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Quality Assurance Project Plan

Monitoring Stream Temperatures and Habitat Characteristics for the Extensive Riparian Status and Trends Program

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Quality Assurance Project Plan

Monitoring Stream Temperatures and Habitat Characteristics for the Extensive Riparian Status and Trends Program

July 2010

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Signatures are not available on the Internet version.
EIM - Environmental Information Management database.
EAP - Environmental Assessment Program.

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Abstract

To date, few studies have addressed key riparian resource indicators using robust and unbiased methods. We will produce an impartial dataset that depicts present stream and riparian conditions on lands covered under forest practice rules throughout the state of Washington. Our datasets will provide baseline values for long- term trend monitoring.

The Extensive Riparian Status and Trends (ERST) program is one monitoring component of the Forests and Fish Cooperative Monitoring Evaluation and Research Committee (CMER). The ERST program, like other components, will inform the adaptive management program. The ERST program will also provide statistically valid estimates of key riparian resource indicators for streams regulated by the Forest and Fish Rules across Washington State. These include:

- Water temperature
- Air temperature
- Riparian cover
- Large woody debris
- Channel metrics

The results of the initial sampling will establish current statewide conditions and help design re-sampling efforts. Future assessment of sites may identify trends in indicators over an appropriate timeframe and aid the development of predictor models.

This Quality Assurance (QA) Project Plan provides a brief overview of the ERST program and a description of the proposed study. Each study conducted by the Washington State Department of Ecology must have an approved QA Project Plan. The plan describes the objectives of the study and the procedures to follow to achieve those objectives. After completing the study, Ecology will post a final report of the study results to the Internet.

Background

In 2001 the Washington State Forest Practice Board (WFPB) approved a comprehensive set of new forest practice rules, based on the Forest and Fish Report (FFR) (WFPB, 2001) (FFR, 1999). The Board developed these rules to implement the agreements in the FFR and to regulate forest management activities on private forest lands. The goals of these rules are to:

- Comply with the federal Endangered Species Act for aquatic and riparian dependent species on non-federal forest lands.
- Restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish.
- Meet the requirements of the federal Clean Water Act for water quality on non-federal forest lands.
- Keep the timber industry economically viable in Washington State (WFPB, 2001)

The FFR calls for both effectiveness and trend monitoring to inform the adaptive management program. In 2002 the Monitoring Design Team (MDT) of the Governor's Salmon Recovery Plan developed a monitoring framework to guide FFR monitoring and research. The framework consists of three types of monitoring at different spatial scales:

- **Prescription monitoring**
Reach-scale monitoring to evaluate the effectiveness of individual FFR prescriptions under a range of different physiographic conditions and to evaluate alternative treatments for meeting resource objectives.
- **Intensive monitoring**
Watershed-scale monitoring to address the cumulative effects of multiple forest practices and biotic effects by conducting concentrated monitoring and research in a single location.
- **Extensive monitoring**
Landscape-scale monitoring to estimate the current status and future trends of key indicators of input processes and habitat conditions statewide.

A number of interrelated factors affect stream temperature, but only canopy closure is directly regulated by forest practice rules. Aspect, bankfull width, wetted width, stream volume, stream depth, LWD, elevation, substrate, and air temperature may all profoundly affect stream temperature.

Stream temperature is one of the most frequently exceeded water quality standards on Washington forested lands (Ecology, 2008). Present conditions of Washington State riparian forest stands on private forest lands result from past disturbances, site productivity, and past forest management. Implementation of forest practice rules alters the trajectory of riparian forest stands. We do not know the extent of change in riparian conditions as a result of forest practice rules or the timeframe in which altered conditions will become evident. Additionally, we do not know if the changes will contribute to improvements in water quality standards and ultimately salmonid recovery within a reasonable timeframe.

Project Description

The project goal is to establish a baseline for trend monitoring and determine the current status of these parameters to clarify the relationship between landscape level changes and FFR riparian prescription implementations.

Phase I of the ERST monitoring program will use rigorous statistical and analytical methods based on the Environmental Protection Agency's (EPA) Environmental Mapping and Assessment Program (EMAP) (Peck et al., 2003). Using EMAP protocols as a reference we will assess water temperature, channel metrics, and riparian stand conditions in a robust and unbiased manner. We will produce the datasets necessary to approximate current statewide distribution of these features across lands subject to forest practice rules.

The ERST (Phase I) monitoring program will:

- Provide statistically valid baseline estimates of key riparian resource indicators, including:
 - Water temperature
 - Air temperature
 - Riparian stand composition
 - Riparian shade
 - Large woody debris
 - Channel metrics
- Determine the strength of any relationships that exist among key riparian resource indicators.
- Provide data needed to evaluate the landscape scale effects of implementing forest practice rules' riparian prescriptions.
- Provide data needed by regulatory agencies to document that water temperature and other resource objectives are on a trend towards recovery from past management practices.

We will randomly select Type F/S (fish-bearing) and Type Np (perennial non-fish-bearing) streams on lands subject to forest practice rules throughout the state of Washington. After being granted access to a site, we will verify site status through a site visit. If a site meets criteria for the selected stream type, we will deploy water and air temperature sensors and assess a host of riparian and channel metrics. We intend to capture the annual thermal peak at each site, likely to occur between July 1 and August 31.

