.990 | 7.280 | 7.370 | 7.240 | 6.760 | Units |
| | SpCond | 89.000 | 81.600 | 62.400 | 68.000 | 67.900 | 65.900 | 65.400 | µS/cm |
| | TSS | | | 2.500 | 3.000 | 4.500 | 0.500 | 5.000 | |
| | LDO | 12.960 | 11.450 | 10.690 | 10.550 | 8.820 | 9.820 | 11.320 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| Delta P | | -0.002 | -0.001 | 0.015 | 0.007 | 0.007 | 0.016 | 0.000 | |
| BU3 | Total P | 0.001 | 0.006 | 0.008 | 0.004 | 0.010 | 0.007 | 0.004 | mg/l |
| Butcher - upstream | Total P | 0.001 | 0.006 | 0.002 | 0.005 | 0.009 | | 0.001 | mg/l |
| | AVG | 0.001 | 0.006 | 0.005 | 0.005 | 0.010 | 0.007 | 0.002 | mg/l |
| | Ortho P | 0.001 | 0.001 | 0.002 | 0.001 | 0.009 | 0.001 | 0.001 | |
| | Ortho P | 0.001 | 0.001 | 0.001 | 0.001 | 0.009 | | 0.001 | |
| | Total Dis. P | 0.006 | 0.006 | 0.007 | 0.005 | 0.010 | 0.001 | 0.001 | |
| | Total Dis. P | 0.006 | 0.006 | 0.003 | 0.007 | 0.009 | | 0.001 | |
| | Temp | 2.950 | 5.680 | 3.810 | 6.060 | 5.950 | 5.680 | 7.110 | °C |
| | pH | 6.100 | 6.650 | 6.640 | 6.710 | 6.910 | 7.230 | 6.290 | Units |
| | SpCond | 72.000 | 70.900 | 46.900 | 45.300 | 36.900 | 38.400 | 37.700 | µS/cm |
| | TSS | | | 0.500 | 0.500 | 3.500 | 1.000 | 1.000 | |
| | LDO | 13.480 | 11.230 | 12.460 | 11.910 | 9.940 | 11.590 | 11.570 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| BU4 | Total P | 0.001 | 0.006 | 0.008 | 0.004 | 0.005 | 0.022 | 0.004 | mg/l |
| Butcher - downstream | Total P | 0.007 | | | 0.005 | 0.004 | | 0.001 | mg/l |
| | AVG | 0.004 | 0.006 | 0.008 | 0.005 | 0.005 | 0.022 | 0.002 | mg/l |
| | Ortho P | 0.001 | | 0.006 | 0.007 | 0.009 | 0.006 | 0.001 | |
| | Ortho P | 0.001 | | | 0.006 | 0.001 | | 0.001 | |
| | Total Dis. P | 0.001 | 0.009 | 0.007 | 0.006 | 0.006 | 0.020 | 0.001 | |
| | Total Dis. P | 0.003 | | 0.500 | 0.005 | 0.007 | | 0.001 | |
| | Temp | 2.830 | 5.850 | 3.640 | 6.510 | 5.970 | 5.710 | 7.700 | °C |
| | pH | 6.340 | 6.930 | 6.800 | 6.960 | 7.090 | 7.080 | 6.400 | Units |
| | SpCond | 75.000 | 75.400 | 49.800 | 47.700 | 39.500 | 41.300 | 40.700 | µS/cm |
| | TSS | | | | 0.500 | 2.500 | 0.500 | 0.500 | |
| | LDO | 13.430 | 11.260 | 12.180 | 11.750 | 9.910 | 11.540 | 11.390 | mg/l |
| | DO, sat | | | | | | | | mg/l |
| Delta P | | 0.003 | 0.000 | 0.003 | -0.002 | -0.005 | 0.015 | 0.000 | |

# 4.2.3. 2009 Total Phosphorous

The figures below show TP data for the Rohlfing and Butcher ponds through the full 2009 year.

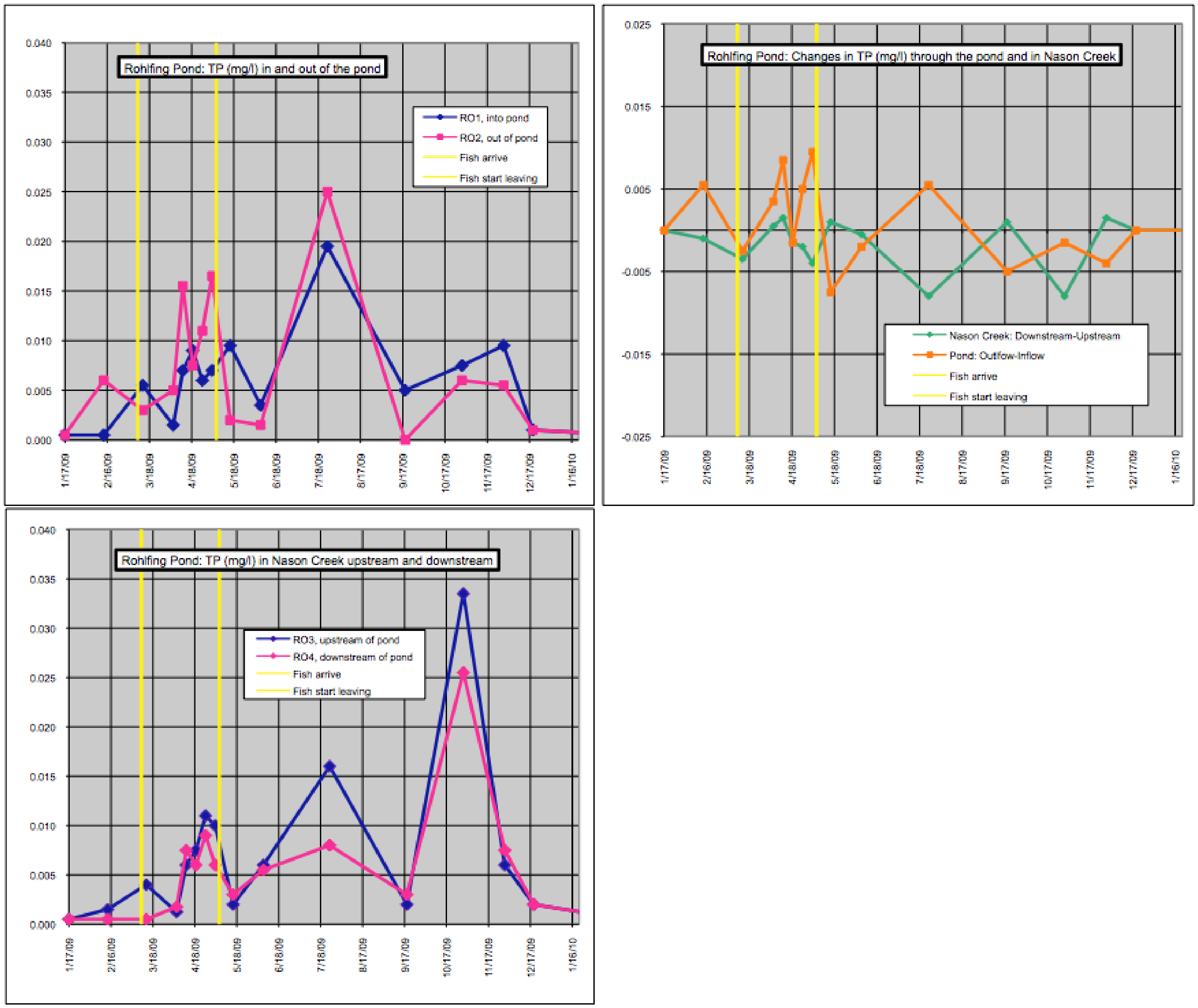



**Figure 4-6. 2009 Rohlfing TP**


**Figure 4-7. 2009 Butcher TP**

## 4.2.4. 2010 Total Phosphorous

The figures below show TP data for the Rohlfing and Butcher ponds during the 2010 acclimation season.

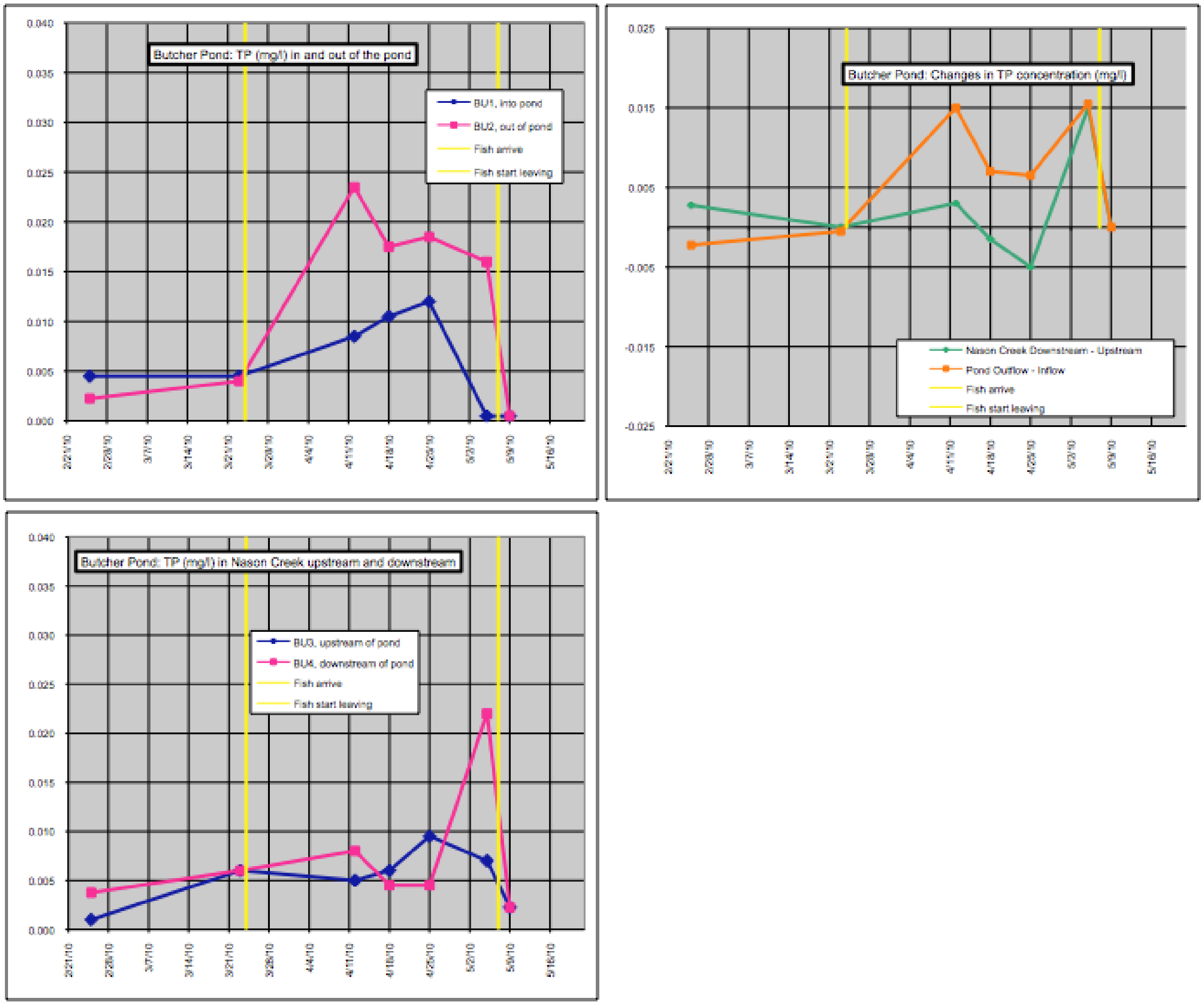



**Figure 4-8. 2010 Rohlfing TP**

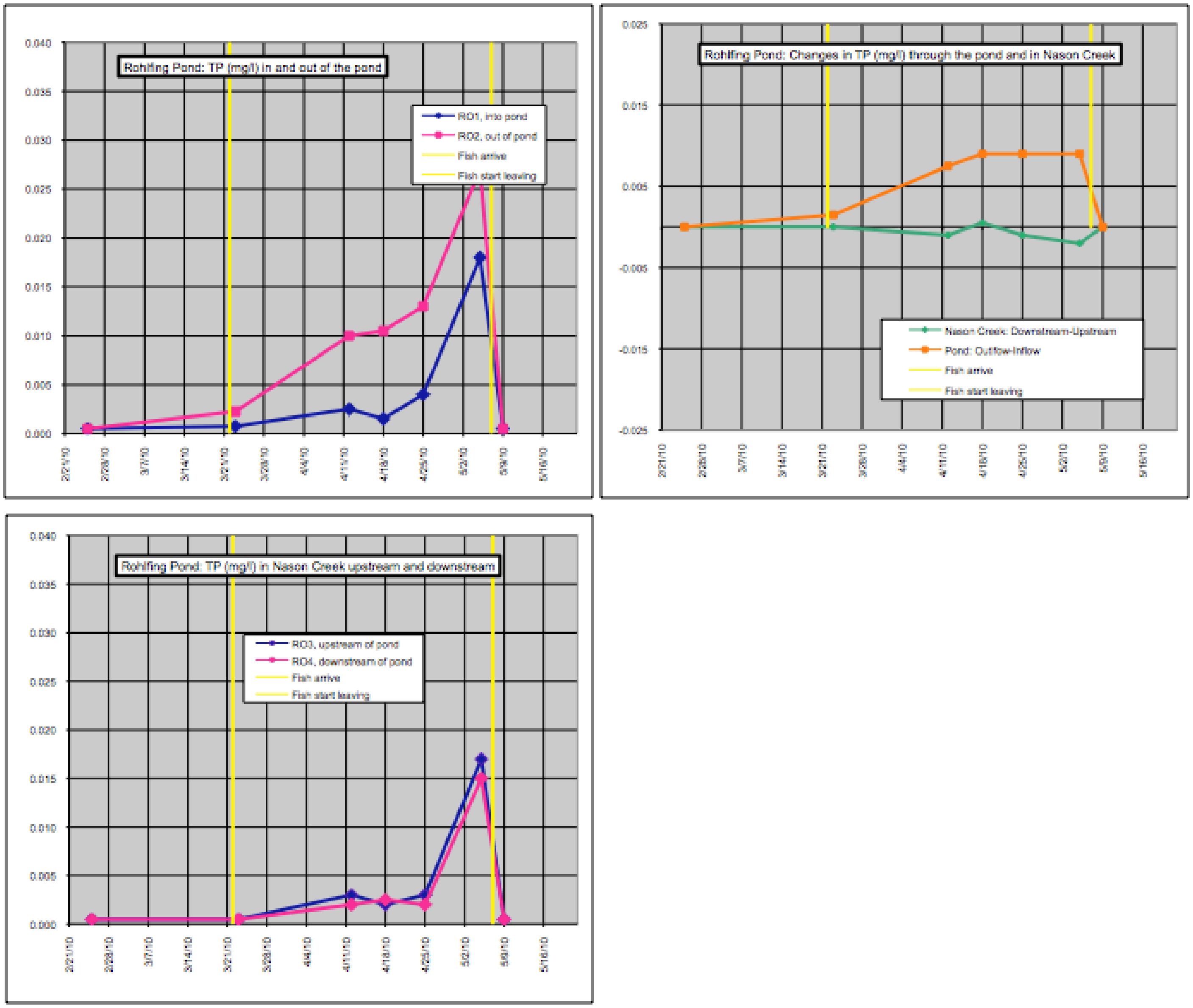



**Figure 4-9. 2010 Butcher TP**

## 4.2.5. 2009 DO, pH, and Temperature

Other parameters measured with the Hydrolab sondes are plotted below.


**Figure 4-10. Rohlfing DO, pH, and Temperature**


**Figure 4-11. 2009 Butcher DO, pH, and Temperature**

## 4.2.6. 2010 DO, pH, and Temperature


**Figure 4-12. 2010 Rohlfing DO, pH, and Temperature**

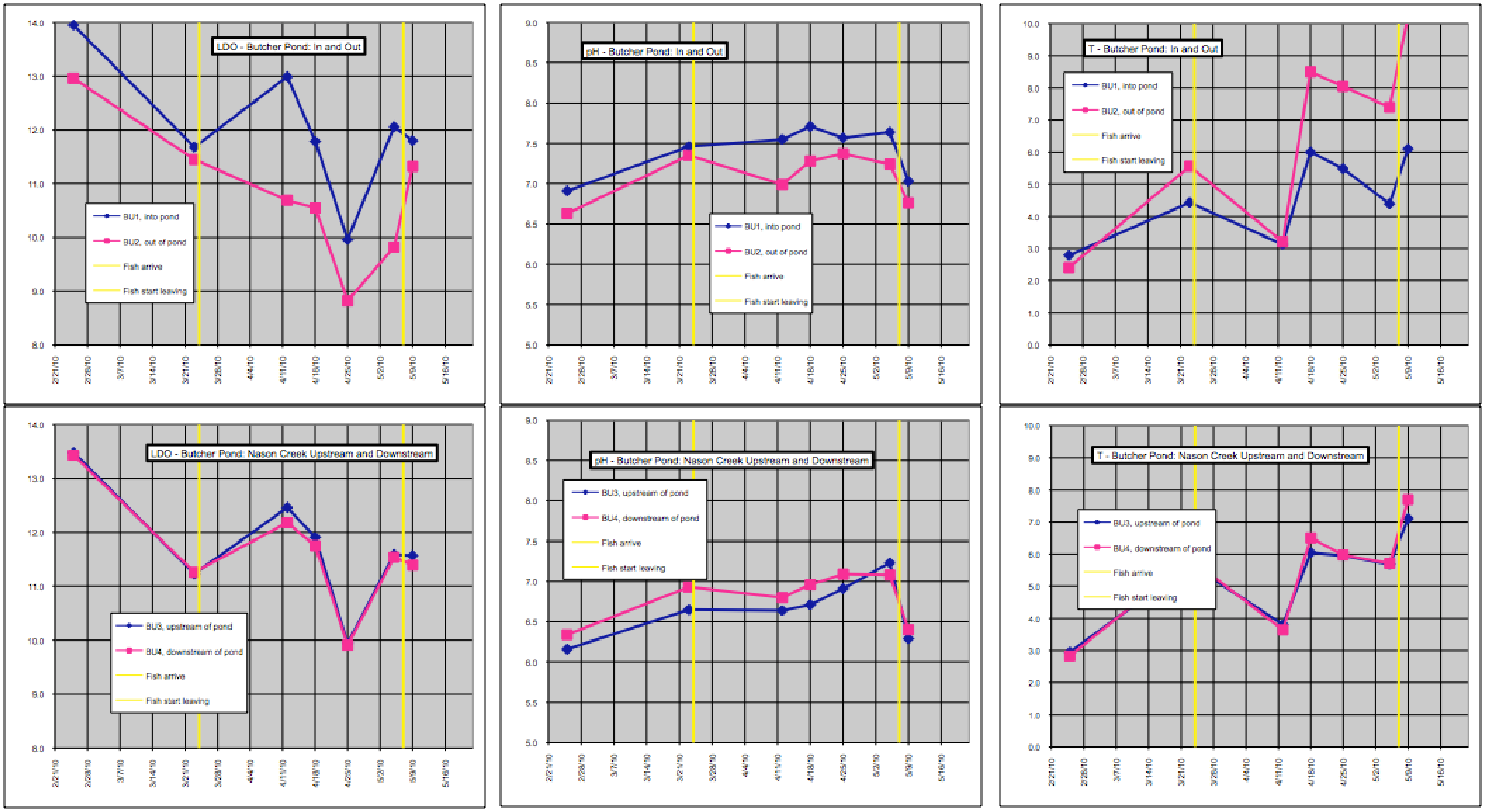



**Figure 4-13. 2010 Butcher DO, pH, and Temperature**

## 4.2.7. 24 Hour Test Data

On 5/5/2010 and 5/6/2010 a Hydrolab sonde was moved between the 4 Butcher Creek sites, BU1, BU2, BU3, and BU4. Sample bottles were also filled at the time sonde measurements were recorded. Measurements were made every 2 hours over a 24 hour period, except for a gap between 23:30 and 05:30. Fish were released from the site on 5/7/10.

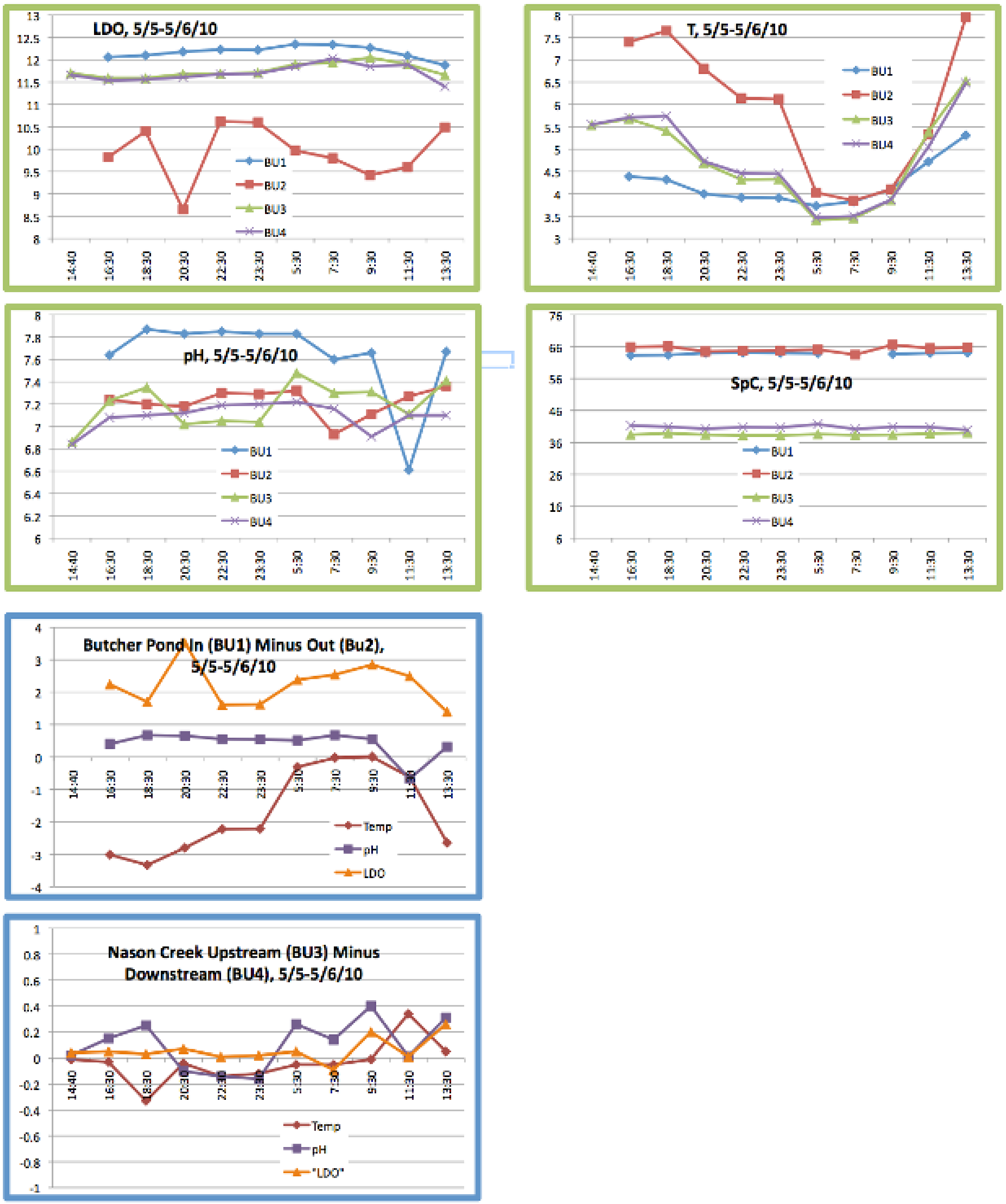



**Figure 4-14. 24 Hr. Butcher DO, pH, and Temperature**

## 4.3. Other Basin Sites

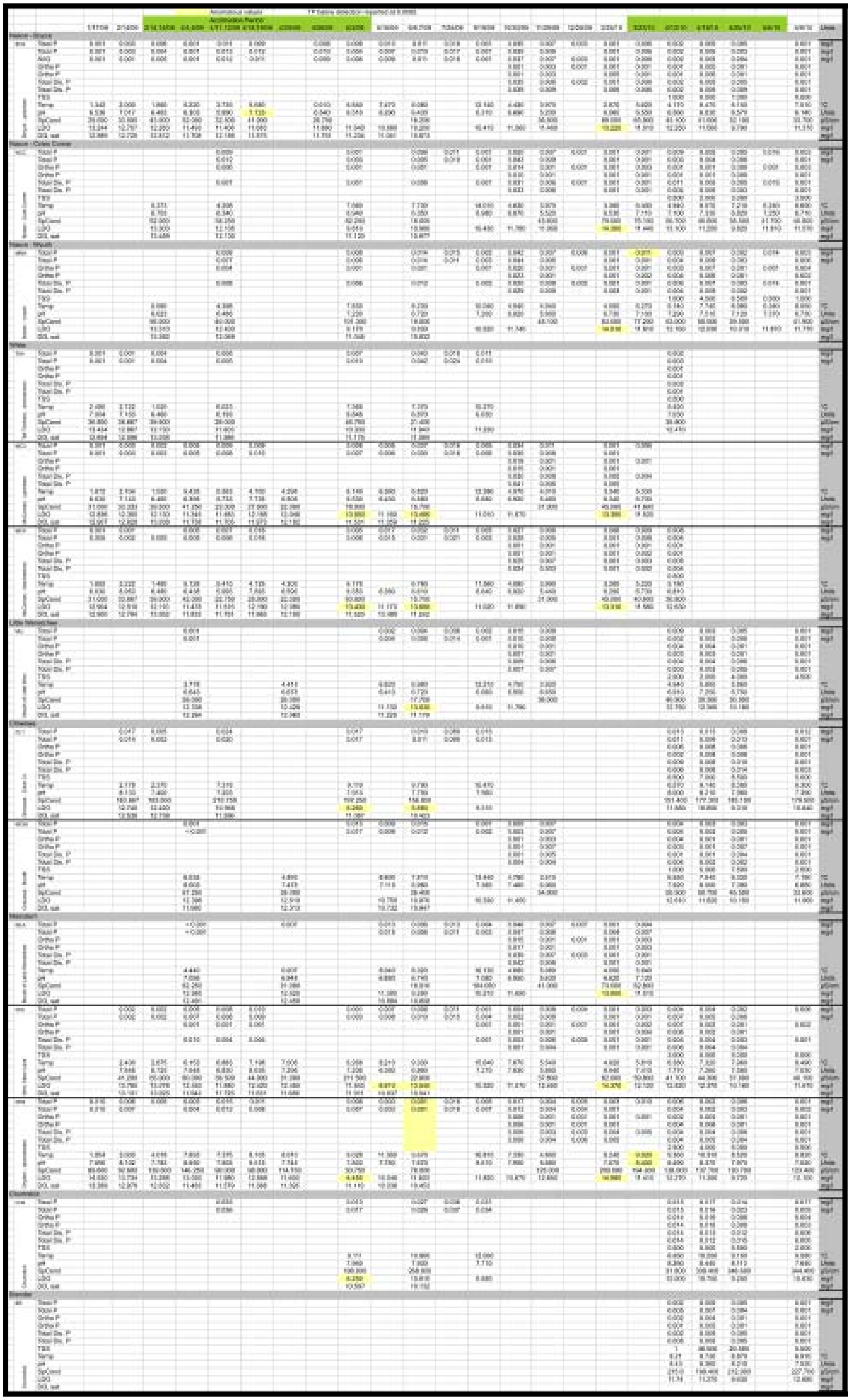


**Figure 4-15. Water Quality at Other Sample Locations**

## 4.4. Upper Wenatchee Basin TP Load

The figure below shows the 2009 phosphorous load at the WIC site, just upstream of the mouth of the Icicle and the town of Leavenworth. The TMDL defines "upstream load" as the Wenatchee River load above the confluence with the Icicle. Loads are calculated by multiplying TP concentration times the river flow rate.

The current TP upstream load estimate in the TMDL is 1.24 kg/day and the target load is 0.93 kg/day. The loads measured in this study were much higher than these values with the lowest load measured on 3/15/09 at 4.8 kg/day.

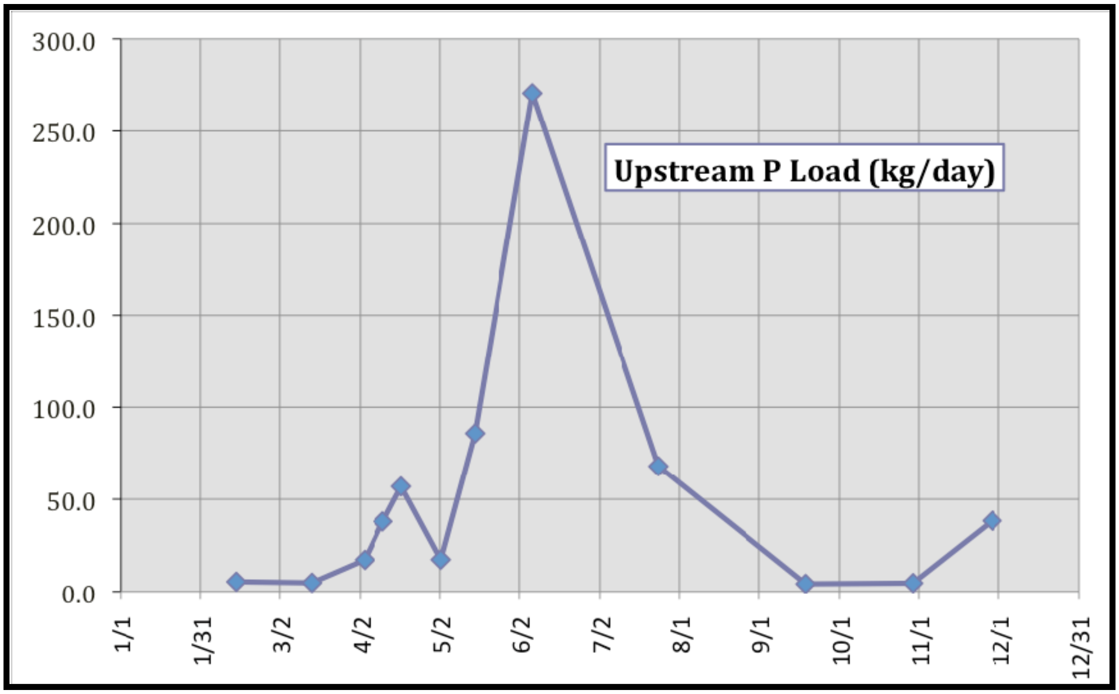



**Figure 4-16. Upstream TP Loads**

## 4.5. Detailed Water Quality Sites

A larger suite of water quality parameters were monitored periodically at 3 selected sites, one each on Nason Creek, White River, and the Wenatchee River respectively.

| | | 1/17/09 | 2/14/09 | 3/14,15/09 | 4/4,5/09 | 4/11.12/09 | 4/18,19/09 | 4/25/09 | 4/26/09 | 5/3/09 | 5/16/09 | 6/6.7/09 | 7/25/09 | 9/19/09 | 10/30/09 | 11/29/09 | 12/20/09 | 2/25/10 | 3/23/10 | 4/12/10 | 4/18/10 | 4/25/10 | 5/8/10 | 5/9/10 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water Quality (minimumums reported at the detection limit) | | | | | | | | | | | | | | | | | | | | | | | | | |
| BU4 | Total Organic Carbon | 4.100 | 2.900 | 3.100 | 9.000 | | | | | 3.500 | | 1.60 | 1.00 | 4.40 | 9.20 | 6.40 | | 6.500 | 4.500 | 1.000 | <1 | <.5 | | | mg/l |
| BU4 | Dissolved Organic C | 0.500 | 2.200 | 2.100 | 3.700 | | | | | 2.700 | | 1.600 | 0.500 | 0.830 | 2.600 | 1.500 | | 2.600 | 0.890 | 0.970 | <.5 | <1 | | | mg/l |
| BU4 | Chlorophyll a | 0.800 | 0.800 | 0.300 | 0.300 | | | | | 0.300 | | 10.000 | 0.800 | 0.530 | 0.800 | | | 0.530 | 7.500 | <.3 | 2.700 | 1.600 | 7.500 | 1.300 | mg/m3 |
| BU4 | Pheophytin | 0.300 | 1.000 | 4.200 | 4.600 | | | | | 1.200 | | 0.300 | 0.300 | 1.000 | 1.500 | | | 4.000 | <.3 | <.3 | 11.000 | 0.640 | <.3 | 0.910 | mg/m3 |
| BU4 | Ammonia Nitrogen | 0.020 | 0.009 | 0.013 | 0.022 | | | | | 0.022 | | 0.082 | 0.210 | 0.032 | <.005 | 0.030 | | 0.033 | <.005 | 0.040 | <.005 | <.01 | 0.010 | 0.011 | mg/l |
| BU4 | Nitrate + Nitrite | 0.062 | 0.031 | 0.048 | 0.035 | | | | | 0.060 | | 0.032 | 0.014 | 0.005 | 0.050 | 0.039 | | 0.035 | 0.050 | 0.036 | 0.110 | 0.087 | 0.070 | 0.071 | mg/l |
| BU4 | Total Persulfate N | 0.150 | 0.016 | 0.070 | 0.070 | | | | | 0.090 | | 0.040 | 0.060 | 0.060 | 0.150 | 0.070 | | 0.007 | 0.100 | | | | 0.010 | 0.120 | mg/l |
| BU4 | Ortho-Phosphate | 0.001 | 0.001 | 0.001 | 0.002 | | | | | 0.001 | | 0.001 | 0.002 | 0.001 | | | | 0.001 | | 0.006 | 0.007 | 0.009 | <.001 | <.001 | mg/l |
| BU4 | Suspended Solids | | | 1.000 | 2.000 | | | | | 3.000 | | 15.000 | 1.000 | 9.000 | 54.000 | 2.000 | | 1.000 | 13.000 | <1 | <1 | 4.000 | <1 | <1 | |
| BU4 | Nitrite Nitrogen | | | | 0.001 | | | | | | | | | | | | | | | | | | | | |
| BU4 | BOD-low | | | | | | | | | 2.000 | | 2.000 | | 1.000 | <2 | | | 1.000 | | <2 | <2 | <2 | <2 | <2 | |
| DR4 | Total Organic Carbon | 8.100 | 6.200 | 5.500 | 4.200 | | | | | 2.700 | | 7.500 | 1.500 | | <1 | 4.700 | | 10.000 | 8.400 | 8.500 | 6.000 | 6.900 | | | mg/l |
| DR4 | Dissolved Organic C | 7.700 | 5.500 | 3.300 | 3.100 | | | | | 2.100 | | 6.200 | 0.600 | 3.500 | <.5 | 4.600 | | 7.000 | 2.500 | 2.400 | 5.600 | 6.900 | | | mg/l |
| DR4 | Chlorophyll a | 1.100 | 1.100 | 1.900 | 3.200 | | | | | 1.600 | | 25.000 | 1.300 | 0.530 | 7.500 | | | 0.530 | 5.300 | 8.200 | 4.300 | 1.600 | | 1.200 | mg/m3 |
| DR4 | Pheophytin | < 0.3 | 1.700 | 0.960 | 1.500 | | | | | 0.300 | | 0.300 | 0.300 | 0.150 | 4.800 | | | 1.500 | <.3 | <.3 | 4.500 | <.3 | | <.3 | mg/m3 |
| DR4 | Ammonia Nitrogen | 0.026 | 0.100 | 0.012 | 0.005 | | | | | 0.005 | | 0.074 | 0.020 | 0.042 | <.005 | 0.023 | | 0.018 | <.005 | <.005 | <.005 | <.01 | | <.005 | mg/l |
| DR4 | Nitrate + Nitrite | 0.065 | 0.040 | 0.031 | 0.011 | | | | | 0.024 | | <.01 | 0.011 | 0.036 | <.01 | 0.016 | | 0.028 | 0.011 | <.01 | <.01 | 0.018 | | 0.021 | mg/l |
| DR4 | Total Persulfate N | 0.150 | 0.190 | 0.090 | 0.070 | | | | | 0.050 | | 0.020 | 0.080 | 1.100 | 0.070 | 0.050 | | 0.230 | 0.060 | 0.080 | | | | 0.060 | mg/l |
| DR4 | Ortho-Phosphate | 0.001 | 0.001 | 0.001 | 0.001 | | | | | 0.001 | | 0.001 | 0.002 | 0.001 | | | | 0.001 | | 0.002 | 0.003 | <.001 | | <.001 | mg/l |
| DR4 | Suspended Solids | | | 4.000 | 1.000 | | | | | 2.000 | | | 2.000 | 2.000 | 40.000 | <1 | | 4.000 | 9.000 | 3.000 | 1.000 | 5.000 | | <1 | |
| DR4 | Nitrite Nitrogen | | | | 0.001 | | | | | | | | | | | | | | | | | | | | |
| DR5 | BOD-low | | | | | | | | | 2.000 | | | | 1.000 | | | | 1.000 | | <2 | <2 | <2 | | <2 | |
| MC4 | Total Organic Carbon | 5.200 | 2.900 | 1.000 | 8.300 | | | | | 2.600 | | 1.800 | 1.000 | 2.600 | <1 | 3.400 | | 3.600 | <1 | <1 | | | | | mg/l |
| MC4 | Dissolved Organic C | 4.700 | 2.700 | 0.500 | 4.200 | | | | | 2.300 | | 0.500 | 0.500 | 0.025 | <.5 | 1.400 | | 3.500 | <.5 | <.5 | | | | | mg/l |
| MC4 | Chlorophyll a | 2.700 | 0.530 | 0.300 | 1.600 | | | | | 1.600 | | 27.000 | 0.530 | 0.720 | 0.530 | | | 0.800 | 4.300 | <.3 | | | | | mg/m3 |
| MC4 | Pheophytin | 0.300 | 0.300 | 2.300 | 0.640 | | | | | 0.300 | | 0.300 | 0.300 | 0.015 | <.3 | | | 1.100 | <.3 | <.3 | | | | | mg/m3 |
| MC4 | Ammonia Nitrogen | 0.031 | 0.009 | 0.010 | 0.073 | | | | | 0.005 | | 0.061 | 0.044 | 0.040 | 0.007 | 0.021 | | 0.035 | <.005 | <.005 | | | | | mg/l |
| MC4 | Nitrate + Nitrite | 0.083 | 0.092 | 0.044 | 0.010 | | | | | 0.120 | | 0.068 | 0.010 | 0.027 | 0.042 | 0.068 | | 0.055 | 0.046 | 0.045 | | | | | mg/l |
| MC4 | Total Persulfate N | 0.170 | 0.030 | 0.090 | 0.090 | | | | | 0.160 | | 0.100 | 0.030 | 0.080 | 0.080 | 0.080 | | 0.130 | 0.100 | 0.100 | | | | | mg/l |
| MC4 | Ortho-Phosphate | 0.001 | 0.001 | 0.001 | 0.001 | | | | | 0.001 | | 0.001 | 0.001 | 0.001 | | | | 0.001 | 0.001 | <.001 | | | | | mg/l |
| MC4 | Suspended Solids | | | 1.000 | 6.000 | | | | | 2.000 | | | 1.000 | 3.000 | 23.000 | 4.000 | | 5.000 | 8.000 | <1 | | | | | |
| MC4 | Nitrite Nitrogen | | | | 0.001 | | | | | | | | | | | | | | | | | | | | |
| MC4 | BOD-low | | | | | | | | | 2.000 | | | | 1.000 | <2 | | | 1.000 | | <2 | | | | | |

**Figure 4-17. Other Water Quality Data**

# 5. Data Accuracy Analysis

Due to the importance of phosphorous, most of the following error analysis is focused on that parameter. Data is available that would allow detailed analysis of error for the other water quality properties measured as well.

The following error estimates were made using 2009 data only.

## 5.1. Detection Limits

The following detection limits for the laboratory measured parameters were provided by AM Test. They refer to the Method Detection Limits (MDL) that the EPA defines as “the minimum concentration that can be determined with 99% confidence that the true concentration is greater than zero.”

| | |
|---|---|
| Chlorophyll a SM | 0.03 mg/m3 |
| Pheophytin | 0.03 mg/m3 |
| Total Suspended Solids | 1.0 mg/l |
| BOD-low | 2.00 mg/l |
| Dissolved Organic Carbon | 0.50 mg/l |
| Ammonia Nitrogen | 0.005 mg/l |
| Nitrate/Nitrite | 0.01 mg/l |
| Nitrogen -Total Persulfate | 0.01 mg/l |
| Orthophosphate | 0.001 mg/l |
| Total Phosphorous | 0.001 mg/l |
| Total Dissolved Phosphorous | 0.001 mg/l |
| Total Organic Carbon | 1.0 mg/l |

**Figure 5-1. Detection Limits**

Phosphorous measurements were made at levels close to the detection limits of the instrumentation, 0.001 mg/l for orthophosphate, total dissolved phosphorous, and total phosphorous. Most of the TP measurement made in January and February were below this limit and the average TP value for all samples was 0.01 mg/l.

## 5.2. TP Repeatability

Three different repeatability (precision) error estimates were made. One used duplicated measurements of the same samples in the laboratory; another used duplicate field samples collected at the same location, and the third used samples collected in close proximity.

1). For each two day collection period, AM Test pulled every $10^{th}$ sample and repeated the measurement. This data set consisted of 64 duplicates. The standard deviation of the difference between the two measurements for this data set was 0.001 mg/l or 2.6% of the average measured value.

2). The duplicate TP samples collected in the field provide a large data set for estimating repeatability. The figure below shows the average standard deviation of the differences between the two samples collected at each site.

| Site | SD (mg/l) |
|---|---|
| BO3 | 0.0021 |
| NCC | 0.0029 |
| NMA | 0.0018 |
| TA4 | 0.0026 |
| MC3 | 0.0022 |
| MC4 | 0.0034 |
| MLI | 0.0036 |
| CL1 | 0.0044 |
| MCHI | 0.0029 |
| MLA | 0.0023 |
| WIC | 0.0016 |
| DR4 | 0.0017 |
| CH4 | 0.0017 |
| RO1 | 0.0014 |
| RO2 | 0.0022 |
| RO3 | 0.0034 |
| RO4 | 0.0020 |
| BU1 | 0.0017 |
| BU2 | 0.0023 |
| BU3 | 0.0019 |
| BU4 | 0.0028 |
| | |
| Average | 0.0024 |

**Figure 5-2. TP Repeatability, Field Samples**

The average of all TP measurement taken was 0.011 mg/l for this data set of 480 values. The average standard deviation for all the sites of 0.0024 mg/l is 28% of this value, higher than the accuracy data quality objective for P (see section 3.4). The impact evaluation uses TP values at each site that are the average of the two measurements taken in order to reduce error.

3). Another repeatability estimate can be made by comparing samples taken nearly simultaneously at separate collection sites located in close proximity and where there is no obvious nutrient source or sink between them. A pair of sites on Nason Creek, BO3 and BU4 (separated by 200 meter), and a pair on the White River, MC3 and MC4 (separated by 190 meters), meet these conditions. Neither pair have any incoming tributaries between the sample sites. The standard deviation of the differences between the pairs of TP values (a data set of 100 measurements) at these two locations was 0.0038 mg/l and the average measured value was 0.010 mg/l. The error ratio was then 38%. This large value indicates that there is high instream TP variation within relatively short distances and sampling intervals.

## 5.3. TP Measurement Accuracy

Estimates of other components of total error were also made. The accuracy of the AM Test laboratory measurements was estimated by comparing them to standard references and to blank samples. References before 4/11/09 had true values of between 0.010 and 0.230 mg/l. After that date, all comparisons were made at 0.100 mg/l. References meet National Environmental Laboratory Accreditation Conference standards and can be traced to National Institute of Standards and Technology reference materials.

The standard reference comparison for TP produced a data set of 68 values. The standard deviation of the difference between the reference and the measured value was 0.0034 mg/l which is 3.5% of the reference value. This accuracy estimate is well below the objective of 25%. However, this estimate was made at TP values that were much higher than the field samples and it is expected that accuracy is lower closer to the resolution limit of the TP measurement method.

Comparisons with blank values (de-ionized water) were also made. The average blank value measured was below the detection limit of the instrumentation, 0.001 mg/l.

## 5.4. DO and pH Error

The Hydrolab sonde DO and pH parameters were calibrated prior to use on day 1 and after use on day 2. The comparison between these values is shown in the table below. Both DO and pH generally drifted higher. The standard deviation for DO was 3.8% and for pH, 0.21 units. Collected data was not corrected based on the pre and post calibrations. pH data for 4/19/09 and 10/30/09 was not used in the accuracy analysis or in the impact evaluations due to the large shift shown by post-calibration which occurred at some point in the sensor output.

| Date | LDO Before | LDO After | Difference | | pH Before | pH After | Difference |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 2/13/09 | 100.0% | 101.5% | 1.46% | | 7.06 | 7.13 | 0.07 |
| 2/22/09 | 100.0% | 99.5% | -0.50% | | | | |
| 3/21/09 | 100.0% | 98.2% | -1.80% | | 7.18 | 7.04 | -0.14 |
| 4/4/09 | 100.0% | 101.2% | 1.20% | | 6.98 | 7.04 | 0.06 |
| 4/11/09 | 100.0% | 95.6% | -4.40% | | 6.98 | 6.6 | -0.38 |
| 4/19/09 | 100.0% | 108.5% | 8.50% | | 6.98 | 8.46 | |
| 4/25/26 | 100.0% | 105.2% | 5.20% | | 6.98 | 7.23 | 0.25 |
| 5/2/09 | 100.0% | 100.2% | 0.20% | | 6.98 | 7.18 | 0.2 |
| 5/9/09 | 100.0% | 102.2% | 2.20% | | 6.98 | 7.14 | 0.16 |
| 7/25/09 | 100.0% | 106.9% | 6.90% | | 7.01 | 7.22 | 0.21 |
| 8/9/09 | 100.0% | 98.0% | -2.00% | | 7.04 | 6.89 | -0.15 |
| 10/30/09 | 100.0% | 102.2% | 2.20% | | 7.01 | 7.89 | |
| Average | | | 1.6% | | | | 0.03 |
| Stnd Dev | | | 3.8% | | | | 0.21 |

**Figure 5-3. Hydrolab Sonde Calibrations**

All the Hydrolab sondes used had Luminescent Dissolved Oxygen technology (LDO) sensors. The manufacturer specifications are:

Accuracy: +/- 0.2 mg/L

Resolution: 0.01 mg/L

The pH sensors were KCl impregnated glass bulbs with a refillable reference electrode. Manufacturer specifications are:

Accuracy: +/- 0.2 units

Resolution: 0.01 units

## 5.5. General Error Discussion

Overall measurement accuracy will be a function of error introduced by the field collection methods and by the instrumentation used.

Data collection methods were designed to minimize error but it could have been introduced through several possible mechanisms. A significant error source for phosphorous and possibly other parameters, may be a result of spatial variations in concentrations, flow or other characteristics within the stream and temporal variations in sample collection. This is evidenced by the large differences (38% SD) in TP measurements made at the two sets of collection sites that were close together.

Any estimate of total instrumentation measurement accuracy would need to include several different sources and types of error. Calibration, precision, detection limits, and drift would need to be accounted for.  Several of the error terms are interdependent and estimating values for overall accuracy would be complex.  Also, some of the error terms are less critical for important parts of the effort to predict impacts due to acclimation.  For instance, calibration and precision errors are largely eliminated when differences between measurements made by the same instruments are used in the evaluation.

Total error for LDO was assumed to be the root mean square (RMS) of the manufacturers reported accuracy and the standard deviation of the pre and post calibrated values, +/- 0.56 mg/l. Total pH error used the same assumptions, resulting in an estimated total error value of +/- 0.29 units.

Total phosphorous accuracy was assumed to be +/- 38%, the highest of the errors discussed in the sections above.  The RMS of all the error terms was not used because the measurement differences between values collected at sites in proximity include most of the other important sources of error.

# APPENDIX 7
# WATER QUALITY IMPACTS OF DISCHARGES

**Prepared for**
Sea Springs and Yakama Nation

**Prepared by**
Anchor QEA, LP
400 Montgomery Street, Suite 650
San Francisco, California 94104

**November 2010**

# TABLE OF CONTENTS

## List of Tables



## List of Figures

# LIST OF ACRONYMS AND ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| µg/L | micrograms per liter |
| cfs | cubic feet per second |
| degrees C | degrees Celsius |
| DMR | Discharge Monitoring Report |
| DO | Dissolved Oxygen |
| EIS | Environmental Impact Statement |
| g/d | grams per day |
| kg/d | kilograms per day |
| L/d | liters per day |
| LNFH | Leavenworth National Fish Hatchery |
| MSRF | Methow Salmon Recovery Foundation |
| MSWA | Methow State Wildlife Area |
| $m^3/s$ | cubic meters per second |
| mg | milligrams |
| mg/L | milligrams per liter |
| NOAA | National Oceanic and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| pH | $-\log_{10}[H^+]$ |
| POTW | Publicly Owned Treatment Works |
| PUD | Public Utility District |
| RKM | River Kilometer |
| TMDL | Total Maximum Daily Load |
| TP | Total Phosphorus |
| USGS | U.S. Geological Survey |
| WAC | Washington Administrative Code |
| WDOE | Washington Department of Ecology |
| WNFH | Winthrop National Fish Hatchery |

# 1 SUMMARY

The proposed coho salmon (coho) restoration activities within the Wenatchee and Methow subbasins pose a negligible impact on surface water quality. In the Wenatchee subbasin, the results of mechanistic modeling indicated that, even under the conservative assumptions applied, the proposed activity is expected to have a negligible impact on the water quality of the Wenatchee River. Indeed, in most instances the measured and predicted impacts were within the range of natural variability or the measurement error of targeted water quality standards. In the Methow subbasin, the assessment of basin-wide impacts of acclimation activity also led to the conclusion that acclimation activity is likely to have a negligible impact on water quality.

The assessment in the Wenatchee subbasin was based on extensive site-specific data analysis and mechanistic water quality modeling of actual and potential discharges and included an evaluation of the cumulative impacts of the proposed acclimation and rearing sites. Impact in the Methow subbasin was assessed by evaluating the total phosphorus (TP) loading estimates for the proposed sites from the context of Methow subbasin characteristics and also by comparison to the impacts estimated for the Wenatchee subbasin.

Water quality data collected through 2009 and 2010 at select locations of proposed and existing acclimation sites within the Wenatchee subbasin formed the basis for the analysis presented herein. Water quality data, collected in the vicinity of active acclimation sites, provided direct measurement of the impacts of ongoing acclimation activity that established acclimation-activity-related nutrient loading rates (total phosphorus load per fish) to the receiving stream. This estimate was then used in the assessment of impacts in the vicinity of the proposed sites in the Wenatchee and Methow subbasins, based on the number of fish proposed for acclimation at each site.

Analysis of dissolved oxygen (DO), pH (negative logarithm of the proton concentration), TP, and temperature data collected upstream and downstream of active acclimation sites in Nason Creek in the Wenatchee subbasin suggested that ongoing acclimation activity has a negligible impact on the receiving stream.

Basin-wide impact of the acclimation and rearing sites was estimated for the Wenatchee subbasin through mechanistic water quality modeling. The QUAL-2K model developed by Washington State Department of Ecology (WDOE) for TP load allocations in the Wenatchee subbasin (Carroll et al. 2006; Carroll and Anderson 2009) was adapted for this basin-wide impact assessment. Several conservative assumptions were made in the mechanistic model application to provide an upper bound estimate of the impact of the site activity on nutrient loading to the Wenatchee River. The results of mechanistic modeling indicated that the proposed activity is expected to have a negligible impact on the water quality of the Wenatchee River. Model predictions indicated that contraventions in DO and pH standards

are unlikely even when the Wenatchee River receives maximum allocated loads (as specified in the WDOE Total Maximum Daily Load [TMDL], Carroll and Anderson 2009) from publicly owned treatment works and other point and distributed sources.

It is concluded that the cumulative impact of the proposed coho restoration activities on the Wenatchee subbasin water quality is expected to be negligible because:

1. The nutrient load is negligible. The maximum total addition of phosphorous due to the project, at peak production levels, is estimated to be 0.38 kilogram per day during the acclimation period, which is about 1% of average Wenatchee River load when acclimation activity is ongoing.
2. Despite the conservative modeling assumptions used, impacts to DO and pH due to upstream acclimation are estimated to be negligible in the TMDL domain (the lower Wenatchee River downstream of the city of Leavenworth).
3. Lower water temperatures during the acclimation period limit in-stream biological activity.
4. An analysis of travel times suggests that the residence times of any nutrients discharged to the system would be small during spring high flows that are prevalent when feed rates are highest. Most of the loads are expected to be removed during spring high flows and impacts are not expected later in the year including the summer low flow period.
5. In-stream data collected from the Wenatchee subbasin showed that most of the phosphorous being discharged is not in a readily bio-available form. Even the travel times calculated under low flow conditions was not expected to provide a sufficiently long residence of the total phosphorus loading in the system thereby keeping it largely unavailable for biological uptake during transport through the subbasin.

Basin-wide impact of acclimation activity within the Methow subbasin was assessed by comparing the TP loading estimates for the proposed sites to the basin-wide TP loads calculated from historical data collected in the basin. The similarity in the characteristics of the two basins, combined with the assessments derived from mechanistic modeling of the basin-wide impacts for the Wenatchee subbasin, led to the conclusion that the basin-wide impacts within the Methow subbasin are also likely to have a negligible impact on water quality.

# 2 INTRODUCTION AND DISCHARGE EVALUATION OBJECTIVES

Discharges from proposed coho salmon (coho) acclimation sites in the Wenatchee and Methow subbasins may contain nutrients (phosphorus and nitrogen) at levels that promote algal growth. Algal photosynthesis and respiration cycles results in diurnal pH (negative logarithm of the proton concentration) and Dissolved Oxygen (DO) swings and can induce changes in pH and DO beyond the ranges found under natural conditions. Such changes contravene water quality standards and negatively impact the designated uses of these waterbodies, which include swimming; domestic, industrial, and agricultural water supply; aesthetic value; wildlife habitat; harvesting; and spawning, rearing, and migration for Endangered Species Act-listed coho.

The Wenatchee River and portions of Icicle Creek are on the State of Washington's 303(d) list of impaired waterbodies for DO, pH, and temperature excursions. The lower Wenatchee River downstream of the City of Leavenworth, and Icicle Creek below the Leavenworth National Fish Hatchery (LNFH) have a phosphorus Total Maximum Daily Load (TMDL) in effect. The TMDL analysis undertaken by Washington Department of Ecology

(WDOE) advocates the implementation of a phased load reduction from point and non-point sources to prevent water quality excursions during critical low-flow conditions occurring in summer and fall (Carroll et al. 2006; Carroll and Anderson 2009). The Wenatchee River upstream of Leavenworth is presently not included in the State's 303(d) list for DO and pH violations (Carroll and Anderson 2009). However, the WDOE TMDL document has recommended a limit for the total phosphorus (TP) loads entering the lower Wenatchee River from sources upstream of Leavenworth to address water quality degradation in the lower section of the Wenatchee River where the TMDL is in effect.

The Methow River is not listed in the State's 303(d) list of impaired water bodies for pH or dissolved oxygen violations. However, it is currently listed for temperature.

This Appendix presents an analysis of potential water quality impacts (pH and DO) attributable to proposed coho acclimation sites (through nutrient addition) within the Wenatchee and Methow subbasins. The WDOE TMDL analysis of the Wenatchee River focused on phosphorus because it was determined to be the limiting nutrient for algal growth in the lower river and is the primary concern for water quality degradation. Thus, phosphorus was the primary nutrient considered in the analysis presented herein.

The Wenatchee subbasin contains active acclimation sites from which extensive data were collected to form a basis for assessing coho acclimation activity impacts on water quality[1]. Nutrient loading estimates derived from these active acclimation sites were then used as a basis for forecasting nutrient loading from sites proposed in both the Wenatchee and Methow subbasins. Where appropriate, water quality modeling was used to facilitate the evaluation.

## 2.1 Objectives

The purpose of this evaluation is to provide an assessment of the water quality impact of discharges originating from coho acclimation sites proposed in this project. This evaluation had the following objectives:

- Assess phosphorus loading and the potential impacts on receiving waters from active

[1]Appendix 6 contains details on the data collection effort as well as a preliminary presentation of the data.

acclimation sites in the Wenatchee subbasin

- Use evidence from active sites in the Wenatchee to assess phosphorus loads from sites in the Wenatchee and Methow subbasins
- In each subbasin, assess the combined impact of the project based on the contribution of loading from all acclimation sites relative to the background levels
- Estimate the cumulative impact of the project in each subbasin based on existing subbasin phosphorus loads

## 2.2 Criteria for Evaluation

### *2.2.1 Regulatory Guidelines*

Washington state law provides protection for surface water quality through an anti-degradation policy (WAC 173-201A-300 of Washington Administrative Code; WAC 2006). Under this law, three levels of protection are provided: Tier I protection extends to all water bodies and maintains the current and designated uses for a given water body and prevents any further pollution; Tier II does not allow degradation of surface waters that are of exceptional quality (exceeding the water quality standards) through new or proposed actions unless such degradation is necessary and in the overriding public interest; and Tier III protection applies to water bodies classified as outstanding resource waters.

Much of the upper Wenatchee subbasin and nearly the entire Methow subbasin exceed the water quality standards for temperature, DO, and pH. Thus, these waters are protected by the Tier II anti-degradation policy. The lower Wenatchee River and portions of Icicle Creek where the TMDL is in effect (to prevent pH and DO excursions) are protected under the Tier I policy.

Most of the existing and proposed acclimation-related sites are located in waters protected by the Tier II anti-degradation policy. A Tier II anti-degradation evaluation will be required if the proposed activity has the potential to cause a measureable change in water quality, where measurable changes relevant to this context as defined in the legislation (WAC 2006) are: temperature increase of 0.3 degree Celsius (C) or greater; DO decrease of 0.2 milligrams per liter (mg/L) or greater; and pH change of 0.1 unit or greater. For Tier I waters, anthropogenic discharges must not affect the existing and designated uses.

Based on the regulatory guidelines presented above, the following criteria were used to evaluate the local and cumulative impacts of the acclimation sites:

- For active discharges in waters protected by the Tier II policy, evaluate the phosphorus levels with reference to the existing background conditions to assess whether acclimation-related discharges produces algal blooms that are sufficient to cause a measurable change in DO and pH beyond the mixing zone of the discharge
- For proposed discharges in waters protected by the Tier II policy, estimate phosphorus load from discharge relative to existing background load to assess the

likelihood of measurable change in DO and pH

- For the lower Wenatchee River (currently protected by Tier I policy), determine whether activities proposed in this project are likely to cause a measurable change in DO and pH, as defined above, that is sufficient to affect the existing and designated uses

### 2.2.2 Data Quality

Whenever possible, instrument accuracy and precision were used to supplement the interpretations of significance in impacts in addition to the regulatory guidelines discussed in Section 2.2.1. For instance, small changes in DO and/or pH may be undetectable due to equipment limitations.

Field duplicates for TP collected during sampling events were analyzed to obtain an estimate of instrument accuracy and precision. A detailed discussion is available in Chapter 5 of Appendix 6. When evaluating differences in nutrient levels between the acclimation sites and receiving streams, instrument accuracy and precision will be considered.

# 3 ASSESSMENT OF IMPACTS AT ACTIVE SITES

Nason Creek in the upper Wenatchee subbasin has three coho acclimation sites presently in operation for this project: Rohlfing; Butcher; and Coulter. In all three locations, fish acclimation activity was carried out in spring 2009 and 2010. The construction and operational details of the acclimation sites were presented in Appendix 2, and the associated data collection was presented in Appendix 6.

## 3.1 Approach

To meet the objectives laid out in Section 2.1, a mass balance approach was adopted where phosphorus loadings entering and leaving the acclimation ponds were evaluated. The inflow phosphorus level provides the background or natural condition existing in the creek feeding the pond, while the outflow concentration reflects any potential impact of acclimation activity.

The relative change in water quality at the upstream and downstream sampling locations compared to the criteria specified for measurable change (see Section 2.2) formed the basis for the evaluation of acclimation pond impacts on the receiving stream (Nason Creek). The applicability of these criteria was based on the following assumptions:

- The concentrations in Nason Creek are unlikely to be affected during non-acclimation periods, given the low flows out of the ponds (typically less than 1 percent (%) of Nason Creek flows). Data collected from Nason Creek in the 2009 post-acclimation period supported this assumption.
- In-stream water quality changes are unlikely due to factors other than the discharge over the reach of the natural waterway between the sampling locations that are

upstream and downstream of the discharge from the acclimation pond because of the proximity of the upstream and downstream locations.

Combined effects of the acclimation ponds were evaluated by comparing relative changes in water quality from upstream to downstream along the length of Nason Creek.

## 3.2 Analysis of Data Collected at Pond Inflow and Outflow

### *3.2.1 Rohlfing*

#### *3.2.1.1 TP Loads from Acclimation Activity*

TP concentrations measured at the pond inflow and outflow measured during 2009 and 2010 are presented in Figure 1. The figure suggests that while there was significant variability in outflow concentrations, the overall pattern indicated that outflow generally tracked inflow concentrations. Outflow concentrations were higher in all but two cases (both in 2009) when acclimation activity was ongoing, suggesting that there was nutrient addition to the receiving stream due to acclimation activity.

Calculations that show the load introduced due to acclimation activity are presented in Table 1. The load calculations showed an average TP load of about 37 grams per day (g/d) being introduced into the outflow. The data also show that the loading occurred during the acclimation period in April and May.

**Table 1**
**TP loads introduced due to acclimation activity at Rohlfing Pond**

| Date[1] | Flow[2] (cfs) | Flow (L/d) | Average TP Concentration (µg/L) | | | TP Load Introduced[4] (g/d) |
|---|---|---|---|---|---|---|
| | | | Inflow | Outflow | Difference[3] | |
| 3/14/2009 | 1.4 | 3425206 | 5.5 | 3 | -2.5 | 0.0 |
| 4/5/2009 | 1.4 | 3425206 | 1.5 | 5 | 3.5 | 12.0 |
| 4/12/2009 | 4.1 | 10030960 | 7 | 15.5 | 8.5 | 85.3 |
| 4/19/2009 | 4.1 | 10030960 | 9 | 7.5 | -1.5 | 0.0 |
| 5/3/2009 | 3.5 | 8563014 | 7 | 16.5 | 9.5 | 81.3 |
| 3/23/2010 | 2.1 | 5137809 | 1 | 2.5 | 1.5 | 7.7 |
| 4/18/2010 | 2.8 | 6850412 | 1.5 | 10.5 | 9 | 61.7 |
| 4/25/2010 | 2.1 | 5137809 | 4 | 13 | 9 | 46.2 |
| **Average** | | | | | | **36.8** |

**Notes:**
1. 4/26/2009, 4/12/2010, and 5/5/2010 TP data were not used due to lack of paired stage measurements
2. Flow was estimated from the stage-discharge relationship developed for the stream feeding into ponds.
3. Difference = total phosphorus concentration between pond inflow and outflow.
4. Volumetric inflows and outflows were assumed to be equal in load calculation. Whenever the difference in loads was negative, load introduced due to acclimation activity was set to 0.
µg/L - micrograms per liter, cfs - cubic feet per second, L/d - liters per day, g/d - grams per day

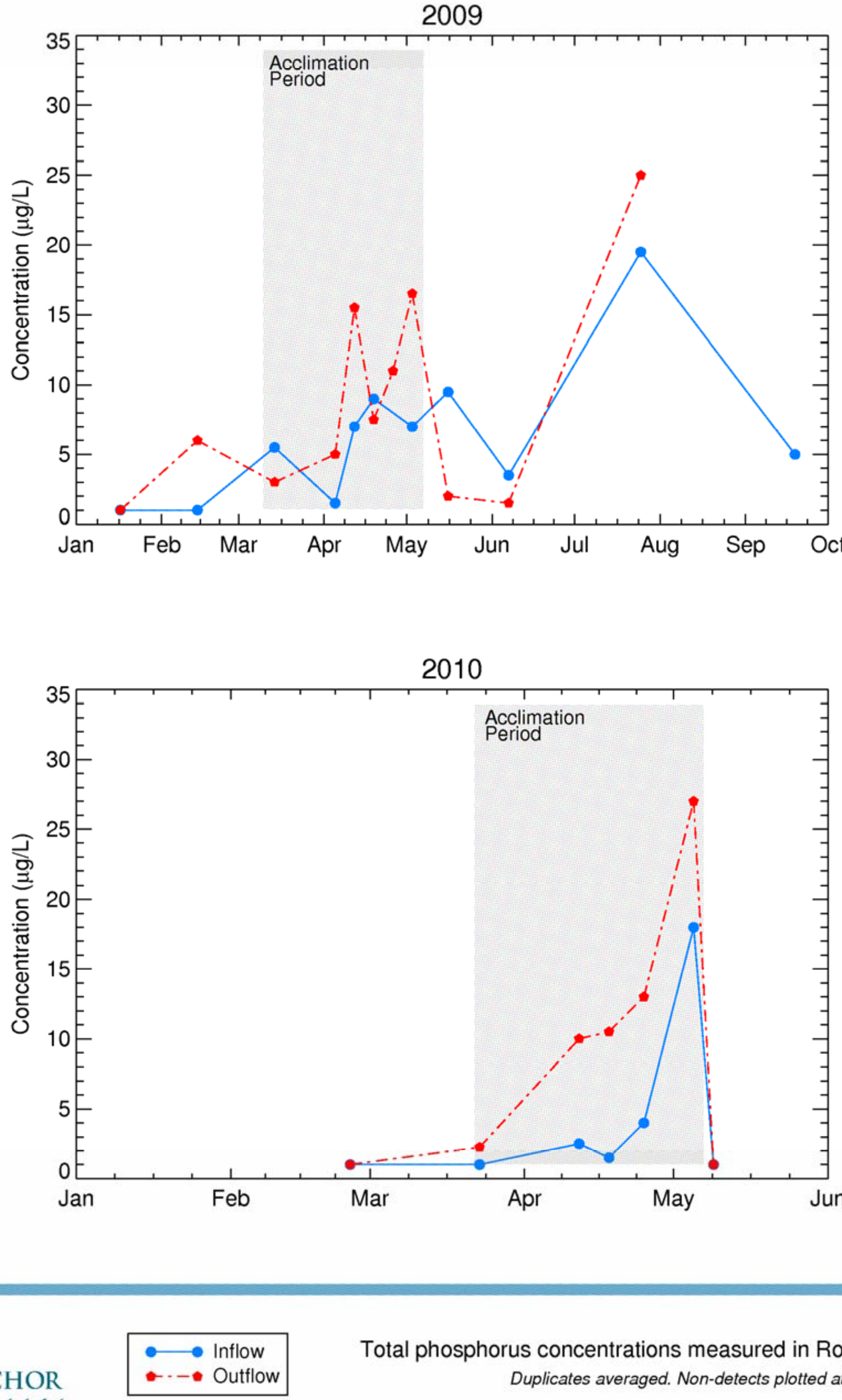



**Figure 1**

Total phosphorus concentrations measured in Rohlfing Pond

*Duplicates averaged. Non-detects plotted at detection limit*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Discharge_WQ\process_discharge_data_ponds_only.pro Mon May 31 13:08:15 2010

#### *3.2.1.2 Impact on Receiving Stream*

Temporal changes in DO, pH, TP, and temperature at two locations in Nason Creek that are upstream and downstream of the Rohlfing discharge are shown in Figures 2a and 2b for 2009 and 2010, respectively. The sampling locations are shown in Figure 3-6 of Appendix 6. The difference between the downstream and upstream values for each component has also been presented (right ordinate in each panel).

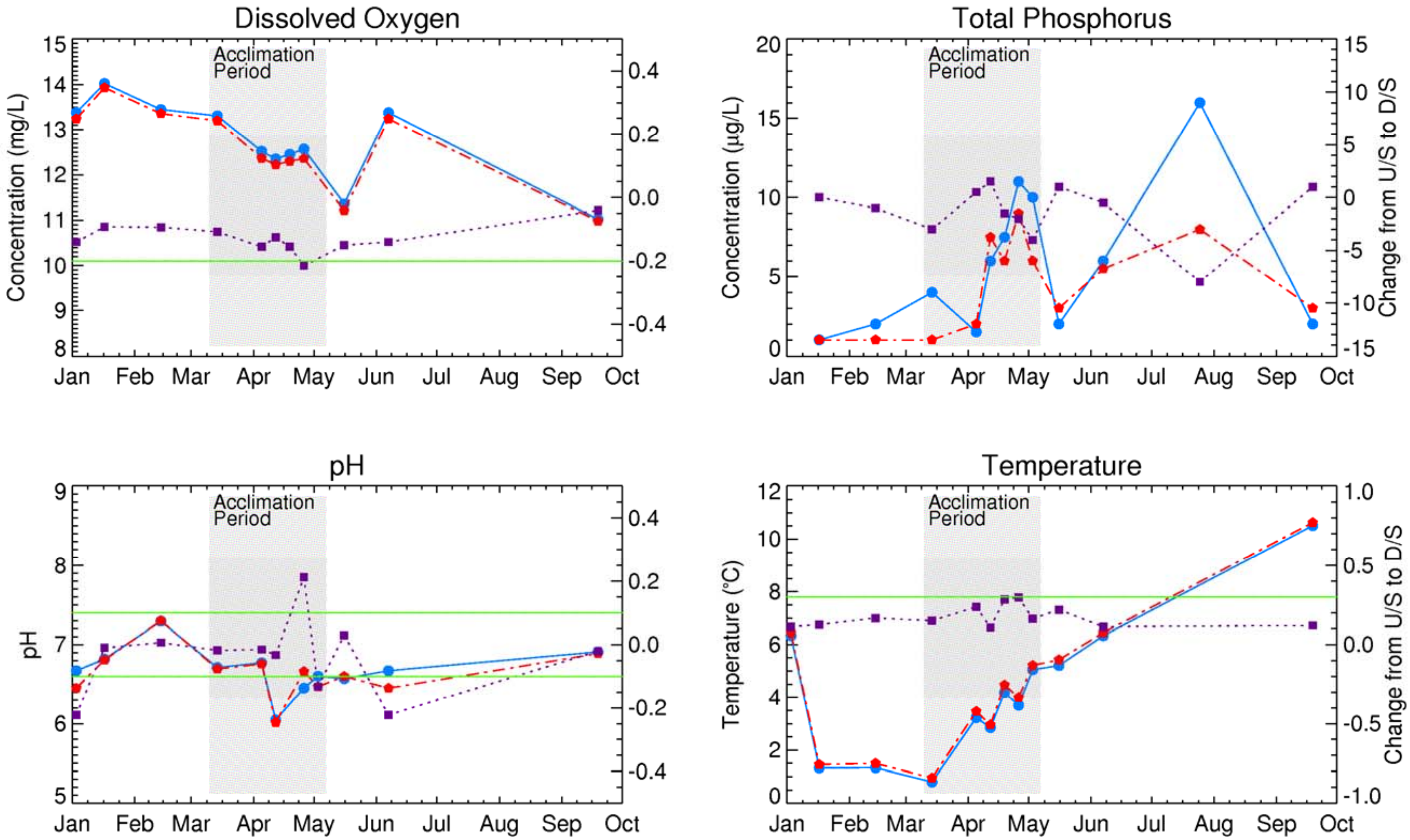
Figure 2 shows that the DO value at the downstream location was consistently lower than the upstream measurements although differences were small. A review of the DO measurement at the pond outflow during the acclimation months (March through May) suggested that DO at the outflow was consistently lower than the corresponding downstream measurements (by about 0.8 mg/L and 1.0 mg/L on average, respectively, for 2009 and 2010; see Figure 4-8 in Appendix 6). Moreover, the DO in the pond inflow was higher than in pond outflow when acclimation activity was ongoing (the average differences between outflow and inflow in 2009 and 2010 were, respectively, 0.4 mg/L and 0.7 mg/L; the average difference during non-acclimation periods in 2009 was 0.07 mg/L—see Figure 4-8 in Appendix 6). These data suggest that DO levels undergo some decline through the ponds when fish acclimation is ongoing. This is likely due to fish respiration. Thus, the somewhat lower DO levels in the downstream location could be a consequence of the discharge. However, it is clear from Figure 2 that even though the values in the downstream location were lower than in the upstream location, the difference is well above the limit for measurable change stipulated for waters protected under the Tier II anti-degradation policy (WAC 2006).

In both years, TP levels downstream of the Rohlfing discharge were typically lower than upstream, suggesting that the loading from the ponds was not significant enough to affect the naturally high background levels that attenuated as the creek flowed past the Rohlfing discharge.

The pH changes from upstream to downstream are negligible and generally fall within the bounds for measurable changes of 0.1 unit (WAC 2006). In 2009, one measurement in late April and one in early May, immediately before release of the acclimated coho, showed changes beyond the limits stipulated for Tier II waters, albeit in opposite directions. The larger of the two changes occurred in late April. Upon comparison with the TP concentrations, it is clear that the upstream TP sample corresponding to the higher pH change in late April showed a significantly larger TP level than the downstream sample suggesting a naturally high background TP level in the stream. This confirms that the departure in pH, if caused by algal activity stimulated by nutrient levels in the stream, did not result from nutrient loading from the Rohlfing discharge.

In 2010, one measurement in mid-April, on the same date when an unusually low DO concentration was measured upstream, showed a pH increase of 0.4 unit at the downstream station. Given that there was no appreciable increase in TP levels from the discharge (see Figure 1) before or during this period, it is unlikely that the discharge caused these water quality changes. On this date, upstream TP was unusually high (about 10 micrograms per liter [μg/L]) and dissolved inorganic phosphorus (used interchangeably with orthophosphate throughout this appendix) was measured to be above the detection limit on this date. This was the only orthophosphate measurement that was above the detection limit among all samples collected in 2010 in the vicinity of Rohlfing discharge. On the same date water temperature was also about 2 degrees C warmer. The elevated orthophosphate levels from upstream and the somewhat warmer water temperature could have contributed to localized algal bloom over the reach spanning the upstream and downstream stations and the resulting photosynthesis and respiration activity may have impacted DO and pH.

The pH excursions occurred during periods when there was no acclimation activity, indicating substantial natural variability in pH. This suggests that the second assumption laid out in Section 3.1 may not be true for all in-stream conditions. Naturally occurring variability in pH could result in localized habitats that are more conducive for algal growth and also result in conditions that promote greater exchange of atmospheric DO and carbon dioxide, all of which could affect pH. Another possible explanation for the detections of pH variability is instrument accuracy—the data sonde (underwater data collection device) accuracy for pH measurement is estimated at 0.29 unit (see Chapter 5 in Appendix 6), which is greater than the differences detected in downstream and upstream measurements in 2009. Temperature changes upstream and downstream of the discharge were within the stipulated increase of 0.3 degree C on all dates when data were collected.



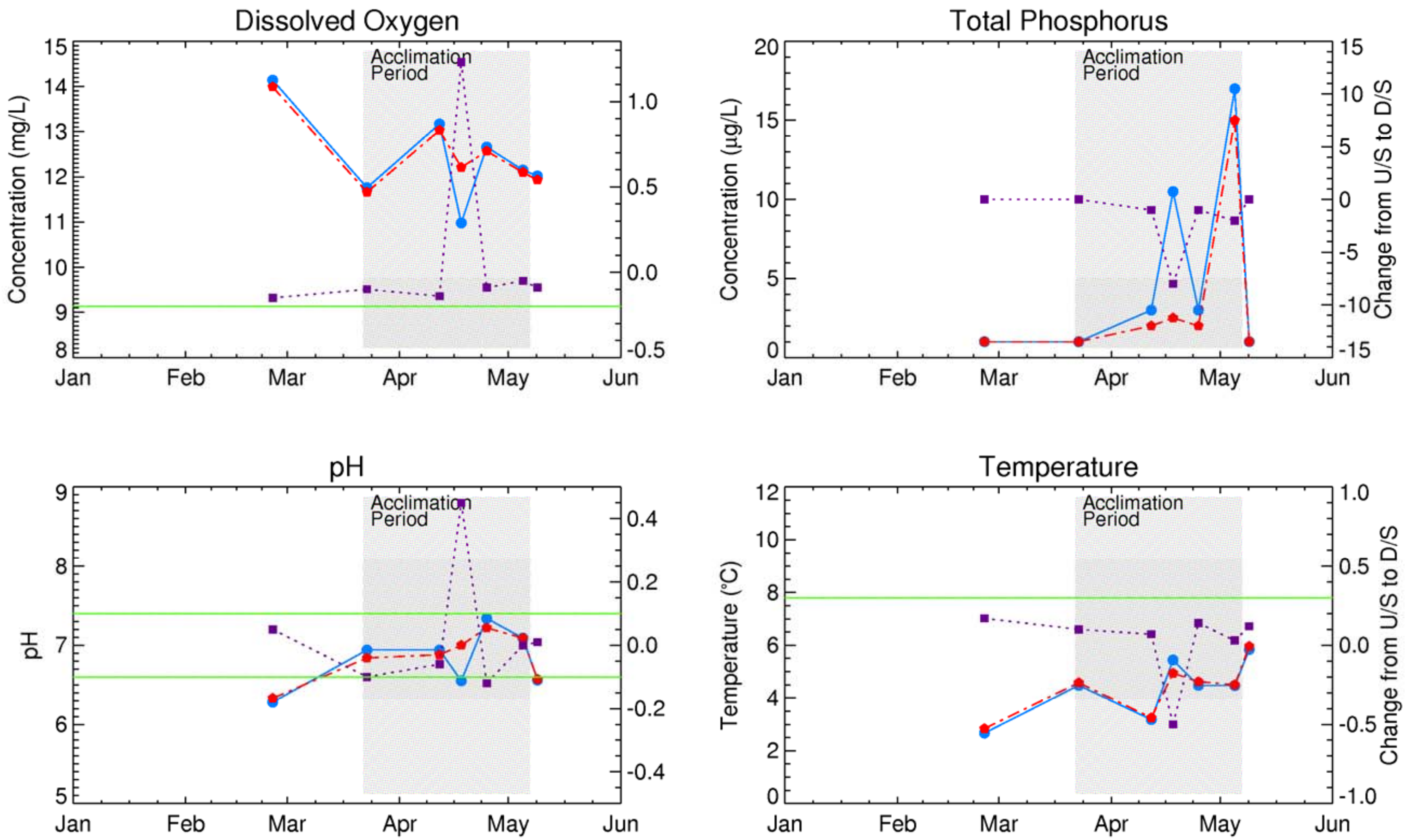

ANCHOR QEA

**Figure 2a**

Water quality changes in Nason Creek in 2009 in the vicinity of Rohlfing Discharge

*Duplicates averaged. Non-detects plotted at detection limit. Horizontal solid green line(s) show the limit(s) for measurable change. Units are same for the right and left axes*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Discharge_WQ\process_discharge_data_v2.pro Thu Jun 24 13:26:21 2010




Upstream
Downstream
Change
Limit(s) for Measurable Change

**Figure 2b**

Water quality changes in Nason Creek in 2010 in the vicinity of Rohlfing Discharge

*Duplicates averaged. Non-detects plotted at detection limit. Horizontal solid green line(s) show the limit(s) for measurable change. Units are same for the right and left axes*

### 3.2.2 Butcher

#### 3.2.2.1 TP Loads from Acclimation Activity

The total phosphorus concentrations measured at the inflow and outflow of Butcher Pond are shown in Figure 3. Based on these measurements and flows estimated from the stage-discharge relationship, the average TP load introduced due to acclimation activity is estimated to be about 39 g/d (see Table 2). As at Rohlfing, in 2009 the dominant portion of the load entered Nason Creek immediately prior to release in early May, which coincided with the highest flow and fish feed rates during the acclimation period.

More fish were acclimated at Butcher than at Rohlfing pond. This difference explains the relatively higher load exiting Butcher compared to Rohlfing.

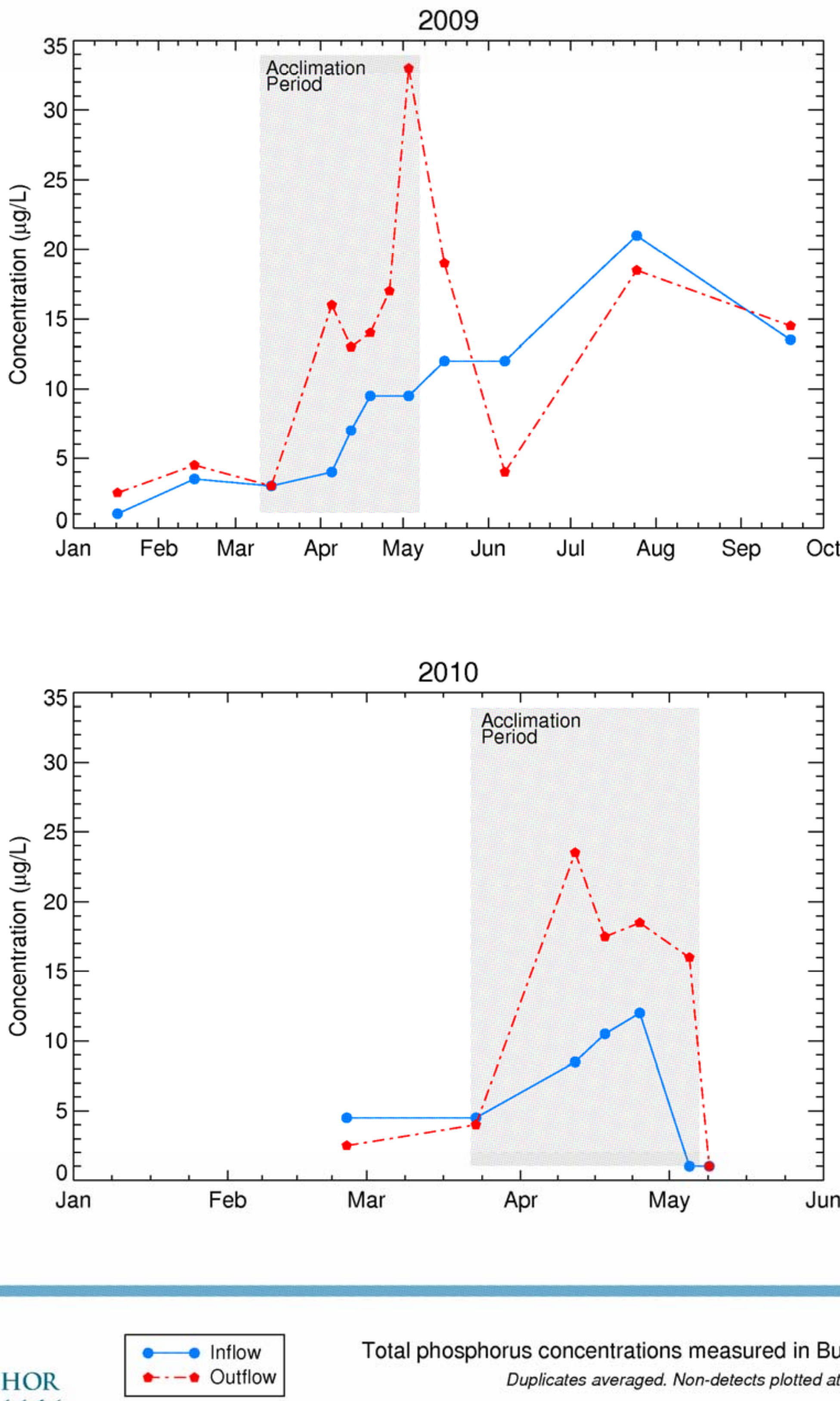
**Table 2**
**TP loads introduced due to acclimation activity at Butcher Pond**

| Date[1] | Flow[2] (cfs) | Flow (L/d) | Average TP Concentration (µg/L) | | | TP Load Introduced[4] (g/d) |
|---|---|---|---|---|---|---|
| | | | Inflow | Outflow | Difference[3] | |
| 3/14/2009 | 1.6 | 3914521 | 3 | 3 | 0 | 0.0 |
| 4/5/2009 | 1.6 | 3914521 | 4 | 16 | 12 | 47.0 |
| 4/12/2009 | 1.9 | 4648494 | 7 | 13 | 6 | 27.9 |
| 4/19/2009 | 1.9 | 4648494 | 9.5 | 14 | 4.5 | 20.9 |
| 5/3/2009 | 2.8 | 6850412 | 9.5 | 33 | 23.5 | 161.0 |
| 3/23/2010 | 1.0 | 2446576 | 4.5 | 4 | -0.5 | 0.0 |
| 4/12/2010 | 1.3 | 3180548 | 8.5 | 23.5 | 15 | 47.7 |
| 4/18/2010 | 1.3 | 3180548 | 10.5 | 17.5 | 7 | 22.3 |
| 4/25/2010 | 1.3 | 3180548 | 12 | 18.5 | 6.5 | 20.7 |
| **Average** | | | | | | **38.6** |

**Notes:**

1. 4/26/2009 and 5/5/2010 TP data were not used due to lack of paired stage measurements.
2. Flow was estimated from the stage-discharge relationship developed for the stream feeding into ponds.
3. Difference represents the difference in total phosphorus concentration between the inflow and outflow from the ponds.
4. Volumetric inflows and outflows were assumed to be equal in load calculation. Whenever the difference in loads was negative, load introduced due to acclimation activity was set to 0.

µg/L micrograms per liter    g/d grams per day
cfs cubic feet per second    L/d liters per day g/d grams per day




ANCHOR QEA

**Figure 3**

Total phosphorus concentrations measured in Butcher Pond

*Duplicates averaged. Non-detects plotted at detection limit*

#### 3.2.2.2 Impact on Receiving Stream

The water quality changes in the vicinity of the Butcher discharge at upstream and downstream sampling locations (see Figure 3-7 in Appendix 6 for sampling locations) are shown in Figures 4a and 4b for 2009 and 2010, respectively. The solid green lines depict the state criteria for measurable change in Tier II waters (WAC 2006).

With the exception of two pairs of measurements, one in May 2009 and one in April 2010, changes in DO concentrations during the acclimation period were below the criterion stipulated for waters protected by Tier II policy (WAC 2006). As with Rohlfing pond, DO at the Butcher Pond outflow was consistently lower than the inflow during acclimation periods (see Figure 4 through 9 in Appendix 6). On May 3, 2009, and April 12, 2010, the dates when these excursions occurred, the differences were particularly large (about 4.0 mg/L and 2.3 mg/L, respectively), which explains the excursion. Notwithstanding these large differences between the pond outflow and inflow, the differences between downstream and upstream DO concentrations are generally small. The larger of the two differences between the upstream and downstream sample is 0.35 mg/L, which is comparable to the accuracy of the data sonde used for measuring DO (see Chapter 5 in Appendix 6). Moreover, this change relative to the upstream DO concentration is less than 3% of the average DO for both cases, and for both cases, the actual DO concentrations are well above the highest surface water aquatic life DO standard of 9.5 mg/L (WAC 2006). Therefore, it is concluded that this decline is sufficiently small and is unlikely to impact the designated uses for the system (whether for recreational contact or as aquatic habitat).

TP levels were quite variable in both years in the upstream and downstream stations. As seen in the Rohlfing measurements, TP levels upstream of the discharge frequently exceeded the value of the downstream measurement, suggesting that TP load from the discharge was insignificant compared to the natural background variability.

Levels of pH measured downstream in 2009 were higher than upstream, frequently exceeding the upper 0.1 unit threshold for measurable change. The pH of discharge from Butcher pond was consistently about .5 units higher than Nason despite being reduced in the pond itself (see Figures 4-11 and 4-12 in Appendix 6). This trend in pH is likely natural to the system because pH measured in the creek feeding Butcher pond were consistently higher at the inflow compared to the outflow, during and after the acclimation period. It is possible that the small increase in pH downstream of the Butcher discharge is a result of the discharge. Moreover, most of the excursions over the upper limit of measurable change were within the instrument accuracy range of 0.29 unit (see Chapter 5 in Section 6). Therefore, it is unclear whether these excursions are real or an artifact of the limitation in instrumentation. In any case, these excursions are small and do not appear to be correlated to acclimation activity.

A similar pattern in pH changes was observed in 2010 though the increases downstream were beyond the limits for measurable change in all cases. The pH measurements in the Butcher pond inflow in 2010 were similarly lower than the pond outflow. As in 2009, the changes in Nason Creek downstream of the pond discharge were generally small, with a largest difference of 0.28 unit, which is comparable to the instrument accuracy range. The same trend in two successive years, under different flow conditions (Spring of 2010 was significantly drier than 2009), suggest that the pH variations in the vicinity of the Butcher pond are natural to the system and are unlikely to be a result of acclimation activity. The pH measurements on May 5, 2010, were the only exception to this pattern observed on all other dates in 2010, with the upstream value exceeding the downstream value by a small amount (0.15 unit).

In order to better understand the pH and TP patterns, correlation coefficients ($R^2$) were calculated to assess the relationship of pH and TP downstream of the discharge with the corresponding values measured at the discharge point as well as at the location upstream of the discharge. Table 3 shows the $R^2$ relationships for pH and TP. Correlation does not indicate a direct cause and effect relationship. Nonetheless, $R^2$ was interpreted simply as the percentage of variance in the second variable that may be explained by the first. Thus, these tables present an estimate of the variability in samples collected downstream of the Butcher discharge that may be explained by the corresponding samples collected at the point of discharge (i.e., pond outflow) and upstream of the discharge.

Table 3 shows that the downstream pH is highly correlated with both the pond outflow data and the upstream data, regardless of status of acclimation activity. In contrast, the variability in downstream TP data is aligned more closely with the upstream data during the non-acclimation periods and only weakly correlated to the discharge data under all conditions. Acclimation-period TP correlations with pH were generally poor for the discharge as well as the upstream locations.

The relationship between TP and pH was also studied to assess whether variations in downstream pH can be explained by variations in upstream, downstream, and discharge TP. The correlations are presented in Table 4. In general, there are no significant correlations between downstream pH and upstream or discharge TP concentrations. The correlations are weak between the downstream TP concentration and pH.

The analysis above indicates that it is difficult to explain the variability in pH through in-stream TP levels. This adds weight to the hypothesis posited above that factors other than TP and its affect on algal metabolism contribute to variability in pH. Another confounding factor is the lack of relationships between downstream TP with either the upstream TP or the discharge TP. This suggests that TP variability is large both spatially and temporally.

The small magnitude of the loads from the ponds (see Table 1 and Table 2) is within the levels of natural variability in the system and is unlikely to be a significant contributor to water quality degradation.

**Table 3**
**Relationships of downstream pH and TP measurements with Butcher discharge and upstream measurements**

| Period | No. of Samples | $R^2$ for pH | | No. of Samples | $R^2$ for TP | |
|---|---|---|---|---|---|---|
| | | Discharge | Upstream | | Discharge | Upstream |
| All Data | 16 | 0.88 | 0.82 | 20 | 0.07 | 0.14 |
| Acclimation Period | 10 | 0.84 | 0.77 | 11 | 0.00 | 0.00 |
| Non-Acclimation Period | 6 | 0.98 | 0.98 | 9 | 0.42 | 0.79 |

**Table 4**
**Relationship between pH measurements downstream of Butcher discharge with TP**

| Period | No. of Samples | $R^2$ for Downstream pH vs. | | |
|---|---|---|---|---|
| | | Discharge TP | Upstream TP | Downstream TP |
| All Data | 17 | 0.02 | 0.01 | 0.09 |
| Acclimation Period | 10 | 0.00 | 0.05 | 0.21 |
| Non-Acclimation Period | 6 | 0.03 | 0.01 | 0.00 |

Temperature changes between the upstream and downstream locations were generally small and did not exceed the measurable change criterion in 2009 (see Figure 4). Two measurements in 2010 exceeded the criterion. In both instances, the temperature from the discharge was higher than the upstream temperature (see Figure 4-9 in Appendix 6). Therefore, it is likely that the discharge had an impact on the downstream temperature. The Butcher Pond is an existing, natural system. Acclimation activity does not affect the temperature in the pond in any way because an artificial temperature control system for the pond water has not been installed. Thus, the changes in downstream temperature are a consequence of the natural heat exchanges within the system, which includes the discharge from the Butcher Pond.

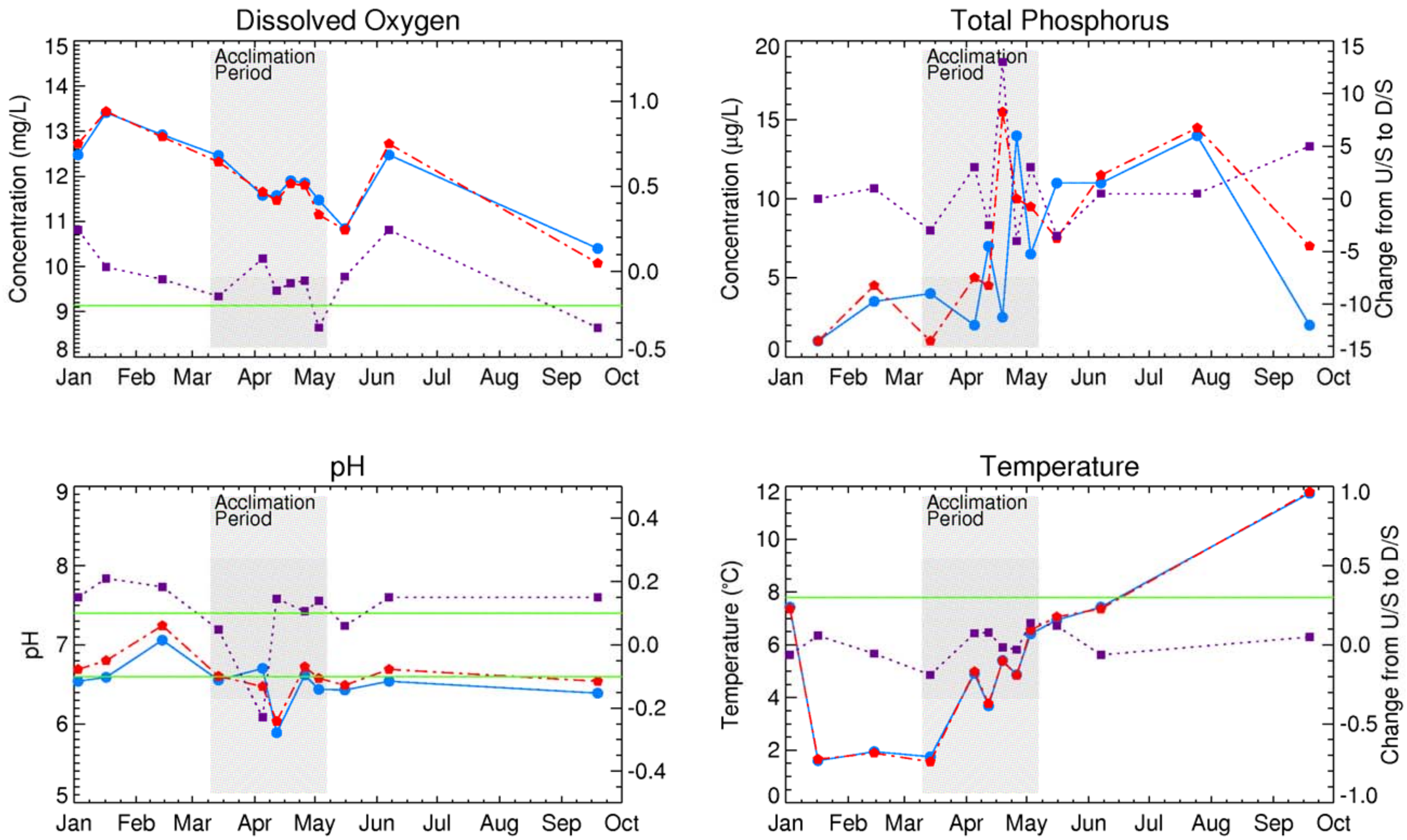
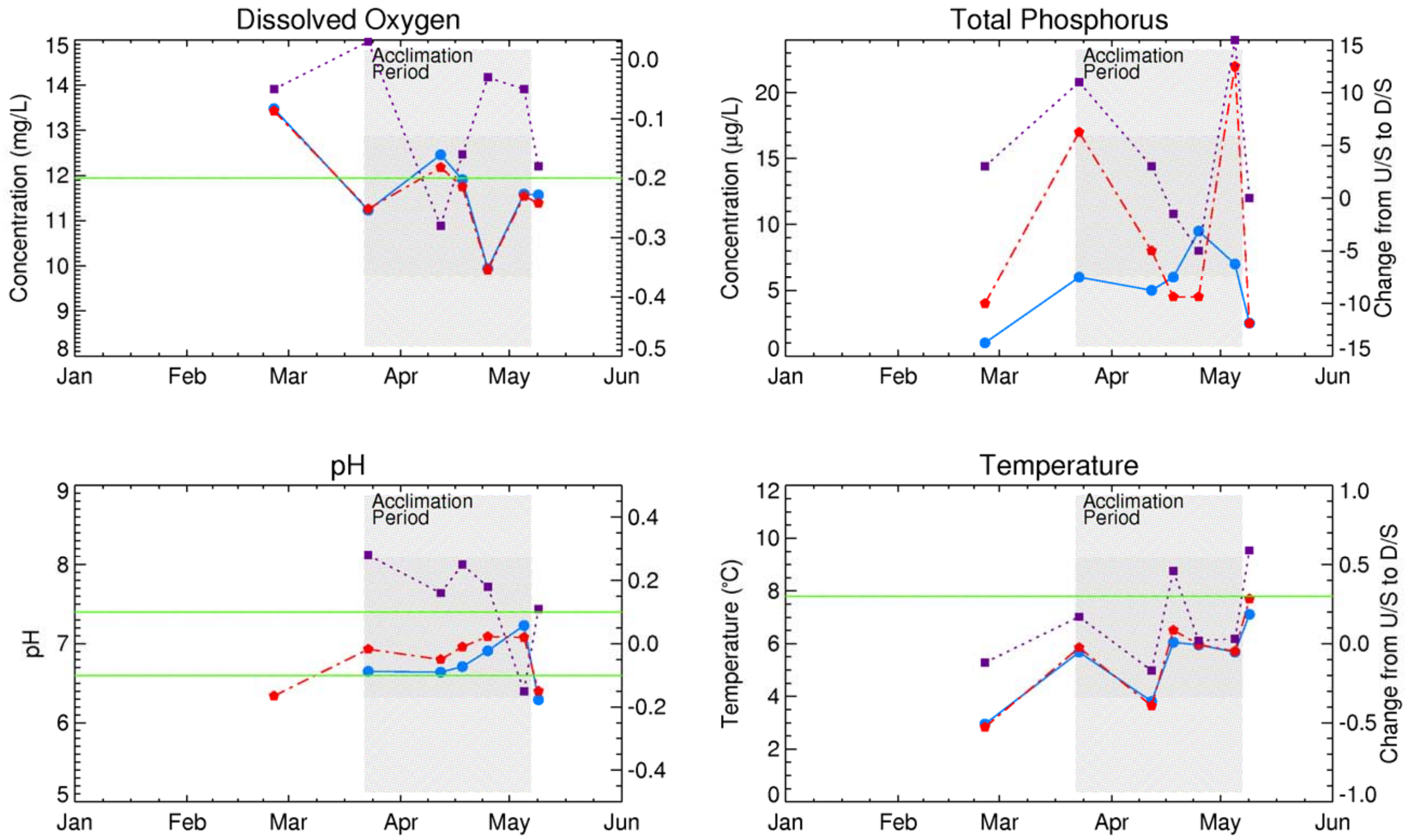



**Figure 4a**

Water quality changes in Nason Creek in 2009 in the vicinity of Butcher Discharge

*Duplicates averaged. Non-detects plotted at detection limit. Horizontal solid green line(s) show the limit(s) for measurable change. Units are same for the right and left axes*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Discharge_WQ\process_discharge_data_v2.pro Mon May 31 13:15:05 2010




Upstream
Downstream
Change
Limit(s) for Measurable Change

ANCHOR QEA

**Figure 4b**

Water quality changes in Nason Creek in 2010 in the vicinity of Butcher Discharge

*Duplicates averaged. Non-detects plotted at detection limit. Horizontal solid green line(s) show the limit(s) for measurable change. Units are same for the right and left axes*

### 3.2.3 Estimation of Net Phosphorus Loading to Nason Creek

Based on flows estimated through the ponds and the number of fish acclimated at each site, an estimate of the average daily phosphorus load was developed. The calculation of aggregate load is presented in Table 5. The average daily load estimated here provided a basis for evaluating the acclimation-induced loading to receiving streams for the proposed sites.

