Quality Assurance Project Plan

Puyallup and White Rivers Temperature and Dissolved Oxygen Monitoring

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Bill Kammin, Quality Assurance Officer, Environmental Assessment Program	Date

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Abstract

The Washington State Department of Ecology's (Ecology) monitoring of the Puyallup and White rivers is an outgrowth of the Puyallup River Total Maximum Daily Load study in 1993 under which Ecology agreed to expand its water quality monitoring in the basin using continuous instrumentation with partial funding from interested parties. The purpose of this 2006 monitoring program is to assess spatial and temporal changes in water quality, determine if designated uses are supported by existing in-stream water quality, and provide site-specific water quality information in support of Ecology's water quality-based permitting of dischargers.

Background

The Washington State Department of Ecology's (Ecology) monitoring of the Puyallup and White rivers is an outgrowth of the Puyallup River Total Maximum Daily Load (TMDL) study (Pelletier, 1993) under which Ecology agreed to expand its water quality monitoring in the basin using continuous instrumentation with partial funding from interested parties. The purpose of this monitoring program is to assess spatial and temporal changes in water quality, determine if designated uses are supported by existing in-stream water quality, and provide site-specific water quality information in support of Ecology's water quality-based permitting of dischargers.

The primary goal of previous monitoring activities was to gather continuous dissolved oxygen and temperature data on the White River downstream of Lake Tapps during late summer and early fall critical conditions. In 2001, the United States Geological Survey (USGS) measured dissolved oxygen levels near 8.0 mg/L in this reach of the river, when flows were dominated by releases from Lake Tapps (Ebbert, 2002). In 2004, Puget Sound Energy reduced diversions for power generation, suggesting a need to determine current dissolved oxygen levels under the new operating regime.

Waterbody Description

The Puyallup and White rivers are located in the Puget Sound region of western Washington. The White River flows into the Puyallup River near the city of Puyallup, and the Puyallup River empties into Puget Sound at Tacoma. The lower Puyallup River Valley is a relatively flat floodplain. Streambed altitudes in the study area range from about 18 feet (ft) below NGVD 29 at river mile 1.5 on the Puyallup River to about 50 ft above NGVD 29 at river mile 4.9 on the White River. The lower part of the Puyallup River is a salt wedge estuary with deeper salt water overlain by a layer of freshwater. The salt wedge generally extends less than 2.5 miles upstream from the river mouth.

During summer, past operation of the Lake Tapps hydropower facility by Puget Sound Energy had a substantial effect on discharge in the lower White and Puyallup rivers. Water was diverted into Lake Tapps from the White River at river mile 24.3, stored and then released to produce electric power as it passed through a powerplant located on the tailrace canal that connects with the White River at river mile 3.6. Power was generated to meet demand during peak usage, and the cycle of releasing and then holding water often caused discharge in the lower White and Puyallup rivers to increase by a factor of 2 and then decrease to base levels in about 12 hours. The capacities of the diversion channel and the outlet from the hydropower facility are each about 2,000 cfs. According to Greg Zentner (Ecology Water Quality Program, personal communication), the diversion to Lake Tapps was reduced in January 2004, with a potential to affect mainstem downstream water quality.

Water in the White and Puyallup rivers is usually turbid during the summer because fine sediment from the melting of a Mount Rainier glacier is transported downstream. Turbidity limits light penetration, which reduces primary productivity and moderates 24-hour variations in pH caused by photosynthesis and respiration. Other effects of turbidity can include the clogging of fish gills and invertebrate filters, reducing spawning and juvenile fish survival as well as angling success, smothering of bottom-dwelling aquatic organisms such as benthic organisms, and introduction of pollutants into the waterbody.

Water in the lower White and Puyallup rivers is classified by the State of Washington as Class A (excellent). The current water quality standard for turbidity is *"Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU."*

Low dissolved oxygen can stress fish and other organisms, causing them to seek other areas of the waterbody which have sufficient oxygen levels. Another effect of low dissolved oxygen is the potential release of pollutants (e.g., mercury) which occurs under anoxic conditions. The current water quality standard for dissolved oxygen is 8.0 mg/L or higher.

The water quality standard for temperature is "*Temperature shall not exceed 18.0°C (freshwater) due to human activities. When natural conditions exceed 18.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C. Incremental temperature increases resulting from point (discrete) source activities shall not, at any time, exceed t=28/ (T+7) (freshwater). Incremental temperature increases resulting from nonpoint (diffuse) source activities shall not exceed 2.8°C. For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary, and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.*"

Waterbody Studies

Ecology's Total Maximum Daily Load (TMDL) studies established annual and seasonal TMDLs for five-day biochemical oxygen demand (BOD_5) and ammonia (NH_3) in 1993 and 1994 (Pelletier, 1993). In 1996, EPA, the Puyallup Tribe of Indians, and Ecology initiated a mediation process to allocate the reserve capacity identified in the TMDL. The resulting 1998 agreement (Ecology, 1998) included a provision for monitoring dissolved oxygen and related parameters.