Development of a re-sampling protocol based on the initial sampling procedures may occur in the future (Phase II). This re-sampling protocol would likely result in the establishment of a long-term monitoring component to reveal long-term trends associated with implementation of forest practice rules riparian prescriptions. Using this data, policy makers will be able to develop a better understanding of the effectiveness of forest practice rules and management systems. Any discovered trends would inform adaptive management on the effect of current forest management practices.

Organization and Schedule

The following people will contribute to this project. All are employees of the Washington State Department of Ecology, except the client.

Table 1. Organization of project staff and their corresponding responsibilities.

| Staff (all are EAP except client) | Title | Responsibilities |
|--|---|---|
| Brian Engeness Groundwater/Forest & Fish Unit Statewide Coordination Section Phone: (360) 407-6007 | Author | Writes, reviews the QAPP. Oversees training, field sampling, and scheduling. Obtains landowner approvals and site access. Collects samples and records field information. Conducts QA review of data; analyzes and interprets data. |
| William Ehinger Groundwater/Forest & Fish Unit Statewide Coordination Section Phone: (360) 407-6416 | Principal Investigator | Writes, reviews the QAPP. Analyzes and interprets data. Writes, reviews draft and final reports and oral presentations of results. |
| Matthew Peter Groundwater/Forest & Fish Unit Statewide Coordination Section Phone: (360) 407-6447 | Author, Project Manager, Field Manager | Writes, reviews the QAPP. Oversees field sampling, collects samples, and records field information. Creates, manages databases, conducts QA review of data, and analyzes and interprets data. Writes draft and final reports. |
| Martha Maggi Groundwater/Forest & Fish Unit Statewide Coordination Section Phone: (360) 407-6453 | Unit Supervisor for the Project Manager | Provides internal review of the QAPP, approves the budget, and approves the final QAPP. |
| Will Kendra Statewide Coordination Section Phone: (360) 407-6698 | Section Manager for the Project Manager | Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. |
| Jenelle Black Cooperative Monitoring, Evaluation and Research Committee Phone: (425) 445-7034 | EAP Client | Clarifies scope of the project, provides internal review of the QAPP, and approves the final QAPP. |
| William R. Kammin Phone: (360) 407-6964 | Ecology Quality Assurance Officer | Reviews the draft QAPP and approves the final QAPP. |

EAP – Environmental Assessment Program.

QAPP – Quality Assurance Project Plan.

The following includes our proposed project deadlines for Phase I of the ERST monitoring program.

Table 2. Proposed schedule for phase I of the Extensive Riparian Status and Trend (ERST) monitoring program.

| Domain | Eastside Type F/S Schedule* | Westside Type F/S Schedule | Eastside Type Np Schedule** | Westside Type Np Schedule |
|-------------------------------|-----------------------------|----------------------------|-----------------------------|---------------------------|
| Site selection | 2006-2007 | Autumn-Winter 2007-2008 | TBD | Autumn-Winter 2007-2008 |
| Site evaluation | Spring 2007 | Autumn-Winter 2007-2008 | TBD | Autumn-Winter 2007-2008 |
| Deploy loggers | June 2007 | May-June 2008 and 2009 | TBD | May-June 2008 and 2009 |
| Field riparian data | Summer 2007 and 2008 | Summer 2008 and 2009 | TBD | Summer 2008 and 2009 |
| Logger downloads | Spring-Fall 2007 and 2008 | Spring-Fall 2008 and 2009 | TBD | Spring-Fall 2008 and 2009 |
| Retrieve loggers | Oct- Nov 2008 | Oct- Nov 2009 | TBD | Oct-Nov 2009 |
| Entry into Access databases | Nov- Dec 2007 and 2008 | Nov- Dec 2008-2009 | TBD | Nov-Dec 2008-2009 |
| Analyze data, progress report | Winter 2008-2009 | Winter 2009-2010 | TBD | Winter 2009-2010 |

*Implemented in conjunction with Eastside Type F Riparian Characterization.

** Implemented in conjunction with Eastside Type N Riparian Characterization.

Table 3. Proposed schedule for completing field and laboratory work and reports.

| Field and laboratory work | Due date | Lead staff |
|--|--|----------------|
| Field work completed | June 2010 | Peter, Matthew |
| Laboratory analyses completed | NA | |
| Final report | | |
| Author lead / Support staff | Peter, Matthew / Engeness, Brian; Ehinger, William | |
| Schedule | | |
| Draft due to supervisor | March 2010 | |
| Draft due to client/peer reviewer | March 2010 | |
| Draft due to external reviewer(s) | Sept 2010 | |
| Final (all reviews done) due to publications coordinator | June 2011 | |
| Final report due on web | August 2011 | |

Quality Objectives

The quality objective for Phase I of the ERST monitoring program establishes a baseline of Type F/S and Np stream characteristics across the FFR landscape. We do not have a goal of making critical decisions from our initial (Phase I) data collection. Therefore, we will only specify our quality objectives at a single level. This refers to the measurement quality objectives (MQO) level. MQOs determine performance or acceptance criteria for the data quality indicators precision, bias, and sensitivity (Lombard and Kirchmer, 2004). They identify threshold limits our temperature data must not exceed in order to meet the objectives of our projects.