## 3.3 Assessment of Combined Impacts on Receiving Stream

To evaluate the combined impact of acclimation activity on Nason Creek and ultimately on the Wenatchee River, an evaluation of the variability in water quality and bioavailability of phosphorus forms along the length of Nason Creek downstream of all discharges was conducted.

### 3.3.1 Spatial Variability in Water Quality

The spatial variation in water quality along the length of Nason Creek from upstream of the Rohlfing discharge to the mouth of Nason Creek in 2009 and 2010 are presented in Figures 5a and 5b, respectively. The Rohlfing and Butcher discharges enter Nason Creek at approximately River Kilometers (RKM) 23.4 and 19.3, respectively.

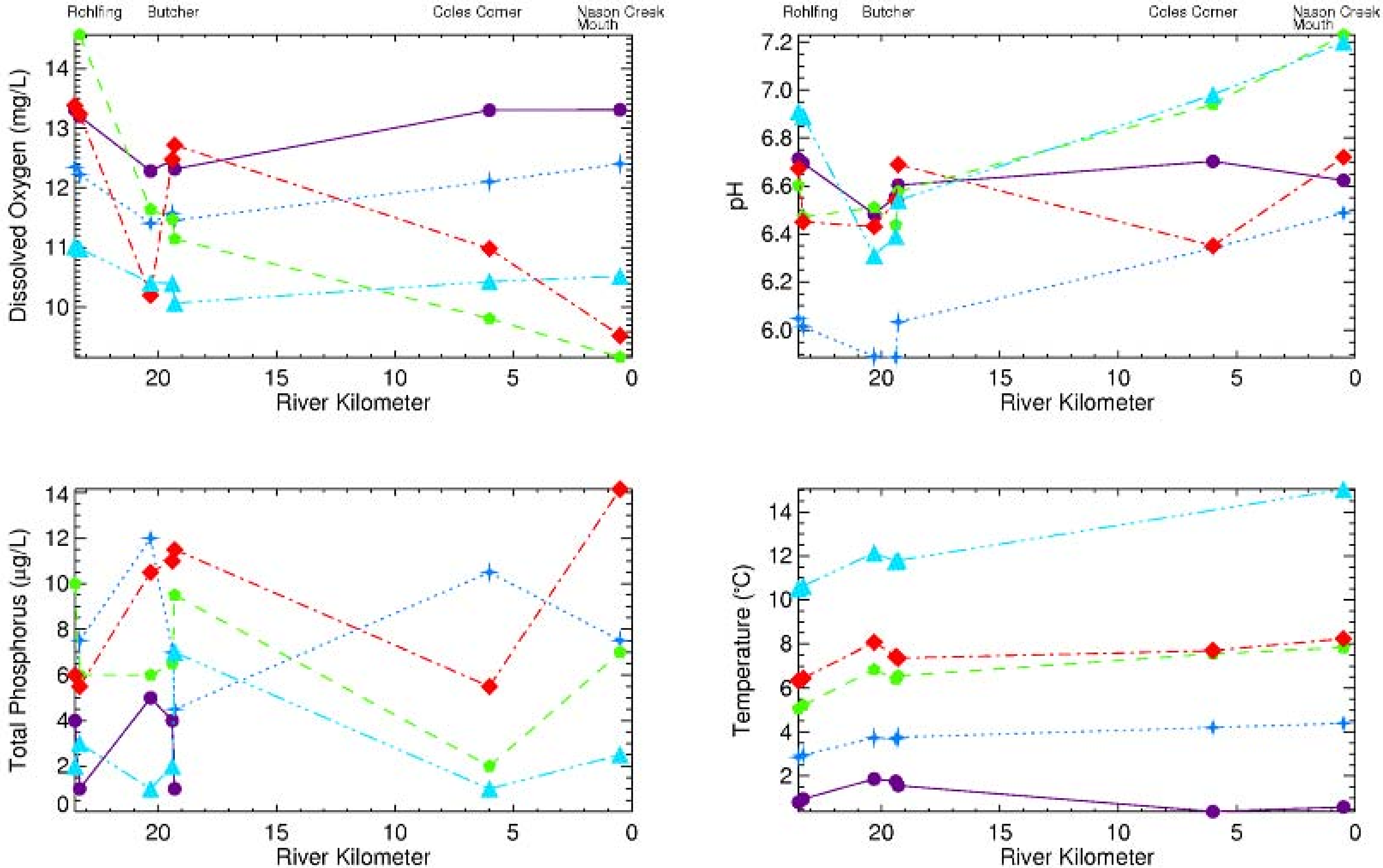
The 2009 data consistently showed a drop in DO from the Rohlfing to Butcher discharges, regardless of whether it was during or after the acclimation period, and either rose slightly or fell significantly downstream of the Butcher discharge. Over the same reach, temperature showed a consistent increase of up to 2 degrees C, which likely explains the decline in DO.

The spatial trends in DO in the 2010 acclimation season were consistent with the trends observed in 2009, with the exception of one unusual decline from the Boyce Station (RKM 20.3) to station upstream of Butcher discharge (RKM 19.4). On this same date, pH also showed a sharp decline while the changes in TP and temperature were not unusual. Because the DO and pH levels and the temperature from the Rohlfing discharge were within the observed ranges, this decline could not have been caused by the Rohlfing discharge. It is unclear whether the declines in DO and pH were a consequence of discharge from the wetland complex near Boyce, groundwater influx, or instrument error.

**Table 5**
**Combined TP loads introduced due to acclimation activity in Nason Creek**

| | Rohlfing | | | Butcher | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | **2009** | **2010** | **Overall** | **2009** | **2010** | **Overall** | **2009** | **2010** | **Overall** |
| Total number of fish acclimated | 101000 | 85656 | 186656 | 136000 | 144632 | 280632 | 237000 | 230288 | 467288 |
| Average TP load (g/d) | 35.72 | 38.53 | 74.25 | 51.35 | 22.66 | 74.02 | 87.07 | 61.19 | 148.27 |
| TP load per fish acclimated (mg/d/fish) | 0.35 | 0.45 | 0.40 | 0.38 | 0.16 | 0.26 | 0.37 | 0.27 | **0.32** |

Notes:
g/d grams per day
mg/d/fish milligrams per day per fish




ANCHOR QEA

**Figure 5a**

Spatial variations in Nason Creek water quality in 2009

*Duplicates averaged. Non-detects plotted at detection limit. Only paired data are plotted*

PM - C:\AQJobs\SeaSprings\Yakama_Nation_Coho\Analysis\Discharge_WQ\process_discharge_data_v2.pro Mon May 31 13:12:09 2010

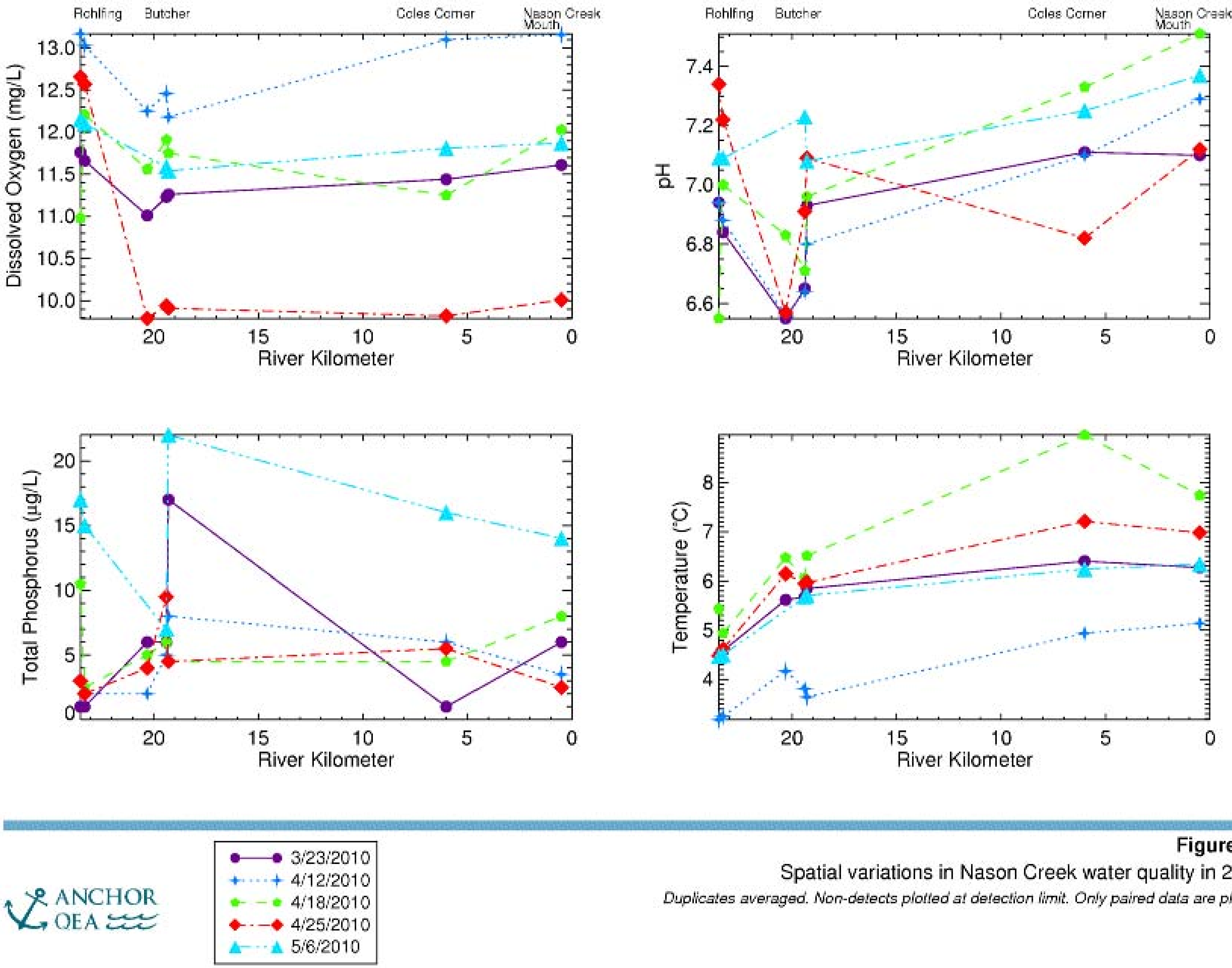



**Figure 5b**

Spatial variations in Nason Creek water quality in 2010

*Duplicates averaged. Non-detects plotted at detection limit. Only paired data are plotted*

Downstream of the Butcher discharge, DO rose slightly on three of the five sampling dates in both 2009 and 2010. DO measurements on April 25, 2010, remained low in-stream, from Boyce station downstream to the confluence with the Wenatchee River. Flows in April 2010 were lower than 2009 but the temporal patterns were comparable. Therefore, the cause for the lack of recovery in DO (pH recovered along this reach) on this date is unclear. The lower values in 2009 occurred during spring high flows. This may be a consequence of the widening and subsequent reductions in creek flow turbulence, and the corresponding reduction in aeration potential in this section of the creek. During lower flows (March, April, and September samples), the DO patterns were similar during and after the acclimation period. The significant drop in DO downstream of the Butcher discharge in May and June samples may have resulted from a reduction in velocity as the creek widens in these reaches, but this could not be established definitively due to lack of stream flow information within this reach.

The data showed an increase in TP for both years from downstream of the Rohlfing discharge to upstream of the Butcher discharge. TP data consistently showed a decline downstream of the Butcher discharge to Coles Corner (at RKM 6), and then an increase to the mouth of Nason Creek, with the exception of one out of four measurements in 2009 and two out of five in 2010. Discharge from the wetland complex upstream of the Route 2 bridge (see Figure 3-7 in Appendix 6) may contribute to the observed increase in TP between the location downstream of the Rohlfing discharge and the location upstream of the Butcher discharge. The decline from Butcher to Coles Corner suggests some in-stream assimilation, while an increase from Coles Corner to the creek mouth is indicative of a potential TP source. As there are no known point sources downstream of Coles Corner, the increase in TP observed at the mouth may result from non-point source inputs, such as groundwater inflow.

The pH data from both years showed a decline downstream of Rohlfing to Boyce station (RKM 20.3), and an increase from downstream of the Butcher discharge to the mouth of Nason Creek. These patterns are consistent with the observations for DO and TP. Data collected during and after acclimation activity were similar (with the exception of the June sample), suggesting that pH changes are minimally affected by discharges from the acclimation ponds.

Temperature patterns suggested negligible impact from acclimation pond discharges. Small changes in the mixing zone of the discharges could result from the natural variability within the system (see Section 3.2.2.2). With the exception of March 2010, changes in temperature were consistent with the season and showed little impact from the discharges. Air temperatures in March were unusually warm in 2010, which was reflected in the recorded water temperatures. In general, a small decline from Boyce Station to upstream of Butcher discharge (RKM 19.3) was observed and is likely a consequence of inherent variability in stream flow, cooler discharge from the nearby wetlands complex, or groundwater influx. Temperatures increased slightly from downstream of Butcher to the creek mouth, reflecting the change in elevation and the associated changes in air temperature.

### *3.3.2 Phosphorus Bioavailability*

Another important metric that determines the amount of available phosphorus for algal uptake is the orthophosphate concentration. Phosphorus in natural aquatic ecosystems consists of particulate and dissolved forms. Both forms can be organic, inorganic, or a combination of organic and inorganic. Particulate organic phosphorus can undergo dissolution to form dissolved organic phosphorus, which in turn can hydrolyze to form dissolved inorganic phosphorus (in this appendix used interchangeably with orthophosphate, the simplest form to which all forms of dissolved inorganic phosphorus are converted prior to measurement in the laboratory).

Phosphorus is an essential nutrient for algal growth. However, not all forms of phosphorus can be taken up by algae. Any form of phosphorus that is readily available for biological uptake is said to be bioavailable (i.e., available for ready assimilation by algae). Orthophosphate is readily utilized by algae during photosynthesis and is therefore considered bioavailable. Because dissolution and hydrolysis are slow processes, other forms such as dissolved organic phosphorus or particulate phosphorus cannot be incorporated into an algal cell. These forms are therefore not considered to be readily bioavailable.

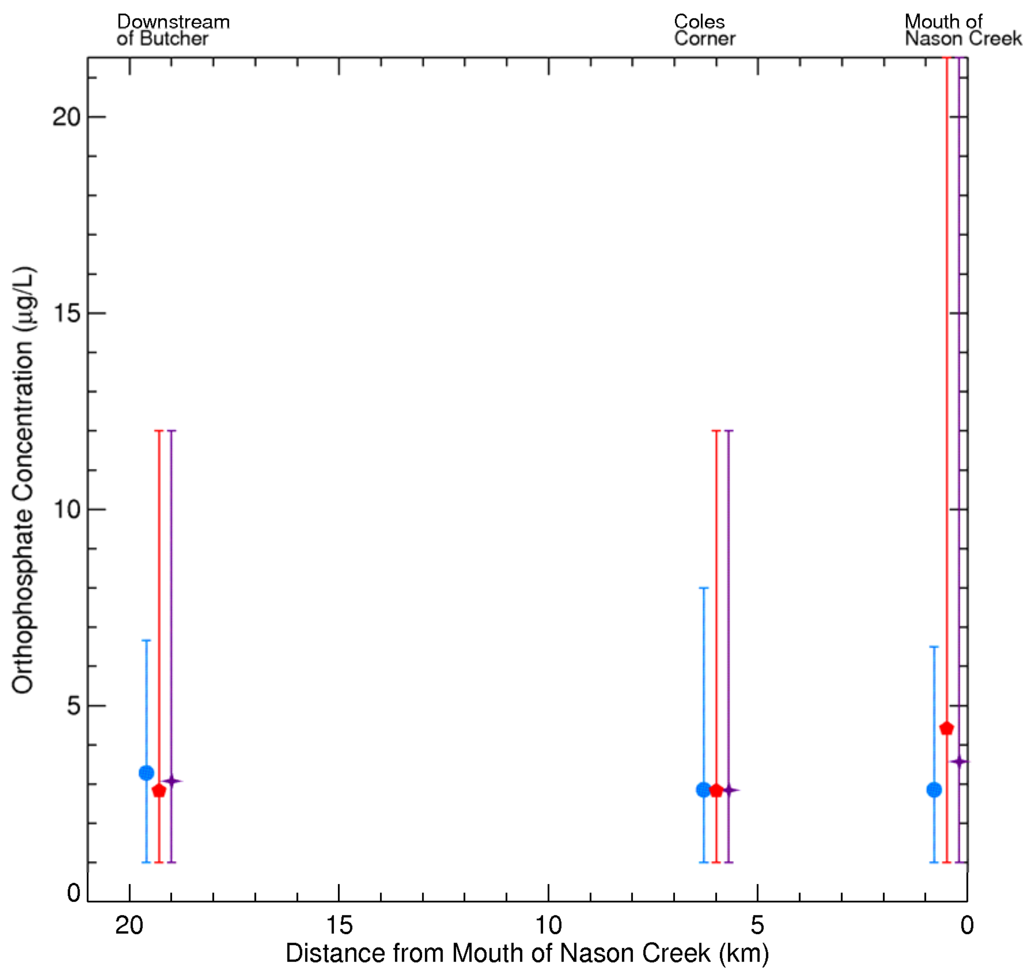
Figure 6 shows the range in orthophosphate concentrations from downstream of the Butcher discharge to the mouth of Nason Creek for periods with and without ongoing acclimation activity. The patterns suggest that there is little difference in the average orthophosphate levels throughout the year regardless of whether acclimation activity was ongoing or not. The variability in the orthophosphate levels is higher during non-acclimation periods in 2009, which is reasonable given that the acclimation period spans only 3 months (March through May). There were occasional spikes during non-acclimation periods, particularly near the mouth of Nason Creek, suggesting that there could be a source of orthophosphate farther downstream of the acclimation sites in Nason Creek that is not related to discharges from the acclimation ponds.

Figure 7 shows the forms of phosphorus entering the Wenatchee River at the Nason Creek mouth. On most dates sampled, the major component of the TP load entering the Wenatchee River was not readily bioavailable. During the 2009 acclimation period (March through May), the bioavailable fraction remained low (a maximum of 50%). In 2010, the bioavailable fractions were calculated to be greater than 50% on several occasions. On most dates when the bioavailable fraction exceeded 50%, the TP concentration was less than 10 µg/L. This phenomenon suggests that even though the bioavailable fractions were higher, the loadings remained low.

It is possible that even though the phosphorus entering the upper Wenatchee River is in a non-bioavailable form (such as dissolved organic phosphorus), it could convert to orthophosphate as the water moves downstream. Assuming an upper bound (i.e., fastest) decay rate of 0.11 per day for conversion of dissolved organic phosphorus to orthophosphate (based on the range reported in Cole and Wells 2003), it would take roughly 6 days for 50% of the organic phosphorus at the headwater to be converted to orthophosphate.

WDOE's TMDL analysis indicated that during September 2002 low-flow conditions (comparable to the 7Q10 low-flow), the travel time from the headwater at Lake Wenatchee to the confluence with the Columbia River is less than 2.5 days (Carroll et al. 2006). This travel time is well below the 6-day estimate for conversion of 50% of the TP to bioavailable forms. Flows encountered during the higher feeding periods in April and May are typically higher, and so travel times would be even shorter. Thus, the fraction of acclimation pond-related phosphorus that enters the upper Wenatchee River will likely be negligible when feeding rates are the highest.

This analysis suggests that the phosphorus released due to acclimation pond activity generally contributes a small proportion of bioavailable load to the Wenatchee River. Moreover, the non-bioavailable form released to the upper subbasin is likely to remain largely non-bioavailable as it is carried through the critical regions of the lower Wenatchee River.




- Acclimation Period
- Non-acclimation Period
- Overall

**Figure 6**

Spatial variations in orthophosphate concentrations measured downstream of all active acclimation discharges in Nason Creek

*Duplicates averaged. Non-detects plotted at detection limit. This analysis used only data from dates when samples were collectedat all locations Error bars show range of data*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Phosphorus\tp_fracs_and_p_bioavailability.pro Tue Jun 01 16:12:00 2010

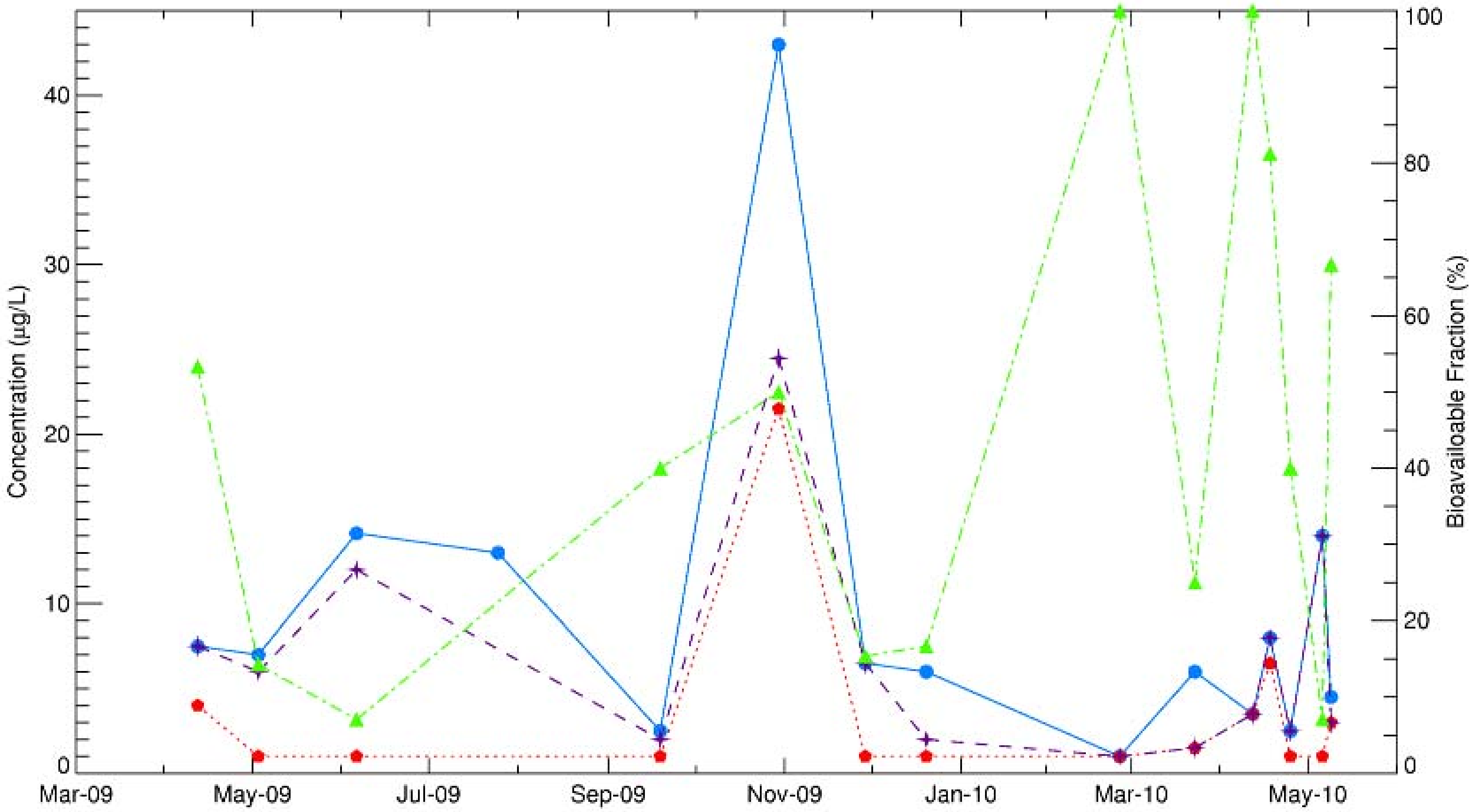



**Figure 7**

Forms of total phosphorus entering Wenatchee River from Nason Creek

*Duplicates averaged. Non-detects plotted at detection limit. TDP data adjusted for consistency with TP and SRP*
*Bioavailable fraction estimated from paired SRP and TP measurements*

PM - C:\AG\Jobs\GeoSprings\Yakama_Nation_Coho\Analysis\Phosphorus\tp_fracs_and_p_bioavailability.pro Tue Jun 01 15:11:59 2010

# 4 ASSESSMENT OF IMPACTS AT PROPOSED SITES

## 4.1 Approach

The main challenge in the evaluation of impacts for proposed acclimation sites is to assign the phosphorus loads that would result from the proposed acclimation activity. A data-based approach was adopted for this project to estimate nutrient loads at proposed acclimation sites[2]. Water quality data collected at Nason Creek in the spring of 2009 and 2010, when active acclimation was ongoing, provided a basis for estimating acclimation activity-related nutrient loads from the proposed sites. Based on these data, the TP load contributed to the receiving stream was estimated to be 0.32 milligrams (mg) per day per fish (see Table 5). This estimate was scaled up or down by multiplying by the number of fish to be acclimated at each proposed site. This contribution was evaluated against the phosphorus loads calculated at the mouth of the major creeks that carried these loads into the Wenatchee and the Methow rivers. The objective behind this approach was to assess the significance of the loads relative to the background loads in the system.

A different approach was adopted for the Dryden Hatchery because it is planned for proposed use as a year-round rearing facility. The Dryden Hatchery will discharge into a critical area of the Wenatchee River that is currently exhibiting water quality excursions. For this site, the mass balance modeling approach used in the WDOE TMDL analyses (Carroll et al 2006; Carroll and Anderson 2009) was adopted, with minor modifications as described in the following sections.

### *4.1.1 Applicability of Active Site Data to Proposed Sites*

Applying the active site data as a means of assessing the impacts of the proposed sites on water quality is reasonable for the proposed sites, aside from Dryden, because: 1) the sites will be used to acclimate the same species; 2) feeds are expected to be similar or identical to those used in the Nason Creek sites; 3) climatic conditions will be similar, which will result in similar metabolism; and 4) the majority of the acclimation sites are small, natural ponds that are fed by small tributary streams.

As discussed above, the Dryden facility is proposed to operate as a year-round rearing facility. It will be a constructed site with discharges being treated to some level before being

[2] An approach that was considered and then abandoned in favor of the direct measurement approach included the estimation of potential acclimation pond loads using the anticipated feed rates, in conjunction with literature-reported rates of fish metabolism and growth, to estimate the amount of phosphorus excreted and egested into the water column, and to predict rates at which nutrients are assimilated in the acclimation ponds. While this approach is technically rigorous, there is considerable uncertainty in applying metabolic estimates from different sources that are potentially derived under different conditions. Moreover, fish rearing pond assimilation rates have not been extensively studied. Therefore, this approach was abandoned in favor of the more empirical approach described herein.

released into the Wenatchee River. Therefore, nutrient loading estimated from active acclimation sites operated over a specific time period (March through May) were not representative of the operations proposed at the Dryden facility.

## 4.2 Impacts at Wenatchee Subbasin Sites

The estimated TP loads at the proposed sites in the Wenatchee subbasin are shown in Table 6. The details of estimation for each site are discussed in the following subsections.

### *4.2.1 White River*

Three acclimation ponds are proposed in the White River watershed. Flows in the White River were estimated based on the WDOE gauge near Plain (Gauge ID: 45K090). Water quality data were derived from multiple sources: data collected by the Yakama Nation as part of this project at the McComas Site (presented in Appendix 6) were supplemented with monitoring data collected to support ongoing acclimation programs in Lake Wenatchee by Grant County Public Utility District (PUD) No. 2 (Grant PUD 2009) and Chelan PUD (2009 – unpublished data).

#### *4.2.1.1 Tall Timber*

Tall Timber is the most upstream of the three proposed acclimation ponds and does not directly flow into the White River, but it is located close to the confluence of the Napeequa and White rivers (see Appendix 2 for details). The estimated TP load from this acclimation site is 19.1 g/d, which is less than one fifth of a percent of the average TP loads delivered by the White River to Lake Wenatchee during the acclimation periods in 2009 and 2010. This level is well within the natural variability of the TP loads in the White River. Moreover, loads released at this site would have to travel a substantial distance prior to entering Lake Wenatchee. In-stream processes such as settling and uptake by biota would mitigate any impact farther downstream from the discharge.

#### *4.2.1.2 Gray*

This is one of the smallest proposed ponds, with acclimation of 50,000 coho. Loads from this site are expected to be quite small, at less than one-tenth of a percent of the average White River loads.

#### *4.2.1.3 Dirty Face*

Data from Nason Creek are not applicable to the Dirty Face site because adult fish acclimation is proposed at this site. Adult fish are not fed, so water quality impacts associated with the acclimation and feeding of juvenile fish are not relevant to the Dirty Face site.

### 4.2.2 Little Wenatchee River – Two Rivers

The Two Rivers site is located above the confluence of the Little Wenatchee River with Lake Wenatchee (see Appendix 2). This is one of the larger sites, with an estimated 120,000 coho being proposed for acclimation.

WDOE's gauge at Little Wenatchee River below Rainy Creek (Gauge ID: 45L110) was used to estimate flows. As with White River, water quality data for estimation of loads came from the program described herein, as well as from the Grant and Chelan PUD monitoring programs (Grant PUD 2009; Chelan PUD 2009 – unpublished data).

The estimated loads contributed by this proposed site are higher than for the White River sites because of the greater number of fish proposed for acclimation. Nevertheless, the TP loads from acclimation activity are estimated to be about one-third of a percent of the average TP loads carried by Little Wenatchee River during the acclimation period.

**Table 6**
**TP loads estimated for proposed acclimation activity within the Wenatchee Subbasin**

| Proposed Site | No. of Fish (thousands) | TP Load[1] (kg/d) | Receiving Stream[2] | No. of Days[3] | No. of Sampling Events[4] | Record Start Date | Record End Date | Receiving Stream Load[5] (kg/d) | Relative Contribution (%) |
|---|---|---|---|---|---|---|---|---|---|
| Tall Timber | 110 | 0.035 | White River | 84 | 14 | 3/15/2009 | 4/12/2010 | 19.1 | 0.18 |
| Gray | 50 | 0.016 | White River | 84 | 14 | 3/15/2009 | 4/12/2010 | 19.1 | 0.08 |
| Two Rivers | 120 | 0.038 | Little Wenatchee | 83 | 12 | 3/23/2009 | 5/9/2010 | 11.8 | 0.33 |
| Chikamin | 100 | 0.032 | Chiwawa | 71 | 7 | 4/4/2009 | 5/9/2010 | 7.3 | 0.44 |
| Minnow | 100 | 0.032 | Chiwawa | 71 | 7 | 4/4/2009 | 5/9/2010 | 7.3 | 0.44 |
| Clear | 150 | 0.048 | Chiwawa | 71 | 7 | 4/4/2009 | 5/9/2010 | 7.3 | 0.66 |
| Beaver | 100 | 0.032 | Beaver | N/A | N/A | N/A | N/A | N/A | N/A |
| Scheibler | 65 | 0.021 | Chumstick | 23 | 2 | 4/11/2009 | 5/3/2009 | 2.7 | 0.77 |
| Leavenworth NFH[6] | 100 | 0.032 | Icicle | N/A | N/A | N/A | N/A | 1.5 | 2.21 |
| Brender[7] | 50 | 0.016 | Brender | N/A | 11 | 3/10/1997 | 5/3/2004 | 1.2 | 1.39 |

**Notes:**
1. Estimated from average load of 0.32 mg per fish per day calculated from measured data at active discharges in Nason Creek.
2. Nearest stream for which estimation of TP load at the downstream end of the receiving stream was possible.
3. Number of days in the acclimation period over which interpolation of loads was possible with available flow and concentration data.
4. Number of events during the acclimation period (3/10/2009 through 5/10/2009 and 3/23/2010 through 5/9/2010). To maximize data coverage, this period was extended to include additional samples. Some events included collection of duplicates.
5. TP load estimated at the mouth of the receiving stream was based on nutrient data collected during the acclimation period.
6. Loads for the receiving stream (Icicle Creek) represent the total load at the mouth of Icicle Creek for 2002 as determined in WDOE TMDL.
7. Average TP load for receiving stream (Brender) was calculated over the acclimation months (March through May) based on historical flow and TP data reported by WDOE for Brender Creek near Cashmere Station (45D070).

kg/d kilograms per day

### 4.2.3 Chiwawa

Three sites are proposed in the Chiwawa River watershed. This river joins the Wenatchee River near Plain, Washington. Flow data for this site were obtained from the U.S. Geological Survey (USGS) Chiwawa River gauge near Plain (Station ID: 12456500). Water quality data were collected by the Yakama Nation near the mouth of the Chiwawa River.

#### 4.2.3.1 Minnow

This is the most upstream of the three proposed acclimation ponds and enters the Chiwawa River through Chikamin Creek. TP contributions from this site are expected to be less than one half of a percent of the load carried by the Chiwawa River during the acclimation period. Also, given its distance from the mouth of the Chiwawa River, loads from this site are likely to be mitigated by in-stream processes and are unlikely to impact the Wenatchee River.

#### 4.2.3.2 Chikamin

The Chikamin site is close to the Minnow site and similarly enters the Chiwawa River through Chikamin Creek. Because the number of fish acclimated at this site is the same as at the Minnow site, the TP contributions from this site are expected to be similarly less than one half of a percent of the load carried by the Chiwawa River during the acclimation period. As with the Minnow site, loads from this site are also likely to be assimilated in-stream due to the distance from the confluence with the Wenatchee River, and therefore, they are unlikely to impact its water quality.

#### 4.2.3.3 Clear

Discharge from the Clear Creek site would enter the Chiwawa River through Clear Creek close to the confluence with the Wenatchee River. This is the largest site that is being proposed in the Wenatchee subbasin, with 150,000 coho planned for acclimation. Therefore, this site has the highest estimated TP load among all sites. However, in terms of relative magnitude, this load is about two-thirds of a percent of the average TP loads carried by the Chiwawa River. Therefore, this site, on its own, is not expected to significantly alter loads to the Wenatchee system.

### 4.2.4 Beaver

Water quality data for this site is limited. Given the relatively small phosphorus loads, impacts from this site are expected to be similar to the other sites.

### 4.2.5 Chumstick Creek - Scheibler

Scheibler Creek is located 13 kilometers upstream of the confluence of Chumstick Creek with the Wenatchee River. Water quality data collected by the Yakama Nation at the mouth of Chumstick Creek (CH4—see Appendix 6) and flow estimated by WDOE near the river mouth (Station ID: 45C060) were used to calculate background loads. Even though nutrient data were collected in 2010, the loading calculations used data from 2009 only, due to lack of paired flow measurements in 2010 (WDOE has suspended the gage operation). The loads from acclimation pond activity are estimated to be less than 1% of the average background load carried by Chumstick Creek. Given the small proportion of the background load, the water quality impacts are expected to be negligible.

### 4.2.6 Icicle Creek – Leavenworth National Fish Hatchery (LNFH)

Facilities at the LNFH are being used for acclimation as part of this project. Discharges from this facility flow through the main hatchery outfall that dominates the Icicle Creek flow during low-flow season. Data at Icicle Creek were not collected as part of this project. The LNFH is required to provide a discharge report as part of the National Pollution Discharge Elimination System (NPDES). However, a review of recent discharge reports did not yield any nutrient data. Thus, TP load specified at the Icicle Creek mouth in the WDOE TMDL (Carroll et al. 2006) was used as a basis for comparison.

The proposed coho acclimation project was estimated to contribute about 2% of the TP loads used in the WDOE TMDL for summer 7Q10 conditions. Recognizing that acclimation activity is proposed overwinter and during spring, the load comparison here is illustrative. Nonetheless, because a large portion of the load enters during spring high flow, it will likely be rapidly flushed from the system and is unlikely to have a direct impact on the water quality of the lower Wenatchee River and Icicle Creek.

### 4.2.7 Brender Creek

Brender Creek site discharge would reach the Wenatchee River through Mission Creek. Water quality data were not collected for this site as part of this project. However, historical water quality and flow data were available for this site from WDOE (Brender Creek at Cashmere). A comparison to historical data shows that TP loads discharged from the acclimation site could contribute up to 2% of the loads carried by the creek. This comparison suggests that the loads from this site may have localized impacts, but the estimated average contribution of 16 g/d is unlikely to directly impact Wenatchee River water quality because much of this load will enter during the spring high flow season when loads from the site would be rapidly flushed from the system.

### 4.2.8 Back-up Acclimation Sites

#### 4.2.8.1 McComas

The McComas site is located in White River and it may be used to acclimate up to 50,000 juvenile fish. The corresponding phosphorus loads are expected to be less than one-tenth of a percent of the loads carried by White River (see Table 7). Therefore, the impacts are not expected to adversely affect water quality.

#### *4.2.8.2 Squadroni*

The Squadroni site is located on Nason Creek and is planned as a back-up site should the other Nason Creek sites not be used. If used, 105,000 fish are expected to be acclimated at this site. Based on the active Nason Creek sites, the TP load due to acclimation activity is expected to be 34 g/d (see Table 7). This is about half a percent of the TP loading from Nason Creek to the Wenatchee River. Moreover, it was demonstrated earlier that the active acclimation occurring simultaneously at Rohlfing and Butcher with more than twice the number of fish (237,000 in 2009 and about 230,000 in 2010) did not adversely affect water quality in Nason Creek. Thus, the Squadroni site, if developed, is not likely to adversely affect water quality.

#### *4.2.8.3 Coulter/Roaring*

The Coulter/Roaring site is part of a wetland complex owned by the Yakama Nation. As with Squadroni, if used, up to 105,000 fishes could be acclimated here and the impacts are likely to be similar to those at the Squadroni site. However, because this site is in a wetlands complex, the TP loads from ponds are likely to be assimilated within the marsh environs. Thus, impacts from acclimation activity are likely to be minimal.

#### *4.2.8.4 Allen*

The Allen site, if used, is expected to acclimate up to 50,000 fishes, which could result in phosphorus loading of up to 16 g/d to Peshastin Creek. There were no nutrient or flow data available for Peshastin Creek for the month of March. In order to obtain a general sense of the relative contribution, the loading estimate for this site was compared to the loads specified in the WDOE TMDL summer natural conditions model (Carroll and Anderson 2009). It is estimated that acclimation activity at this site could contribute about 10% of the loads carried by the stream during the summer season. Given that 7Q10 flows used in the WDOE TMDL are substantially lower than typical spring flows, the upstream loads calculated for 7Q10 conditions are substantially lower than what would be carried by the creek during spring high-flow season. Therefore, the contribution from acclimation activity is likely to be a much smaller fraction of the creek TP loads than that estimated using the 7Q10 conditions. Regardless of the seasonal differences, 10% is still a small fraction of the total loads carried by the creek and is not likely to affect the water quality dynamics in the creek substantially.

**Table 7**
**TP loads estimated for proposed acclimation activity at back-up sites in Wenatchee Subbasin**

| Proposed Site | No. of Fish (thousands) | TP Load[1] (kg/d) | Receiving Stream[2] | No. of Days[3] | No. of Sampling Events[4] | Record Start Date | Record End Date | Receiving Stream Load[5] (kg/d) | Relative Contribution (%) |
|---|---|---|---|---|---|---|---|---|---|
| McComas | 50 | 0.016 | White River | 84 | 14 | 3/15/2009 | 4/12/2010 | 19.1 | 0.08 |
| Squadroni | 105 | 0.034 | Nason Creek | 112 | 22 | 3/14/2009 | 5/9/2010 | 6.3 | 0.53 |
| Coulter/Roaring | 105 | 0.034 | Nason Creek | 112 | 22 | 3/14/2009 | 5/9/2010 | 6.3 | 0.53 |
| Allen[6] | 50 | 0.016 | Peshastin Creek | N/A | N/A | N/A | N/A | 0.2 | 10.46 |

**Notes:**
1. Estimated from average load of 0.32 mg per fish per day calculated from measured data at active discharges in Nason Creek.
2. Nearest stream for which estimation of TP load at the downstream end of the receiving stream was possible.
3. Number of days in the acclimation period over which interpolation of loads was possible with available flow and concentration data
4. Number of events during the acclimation period (3/10/2009 through 5/10/2009 and 3/23/2010 through 5/9/2010). To maximize data coverage, this period was extended to include nearby samples. Some events included collection of duplicates.
5. TP load estimated at the mouth of the receiving stream was based on nutrient data collected during the acclimation period.
6. There were no data available for the receiving stream. Loads from the WDOE TMDL model for the 7Q10 natural conditions simulation are used here for comparison.

kg/d kilograms per day

### 4.2.9 Dryden Hatchery

#### 4.2.9.1 Mass Balance Modeling Setup

As mentioned in Section 4.1, the Dryden Hatchery site is proposed for use as a year-round rearing operation. Therefore, it was necessary to evaluate impacts during low-flow conditions when water quality is most vulnerable to increases in nutrient loading.

The QUAL-2K model was used in the WDOE TMDL (Carroll et al. 2006; Carroll and Anderson 2009) to allocate nutrient loading to point and non-point sources to bring DO and pH into compliance with existing state regulations. A phased implementation of load reductions has been recommended in the TMDL. Based on discussion with WDOE (November 12, 2009, meeting with Ryan Anderson, Yakima Regional office, Yakima), it is assumed for this evaluation that the load reduction measures will be implemented as recommended in the TMDL.

The QUAL-2K model was set up for 7Q10 low-flow conditions with publicly owned treatment works (POTW) discharging at design flow and a phosphorus concentration of 90 µg/L, and other sources were set to the estimated maximum natural condition values as determined in the WDOE TMDL (Carroll and Anderson 2009).

Nutrient loading for the proposed hatchery was estimated based on the anticipated rearing of approximately 220,000 smolts at the hatchery, such that about 110,000 smolts will be removed in November and 110,000 will be removed the following March. Table 8 presents the details on the nutrient loading that is expected to result from hatchery operation. The average flow for the month of September, estimated at about 0.06 cubic meter per second ($m^3/s$) (about 1,000 gallons per minute), was specified for the QUAL-2K model. Discharge from Dryden Hatchery was assumed to occur immediately upstream of Dryden Dam (at RKM 56.5).

The Skretting Nutra Fry feed that is proposed for use at the hatchery contains about 1.42% phosphorus by weight. Tipping and Shearer (2007) have reported a phosphorus retention range of 29% to 36% for coho salmon fed commercial diets with similar phosphorus content (range 1.1% to 1.3%). Similar research on rainbow trout estimated phosphorus retention at 50% (Flimlin et al. 2003). The average of these values, 39% phosphorous retention, was assumed for the analysis presented herein. The effluent from the hatchery is expected to undergo treatment prior to discharge to the Wenatchee River. For our purposes, we have assumed a treatment efficiency of 50%, which is the minimal requirement for any treatment system that will be designed for the system.

The phosphorus loads estimated for the month of September (see Table 8) were specified as a point source in the QUAL-2K model. Other water quality parameters were set to the same values as those used for LNFH in the Icicle Creek water quality model used in the WDOE

TMDL analysis (Carroll et al 2006). This is appropriate because the level of treatment at Dryden Hatchery is expected to be similar or better than what is being implemented at LNFH. All other settings remained unchanged from the 7Q10 simulations in the WDOE TMDL analysis (Carroll and Anderson 2009).

#### 4.2.9.2 Model Predictions and Impact Analysis

Steady-state predictions for flow, TP, DO, pH, and temperature over the length of the Wenatchee River are shown in Figures 8 through 12. Given the relatively small flows out of the proposed Dryden Hatchery, mass balance modeling has shown that effluent from the hatchery is unlikely to change flows and water quality significantly in the lower Wenatchee River. Indeed, DO remains in compliance downstream of the hatchery discharge (Figure 10) and the change in minimum DO meets the measurable change criterion laid out in state standards (Figure 13; WAC 2006).

The model predicts that pH could exceed the upper limit of 8.5 units downstream of Cashmere POTW discharge (Figure 11). After about RKM 60, there is little difference in the model predictions with and without the proposed hatchery discharge. This suggests that the pH excursion does not result from the hatchery loads, but is rather a consequence of the Cashmere POTW loads. This interpretation is reinforced by the WDOE TMDL, which acknowledges that Cashmere POTW discharge should release phosphorus at less than 90 µg/L to prevent pH excursion downstream of the city of Cashmere.

## Table 8
## Estimation of effluent phosphorus loads for proposed hatchery at Dryden

| Month | Number of Fish[1] | Flow ($m^3/s$) | Total Weight of Fish (kg) | Feed Rate (g feed/ g fish/d) | Phosphorus Feed Rate[2] (g/d) | Phosphorus Concentration (mg/L) | | | Effluent Phosphorus Load (g/d) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Feed | Untreated Effluent[3] | After Treatment[4] | |
| Mar | 236703 | 0.010 | 106.5 | 2.9% | 43.86 | 0.051 | 0.016 | 0.008 | 6.69 |
| Apr | 235135 | 0.015 | 190.5 | 2.8% | 75.73 | 0.060 | 0.018 | 0.009 | 11.55 |
| May | 233578 | 0.020 | 315.3 | 2.7% | 120.90 | 0.069 | 0.021 | 0.010 | 18.44 |
| Jun | 232031 | 0.028 | 511.6 | 2.6% | 188.89 | 0.078 | 0.024 | 0.012 | 28.81 |
| Jul | 230495 | 0.033 | 663.8 | 2.6% | 245.08 | 0.085 | 0.026 | 0.013 | 37.38 |
| Aug | 228968 | 0.041 | 906.7 | 2.5% | 321.88 | 0.091 | 0.028 | 0.014 | 49.09 |
| Sep | 227452 | 0.060 | 1627.4 | 2.4% | 554.62 | 0.106 | 0.032 | 0.016 | 84.58 |
| Oct | 225946 | 0.079 | 2420.8 | 2.2% | 756.27 | 0.111 | 0.034 | 0.017 | 115.33 |
| Nov | 224449 | 0.089 | 2929.1 | 2.0% | 831.85 | 0.108 | 0.033 | 0.016 | 126.86 |
| Dec | 112963 | 0.048 | 1626.7 | 1.9% | 438.87 | 0.106 | 0.032 | 0.016 | 66.93 |
| Jan | 112215 | 0.049 | 1666.4 | 1.9% | 449.59 | 0.107 | 0.033 | 0.016 | 68.56 |
| Feb | 111472 | 0.049 | 1705.5 | 1.9% | 460.15 | 0.108 | 0.033 | 0.017 | 70.17 |
| Mar | 110733 | 0.052 | 1843.7 | 1.9% | 497.43 | 0.111 | 0.034 | 0.017 | 75.86 |

**Notes:**

1 Numbers back-calculated to produce 220,000 smolts, and assuming mortality of 0.7 percent per month, with 110,000 fish removed in November and the remaining 110,000 removed in March.

2 Skretting Nutra Fry diet contains 1.42 percent phosphorus by weight.

3 Assumes assimilation of 39 percent based on a highly digestible diet.

4 Assumes treatment efficiency of 50 percent.

mg/L milligrams per liter

$m^3/s$ cubic meters per second

kg kilograms

g feed/g fish/d grams of feed per gram of fish per day

g/d grams per day

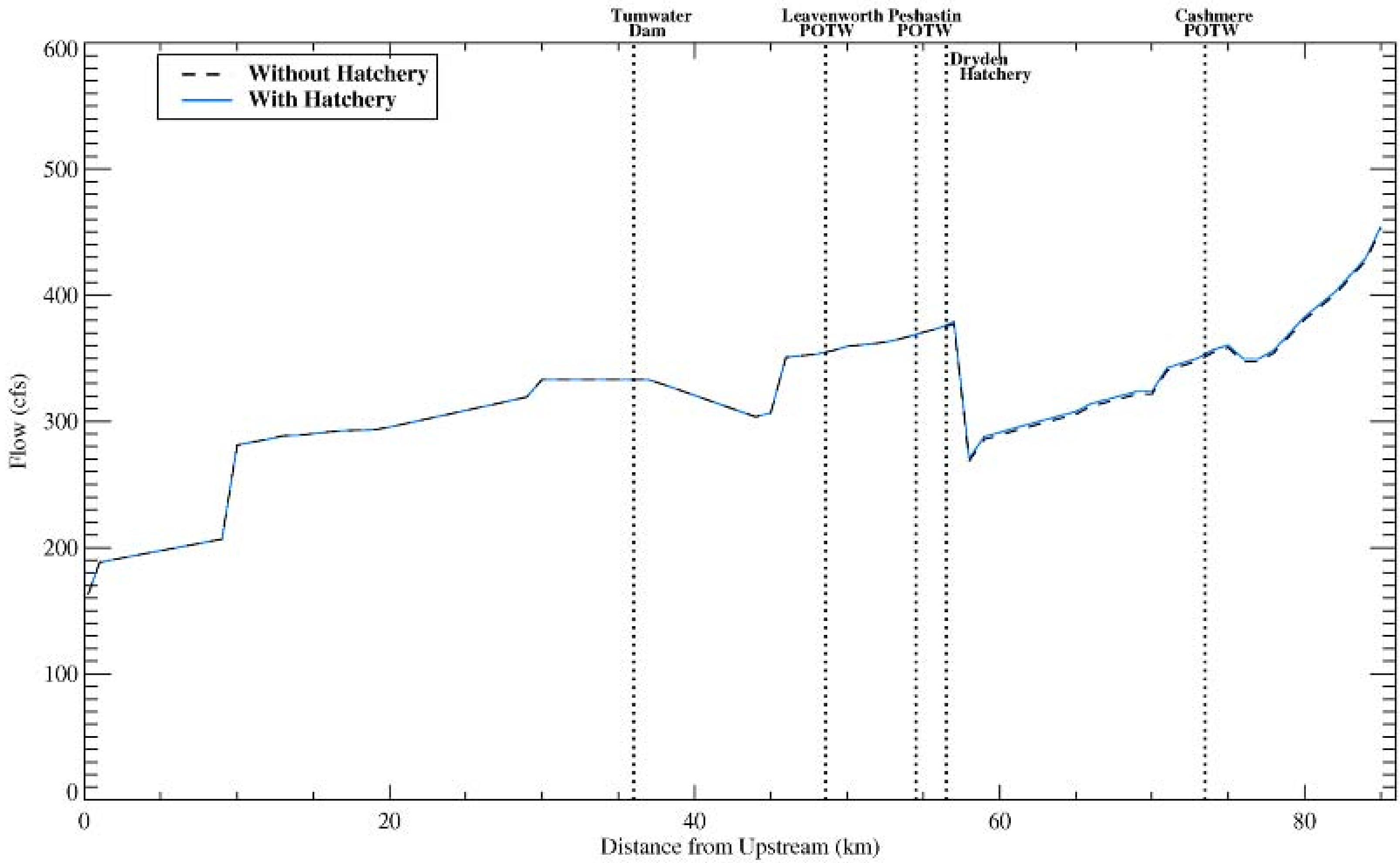



**Figure 8**

Flows simulated by QUAL-2K model shown compared for cases with and without proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*"Natural conditions" in all figures from here onwards refer to background conditions as defined in WDOE TMDL (Carroll and Anderson 2009)*



PM - C:\AQJobs\SeaSprings\Yakama_Nation_CohoModel\Postprocessor\plot_q2k_res_dryden.pro Thu Jul 22 08:32:16 2010

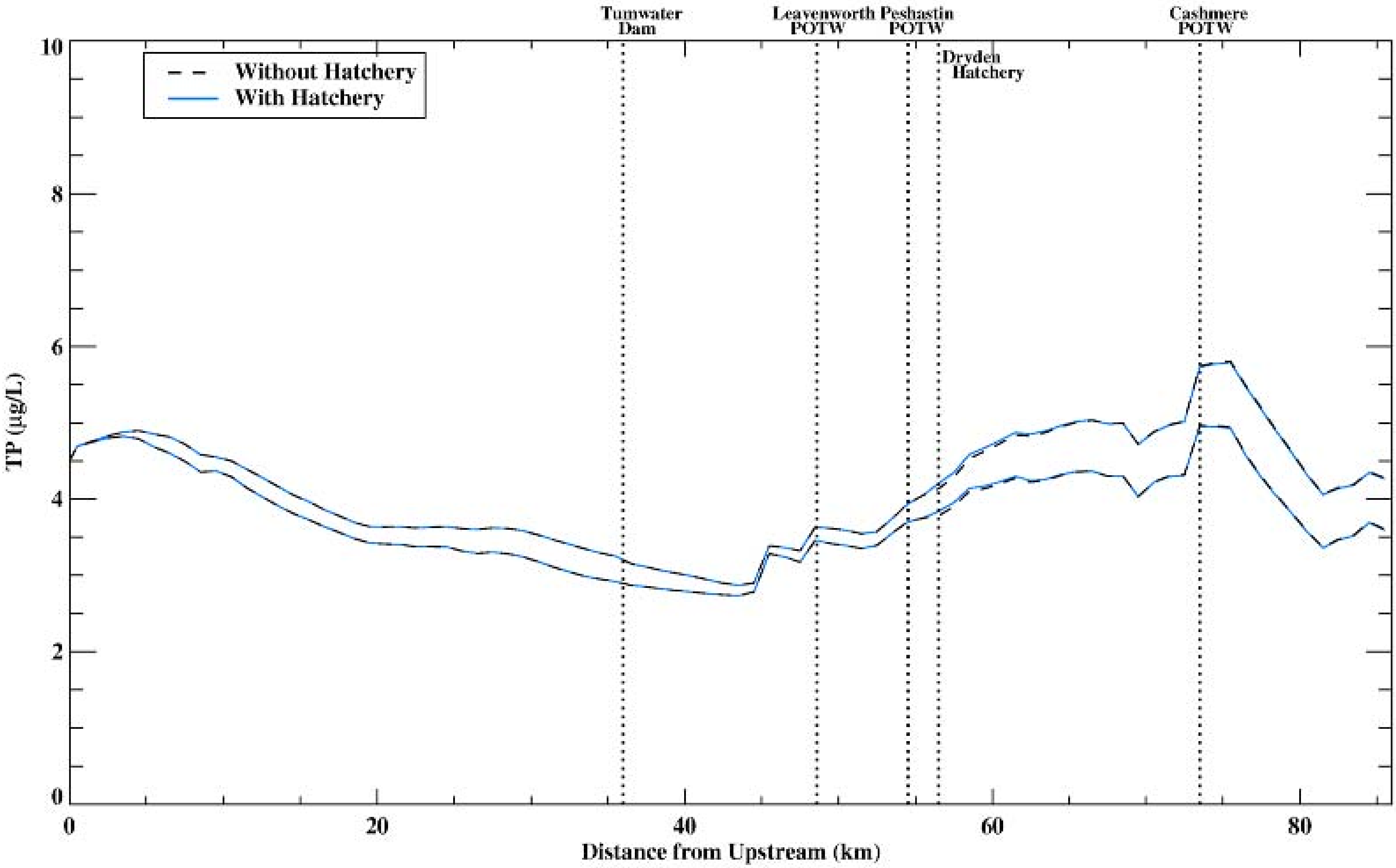



**Figure 9**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for cases with and without proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\GeoSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_dryden.pro Thu Jul 22 08:32:18 2010

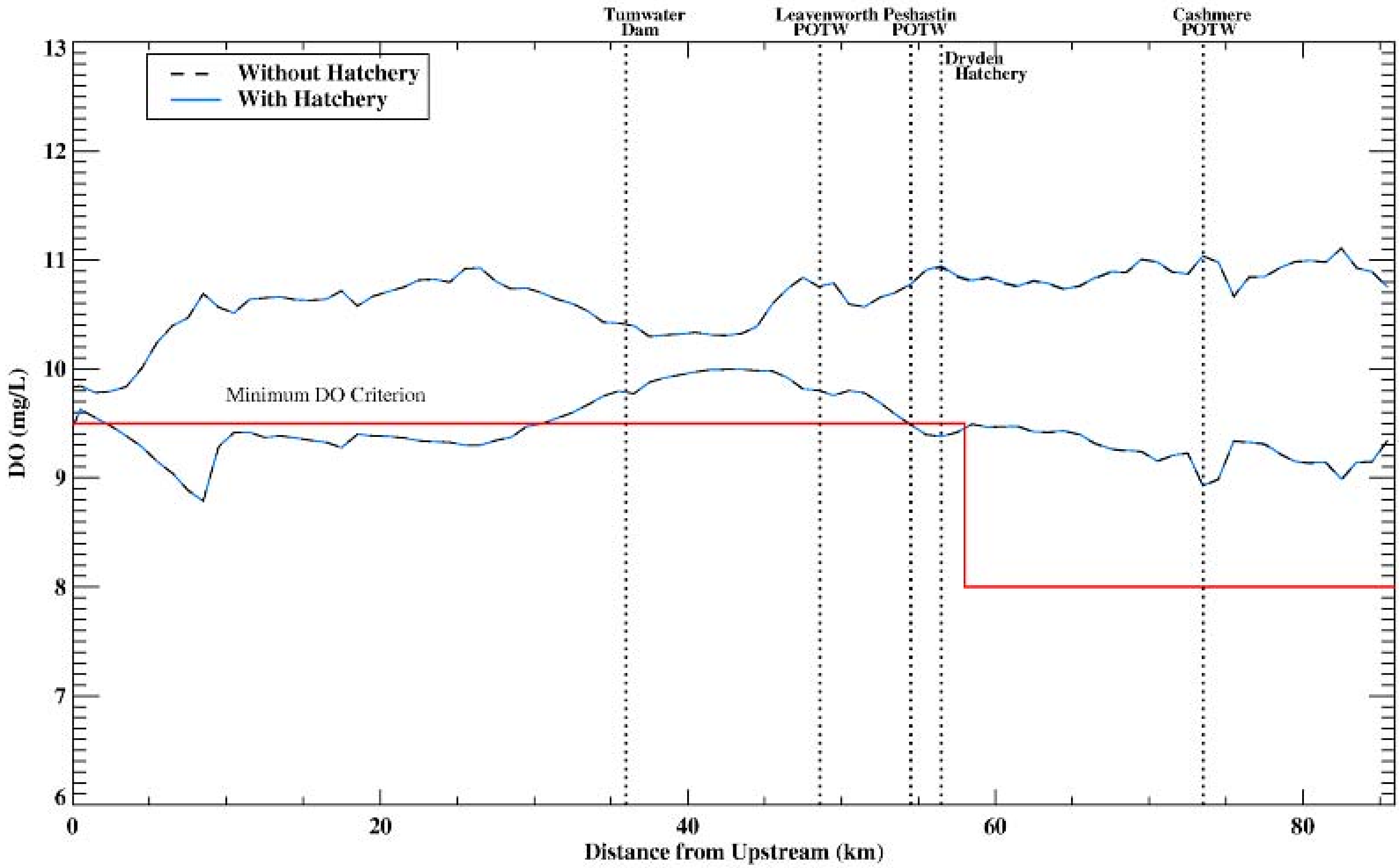



**Figure 10**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for cases with and without proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AQ\Jobs\GeoSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_dryden.pro Thu Jul 22 08:32:17 2010

ANCHOR QEA

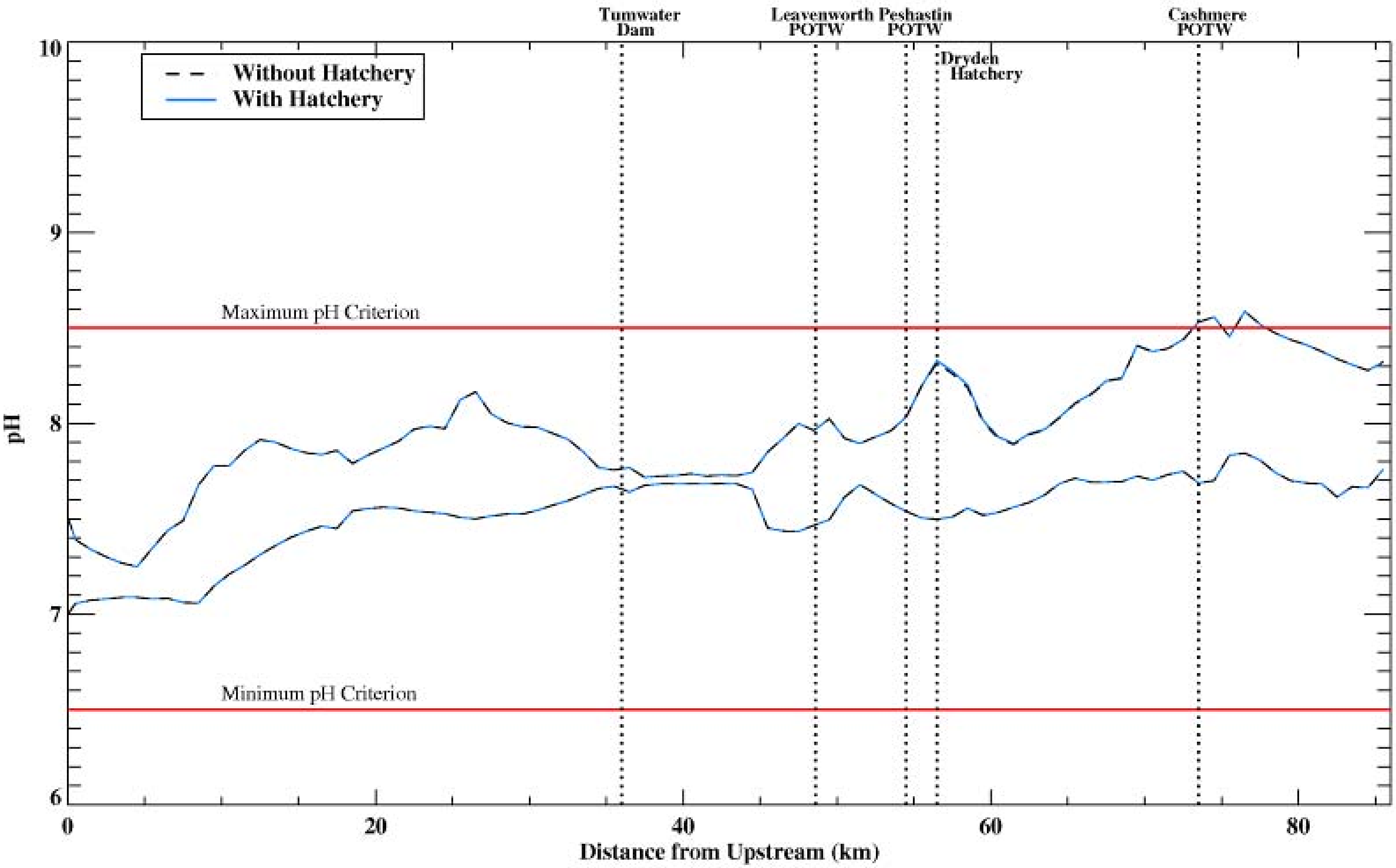



**Figure 11**

pHs simulated by QUAL-2K model shown compared for cases with and without proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_dryden.pro Thu Jul 22 08:32:17 2010

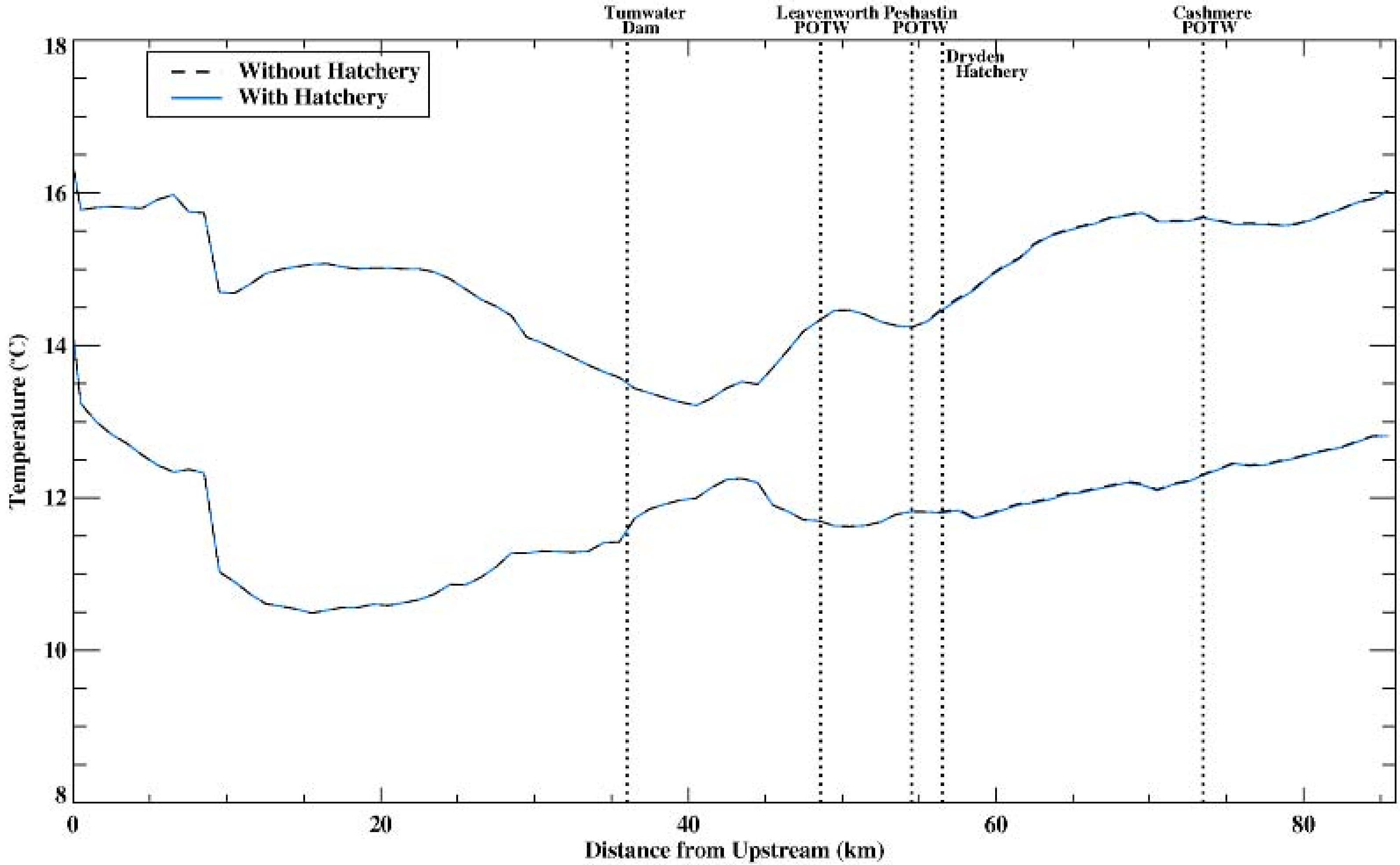



**Figure 12**

Temperatures simulated by QUAL-2K model shown compared for cases with and without proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

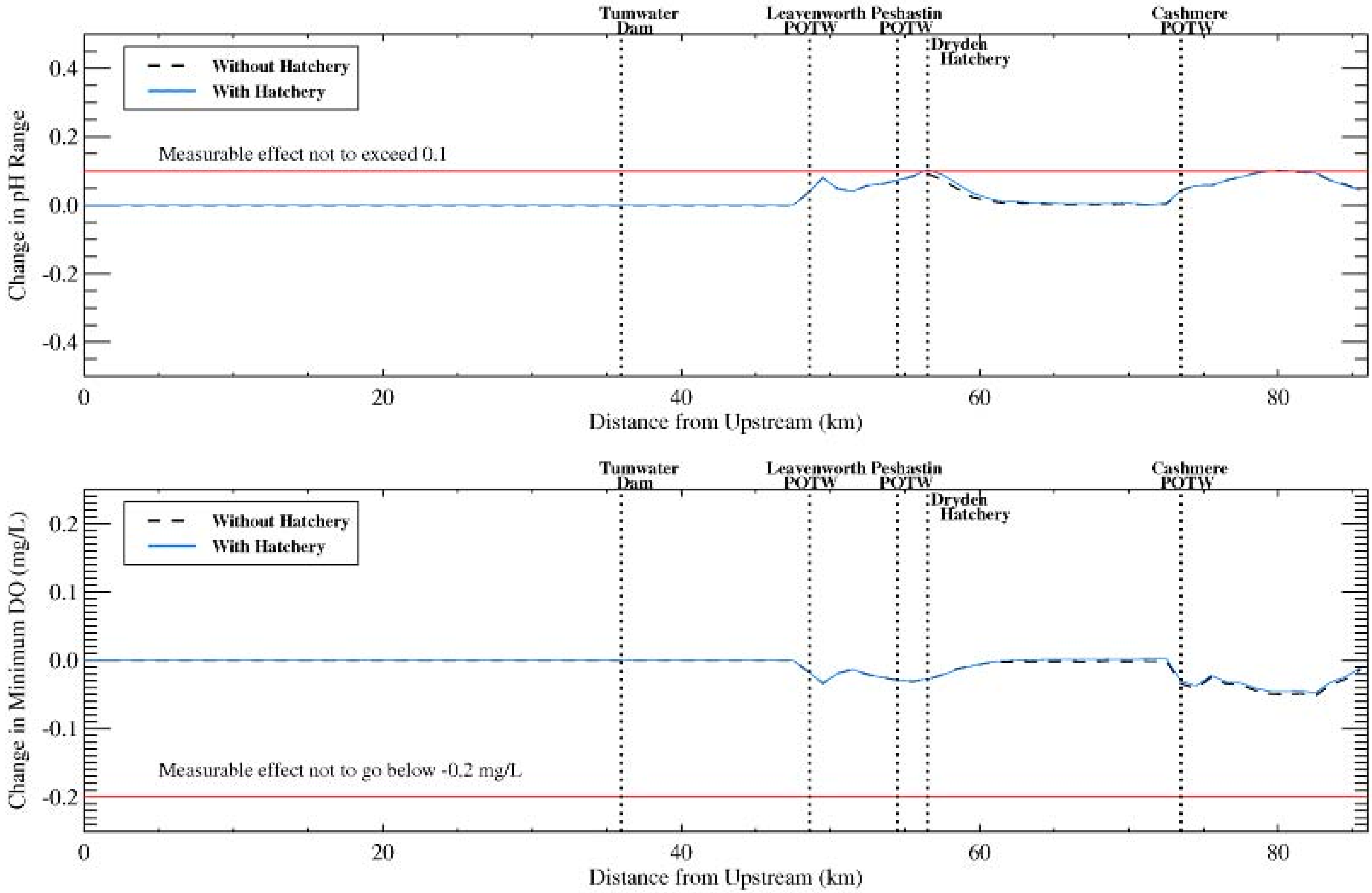



**Figure 13**

Difference from natural conditions in range of pH and minimum dissolved oxygen at permissible POTW loading with and without the proposed hatchery at Dryden

*Dryden Hatchery discharge was assumed to occur at river km 56.5 just upstream of Dryden Dam with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*

ANCHOR OEA

PM - C:\AC\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_dryden.pro Thu Jul 22 08:32:17 2010

In the vicinity of the hatchery as well as downstream of the Cashmere POTW, the difference in the pH range marginally exceeds the measurable change criterion (by much less than 0.1 unit which is well below the limits of instrument accuracy—see Chapter 5 in Appendix 6) and is well within the typical ranges encountered within a day (Figure 13).

Based on the analysis provided here, it is expected that the discharges from the Dryden Hatchery will have minimal impacts on the water quality of the lower Wenatchee River even under critical low-flow conditions.

### *4.2.10 George Hatchery*

George Hatchery is being considered as an alternative to the Dryden Hatchery if the operation of the latter is determined to be infeasible. Discharge from the hatchery will enter the Wenatchee River 3 km downstream of the Lake Wenatchee outlet. Discharges from this hatchery, if operated, will flow through a disconnected side channel for about a mile before entering the Wenatchee River.

The hatchery is expected to be operated under the same conditions as Dryden. Therefore, the QUAL-2K modeling approach taken to evaluate the discharge impacts was adopted here. The impact of hatchery operation was evaluated for 7Q10 summer low flow conditions. The only difference between this model setup and the one employed for Dryden is the location of the discharge. The reader is referred to the previous section for details on the assumptions, and phosphorus loading calculations.

The channel into which the discharge from the proposed hatchery will enter is vegetated significantly and flows only during flood events. Therefore, it is unlikely that the hatchery discharge will enter the Wenatchee River in its entirety during critical summer conditions due to infiltration losses to the underlying aquifer. Also, significant amounts of nutrients will be assimilated in the 20 acres of side channel habitat that exists between the hatchery discharge and the river. However, for the purposes of this evaluation it is assumed that the discharge will reach the Wenatchee River in its entirety without any assimilation of phosphorus, and without any loss in flow. This is likely a substantial over estimate of the loading to the Wenatchee River, but in the absence of additional information further refinement was not possible and this conservative approach was adopted.

#### *4.2.10.1 Model Predictions and Impact Analysis*

Figures 14 through 18 show the simulated steady state flow, TP, DO, pH and temperature respectively for the cases with and without the proposed hatchery. Changes to flow (Figure 14) are minimal given the small quantity of flow expected from the discharge. Phosphorus concentration (Figure 15) was predicted to increase downstream of the discharge but the differences over natural conditions are imperceptible past Tumwater Dam. In the same section of the river both dissolved oxygen (Figure 16) and pH (Figure 17) show significantly wider ranges compared to the natural condition predictions. Predicted temperature range (Figure 18) showed negligible change over natural conditions simulation.

Figure 19 shows the difference over the maximum natural conditions simulation for the case with the hatchery discharge. The differences in section of the river upstream of Tumwater Dam are relatively higher, particularly between river kilometer 5 through 15 where the changes are predicted to exceed the threshold for measurable change.

These differences can be explained from the context of the hatchery loading relative to the background phosphorus load. The hatchery loading contribute to about 9% of the background load in the upstream section. The relative contribution for the Dryden Hatchery was calculated to be about 3% of the predicted background load immediately upstream of the discharge. Thus, the higher background concentration downstream of the George Hatchery discharge could produce a measurable change in DO and pH on a localized scale.

When viewed in light of the fact that a very conservative estimate was used for specifying the load, the negligible impacts in the downstream reaches particularly in the TMDL domain (i.e., downstream of the city of Leavenworth) where the water quality changes resulting from the hatchery loads are imperceptible from the background condition simulation. Thus, it is concluded that while localized impacts are possible due the proposed hatchery, impacts farther downstream is unlikely.

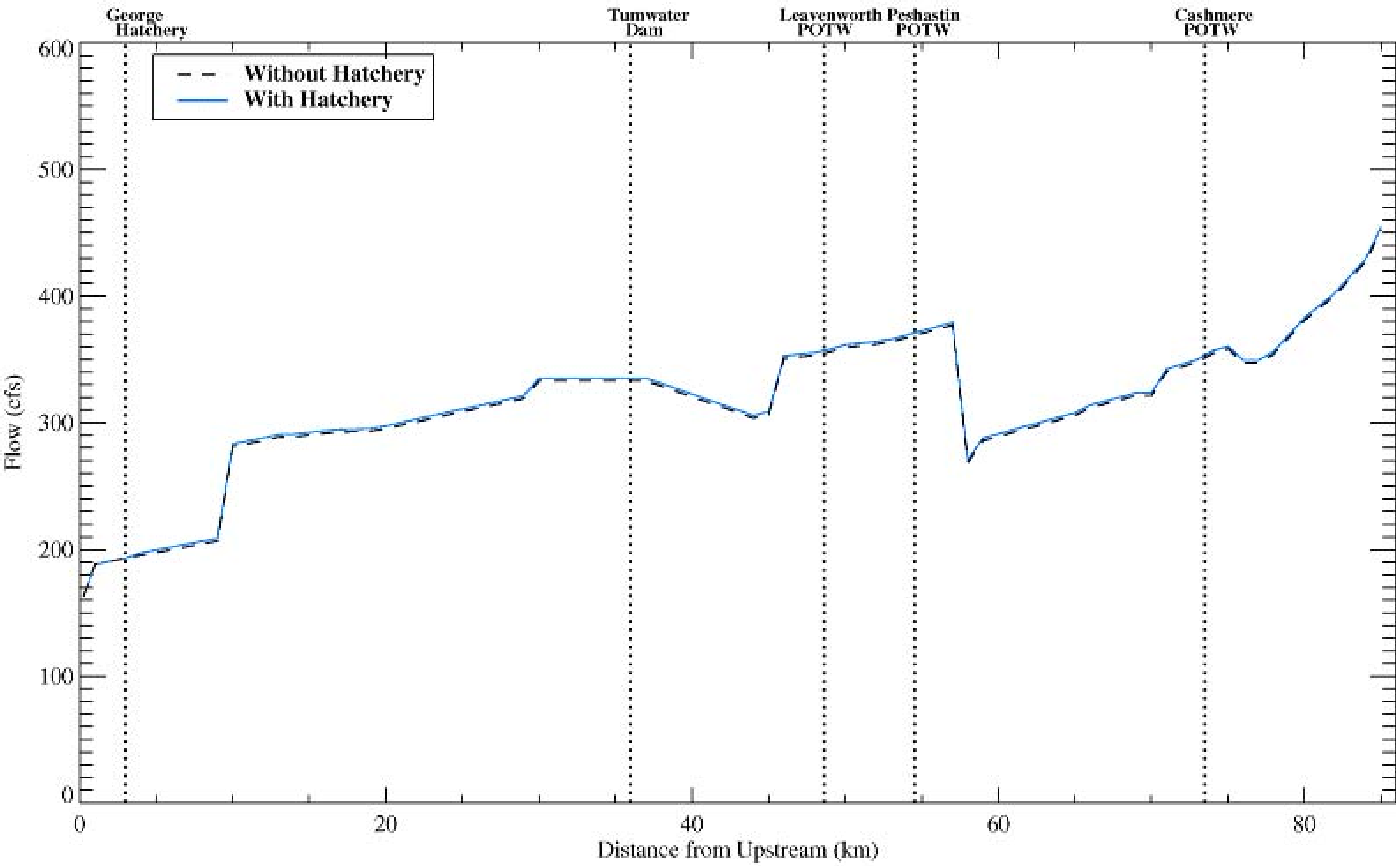



**Figure 14**

Flows simulated by QUAL-2K model shown compared for cases with and without discharge from George Hatchery

*George Hatchery discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

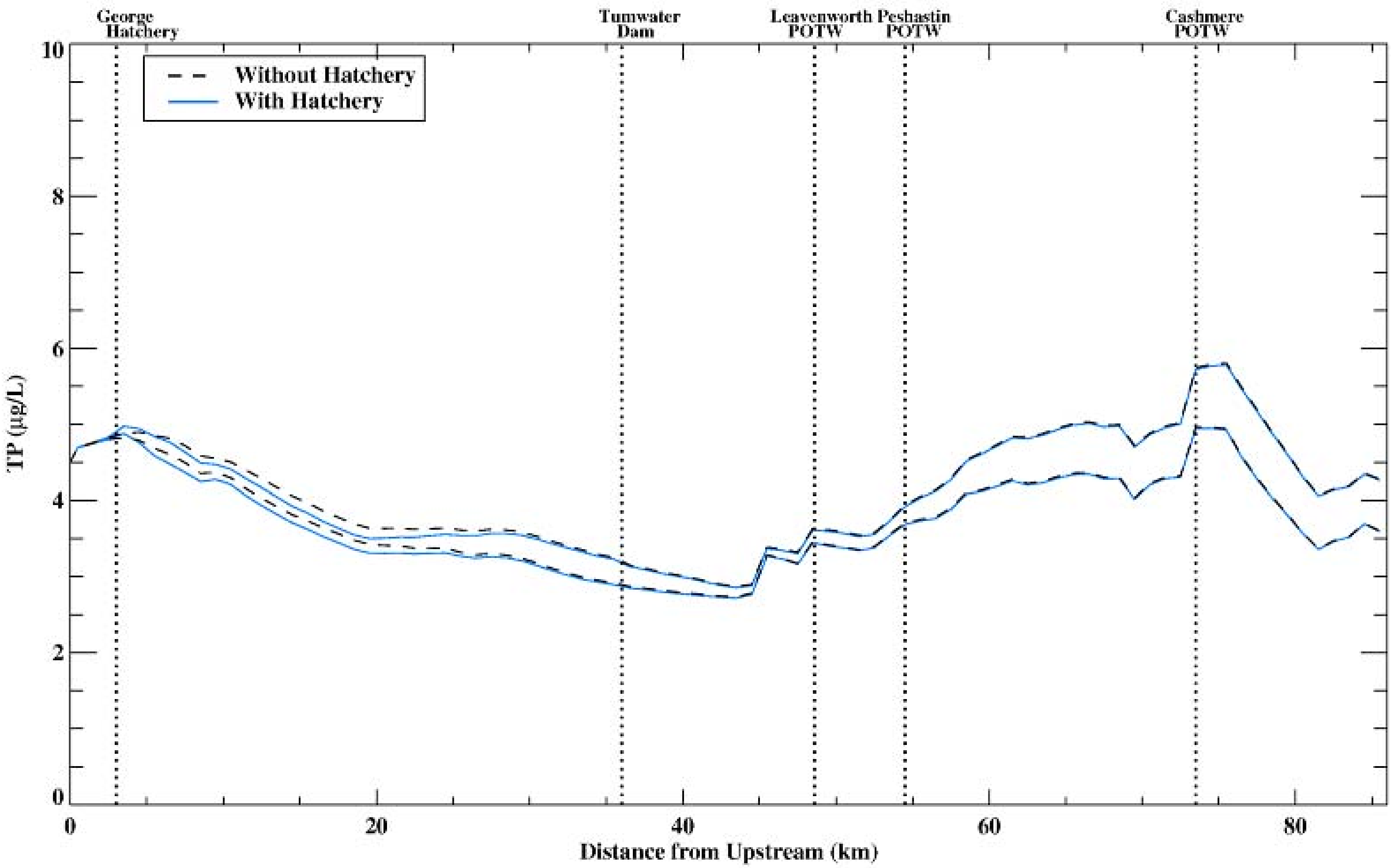



**Figure 15**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for cases with and without discharge from George Hatchery

*George Hatchery discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR OEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_dryden.pro Tue Nov 02 12:13:39 2010

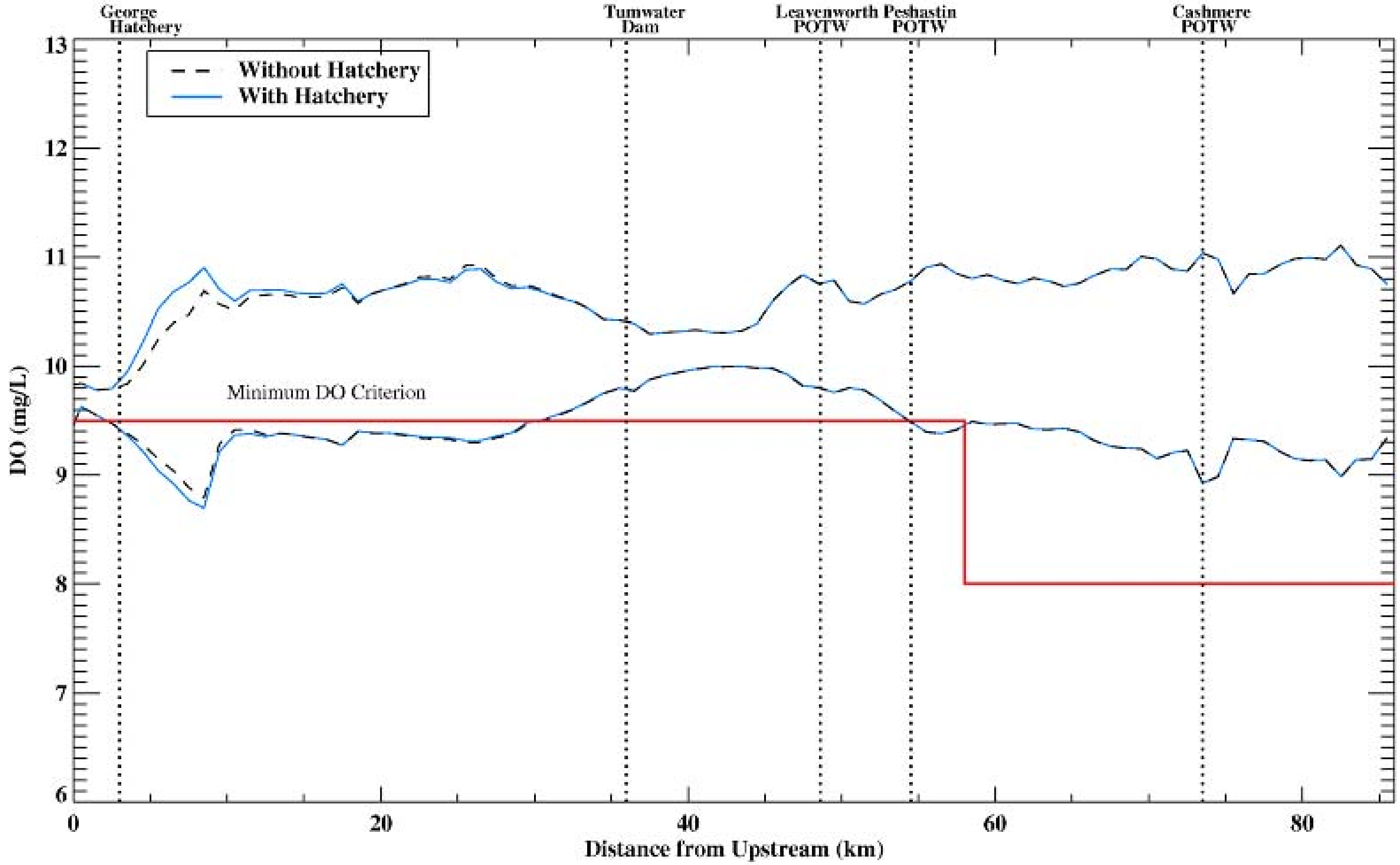



**Figure 16**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for cases with and without discharge from George Hatchery

*George Hatchery discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_oxygen.pro Tue Nov 02 12:13:39 2010

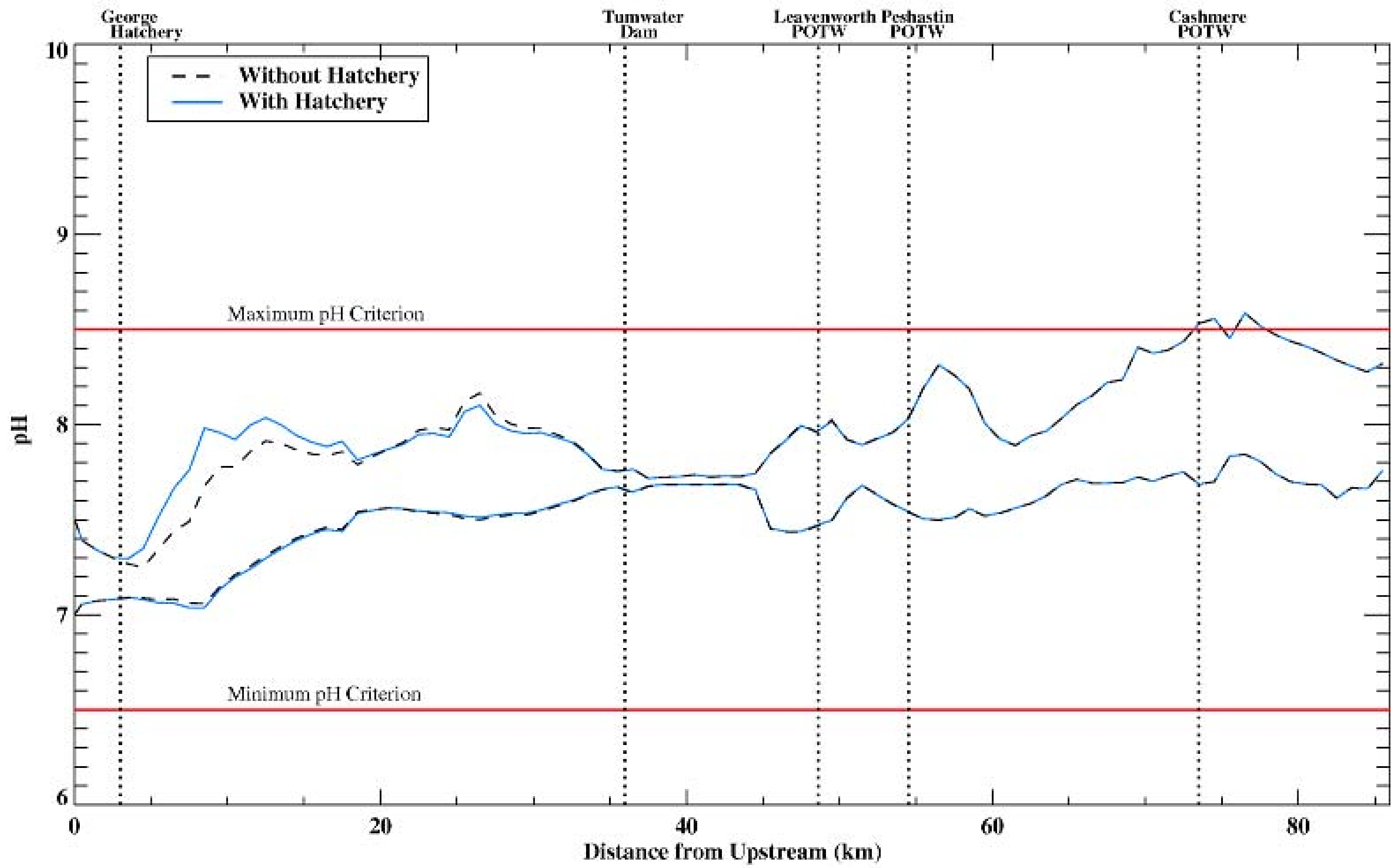



**Figure 17**

pHs simulated by QUAL-2K model shown compared for cases with and without discharge from George Hatchery

*George Hatchery discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

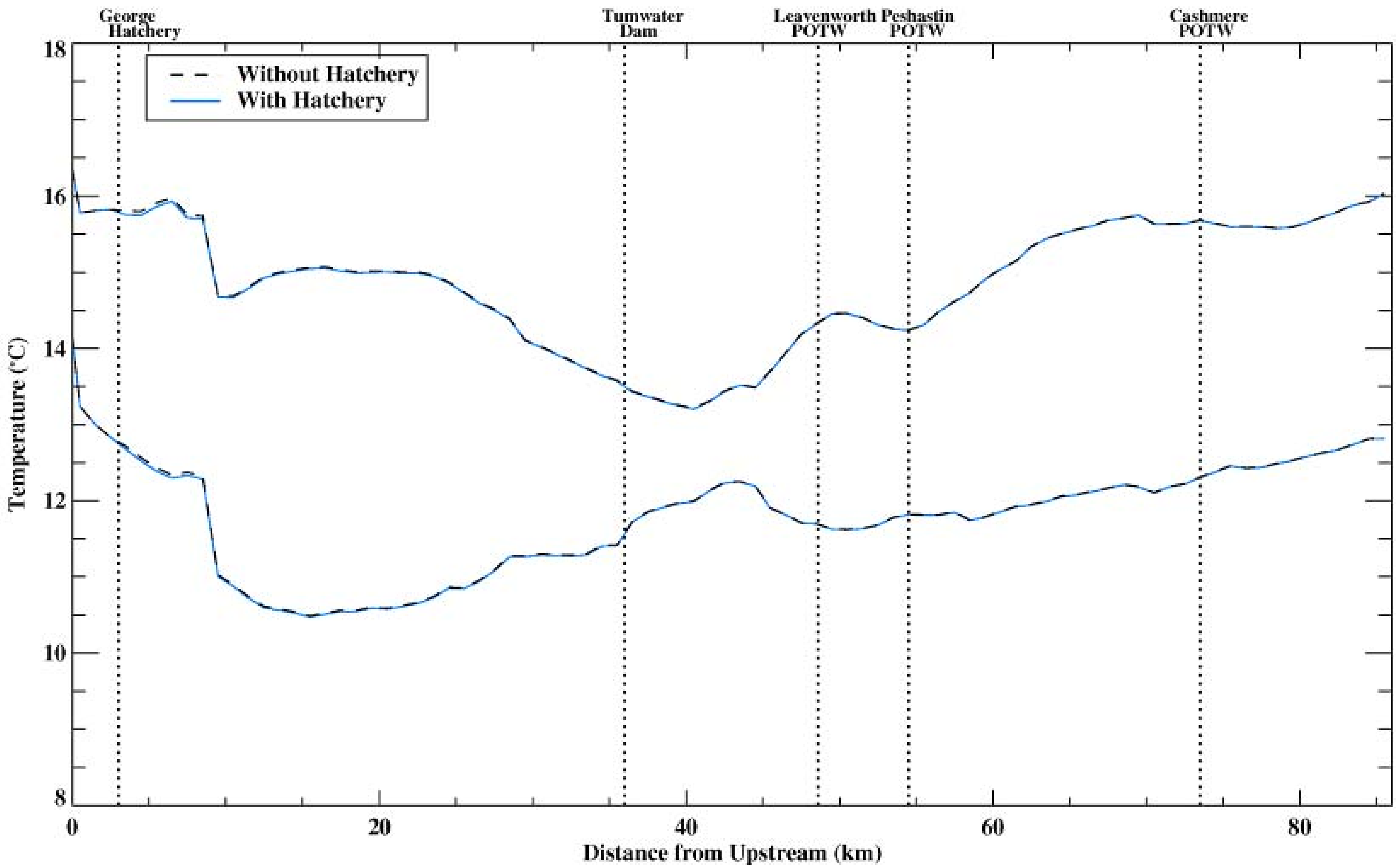



**Figure 18**

Temperatures simulated by QUAL-2K model shown compared for cases with and without discharge from George Hatchery

*George Hatchery discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_CohoModel\Postprocessor\plot_q2k_res_dryden.pro Tue Nov 02 12:13:39 2010

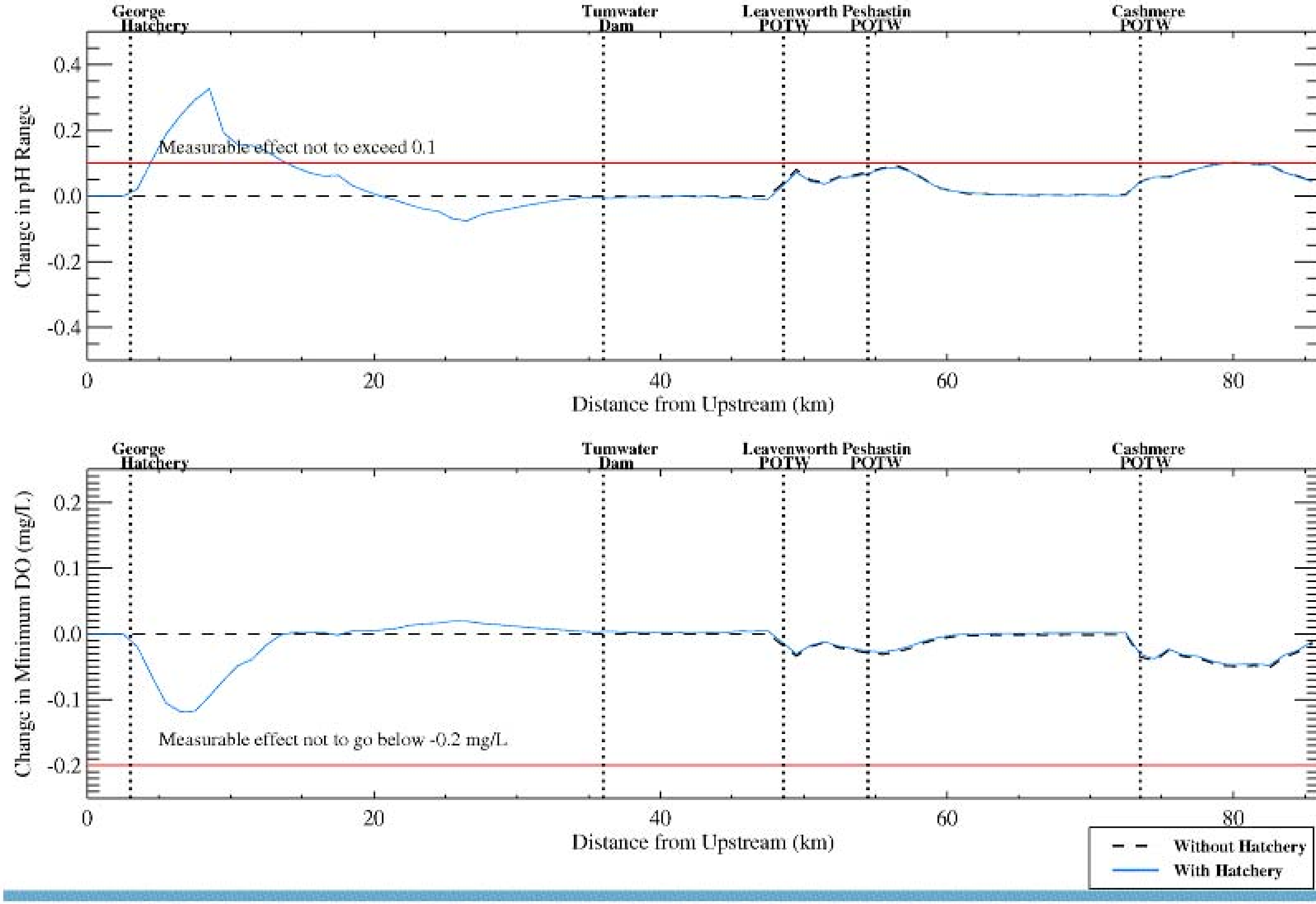



**Figure 19**

Difference from natural conditions in range of pH and minimum dissolved oxygen at permissible POTW loading with and without George Hatchery discharge

ANCHOR QEA

*Discharge was assumed to occur at river km 3 with an estimated inorganic phosphorus load of 42.5 g/d*
*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*

## 4.3 Methow Subbasin Sites

The site-specific acclimation-related nutrient loads for the Methow sites were calculated using an approach similar to that of the Wenatchee sites. Loads estimated from measured data at active acclimation sites in Nason Creek (see Table 5) were used for this analysis. The TP loads estimated for the proposed sites in the Methow subbasin are shown in Table 9.

The Methow subbasin was not sampled at the same spatial and temporal resolutions as the Wenatchee subbasin. Historical information on phosphorus concentrations for the acclimation months was limited. Therefore, the evaluations performed here are based on the potential for the acclimation-related TP loads dominating the background conditions as determined by a comparison to the impacts assessed for the Wenatchee subbasin. This method is possible because the characteristics of the Wenatchee and Methow subbasins are comparable (see Section 5.1.2 for a detailed discussion of the similarities).