Ecology and the Puyallup Tribe began monitoring under the TMDL agreement in 2000 by establishing two stations in the lower Puyallup River. The data suggested the river was not meeting the dissolved oxygen standard, and Ecology issued a moratorium on allocating the reserve capacity. In 2001, the United States Geological Survey (USGS), in partnership with Ecology and the Puyallup Tribe, monitored water quality in the Puyallup and White rivers (Ebbert, 2002). That data and the 2002 data from the White River (Ebbert, 2003) showed that some of the year 2000 data were inaccurate, a result of probe fouling with sediment, but the White River at times either violated standards or was meeting standards by only a small amount.

Project Description

Ecology will be monitoring the Puyallup River during 2006 to assess late summer and early fall dissolved oxygen levels. Ecology prepared this Quality Assurance Project Plan to guide this year's data collection effort. The goals of the project are twofold:

1. Gather continuous temperature and dissolved oxygen data for the White and Puyallup rivers during the months of lowest dissolved oxygen (mid-August through mid-October) and following recovery in the fall through mid-December.
2. Evaluate the use of the Solinst® LTDO Levelogger probe and the HydroLab® MS5 probe over multi-week deployments.

The objectives of the study are to define the variability of dissolved oxygen and temperature in the Puyallup and White rivers. The data needed to achieve these goals include continuous measurements of dissolved oxygen and temperature in designated reaches of both the White and Puyallup rivers. Decisions made from the results of this data collection effort include determining whether water quality standards are being met.

Organization and Schedule

Ecology staff will deploy probes to continuously measure dissolved oxygen and temperature levels at three sampling locations. The planned monitoring period is from mid-August through mid-October and from November 1 to December 15. Site visits would be required approximately twice a week for maintenance and calibration of the probes. Additionally, water samples will be taken for dissolved oxygen quality control purposes. There are no laboratory costs for this project. Table 1 shows the proposed schedule for the entire project.

The following are key personnel involved with the project:

- EAP project co-leads: Bill Ward 360.407.6621 and Maggie Bell-McKinnon 360.407.6124; responsible for project design and implementation.
- EAP field personnel: Betsy Dickes 360.407.6296 and Randy Walton 360.407.6530; responsible for field activities.
- Ecology Quality Assurance Officer: Bill Kammin 360.407.6964; responsible for review and approval of the Quality Assurance Project Plan.

Table 1. Proposed Schedule

Reconnaissance survey	August 2006
Verification sampling	Mid-August to mid-October 2006, and November to mid-December 2006
Data compilation, verification, and validation	August to December 2006
Data review and analysis	January to March 2007
Draft technical report	April 2007
EIM[1] entry complete	April 2007
Final report	May 2007

[1] Ecology's Environmental Information Management database

Quality Objectives

Data quality objectives are statements of the precision, bias, and lower reporting limits necessary for the data to address project objectives. The primary indicators of data quality are precision and bias which together express the data accuracy by the relationship (Onwumere and Batts, 2004):

- Accuracy = Bias + Precision
- Precision = (±1Standard Deviation) = Relative Standard Deviation = RSD
- Accuracy = Bias + 2·RSD

"Precision, expressed as the standard deviation of replicate sample analyses, is a measure of data scatter due to random error, while bias is a measure of the difference between the result for a parameter and the true value due to systematic errors. Potential sources of errors include sample collection, physical and chemical instability of samples, interference effects, instrument calibration, and contamination. Random error affects bias; thus bias estimation may be problematic" (Onwumere and Batts, 2004).

Consequently, adherence to established protocols is one method used to minimize impacts due to bias (Lombard and Kirchmer, 2001). Specific quality objectives for this project are discussed below.

Bias

Sampling bias will be minimized by strictly adhering to the protocols discussed and referenced herein. This Quality Assurance Project Plan provides procedures for collecting representative samples.

The decision quality objective of this project is to determine whether water quality standards for dissolved oxygen and temperature are being met.

Representativeness

The continuous dissolved oxygen data collected may not be considered representative of a watershed, but will be considered representative of the stream reach being sampled by virtue of the selection of the sampling location through best professional judgment.

Comparability

All measurements and analytical procedures will be documented so the data can be comparable with samples collected and analyzed in a like manner.

Completeness

Completeness is a measure of the amount of valid data needed to meet the goals defined for the uses of the data. The goals for the collected data will be:

- Produce verified records of dissolved oxygen concentration and temperature measured at 30-minute intervals.
- Evaluate the use of the Solinst® LTDO Levelogger probe and the HydroLab® MS5 probe over multi-week deployments.

