2014
LOWER DESCHUTES RIVER
WATER QUALITY RESULTS

DESCHUTES RIVER ALLIANCE

Oregon Wildlife

Prepared by Rick Hafele
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INTRODUCTION

Ecological changes have been observed on the lower Deschutes River since the Selective Water Withdrawal tower (SWW) at Pelton Round-Butte Dam began operation in 2010. The Pelton Round Butte hydroelectric complex, located at river mile 100 on Oregon's Deschutes River is owned and operated jointly by Portland General Electric (PGE) and the Confederated Tribes of Warm Springs Reservation of Oregon (CTWS). These changes, observed by numerous long-time anglers and experienced fishing guides and reported by the Deschutes River Alliance (DRA) (Hafele 2014 & 2015), include shifts in emergence timing of well known insects, declining abundance of historically famous and abundant adult insects including the near extirpation of the *Antocha* sp. crane fly, a rapid increase in species of diatom algae not previously observed in the river, and notable declines in swallows, nighthawks and bats that largely depend on adult aquatic insects from the river for their food. These changes all point to some underlying shift in the quality of water released from the Pelton Round-Butte Dam complex (PRB).

The lower 100 miles of the Deschutes River has been listed as water quality limited (Clean Water Act, Section 303d) by the Oregon Department of Environmental Quality (ODEQ) for several water quality parameters: pH, dissolved oxygen (DO), and temperature (ODEQ 2010). Declines in the quality of water released from PRB are therefore a concern if these changes exacerbate already existing water quality problems. Water quality as it relates to the hydroelectric project was addressed in Exhibit A to PGE's 2005 operation license issued by the Federal Energy Regulatory Commission's (FERC) as the Water Quality Management & Monitoring Plan (WQMMP). The WQMMP defines specific water quality limits and objectives for specific parameters, monitoring actions and requirements, and actions to be taken if water quality parameters fail to meet objectives. The WQMMP was agreed to by PGE, CTWS and ODEQ.

While PGE has collected the required water quality data and reported the results in annual water quality reports to FERC, their results show that some of the water quality parameters have not met the requirements defined in the WQMMP (Campbell 2014). In particular pH and dissolved oxygen (DO) have been out of compliance with the limits outlined in the WQMMP indicating that negative impacts to the ecological health of the lower Deschutes River are likely. As a result of these concerns the DRA conducted studies in 2014 to document water quality conditions for pH, DO, conductivity, turbidity, and water temperature at regular intervals in the Deschutes River from just below the PRB complex downstream to near the Deschutes River/Columbia River confluence. This report describes the results from that water quality sampling.

SURVEY METHODS

Water quality studies completed in 2014 by DRA include:

1. Continuous temperature data collected at five sites from May through early November.
2. On August 2, 2014, Quantum Spatial, Inc. gathered aerial thermal infrared (TIR) imagery for the lower 100 miles of the Deschutes River.
3. Between July 21 and July 23, 2014, multiple daily grab samples for dissolved oxygen, pH, conductivity, turbidity and temperature were collected at five sites on the lower Deschutes River from Mecca Flats (RM 96) downstream to Wagonblast campsite (RM 4).
4. From August 5-8, 2014, continuous water quality data were collected for dissolved oxygen, pH, temperature, and conductivity every 15 minutes at three sites: just downstream of the PRB complex (RM 100), near Harpham Flat campground (RM 57), and at Wagonblast campsite (RM 4).

This report provides an assessment of the water quality grab samples and continuous water quality data. An assessment of the continuous water temperature data and the thermal infrared study will be provided in separate reports.

A monitoring & quality assurance plan was developed for these studies, and is available online at: http://images.wolfpk.com/deschutesriveralliance/pdf/2014DeschutesRiverAllianceWaterQualityMonitoringPlanfortheLowerDeschutesRiver.pdf

The objectives of the water monitoring studies described in this report include:

1. Assess the diurnal pattern for pH, DO, and temperature in the lower Deschutes River, and how it varies from near the Deschutes/Columbia confluence upstream to near the PRB complex.
2. Document if any of the water quality parameters measured by DRA were in violation of Oregon's water quality standards for the Deschutes Basin.
3. Better understand if water quality in the Deschutes River downstream from the PRB complex is being affected by water releases through the SWW.
4. Assess if water quality changes in the Deschutes River downstream from the PRB complex may be causing the changes observed in the algal and macroinvertebrate communities.
5. Assess if tributaries below the PRB complex have a measurable influence on water quality in the lower 100 miles of the Deschutes River.

In addition to answering these questions, we hope that the data collected from this project can be used to work with PGE, The Confederated Tribes of Warm Springs (CTWS), ODEQ, the US Environmental Protection Agency (EPA), and other appropriate state government agencies to address and correct water quality problems in the lower 100 miles of the Deschutes River.

Grab Sample Collection:

Beginning on the morning of July 21, 2014, and ending the morning of July 24, 2014, water samples were collected at five sites twice per day; once in the morning between 8:00 and 9:30am, and once in the afternoon between 4:00 and 5:00pm. Sites sampled were located at: Mecca Flats campground (RM 96), Davidson Flats campground (RM 74), Oasis campground (RM 51), Macks Canyon campground (RM 24), and Wagonblast campground (RM 4). Field measurements from each sample included temperature, pH, dissolved oxygen, conductivity, and turbidity.

Sample crews went through a field training session on the afternoon of July 20, 2014, to ensure all field procedures and instrument use were carried out uniformly and correctly. Field samples were collected using standard field procedures outlined in ODEQ's Mode of Operations Manual (ODEQ 2009). Precision and accuracy targets for field measurements are shown in Table 1. Duplicate samples were collected once each day at each site for quality assurance and control (QA/QC), a standard procedure to assess sample accuracy.