### *4.3.1 Methow River Mainstem*

#### *4.3.1.1 Goatwall*

This is the most upstream site proposed that would discharge directly into the Methow River. For the relatively small number of smolts (50,000) acclimated, the TP loading to the Methow River is expected to be about 16 g/d. The average flow from 1990 through 2010 for the months of March through May in this section of the Methow River (USGSG Gage 12447383, Methow River near Goat Creek) is about 900 cfs, which is comparable to the flow at the mouth of the White River in the Wenatchee subbasin (WDOE Station 45K090, March through May average from 2003 through 2010 is about 1,000 cfs). Given the predominantly forested nature of the upper portions of the Wenatchee and Methow subbasins, the background phosphorus concentrations are likely to be similar. It was shown that a TP load of up to 35 g/d (see Table 6) from individual acclimation-related discharges in the White River will only comprise a very small fraction (less than a fifth of a percent) of the background load. Given the similarity in the flows and land type between the two watersheds, the impacts are expected to be similarly negligible in this reach of the Methow River due to discharges from this site.

#### *4.3.1.2 Heath*

About 200,000 smolts are expected to be acclimated in a large pond at the proposed Heath acclimation site. The TP loads from this site are estimated to be four times that of Goatwall at about 64 g/d. This site is located upstream of the city of Winthrop in the same section of the river as Goatwall (although farther downstream). Therefore, the assessment applied for Goatwall can be extended here. Even though the load is higher, this is comparable in magnitude to the largest load expected for the White River sites. By extending the reasoning from Goatwall, the impacts are expected to be similarly negligible.

#### 4.3.1.3 Winthrop National Fish Hatchery (WNFH)

This is a public hatchery and discharges from this site are covered by a discharge permit. The loads from acclimation activity are expected to be about 32 g/d. Some level of treatment of the discharge that is associated with hatchery operations is expected. Thus, the loads from this site will be even smaller. Therefore, potential impacts related to acclimation activity are expected to be negligible.

### 4.3.2 Chewuch River

#### 4.3.2.1 Methow State Wildlife Area (MSWA)

The MSWA site is the most upstream proposed site on the Chewuch River, located in a side channel above the confluence with Eight Mile Creek. About 87,500 smolts are proposed to be acclimated, for which the estimated TP load to the system is 28 g/d. The watershed for the Chewuch is similar to the upper portions of the Methow River (predominantly forested with very little anthropogenic influence). Thus, a similar approach as that used for the upper Methow sites (Goatwall and Heath) was used here. The long-term (1991 through 2010) average flow for March through May reported at the USGS Gage in Winthrop (Chewuch at Winthrop, USGS Gage 12448000) is about 700 cfs, which is lower than but comparable to the upper Methow River flows. Given the similarity in the subbasin characteristics, background loads, and acclimation-related nutrient loads, water quality impacts from acclimation activity are expected to negligible.

#### 4.3.2.2 Mason

Discharges from this proposed site enter the Chewuch River through Eight Mile Creek. The number of smolts proposed to be acclimated at this site is identical to MSWA. Given its proximity to MSWA and the similarity in in-stream conditions, impacts are expected to be similar to MSWA.

#### 4.3.2.3 Pete Creek Pond

Approximately 125,000 smolts are expected to be acclimated at this site, corresponding to a TP load of 40 g/d. This site is proposed on the lower Chewuch River where the watershed and background loads will be comparable to the other two Chewuch River sites. While the acclimation-related loads are expected to be higher (by 40% compared to MSWA) due to the greater number of fish acclimated, the background loads in the Chewuch River will be much higher. Moreover, this site is located closer to the confluence with the Methow River, thereby providing greater dilution of any phosphorus loading that is transported farther downstream. Given these factors, acclimation activity-related impacts on the receiving stream are expected to be negligible.

**Table 9**
**TP loads estimated for proposed acclimation activity in the Methow Subbasin**

| Proposed Site | # of Fish (thousands) | TP Load[1] (kg/d) | Receiving Stream |
|---|---|---|---|
| Goat Wall | 50 | 0.016 | Methow |
| Heath | 200 | 0.064 | Methow |
| Winthrop NFH | 100 | 0.032 | Methow |
| MSWA | 87.5 | 0.028 | Chewuch |
| Mason | 87.5 | 0.028 | Chewuch |
| Pete Creek Pond | 125 | 0.040 | Chewuch |
| Lincoln | 110 | 0.035 | Twisp |
| Twisp Weir | 110 | 0.035 | Twisp |
| Lower Twisp | 30 | 0.01 | Twisp |
| Parmley | 50 | 0.016 | Beaver |
| Gold | 50 | 0.016 | Gold |

Notes:
1. Estimated from average load of 0.32 mg per fish per day calculated from measured data at active discharges in Nason Creek.

kg/d kilograms per day

### *4.3.3 Twisp River*

#### *4.3.3.1 Lincoln*

This site is the most upstream among the proposed sites on the Twisp River. The TP load in the discharge associated with the proposed acclimation of 110,000 smolts is expected to be about 35 g/d.

The primary anthropogenic influence in the Twisp River occurs near the city of Twisp, which is at the confluence of the Twisp and Methow rivers. Thus, much of the Twisp River watershed is forested, which is similar to the upper section of the Methow River and the Chewuch River. Therefore, background phosphorus concentrations in the Twisp River will likely be similar. The Twisp River flows are smaller than those in the upper Methow River and Chewuch River (average flow at the USGS Gage 12448998 on the Twisp River near the city of Twisp for March through May in 1990 through 2010 is about 440 cfs). Therefore, background loads in the Twisp River will be smaller, and the acclimation-related loads can be a larger proportion of the background loads than what will be encountered in the Chewuch River and upper Methow River sites. Even if the proportion is double what is expected at the upper Methow River and Chewuch River sites, it is still expected be a small fraction of the background conditions (see proportions calculated for the upper Wenatchee River sites in Table 6 for an order of magnitude estimate). Impacts on the receiving stream are therefore expected to be negligible.

#### 4.3.3.2 Twisp Weir

This site is the located approximately midway between the Lincoln site and the confluence of the Twisp River with the Methow. As with Lincoln, the TP load in the discharge associated with the proposed acclimation of 110,000 smolts is expected to be about 35 g/d. Given the similar in-stream conditions to the Lincoln site and the same number of fish being proposed, impacts resulting from the Twisp Weir site are expected to be negligible.

#### 4.3.3.3 Lower Twisp

The Lower Twisp proposed acclimation site is located close to the Twisp River confluence with the Methow River. For the 30,000 fish proposed at this site the acclimation-related TP loads are expected to be less than 10 g/d. Given the Lower Twisp River site's proximity to the Methow River, greater dilution of the TP load can be expected downstream of the confluence. Therefore, impacts for this site will likely be lower than for the Lincoln site.

### 4.3.4 Beaver Creek – Parmley

The Parmley site is expected to be used for acclimating 50,000 smolts. The TP load associated with this site is an estimated 16 g/d. Beaver Creek is smaller than the other streams considered thus far; however, the number of fish proposed for acclimation at this site is proportionally smaller. Consequently, the nutrient loading that could occur as a result of acclimation at this site is also expected to be smaller than the other sites discussed thus far. Impacts are therefore likely to be negligible. A more definitive evaluation was not possible due to the lack of sufficient data for calculating background loads in the creek.

### 4.3.5 Gold Creek – Gold

This proposed site is located in the lower Methow subbasin. About 50,000 smolts are expected to be acclimated here, with a corresponding TP load of about 16 g/d to Gold Creek. Gold Creek is similar in size to Beaver Creek. Also, because this is the only acclimation site proposed on Gold Creek with the same number of fish as proposed for the Parmley site on Beaver Creek, localized impacts are expected to be similarly negligible.

### 4.3.6 Back-up Acclimation Sites

Five backup sites are proposed for the Methow subbasin. The TP loads estimated for these sites are presented in Table 10 and discussed in the following sections.

#### 4.3.6.1 Chewuch Acclimation Facility

This is an existing acclimation facility proposed for expansion under this project in case other sites on the Chewuch River are not developed. About 125,000 smolts will be acclimated in the proposed site. The TP loads associated with this activity are expected to be about 40 g/d. The assessments from the other Chewuch River sites can be extended here due to the similarity in location and number of fish. Impacts are expected to be negligible.

#### 4.3.6.2 Methow Salmon Recovery Foundation (MSRF)

The number of fish proposed for acclimation at the MSRF site is the same as proposed for the Chewuch Acclimation Facility (about 125,000). Given the site's proximity to the confluence with the Methow River and the similarity in the magnitude of the estimated TP loads to the other Chewuch sites for which localized impacts were expected to be negligible, localized impacts on the Chewuch River due to TP loading from this site are expected to be negligible.

#### 4.3.6.3 Biddle

This acclimation site is located on Wolf Creek. About 16 g/d of TP is expected to be discharged due to the proposed acclimation of about 50,000 smolts. Given that this is the only site on a relatively small creek, the impacts are likely to be similar to those estimated for the Parmley and Gold Creek sites. A detailed evaluation of localized impacts associated with this proposed site was precluded by a paucity of data.

#### 4.3.6.4 Canyon

This is the most upstream of the proposed back-up acclimation sites on the Twisp River. For the 83,000 smolts proposed to be acclimated here, the TP loads are expected to be about 27 g/d. The number of fish proposed is less than Lincoln and Twisp Weir (the two primary sites) on the Twisp River. Following the discussion for the larger primary sites (Section 4.3.3) the arguments for negligible impact from those sites can be extended here.

#### 4.3.6.5 Utley

The Utley site is proposed with the same number of smolts downstream of the Canyon site. The TP loads and the impacts are expected to be similar.

**Table 10**
**TP loads estimated for backup sites in the Methow Subbasin**

| Proposed Site | No. of Fish (thousands) | TP Load[1] (kg/d) | Receiving Stream |
|---|---|---|---|
| Chewuch A.F. | 125 | 0.040 | Chewuch |
| MSRF | 125 | 0.040 | Chewuch |
| Biddle | 50 | 0.016 | Wolf |
| Canyon | 83 | 0.027 | Twisp |
| Utley | 83 | 0.027 | Twisp |
| Newby | 83 | 0.027 | Twisp |
| Poorman | 83 | 0.027 | Twisp |
| Balky Hill | 50 | 0.016 | Beaver |

Notes:
1. Estimated from average load of 0.32 mg per fish per day calculated from measured data at active discharges in Nason Creek.

kg/d kilograms per day

#### *4.3.6.6 Newby*

The Newby site is proposed with the same number of smolts downstream of the Canyon and Utley sites. The TP loads and the impacts are expected to be similar to the other two sites.

#### *4.3.6.7 Poorman*

This proposed acclimation site is located farthest downstream of all back-up sites on the Twisp River. Given its proposed location on the Twisp River and the identical number of fish to the other Twisp sites, the arguments for negligible impact from those sites can be extended here.

#### *4.3.6.8 Balky Hill*

This site is located in Beaver Creek, and impacts are expected to be similar to those at the Biddle and Parmley sites. As with the Biddle site, due to lack of sufficient data, a detailed evaluation of localized impacts was not possible.

# 5 EVALUATION OF COMBINED AND CUMULATIVE IMPACTS

The assessments provided in the previous sections have indicated that water quality impacts from the individual sites are likely to be negligible because they would not result in a measurable change in the DO and pH levels in the receiving water. In addition to the assessment of the impacts from the individual sites, the combined and cumulative impacts on the water quality of the Wenatchee and Methow rivers required assessment. For the purposes of this assessment, combined and cumulative impacts were defined as follows:

- *Combined impacts* are the water quality impacts, specifically pH, DO, and temperature excursions, that lead to measurable change, as defined in Section 2.2, in the Wenatchee and Methow subbasins based on all the discharges proposed in this project at each subbasin without the influence of any other anthropogenic sources. Back-up sites are not included as they will be used only as replacements for the primary proposed sites.
- *Cumulative impacts* are the combined water quality impacts under the condition that all anthropogenic and natural influences are simultaneously considered while evaluating the discharges proposed in this project.

## 5.1 Approach

The approach for evaluation of combined and cumulative impacts differed between the two subbasins because a calibrated water quality model was readily available for the Wenatchee River, but such a model was not available for the Methow River. Development of such a model for the Methow would require a great deal of focused data collection, which was beyond the scope of this assessment. Thus, a more simplistic approach, as discussed in the following sections, was adopted for the Methow.

### 5.1.1 Wenatchee Subbasin

The mass balance model developed by WDOE for the purpose of establishing load allocations (Carroll et al. 2006; Carroll and Anderson 2009) was applied to assess both the combined and cumulative impact evaluations for the Wenatchee River (hereafter referred to as the lower Wenatchee subbasin). The portion of the Wenatchee subbasin composed of Lake Wenatchee and its tributaries, the White River and the Little Wenatchee River (hereafter referred to as the upper Wenatchee subbasin) was evaluated based on mass balance analyses using existing water quality and flow data as discussed below.

### 5.1.2 Methow Subbasin

A rigorous mass balance model, such as the one developed by WDOE for the Wenatchee subbasin, was not undertaken for the Methow subbasin due to the paucity of data for model development and calibration. The evaluation for the Methow subbasin applied existing data. Loads estimated for the Methow were compared to the trends simulated using the QUAL-2K model for the Wenatchee subbasin and results and conclusions from the Wenatchee subbasin were used to inform the assessment of impacts in the Methow subbasin.

Important subbasin characteristics that affect in-stream conditions including water quality and quantity are shown compared for the two subbasins in Table 11. Both watersheds are predominantly forested. Both have the high peaks of the Cascade Mountains that contribute the majority of flows through snowmelt in spring. In both subbasins, much of the precipitation occurs during the months of October through March, and this precipitation is predominantly in the form of snow (Andonaegui 2001; Konrad et al. 2003).

**Table 11**
**Comparison of Methow and Wenatchee subbasins**

| Attribute | Methow | Wenatchee |
|---|---|---|
| Area (sq.mi.) | 1,825 | 1,333 |
| Elevation Range (ft) | 800 (near Pateros) to 8,500 (Cascade Crest) | 610 (near Wenatchee) to 5,000 (Cascade Crest) |
| Annual Precipitation (inches) | 10 (Pateros) to 80 (Cascade Crest) | 8.5 (Wenatchee) to 150 (Cascade Crest) |
| Predominant Form of Precipitation | Snow | Snow |
| Predominant Land Type | Forest (about 87%) | Forest (about 70%) |

Data Sources: KWA Ecological Sciences Inc. et al. 2004; Andonaegui 2000; Andonaegui 2001

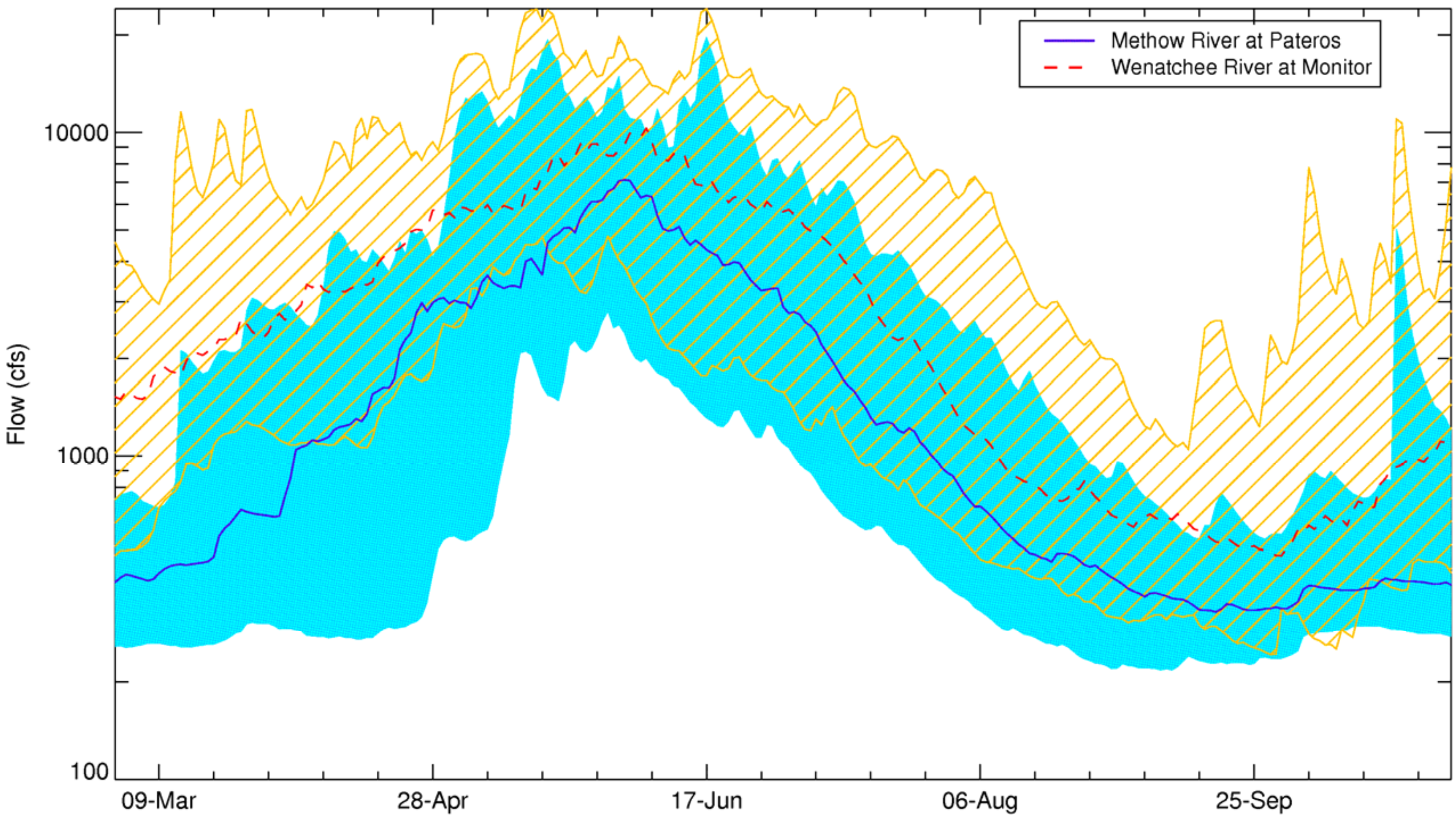



**Figure 20**

Comparison of flows in Methow and Wenatchee Rivers

*Medians and ranges over 1990 to 2009 are plotted. Shaded regions show the respective ranges and central lines show the medians*

Table 11 shows that the Methow subbasin is somewhat drier (even though it is larger in terms of area) than the Wenatchee subbasin. This is evident in the long-term flows shown in Figure 20 where the Wenatchee River flows are higher. Notwithstanding these differences, the flow patterns in Figure 20 are consistent between the two subbasins with coincident peak and dry flow periods. This indicates that flow-driven processes such as mobilization of particulates, dilution of nutrients, in-stream re-aeration, and habitat conditions for attached algae are likely to be similar between the two subbasins. Moreover, a majority of the watershed is forested for both subbasins, with minimal anthropogenic influence. The populations within the Methow and Wenatchee subbasins, excluding the city of Wenatchee, are similar, at around 5,000 based on the census from the year 2000. The city of Wenatchee is at the confluence of the Wenatchee and Columbia rivers. Nutrient loads from the city's sources do not pose any water quality concerns for the Wenatchee River.

Based on this discussion, it is evident that the similarities between the two subbasins provide some justification for using the evaluation for the Wenatchee subbasin to inform the assessment performed for the Methow subbasin.

## 5.2 Conservative Assumptions to Determine Reasonably Maximum Impacts

As described in Section 4, local impacts in the vicinity of the discharges are not expected to adversely impact water quality. The objective of the mass balance modeling was to assess potential combined and cumulative water quality impacts imposed by the proposed project in the most critical areas of the Wenatchee River (i.e., below the City of Leavenworth).

To achieve this objective, several assumptions were made to determine the reasonable maximum impact in the lower Wenatchee River:

1. March was chosen as the critical period for evaluation. All the proposed acclimation sites would be operational at this time. Flows later in the spring increase significantly, diluting nutrient loads and scour attached algae from the system. Approximately half the sites may be operated through the winter but due to the smaller number of fish being acclimated, low water temperatures, and low feed rates, water quality impacts in winter are expected to be lower than during March.
2. Flows in March were specified as the 7Q10 summer low flow calculated by WDOE for the TMDL evaluation (typically, March flows are somewhat higher).
3. Phosphorus discharged due to acclimation activity was considered to be 100% bioavailable (i.e., phosphorus discharges are all in the orthophosphate form such that they can be readily taken up by algae during photosynthesis).
4. Phosphorus released from the acclimation ponds enters the Wenatchee River without undergoing any change while being transported through the receiving stream (i.e., there is no assimilation of phosphorus prior to reaching the Wenatchee River).

This bounding assumption ensures that the entire phosphorus load discharged from the ponds reaches the Wenatchee River.

5. Average phosphorus loads from the proposed acclimation ponds that were developed based on the data collected from the active ponds in Nason Creek from late March through early May are applicable in March. The implication of this assumption is that fish feed rates in March reflect the overall average feed rate. However, feed rates are typically highest immediately before release, which occurs in the beginning of May, and lowest in March when the smolts are smaller.

The assumption that the loadings occur under extreme low-flow conditions maximizes any potential impacts the discharges may have on water quality because the effect of dilution in the receiving water is minimal under these conditions (i.e., this will manifest the highest possible concentration in the receiving water). The other assumptions provide an upper bound estimate of bioavailable phosphorus loads from the discharge location to the lower Wenatchee River. Combined, these assumptions provide an upper bound on the potential impacts that acclimation activity may have in the lower Wenatchee River. If river water quality is protected under these extreme conditions, then it provides a level of confidence that the water quality of the Wenatchee River will be fully protected under the proposed project.

## 5.3 Assessment of Combined Impacts

### *5.3.1 Upper Wenatchee Subbasin – Lake Wenatchee*

Lake Wenatchee is a deep water lake (maximum depth of nearly 100 feet) that is fed by the Little Wenatchee River and the White River and discharges to the Wenatchee River. Four of the proposed acclimation sites discharge to this receiving water system. These include the Two Rivers site in the Little Wenatchee River and the Tall Timber, Gray, and Dirty Face sites in the White River.

Given the relatively large size of the lake and its associated long hydraulic retention period, it is unlikely that loads entering the lake will reach the Wenatchee River directly; instead, they are likely to be cycled within the lake. Therefore, the water quality impact of concern within the upper Wenatchee subbasin is Lake Wenatchee proper. The approach adopted here was to perform a mass balance analysis for phosphorus for the lake based on tributary flows and measured TP concentrations.

Flows estimated for the upper Wenatchee subbasin are shown in Figure 21. Flows for the outlet were estimated based on simple flow balance of gauged flows at the mouth of Nason Creek, the Wenatchee River at Plain, and the mouth of the Chiwawa River. TP data for Lake Wenatchee, the White River, and the Little Wenatchee River were based on Grant and Chelan PUD monitoring programs (Grant PUD 2009; Chelan PUD 2009 – unpublished data).

In addition, for the White and Little Wenatchee rivers, data collected under the project described herein were applied to construct the mass balance.

Figure 22 shows the estimated TP loads for the upper Wenatchee subbasin including the loads at the mouth of Lake Wenatchee. A comparison of flows in conjunction with the TP data shows a clear correlation—higher flows mobilize more phosphorus in the system. The data suggest that TP concentrations in the White River can be high (up to 50 µg/L), while background levels in the Little Wenatchee River did not reach such levels in 2009.

Figure 23 shows the estimated cumulative monthly TP loads that entered and exited the lake in 2009. The differences between the loads brought in by the inflows and the loads leaving the lake are shown in the bottom panel. As expected, the data suggest that the lake acts as a net sink of phosphorus loading from the tributaries. The lake is known to be oligotrophic and the tributaries that contribute to the lake are in forested watersheds with little to no anthropogenic influence. The TP loads brought in are typically associated with high flows (see Figures 21 and 22); much of it is from watershed and snowmelt runoff from forested lands (Chelan County and Yakama Nation 2004), which typically do not have readily bioavailable forms of phosphorus. The TP load entering the lake is therefore most likely dominated by non-reactive particulate forms. These likely settle upon reaching the lake. The lake thus buffers the upstream phosphorus loads and transmits only a fraction of the upstream loads to the Wenatchee River.

To estimate the combined impact of the four proposed locations, the total phosphorus loads anticipated from acclimation activity were calculated based on the proposed number of coho to be acclimated. Table 12 shows the relative contribution of the loads from combined acclimation activity in the White River and the Little Wenatchee River. In 2009, these loads were estimated to contribute less than 0.25% of the total background loads that entered the lake over the acclimation period (March through May) from these two tributaries. This calculation does not account for in-stream assimilation, which, if considered, would further reduce the relative contribution from acclimation activity.

**Table 12**
**Estimated relative contribution of TP loads from 50 days of acclimation activity in upper Wenatchee sites**

| Location | No. of Fish | TP Loading from Acclimation[1] (kg) | TP Load In System[2] (kg) | Contribution to Total |
|---|---|---|---|---|
| Little Wenatchee River | 120,000 | 1.92 | 604.50 | 0.32% |
| White River | 160,000 | 2.56 | 1242.86 | 0.21% |

**Notes:**
1. Uses an estimate of 0.32 mg/d/fish derived from active sites in Nason Creek, see Table 5
2. Loads calculated using 2009 flows and TP measurements from 3/23/2009 to 5/10/2009

kg kilograms

Based on this analysis, the proposed acclimation activity in the upper Wenatchee subbasin will produce TP loads that are sufficiently low as to not produce a measurable impact on the water quality of the tributaries and Lake Wenatchee.

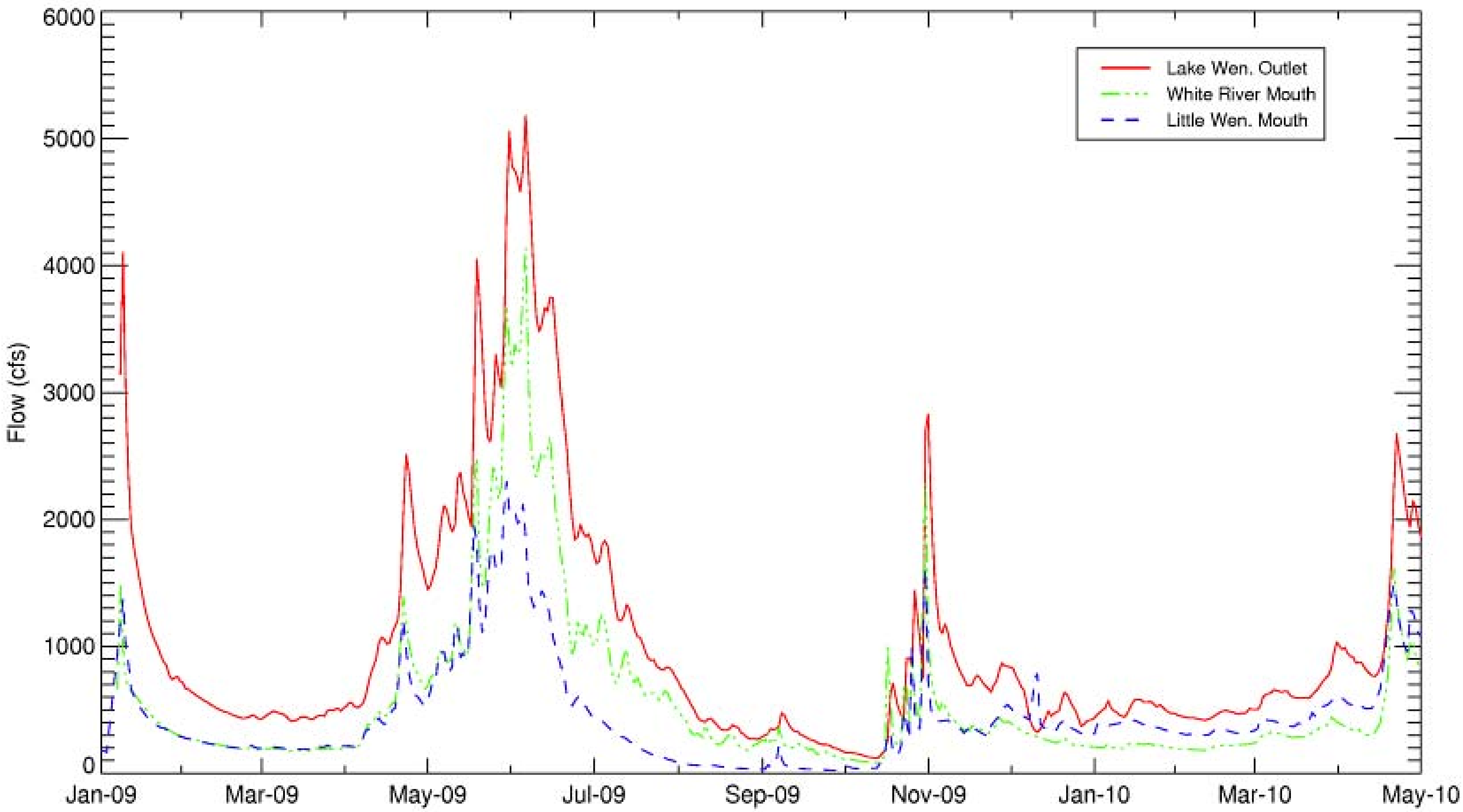


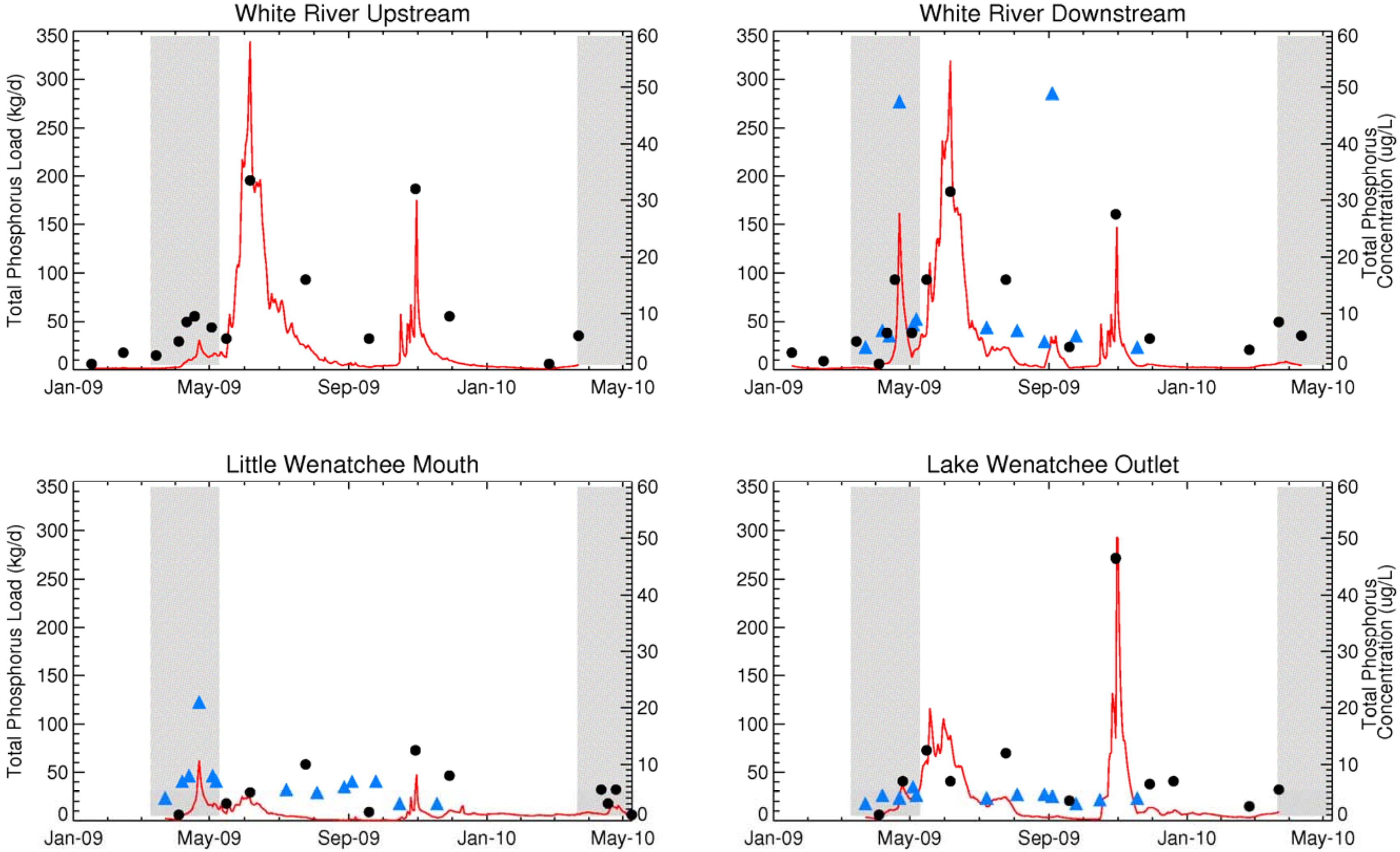

**Figure 21**

Streamflows in the upper Wenatchee subbasin in 2009 and 2010

*Flows at lake outlet estimated from WDOE gage at Nason Creek mouth, and USGS gauges at Wenatchee River at Plain and Chiwawa at Plain*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Lake_Wenatchee\lake_wen_tp_mass_balance.pro Mon Nov 01 10:50:32 2010



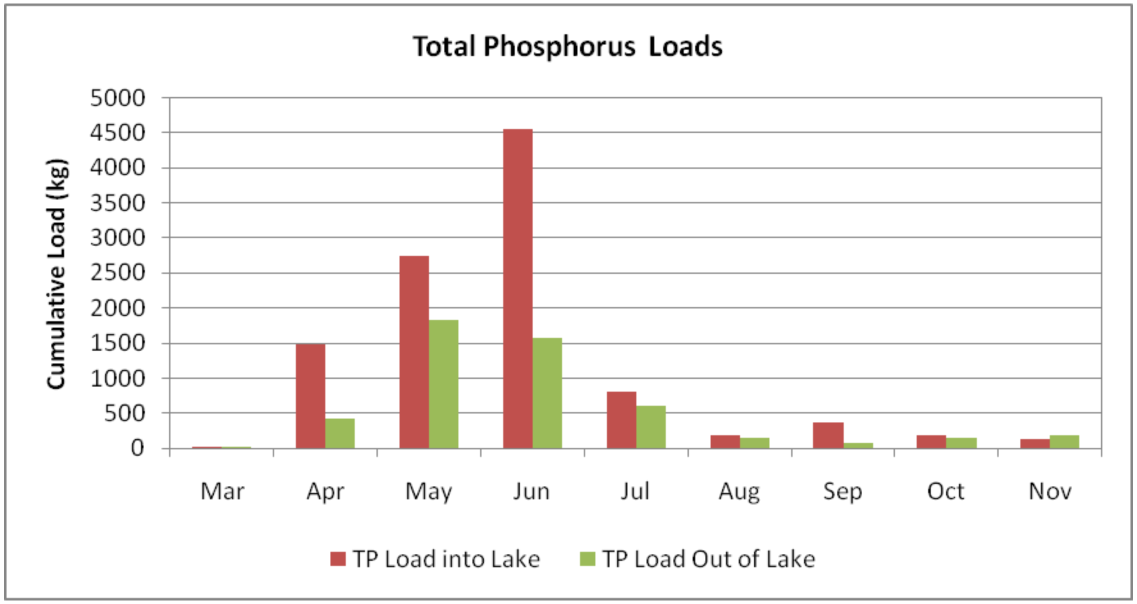

ANCHOR QEA

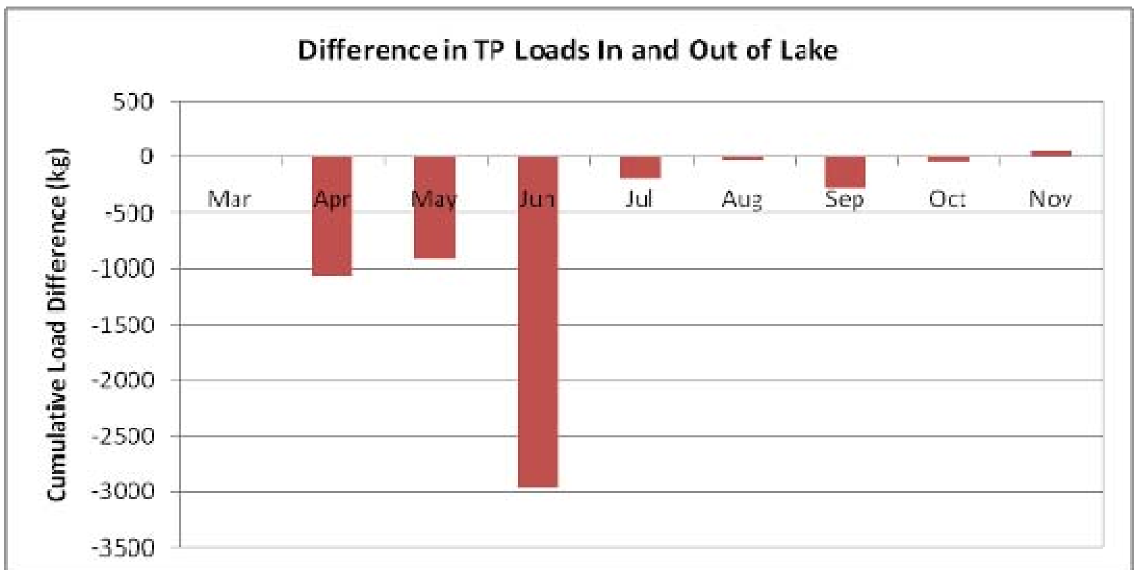
**Figure 22**

Total phosphorus concentration and estimated loads in the upper Wenatchee subbasin

*Daily loads for 2009 were estimated by interpolating within the range of measured concentrations. Concentrations shown are averages of all data collected on any given day. Gray shaded areas show period of proposed acclimation activity. Data Sources: Yakama Nation Monitoring Program; Grant PUD and Chelan PUD Lake Wenatchee Monitoring Programs*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Lake_Wenatchee\lake_wen_tp_mass_balance.pro Mon Nov 01 10:48:02 2010




\\SF-PMUGUNTHAN\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Analysis\Lake_Wenatchee\Mass_balance_analysis.xlsx

ANCHOR QEA

**Figure 23**
Monthly TP loads entering and leaving Lake Wenatchee in 2009
Discharge Evaluation Appendix
Mid-Columbia Coho Restoration Project

### 5.3.2 Lower Wenatchee Subbasin – Wenatchee River

#### 5.3.2.1 Approach for Adopting WDOE's Model

The WDOE TMDL model that was used to determine the Wenatchee River and Icicle Creek phosphorus load allocations (Carroll and Anderson 2009) was applied with minimal changes to assess the potential impacts of the proposed acclimation sites on water quality within the lower Wenatchee subbasin. Changes to the model focused on representing boundary conditions for the month of March. As discussed in Section 5.1, 7Q10 low-flow conditions were used for headwater and all tributaries without modification from the WDOE TMDL model. The simulation was setup to represent March 23 (near the spring equinox), so that photoperiod was approximately equal to that used by WDOE for development of the TMDL which simulated the autumnal equinox period (September 23). Model parameters (e.g., reaction rates, stoichiometric coefficients, etc.) remained unchanged from those applied by the WDOE for the TMDL. Finally, nutrient loads, with the exception of those pointed out in the subsequent sections, were applied unchanged.

Forcing functions applied to the model reflected climatic conditions for the month of March. Long-term March air temperature readings were obtained from National Ocean and Atmospheric Agency's (NOAA's) meteorological station in Leavenworth, Washington. Based on the daily minimum and maximum temperatures recorded for the month of March, a sinusoidal function was developed to capture the diurnal variations (see Figure 24). This function was assumed to be representative of the entire domain from the mouth of Lake Wenatchee to the confluence with the Columbia River. A similar approach was adopted in the WDOE TMDL model. Dew point temperature was estimated from the temperature function in Figure 24, and the relative humidity values were estimated from the WDOE TMDL model. This approach was adopted due to a lack of dew point temperature data for the month of March.

Water temperature is also significantly colder in March compared to summer conditions. A temperature function was developed for the headwater to encompass the range of temperatures measured at the mouth of Lake Wenatchee and in the Wenatchee River in the month of March (see Figure 25).

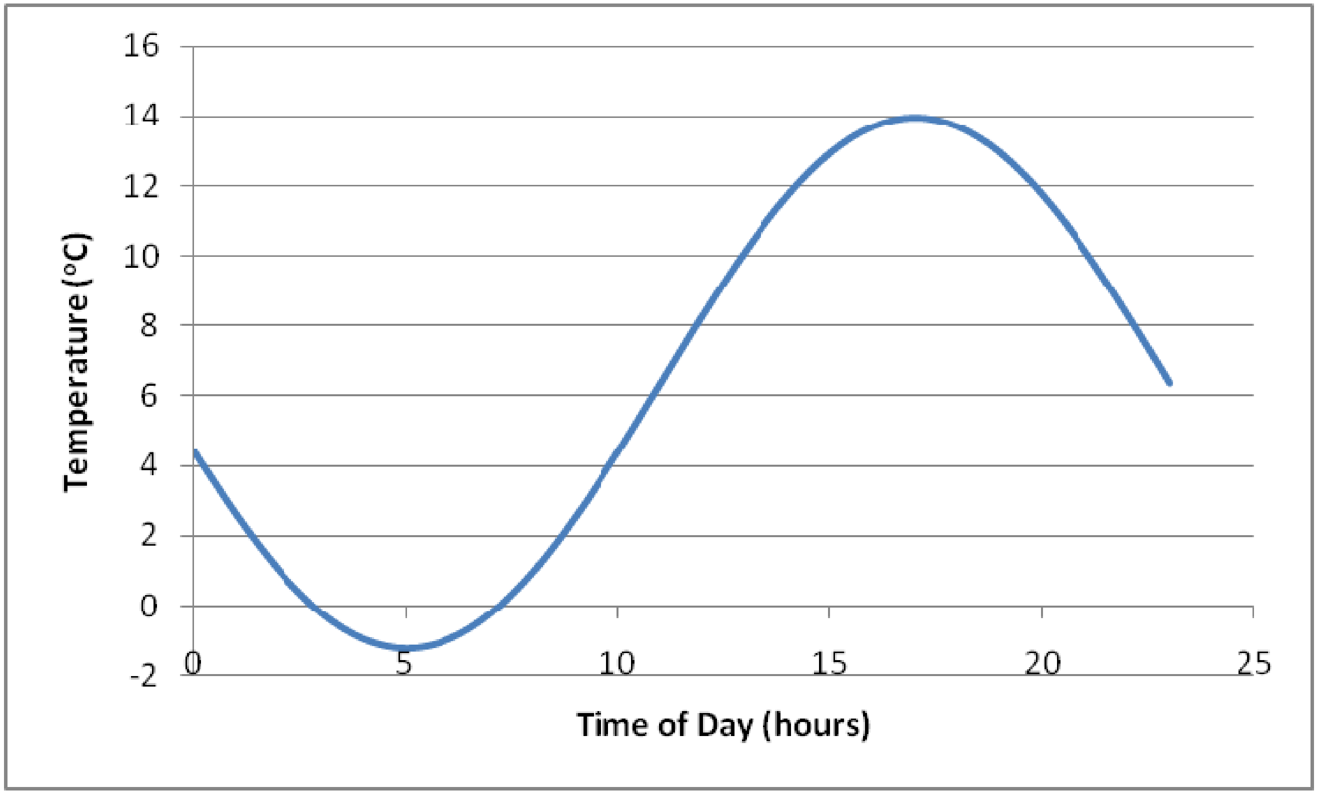
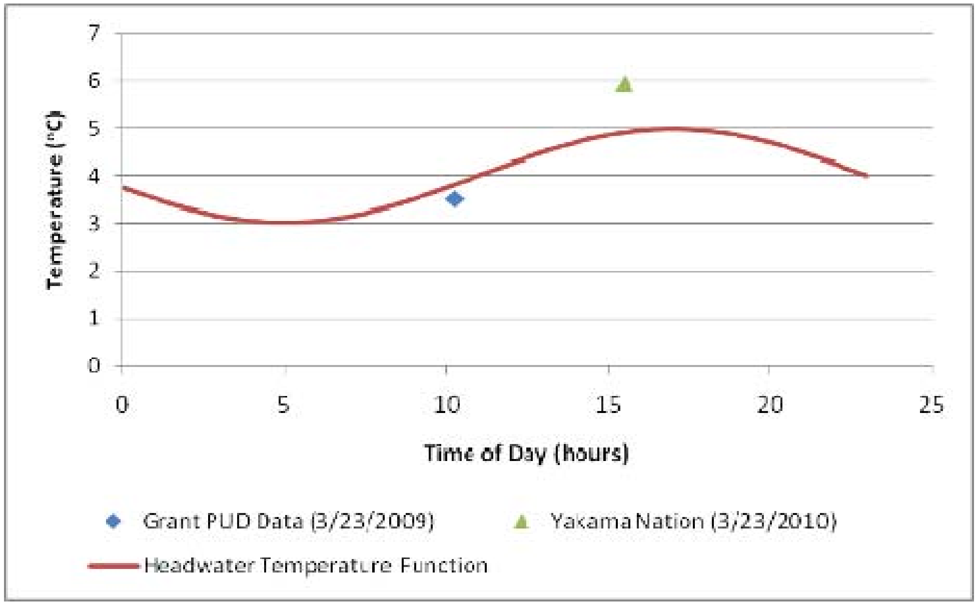



**Figure 24**
Air temperature function for QUAL-2K model
Discharge Evaluation Appendix
Mid-Columbia Coho Restoration Project



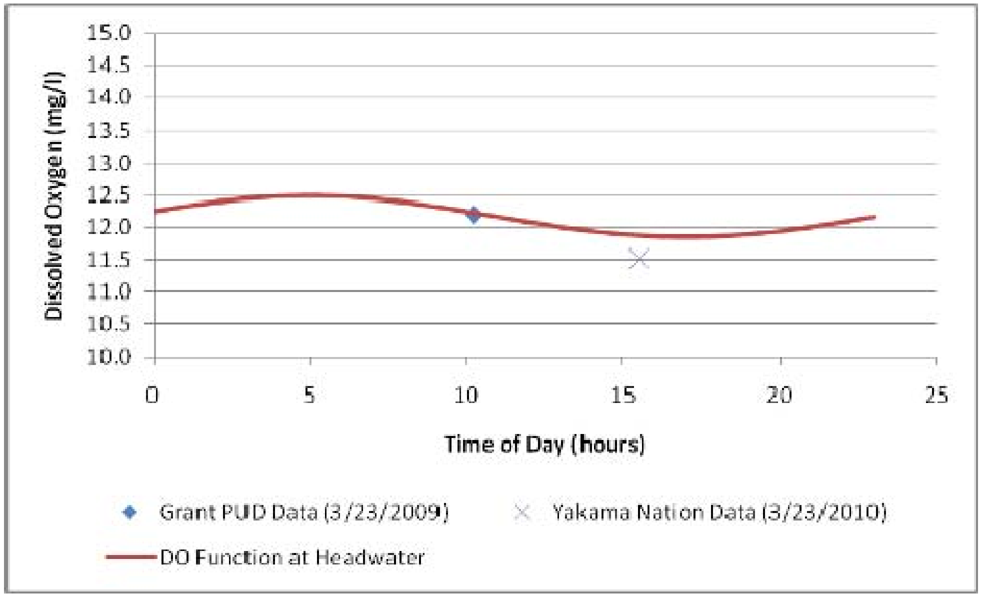




**Figure 25**

Water temperature and dissolved oxygen functions specified at the mouth of Lake Wenatchee
for the QUAL-2K model for March conditions
Discharge Evaluation Appendix
Mid-Columbia Coho Restoration Project

\\SF-PMUGUNTHAN\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Combined\Inputs\Temperature_and_DO_for_tribs_and_point_Sources.xlsx

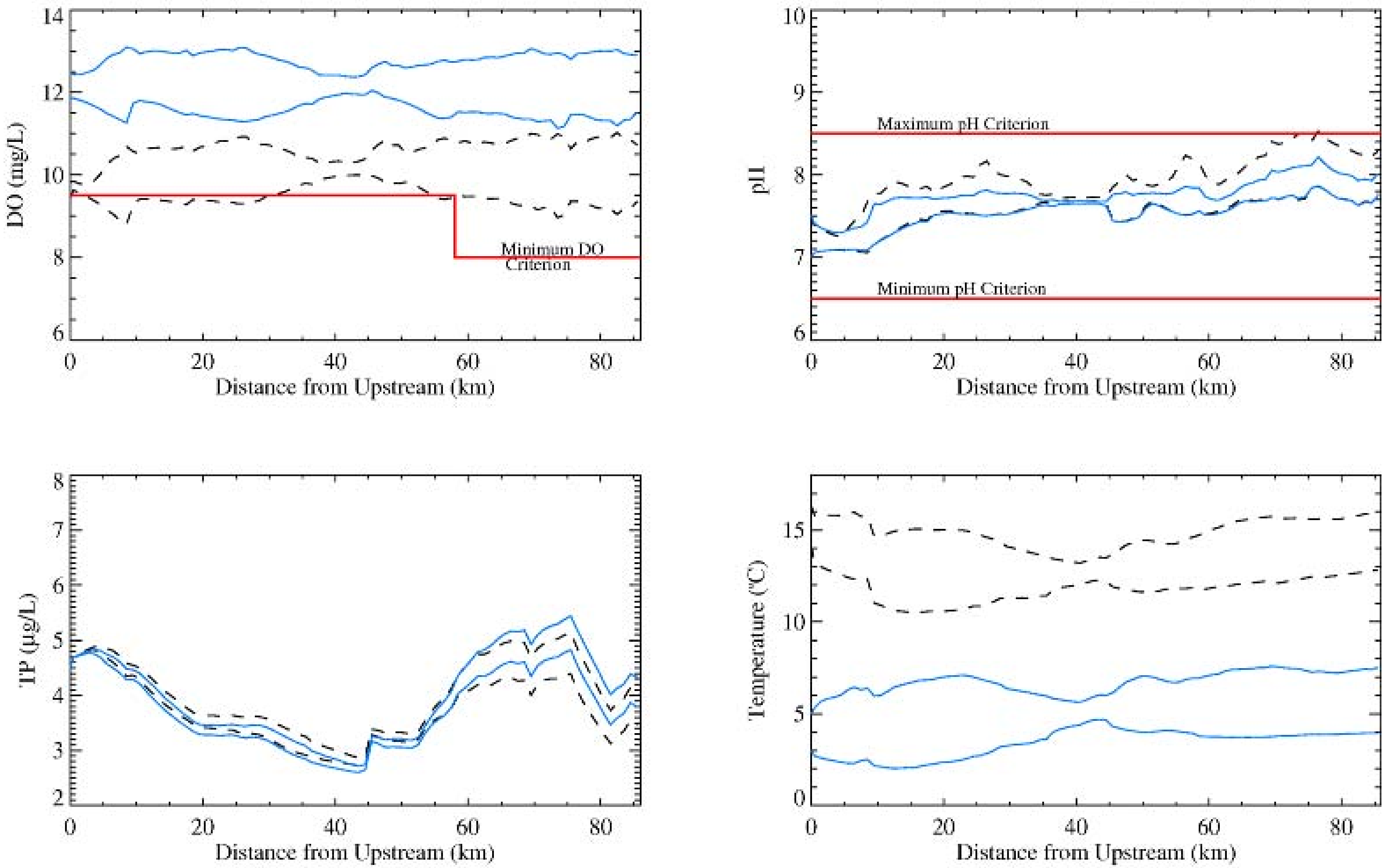
Temperatures for tributaries and groundwater inflows for the month of March were estimated using the headwater temperature and the ratio of respective tributary/groundwater source temperature to the headwater temperature available in the WDOE TMDL model.

DO was assumed to be at saturation for the headwater and all other inflows. It was estimated from the water temperature and river elevation. Figure 25 shows the DO function specified in the QUAL-2K model at the mouth of Lake Wenatchee along with observations from March 2009 and 2010.

#### *5.3.2.2 Determination of Background Conditions in March*

Due to the differences in some of the boundary conditions as described previously, the upper bound in natural conditions developed for the summer period as represented in the WDOE TMDL model cannot be used as the basis for evaluation of potential impacts of the acclimation sites. Hence, new background water quality conditions were established by simulating the model with the changes described above, but without introducing any loads from the proposed acclimation sites. The term “background conditions” is used to describe this simulation, rather than WDOE’s terminology of “maximum natural conditions,” to emphasize that the conditions simulated here are representative of critical conditions expected to occur in March during operation of the acclimation ponds and not the summer critical period in the TMDL evaluation.

Figure 26 compares the differences in summer (WDOE TMDL) and March background simulations. Model results indicated that temperature is the primary driver of water quality in March. DO levels generally reflected saturation conditions for the range of water temperatures simulated in March. Diurnal pH variations were generally smaller in March, likely a result of depressed biological activity and temperature (higher water temperature stimulates biological activity and reduces the solubility of carbon dioxide and oxygen). TP variations were similar between the two periods, with the summer model showing slightly lower TP in the lower reaches which correlated well with bottom algae levels (not shown) and suggests stimulated biological activity in summer (and hence higher use of phosphorus).




ANCHOR QEA

**Figure 26**

Water quality parameters simulated by QUAL-2K model with background TP loads under 7Q10 low-flow, and summer and March climatic conditions

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

#### *5.3.2.3 Estimation of Nutrient Loads for Assessing Combined Impacts*

To assess the combined impacts, TP loads were estimated for the active sites (Table 5) and proposed sites (Table 6). Dryden Hatchery inputs determined for the month of March (see Table 8) were also used. The estimated TP loads from the discharges were included with the background orthophosphate load in the model. The final orthophosphate concentrations were calculated using the flows used in the model and the combined load estimate. The calculations are summarized in Table 13.

Even though a separate analysis was presented in Section 5.2.1 for upper Wenatchee subbasin sites in White River and Little Wenatchee River, and given that Lake Wenatchee will buffer TP loads originating from the upper subbasin sites, discharges from these sites were represented in the model as being 100% available at the outlet of Lake Wenatchee. Hence, these assumptions provide an upper bound estimate of the potential impacts in the Wenatchee River. As with the background conditions simulation, nutrient inputs from POTWs were not considered (see the introduction in Section 5 for definition of combined impacts). Other model inputs remained unchanged from the March background conditions simulation. As pointed out in Section 5.1, phosphorus loads were represented in the model as being available for biological uptake and were assumed to discharge to the Wenatchee River proper without any assimilation in the receiving tributary.

#### *5.3.2.4 Model Predictions*

Figure 27 presents model-predicted flows as compared to March background conditions. Differences in flow between the two simulations were imperceptible because acclimation-related inflows were predominantly derived from natural inputs that contribute to the Wenatchee system under background conditions. Moreover, Dryden Hatchery inflows were relatively too minor to substantially alter flows in the system.

**Table 13**
**Estimation of inorganic phosphorus concentration for acclimation impacted point sources in the Wenatchee subbasin**

| Source[1] | Station ID | River Kilometer | Flow ($m^3/s$) | Natural Conditions Orthophosphate[2] | | TP Load due to Acclimation Activity (g/d) | Combined Orthophosphate | |
|---|---|---|---|---|---|---|---|---|
| | | | | Concentration (µg/L) | Load (g/d) | | Load (g/d) | Concentration (µg/L) |
| Upper Wenatchee Subbasin Loads[3] | -- | 0 | 4.616 | 1.50 | 598.2 | 89.6 | 687.8 | 1.72 |
| Nason Creek Sites[4] | 45NC00.7 | 0.5 | 0.655 | 4.55 | 257.4 | 67.2 | 324.6 | 5.74 |
| Chiwawa Sites | 45CW00.5 | 9.1 | 2.039 | 3.90 | 687.0 | 112.0 | 799.0 | 4.54 |
| Beaver | 45BC00.1 | 12.2 | 0.051 | 4.70 | 20.8 | 32.0 | 52.8 | 11.92 |
| LNFH - Icicle Creek | 45IC00.1 | 45.9 | 1.214 | 4.70 | 492.9 | 32.0 | 524.9 | 5.01 |
| Chumstick | 45CS00.1 | 49.4 | 0.066 | 4.70 | 26.9 | 20.8 | 47.7 | 8.33 |
| Dryden[5] | -- | 59.0 | 0.010 | -- | -- | 6.7 | 6.7 | 7.74 |
| Brender | 45BR00.1 | 70.8 | 0.187 | 4.70 | 75.9 | 16.0 | 91.9 | 5.69 |

Notes:
1. See Table 6 for a list of proposed sites in the Wenatchee subbasin and the estimated TP loads from these sites.
2. Loads estimated from flows and concentrations specified for natural conditions QUAL-2K model simulation in WDOE TMDL (Carroll and Anderson 2009).
3. Loads from the White and Little Wenatchee River sites were assumed to enter the Wenatchee River at the mouth of Lake Wenatchee.
4. Includes loads from the Coulter site in addition to Rohlfing and Butcher ponds (see Table 2 in Appendix 2 for number of fish at each site).
5. Estimated TP loads from proposed Dryden Hatchery for the month of March (see Table 8).

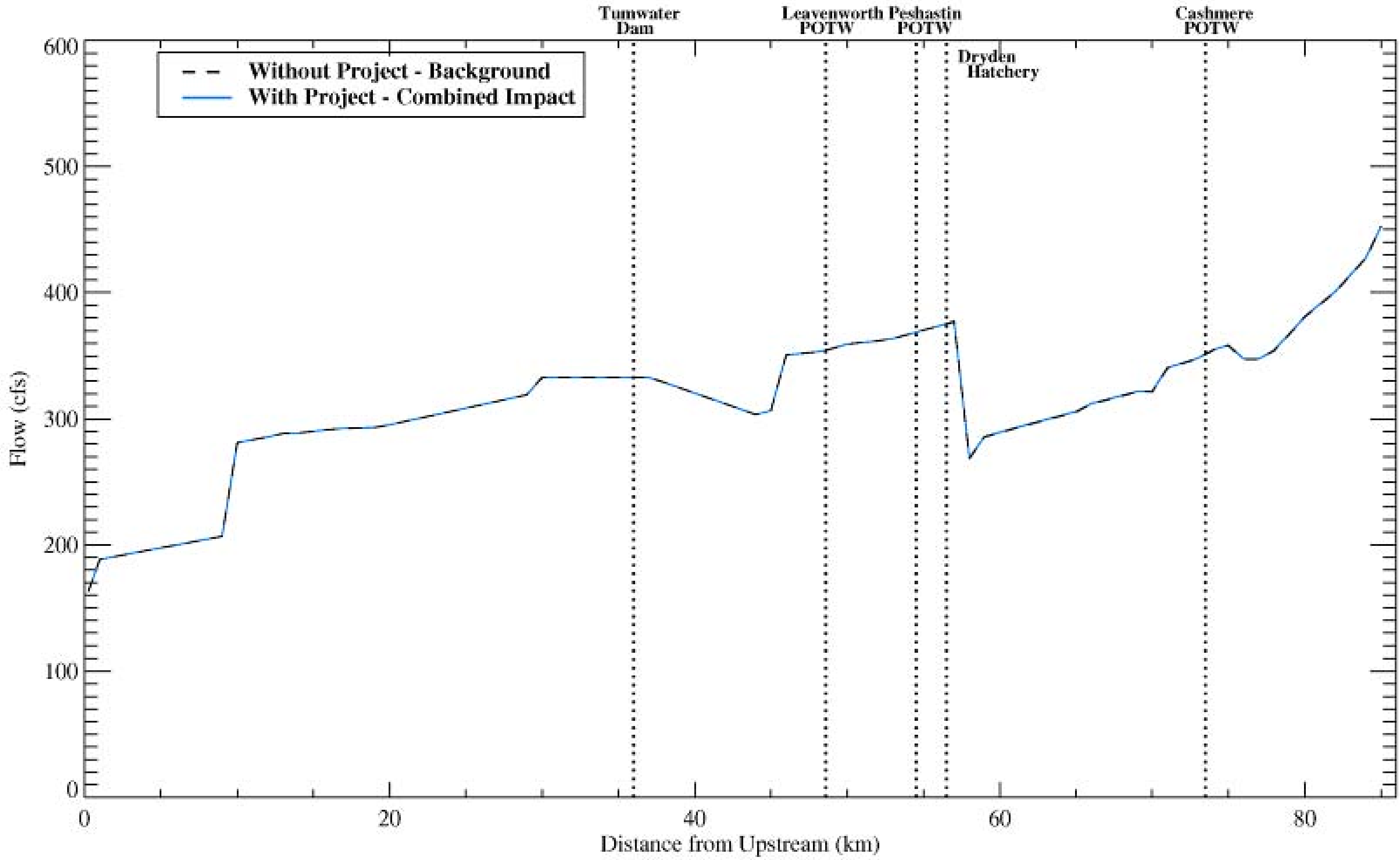



**Figure 27**

Flows simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*

ANCHOR OEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_rec_combined.pro Mon Nov 01 11:04:15 2010

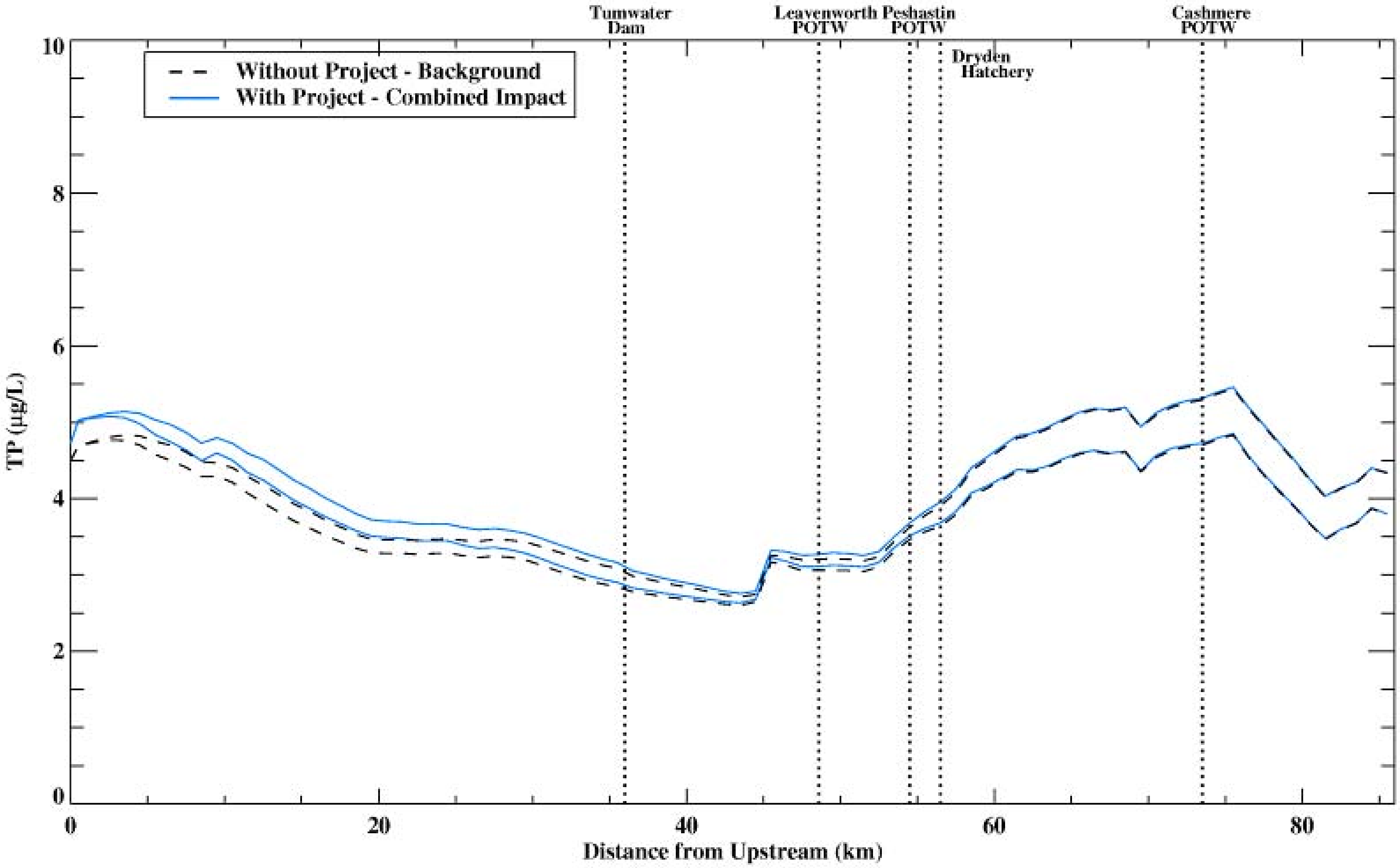



**Figure 28**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_combined.pro Mon Nov 01 11:04:15 2010

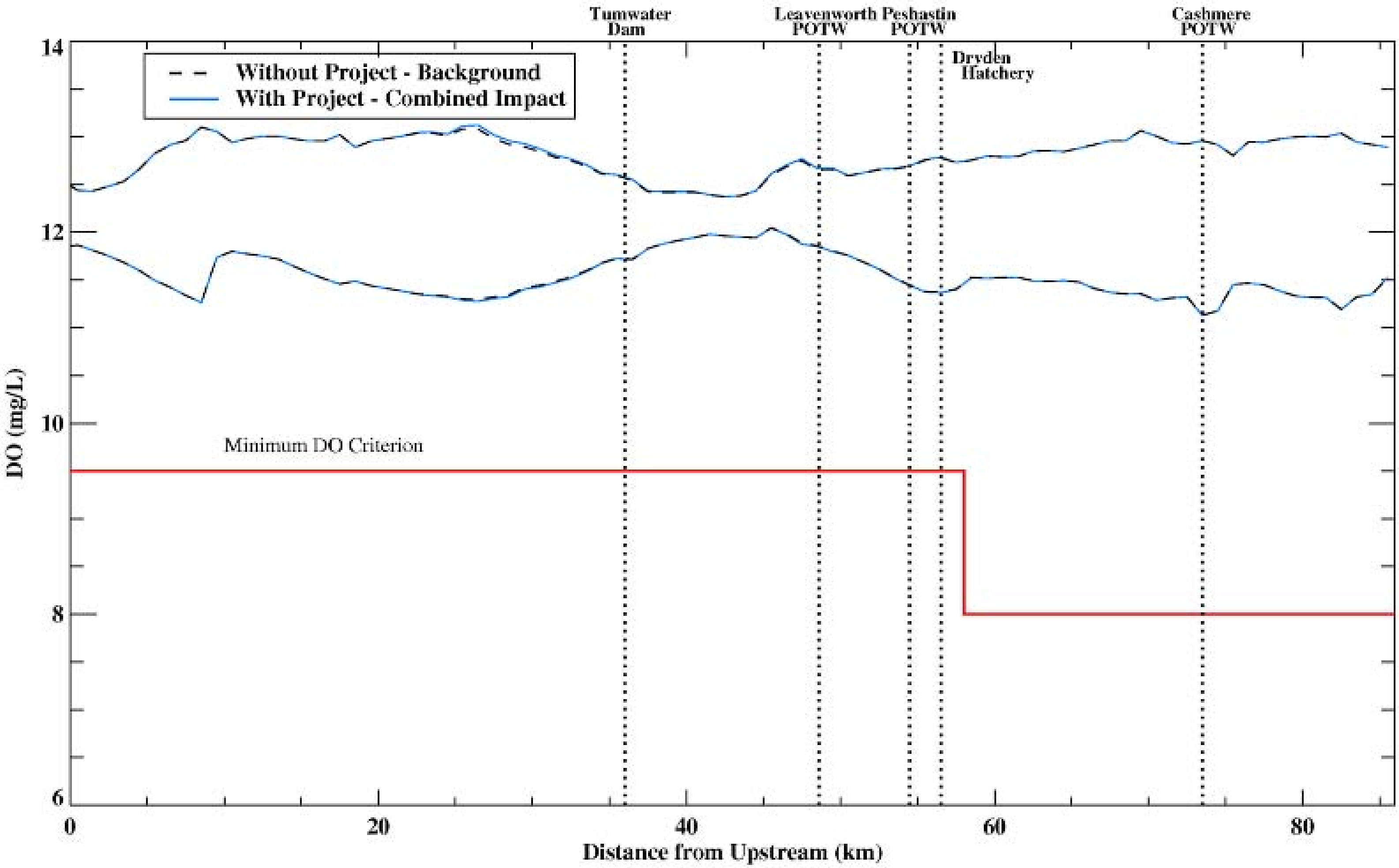



**Figure 29**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

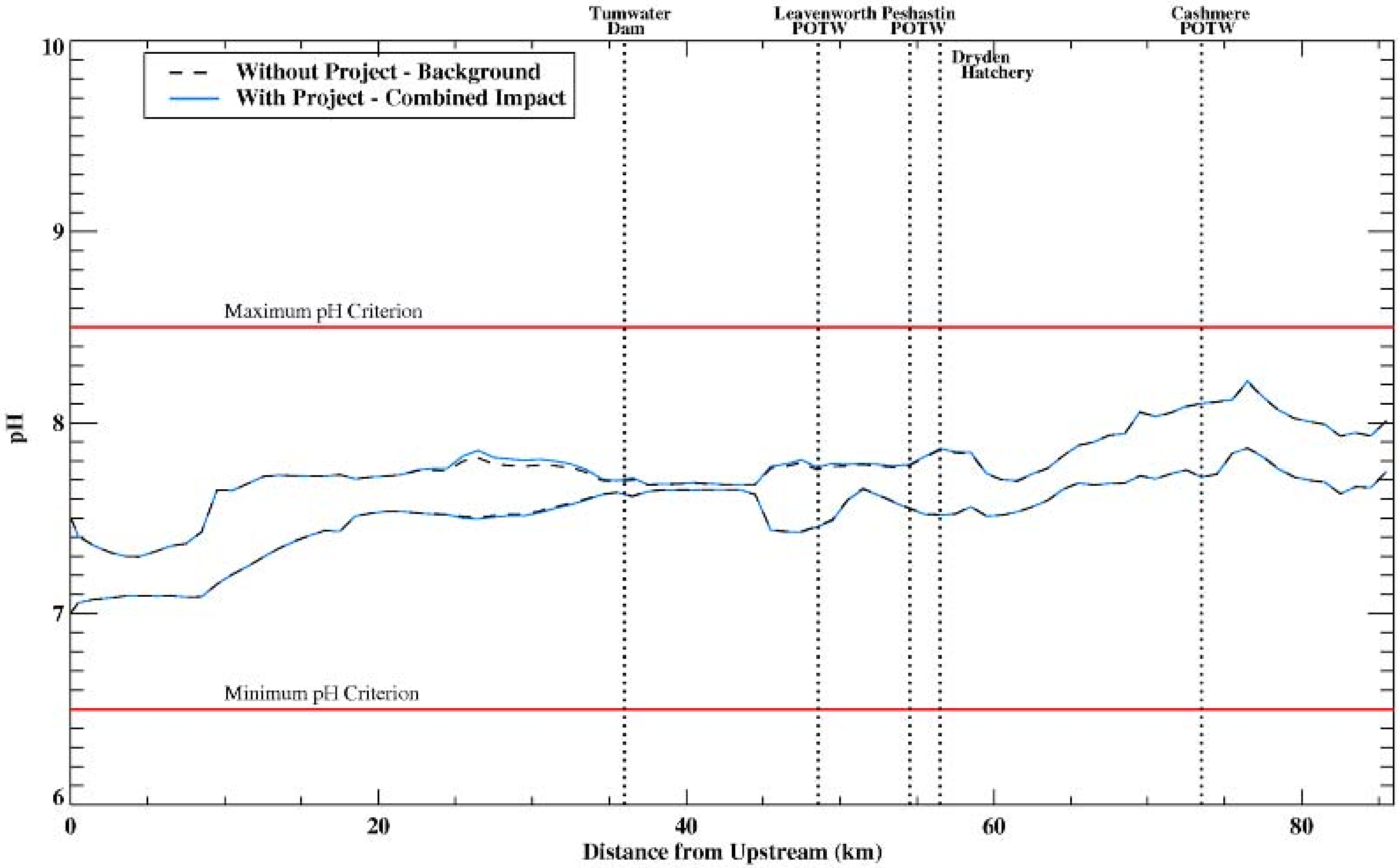



**Figure 30**

pHs simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_combined.pro Mon Nov 01 11:04:16 2010

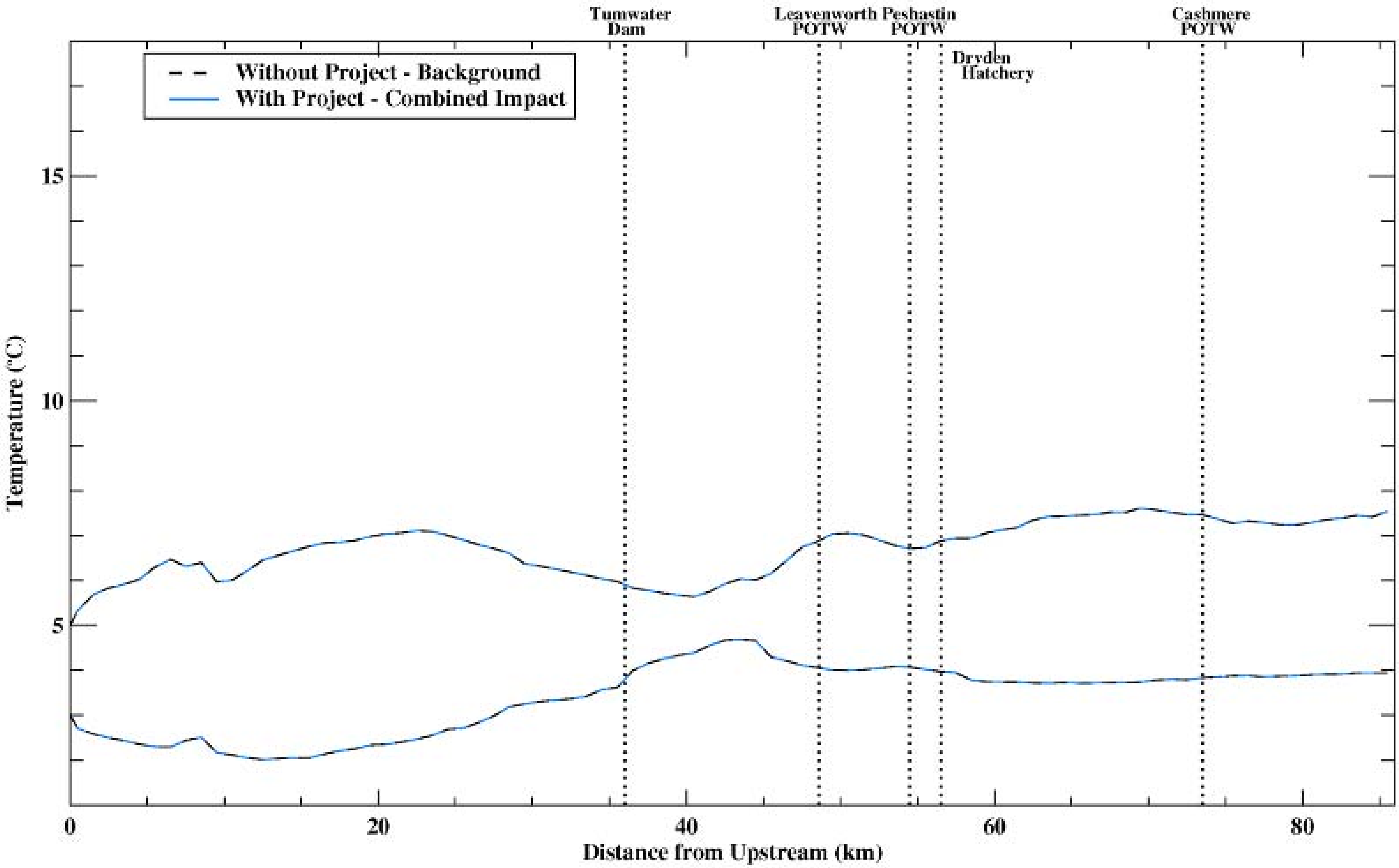



**Figure 31**

Temperatures simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

TP predictions for combined impacts are presented and compared to background conditions in Figure 28. TP is higher in the upper reaches (upstream of Leavenworth) and declines steadily after an initial increase. The increase in the first 10 kilometers of the river reflects inputs from the Nason Creek, the upper Wenatchee subbasin, and the Chiwawa River sites. Much of the phosphorus appears to be assimilated around RKM 27, which is upstream of Tumwater Canyon. In this stream reach, lower simulated flows provide habitat for bottom algae whose growth was elevated relative to the simulated values for background conditions in this reach.

Differences in the range of DO simulated with and without the project-related loads are negligible (see Figures 29 and 32; the maximum difference is less than 0.1 mg/L). The daily minimum DO is well above the water quality threshold for DO. These results indicate that in the absence of other nutrient sources, the project alone is not expected to adversely impact DO resources within the Wenatchee River.

The range of pH with the project is generally equal to the range simulated for the natural conditions (Figure 30). At approximately RKM 27, the upper bound of the pH appears to be somewhat higher than the pH simulated for background conditions. This is a consequence of the higher algal levels simulated in this reach over background conditions, as discussed above.

Finally, there is no appreciable difference in the range of the temperature simulated with and without the project loads (Figure 31).

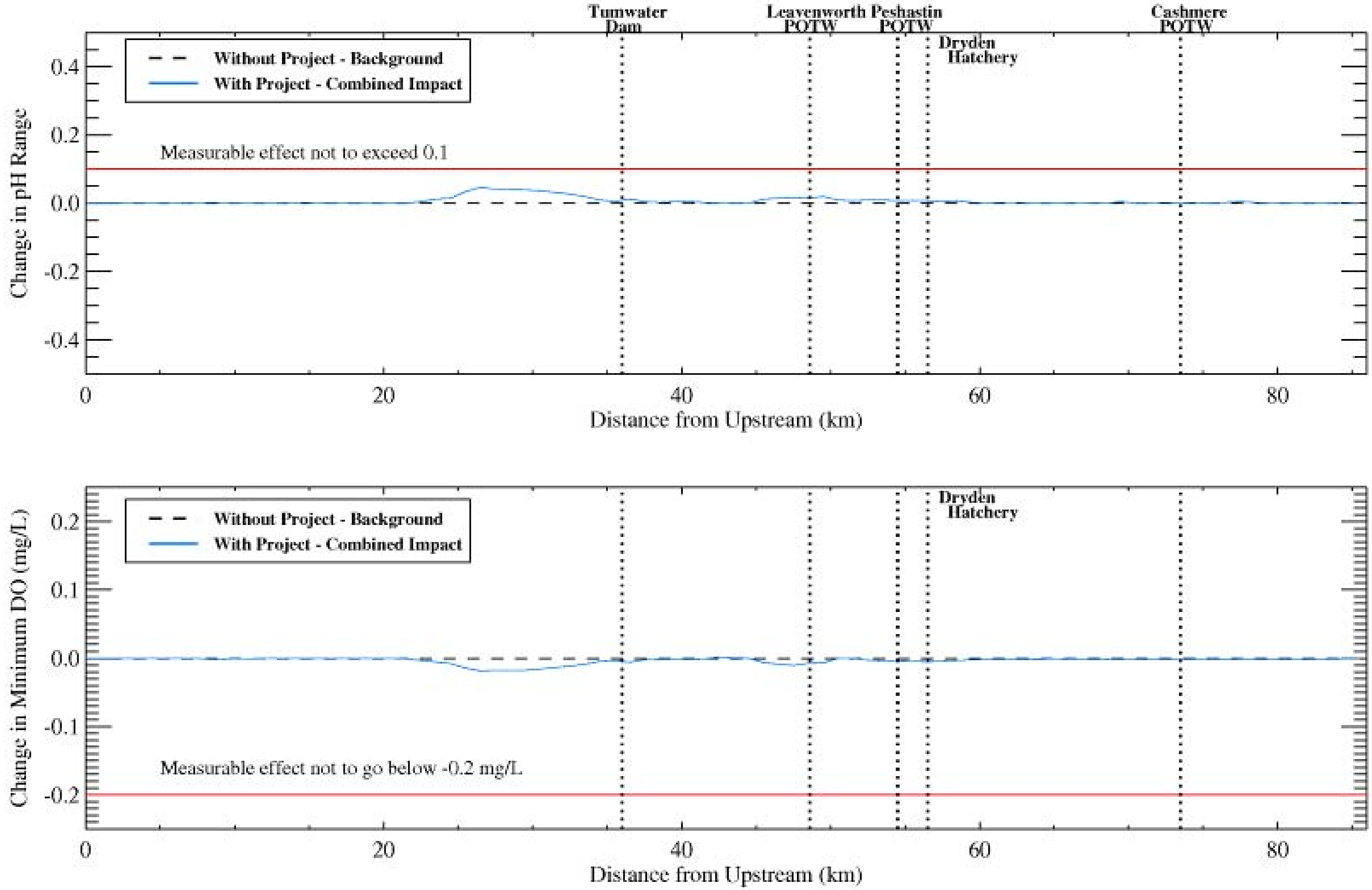



**Figure 32**

Difference from March background conditions in the range of pH and minimum dissolved oxygen with and without the proposed project in the Wenatchee subbasin

ANCHOR QEA

#### *5.3.2.5 Determination of Significance of Impacts*

The measurable change criterion defined in Section 2.2 was applied as the basis for assessing the QUAL-2K model outputs and determining potential water quality impacts of the proposed project. The difference in the range of pH evaluated against the measurable change criterion of 0.1 unit is presented in Figure 32. The model simulations are generally well below the criterion. The minor increase in the difference in range near RKM 27 can be attributed to induced biological activity associated with project loads. Nonetheless, these increases were well below the criterion. Moreover, Figure 32 also shows that the DO concentrations simulated by the model do not produce any deficit that exceeds 0.2 mg/L. The only deviation from the background conditions appears to be at RKM 27 and is associated with algal activity.

The spatial differences in TP, DO, and pH simulated by the model with and without the loads from the proposed project show that the majority of the phosphorus load from the project enters in the upstream reaches and much of it is assimilated in the Wenatchee River prior to entry into the lower reaches (below the city of Leavenworth). Collectively, these results indicate that even under the extreme flow and extreme project-related loading conditions simulated here, the proposed project will not adversely impact water quality. The model simulations presented herein have demonstrated that the maximum predicted impact from the proposed project, including discharges from the proposed hatchery at Dryden, is so small as to be undetectable.

### *5.3.3 Methow Subbasin*

The sparsely populated Methow subbasin[3] has very little anthropogenic impacts upstream of the city of Winthrop (Ely 2003). Even between Winthrop and Pateros, the subbasin is sparsely populated[3]. Konrad et al. (2003) concluded, based on an analysis of water quality data collected throughout the subbasin, that anthropogenic impact is generally low. The major anthropogenic sources within the subbasin are the Twisp and Winthrop POTWs and WNFH.

Figure 33 shows TP loads calculated at the city of Pateros for the months of March, April, and May, and the overall average loads for this period based on data collected by WDOE from 2005 to 2009. These TP loads represent the cumulative loads from the entire subbasin. As with the Wenatchee subbasin, the loads generally followed the flow (compare to Figure 20) with peaks in May that were much larger than March and April. The average TP load over the 3-month period was estimated at approximately 36 kg/d.

[3] Population of less than 5000, based on 2000 census.

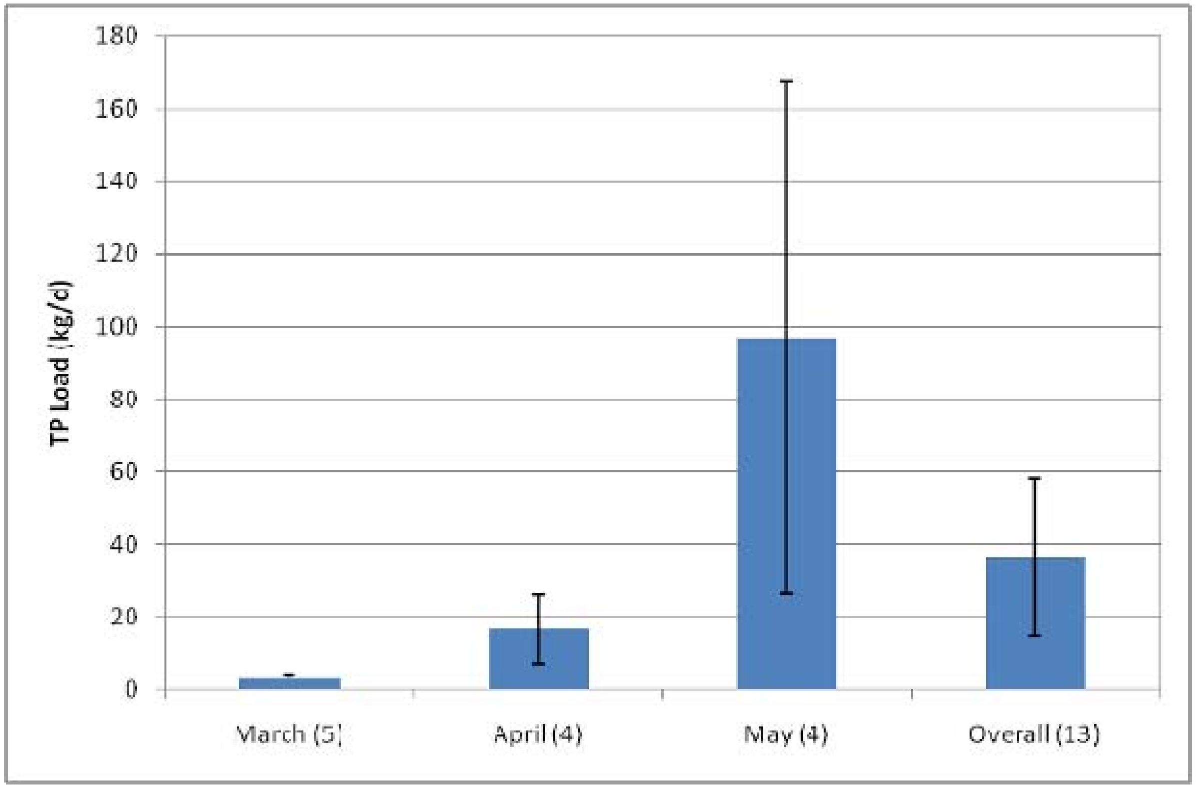



**Figure 33**
TP loads in the Methow River calculated at the city of Pateros
Discharge Evaluation Appendix
Mid-Columbia Coho Restoration Project

In order to estimate the combined impact of the proposed project, the TP loads from POTWs were separated out of the overall loads to provide an estimate of background conditions. Based on discharge monitoring reports (DMR), the average daily loads from the POTWs were estimated and subtracted out of the average loads calculated for the Methow River at Pateros. A DMR was not available for WNFH. Thus, the loads from this facility could not be differentiated.

Acclimation activity may contribute about 0.9% of the average background loads (Table 14). Noting that loads from WNFH and other minor point sources were not included, this is likely an underestimate of the relative contribution of the acclimation activity loads.

There is some incongruence in the overall analysis because DMR data from fall were used for estimation of the loads due to lack of data for spring periods. Loads from municipal POTWs generally do not show strong seasonal variability. Moreover, subbasin flows in October through February are generally comparable to flows in early spring (see Figure 20). Thus, loads estimated for POTW presented herein, while seemingly inexact, are meaningful for the analysis performed.

In order to determine the veracity of the calculations for Methow subbasin, a similar loading calculation was performed for the Wenatchee subbasin (see Table 15), where point source discharge data were available for spring, and a comparison between the two subbasins was performed. Major point source loads were estimated for April 2003 based on point source measurements reported in WDOE TMDL appendices (Carroll et al. 2006). TP loads were estimated for the Wenatchee subbasin based on paired flow and TP measurements for the WDOE station at Wenatchee for the month of April 2003. An estimate of the background loads for the Wenatchee subbasin was obtained by subtracting the major point source loads from the subbasin loads (Table 15). Once the anthropogenic influences were subtracted from the loads, the background load at the downstream reaches of either subbasin is comparable (about 35 kg/d for Wenatchee and 39 kg/d for Methow).

The relative contribution for the Wenatchee subbasin sites relative to the background load is approximately 1.5%. This is higher than the Methow subbasin estimate of 0.9%. This difference is expected because a larger number of fish are proposed for acclimation in the Wenatchee subbasin (about 1.155 million versus 1 million in Methow) and because of the contribution of TP loads from the proposed year-round rearing activities at the Dryden Hatchery in the Wenatchee subbasin.

**Table 14**
**TP loads estimated for the Methow subbasin with and without POTW loads**

| Source | TP Load (kg/d) |
|---|---|
| Methow River at Pateros[1] | 39.20 |
| Twisp POTW[2] | 1.30 |
| Winthrop POTW[3] | 0.58 |
| Estimated Background Load | 37.31 |
| Acclimation Activity Loads[4] | 0.32 |

Notes:
1. Average over March - May calculated from paired TP and flow data collected respectively by WDOE (48A070) and USGS (12449950) in the Methow River at Pateros in 2005 through 2009.
2. Based on NPDES discharge monitoring report information from October 2009 through February 2010.
3. Based on NPDES discharge monitoring report information from November 2009.
4. Sum of the loads estimated for the individual sites in Table 9.

**Table 15**
**TP loads estimated for Wenatchee subbasin with and without point source contributions**

| Source | TP Concentration (mg/L) | Average Flow (cfs) | Load (kg/d) |
|---|---|---|---|
| Lake Wenatchee POTW[1] | 2.850 | 0.020 | 0.139 |
| Leavenworth POTW[1] | 2.260 | 0.440 | 2.433 |
| LNFH - Main Outfall[2,3] | 0.015 | 34.534 | 1.225 |
| Peshastin POTW[1] | 7.050 | 0.050 | 0.862 |
| Dryden POTW[2,5] | 4.170 | 0.030 | 0.306 |
| Cashmere POTW[1] | 2.330 | 0.680 | 3.876 |
| Non-contact Cooling Water[6] | -- | -- | 0.020 |
| Total Point Source Loads | -- | -- | 8.862 |
| TP Loads from Acclimation Activity[7] | -- | -- | 0.376 |
| TP loads for Wenatchee River at Wenatchee[8] | 0.0043 | 3280 | 34.507 |
| Background Loads[9] | -- | -- | 25.644 |

Notes:
1. TP concentration reported for composite samples from April 2003 were used.
2. Composite values were not reported. Values reported for grab samples from April 2003 were used.
3. Paired flow for April 2003 not available. Flows represent average of monthly average flows for April reported in DMR from 2006 to 2010.
4. TP measurement was not reported in WDOE TMDL study. Orthophoshpate values from April 2003 were used.
5. Paired flow not available. Design flow used in WDOE TMDL study is used here.
6. Critical period loads used in WDOE TMDL used here.
7. Sum of acclimation loads estimated in Table 13 and estimated April TP load for proposed hatchery in Dryden (see Table 8).
8. April 2003 data reported for Wenatchee River at Wenatchee WDOE station (45A070).
9. Background loads estimated as difference between TP load at Wenatchee and total point source loads.

This analysis suggests that the background conditions in the two subbasins are comparable. Furthermore, loads from the proposed project contribute to a smaller proportion of the background phosphorus loads in the Methow subbasin.

Mechanistic modeling for the Wenatchee subbasin suggests that even for critical conditions, acclimation-related nutrient loads are not expected to produce a measurable change in DO and pH (see Section 5.3.2.5). Based on the analysis in this section and considering the similarities between the two subbasins (see Section 5.1.2), it is concluded that, in the absence of anthropogenic sources, the TP loads introduced to the Methow subbasin from this project are unlikely to produce a measurable change (as defined in Section 2.2.1) in DO and pH.

### *5.3.4 The Effect of Seasonal Flow Patterns on Combined Impacts*

The timing of acclimation nutrient discharges, in relation to annual subbasin flow patterns, is important to the evaluation of combined project impacts on water quality. The Wenatchee and Methow rivers have peak average flows in early June (see Figure 20). Acclimation ends in early May just as spring runoff begins. Data collected from the subbasins (see Figure 4-16 in Appendix 6) demonstrated that river phosphorous concentrations and loads peak along with river flows, as accumulated nutrients and attached algae that have been suspended are flushed from the subbasins. The majority of the phosphorous introduced by acclimation is included in this mechanical removal process thereby limiting the impact of project nutrients on water quality in the critical late summer through winter period.

## 5.4 Assessment of Cumulative Impacts

### *5.4.1 Wenatchee Subbasin*

The cumulative impacts of the proposed project were assessed by applying the WDOE TMDL model and including discharges from POTWs in addition to the project-related loads. For this purpose, POTWs were assumed to be discharging at the load allocations specified in the WDOE TMDL (at a TP concentration of 90 µg/L) and at their design flows. The WDOE load allocation included allowance for future growth. Hence, it is assumed for the purpose of cumulative impact assessment that this represents a reasonable estimate of future loading conditions from municipal sources.

#### *5.4.1.1 Background Conditions*

For the purpose of comparing the cumulative impacts, background conditions were determined by including loads from POTWs (as specified above) to the base case simulation presented in Section 5.2.2. Figure 34 presents simulated water column TP concentration for the cases with and without the POTW loads.

DO changes with and without the POTW loads are generally small and limited to the vicinity and immediately downstream of the discharges (Figure 35). The simulated DO levels were well above minimum DO criterion. In the lower reaches of the Wenatchee River where the POTW loads enter, the upper bound of the simulated pH levels appears to be affected more than the lower bound (Figure 36). POTW loading does not affect the temperature as there was no change in the specified temperature function (Figure 37).

The change in the range of pH and DO for the simulation that included loads from POTWs is presented in Figure 38. As expected, the highest changes were predicted in the vicinity of and downstream from the POTW discharges. In all cases, the changes were less than the measurable effect criteria for both pH and DO.

