

PUBLIC UTILITY DISTRICT NO. 1 *of* CHELAN COUNTY
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November 15, 2013

VIA ELECTRONIC FILING

Honorable Kimberly D. Bose, Secretary, and
Nathaniel J. Davis, Sr., Deputy Secretary
FEDERAL ENERGY REGULATORY COMMISSION
888 First Street, NE
Washington, DC 20426

Ms. Patricia S. Irle, Hydropower Projects Manager
Washington Department of Ecology
Central Regional Office
15 West Yakima Avenue, Suite 200
Yakima, WA 98902-3452

Re: **Rocky Reach Hydroelectric Project No. 2145**
License Article 401 and Appendix A, Sections 5.6.1, 5.7.1, and 5.72
Shallow Water/Macrophyte Bed Water Quality Monitoring Report

Dear Secretary Bose, Deputy Davis, and Ms. Irle:

On September 18, 2013, the Federal Energy Regulatory Commission (Commission) issued a letter order for the Rocky Reach Hydroelectric Project (Project) accepting the Public Utility District No. 1 of Chelan County, Washington (Chelan PUD) request to file the final report for the Shallow Water/Macrophyte Bed Water Quality Monitoring study on November 15, 2013.

As specified in the letter order, Chelan PUD hereby files the Shallow Water/Macrophyte Bed Water Quality Monitoring Report. The report contains the completed analysis of the extensive data set collected during the Shallow Water/Macrophyte Bed Water Quality Monitoring study conducted during August and September of 2012 and references pertinent fish sampling data collected by the Washington Department of Fish and Wildlife from shallow water and macrophyte beds during the same months in 2012. The fish sampling information is documented in the final Rocky Reach Project Resident Fish Study report dated October 10, 2013.[1] Both of these studies were conducted in consultation with the Rocky Reach Fish Forum.

[1] *See* link, http://www.chelanpud.org/departments/licensingCompliance/rr_implementation/ResourceDocuments/41591.pdf

A summary of consultation with the Rocky Reach Fish Forum, including comments received on the draft report and response to those comments, is contained in Appendix A of this Shallow Water/Macrophyte Bed Water Quality Monitoring Report.

Please contact me or Steven Hays at (509)661-4181 if you would like to discuss this work or if additional information would be helpful.

Sincerely,

Michelle Smith
License and Compliance Manager
michelle.smith@chelanpud.org
(509) 661-4180

Attachments

cc: Rocky Reach Fisheries Forum

Shallow Water/Macrophyte Bed Water Quality Monitoring Report

SHALLOW WATER/MACROPHYTE BED WATER QUALITY MONITORING REPORT

LICENSE ARTICLE 401 and APPENDIX A

Final

ROCKY REACH HYDROELECTRIC PROJECT
FERC Project No. 2145

November 15, 2013

Public Utility District No. 1 of Chelan County
Wenatchee, Washington

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SECTION 1: INTRODUCTION

Public Utility District No. 1 of Chelan County, Washington (Chelan PUD) owns and operates the Rocky Reach Hydroelectric Project (Project), located on the Columbia River (Figure 1). The Project boundary, which extends for about 43 miles along the Columbia River, begins at the Project tailrace (River Mile [RM] 474) and extends upriver to the Wells Dam tailrace at RM 516 (Figure 1).

On February 19, 2009 the Federal Energy Regulatory Commission (FERC) issued its Order On Offer of Settlement and Issuing New License (License) for the Rocky Reach Hydroelectric Project for a term of 43 years to Chelan PUD (License term ends February 1, 2052). In its order, FERC states in (D):

> *This license is subject to the conditions issued by the Washington Department of Ecology on March 17, 2006, under section 401(a)(1) of the Clean Water Act, 33 U.S.C. § 1431(a)(`1)(2006), as those conditions are set forth in Appendix A to this order.*

Among the conditions contained in Appendix A, the 401 Water Quality Certification (401 Certification) issued by Ecology, the following in section 5.6 is the subject of this monitoring plan:

> *Chelan PUD shall implement the actions identified in the WQMP, Section 4, with respect to localized impacts on macrophyte beds. Chelan PUD will develop a QAPP (per requirements in Section 5.7 below) to determine if the water quality criteria for dissolved oxygen (DO), temperature and pH are met in shallow water habitats, including macrophyte beds, in the reservoir. If measurements reveal non-compliance with water quality numeric criteria or potential problems for designated uses, further sampling will be conducted, in coordination with the RRFF and Ecology, to determine the impact on aquatic habitat and associated biota. This additional sampling will be coordinated with any concurrent resident fish monitoring that may be developed by Chelan PUD, in consultation with the RRFF.*

The general QAPP that was required in Section 5.7 of the 401 Certification was completed, reviewed by Ecology, and filed with FERC on February 19, 2010. The QAPP stated that the monitoring plan for macrophyte bed water quality monitoring will be developed to coordinate with the resident fish study expected to be conducted in 2011, but was postponed until 2012. An update to the 2010 QAPP, developed specifically for the Shallow Water/Macrophyte Bed Water Quality Monitoring Study was filed with Ecology on July 10, 2012 and with FERC on July 26, 2012.

The actions identified in the WQMP (referenced above) are as follows:

> *Chelan PUD shall develop a one-year sampling program, in consultation with Ecology, to determine if the water quality criteria for DO, temperature, and pH are met in shallow water habitats, including macrophyte beds, in the Reservoir….If Project impacts to water quality in shallow water habitats, which also may have macrophyte beds, create*

> *conditions in which site-specific impact to resident or anadromous fish are attributed to direct adverse water quality effects, Chelan PUD will consult with the RRFF and Ecology to determine what actions may be reasonable and feasible to protect aquatic life.*

This Shallow Water/Macrophyte Bed Water Quality Monitoring Study was designed to determine if water quality criteria for DO, temperature and pH are being met in shallow water habitats in the reservoir during the summer months when macrophyte beds are at full growth, water temperatures are warm, and river flows are typically low. These conditions create the most likely opportunity for low DO levels and high pH levels that fail to meet water quality criteria, particularly in macrophyte beds where photosynthetic activity can raise pH during the day and lower DO at night in localized areas within the macrophyte beds. If water quality criteria are met under these conditions, then criteria are almost certainly met at other times of the year.

The Washington DOE Water Quality Standards for Surface Waters of the State of Washington Chapter 173-201A WAC states that water quality measurements "*…should be taken to represent the dominant aquatic habitat of the monitoring site. This typically means samples should:(A) Be taken from well mixed portions of rivers and streams; and (B) Not be taken from shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge.*"

The Rocky Reach reservoir is predominately deep and riverine in nature. The reservoir has a normal surface area of approximately 8,235 acres. An aquatic habitat mapping survey conducted in 1999 found that 906 acres (11%) of the reservoir was no greater than 10 feet deep. Aquatic macrophytes beds occupied 30% of the shallow water habitat (385 acres), of which 268 acres were classified as dense plant beds (DES, 2001a). The total acreage of plant beds comprised less than five percent of the surface area of the Rocky Reach reservoir, thus shallow water areas, both with and without macrophyte beds, could arguably be considered "not representative" of the dominant aquatic habitat of the Rocky Reach reservoir. However, these shallow water areas do constitute a significant portion of the reservoir and are an important component of the habitat available for small fish, which includes the juveniles for most of the fish species that inhabit the reservoir.

This Shallow Water/Macrophyte Bed Water Quality Monitoring Study was coordinated to take place during August and September of 2012, which is concurrent with the schedule for resident fish habitat use studies that are also a component of the Rocky Reach Settlement Agreement and FERC License (Resident Fish Management Plan). The sampling was scheduled for August and September because this time of year is when water temperatures typically are highest and the aquatic plant beds are at seasonal maturity, when the effects of photosynthesis and decomposition of plant material are most likely to affect pH and dissolved oxygen levels. The resident fish habitat use studies will provide complementary data regarding the aquatic life uses that are present in the shallow water habitats at the time of year when temperature, pH and dissolved oxygen are near or outside the limits of the Washington Water Quality Standards numeric criteria for these parameters for the designated uses of Salmonid, Rearing, and Migration. Fish may use macrophyte beds as rearing habitat, as a foraging area due to macroinvertebrates associated with macrophytes, as cover by prey fish, or as ambush sites by predatory fish. The resident fish study was designed to evaluate the presence or absence of fish, with some quantitative comparisons, in various habitat types, including macrophyte beds, in the

Rocky Reach reservoir. In the literature, areas with dense macrophytes populations often are described as "dead zones" due to depletion of dissolved oxygen. The information from the resident fish study provides insight into whether the dense macrophyte beds in the Rocky Reach reservoir are used as habitat. This Shallow Water/Macrophyte Bed Water Quality Monitoring Study was designed to determine if dissolved oxygen and pH levels within the macrophytes beds are supportive of aquatic life and whether they meet criteria for Salmonid Spawning, Rearing and Migration.

SECTION 2: METHODS

2.1 Fixed-site Continuous Monitoring

The water quality parameters of dissolved oxygen and pH generally exhibit a diurnal cycle in aquatic macrophyte beds due to the production of oxygen from photosynthesis during the day and the consumption of oxygen at night due to plant respiration and decomposition of dead plant material near the river bed. Four sites in dense macrophyte beds were chosen for continuous monitoring; Turtle Rock (RM 475), Entiat (RM 484), Daroga (RM 487) and Goose Tail (RM 493), which in this report are designated as "fixed-sites". These monitoring locations were representative of the largest dense macrophyte beds in the Rocky Reach reservoir. Three of these locations were in shallow, shoreline areas, whereas the Daroga location was in a very large macrophyte bed that is out in the main channel of the reservoir (Figure 2-1). Upstream of the Goose Tail fixed-site, the reservoir is more riverine with smaller macrophyte beds, thus these areas were not chosen for continuous monitoring locations.

The fixed-sites were equipped with a large steel anchor frame that rested on the river bed, with a mounting bracket that allowed attachment of a Hydrolab MS5 minisonde (MS5) with the sensor at a level of up to two feet above the river bed. Four steel rods connected from the corners of the anchor frame to a picking eye. A steel cable for lifting the frame and a rope for attachment of a buoy were secured to the picking eye. The MS5 was attached to the mounting bracket with hose clamps at a position estimated to be about 18 inches above the river bed and a data cable was secured to the rope and tethered to the buoy (Figure 2-2). The MS5 was downloaded from the cable and, for changing batteries and recalibration of the sensors, the entire frame was lifted to the surface and accessed from a boat equipped with a jib boom hoist.

Following installation, and periodically during the course of this study, additional data were collected at the fixed-site locations using the MS5 used for roving data collection. These additional data were collected with the roving MS5 positioned in close proximity and at similar depth to the MS5 unit stationed at the fixed-site. Additional data at other depths were also collected at the fixed-site location. Comparison of these data provided either confirmation or contrasting readings that are useful for evaluation of fixed-site and roving data regarding accuracy. The fixed-site MS5s were calibrated prior to deployment and every second week during mobile surveys and battery changes, while the roving MS5 was recalibrated on nearly a daily basis.

The Turtle Rock fixed-site was installed on August 13. During pre-installation operation over the weekend, the dissolved oxygen probe failed on the MS5 scheduled for installation. A second MS5 (which did not have a pH sensor) was added to the anchor frame and synchronized to record dissolved oxygen, while the pH and temperature data were recorded by the MS5 with the defective oxygen sensor. The pH sensor failed on that MS5 on August 31, thus temperature and dissolved oxygen data are from the other MS5. During the period from September 14 – 24, the MS5 used for mobile surveys was installed at the Turtle Rock fixed-site. That MS5 was removed on September 24 for use during the final mobile surveys. The MS5 used to record dissolved oxygen was reinstalled, but no useable data was collected because all data functions failed one hour after installation. Water was found to have seeped into the electronics chamber when this

unit was sent in for repair, which apparently shorted out data circuits after installation on September 24. No further continuous data were recorded at this fixed-site location.