Continuous Data Collection:

Table 1: Accuracy and Precision Targets

Matrix	Parameter	Precision	Accuracy	Measurement Range
Water	Temperature Cont. Temp.	± 0.5 °C ± 1.5 °C/30 min	± 0.5 °C ± 0.5 °C	-5 to 35 °C -5 to 35 °C
Water	pH	± 0.3 SU	± 0.2 SU	0 to 14 SU
Water	Conductivity	± 10% Relative percent difference	± 7% of Std. Value	≤ 1 to 4999 µS/cm
Water	Turbidity	± 5% Relative percent difference (± 1 NTU if NTU < 20 NTU)	± 5% of Std. Value	≤ 1 to 1000 NTU
Water	Dissolved Oxygen	± 0.3 mg/l	± 0.2 mg/l	≤ 0.1 to 20 mg/l

In addition to collecting grab samples, three sites were monitored using YSI Data Sondes to collect a time series of data at 15 minute intervals starting at noon on August 5, 2014, and ending the morning of August 8, 2014. The three sample sites were located from just downstream of the PRB complex (RM 100), near Harpham Flat campground (RM 57) and at Wagonblast campground (RM 4). Parameters measured by the data sondes were temperature, DO, pH, and conductivity. Field grab samples were also collected each day during the data sonde deployment for QA/QC audits.

Data Analysis:

Sample results were analyzed by John Van Sickle, Environmental Statistician (former EPA and Oregon State University statistician). All analyses and graphics were done using the R language (v.3.1.1). Results were tested for a possible upstream linear trend, for each analyte across the n=5 sites, by estimating the linear (product-moment) correlation coefficient between the site mean and the site river mile. Assuming statistical independence between the sites (adjacent sites are about 25 miles apart), the data were also tested whether each correlation was significantly different from zero. This analysis was done separately for the AM and PM means.

The means for each analyte were plotted and tabulated versus the site river mile, and the plots report the correlations and their P-values. A significant positive correlation indicates that the analyte was increasing in an upstream direction. No multiple-testing adjustments were made for the correlation significances.

For continuous data, the sinusoidal (sine wave) models of pH and DO were fit to the full periods of time series data available at each of the 3 continuous data sites. In addition, the time series plots for all analytes span the full series length at each site. However, estimating the means or other summary statistics over the full periods would generate bias, because of the differing period lengths. To eliminate such bias, all summary statistics were calculated over the exact same time period, defined as longest time period that was covered at all 3 sites. Thus, all summary statistics from sondes are estimated over the period from 13:30, August 5, 2014, to 13:45, August 7, 2014.

RESULTS & DISCUSSION

A summary of results for the July grab sample data are shown in Table 2. These data show a linear trend from the lower most sample site near the river mouth, upstream to the upper most site for most parameters. A discussion of each parameter for both grab sample and continuous data follows.

Table 2 – Mean grab-sample concentrations of 5 analytes at 5 sites on the Deschutes River, July 21-23, 2014. Each value is the mean of one sample from each of 3 successive days, taken at approximately the same time (AM or PM) on each day.

Site	Riv_Mile	AM/PM	Temp	pH	SpCond	DO	Turbidity	
WagonBlast	4	AM	16.93	8.27	115.00	9.37	2.40	
WagonBlast	4	PM	18.47	9.03	114.33	10.27	2.47	
Macks Canyon	24	AM	16.33	8.53	116.33	9.60	2.27	
Macks Canyon	24	PM	17.27	8.83	116.67	10.47	2.17	
Oasis	52	AM	15.30	7.73	117.00	9.37	1.93	
Oasis	52	PM	15.57	8.30	116.00	10.50	1.77	
Davidson Flat	74	AM	14.00	8.23	100.33	8.77	1.73	
Davidson Flat	74	PM	15.30	8.93	108.67	9.63	1.93	
Mecca Flats	96	AM	13.67	8.57	121.33	8.80	1.67	
Mecca Flats	96	PM	14.17	8.70	118.00	9.60	1.57	

Temperature:

The mean of July temperature grab samples showed a statistically significant, approximately linear decrease moving upstream from RM 4 to RM 96, for both AM and PM samples. Or conversely, the July temperature data showed that water temperature increased in more or less a linear fashion from the PRB complex as it traveled downstream. Temperature time series from the August sampling showed clear diurnal variation at all 3 sonde sampling locations, although the diurnal pattern was a clean sinusoid only at RM 4. There was also almost no overlap in temperature time series at the 3 locations, which is consistent with the upstream temperature trends seen in the July grab samples. Mean temperatures between adjacent sonde locations, over the 2-day period in August, differed by 2.5 to 3 degrees centigrade.