We will not complete field QC checks, but will perform pre- and post-calibration procedures for all temperature sensors. Our acceptability limits coincide with our temperature sensor manufacturer's stated accuracy of the instruments, ± 0.2 °C for water temperature sensors and ± 0.4 °C for air temperature sensors (Onset, 2004). Each Onset StowAway Tidbit[®] will undergo both a pre- and post-calibration procedure to document instrument bias and performance at representative temperatures. Our calibration procedure will use a National Institute of Standards and Technology (NIST) certified reference thermometer (Ecology, 1993). We will assign measurement accuracy values to each temperature sensor based on our pre- and post-study calibration results at the completion of monitoring. These accuracy values will determine if we include or exclude data from our analyses.

Sampling Process Design (Experimental Design)

The ERST project will occur in two distinct phases. Phase I will estimate current status. Phase I results will inform the need for and design of Phase II. Phase II will consist of analogous future sampling. Phase II will determine what changes may have occurred over time (trends).

Phase I objectives:

- Describe the frequency distribution of the following:
 - Water temperature metrics (maximum summer stream temperature and 7-day mean maximum summer stream temperature).
 - In-channel physical characteristics.
 - Riparian stand indicators.
- Provide data that will help Ecology determine whether forested streams are on a cooling trend and allow for the temperature status of streams to be compared with the Washington State water quality standards (WAC 173-201a) for summer maximum temperature.

To organize the ERST monitoring program into smaller divisions, we partitioned the state by region (Eastside vs. Westside), and waterbodies by stream type: Type F/S vs. Type Np. This resulted in a division of the ERST monitoring program into four separate project domains.

Project Domains:

- Westside Type F/S.
- Westside Type Np.
- Eastside Type F/S.
- Eastside Np perennial.

We have three universal goals encompassing the four project domains of the ERST program. ERST project goals:

- Documentation of the current status (frequency distribution) of riparian stand conditions, channel metrics, and annual thermal maximum stream temperatures for Type F/S and Np streams statewide across lands subject to forest practice rules.
- Discovery of any relationships that may exist among parameters and their relative strengths.
- Discovery of any trends that may exist in the indicators over time (Phase II).

The ERST monitoring program will use a random site selection method developed by EPA in order to reduce bias related to sampling location. Upon arrival at a site and verification of site suitability, we will establish a reach consisting of five equal length segments separated by six transects. Installation of water temperature loggers at the upstream and downstream transects of each reach, along with an air temperature sensor at the downstream transect will follow site validation. We will record annual thermal maximums and assess riparian and channel metrics at each site.

For the initial phase of the ERST monitoring program we will use our channel metrics, riparian canopy condition, and stream temperature data sets to create frequency distributions of current annual maximum water temperatures. As the program progresses to Phase II, changes in temperature frequency distributions will enable us to identify spatiotemporal temperature trends.

Sampling Strategy and Sample Size

The design of the ERST monitoring program takes into account the spatiotemporal variation of thermal maximums across Type F/S and Np streams under FFR regulations. By randomly selecting sites and stratifying them by region and stream type, we intend to obtain an unbiased estimate of the current conditions of riparian and in-stream characteristics on lands subject to forest practice rules.

A tradeoff exists between estimating status and detecting trends. With a greater number of sites, status estimates will improve. In contrast, repeated data collection at specific sites over time results in higher detection of existing trends. One option to alleviate this discrepancy involves a rotating panel study design. This involves visits to a core collection of sites over time, with the introduction of new sites on an annual basis (Rao and Graham, 1964) (Skalski, 1990). We propose to use the results of Phase I data analyses (status estimate) to determine the design, timing, and necessity for Phase II (trend estimate) sampling.

We will base our sample size on the goal of estimating the proportion of stream miles meeting water quality standards for stream temperature. We plan to sample 50 sites for each project domain during Phase I, or 200 total sites: 50 Westside Type F streams, 50 Westside Type N streams, 50 Eastside Type F streams, and 50 Eastside Type N streams (Figure 1). For the eastside Type F project we will select from sites used by the Eastside Type F Riparian Characterization study.

During site visits we will determine stream suitability. Field crew leaders will decide if adequate perennial flow exists, enabling temperature sensors to accurately record water temperatures during annual thermal peaks. A high likelihood exists that some selected sites will remain inaccessible due to lack of landowner permission and safety concerns. Other sites may be unacceptable due to being misclassified or falling outside of lands subject to forest practice rules. For these reasons, we will select additional sites of each typed designation for backup. Sites will receive a sampling order when selected to facilitate random spatial distribution. The ERST monitoring program project domains shall each use the first 50 suitable sites, in numerical order, for which we obtain access permission.

