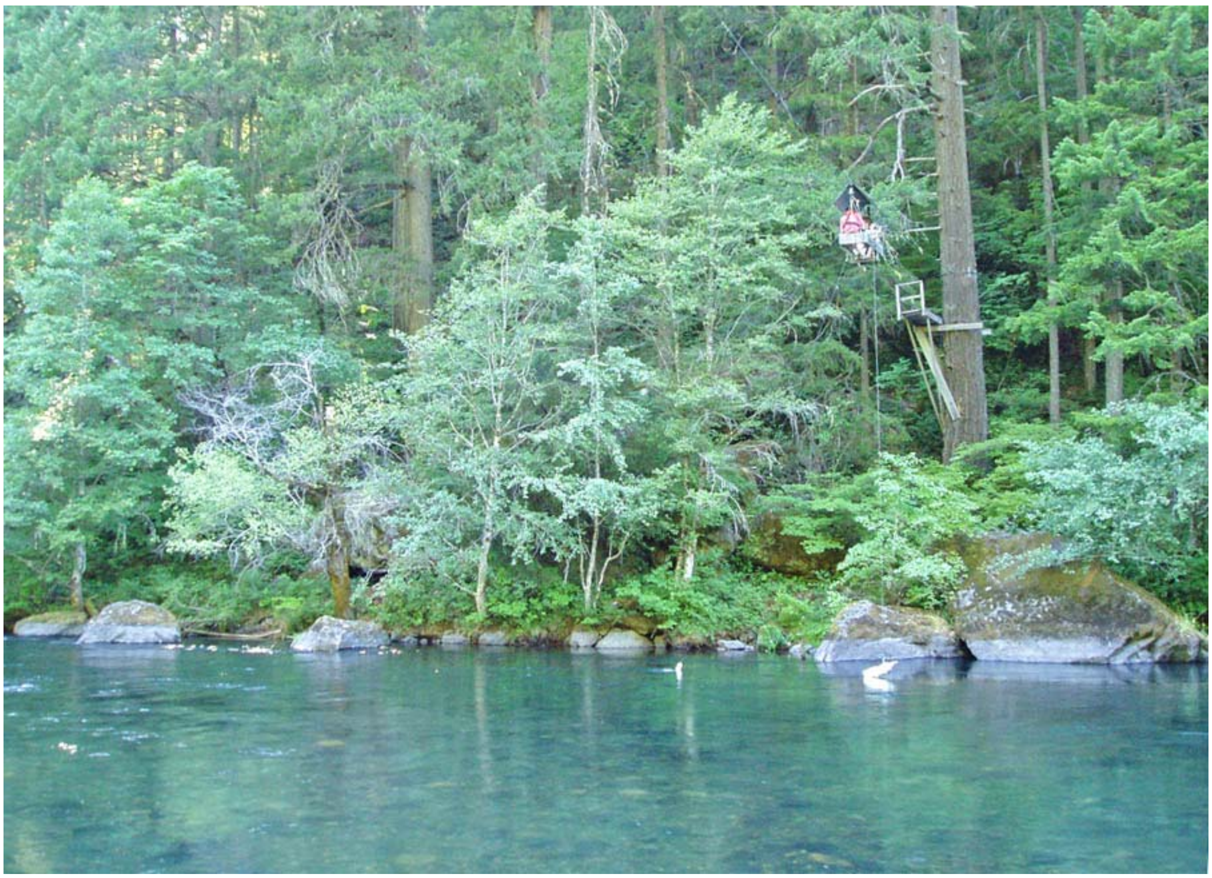
Prepared in cooperation with Douglas County

Water Quality and Algal Data for the North Umpqua River Basin, Oregon, 2005

By Dwight Q. Tanner, Andrew J. Arnsberg, Chauncey W. Anderson, and Kurt D. Carpenter



Data Series 229

U.S. Department of the Interior
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Cover: A USGS scientist collects water samples from the North Umpqua River.

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Suggested citation:
Tanner, D.Q., Arnsberg, A.J., Anderson, C.W., and Carpenter, K.D., 2006, Water quality and algal data for the North Umpqua River Basin, Oregon, 2005: U.S. Geological Survey Data Series Report 229, http://pubs.usgs.gov/ds/2006/229/.