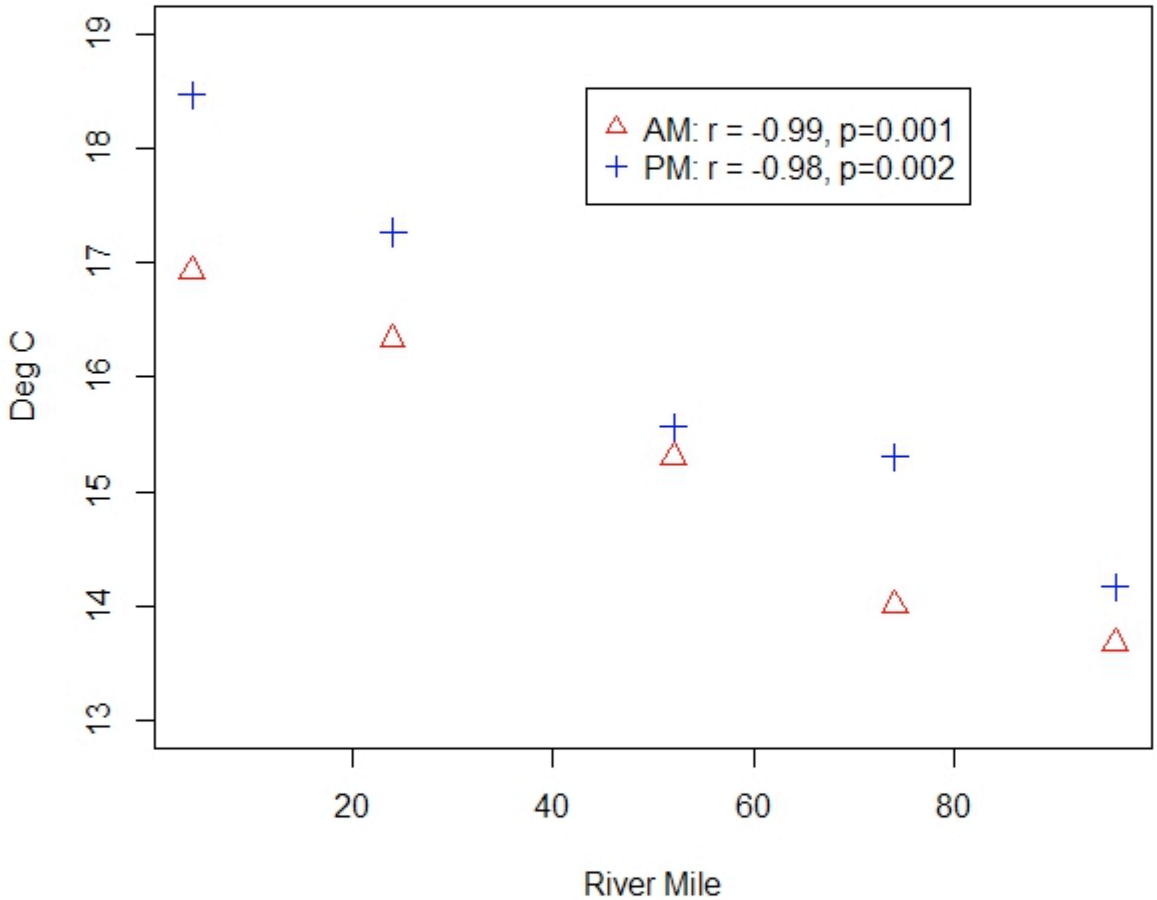

Figure 1 - Grab Samples, July 21-23, 2014: Mean temperature versus river mile, separately for AM and PM samples. Correlations and their p-values are for a linear trend. Means are listed in Table 2.

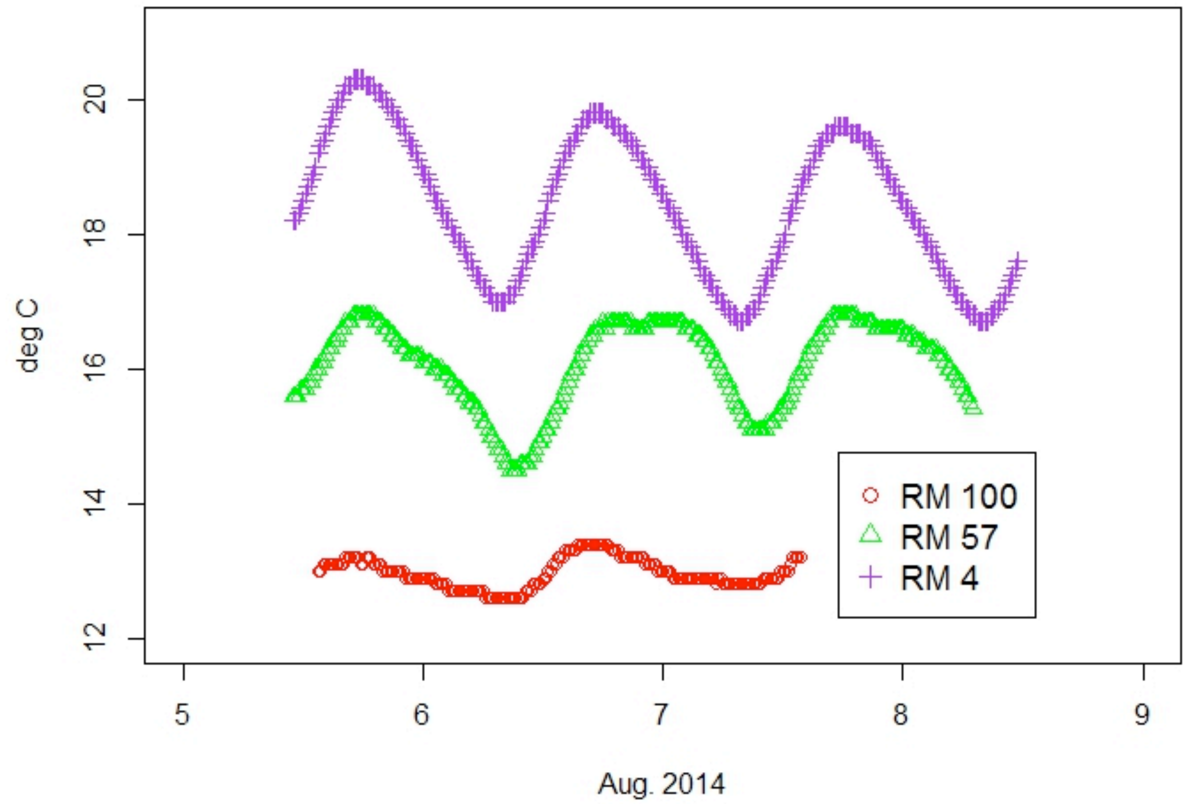

Figure 2 - Temperature time series from sonde data at 3 sites (RM 4, 57, 100).

Table 3 - Summary statistics (Deg. C) for observed temperature time series, from 13:30 8/5 to 13:45 8/7

River Mile	Mean	Max	Time of Max	Min	Time of Min
4	18.5	20.3	17:00-18:00 08/05	16.7	7:30-8:00 08/07
57	16.0	16.8	17:00-19:00 08/05	14.5	8:45-9:30 08/06
100	13.0	13.4	15:30-18:30 08/06	13.4	6:15-10:00 08/06

pH:

The grab-sample mean values showed no upstream trends in pH during the July grab sampling period, either for AM or PM samples. The sonde time series from the August sampling at each of the 3 locations were well-fitted by simple sinusoidal models, with very small estimated time trends. The sonde time series had slight upstream decreases in mean pH, however, these differences were quite small relative to the striking diurnal variation in pH at all 3 sites. During each daily cycle, pH ranged over 0.30 units (max-min) at RM 100, and this range increased to 1.4 units at RM 4. Maximum and minimum pH values occurred each day at approximately the same time, at all 3 sampling locations.