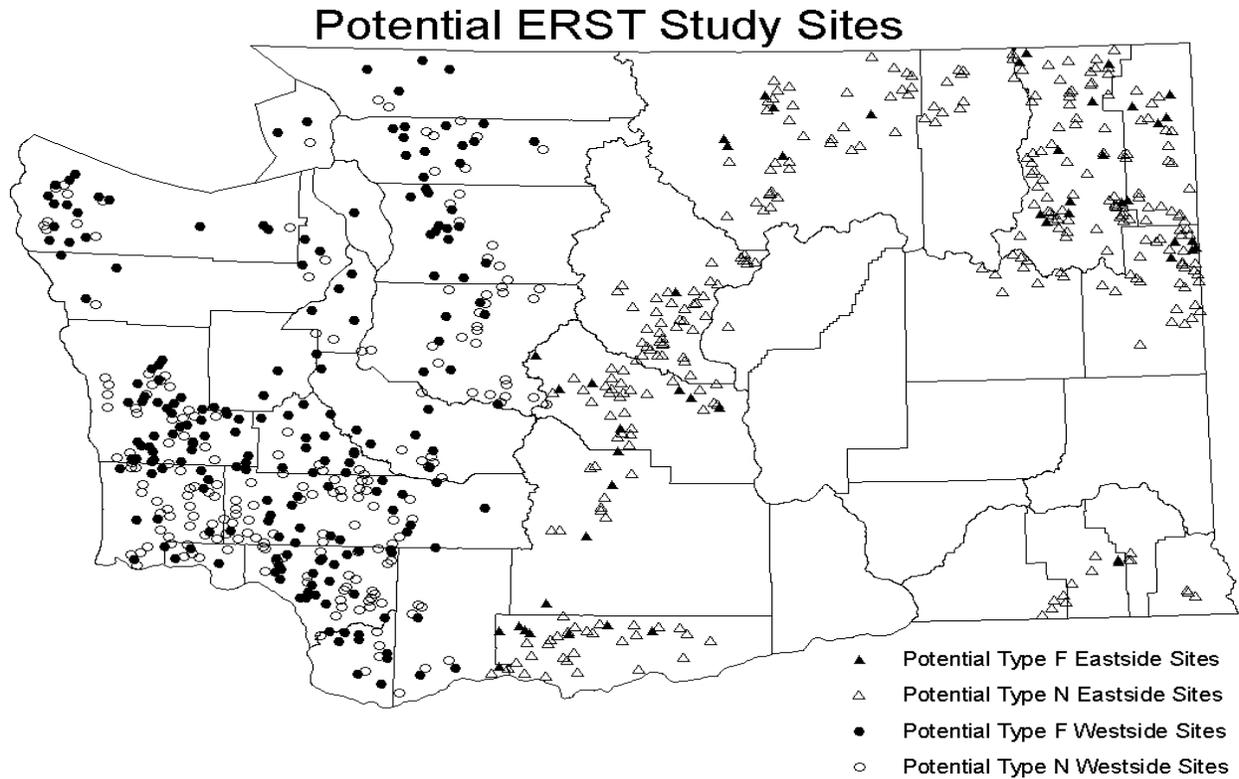


Figure 1. ERST potential study locations stratified by region (Eastside vs. Westside) and stream type (type F/S vs. type Np).

An all-encompassing objective of technical inquiries is acquiring a representative sample of a target population. Scientific investigations can become increasingly complex and can be difficult to assess and to account for each variable within the scope of a study. We will make several assumptions that address numerous issues associated with the ERST monitoring program.

ERST project assumptions:

- Thermal peaks generally occur between July 1 and August 31.
- Sites undergo a randomized selection process.
- Selected sites accurately represent the population of type F/S and Np streams statewide across lands subject to forest practice rules.
- Protocols will provide accurate descriptor variables needed to assess baseline values.
- Future replication will uncover trends that exist in relation to implementation of prescribed forest practices.

Assessments will begin in early May to assure the capture of thermal maximums in July and August.

Elements of Data Collection at Each Site

- Location descriptors of all temperature sensors using Global Positioning System (GPS) units and hand-drawn diagrams.
- Determination of reach and segment lengths, using average bankfull widths.
- Bankfull width (BFW), wetted width (WW), bar width, and thalweg measurements at each of six transects for each study site.
- 11-count substrate analysis determining depth, substrate class, and embeddedness at each of six transects for each study site.
- Upstream, leftbank, downstream, and rightbank percentage of canopy closure at each of six transects for each study site.
- Riparian vegetation assessment (RVA) of vegetation structure at each of six transects for each reach, performed after approximate full leaf-out condition.
- Dominant channel morphology for each of five segments at each study site, noting if side channels, back waters, and wetlands exist.
- Large woody debris (LWD) counts of downed, suspended, and jammed for each of five segments for each study site.
- Evaluation of average percent slope along each of five segments for each study site.
- Documentation of the location, bankfull width, percent of flow contributing to the main channel, of all tributaries encountered within each evaluated study site.
- Upstream and downstream water temperature measurements at 30 minute intervals, via in situ StowAway[®] tidbit temperature sensors at each study site.
- Downstream air temperature measurements every 30 minutes, via in situ StowAway[®] tidbit temperature sensors at each study site.

Representativeness

A valid set of representative samples must provide a true representation of the spatiotemporal variations of the population characteristic. Streams and the riparian ecosystems surrounding them change dynamically, with large diurnal and annual fluctuations. Flow patterns change as channels meander and inputs and exports flux. To account for this variability, we will stratify our samples by region and stream type.

We will not perform any chemical analyses in the ERST monitoring project, making our order of data collection irrelevant. We may assess waterbodies from downstream to upstream or vice versa. However, we will perform vegetation assessments after full leaf-out condition occurs in the summer. Sample collection should take place in order to best characterize the problem or objective. Thermal maximums typically occur between July 1 and August 31 in Washington State. Therefore, our efforts will focus on the summer period of low flow and increased thermal impact on the water quality parameter of temperature.