The Entiat fixed-site was installed on August 13 and operated continuously through September 30, with two exceptions. When first installed, the MS5s at both the Turtle Rock fixed-site and the Entiat fixed-site were set to record data at 15 minute intervals. The MS5 at Entiat had an unexpectedly high power demand and the batteries were discharged by the morning of August 16. The batteries were replaced on August 17 and the MS5 was reprogrammed to record data on hourly intervals. The Turtle Rock MS5 was also switched to hourly recording later that day. On September 10 the Entiat MS5 lost power due to a water leak into the battery compartment that

Figure 2-1. Project Area and Fixed-site Locations.

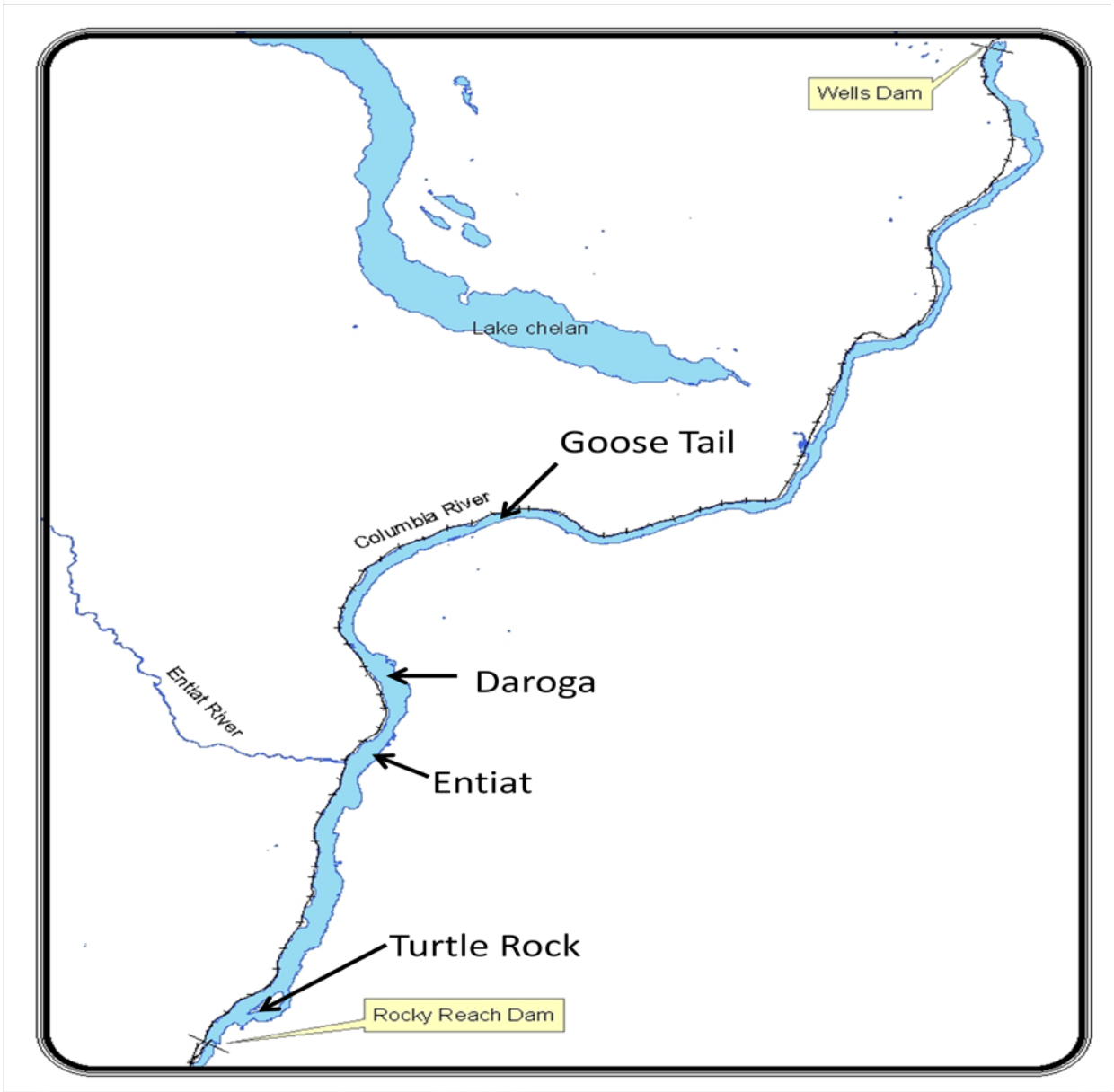
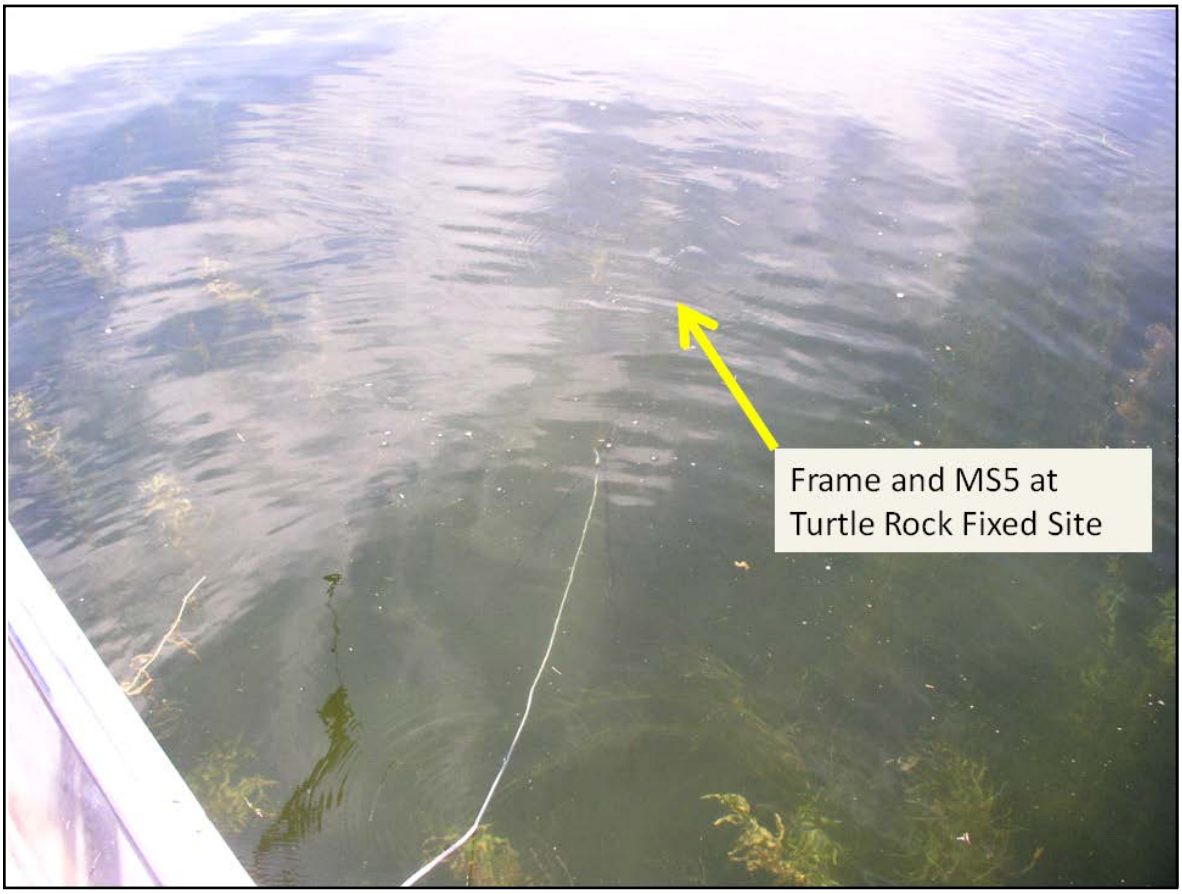


Figure 2-2. Fixed-site frame and MS5 at Turtle Rock.



was caused when the thin plastic housing spontaneously cracked open at the threaded juncture with the electronics section of the MS5. Operation of this unit was restored on September 12 and operated without further incident through September 30.

The Daroga and Goose Tail fixed-sites were both installed on August 27 and operated without incident through September 28. Batteries were changed once at each site.

2.2 Mobile Survey Monitoring

The mobile surveys were conducted throughout the reservoir, sampling sites in numerous macrophyte beds from the lower end of the reservoir at the Rocky Reach Dam boat restricted zone buoy line just upstream from the dam at river mile 474 to the upper reservoir at river mile 510. These samples were generally taken at two depths per location, usually one foot above the river bed and one foot below the surface. The MS5 was connected to a Hydrolab Surveyor 4a that was programmed to provide continuous digital readings for the water quality parameters. The procedure for a mobile site measurement was to anchor the boat at the location (front and rear anchor to minimize drift during sample), lower the MS5 until it touched the river bed and record the total depth, raise the MS5 by one foot and wait until the DO and pH readings had stabilized, record data, then raise the MS5 to one foot below the surface, wait for DO and pH to

stabilize, and record that data. The DO, pH, specific conductivity and water temperature were entered into a data record on a Trimble handheld GPS unit, which also recorded the GPS position of the measurement. Additional information was noted in the data record, including a visual category for density of macrophytes at the measurement site, the apparent dominant and subdominant species of macrophyte, and other comments regarding the measurement site. The principal species of macrophytes observed during this study were easily identified, however some macrophyte beds contained species of pondweeds (*Potamogeton sp.*) that have several species similar in appearance. Since identification of macrophytes by species was not an objective of this study, the pondweeds were identified only as either *P. crispus* (Curly-leaf pondweed), fine-leaf pondweed (likely *P. foliosus* in most cases), *P. richardsonii* and broad-leaf pondweed (likely *P. nososus* or *P. illinoensis*).

The MS5 used for the mobile surveys was generally calibrated after each day during the surveys. The calibration procedures were done according to manufacturer's recommended procedures. The DO calibration used the air saturated water procedure and the pH calibration was based on known pH buffer solutions of pH 10 and pH 7. The specific conductivity was not calibrated against a standard since this information was ancillary to the purposes of this study. However, the specific conductivity was compared across the five MS5 units used during the study and the data were consistent between the MS5s within a range of about 10µS/cm. The water temperature sensors on the MS5s were factory calibrated and all were within ± 0.2°C of a NIST certified reference thermometer.

2.3 Data Analysis

Data were examined for transcription and field recording errors, equipment malfunctions and data logged during calibrations and battery replacements. The data were combined into spreadsheet files with invalid data identified and removed from the analysis. Graphical presentation and summary statistics were prepared from the spreadsheet files. The relevant criteria from the water quality standards (Table 2-1) were included in the graphical presentations and used to determine the number and frequency of deviations from criteria.

Table 2-1. Water Quality Parameter Criteria and Decision Reference Levels.