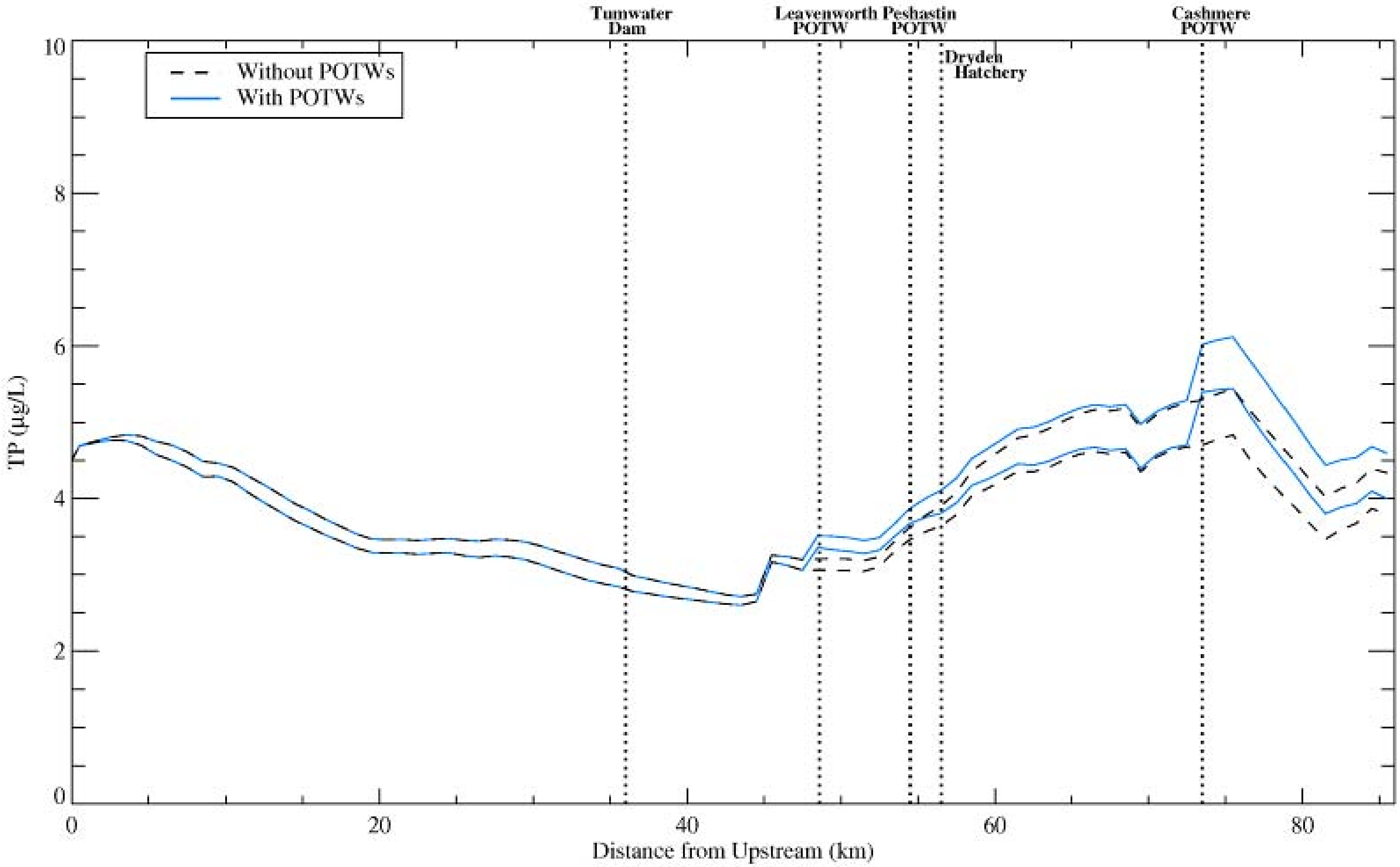



**Figure 34**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for cases with and without POTW discharges for 7Q10 low-flow and March climatic condition

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_base.pro Mon Nov 01 11:13:21 2010

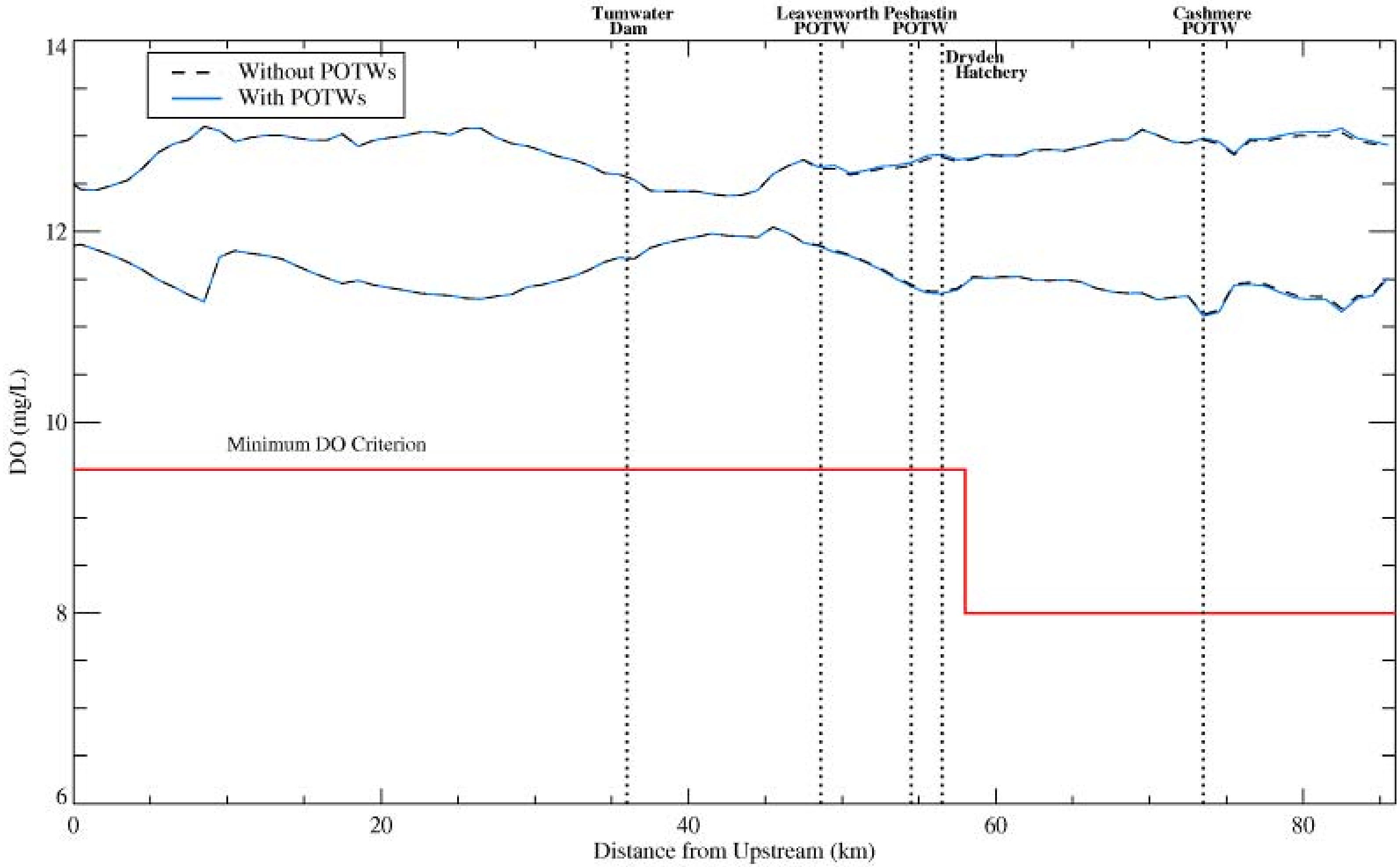



**Figure 35**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for cases with and without POTW discharges for 7Q10 low-flow and March climatic condition

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_base.pro Mon Nov 01 11:13:21 2010

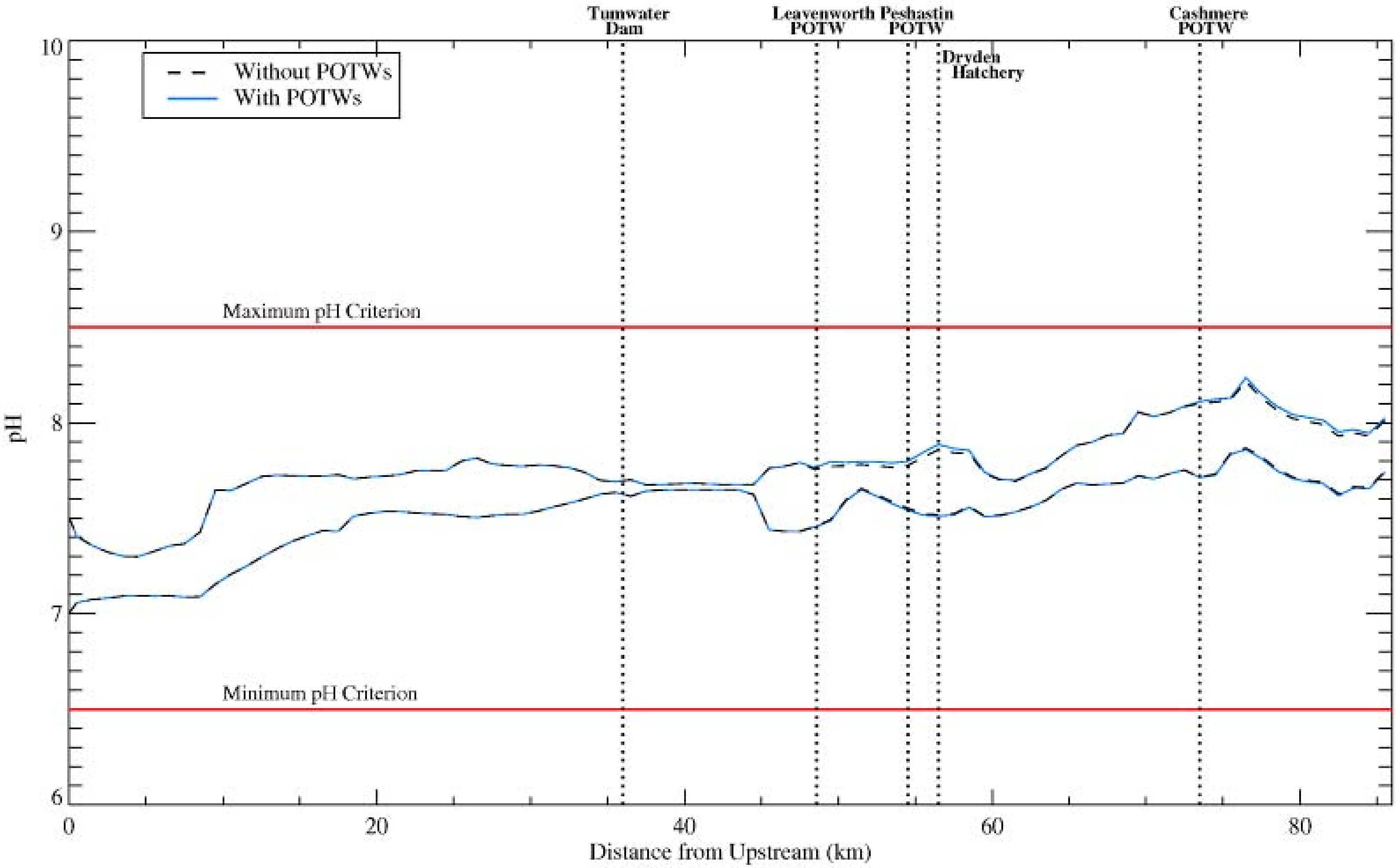



**Figure 36**

pHs simulated by QUAL-2K model shown compared for cases with and without POTW discharges for 7Q10 low-flow and March climatic condition

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AG\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_base.pro Mon Nov 01 11:13:21 2010

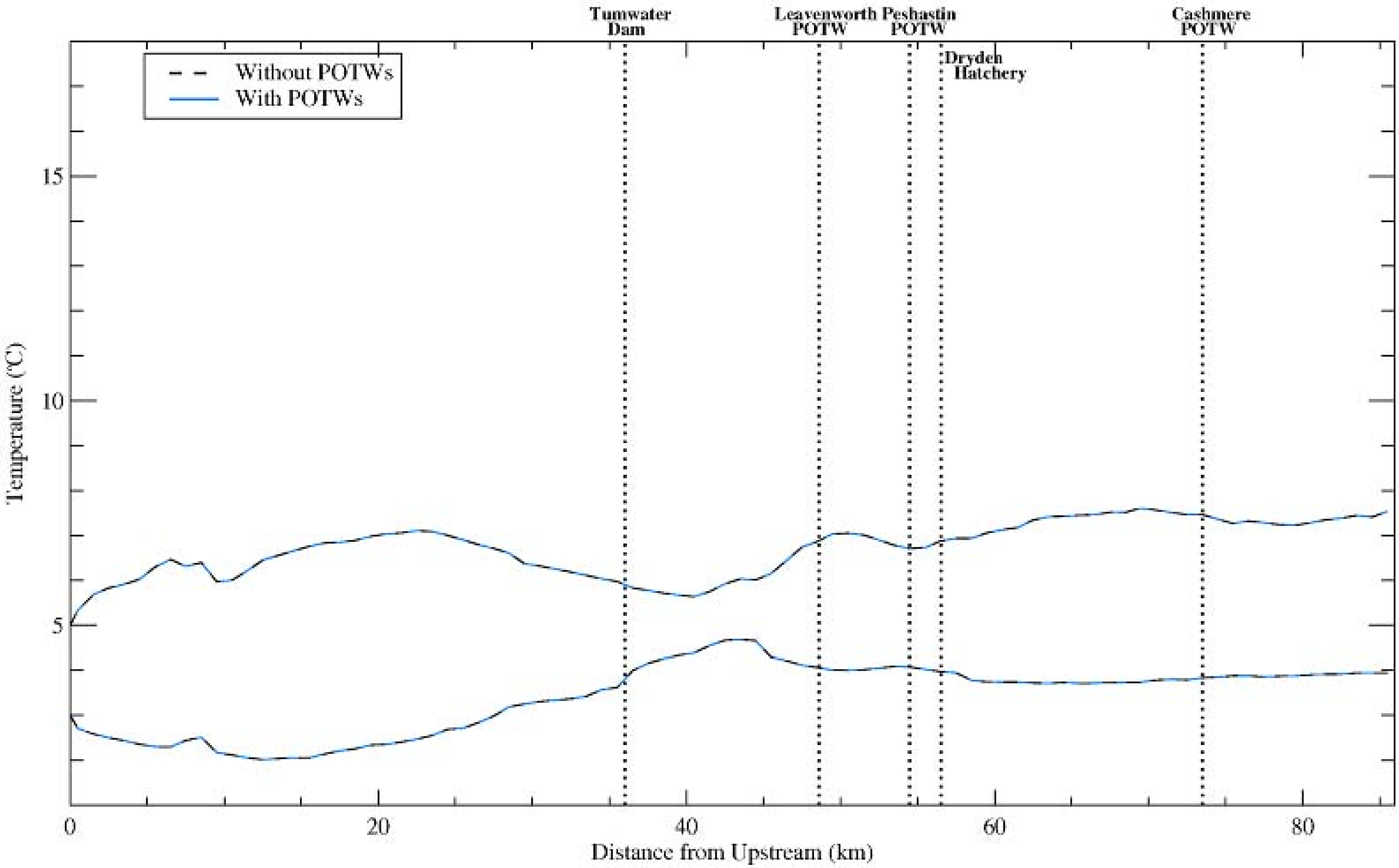



**Figure 37**

Temperatures simulated by QUAL-2K model shown compared for cases with and without POTW discharges for 7Q10 low-flow and March climatic condition

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_base.pro Mon Nov 01 11:13:22 2010

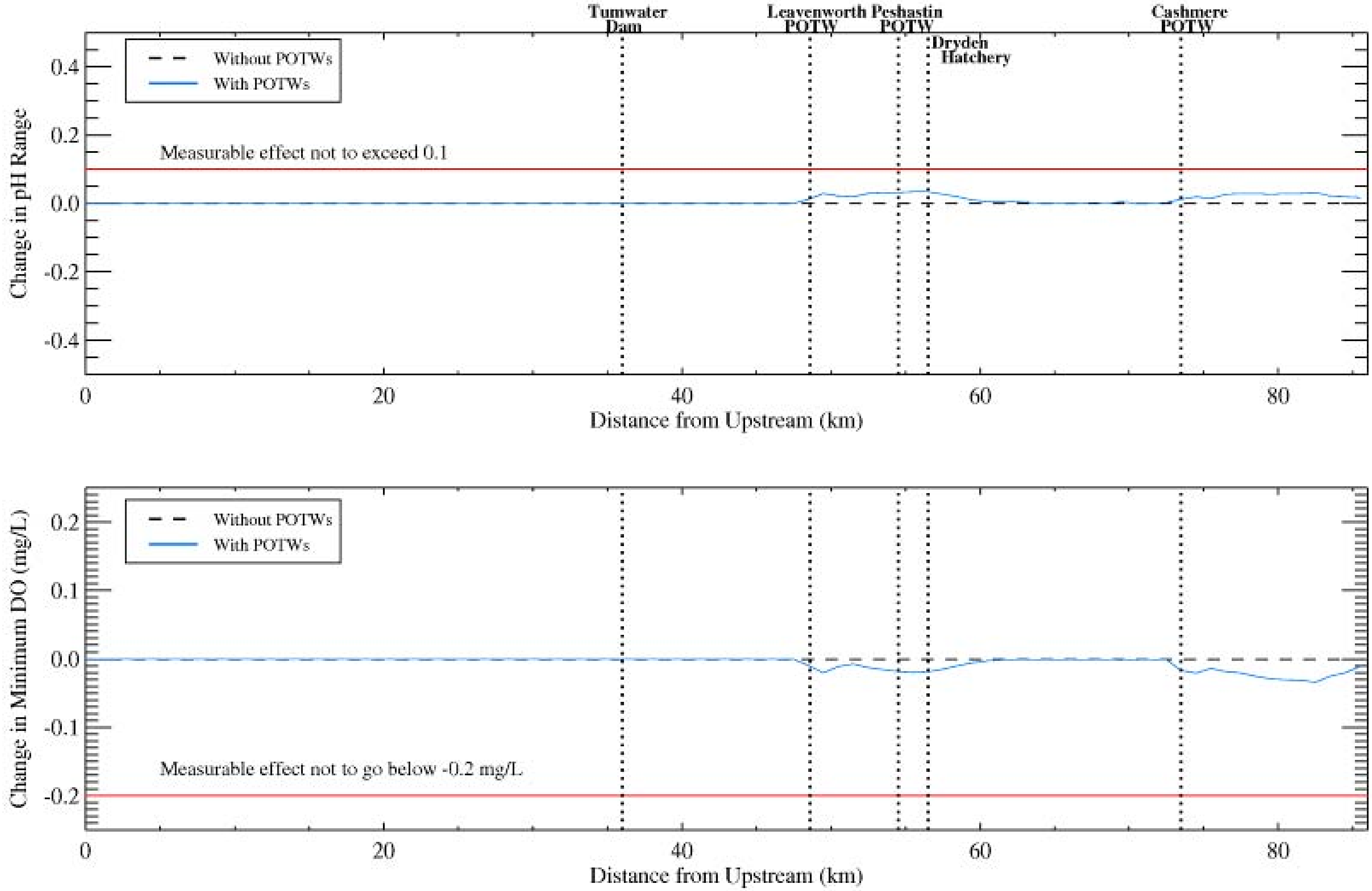



**Figure 38**

Difference from March background conditions in the range of pH and minimum dissolved oxygen with and without the POTW discharges in the Wenatchee subbasin

ANCHOR QEA

The model simulations with and without the POTW loading have indicated only minor changes in water quality. The principal difference between these sets of simulations performed for March conditions and those performed for load allocations in the WDOE TMDL are the climatic conditions and water temperature. In the WDOE TMDL analysis, these same POTW loads when introduced in summer resulted in significantly elevated effects in water quality deterioration. These results suggest that temperature plays an important role in determining water quality of the Wenatchee River.

#### *5.4.1.2 Assessment of Cumulative Impacts*

The loads estimated for the proposed project (Section 5.2.2.3) were added to the background conditions and POTW model presented in the previous sub-section. This setup provided a reasonable conservative estimate of the cumulative nutrient loads to the Wenatchee River.

Figure 39 depicts the TP concentrations simulated by the QUAL-2K model both with and without the loads estimated from the proposed project. As observed in the analysis of the combined impacts, TP levels are slightly elevated in the upper section of the river (up to RKM 60) from the project loads. The downstream reaches do not show an appreciable increase in TP. This phenomenon is due to the proposed locations for the acclimation ponds, which are in the upper subbasin. This also suggests that TP loads introduced in the upper subbasin are largely assimilated prior to entering the TMDL domain, which is downstream of the city of Leavenworth.

The DO (Figure 40) and pH (Figure 41) ranges follow a very similar trend compared to those estimated under the combined impacts scenario (i.e., higher upper bound values in the vicinity of RKM 27 and minor changes elsewhere). As explained in the combined impacts analysis, this area likely provides habitat conducive to the establishment of bottom algae due to slower flows. Nonetheless, the model does not predict any water quality criteria excursions for DO and pH in the river. Finally, temperature changes under the cumulative impacts scenario are negligible (Figure 42).

#### *5.4.1.3 Determination of Significance of Impacts*

The change in the range of pH and DO for the cumulative impact simulation compared to the case without the project loads (note that the latter includes POTW discharges over background conditions simulations) is presented in Figure 43. The differences between simulations represent changes from the March background conditions established in Section 5.2.2.2. As expected, the largest differences occur in the vicinity of RKM 27 due to enhanced algal activity.

In all cases, the model simulations suggest that potential impacts of the proposed project, as defined by the criteria for DO and pH, will be negligible under foreseeable future conditions.

When viewed in light of the conservative assumptions employed in establishing the translation of loads and flow conditions within the model framework (see Section 5.1), the actual impacts under average flow conditions will be much smaller than what was determined by the QUAL-2K modeling exercise. The fact that the model results indicated that much of the loads are likely to be assimilated upstream of Leavenworth suggests that existing POTWs are not likely to be further burdened to exceed their treatment requirements to buffer activity from the proposed project in the upper reaches.

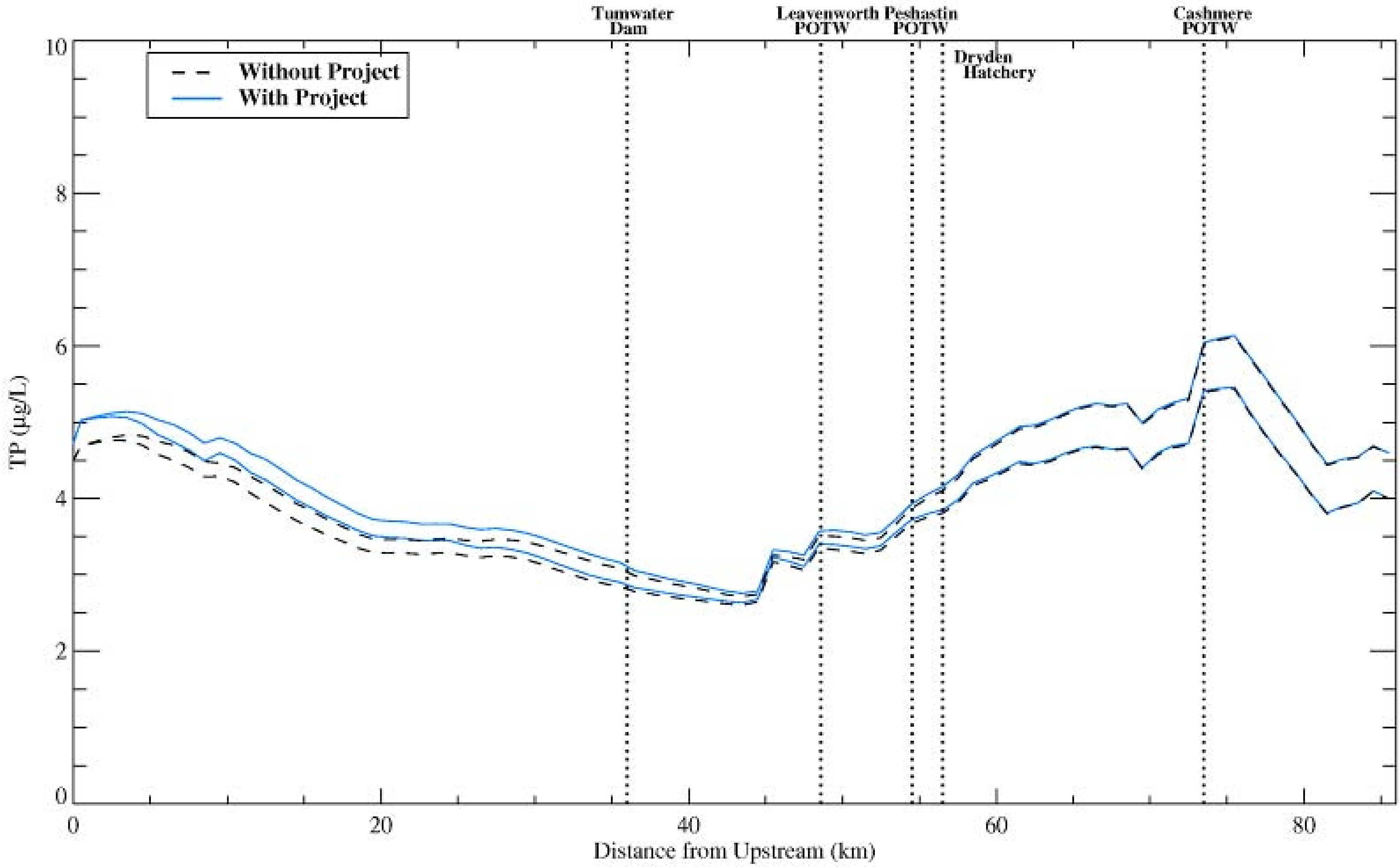



**Figure 39**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative.pro Mon Nov 01 11:25:22 2010

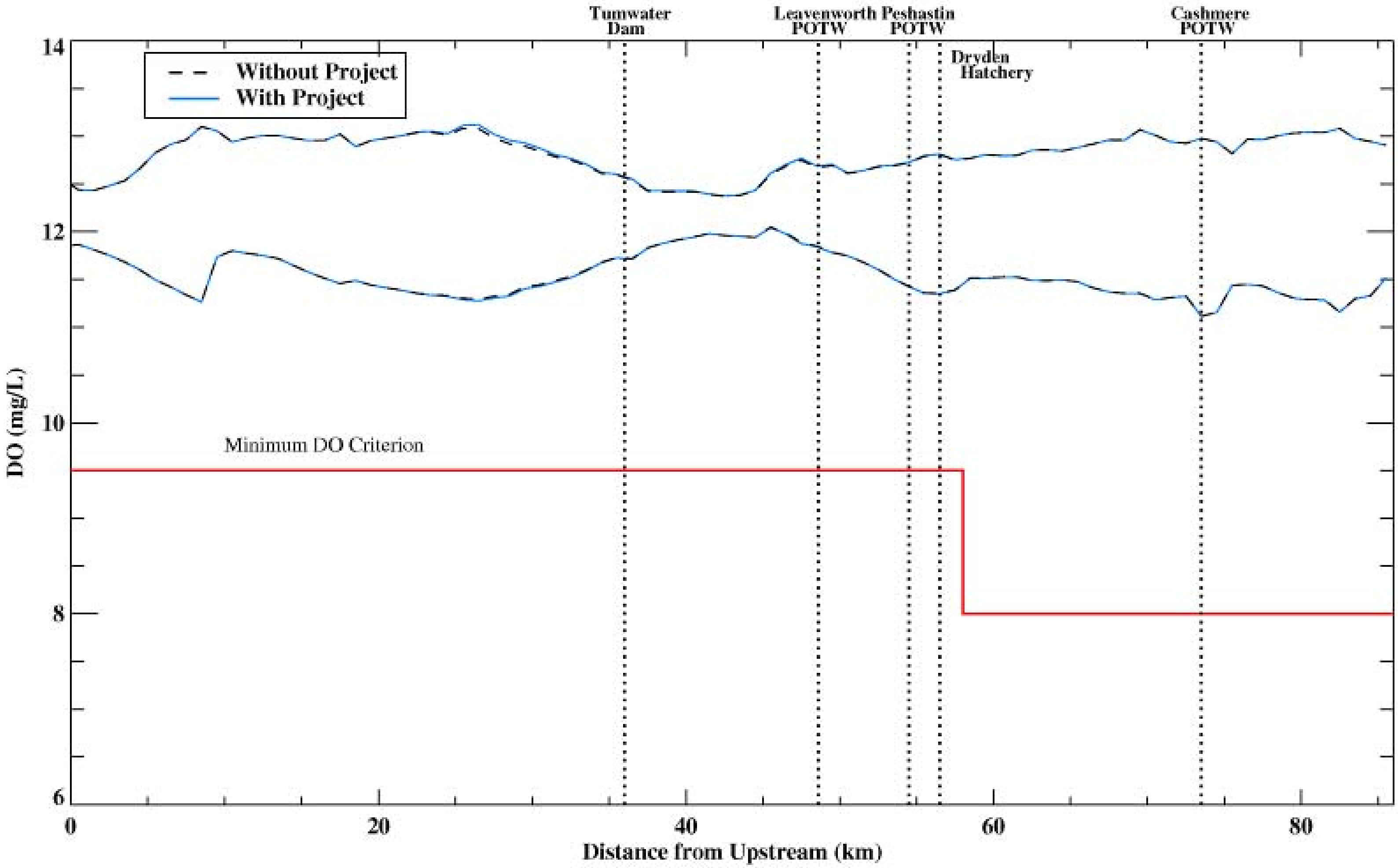



**Figure 40**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative.pro Mon Nov 01 11:25:22 2010

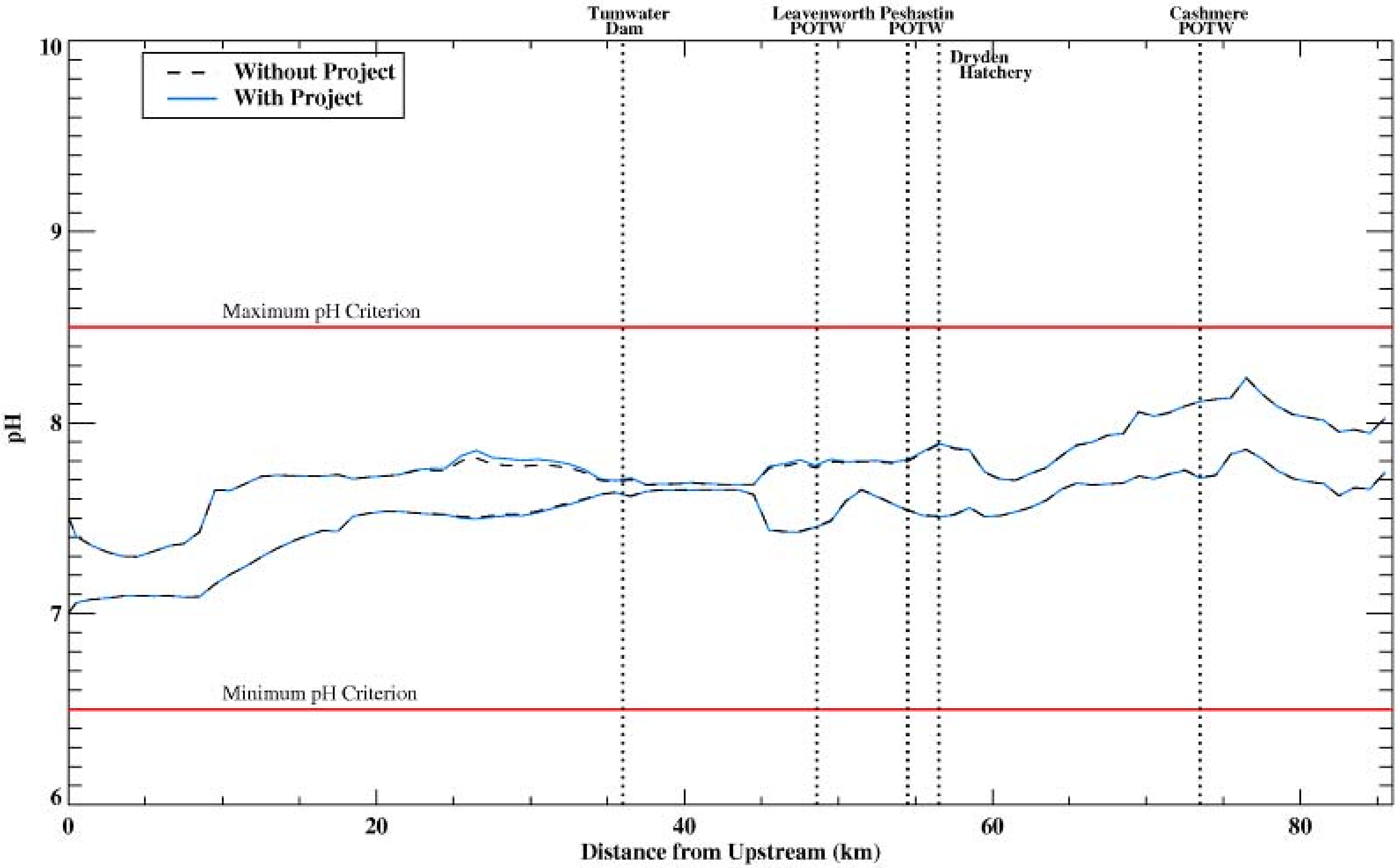



**Figure 41**

pHs simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQJobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative.pro Mon Nov 01 11:25:22 2010

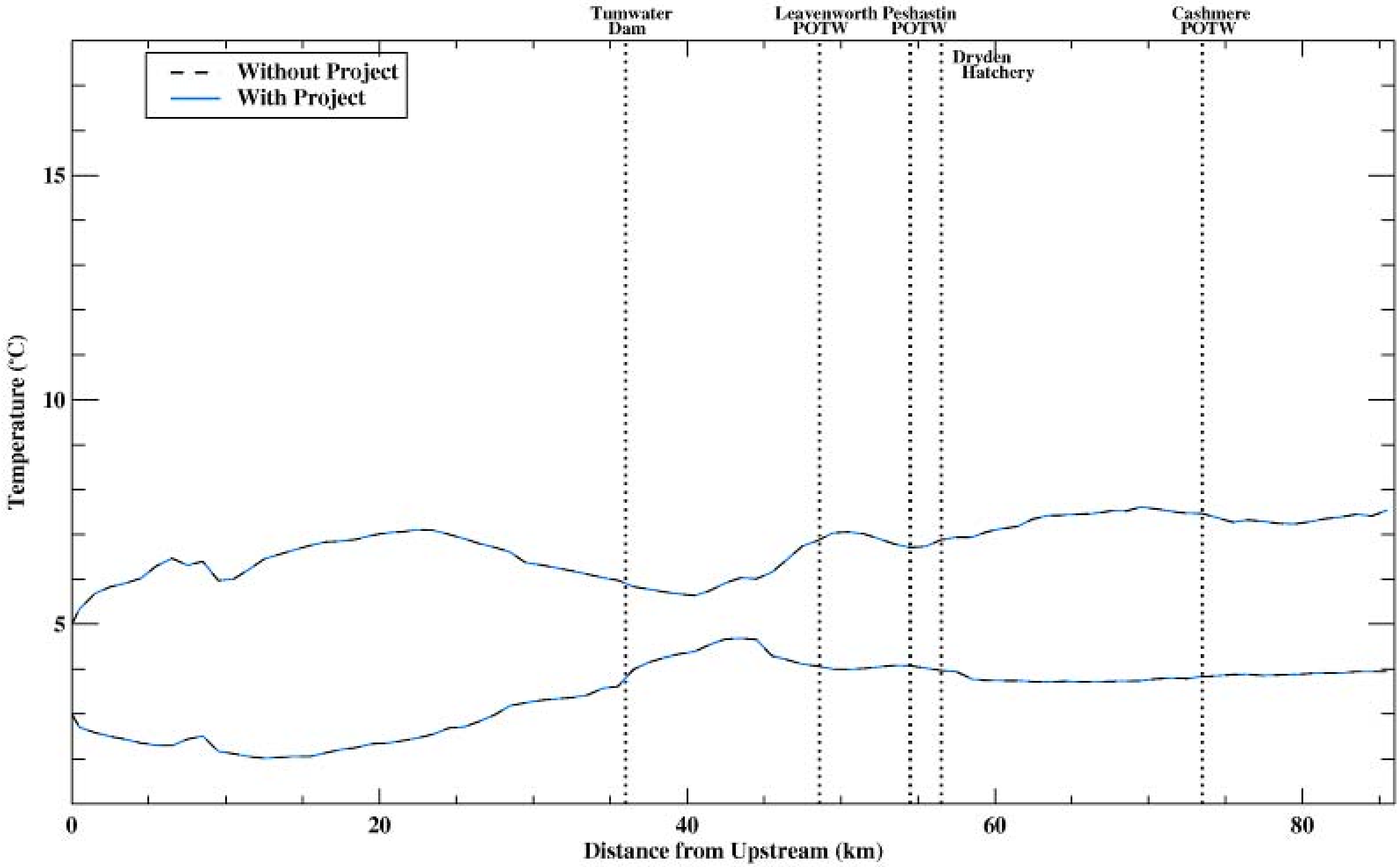



**Figure 42**

Temperatures simulated by QUAL-2K model shown compared for cases with and without the proposed project for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQJobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative.pro Mon Nov 01 11:25:22 2010

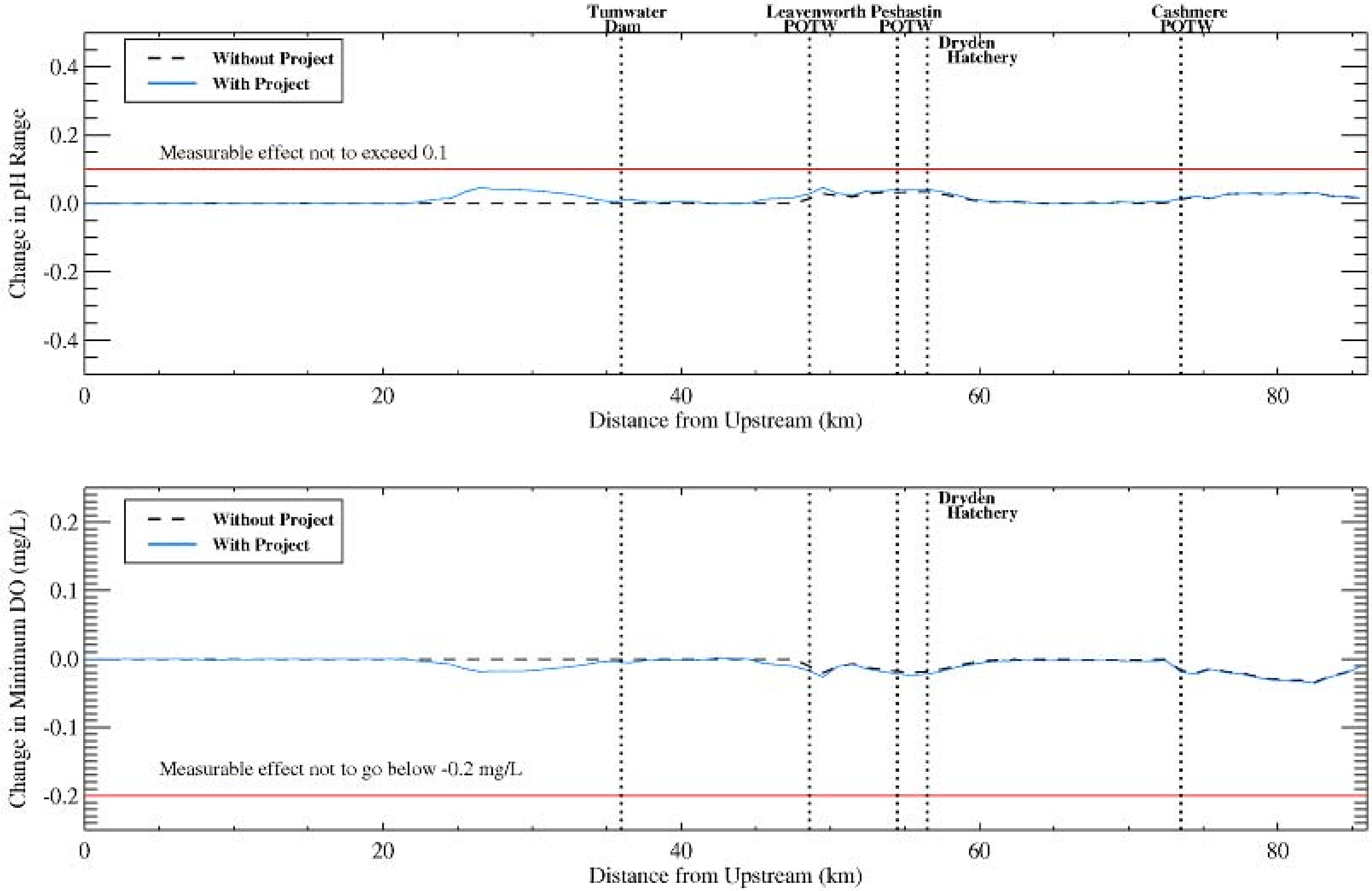



**Figure 43**

Difference from March background conditions in the range of pH and minimum dissolved oxygen with and without the proposed project in the Wenatchee subbasin with maximum POTW loading

ANCHOR QEA

### *5.4.2 Methow Subbasin*

An estimate of the cumulative project impact was assessed from the calculations performed for the combined project impacts presented in Section 5.3.3. The contribution of the project related loads relative to the cumulative subbasin load (Methow River at Pateros in Table 14) was estimated to be about 0.8%.

The equivalent calculation for the Wenatchee sites resulted in a relative project contribution of 1.1% of the subbasin TP loading (Table 15). Mechanistic modeling in the previous section indicated that acclimation-related loads in the Wenatchee subbasin caused a negligible change in DO and pH even in the presence of anthropogenic sources. Given the lower estimate of nutrient loading from acclimation activity in the Methow subbasin (see Table 14) and the similarity in the basin characteristics (see Section 5.1.2), the TP loads from acclimation activity are unlikely to cause a measurable change in DO and pH in the Methow River.

# 6 NO ACTION ALTERNATIVE

The No Action alternative is described in the Environmental Impact Statement (EIS). The sites included in the No Action alternative for the Wenatchee and the Methow subbasins are shown respectively in Table 16 and Table 17. This section presents the combined and cumulative impacts expected from the No Action alternative.

## 6.1 Assessment of Impacts for the Wenatchee Subbasin

The mechanistic modeling approach used for estimating the combined and cumulative impacts for the preferred alternative (see Sections 5.3 and 5.4.1) was extended for the No Action alternative sites. The estimated phosphorus loads for the sites in the No Action alternative (see Table 16) were used to calculate the phosphorus concentrations of the respective tributaries receiving the discharge in the QUAL-2K model. Loading from any other site in the preferred alternative that is not listed in Table 16 was excluded. All other simulation conditions and modeling assumptions remained unchanged from the preferred alternative simulations.

### *6.1.1 Combined Impacts*

Figures 44 through 47 show the water quality parameters for the combined impact simulation. These figures show that the impacts to water quality are negligible if the project were to continue without the changes proposed in the preferred alternative. This is not surprising given that the results discussed in previous sections demonstrated that even with the greater number of sites proposed in the preferred alternative, impacts were determined to be negligible.

Figure 48 shows that the DO and pH changes over the background conditions are expected to be milder than the preferred alternative. Because two-thirds of the loads in the No Action alternative are released into Nason Creek, impacts in the upper section of the river (particularly near RKM 27) are comparable to, albeit smaller than, those resulting from the preferred alternative. In the lower Wenatchee River, there is almost no change in DO and pH over the background conditions for both alternatives.

**Table 16**
**No Action alternative sites in Wenatchee subbasin**

| No Action Site | No. of Fish ('000s) | TP Load[1] (kg/d) | Receiving Stream |
|---|---|---|---|
| Rohlfing | 100 | 0.032 | White River |
| Coulter | 100 | 0.032 | White River |
| Butcher | 100 | 0.032 | Little Wenatchee |
| Beaver | 100 | 0.032 | Beaver |
| Leavenworth NFH | 100 | 0.032 | Icicle |
| **Total** | **500** | **0.16** | |

Notes:
1. Uses an estimate of 0.32 mg/d/fish derived from active sites in Nason Creek; see Table 5.

**Table 17**
**No Action alternative sites in Methow subbasin**

| No Action Site | No. of Fish ('000s) | TP Load[1] (kg/d) | Receiving Stream |
|---|---|---|---|
| Heath | 20 | 0.006 | Twisp River |
| Lincoln | 60 | 0.019 | Twisp River |
| Lower Twisp | 20 | 0.006 | Methow River |
| WNFH | 100 | 0.032 | Methow River |
| **Total** | **200** | **0.064** | |

Notes:
1. Uses an estimate of 0.32 mg/d/fish derived from active sites in Nason Creek; see Table 5.

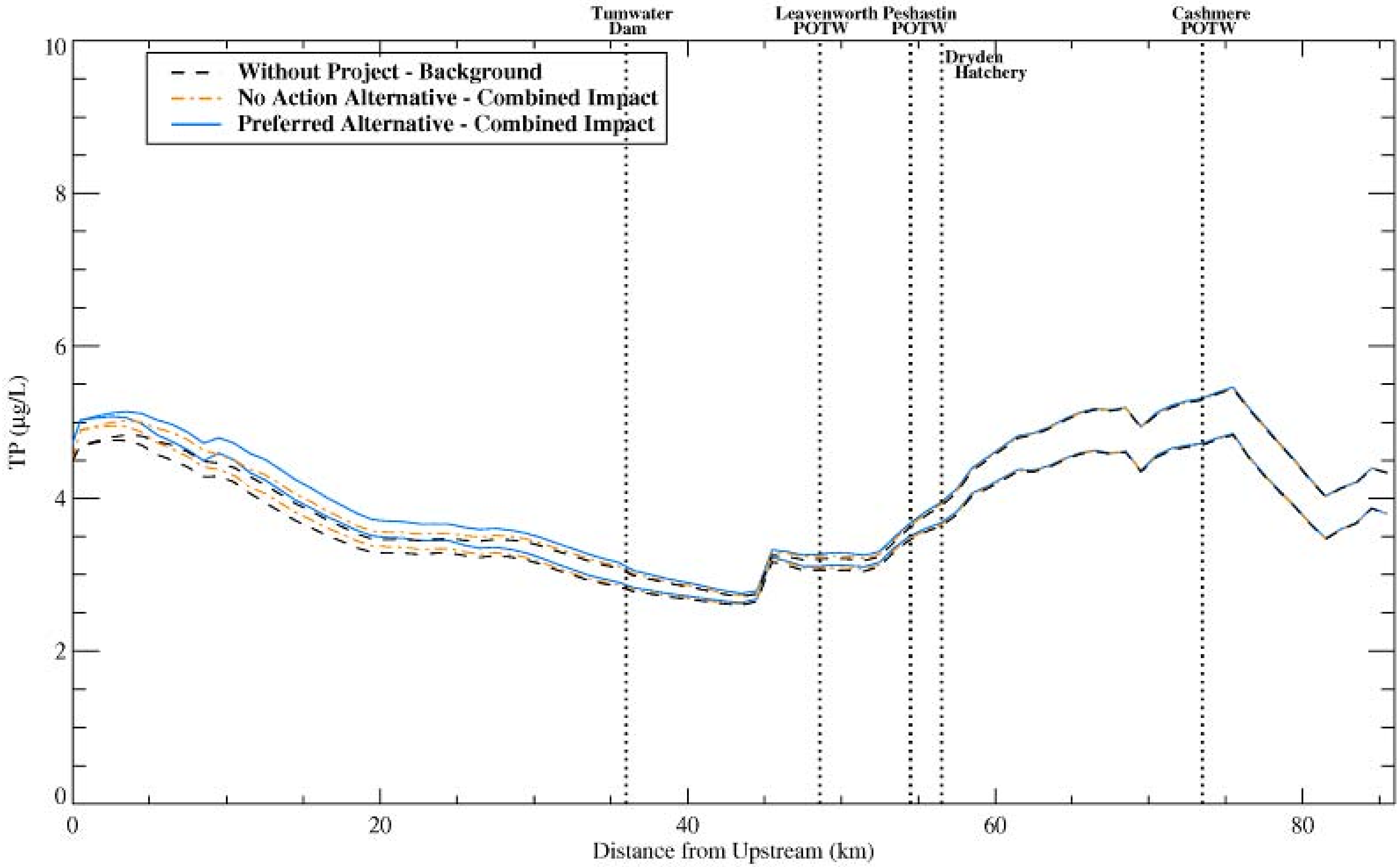



**Figure 44**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for the No Action and Preferred alternatives for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_rec_combined_no_action.pro Mon Nov 01 11:30:40 2010

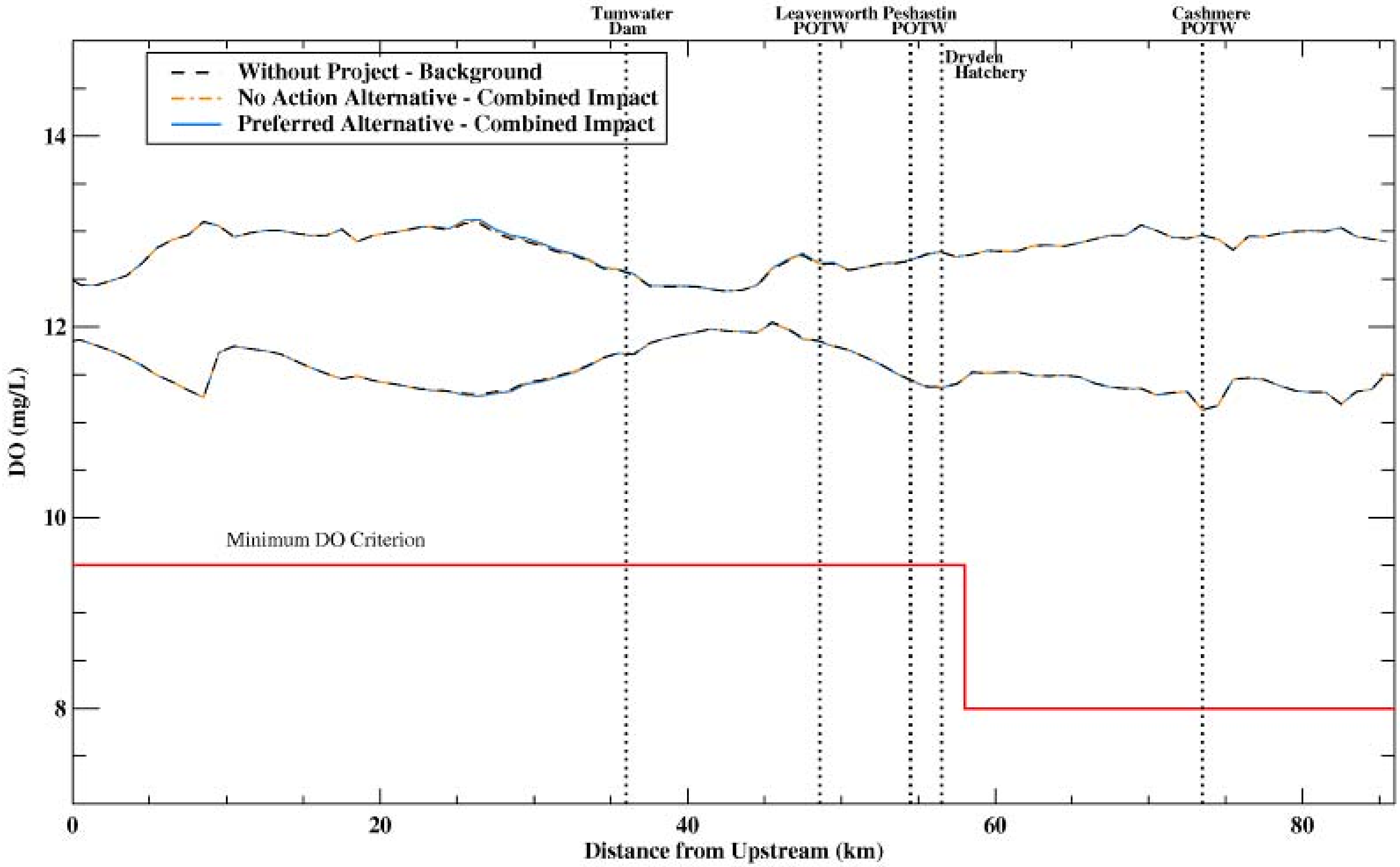



**Figure 45**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for the No Action and Preferred alternatives for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_rec_combined_no_action.pro Mon Nov 01 11:30:40 2010

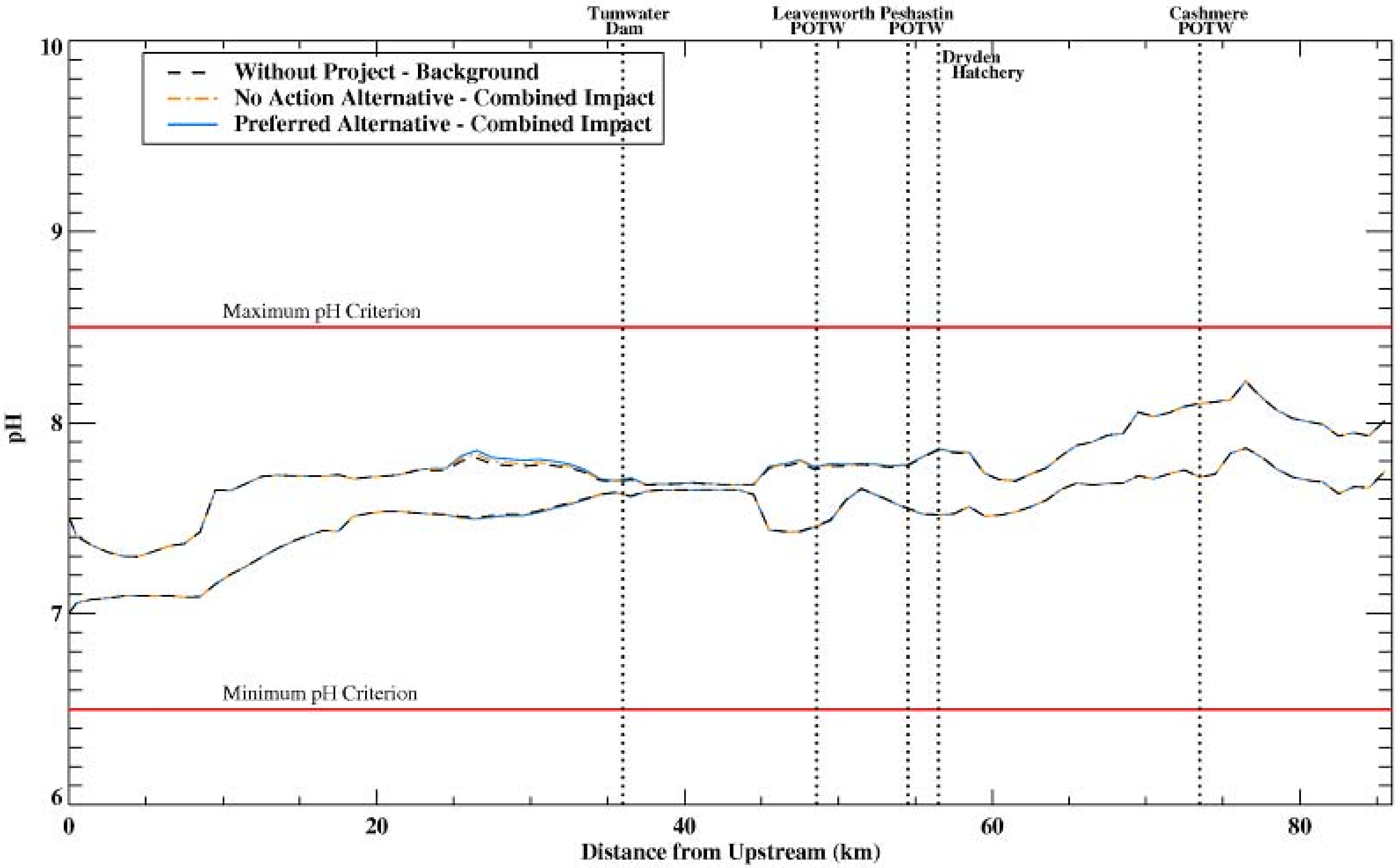



**Figure 46**

pHs simulated by QUAL-2K model shown compared for the No Action and Preferred alternatives for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AG\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_combined_no_action.pro Mon Nov 01 11:30:40 2010

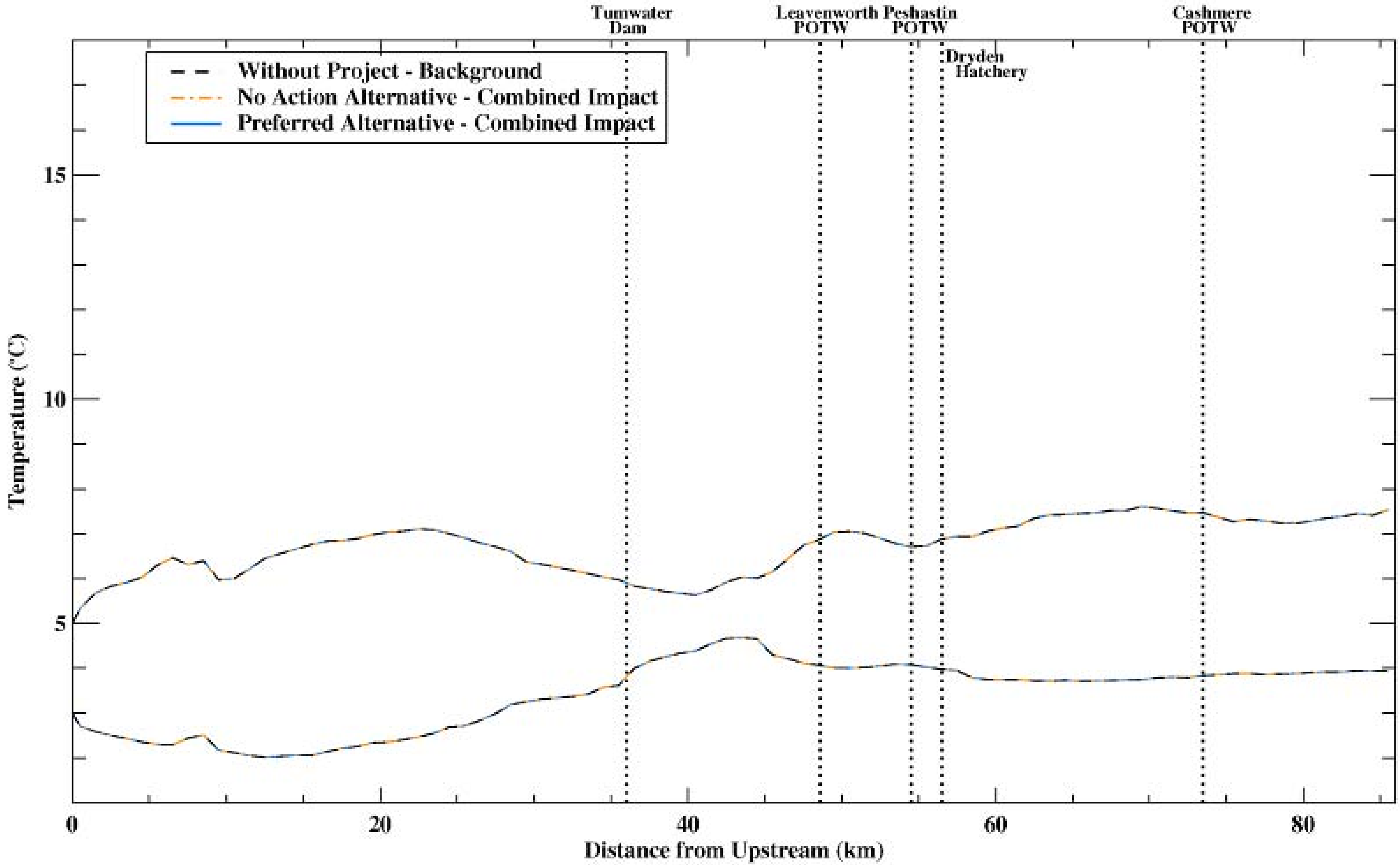



**Figure 47**

Temperatures simulated by QUAL-2K model shown compared for the No Action and Preferred alternatives for 7Q10 low-flow and March climatic condition with maximum background loadings determined in WDOE TMDL

*Phosphorus concentrations from all sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_combined_no_action.pro Mon Nov 01 11:30:40 2010

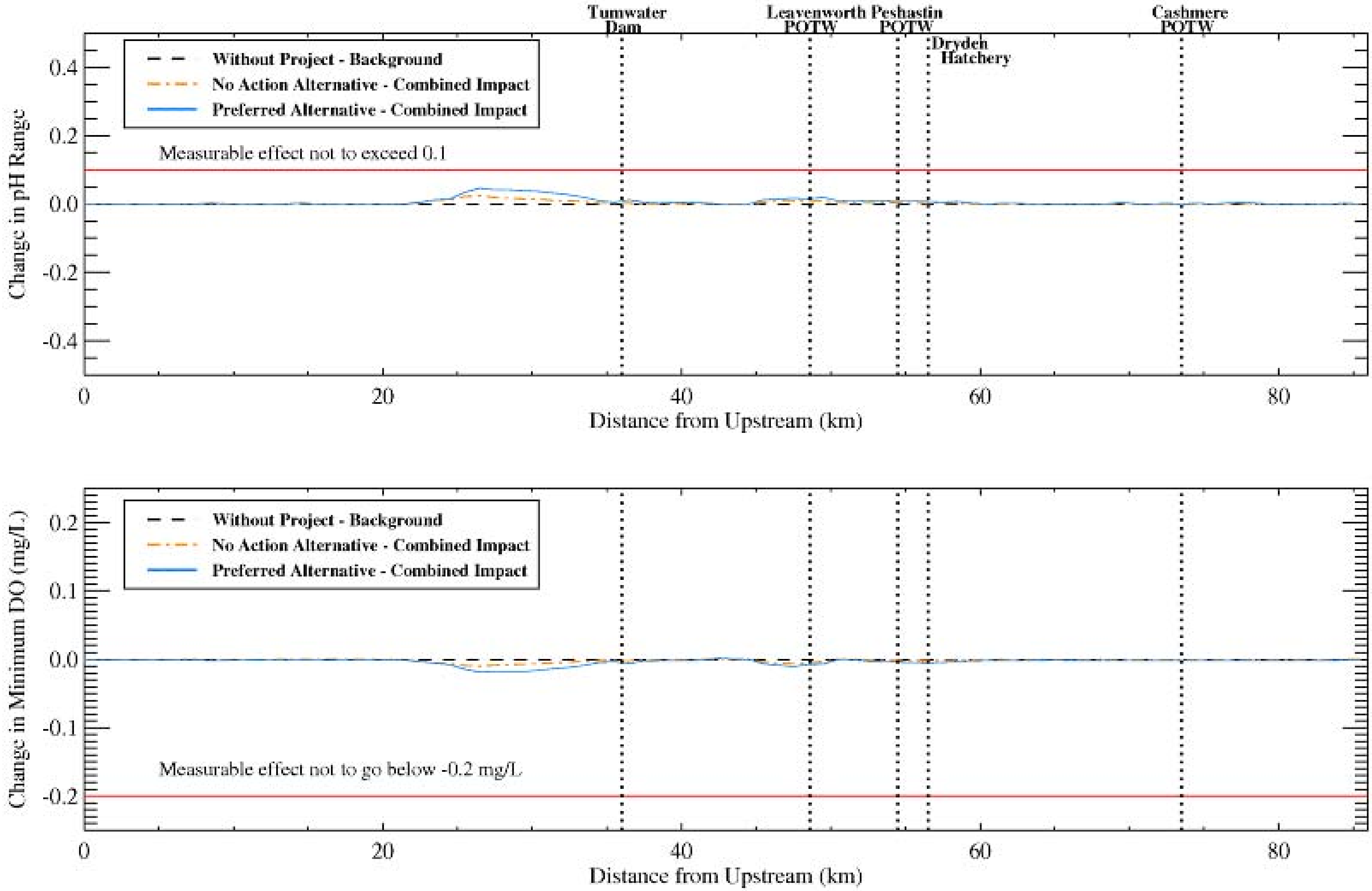



**Figure 48**

Difference from March background conditions in the range of pH and minimum dissolved oxygen in the Wenatchee subbasin for the No Action and Preferred alternatives

ANCHOR QEA

PM - C:\AQJobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2h_res_combined_no_action.pro Mon Nov 01 11:30:41 2010

### *6.1.2 Cumulative Impacts*

As with the preferred alternative, the impacts of discharges from the sites in the No Action alternative were assessed for the case when POTWs discharge at their design capacity, contributing a phosphorus load as allocated in the WDOE TMDL (corresponding to 90 µg/L). The spatial trends in water quality parameters (see Figures 49 to 52) were similar to those predicted for the preferred alternative. As expected, the changes in minimum DO and pH range over the background conditions were predicted to be milder than for the preferred alternative (Figure 53).

## 6.2 Assessment of Impacts for the Methow Subbasin

The No Action alternative involves acclimation of 200,000 fish (see Table 17), which is 20% of the number of fish for the preferred alternative (see Table 9). Therefore, the TP loads for the No Action alternative are expected to be lower by 80%. Based on the background and subbasin loads estimated for the Methow subbasin (Table 14), it is expected that the No Action alternative will contribute less than 0.2% of the subbasin loads. Therefore, water quality impacts on the Methow River are expected to be negligible if the No Action alternative is implemented as proposed.

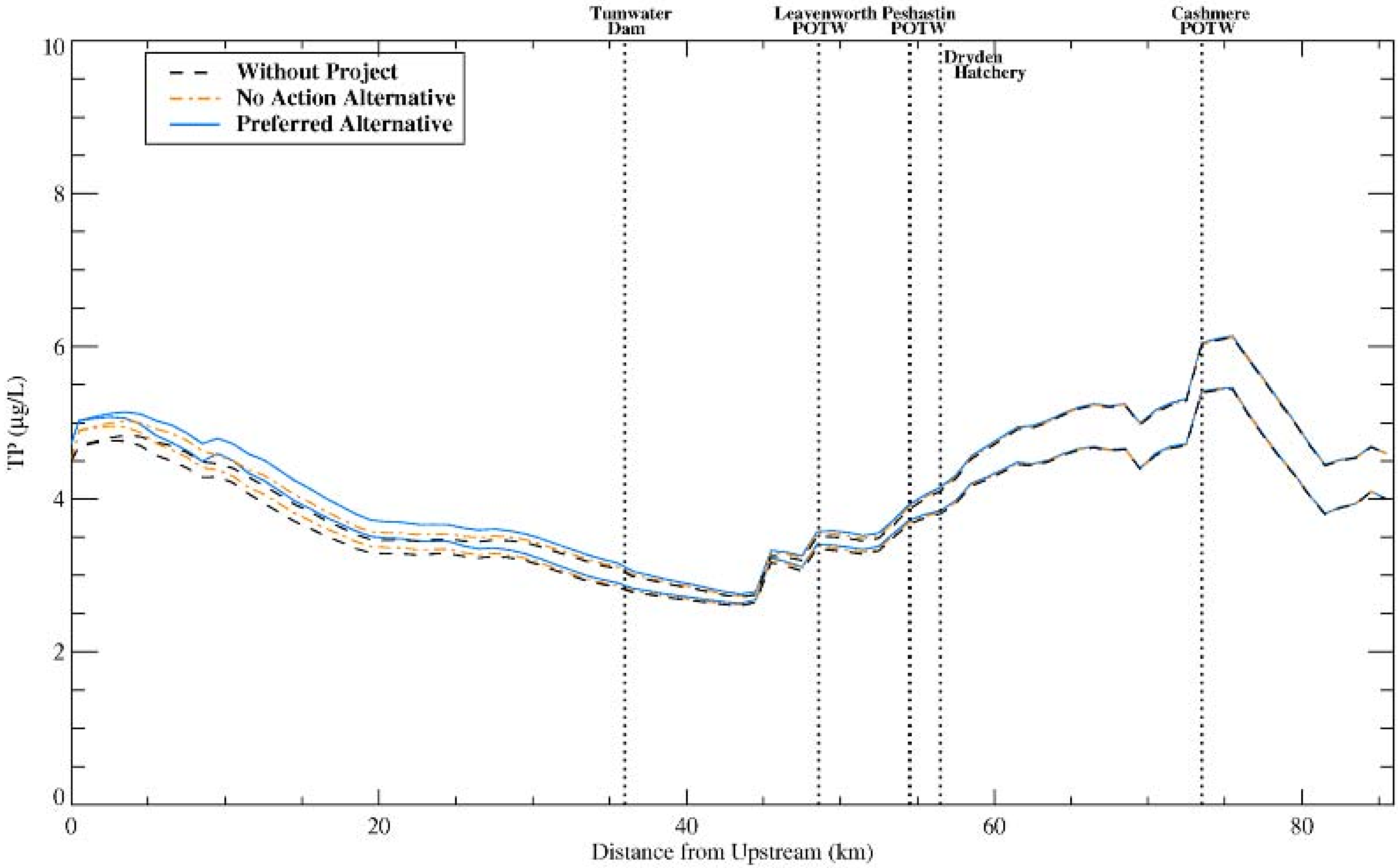



**Figure 49**

Total phosphorus concentrations simulated by QUAL-2K model shown compared for the Preferred and No Action alternatives for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*

ANCHOR QEA

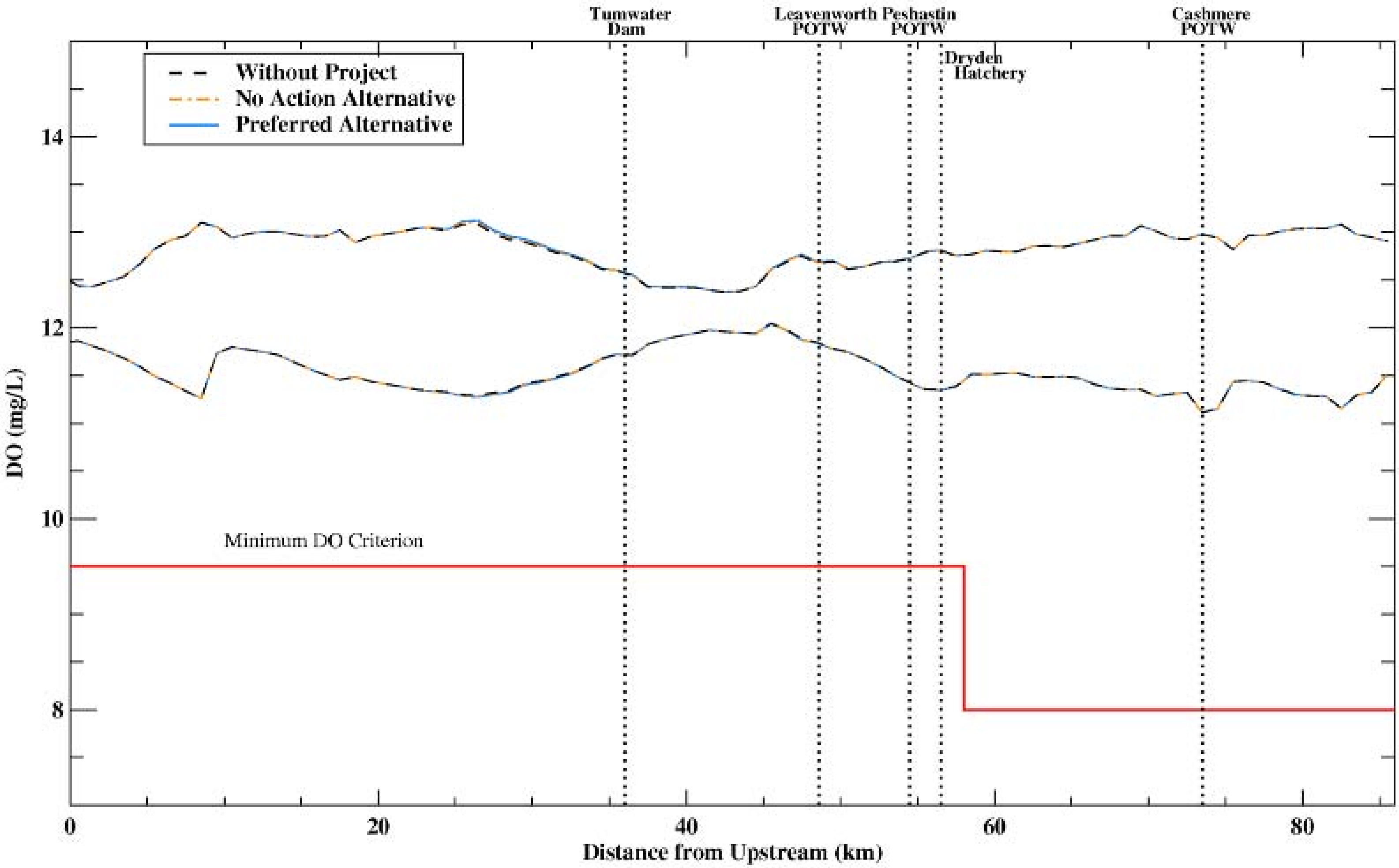



**Figure 50**

Dissolved oxygen concentrations simulated by QUAL-2K model shown compared for the Preferred and No Action alternatives for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AQJobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_no_action.pro Mon Nov 01 11:34:50 2010

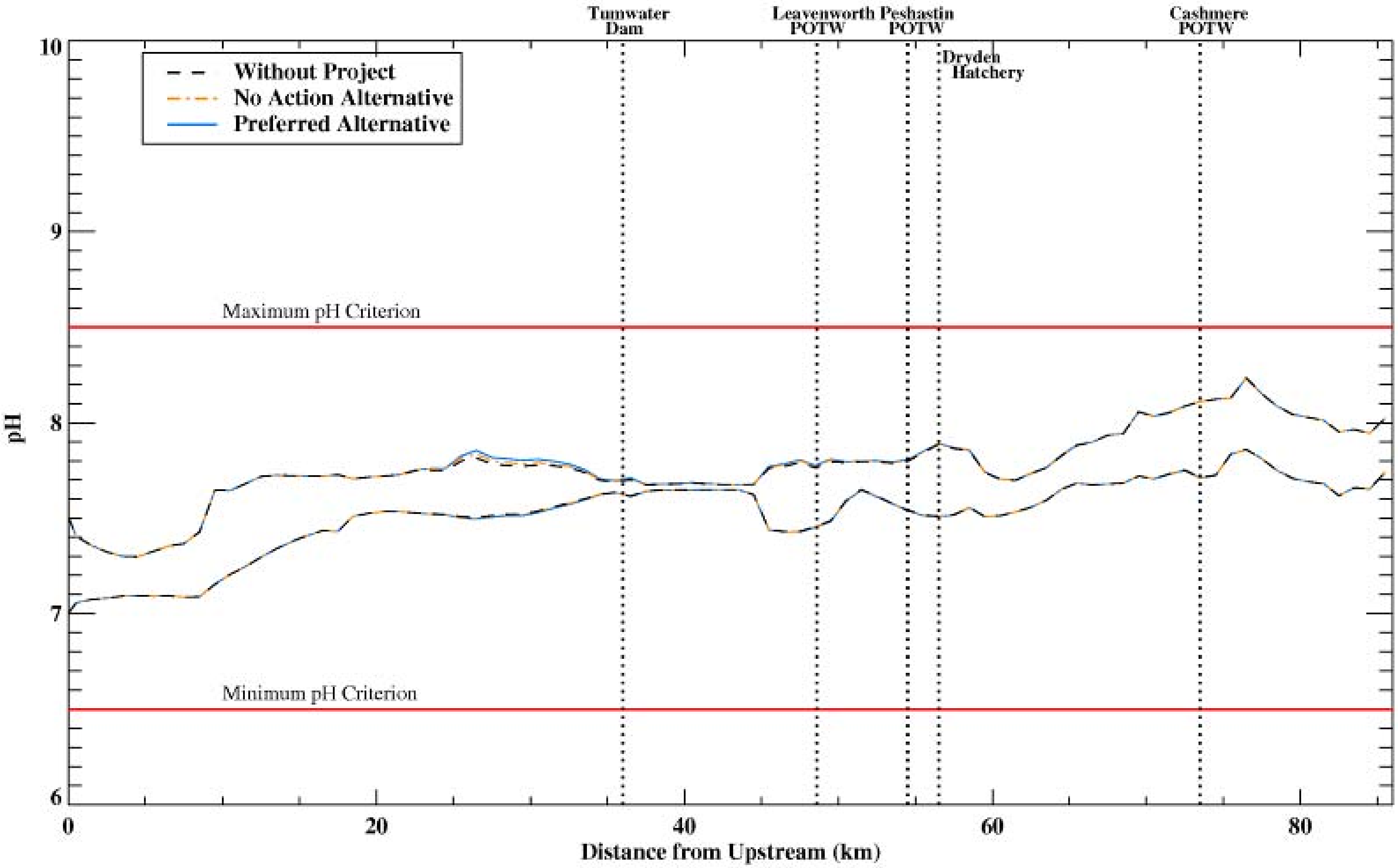



**Figure 51**

pHs simulated by QUAL-2K model shown compared for the Preferred and No Action alternatives for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_no_action.pro Mon Nov 01 11:34:50 2010

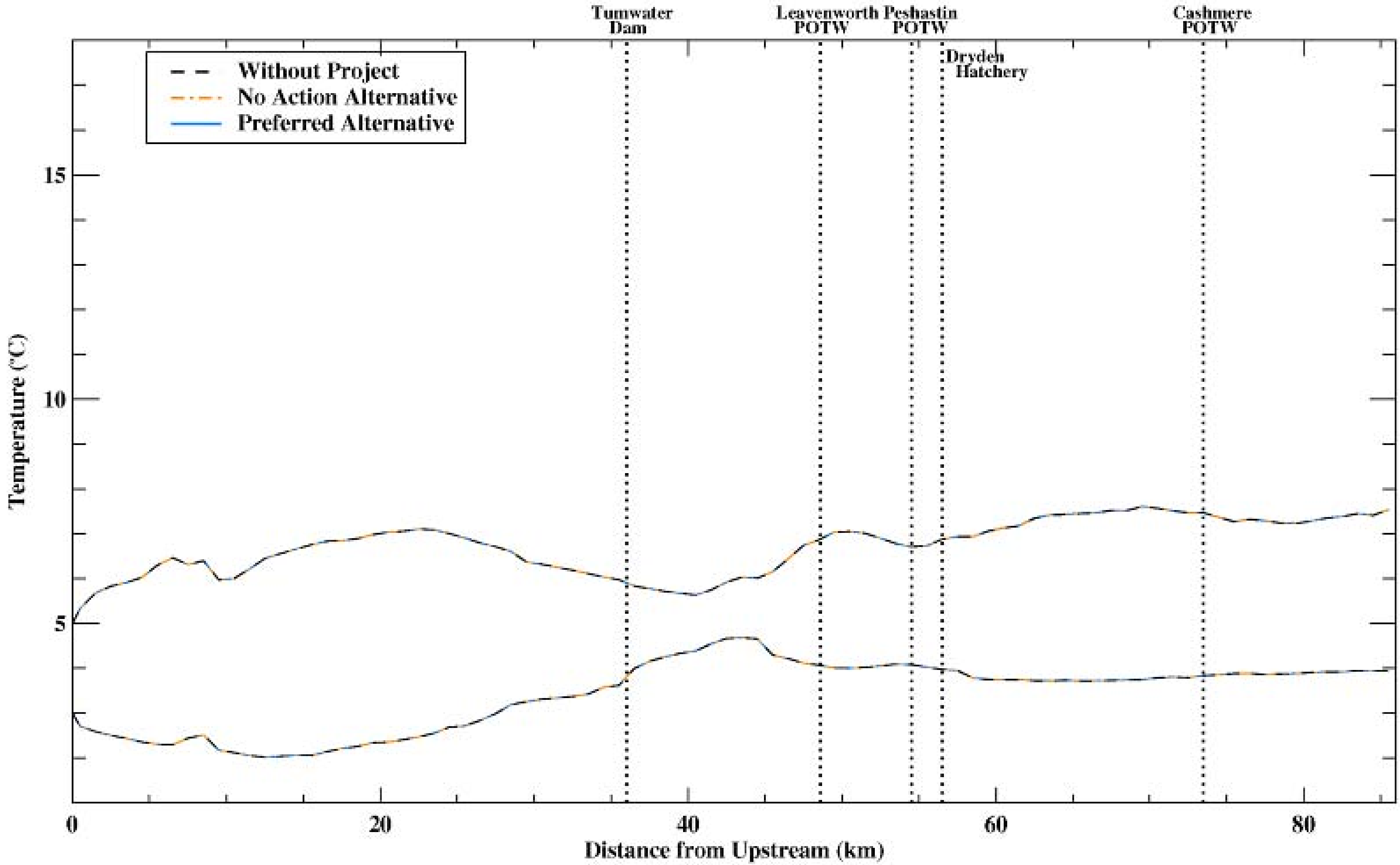



**Figure 52**

Temperatures simulated by QUAL-2K model shown compared for the Preferred and No Action alternatives for 7Q10 low-flow and March climatic condition with maximum POTW loading

*Phosphorus discharges from Leavenworth, Peshastin and Cashmere POTWs occured at design flow and 90 ug/L concentration*
*Phosphorus concentrations from all other sources set to background levels used in WDOE TMDL natural conditions simulation*
*Minimum and maximum values simulated by the model are shown*

PM - C:\AG\Jobs\GeoSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_rec_cumulative_no_action.pro Mon Nov 01 11:34:50 2010

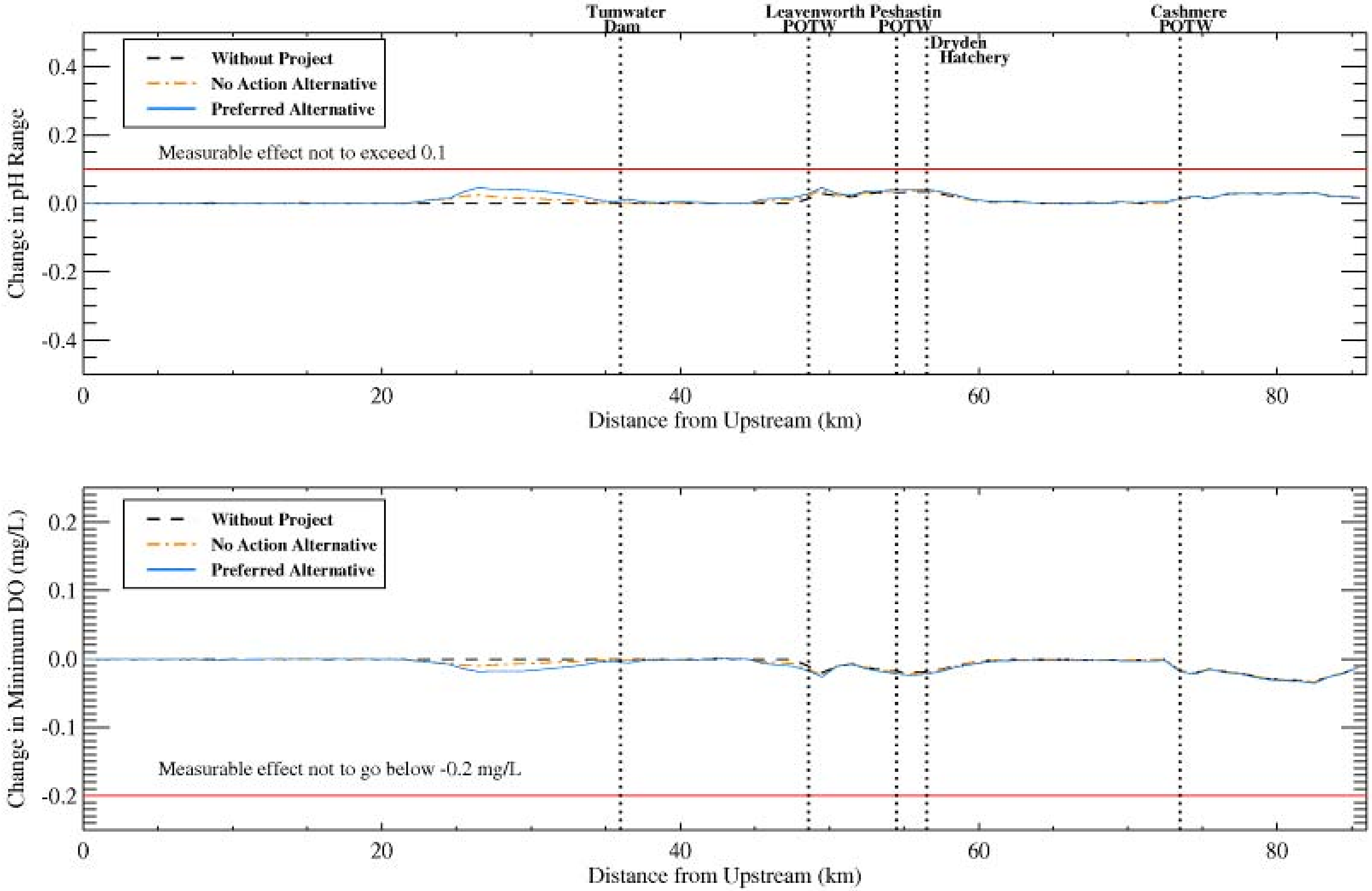



**Figure 53**

Difference from March background conditions in the range of pH and minimum dissolved oxygen for the Preferred and No Action alternatives in the Wenatchee subbasin with maximum POTW loading

ANCHOR QEA

PM - C:\AQ\Jobs\SeaSprings\Yakama_Nation_Coho\Model\Postprocessor\plot_q2k_res_cumulative_no_action.pro Mon Nov 01 11:34:51 2010

# 7 MITIGATION

The project is proposed with several practices listed below that are aimed at reducing nutrient efflux in the discharge:

- Acclimate and release small numbers of coho smolts from multiple sites. This dilutes the loads and reduces localized effects.
- Select ponds with flow rates that are higher than those used in constructed regional fish facilities so that there is substantial dilution of nutrients in the discharges.
- Acclimate in large, natural ponds. The higher water volumes in large ponds provide greater dilution of fish feed and wastes and buffer nutrient loading to the receiving stream.
- Feed high-phosphorus digestibility foods.
- Periodically remove sediments from some acclimation ponds, thereby eliminating potential long-term accumulation of nutrients.
- At the Dryden Hatchery, provide a level of treatment that is comparable to LNFH.

# 8 REFERENCES

Andonaegui, C., 2000. Salmon, Steelhead and Bull Trout habitat limiting factors, Water Resource Inventory Area 48, Washington State Conservation Commission, Washington State Department of Ecology, Olympia, WA.

Andonaegui, C., 2001. Salmon, Steelhead and Bull Trout habitat limiting factors, Water Resource Inventory Area 43 and 40, Washington State Conservation Commission, Washington State Department of Ecology, Olympia, WA.

Carroll, J., S. O'Neal, and S. Golding, 2006. *Wenatchee River Basin Dissolved Oxygen, pH, and Phosphorus Total Maximum Daily Load Study*. Publication No. 06-03-018, Watershed Ecology Section, Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington 98504-7710.

Carroll, J. and R. Anderson, 2009. *Wenatchee River Watershed Dissolved Oxygen and pH Total Maximum Daily Load, Water Quality Improvement Report*. Publication No. 08-10-062, Water Quality Program, Central Regional Office, Washington Department of Ecology, Yakima, WA.

Chelan County and Yakama Nation, 2004. *Wenatchee Subbasin Plan*, prepared for Northwest Power and Conservation Council. Internet reference: http://www.nwcouncil.org/fw/subbasinplanning/wenatchee/plan/

Chelan County Public Utility District (Chelan PUD), 2009. Unpublished data - upon request this data was received by e-mail from Waikele Hampton on behalf of Chelan County PUD by Carmen Andonaegui of Anchor QEA on Dec 9, 2009.

Cole, T.M. and S.A. Wells, 2006. *CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model*, Version 3.5, Instruction Report EL-06-1. U.S. Army Engineering and Research Development Center, Vicksburg, MS.

Ely, D.M., 2003. *Precipitation-runoff simulations of current and natural streamflow conditions in the Methow River Basin, Washington, Water-Resources Investigations Report* 03-4246, U.S. Geological Survey, Tacoma, WA, 35 p.

Flimlin, G., S. Sugiura, and P. Ferraris, 2003. Examining Phosphorus in Effluents from Rainbow Trout (*Oncorhyncus mykiss*) Aquaculture, Rutgers Cooperative Extension, Bulletin E287.

Grant County Public Utility District (Grant PUD), 2009. *Final Water Quality Monitoring Report*, Public Utility District No. 2 of Grant County Lake Wenatchee Water Quality Monitoring, July 2009, Grant County PUD, Ephrata, Washington.

KWA Ecological Sciences Inc., Okanogan County; Washington Department of Fish and Wildlife; and Confederated Tribes of the Colville Reservation Tribes, 2004. *Final Methow Subbasin Plan*, prepared for Northwest Power and Conservation Council. Internet reference: http://www.nwcouncil.org/fw/subbasinplanning/methow/plan

Konrad, C.P., B.W. Drost, and R.J. Wagner, 2003. *Hydrogeology of the unconsolidated sediments, water quality, and ground-water/surface-water exchanges of the Methow River Basin, Okanagon County, Washington, Water Resources Investigations Report* 03-4322, United States Geological Survey, Tacoma, WA, 137 p.

Tipping, J.M., and K.D. Shearer, 2007. Postrelease Survival of Hatchery-Reared Coho Salmon Juveniles Fed Low-Phosphorus and Other Diets, *North American Journal of Aquaculture*, 69, 340–344.

WAC (Washington Administrative Code), 2006. *Water quality standards for surface waters of the State of Washington*, Chapter 173-201A WAC, Internet reference: http://apps.leg.wa.gov/wac/default.aspx?cite=173-201A

# APPENDIX 8.2
# FLOOD IMPACT ANALYSIS

**Prepared by**
Anchor QEA, LLC
811 Kirkland Avenue, Suite 200
Kirkland, Washington 98033

**October 2010**

# TABLE OF CONTENTS

## List of Tables



## List of Figures

# 1 SUMMARY

Implementation of the Mid-Columbia Coho Restoration Project (MCCRP) will likely have little or no effect on flood elevations. Where there is an effect, it is likely to be beneficial as the acclimation ponds will provide some small amount of additional floodplain storage (difference between the existing land surface elevation and the working water surface elevation). While minor construction activities will occur at some sites (excavation of ponds and ditches, grading of roads to improve winter access, or installation of buried water supply pipes), the spoil materials created by these activities will be disposed of outside the 100-year floodplain in accordance with the local grading and floodplain management ordinances. Consequently, there are not likely to be changes in grades that could direct or diverts flood flows affecting properties either upstream or downstream of the individual project sites.

# 2 INTRODUCTION

This Flood Impact Analysis report has been prepared to assist with an evaluation of the flooding impacts at proposed coho salmon acclimation sites for the Mid-Columbia Coho Restoration Project Environmental Impact Statement (EIS). Executive Order 11988 (Floodplain Management) directs federal agencies to evaluate the potential effects of their actions in 100-year flood hazard zones shown on Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs).

This report has been prepared as a companion document to support the EIS analysis. Consequently, project site details such as site locations; project descriptions; and associated maps, figures, and photographs are presented in the *Brood Capture and Rearing Site Descriptions* (Appendix 1 of the EIS), the *Wenatchee Acclimation Site Descriptions* (Appendix 2 of the EIS), and the *Methow Acclimation Site Descriptions* (Appendix 3 of the EIS), which were also prepared for the project, and the information is not duplicated in this report.

# 3 METHODS

Consistency of the proposed actions with rules and regulations and impacts to floodplains as a result of implementing the proposed actions are evaluated qualitatively. Existing flood hazards and potential flooding sources are identified. Where no floodplain mapping has occurred or no base flood elevation (BFE) established, potential sources of supplemental information are identified. No new hydrologic or hydraulic modeling was completed for this analysis.

Many of the acclimation sites described in the EIS and identified in Section 2 of this report are located in or adjacent to special flood hazard areas designated Zone A on FEMA FIRMs. As such, these areas do not have BFEs determined. Although BFEs are not provided, the community (e.g., Chelan County or Okanogan County) is still responsible for ensuring that new development within "approximate" Zone A areas is constructed using methods that will minimize flood damages. Additionally, community floodplain management programs typically extend their regulations to all lands subject to inundation from any sources; this means that in order to obtain grading, building, development, or possibly conditional use permits for individual projects of the proposed action, these projects may be required to go through the floodplain development permit process. If it were determined that the floodplain development permit process is required, there would be a need for substantially more detailed analysis performed by a professional civil engineer to determine the BFEs in areas mapped Zone A or unmapped areas, as well as to perform an analysis of floodplain impacts. These additional analyses would possibly include hydrologic as well as hydraulic modeling and surveying. These detailed floodplain analyses are not part of this impact evaluation and are beyond the scope of the EIS.

# 4 EXISTING ENVIRONMENT

## 4.1 Regulatory Environment

### *4.1.1 Federal Rules and Regulations*

#### *4.1.1.1 Executive Order 11988 – Floodplain Management*

Executive Order 11988 (EO) requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities" for the following actions:

- Acquiring, managing, and disposing of federal lands and facilities
- Providing federally-undertaken, financed, or assisted construction and improvements
- Conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulation, and licensing activities

The guidelines address an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps, which are summarized below, reflect the decision-making process required in Section 2(a) of the EO.

1. Determine if a proposed action is in the base floodplain (that area with a 1 percent or greater chance of flooding in any given year).
2. Conduct early public review, including public notice.
3. Identify and evaluate practicable alternatives to locating in the base floodplain, including alternative sites outside of the floodplain.
4. Identify impacts of the proposed action.
5. If impacts cannot be avoided, develop measures to minimize the impacts and restore and preserve the floodplain, as appropriate.
6. Re-evaluate alternatives.

7. Present the findings and a public explanation.
8. Implement the action.

Among a number of things, the Interagency Task Force on Floodplain Management clarified the EO with respect to development in floodplains, emphasizing the requirement for agencies to select alternative sites for projects outside the floodplains, if practicable, and to develop measures to mitigate unavoidable impacts.

#### *4.1.1.2 National Flood Insurance Program*

Congress, alarmed by increasing costs of disaster relief, passed the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. The intent of these acts is to reduce the need for large, publicly funded flood control structures and disaster relief by restricting development on floodplains.

FEMA administers the National Flood Insurance Program (NFIP), which provides subsidized flood insurance to communities that comply with federal regulations that limit development in floodplains. The agency issues FIRMs for communities participating in the flood insurance program. These maps delineate flood hazard zones in the community.

The primary requirement for community participation in the NFIP is the adoption and enforcement of floodplain management regulations that meet the minimum standards of the NFIP regulations in Title 44 of the Code of Federal Regulations (CFR) Section 60.3. These minimum standards are also codified by the State of Washington as described in the following section.

Flood zones are geographic areas that FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's FIRM or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.

##### 4.1.1.2.1 Moderate to Low Risk Areas

Zones B, C, and X include areas outside the 1 percent annual chance floodplain; areas of 1 percent annual chance sheet flow flooding where average depths are less than 1 foot; areas of

1 percent annual chance stream flooding where the contributing drainage area is less than 1 square mile; or areas protected from the 1 percent annual chance flood by levees. No BFEs or depths are shown within this zone.

#### 4.1.1.2.2 High Risk Areas

Zone A includes areas with a 1 percent annual chance of flooding. Because detailed analyses are not performed for such areas, no depths or BFEs are shown within these zones.

Zones AE and A1-A30 include areas with a 1 percent annual chance of flooding. In most instances, BFEs derived from detailed analyses are shown at selected intervals within these zones.

Zone AH includes areas with a 1 percent annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. BFEs derived from detailed analyses are shown at selected intervals within these zones.

Zone AO includes river or stream flood hazard areas, and areas with a 1 percent or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. Average flood depths derived from detailed analyses are shown within these zones.

Zone AR includes areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam).

Zone A99 includes areas with a 1 percent annual chance of flooding that will be protected by a federal flood control system where construction has reached specified legal requirements. No depths or BFEs are shown within these zones.

#### 4.1.1.2.3 Undetermined Risk Areas

Zone D includes areas with possible but undetermined flood hazards, and no flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

### 4.1.2 State Rules and Regulations

Chapter 86.16 Revised Code of Washington (RCW) establishes state-wide authority for floodplain management through the adoption and administration by local governments of regulatory programs that are compliant with the minimum standards of the NFIP. Chapter 86.16 RCW directs the Washington State Department of Ecology (Ecology) to establish minimum state requirements for floodplain management that equal the NFIP minimum standards; to provide technical assistance and information to local governments related to administration of their floodplain management ordinances and the NFIP; to provide assistance to local governments in identifying the location of the 100-year (base) floodplain; and to allow for the issuance of regulatory orders.

Floodplains are also regulated by both the Ecology and the Department of Commerce (Commerce) via the Shoreline Management Act of 1971 (SMA) and the Growth Management Act of 1990 (GMA), respectively. The SMA Guidelines translate the broad policies of RCW 90.58.020 into standards for regulation of shoreline uses including the floodplains of larger rivers.

Commerce regulates floodplain development through the GMA. Local governments, counties, and cities must develop Comprehensive Plans that guide and regulate development in the community. The GMA requires local communities to develop and implement Critical Areas Ordinances; floodplains are one such critical area.

The state agencies provide guidelines to local agencies and provide oversight to ensure that the minimum standards set forth in the rules and regulations are implemented at the local level.

### 4.1.3 Local Rules and Regulations

As described previously, the primary requirement for community participation in the NFIP is the adoption and enforcement of floodplain management regulations that meet the minimum standards. The intent of floodplain management regulations is to minimize the potential for flood damages to new construction and to avoid aggravating existing flood hazard conditions that could increase potential flood damages to existing structures.

#### 4.1.3.1 Chelan County

Chelan County Code "Chapter 3.20 Flood Hazard Development" regulates development in flood prone areas of the county (Chelan County 2009). The ordinance prohibits development within the floodway, but allows development in the floodplain outside the floodway, as long the cumulative effect of the proposed and existing development does not increase water surface elevation of the BFE by more than 1 foot at any point. Special provisions apply for impacts inside the FEMA-designated shallow flooding areas (Zones AH and AO), where developments are allowed but restricted. The ordinance does not impose any restriction on a development in the FEMA-designated Zone X. Generally, Chelan County relies on the most recent FIRMs published by FEMA to designate areas of special flood hazard. When BFE data have not been provided or flood hazard areas established, the Chelan County shall obtain, review, and reasonably use any BFE data and floodway data available from federal, state, or other sources, in order to administer the development standards. Topographic data and hydrologic and hydraulic analyses by a professionally licensed surveyor and/or professionally licensed engineer are required to determine the BFE and floodway for a development permit.

#### 4.1.3.2 Okanogan County

Okanogan County Code "Chapter 15.08 Floodplain Management" regulates development in flood prone areas of the county (Okanogan County 2008). The ordinance prohibits development within the floodway, but allows development in the floodplain outside the floodway, as long the cumulative effect of the proposed and existing development does not increase water surface elevation of the BFE by more than 1 foot at any point. Special provisions apply for impacts inside the FEMA-designated shallow flooding areas (Zones AH and AO), where developments are allowed but restricted. The ordinance does not impose any restriction on a development in the FEMA-designated Zone X. Generally, Okanogan County relies on the most recent FIRMs published by FEMA to designate areas of special flood hazard, but the best available information shall be used if these maps are not available or sufficient as required by the State of Washington (RCW 86.16.051). Topographic data and hydrologic and hydraulic analyses by a professionally licensed surveyor and/or professionally licensed engineer are required for development in non-detailed study areas (Zone A).

## 4.2 Existing Flood Information

### *4.2.1 Wenatchee Subbasin Primary Sites*

The climate of Wenatchee subbasin is characterized by warm, dry summers and relatively cold winters. The average annual precipitation in the lower elevations is just greater than 11 inches, increasing with elevation to about 35 inches. The bulk of this precipitation falls as snow, which reaches 100 inches or more in the upper watersheds. The Wenatchee River and other perennial streams follow an annual cycle with peak stream flow in April and May and low stream flow in August and September. Normally, stream flow in many of the smaller drainages is seasonally intermittent, while drainages in lower elevations are often dry (Chelan County Department of Emergency Management 2006).

Two types of flooding common in the basin are stage and flash flooding. Stage flooding is usually seen during periods of heavy rains, especially upon existing snow packs during early winter and late spring. Stage flooding problem areas occur along the Wenatchee River near its confluence with Icicle Creek, the headwaters of the Wenatchee River, and the confluence area of the Wenatchee River (Chelan County Department of Emergency Management 2006).

Flash floods are more likely to occur during the summer months, in thunderstorm season. The primary cause of flash flooding, which can occur in any drainage area in the county, is high-intensity rainfall. Although infrequent, and usually of short duration, high-intensity rainfall has been seen in all seasons in the past. Depending upon the characteristics of a particular watershed, peak flows may be reached from less than 1 hour to several hours after rain begins. The debris flows and mudslides accompanying rapid runoff conditions make narrow canyons and alluvial fans at the mouths of the canyons extremely hazardous areas (Chelan County Department of Emergency Management 2006).

The most recent floodplain mapping information is available from the FEMA Flood Insurance Study (FIS) for Chelan County, Washington (FEMA 2004a) and the associated FIRMs. The following sections provide a brief narrative describing the location of each project site with respect to mapped floodplains as well as identifying the FIRM panel and effective date; the special flood hazard zone, if any; BFEs, if any; stream gage information that could be used to extrapolate the BFE, if any; and potential sources of additional information, which are typically county road crossings immediately upstream or downstream of the project that may have hydrologic and hydraulic data that were used in the crossing design.

Table 1 lists all the Wenatchee subbasin acclimation sites, the floodplain development activities associated with each project, and the likely need for a floodplain development permit. As stated previously, where the floodplain development permit process is required, there would be a need for a professional civil engineer to perform substantially more detailed analysis of floodplain impacts. These detailed floodplain analyses are not part of this impact evaluation and are beyond the scope of the EIS.

**Table 1**
**Wenatchee Acclimation Sites with Floodplain Development Activities**

| Wenatchee River Subbasin, in Chelan County, Washington | | |
|---|---|---|
| **Site** | **Development Activities in Floodplain** | **Floodplain Development Permit Required** |
| Butcher | Excavation of an open channel | Yes |
| Tall Timber | Excavation of Napeequa River bank and pipeline corridor | Yes |
| Chikamin | Excavation of a pond, Chikamin Creek bank, open channel, and pipeline corridor | Yes |
| Minnow | Excavation of bed and banks of Minnow Creek | Yes |
| Scheibler | Excavation of bed and bank of Chumstick Creek | Yes |
| Coulter | None | No |
| Rohlfing | None | No |
| White River Springs | None | No |
| Dirty Face | None | No |
| Two Rivers | None | No |
| Clear | None | No |
| Beaver | None | No |
| Brender | None | No |
| Leavenworth National Fish Hatchery | None | No |
| Squadroni | Excavation of pond and open channels | Yes |
| Dryden | Possible development of water quality treatment wetlands | Maybe |

| Wenatchee River Subbasin, in Chelan County, Washington | | |
|---|---|---|
| **Site** | **Development Activities in Floodplain** | **Floodplain Development Permit Required** |
| Allen | None | No |
| Coulter/Roaring | None | No |
| McComas | None | No |
| George | Excavation and construction of a fish hatchery and associated facilities | Yes |

#### *4.2.1.1 Butcher*

The Butcher site is located on Butcher Creek at its confluence with Nason Creek and lies just north of Highway 2. The property is in the 100-year floodplain, designated as Zone AH by FEMA (FEMA 1989b). It appears that the primary source of flooding is backwater from Nason Creek.

- Potential Sources of Flooding: Butcher Creek and Nason Creek
- FIRM: 530015 0775 B June 5, 1989 (Figure 1; FEMA 1989b)
- Special Flood Hazard Area (SFHA): AH
- BFE: 2,140-2,141 feet (National Geodetic Vertical Datum of 1929 [NGVD29])
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Washington State Department of Transportation (WSDOT) – State Route (SR) 2 Crossing of Nason Creek; Chelan County Public Works – Nason Ridge Road crossing of Nason and Butcher Creeks

#### *4.2.1.2 Tall Timber*

The Tall Timber site is located on the Napeequa River near its confluence with the White River. FEMA has designated a special flood hazard area along the White River (Zone A) that extends upstream of this confluence (FEMA 1989a). The site is located outside the special flood hazard area.