Comparability

To evaluate one data set with another and combine those data for decision making, we must address the issue of comparability. By selecting and documenting standardized procedures for sampling and analysis, and by clearly stating any non-standard requirements, we increase the possibility for comparison. We accomplish our quality objectives for comparability through ease of replication of our study. The creation of straightforward descriptions of the processes employed through detailed standard operating procedures (SOPs) will ensure the possibility of future comparisons. However, stream systems do not remain static and substantial spatiotemporal variation occurs. By our careful documentation of our procedures, replication of our data collection methods should allow for reliable discovery of existing trends.

Completeness

Completeness can be considered a measure of the amount of valid data needed from a measurement system. We have yet to define completeness for the ERST monitoring program. Analogous to our determination of QA threshold criterion, we will determine the quantity of valid data required to validate our investigation, as the ERST program progresses. As stated in our project description, we will attempt to obtain 50 complete sets of data for each region/type classification. With a predictable loss of some temperature sensors, we expect fewer complete datasets, but we have not estimated acceptable data loss.

Data Analysis

The ERST monitoring program defines riparian stand condition and water temperature as our primary variables of interest because:

- The basic strategy for protecting water quality, aquatic habitat, and biota involves the buffering of riparian zones.
- The FFR sets specific performance targets for riparian stands and water temperature (water quality standards).
- Riparian buffers provide riparian functions (e.g., LWD recruitment, litter fall, shade necessary to achieve FFR resource objectives)

If a lack of riparian shade negatively impacts stream temperature, then as stands mature toward more riparian shade, a downward shift in the distribution of temperatures should occur over time.

We will generally illustrate the proportion of streams meeting water quality standards by using the frequency distribution of stream temperature by stream type. Figure 2 depicts a hypothetical example of a shift in the distribution of stream temperatures. Summaries of riparian stand data will occur using the same frequency distribution method. Phase I of the ERST monitoring program will produce cumulative distributions and calculate estimates of population means and variances. Phase II will presumably make comparisons of present and future cumulative distribution functions (Dia-Ramos et al., 1996).

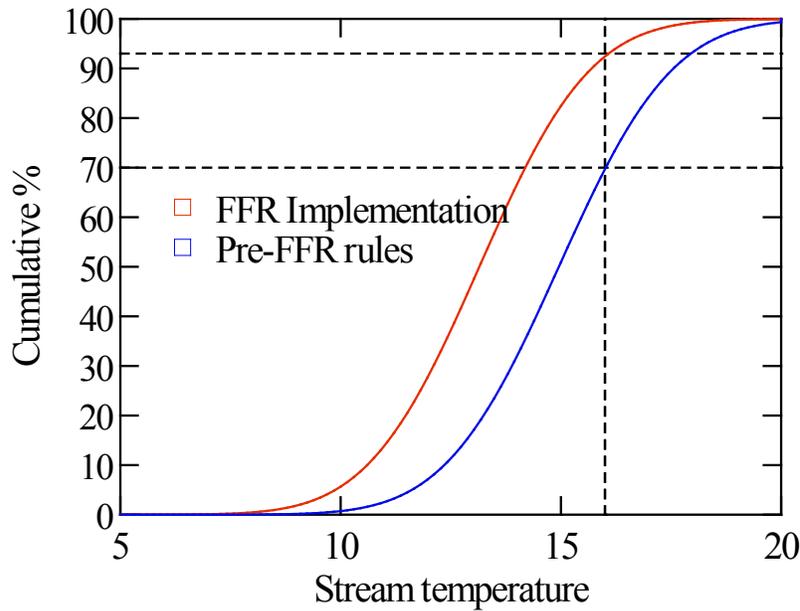


Figure 2. Hypothetical cumulative frequency distribution of maximum stream temperature prior to FFR and post-FFR implementation.

This scenario shows a shift to the left (decreasing temperature) and the percentage of stream miles with maximum temperature less than 16 °C increasing.

In addition to data summaries, we will use regression analyses to describe patterns in stream temperature due to elevation, air temperature, riparian shade, and geographic location. The results of our first analyses will enable characterization of areas or site conditions that do not meet temperature standard requirements. This information will allow us to include these factors in interpreting current status and will also feed back into the adaptive management system to direct monitoring and research efforts or policy actions in the future.

Procedures

Indicators used in other EMAP-based surveys have included both ecological condition (macroinvertebrate, vertebrate, and periphyton assemblages or indices derived from these) and stressor condition (physical, chemical, or biological stressors on the system) (Overton et al., 1990). Generally, the regulatory means of meeting FFR standard targets for the most commonly violated water quality standard in Washington State, water temperature (303d report), involves establishment of increased riparian shade (via riparian buffer requirements). For this reason, our study focuses on a subset of stressor variables with special emphasis on water temperature and shade. We intend to measure other channel and habitat descriptive variables as well, to provide context for our water temperature results.