The information collected by the probes may have periods of time with data gaps caused by instrument malfunction or from the probe being exposed to air when flows drop below the deployment location. If these data gaps exist, this may preclude use of the affected portion of the dataset to determine whether water quality standards were met. The goal is to have at least 90% of the data collected usable for analysis.

Sampling Process Design

Solinst® LTDO Levelogger probes will be deployed at two locations: the White River at river mile 1.8 and the Puyallup River at river mile 11.8 (Figure 1). The probes will continuously monitor dissolved oxygen and temperature levels at 30-minute intervals. A HydroLab® MS5 probe will be deployed at the River Mile 2.9 on the Puyallup River. The purpose of the HydroLab® probe is primarily to monitor dissolved oxygen and the specific conductance levels and how they could correlate to dissolved oxygen levels.

A secured streamside location, representative of low-flow stream conditions, will be identified for probe deployment. The probes will be placed in an anchored, locked tube, extending from the shore into the river, with the probe situated roughly one foot off of the stream-bed.

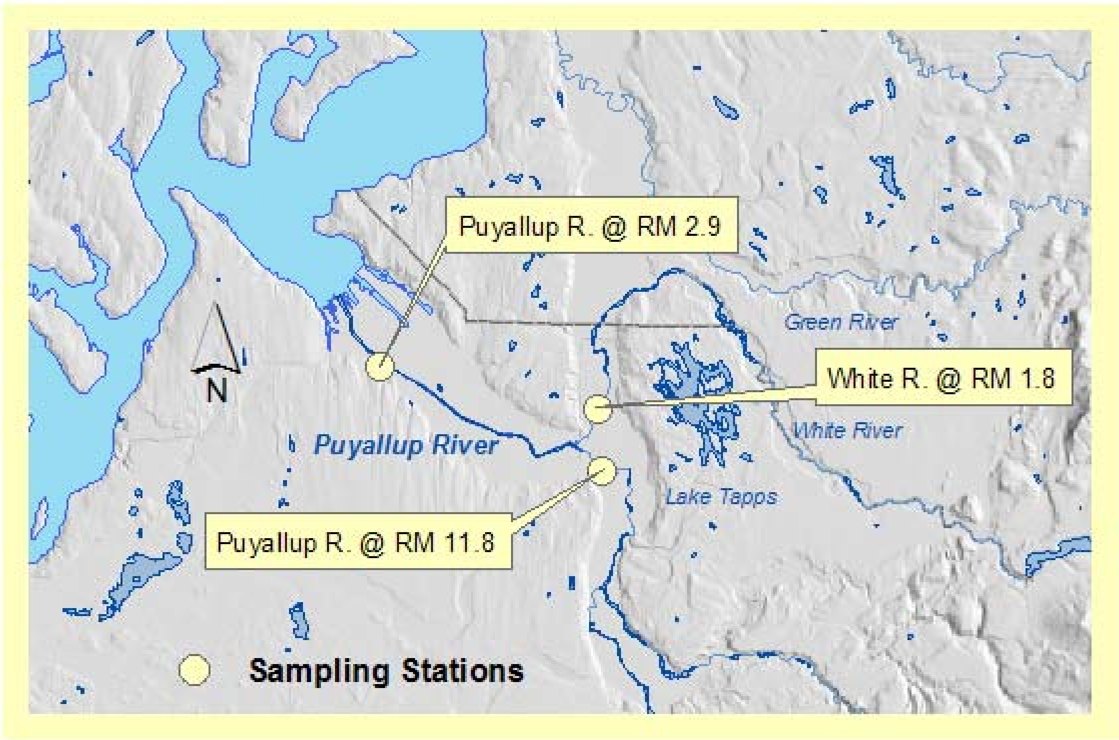

Figure 1. Sampling Locations

Once the probes are deployed, site visits will occur twice a week to download the instrument data recordings, check for siltation or fouling, check instrument calibration, recalibrate if necessary, and collect a water sample for quality control. Each time Ecology staff service the probe, they will:

1. Measure air and water temperature (pre-data download).
2. Obtain samples for Winkler dissolved oxygen analysis (pre-probe cleaning).
3. Inspect the probes for sediment build-up in the housing and clean if necessary.
4. Download data and re-deploy the probe.
5. Measure air and water temperature (post-data download).
6. Obtain samples for Winkler dissolved oxygen analysis (post-probe cleaning).

Field Procedures

Safety procedures are described in Ecology's Environmental Assessment Program's Safety Manual (2002). Field operations will be discontinued any time personnel determine that driving conditions, site access, or sampling conditions are unsafe for that site and parameter.

Standard Ecology sampling protocols (Ward, 2001) will be used for field measurements and to collect quality control samples.

Laboratory Procedures

Water samples will be collected for dissolved oxygen analysis using the Winkler titration method APHA, 1998.