Parameter	Criterion – Salmonid Spawning, Rearing, Migration	Smallest Reference Level for Decision Making
Temperature	≤ 17.5°C DADMax	0.3°C
DO	≥ 8.0 mg/L	0.2 mg/l
pH	6.5-8.5 units	0.5 pH units

SECTION 3: RESULTS

3.1 Fixed-site Continuous Monitoring

The continuous monitoring at the four fixed-sites produced a total of 4,215 valid data points for dissolved oxygen, 3,923 valid data points for pH, and 4,232 valid data points for water temperature. Data editing consisted of removing readings from the MS5 log files that occurred when the instrument was out of the water for recalibration or battery changes, bad data when battery voltage was low, and seven anomalous data readings (4 DO, 3 pH, 1 temperature) that were not credible based on the range of values preceding and following these data.

3.1.1 Fixed-site Dissolved Oxygen

The dissolved oxygen levels at the four fixed-site monitoring locations were generally at or above the criterion of 8.0 mg/l established for Salmonid Spawning, Rearing and Migration, with the exception of the Turtle Rock fixed-site (Table 3-1). At that location, about eight percent of the readings were below 8.0 mg/l, with over half (69) of these low readings recorded during the first five days when data were collected at 15 minute intervals. At the other three sites, less than two percent of the readings were below 8.0 mg/l. At all sites, the lowest dissolved oxygen readings were above 6.5 mg/l, which is the criterion for salmonid rearing and migration only. None of the fixed-site locations were suitable spawning habitat for salmonids due to low flow velocities and the river bed substrates did not have suitable spawning gravel.

The dissolved oxygen levels at the fixed-sites followed a diel pattern, as expected due to the dense macrophyte populations at these sites (Figures 3-1, 3-2, 3-3, 3-4). The low dissolved oxygen levels generally occurred at night, but some low values were observed during daylight hours at each of the fixed-sites.

Table 3-1. Dissolved oxygen levels at four fixed-site continuous monitoring locations.

Monitoring Location	Turtle Rock	Entiat	Daroga	Goose Tail
Number of Data Points	1,305	1,345	784	781
Number Below 8.0 mg/l	107	17	13	14
Lowest mg/l at Location	7.0	7.3	6.7	6.6
Highest mg/l at Location	11.3	16.3	10.6	11.0

At each fixed-site, there were several dissolved oxygen readings taken during the mobile surveys at the location and depth of the fixed-site MS5s. These data were collected to assure that the fixed-site MS5s continued to collect accurate and representative data between calibrations. These "side-by-side" readings were generally within the range of dissolved oxygen levels recorded at the fixed-site. These data points collected during the mobile surveys are shown as red bars in Figures 3-1, 3-2, 3-3, 3-4.

Figure 3-1. Dissolved oxygen levels at the Turtle Rock fixed-site.

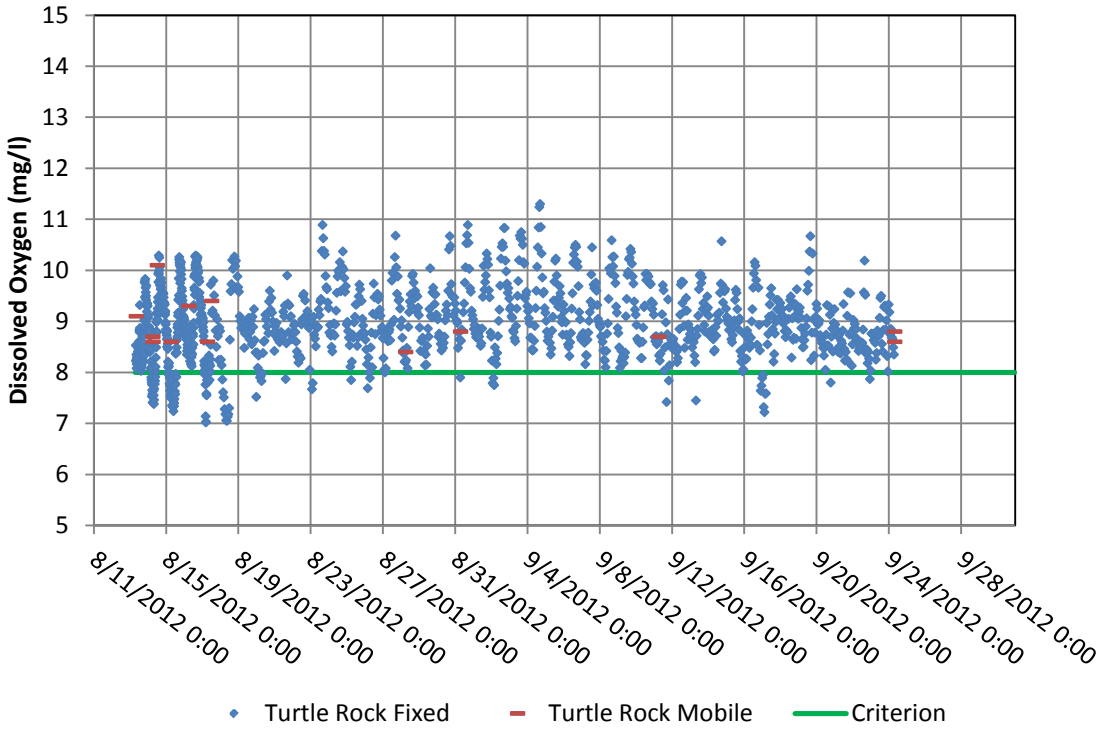


Figure 3-2. Dissolved oxygen levels at the Entiat fixed-site.

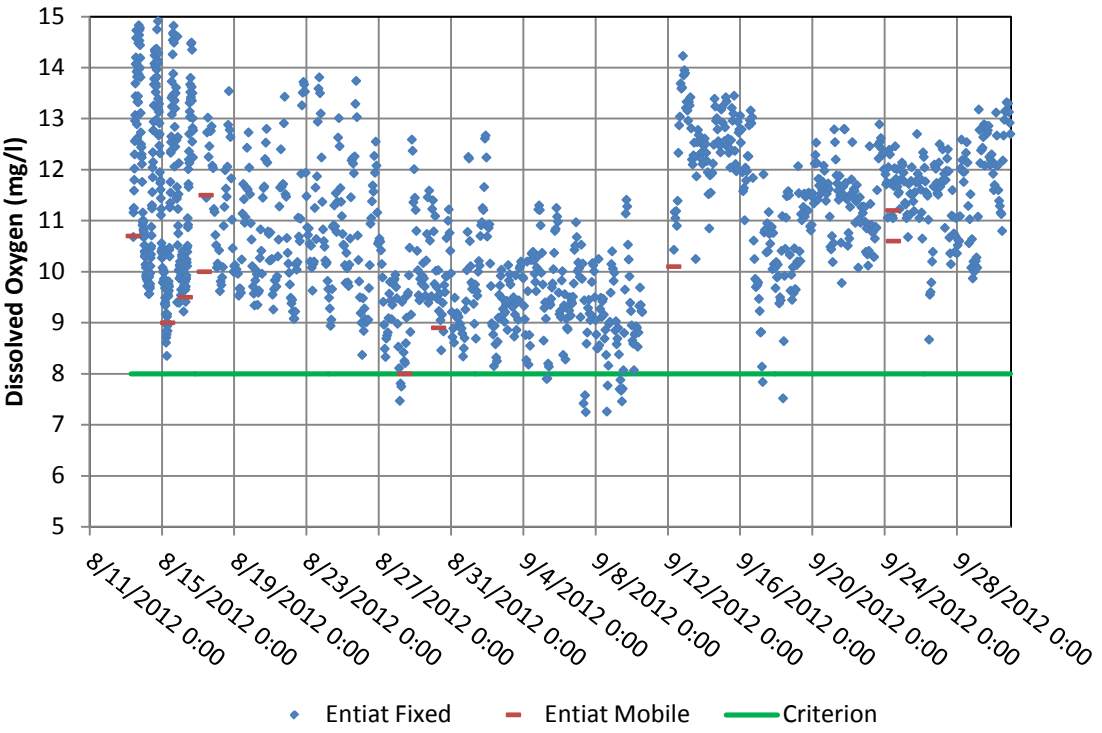


Figure 3-3. Dissolved oxygen levels at the Daroga fixed-site.

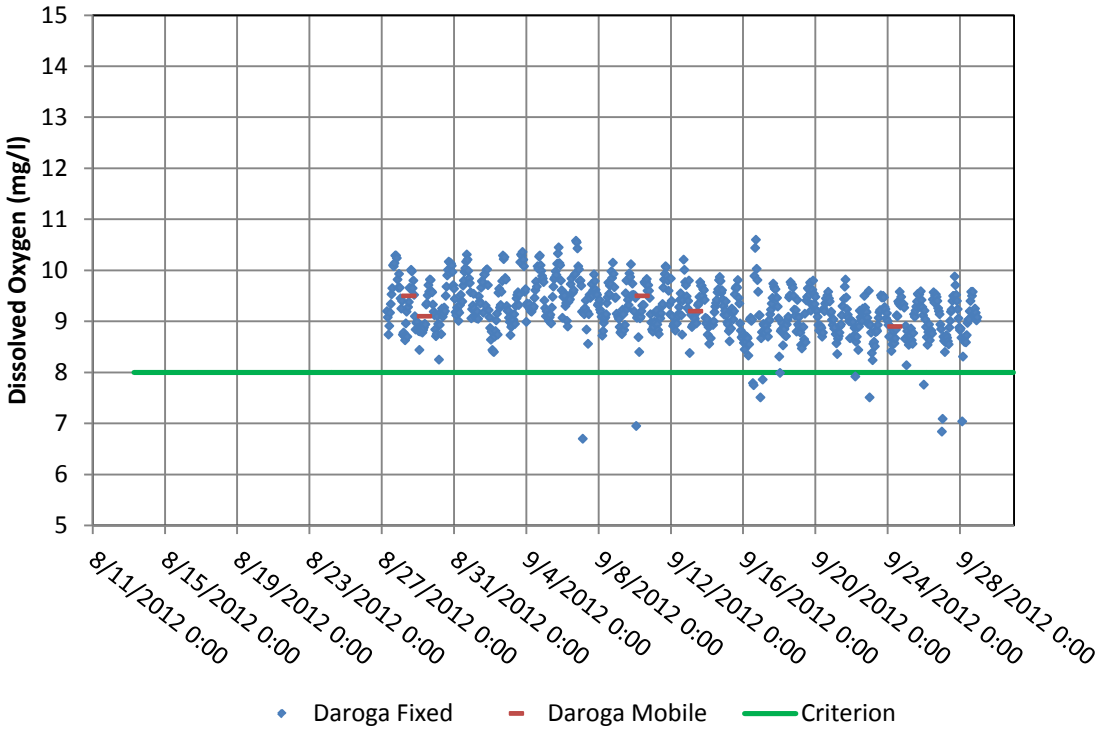
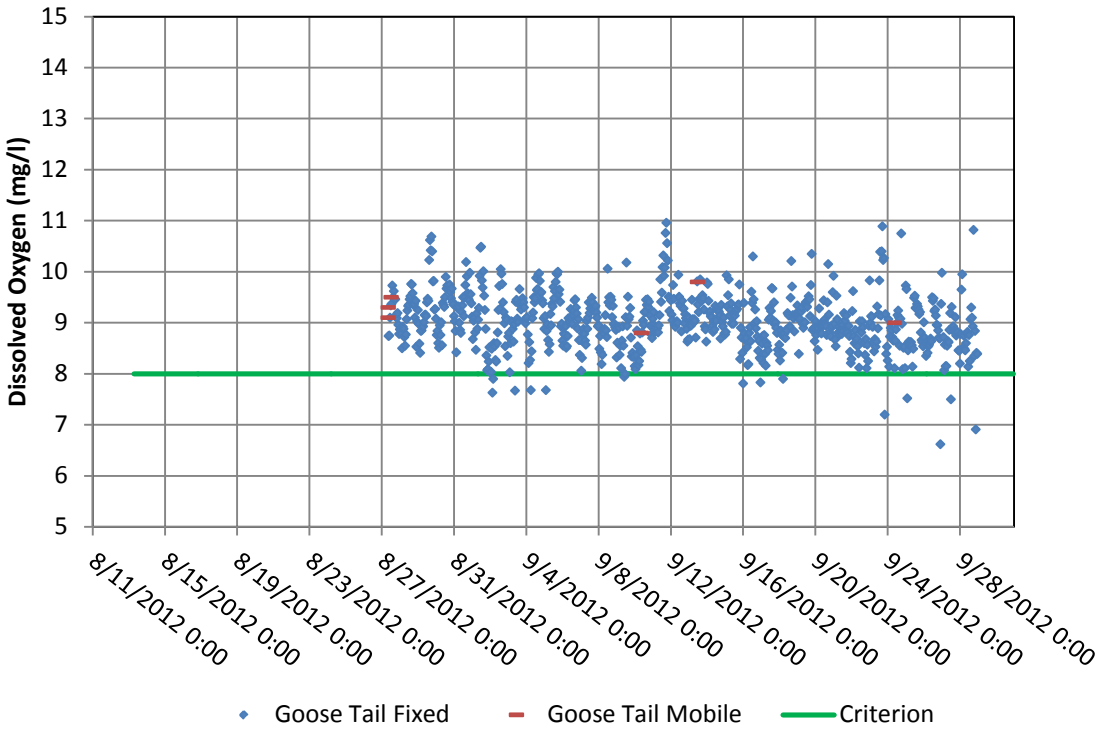