Pre- and Post-Calibration

Prior to field deployment, we shall compare the temperature sensors to a National Institute of Standards and Technology (NIST) thermometer at 0 and $\sim 18^{\circ}\text{C}$ in a pre-calibration procedure. If temperature sensors fall outside of the manufacturer's specified tolerance range (0.2°C for water temperature sensors, 0.4°C for air temperature sensors) we will replace them. At the conclusion of the 2009 field season we will again compare all temperature sensors to an NIST thermometer in a post-calibration procedure to ensure data reliability. If the average temperature difference for a temperature sensor equals or falls within the manufacturer stated accuracy of the instrument, (i.e., $\pm 0.2^{\circ}\text{C}$ or $\pm 0.4^{\circ}\text{C}$) we will use the instrument without further qualification. If the average temperature difference for a temperature sensor exceeds the stated accuracy, then we will perform a second check to ensure there was not an error during the calibration process.

If the second result still exceeds the manufacturer accuracy range in the pre-study check, we will not use the temperature sensor in our study. If the second result exceeds the manufacturer accuracy range in the post-study check, then the stated accuracy for the data equals the mean difference of the pre- and post-study calibration values from the NIST thermometer.

We will use the following laboratory procedure to determine both pre and post-calibration accuracy:

1. We will prepare two insulated coolers for water baths at least 12 hours prior to the temperature sensor calibration. Our investigators will conduct this test in a room where we can hold air temperature relatively constant for the duration of the calibration procedure. One water bath will acclimate to ambient temperature (typically around 16°C). The other bath will contain ice and water.
2. We will program the temperature sensors using a delayed launch so they all begin at the same time and use a one-minute sample interval to measure temperatures. To assure temperature sensors remain in close proximity we will use a cord or long rubber band to string them together. We will keep temperature sensors at room temperature until submersion into the baths.
3. Temperature sensors will soak in the ambient bath for 20 minutes before the recording of comparison temperature measurements using the NIST calibrated thermometer. We will stir the bath constantly to maintain homogeneous water temperature.

4. After the 20-minute soak time has elapsed, we will record the bath temperature using the NIST thermometer. This occurs every two minutes beginning at the time the temperature sensors record their temperature measurements. We will record the time and temperature of the NIST measurement and continue stirring the bath to ensure a homogeneous temperature. (Note that Appendix C contains a sample data logger calibration form. Additionally, we will use Access database program to store calibration data).
5. We will record 10 comparison readings in the ambient bath.
6. Following the ambient bath, we will transfer all temperature sensors to the cool water bath and soak for 20 minutes. We will keep stirring the bath to ensure a well-mixed (non-stratified) water bath. Enough of the ice will be removed at the beginning of the soak to facilitate easy access to the temperature sensors.
7. After the soak time has elapsed, we will repeat steps 4 and 5, using the cool bath.

Site Selection

The EMAP site selection method developed by EPA estimates the status and trends of ecological resources across broad landscapes. It also examines the relationships between ecological conditions and natural and anthropogenic stressors. The ERST monitoring program will employ this method to reduce bias related to location choice. The EMAP sampling design allows for the estimation of the proportion of a stream network that meets a specific numeric criterion (Overton et al., 1990; Diaz-Ramos et al., 1996; Peck et al., 2003). Often, we weight a sample draw to include more large (3rd order or higher) streams to ensure that estimates of stream condition get extrapolated to large and small streams separately. Water temperature has a significant impact on all stream systems, regardless of size. We will not weight our sample draw in this study. Therefore, the probability that we select a particular stream will equal the frequency of occurrence for that stream.

The target population for our study includes all streams classified as Type F/S or Type Np (fish bearing and non-fish bearing waters designated on the WDNR 1:24,000 hydrology GIS layer) in the state of Washington that fall under forest practices rules. The ERST monitoring program will define lands regulated under the forest practice rules as:

- Forest land-cover based on USGS (U.S. Geological Survey) Landsat-based 'Forest Land' classification
- Not federally owned
- Not part of a separate Habitat Conservation Plan
- Not included in an Urban Growth Area

Our investigation will examine forestland not covered by one of the last three management scenarios. The USGS *forestland* designation likely included some non-forested land (inclusive designation). We will screen individual sites using orthophotos, tax parcel information, landowner contacts, and site visits to ensure each stream meets the criteria listed above and lies within a forested land use area.

The lack of perennial flow in seasonal non-fish bearing (Type Ns) streams precludes accurate estimates of maximum stream temperatures. Consequently, we will only include perennial non-fish bearing (Type Np) streams in our sample. The Washington State Department of Natural Resources (WDNR) stream typing GIS layer does not differentiate between perennial and seasonal non-fish bearing streams, so we will apply the probability-based sampling procedure to the entire Type N stream network and will screen each selected site using orthophotos and field visits. Upon arrival at a potential site we will follow the guidelines from Palmquist (2003) and Topping et al. (2009) to differentiate between Np and Ns streams.

Implementation of our Eastside Type F project will closely coordinate with the Eastside Type F Riparian Assessment project. Where feasible, we intend to use the same sites for both projects. We hope to eliminate duplicate site selection efforts and provide additional datasets for streams common to both projects.

The ERST monitoring program will generate a master list of random Type F/S and Np sites throughout the state, and investigations to determine ownership and obtain access to the sites will begin. Once we obtain access to sites, we will visit them during the field season, beginning in May, and assess each for suitability. If our field crews deem a site suitable (i.e., they appear typed correctly, have sufficient flow for analysis, lie on forest lands, and lie on lands subject to forest practice rules), then further site evaluation will continue.