- Potential Sources of Flooding: Napeequa River
- FIRM: 530015 0750 B June 5, 1989 (Figure 2; FEMA 1989a)
- SFHA: None
- BFE: None

- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – County Road 167 crossing of Napeequa River

#### 4.2.1.3 Chikamin

The Chikamin site is along Chikamin Creek, which is a tributary of the Chiwawa River. Chikamin Creek will supply water to the Chikamin Pond, which would be located in the right floodplain of Chikamin Creek. FEMA has not determined the 100-year special flood hazard areas on the Chiwawa River in the vicinity of the site.

- Potential Sources of Flooding: Chikamin and Minnow Creeks
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Chikamin Ridge Road crossing of Minnow Creek and Chiwawa River Road crossing of Chikamin Creek

#### 4.2.1.4 Minnow

The Minnow site is along Minnow Creek South, which is tributary to Chikamin Creek. The outflow from a complex of beaver ponds located on Minnow Creek just downstream of the Chikamin Ridge Road crossing is conveyed by two creeks: Minnow Creek North and Minnow Creek South. Minnow Creek North discharges directly to the Chiwawa River. Minnow Creek South flows into Chikamin Creek. Minnow Pond is planned on Minnow Creek South before its confluence with Chikamin Creek. FEMA has not determined the 100-year special flood hazard areas on the Chiwawa River in the vicinity of the site.

- Potential Sources of Flooding: Chikamin and Minnow Creeks
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: None

- Potential Sources of Supplemental Information: Chelan County Public Works – Chikamin Ridge Road crossing of Minnow Creek and Chiwawa River Road crossing of Chikamin Creek

#### *4.2.1.5 Scheibler*

The Scheibler site is located on Chumstick Creek, 8 miles upstream of its confluence with the Wenatchee River. FEMA has not studied or produced a floodplain map of this reach of the creek. It appears that the site is about 2,000 feet upstream of the limits of the FIS, where a BFE of 1,609 feet (NGVD29) was established.

- Potential Sources of Flooding: Chumstick Creek
- FIRM: 530015 0775 B June 5, 1989 (Figure 3; FEMA 1989b)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Chumstick Road crossing of Chumstick Creek

#### *4.2.1.6 Coulter*

The Coulter site is located on a parcel of rural residential property adjacent to Coulter Creek, approximately 1,500 feet upstream from its confluence with Nason Creek. The property is in the 100-year floodplain, designated as Zone AH by FEMA (FEMA 1989b). It appears that the source of flooding may either be backwater from Nason Creek or undersized culverts through the railroad grade resulting in flooding from the combined flows of Coulter and Roaring Creeks.

- Potential Sources of Flooding: Coulter, Roaring, and Nason Creeks
- FIRM: 530015 0775 B June 5, 1989 (Figure 1; FEMA 1989b)
- SFHA: AH
- BFE: 2,142 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: WSDOT – SR 2 Crossing of Nason Creek; Chelan County Public Works – Coulter Creek Road crossings of Coulter and

Roaring Creeks, W. Dardenells Road crossing of Coulter Creek

#### 4.2.1.7 Rohlfing

The Rohlfing site is located on an unnamed seasonal stream that discharges into Nason Creek, near its confluence with Mahar Creek. FEMA has designated the 100-year floodplain of Nason Creek as Zone A3 in the vicinity of the site. The proposed site is located outside the special flood hazard area (Zone A3)

- Potential Sources of Flooding: Unnamed Creek and Nason Creek
- FIRM: 530015 0750 B June 5, 1989 (Figure 4; FEMA 1989a)
- SFHA: None
- BFE: 2,230 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – White Pine Road crossing of unnamed tributary

#### 4.2.1.8 White River Springs

The White River Springs site is located along the left bank of the White River (River Mile [RM] 8) downstream of the confluence of two unnamed creeks. The property is in the 100-year floodplain, designated as Zone A by FEMA (FEMA 1989a). It appears that the White River is the source of flooding.

- Potential Sources of Flooding: White River
- FIRM: 530015 0750 B June 5, 1989 (Figure 2; FEMA 1989a)
- SFHA: A
- BFE: None
- Stream Gage Data: U.S. Geological Survey (USGS) gage 12454000
- Potential Sources of Supplemental Information: Chelan County Public Works – County Road 167 intersection with National Forest Development Road (NFDR) 6434; U.S. Forest Service – NFDR 6435 crossing of the White River

#### 4.2.1.9 Dirty Face

The Dirty Face site is located at the confluence of Dirty Face Creek and White River (near RM 7). The property is in the 100-year floodplain, designated as Zone A by FEMA (FEMA 1989a). It appears that the White River is the source of flooding.

- Potential Sources of Flooding: White River
- FIRM: 530015 0750 B June 5, 1989 (Figure 2; FEMA 1989a)
- SFHA: A
- BFE: None
- Stream Gage Data: USGS gage 12454000
- Potential Sources of Supplemental Information: Chelan County Public Works – County Road 167 crossing of Dirty Face Creek; U.S. Forest Service – NFDR 6435 crossing of the White River

#### 4.2.1.10 Two Rivers

The Two Rivers site is located on the left overbank of Little Wenatchee River, approximately 1.5 miles upstream of its mouth at Lake Wenatchee. The site has been recently used as a gravel pit and settling basin. The property is in the 100-year floodplain, designated as Zone A by FEMA (FEMA 1989a). It appears that the site may be subject to flooding from either the Little Wenatchee River or Lake Wenatchee as a result of high flows in the White River and Little Wenatchee River.

- Potential Sources of Flooding: Little Wenatchee River, White River, Lake Wenatchee
- FIRM: 530015 0750 B June 5, 1989 (Figure 5; FEMA 1989a)
- SFHA: A
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Little Wenatchee River Road

#### 4.2.1.11 Clear

The Clear site is located on Clear Creek, a tributary of the Chiwawa River, approximately 1/2 mile upstream of its confluence. There is no designated floodplain (FEMA 1989c).

- Potential Sources of Flooding: Clear Creek
- FIRM: 530015 0575 B June 5, 1989 (Figure 6; FEMA 1989c)
- SFHA: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Chiwawa River Road crossing of Clear Creek

#### *4.2.1.12 Beaver*

The Beaver site is located on Beaver Creek, approximately 1/2 mile upstream of its confluence with the Wenatchee River. The site is outside the designated floodplain (FEMA 1989c).

- Potential Sources of Flooding: Beaver Creek
- FIRM: 530015 0575 B June 5, 1989 (Figure 6; FEMA 1989c)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Chiwawa River Road crossing of Beaver Creek

#### *4.2.1.13 Brender*

The Brender site is located on Brender Creek near the town of Cashmere. Brender Creek flows into Mission Creek, a tributary to the Wenatchee River (RM 10). The site is outside the designated floodplain (FEMA 2004c).

- Potential Sources of Flooding: Brender Creek
- FIRM: 53001502763 D September 30, 2004 (Figure 7; FEMA 2004c)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Kimber Road or Evergreen Drive crossings of Brender Creek

#### *4.2.1.14 Leavenworth NFH*

The Leavenworth NFH site is located at the existing U.S. Fish and Wildlife Service (USFWS) hatchery on Icicle Creek, tributary to Wenatchee River, south of Leavenworth. The hatchery is outside the special flood hazard area (Zone AE). The Icicle Creek BFE just downstream of the hatchery was estimated at 1,122 feet NGVD (FEMA 2002b).

- Potential Sources of Flooding: Icicle Creek
- FIRM: 530015 0787 B July 2, 2002 (Figure 8; FEMA 2002b)
- SFHA: None
- BFE: 1,122 feet (NGVD29)
- Stream Gage Data: USGS gage 12458000
- Potential Sources of Supplemental Information: USFWS

### *4.2.2 Wenatchee Subbasin Back-up Sites*

#### *4.2.2.1 Squadroni*

The Squadroni site is located adjacent to Nason Creek, near its confluence with Gill Creek. FEMA has designated the 100-year floodplain of Nason Creek as Zone A3 in the vicinity of the site (FEMA 1989a). The proposed site is located outside the special flood hazard area (Zone A3)

- Potential Sources of Flooding: Nason Creek
- FIRM: 530015 0750 B June 5, 1989 (Figure 1; FEMA 1989a)
- SFHA: None
- BFE: 2,156 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Gill Creek Road crossing of Nason Creek

#### *4.2.2.2 Dryden*

The Dryden site is on Peshastin Creek near its confluence with the Wenatchee River. Evaluation of flow and water surface elevation at the Dryden site is provided in a separate document *Flood Evaluation Near Dryden Dam* (Appendix 8.1). FEMA has designated a special flood hazard area along Peshastin Creek (Zone A).

- Potential Sources of Flooding: Peshastin Creek and Wenatchee River
- FIRM: 530015 2740 D September 30, 2004 (Figure 9)
- SFHA: A
- BFE: 990 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: *Flood Evaluation near Dryden Dam* (Appendix 8.1)

#### *4.2.2.3 Allen*

The Allen site is located west of Peshastin Creek, just upstream of the confluence with Allen Creek. The site is outside the designated floodplain (FEMA 2004b).

- Potential Sources of Flooding: Peshastin Creek
- FIRM: 530015 0800D September 30, 2004 (Figure 10; FEMA 2004b)
- SFHA: AH
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Development permits for properties on Hansel and Allen Lanes

#### *4.2.2.4 Coulter/Roaring*

The Coulter/Roaring site is located on Roaring Creek near its confluence with Coulter Creek, which then discharges to Nason Creek. The property is in the 100-year floodplain, designated as Zone AH by FEMA (FEMA 1989b). It appears that the source of flooding may be either back water from Nason Creek or undersized culverts through the railroad grade resulting in flooding from the combined flows of Coulter and Roaring Creeks.

- Potential Sources of Flooding: Roaring, Coulter, and Nason Creeks
- FIRM: 530015 0775 B June 5, 1989 (Figure 1; FEMA 1989b)
- SFHA: AH
- BFE: 2,142 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: WSDOT – SR 2 Crossing of Nason

Creek; Chelan County Public Works – Coulter Creek Road crossings of Coulter and Roaring Creeks

#### 4.2.2.5 McComas

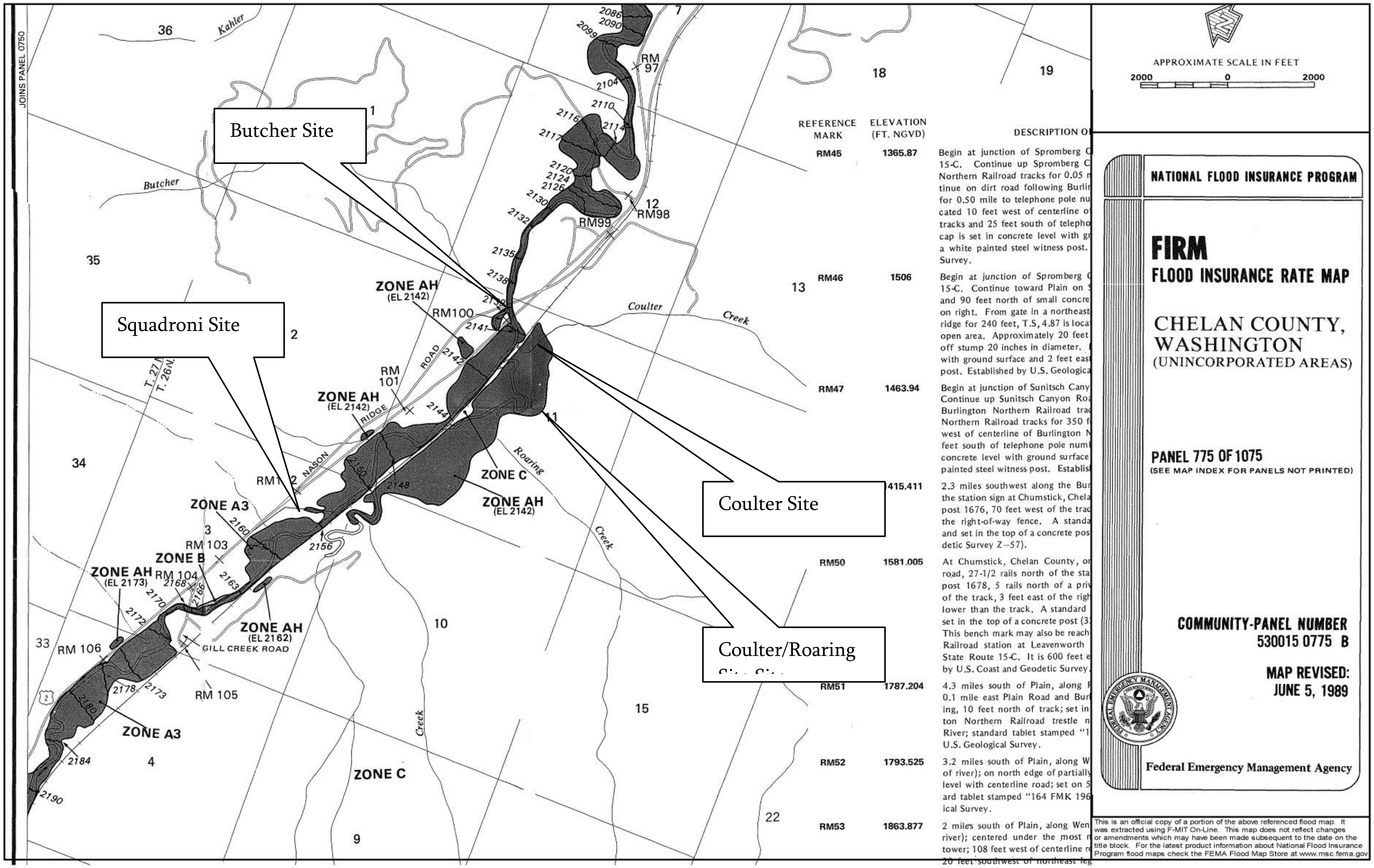
The McComas site is located on the left overbank of White River near the confluence of Siverly Creek, approximately 1 mile upstream of its mouth at Lake Wenatchee. The property is in the 100-year floodplain, designated as Zone A by FEMA (FEMA 1989a). It appears that the site may be subject to flooding from either the White River or Lake Wenatchee as a result of high flows in the White River and Little Wenatchee River.

- Potential Sources of Flooding: Little Wenatchee River, White River, Lake Wenatchee
- FIRM: 530015 0750 B June 5, 1989 (Figure 5; FEMA 1989a)
- SFHA: A
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Chelan County Public Works – Little Wenatchee River Road crossing of the White River

#### 4.2.2.6 George

The George site is located on the right overbank of the Wenatchee River. The property is in the 100-year floodplain, designated as Zone A3 by FEMA (FEMA 1989c). It appears that the site is subject to flooding from the Wenatchee River.

- Potential Sources of Flooding: Wenatchee River
- FIRM: 530015 0575B June 5, 1989 (Figure 6; FEMA 1989c)
- SFHA: A3
- BFE: 1871 feet (NGVD1929)
- Stream Gage Data: USGS 12455000, Wenatchee River below Wenatchee Lake, and 12457000, Wenatchee River at Plain
- Potential Sources of Supplemental Information: WSDOT – State Route 207 crossing of the Wenatchee River




ANCHOR QEA

**Figure 1**

FIRM 530015 0775 B – June 5, 1989; Butcher, Coulter, Squadroni, and Coulter/Roaring Sites

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

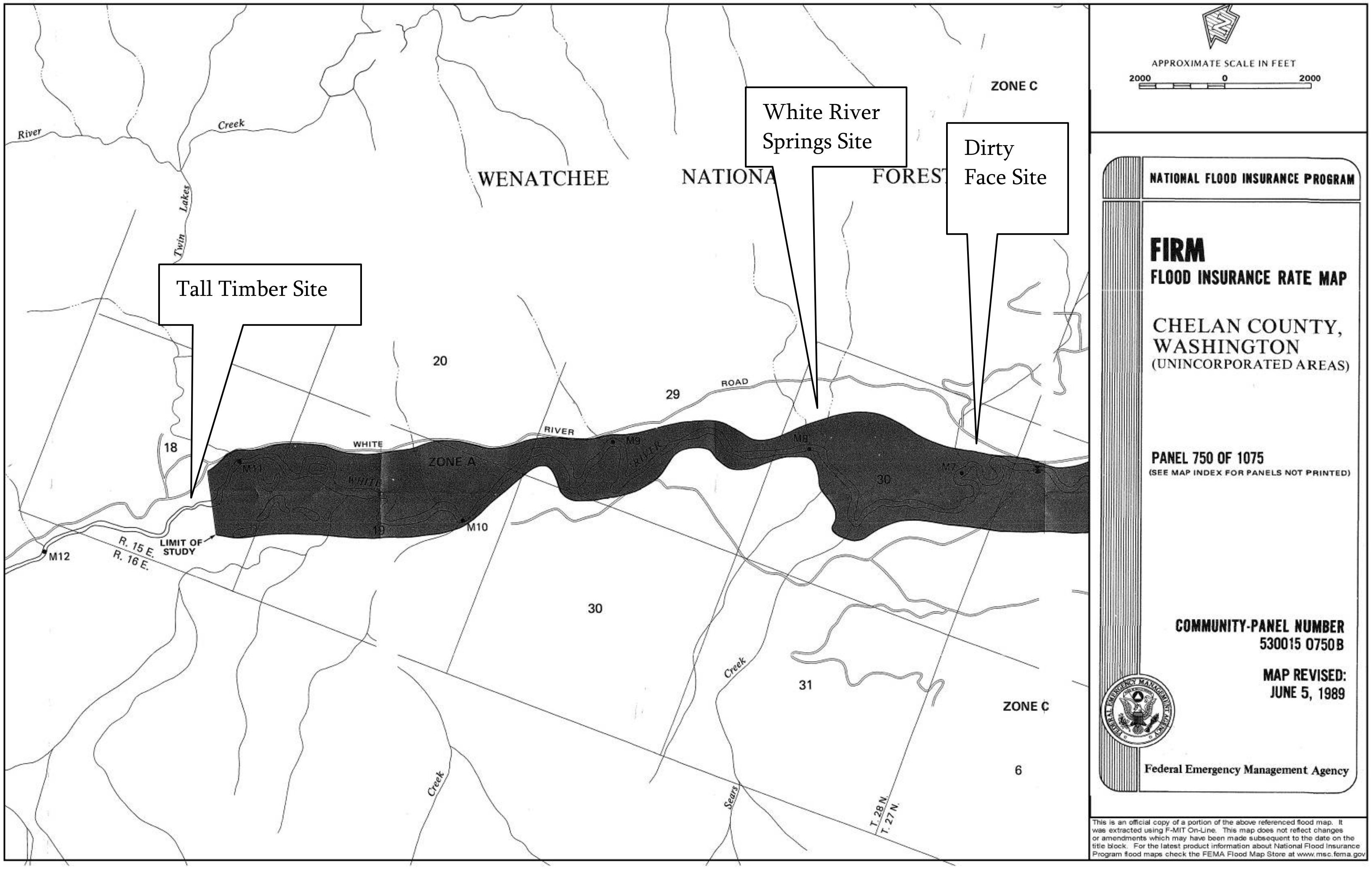



**Figure 2**

F FIRM 530015 0750 B – June 5, 1989; Tall Timber, White River Springs, and Dirty Face Sites

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

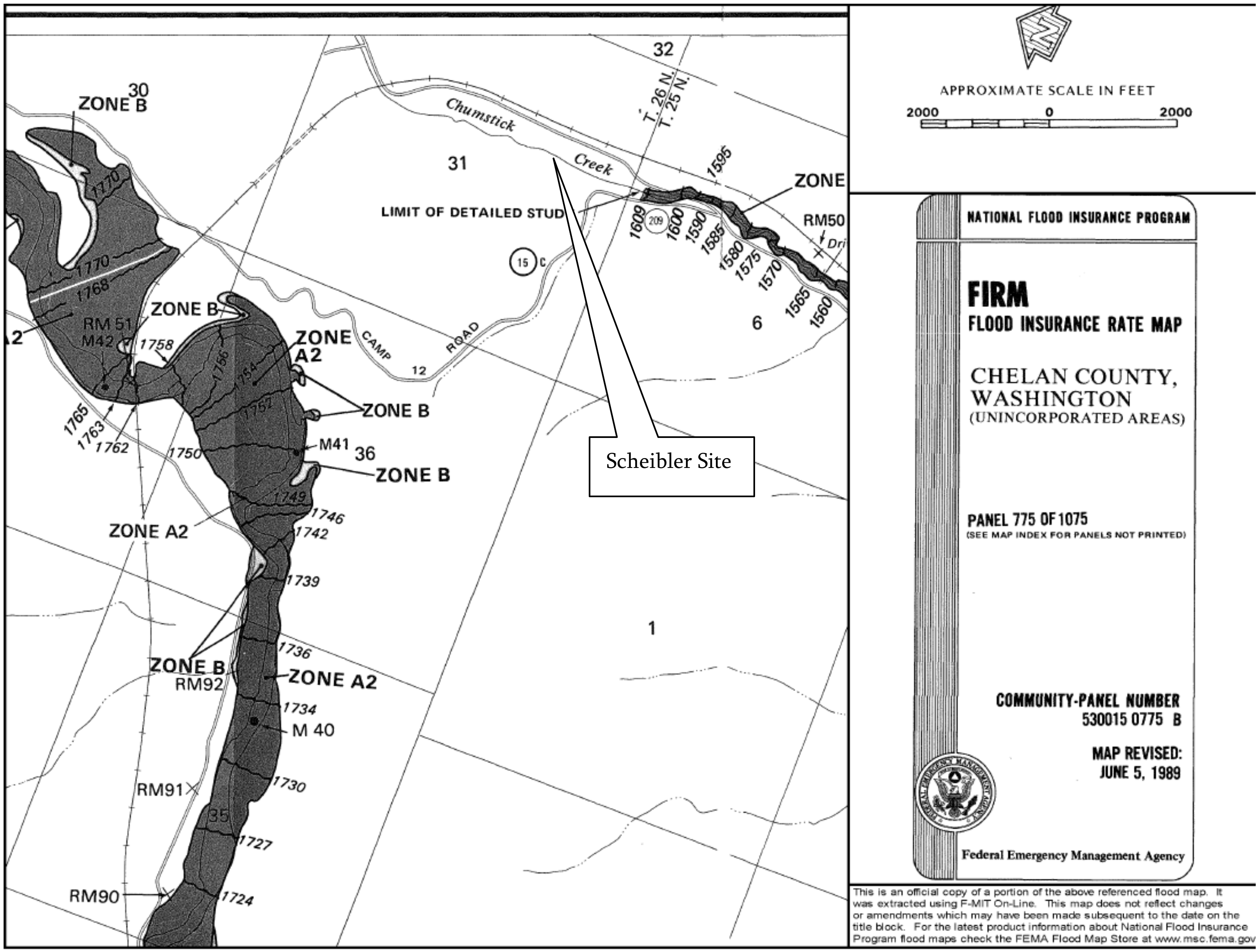



**Figure 3**
FIRM 530015 0775B – June 5, 1989; Scheibler Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

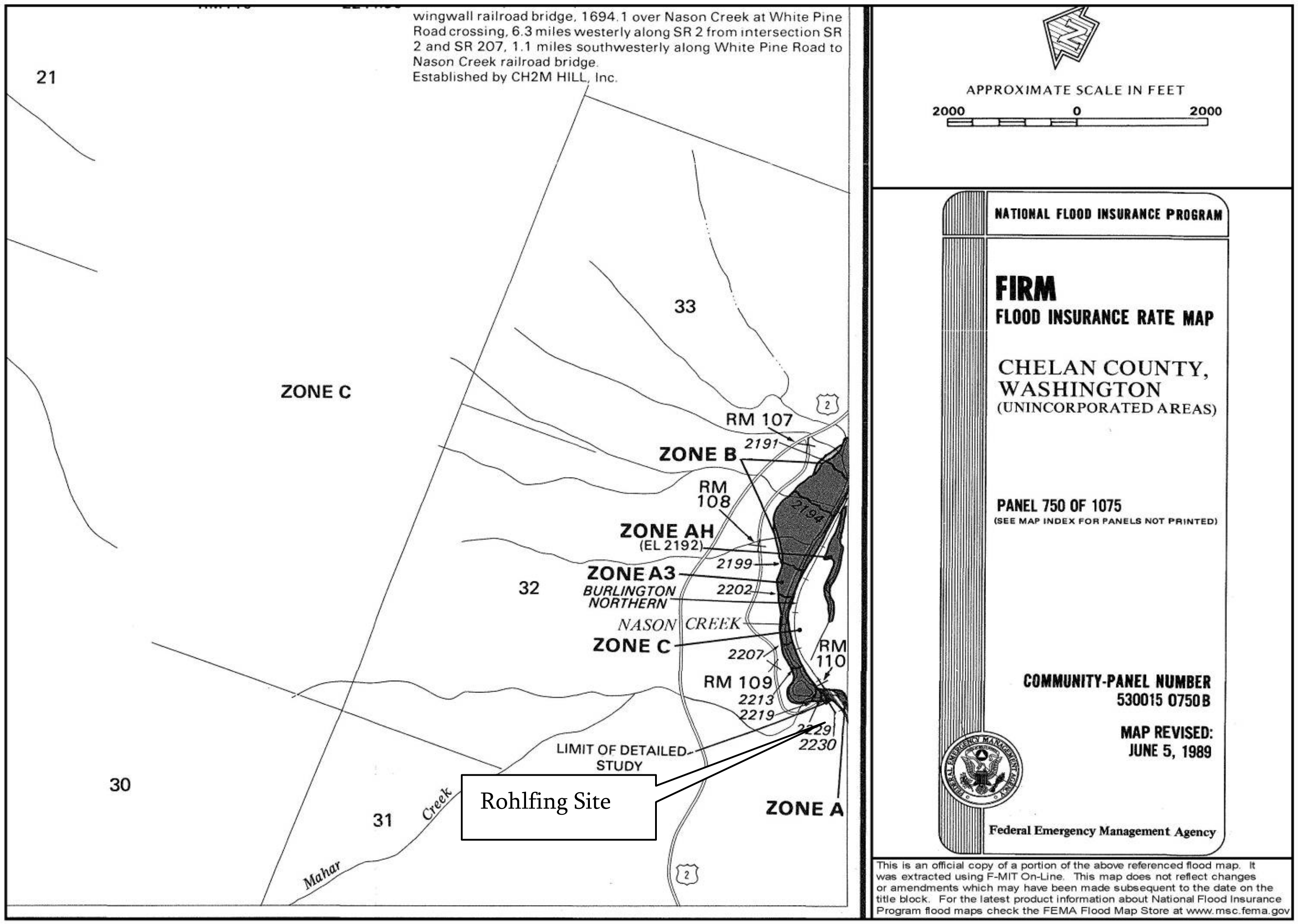



**Figure 4**
FIRM 530015 0750 B – June 5, 1989; Rohlfing Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

ANCHOR QEA

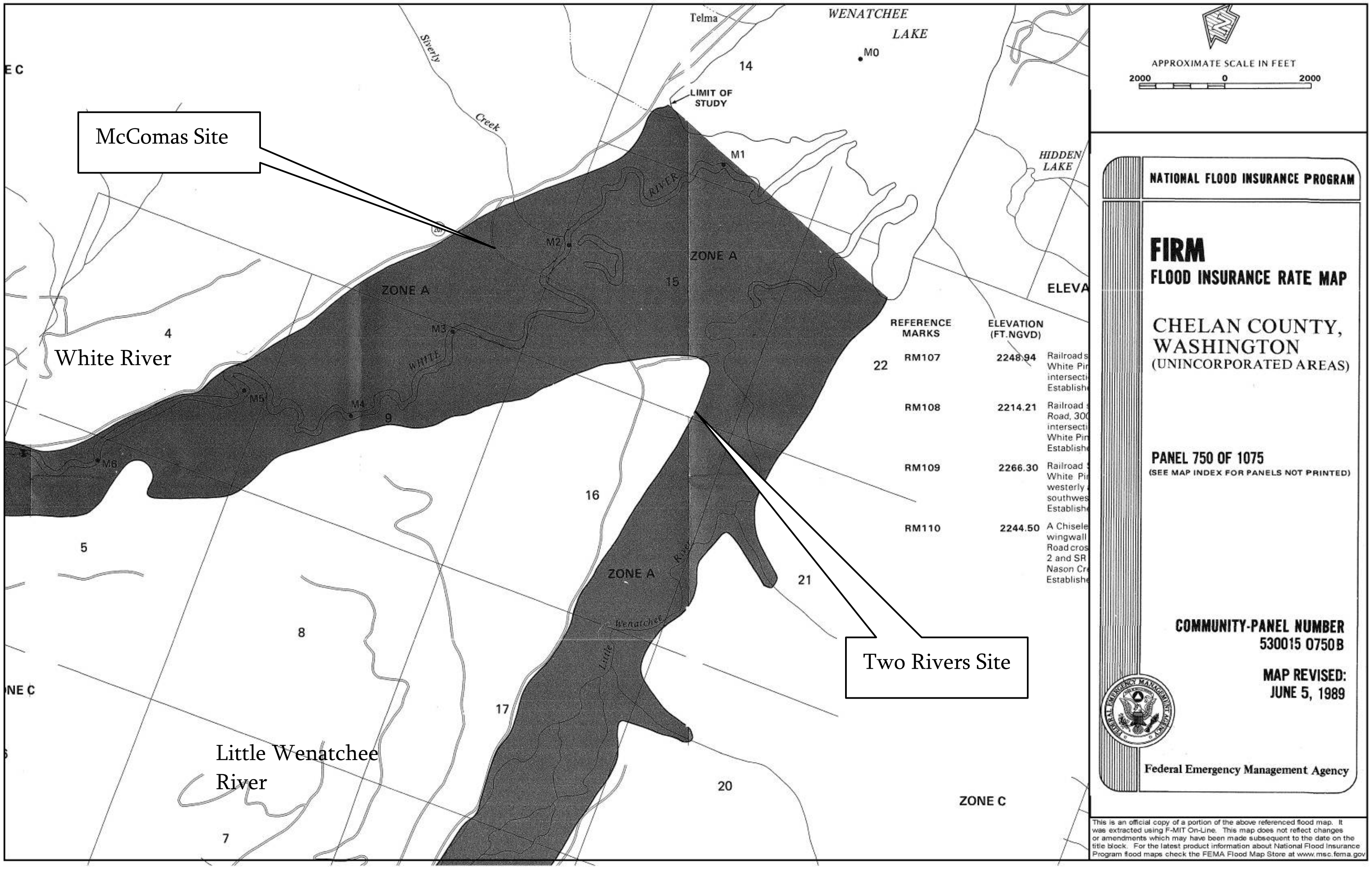



**Figure 5**
FIRM 530015 0750 B – June 5, 1989; Two Rivers and McComas Sites
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

ANCHOR QEA

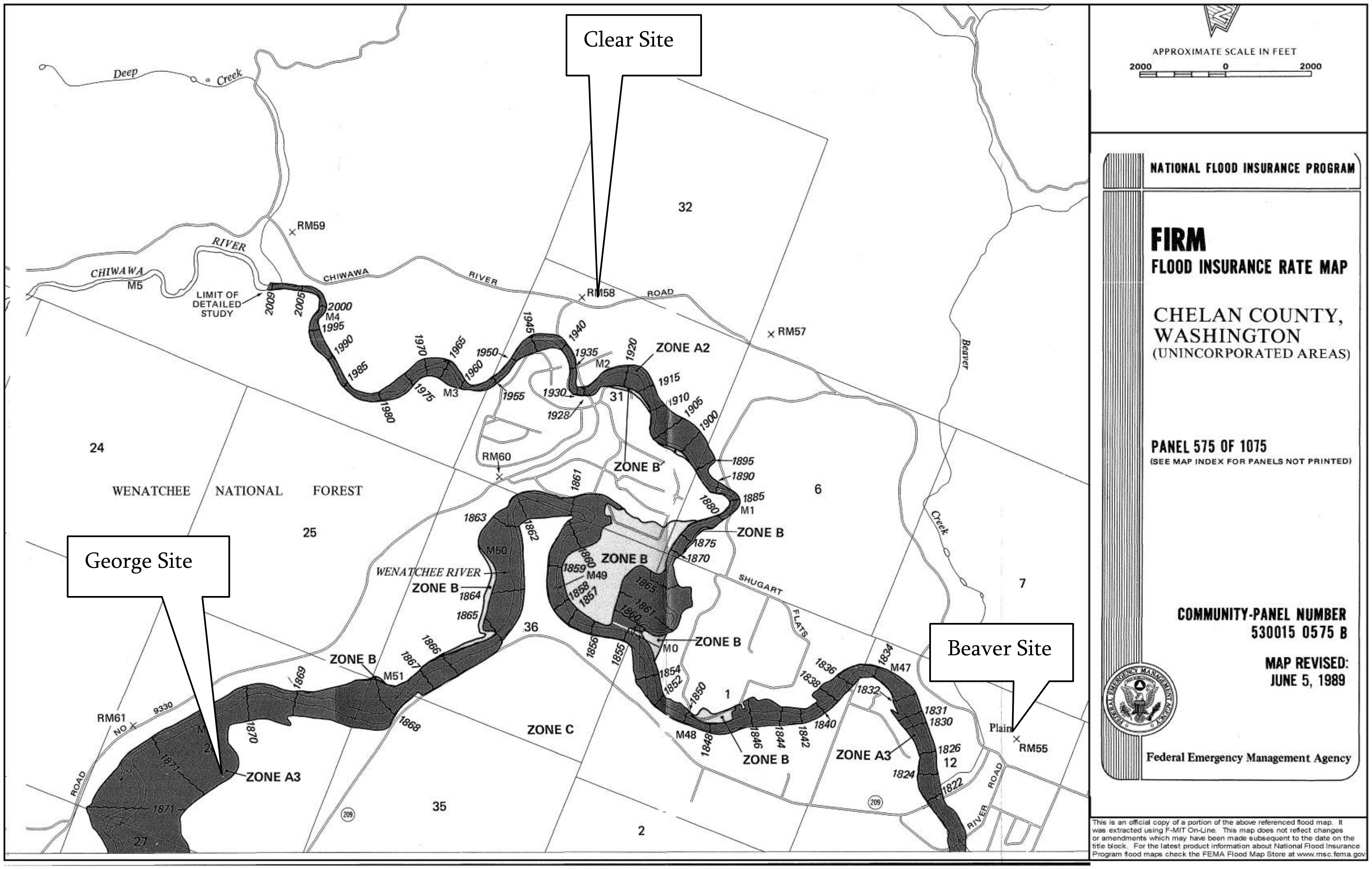



**Figure 6**

FIRM 530015 0575 B – June 5, 1989; Clear, Beaver, and George Sites

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

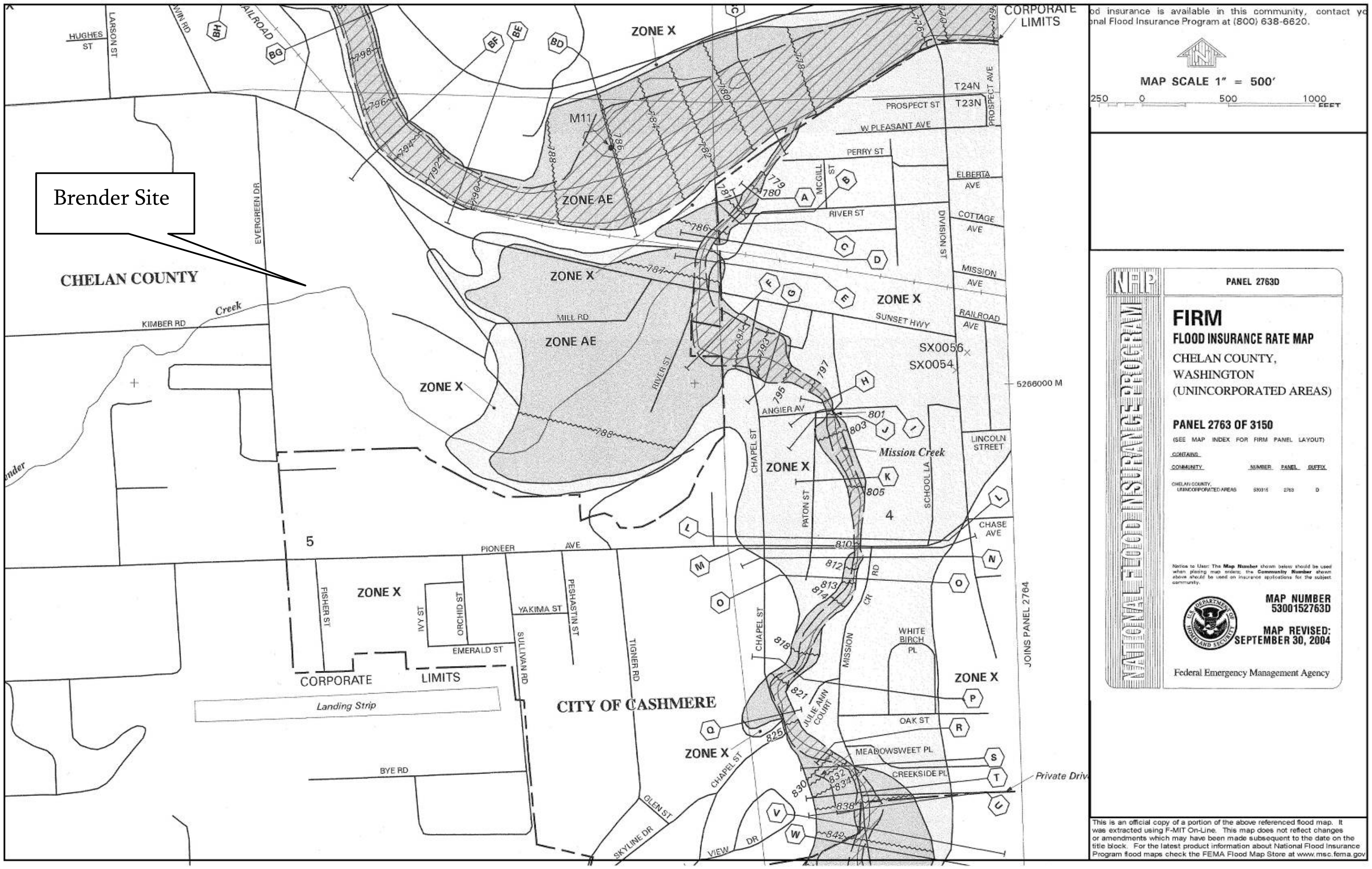



**Figure 7**
FIRM 53001502763 D – September 30, 2004; Brender Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

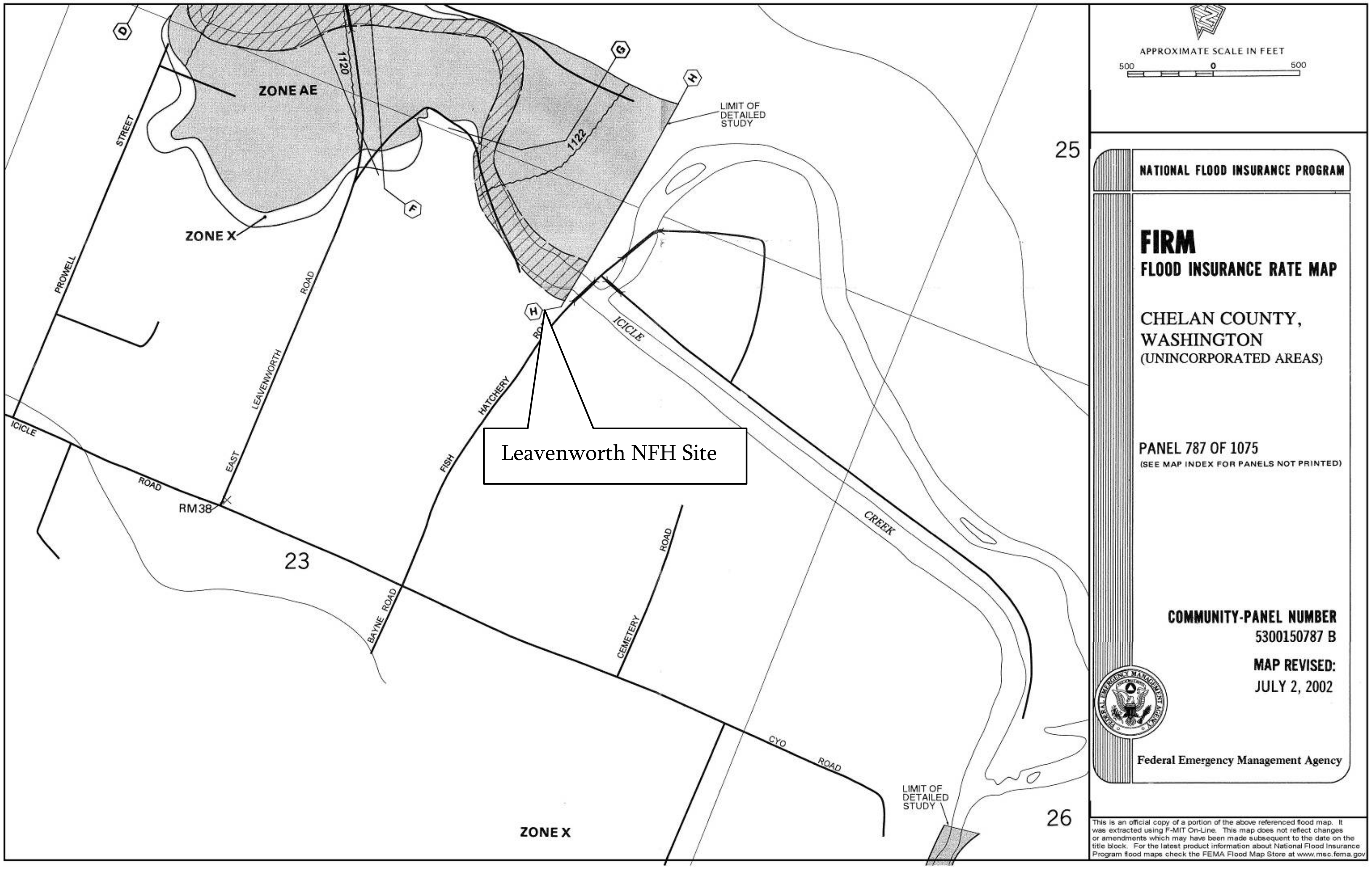



**Figure 8**

FIRM 530015 0787 B – July 2, 2002; Leavenworth NFH Site

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

ANCHOR QEA

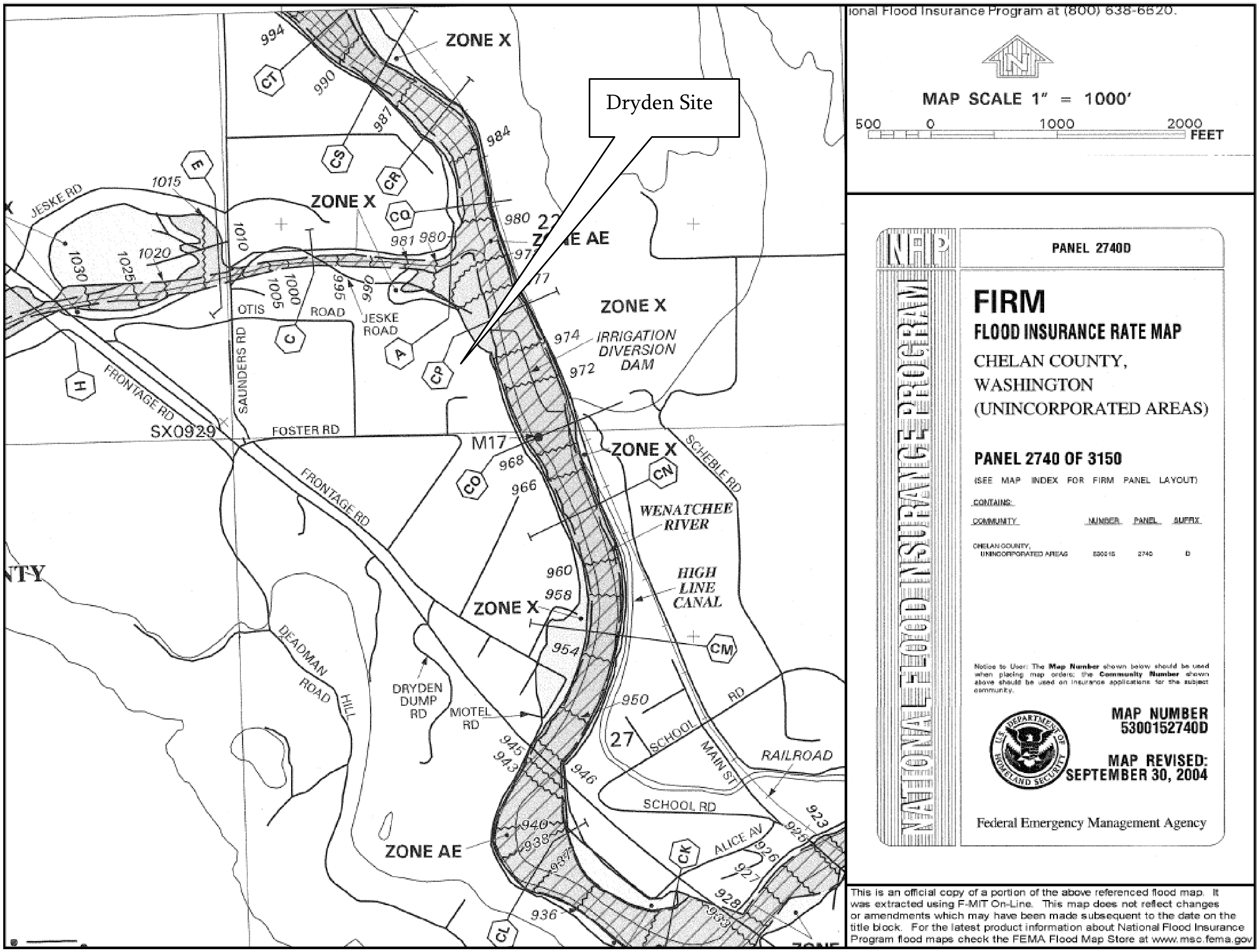



**Figure 9**
FIRM 5300152740D – September 30, 2004; Dryden Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

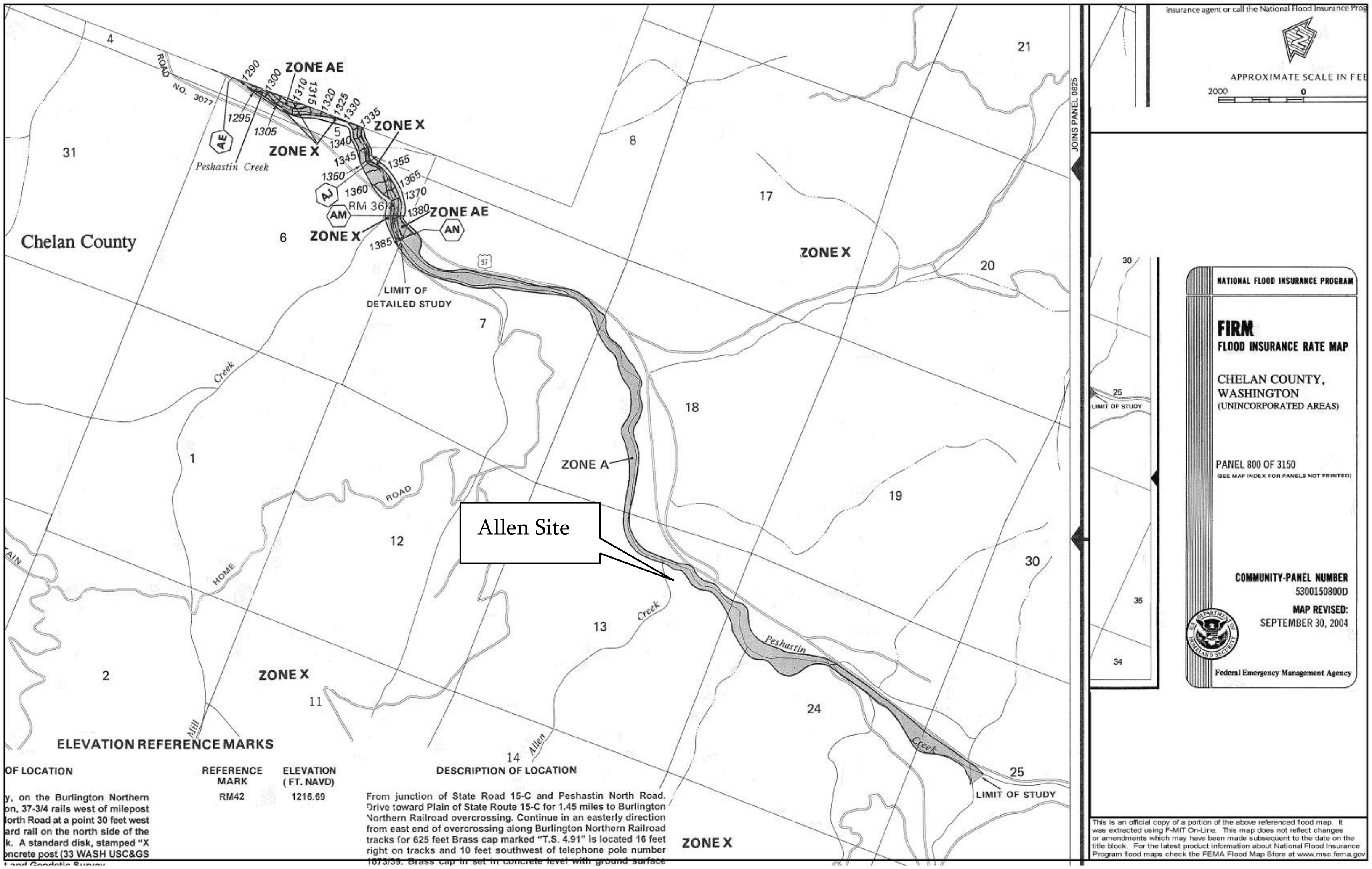



**Figure 10**
FIRM 530015 0800D – September 30, 2004; Allen Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

### 4.2.3 Methow Subbasin Primary Sites

The climate of Methow River subbasin is characterized by warm, dry summers and relatively cold winters. The average annual precipitation in the lower elevations is just greater than 11 inches, increasing with elevation to about 35 inches. The bulk of this precipitation falls as snow, which reaches 100 inches or more in the upper watersheds. The Methow River and other perennial streams follow an annual cycle with peak stream flow in April and May and low stream flow in August and September. Normally, stream flow in many of the smaller drainages is seasonally intermittent, while drainages in lower elevations are often dry (Okanogan County Department of Emergency Management 2009).

Two types of flooding common in the basin are stage and flash flooding. Stage flooding is usually seen during periods of heavy rains, especially upon existing snow packs during early winter and late spring. Stage flooding problem areas occur along the Methow River, especially where the Twisp River and Chewuch River join (Okanogan County Department of Emergency Management 2009).

Flash floods are more likely to occur during the summer months, in thunderstorm season. The primary cause of flash flooding, which can occur in any drainage area in the county, is high-intensity rainfall. Although infrequent, and usually of short duration, high-intensity rainfall has been seen in all seasons in the past. Depending upon the characteristics of a particular watershed, peak flows may be reached from less than 1 hour to several hours after rain begins. The debris flows and mudslides accompanying rapid runoff conditions make narrow canyons and alluvial fans at the mouths of the canyons extremely hazardous areas. Present problem areas for flash flooding include drainages in the Methow/Twisp area where forest fires occurred in the recent past (Okanogan County Department of Emergency Management 2009).

The most recent floodplain mapping information for the Methow subbasin sites was available from the FEMA FIS for Okanogan County, Washington (FEMA 2003), and the associated FIRMs. The following sections provide a brief narrative describing the location of each project site with respect to mapped floodplains as well as identifying the FIRM panel and effective date; the special flood hazard zone, if any; BFEs, if any; stream gage information that could be used to extrapolate the BFE, if any; and potential sources of additional information, which are typically county road crossings immediately upstream or downstream of the project that may have hydrologic and hydraulic data that were used in the crossing design.

Table 2 lists all the Methow subbasin acclimation sites, the floodplain development activities associated with each project, and the likely need for a floodplain development permit. As stated previously, where the floodplain development permit process is required, there would be a need for substantially more detailed analysis performed by a professional civil engineer to perform an analysis of floodplain impacts. These detailed floodplain analyses are not part of this impact evaluation and are beyond the scope of the EIS.

**Table 2**
**Methow Acclimation Sites with Floodplain Development Activities**

| Methow River Subbasin, in Okanogan County, Washington | | |
|---|---|---|
| **Site** | **Development Activities in Floodplain** | **Floodplain Development Permit Required** |
| Methow State Wildlife Area - Eightmile | None | No |
| Mason (Eightmile) | None | No |
| Lincoln | Excavation of an open channel and pipeline corridor | Yes |
| Twisp Weir | Excavation of pond and pipeline corridor | Yes |
| Gold | None | No |
| Goat Wall | None | No |
| Pete Creek Pond | None | No |
| Heath | None | No |
| Parmley | None | No |
| Lower Twisp | None | No |
| Hancock | None | No |
| Winthrop National Fish Hatchery | None | No |
| Methow Salmon Recovery Foundation - Lower Chewuch | Excavation of a pond and open channels | Yes |
| Chewuch Acclimation Facility | Excavation of the Chewuch River bank, pond and pipeline corridors | Yes |
| Canyon | None | No |
| Utley | Excavation of outlet channel to the Twisp River | Yes |
| Newby | Excavation of pond and pipeline corridors | Yes |
| Poorman | None | No |
| Biddle | None | No |
| Balky Hill | None | No |

#### *4.2.3.1 MSWA Eightmile*

The MSWA Eightmile site is located on an existing, disconnected side channel of the Chewuch River, approximately 1/2 mile upstream of Eightmile Creek confluence with the Chewuch River. FEMA studied the Chewuch River from its confluence with the Methow

River upstream to the Cub Creek confluence, which is several miles downstream of the project site. FEMA has not mapped a special flood hazard zone near the site.

- Potential Sources of Flooding: Chewuch River
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works and U.S. Forest Service – Forest Development Road (FDR) 51, possible bank stabilization projects along Chewuch River

#### *4.2.3.2 Mason (Eightmile)*

The Mason (Eightmile) site is located just downstream of the mouth of Eightmile Creek. FEMA studied the Chewuch River from its confluence with the Methow River upstream to the Cub Creek confluence, which is several miles downstream of the project site. FEMA has not mapped a special flood hazard zone near the site.

- Potential Sources of Flooding: Chewuch River
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works and U.S. Forest Service – FDR 51, possible bank stabilization projects along Chewuch River

#### *4.2.3.3 Lincoln*

The Lincoln site is located on the Twisp River. The site appears to be within the special flood hazard area designated along the Twisp River (Zone A; FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 11; FEMA 2000a)
- SFHA: A

- BFE: None
- Stream Gage Data: USGS Gage 12448998
- Potential Sources of Supplemental Information: U.S. Forest Service – NFDR crossing of Twisp River near War Creek Campground

#### *4.2.3.4 Twisp Weir*

The Twisp Weir site is located adjacent to the Twisp River. Portions of the site appear to be within the special flood hazard area designated along the Twisp River (Zone A, FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 19; FEMA 2000a)
- SFHA: A
- BFE: None
- Stream Gage Data: USGS Gage 12448998
- Potential Sources of Supplemental Information: Twisp Valley Power and Irrigation Company, operators of the diversion weir on the Twisp River.

#### *4.2.3.5 Gold*

The Gold site, located on South Fork Gold Creek just upstream of its confluence with Gold Creek, is approximately 2 miles upstream from the Gold Creek confluence with the Methow River. No flow monitoring data are available for Gold Creek. FEMA has not studied Gold Creek or its tributaries. The Gold site is not within a designated special flood hazard area.

- Potential Sources of Flooding: South Fork Gold Creek
- FIRM: 530117 1200 B February 10, 1981 (Figure 12; FEMA 1981)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works – South Gold Creek Road crossing of Gold Creek

#### *4.2.3.6 Goat Wall*

The Goat Wall site is located at a disconnected side channel system on the Methow River (RM 70), upstream of the mouth of Gate Creek. The site appears to be within the special flood hazard area designated by FEMA (Zone A2; FEMA 1994).

- Potential Sources of Flooding: Gate Creek and Methow River
- FIRM: 530117 0450C May 2, 1994 (Figure 13; FEMA 1994)
- SFHA: A2
- BFE: 2,250 to 2,260 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: None

#### *4.2.3.7 Pete Creek Pond*

The Pete Creek Pond site is part of a disconnected side channel system of the Chewuch River located upstream of Pete Creek. The site is located within the special flood hazard area designated by FEMA (Zone A3; FEMA 1999).

- Potential Sources of Flooding: Chewuch River
- FIRM: 530117 0675 D January 20, 1999 (Figure 14; FEMA 1999)
- SFHA: A3
- BFE: 1,848 to 1,852 feet (NGVD29)
- Stream Gage Data: USGS gage 12448000
- Potential Sources of Supplemental Information: Okanogan County Public Works – development permits for the Windhaven Golf Club

#### *4.2.3.8 Heath*

The Heath site is part of the Heath Springs complex located between the Methow River (RM 55) and Highway 20. The site is within the special flood hazard area mapped by FEMA (Zone AE; FEMA 1999).

- Potential Sources of Flooding: Methow River
- FIRM: 530117 0675 D January 20, 1999 (Figure 15; FEMA 1999)
- SFHA: AE
- BFE: 1,830 (NGVD29)

- Stream Gage Data: USGS gages 12447370 and 12448500
- Potential Sources of Supplemental Information: Okanogan County Public Works – access roads from Highway 20

#### 4.2.3.9 Parmley

The Parmley site is located on Beaver Creek, about 8 miles upstream of its confluence with the Methow River. USGS maintains several flow monitoring gages: Gage 12449600 (Beaver Creek below South Fork near Twisp) is close to the site. FEMA has not studied or designated special flood hazard areas for Beaver Creek. Anchor QEA, LLC, completed detailed hydrologic and hydraulic analysis of Beaver Creek between RM 6.2 and RM 7.0, downstream of this site (Anchor QEA 2008).

- Potential Sources of Flooding: Beaver Creek
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: USGS Gage 12449600
- Potential Sources of Supplemental Information: Anchor QEA 2008; Okanogan County Public Works – Beaver Creek Road crossings of Beaver Creek

#### 4.2.3.10 Lower Twisp

The Lower Twisp site is located in the Twisp River floodplain just upstream of the Town of Twisp and its confluence with the Methow River (RM 40). The site is within the FEMA designated special flood hazard area (Zone A3; FEMA 2000b).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0875 C December 20, 2000 (Figure 16; FEMA 2000b)
- SFHA: A3
- BFE: 1,623 to 1,627 feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works

#### 4.2.3.11 Hancock

The Hancock site is located on Hancock Creek, a small spring-fed tributary of the Methow River (RM 60). Hancock Creek originates at a large spring 0.8 mile upstream from the Methow River. The site is located outside of the special flood hazard area designated by FEMA along the Methow River (Zone A2; FEMA 1999). The Methow River BFE is estimated between 1,922 feet and 1,925 feet (NGVD29) at the mouth of Hancock Creek.

- Potential Sources of Flooding: Hancock Creek
- FIRM: 530117 0675 D January 20, 1999 (Figure 17; FEMA 1999)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works – Wolf Creek Road crossing of Hancock Creek

#### 4.2.3.12 Winthrop NFH

The Winthrop NFH site is located on the Methow River in the Town of Winthrop at an existing NFH site. Methow River flows have been recorded by USGS at the nearby gage (12448500). The NFH site is within the FEMA designated special flood hazard area (Zone A4; FEMA 1999).

- Potential Sources of Flooding: Methow River
- FIRM: 530117 0675 D January 20, 1999 (Figure 14; FEMA 1999)
- SFHA: A4
- BFE: 1,748 feet (NGVD29)
- Stream Gage Data: USGS Gage 12448500
- Potential Sources of Supplemental Information: Okanogan County Public Works

### 4.2.4 Methow Subbasin Back-up Sites

#### 4.2.4.1 MSRF Lower Chewuch

The MSRF Lower Chewuch site is located on the Chewuch River approximately 1 mile upstream of its confluence with the Methow River. FEMA designated a special flood hazard area (Zone A5) along the Chewuch in the vicinity of the site, but the site is outside this flood hazard area (FEMA 1999). The Chewuch River BFEs are estimated between 1,757 and 1,760 feet (NGVD29) in the vicinity of the site.

- Potential Sources of Flooding: Chewuch River
- FIRM: 530117 0675 D January 20, 1999 (Figure 14; FEMA 1999)
- SFHA: None
- BFE: None
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works

#### *4.2.4.2 Chewuch AF*

The Chewuch AF site is located in the left floodplain of the Chewuch River on to the north of the Eastside Chewack Road bridge crossing. The site is located in a special flood hazard area (Zone A3; FEMA 1999).

- Potential Sources of Flooding: Coulter Creek and Nason Creek
- FIRM: 530117 0675 D January 20, 1999 (Figure 18; FEMA 1999)
- SFHA: A3
- BFE: 1,995 to 2,000
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works – Eastside Chewack Road crossing of the Chewuch River

#### *4.2.4.3 Canyon*

The Canyon site is located adjacent to the Twisp River. The site appears to be outside the special flood hazard area designated along the Twisp River (FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 11; FEMA 2000a)
- SFHA: None
- BFE: None
- Stream Gage Data: USGS Gage 12448998
- Potential Sources of Supplemental Information: Okanogan County Public Works – West Buttermilk Creek Road crossing of the Twisp River.

#### *4.2.4.4 Utley*

The Utley site is located adjacent to the Twisp River. The site appears to be within the special flood hazard area designated along the Twisp River (Zone A, FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 11; FEMA 2000a)
- SFHA: A
- BFE: None
- Stream Gage Data: USGS Gage 12448998
- Potential Sources of Supplemental Information: Okanogan County Public Works – Possible bank protection projects along the Twisp River to protect Twisp River Road.

#### *4.2.4.5 Newby*

The Newby site is located adjacent to the Twisp River. The site appears to be within the special flood hazard area designated along the Twisp River (Zone A, FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 19; FEMA 2000a)
- SFHA: A
- BFE: None
- Stream Gage Data: USGS Gage 12448998
- Potential Sources of Supplemental Information: Okanogan County Public Works – Newby Creek Road crossing of the Twisp River; Twisp Valley Power and Irrigation Company, operators of the diversion weir on the Twisp River.

#### *4.2.4.6 Poorman*

The Poorman site is located on the Twisp River, downstream of the mouth of Poorman Creek. The site is within the FEMA designated special flood hazard area (Zone A2; FEMA 2000a).

- Potential Sources of Flooding: Twisp River
- FIRM: 530117 0850 C December 20, 2000 (Figure 19; FEMA 2000a)
- SFHA: A2

- BFE: 1,760 Feet (NGVD29)
- Stream Gage Data: None
- Potential Sources of Supplemental Information: Okanogan County Public Works

#### *4.2.4.7 Biddle*

The Biddle site is located on Wolf Creek, approximately 1 mile upstream of its confluence with the Methow River. FEMA has not studied or designated special flood hazard areas on Wolf Creek. The site is outside the special flood hazard area designated for the Methow River (FEMA 1999). The Methow River BFE was estimated at 1,802 feet NGVD at the Wolf Creek confluence. Wolf Creek flows are monitored by the USGS approximately 3 miles upstream of the site.

- Potential Sources of Flooding: Wolf Creek
- FIRM: 530117 0675 D January 20, 1999 (Figure 15; FEMA 1999)
- SFHA: None
- BFE: None
- Stream Gage Data: USGS Gage 12447397
- Potential Sources of Supplemental Information: U.S. Forest Service and Okanogan County Public Works – NFDR crossing of Wolf Creek

#### *4.2.4.8 Balky Hill*

The Balky Hill site is located on Beaver Creek, 5 miles upstream of its confluence with the Methow River. USGS maintained several flow monitoring gages: Gage 12449600 (Beaver Creek below South Fork near Twisp) is close to the site. FEMA has not studied or designated special flood hazard areas for Beaver Creek. Anchor QEA completed detailed hydrologic and hydraulic analysis of Beaver Creek between RM 6.2 and RM 7.0, upstream of this site (Anchor QEA 2008).

- Potential Sources of Flooding: Beaver Creek
- FIRM: None
- SFHA: None
- BFE: None
- Stream Gage Data: USGS Gage 12449600

- Potential Sources of Supplemental Information: Anchor QEA 2008; Okanogan County Public Works – State Route 20 crossing of Beaver Creek

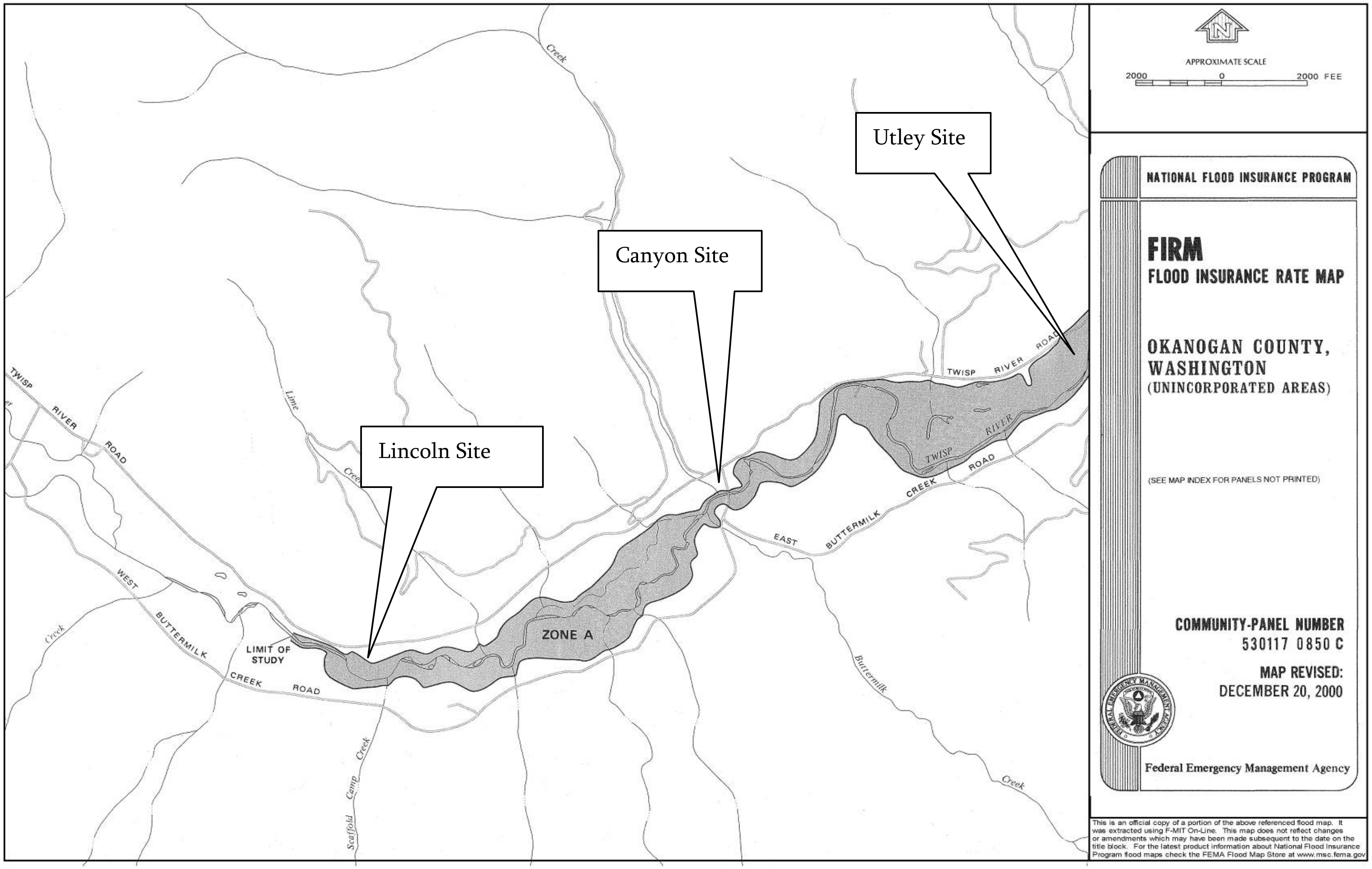
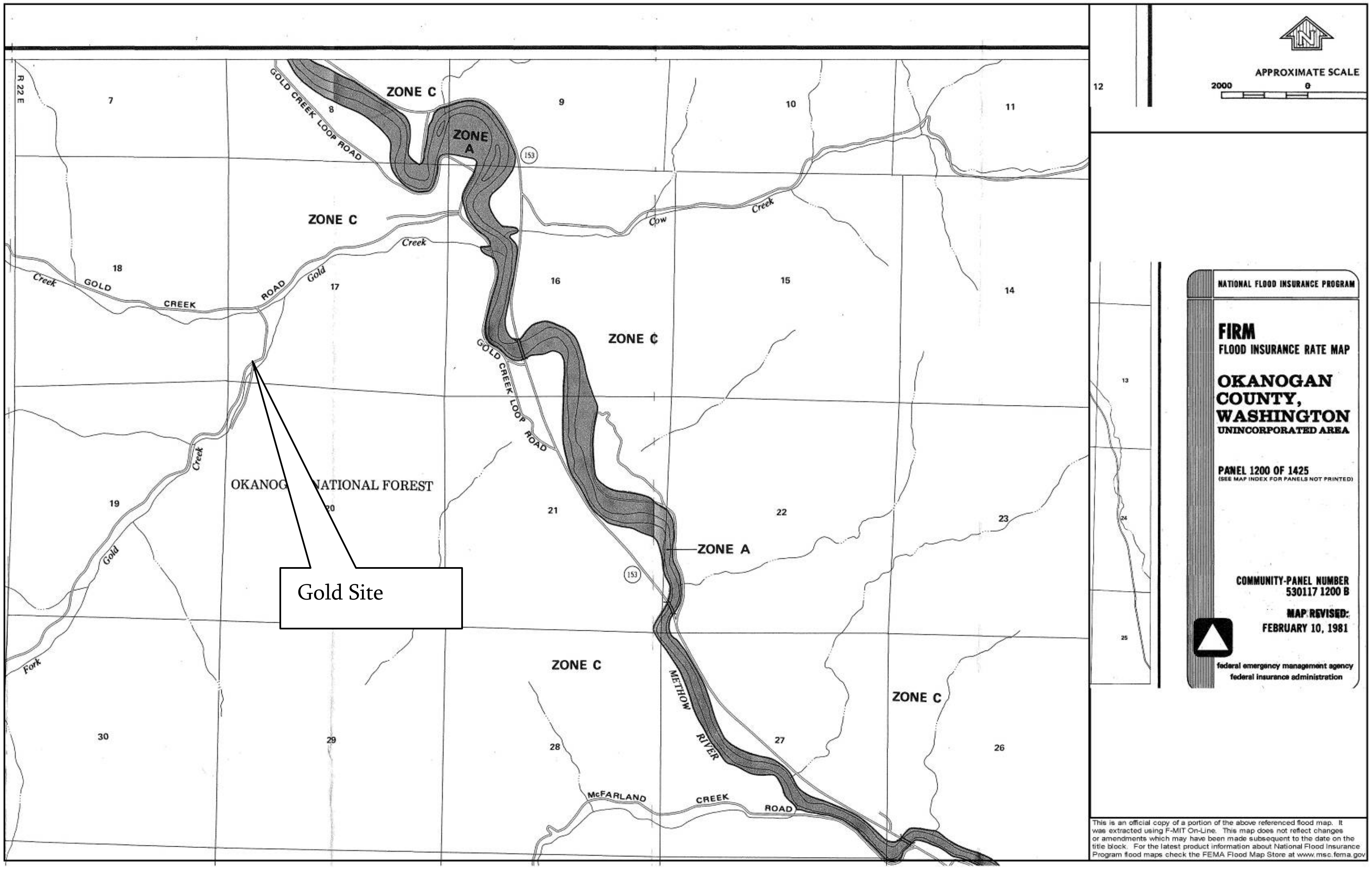



**Figure 11**
FIRM 530117 0850 C – December 20, 2000; Lincoln, Canyon, and Utley Sites
Flood Impact Analysis
Mid-Columbia Coho Restoration Project




ANCHOR QEA

**Figure 12**

FIRM 530117 1200 B – February 10, 1981; Gold Site

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

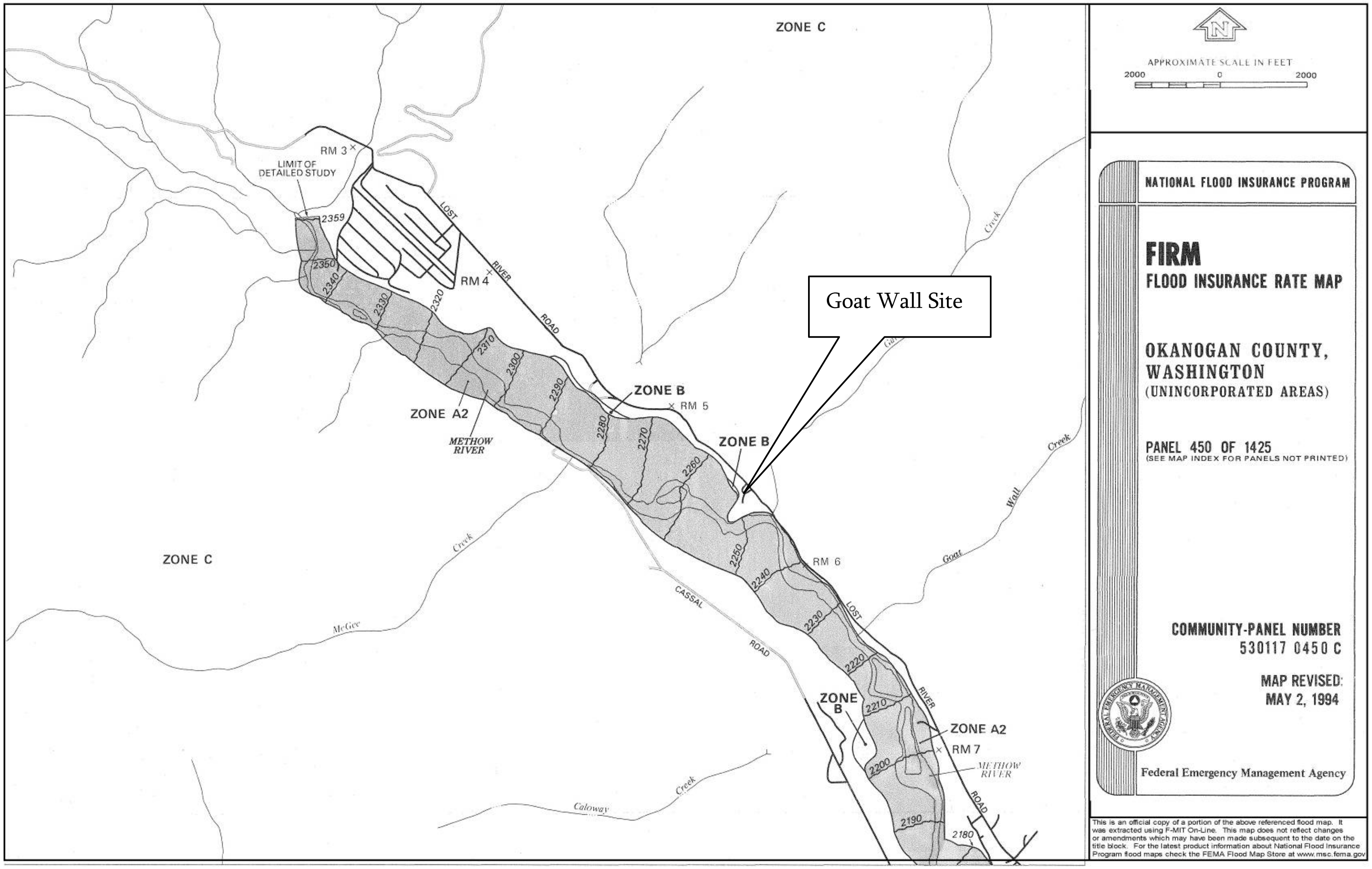



**Figure 13**
FIRM 530117 0450C – May 2, 1994; Goat Wall Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

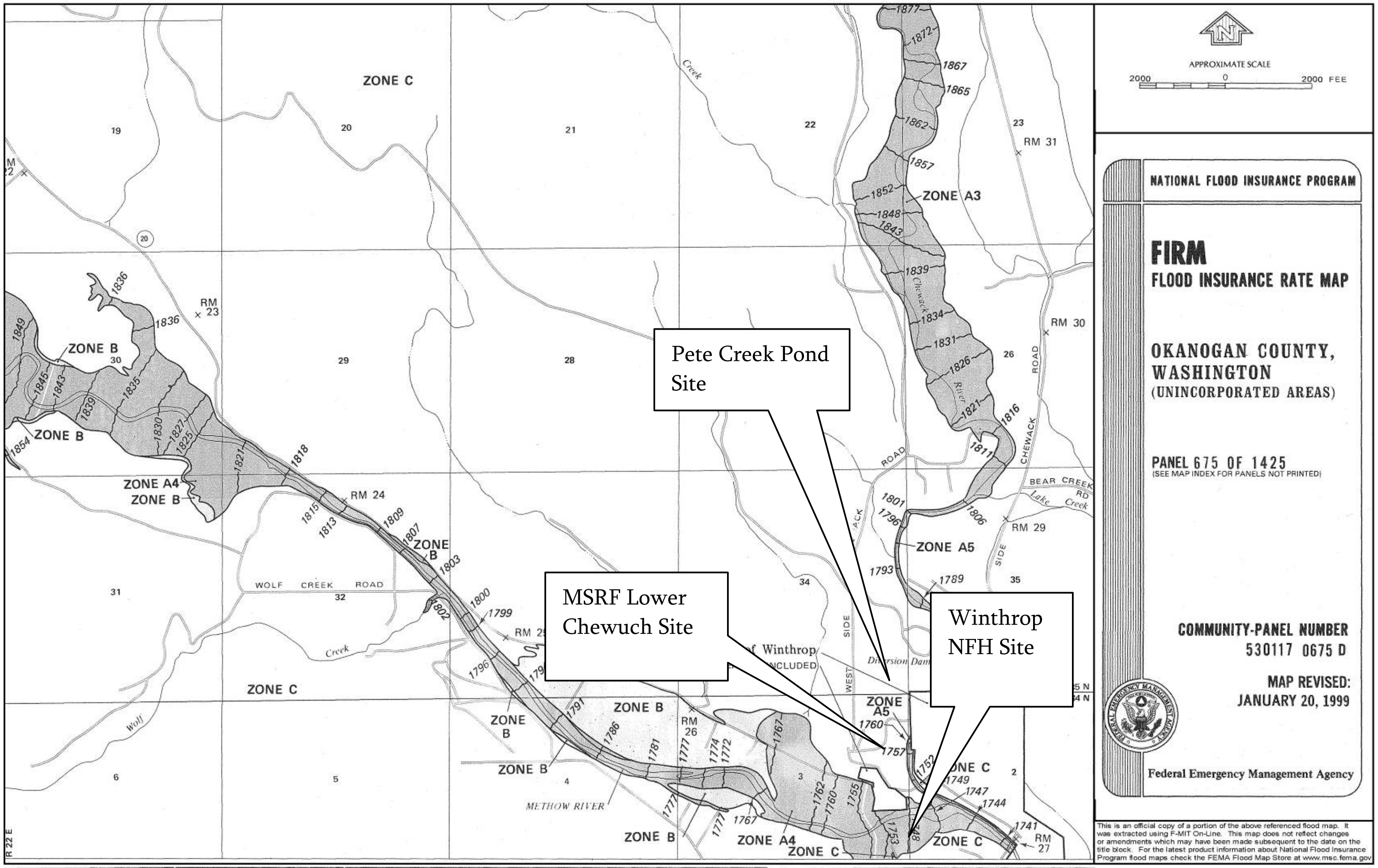



**Figure 14**

FIRM 530117 0675 D – January 20, 1999; Pete Creek, Winthrop NFH, and MSRF Lower Chewuch Sites

Flood Impact Analysis

Mid-Columbia Coho Restoration Project

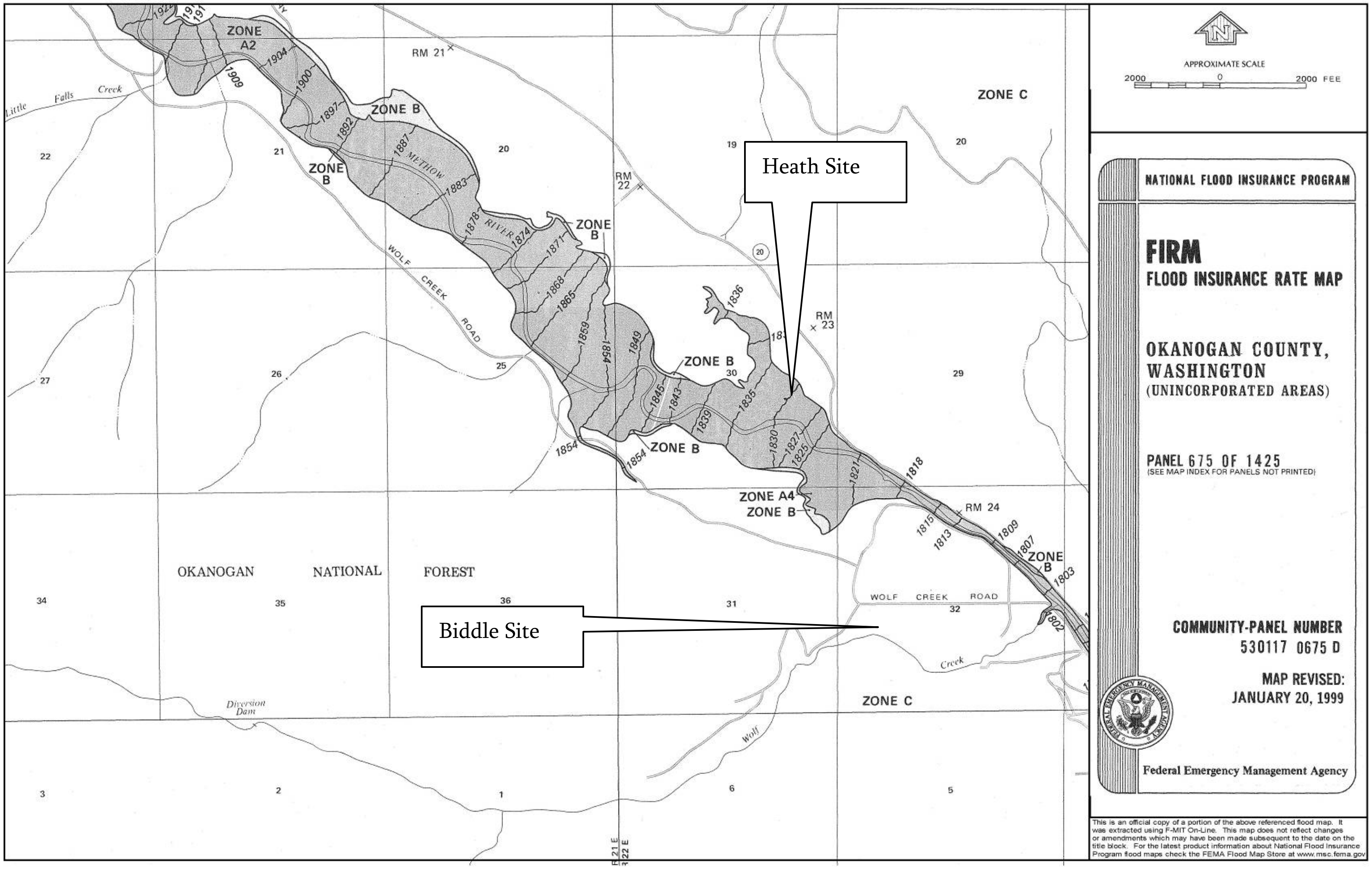



**Figure 15**
FIRM 530117 0675 D – January 20, 1999; Heath and Biddle Sites
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

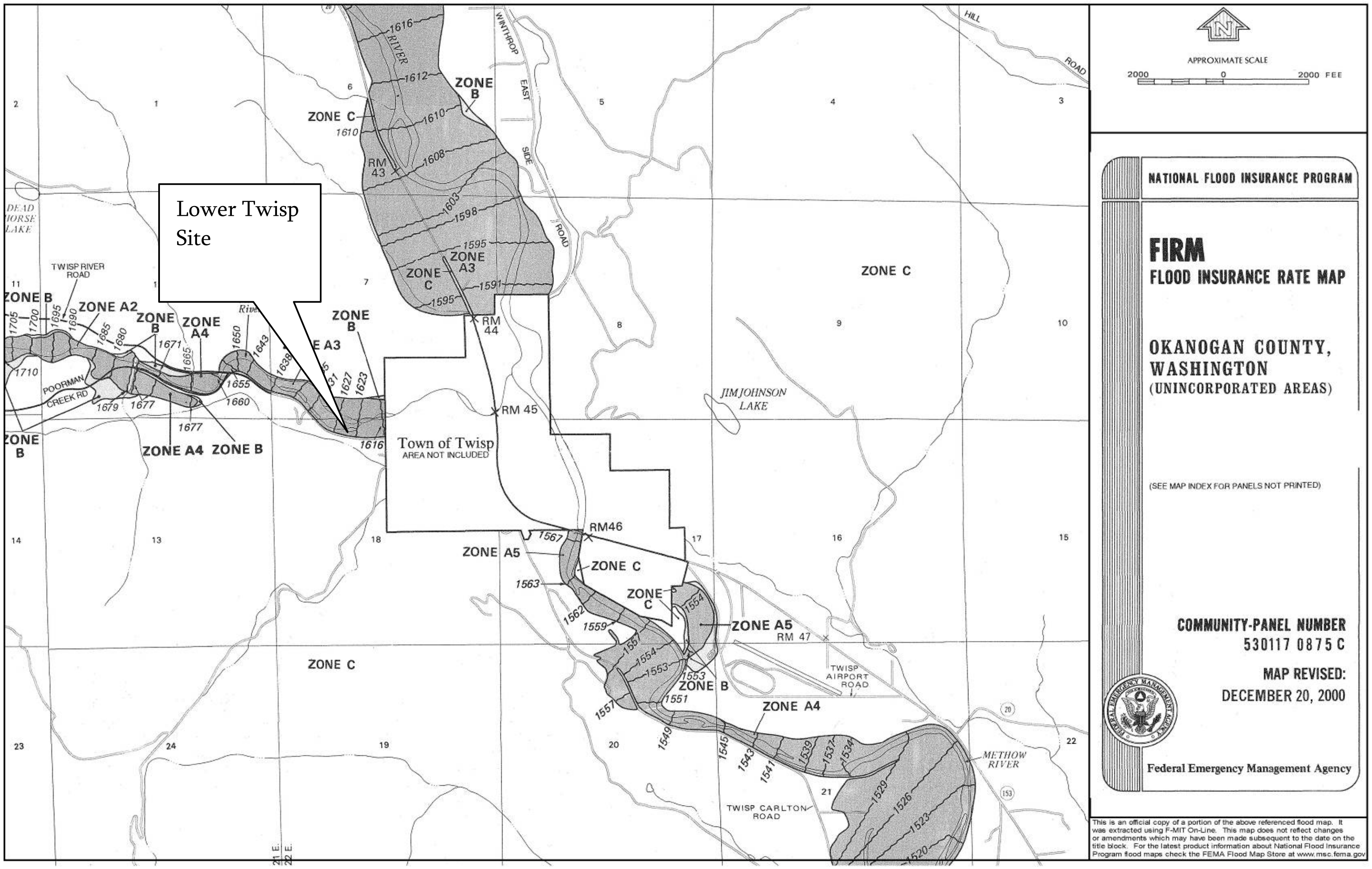



**Figure 16**
FIRM: 530117 0875 C – December 20, 2000; Lower Twisp Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

ANCHOR QEA

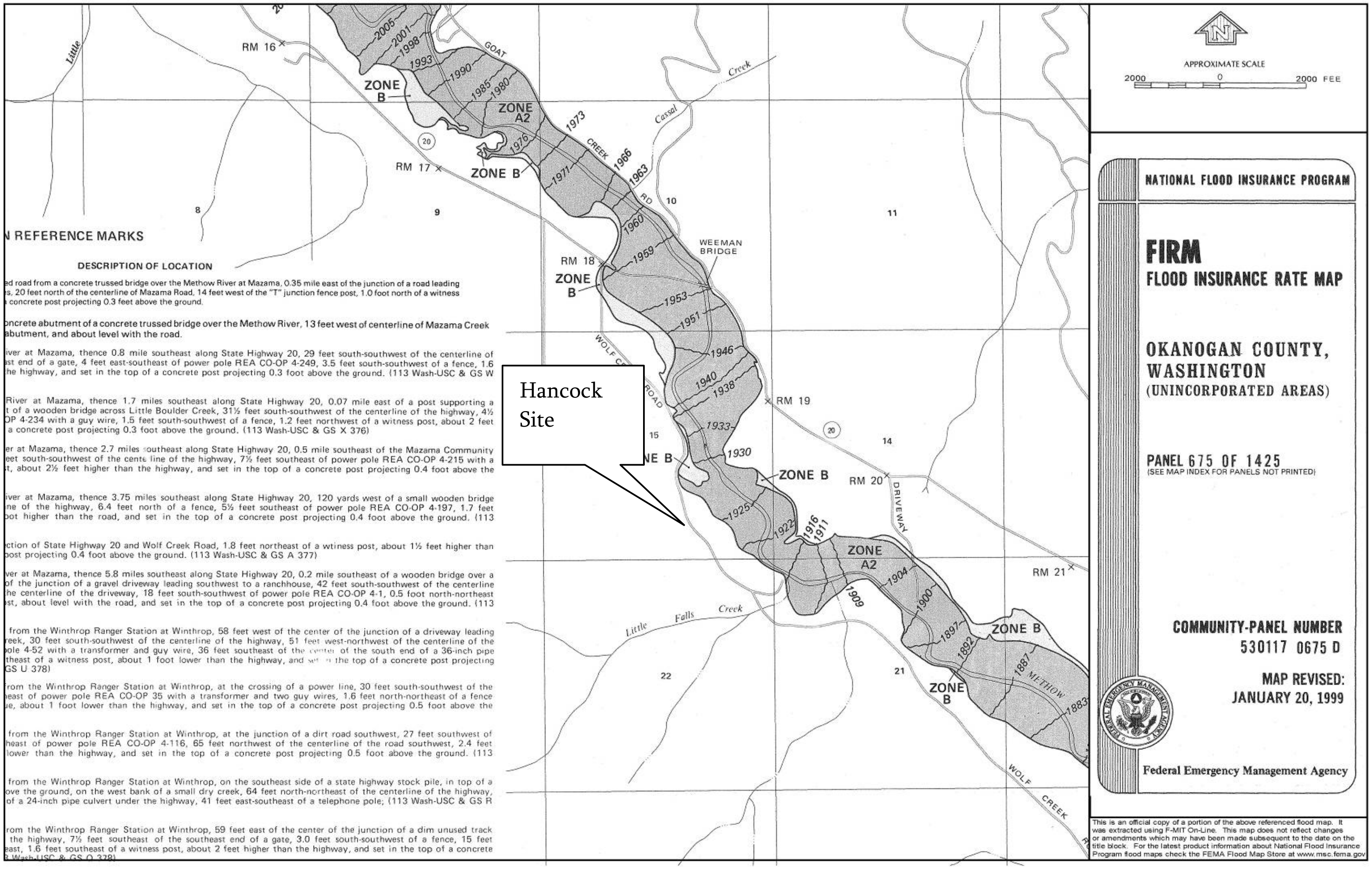



**Figure 17**
FIRM 530117 0675 D – January 20, 1999; Hancock Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

ANCHOR QEA

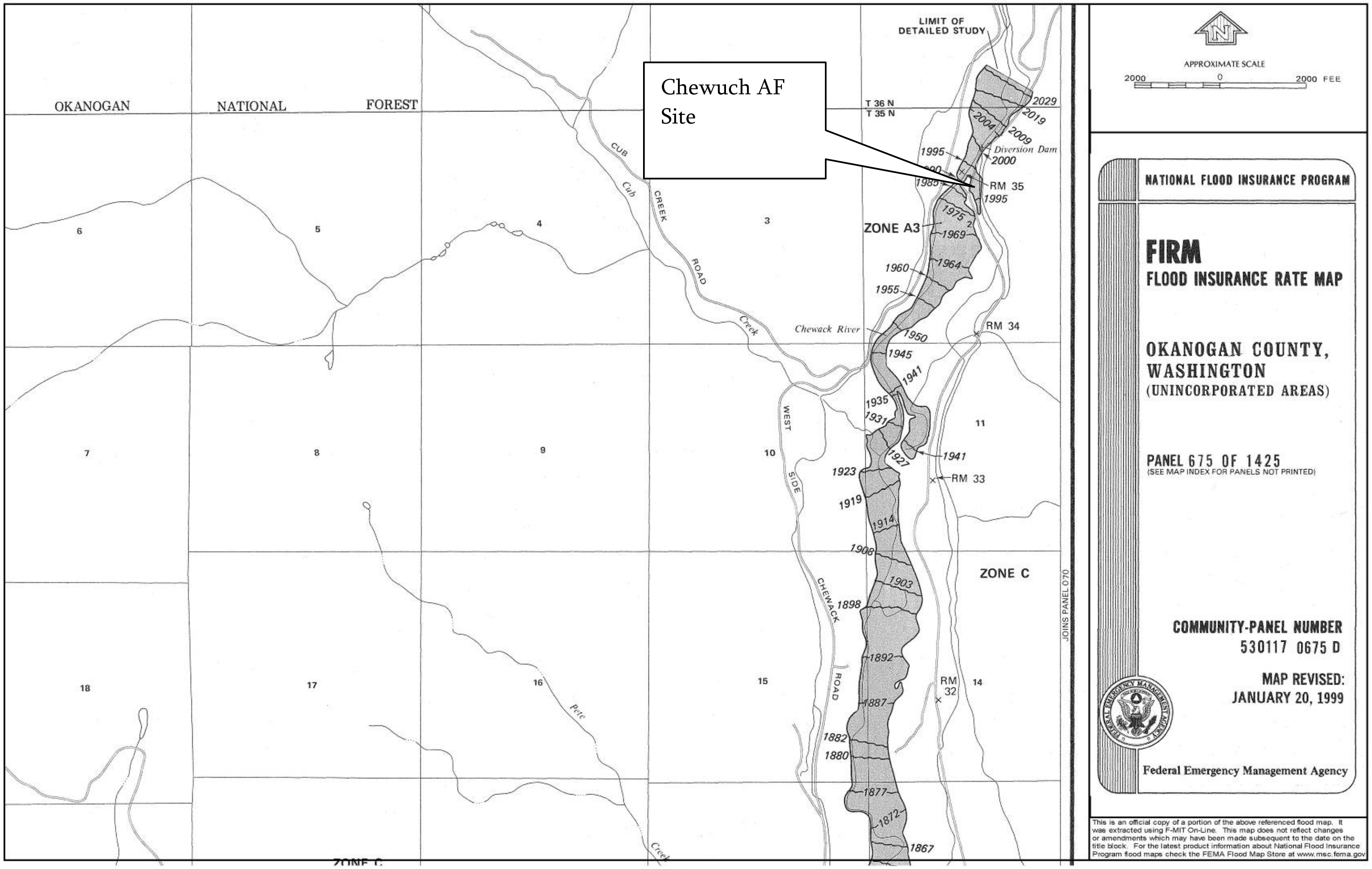



**Figure 18**
530117 0675 D – January 20, 1999; Chewuch AF Site
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

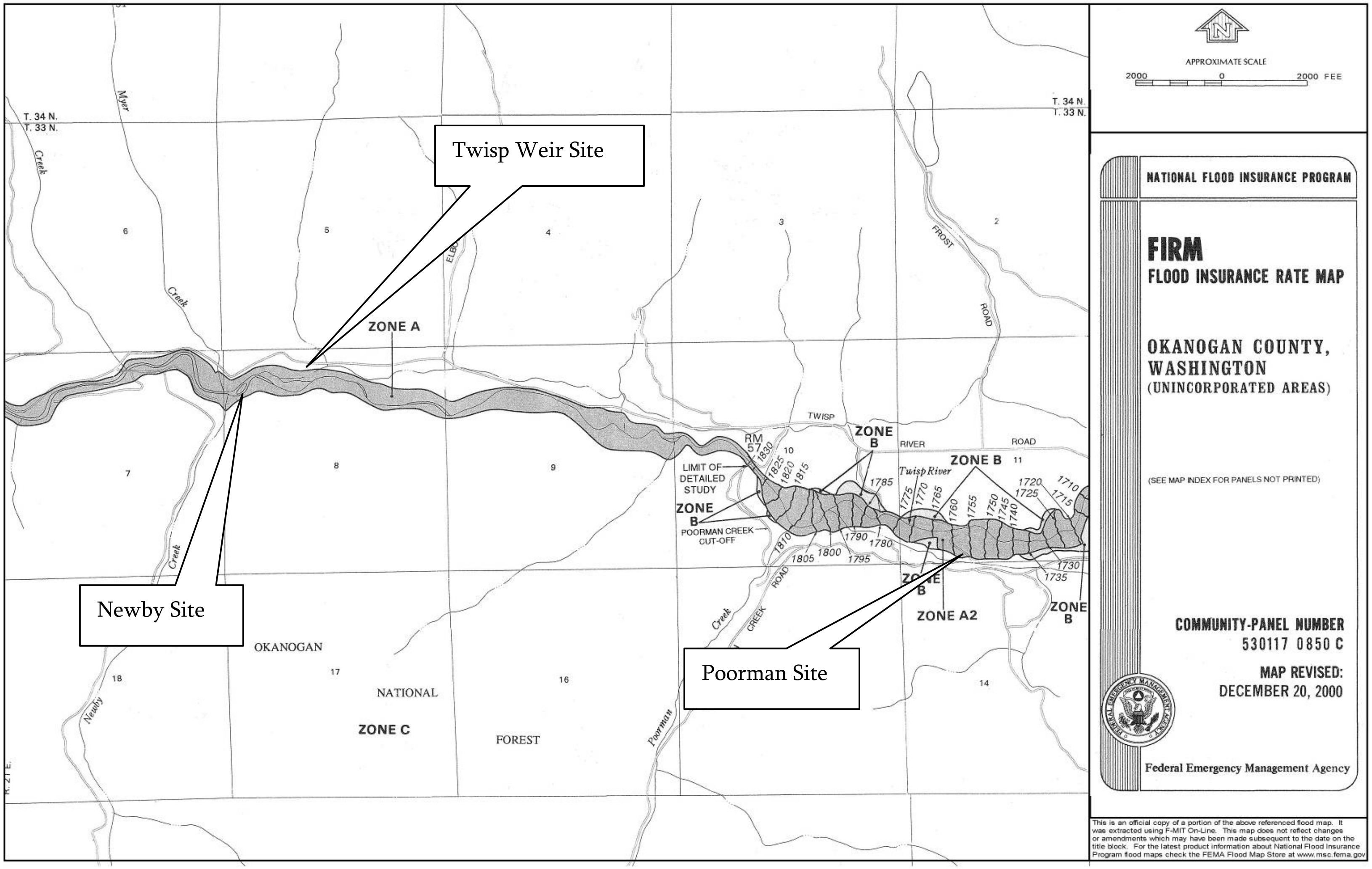



**Figure 19**
530117 0850 C – December 20, 2000; Twisp Weir, Newby, and Poorman Sites
Flood Impact Analysis
Mid-Columbia Coho Restoration Project

# 5 IMPACT OF FACILITIES ON FLOOD ELEVATIONS

## 5.1 Significance Criteria

The National Environmental Policy Act (NEPA) determination of "significant" impacts is defined in the Council Environmental Quality (CEQ) regulations at 40 CFR 1508.27. The definition of "significance" involves both the context and intensity of proposed project actions. A general discussion of context and intensity is presented in the EIS.