Figure 3-4. Dissolved oxygen levels at the Goose Tail fixed-site.



3.1.2 Fixed-site pH

The pH levels at the four fixed-site monitoring locations were never below the criterion of 6.5, but were often above the criterion of 8.5 (Table 3-2). At the Entiat fixed-site, over half of the pH measurements exceeded the criterion of 8.5. At the Goose Tail fixed-site, six percent of the measurements exceeded the criterion, but exceedances were less than one percent of the measurements at the other two fixed-sites. The Entiat fixed-site was quite shallow, with the total depth at this site ranging from 6.0 – 7.5 feet, depending on reservoir water level at the time of measurement. The Goose Tail fixed-site was the next shallowest, with a total depth range of 7-8 feet, while the Daroga and Turtle Rock fixed-sites had depth ranges of 8-9 feet and 10-11 feet, respectively. The shallow depth is relevant because the high pH measurements are due to high concentrations of dissolved oxygen during daylight hours. The Entiat fixed-site had high dissolved oxygen levels, even at the depth of the fixed-site sensor (Figure 3-2), whereas dissolved oxygen levels were not as high at the other fixed-sites, although high pH corresponded to spikes in dissolved oxygen levels at the Goose Tail site (Figure 3-4).

The pH levels at the Entiat fixed-site followed a diel pattern, but the trend was less evident at the other sites (Figures 3-5, 3-6, 3-7, 3-8). The diel range in dissolved oxygen levels at the Entiat fixed-site was the greatest of all the fixed-sites, which combined with the shallow depth at that site provided opportunity for the oxygen levels to affect the pH at the depth of the MS5 sensor.

Table 3-2. pH levels at four fixed-site continuous monitoring locations.

Monitoring Location	Turtle Rock	Entiat	Daroga	Goose Tail
Number of Data Points	970	1,385	785	783
Number Below 6.5	0	0	0	0
Number Above 8.5	7	786	4	48
Lowest pH at Location	6.7	7.4	7.7	7.8
Highest pH at Location	8.8	9.5	8.7	9.0

As was the case for measurement of dissolved oxygen, there were several pH readings taken during the mobile surveys at the location and depth of the fixed-site MS5s. These “side-by-side” readings were also generally within the range of pH levels recorded at the fixed-site, although there were some mobile pH measurements that were lower than any of the readings at each of the fixed-sites except for Turtle Rock. These data points collected during the mobile surveys are shown as red bars in Figures 3-5, 3-6, 3-7, 3-8.

A possible reason for these lower readings could be that the mobile readings were only one foot above the river bed, while the fixed-site MS5s were at least six inches higher above the sediments that were present in these macrophyte beds. The total depth measurement during mobile surveys was determined by feeling when the sensor hit solid river bed, which could have been a few inches below the layer of soft sediments and detritus that covered the harder materials. The anchor frames for the fixed-sites settled into the muck somewhat, but may have still rested on top of some of the soft material.

Figure 3-5. pH levels at the Turtle Rock fixed-site.

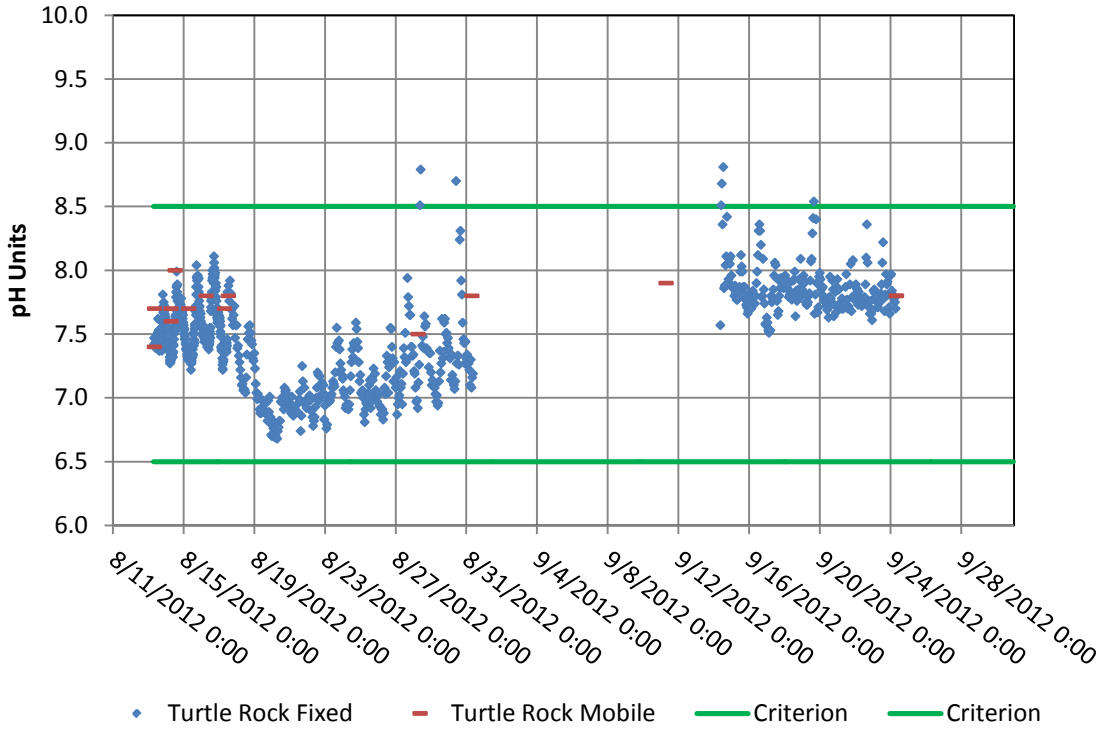


Figure 3-6. pH levels at the Entiat fixed-site.

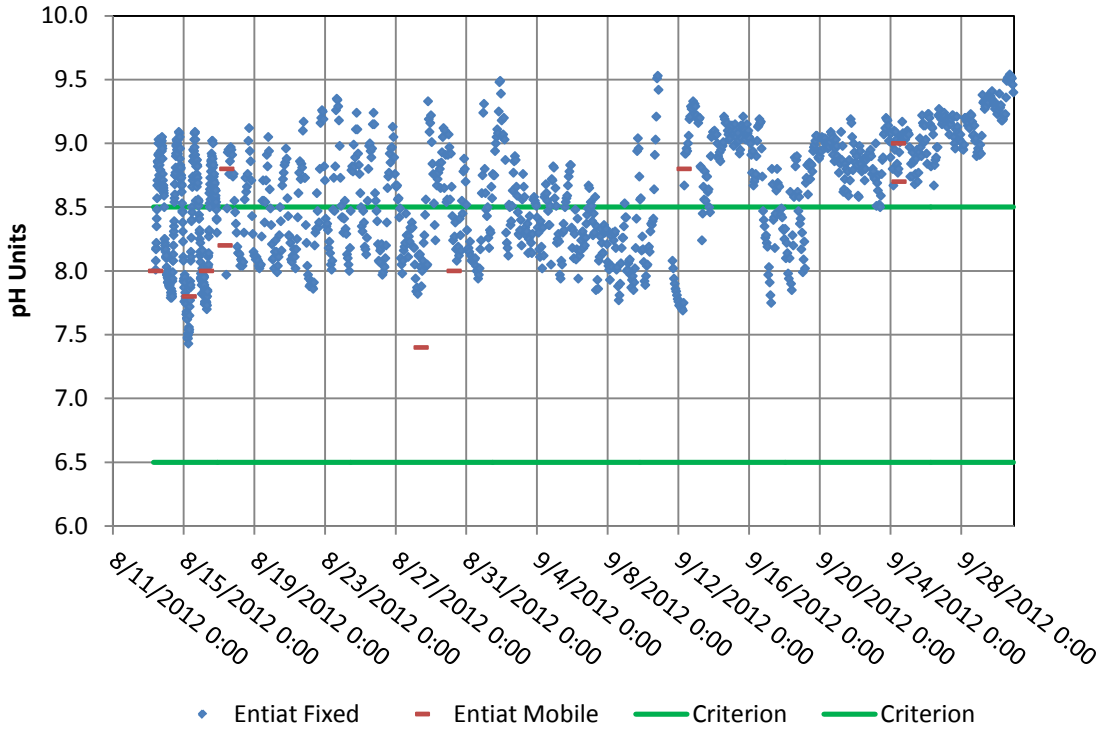


Figure 3-7. pH levels at the Daroga fixed-site.