Reach Establishment

We will visit our randomly selected points in sequential order and establish a sample reach at each suitable location. Upon arrival and validation of a study site, we will establish a sampling reach following [Standard Operating Procedure for Establishing a Reach for the Extensive Riparian Status and Trends Monitoring Program](#)

Installation

Upon installation of temperature sensors, we will complete a site installation form, which includes:

- Stream type
- Field crew
- Site ID #
- Reach length
- Segment length
- Serial #
- Position
- Install time
- Water depth
- Distance above streambed
- Distance from bank full channel edge
- Downstream aspect
- Latitude/Longitude

- Estimated precision of error
- Number of satellites locked
- Presence of WAAS satellites
- Diagrams of temperature sensor location
- Notes and site description

Stream Temperature

We will evaluate stream temperatures at 30-minute intervals at the upper and lower ends of each reach via in-situ StowAway[®] tidbit temperature sensors (Onset, 2004). Our installations will follow the methods described in Schuett-Hames et al. (1999a). If we shift a reach downstream, we will install an additional water temperature sensor at the random GPS location. Reaches will be shifted downstream to avoid non-FFR land upstream of point, to ensure perennial flow if a stream is dry upstream of the point, to avoid unsafe conditions, to avoid beaver dams or man-made impoundments, and if there is an unwilling landowner upstream of the point.

Installation will consist of attachment of temperature sensors to rebar driven into the streambed. Using both zip and wire ties, we will suspend temperature sensors in the water column. Occasionally, we may need to employ novel methods of installation (e.g., exclusively bedrock substrate precludes rebar installation). To protect the water temperature sensors from exposure we will adjust their distances above the streambed at revisits. Installation will commence annually in May and continue through June.

Due to the high elevation of some sites, we may delay several site installations until late in the field season as a consequence of melt out dates. We will leave sites we installed late in the field season in over the winter. At these sites we will collect data at the end of the following field season to insure capture of annual thermal peaks.

Air Temperature

We will deploy air temperature sensors adjacent to downstream water temperature sensors at a height of approximately 30 cm above the water surface. Comparing air and water temperatures will allow us to determine when water temperature sensors become exposed as stage levels drop. If it is not possible to hang the air temperature sensor directly above the water surface, we will hang it as close as possible and note the exact location. A flowerpot will shield each air temperature sensor from direct sunlight (Schuett-Hames et al., 1996) and the air temperature sensors will collect temperature data at 30-minute intervals. We will attach the temperature sensor/flower pot set-up with zip-ties to available vegetation or metal spikes driven into logs, allowing for effective air transfer under the flower pot. To protect the air temperature sensors from submersion and direct sun exposure, we will adjust their heights above the water surface at revisits. Installation will commence annually in May and continue through June.

Channel Metrics

Channel Dimensions

Following the descriptors used by Harrelson et al. (2004), we will assess wetted width, bankfull width, bars, and thalweg depths using [Standard Operating Procedure for Determining Channel Dimensions in Streams and Rivers for the Extensive Riparian Status and Trends Monitoring Program](#).

Depth, Substrate, and Embeddedness

We will use an eleven-count technique to characterize depth, substrate class, and percent embeddedness at each transect of our sampled reaches. We will follow [Standard Operating Procedure for Measuring Sediment Size and Channel Dimensions: The 11 – Count Method](#).

Stream Gradient

Using clinometers, we will measure stream gradient at the water surface between transects. We will then average our readings over an entire reach, resulting in an average site gradient. We will follow [Standard Operating Procedure for Determining Channel Dimensions in Streams and Rivers for the Extensive Riparian Status and Trends Monitoring Program](#).

Morphology

Using methods and morphology type definitions described in Montgomery and Buffington (1997), we will assess channel form by determining dominant stream morphology types of the five segments within each study site. In addition, we will note the presence of side channels, backwaters, and wetlands, along with the location, bankfull width, and percent contribution of all tributaries within each study site. The influence of each of these can have a profound impact on stream temperature. By accounting for each of these riparian components, we hope to explain any temperature anomalies that may occur.

Large Woody Debris

The presence of large woody debris (LWD) profoundly affects stream channel characteristics and ultimately provides habitat for a variety of species. Within each segment we will tally LWD pieces greater than 10 cm in diameter, similar to the state Timber Fish and Wildlife program protocols (Schuett-Hames et al., 1999b). Specifically we will follow [Standard Operating Procedure for Counting Large Woody Debris for the Extensive Riparian Status & Trends Monitoring Program](#).

Vegetation

Shading provides a vital component to the thermal regime of streams. We will make an estimate of riparian vegetative cover through means of single point canopy closure measurements and a more subjective riparian vegetation assessment method.

Canopy Closure

Using a concave spherical densiometer we will determine average canopy closure at each site. For each of six transects, we will take densiometer measurements facing upstream, the left bank, downstream, and the right bank at the midpoint of the bankfull width at each transect. We will then average the measurements across an entire reach and produce a value of average canopy closure per site. We will follow [Standard Operating Procedure for Determination of Canopy Closure using a Concave Spherical Densiometer – Model C for the Extensive Riparian Status and Trends Monitoring Program](#).