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
micrometer (µm)	0.00004	inch (in.)
cubic micrometer (μm^3)	6.10237×10^{-14}	cubic inch ($in.^3$)
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
square centimeter (cm^2)	0.1550	square inch ($in.^2$)
square meter (m^2)	10.76	square foot (ft^2)
milligram	0.03527	ounce, avoirdupois (oz)
milliliter (mL)	0.00382	ounce, fluid (fl. oz)
liter (L)	33.82	ounce, fluid (fl. oz)
liter (L)	1.057	quart (qt)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Concentrations of water chemistry constituents are reported in milligrams per liter (mg/L), which is approximately equivalent to parts per million, and micrograms per liter (µ/L), which is approximately equivalent to parts per billion.

Specific conductance is reported in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

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Introduction

The upper North Umpqua River Basin (fig. 1), including the PacificCorp hydroelectric project area in the headwaters and the Wild and Scenic Reach farther downstream, has experienced a variety of water-quality problems since at least the early 1990's. A previous report documented nutrient and algal conditions, the degree of compliance with State of Oregon water-quality standards, and associations with land use in the North Umpqua River during summer of 1995 (Anderson and Carpenter, 1998). Several reaches of the North Umpqua River are listed as water-quality limited under section 303(d) of the Clean Water Act (Oregon Department of Environmental Quality, 2006). The main-stem North Umpqua River is listed as water-quality limited between Lemolo Reservoir and Steamboat Creek (temperature, total dissolved gases, and arsenic) and Diamond Lake, in the headwaters of the Basin, is also listed as a water-quality limited waterbody (pH, nuisance algae) (Oregon Department of Environmental Quality, 2006). A draft Total Maximum Daily Load (TMDL) was proposed for various parameters (Eilers and others, 2003) and is expected to be adopted in full in 2006.

Diamond Lake, a eutrophic lake that is an important source of water and nutrients to the upper North Umpqua River (Anderson and Carpenter, 1998), has experienced potentially toxic blue-green algae blooms since 2001 that have resulted in closures to recreational water contact and impacts to the local economy. Increased populations of the invasive tui chub fish are reportedly responsible, because they feed on zooplankton that would otherwise control the algal blooms. The Final Environmental Impact Statement (FEIS) for the Diamond Lake Restoration Project (U.S. Forest Service, 2004) advocates reduced fish biomass in Diamond Lake in 2006 as the preferred alternative. A restoration project scheduled to reduce fish biomass for the lake includes a significant water-level drawdown that began in January 2006. After the drawdown of Diamond Lake, the fish toxicant rotenone was applied to eradicate the tui chub. The lake will be refilled and restocked with game fish in 2007 (U.S. Forest Service, 2004).

Winter exports of nutrients from Diamond Lake during the restoration project could affect the summer trophic status of the North Umpqua River if retention and recycling in Lemolo Lake are significant. The FEIS includes comprehensive monitoring to assess the water quality of the restored Diamond Lake and the effects of that restoration downstream. Included in the monitoring is the North Umpqua River from Lake Creek through the Wild and Scenic Reach of the North Umpqua River, to the terminus of the Wild and Scenic Reach upstream of Idleyld Park (fig. 1).

Figure 1. Sampling-site locations in the North Umpqua River Basin, Oregon

One component of the monitoring is the collection of baseline data, in order to observe changes in the river's water quality and algal conditions resulting from the restoration of Diamond Lake. During July 2005, the U. S. Geological Survey (USGS), in cooperation with Douglas County, performed a synoptic survey of water quality and algal conditions, the results of which can be used for comparison with post-restoration conditions in the river as well as with those documented for 1995 (Anderson and Carpenter, 1998). The data in this report are an essential component of a project being implemented by the local, State, and Federal partners of the Diamond Lake Working Group to address the lake's water-quality problems. The Diamond Lake Working Group includes the Umpqua National Forest, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Economic and Community Development Department, Oregon Water Resources Department, Oregon Division of State Lands, Douglas County, PacificCorp, and State Representative Susan Morgan.

Purpose and Scope

The overall study objective was to observe changes in water quality and algae condtions of the North Umpqua River Basin that could result from restoration efforts at Diamond Lake. The specific objectives were to (1) collect data on nutrients and algae before the drawdown at Diamond Lake to allow an assessment of potential nutrient sources or sinks, and the status of adherence to State water-quality standards and (2) provide data for subsequent evaluation of potential changes in water quality resulting from the drawdown.