As described in Section 4.1, the primary goal of floodplain management is to restrict non-compatible development in the floodplain to avoid repetitive losses. FEMA delegates the responsibility of project review to the local regulatory agency through the NFIP program. Both Chelan and Okanogan Counties prohibit development within the floodway, but do allow development in the floodplain outside the floodway, as long the proposed development does not increase water surface elevation of the base flood by more than 1 foot. The context of significance estimates involves the local river basin floodplain and the intensity is measured by changes to flood elevations. Therefore, a project that would encroach into the floodway and increase the BFE or that would encroach upon the floodplain and increase the BFE by more than 1 foot would be determined to have a significant impact on flooding. A project that reduced the BFE would have a beneficial effect on flooding.

## 5.2 General Impacts

Sections 5.2.1 and 5.2.2 describe the general kinds of impacts that construction and operation of the proposed project could cause. Many of the proposed acclimation sites would not require construction activity or any permanent change to the landscape. Such sites would be subject only to impacts resulting from program operation. Potential site-specific impacts where there would be substantial construction activities are described in Sections 5.3 and 5.4.

### *5.2.1 Construction*

Proposed construction activities include:

- Road building; clearing, grading, and surfacing with crushed rock.
- Surface water supply system construction, including intake structures, pipelines, and

open channels. New intakes will require some excavation along stream banks. Pipeline ditches will be excavated and refilled. Open channels will be surfaced with gravel and rock.

- Groundwater supply system installation, including wells, buried pipelines, open channels, power lines, and generators. Wells require temporary access roads and areas for storage of drilled materials. Pipelines and open channels require excavation. Power lines will be placed in conduits and buried. Generators will be mounted near the wells in secondary containment systems to prevent potential spills or leaks of fuel, oil, or other fluids to the environment.
- New pond creation or enlargement of existing ponds. Ponds will be excavated with heavy equipment. They will be earthen-bottomed and will have rock and gravel placed in areas where high flow rates may occur.

Potential impacts to flooding from these activities include:

- Obstruction of flood flows and alteration of local drainage patterns.
- Disposal of spoil materials, filling the floodplain.
- Pond creation or expansion, adding floodplain storage.

Construction details specific to the individual sites are provided in the *Brood Capture and Rearing Site Descriptions* (Appendix 1 of the EIS), the *Wenatchee Acclimation Site Descriptions* (Appendix 2 of the EIS), and the *Methow Acclimation Site Descriptions* (Appendix 3 of the EIS).

#### *5.2.1.1 Impact Avoidance and Mitigation*

Measures that could be implemented to minimize potential impacts to flooding include:

- Compensatory storage incorporated in the project design where aboveground facilities are located within the floodplain.
- Spoil materials removed and disposed of in uplands or at offsite locations outside of the floodplain.
- Infrastructure buried below grade not in elevated road prisms, preventing diversion or rerouting of floodwaters.
- Disturbed areas will be restored with native vegetation.

### *5.2.2 Operation*

Activities required to operate the project acclimation and new rearing sites include:

- Setting and removing block nets
- Operating generators and wells
- Transporting salmon to each acclimation site for release
- Transferring salmon from vehicles into ponds using flexible hoses temporarily laid on the ground
- Daily feeding of juvenile fish and the non-lethal hazing of predators
- Monitoring the volitional release of migrants with tag detectors

Potential impacts on flooding from these activities include:

- Potential increase in flows due to discharge of groundwater

## 5.3 Site-Specific Impacts

Site-specific impacts are discussed only for the primary and back-up sites with substantial construction activities. Projects that only include minor improvements to existing ponds, access roads, or conveyance facilities are not expected to alter the potential for flooding at those sites and are therefore not discussed further. New wells, although providing additional flow through the acclimation sites, will be withdrawing water from shallow aquifers that are typically hydraulically connected to the adjacent creek or river (Appendix 12. *Ground Water Withdrawal Impacts*). Therefore, there is no real gain or loss of water. Additionally, the well discharge will be very minor compared to flood flows. Consequently, projects that only include flow augmentation from wells are not discussed further.

Surface water intakes proposed at the Tall Timber, Chikamin, and Dryden sites will be below grade and will match the existing contours of the river banks. They will be designed so they do not decrease flood storage volume and will not impede flow. Pipelines delivering water from these intakes will be buried and will have no impact on flood elevations.

### 5.3.1 Wenatchee Subbasin Primary Sites

Site construction for each program location is detailed in the *Brood Capture and Rearing Site Description* (Appendix 1 of the EIS) and the *Wenatchee Acclimation Site Descriptions* (Appendix 2 of the EIS). Primary sites with construction include: Butcher, Tall Timber, Chikamin, Minnow, Scheibler, and the Dryden Hatchery. One back-up site with construction is included: Squadroni.

#### 5.3.1.1 Butcher

A new well is proposed for the Butcher acclimation site. The exact location has not yet been determined but it will be close to existing roads to minimize access disturbance. An approximately 50-foot-long, 5-foot-wide, rock-lined, open channel would deliver water from the well to Butcher Creek upstream of the existing pond. Although the site is within the 100-year floodplain (Zone AH), it appears that the source of flooding is backwater from Nason Creek rather than Butcher Creek. Construction or operation of the well and associated facilities would have no effect on flooding.

#### 5.3.1.2 Tall Timber

The Tall Timber site is located on the unmapped section of the Napeequa River near its confluence with the White River. Although FEMA has designated a special flood hazard area along the White River (Zone A), the project site is located outside the special flood hazard area. The Tall Timber acclimation site would require a river intake and pipeline delivering water to an existing disconnected side channel. An 800-foot-long water supply pipeline from the intake to the side channel would be buried. An existing culvert would convey water from the side channel back to the river. Because the pipeline would be buried, it is expected that there would be no effect on flooding. Flood water elevations in the stream reach between the intake and the outlet of the acclimation diversion may be slightly reduced due to the withdrawal of water from the main channel.

#### 5.3.1.3 Chikamin

Construction of an acclimation pond at the Chikamin site would require excavation of approximately 1,370 cubic yards of material. An intake would be constructed on the bank of

Chikamin Creek and a 200-foot-long water supply pipeline from the intake to the pond would be buried. A rock-lined open channel, 100 feet long and 5 feet wide, would be constructed to convey water from the pond back to the creek. The Chikamin site is not located in a FEMA mapped flood hazard area, but is likely in the 100-year floodplain of Chikamin Creek. The construction of a pond would likely lower flood elevations a small amount due the removal of excavated soils from the floodplain. Overall, the project would have little effect on flooding.

#### *5.3.1.4 Minnow*

Construction of an acclimation pond at the Minnow site would require excavation of approximately 1,370 cubic yards of material from the bed and banks of Minnow Creek, essentially widening and deepening the channel. The Minnow site is not located in a FEMA mapped flood hazard area, but is in the 100-year floodplain and floodway of Minnow Creek. During a flood event, the flows would be essentially the same because there is not a substantial amount of active storage in the pond. Consequently, there may be very small reduction in flooding and no change to the floodway.

#### *5.3.1.5 Scheibler*

An impoundment was built in the Chumstick Creek channel forming a pond. Project construction would include excavating 350 cubic yards of material and enlarging the existing pond. Material excavated from the pond would be spread at approved areas, outside the floodplain. The site is located on Chumstick Creek floodplain in an area that has not been studied by FEMA. Furthermore, FEMA has not produced a flood hazard map of this reach. Because the construction is limited to excavation and the spoils will be disposed of outside the floodplain, the project may reduce flooding slightly along Chumstick Creek.

### *5.3.2 Wenatchee Subbasin Back-up Sites*

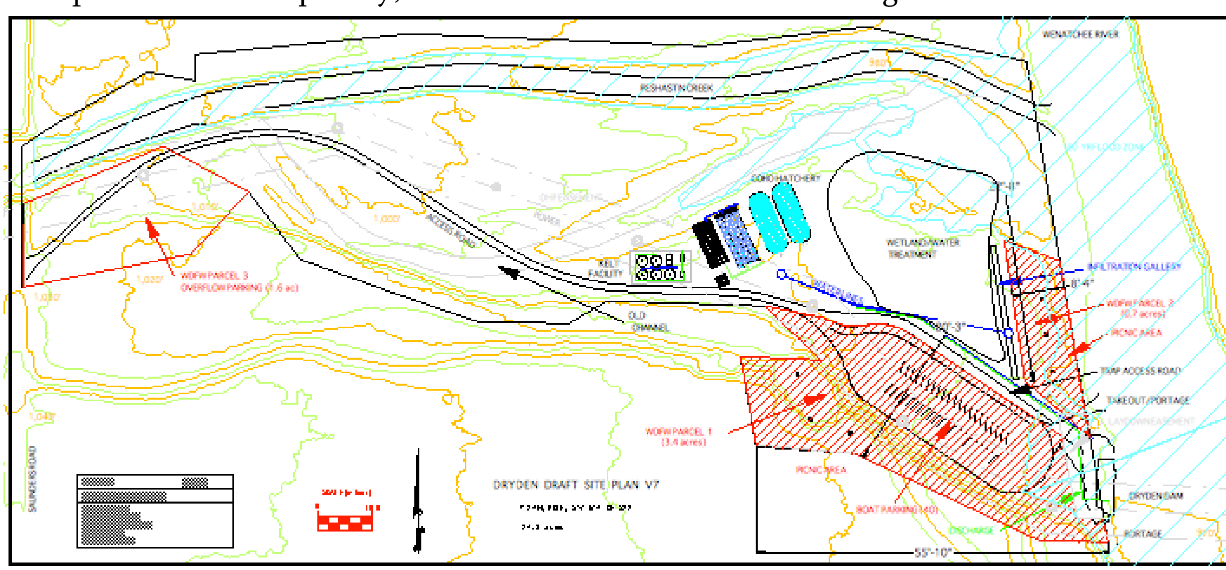
#### *5.3.2.1 Squadroni*

To construct the Squadroni acclimation pond site, 1,200 cubic yards of material would be excavated. The seasonal flow from an existing ditch would contribute surface water and a well would be constructed to supply additional water. Water from the well would be delivered through a 50-foot-long, rock-lined, open channel. A 20-foot-long discharge channel would return water from the pond to the ditch prior to discharge to Nason Creek. Spoil materials will be removed from the site for disposal outside the floodplain. Although the pond would provide some additional floodplain storage, the volume is very small compared to the flood flows. Consequently, the project may slightly reduce flooding on Nason Creek.

### *5.3.2.2 Dryden*

The Dryden hatchery will require excavations to create rearing ponds, raceways, a hatchery building, an infiltration gallery, and an effluent treatment system. These excavations would occur outside the flood hazard area. A flood study of the site was completed (Anchor QEA, 2009) and 100-year flood boundaries were mapped. They are shown in blue in the following illustration. Some construction may occur in the floodplain if constructed wetlands are built to treat hatchery discharges. Treatment systems have not yet been designed but if constructed wetlands are used, they will be built at existing grade and will not impact flood elevations.

Approximately 2,050 cubic yards of material is proposed to be removed from areas outside the floodplain. Material disposal areas have not yet been located but they will be in approved locations that meet grading permit conditions and minimize potential for floodplain fill. Consequently, there would be no effect on flooding.



#### *5.3.2.3 George*

The George hatchery will require grading to create rearing ponds, raceways, a hatchery building, parking areas, back-up generator station, and an effluent treatment system. Four concrete raceways (100-foot by 10-foot by 4-foot) would be used for fish production. Also, two ponds measuring 40-foot by 120-foot by 3-foot deep would provide low density rearing space. The site would be fenced and an overhead net system installed over the rearing units. Discharge water treatment would likely require a high degree of nutrient removal to meet conditions of the Total Maximum Daily Load restrictions in place for the Wenatchee River. An off-line treatment tank measuring 10-foot by 20-foot by 4-foot will hold and settle wastes vacuumed from the rearing units. A 3,000 sf hatchery building will enclose the incubators, rearing troughs, offices, and a small shop. Generators will provide back-up power. Parking will be provided for up to 10 vehicles. The hatchery facilities will require a permanent footprint of 1.5 acres. Including pipelines, water supply construction, and hatchery facilities; a total of 4 acres of land will be disturbed during construction.

It appears that all permanent facilities would be located within, but near the limits of, the special flood hazard zone (A3) and be subject to inundation of less than 1 foot deep. As this is a back-up site, detailed engineering studies have not been completed. If this site were to be selected, it is expected that a detailed floodplain analysis would be completed to evaluate the project affects on flooding as well as to evaluate methods to flood proof the hatchery building and the back-up generator station to comply with the local floodplain ordinance. Although the raceways and ponds would be largely below grade, the hatchery building, fencing, and generator station would be located above grade and could be damaged by the 100-year or potentially lesser floods. Because the project is near the edge of the floodplain, at an elevation similar to the BFE, it is not expected that the project would measurably obstruct flood flows or reduce floodplain storage. The project would have not have a substantial adverse effect on flooding.

### *5.3.3 Methow Subbasin Primary Sites*

Site construction for each program location is detailed in *Methow Acclimation Site Descriptions* (Appendix 3 of the EIS). Primary sites with construction include: MSWA

Eightmile, Mason (Eightmile), Lincoln, and Gold. Back-up sites with construction include: MSRF Lower Chewuch and Chewuch A.F.

#### 5.3.3.1 MSWA Eightmile

The MSWA Eightmile site is located in an abandoned side channel of the Chewuch River, just upstream of the mouth of Eightmile Creek. Construction would include a well and a 100-foot-long, 5-foot-wide, rock-lined, open channel that would deliver water from the well to the side channel. FEMA has not mapped a special flood hazard zone near the site. There would be no effect on flooding.

#### 5.3.3.2 Mason (Eightmile)

The Mason (Eightmile) site consists of three existing ponds adjacent to Eightmile Creek that are maintained by an irrigation diversion from the creek. A well is also proposed for the Mason (Eightmile) acclimation site. The exact location has not yet been determined, but it will be in a field near the existing ponds. A 50-foot-long, 5-foot-wide, rock-lined, open channel will deliver water from the well to the ponds. FEMA has not mapped a special flood hazard zone near the site. There would be no effect on flooding.

#### 5.3.3.3 Lincoln

Proposed construction at the Lincoln site would involve two wells to provide water to the existing two-pond system when water levels in the river are below the existing surface water diversion. A 50-foot-long, 5-foot-wide, rock-lined, open channel will deliver water from the wells to the upper pond. Buried water lines (approximately 600 feet long) will deliver water from the wells to this open channel. Excavation of material that has accumulated in one of the ponds is proposed to be removed but the flood storage capacity of the pond will not be changed. The Lincoln site is located in a FEMA mapped special flood hazard area (Zone A) on the Upper Twisp River. Spoil materials from any of the excavations will be disposed of outside the floodplain in accordance with local floodplain management ordinance requirements. There would be no effect on flooding.

#### 5.3.3.4 Twisp Weir

Proposed construction at the Twisp Weir site would include a 140-foot long, 50-foot wide, 3.5-foot deep, constructed, earthen pond, occupying approximately 0.2 acres. Because the pond will be below existing grade and material will be removed and disposed of outside the flood plain, there would be no effect on flooding.

#### 5.3.3.5 Gold

The Gold site consists of several existing ponds located adjacent to Gold Creek. Construction activities would involve removing some accumulated sediment from the ponds to restore water depths adequately for acclimation. Excavated materials would be disposed of outside the floodplain in accordance with grading permits. The project site is not within a FEMA mapped special flood hazard area. The proposed construction would not alter the diversions from Gold Creek. Consequently, there would be no effect on flooding.

### 5.3.4 Methow Subbasin Back-up Sites

#### 5.3.4.1 MSRF Lower Chewuch

Acclimation pond construction would include the excavation of approximately 890 cubic yards of material. A well would also be constructed. Rock-lined, open channels, a total of 320 feet long and 5 feet wide, will be constructed from the well to the pond and from the pond to the Chewuch River. FEMA designated a special flood hazard area (Zone A5) along the Chewuch River in the vicinity of the project, but the project is outside the flood hazard area. There would be a minor increase in floodplain storage capacity and potentially a slight reduction in flood elevations due to pond construction.

#### 5.3.4.2 Chewuch AF

Acclimation pond construction would include the excavation of approximately 975 cubic yards of material. Water would be diverted from the Chewuch River. Water delivery pipelines with fish screens would also be constructed. The Chewuch AF site is located in the FEMA mapped flood hazard area (A3). Excavated materials would be removed from the site and disposed of in an upland location outside of the floodplain in accordance with local floodplain management ordinance requirements. Consequently, there would a minor increase in floodplain storage capacity and potentially a slight reduction in flood elevations due to pond construction.

##### *5.3.4.3 Canyon*

Approximately 200 cubic yards of material are proposed to be removed from an existing pond to deepen it and expanded it by 0.04 acres. Excavated materials will be disposed of outside the floodplain. The site is outside the special flood hazard area designated along the Twisp River. There would be no effect on flooding.

##### *5.3.4.4 Utley*

An 80-foot long, 3-foot wide channel from an pond to the Twisp River is proposed to allow acclimated smolts a route to the River. The existing pond and the proposed channel are within the special flood hazard area. Because excavated materials will be disposed of outside the floodplain there would be no effect on flooding.

##### *5.3.4.5 Newby*

A 140-foot long, 50-foot wide, 3.5-foot deep earthen bottom pond and an intake on Newby Creek are proposed for the site. Buried water delivery pipelines from the intake to the pond and from the pond back to the Twisp River would also be constructed. The construction activities would occur within the special flood hazard along the Twisp River. Because excavated materials will be disposed of outside the floodplain there would be no effect on flooding.

## 5.4 Combined Impacts

### *5.4.1 Proposed Alternative*

The *Wenatchee Acclimation Site Descriptions* (Appendix 2 of the EIS) and *Methow Acclimation Site Descriptions* (Appendix 3 of the EIS) identify the primary acclimation site locations for the Proposed Alternative. Approximately half of the releases proposed are from acclimation sites capable of overwinter acclimation, having groundwater supplies that can provide secure flow during icing conditions. Back-up acclimation sites have also been identified, but may not be used.

The majority of the project sites are located in rural and undeveloped areas of Chelan County and Okanogan County with high quality forested, riparian, and wetland habitats within the sites, or in the vicinity of the sites. Site-specific potential impacts associated with the Methow and Wenatchee sites were described in Sections 5.3 and 5.4. A combined impact evaluation considers the potential collective effects of the total MCCRP, as opposed to individual site-specific impacts.

Combined impacts are summarized in Table 3. There are a total of 27 primary sites, including the Dryden hatchery, and 12 back-up sites. Combined impacts of the proposed project alternative will be evaluated only for the primary sites. Back-up sites will be used as replacements for primary sites that may become unavailable. A switch from a primary to a back-up site is not expected to alter the combined impact of the project on floods.

The total amount of ground disturbed during construction of all the primary sites is proposed to be less than 2.5 acres and will include four new water intake structures, seven new wells, and 650 feet of unpaved road. New ponds are proposed for the Dryden hatchery, three primary acclimation sites, and three back-up sites. The construction details for each project are described in either the *Wenatchee Acclimation Site Descriptions* (Appendix 2 of the EIS) or the *Methow Acclimation Site Descriptions* (Appendix 3 of the EIS). The new ponds will remove material from floodplains, slightly increasing floodplain storage capacity and potentially decreasing flood elevations.

**Table 3**

**Combined Impacts of MCCRP Projects**

| | ACCESS | SURFACE WATER | | | GROUND WATER | | EARTH | | | | | | SITES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New road construction (ft) | New intake construction | Conveyance channel (ft) | Inlet water screen | New wells | Existing wells | Volume excavated (cy) - pond | Surface disturbance (acre) - pond construction | Surface disturbance (sf) - water systems, intakes | Surface disturbance (sf) - water systems, open channel | Buried water piepline (ft) | Buried power line (ft) | Primary | Back-ups |
| **Wenatchee** | 650 | 3 | 2,080 | 7 | 3 | 2 | 4,791 | 1.6 | 700 | 1,000 | 2,500 | 500 | 15 | 5 |
| **Methow** | - | 1 | - | 7 | 4 | 1 | 2,685 | 0.9 | 350 | 2,000 | 1,200 | 950 | 12 | 7 |
| **TOTAL** | 650 | 4 | 2,080 | 14 | 7 | 3 | 7,476 | 2.5 | 1,050 | 3,000 | 3,700 | 1,450 | 27 | 12 |

Proposed clearing and grading during construction is limited to small areas relative to total floodplain areas. At each site, impacts to flooding would be avoided or compensatory floodplain storage would be created to offset facilities located above ground in the floodplain.

Overall, the combined effects to flooding due to proposed construction and operation of acclimation and rearing sites are not considered to be a significant impact because the projects individually have negligible or no effect, and the limits of effects are confined to the immediate project areas such that the effects of one do not overlap with the effects of another.

### *5.4.2 No Action*

The No Action Alternative is described in the EIS. It includes operation of fewer of the same sites described for the Proposed Alternative. Because fewer sites would be operated and no new construction is involved, the combined effects would be less than those of the Proposed Alternative; consequently, the impacts of the combined projects are considered to be less than significant.

## 5.5 Cumulative Impacts

The EIS defines cumulative effects as the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Other, outside impacts could result from any development in the floodplain not associated with MCCRP actions, which could exacerbate flooding; for example, diking, road development, and residential/urban development.

### *5.5.1 Proposed Alternative*

Because construction activities associated with the project are anticipated to result in very minor conversion of forested lands compared to the watershed as a whole, because the some acclimation sites would provide additional floodplain storage, and because new construction would be in accordance with floodplain development codes, the cumulative effects of these actions are not considered a significant impact. Additionally, many proposed county and state-funded road improvement projects include culvert replacements on existing roads having the potential to mitigate or reduce the effects of existing flooding. The known road improvement projects are identified in the following sections.

Habitat improvement projects are also proposed for implementation throughout the project area. These habitat projects are funded by federal and state dollars under multiple programs and implemented by local stakeholder groups, counties, and conservation districts. Habitat improvement projects that re-establish floodplain access to undeveloped floodplain habitat have the potential to further mitigate or reduce the effects of existing flooding. Habitat improvement projects funded and proposed for implementation in the Wenatchee and Methow subbasins using Washington State Salmon Recovery Funding Board (SRFB) grants can be tracked at the Upper Columbia Salmon Recovery Board's salmon habitat implementation website (http://uc.ekosystem.us//). Habitat improvement projects funded in the Wenatchee and Methow subbasins using Chelan County Public Utility District (PUD) and Douglas County PUD Habitat Conservation Plan (HCP) Tributary Fund dollars can be tracked at the Chelan County PUD HCP website (http://www.midcolumbiahcp.org/). Other projects may be implemented by various other public agencies or private parties that are not known at this time.

#### *5.5.1.1 Wenatchee Subbasin Sites*

Planned projects in the basin include road improvement projects throughout the watershed that could have localized effects on nearby creeks. These projects are Chelan County projects: CRP636-North Road and CRP612-Eagle Creek Road that could impact Chumstick Creek, CRP597-Old Blewett Highway that could impact Peshastin Creek; and Washington State Department of Transportation (WSDOT) projects: US 2 bridge over Chiwaukum Creek, US 2 Wenatchee River bridge at Tumwater, and road improvements along US 97 that could impact Peshastin Creek. It is anticipated that the County and WSDOT would implement mitigation measures and Best Management Practices (BMPs) according to the Highway Runoff Manual (WSDOT 2008) to minimize floodplain impacts from any of these projects. Consequently the cumulative effects of the Proposed Action and other known projects in the Wenatchee Subbasin are not considered to be a significant cumulative impact.

#### *5.5.1.2 Methow Subbasin Sites*

In the Methow subbasin, other known planned projects include road improvement projects throughout the watershed that could have localized effects on nearby creeks. These projects are Okanogan County and WSDOT road improvement projects such as Twisp River Road (affecting Twisp River), and Twin Lakes Road (affecting Methow River). It is anticipated that Okanogan County and WSDOT would implement mitigation measures and BMPs according to the Highway Runoff Manual (WSDOT 2008) to minimize floodplain impacts from any of these projects. Consequently, the effects of the Proposed Alternative combined with the effects of other known projects in the Methow Subbasin are not considered to create a significant cumulative impact.

### *5.5.2 No Action*

As described for the Proposed Alternative, additional projects are likely to be implemented in the Wenatchee and Methow subbasins that may have floodplain effects. Because construction activities associated with these projects are anticipated to be conducted in accordance with floodplain development codes, the combined effects of the No Action Alternative and the other known projects are not considered to create a significant cumulative impact. Many culvert replacement projects on existing roads have the potential to reduce the effects of flooding, as do habitat improvement projects. The known road projects and links to funded habitat improvement projects are provided in Section 5.1.1.

# 6 REFERENCES


Anchor QEA, LLC. 2008. Hydrology Memorandum to Bureau of Reclamation.

Anchor QEA, LLC. 2009. Flood Evaluation near Dryden Dam. June, 2009.

Chelan County 2009. Chelan County Code, Chapter 3.20 Flood Hazard Development. Code Publishing Company. Accessed at: http://www.codepublishing.com/WA/chelancounty.html.

Chelan County Department of Emergency Management, 2006. Chelan County Hazard Inventory and Vulnerability Assessment. Wenatchee, WA.

Ecology, see Washington State Department of Ecology.

Federal Emergency Management Agency (FEMA). 1980. Flood Insurance Study (FIS), Chelan County, Washington, Unincorporated Areas.

FEMA. 1981. Flood Insurance Rate Map (FIRM), Okanogan County, Washington, Unincorporated Areas, Community Panel 5301171200B.

FEMA. 1989a. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300150750B, June 5, 1989.

FEMA. 1989b. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300150775B, June 5, 1989.

FEMA. 1989c. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300150575B, June 5, 1989.

FEMA. 1994. FIRM, Okanogan County, Washington, Unincorporated Areas, Community Panel 5301170450C.

FEMA. 1999. FIRM, Okanogan County, Washington, Unincorporated Areas, Community Panel 5301170675D.

FEMA. 2000a. FIRM, Okanogan County, Washington, Unincorporated Areas, Community Panel 5301170850C.

FEMA. 2000b. FIRM, Okanogan County, Washington, Unincorporated Areas, Community Panel 5301170875C.

FEMA. 2000c. FIS, Okanogan County, Washington, Unincorporated Areas (Fourth Revision).

FEMA. 2002a. FIS, Chelan County, Washington, Unincorporated Areas, First Revision.

FEMA. 2002b. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300150787B, July 2, 2002.

FEMA. 2003. FIS, Okanogan County, Washington, Unincorporated Areas, January 2003 (Fifth Revision).

FEMA. 2004a. FIS, Chelan County, Washington, Unincorporated Areas, Second Revision.

FEMA. 2004b. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300150800D, September 30, 2004.

FEMA. 2004c. FIRM, Chelan County, Washington (Unincorporated Areas), Community Panel 5300152763D, September 30, 2004.

Okanogan County. 2008. Okanogan County Code Chapter 15.08 Floodplain Management. Code Publishing OnLine. Accessed at: http://nt5.scbbs.com/cgibin/om_isapi.dll?clientID=431830999&infobase=okanco.nfo&record={451D}&softpage=PL_frame.

Okanogan County Department of Emergency Management, 2009. All Hazards Mitigation Plan. Okanogan, WA.

U. S. Department of Agriculture, Soil Conservation Service. 1975. Flood Hazard Analysis, Chewuch River, Portland, Oregon.

Washington State Department of Ecology (Ecology). 2009. River and Stream Flow Monitoring. Accessed at: https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp.

Washington State Department of Transportation (WSDOT). 2008. Highway Runoff Manual. Accessed at: http://www.wsdot.wa.gov/Environment/WaterQuality/Runoff/HighwayRunoffManual.htm

# Appendix 9. Impact of Fish Culture on ESA-Listed Fish

Report Prepared by:
Randolph Ericksen
Cramer Fish Sciences
600 NW Fariss Road
Gresham, Oregon 97030

**November 2010**

# TABLE OF CONTENTS

## LIST OF FIGURES

# LIST OF TABLES

# 1.0 SUMMARY

The presence of ESA listed fish by life stage was assessed using a two-step process. First, existing data on fish distribution available in the Wenatchee and Methow Subbasins was compiled and reviewed. This information was used to identify sites where fish presence information was lacking. Second, snorkel surveys were conducted at those sites without sufficient information to determine the presence and life stages of ESA listed fish during the time of year of proposed acclimation activities. Life history information was used to determine what life stages and size ranges were likely to be present during overwinter rearing, spring acclimation and construction activities for each species. Results are summarized for the Wenatchee Subbasin in Table 11 and Methow Subbasin in Table 12.

Implementation of the Mid-Columbia Coho Restoration Project (MCCRP) proposed alternative could result in ESA listed fish temporarily being excluded from 0.3 acres of currently accessible habitat from December through early May, and an additional 0.9 acres from mid-March through early May in the Wenatchee Subbasin. In the Methow Subbasin, they could be temporarily excluded from 0.7 acres of currently accessible habitat from December through early May, and an additional 0.6 acres from mid-March through early May. These impacts will be balanced to some degree by newly constructed ponds. About 0.3 acres of new pond habitat in the Wenatchee Subbasin will be available to other fish for at least a portion of the year. The number of fish projected to be temporarily dislocated or excluded during rearing and acclimation is low (314 fish or less) and represents a small percentage of the average smolt production in each Subbasin (less than 0.5% in the Wenatchee, and less than 1.7% in the Methow). These fish would be excluded from acclimation sites but could potentially occupy other available habitat.

Other potential adverse impacts associated with coho acclimation on ESA listed fish are expected to be small. New site construction activities will be short-term and bank disturbances will be small. Hatchery coho could potentially prey on smaller fish including Chinook and bull trout fry but the incidence of predation has been low and other fish will be excluded from rearing and acclimation sites.

Potential negative impacts to ESA listed fish will be avoided or minimized using the following measures:

- Barrier nets will be used at acclimation sites where ESA listed fish do not reside or use to migrate through to existing habitat. This will minimize premature escape of coho salmon.
- Seine nets will be used at acclimation sites to partition off a portion of a water body while allowing free upstream and downstream passage of ESA listed fish to available habitat. In areas where emergent spring Chinook or bull trout fry will be present, predation will be minimized by using fine seine mesh to exclude fry from enclosed areas. Seines will be installed in a manner that excludes fry from the coho acclimation area by moving out from the bank to encapsulate the rearing area. The enclosed area will be snorkeled to verify no ESA listed fish are present before hatchery coho are added.
- Timing and methodology of construction activities will be coordinated with resource agencies to minimize disturbance to listed species and life-stages. Best management practices will be used and permit conditions will be followed during construction activities, to prevent sedimentation inputs.

# 2.0 INTRODUCTION

The objective of this study was to determine if and when fish listed under the Endangered Species Act (ESA) are present in selected sites within the Wenatchee and the Methow Subbasins and to assess the potential effects of acclimation, rearing, and adult holding activities related to the Yakama Nation's Mid-Columbia Coho Reintroduction Project on ESA listed fish. A list of all fish species documented in these Subbasins is found in Table 1.

ESA listed fish that are likely to be present at these sites include spring Chinook *Oncorhynchus tshawytscha*, summer steelhead *O. mykiss*, and bull trout *Salvelinus confluentus*. The Upper Columbia River spring-run Chinook salmon Evolutionary Significant Unit (ESU) was listed as endangered on March 24, 1999 (64 FR 14308), and its status was reaffirmed on June 28, 2005 (70 FR 37160). The ESU includes all naturally spawned populations of spring-run Chinook salmon (spring Chinook) in Columbia River tributaries upstream of the Rock Island Dam as well as six artificial propagation programs. The Upper Columbia River steelhead distinct population segment (DPS) was listed as endangered on August 18, 1997 (62 FR 43937) and subsequently upgraded to 'threatened" status in 2009 (74 FR 42605). Critical Habitat was designated in the Wenatchee and Methow basins for both Chinook and steelhead in 2005 (70 FR 52630). Columbia River bull trout were listed as threatened on June 10, 1998 (63 FR 31647). The Wenatchee, Entiat, and Methow Rivers have been identified as core bull trout habitats for the Upper Columbia Recovery Unit, and designated as Critical Habitat October 18, 2010 (75 FR 63898).

Information in this report has been prepared as a companion document to support the project analysis. Project site details such as their locations; project descriptions; and associated maps, figures, and photographs, are presented in the *Brood Capture and Rearing Site Descriptions* report (Appendix 1 of the EIS), the *Wenatchee Acclimation Site Descriptions* report (Appendix 2 of the EIS), and the *Methow Acclimation Site Descriptions* report (Appendix 3 of the EIS) prepared for the project, and are not duplicated in this report. Impacts to listed fish resulting from acclimation activities that affect surface waters are discussed in a separate report entitled *Effect of Surface Water Withdrawals on Listed Fish* (Appendix 10 of the EIS) prepared for the project.

Maps of the Wenatchee and Methow Subbasins showing the location of proposed acclimation and rearing sites are shown on Figures, 1-2 in Appendix 1, and Figures 1-1 in Appendix 2 and Appendix 3. Figures 2-1 in Appendix 2 and 3 include the site locations based on Section, Township, and Range as well as their latitude and longitude.

## 2.1 Life History of ESA Listed Fish

An understanding of a species life history is needed to predict impacts to the population from proposed activities. Life histories for the three ESA listed species are described below.

**Spring Chinook**

Chinook salmon life history patterns, including run timing, have evolved over thousands of years to match stream flow, water temperatures, and habitat in a particular stream. Spring Chinook are distinguished from late run Chinook salmon by an early adult entry into freshwater and a typical stream-type (yearling) juvenile life history. Both spring run and late run (summer) Chinook salmon spawn in the Wenatchee and Methow Subbasins. However, only spring Chinook are

**Table 1. List of fish species documented in the Wenatchee[a] and Methow[b] Subbasins. An "X" indicates the species is present in the Subbasin.**

| Family & Species | Scientific Name | Wenat-chee | Met-how | Habitat | Origin |
|---|---|---|---|---|---|
| Lamprey Family | Petromyzontidae | | | | |
| Pacific Lamprey | *Entosphenus tridentatus* | X | X | Larvae found in backwater silt | Native |
| Salmon Family | Salmonidae | | | | |
| Mountain Whitefish | *Prosopium williamsoni* | X | X | Riffles in summer, pools in winter | Native |
| Brown Trout | *Salmo trutta* | | X | Streams up to 75 degrees F. | Introduced |
| Cutthroat Trout | *Oncorhyncus clarki* | X | X | Cold water lakes and streams | Native |
| Rainbow/Steelhead | *O. mykiss* | X | X | Cold water lakes and streams | Native |
| Chinook Salmon | *O. tshawytscha* | X | X | Larger rivers and streams | Native |
| Sockeye/kokanee | *O. nerka* | X | X | Primarily lake rearing | Native |
| Coho Salmon | *O. kisutch* | X | X | Recently re-introduced | Native |
| Brook Trout | *Salvelinus fontinalis* | X | X | Cold water lakes and streams | Introduced |
| Bull Trout | *S. confluentus* | X | X | Cold water streams and pools | Native |
| Minnow Family | Cyprinidae | | | | |
| European Carp | *Cyprinus carpio* | X | X | Shallow quiet water with dense vegetation | Introduced |
| Peamouth | *Mylocheilus cauinus* | X[c] | | Lakes and slow stretches of rivers | Native |
| Chiselmouth | *Acrocheilus alutaceus* | X | | Faster, warmer streams and rivers, and lakes | Native |
| Longnose Dace | *Rhinichthys cataractae* | X | X | Among stones at the bottom of swift streams | Native |
| Speckled Dace | *R. osculus* | X | | Small clear well oxygenated streams | Native |
| Northern Pikeminnow | *Ptychocheilus oregonensis* | X | X | Lakes and slow streams | Native |
| Redside Shiner | *Richardsonius balteatus* | X | X | Warmer ponds, lakes, streams | Native |
| Sucker Family | Catostomidae | | | | |
| Bridgelip Sucker | *Catostomus columbianus* | X | X | Bottom feeder in river backwaters and pools | Native |
| Largescale Sucker | *C. macrocheilus* | X | X | Bottom feeder in lakes, and pools in rivers | Native |
| Mountain Sucker | *C. platyrhynchus* | X | | Bottom feeder in cool mountain streams | Native |
| Longnose Sucker | *C. catostomus* | X | | Bottom feeder in lakes and streams | Native |
| Sunfish Family | Centrarchidae | | | | |
| Smallmouth Bass | *Micropterus dolomieui* | | X | Warm streams and lakes | Introduced |
| Largemouth Bass | *M. salmoides* | | X | Shallow, warm weedy lakes and backwaters | Introduced |
| White Crappie | *Pomoxis annularis* | X | X | Lakes and streams with dense vegetation | Introduced |
| Catfish Family | Ctaluridae | | | | |
| Brown Bullhead | *Ctalurus nebulosus* | | X | Warm-water ponds, lakes, sloughs | Introduced |
| Sculpin Family | Cottidae | | | | |
| Mottled Sculpin | *Cottus bairdi* | X[c] | X | Cold rivers | Native |
| Shorthead Sculpin | *C. confusus* | X[c] | X | Cold rivers | Native |
| Torrent Sculpin | *C. rhotheus* | X[c] | X | Cold rivers and lakes | Native |
| Perch Family | Percidae | | | | |
| Stickleback | *Gasterosteus aculeatus* | X[c] | | Lakes, sloughs, and slow moving streams | Native |
| Walleye | *Stizostedion vitreum* | | X | Large lakes and streams | Introduced |
| Yellow Perch | *Perca flavescens* | X | | Warm to cool clear lakes; slow weedy streams | Introduced |

[a] Source: Wenatchee Subbasin Plan (NPCC 2004a) except where noted otherwise.
[b] Source: Methow Subbasin Plan (NPCC 2004b).
[c] Source: ISEMP database.

currently listed under ESA. Early entry of adults allows spring Chinook to reach snowmelt headwater tributaries that are generally only accessible during peak spring stream flows. Once they arrive at these upper reaches, adults hold for extended periods prior to spawning (Figure 1). Since spring Chinook enter freshwater well before the time of spawning, survival until the spawning period is primarily a function of body fat reserves at the time of freshwater entry.

Spawning distributions of spring run and late run Chinook salmon tend to be segregated from one another. While spring run fish tend to spawn in colder headwater streams, late run Chinook tend to spawn in larger, lower elevation rivers where water temperatures are warmer. Late run Chinook typically have an ocean-type life history where juveniles migrate to sea during the same year that they emerge from the gravel. Because spring run Chinook spawn in headwater streams that are much colder than lower elevation reaches, they tend to have a stream-type life history; rearing in freshwater for a full year. This extended freshwater residency is characteristic of Chinook that inhabit more productive watersheds where temperature and flow conditions are relatively consistent.

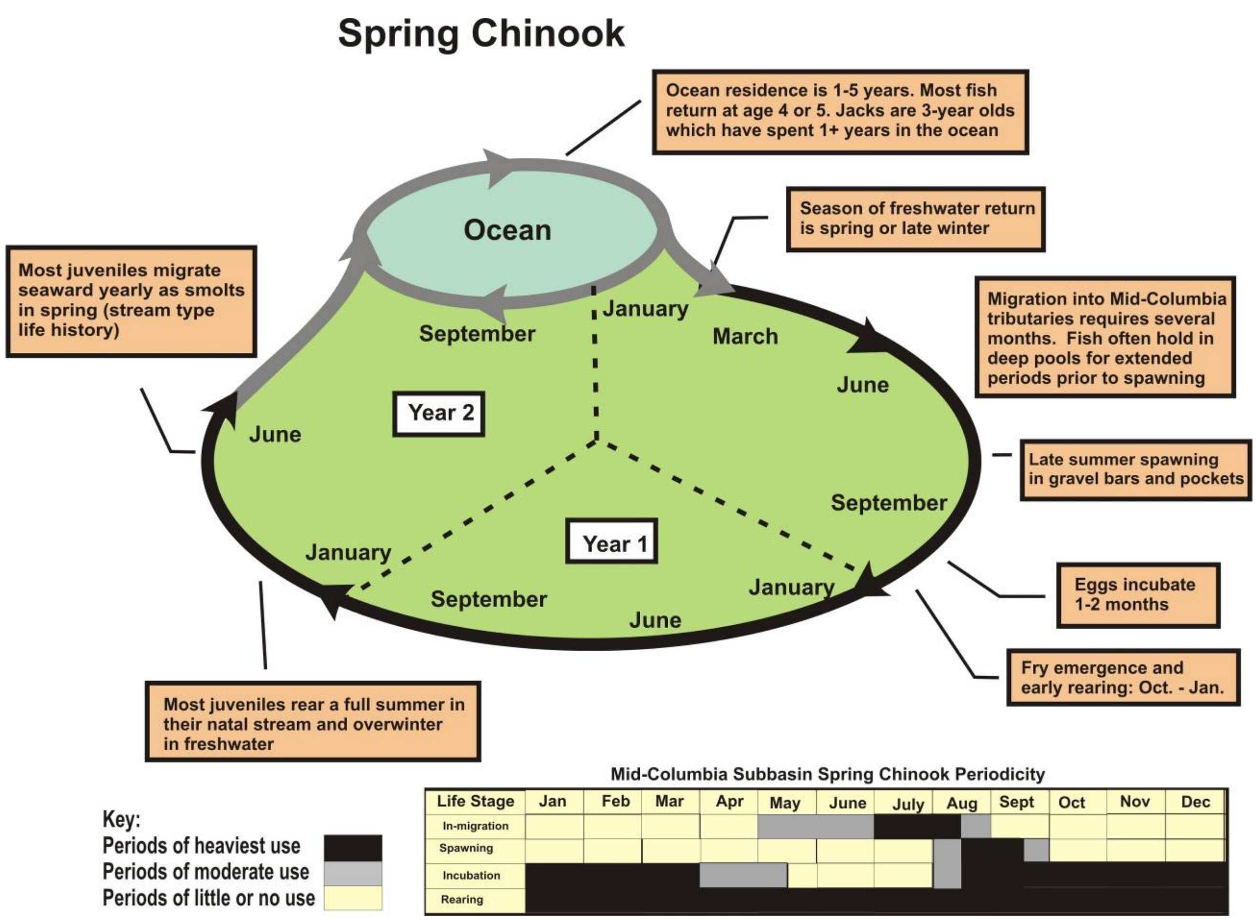



**Figure 1. Life cycle of mid Columbia River spring Chinook salmon.**

Adult spring Chinook enter the lower Columbia River from March through May, well in advance of spawning in August and September (Figure 1). Migration into the Wenatchee and Methow

Subbasins occurs between May and August. Snow et al. (2008) reported peak migration of upstream passage at Wells Dam in 2007 occurred between May 15 and June 19. However, peak spawning in the Methow Subbasin that year occurred much later, between August 27 and September 8 (Snow et al. 2008). Successful spawning depends on sufficient clean gravel of the right size, in addition to the constant need of adequate flows and water quality. The driving force in redd site selection appears to be the presence of good subgravel flow; this need is likely greater in Chinook than the other salmon species.

Chinook eggs incubate throughout the autumn and winter months with of fry emergence in early spring. Incubation and fry emergence timing depends primarily on water temperature, but are also influenced by dissolved oxygen concentrations, light intensities, and genetic variations (Beacham and Murray 1990, Bjornn and Reiser 1991). The time between egg fertilization and emergence for Chinook salmon was estimated to range between 191 days at 41$^{o}$F to 316 days at 36$^{o}$F (Quinn 2005). Chapman et al. (1995) reported fry emergence timing for the mid-Columbia basin ranging between mid-February and mid-April. Catches of newly emerged Chinook fry and sac fry in smolt traps operating in the Wenatchee Subbasin indicates emergence occurs between late February and mid-April (Todd Miller, Washington Department of Fish and Wildlife biologist, and Matthew Collins, Yakama Nation biologist, personal communications). Floods can have their greatest impact on salmon populations during incubation, as they can scour salmon eggs from the gravel or deposit sediment over spawning gravels (Wade 2002). Gravel conditions can also affect success of emergence. Shelton (1955) found that only 13% of hatched alevins emerged from fine gravel while 80-90% emergence was observed in coarse gravels. Dewatering can occur in regulated rivers where discharge is varied to satisfy domestic or industrial water needs but also occurs in natural systems.

Once fry emerge from the gravel there is a large dispersal of fry downstream, although most apparently take up residence near the spawning locations. The downstream dispersal of fry serves to distribute the fry among suitable freshwater nursery areas (Healey 1991). Emergent spring Chinook fry are rarely captured in smolt traps located greater than 0.6 miles (1 km) downstream of spawning locations within the Wenatchee Subbasin except during spring freshets (Todd Miller, Washington Department of Fish and Wildlife biologist, personal communication). After fry leave the gravel, they seek out suitable rearing habitat within side sloughs, side channels, spring-fed seep areas and along the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat (Wade 2002). The presence of woody debris and overhead cover aid in food and nutrient inputs, and provide protection from predators primarily for the first 2 months of freshwater residence. As Chinook fry grow, they gradually move away from the quiet shallow areas to rear in deeper, faster areas of the stream (Lister and Walker 1966). Chinook salmon parr are typically associated with riverine habitats and are seldom found in beaver ponds or off-channel sloughs (Murphy et al. 1989, Healey 1991). High summer water temperatures in the lower reaches of the Wenatchee and Methow Subbasins limit survival of the stream-type juvenile life-history typical of spring Chinook salmon.

As stream temperatures decrease in the fall, many juveniles move downstream in search of suitable overwintering habitat (Bjornn 1971, Bustard and Narver 1975, Hillman et al. 1987). Others may move upstream in search of suitable habitat (Chapman et al. 1995). During the winter, juvenile spring Chinook tend to prefer pools with adequate concealment cover. Once water temperatures drop below 50$^{o}$F juvenile Chinook tend to conceal during the day and can be found near the substrate at night (Mullan et al. 1992, Hillman et al. 1987). Juveniles utilize a variety of cover types for overwintering habitat, including interstitial spaces amid the substrate (Hillman et al. 1987), large woody debris and rootwads (Bustard and Narver 1975), and overhanging banks and vegetation (Hillman et al. 1987). Van Dyke et al. (2009) found that winter biomass-density of juvenile Chinook salmon was positively associated with the amount of cobble substrate, and inversely associated with embeddedness in the Grande Ronde River Basin. While some may find suitable overwintering habitat in their natal tributaries, other juveniles migrate downstream into larger rivers, including the main stem Columbia River, where they are believed to over-winter before outmigration the next spring as yearling smolts. Within the Wenatchee River, Tumwater Canyon is an important overwintering area for juvenile spring Chinook (Hillman et. al. 1989).

Stream-type Chinook salmon migrate to sea during their second or, more rarely, their third spring. Wild smolts migrate out of the Wenatchee and Methow Rivers between February and June with peak migrations typically from mid March to mid April (Snow et al. 2008, Hillman et al. 2008). Migration timing progresses as the smolts move downstream through the Columbia River with peak migration through Bonneville Dam around the last week of May (Chapman et al. 1995). Once stream-type Chinook salmon leave freshwater, they usually move quickly through the estuary, into coastal waters, and ultimately to the open ocean (Healey 1983, Healey 1991). Adults migrate as far north as the Aleutian Islands and are widely distributed in the open ocean far from coastal waters. Spring Chinook originating from the Mid-Columbia Basin remain at sea from 1 to 5 years, with most returning after 2 winters (Chapman et al 1995).

**Summer Steelhead**

Steelhead are rainbow trout that migrate to and from the ocean. Resident and anadromous life history patterns are often represented in the same population and parents of one type may produce offspring of the other. Columbia River populations include summer and winter steelhead, however summer steelhead dominate inland populations upstream from Bonneville Dam including the mid-Columbia basin.

Summer steelhead return to the Columbia River from May to September (Figure 2), enter freshwater in a sexually immature condition, and require several months in fresh water to reach sexual maturity and spawn. Most adults returning to the mid-Columbia basin migrate into Subbasins between August and September. However, a portion of the run overwinters in main stem reservoirs, passing over the upper mid-Columbia dams in April and May of the following year (Chapman et al. 1994).

Spawning occurs when temperatures are cold but increasing in the late spring of the calendar year following entry into freshwater. Spawn timing optimizes competing risks from gravel-bed scour during periodic winter flood events and emergence when increasing temperatures support productive feeding conditions. During 2007, steelhead were observed spawning from mid-March through May with peak spawning in April in the Wenatchee and Methow Subbasins (Hillman et al. 2008, Snow et al. 2008). Steelhead spawn in clear, cool, well-oxygenated streams with suitable gravel and water velocity. A wide range of stream sizes are utilized, from small tributary streams to moderate sized mainstem areas. Adult steelhead, unlike salmon, do not necessarily die after spawning but can return to the ocean. However, repeat spawning is not common among steelhead migrating several hundred miles or more upstream from the ocean.

Egg incubation and timing of fry emergence is dependent on temperature and to a lesser extent on dissolved oxygen concentrations, light intensities, and genetic variation (Bjornn and Reiser 1991). Steelhead eggs hatch in 35–50 days depending on water temperature and alevins remain in the gravel 2 to 3 weeks until the yolk-sac is absorbed (Barnhart 1986). Chapman et al. (1994) noted that newly emerged steelhead fry have been observed in the Wenatchee Subbasin during June and July and speculated that in colder tributaries they may emerge as late as September. Following emergence, fry usually move into shallow and slow-moving margins of the stream, where they may aggregate in small schools of up to 10 individuals (Barnhart 1986) in waters 3-14 in (8 to 36 cm) deep (Bovee 1978). As they grow, juveniles cease schooling behavior and defend individual territories and inhabit areas with deeper water, a wider range of velocities, and larger substrate (Grant and Kramer 1990). Juvenile steelhead typically favor riffle habitats and are often more abundant in steeper stream reaches than juvenile Chinook or coho.

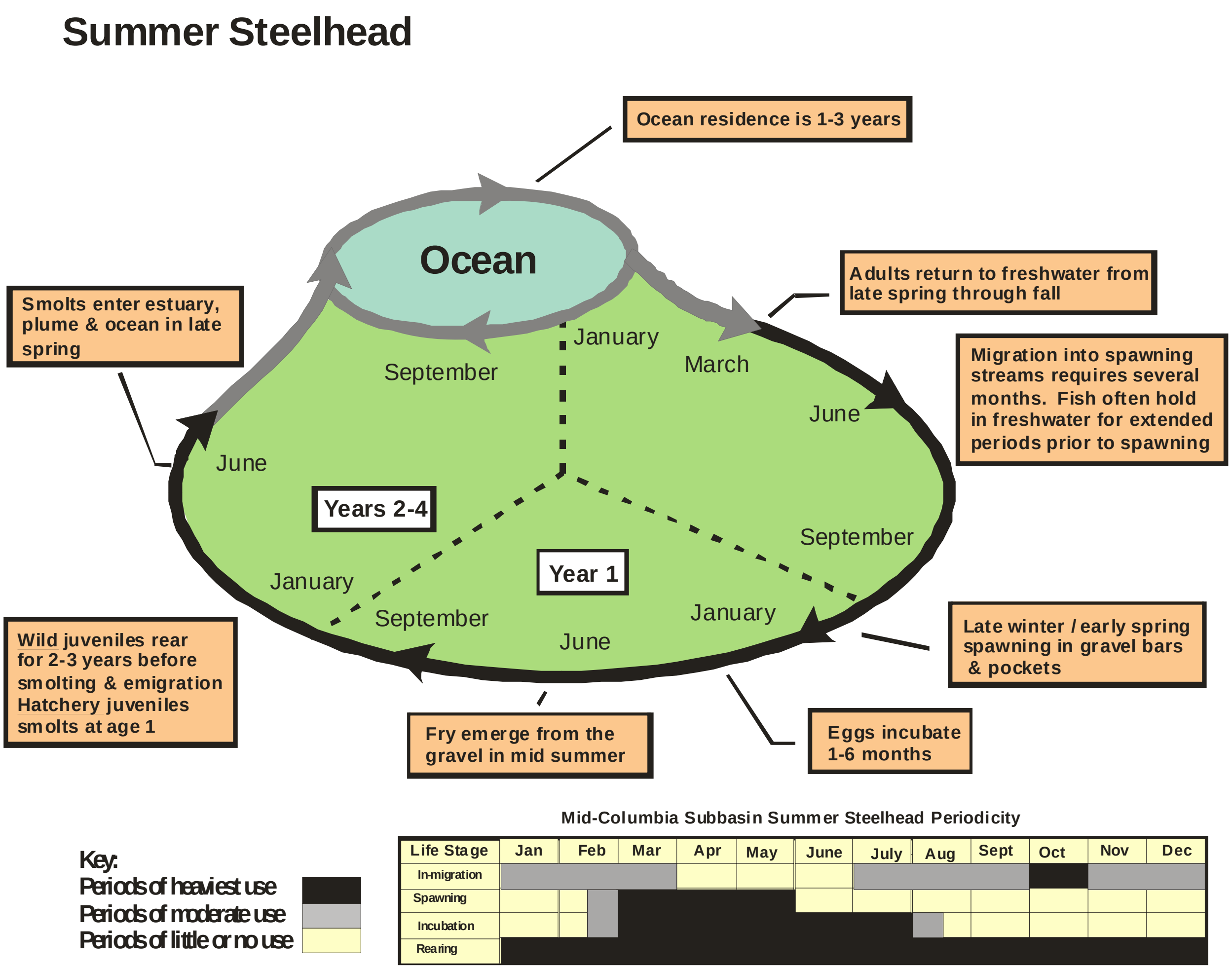



**Figure 2. Life cycle of mid Columbia River summer steelhead.**

Steelhead typically spend 1-3 years in freshwater before migrating to the ocean for the first time. Emigration of steelhead smolts out of the Wenatchee and Methow Rivers generally occurs from March to June, with peak migrations in April or May (Snow et al. 2008, Hillman et al. 2008).

Once they begin their migration, steelhead smolts actively migrate through the Columbia River mainstem and estuary to reach the ocean. In the ocean, steelhead generally migrate north along the continental shelf. Steelhead migrational patterns are generally believed to extend further out in the ocean than other salmonids; however, steelhead are seldom caught in ocean fisheries and limited CWT recovery data is available to conclusively confirm this belief. Individuals grow rapidly in the ocean. Size and age of maturation are related to ocean growth rates. Most adult steelhead return to freshwater after 1 or 2 years at sea.

**Bull Trout**

Bull trout in the Columbia River Basin exhibit resident and freshwater migratory life history patterns (Rieman and McIntyre 1993). Resident forms live out their lives in the tributary where they were born or in nearby streams. Freshwater migratory forms include both fluvial and adfluvial strategies (Fraley and Shepard 1989). The fluvial form migrates between main rivers and tributaries while the adfluvial form migrates between lakes and streams. Tagging studies have confirmed fluvial bull trout in the Wenatchee and Methow Subbasins sometimes migrate into the Columbia River mainstem (USFWS 2002). Resident and migratory forms may coexist in the same stream.

Researchers have consistently found that water temperature is a principal factor influencing distribution of bull trout (Rieman and McIntyre 1993, Baxter and McPhail 1996). Fraley and Shepard (1989) observed that water temperature above 59°F limited bull trout distribution in Montana. Studies in the John Day basin found bull trout present only when maximum summer temperatures were 61°F or below, and maximum densities occurred where maximum temperatures were 54°F or below (Buchanan et al. 1997).

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). As a result bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993).

Preferred spawning habitats include stream reaches with groundwater infiltration, loose clean gravel and cobble substrates, and temperatures 41-48°F in late summer and early fall (Fraley and Shepard 1989, Goetz 1989). Migrating forms may travel to spawning streams during spring or early summer freshets and reside in deep pools up to 2 months before spawning (Figure 3). Adults typically spawn at night from August to November during periods of decreasing water temperatures (McPhail and Baxter 1996). Peak spawning in the Wenatchee and Methow Subbasins occurs between mid-September through October (USFS *in prep.*, USFWS 2004). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Bull trout reach maturity in 4 to 7 years and may live longer than 12 years. Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

Incubating and emergent bull trout require colder water than other salmonid species. Cool water during early life history results in higher egg survival and fry growth rates (Pratt 1992, McPhail and Murray 1979, Shepard et al. 1984). Incubation is normally 100 to 145 days depending on water temperature, (Pratt 1992). After hatching, juveniles remain in the substrate for up to 3 weeks before emerging from the gravel. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

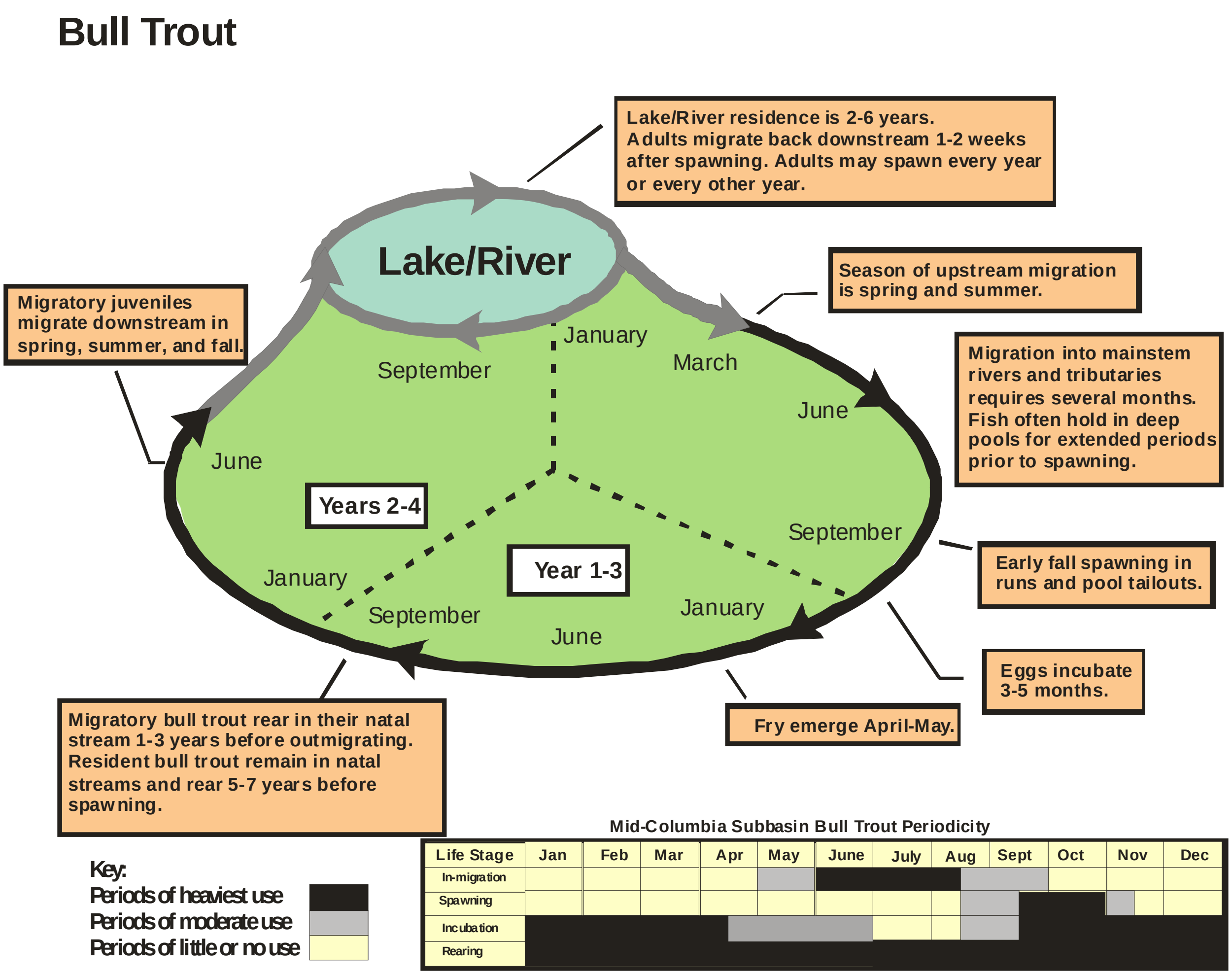



**Figure 3. Life cycle of mid Columbia River bull trout.**

Juvenile bull trout typically rear in their natal streams for several years although some may migrate out as fry (McPhail and Baxter 1996, USFWS 2002). Within the Wenatchee Subbasin, bull trout fry are not typically captured in smolt traps except within the White River drainage where they are thought to migrate downstream to rear in Wenatchee Lake (Todd Miller, Washington Department of Fish and Wildlife biologist, and Matthew Collins, Yakama Nation biologist, personal communications). Similarly, bull trout fry are not captured in smolt traps located in the lower Methow and Twisp Rivers (Alex Repp, Washington Department of Fish and Wildlife biologist, personal communication). Juvenile bull trout are associated with complex cover, including large wood, undercut banks, boulders, and pools (Fraley and Shepard 1989). In addition, they prefer shallow water depths with good cover, near faster-flowing water that delivers food particles (Baxter and McPhail 1996). Fry stay close to the streambed, perhaps as an adaptation to avoid being carried downstream before they are large enough to take up residence in a suitable feeding site. McPhail and Murray (1979) found that bull trout fry grew to larger sizes at lower temperatures, with maximum growth at about 39°F. Migratory bull trout generally leave their natal streams for the first time after 2 to 3 years when about 7.75 inches long. Although juvenile migration can occur any time of the year, it typically peaks during May and June. Once migratory bull trout leave the streams in which they are born, they travel to larger rivers and lakes throughout their range. Migratory corridors link seasonal habitats for all bull trout life histories and are important for the persistence of the species (USFWS 2002). At maturity, resident fish are generally smaller and less fecund than migratory fish (Fraley and Shepard 1989).

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macro-zooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Brown 1992; Donald and Alger 1993).

## 2.2 Potential Life Stages Affected

Potential interactions between rearing coho and other fish will depend on the species and life-stages present at the time of the activity. There are three general classes of potential impacts considered in this analysis: opportunity for direct predation; temporary loss of habitat; and construction related.

Only spring Chinook and bull trout fry would be small enough to be potential prey for juvenile coho during rearing and acclimation. Because Chinook fry typically remain near spawning areas or disperse downstream after emergence, they would be expected to be present at, or within 0.6 miles downstream of, spawning areas. In contrast, juvenile bull trout tend to remain in their natal streams for 1 or more years (McPhail and Baxter 1996, USFWS 2002). Fry would only be expected to be present at sites near spawning locations, except within the White River where bull trout fry have been documented moving downstream. Within the White River drainage, bull trout fry would be assumed to be present in the mainstem down to Lake Wenatchee.

Temporary loss of habitat would potentially occur when barrier nets or seines are used to enclose juvenile coho during rearing and acclimation. Other fish would be excluded from the immediate site and potentially prevented from migrating upstream. Spring Chinook fry, parr, and smolts; summer steelhead adults, parr and smolts; and bull trout fry, juveniles (remaining in natal streams), and migratory subadults (larger immature fish) and adults could potentially be affected by these activities.

Construction is planned for a limited number of sites during the June through August time period. Spring Chinook adults, and parr; summer steelhead adults, fry, parr and smolts; and bull trout juveniles, and migratory subadults and adults could potentially be present during these activities.

A list of life stages and size ranges of ESA listed fish that could be present proposed overwinter rearing sites (December through early May), spring acclimation (mid-March through early May), and site construction activities is found in Table 2. The potential effects of these activities are discussed in greater detail under the Impact Analysis section.

**Table 2. Life stages and size ranges of ESA listed fish that could be present in the Wenatchee and Methow Subbasins during proposed overwinter rearing periods (December-early May), spring acclimation periods (mid-March-early May) and site construction activities (June-September).**

| | | | Overwinter rearing | | Spring acclimation | | During construction | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Life stage | Timing | Present | Size (in) | Present | Size (in) | Present | Size (in) | Reference |
| Spring Chinook | adult migration/holding | May-Aug | yes | 12-36 | yes | 12-36 | yes | 12-36 | Chapman et al. 2005 |
| | adult spawning | Aug-Sep | no | | no | | yes | 12-36 | Snow et al. 2008 |
| | eggs & alevin | Aug-Apr | yes | < 1.2 | yes | < 1.2 | yes | < 1.2 | Chapman et al. 2005 |
| | fry | Feb-May | yes | 1.25-1.75 | yes | 1.25-1.75 | no | | Chapman et al. 2005 |
| | parr | Jun-Mar | yes | 2.75-4.75 | yes | 2.75-4.75 | yes | 1.75-4.75 | Chapman et al. 2005 |
| | smolts | Mar-Apr | yes | 2.75-5.0 | yes | 2.75-5.0 | no | | Chapman et al. 2005 |
| Summer steelhead | adult migration/holding | Aug-Mar | yes | 20-34 | yes | 20-34 | yes | 20-34 | Chapman et al. 2004 |
| | adult spawning | Mar-May | yes | 20-34 | yes | 20-34 | no | | Chapman et al. 2004 |
| | eggs & alevin | Mar-Sep | yes | < 1.2 | yes | < 1.2 | yes | < 1.2 | Chapman et al. 2004 |
| | fry | Jun-Sep | no | | no | | yes | 1.25-1.75 | Chapman et al. 2004 |
| | parr | Year-round | yes | 2.75-6.25 | yes | 2.75-6.25 | yes | 1.75-6.25 | Chapman et al. 2004 |
| | smolts | Mar-Jun | yes | 5.5-8.25 | yes | 5.5-8.25 | yes | 5.5-8.25 | Chapman et al. 2004 |
| Bull trout | adult migration/holding | May-Sep | yes | 14-32 | yes | 14-32 | yes | 14-32 | McPhail & Baxter 1996 |
| | adult spawning | Aug-Nov | no | | no | | yes | 6-32 | USFS *in prep.*,USFWS 2004 |
| | sub-adult/adult feeding | Year-round | yes | 6-32 | yes | 6-32 | yes | 6-32 | Pratt 1992 |
| | eggs & alevin | Aug-Apr | yes | < 1 | yes | < 1 | yes | < 1 | Pratt 1992 |
| | young-of-year | Apr-Dec | yes | 1.0-1.75 | yes | 1.0-1.75 | no | | Pratt 1992 |
| | juveniles | Year-round | yes | 2.25-7.75 | yes | 2.25-7.75 | yes | 2.25-7.75 | Sexauer & James 1997 |

# 3.0 DETERMINING SPECIES PRESENCE

We determined the presence of ESA listed fish by life stage by reviewing existing data and literature on fish distribution for the Wenatchee and Methow Subbasins, and by snorkel surveys at selected sites.

## 3.1 Review of Existing Data

A variety of resources were used to obtain existing data on presence of ESA listed fish for rearing and acclimation sites proposed for the Wenatchee and Methow Subbasins (see Appendices 2 and 3 of the EIS for site descriptions). These included online interactive mapping tools, published reports, and contacting individuals associated with agencies and private organizations to acquire unpublished reports and databases.

The Washington Department of Natural Resources (DNR) in cooperation with the Departments of Fish and Wildlife, and Ecology, and in consultation with affected Indian tribes maintains and updates “fish habitat water typing maps” under WAC 222-16 (See section 031) to help landowners identify and type streams on their property. These maps include both modeled and field-verified stream types and can be viewed on the Forest Practices Application and Review System (FPARS) mapping website (Figure 4). DNR classifies streams, lakes and ponds into four types:

- Type S, shoreline
- Type F, fish bearing
- Type Np, non-fish bearing perennial, or
- Type Ns, non-fish seasonal waters.

In addition, codes used as placeholders include N (Non-fish where the Np or Ns determination has not been made), X (a water feature exists, but does not meet the definition of a typed water as described in WAC 222-16, and U (water type has not yet been presumed or field verified). Stream classifications for streams that would be affected by proposed acclimation sites are found in Figure 2-2 in Appendices 2 and 3. However, this site does not provide information on which species or life-stages are found in each stream.

Washington Department of Fish and Wildlife (WDFW) maintains SalmonScape, an online interactive mapping tool (Figure 5) that provides detailed information about fish distribution and status, habitat characteristics, smolt trapping locations, and passage barriers. Data used to create SalmonScape maps were collected by state, federal, tribal and local biologists as well as regional fisheries enhancement groups and watershed partners. We used SalmonScape to provide an initial list of sites with known fish presence information.

Because SalmonScape may not represent the most current or complete dataset available for fish presence in the Wenatchee and Methow Subbasins, we contacted a wide range of governmental, tribal, and private organizations to obtain additional site-specific fish survey data. A complete list of contacts is found in Table 3.

Within the Wenatchee Subbasin we found two large datasets with site specific information on fish sampling collected by state, federal, and tribal agencies. The Integrated Status and Effectiveness Monitoring Project (ISEMP) manages data on salmon and steelhead populations

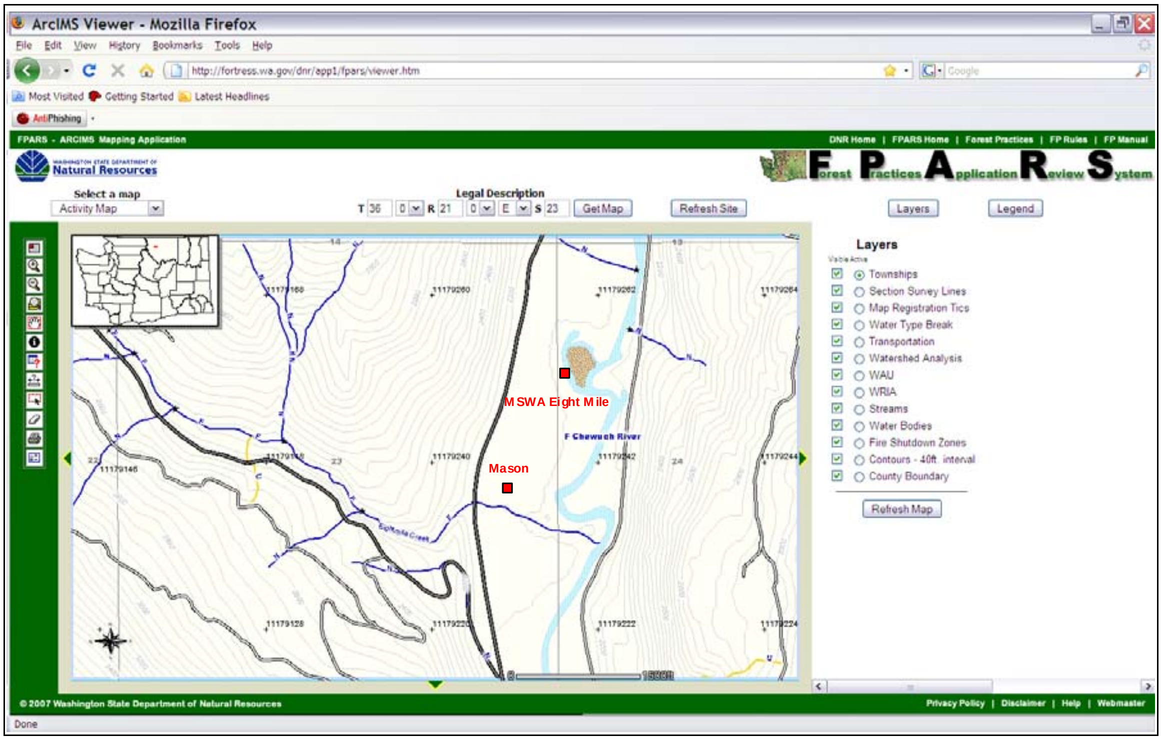



**Figure 4. Map generated using the online DNR interactive mapping program at the FPARS website showing stream classifications near the Mason and MSWA Eight Mile acclimation sites in the Methow River basin.**

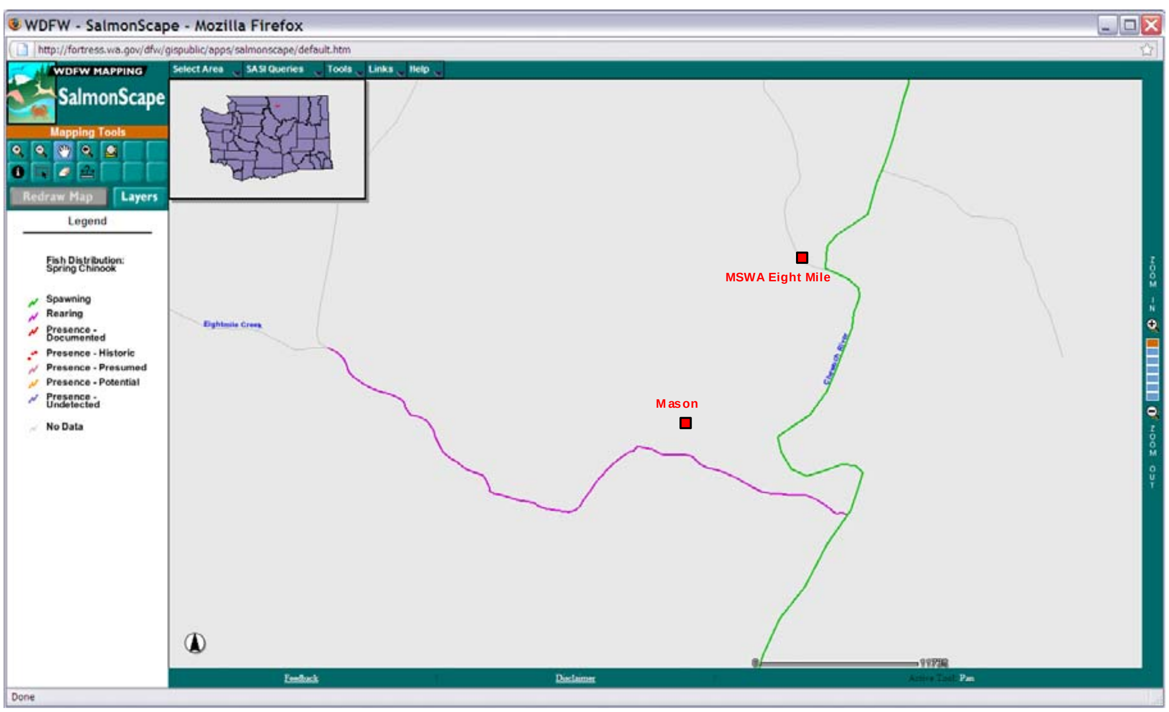



**Figure 5. Map generated using the online WDFW interactive mapping program SalmonScape, showing the distribution of spring Chinook spawning (green) and rearing (purple) near the Mason and MSWA Eight Mile acclimation sites in the Methow River basin.**

**Table 3. List of contacts made to obtain fish survey data in the Wenatchee and Methow Subbasins by agency and location.**

| Contact | Agency | Location |
|---|---|---|
| Tracy Hillman | BioAnalysts, Inc. | Boise, ID |
| Jeff Osborn | Chelan PUD | Wenatchee |
| Shaun Seaman | Chelan PUD | Wenatchee |
| Pamela Nelle | Terraqua, Inc. (ISEMP) | Wenatchee |
| James White | Upper Columbia Salmon Recovery Board (ISEMP) | Wenatchee |
| Barbara Kelly Ringel | US Fish & Wildlife Service | Leavenworth |
| Judy De Lavergne | US Fish & Wildlife Service | Wenatchee |
| David Hopkins | US Forest Service | Winthrop |
| Gene Shull | US Forest Service | Winthrop |
| Pierre Dawson | US Forest Service | Wenatchee |
| Cindy Raekes | US Forest Service | Wenatchee |
| Dan Rife | US Forest Service | Deschutes |
| Patrick Connolly | US Geological Survey | Cook |
| Wes Tibbits | US Geological Survey | Twisp |
| Jennifer Molesworth | US Bureau of Reclamation | Twisp |
| Carol Volk | Volk Consulting (ISEMP) | Seattle |
| Andrew Murdoch | WDFW | Wenatchee |
| Casey Baldwin | WDFW | Wenatchee |
| Charlie Snow | WDFW | Twisp |
| Alex Repp | WDFW | Twisp |
| Mike Tonseth | WDFW | Wenatchee |
| Todd Miller | WDFW | Wenatchee |
| Bob Steele | WDFW | Ephrata |
| John Crandall | Wild Fish Conservancy | Duvall |
| Keely Murdoch | Yakama Nation | Wenatchee |
| Cory Kamphaus | Yakama Nation | Wenatchee |
| Matthew Collins | Yakama Nation | Wenatchee |
| Rick Alford | Yakama Nation | Winthrop |

and habitat collected since 2004. The US Forest Service in Wenatchee maintains a similar database for sampling years 1936 to 2006. We used Geographic Information Systems (GIS) to overlay fish survey data from these two sources on acclimation site locations to determine if fish surveys had been conducted in the near vicinity of each acclimation site (Figure 6). Additional information was provided by Chelan PUD (Hillman et al. 2008) and USFWS (USFWS 2003, 2004).

Site-specific fish survey data for the Methow Subbasin was provided by a number of agencies. Spring Chinook and summer steelhead spawning ground survey and smolt monitoring data was provided by WDFW (Snow et al. 2008). Bull trout redd surveys were provided by the US Forest Service (USFS *in prep.*). Electrofishing and trapping data collected in Lower Methow tributaries between 2004 and 2006 was provided by the US Geological Survey (Martens and Connolly 2008). Additional fish survey data for selected sites was provided by Patrick Connolly (US Geological Survey, personal communication) and Gene Shull (US Forest Service, personal communication).

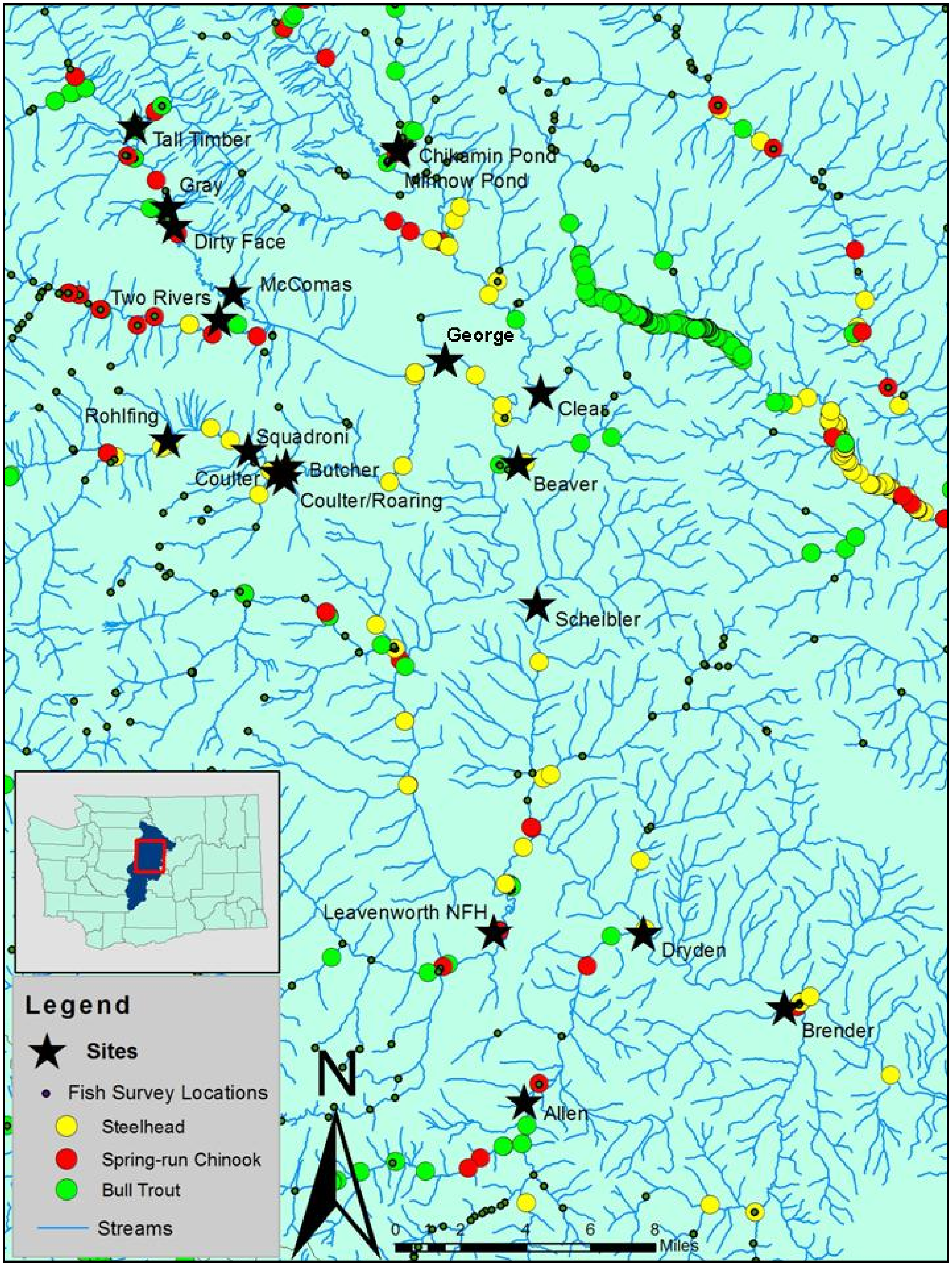



**Figure 6. All acclimation sites in the Wenatchee basin (stars), fish survey sites (small dots), and survey sites with listed species observed. Fish survey data was supplied by USFS and ISEMP for survey years 1936-2007.**

**Protocols**

In some cases the available data was insufficient to determine what life-stages were present for a given species. To deal with these circumstances we established a set of rules to assume which life stages were present as described below:

**Presence documented:** This common classification in SalmonScape did not provide any information on the size or timing of the fish. Unless other information was provided, we assumed these were rearing juvenile Chinook or steelhead, or migratory bull trout (juveniles and adults).

**Presence presumed:** We treated this SalmonScape classification the same as "presence documented" unless actual snorkel/electrofishing sampling in that stream failed to capture any of fish of this species. In that case, the sampling data was assumed correct.

**Spawning:** For all species, we assumed that if spawning was documented in the area, rearing also occurred there. In addition, we assumed that Chinook and steelhead rearing occurred within 0.6 miles downstream of a spawning reach. Because bull trout typically rear in their natal streams for 1-3 years, we did not assume fry would be present downstream of spawning tributaries (except as noted below).

**Rearing:** For Chinook and steelhead, we assumed that if rearing was documented in the area, but spawning was not documented upstream, that these fish had migrated upstream into the stream. We assumed that parr and smolts were present but fry were not because their ability to swim against the current is not fully developed. For bull trout we assumed that if rearing was listed but no spawning, that adult and sub-adult migratory fish were present. Bull trout fry tend to stay in their natal streams and were not assumed to be present in non-natal streams (except in the White River where bull trout fry have commonly been captured in smolt traps).

**Migration:** We assumed that adult Chinook and steelhead migrated through any reach downstream of spawning locations. We assumed that bull trout migrated anywhere they had been documented as present. Because migrating bull trout can include immature fish (sub adults) and adults, we assumed that areas classified as "rearing" were migratory fish unless it was a known spawning area.

## 3.2 On-site Surveys

We conducted snorkel surveys to determine presence or absence of ESA listed fish species at five acclimation sites following methods described in Thurow (1994) and Murdoch and Nelle (2008) (Table 3). All surveys were conducted between April 26-28 to correspond with the general time period during which acclimation sites would be active.

The snorkel crew completed a training exercise prior to conducting any stream surveys. Training consisted of reviewing snorkeling techniques, safety precautions, and photographs and descriptions of commonly observed fish species described in Thurow (1994). They also practiced fish identification and size estimation techniques in the field. Plastic fish cutouts of known length were used to help crew members estimate fish size underwater.

We designated sample reaches at each acclimation site of approximately 475 feet in length, and where appropriate, located such that water intake and discharge sites were encompassed within the sample reach. General site descriptions were made at each site prior to conducting any snorkel surveys. Basic habitat data included reach length (measured with a hip chain), wetted width (at five or more cross sections), and general channel type classification from Montgomery and Buffington (1993) (i.e., pool/riffle, plane-bed, step-pool, cascade, etc.). Upstream and downstream reach boundaries were initially marked with flagging and GPS coordinates were recorded. Information such as sample date (including start and stop time), water temperature, and visibility were recorded for each site. Visibility was measured using a 4 in Rapala fishing lure (Model # XRD-10RT) placed in the mid-water column and a snorkeler moved away from the lure until it was no longer identifiable. The snorkeler then moved towards the lure until it was identifiable again. The distance from the snorkeler to the lure was then measured using a measuring tape.

All snorkel surveys were conducted at night because nighttime snorkel surveys have been shown to be more accurate than daytime surveys during winter months (Roni and Fayram 2000). A glowstick was set at reach boundaries prior to each survey. Surveys were carried out by one or two snorkelers depending on the stream width, habitat complexity, and visibility. Snorkelers entered the river approximately 15 ft downstream of the reach start and proceed upstream. Fish counts started when the snorkeler had passed the glow stick marking the downstream end of the reach. To avoid inaccuracies or double counts, fish were not counted until the observer passed them. For reaches requiring two snorkelers, the two snorkelers held position in the center of the channel as they moved upstream. The observer on the left counted all fish to the left of center, and the observer on the right counted the remainder. All salmonids were identified to species, while dace, suckers, and sculpins were identified to genus. Fish were grouped into commonly observed size categories as described in Thurow (1994). Data was recorded on a slate during the survey and transcribed onto waterproof rite-in-rain paper immediately after completing the survey.

## 3.3 Results

### 3.3.1 Wenatchee onsite surveys

#### *3.3.1.1 Butcher*

The Butcher site was snorkeled between 10:10 and 11:40 PM on April 26, 2009. Water temperature was measured at 45$^{o}$F and visibility at 5.25 ft. Five distinct habitat reaches were identified (Figure 7), including a 30 ft length of stream downstream of the beaver pond (reach 1). The MCCRP was acclimating coho in the beaver pond at the time of the survey and the water visibility was poor due to fish and beaver activity. The number and sizes of fish observed during the survey are found in Table 4. Chinook salmon fry were observed only below the beaver dam in Butcher Creek near the confluence with Nason Creek. We assumed the beaver dam prevented Chinook salmon from accessing the acclimation site. In contrast, juvenile rainbow/steelhead were found in Butcher Creek above and below the beaver pond. While these fish were likely resident rainbow trout, we could not exclude the possibility that juvenile steelhead were able to access the pond above the beaver dam under some flow conditions.

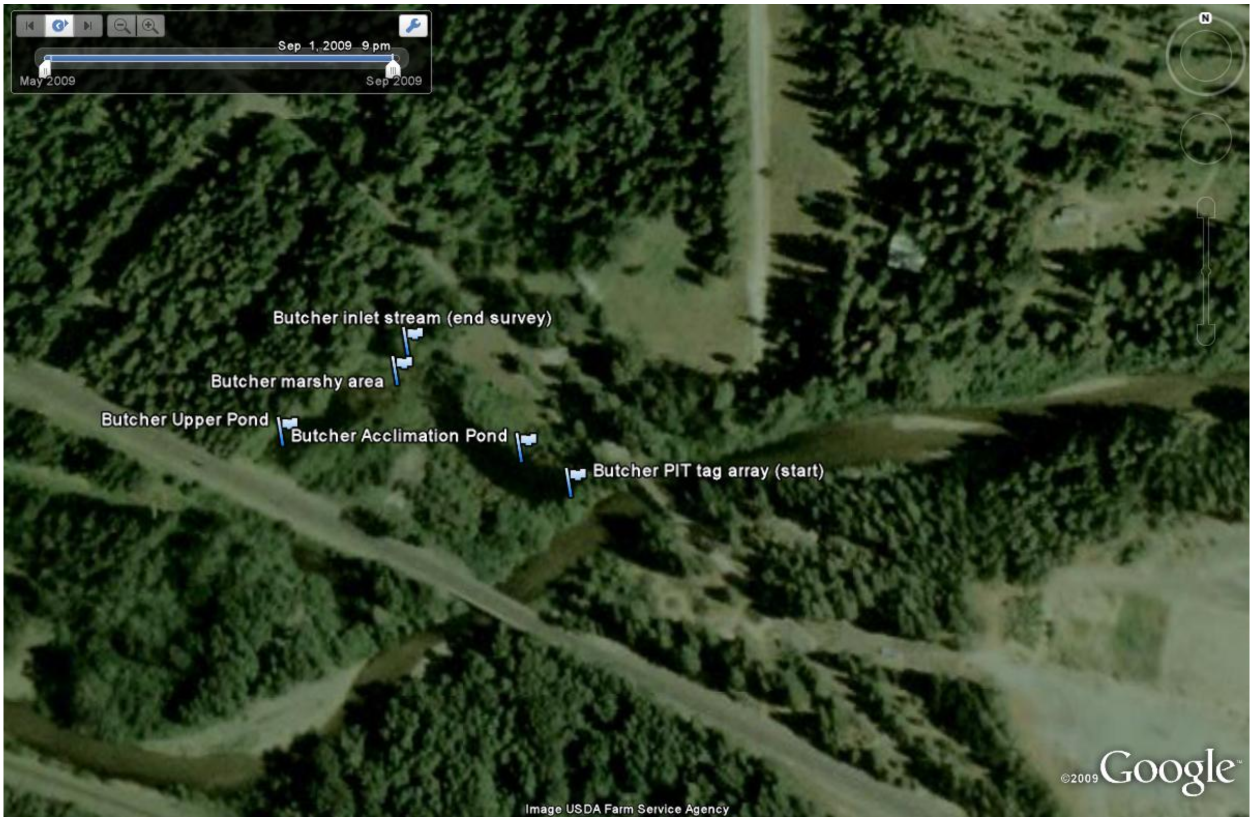



**Figure 7. Aerial view of the Butcher site showing habitat reaches and snorkel survey locations.**

**Table 4. Summary of habitat reaches and fish observed during the snorkel survey at the Butcher site on April 26, 2009.**

| Reach number | Reach description | Length (ft) | Habitat type | Stream channel (ft) | | Fish observed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | avg width | avg depth | species[a] | size (in) | number |
| 1 | PIT tag array to beaver dam | 30 | glide | 9.0 | 1.5 | Chin | 1.0-1.5 | > 100 |
| | | | | | | Sthd | 2.25-2.75 | 1 |
| | | | | | | Sthd | 2.75-6.0 | 2 |
| | | | | | | RSS | < 2.75 | 10 |
| | | | | | | HCoho | 2.75-6.0 | 2 |
| 2 | Acclimation pond | 322 | pond | 80 | 10 | Poor visibility not surveyed | | |
| 3 | Marshy area | 46 | backwater | 105 | 0.3 | Undefined channel not surveyed | | |
| 4 | Upper pond | 230 | pond | 78 | 5 | Sthd | 2.25-2.75 | 1 |
| | | | | | | Sthd | 2.75-6.0 | 1 |
| | | | | | | RSS | < 2.75 | 14 |
| | | | | | | HCoho | 2.75-6.0 | 6 |
| 5 | Inlet stream | 85 | glide | 7 | 0.75 | HCoho | 2.75-6.0 | 3 |

[a] Chin = Chinook, Sthd = rainbow/steelhead, RSS = red sided shiner, HCoho = hatchery coho

### *3.3.1.2 Coulter*

The Coulter site was snorkeled between 9:15 and 10:10 PM on April 28, 2009. Water temperature was measured at 46°F and visibility at 6.5 ft. Two reaches were surveyed (Figure 8): a flowing section downstream of the acclimation site and beaver complex; and a representative section in the beaver complex above the acclimation site. The MCCRP was holding coho at the acclimation pond at the time of the survey and the water visibility was limited due to fish and beaver activity. The number and sizes of fish observed during the survey are found in Table 5.


**Figure 8. Aerial view of the Coulter site showing snorkel survey boundaries in relation to the acclimation pond.**

**Table 5. Summary of habitat reaches and fish observed during the snorkel survey at the Coulter site on April 28, 2009.**

| Reach | Reach description | Length (ft) | Habitat type | Stream channel (ft) avg width | Stream channel (ft) avg depth | Fish observed species[a] | Fish observed size (in) | Fish observed number |
|---|---|---|---|---|---|---|---|---|
| 3 | Flowing section upstream of road | 251 | glide | 8.2 | 1.2 | Sthd | 2.75-6.0 | 1 |
| | | | | | | Sthd | 6-12 | 1 |
| | | | | | | Brook | 2.75-6.0 | 1 |
| | | | | | | Brook | 6-12 | 3 |
| | | | | | | HCoho | 2.75-6.0 | 8 |
| 2 | Beaver complex up-stream of accl. pond | 246 | pond | 10 | 5 | RSS | 2.75-6.0 | 13 |
| | | | | | | HCoho | 2.75-6.0 | 60+ |

[a] Sthd = rainbow/steelhead, Brook = brook trout, RSS = red sided shiner, HCoho = hatchery coho.

Rainbow/steelhead and brook trout were observed in Coulter Creek below the acclimation site and beaver complex, but not above. We assumed that the series of beaver dams prevented upstream migration of these species.

### *3.3.1.3 Rohlfing*

The Rohlfing site was snorkeled between 10:50 and 11:30 PM on April 28, 2009. Water temperature was measured at 44$^{o}$F and visibility at 10 ft. Two reaches of flowing stream were surveyed: one each above and below the acclimation pond (Figure 9) The MCCRP was holding coho at the acclimation pond at the time of the survey and the water visibility was poor due to fish activity. The number and sizes of fish observed during the survey are found in Table 6. Rainbow/steelhead trout were only observed downstream of the acclimation pond. Nevertheless, an adult steelhead was observed upstream of the acclimation pond in the past (Mike Tonseth, WDFW personal communication). However, because the stream goes dry during the summer, the importance of this habitat is likely minimal.

**Table 6. Summary of habitat reaches and fish observed during the snorkel survey at the Rohlfing site on April 28, 2009.**

| Reach | Reach description | Length (ft) | Habitat type | Stream channel (ft) avg width | Stream channel (ft) avg depth | Fish observed species[a] | Fish observed size (in) | Fish observed number |
|---|---|---|---|---|---|---|---|---|
| 1 | Section of stream from Whitepine Rd to acclimation pond | 295 | glide | 12.0 | 1 | Sthd | 2.25-2.75 | 2 |
| | | | | | | Sthd | 2.75-6.0 | 2 |
| | | | | | | HCoho | 2.25-2.75 | 1 |
| | | | | | | HCoho | 2.75-6.0 | 4 |
| 2 | Acclimation pond | 95 | pond | 60.7 | 6.5 | poor visibiility - no survey | | |
| 3 | Stream upstream of acclimation pond | 148 | glide | 6.9 | 0.75 | HCoho | 2.25-2.75 | 3 |

[a] Sthd = rainbow/steelhead, HCoho = hatchery coho


**Figure 9. Aerial view of the Rohlfing site showing snorkel survey boundaries in relation to the acclimation pond.**

### 3.3.2 Methow onsite surveys

#### *3.3.2.1 Goat Wall*

The Goat Wall site was snorkeled between 9:30 and 10:30 PM on April 27, 2009. Water temperature was measured at 45.5$^{o}$F and visibility at 43 ft. One reach beginning just upstream of the Methow River and ending at a pipe crossing near the homestead (Figure 10) was surveyed. The number and sizes of fish observed during the survey are found in Table 7. Rainbow/steelhead and bull trout were scattered throughout the reach. This was surprising because, like the Methow River nearby, the stream was completely dry during a site visit on April 8, 2009.


**Figure 10. Aerial view of the Goat Wall site showing snorkel survey boundaries.**

**Table 7. Summary of fish observed during the snorkel survey at the Goat Wall site on April 27, 2009.**

| Reach | Reach description | Length (ft) | Habitat type | Stream channel (ft) avg width | Stream channel (ft) avg depth | Fish observed species[a] | Fish observed size (in) | Fish observed number |
|---|---|---|---|---|---|---|---|---|
| 1 | Upstream of Methow confluence to overhead pipeline | 522 | pool | 42 | 3.3 | Sthd | 2.75-6.0 | 3 |
| | | | | | | Sthd | 6-12 | 2 |
| | | | | | | Bull | 2.75-6.0 | 1 |
| | | | | | | Bull | 6-12 | 4 |
| | | | | | | Unid | 6-12 | 1 |

[a] Sthd = rainbow/steelhead, Bull = bull trout, Unid = unidentified salmonid (probable Sthd) escaped before positive identification.

### *3.3.2.2 MSWA Eight Mile*

The MSWA Eight Mile site was snorkeled between 11:30 PM April 27, 2009 and 12:10 AM on April 28, 2009. Water temperature was measured at 44$^{o}$F and visibility at 14 ft. One reach beginning just upstream of the Chewuch River and ending 502 ft upstream was surveyed (Figure 11). The number and sizes of fish observed during the survey are found in Table 8. One lamprey and four rainbow/steelhead were observed just upstream (30 ft) of the Chewuch confluence. Upstream of that point, the channel was very wide and shallow, with lots of aquatic vegetation and no measurable flow. Only one rainbow/steelhead was observed in this upper section of the reach. The dominant fish species throughout the channel was the bridgelip sucker.


**Figure 11. Aerial view of the MSWA Eight Mile site showing snorkel survey boundaries.**

**Table 8. Summary of fish observed during the snorkel survey at the MSWA Eight Mile site on April 27, 2009.**

| Reach | Reach description | Length (ft) | Habitat type | Stream channel (ft) | | Fish observed | | |
|---|---|---|---|---|---|---|---|---|
| | | | | avg width | avg depth | species[a] | size (in) | number |
| 1 | Start upstream of Chewuch confluence | 502 | backwater | 67 | ~1.5 | Sthd | 2.75-6.0 | 5 |
| | | | | | | Lamp | 6-12 | 1 |
| | | | | | | Sckr | 2.75-6.0 | > 200 |
| | | | | | | Sckr | 6-12 | 1 |

[a] Sthd = rainbow/steelhead, Lamp = lamprey, Sckr = bridgelip sucker.

### 3.3.3 Summary of fish presence

Summaries of the available data are found in Table 9 for the Wenatchee River Basin and Table 10 for the Methow River Basin.