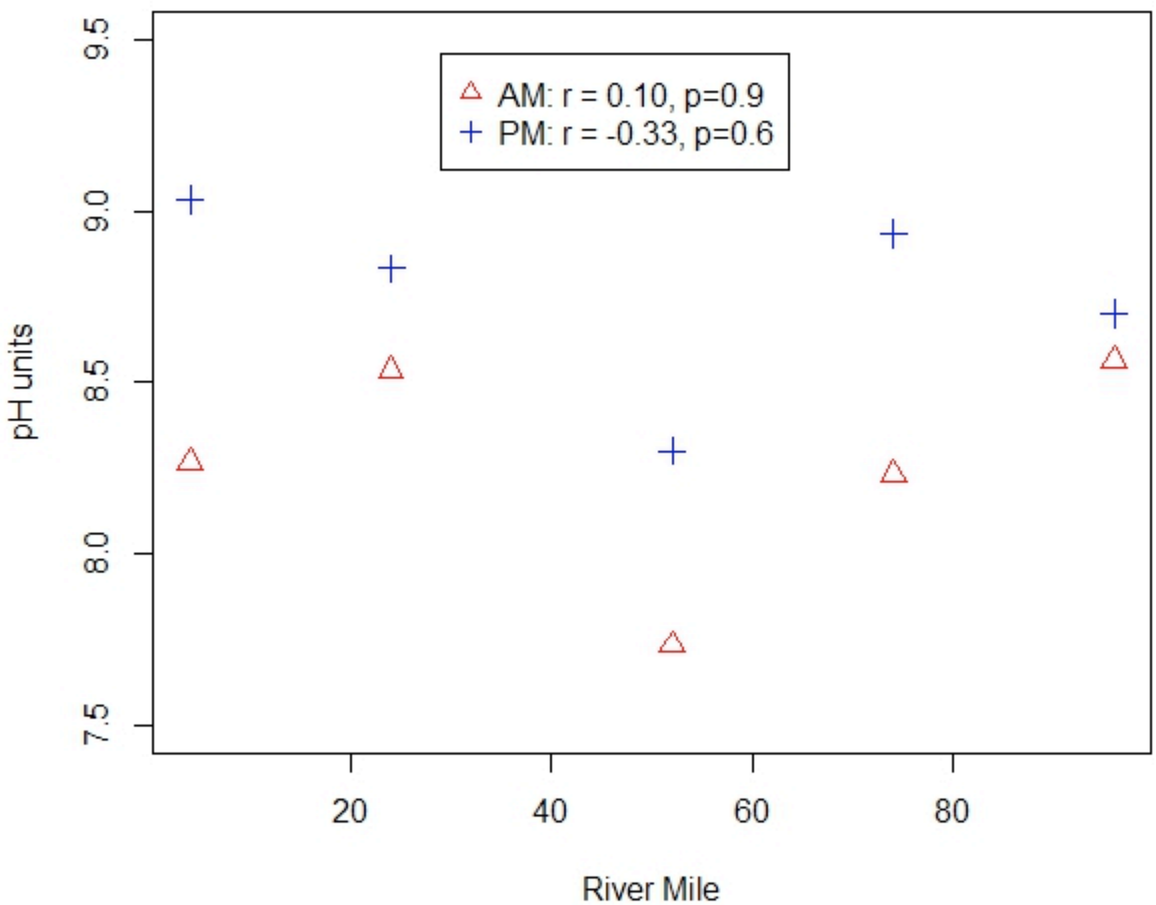

Figure 3 - Grab Samples, July 21-23, 2014: Mean pH versus river mile, separately for AM and PM samples. Correlations and their p-values are for a linear trend. Means are listed in Table 2.

Table 4 - Summary statistics for observed pH time series, and model-estimated trend and R^2 from 13.30 8/5 to 13.45 8/7

River Mile	Mean	Max	Time of Max	Min	Time of Min	Trend (pH units/day)	R^2
4	8.37	9.00	16:30-18:00 08/05, 17:00-17:45 08/06	7.60	5:45-7:00 08/06, 5:15-7:15 08/07	0.0093	0.97
57	8.11	8.60	17:00-19:15 08/05, 17:15-17:45 08/06	7.60	5:45-9:00 08/06, 5:15-9:00 08/07	-0.0361	0.98
100	7.99	8.20	15:15-18:15 08/06,	7.90	1:30-11:45 08/06, 0:30-11:30 08/07	0.0038	0.83