The purpose of this report is to document water-quality data from locations sampled in the North Umpqua River Basin during July 2005 in conjunction with studies of Diamond Lake prior to rotenone application in September 2006. The report presents data from the 2005 survey to help fulfill the requirement for predrawdown water-quality data. Nutrients, field parameters (temperature, specific conductance, pH, and dissolved oxygen), and periphyton algal samples were collected from sites in the hydroelectric project area and in the Wild and Scenic Reach. Most sites sampled in 2005 were the same as those sampled in 1995 (Anderson and Carpenter, 1998). Field parameters were measured at the time of water sampling and also during the morning and afternoon, to attempt to document the patterns and magnitudes of diel minima and maxima of dissolved oxygen and pH as indicators of primary production in the river. Organic carbon and nitrogen, both particulate and dissolved, also were analyzed from selected sites because they are likely to be an important component of material exported from Diamond Lake during the restoration project (U.S. Forest Service, 2004) and were shown to be important factors related to the community structure of periphytic algae in the upper basin during 1995 (Anderson and Carpenter, 1998). Dissolved silica and arsenic were analyzed at two sites. Assistance during the field survey was provided by Douglas County, Oregon Department of Fish and Wildlife, PacifiCorp, and the U. S. Forest Service.

Methods

The methods for data collection for this study were described in the Quality Assurance Project Plan (unpublished) that was prepared by the U.S. Forest Service, Umpqua National Forest, in cooperation with the U.S. Geological Survey and the Oregon Department of Environmental Quality (ODEQ). Twenty-two sites were sampled from July 25 to July 29, 2005 (fig. 1 and table 1).

Table 1. Water-quality sampling sites for the July 2005 synoptic survey of the North Umpqua River Basin, Oregon

[ODEQ, Oregon Department of Environmental Quality; °, degree; ', minute; ", second; N, north; W, west; NA, not applicable]

Map reference number	Site name	Main-stem river mile	Tributary river mile	Site acronym	USGS site number	ODEQ site number	Site latitude and longitude, NAD 27
1	North Umpqua River above Lemolo Lake near Inlet Campground	94.8	NA	INLET	431839122091300	32144	43°18'39" N 122°09'13" W
2	Lake Creek above Lemolo Lake	93.8	1	LAKEM	431750122104500	32415	43°17'50" N 122°10'45" W
3	North Umpqua River below Lemolo Lake	92.6	NA	LEM1G	14313500	32416	43°19'20" N 122°11'40" W
4	North Umpqua River above Toketee Reservoir	77.1	NA	TOKLKI	431617122242200	25694	43°16'17" N 122°24'22" W
5	Clearwater Canal #2 Penstock inflow	75.4	NA	CLR2P	431553122243400	25741	43°15'53" N 122°24'34" W
6	Clearwater River # 2 Bypass Reach	75.4	0	CLR2B	431546122250600	32147	43°15'46" N 122°25'06" W
7	North Umpqua River below Toketee Reservoir	75.4	NA	TOKET	431552122252100	25695	43°15'52" N 122°25'21" W
8	North Umpqua River at Soda Springs	69	NA	BSODA	14316460	25700	43°18'22" N 122°30'42" W
9	Boulder Creek near mouth	67.9	0	BOULM	14316495	32149	43°18'13" N 122°31'45" W
10	North Umpqua River above Copeland Creek	67.2	NA	COPEG	14316500	23897	43°17'46" N 122°32'08" W
11	Copeland Creek near mouth	66.6	0	COPEM	431730122323800	32150	43°17'30" N 122°32'38" W
12	Calf Creek near mouth	61.8	0	CALFM	431728122370800	32151	43°17'28" N 122°37'08" W
13	Panther Creek near mouth	57.7	0	PANTM	431815122404400	32152	43°18'15" N 122°40'44" W
14	North Umpqua River above Apple Creek	57.5	NA	NUAPC	431820122403700	32153	43°18'20" N 122°40'37" W

Table 1. Water-quality sampling sites for the July 2005 synoptic survey of the North Umpqua River Basin, Oregon—continued

[ODEQ, Oregon Department of Environmental Quality; °, degree; ', minute; ", second; N, north; W, west; NA, not applicable]