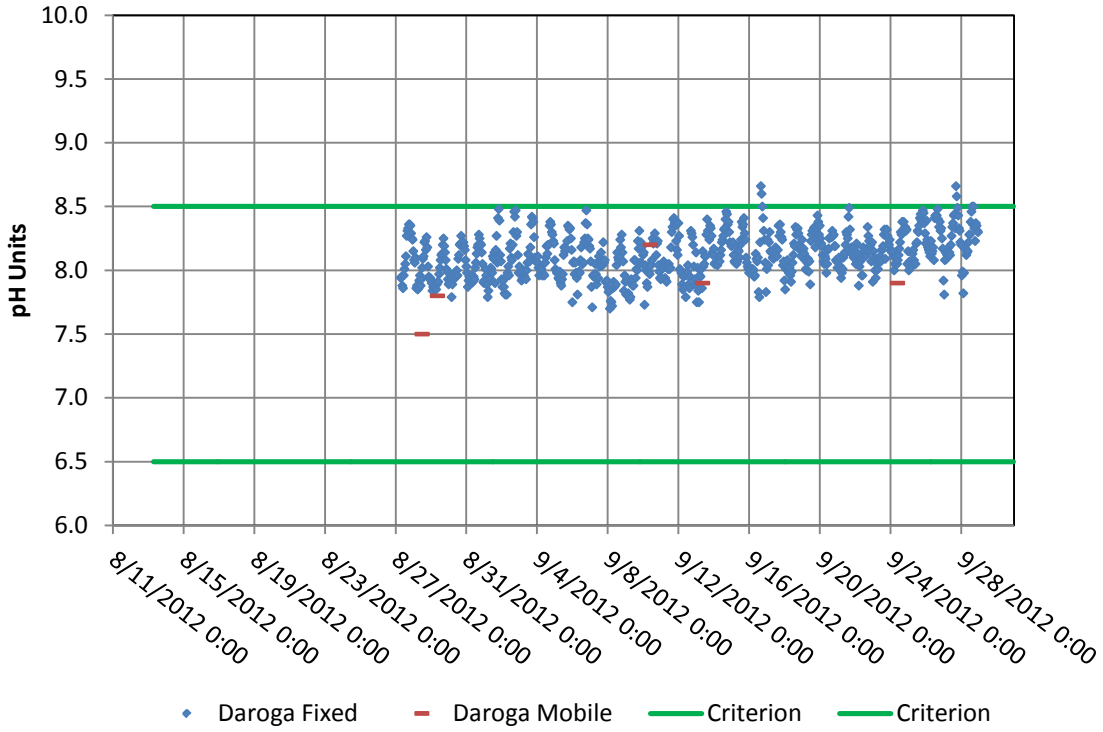
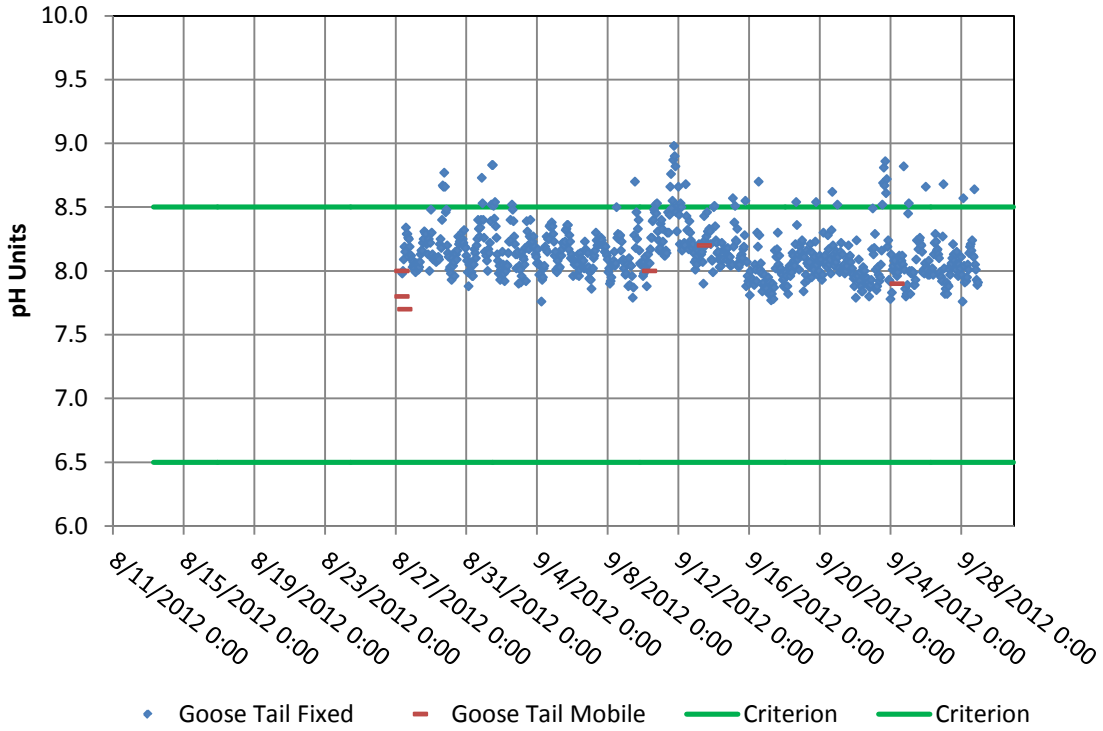


Figure 3-8. pH levels at the Goose Tail fixed-site.



3.1.3 Fixed-site Water Temperature

The water temperatures at the four fixed-site monitoring locations were usually above 17.5 degrees C, except for some days in September at the Entiat fixed-site and four measurements at the Goose Tail fixed-site. Since nearly all the measurements were above 17.5 °C, the daily maximum would be still higher and therefore the water temperature criterion (7-Day Average of Daily Maximum) was exceeded throughout the study. The water temperature at these sites generally reflects the water temperature of the open water areas of the Rocky Reach reservoir and upstream reservoirs, all of which have water temperatures above the criterion during August and September. The cooler temperatures at the Entiat fixed-site were due to localized nighttime cooling at that shallow water location, which also likely had less mixing with the main channel due to its dense macrophyte growth.

Table 3-3. Water temperatures at four fixed-site continuous monitoring locations.

Monitoring Location	Turtle Rock	Entiat	Daroga	Goose Tail
Number of Data Points	1,305	1,361	784	782
Number Above 17.5 °C	1,305	1,175	784	778
Highest °C at Location	19.0	19.1	19.1	19.0
Lowest °C at Location	17.6	16.4	17.5	17.3

There was a minor degree of diel periodicity in the water temperatures at the fixed-sites, with the Entiat fixed-site exhibiting the greatest temperature variability over the course of a day. The water temperatures measured at these sites during mobile surveys were occasionally cooler than measured by the fixed-site MS5s; however, the temperature sensor can be slow to respond which could account for the difference in water temperatures that occurred during early morning measurements. The water temperatures measured at each fixed-site, with the mobile survey comparison measurements, are shown in Figures 3-9, 3-10, 3-11, 3-12.

Figure 3-9. Water temperatures at the Turtle Rock fixed-site.

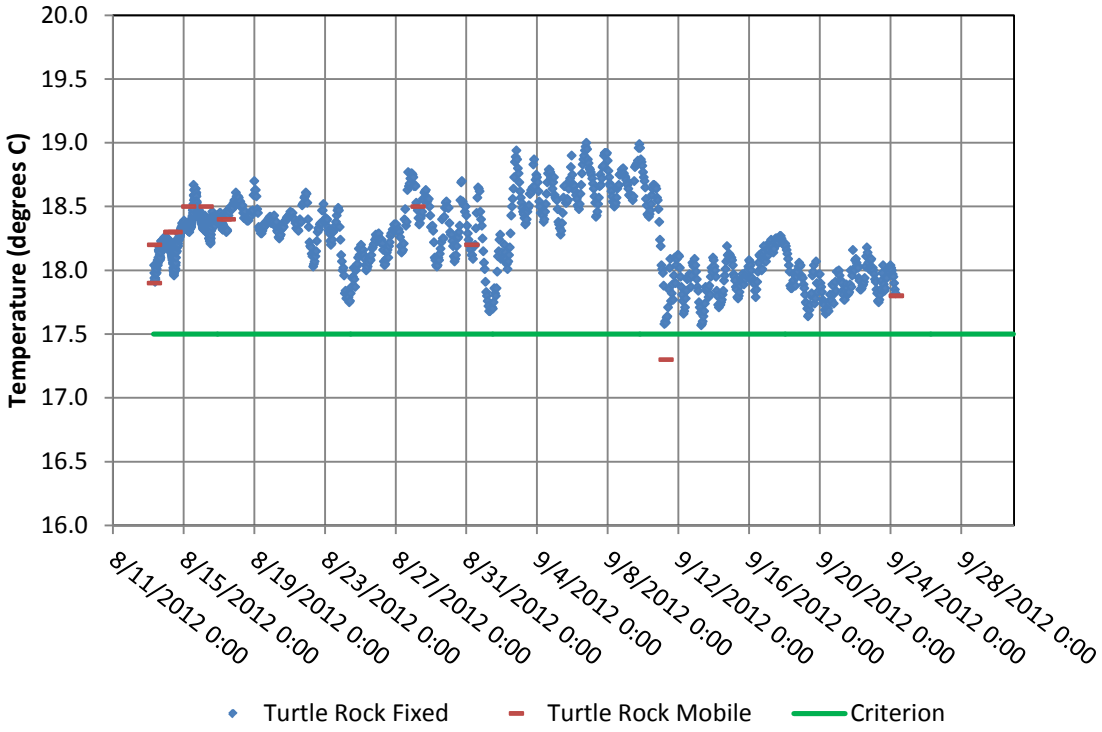


Figure 3-10. Water temperatures at the Entiat fixed-site.

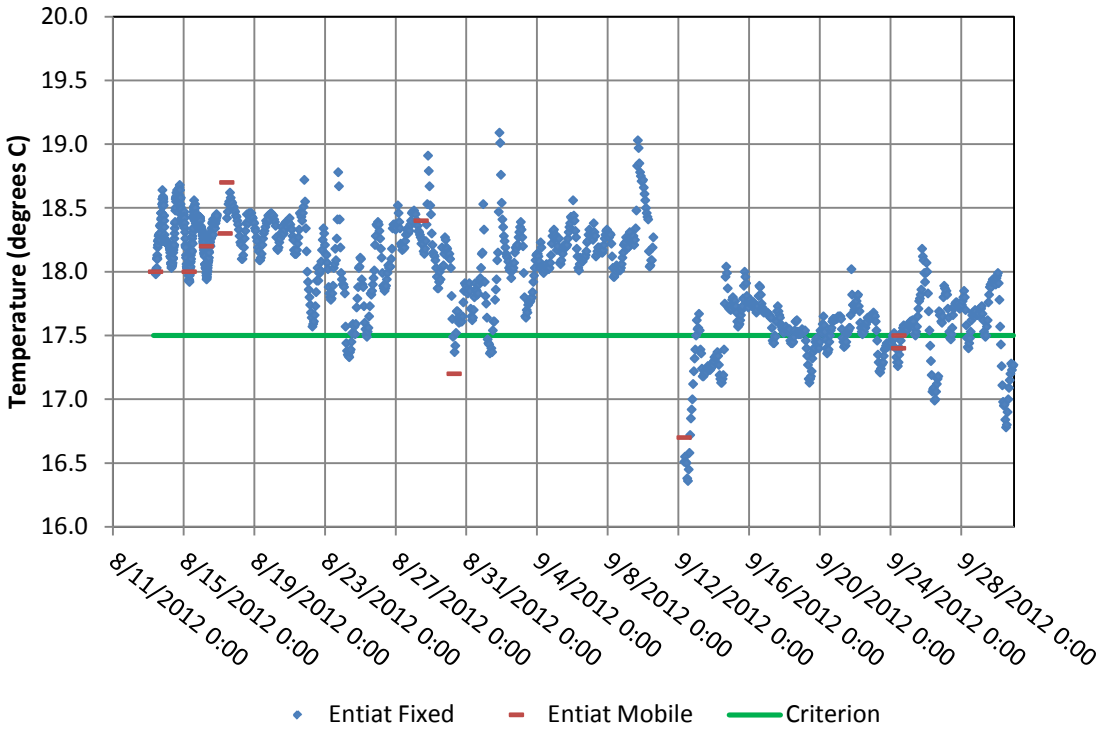


Figure 3-11. Water temperatures at the Daroga fixed-site.