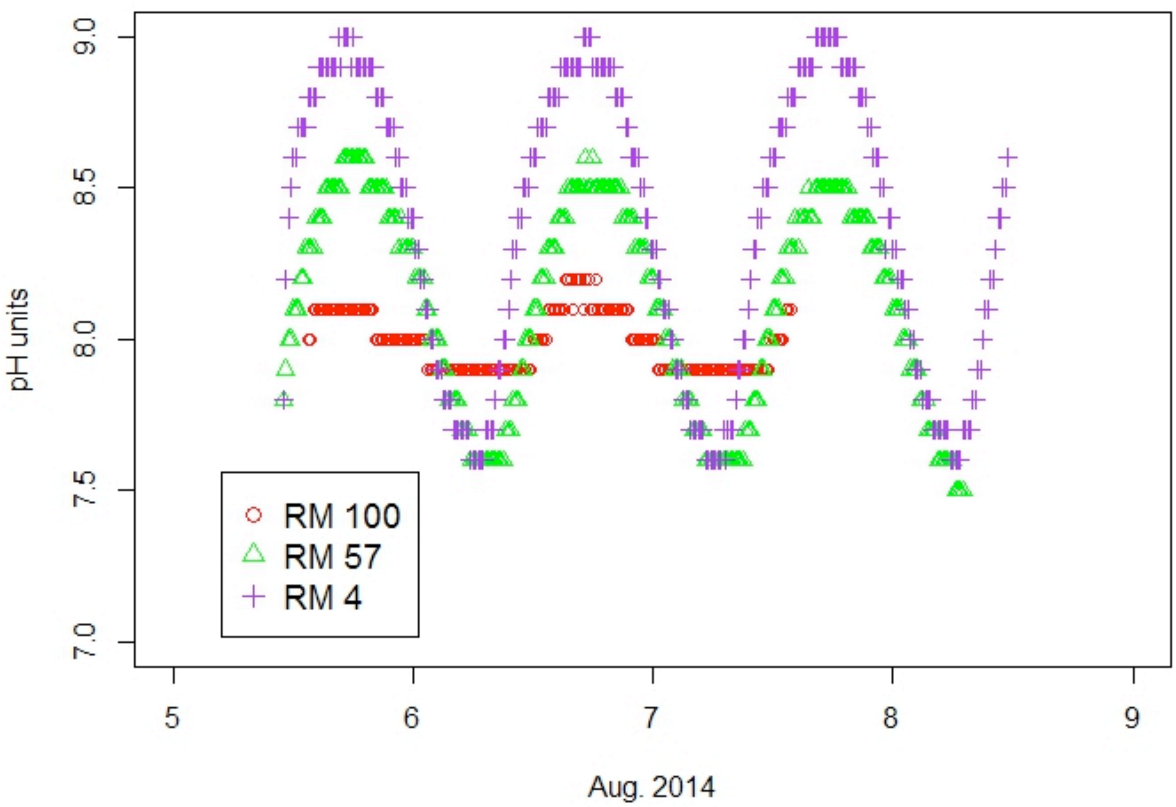

Figure 4 - pH time series from sonde data at 3 sites (RM 4, 57, 100).

Dissolved Oxygen (DO):

The means of DO grab samples from July 21-23, 2014, appeared to generally decline in an upstream direction. However, trend correlation p-values were not convincing, indicating no statistically significant trend. In the August sampling time series, DO values were consistently lower at the upper most site (RM 100) compared to the two downstream locations (Figure 6). Diurnal variation in the 3 time series was sinusoidal, ranging over 2.8 (RM 4), 2.3 (RM 57), and 1.0 (RM 100) mg/l. Estimated time trends at all three sites were small, relative to diurnal variation. The daily maximum and minimum DO at RM 57 was 1-2 hours later than the corresponding daily extremes at RM 4.

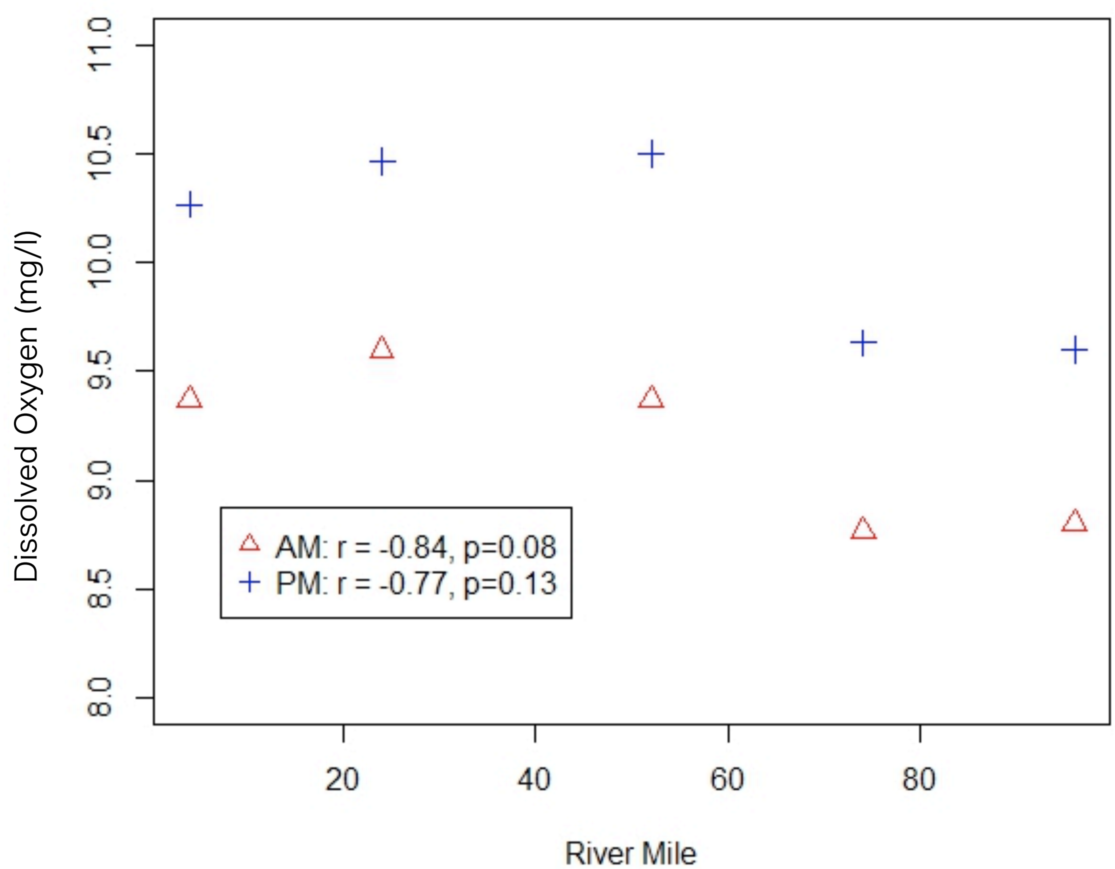

Figure 5 - Grab Samples, July 21-23, 2014: Mean DO versus river mile, separately for AM and PM samples. Correlations and their p-values are for a linear trend. Means are listed in Table 2.