Map reference number	Site name	Main-stem river mile	Tributary river mile	Site acronym	USGS site number	ODEQ site number	Site latitude and longitude, NAD 27
15	North Umpqua River at Mott Bridge	53.2	NA	MOTTB	432034122440100	32154	43°20'34" N 122°44'01" W
16	Steamboat Creek near mouth	53.0	0.5	STEAM	14316700	32155	43°21'00" N 122°43'40" W
17	North Umpqua River near Steamboat	52.5	NA	NUSTM	432034122442500	32156	43°20'34" N 122°44'25" W
18	North Umpqua River below Steamboat Creek	48.2	NA	NUBWC	14316800	32158	43°19'18" N 122°48'30" W
19	North Umpqua River near Idleyld Park	36.2	NA	NURCR	14317450	23892	43°19'29" N 122°59'55" W
20	Rock Creek near mouth	35.7	0	ROCKM	432000123000700	32477	43°20'00" N 123°00'07" W
21	Little River near Glide	29.1	0.04	LITGL	431750123060000	28396	43°17'50" N 123°06'00" W
22	North Umpqua River near Glide	27.8	NA	NUGLD	431827123072200	32159	43°18'27" N 123°07'22" W

Water-Quality Samples and Field Measurements

Water samples for laboratory analysis were collected according to the standard USGS protocols (Wilde and others, 1999) and ODEQ protocols (Oregon Department of Environmental Quality, 1998). Water samples were collected using the Equal-Width-Increment (EWI) method, a depth and width integrating technique described by Edwards and Glysson (1999) and adapted for clean sampling (Wilde and others, 1999). Samples for dissolved constituents were filtered in the field using Gelman capsule filters with a pore size of 0.45 µm. Samples were preserved according to ODEQ requirements as specified in table 2.

Table 2. Methods of water-quality and algal analysis for samples from the North Umpqua River Basin, Oregon, July 2005

[Measurements made directly in the field included water temperature, specific conductance, pH, and dissolved oxygen; NA, not applicable; C, Celsius; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; QAPP, U.S. Forest Service Quality Assurance Project Plan; mg/m^2, milligrams per square meter; g/m^2, grams per square meter.]

Medium sampled	Parameter	Analytical method	Detection limit or resolution	Reporting limit	Sample preservation
Water, *in situ*	Water temperature	170.1 [a]	0.1˚C	0.1˚C	NA
Water, *in situ*	Specific conductance, field	120.1 [a]	1 µS/cm	1 µS/cm	NA
Water, *in situ*	pH, field	150.1 [a]	0.01 standard units	0.1 standard units	NA
Water, *in situ*	Dissolved oxygen, field	4500-O G [b]	0.01 mg/L	0.1 mg/L	NA
Water, filtered	Dissolved orthophosphate as P	4500-P E [b]	0.0004 mg/L	0.005 mg/L	None
	Dissolved organic carbon	5310 B [b]	NA	1 mg/L	H_2SO_4
	Dissolved arsenic	3120 B [b]	0.003 mg/L	0.01 mg/L	None
	Dissolved silica	3120 B [b]	0.003 mg/L	0.15 mg/L	None
Water, unfiltered	Ammonia as N	4500-NH_3 [b]	0.02 mg/L	0.02 mg/L	H_2SO_4
	Total Kjeldahl nitrogen as N (organic+ammonium N in QAPP)	351.2 [a]	0.1 mg/L	0.2 mg/L	H_2SO_4
	Nitrite plus nitrate as N	4500-NO_3 F [b]	0.001 mg/L	0.005 mg/L	H_2SO_4
	Total phosphorus as P	4500-P E [b]	0.003 mg/L	0.01 mg/L	H_2SO_4
	Total organic carbon	5310 B [b]	NA	1 mg/L	H_2SO_4
Algae, periphyton	Chlorophyll a and Pheophytin a	10200-H [b]	NA	0.1 mg/m^2	Freezing
	Ash-free dry weight	10300 C [b]	0.1 g/m^2	1 g/m^2	Freezing

[a] U.S. Environmental Protection Agency, 1983

[b] American Public Health Association, 1992

Laboratory analyses were performed at the ODEQ laboratory following the procedures and protocols described in the ODEQ Laboratory Field Sampling Reference Guide (Oregon Department of Environmental Quality, 1998), and the ODEQ Laboratory Quality Assurance Manual, (Oregon Department of Environmental Quality, 2004). The ODEQ laboratory reported any nutrient value that was below the method reporting limit with the letter "E" appended to the numerical value. If the value was also smaller than the method detection limit, the value was preceded by "<."