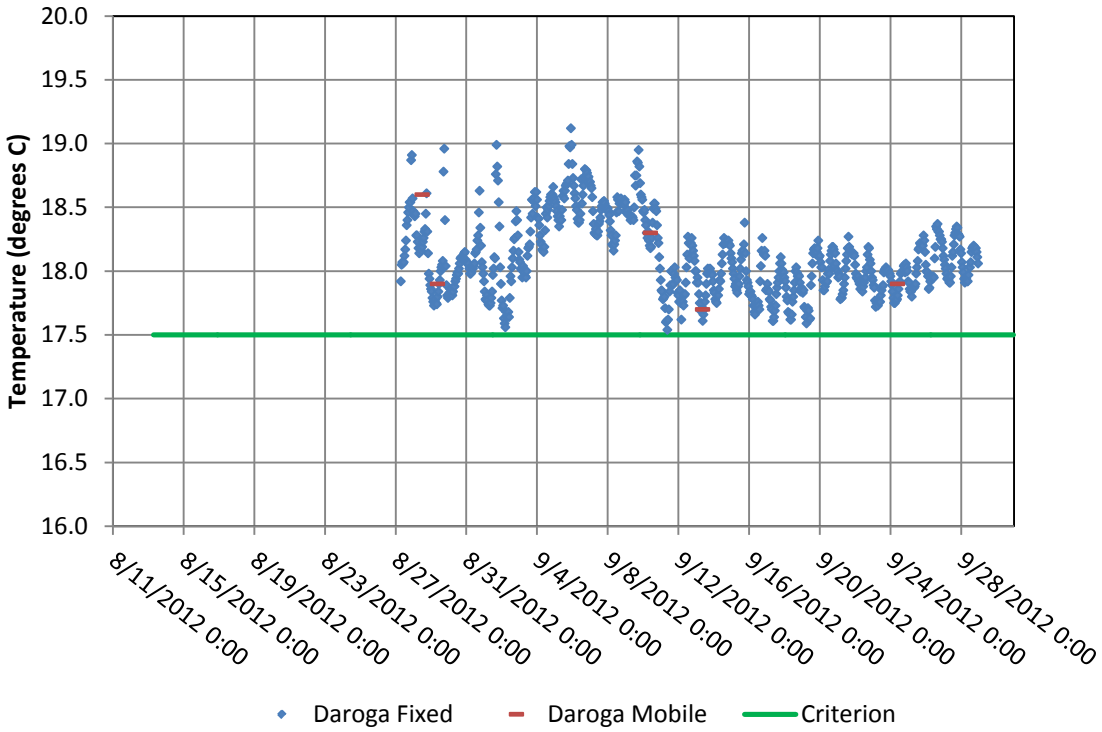
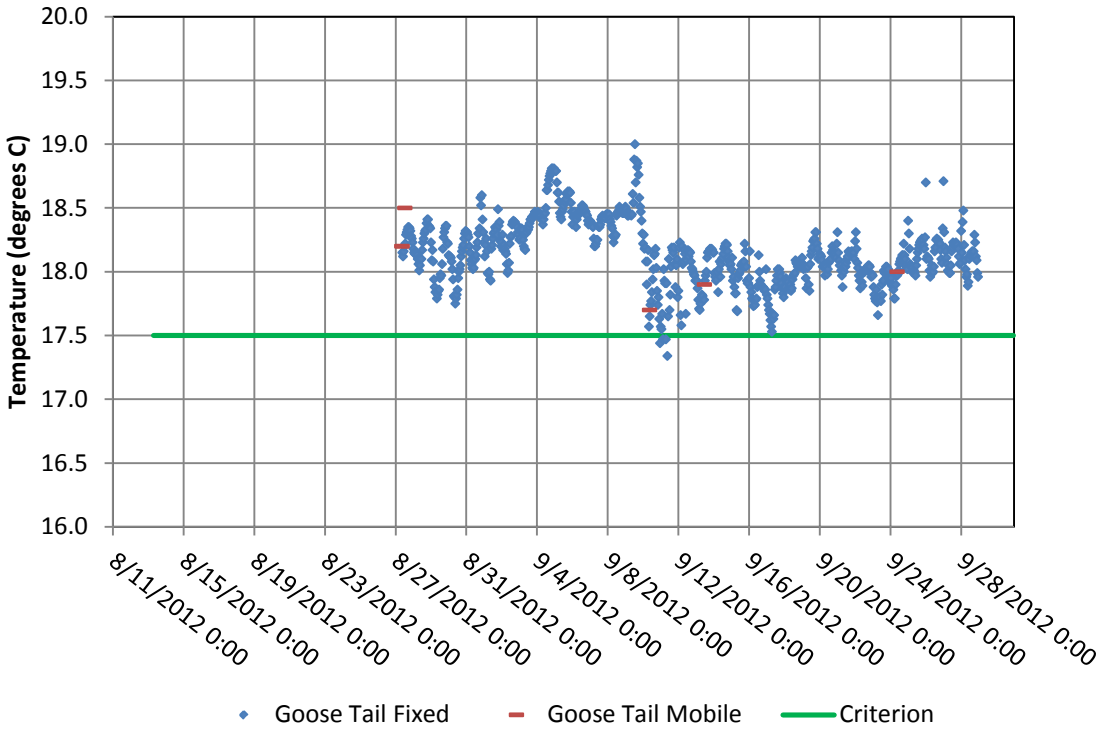


Figure 3-12. Water temperatures at the Goose Tail fixed-site.



3.2 Mobile Survey Monitoring

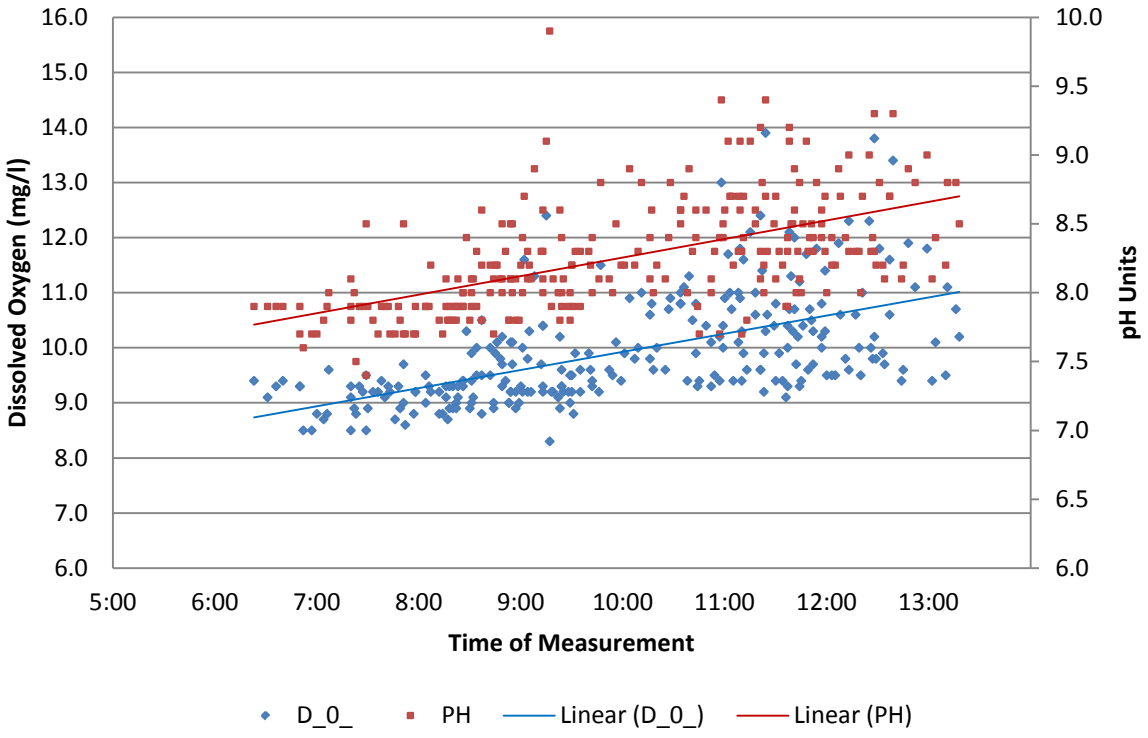
The mobile survey monitoring produced over 500 valid data points for each of the three parameters in this study, as shown in Table 3-4. Since the mobile surveys were conducted during daylight, there were few dissolved oxygen measurements below the 8.0 mg/l criterion. The near surface measurements did pick up some higher water temperatures than observed with the fixed-site monitoring. The frequency of pH measurements outside of criteria was lower than the Entiat fixed-site, despite nearly half of the measurement taken near the surface and during daylight.

Table 3-4. Summary of data from mobile survey monitoring.

Water Quality Parameter	Dissolved Oxygen	pH	Water Temperature
Number of Data Points	520	522	517
Number Below Criterion	3	1	-
Number Above Criterion	-	86	462
Lowest Value	7.2 mg/l	6.3	16.1 °C
Highest Value	13.9 mg/l	9.9	21.1 °C

The near-surface measurements showed that both dissolved oxygen and pH levels increased as sunlight increased from morning to afternoon (Figure 3-13).

Figure 3-13. Dissolved oxygen and pH trends by time of day.



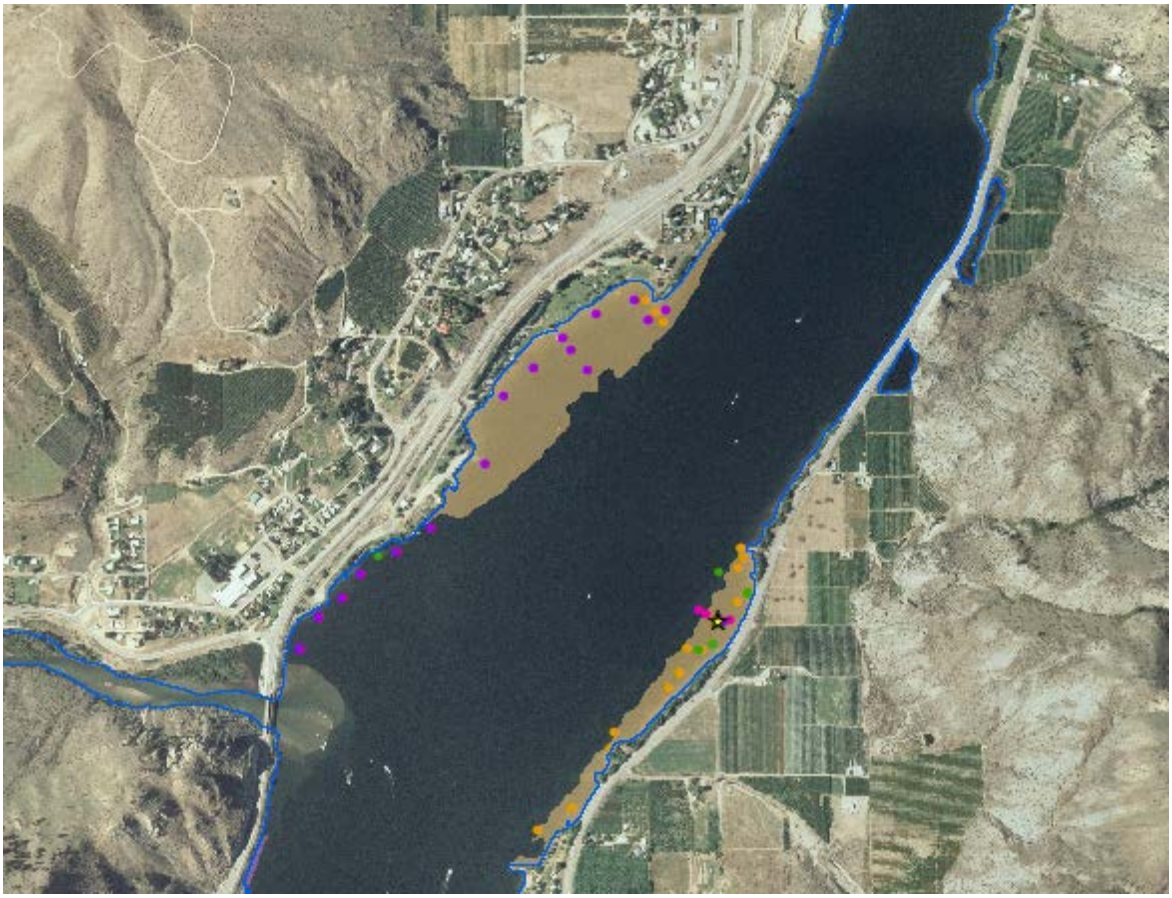
The mobile surveys covered a broad variety of macrophyte bed types and sizes, with measurements taken from various locations within the plant beds, near the outer edge and just beyond the edge in deeper water. A total of 26 measurements were taken in habitats without macrophytes, either in locations just beyond the edge of a plant bed, in areas with hard substrate within the boundary of a plant bed (above flooded roads) or in very shallow water where reservoir fluctuations prevented plant growth. The density of plants in a macrophyte bed was visually categorized as dense, moderate, low or sparse. These were subjective estimates, with dense consisting of plant stems covering the river bed with little space between plants, moderate was nearly continuous coverage with no more than a few inches of space between plants, low density had spaces of 6 inches to 12 inches between clumps of plants and sparse meant scattered clumps of plants more than 12 inches apart. The number of measurements from each category, range of total depth at measurement locations, and the range in dissolved oxygen and pH levels is shown in Table 3-5.