Table 5 - Summary statistics for observed DO time series, and model-estimated trend and R^2 from 13:30 8/5 to 13:45 8/7.

River Mile	Mean	Max	Time of Max	Min	Time of Min	Trend (mg/l/day)	R^2
4	10.22	11.8	13:15-13:45 08/07	9.0	1:15-3:00 08/06,	0.0381	0.97
57	9.90	11.1	15:15-16:45 08/05, 14:30-17:00 08/06	8.8	2:15-5:00 08/07	-0.0315	0.98
100	8.84	9.4	16:15-16:45 08/05, 15:45-17:15 08/06	8.4	6:15-6:45 08/06, 6:30-7:15 08/07	-0.0312	0.90

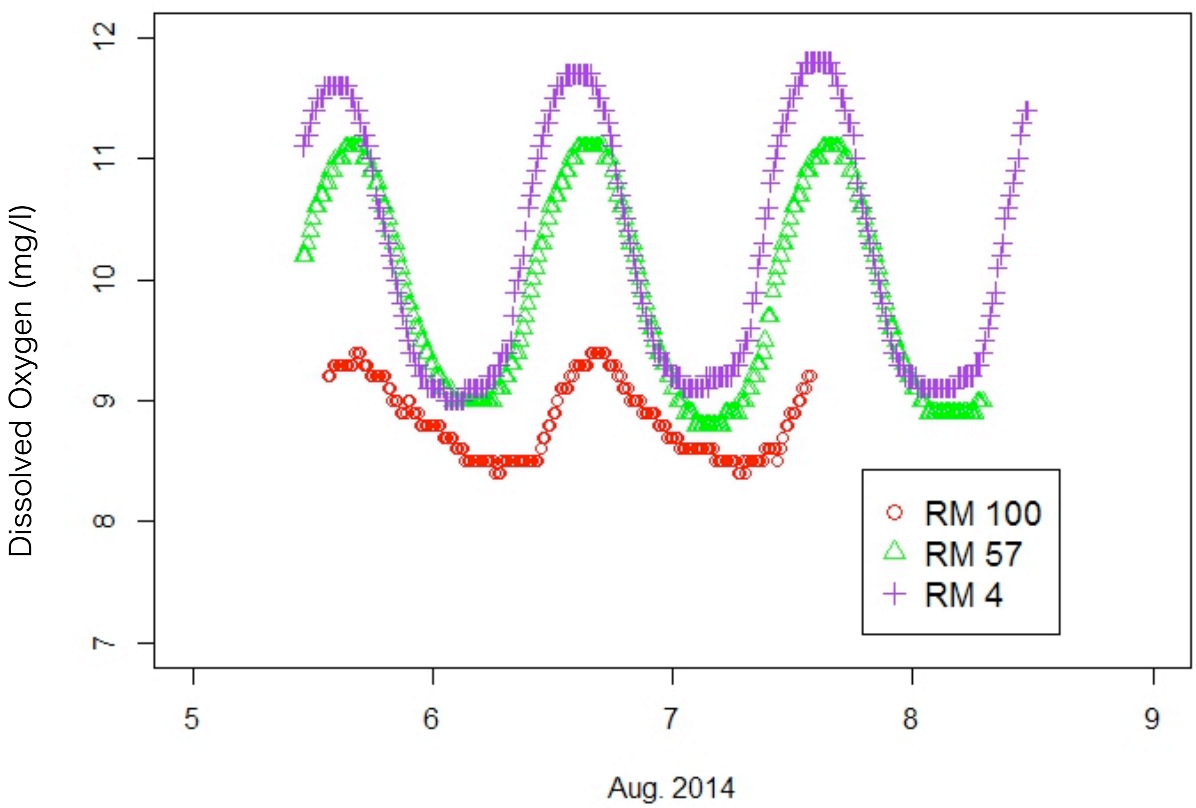

Figure 6 - Dissolved oxygen time series from sonde data at 3 sites (RM 4, 57, 100).

Conductivity:

The plot of July, AM and PM mean conductivity shows a slight trend of increasing conductivity from the downstream to upstream sample sites (Figure 7). However, this pattern was broken by the lower grab sample conductivities sampled at RM 74. The sonde time series from the August sampling also showed a slight increasing trend from downstream to upstream (Figure 8), however, the upward time trend at RM 4 suggested a convergence in conductivity with RM 57 by the third day of sampling. This example shows that conductivity differences across the sampling locations cannot be safely extrapolated outside the 3 day sampling period. The conductivity time series appeared to vary on a 1-day cycle like other analytes, however, the variation was small, especially at RM 57 and 100, relative to the reported measurement precision. Overall, the difference in conductivity values between sites was small and shows no significant change in conductivity along the lower 100 miles of the Deschutes River.