The USGS National Water Quality Laboratory (NWQL) was used to analyze several quality assurance samples. For the 1995 study (Anderson and Carpenter, 1998), the USGS NWQL was used for all water-quality samples. Methods of sample preservation and laboratory analysis used by the NWQL in 1995 and in 2005 differed from the ODEQ methods used for the present study in that the only preservation for nutrients (filtered or unfiltered) used in 1995 for the NWQL was chilling the samples, whereas all nutrients except orthophosphate were preserved with H_2SO_4 for samples collected for analysis by the ODEQ laboratory. In 2005, whole-water samples sent to the NWQL for analysis of total phosphorus and total nitrogen were also preserved with H_2SO_4.

Data for water-quality field measurements and continuous monitors were collected and processed in accordance with USGS protocols (Wagner and others, 2006). Water temperature, dissolved oxygen, pH, and specific conductance were measured using multiparameter probes adapted for low-ionic strength waters. Calibration of these probes is discussed below in the Quality Assurance section. Data for field measurements were collected across the cross section of the stream to document representativeness of the measurements. On the basis of data from existing continuous water-quality monitors in the basin, located at BSODA and NURCR, together with data from Anderson and Carpenter (1998), the time of day targeted to measure dissolved oxygen and pH extremes was generally between 06:30 and 8:30 a.m. and between 3:00 and 7:00 p.m. Data in table 3 represent the daily minima and maxima, for which continuous data collection occurred by short-term deployments of multiparameter sondes.

Discharge was measured according to standard USGS guidelines as described by Rantz and others (1982). Discharge records at continuous-record gaging stations were compiled according to methods described by Buchanan and Somers (1984) and Kennedy (1983). Flow data from two gaging stations (NUBWC and ROCKM) were obtained from Douglas County, which operated the gages (Brian Connors, Douglas County, written commun., 2006). Additional data for continuously measured discharge and water-quality parameters are available elsewhere (Herrett and others, 2005, *http://waterdata.usgs.gov/or/nwis*, and Douglas County Department of Natural Resources), and are not published here, with the exception of selected values measured during the period of study.

Algae sampling

Twelve quantitative algal samples were collected from 11 sites using methods described in Moulton and others (2002). At one site, NURCR, a replicate sample was collected for quality assurance. Algal samples at each site were collected from 10 representative rocks and composited into a single sample. Rocks were removed from wadeable portions of riffles or along stream margin habitats using the top rock scrape method described in Carpenter (2003). Round plastic pipe ends (PVC scribes) with outside diameters ranging from 4 to 10.4 centimeters were placed on each rock and algal material located outside the scribe was removed with a plastic-bristle brush and/or scraped off with a knife and discarded. The circular patch of algae remaining on the rock was scraped into a basin, and the material was rinsed into a sample bottle using stream water to produce algal samples with volumes ranging from 940 to 2,100 milliliters. Algal samples were briefly homogenized in an electric blender and transferred into a 10-liter churn splitter, and subsamples were removed while churning for chlorophyll *a* (chl *a*), ash-free dry mass (AFDM), and species identification. Chl *a* and AFDM subsamples were collected onto glass-fiber filters (nominal pore size 0.7 micrometers) using a polypropylene filtration unit, wrapped in foil, sealed, packed on dry ice, and sent to the ODEQ laboratory in Portland, Oregon, for fluorometric chl *a* and gravimetric AFDM analyses. Algal species identification samples were preserved with a 5% buffered formalin solution and shipped to the Academy of Natural Sciences of Philadelphia (ANSP) for taxon identification and enumeration following protocols described by Charles and others (2002).

Quality Assurance

The collection, preparation, and analysis of water-quality samples for this study included several quality assurance measures. A field replicate is a water sample collected at the same site and concurrently with (water sample) or immediately after (algal samples) the primary sample, as a measure of the precision of the laboratory analysis. The time of sampling for the field replicates was designated as 1 minute later than the primary sample. Field replicate samples were collected at two sites (CLR2P and COPEG). The analyses by the ODEQ laboratory for the primary and field replicates had similar results for the constituents analyzed (table 3).