**Table 9. Summary of spawning (S), rearing (R), and migration (M) data documented for listed species at affected streams near acclimation sites in the Wenatchee Subbasin.**

| | | Spring Chinook | | | Steelhead | | | Bull trout | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Name | Affected Stream | S | R | M | S | R | M | S | R | M |
| Primary Sites | | | | | | | | | | |
| Beaver | Beaver | | 3 | | 2 | 2,3 | | | 2b | 2b |
| Brender | Brender | | 1a,2a | | | 1a | | | | |
| Butcher | Butcher | | | | | 6 | | | | |
| Chikamin | Chikamin | | 1, 3 | | 1 | 1,3a | | | 1,3b | 1,3b,5 |
| Clear | Clear Creek | | | | 1,4 | 1,2 | | | | |
| Coulter | Coulter Creek | | | | | 1a | | | | |
| Dirty Face | unnamed | | | | | No Data | | | | |
| Dryden | Peshastin/Wenatchee | | 1,3 | 1 | 2,4 | 1,3 | | | 1b,2b | 1b,2b |
| White River Springs | unnamed | | | | | No Data | | | | |
| Minnow | Minnow | | 1a, 3 | | | 3a | | | 3b | 3b |
| Rohlfing | unnamed | | | | | 6c | | | | |
| Scheibler | Chumstick | | | | | No Data | | | | |
| Tall Timber | Napeequa | 1,2 | 1,2 | | 4 | 1a,2a | | | 1b,2b | 1b,2b |
| Two Rivers | none | | | | | No Data | | | | |
| Backup Sites | | | | | | | | | | |
| Allen | Allen | | | | | No Data | | | | |
| Coulter/Roaring | Coulter/Roaring | | | | 1,2 | 1 | | | | |
| George | Wenatchee River | 1,2,4 | 1,2,3 | | 1,2,4 | 1,2,3 | | | 1b | 1b,2b |
| McComas | White River | 1 | 1 | | | 1 | 1 | | 1 | 1 |
| Squadroni | unnamed | | | | | No Data | | | | |

Data Source key:
1 = Salmon Scape, 2 = USFS database (1904-2006), 3 = ISEMP database (2004-2007), 4 = Hillman et al. (2008), 5 = USFWS 2003, 2004, 6 = onsite survey, a = Presence documented but size class not specified, b = Presence assumed, c = only found downstream of acclimation site, blanks indicate species/life stage not documented.

**Table 10. Summary of spawning (S), rearing (R), and migration (M) data documented for listed species at affected streams near acclimation sites in the Methow Subbasin.**

| | | Spring Chinook | | | Steelhead | | | Bull trout | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Name | Affected stream | S | R | M | S | R | M | S | R | M |
| Primary Sites | | | | | | | | | | |
| Goat Wall | Cold Creek | | | | | 6 | | | 6 | 6 |
| Gold | S Fork Gold | | 1c | | 1,2,3 | 1,2 | | | | 2 |
| Hancock | Hancock Creek | | | | 1,3,5 | 1,5 | | | | |
| Heath | Heath ponds (spring) | | 2,4 | | | 2,4 | | | | 2 |
| Lincoln | Twisp River | 1,3 | 1 | | 1,3 | 1 | 3 | | 1b | 1b |
| Lower Twisp | Twisp River | 1 | 1 | 3 | 1,3 | 1 | 3 | | 1b | 1b |
| Mason | Eight Mile | | 1 | | 1,3 | 1,4 | | | 1b | 1b,4 |
| MSWA Eight Mile | Chewuch side channel | | | | | 6 | | | | |
| Parmley | Beaver Creek | | | | 1,2,3 | 1,2 | | | 1 | 2 |
| Twisp Weir | Twisp River | 1,3 | 1 | 3 | 1,3 | 1 | 3 | | 1b | 1b |
| Pete Creek Pond | Chewuch River | 1,4 | 1 | 3 | 1,4 | 1 | | | 1 | 4 |
| Backup Sites | | | | | | | | | | |
| Balky Hill | unnamed (Beaver trib) | | | | No Data | | | | | |
| Biddle | Wolf Creek | 1 | 1,4 | | 1,3 | 1,4 | | | 1 | 1,4 |
| Canyon | Canyon Creek | | | | No Data | | | | | |
| Chewuch A.F. | Chewuch River | 1 | 1 | 3 | 1,3 | 1 | | | 1 | 4 |
| MSRF Chewuch | Chewuch River | | | | | | | | | |
| Newby | Newby Creek | | | | No Data | | | | | |
| Poorman | Twisp River | 1 | 1,4 | 3,4 | 1,3 | 1 | | | 1b | 1b |
| Utley | unnamed (Twisp trib) | | | | No Data | | | | | |

Data Source key:
1 = Salmon Scape, 2 = USGS sampling, 3 = Snow et al. 2008 (WDFW), 4 = USFS sampling, 5 = Yakama Nation surveys, 6 = Onsite surveys, a = Presence documented but size class not specified, b = Presence assumed, c = Presence “presumed” in SalmonScape but not verified, blanks indicate species/life stage not documented.

**Table 11. Summary of ESA listed fish by life stage assumed to be present[a] during overwinter rearing, spring acclimation, and construction activities in the Wenatchee Subbasin.**

| | | Rearing/acclimation | | | | | | | | | | | | Construction | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring Chinook | | | | Steelhead | | | | Bull trout | | | | Spring Chinook | | | Steelhead | | | | | Bull trout | | |
| Site name | Affected stream | eggs/alevin | fry | parr | smolts | adults | eggs/alevin | parr | smolts | adults | eggs/alevin | young-of-year | sub-adults | adults | eggs/alevin | parr | adults | eggs/alevin | fry | parr | smolts | adults | eggs/alevin | sub-adults |
| Primary Sites | | | | | | | | | | | | | | | | | | | | | | | | |
| Beaver | Beaver Creek | | | U | U | P | P | P | P | U | | | U | | | | | | none planned | | | | | |
| Brender | Brender Creek | | | U | U | | | P | P | | | | | | | | | | none planned | | | | | |
| Butcher | Butcher Creek | | | | | | | A | A | | | | | | | | | | | A | A | | | |
| Chikamin | Chikamin Creek | | | P | P | P | P | P | P | P | A | P | P | | | P | P | P | P | P | P | P | A | P |
| Clear | Clear Creek | | | | | P | P | P | P | | | | | | | | | | none planned | | | | | |
| Coulter | Coulter Creek | | | | | | | | | | | | | | | | | | none planned | | | | | |
| Dryden[b] | Peshastin/Wenatchee | | | A | P | P | P | P | P | A | | | A | A | | A | P | P | P | P | P | A | | A |
| White River Springs | unnamed | | | A | A | | | A | A | A | | | A | | | | | | none planned | | | | | |
| Minnow | Minnow Creek | | | P | P | | | P | P | A | | | P | | | P | | | | P | P | A | | P |
| Rohlfing | unnamed | | | | | | | U | U | | | | | | | | | | | | | | | |
| Scheibler | Chumstick | | | | | | | A | A | | | | | | | | | | | A | A | | | |
| Tall Timber | Napeequa | P | P | P | P | U | U | U | U | A | | | A | P | P | P | U | U | U | U | U | A | | A |
| Two Rivers | none | | | | | | | | | | | | | | | | | | | | | | | |
| Backup Sites | | | | | | | | | | | | | | | | | | | | | | | | |
| Allen | Allen Creek | | | | | | | | | | | | | | | | | | none planned | | | | | |
| Coulter/Roaring | Coulter/Roaring | | | | | P | A | P | P | | | | | | | | | | none planned | | | | | |
| George | Wenatchee River | P | P | P | P | P | P | P | P | A | U | U | A | P | P | P | P | P | P | P | P | A | U | A |
| McComas | White River | P | P | P | P | U | | U | U | P | | A | P | | | | | | none planned | | | | | |
| Squadroni | unnamed | | | | | | | | | | | | | | | | | | | | | | | |

[a] Presence denoted by "P" indicates presence well documented, "A" presence is assumed, "U" presence possible but unlikely, and blanks indicate presence not expected.
[b] Dryden is listed as both a primary site for a small hatchery facility, and a backup overwinter rearing site.

**Table 12. Summary of ESA listed fish by life stage assumed to be present[a] during overwinter rearing, spring acclimation, and construction activities in the Methow Subbasin.**

| | | Rearing/acclimation | | | | | | | | | | | | Construction | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spring Chinook | | | | Steelhead | | | | Bull trout | | | | Spring Chinook | | | Steelhead | | | | | Bull trout | | |
| Site name | Affected stream | eggs/alevin | fry | parr | smolts | adults | eggs/alevin | parr | smolts | adults | eggs/alevin | young-of-year | sub-adults | adults | eggs/alevin | parr | adults | eggs/alevin | fry | parr | smolts | adults | eggs/alevin | sub-adults |
| **Primary Sites** | | | | | | | | | | | | | | | | | | | | | | | | |
| Goat Wall | unnamed | | | U | U | | | A | P | A | | | P | | | | | | none planned | | | | | |
| Gold | S Fork Gold | | | | | P | A | P | P | A | | | P | | | | P | A | A | P | P | A | | P |
| Heath | Heath ponds (spring) | | | P | P | | | P | P | P | | | P | | | | | | none planned | | | | | |
| Lincoln | Twisp River | P | P | P | P | P | P | P | P | P | | | P | P | P | P | P | P | P | P | P | P | | P |
| Lower Twisp | Twisp River | P | P | P | P | P | P | P | P | P | | | P | | | | | | none planned | | | | | |
| Mason | Eight Mile | | | A | A | P | A | P | P | A | | | P | | | A | P | P | P | P | P | A | | P |
| MSWA Eight Mile | Chewuch side channel | | | A | A | | | P | P | A | | | A | | | | | | | P | P | | | |
| Parmley | Beaver Creek | | | | | P | P | P | P | P | | | P | | | | P | P | P | P | P | P | | P |
| Twisp Weir | Twisp River | P | P | P | P | P | P | P | P | P | | | P | P | P | P | P | P | P | P | P | P | | P |
| Pete Creek Pond | Chewuch River | A | A | P | P | P | P | P | P | A | | | P | | | | | | none planned | | | | | |
| **Backup Sites** | | | | | | | | | | | | | | | | | | | | | | | | |
| Balky Hill | unnamed | | | | | | | U | U | U | | | U | | | | | | none planned | | | | | |
| Biddle | Wolf Creek | A | A | P | P | P | P | P | P | P | | | P | | | | | | none planned | | | | | |
| Canyon | Canyon Creek | | | | | | | A | A | A | | | A | | | | | | | A | A | A | | A |
| Chewuch A.F. | Chewuch River | A | A | A | A | A | A | A | A | P | | | P | A | A | A | A | A | A | A | A | A | | A |
| MSRF Chewuch | Chewuch River | A | A | A | A | A | A | A | A | P | | | P | A | A | A | A | A | A | A | A | A | | A |
| Newby | Newby Creek | | | | | | | | | | | | | | | | | | | U | U | U | | U |
| Poorman | unnamed | | | U | U | | | U | U | U | | | U | | | | | | none planned | | | | | |
| Utley | unnamed | | | | | | | U | U | | | | | | | | | | | U | U | | | |

[a] Presence denoted by "P" indicates presence well documented, "A" presence is assumed, "U" presence possible but unlikely, and blanks indicate presence not expected.

# 4.0 IMPACT ANALYSIS

The potential effects described below are common to all acclimation sites although the extent and duration may vary between sites. Impacts due to water withdrawals are discussed in a separate report entitled *Effect of Surface Water Withdrawals on Listed Fish Report* (Appendix 10 of the EIS) prepared for the project. Potential impacts specific to the location of each acclimation site are further discussed in following sections. Impacts to listed and non-listed fish after coho have been released from the acclimation sites and impacts that result from naturally spawning populations being reintroduced are not evaluated in this Appendix.

In addition to listed fish, a number of other species are present in the Subbasins (Table 1) and could be impacted during acclimation and construction activities. Because the acclimation sites are located higher in the drainages, species with colder water preferences are more likely to be present than warm water species. These cold water associated fish include salmonids (sockeye salmon, Westslope cutthroat trout, non-native brook trout, and mountain whitefish), lamprey, suckers, sculpins and some species of minnows.

The most likely impact to fish that would result is related to access to habitat during rearing and acclimation periods. The amount of area that would be unavailable during rearing/acclimation would be limited to the area enclosed by seine or barrier nets at each acclimation site. The relative impact on listed species from being dislocated or excluded from this habitat will depend to some extent on the local availability of similar habitat which is discussed under each acclimation site in the following sections.

Two sites are proposed as adult holding areas: one in each Subbasin. Temporary weirs would be installed in these streams from early October through November. Adult coho salmon would be planted upstream of the weir to allow them to spawn in available habitat. Potential impacts to other fish would primarily occur to larger adults that would be blocked from migrating in and out of these streams when the weirs are in place. In addition, spawning coho salmon could disturb eggs deposited in spawning redds established earlier in the year. These impacts would be limited to species that spawn in late summer or early fall. Spring spawners such as steelhead and other trout will be able to access these areas and spawn well before the weirs are installed. Further, trout fry emerge during the summer so eggs and alevins would not be disturbed by coho spawning activities in October. Spring Chinook would spawn prior to weirs being installed so they would not be prevented from accessing these sites, but spawning coho salmon could potentially disturb their eggs. However, fall spawning fish such as salmon and bull trout have not been documented spawning in either tributary proposed for adult holding.

Construction is planned for 36% of the primary acclimation sites. Construction would occur during summer months (June – September). Potential impacts to fish would primarily occur from excavation and construction for acclimation ponds, water supply and discharge lines or channels, and electrical lines. Some additional impacts could result from road reconstruction and maintenance, although physical impacts would likely be limited to road crossings or other areas where fish bearing streams are in close proximity to the road prism. See Appendices 2 and 3 of the EIS for construction activities proposed for each site.

The physical impacts from construction are expected to be minimal for all fish species. The acclimation sites are generally disturbed environments regularly subject to human activity. Excavation of accumulated material is proposed at three existing ponds which are discussed in greater detail in following sections. All proposed new pond excavation and well drilling sites are in upland locations. The potential for impacts to listed fish is expected to be greatest when flow is provided to the site and discharged into the nearest stream. Permit conditions will be strictly followed during construction to prevent discharging suspended sediments into the stream. These measures will include but not limited to: use of a temporary revetment to prevent backwater from entering the work area; prior to release of water flow to the project area, any sediment laden water will be pumped out of the project area; and, upon return flow to the active channel, the sediment plume will not exceed 5 Nephelometric Turbidity Units (NTUs) above the background of 150 ft downstream of the project location. If these measures were not followed, a plume of suspended fine sediments could be discharged into the stream and dispersed downstream. These events are rarely lethal to fish, but their response can range from avoidance to temporary cessation of feeding activities (Hicks et al. 1991). Large amounts of fine sediment deposited on spawning gravels can reduce interstitial flow and dissolved oxygen levels causing mortality of eggs and alevins (Koski 1966, Meehan and Swanston 1977, Everest et al. 1987). The discharge of sediments into the stream will be prevented by lining new sites with gravel and rock, and slow filling of ponds to avoid suspending and mobilizing sediments. Localized bank and riparian disturbances will occur during construction of new surface water intake and acclimation discharge structures. The area impacted by these activities is small and the number of individual fish impacted would be few if any.

Juvenile coho salmon have been shown to prey on smaller fish but impacts to other fish populations are expected to be minimal during acclimation periods. Other fish will be physically separated from hatchery coho smolts during acclimation and rearing by barrier nets. Thus, any predation is likely to occur at the time coho are released. Coho salmon sampled in the coastal waters or in aquaria were able consume prey up to 50% of their body length (Brodeur 1991, Pearsons and Fritts 1999). However, they typically consumed prey less than 20% of their length (Brodeur 1991). Coho salmon have been shown to prey on sockeye salmon (Ricker 1941; Foerster and Ricker 1953; Ruggerone and Rogers 1992), and fall Chinook salmon fry (Thompson 1966; Pearsons and Fritts 1999). Assuming that coho will consume prey 1/3 of their body length (or 1/9 of their weight), fish less than 1.8 inches would be vulnerable to predation using the target coho smolt size of 5.5 inches (YNFRM 2009). Chinook and bull trout fry would be listed species of potential prey for hatchery coho during release (Table 2). Predation studies conducted during the feasibility phase of this project found that hatchery coho salmon fed primarily on insects and rarely prey on fish. Less than 0.28% of the 2,159 hatchery coho salmon sampled in Nason Creek over two years were found to have preyed on spring Chinook fry or other fish (Murdoch and LaRue 2002, Murdoch et al. 2005).

The Leavenworth National Fish Hatchery and Winthrop National Fish Hatchery are proposed as acclimation sites but no additional changes are expected as a result of the MCCRP. Impacts to fish due to construction and operations at these sites have been evaluated under past permitting processes. This is also the case for other facilities used for rearing MCCRP coho to pre-smolt sizes (i.e. Cascade and Willard Hatcheries).

## 4.1 Wenatchee Subbasin

Presence of ESA listed fish by life-stage during proposed acclimation and construction periods in the Wenatchee Subbasin is summarized by site in Table 11 and in the following sections.

Detailed descriptions of each site can be found in Appendix 2 of the EIS. For size ranges expected for each life stage and activity refer to Table 2.

Comprehensive quantitative data on rearing habitat available to ESA listed fish is generally lacking throughout the Wenatchee Subbasin. However, spawning survey data is available for these species (Figure 12). Although spawning surveys do not cover every potential spawning area and can be influenced by environmental factors such as high water, this information can be useful for evaluating potential impacts of a given site on Subbasin populations. Between 1989 and 2007, 44% of the spring Chinook redds were counted in the Chiwawa watershed (Hillman et al. 2008). The Nason watershed had the next highest proportion (24%), followed by Icicle, the upper Wenatchee River, White, Little Wenatchee and Peshastin watersheds. However, spring Chinook were considered extirpated from Peshastin Creek. Recent returns are believed to be progeny of adult outplants from non-listed spring Chinook returning to Leavenworth National Fish Hatchery (Cooper and Mallas 2004). An average of 40% of the summer steelhead redds were counted in the Wenatchee River between 2001 and 2007 (Hillman et al. 2008). The Nason watershed had the next highest proportion (33%), followed by Chiwawa, Peshastin, Icicle, Beaver, White, and Little Wenatchee watersheds. In contrast, 78% of the bull trout redds were counted in the upper Chiwawa watershed between 1989 and 2004 (USFWS 2004), followed by the White, Chiwaukum, Nason, White, and Little Wenatchee watersheds (Figure 12).

#### 4.1.1 Brender

This is the only site located in the 59,712 acre Mission Creek watershed. No ESA listed fish have been documented spawning in the Mission Creek drainage but juvenile Chinook and steelhead rearing has been documented. SalmonScape lists spring Chinook presence in Brender Creek. We found one catch record of fish classified as spring Chinook in Brender Creek in 1998 (USFS database). A 2007 electrofishing survey conducted in Mission Creek captured 104 rainbow/steelhead but failed to capture any Chinook salmon (ISEMP database). It is likely that Chinook salmon observed in Mission Creek were summer Chinook which are not ESA listed. However, we can not rule out the possibility that juvenile spring Chinook occasionally rear in the drainage under some conditions. Brender Creek flows directly into the existing pond and the site is proposed as a spring acclimation site. The affected environment would include about 0.08 of the 0.27 acres (30%) of existing pond enclosed by the temporary seine net. This type of habitat is limited in the Mission Creek watershed due to development within the floodplain (NPCC 2004a). No additional construction is planned for this site. Based on available data, Chinook parr, and smolts; and steelhead parr and smolts are assumed to be present during the acclimation period. Juvenile Chinook and steelhead would not be able to use this portion of the pond for six weeks during the spring through 2027 or until project goals are met.

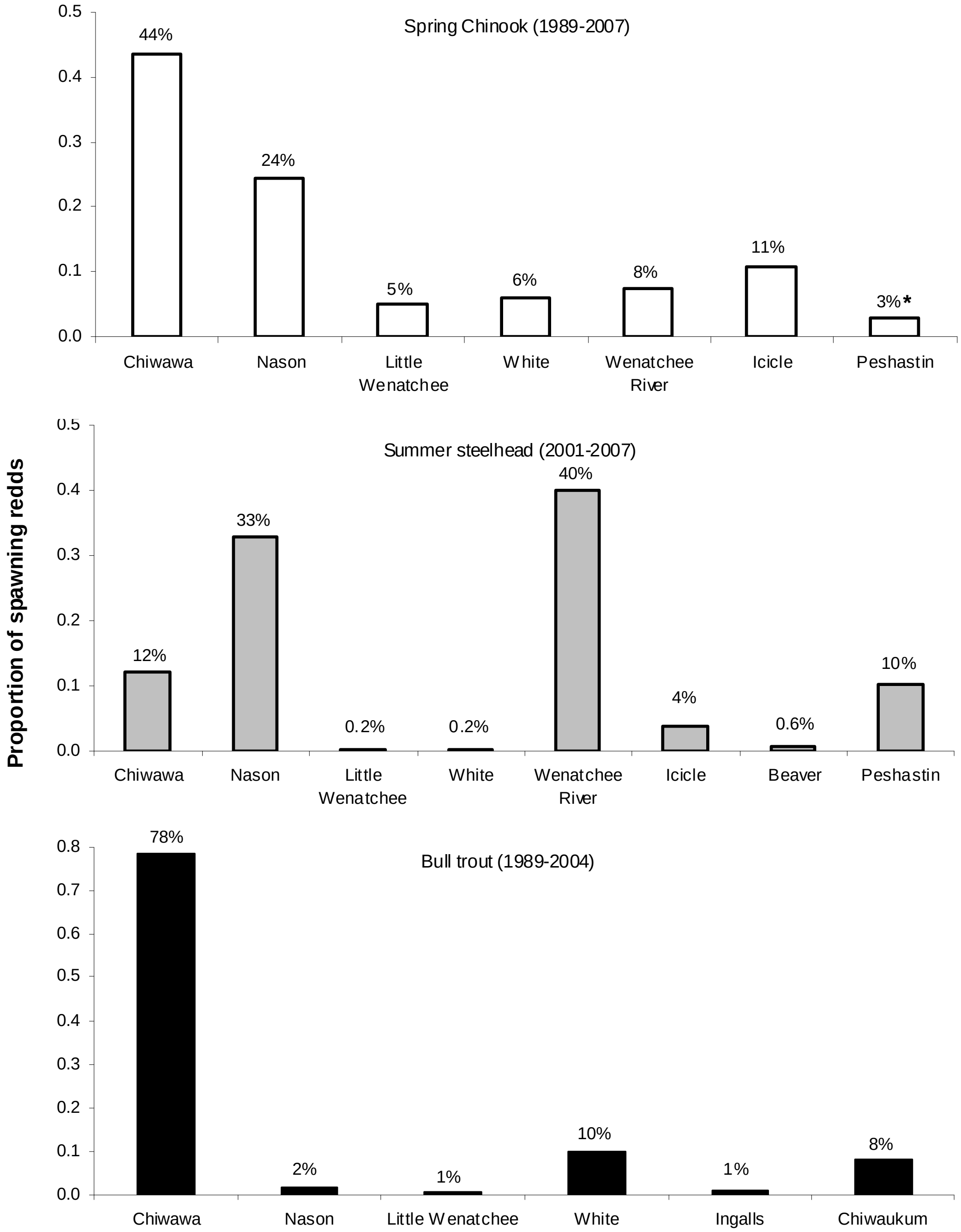



**Figure 12. The average proportion of spring Chinook[1] (top), summer steelhead (middle) and bull trout (bottom) spawning in major tributaries of the Wenatchee Subbasin.**

[1] Note: Spring Chinook were considered functionally extirpated from Peshastin Creek. Recent returns are thought to be progeny of adult outplants from non-listed Leavenworth National Fish Hatchery Chinook salmon.

### 4.1.2 Dryden (new hatchery)

A small hatchery is proposed to be constructed near Dryden Dam. Surface water could be diverted either from the Wenatchee River or Peshastin Creek. However, a well or infiltration gallery is also being considered as a source of groundwater for the hatchery. The affected environment would include the point of diversion to the point of discharge. SalmonScape indicates that non-listed summer Chinook spawn in the Wenatchee River and Peshastin Creek adjacent to this site, and spring Chinook rear in the area. During construction activities, spring Chinook adults, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present. The proposed hatchery will be located at an upland site and depending on the design, there may be localized bank disturbance during construction of the discharge pipe. Potential impacts due to surface water withdrawals are discussed in Appendix 10 of the EIS.

### 4.1.3 Scheibler

Scheibler is the only site proposed within the 47,000 acre Chumstick drainage. Until recently, most adult and all juvenile salmon passage into Chumstick was blocked at RM 0.3 by a perched culvert under North Road. This culvert was removed and replaced with a bridge in 2009. Few steelhead were able to migrate through this culvert before it was replaced, although adults had been documented spawning about 5.7 miles upstream (about 2 miles below Scheibler). Rainbow and steelhead were present in low numbers prior to the removal of the culvert and brook trout had been planted throughout the drainage (NPCC 2004a). Chumstick Creek flows directly into an existing pond which is planned to be enlarged. During acclimation periods the affected environment would include about 0.1 acres of habitat enclosed by a temporary seine net. During construction activities, the affected environment would include the entire excavation site. The Wenatchee Subbasin Plan (NPCC 2004a) indicates that fish habitat is degraded in Chumstick Creek and that instream flows sometimes go subsurface during August and September. This site will be evaluated now that the culvert has been replaced, although it is likely that steelhead parr and smolts will be present during rearing activities. These fish would not be able to use the enclosed portion of the pond from March though early May through 2027, or until project goals are met.

### 4.1.4 Butcher

Butcher is one of three primary sites, including Coulter and Rohlfing, located in the 69,000 acre Nason Creek Watershed. The Nason watershed represents 24% of the Chinook, 33% of the steelhead, and 2% of the bull trout spawning redds counted in the Wenatchee Subbasin (Figure 12). Butcher Creek flows directly into 0.56 acres of existing beaver pond currently used to acclimate coho. A new well is proposed to provide enough water to operate the acclimation site during the winter. The affected environment would include the existing pond upstream of the beaver dam near the confluence of Nason Creek. Although no ESA listed fish have been documented spawning in Butcher Creek, 54% of the steelhead spawning redds counted in Nason Creek in 2007 were upstream of the Butcher Creek confluence (Hillman et al. 2008). Juvenile Chinook salmon do not appear to be able to migrate past the beaver dam. During the onsite snorkel survey, juvenile rainbow/steelhead were observed in the beaver pond. These fish may have been resident rainbow trout but we can not rule out the possibility that juvenile steelhead were able to access the pond under some flow conditions. Therefore we assume that juvenile steelhead will be present during the acclimation period. Other fish would be prevented from migrating into and out of the ponds from December though early May, on alternate years through 2027, or until project goals are met. Although Nason Creek itself does not provide much off-channel habitat, accessible tributaries provide good off-channel habitat (NPCC 2004a).

#### 4.1.5 Coulter

Coulter Creek flows into a series of beaver ponds, one of which is currently used to acclimate coho during the spring. No construction is planned for this site. The affected environment would include 0.37 acres of existing pond that would be blocked with barrier nets. Water spills over the beaver dams at multiple locations so if listed fish were able to migrate up past the beaver dams, they would only be excluded from the area blocked by the barrier nets. SalmonScape indicates steelhead are present upstream in Coulter Creek although no steelhead redds were counted in Coulter Creek in 2007 (Hillman et al. 2008). Based on onsite snorkel surveys, no ESA listed fish are expected to be present during the rearing period because a series of beaver dams appears to prevent upstream migration of anadromous fish to this site. Other fish would be prevented from migrating into and out of the enclosed pond during six weeks during the spring on alternate years through 2027 or until project goals are met. All of the accessible Nason Creek tributaries provide good off-channel habitat.

#### 4.1.6 Rohlfing

An unnamed seasonal stream ("Rohlfing Creek") flows directly into an existing pond currently used for coho acclimation. The affected environment would include 0.17 acres of existing pond and accessible upstream portions of Rohlfing Creek potentially blocked to fish access. SalmonScape does not show Rohlfing Creek within the distribution of ESA listed fish. However, an adult steelhead was observed upstream of the acclimation pond in the past (Mike Tonseth, WDFW personal communication). During the onsite snorkel survey, juvenile rainbow/steelhead were observed in the stream immediately below the acclimation pond. No other fish species were found above the acclimation pond. Because no steelhead were observed upstream of the pond, it is unlikely that they currently access the acclimation pond. The stream goes dry for much of the year, so it is unlikely that it provides critical rearing habitat. Other fish would be prevented from migrating into the pond and upstream from December through early May, through 2027 or until project goals are met.

#### 4.1.7 Beaver

An existing intake on Beaver Creek diverts flow into a constructed pond currently used as a coho spring acclimation site. The existing culvert outlet is perched but other fish can access the pond through the inlet when screens are not in place. About 0.24 acres of existing pond would be affected, including the inlet and outlet which would be screened to prevent free passage of other fish into the acclimation site. No additional construction is planned for this site. Beaver Creek habitat information is limited so availability of similar off-channel habitat in the tributary is unknown. SalmonScape does not list Beaver Creek within the distribution of spring Chinook spawning and rearing, but 5 juvenile Chinook (out of 132 fish) were captured approximately

1,600 ft downstream of the acclimation site during an electrofishing survey on 9/25/2006 (ISEMP database). These fish were likely spring Chinook parr that were seeking overwintering habitat. No Chinook were captured (out of 125 fish) at this site on 7/23/2007, or about 300 ft further downstream (109 fish) on 7/6/2006. No other records for juvenile Chinook were found for Beaver Creek so presence of Chinook smolts during acclimation is viewed as possible but unlikely. Beaver Creek represents an average of 0.6% of the steelhead spawning redds counted in the Wenatchee Subbasin (Figure 12) although no steelhead spawning redds were observed in 2007. Based on available data, Chinook smolts; steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present during the acclimation period and would be excluded from the site from mid-March through early May through 2027, or until project goals are met.

#### 4.1.8 Clear

Clear is one of three primary sites, including Chikamin and Minnow, located in the 117,000 acre Chiwawa Creek Watershed. The watershed represents 44% of the Chinook, 12% of the steelhead, and 78% of the bull trout spawning redds counted in the Wenatchee Subbasin (Figure 12). Clear Creek flows directly into a series of three constructed ponds, and the upper pond is proposed as an overwinter rearing site with no construction activities planned. The affected environment would include about 0.24 of 0.52 acres (46%) of the existing pond area enclosed by the temporary seine net. The Chiwawa Creek watershed has an extensive network of ponds, beaver canals, side channels, abandoned oxbows and other wetlands (NPCC 2004a). Based on available data, steelhead adults, eggs, parr and smolts are expected to be present during the rearing period. Eight steelhead spawning redds were counted in Clear Creek in 2007 (Hillman et al. 2008). Clear Creek is not part of the juvenile monitoring program in the Chiwawa drainage. Other fish would be excluded from the enclosure from December through early May through 2027, or until project goals are met.

#### 4.1.9 Chikamin

A new pond would be constructed next to Chikamin Creek and would be fed with surface water from the creek. During construction, the affected environment would include two-ten foot sections along the bank of Chikamin Creek at the diversion and discharge sites. In addition, Chikamin Creek from the point of discharge downstream approximately 150 ft could potentially be affected. Chinook spawning has not been documented in Chikamin Creek. Summer steelhead spawning has been documented but no redds were counted in 2007 (Hillman et al. 2008). Bull trout redds have been observed in Chikamin Creek above and below the site (USFWS 2004). Chikamin (including the lower 0.2 miles of Minnow Creek) is part of the annual juvenile monitoring program in the Chiwawa Basin (Hillman et al. 2008). Chikamin Creek on average represents 3% of the subyearling Chinook, 8% of the subyearling and 5% of the yearling rainbow/steelhead abundance estimated in the Chiwawa drainage. This area also represented 13% of the juvenile bull trout abundance surveyed in the Chiwawa drainage in 2007, but the survey does not include many upper tributaries where bull trout likely reside (Hillman et al. 2008). Chinook parr; steelhead adults, eggs, fry, parr, and smolts; and bull trout adults, eggs, young-of-year, and sub adults are expected to be present in Chikamin Creek during construction activities. If permit conditions are not followed impacts to fish could potentially occur during bank excavation (one week) and when water is supplied to the pond and discharged back into the stream (one day). The inlet and outlet would be screened to prevent free passage of other fish into the acclimation site. This will not impact other fish because they do not currently use this habitat. Impacts due to surface water withdrawals are discussed in Appendix 10 of the EIS.

#### 4.1.10 Minnow

A new pond would be constructed next to Minnow Creek and the entire stream would be diverted through the pond after completion. During construction, the affected environment would include Minnow Creek from the point of diversion to the point of discharge and 150 ft downstream. If permit conditions are not followed impacts to fish could potentially occur during when the stream is diverted through the pond (one day). During acclimation, the affected environment would include about 0.16 acres of the constructed pond enclosed by the temporary seine net. An area about the size of the existing channel would be left open to allow free upstream and downstream passage of fish. Based on available data, Chinook parr; steelhead parr and smolts; and bull trout sub-adult and adult migrants are expected to be present during the construction period and Chinook parr and smolts; steelhead parr and smolts; and bull trout sub-adult and adult migrants during the acclimation period. Other fish would not be able to use the enclosed portion of the stream for six weeks during the spring through 2027 or until project goals are met. During the rest of the year, other fish would have free access to the newly created pond.

#### 4.1.11 Two Rivers

An existing constructed pond that has been used in the past for coho acclimation is proposed as an overwintering site in the Little Wenatchee River watershed. Water is pumped from an existing constructed lake located in an active gravel mine. Water is returned to the lake which drains into the Little Wenatchee River. The proposed acclimation pond is not connected to the Little Wenatchee River and is not accessible to anadromous fish. Thus, no ESA listed fish are assumed to be present during the acclimation period.

#### 4.1.12 White River Springs

The White River Springs and Tall Timber primary acclimation sites and the Dirty Face adult holding area are located within the 99,956 acre White River Watershed. The watershed represents 6% of the Chinook, 0.2% of the steelhead, and 10% of the bull trout spawning redds counted in the Wenatchee Subbasin (Figure 12). The White River Springs site is an existing beaver pond that is fed by unnamed spring-fed streams. This is a proposed overwinter rearing site with no construction activities planned. The affected environment would include the entire 0.07 acres of existing pond blocked by barrier nets, and accessible upstream portions of streams potentially blocked to fish access. This site was added to the list after spring snorkeling surveys were completed, and no sampling data was found for this site. However, this stream is a tributary of the White River which is listed within the spawning and rearing distribution of Chinook, steelhead, and bull trout. We assume Chinook parr, and smolts, and bull trout sub-adult and adult migrants will migrate upstream and be present during the acclimation period. Although bull trout fry are assumed to be migrating down White River, we do not expect them to move upstream to this site. Because very few steelhead spawn in the White River drainage and no steelhead have been documented in this tributary, we do not expect steelhead to be present at this site. Other fish would be prevented from using the pond from December through early May, through 2027 or until project goals are met. The White River drainage still maintains high quality, complex habitat with refuge and rearing habitat for multiple life stages and life histories (NPCC 2004a).

### 4.1.13 Tall Timber

Surface water from the Napeequa River will be diverted into a 0.61 acre disconnected side channel for acclimating coho salmon. The affected environment would include 0.18 acres of the side channel enclosed by a temporary seine net, a ten foot section along the bank of the Napeequa River where a diversion pipe will be buried, and a 150 ft section of the Napeequa River downstream of the discharge pipe. ESA listed fish do not currently have access to the side channel because it is not connected to the Napeequa River. Steelhead are not common in the White River drainage. Between 2002 and 2007, only two spawning redds were counted in Napeequa River (both in 2003, Hillman et al. 2007). During construction activities, Chinook adults, eggs, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present. Potential impacts to fish could occur during bank excavation (one week) and when water is supplied to the channel and discharged back into the stream (one day). Based on available data, Chinook eggs, fry, parr and smolts; steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present during the acclimation period. Other fish will be excluded from the acclimation site enclosed by the seine net for six weeks during the spring through 2027 or until project goals are met. During this time the fish will have access to the remaining 0.43 acres of the previously inaccessible channel. Impacts due to surface water withdrawals are discussed in Appendix 10 of the EIS.

### 4.1.14 Dirty Face

A small unnamed spring-fed tributary of the White River is proposed as an adult holding area. A temporary weir would be installed near the mouth of the tributary from early October through November. Adult coho salmon would be planted upstream of the weir to allow them to spawn in available habitat. No ESA listed fish are known to spawn in this tributary and only bull trout spawn during this time period. Steelhead and spring Chinook spawn before October and would not be blocked by the weir. Nevertheless, any larger fish (adult salmon and steelhead) in the area would be prevented from migrating in or out of the tributary from early October through the end of spawning in November through 2027, or until project goals are met. Smaller fish would not be blocked by the temporary weir.

### 4.1.15 Wenatchee Backup Sites

#### *4.1.15.1 Allen*

The existing constructed pond is fed by a surface water diversion from Allen Creek, a tributary of Peshastin Creek. The pond was constructed by the community of Valley Hi and is seasonally filled and drained for the purpose of fire protection. This site is listed as a backup spring acclimation site with no construction planned. The affected environment would include 0.08 of the 0.72 acres of pond (11%) that would be enclosed by a seine net. Peshastin Creek near the Allen Creek confluence is listed within the distribution of spring Chinook spawning, rearing, migration; steelhead rearing and migration; and bull trout migration. However, spring Chinook were considered functionally extirpated from Peshastin Creek and non-listed spring Chinook adults from Leavenworth National Fish Hatchery were outplanted there from 2001-2004 (Cooper and Mallas 2004). This site was added to the list after spring snorkeling surveys were completed, and no sampling data was found for Allen Creek. However, ESA listed fish are not assumed to use the pond because they would have to ascend a high gradient reach of Allen Creek and the pond is seasonally drained every year (Keely Murdoch, Yakama Nation biologist, personal communication). Other fish would not be able to use the enclosed portion of the pond for six weeks during the spring.

#### *4.1.15.2 Coulter/Roaring*

Coulter and Roaring Creeks located in the Nason Creek Watershed flow directly into beaver dams near their confluence. If this site is used, the affected environment would include 0.17 of the 5.8 acres (3%) of available pond habitat enclosed by a temporary seine net. Based on available data, steelhead adults, eggs, parr and smolts are expected to be present during the acclimation period. Other fish would be excluded from the enclosed area for six weeks in the spring.

#### *4.1.15.3 Dryden (rearing)*

Overwintering rearing ponds could be constructed near Dryden Dam. Surface water could be diverted either from the Wenatchee River or Peshastin Creek, or groundwater could be used. If this site is used, the affected environment would include the point of diversion to the point of discharge. SalmonScape indicates that non-listed summer Chinook spawn in the Wenatchee River and Peshastin Creek adjacent to this site, and that spring Chinook rear in the area. Based on available data, spring Chinook parr and smolts; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present during the rearing period. Screens would block access to the site by other species. This would not impact other fish because they do not currently use this habitat. During construction activities, spring Chinook adults and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present. The proposed rearing facilities would be at an upland location and depending on the design, there may be localized bank disturbance during construction of the discharge pipe. Impacts due to surface water withdrawals are discussed in Appendix 10 of the EIS.

#### *4.1.15.4 George (back-up hatchery)*

An alternate to the proposed Dryden hatchery is a located on the Wenatchee River just downstream of Lake Wenatchee. The facility would have the same water and space needs as the Dryden site. Both surface and groundwater sources are being evaluated. Ground water would be developed by drilling two or more wells. Surface water would be pumped from the Wenatchee through a screened intake built into an existing rock barb. The site is currently undeveloped so construction would include disturbance of 4 acres of upland to develop the hatchery building, raceways, excavation of two ponds, well drilling, installation of water lines, construction of a permanent access road, water treatment tank and other supporting infrastructure. During construction activities, spring Chinook adults and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are assumed to be present in the Wenatchee River. The proposed facilities would be at an upland location, and depending on the design, there may be localized bank disturbance during construction of the intake line. Water is proposed to be discharged into an existing side channel which drains into the Wenatchee River. The side channel is classified as fish bearing on the FPARS, but is not within the distribution of ESA listed species according to SalmonScape. Screens would block access to the ponds by other species. This would not impact other fish because they do not currently use this habitat. Potential impacts due to surface water withdrawals are discussed in Appendix 10 of the EIS.

#### *4.1.15.5 McComas*

Grant PUD has proposed constructing overwintering ponds fed with surface water from the White River. Very few steelhead spawn in the White River drainage, so steelhead presence is viewed as possible but unlikely. Based on available data, spring Chinook eggs, fry, parr, and smolts; steelhead adults, parr and smolts; and bull trout fry, sub-adult and adult migrants are assumed to be present in the White River during the acclimation period. Fish screens would prevent other fish from accessing the acclimation pond. This would not impact other fish because they do not currently use the pond.

#### *4.1.15.6 Squadroni*

A pond would need to be constructed at this backup spring acclimation site and connected to a ditch that drains into Nason Creek. However, the ditch only has intermittent flow during snow-melt and rainwater events, so a new well would be needed to provide ground water for acclimation purposes. The affected environment would include the ditch from the point of diversion to the point of discharge. This ditch is not listed on FPARS or SalmonScape, and no survey data was found for this site. Because the ditch is dry during most of the year, it is unlikely that fish use the ditch and if they did, it would be short-term. If construction activities were conducted during dry periods, no ESA listed fish would be present.

## 4.2 Methow Subbasin

Presence of ESA listed fish by life-stage during proposed acclimation and construction periods in the Methow Subbasin is summarized by site in Table 12 and in the following sections. Detailed descriptions of each site can be found in Appendix 3 of the EIS. For size ranges expected for each life stage and activity refer to Table 2.

Comprehensive quantitative data on rearing habitat available to ESA listed fish is generally lacking throughout the Methow Subbasin. However, spawning survey data is available for these species (Figure 13). Although spawning surveys do not cover every potential spawning area and can be influenced by environmental factors such as high water, this information can be useful for evaluating potential impacts of a given site on Subbasin populations.  Between 2000 and 2007, 61% of the spring Chinook redds were counted in the Methow River, followed by the Chewuch and Twisp watersheds (Snow et al. 2008). However, estimates of wild spawners show a more even distribution among the three areas (Figure 13). An average of 38% of the summer steelhead redds were counted in the Upper Methow River between 2000 and 2007 (Snow et al. 2008). Estimates of the proportion of hatchery steelhead spawning naturally in each basin are not currently available, although are thought to be high (Snow et al. 2008). The Twisp watershed had the next highest proportion (31%), followed by Lower Methow and Chewuch watersheds. In contrast, most (53%) of the bull trout redds were counted in the Twisp watershed between 2000 and 2007 (USFS *in prep.*), followed by the Upper Methow, Chewuch, Wolf, and Gold watersheds (Figure 13).

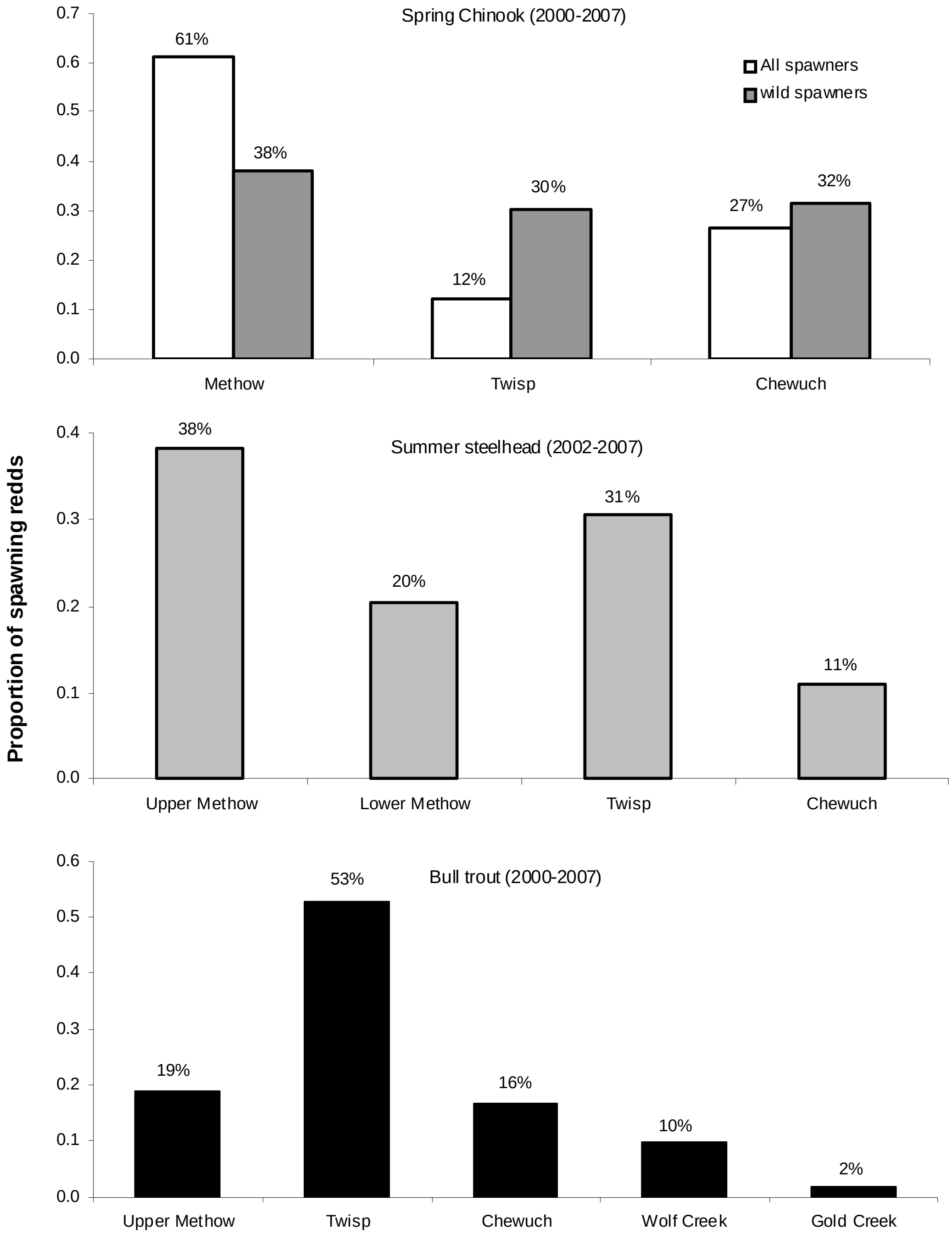



**Figure 13. The average proportion of spring Chinook (top), summer steelhead (middle), and bull trout (bottom) spawning in major tributaries of the Methow Subbasin.**

### 4.2.1 Gold

South Fork Gold Creek water is a tributary of Gold Creek located in the Lower Methow River. The Lower Methow represents an average of 20% of the steelhead redds counted in the Methow

Subbasin (Figure 13). A portion of South Fork Gold Creek flow at RM 1.6 is diverted into a series of man-made ponds proposed as a spring acclimation site. Some additional construction is planned to remove accumulated sediments and increase depth. During construction, the affected environment would include the ponds, and South Fork Gold Creek from the point of discharge downstream 150 ft. Based on available data, steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in South Fork Gold Creek during construction activities. SalmonScape lists Chinook salmon presence as "presumed" in South Fork Gold Creek. However, we did not find any sampling data to confirm their presence near the acclimation site. USGS sampling confirmed the presence of rainbow/steelhead adults and juveniles, and bull trout juveniles in South Fork Gold Creek near the acclimation site (Pat Connolly, USGS, personal communication). South Fork Gold accounted for an average of 11% of the steelhead redds counted in the Lower Methow River between 2005 and 2007 (Snow et al. 2008). Although an average of 2% of the bull trout redds in the Methow Subbasin were counted in Gold Creek (Figure 13), South Fork Gold Creek was not surveyed (USFS *in prep*.). Impacts from construction activities are expected to last 1-2 days. During acclimation, the affected environment would include 0.08 of 0.10 acres (80%) of existing pond enclosed by a temporary seine net. Based on available data, steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present during the acclimation period. The lower 3.5 miles of Gold Creek has had rip-rap placed along the banks. No habitat data was found for the lower 2.1 miles of South Fork Gold Creek where the proposed acclimation site is located. However, a survey of the stream was conducted on US Forest Service land upstream (RM 2.1-5.5) in 1996 (unpublished data, Gene Shull US Forest Service, personal communication). This survey indicated that off-channel habitat was limited to a small number of old beaver dams scattered throughout. Other fish would be excluded from the seine net enclosure for six weeks in the spring through 2027, or until project goals have been met.

### 4.2.2 Parmley

Parmley is the only primary site located in the Beaver Creek Watershed. A portion of the surface water from Beaver Creek is currently diverted into a farm pond proposed as a spring acclimation site. The affected environment would include 0.08 of 0.11 acres of pond enclosed by a temporary seine net. Based on existing data, steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in Beaver Creek during the acclimation period. Beaver Creek represented an average of 9% of the steelhead spawning redds counted in the Lower Methow between 2004 and 2007(Snow et al. 2008). The percent of steelhead redds counted in Beaver Creek above this site has varied from 4% in 2005 to 50% in 2007. Other fish would be excluded from the enclosure for six weeks each spring through 2027, or until project goals are met. A habitat assessment of Beaver Creek conducted by the USFS indicated that side channel/off-channel habitat is very limited from RM 5.8 to 9.3 (unpublished data, Gene Shull, US Forest Service, personal communication). The reach of Beaver Creek that includes the Parmley site (RM 6.6 to 7.5) contained some of the best side channel/off-channel habitat surveyed.

### 4.2.3 Lower Twisp

Three primary acclimation sites are proposed for the 157,000 acre Twisp Watershed; Lower Twisp, Twisp Weir, and Lincoln. The watershed represents 30% of the wild Chinook, 31% of the steelhead, and 53% of the bull trout spawning redds counted in the Methow Subbasin (Figure 13). Surface water is diverted from the Twisp River to a series of man-made ponds owned by the Methow Salmon Recovery Foundation currently used for steelhead and coho acclimation. Other fish currently have access to these ponds during non-acclimation times. No construction activities are planned for this site. The affected environment would include 0.14 acres of pond that would be confined by a temporary barrier net. Over 95% of the Chinook and steelhead spawning in the Twisp River typically occurs upstream of this site (Snow et al. 2008). Based on existing data, Chinook eggs, fry, parr and smolts; steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Twisp River during the acclimation period. We assume that Chinook parr and smolts, steelhead parr and smolts, and bull trout sub-adult and adult migrants would access the pond during the overwinter period. A temporary barrier net would be used to prevent other fish migrating into the site. Habitat data is lacking for the lower Twisp River (below RM 2.1). However, the lower Twisp River from Buttermilk Creek to the mouth has been diked and riprapped in places, resulting in a highly simplified channel and disconnected side channels (NPCC 2004b). This combined with the fact that beaver activity is very limited in the lower Twisp, suggests that the availability of off-channel habitat in this reach is low. Other fish would be excluded from the acclimation pond from December though early May through 2027, or until project goals are met.

### 4.2.4 Twisp Weir

Surface water is currently diverted from the Twisp River to an existing spring Chinook acclimation pond through a screened irrigation ditch. A 0.2 acre pond is proposed to be constructed adjacent to the existing pond to overwinter coho salmon. On average 91% of the Chinook and 84% of the steelhead spawning in the Twisp River occurs upstream of this site (Snow et al. 2008). Construction plans include excavating an earthen pond, drilling new wells, and installing water delivery pipelines from the irrigation channel to the pond and from the pond back to the river. During construction, the affected environment would include the Twisp River from the discharge site downstream 150 ft. Chinook adults, eggs, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Twisp River during construction activities. Impacts to fish are expected to occur when water is supplied to the pond and discharged into the Twisp River (one day). Other fish would be excluded from the irrigation ditch and acclimation pond by inlet and outlet screens. This will not impact other fish because they do not currently use this habitat.

### 4.2.5 Lincoln

Surface water is currently diverted from the Twisp River during high flows to a side channel which includes two ponds. The lower pond is proposed as an overwinter rearing site. On average 64% of the Chinook and 41% of the steelhead spawning in the Twisp River occurs upstream of this site (Snow et al. 2008). Construction plans include deepening the lower pond, drilling new wells, excavating an inflow channel and power line burial. During construction, the affected environment would include the lower pond and the Twisp River from the discharge site downstream 150 ft. Chinook adults, eggs, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Twisp River during construction activities. A recent snorkel survey found juvenile Chinook and steelhead present in the existing ponds (Rick Alford, Yakama Nation, personal communication). Impacts to fish are expected to occur during pond and inflow channel excavation (1-3 days) and when water is supplied to the side-channel and discharged back into the Twisp River (one day). During acclimation, the affected environment would include 0.2 of 0.31 acres (65%) of the existing pond habitat enclosed by a temporary seine net used to hold coho salmon. Other fish would be excluded from the enclosed area from December through early May through 2027, or until project goals are met. Side channel habitat is relatively abundant in this reach of the Twisp River (RM 13.7 to 17.6), consisting of about 11% of the available habitat (unpublished data, Gene Shull, US Forest Service, personal communication).

### 4.2.6 Mason

Mason is one of three primary sites, including MSWA Eight Mile and Pete Creek Pond, located in the 340,000 acre Chewuch River Watershed. The watershed represents 32% of the wild Chinook, 11% of the steelhead, and 16% of the bull trout spawning redds counted in the Methow Subbasin (Figure 13). Surface water from Eight Mile Creek is seasonally diverted into a series of man-made ponds that have been used in the past to acclimate coho salmon. Construction activities may include developing a new well and channel to supplement flow into the ponds during the winter. The affected environment would include a 10 ft section of pond bank where the new channel would deliver water from the well. Chinook salmon spawning has not been documented but SalmonScape indicates that spring Chinook rear in Eight Mile Creek. Between 2004 and 2007, 11% of the steelhead redds in the Chewuch watershed were counted in Eight Mile Creek (Snow et al. 2008). However, the percentage drops to 4% if 2005 is excluded (nearly 50% were counted in Eight Mile that year). Based on existing data, Chinook parr; steelhead adults, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in Eight Mile Creek during construction activities. Impacts to fish are expected to occur during channel construction (1 day). Screens will prevent other fish from using the ponds from December through early May. Because the ponds are normally dry during this period and thus not available for rearing, acclimation should not impact other fish.

### 4.2.7 MSWA Eight Mile

A spring acclimation site is proposed at a side channel to the Chewuch River. Construction plans include drilling a well and building a rock lined channel from the well to the site. During construction, the affected environment would include a 10 ft section of bank along the existing side channel and the side channel to the confluence with the Chewuch River. Based on the onsite snorkel survey, steelhead fry and parr are expected to be present during the construction period. Based on existing data for the Chewuch River at this site, we assume that Chinook parr, and smolts, steelhead parr and smolts, and bull trout sub-adult and adult migrants will be present during acclimation periods. SalmonScape indicates that spring Chinook and steelhead spawn and bull trout rear in this section of the Chewuch River. USGS confirmed the presence of spring Chinook adults and juveniles, rainbow/steelhead juveniles in this section of the Chewuch River (Pat Connolly, USGS, personal communication). On average, 47% of the Chinook and 36% of the steelhead spawning redds in the Chewuch River were counted upstream of this site (Snow et al. 2008). Impacts to fish are expected to occur during channel construction (3 days). During acclimation, the affected environment will include 0.14 of the 0.64 acres (22%) of existing side channel habitat enclosed by the seine net. Other fish would be excluded from the enclosed area for six weeks during the spring each year through 2027, or until project goals are met. Beavers are active in this reach of the Chewuch River (RM 11.8 to 14.1, unpublished data, Gene Shull, US Forest Service, personal communication), indicating that off-channel habitats are relatively common.

#### 4.2.8 Pete Creek Pond

The Methow Salmon Recovery Foundation is planning to reconnect the Chewuch River to a disconnected side channel that forms a series of ponds. The existing ponds are currently fed by Pete Creek, a seasonal stream. The affected environment would include 0.2 of 0.23 (87%) existing acres of pond enclosed by a temporary seine net. Based on available data, Chinook eggs, fry, parr and smolts; steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are present in the Chewuch River. On average, over 90% of the Chinook and 95% of the steelhead spawning redds in the Chewuch River were counted upstream of this site. The additional flow will likely attract Chinook parr and smolts; steelhead parr and smolts; and bull trout sub-adult and adult migrants into the side channel to rear. Other fish would be excluded from the enclosed area for six weeks during the spring through 2027, or until project goals have been met. A US Forest Service habitat assessment of this reach of the Chewuch River (RM 2.2 to 5.6) found numerous backwater pools and some beaver activity that provided excellent rearing habitat (unpublished data, Gene Shull, US Forest Service, personal communication). However, the available side channel habitat was low compared to other streams with similar gradient depositional reaches without rip-rap or other hardened structures.

#### 4.2.9 Heath

Heath and Goat Wall are primary acclimation sites and Hancock is an adult holding site proposed for the 322,385 Upper Methow River Watershed (above the Chewuch River confluence). The Upper Methow represents 38% of the wild Chinook, 38% of the steelhead, and 19% of the bull trout spawning redds counted in the Methow Subbasin (Figure 13). At the Heath site, spring water provides flow to a series of large ponds that drain into the Methow River. The lowest pond is proposed as an overwinter acclimation site. Juvenile Chinook salmon, rainbow/steelhead, and adult and juvenile bull trout rear in the lower pond (Pat Connolly, USGS and Gene Shull, US Forest Service, personal communication). No construction activities are planned for this site. The affected environment would include 0.32 of the 0.72 acres (44%) of existing pond enclosed by a temporary seine. No ESA listed spawning fish have been documented in the stream, but on average 79% of the Chinook and 96% of the steelhead spawning redds counted in the Upper Methow were upstream of this site (Snow et al. 2008). Based on existing data, Chinook parr, and smolts; steelhead parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the lower pond during rearing activities. Other fish would be excluded from the enclosed area each year from December through early May until 2027, or when project goals are met. Habitat data is lacking for the Upper Methow River to assess the availability of similar habitat.

#### 4.2.10 Hancock

Hancock Creek is a spring-fed tributary of the Upper Methow River proposed as an adult holding area. A temporary weir would be installed near the mouth of Hancock Creek (RM 0 to 0.5) from early October through November. Adult coho salmon would be planted upstream of the weir to allow them to spawn in available habitat. Steelhead are known to spawn in this stream, and 23 spawning redds were counted in the lower 0.7 miles of Hancock in 2007 (Snow et al. 2008). Adult steelhead are not expected to be present when the weir is in use and any steelhead fry will have emerged from the gravel well before coho spawn. Spring Chinook and bull trout have not been documented in Hancock Creek. In addition, spring Chinook spawn before October and would not be blocked by the weir. Nevertheless, any larger fish (adult salmon and steelhead) in the area would be prevented from migrating in or out of the tributary from early October through the end of spawning in November through 2027, or until project goals are met. Smaller fish would not be blocked by the temporary weir.

### 4.2.11 Goat Wall

A disconnected side channel of the Methow River is fed by ground water and surface water diverted from Gate Creek. The site is located in a portion of the Methow River that has no surface flow during some fall and winter months. No construction is planned for this site. The affected environment would include 0.08 acres of approximately 0.63 acres (13%) of accessible channel enclosed by a seine net system. No ESA listed fish have been documented spawning in this stream. On average 7% of the Chinook and 8% of the steelhead spawning redds counted in the Upper Methow were upstream of this site (Snow et al. 2008). Based on an onsite snorkel survey, steelhead parr and smolts, and bull trout sub-adult and adult migrants are expected to be present during the spring acclimation period. These fish would be excluded from the enclosed area for six weeks during the spring through 2027, or until project goals are met. Habitat data is lacking for the Upper Methow River to assess the availability of similar habitat.

### 4.2.12 Methow Backup Sites

#### *4.2.12.1 Balky Hill*

An unnamed groundwater fed Beaver Creek tributary was previously dammed to create a pond on private farm property. This backup site would need no construction. The affected environment would include the groundwater stream from the pond to the origin of the spring water. This site was added to the list after spring snorkeling surveys were completed, and no sampling data was found for this stream. However, the existing dam is likely a barrier to fish migration except during high water events. Beaver Creek near the stream is listed within the distribution of steelhead spawning, rearing and migration; and bull trout migration. If this site is used, other fish would be excluded from the acclimation site for six weeks during the spring.

#### *4.2.12.2 Biddle*

Wolf Creek surface water is diverted into two existing constructed ponds of which one is proposed as a backup spring acclimation site. The affected environment would include 0.08 of the 0.17 acres (47%) of pond habitat enclosed by a temporary seine net. No additional construction is planned for this site. Based on available data, Chinook fry, parr, and smolts; steelhead parr and smolts; and bull trout sub-adult and adult migrants may be present in the ponds during the acclimation period. If this site is used, other fish would be excluded from the enclosed area for six weeks during the spring.

#### *4.2.12.3 MSRF Lower Chewuch*

If this site is used, a 0.2 acre pond would be constructed on land owned by the Methow Salmon Recovery Foundation. Ground water would be supplied from an existing well. Proposed construction activities would include excavation of an earthen bottom pond and two rock lined channels: from the well to the pond; and from the pond to the Chewuch River. The affected environment during construction would include one 10 ft Chewuch bank section at the discharge site and the Chewuch River from the point of discharge 150 ft downstream. Based on available data, Chinook adults, eggs, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Chewuch River during construction activities. Impacts to fish are expected to occur when the pond is filled and discharged into the river the first time (1 day). Screens would block access to the site by other species. Listed fish are not expected to be impacted during acclimation because they are not currently using this habitat.

#### *4.2.12.4 Chewuch Acclimation Facility*

If this site were used, a pond would be constructed downstream of an existing Chinook acclimation pond. Chewuch River surface water would be delivered from an existing irrigation diversion through a pipeline. Proposed construction activities would include excavation of an earthen bottom pond and installation of water delivery lines from the existing intake to the Chewuch River. The affected environment during construction would include one 10 ft bank section at the discharge site and the Chewuch River from the point of discharge 150 ft downstream. Based on available data, Chinook adults, eggs, and parr; steelhead adults, eggs, fry, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Chewuch River during construction activities. Impacts to fish are expected to occur during the installation of pipelines and when the pond is filled and discharged into the river the first time (1 day). Listed fish are not expected to be impacted during acclimation because they are not currently using this habitat.

#### *4.2.12.5 Poorman*

Surface water is currently diverted from a screened irrigation intake in the Twisp River to a series of constructed ponds proposed as a backup acclimation site. No additional construction activities are planned for this site. This site was added to the list after spring snorkeling surveys were completed, and no sampling data was found for this site. Two juvenile salmonids (likely rainbow/steelhead) were observed in the westernmost pond (David Hopkins, US Forest Service, Fisheries Bio Tech, personal communication), and Chinook eggs, fry, parr and smolts; steelhead adults, eggs, parr and smolts; and bull trout sub-adult and adult migrants are expected to be present in the Twisp River during the acclimation period. Fish access from the Twisp River is currently blocked by irrigation screens so impacts to ESA listed fish are not expected.

#### *4.2.12.6 Newby*

This site is a potential backup to other Twisp acclimation sites. If this site is used, a pond would be constructed adjacent to Newby Creek a non-fish bearing, high gradient, small tributary to the Twisp River. SalmonScape does not list Newby Creek within the distribution of listed fish. The proposed backup site would be located above a series of cascades (Figure 14) which make the site inaccessible to salmonids. A habitat survey conducted by CFS personnel revealed that there were natural fish passage barriers throughout the stream and the substrate was comprised mostly of fines (Ian Courter, fisheries biologist, Cramer Fish Sciences, personal communication). Based on this information we believe that listed fish do not currently access this site. The effect of water withdrawals on other fish are discussed in Appendix 10 of the EIS.


**Figure 14. Confluence of Newby Creek and the Twisp River depicting the first of several fish passage impediments.**

### *4.2.12.7 Utley*

An existing constructed spring fed pond drains into a wetland area adjacent to the Twisp River about 3.75 miles upstream of Twisp Weir. The wetland area has no direct connection to the Twisp River. This site is a backup to other Twisp acclimation sites and would require construction of an 80 ft channel connecting the pond to the Twisp River. This site was added to the list after spring snorkeling surveys were completed, and no sampling data was found for this stream. However, because there is no direct connection to the Twisp River it is unlikely that ESA fish currently access the pond. The Twisp River near the stream is listed within the distribution of spring Chinook spawning, rearing and migration; steelhead spawning, rearing and migration; and bull trout migration. It is possible but unlikely that steelhead parr and smolts access the site during high flows. However, if the channel is constructed to the Twisp River it is likely that ESA listed fish will access the pond. If this site is used, other fish would be excluded from the area enclosed by the seine net for six weeks during the spring.

#### *4.2.12.8 Canyon*

An unscreened diversion on Canyon Creek, a tributary of the Twisp River, provides water to a 0.4 acre constructed pond. If this site is used, the pond would be deepened and enlarged to 0.8 acres. During construction, the affected environment would include the pond, and Canyon Creek from the point of discharge downstream 150 ft. SalmonScape does not show Canyon Creek within the distribution of spring Chinook salmon, steelhead, or bull trout. However, the pond is located within 200 ft of the Twisp River within the distribution of spring Chinook spawning, rearing and migration; steelhead spawning, rearing and migration; and bull trout migration. Based on this information, we assume that juvenile steelhead and migratory bull trout may use the pond. Impacts from construction activities are expected to last 1-2 days. During spring acclimation, the affected environment would include 0.08 acres pond enclosed by a temporary seine net. The remainder of the year, other fish would have free access to the enlarged pond.

## 4.3 Combined Impacts

### 4.3.1 Proposed Alternative

The most likely impact to fish that would result is related to access to available habitat during rearing and acclimation periods. Disturbance activities would be limited to the amount of area excluded by seine or barrier nets at each acclimation site. Other fish species would be blocked from 1.22 of the 1.69 acres of habitat currently accessible to ESA listed fish at primary sites in the Wenatchee Subbasin, and 1.24 of the 2.88 acres of those in the Methow Subbasin during a portion of the year (Table 13). Other fish would be dislocated or excluded from about 54% of the existing accessible habitat at the Wenatchee primary sites and 20% at the Methow primary sites from mid-March through early May. An additional 18% at the Wenatchee and 23% at the Methow sites would be inaccessible to other fish from December through early May. These impacts will be balanced to some degree by newly constructed habitat. About 0.26 acres of new habitat in the Wenatchee Subbasin will be available to other fish for at least a portion of the year (Table 13).

The relative impact on listed species from being dislocated or excluded from this habitat will depend to some extent on the availability of similar habitats within each Subbasin. Because a comprehensive habitat database was not available for these subbasins, an alternate method was needed to evaluate the relative magnitude of these impacts to ESA listed populations.

**Table 13. Amount (acres) of existing pond or side channel habitat at primary sites that is currently accessible to listed fish or proposed to be added for new sites, versus the amount that would be potentially excluded during overwinter rearing and spring acclimation activities, by Subbasin.**

| | | Habitat excluded (acres) | | | Accessible |
|---|---|---|---|---|---|
| | Habitat (acres) | Overwinter | Spring | Total | off-season[a] |
| *Wenatchee Subbasin* | | | | | |
| Existing habitat | 2.23 | 0.48 | 1.28 | 1.76 | 2.06 |
| Currently accessible[b] | 1.69 | 0.31 | 0.91 | 1.22 | 1.69 |
| Area added | 1.03 | 0.00 | 0.60 | 0.60 | 0.26 |
| *Methow Subbasin* | | | | | |
| Existing habitat | 2.88 | 0.66 | 0.58 | 1.24 | 2.88 |
| Currently accessible[b] | 2.88 | 0.66 | 0.58 | 1.24 | 2.88 |
| Area added | | | None | | |

[a] Rohlfing goes dry during the summer and early fall so is not considered accessible to fish during most of the off season.
[b] Accessible to ESA listed fish.

Cramer and Ackerman (2009) demonstrated that the carrying capacity of various salmonids can be predicted based on channel units (e.g. pool, riffle, glide) and maximum fish densities based on a species life-stage and habitat preference. The proposed rearing and acclimation sites are similar to beaver pond and backwater habitats. In the natural environment coho salmon prefer these slower velocity habitats above other habitats with more current (Solazzi et al. 1998). While other salmonid parr use these habitats, many prefer pools in streams or other channel habitats with more velocity (Cramer and Ackerman 2009). For the purposes of this analysis, we assumed average fish (parr) densities for each species based on literature values for similar habitats, or average values observed in the Chiwawa Watershed (Hillman et al. 2008). We assumed a value of 291 Chinook parr per acre based on average densities in Chiwawa pool habitats (720/ha) between 1992 and 2007 (Hillman et al. 2008). This assumption is likely high because juvenile Chinook are rarely found in off-channel habitats or beaver ponds (Murphy et al. 1989). Further during the winter, Chinook are usually associated with cobble substrate (Hillman et al. 1987, Van Dyke et al. 2009) rather than fine sediments typically associated with backwater habitats. Therefore, juvenile Chinook are unlikely to be found in the acclimation ponds and our estimate of 291 parr/acre should be considered very conservative. We assumed 162 steelhead per acre based on average winter densities of similar habitat in Oregon (Johnson et al. 1993). Finally, we assumed a density of 7.6 subadult or adult bull trout per acre wherever migratory fish were expected to occur, and 23.6 juvenile bull trout per acre wherever spawning and rearing was expected to occur. The bull trout densities were based on sampling in the Chiwawa Watershed (Hillman et al. 2008). We acknowledge fish densities vary seasonally and annually depending on environmental conditions and population abundances. Further, excluding ESA listed fish from these habitats would presumably only affect the populations if the available habitat is fully seeded. If the habitats are not at carrying capacity, dislocated fish could occupy other underutilized habitat. However, this analysis provides a context to assess the relative magnitude of impacts due to acclimation and rearing on listed species.

Our analysis suggests that the number of juvenile ESA listed fish potentially excluded during acclimation and rearing would be relatively small compared to overall Subbasin populations. Less than 250 juveniles of each species were projected to be excluded from sites in the

Wenatchee Subbasin (Table 14). This compares with the range of wild production estimated of 55,619 – 311,669 for Chinook and 17,499 - 85,443 for steelhead smolts from the entire Wenatchee Subbasin between 2002 and 2007 (Hillman et al. 2008). Using an average smolt to adult survival rate of 0.00465 for hatchery spring Chinook and 0.0105 for summer steelhead from the Wenatchee Subbasin (Hillman et al. 2009), the number of juveniles excluded would represent 0.5 Chinook and 2.5 steelhead adult equivalents. In the Methow Subbasin, less than 270 juveniles of each species were projected to be excluded from acclimation and rearing sites (Table 15). This compares with the range of wild production 15,306 – 33,710 estimated for Chinook and 8,809 - 15,003 for steelhead smolts from the entire Methow Subbasin between 2000 and 2008 (data provided by Alex Repp, Washington Department of Fish and Wildlife, personal communication). Using the same smolt to adult survival rates used above, the number of juveniles potentially excluded from acclimation sites in the Methow basin would represent 1.5 spring Chinook and 2.1 summer steelhead adult equivalents. No Subbasin juvenile bull trout abundance estimates are available but the number of juveniles projected to be excluded from sites in each Subbasin was very small (10 or less). It is important to understand that excluding juveniles from rearing and acclimation sites does not necessarily mean these fish will not survive. As previously noted, the acclimation and rearing sites are not ideal habitat for listed species. Juveniles displaced or excluded from these habitats will seek out other suitable habitat in the area. Assuming that other habitats are not fully occupied by other fish, these fish will likely continue to rear in these areas.

**Table 14. Potential juvenile Chinook, steelhead, and bull trout dislocated from currently accessible habitat at proposed primary rearing and acclimation sites in the Wenatchee Subbasin based on assumed fish densities.**

| | | Accessible area | Potential juveniles dislocated | | |
|---|---|---|---|---|---|
| Site name | Overwinter | excluded (acres) | Chinook | steelhead | bull trout |
| Beaver | N | 0.24 | 70 | 39 | 2 |
| Brender | N | 0.08 | 23 | 13 | 0 |
| Butcher | N | 0.56 | 0 | 91 | 0 |
| Chikamin | N | | 0 | 0 | 0 |
| Clear | Y | 0.24 | 0 | 39 | 0 |
| Coulter | N | 0.37 | 0 | 0 | 0 |
| White River Springs | Y | 0.07 | 20 | 11 | 1 |
| Minnow | N | | 0 | 0 | 0 |
| Rohlfing | Y | 0.17 | 0 | 28 | 0 |
| Scheibler | N | 0.03 | 0 | 16 | 0 |
| Tall Timber | N | | 0 | 0 | 0 |
| Two Rivers | Y | | 0 | 0 | 0 |
| Total dislocated | | | 113 | 237 | 3 |
| Wenatchee smolt production range (2002-2007)[a] | | | 55,619 - 311,669 | 17,499 - 85,443 | not applicable |

[a] Data source Hillman et al. (2008).

**Table 15. Potential juvenile Chinook, steelhead, and bull trout dislocated from currently accessible habitat at proposed primary rearing and acclimation sites in the Methow Subbasin based on assumed fish densities.**

| Site name | Overwinter | Accessible area excluded (acres) | Potential juveniles dislocated | | |
|---|---|---|---|---|---|
| | | | Chinook | steelhead | bull trout |
| Goat Wall | | 0.08 | 23 | 13 | 1 |
| Gold | | 0.08 | 0 | 13 | 1 |
| Heath | Y | 0.32 | 93 | 52 | 2 |
| Lincoln | Y | 0.20 | 58 | 32 | 2 |
| Lower Twisp | Y | 0.14 | 41 | 23 | 1 |
| Mason | Y | 0.00 | 0 | 0 | 0 |
| MSWA Eight Mile | | 0.14 | 41 | 23 | 1 |
| Parmley | | 0.08 | 0 | 13 | 1 |
| Twisp Weir | Y | 0.00 | 0 | 0 | 0 |
| Pete Creek Pond | | 0.20 | 58 | 32 | 2 |
| Total dislocated | | | 314 | 201 | 11 |
| Methow smolt production range (2000-2008) | | | 15,306 - 33,710 | 8,809 - 15,003 | not applicable |

[a] Data source Alex Repp Washington Department of Fish and Wildlife, personal communication.

### 4.3.2 No Action

The No Action Alternative described in the EIS includes operation of fewer of the same sites described for the Proposed Alternative. Because fewer sites would be operated and no new construction is involved, the combined effects would be less than those of the Proposed Alternative; consequently, the impacts of the combined projects are considered to be less than significant.

## 4.4 Cumulative Impacts

The EIS defines cumulative impacts as the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Past and present activities that may have affected fish habitat in the Wenatchee and Methow Subbasins include diversions and dams, agricultural activities, stream channelization and diking, roads and railways, timber harvest, and urban and rural development (Mullan et al. 1992; Chapman et al. 1994, 1995; NPCC 2004a-b). A hydro-power dam constructed on the lower Methow River near Pateros in 1915 was blocked upstream anadromous fish passage until it was removed in 1929 (Mullan et al. 1992; Peven 1992; Andonaegui 2000).These human induced habitat alterations have primarily occurred in the lower gradient, lower reaches of the subbasins (Andonaegui 2000, 2001) and have resulted in blocked access to habitat, loss of habitat complexity, off-channel habitats, and large, deep pools. Extensive use of rip rap to stabilize streambanks has decreased the channel sinuosity and recruitment of large woody debris (LWD). Chronic sedimentation from land and water management activities has caused habitat degradation in some areas. In contrast, upper reaches of these subbasins are in relatively good condition (Andonaegui 2000, 2001; NMFS et al. 1998).

Habitat conditions have improved in recent years and further improvements are expected in the future. Some of the factors that have affected habitat of ESA listed fish been partially addressed through changes in land-use practices (UCSRB 2007). These include improving fish passage at dams, installing irrigation diversion screens, culvert replacement, riparian buffer strips, and improved livestock management. Two major habitat restoration efforts are being been funded by BPA in the Wenatchee and Methow Subbasins. The Yakama Nation will be receiving 6-7 million dollars annually over ten years for habitat restoration in these Subbasins. In addition, the Upper Columbia Salmon Recovery Board will be receiving about 3.5 million dollars for habitat restoration projects beginning in 2011 (Bruce will provide citation). These efforts should result in substantial habitat improvements over the next decade.

The proposed action would result in reduced seasonal access to existing off-channel habitats used for acclimation and rearing of hatchery coho salmon, and potential short term delivery of additional sediment from bank disturbance and pond construction. Because these off-channel habitats are not preferred by spring Chinook, steelhead and bull trout, the impacts from the proposed seasonal use of small areas for acclimation and rearing purposes will not be additive to cumulative effects of past, present, and anticipated future anthropogenic impacts to habitat. In addition, permit conditions will require that sediment be strictly controlled during construction, and the small areas affected during construction, any unforeseen increased sediment delivery is likely to be minimal and highly localized. Also the construction is not expected to result in conditions that cause chronic sediment loads to increase. Therefore although there may be some short-term localized contribution to the cumulative effects, it would not persist more than 1-2 weeks past construction.

### 4.4.1 Proposed Alternative

The amount of habitat excluded during acclimation and rearing activities or added through additional sites under the proposed alternative is not likely to have a measureable impact compared to past and current impacts and those likely to occur.

### 4.4.2 No Action

The no action alternative would have less impacts than the proposed alternative.

## 5.0 IMPACT AVOIDANCE OR MITIGATION

- Barrier nets (see Appendix 2 of the EIS for a description) will be used at acclimation sites where ESA listed fish do not reside, or use to migrate to existing habitat. This will minimize premature escape of coho salmon.
- Seine nets (see Appendix 2) will be used at acclimation sites to partition off a portion of a water body while allowing free upstream and downstream passage of ESA listed fish to available habitat. In areas where emergent spring Chinook or bull trout fry will be present, predation will be minimized by using fine seine mesh to exclude fry from enclosed areas. Seines will be installed in a manner that excludes fry from the coho acclimation area by moving out from the bank to encapsulate the rearing area. The

enclosed area will be snorkeled to verify no ESA listed fish are present before hatchery coho are added.

- Nets will be removed at a time of year when coho reach a size that maximizes the ratio of fully smolted fish. Smolts will migrate from the acclimation area quickly, reducing potential interactions with other species.
- Timing and methodology of construction activities will be coordinated with resource agencies to minimize disturbance to listed species and life-stages. Best management practices will be used and permit conditions will be followed during construction activities, to prevent sedimentation inputs.

## 6.0 REFERENCES

Andonaegui, C. 2000. Salmon, steelhead, and bull trout habitat limiting factors for the Methow subbasin (Water Resource Inventory Area 48). Final draft report. WSCC.

Andonaegui, C. 2001. Salmon, steelhead, and bull trout habitat limiting factors for the Wenatchee subbasin (Water Resource Inventory Area 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages). Final draft report. WSCC.

Barnhart, R.A. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – Steelhead. Biological Report 82(11.60) U.S. Army Corp of Engineers, Coastal Ecology Group, Vicksburg, Mississippi.

Baxter, J.S. and J.D. McPhail. 1996. Bull trout spawning and rearing habitat requirements: summary of the literature. British Columbia Ministry of Environment, Lands and Parks, Fisheries Branch, Fisheries Technical Circular 98.

Beacham, T. D., and C. B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of Pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119: 927-945.

Bjornn, T. C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Transactions of the American Fisheries Society 100: 423-438.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in W. R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Bethesda, Maryland.

Boag, T.D. 1987. Food habits of bull char, *Salvelinus confluentus*, and rainbow trout, *Salmo gairdneri*, coexisting in a foothills stream in northern Alberta. Canadian Field-Naturalist 101:56-62.

Bovee, K. D. 1978. Probability-of-use criteria for the family Salmonidae. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

Brodeur, R. D. 1991. Ontogenetic variations in the type and size of prey consumed by juvenile coho and Chinook salmon. Environmental Biology of Fishes. 30:303-315.

Brown, L.G. 1992. On the zoogeography and life history of Washington native char Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*). Washington Department of Wildlife, Fisheries Management Division Report, Olympia, Washington.

Buchanan, D. V., M. L. Hanson and R. M. Hooten. 1997. 1996 Status of Oregon's bull trout. Draft report. Oregon Department of Fish and Wildlife, Portland.

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 32: 667-680.

Chapman, D.W., C. Peven, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia region. Report for the Mid-Columbia PUDs. 235 pp.+ app.

Chapman, D.W., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring Chinook salmon in the mid-Columbia region. Report for thd Mid-Columbia PUDs. 270 pp.+ app.

Cooper, M. and S. Mallas, 2004. Peshastin Creek smolt monitoring program, Annual Report 2004. U.S. Fish and Wildlife Service, Mid-Columbia River Fishery Resource Office, Leavenworth, WA.

Cramer, S.P., and N.K. Ackerman. 2009. Linking stream carrying capacity for salmonids to habitat features. Pages 225-254 *in* E.E. Knudson and J.H. Michael Jr., editors. Pacific salmon environmental and life history models: advancing science for sustainable salmon in the future. American Fisheries Society, Symposium 71, Bethesda, MD.

Donald, D.B. and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71: 238-247.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm.1987. Fine sediment and salmonid production: a paradox. Pages 98-142 in Salo and Cundy (1987).

Foerster, R. E., and W. E. Ricker. 1953. The coho salmon of Cultus Lake and Sweltzer Creek. Journal of the Fisheries Research Board of Canada 10:293-319.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*, literature review. Willamette National Forest, Eugene, Oregon.

Grant, J. W. A. and D. L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47:1724–1737.

Healey, M.C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type chinook salmon, *Oncorhynchus tshawytscha*. Canadian Field Naturalist 97-427-433.

Healey, M.C. 1991. Life History of Chinook Salmon. In: C. Groot, and L. Margolis. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Hicks, B.J., J.D. Hall, P.A. Bisson, and J.R. Sedell. 1991. Responses of salmonids to habitat changes. American Fisheries Society Special Publication 19:483-518.

Hillman, T. W., D. W. Chapman, and J. S. Griffith. 1989. Seasonal habitat use and behavioral interaction of juvenile Chinook salmon and steelhead. I: Daytime habitat selection. Pages 42-82 *In*: Don Chapman Consultants, Inc. Summer and winter ecology of juvenile chinook salmon and steelhead trout in the Wenatchee River, Washington. Final report to Chelan County Public Utility District, Wenatchee, Washington.

Hillman, T. W., J. S. Griffith, and W. S. Platts. 1987. Summer and winter habitat selection by juvenile chinook salmon in a highly sedimented Idaho stream. Transactions of the American Fisheries Society 116: 185-195.

Hillman, T., M. Miller, C. Peven, M. Tonseth, T. Miller, K. Truscott, and A. Murdoch. 2008. Monitoring and evaluation of the Chelan County PUD hatchery programs. 2007 Annual Report. Prepared for the HCP Hatchery Committee, Wenatchee, WA.

Hillman, T., M. Miller, C. Peven, J. Miller, M. Tonseth, T. Miller, K. Truscott, and A. Murdoch. 2009. Monitoring and evaluation of the Chelan County PUD hatchery programs. 2008 Annual Report. Prepared for the HCP Hatchery Committee, Wenatchee, WA.

Hoelscher, B. and T.C. Bjornn. 1989. Habitat, density and potential production of trout and char in Pend Oreille Lake tributaries. Project F-71-R-10, Subproject III, JobNo. 8. Idaho Department of Fish and Game, Boise, Idaho.

Howell, P.J. and D.V. Buchanan. 1992. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Johnson, S. L., M. F. Solazzi, and J. D. Rodgers. 1993. Development and evaluation of techniques to rehabilitate Oregon's wild salmonids. Oregon Department of Fish and Wildlife, Fish Research Project F-125-R, Annual Progress Report, Portland.

Koski, K.V. 1966. The survival of coho salmon from egg deposition to emergence in three Oregon coastal streams. Master's Thesis. Oregon State University, Corvallis.

Leathe, S.A. and P. Graham. 1982. Flathead Lake fish food habits study. Environmental Protection Agency, through Steering Committee for the Flathead River Basin Environmental Impact Study. Contract R008224-01-4 to Montana Department of Fish, Wildlife and Parks.

Lister, D.B., and C.E. Walker. 1966. The effect of flow control on freshwater survival of chum, coho, and chinook salmon in the Big Qualicum River. Canadian Fish. Cult. 37:3-25.

Martens, K.D., and P.J. Connolly. 2008. Lower Methow tributaries intensive effectiveness monitoring study. Interim Report. USGS Western Fisheries Research Center, Columbia River Research Laboratory, Cook, WA.

McPhail, J.D. and J.S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Department of Zoology, University of British Columbia. Fisheries Management Report No. 104. Vancouver, British Columbia, Canada.

McPhail, J.D. and C. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Report to the British Columbia Hydro and Power Authority and Kootney Department of Fish and Wildlife.

Meehan, W.R., and D.N. Swanston. 1977. Effects of gravel morphology on fine sediment accumulation and survival of incubating salmon eggs. U.S. Forest Service Research Paper PNW-220.

Montgomery, D.R., and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Washington State Timber/Fish/Wildlife Agreement, TFW-SW-93-002, Department of Natural Resources, Olympia, WA.

Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Monograph I, U.S. Fish and Wildlife Service, Leavenworth, Washington.

Murdoch, K., C.K. Kamphaus, and S.A. Prevatte. 2005. Mid-Columbia coho reintroduction feasibility study: 2003 monitoring and evaluation report, project No. 1996-040-000. Bonneville Power Administration, Portland Or.

Murdoch, K., and M. LaRue. 2002. Feasibility and risks of coho reintroductions in mid-Columbia tributaries: 2001 annual monitoring and evaluation report, project No. 1996-040-000. Bonneville Power Administration, Portland Or.

Murdoch, K., and R.D. Nelle. 2008. A field manual of scientific protocols for underwater observations within the Upper Columbia Monitoring Strategy. Working Version 1.0. Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Published by Terraqua, Inc., Wauconda, WA. 23 pp.

Murphy, M.L., J. Heifetz, J.F. Thedinga, and K.V. Koski. 1989. Habitat utilization by juvenile Pacific salmon (*Onchorynchus*) in the glacial Taku River, Southeast Alaska. CJFAS, 46: 1677-85.

National Marine Fisheries Service, U.S. Fish and Wildlife Service, U. S. Forest Service, Washington Department of Fish and Wildlife, Confederated Tribes of the Yakama Indian Nation, Confederated Tribes of the Colville Indian Reservation, Confederated Tribes of the Umatilla Indian Nation, Chelan County Public Utility District, Douglas County Public Utility District, and Grant County Public Utility District (NMFS et al.). 1998. Aquatic species and habitat assessment: Wenatchee, Entiat, Methow, and Okanogan watersheds. Report available at Chelan County Public Utility District, Wenatchee, Wa.

Northwest Power and Conservation Council (NPCC). 2004a. "Wenatchee Subbasin Plan." In Columbia River Basin Fish and Wildlife Program. Portland, Oregon, 2005.

Northwest Power and Conservation Council (NPCC). 2004b. "Methow Subbasin Plan." In Columbia River Basin Fish and Wildlife Program. Portland, Oregon, 2005.

Pearsons, T. D., and A. L. Fritts. 1999. Maximum size of Chinook salmon consumed by juvenile coho salmon. North American Journal of Fisheries Management. 19:165-170.

Peven, C.M. 1992. Population status of selected stocks of salmonids from the Mid-Columbia River Basin. Chelan County Public Utilities Division, Wenatchee, WA. 52 p.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5-9 in P.J. Howell, and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon & trout. American Fisheries Society, Bethesda Maryland.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Rich, C.F., Jr. 1996. Influence of abiotic and biotic factors on occurrence of resident bull trout in fragmented habitats, western Montana. M.S. Thesis, Montana State University, Bozeman, Montana.

Ricker, W. E. 1941. The consumption of young sockeye salmon by predaceous fish. Journal of the Fisheries Research Board of Canada 5:104-105.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. U.S. Forest Service, Intermountain Research Station General Technical Report INT-302.

Rieman, B.E. and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124:285-296.

Rieman, B.E. and J.D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16:132-146.

Roni, P., and A. Fayram. 2000. Estimating winter salmonid abundance in small Western Washington streams: a comparison of three techniques. North American Journal of Fisheries Management 20: 683-692.

Ruggerone, G. T., and D. E. Rogers. 1992. Predation on sockeye salmon fry by juvenile coho salmon in the Chignik Lakes, Alaska: Implications for salmon management. North American Journal of Fisheries Management 12:87-102.

Sedell, J.R. and F.H. Everest. 1991. Historic changes in pool habitat for Columbia River Basin salmon under study for TES listing. Draft U.S. Department of Agriculture Report, Pacific Northwest Research Station, Corvallis, Oregon.

Sexaur, H.M., and P.W. James. 1997. Microhabitat use by juvenile bull trout in four streams located in the eastern Cascades, Washington. Pages 316-370.In. Mackay, W.C., M.K. Brewin and M. Monita. Friends of the bull trout conference proceedings. Calgary, Alberta.

Shelton, J.M. 1955. The hatching of chinook salmon eggs under simulated stream conditions. Prog. Fish-Cult. 17:20-35.

Shepard, B., K. Pratt, and J. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River Basin, Montana. Montana Department of Fish, Wildlife and Parks, Kalispell.

Snow, C., C. Frady, A. Fowler, and A. Murdoch. 2008. Monitoring and evaluation of Wells and Methow Hatchery Programs in 2007. Prepared for Douglas County Public Utility District and Wells Habitat Conservation Plan Hatchery Committee, Twisp, WA.

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and J. D. Rodgers. 1998. Development and evaluation of techniques to rehabilitate Oregon’s wild salmonids. Oregon Department of Fish and Wildlife, Fish Research Project F-125-R-13, Final Report, Portland.

Thompson, R. B. 1966. Effects of predator avoidance conditioning on the post-survival rate of artificially propagated salmon. Ph.D. dissertation submitted to University of Washington, Seattle.

Thurow, R.F. 1994. Underwater methods for study of salmonids in the Intermountain West. General Technical Report INT-GTR-307. United States Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT. 29 pp.

Upper Columbia Salmon Recovery Board (UCSRB). 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. 307 pp.

U.S. Fish and Wildlife Service (USFWS). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 137 pp.

U.S. Fish and Wildlife Service (USFWS). 2003. Bull Trout monitoring results. Unpublished Wenatchee Basin annual redd survey report provided by Barbara Kelly Ringel, USFWS Mid Columbia River Fishery Resource Office. 15 pp.

U.S. Fish and Wildlife Service (USFWS). 2004. Bull Trout monitoring results. Unpublished Wenatchee Basin annual redd survey report provided by Barbara Kelly Ringel, USFWS Mid Columbia River Fishery Resource Office. 17 pp.

U.S. Forest Service (USFS). *In prep*. Methow Sub-basin bull trout redd survey report 2008. Draft report provided by Gene Shull, U.S. Forest Service. Winthrop, WA. 15 pp.

Van Dyke, E.S., D.L. Scarnecchia, B.C. Jonasson, and R.W. Carmichael. 2009. Relationship of winter concealment habitat quality on pool use by juvenile spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Grande Ronde River Basin, Oregon USA. Hydrobiologia 625:27-42.

Wade, G. 2002. Salmon and Steelhead Habitat Limiting Factors, WRIA 25 (Grays-Elochoman). Washington Department of Ecology.

Watson, G. and T.W. Hillman. 1997. Factors affecting the distribution and abundance of bull trout: and investigation at hierarchical scales. North American Journal of Fisheries Management 17:237-252.

Yakama Nation Fisheries Resource Management (YNFRM). 2009. Mid-Columbia coho restoration master plan. Prepared for the Northwest Power and Conservation Council. 197 pp.

# Appendix 10. Effect of Surface Water Withdrawals on ESA-Listed Fish

Report Prepared by:

Randolph Ericksen,

Clark Watry,

Ian Courter,

Jay Vaughan

and

Shadia Duery

Cramer Fish Sciences
600 NW Fariss Road
Gresham, Oregon 97030

**November 2010**

# TABLE OF CONTENTS

# LIST OF FIGURES

## LIST OF TABLES

# 1.0 SUMMARY

A total of five proposed primary sites in the Wenatchee and five in the Methow Subbasin require new water sources. Three primary sites within the Wenatchee Subbasin (Dryden, Chikamin, and Tall Timber) and one within the Methow Subbasin (Twisp Weir) will require surface water withdrawals. These withdrawals will have local impacts to surface water from the point of withdrawal to the point of discharge. The impacts to listed fish will be limited to the affected portion of the stream and will vary depending on stream flow, species and life-stage.

Depending on the final design of the proposed hatchery at Dryden, water withdrawals could have no measureable impact, or increase available habitat in a 200 ft section of Peshastin Creek during low flows.

The maximum amount of water proposed for withdrawal at the Chikamin site would result in a very small reduction in weighted useable area (WUA) for all species. The reduction due to the withdrawal was less than one square foot of habitat for all species and life-stages.

The effect of the proposed withdrawal at the Tall Timber site on ESA listed fish varied with the flow and species. The maximum proposed withdrawal at this site generally resulted in small decreases in WUA for most species at extreme low flows, and slight increases in WUA at higher flows. However, the modeled withdrawal generally increased WUA for Chinook salmon rearing.

The proposed surface water withdrawal at the Twisp Weir site was projected to generally decrease the WUA of habitat for most species during low flows by a small amount.

We caution readers that the absolute values presented in this report are presented to evaluate the relative effect of surface water withdrawals. The model predictions for the amount of WUA under the different scenarios should be used with caution, because the difference in flow between the two scenarios is small and model analyses are most useful for evaluating a broad range of flows. Specific values are provided to demonstrate that the relative change in WUA for all species and life-stages.

The remaining sites require groundwater withdrawals that are expected to have some localized impacts to surface waters that will be completely offset by water discharged into the acclimation site. Because water is returned to the site, there will be no watershed impacts to surface water flow.

The amount of habitat reduced through water withdrawals under the proposed alternative is not likely to have a measureable impact compared to past and current impacts and those likely to occur.

Potential negative impacts to ESA listed fish can be avoided or minimized by:

- Using existing sites wherever possible.
- Minimizing the distance between surface water withdrawals and returns.
- Returning ground water to surface streams at locations that minimize pumping impacts.
- Constructing and operating intakes that meet guidelines for juvenile fish screens.

## 2.0 INTRODUCTION

Information in this report has been prepared as a companion document to support the Environment Impact Statement (EIS) of the Yakama Nation's Mid-Columbia Coho Reintroduction Project (MCCRP). The objective of this technical report was to evaluate the effect of project related water withdrawals on fish listed under the Endangered Species Act (ESA). Project site details such as their locations; project descriptions; and associated maps, figures, and photographs, are presented in the *Brood Capture and Rearing Site Descriptions* report (Appendix 1 of the EIS), the *Wenatchee Acclimation Site Descriptions* report (Appendix 2 of the EIS) and the *Methow Acclimation Site Descriptions* report (Appendix 3 of the EIS) prepared for the project, and are not duplicated in this report. Maps of the Wenatchee and Methow Subbasins showing the location of proposed acclimation and rearing sites are shown on Figure 1-2 in Appendix 1, and Figures 1-1 in Appendix 2 and Appendix 3. Figures 2-1 in Appendix 2 and 3 include the site locations based on Section, Township, and Range as well as their latitude and longitude. Site specific information on the presence of listed fish and effects of acclimation activities are discussed in *Presence and Impact of Fish Culture on Listed Fish* (Appendix 9 of the EIS). The effect of groundwater withdrawals on surface water is found in *Groundwater Withdrawal Impact Report* (Appendix 11 of the EIS).

The Washington Department of Ecology (WDEC) is charged both with administering state water rights laws and the federal Clean Water Act. Chapters 90.54 and 90.22 RCW require WDEC to maintain instream flows sufficient to protect and preserve fish and wildlife habitat, scenic and aesthetic values, navigation and other environmental values (WDFW and WDOE 2004). The Washington Department of Fish and Wildlife (WDFW) recommends instream flows to be conditions of water rights or Clean Water Act Section 401 certification (issued by WDEC). When a major water project is planned, WDFW and WDEC request that the project proponent conduct an instream flow study to provide adequate information on which to base an instream flow recommendation or requirement. WDFW defines a major water project as a project that:

a) diverts at least 1.0 cubic feet per second (cfs), and

b) changes flow by at least 10% of the monthly 90% exceedence flow (the flow that is equaled or exceeded 90 percent of the time) at any point along the stream channel.

The proposed surface water withdrawals are greater than 1.0 cfs, but less than 10% of the monthly 90% exceedance flows and are therefore not considered major water projects.

ESA listed fish that are likely to be present at these sites include spring Chinook *Oncorhynchus tshawytscha*, summer steelhead *O. mykiss,* and bull trout *Salvelinus confluentus*. The Upper Columbia River spring-run Chinook salmon Evolutionary Significant Unit (ESU) was listed as endangered on March 24, 1999 (64 FR 14308), and its status was reaffirmed on June 28, 2005 (70 FR 37160). The ESU includes all naturally spawned populations of spring-run Chinook salmon (spring Chinook) in Columbia River tributaries upstream of the Rock Island Dam as well as six artificial propagation programs. The Upper Columbia River steelhead distinct population segment (DPS) was listed as endangered on August 18, 1997 (62 FR 43937) and subsequently upgraded to 'threatened" status in 2009 (74FR 42605). Critical Habitat was designated in the Wenatchee and Methow basins for both Chinook and steelhead in 2005 (70 FR 52630). Columbia River bull trout were listed as threatened on June 10, 1998 (63 FR 31647). The Wenatchee, Entiat, and Methow Rivers have been identified as core bull trout habitats for the

Upper Columbia Recovery Unit, and designated as Critical Habitat October 18, 2010 (75 FR 63898).

# 3.0 METHODS

A total of five primary sites in the Wenatchee and five in the Methow Subbasin require new water sources (Table 1). Three primary sites within the Wenatchee Subbasin (Chikamin, Tall Timber and Dryden) and one within the Methow Subbasin (Twisp Weir) will require surface water withdrawals. The affected environments for these sites include the affected stream from the point of diversion to the point of discharge, unless noted otherwise. The impact of these surface withdrawals on the affected environment is analyzed in detail below. The remaining sites will require new groundwater sources. The effect of these groundwater withdrawals on surface water flows is discussed in *Groundwater Withdrawal Impact Report* (Appendix 11 of the EIS). Only the impacts resulting from the change in surface flows on ESA listed fish are discussed in this report.

**Table 1. Proposed sites within the Wenatchee and Methow Subbasins that require new water sources.**

| Site name | Affected stream | Water source | Purpose[a] |
|---|---|---|---|
| Wenatchee primary sites | | | |
| Butcher | Butcher | ground | overwinter |
| Chikamin | Chikamin | surface | spring |
| Rohlfing | unnamed | ground | overwinter |
| Tall Timber | Napeequa | surface | spring |
| Dryden[b] | Peshastin/Wenatchee | ground/surface | hatchery/overwinter |
| Wenatchee backup | | | |
| George | Wenatchee | ground/surface | hatchery |
| Squadroni | unnamed | ground | spring |
| Methow primary sites | | | |
| Lincoln | Twisp River | ground | overwinter |
| Lower Twisp | Twisp River | ground | overwinter |
| Mason | Eight Mile | ground | overwinter |
| MSWA Eight Mile | Chewuch side channel | ground | spring |
| Twisp Weir | Twisp River | ground/surface | overwinter |
| Methow backup | | | |
| MSRF Chewuch | Chewuch River | ground | overwinter |
| Newby | Twisp River | surface | spring |

[a] Overwinter rearing, spring acclimation, or proposed hatchery site.
[b] Dryden is a proposed hatchery site that is still under design. It would use either groundwater or surface water depending on the ongoing evaluations. The site is also listed as a backup overwinter acclimation site.

A small hatchery facility is proposed for the Dryden site for coho and steelhead adult capture and culture purposes. This site is also a backup overwinter rearing site. Both surface water and groundwater (wells and/or infiltration galleries) sources are being considered. The effect of surface water withdrawals on listed fish at the Dryden site was evaluated using previous Physical

Habitat Simulation System (PHABSIM) modeling for the lower Wenatchee River and Peshastin Creek (EES Consulting 2005). A backup hatchery facility is proposed for the George site in the event that the Dryden site is not developed. A similar PHABSIM analysis was conducted for this site.