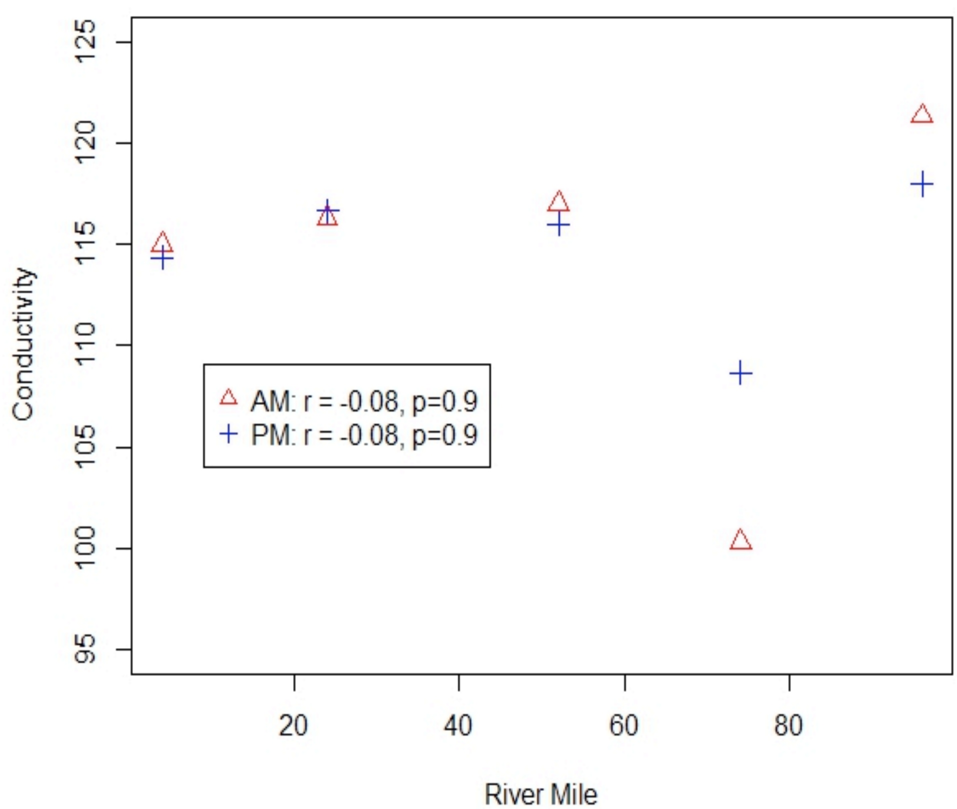

Figure 7 - Grab Samples, July 21-23, 2014: Mean conductivity versus river mile, separately for AM and PM samples. Correlations and their p-values are for a linear trend.

Table 6 - Summary statistics for observed conductivity (umhos/cm) time series, from 13:30, 8/5 to 13:45, 8/7.

River Mile	Mean	Max	Time of Max	Min	Time of Min
4	116.6	119	22:00-5:30 08/06-07	114	13:30-16:00 08/05
57	117.9	119	1:00-7:00 08/06	117	13:30-22:00 08/06, 7:30-13:45 08/07
100	121	123	1:30 08/05	120	6:15-22:15 08/06

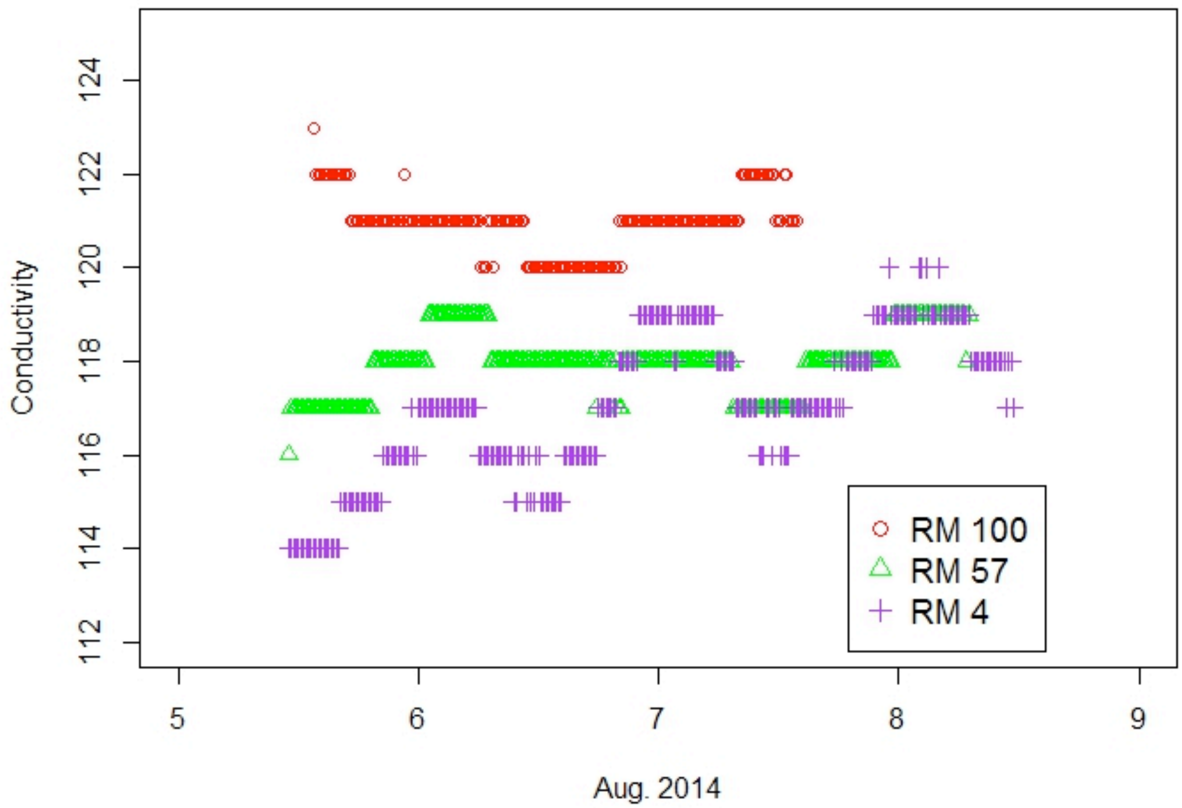

Figure 8 - Conductivity time series from sonde data at 3 sites (RM 4, 57, 100).

Turbidity:

Grab-sample mean turbidities from the July samples showed clear and significant linear declines, moving upstream from RM4, for both AM and PM samples. Turbidity measurements were not available in the August sonde data.