Two equipment blanks were analyzed (from COPEG and NURCR) to determine if sample handling added contamination. There were nutrient detections for the equipment blanks (table 4), but those values were small compared to environmental concentrations. A transport blank showed no detection of any analyzed constituent (table 4), demonstrating that transporting the water-quality samples did not result in measurable contamination.

On August 1, 2005, a reference sample, designed to test low-level nutrient analyses, was prepared at the USGS Oregon Water Science Center laboratory for blind submittal to the ODEQ laboratory. The reference sample contained known concentrations of nutrients from reagent-grade chemicals in an aliquot of water that was previously certified to be free of inorganic constituents at the microgram per gram level (Micelis Doyle, USGS, written commun., 2005). The DEQ laboratory results were similar to the expected concentrations for ammonia, total Kjeldahl nitrogen, total phosphorus, and dissolved orthophosphrous (table 4). The maximum relative difference was 13 percent, for total Kjeldahl nitrogen, and the analytical precision at the indicated concentrations was acceptable.

Interlaboratory split samples were collected at BSODA on July 26 and at NURCR on July 27, 2005. These samples were similar to a field replicate, but one of each pair of samples was instead sent to the USGS NWQL. The results of nutrient analysis by both laboratories were similar where detection levels were comparable (table 3). However, the detection levels of the NWQL for dissolved ammonia and nitrate were significantly higher that those provided by ODEQ, and the comparison is not valid for those constituents. Differences in unfiltered-water analysis of total phosphorus, total Kjeldahl nitrogen, dissolved orthophophosphate, and dissolved organic carbon were within acceptable limits.

For measuring field parameters, the multiparameter probes were calibrated before and after use according to the manufacturer's recommendations. Slight linear shifts were applied when differences after use exceeded 0.2°C, 0.2 mg/L of dissolved oxygen, 0.2 pH units, or 5% of the specific conductance standard. These shifts were equal to the difference between the expected value and the measured value. Data were not accepted if the shift would exceed 2.0°C, 2.0 mg/L of dissolved oxygen, 2.0 pH units, or 30% of the specific conductance.

Results

Click on a table number to open the PDF file, which will appear in the browser window. Use the Back button on the browser window to return to the report text.

Water-Quality Samples and Field Measurements

Table 3. Water-quality data and selected quality assurance data from the July 2005 synoptic sampling in the North Umpqua River Basin, Oregon

Table 4. Quality assurance data from the July 2005 synoptic sampling in the North Umpqua River Basin, Oregon

Table 5. Logged (10 minute interval) field parameter data from Lake Creek above Lemolo Lake (LAKEM, 431750122104500), from July 25 at 17:10 to July 26 at 09:30

Table 6. Logged (10 minute interval) field parameter data from North Umpqua River, Oregon, below Toketee Reservoir (TOKET, 431552122252100) from July 24 at 17:40 to July 25 at 16:00

Table 7. Logged (10 minute interval) field parameter data from Steamboat Creek near Mouth (STEAM, 14316700), North Umpqua River Basin, Oregon, from July 27 at 15:40 to July 28 at 11:30

Table 8. Logged (10 minute interval) field parameter data from North Umpqua River, Oregon, near Steamboat Creek (NUSTM, 432034122442500), from July 28 at 18:50 to July 29 at 13:20

Table 9. Vertical profile of pH, temperature, specific conductance, and dissolved oxygen in Lemolo Lake, North Umpqua River Basin, near the deep intake structure, July 29, 2005

Table 10. Weather data (rainfall, temperature, barometric pressure) recorded in the upper North Umpqua River Basin, Oregon, July 25–29, 2005

Table 11. Particulate carbon and nitrogen in whole water samples, July 2005 synoptic sampling in the North Umpqua River Basin, Oregon

Algae

Table 12. Biovolumes of algal taxa collected from 11 sites in the North Umpqua River Basin, Oregon, July 2005

Table 13. Cell densities of algal taxa collected from 11 sites in the North Umpqua River Basin, Oregon, July 2005

Table 14. Periphyton chlorophyll a, pheophytin a, and biomass from the July 2005 synoptic sampling in the North Umpqua River Basin, Oregon

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