Table 3-5. Summary of data from mobile survey monitoring.

Macrophyte Density	Number of Measurements	Total Depth Range (ft)	Dissolved Oxygen Range	pH Range
Dense	373	1.5-14	8.3-13.9	7.8-9.9
Moderate	62	1.0-15	8.1-11.3	7.6-8.6
Low	45	2.0-16	8.3-11.0	7.5-8.7
Sparse	18	2.5-17	8.5-12.1	7.6-8.8
None	26	2.0-24	8.8-11.4	7.6-8.8

The mobile survey monitoring data were entered into a GIS database for mapping and interactive display of data by location. In addition to the measurement sites and information, the margins of many macrophyte beds and shoreline bands of macrophytes were contoured with the GPS and the polygons representing those macrophyte beds are part of the GIS database. An example of a GIS map with the four weeks of sample locations, color coded by week, is shown in Figure 3-14.

Figure 3-14. GIS map of sample locations and macrophyte beds at the Entiat fixed-site.



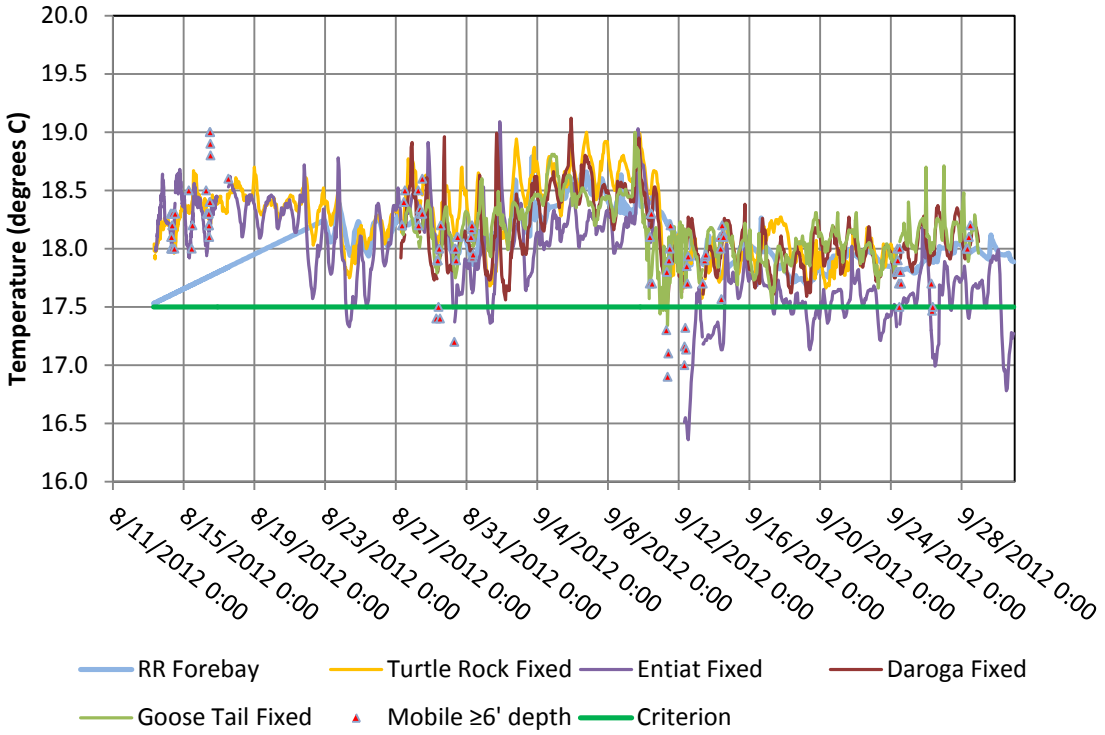
SECTION 4: DISCUSSION

The water quality in macrophyte beds in the Rocky Reach reservoir is generally favorable for aquatic life, but there are excursions from water quality criteria for the designated use of Salmonid Spawning, Rearing and Migration during August and September. The water temperatures in the shallow water areas, which commonly were also populated with macrophytes, are generally higher than the water quality criteria during August and September. This is not solely due to the effects of the macrophytes, rather it is typical for the Columbia River to exceed the 17.5 °C temperature criterion throughout Washington State. Although some water temperatures measured in shallow areas were higher than found in the main river channel, these water temperatures were localized and temporal. Following cool nights, water temperatures in the shallow areas were often cooler in the morning than temperatures in the main river channel.

Water temperatures measured at Rocky Reach Dam increased steadily during August, reaching 18.5 °C in late August and early September (Figure 4-1). The Rocky Reach forebay temperature peaked at 18.8 °C while the highest temperature recorded at the fixed-sites was 19.1 °C. These temperatures are well below the lethal temperature for salmonids. Despite nearly half of the mobile measurements being taken within a foot of the water surface, primarily in shallow areas

isolated from the main flow, only 69 of the 517 water temperature measurements were higher than 18.5 °C. A comparison of the water temperatures measured at the Rocky Reach forebay, at a depth of 15 feet, the temperature measurements at the fixed-sites, and temperatures measured during mobile surveys at depths of six feet or greater is shown in Figure 4-1. The Rocky Reach forebay measurements are from a location that has vertical circulation and mixing, thus these temperatures represent the average conditions in the main river channel.

Figure 4-1. Water temperatures at Rocky Reach foregay, fixed-sites and at mobile site at depths at six feet of depth or greater.



The dissolved oxygen measurements below 8.0 mg/l were relatively few (151/4215 = 3.6%) and none were below the 6.5 mg/l criterion for the Salmonid Rearing and Migration Only designated use category (substrates and flow velocities in the shallow habitats were not suitable for salmon spawning). The pH exceedances were common at the Entiat fixed-site and frequent in the mobile surveys in similar shallow, dense macrophyte beds. However, pH levels above 8.5 were uncommon at the other fixed-sites (59/2538 = 2.3%).

The macrophyte beds are heavily used as rearing habitat by small fish. During this study, small fish were readily visible moving about in the plant beds and larger fish were observed darting into the cover of the plant when running GPS contours along the outside edge of the macrophyte beds. In 1999, DES conducted fish presence and habitat use surveys of the Rocky Reach reservoir. During those surveys, one of their fyke net sampling sites was in the vicinity of the Turtle Rock fixed-site. Although the DES report does not mention macrophytes as present, that fyke net site did have sandy substrate, which is abundant within the confines of the large macrophyte bed at the Turtle Rock fixed-site. They reported catches of largescale and longnose

sucker, Northern pikeminnow, redside shiner, chiselmouth and threespine stickleback (DES, 2001b).

The Rocky Reach Resident Fish Study, conducted during 2012, sampled dense macrophyte beds with pop nets during the period from August 27 – September 6 (WDFW 2013). They reported capturing chiselmouth, Northern pikeminnow, sculpin, smallmouth bass, suckers, peamouth, redside shiner, and threespine stickleback. The native threespine stickleback (mean length 30 mm) were the dominant fish species captured in the pop nets, comprising 70.5% of the fish captured. They also reported water quality measurements at the pop net sample sites that are consistent with the range of measurements reported in this study (WDFW 2013).

All the species captured in pop nets reported in the resident fish study were tolerant of warm water temperatures, with the possible exception of the sculpins (species not identified), which tend to prefer the same water temperatures as salmonids. The most common species present, threespine stickleback, are tolerant of warm water temperatures, with Columbia River specimens having an LD 50 of 26 °C after acclimation at 19 °C (Blahm and Snyder, 1975 as cited in Wooten, 1984) Threespine stickleback are also tolerant of a wide range of dissolved oxygen and pH levels (Wootton, 1984).

While the macrophyte beds can have high pH levels and some reductions in dissolved oxygen levels due to plant respiration and photosynthesis, this type of habitat provides important cover for small fish and a food source due to the insects that are associated with the plant life. These small fish, in turn, serve as food for larger fish, birds and aquatic mammals. Also, the pondweed species provide important food for waterfowl during the summer and winter. Large flocks of Canada geese were often observed grazing on the macrophyte beds during the mobile survey data collection. Despite minor deviations from water quality criteria, the benefits provided by these habitats, which comprise less than five percent of the area of Rocky Reach reservoir, likely outweigh their effects on water quality.

SECTION 5: LITERATURE CITED

DES. 2001a. Rocky Reach aquatic habitat mapping - final, Rocky Reach Hydroelectric ProjectNo. 2145. Prepared by Duke Engineering & Services, Inc., Bellingham, Washington, forChelan PUD. June 1, 2001. 39 pp.

DES. 2001b. Rocky Reach fish presence and habitat use survey - final, Rocky ReachHydroelectric Project No. 2145. Prepared by DES, Bellingham, Washington, for ChelanPUD. June 1, 2001. 81 pp.

Wootton, Robin J. 1984. A functional biology of sticklebacks. University of California Press.

WDFW, 2013. Rocky Reach Project resident fish study. Completion report, Contractor Number 11-1914, Contract # 12-059. Prepared by Washington Department of Fish and Wildlife, Large Lakes Research Team. 54 pp.

APPENDIX A: CONSULTATION RECORD

Chelan PUD provided a draft of the Shallow Water/Macrophyte Bed Water Quality Monitoring Report to Ecology and the other members of the RRFF in accordance with the requirements of the September 18, 2013, FERC Letter Order granting a time extension, which set the date for issuance of the draft report as September 30, 2013. The draft was sent out for review, as described in an email notification dated September 30, 2013 (see below).