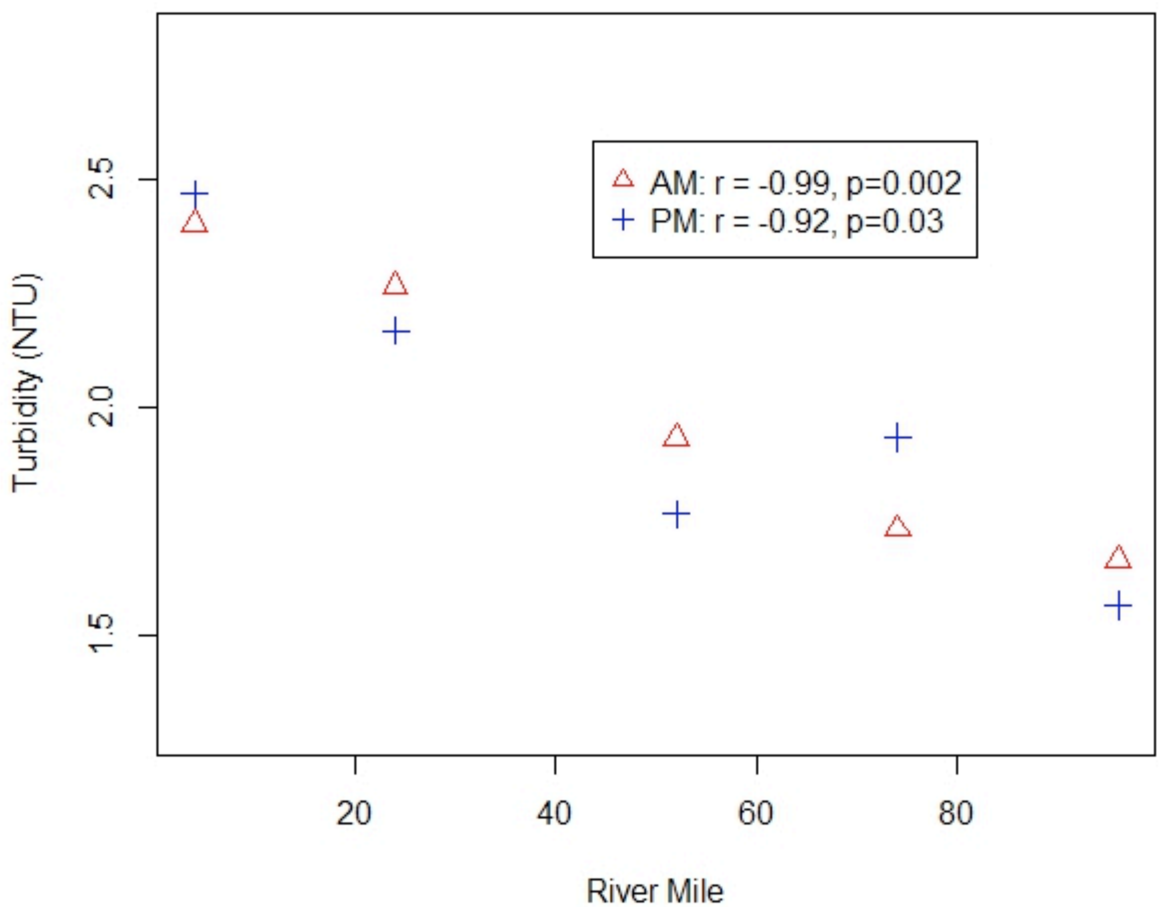

Figure 9 - Grab Samples, July 21-23, 2014: Mean turbidity versus river mile, separately for AM and PM samples. Correlations and their p-values are for a linear trend. Means are listed in Table 2.

SUMMARY

Based on field samples collected in July and August 2014, basic water quality conditions were assessed using both grab samples collected in the morning and late afternoon, and continuous data (measurements every 15 minutes) collected with YSI data sondes. Results can be summarized as follows:

1. Afternoon pH values exceeded the Deschutes basin water quality standard for pH (8.5) at all sites except the site at RM 51 in July and RM 100 in August. The highest pH values were measured at RM 4, with afternoon levels at or just above a pH of 9.0. Maximum pH values were generally lower at upstream sites compared to downstream sites; however pH values over 8.5 were still measured at the uppermost site (RM 96) in July.

2. Continuous data collected in August for pH, DO, and temperature showed a strong diurnal signal with maximum values recorded in mid to late afternoon (generally sometime between 1:30PM and 5:30PM). The magnitude of the diurnal fluctuations increased from upstream to downstream. Changes in the diurnal pattern for pH and DO are generally due to changes in algal production, with greater algal production resulting in larger diurnal swings in these parameters (Dodds 2002). The larger diurnal swings at lower sites reflects both robust algal growth near the downstream sample sites, and also the cumulative effect of algal photosynthesis and respiration from upstream reaches. This is shown by periphyton chlorophyll-*a* measurements taken in July that found chlorophyll-*a* levels at or above 100 mg/m^2 (Kurt Carpenter personal communication), at upstream sites including Mecca Flats (RM 96) and just above Trout Creek (RM 88). Chlorophyll-*a* above 100 mg/m^2 is considered nuisance levels of periphyton (Dodds 2002).

3. DO concentrations also showed a strong diurnal pattern with larger diurnal fluctuations at the lower most site (RM 4) compared to the upper site (RM 100). In August 2014, the lowest DO concentrations were in the morning between 2:00AM and 6:30AM. Low values ranged between 8.4 to 9.0 mg/l from the upper to the lower site, respectively. DO concentrations were within basin standards at all sites.

4. Temperature results showed a clear increase from the upstream sample sites to the down stream sample sites (Figures 1 & 2). The diurnal fluctuations in temperature also increased from the upstreams to the downstream sites (Figure 2). Such a downstream warming pattern is typical in streams without significant tributary inputs or large spring sources (Hauer & Lamberti 2006).

5. Conductivity showed relatively small differences between sample sites as well as little diurnal fluctuations.

6. Turbidity values were low at all sites (highest levels < 2.5 NTU). There was a clear linear decline in turbidity from the lower to upper site meaning the river was clearer near the mouth than near the PRB complex (Figure 9). However, the overall change was less than 1.0 NTU, which is a very small change in turbidity.

7. The water quality data collected and analyzed by this study showed that there were no water sources entering the lower 100 miles of the Deschutes River that measurably affected the parameters sampled. This strongly suggests that in order to make measurable improvements in water quality in the Deschutes River downstream from the PRB complex, changes in the quality of water released from the PRB complex will be required.

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