The effects of surface water withdrawal on listed fish at the Chikamin and Tall Timber sites were evaluated using a two-dimensional hydraulic and habitat model (River2D) intended for use on natural streams and rivers; this program was developed at the University of Alberta with funding provided by numerous governmental agencies including the United States Geological Survey (Steffler and Blackburn 2002). Two-dimensional modeling produces similar results to PHABSIM; however, River 2D is also able to model complex flow conditions which PHABSIM cannot (Gard 2009a). The model predicts the relative change in fish habitat at different flows; and compared to other models, River2D is regarded as more robust and capable of reproducing results (Gard 2009b). Model inputs included bed topography for the active channel and adjacent floodplain, bed roughness and transverse eddy viscosity distributions, boundary conditions, and initial flow conditions. Using model inputs, a discrete mesh, or grid, was designed to capture active channel flow variations. The preliminary mesh was refined to interpolate data for areas with poor resolution to increase modeling accuracy. From the refined mesh, the hydraulic component predicts velocities and depths throughout the channel to be used in the fish habitat component of the model.

The fish habitat component of River2D was based on the Weighted Usable Area (WUA) (Bovee, 1982) concept used in PHABSIM and other fish habitat models. The WUA was calculated as an aggregate of the product of a composite suitability index (CSI, range 0.0 - 1.0) evaluated at every point in the domain and the "tributary area" associated with that point. The suitability index for each parameter is evaluated by linear interpolation from an appropriate fish preference curve. The Chinook and steelhead preference curves used in these analyses were developed in Washington State for each target species and life stage as presented in WDFW and WDOE (2004). The preference curves for juvenile and adult bull trout used in this analysis (see Appendix A of EES Consulting 2005) were developed specifically for the Wenatchee Basin and utilized more data sets than Washington standard criteria (WDFW and WDOE 2004). To determine the overall wetted area, we used a 100% preference curve for suitability at depths greater than zero. WUA was calculated for each species and life stage. Further River2D model details can be found in Steffler and Blackburn (2002).

The Twisp Weir site is the only primary acclimation site located in the Methow Subbasin that would require a new surface water withdrawal. The effect of surface water withdrawals on listed fish at the proposed Twisp Weir site was assessed using PHABSIM analysis.

The model predictions for the amount of WUA under the different scenarios should be used with caution, because the difference in flow between the two scenarios is small and model analyses are most useful for evaluating a broad range of flows. Specific values are provided to demonstrate that the relative change in weighted useable area (WUA) is expected to be extremely small for all species and life-stages.

## 4.0 IMPACT ANALYSIS

The potential effects described below are common to all acclimation sites where new water sources impact surface water, although the extent and duration may vary between sites. Other impacts due to fish culture are discussed in a separate report entitled Presence and Impact of Fish Culture on Listed Fish (Appendix 9 of the EIS) prepared for the project. Potential impacts specific to each primary site listed in Table 1 are further discussed in following sections.

The impact of water withdrawals on fish will depend on the type of water (surface or ground water), the length of stream affected, the amount of water withdrawn, the time of year, and the amount of surface water available. In general, potential impacts are expected to be greater where surface water is withdrawn directly from the stream, rather than groundwater withdrawals where the effect on surface water is dispersed over a larger area. Where surface water is withdrawn directly from a stream, the affected reach will include that portion of stream from the point of diversion to the discharge site. Withdrawing water during low flow periods has the potential to affect fish migration, and availability and quantity of habitat. Withdrawing water during high flow periods can improve habitat by reducing depth and velocities that are greater than optimal for fish. However the volume of water proposed to be diverted is relatively small and is not expected to substantially reduce instream flow quantities, change habitat availability including hiding/resting/foraging habitats, or affect migratory movements (fry, juvenile, and adult) of listed salmonids.

Another potential impact to listed fish due to surface water withdrawals is entrainment in the intake system. If allowed to pass through the intake screens, fry of a small enough size could be subject to predation by coho in the acclimation ponds, and all entrained fish could have free migration delayed by the pond discharge fish screens. Fish entering the Dryden intake could be harmed by pump impellor blades and by rapid pressure changes in the water supply system.

Fish screen guidelines have been published by the National Marine Fisheries Service (NMFS 1996) that minimize risks to anadromous fish. Structure placement, approach velocity, sweeping velocity, screen material, structural features, operation, and maintenance criteria have been developed. The intake systems at all sites will meet these screen guidelines to reduce threats to all fish.

## 4.1 Surface Water Withdrawal Impacts

### 4.1.1 Wenatchee Subbasin

#### *4.1.1.1 Dryden Site*

A small hatchery is proposed to be developed at this site. A combination of surface and groundwater sources is being explored to supply of up to 7.4 cfs (4.5 cfs surface water) to the site. The amount needed changes over the year (Figure 1). The impact of groundwater withdrawals on surface water is expected to be small as discussed in section 4.2.1.2 of this report.

An intake located on the Dryden fishway is currently the preferred source for surface water. Two options are being considered for the return flow. One is to discharge return water into Peshastin Creek upstream of the fishway, and another is in a pipeline on the river bottom in the vicinity of the fishway near the proposed intake. The Peshastin discharge could help adult salmon navigate the mouth during low flow and would increase flow from the discharge site to the intake site downstream. Discharge near the fishway could help flush rock away from the fishway but would essentially result in minimal change in flow because water would be discharged near the intake.

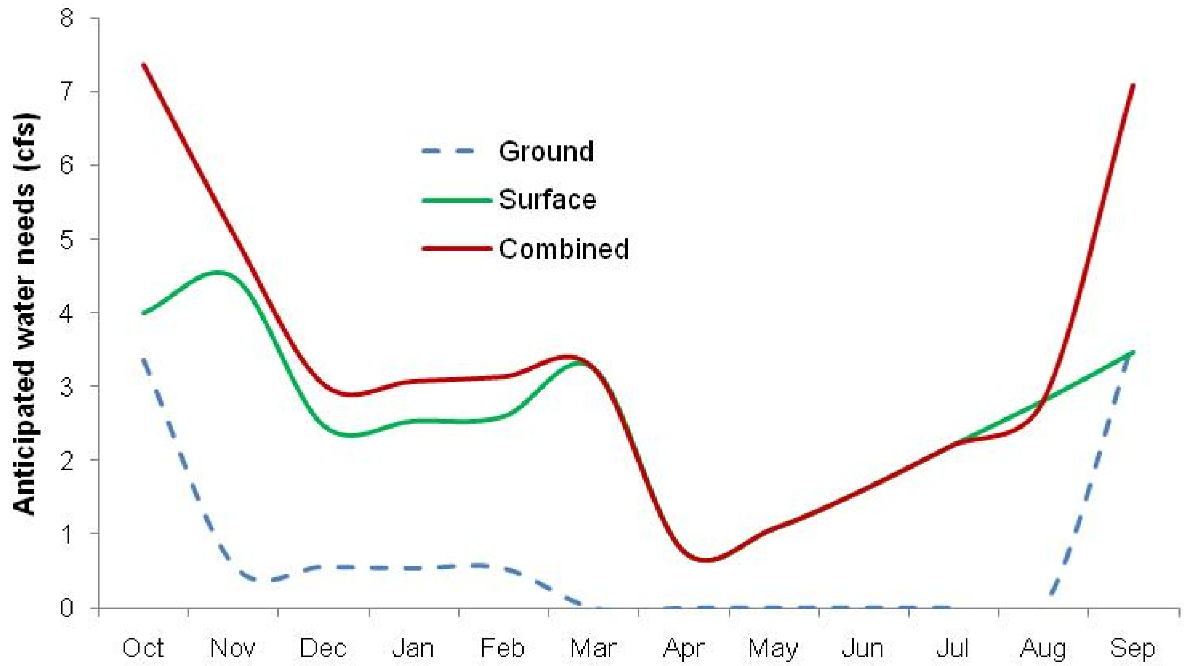



**Figure 1. Proposed water needs for all species at the proposed MCCRP Dryden hatchery.**

We used the PHABSIM analysis developed by EES Consulting to assess the potential impacts of the proposed MCCRP component of the Dryden hatchery water use on ESA listed fish in Peshastin Creek and Wenatchee River. We analyzed the Peshastin discharge option because it has the largest possible impact on stream flow, and therefore represents the greatest potential to affect fish and fish habitat. The affected environment would include Peshastin Creek from the point of discharge downstream to the proposed intake at the fishway in the Wenatchee River. This includes about 200 lineal feet of Peshastin Creek, and 650 feet of the Wenatchee River. The daily mean flow in Peshastin Creek ranges from a low of around 10 cfs in mid-August to over 500 cfs in May (Figure 2). The daily mean flow in the Wenatchee River ranges from a low of around 750 cfs in September to nearly 10,000 cfs by late May (Figure 2).

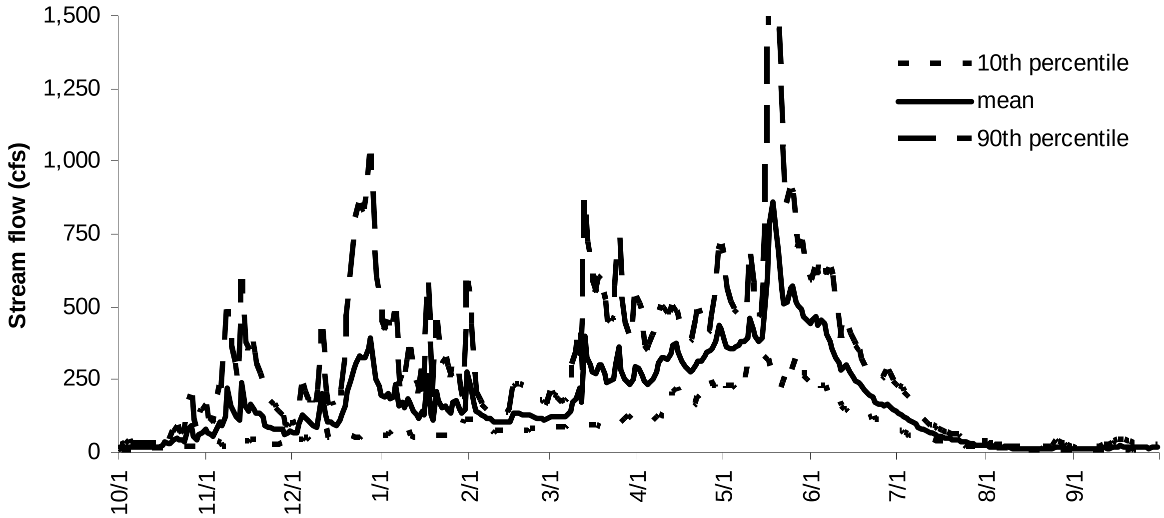



**Figure 2. Peshastin Creek stream gage data collected at Green Bridge Rd by Washington Department of Ecology, 2002-2009 (Data source: https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=45F070).**

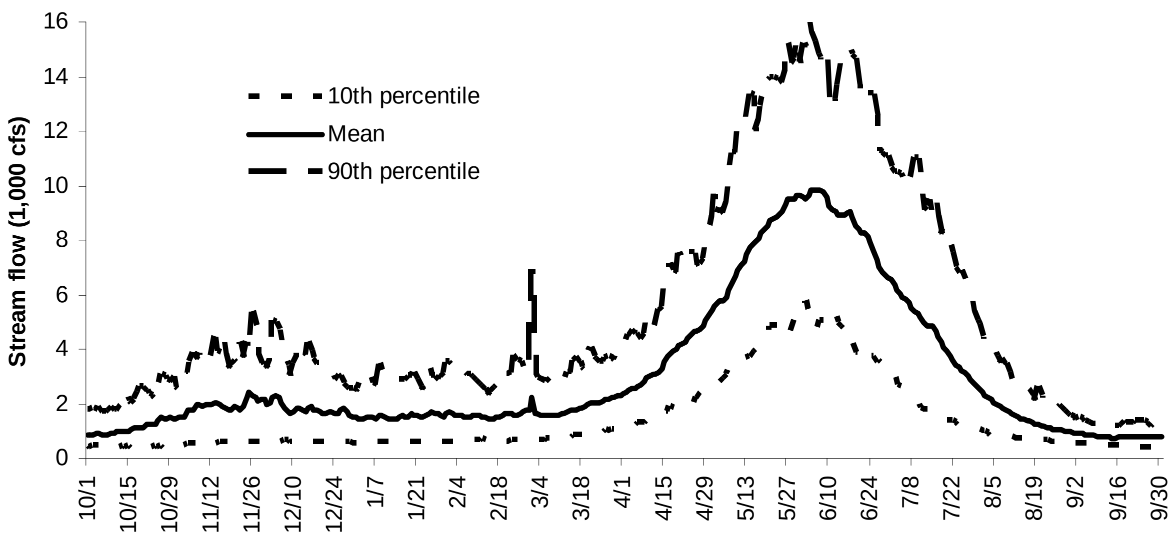



**Figure 3. Wenatchee River stream gage data collected at Peshastin by US Geological Survey, 1930-2008 (Data source: http://waterdata.usgs.gov/wa/nwis/inventory/?site_no=12459000&agency_cd=USGS&).**

EES Consulting (2005) completed PHABSIM analyses of four reaches of the mainstem Wenatchee River from the Leavenworth National Fish Hatchery downstream to its mouth, and the lower reach of Peshastin Creek from approximately RM 5.0 downstream to its mouth. They estimated that spawning habitat WUA was maximized at Peshastin Creek flows of 80 cfs for non-ESA listed summer Chinook salmon (spring Chinook do not spawn in the affected portions of the Wenatchee River and Peshastin Creek) and 120 cfs for ESA listed summer steelhead (Figure 4 top). Estimated rearing habitat was maximized at flows of 55 cfs for Chinook, 130 cfs for steelhead, and 19 cfs for bull trout (Figure 4 bottom).

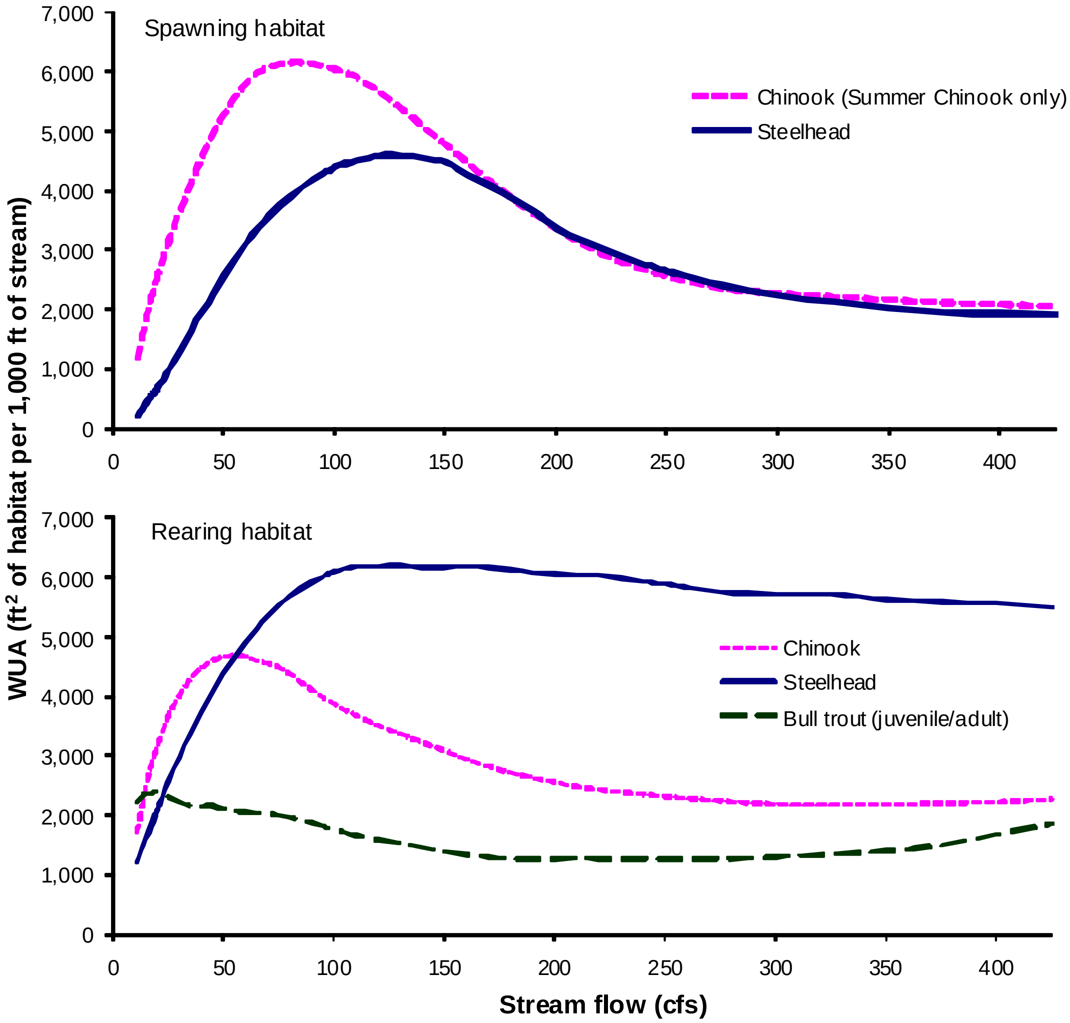



**Figure 4. Estimated weighted useable area (WUA) of spawning habitat (top) and rearing habitat (bottom) as a function of stream flow in Peshastin Creek. Figure derived from EES Consulting (2005).**

The portion of the Wenatchee River from Peshastin Creek down to Dryden Dam was encompassed in Reach 1 of their analysis. EES Consulting (2005) estimated that spawning habitat was optimized in this reach of the Wenatchee River at flows of 2,800 cfs for Chinook and 2,400 cfs for steelhead (Figure 5 top). Estimated rearing habitat was maximized at flows of 400 cfs for Chinook, 900 cfs for steelhead, and 220 cfs for bull trout (Figure 5 bottom).

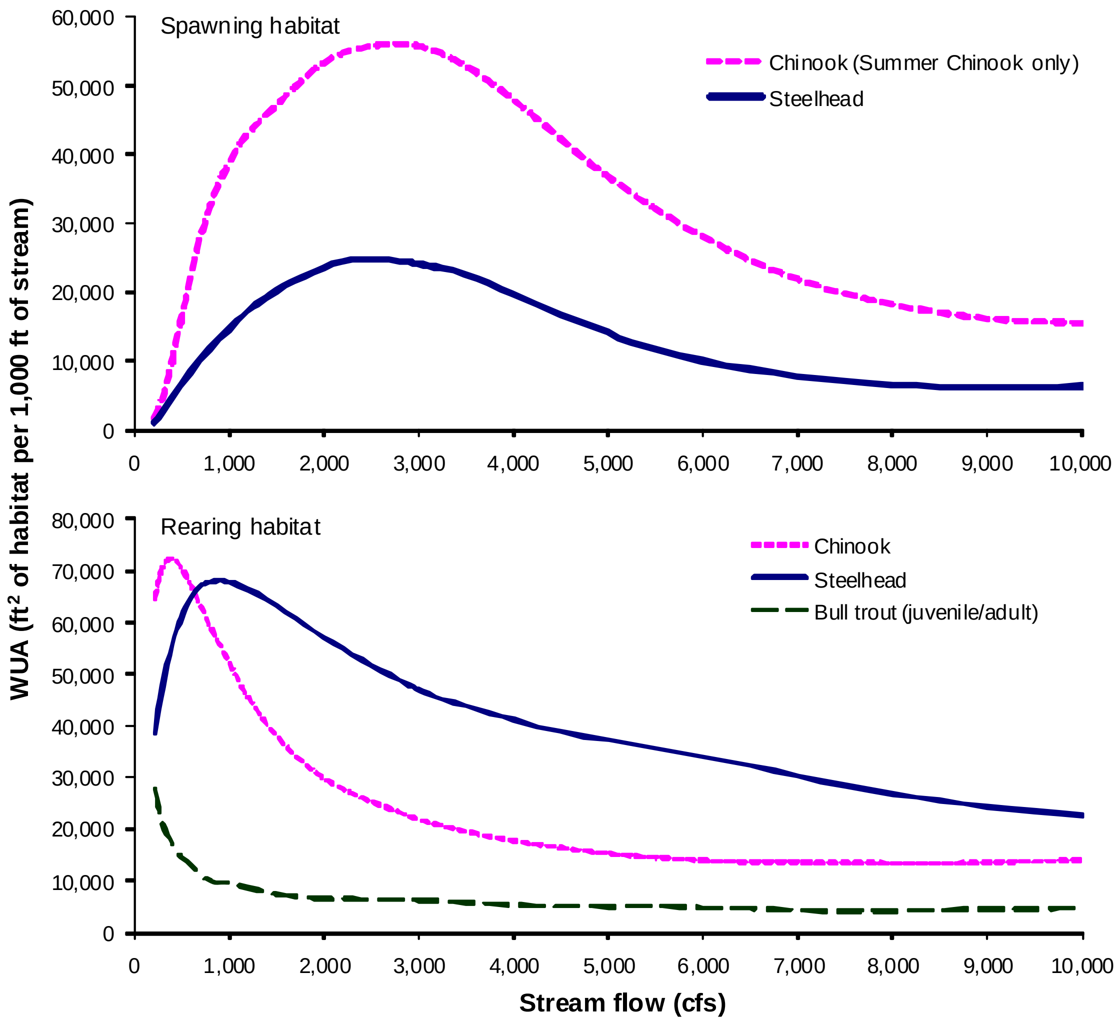



**Figure 5. Estimated weighted useable area (WUA) of spawning habitat (top) and rearing habitat (bottom) as a function of stream flow in the Wenatchee River. Figure derived from EES Consulting (2005).**

For modeling purposes, we assumed that 6.2 cfs (approximately 40% above the maximum proposed surface water needs, Figure 1) of water was drawn from the proposed intake site at the Dryden fishway and discharged upstream into Peshastin Creek (impact reach). This would result in a net increase of 6.2 cfs flow from the point of discharge to the intake site and that downstream flows would not be affected (because the increased flow would be offset by the intake). In reality, the amount of water needed will vary depending on the time of year (Figure 1) so the change in flow will be substantially less during some months than others. We evaluated WUA of spawning habitat for summer Chinook salmon during August and September, and steelhead from March through May. WUA of rearing habitat was evaluated over the entire year for all species. For each time period, we evaluated the minimum and maximum mean daily flows and the extreme low flow (minimum 10$^{th}$ percentile flow) where possible. For Peshastin Creek, the extreme low flow and maximum mean flows were sometimes beyond the range of flows used in the PHABSIM analysis (EES Consulting 2005). The Peshastin River extreme low flows were outside the range of flows used in the PHABSIM analysis so we were not able to evaluate the impact on habitat at these flows .

**Table 2. Estimated percent of weighted useable area (WUA) of habitat for various flow values in Peshastin Creek compared to the additional flow resulting from a discharge of 6.2 cfs into Peshastin Creek from the proposed MCCRP component at the Dryden hatchery.**

| Species | Lifestage | Timing | Flow type | Flow (cfs) | % of WUA | +6.2cfs % of WUA |
|---|---|---|---|---|---|---|
| Chinook | Spawning | Aug-Sep | Optimal | 80 | 100.0% | |
| | | | Extreme low[a] | 1 | | |
| | | | Mean low | 10 | 15.9% | 34.8% |
| | | | Mean high | 22 | 45.9% | 57.1% |
| | Rearing | All year | Optimal | 55 | 100.0% | |
| | | | Extreme low[a] | 1 | | |
| | | | Mean low | 10 | 32.5% | 58.2% |
| | | | Mean high[b] | 425 | 48.2% | 48.4% |
| Steelhead | Spawning | Mar-May | Optimal | 120 | 100.0% | |
| | | | Extreme low | 74 | 80.7% | 85.7% |
| | | | Mean low | 120 | 100.0% | 99.9% |
| | | | Mean high[b] | 425 | 41.6% | 41.5% |
| | Rearing | All year | Optimal | 130 | 100.0% | |
| | | | Extreme low[a] | 1 | | |
| | | | Mean low | 10 | 17.7% | 28.3% |
| | | | Mean high[b] | 425 | 88.8% | 88.6% |
| Bull trout | Rearing | All year | Optimal | 19 | 100.0% | |
| | | | Extreme low[a] | 1 | | |
| | | | Mean low | 10 | 91.1% | 98.6% |
| | | | Mean high[b] | 425 | 77.3% | 79.4% |

[a] The extreme low represented by the minimum 10th percentile of daily flows for that period, was more than 10% less than the lowest flow used in the PHABSIM analysis by EESConsulting. No estimates of WUA were available.

[b] The mean high was greater than 10% of the highest flow used in the PHABSIM analysis by EES Consulting. We used the highest value they evaluated in this analysis.

The increased flow had very little effect on the modeled percent of WUA in the Wenatchee River (Table 3). Although there were both positive and negative effects on the percent of WUA, the difference was always less than 1%.

The increased flow typically resulted in a modeled increase in the percent of WUA in Peshastin Creek but varied with species and lifestage (Table 2). The increased flow had a greater effect on WUA at low flows than during high flow periods. Optimal flow for summer Chinook salmon spawning (80 cfs) is typically not reached during the spawning season so any increase in flow had a positive effect on amount of WUA. The increased flow during the mean low flow increased the percent of WUA of summer Chinook salmon spawning habitat from 15.9 to 34.8%. In a few scenarios, the increased flow resulted in slight reductions (less than 1%) in the percent of WUA.

**Table 3. Estimated percent of weighted useable area (WUA) of habitat for various flow values in the Wenatchee River compared to the additional flow resulting from a discharge of 6.2 cfs into Peshastin Creek from the proposed MCCRP component at the Dryden hatchery.**

| Species | Lifestage | Timing | Flow type | Flow (cfs) | % of WUA | +6.2cfs % of WUA |
|---|---|---|---|---|---|---|
| Chinook | Spawning | Aug-Sep | Optimal | 2,800 | 100.0% | |
| | | | Extreme low | 405 | 17.2% | 17.9% |
| | | | Mean low | 751 | 53.5% | 54.0% |
| | | | Mean high | 2,310 | 98.4% | 98.5% |
| | Rearing | All year | Optimal | 400 | 100.0% | |
| | | | Extreme low | 397 | 99.9% | 99.9% |
| | | | Mean low | 751 | 84.6% | 84.3% |
| | | | Mean high | 9,840 | 19.3% | 19.3% |
| Steelhead | Spawning | Mar-May | Optimal | 2,400 | 100.0% | |
| | | | Extreme low | 664 | 37.9% | 38.4% |
| | | | Mean low | 1,570 | 83.6% | 83.8% |
| | | | Mean high | 9,660 | 24.8% | 24.8% |
| | Rearing | All year | Optimal | 900 | 100.0% | |
| | | | Extreme low | 397 | 81.2% | 81.9% |
| | | | Mean low | 751 | 99.1% | 99.2% |
| | | | Mean high | 9,840 | 33.8% | 33.7% |
| Bull trout | Rearing | All year | Optimal | 220 | 100.0% | |
| | | | Extreme low | 397 | 62.7% | 61.9% |
| | | | Mean low | 751 | 38.0% | 37.7% |
| | | | Mean high | 9,840 | 16.2% | 16.2% |

The results of this analysis indicated that withdrawing water from the Dryden fishway and discharging it into Peshastin Creek would generally have a positive effect on ESA listed fish in Peshastin Creek and little to no effect on those in the Wenatchee River. The effects will be limited to the impact reach and the magnitude will depend on the amount of water involved.

Fish passage at the mouth of Peshastin Creek has been identified as being limited by low flow conditions in the late summer and early fall (Andonaegui 2001, NPCC 2004). Discharge of hatchery water into the creek during these periods could improve hydraulic conditions for returning adults.

#### *4.1.1.2 Chikamin Site*

Chikamin Creek is a tributary of the Chiwawa River which accounts for 44% of the Chinook, 12% of the steelhead, and 78% of the bull trout spawning redds counted in the Wenatchee Subbasin (see Appendix 9 of the EIS for more information). Chinook spawning has not been documented in Chikamin Creek although summer steelhead and bull trout have been documented spawning in the stream. Chikamin Creek on average represents 3% of the subyearling Chinook, 8% of the subyearling and 5% of the yearling rainbow/steelhead abundance estimated in the Chiwawa drainage. Chikamin Creek also represented 13% of the juvenile bull trout abundance in the Chiwawa drainage in 2007, but the survey does not include many upper tributaries where bull trout likely reside (Hillman et al. 2008). A new pond is proposed to be constructed next to Chikamin Creek and would be fed with surface water from the creek. The affected reach would include Chikamin Creek from the intake downstream about 450 feet of channel to the discharge pipe (Figure 6).

Model inputs for the Chikamin analysis (Table 4) were based on onsite topographic survey and data from a stream gage located immediately downstream of the site. Topographic data from the affected reach of the creek (Figure 6) was collected during the fall of 2009. A second survey was conducted on April 27, 2010 to gather additional flow and channel data.

**Table 4. Topographic survey dates and model inputs used in the River2D model to evaluate surface water withdrawal impacts to listed fish.**

| | Chikamin | Napeequa |
|---|---|---|
| Channel topography survey dates | Oct. 19-20, 2009 | Oct. 5 - Nov. 5, 2009 |
| Date water edge surveyed | Oct. 19, 2009 | Oct. 7, 2009 |
| Flow during water edge survey | 13.7 | 34.4 |
| Date second survey | Apr. 27, 2010 | Apr. 26-27, 2010 |
| Flow during second survey | 81.6 | 242 |
| Minimum withdrawal (cfs) | 1.5 | 1.7 |
| Maximum withdrawal (cfs) | 2.3 | 2.6 |
| Withdrawal period | Mid March to early May | Mid-March to early May |
| Mean flow range (cfs) | 20-68 | 109-372 |
| Extreme low flow (cfs) | 8.5 | 47 |

Surface water is proposed to be withdrawn from Chikamin Creek from mid March through early May to provide water to the acclimation pond. A minimum flow of 1.5 cfs is required for coho acclimation at this site (Appendix 2 of the EIS) and assumed withdrawals 50% greater (2.3 cfs) for modeling purposes. Juvenile Chinook salmon, and adult and juvenile steelhead and juvenile and adult bull trout are expected to be present in Chikamin Creek during this time (Appendix 9 of the EIS). Daily flows typically start to increase around mid March and peak between mid May and early June (Figure 7). Mean flows during the acclimation period ranged between 20 and 68 cfs between 2000 and 2008, with the $10^{th}$ percentile flows as low as 8.5 cfs and $90^{th}$ percentile as high as 105 cfs.

The model results indicated that the amount of habitat in the affected reach of Chikamin Creek would generally increase with flow during the spring acclimation period (Figure 8). However, the amount of WUA of habitat for all species was very small (0.1% or less) compared to the wetted channel area (Table 5). This is due primarily to a lack of finer substrate (gravel and small cobbles) in this reach. As a result, the model did not predict any WUA for steelhead spawning in the affected reach at any flow levels (Table 5). Because WUA generally increased with flow, the modeled water withdrawal of 2.3 cfs tended to reduce the WUA of habitat for all species. The reduction due to the withdrawal was less than one square foot of habitat for all species. Thus, the maximum amount of water proposed for withdrawal would result in a very small reduction in WUA for all species.

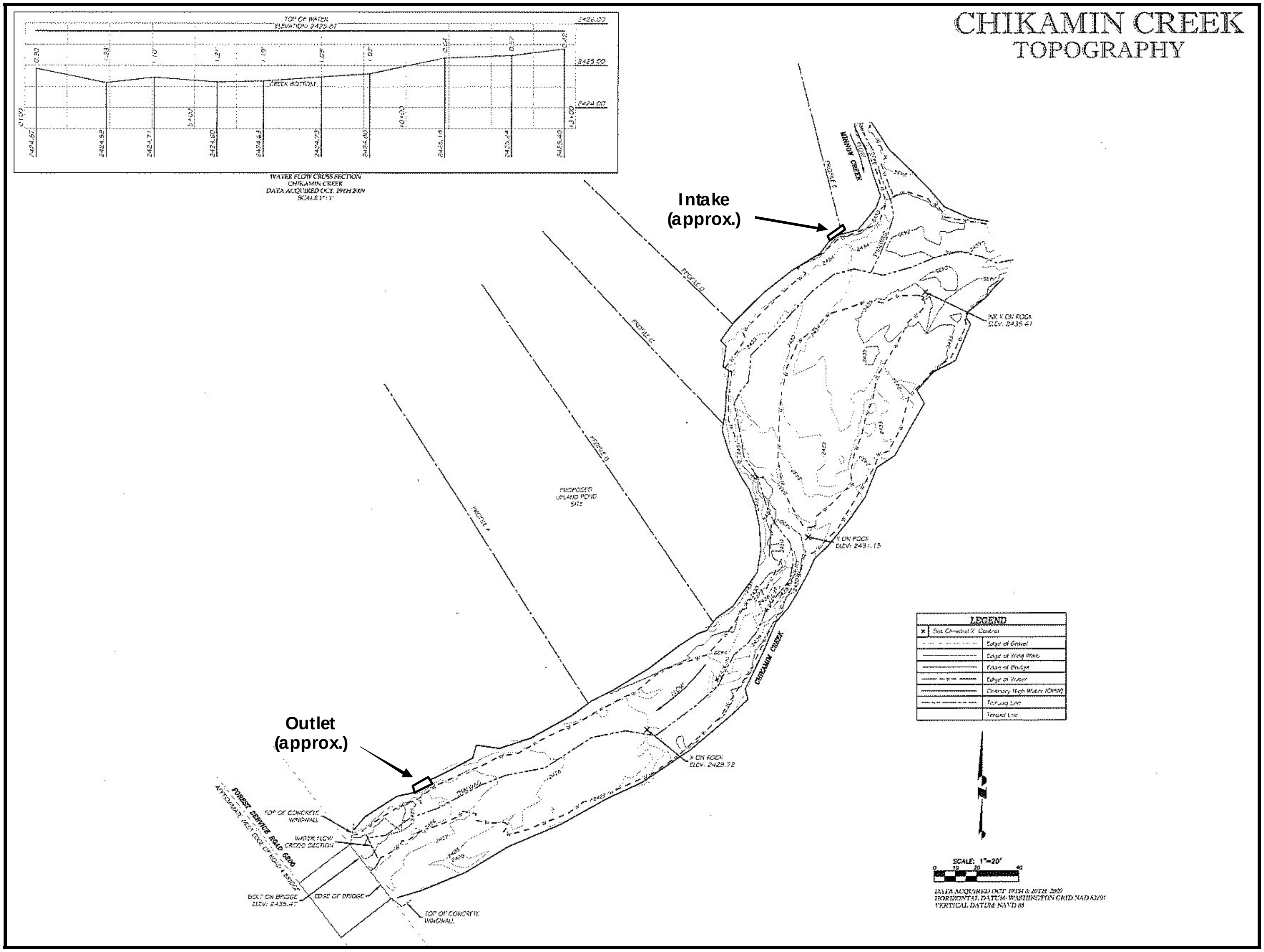



**Figure 6. Chikamin Creek channel topography of the affected reach.**

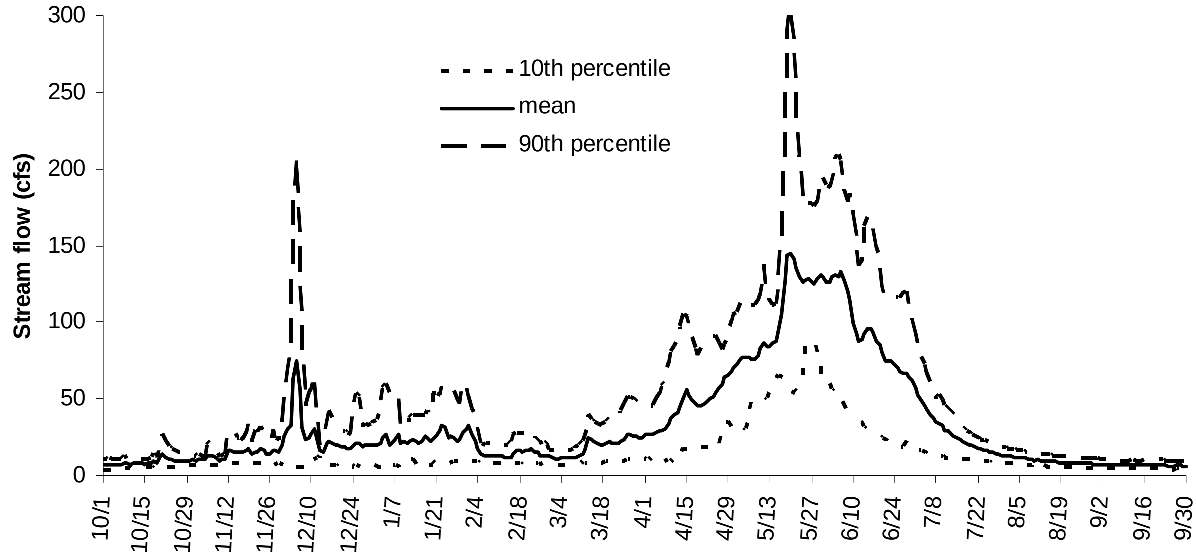



**Figure 7. Chikamin Creek stream gage data collected by the US Forest Service, 2000 – 2008.**

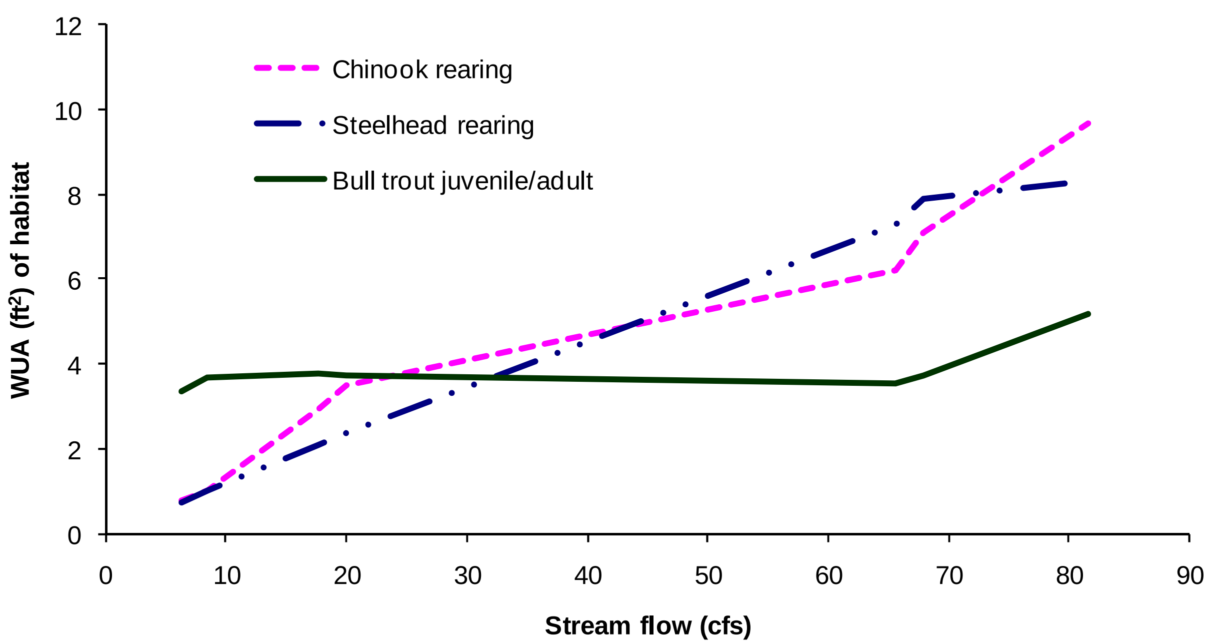



**Figure 8. Estimated weighted useable area (WUA) of habitat as a function of stream flow in the affected reach of Chikamin Creek.**

**Table 5. Modeled weighted useable area (WUA) of habitat in the affected reach of Chikamin Creek for expected flow values during the spring acclimation period and with a maximum withdrawal of 2.3 cfs.**

| Flow type | Model type | Flow (cfs) | Water surface elevation (ft) | Wetted surface area ($ft^2$) | Weighted usable area ($ft^2$) Chinook rearing | Steelhead spawning | Steelhead rearing | Bull trout juvenile/adult |
|---|---|---|---|---|---|---|---|---|
| Extreme low | -2.3 cfs | 6.2 | 2,425.5 | 6,056 | 0.8 | 0 | 0.7 | 3.4 |
| | normal | 8.5 | 2,425.0 | 7,194 | 1.0 | 0 | 1.0 | 3.7 |
| Mean low | -2.3 cfs | 17.7 | 2,425.8 | 9,045 | 2.9 | 0 | 2.1 | 3.8 |
| | normal | 20.0 | 2,425.8 | 9,373 | 3.5 | 0 | 2.4 | 3.7 |
| Mean high | -2.3 cfs | 65.7 | 2,426.3 | 12,848 | 6.2 | 0 | 7.3 | 3.5 |
| | normal | 68.0 | 2,426.4 | 12,909 | 7.1 | 0 | 7.9 | 3.7 |

### *4.1.1.3 Tall Timber Site*

The proposed Tall Timber acclimation site is located adjacent to the glacially fed Napeequa River, a tributary of the White River. The White River watershed represents 6% of the Chinook, 1% of the steelhead, and 10% of the bull trout spawning redds counted in the Wenatchee Subbasin (see Appendix 9 of the EIS for further details). The White River drainage still maintains high quality, complex habitat with refuge and rearing habitat for multiple life stages and life histories (NPCC 2004). Both Chinook and steelhead have been observed spawning in the Napeequa River but few redds have been counted there in recent years (Hillman et al. 2008). No bull trout have been documented spawning in Napeequa River. A portion of the surface water from the Napeequa River is proposed to be diverted into disconnected side channel for acclimating coho salmon. The affected environment would include the Napeequa River from the intake downstream about 1,800 feet of channel to the outlet culvert (Figure 9).

Model inputs for the Tall Timber (Napeequa) analysis (Table 4) were based on onsite topographic survey and a combination of onsite discharge measurements and White River stream gage data. Topographic data from the affected reach of the river (Figure 9) was collected during the fall of 2009. A second survey was conducted on April 26 and 27, 2010 to gather additional flow and channel data.

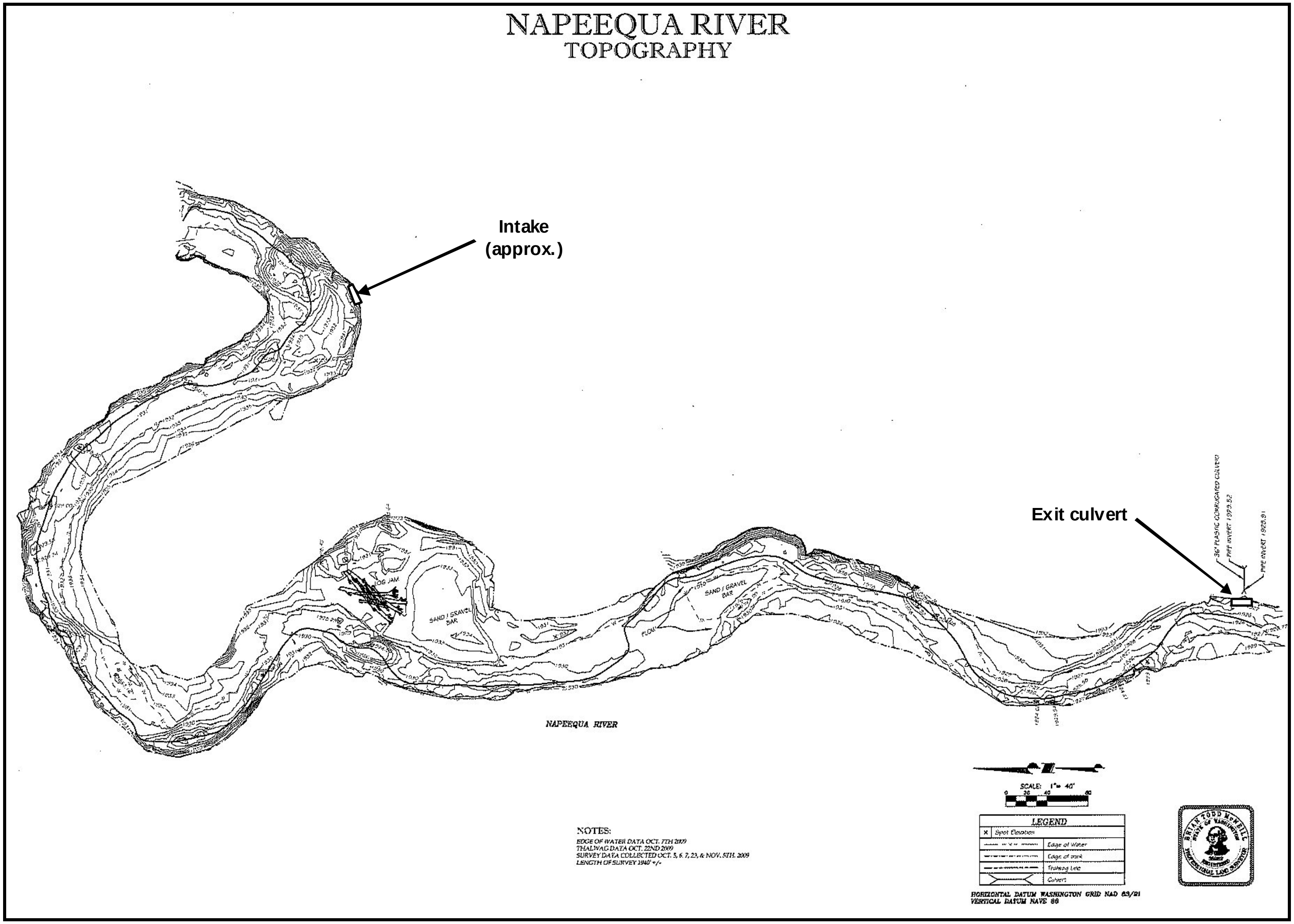



**Figure 9. Napeequa River channel topography of the affected reach.**

Surface water is proposed to be withdrawn from the Napeequa River from mid March through early May. A minimum flow of 1.7 cfs is required for coho acclimation at this site (Appendix 2 of the EIS) and withdrawals were assumed to be 50% greater (2.6 cfs) for modeling purposes. Juvenile Chinook salmon, and adult and juvenile steelhead and migrant bull trout are assumed to be present in Napeequa River during this time (note that steelhead are uncommon in the White River drainage, see Appendix 9 of the EIS). Stream gage data is not available for the Napeequa River. However, a stream gage was operated on the White River at about river mile 6.5 between 1955 and 1983 (Figure 10) by the US Geological Survey (USGS). Washington Department of Ecology has operated a stream gage at the same site beginning in 2002. Daily flows in the White River typically start to increase around the end of March and peak in June (Figure 10). We compared seven flow measurements collected by the USGS between September 1975 and October 2001 (provided by John Clemens, USGS, Tacoma, Washington) and one collected by Cramer Fish Sciences in October 2009, with corresponding White River stream gage data (Figure 11). Flows from the two rivers were highly correlated ($R^2 = 0.94$). This is not surprising because they are both glacially fed rivers, and the Napeequa is the largest tributary in the White River Watershed (NPCC 2004). Based on the regression on the White River stream gage, we estimated that mean flows in the Napeequa River during the acclimation period will range between 109 and 372 cfs with the $10^{th}$ percentile as low as 47 cfs and the $90^{th}$ as high as 732 cfs.

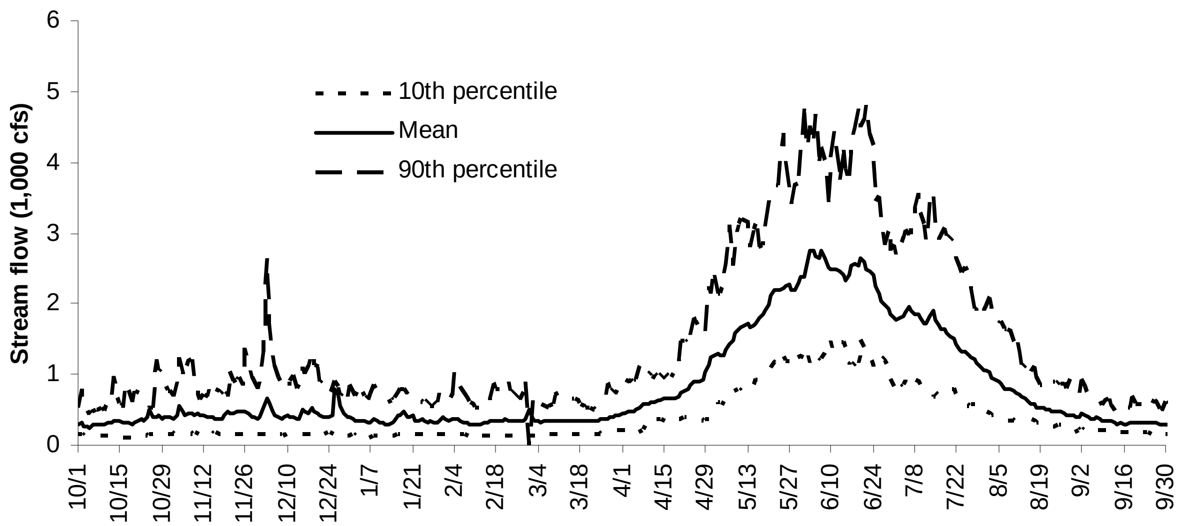



**Figure 10. White River stream gage data collected by the US Geological survey, 1955-1983 (Data source: http://waterdata.usgs.gov/wa/nwis/inventory/?site_no=12454000&agency_cd=USGS&).**

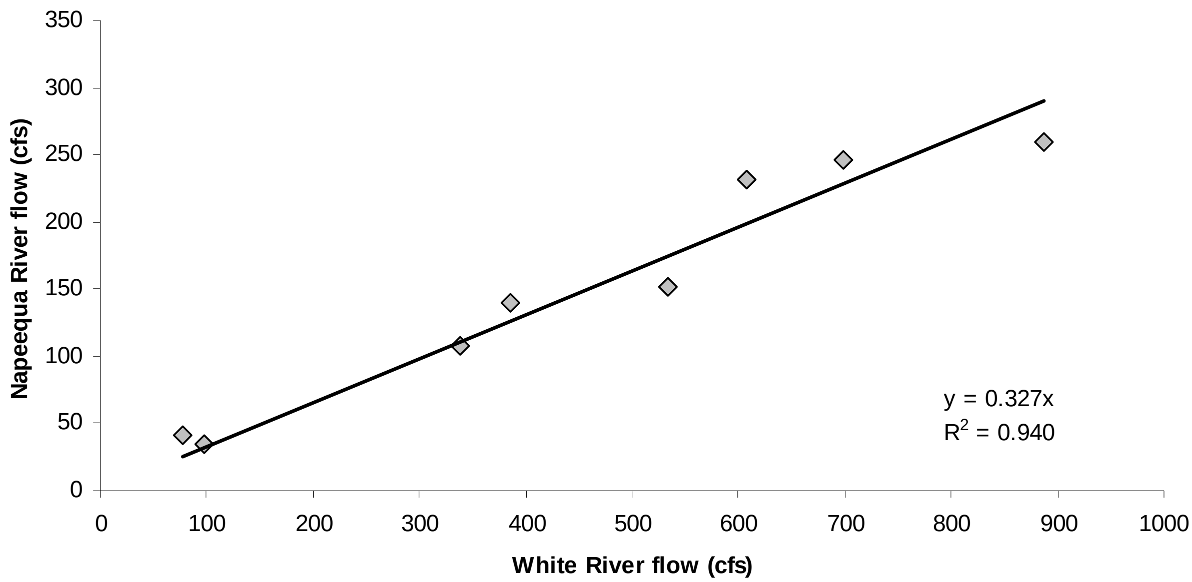



**Figure 11. Relationship between Napeequa and White River flows.**

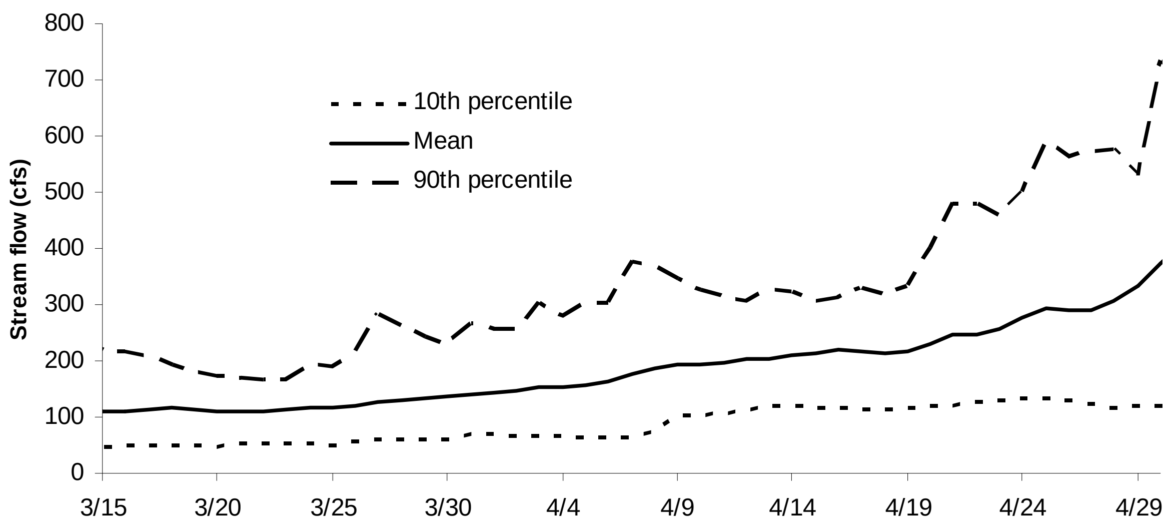



**Figure 12. Estimated Napeequa River flows during the spring acclimation period based on the regression on White River gage data.**

The modeled effect of flow on WUA of habitat in the affected reach of the Napeequa River varied with the species and lifestage during the spring acclimation period (Figure 13). The substrate in the affected reach was dominated by gravel and therefore was more suitable habitat for all species than was modeled for the affected reach of Chikamin Creek. The amount of steelhead spawning WUA peaked at about 13,000 $ft^2$ at 242 cfs and then decreased with increased flow (Table 6). The WUA of Chinook rearing habitat generally decreased with flow until about 180 cfs and then increased slightly. The modeled water withdrawal of 2.6 cfs tended to reduce the WUA of habitat for most species except at the highest flows which showed a slight increase for all species except bull trout which decreased by 3% (Table 6). The withdrawal generally increased WUA for Chinook salmon rearing. The change in WUA due to the water withdrawal was typically 1% or less for each modeled flow type except for the extreme low flow. The modeled 2.6 cfs withdrawal at the extreme low flow resulted in a 3% increase in Chinook rearing, a 5% decrease in steelhead spawning, a 2% reduction in steelhead rearing, and less than 1% decrease in bull trout WUA. Thus, the maximum proposed withdrawal at this site would generally decrease WUA for most species at extreme low flows by a small amount, and slightly increase WUA at higher flows.

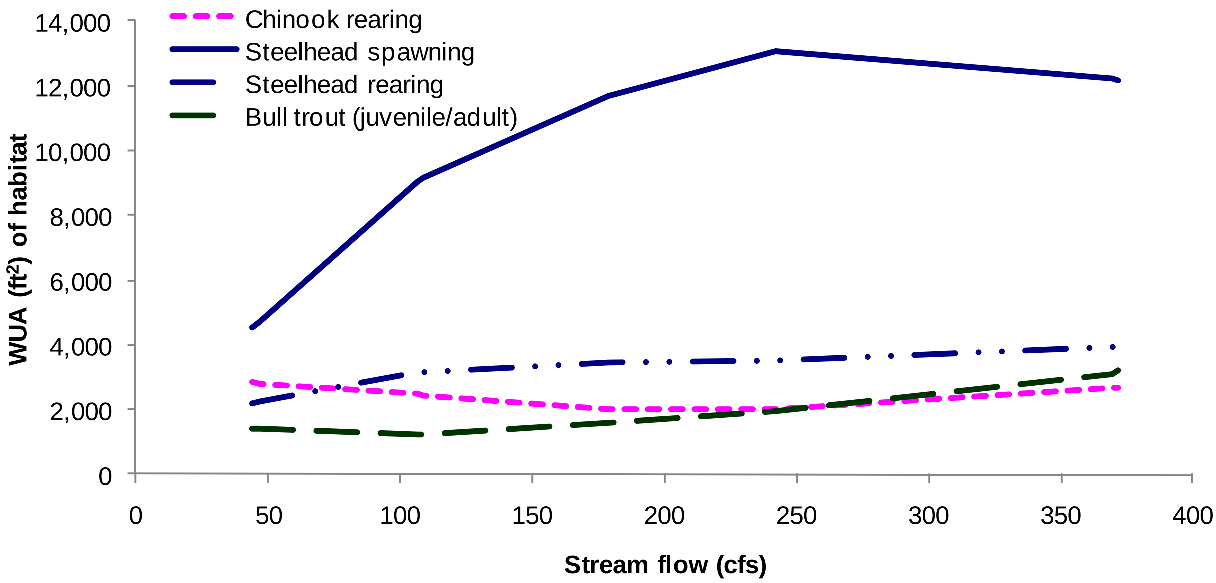



**Figure 13. Estimated weighted useable area (WUA) of habitat as a function of stream flow in the affected reach of Napeequa River.**

**Table 6. Modeled weighted useable area (WUA) of habitat in the affected reach of the Napeequa River for expected flow values and a maximum withdrawal of 2.6 cfs.**

| Flow type | Model type | Flow (cfs) | Water surface elevation (ft) | Wetted surface area (ft²) | Weighted usable area (ft²) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Chinook | Steelhead | | Bull trout |
| | | | | | rear | spawn | rear | juvenile/adult |
| Extreme low | -2.6 cfs | 44.4 | 1,927.9 | 81,388 | 2,858 | 4,514 | 2,199 | 1,414 |
| | normal | 47.0 | 1,927.9 | 81,949 | 2,781 | 4,741 | 2,245 | 1,416 |
| Mean low | -2.6 cfs | 106.4 | 1,928.4 | 96,432 | 2,472 | 9,013 | 3,154 | 1,209 |
| | normal | 109.0 | 1,928.5 | 96,753 | 2,445 | 9,134 | 3,164 | 1,204 |
| Mean high | -2.6 cfs | 369.4 | 1,930.8 | 131,228 | 2,692 | 12,218 | 3,963 | 3,098 |
| | normal | 372.0 | 1,930.8 | 132,520 | 2,674 | 12,168 | 3,925 | 3,196 |

The design of the Tall Timber site allows use of the side channel by other species during coho acclimation (see Appendix 2 of EIS). Diverting flow into the system may increase off-channel habitat.

### *4.1.1.4 George (backup hatchery site)*

The George hatchery site offers a potential alternative to the Dryden hatchery site. Located approximately 1.25 miles downstream of Lake Wenatchee, the George hatchery would be positioned just south of the Wenatchee River main stem. The Wenatchee River provides spawning and/or rearing habitat for ESA listed spring Chinook salmon, steelhead, and bull trout (Appendix 9 of the EIS). We evaluated potential impacts of hatchery surface water withdrawals on microhabitat availability for ESA listed fish using the PHABSIM methodology. This approach was chosen to enable direct comparison to flow effects quantified for the Dryden hatchery site.

Wenatchee River mean discharge below Lake Wenatchee ranges between 200 cfs and 8,000 cfs annually (Figure 14). A total of 8 cfs of water would be supplied to the George hatchery via ground and surface water sources. Surface water, approximately 4.7 cfs, would be withdrawn from the Wenatchee River and piped to the hatchery. Hatchery discharge would be returned to the river 3,800 feet downstream of the withdrawal via a historic side channel that maintains hyporheic (subsurface) connectivity to the main stem. Discharged hatchery water would travel 5,600 feet before reaching the main stem, and some water would likely be lost to the ground depending on the river's flow stage. For simplicity, we assumed that returned flows would be equivalent to the amount of surface flow withdrawn; thus, our study reach was defined by the upstream withdrawal and downstream discharge locations (Figure 15).

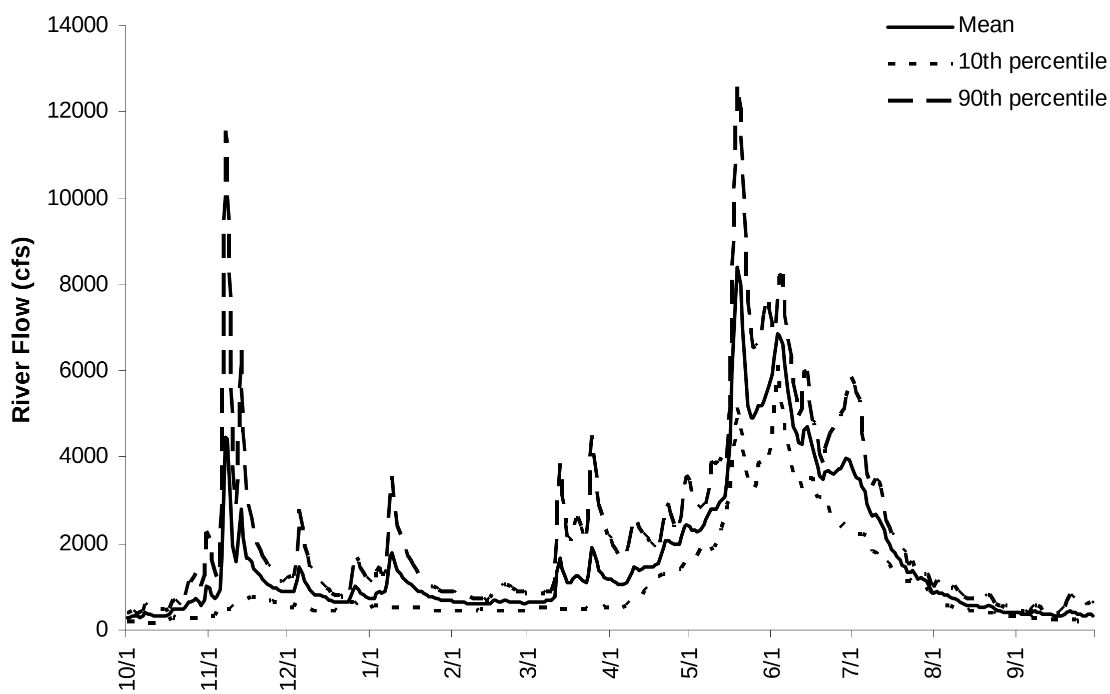



**Figure 14. Wenatchee River discharge below Lake Wenatchee, water years 2005-2010. Washington Department of Ecology stream gage 45A240.**

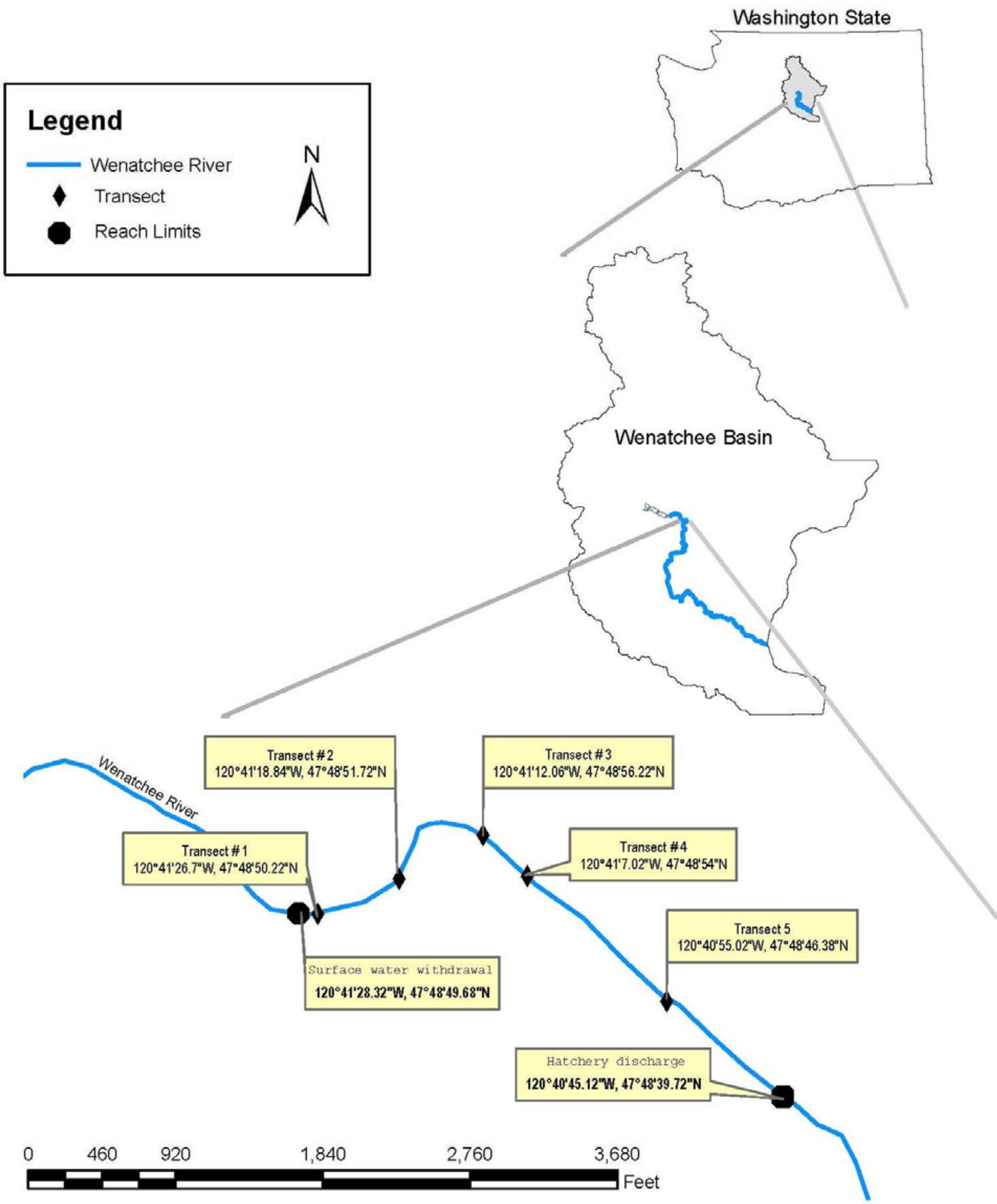



**Figure 15. Map of the study reach adjacent to the George hatchery site. The reach was defined by the locations of surface water withdrawal and discharge. Locations of data collection transects are provided for reference.**

The majority of the study reach was comprised of glide habitat (~60%), followed by pool (~30%) and riffle (~10%) habitat types. Stream substrate in pools was composed of equal proportions of fines, gravel, and cobble with a small amount of boulder. Riffles had primarily gravel and cobble substrate. Glides were composed of near equal parts of fines, gravel and cobble. In-stream wood complexity was judged to be fair throughout the reach, and a total of 69 pieces of large wood were counted. Following completion of the stream habitat survey, five transects were selected in locations representative of the observed habitat composition within the study reach (Figure 15). Channel profile and water velocity data were collected at each transect in October 2010 and used to define the hydraulic characteristics of the study reach at base flows.

Field data was used to parameterize the IFG4 hydraulic model following the "one-velocity" method described by Milhous (1984). Habitat Suitability Criteria recommended by the State of Washington (WDFW and WDOE 2004) for steelhead, spring Chinook salmon and bull trout were coupled with IFG4 program output to simulate relative changes in microhabitat availability across a range of flows. Figure 16 provides PHABSIM results across the range of flows simulated. Note that simulations were not completed for flows above 450 cfs and, therefore, our analysis was limited to low flow periods. The effect of flow withdrawals on WUA was expected to be greatest during the low flow season. Results of comparisons between the no-withdrawal and 4.7 cfs withdrawal scenarios are presented in Table 7. We caution readers not to overuse the absolute values presented in Table 7 because the difference in flow between the two scenarios is small and PHABSIM analyses are most useful for evaluating a broad range of flows. Specific values are provided in Table 7 to demonstrate that the relative change in weighted useable area (WUA) was extremely small (less than 1.5%) for all species and life-stages. Thus, a 4.7 cfs flow change during low and extreme low flows in the Wenatchee River had negligible effects on WUA simulated for spring Chinook, steelhead and bull trout.

A secondary discharge location just downstream of the withdrawal site is being considered for the George hatchery (see Appendix 1 of the EIS). The close proximity of "Discharge 2" to the intake leads us to conclude that if this option is chosen there would be no measurable effect on fish habitat in the Wenatchee River.

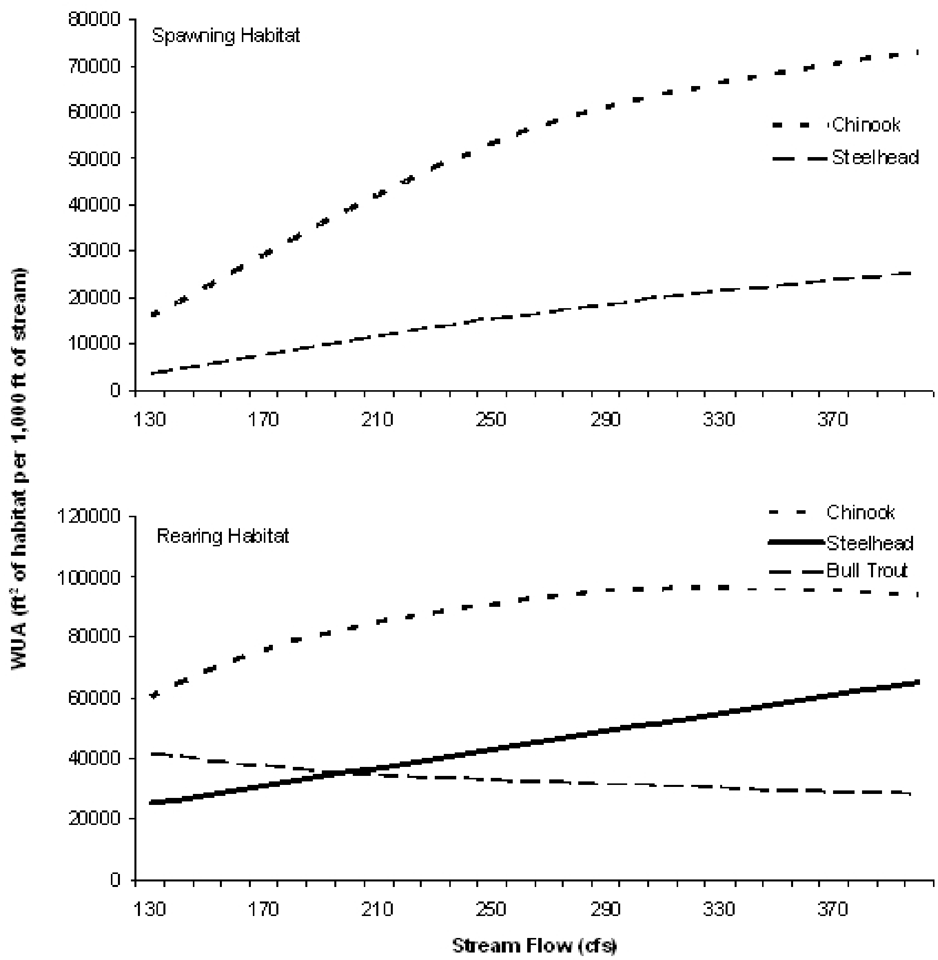



**Figure 16. Estimated weighted useable area for spawning and rearing habitat as a function of fall stream flow in the Wenatchee River study reach.**

**Table 7. Estimated percent of weighted usable area for ESA listed species in the Wenatchee River study reach under low flow and extreme low flow conditions. Low flows for the study reach were calculated from available WDOE stream gauge data. Values are provided for current conditions and conditions expected if flows are reduced by 4.7 cfs.**

| Species | Lifestage | Timing | Flow type | Flow (cfs) | % of WUA | - 4.7cfs % of WUA |
|---|---|---|---|---|---|---|
| Chinook | Spawning | Aug-Sep | Extreme low | 136 | 13.2% | 12.1% |
| | | | Mean low | 263 | 37.5% | 36.7% |
| | Rearing | All year | Extreme low | 136 | 44.8% | 43.4% |
| | | | Mean low | 263 | 62.4% | 62.0% |
| Steelhead | Spawning | Mar-May | Extreme low | 136 | 3.2% | 2.9% |
| | | | Mean low | 263 | 11.0% | 10.7% |
| | Rearing | All year | Extreme low | 136 | 18.5% | 18.0% |
| | | | Mean low | 263 | 30.1% | 29.6% |
| Bull trout | Rearing | All year | Extreme low | 136 | 28.2% | 28.6% |
| | | | Mean low | 263 | 22.1% | 22.2% |

### 4.1.2 Methow Subbasin

#### *4.1.2.1 Twisp Weir*

The proposed Twisp Weir acclimation site is located adjacent to an existing spring Chinook salmon acclimation site operated by WDFW on the Twisp River (see Appendix 3 of the EIS). Mean discharge downstream of the Twisp Weir near Twisp, WA ranges between 60 cfs and 2,000 cfs annually (Figure 17). The new coho acclimation pond would be fed by a combination of ground and surface water sources. In total, the site requires 1.7 cfs of water: 0.5 cfs of ground water and 1.2 cfs of surface water withdrawn from the Twisp River. Withdrawals would be discharged back into the river approximately 450 feet downstream of the acclimation pond intake. Water would be diverted from the Twisp River to the acclimation pond from approximately December 1 through early May. The Twisp River provides spawning and/or rearing habitat for ESA listed spring Chinook salmon, steelhead, and bull trout (Appendix 9 of the EIS). We evaluated potential impacts of surface water withdrawals on relative changes in microhabitat availability for ESA listed fish using PHABSIM.

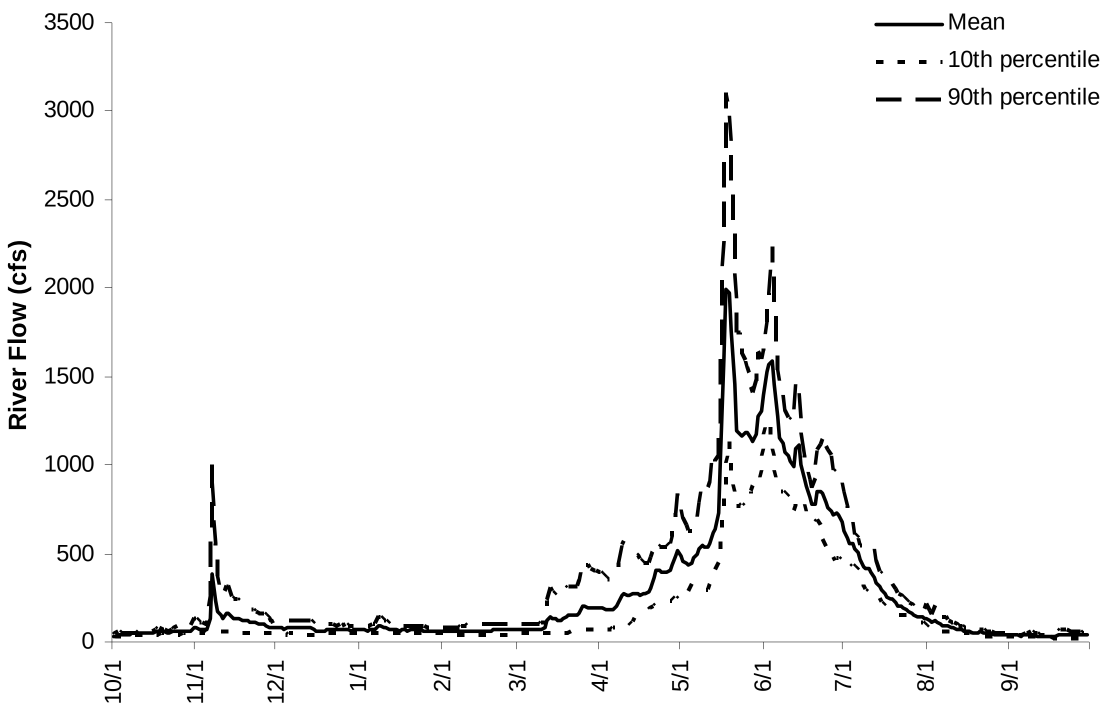



**Figure 17. Twisp River discharge near Twisp, WA, water years 2005-2010. USGS stream gage 12448998.**

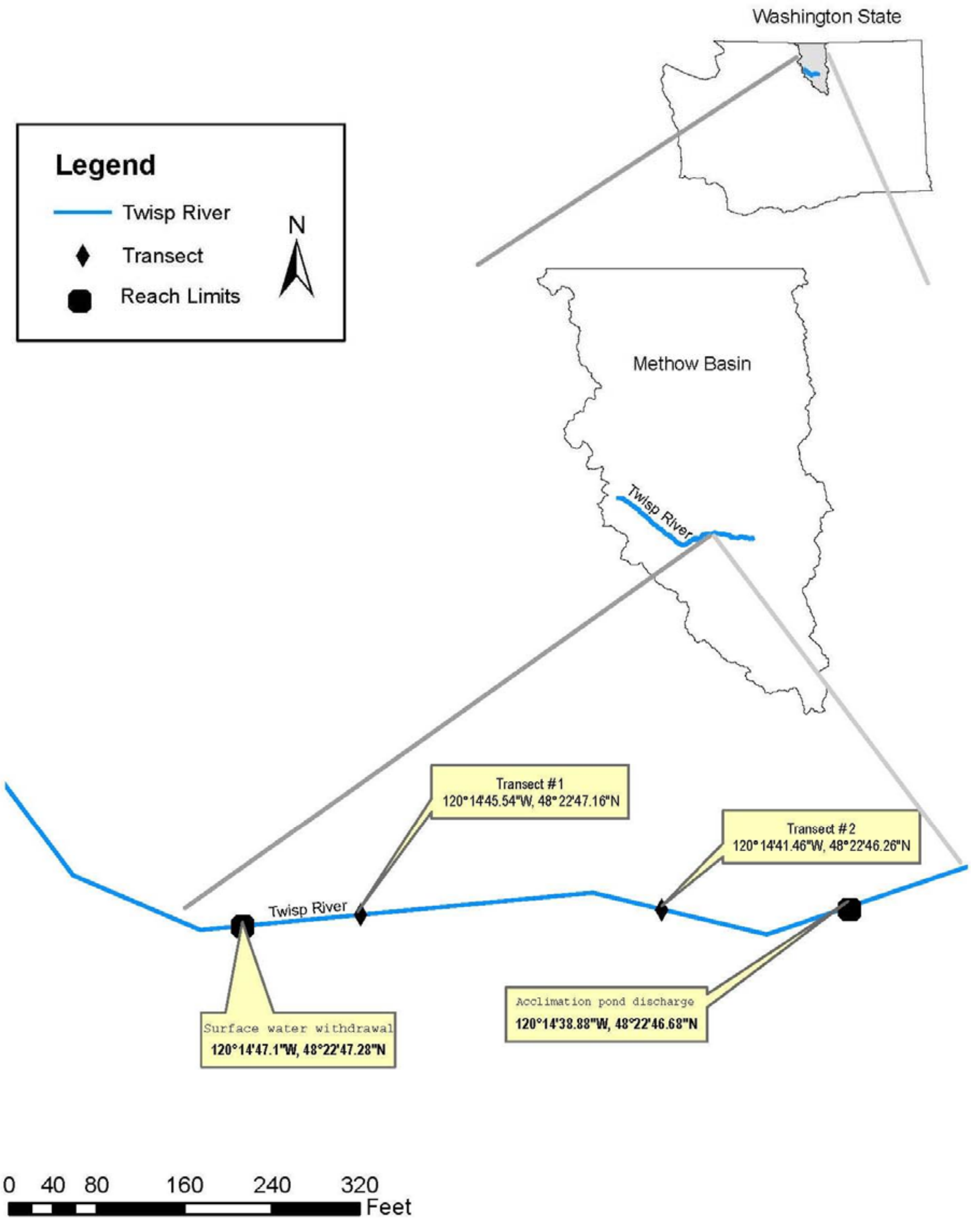



**Figure 18. Map of the study reach adjacent to the Twisp Weir acclimation site. The reach was defined by the locations of surface water withdrawal and discharge. Locations of data collection transects are provided for reference.**

Mesohabitat composition within the study reach was ~70% riffle and ~30% glide habitat types. Stream substrate was composed primarily of cobble and boulders with a small amount of gravel and fines. In-stream wood complexity was judged to be low, with a total of two pieces of large wood counted. After completion of the habitat survey, two transects were selected in representative locations within the study reach (Figure 18), one upstream and one downstream of the Twisp Valley Power and Irrigation District Diversion. Channel profile and water velocity data were collected at each transect in October 2010 and used to define the hydraulic characteristics of the study reach at base flows. Since the location of withdrawal occurred in a portion of the river with multiple side channels, our data collection and analysis focused exclusively on the side channel that would be affected by the withdrawal.

Field data was used to parameterize the IFG4 hydraulic model following the "one-velocity" method described by Milhous (1984). Habitat Suitability Criteria recommended by the State of Washington (WDFW and WDOE 2004) for steelhead, spring Chinook salmon and bull trout were coupled with IFG4 program output to simulate microhabitat availability across a range of flows in the affected side channel. Figure 19 provides PHABSIM results across the range of flows simulated. Note that simulations were not completed for flows above 40 cfs in the study reach and, therefore, our analysis is limited to the low flow period when juvenile coho would be held overwinter. The effect of flow withdrawals on WUA was expected to be greatest during the low flow period when the proportion of flow diverted from the side channel would be highest. Results of comparisons between the no-withdrawal and 1.2 cfs withdrawal scenarios are presented in

Table 8. We caution readers not to overuse the absolute values presented in

Table 8 because the difference in flow between the two scenarios is small and PHABSIM analyses are most useful for evaluating a broad range of flows. Specific values are provided to demonstrate that the relative change in WUA was small, 1.5% or less, for all species and life-stages. Therefore, a 1.2 cfs flow change during low and extreme low flows in the Twisp River had negligible effects on WUA simulated for spring Chinook, steelhead and bull trout.

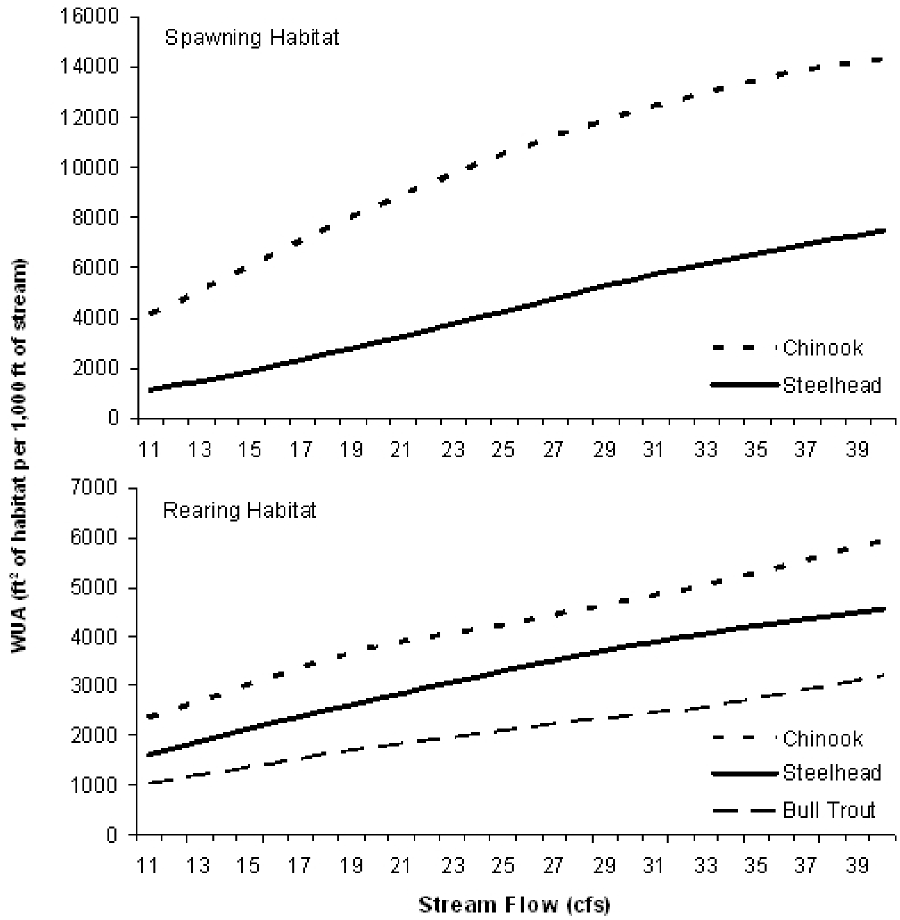



**Figure 19. Estimated weighted useable area for spawning and rearing habitat as a function of fall stream flow in the Twisp River study reach.**

**Table 8. Estimated percent of weighted usable area for ESA listed species in the Twisp River study reach under low flow and extreme low flow conditions. Low flows for the study reach were calculated from available USGS stream gauge data. Values are provided for current conditions and conditions expected if flows are reduced by 1.2 cfs.**

| Species | Lifestage | Timing | Flow type | Flow (cfs) | % of WUA | -1.2cfs % of WUA |
|---|---|---|---|---|---|---|
| Chinook | Spawning | Aug-Sep | Extreme low | 12 | 18.7% | 17.0% |
| | | | Mean low | 22 | 35.3% | 33.8% |
| | Rearing | All year | Extreme low | 12 | 10.3% | 9.7% |
| | | | Mean low | 22 | 15.1% | 14.8% |
| Steelhead | Spawning | Mar-May | Extreme low | 12 | 5.3% | 4.6% |
| | | | Mean low | 22 | 13.3% | 12.4% |
| | Rearing | All year | Extreme low | 12 | 7.1% | 6.6% |
| | | | Mean low | 22 | 11.3% | 10.9% |
| Bull trout | Rearing | All year | Extreme low | 12 | 4.5% | 4.3% |
| | | | Mean low | 22 | 7.2% | 7.0% |

#### *4.1.2.2 Newby (backup acclimation site)*

Newby Creek is a non-fish bearing, high gradient, small tributary to the Twisp River (Appendix 9 of the EIS). The proposed backup acclimation site, including the proposed water intake and discharge sites, would be located adjacent to Newby Creek above a series of cascades, which makes the site inaccessible to migratory fish. We estimated flow to be less than 1 cfs in October 2010 based on depth and velocity measurements taken at three sites within the creek. The accuracy of the flow estimate is questionable due to the fact that it was difficult to find locations deep enough to fully submerge the flow meter. A habitat survey revealed that there were natural fish passage barriers throughout the stream and the substrate was comprised mostly of fines. Based on these facts we conclude that a diversion of flow from Newby Creek into an acclimation pond and return of water to Newby Creek would have no adverse affects on ESA listed spring Chinook salmon, steelhead or bull trout.

## 4.2 Groundwater Impacts

A complete analysis of the effect of groundwater withdrawals on surface water can be found in the *Groundwater Withdrawal Impact Report* (Appendix 11 of the EIS). The following section discusses the potential impacts to listed fish due to groundwater withdrawals.

### 4.2.1 Wenatchee Subbasin

#### *4.2.1.1 Butcher*

A new well is proposed for this site to facilitate overwinter rearing of coho. A pump would draw 225 gpm from the well to provide an additional 0.5 cfs of flow to the pond. The well will likely be less than 250 feet? deep and is expected to be in hydraulic continuity with Nason Creek. There may be localized impacts to stream flow that will be completely offset by return flows from the acclimation pond. The magnitude of this localized impact cannot be estimated until the well has been dug and tested. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Wenatchee Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawal at this site.

#### *4.2.1.2 Dryden Hatchery*

A small hatchery is proposed to be developed at this site. A combination of surface and groundwater sources is being explored to supply of up to 2,775 gpm (6.2 cfs) to the site. Potential groundwater sources include an infiltration gallery or production wells. Groundwater levels are shallow and expected to be in hydraulic continuity with the Wenatchee River and Peshastin Creek. The effect of groundwater withdrawals on surface water will depend on the percentage of the demand supplied by wells and on the discharge site. As discussed in section 4.1.1, if return water is discharged upstream in Peshastin Creek there will be a small increase in flow from the discharge site to the Dryden fishway. This is expected to provide some benefits to ESA listed fish in the affected reach of Peshastin Creek but little to no impact to those in the Wenatchee River. If return water is discharged at the Dryden fishway, the impacts to surface water from groundwater withdrawals are expected to be localized and completely offset by return flows from the facility. Therefore, there are likely to be little to no negative impacts to fish from groundwater withdrawals at this site.

#### *4.2.1.3 Backup Sites*

4.2.1.3. SQUADRONI

A new well would be developed to provide 1.6 cfs needed for overwinter rearing if this site is needed. It is anticipated that 720 gpm will be drawn from the aquifer to meet this demand. The wells are likely to be in hydraulic continuity with Nason and Gill Creeks. There may be localized impacts to stream flow that will be completely offset by return flows from the acclimation pond. The magnitude of this localized impact cannot be estimated until the wells have been dug and tested. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Wenatchee Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawals at this site.

### 4.2.2 Methow Subbasin

#### *4.2.2.1 Lincoln*

Two wells will likely to be needed to provide 2.6 cfs needed for overwinter rearing at this site. It is anticipated that 1,170 gpm will be drawn from the aquifer to meet this demand. The wells are in hydraulic continuity with the Twisp River. There may be localized impacts to stream flow which will be completely offset by return flows from the acclimation pond. The magnitude of the localized impact cannot be estimated until the wells have been dug and tested. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Methow Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawals at this site.

#### *4.2.2.2 Lower Twisp*

An existing well is proposed to be used at this site to facilitate overwinter rearing of coho. A pump would draw 225 gpm from the well to provide an additional 0.5 cfs of flow to the pond. The well is likely in hydraulic continuity with the Twisp River. There may be localized impacts to stream flow that will be completely offset by return flows from the acclimation pond. The magnitude of this localized impact cannot be estimated until the well has been dug and tested. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Methow Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawal at this site.

#### *4.2.2.3 Mason*

A new well may be needed at this site to facilitate overwinter rearing of coho. A pump would draw 225 gpm from the well to provide an additional 0.5 cfs of flow to the pond. The well is likely in hydraulic continuity with Eight Mile Creek and possibly the Chewuch River. There may be localized impacts to stream flow (perhaps a few gallons per day) which will be completely offset by return flows from the acclimation ponds. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Methow Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawal at this site.

#### *4.2.2.4 MSWA Eight Mile*

A new well is proposed at this site to facilitate overwinter rearing of coho. An estimated 800 gpm would be drawn from the aquifer to provide 1.8 cfs of flow to the existing side channel. The aquifer is likely in hydraulic continuity with the Chewuch River. There may be localized impacts to stream flow (perhaps a few gallons per day) which will be completely offset by return flows from the acclimation ponds. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Methow Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawal at this site.

#### *4.2.2.5 Backup Sites*

##### 4.2.2.5. MSRF CHEWUCH

An existing well and likely one or more additional wells will be required to provide 1.9 cfs for overwinter rearing if this site is needed. It is anticipated that 850 gpm will be drawn from the aquifer to meet this demand. The well(s) are likely to be in hydraulic continuity with the Chewuch River. There may be localized impacts to stream flow (perhaps hundreds of gallons per day) which will be completely offset by return flows from the acclimation pond. Because of the water-balance neutrality of the proposed withdrawal of groundwater from an aquifer in hydraulic continuity with the stream and discharge of the groundwater back into the stream, there will be no regional impacts to stream flow within the Methow Subbasin. Thus, there are likely to be little to no impacts to fish from the groundwater withdrawals at this site.

## 4.3 Combined Impacts

### 4.3.1 Proposed Alternative

The impact of the proposed alternative on surface waters is expected to be small. The combined surface water withdrawals at the primary sites proposed for the Wenatchee River Subbasin total 4.0 to 11.1 cfs, and 1.2 cfs for the Methow Subbasin. An additional 7 cfs of groundwater is proposed to be withdrawn at primary sites in the Wenatchee Subbasin, and 5.4 cfs at primary sites in the Methow River Subbasin (see Appendix 11 of the EIS). The effect on surface water from these groundwater withdrawals is expected to be minor. Because withdrawn water will be returned to the stream, there will be no regional impacts to flow. There will be localized impacts to stream flow but impacts to listed fish are expected to be small and seasonal.

Depending on the final design for the Dryden hatchery, impacts could range from increased spawning and rearing habitat during low flows in a 200 ft section of lower Peshastin Creek, to undetectable changes in a 650 ft section of the Wenatchee River. The proposed water withdrawal at the Chikamin site would result in small decreases in available WUA (generally less than 1 $ft^2$)

for all species. The proposed surface water withdrawal for the Tall Timber site would generally decrease the amount of available WUA of habitat for most species at the extreme low flow and increase WUA of habitat at higher flows. The proposed surface water withdrawal at the Twisp Weir site was projected to generally decrease the WUA of habitat for most species during low flows by a small amount. These effects would occur between mid-March through early May at the Chikamin and Tall Timber sites, and between December and early May at the Twisp Weir site. The effects at the Dryden site would occur year-round but vary seasonally.

### 4.3.2 No Action

The No Action Alternative is described in the EIS. It includes operation of fewer of the same sites described for the Proposed Alternative. Because fewer sites would be operated and no new construction is involved, the combined effects would be less than those of the Proposed Alternative.

## 4.4 Cumulative Impacts

The EIS defines cumulative impacts as the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Past and present water rights exist in the Wenatchee and Methow Subbasins for industrial, irrigation, and domestic uses. In general, the lower portions of the subbasins are more affected by withdrawals for irrigation, commercial, industrial, municipal and domestic uses, and other activities (Montgomery Water Group et al. 1995, MBPU 2004). Streamflows in the upper portions of the subbasins are relatively unaffected by anthropogenic actions because these areas are largely mountainous and undeveloped.

Substantial water use rights exist in both subbasins. Within the Wenatchee Subbasin, users have 420 cfs in water rights permits and certificates (357 cfs surface water, 63cfs ground water) (NPCC 2004). The largest user is the Wenatchee Reclamation District, which serves over 9,000 users by diverting up to 200 cfs at Dryden Dam. In the Methow Subbasin, total irrigation deliveries are estimated to be on the order of 200 – 250 cfs (MBPU 2004). Of the irrigation water withdrawn, approximately 30 60% of this use is consumptive (not water-balance neutral) and the remaining 40% returns to the aquifer as groundwater (MBPU 2004). Additional quantities of water are diverted from the Wenatchee River for consumptive use outside of the watershed (NPCC 2004).

Irrigation water uses constitute the majority of withdrawals in the Wenatchee and Methow Subbasins (NPCC 2004, MBPU 2004). Irrigation use is greatest during the summer months exacerbating natural low flow conditions during July, August, and especially September (Andonaegui 2000, Andonaegui 2001). Other proposed groundwater withdrawals or surface water diversions, if consumptive, could impact the stream flows in the two basins.

Water withdrawals due to proposed MCCRP activities would occur between December and early May when irrigation use is low. In addition, the water would be returned to the river near the point of withdrawal so that the affects will be localized and negated by the return flow. Thus, the impacts from the proposed water withdrawals would not be additive to cumulative effects because anthropogenic withdrawals occur at different time periods.

### 4.4.1 Proposed Alternative

The amount of habitat reduced through water withdrawals under the proposed alternative is not likely to have a measureable impact compared to past and current impacts and those likely to occur. In addition, the proposed water withdrawals would occur primarily during the winter and spring (with the exception of the Dryden hatchery which would occur year-round and result in a slight increase in flow) not during the low flow summer and early fall period.

### 4.4.2 No Action

The No Action Alternative is described in the EIS. It includes operation of fewer of the same sites described for the Proposed Alternative. Because fewer sites would be operated and no new construction is involved, the combined effects would be less than those of the Proposed Alternative; consequently, the impacts of the combined projects are considered to be less than those of the Proposed Alternative.

## 5.0 IMPACT AVOIDANCE OR MITIGATION

Potential negative impacts to ESA listed fish will be avoided or minimized by:

- Using existing sites wherever possible.
- Minimizing the distance between surface water withdrawals and returns.
- Returning ground water to surface streams at locations that minimize pumping impacts.
- Constructing and operating intakes that meet guidelines for fish screens.

## 6.0 REFERENCES

Andonaegui, C. 2000. Salmon, steelhead, and bull trout habitat limiting factors for the Methow subbasin (Water Resource Inventory Area 45) and Portions of WRIA 48. Final draft report. WSCC.

Andonaegui, C. 2001. Salmon, steelhead, and bull trout habitat limiting factors for the Wenatchee subbasin (Water Resource Inventory Area 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum drainages). Final draft report. WSCC.

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper No. 12. U.S. Fish and Wildlife Service. FWS/OBS-82/26.

EES Consulting. 2005. Lower Wenatchee River PHABSIM studies. Final Technical Report. Prepared for Chelan County Natural Resources Department and WRIA 45 Watershed Planning Unit. EES Consulting, Inc., Bellingham, WA.

Gard, M. 2009a. Comparison of spawning habitat predictions of PHABSIM and River2D models. International Journal of River Basin Management, 7:55-71.

Gard, M. 2009b. Demonstration flow assessment and 2-D modeling: Perspectives based on instream flow studies and evaluation of restoration projects. AFS, Fisheries Magazine, 34:320-329.

Hillman, T., M. Miller, C. Peven, M. Tonseth, T. Miller, K. Truscott, and A. Murdoch. 2008. Monitoring and evaluation of the Chelan County PUD hatchery programs. 2007 Annual Report. Prepared for the HCP Hatchery Committee, Wenatchee, WA.

Methow Basin Planning Unit (MBPU). 2004. Methow Basin (WRIA 48) watershed plan. Draft report approved by the Okanogan County Board of County Commissioners June 20, 2005. Available at: http://www.okanogancounty.org/water/Documents%20on%20Site/Methow%20Basin%20plan%20text.pdf

Milhous, R.T. 1984. Technical Note No. 4: the use of one velocity calibration data set with IFG4. United States Fish and Wildlife Service, Fort Collins, Colorado. 6 pp.

Montgomery Water Group, Inc, Adolfson Associates, Inc., Hong West & Associates, Inc., R2 Resource Consultants, Inc., Marshall and Associates, Inc., and Washington Department of Ecology. 1995. Initial watershed assessment: Water resources inventory area 45, Wenatchee River Watershed. Open file Report 95-12.

Northwest Power and Conservation Council (NPCC). 2004. "Wenatchee Subbasin Plan." In Columbia River Basin Fish and Wildlife Program. Portland, Oregon, 2005.

National Marine Fisheries Service (NMFS). 1996. Juvenile fish screen criteria for pump intakes. Developed by National Marine Fisheries Service Environmental & Technical Services Division Portland, Oregon May 9, 1996. Available at: http://swr.nmfs.noaa.gov/hcd/pumpcrit.htm

Steffler, P. and Blackburn, J. 2002. River2D, Two-dimensional depth averaged model of river hydrodynamics and fish habitat, Introduction to depth averaged modeling and user's manual. University of Alberta.

Washington Department of Fish and Wildlife (WDFW) and Washington Department of Ecology (WDOE). 2004. Instream flow guidelines: Technical and habitat suitability issues including fish preference curves. Error correction update 2/12/2008. Olympia WA.