The following individuals external to Chelan PUD were sent draft copies for review:

NAME	***AGENCY***	***Comments***
Irle, Pat	Washington State Department of Ecology	
Korth, Jeffrey	Washington State Department of Fish and Wildlife	
Burgess, Dave	Washington State Department of Fish and Wildlife	
Maitland, Travis	Washington State Department of Fish and Wildlife	
James, Brad	Washington State Department of Fish and Wildlife	
Jackson, Chad	Washington State Department of Fish and Wildlife	
Verhey, Patrick	Washington State Department of Fish and Wildlife	
Simmons, Katrina	Washington State Department of Fish and Wildlife	
Glesne, Reed	National Park Service	
Rosebrough, Susan	National Park Service	
Lewis, Steve	United States Fish and Wildlife Service	
Nelle, R. D.	United States Fish and Wildlife Service	
Rainey, Steve	United States Fish and Wildlife Service (consultant)	
Yeager, Justin	National Marine Fisheries Services	
Nordland, Bryan	National Marine Fisheries Services	
McLellan, Jason	Confederated Tribes of the Colville Reservation	
Rose, Bob	Yakama Indian Nation	
Lampman, Ralph	Yakama Indian Nation	
Skiles, Tom	Columbia River Inter-Tribal Fish Commission	
Jackson, Aaron	Confederated Tribes of the Umatilla Indian Reservation	
Vradenburg, Keith	City of Entiat	
Huber, Bob	Alcoa	
Finicle, Ken	Puget Sound Energy	
Gingerich, Andrew	Douglas County PUD	
Clement, Mike	Grant County PUD	

Commenting Agency	Agency Comment	Chelan PUD Response
Ecology	First wanted to say this is really a well written and well presented report! Regarding your Discussion of the results (Section 4): This did a nice job of summarizing the results and putting the values into perspective, especially in the second and last paragraphs. I'm glad you thought to include the water temperature at Rocky Reach Dam. That said, it would be helpful to go one step farther and include a plot of the temperature near the surface at the Rocky Reach forebay to water at a similar depth at your four fixed monitoring stations (and maybe an average of the mobile measurements at the same depths), plotted against time.	Figure 4-1 was added to the discussion, which incorporated hourly water temperature data from the Rocky Reach forebay monitoring location and the discussion was expanded relevant to this additional information.
Ecology	Could you include the actual numeric value (and resulting percentage) when you say "relatively few" of the dissolved oxygen measurements were below 8.0?	The numeric values and percentages were added to the discussion for dissolved oxygen and pH.
Ecology	This is where the comparison with the results of the Resident Fish Study makes this report most interesting. Could you include the basic conclusions of the WDFW of their results of sampling in the macrophyte beds, with respect to which primary specie was caught? I think they said that the results of the popnets were most relevant. If so, it would help to specifically mention that 70% of the fish caught in the macrophyte beds were the native Threespine Stickleback, with an average length of 3 cm.	The information regarding threespine stickleback comprising 70.5% of the fish samples, with mean length of 30 mm was added to the discussion.
Ecology	To go one step farther, it would be useful to include basic information about what kind of environment this fish prefers/tolerates (temperature, pH, macrophyte beds) compared to other native species. As a bonus, it would be good to include how it interacts with other native fish species in the Columbia River (e.g., a good source of food?)	Information from the published literature, with citation, regarding the broad tolerance of threespine stickleback for warm water temperatures, low dissolved oxygen and a broad range in pH was added to the discussion.
Ecology	And one minor edit: Table 3-2. Did you want the title to be pH (instead of Dissolved oxygen)	This correction was made to the figure caption.
RRFF T Hillman, Chairperson	I read the draft shallow water/macrophyte bed water quality monitoring report and found it well written. I made only a few minor edits and added a few comments. Hopefully you can see them in the pdf.	The edits in the PDF file were made to the report, including the addition of Section 2.3 Data Analysis.

From: Tracy Hillman [mailto:tracy.hillman@bioanalysts.net]
Sent: Monday, September 30, 2013 2:20 PM
To: Aaron Jackson; Andrew Gingerich; 'Bob Huber'; Bob Rose; 'Brad James'; 'Bryan Nordlund'; 'Catherine Willard'; 'Chad Jackson'; 'Dave Burgess'; Bitterman, Deborah; Jason McLellan; 'Jeff Korth'; Osborn, Jeff; 'Jerry Marco'; Joe Miller; Josh Murauskas; Justin Yeager; 'Katrina Simmons'; Truscott, Keith; 'Keith Vradenburg'; 'Ken Finicle'; Keller, Lance; 'Mike Clement'; 'Pat Irle'; 'Patrick Verhey'; Paul Anders; Ralph Lampman; 'RD Nelle'; 'Reed Glesne'; Hays, Steve; Hemstrom, Steven; 'Steve Lewis'; Steve Rainey; 'Susan Rosebrough'; Hodgson, Suzanne; Tom Skiles; Travis Maitland; Frantz, Waikele M.
Cc: Sokolowski, Rosana; Smith, Michelle
Subject: RRFF: Draft Water Quality Macrophyte Bed Report

Hello RRFF,

Attached for your review is the draft water quality macrophyte bed report from Chelan PUD. Please provide comments to Steve Hays by Friday, 1 November. Let me or Steve know if you have questions.

Thanks,
Tracy

Tracy W. Hillman, Ph.D.
Senior Ecologist

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From: Irle, Pat (ECY) [mailto:PIRL461@ECY.WA.GOV]
Sent: Thursday, October 31, 2013 10:21 AM
To: Hays, Steve
Cc: Coffin, Chris (ECY)
Subject: FW: RRFF: Draft Water Quality Macrophyte Bed Report

Hi, Steve –

How's your Achilles' tendon doing?

First wanted to say this is really a well written and well presented report!

Regarding your Discussion of the results (Section 4):

This did a nice job of summarizing the results and putting the values into perspective, especially in the second and last paragraphs.

1) Regarding the second paragraph:
    a. I'm glad you thought to include the water temperature at Rocky Reach Dam. That said, it would be helpful to go one step farther and include a plot of the temperature near the surface at the Rocky Reach forebay to water at a similar depth at your four fixed monitoring stations (and maybe an average of the mobile measurements at the same depths), plotted against time.
    b. Could you include the actual numeric value (and resulting percentage) when you say "relatively few" of the dissolved oxygen measurements were below 8.0?
2) Regarding the last paragraph:
    a. This is where the comparison with the results of the Resident Fish Study makes this report most interesting. Could you include the basic conclusions of the WDFW of their results of sampling in the macrophyte beds, with respect to which primary specie was caught? I think they said that the results of the popnets were most relevant. If so, it would help to specifically mention that 70% of the fish caught in the macrophyte beds were the native Threespine Stickleback, with an average length of 3 cm. To go one step farther, it would be useful to include basic information about what kind of environment this fish prefers/tolerates (temperature, pH, macrophyte beds) compared to other native species. As a bonus, it would be good to include how it interacts with other native fish species in the Columbia River (e.g., a good source of food?)

And one minor edit: Table 3-2. Did you want the title to be pH (instead of Dissolved oxygen)?

Nice job!

Pat

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From: Tracy Hillman [mailto:tracy.hillman@bioanalysts.net]
Sent: Thursday, October 17, 2013 10:49 AM
To: Hays, Steve
Subject: Macrophyte Water Quality Report

Hi Steve,

I read the draft shallow water/macrophyte bed water quality monitoring report and found it well written. I made only a few minor edits and added a few comments. Hopefully you can see them in the pdf. Let me know if you do not see my comments/edits in the report. I lack the necessary skills and software to effectively edit pdfs.

Thanks,
Tracy

Tracy W. Hillman, Ph.D.
Senior Ecologist

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From: Tracy Hillman [mailto:tracy.hillman@bioanalysts.net]
Sent: Wednesday, October 30, 2013 10:43 AM
To: Aaron Jackson; Andrew Gingerich; 'Bob Huber'; Bob Rose; 'Brad James'; 'Bryan Nordlund'; 'Chad Jackson'; 'Dave Burgess'; Bitterman, Deborah; Jason McLellan; 'Jeff Korth'; Osborn, Jeff; 'Jerry Marco'; Joe Miller; Josh Murauskas; Justin Yeager; 'Katrina Simmons'; Truscott, Keith; 'Keith Vradenburg'; 'Ken Finicle'; Keller, Lance; 'Mike Clement'; 'Pat Irle'; 'Patrick Verhey'; Paul Anders; Ralph Lampman; 'RD Nelle'; 'Reed Glesne'; Hays, Steve; Hemstrom, Steven; 'Steve Lewis'; Steve Rainey; 'Susan Rosebrough'; Hodgson, Suzanne; Tom Skiles; Travis Maitland; Frantz, Waikele M.
Subject: RRFF: Final Resident Fish Report from WDFW

Hello RRFF,

Attached please find the final Rocky Reach Resident Fish Report prepared by WDFW. Please read the Discussion and Conclusions sections. We will discuss these during the RRFF meeting.

Thanks,
Tracy

Tracy W. Hillman, Ph.D.
Senior Ecologist

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FEDERAL ENERGY REGULATORY COMMISSION
Division of Hydropower Administration and Compliance
Washington D.C. 20426

Office of Energy Projects

Project No. 2145-116—Washington
Rocky Reach Hydroelectric Project
Public Utility District No. 1 of Chelan County

September 18, 2013

Mr. John Janney
Public Utility District No. 1 of Chelan County
327 North Wenatchee Avenue
P.O. Box 1231
Wenatchee, WA 98807-1231

Subject: Schedule Revision for Implementation of the Shallow Water / Macrophyte Bed Sampling Report

Dear Mr. Janney:

This letter acknowledges the receipt of your August 29, 2013 filing with the Federal Energy Regulatory Commission (Commission) regarding the sampling and reporting schedule for shallow water / macrophyte bed sampling as required by Article 401 of the Rocky Reach Hydroelectric Project license.[1] The Update for Shallow Water / Macrophyte Bed Sampling Study Plan, filed with the Commission on July 26, 2012, identified April 15, 2013 as the target deadline for filing the final report with the Commission, depending on weather, equipment, and other unforeseen circumstances that could affect the sampling schedule.

In your August 29, 2013 letter, you stated that data analyses remain incomplete and that the Washington Department of Ecology (Ecology) requested that you make the final macrophyte report available for their review and comment concurrently with your final Resident Fish Study Report.[2] Accordingly, you suggest postponing the report filing date with the Commission to November 15, 2013, stating this should provide adequate

[1] Order on Offer of Settlement and Issuing New License. 126 FERC ¶ 61,138 (issued February 19, 2009).
[2] The agencies' 30-day review and comment period for the final Resident Fish Study Report was scheduled to begin August 30, 2013.

time for a thorough analysis that will incorporate comments from Ecology and the Rocky Reach Fish Forum.[3]

You provided the proposed revised schedule to Ecology and the Rocky Reach Fish Forum on August 18, 2013 for comment. Ecology approved the new schedule on August 19, 2013. The Confederated Tribes of the Colville Indian Reservation and the Washington Department of Fish and Wildlife also approved the revised schedule on August 20, 2013 and August 26, 2013 respectively. No other responses were received.

This revised schedule is acceptable. The original schedule was filed with a clear understanding that the target deadline was a rough estimate and would likely be altered. Moreover, it seems apparent that additional time is necessary to provide an accurate analysis of the sampling data and to conduct agency consultation.

Thank you for your cooperation. We look forward to your final report, expected to be filed before November 15, 2013. If additional time is needed to file your report with the Commission, you must file a request for an extension of time before the November 15, 2013 deadline. If you have any questions concerning this letter please contact me at (202) 502-8038 or alicia.burtner@ferc.gov.

Sincerely,

Alicia Burtner
Fish Biologist
Division of Hydropower Administration
and Compliance

[3] The Fish Forum includes representatives from the Ecology, Washington Department of Fish and Wildlife, Confederated Tribes of the Colville Indian Reservation, Confederated Tribes and Bands of the Yakama Nation, U.S. Fish and Wildlife Service, National Park Service, City of Entiat, and Alcoa.