Quality Control

Field Quality Control

All Solinst® LTDO Levelogger probes and HydroLab® MS5 probes will be calibrated prior to the start of the monitoring project.

Air and water temperature will be measured at each deployment location before and after the data downloading for comparison to the probe measurements. A minimum of two water samples (collected before and after cleaning the probe housing) will also be collected for dissolved oxygen analysis using the Winkler titration method (APHA, 1998 and Ward, 2001). The dissolved oxygen results from each probe will be field verified to the average of the two Winkler grab sample results taken before probe removal (for maintenance and data download) and also after probe re-deployment.

The comparison of the results can serve two purposes:

- Help determine if the probe had possibly become isolated by sediment buildup in the protective pipe housing.
- Determine if the probe results require a correction factor based on the Winkler results to correct for any calibration errors.

The correction factor will only be applied if there is a consistent difference in the Winkler and probe results and if the results are greater than 0.2 mg/L.

The Solinst® LTDO Levelogger probes and the HydroLab® MS5 probes will be tested in controlled water temperature baths that bracket the expected temperature monitoring range (near 0ºC and near 20ºC). The results are then compared to those obtained with a certified reference thermometer. All probes that fail to meet the instrument accuracy will be checked a second time. Probes that fail a second pre-deployment check will not be used. Table 2 shows the accuracy and resolution of the instruments used in this study.

Table 2. Instrument Accuracy

Equipment	Accuracy	Resolution
Certified Reference Thermometer # 61099-035, HB Instrument Co.	± 0.1°C	0.1°C
Field Thermometer # 1546RL, Brooklyn Thermometer Co.	± 0.2°C	0.1°C
Thermistor Thermometer #U-08402 Thermistor & #U-93823 Probe, Cole Parmer Co.	± 0.3°C	0.1°C
Solinst® LTDO Levelogger probe Temperature Dissolved oxygen	± 0.2°C ± 0.2 mg/L	0.01°C 0.01 mg/L
HydroLab® MS5 probe Temperature Dissolved oxygen	± 0.10°C ± 0.1 mg/L @ < 8 mg/L ± 0.2 mg/L @ > 8 mg/L	0.01°C 0.01 mg/L

Data Management Procedures

Field data will be entered into a Microsoft Excel® spreadsheet before exporting to Ecology's Environmental Information Management (EIM) database. Data entry and validation will be performed by staff within Ecology's Environmental Assessment Program. All data entered will be validated by an internal, independent reviewer; and errors found will be identified, flagged, and corrected by the project manager. Final project report will be delivered to Greg Zentner, Ecology Southwest Regional Office, Water Quality Section.

Data Verification and Validation

Both data verification and validation require adequate documentation of the process.

Data Review

Accurate transfer of data at each stage, including checking data that will be entered into the EIM system for accuracy, is vital to project success. Environmental Assessment Program staff are responsible for reviewing, documenting, and entering field results into a Microsoft Excel® spreadsheet before exporting to the EIM database. The individual tasked with the data entry is responsible for reviewing the data to ensure completeness, consistency, and correctness as well as to document the data reviewing process.

Data Verification

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria.

After measurement results have been recorded, they are verified by one of the project co-leads to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions.
- Results of QC samples accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers and correction factors are properly assigned where necessary.
- Data specified in the Sampling Process Design were obtained.
- Methods and protocols specified in the Quality Assurance Project Plan were followed.

Detailed field notes will be kept to meet the requirements for documentation of field measurements. The project co-lead is responsible for checking that field data entries are complete and error free. The project co-lead should check for consistency within an expected range of values, verify measurements, ensure measurements are made within the acceptable instrumentation error limits, and record anomalous observations.

Data Validation

Data validation is the next step following verification. The project lead examines the complete data package to determine compliance with procedures outlined in the Quality Assurance Project Plan and the Standard Operating Procedures (Ward, 2001).

The temperature and dissolved oxygen data will be verified and validated by the project lead following these procedures:

- Calibration checks and field procedures will be documented on appropriate forms.
- Data will be checked for entry errors and completeness.
- Pre- and post-calibration check results and field measurements will be reviewed to ensure the data quality objectives were met.
- Results will be checked for reasonableness using data plots and field measurements.
- Detected data errors will be corrected, flagged with data qualifiers, or deleted.

The dissolved oxygen data will be assessed by comparing field measurements to field Winkler titration results. Only corrected data with a difference less than 0.2 mg/L dissolved oxygen between the Winkler analyzed sample and the probe reading are acceptable.

Data Quality (Usability) Assessment

The data will be assessed by comparing the results to current Washington State water quality standards. The data will be graphed using an EXCEL spreadsheet for easy analysis. Based on best professional judgment, data that appear to be anomalous because of low-flow conditions, vandalism, or other unexplainable conditions will be disregarded. Sampling design modifications will be considered for future projects if the data appear to not support the stated objectives.

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