Riparian Vegetation Structure

To characterize vegetative structure, we will employ a visual estimation method. It involves visually dividing riparian vegetation into several horizontal layers. At each transect we will perform the riparian vegetation assessment to both banks. We will follow [Standard Operating Procedure for Visual Characterization of Riparian Vegetation Structure for the Extensive Riparian Status and Trends Monitoring Program](#).

Storm Damage

In the fall/winter of 2007 and 2008 large storms caused severe damage to many Western Washington areas. These events resulted in varying severity levels of wind throw and bank erosion. In cooperation with forest owners, Ecology has agreed to document the severity of the damage within our study sites. We will follow [Standard Operating Procedure for Assessing Storm Damage for the Extensive Riparian Status & Trends Monitoring Program](#) to assess site disturbances resulting from the 2007 and 2008 storm events.

Site Descriptors

In addition to the other variables that we will evaluate in the field, we will acquire several more through the use of geographic information systems (GIS). We will obtain site elevation, basin area, and basin slope by utilizing a 30 m digital elevation model (DEM) data layer imported to ArcView 9.3. This will enable our field planning to account for variations in melt out dates, determine probable waterbody size, and determine difficulty of access. Due to the ease of GIS data acquisition, we can make comparisons between these variables and water quality parameters relatively simply.

Decontamination of Field Gear

Washington State law (RCW 77.15.290) prohibits the transportation of plants or animals (*any* plants or animals, not just invasive species). All field staff must remain diligent in preventing the spread of organisms from site to site as we conduct our field work.

Areas of Moderate Concern

The majority of our sites will lie within the *Areas of Moderate Concern*. Therefore, we will generally follow [Standard Operating Procedures to Minimize the Spread of Invasive Species from Areas of Moderate Concern](#) in relation to decontamination of field gear.

Areas of Extreme Concern

If our sites lie in *Areas of Extreme Concern*, we will follow more intensive decontamination procedures (e.g., known areas inhabited by New Zealand mud snails). In these areas we will use [Standard Operating Procedures to Prevent Accidental Introductions of Aquatic Organisms from Areas of Extreme Concern through aquatic plant monitoring activities](#) as our protocol.

Quality Control Procedures

Data Flagging

We expect the exposure of water temperature sensors to occur at several monitoring locations as water levels recede. We will take measures to identify suspect data and exclude them from the analyses. First, we will use field notes from the fall downloads to flag sites for general time periods when sensor exposure or submersion may have occurred. Second, we will examine the data from both the water and air temperature sensors to determine the date and time when unintended forces, for example water or air, may have adversely affected a temperature sensor. Data from nearby sites may provide additional information regarding temperature trends. Typically, we would expect both upstream and downstream water temperature records to closely correlate.

Water temperature data should begin tracking the air temperature data (and vice versa) as temperature sensor exposure to air takes place. Generally, we will know when temperature sensor exposure has occurred due to the large difference in afternoon air versus water temperatures. If we notice any indication of even partial exposure of a water temperature sensor or the influence of water on an air temperature sensor we will censor the data and not use them in our analyses.

Replicates

Replicate results provide a way to estimate the total random variability (precision) of individual results. The dynamic nature of stream systems makes true spatiotemporal replication impossible. Our riparian and in-channel habitat data will undergo a spatial quality assurance procedure. We will perform replicate data collection procedures using varied crews at 10% of sites within each of our four project domains. These replicates will include canopy closure, stream substrate (depth/size class/embeddedness), gradient, large woody debris count, riparian vegetation assessment, tree blow-down, bank erosion, and several channel form and dimension descriptors.

Training

Quality control procedures will include annual training of the field crews and refresher training exercises designed to develop accuracy and precision of data collection techniques. When possible, we will utilize crews from previous years. Field crew experience will help the project run at maximum efficiency.

Corrective Actions

When we encounter suspect or missing data, we will take corrective actions to exclude them from analyses. As we collect data we will review datasheets for possible errors or omissions before entering them into corresponding databases. We will enter all problems that we encounter into a QA spreadsheet. The project manager will decide if we need to re-evaluate a site or

collect additional data when issues arise. We will use our post-calibration procedure to assess the likelihood that temperature sensors functioned appropriately while in the field. Due to the impracticality of the field calibration of temperature sensors, we can only use post-calibration data to determine overall data usability in our analyses.

Data Management Procedures

Data management addresses the path of data from recording in the field or laboratory to final use and archiving. We will record habitat field data on project- specific designed Rite-in-the-Rain® datasheets. After an initial QC check of the datasheets, we will scan each datasheet into site and project- specific folders for ease of accessibility and review. Following scanning, we will enter data into corresponding tables within project- specific databases. After a final database QC review, we will export data as .txt files before importing them into Systat 10 for analysis and table/figure output.

We will offload temperature data files directly from our temperature sensors to Optic Shuttles™. Using Boxcar 4.3, our data manager will download temperature files from the shuttles as .dtf files. The data manager will then review each .dtf file to document any obvious anomalies that may exist, and will establish timeframes for leader and tail deletions. After we note all errors in a QC spreadsheet, the data manager will convert each .dtf file to a .txt file and eliminate all leaders and tails within the .txt file. Following conversion and clipping of leaders and tails, the data manager will import the .txt files into corresponding tables within specific project domain databases. Following database import, we will flag suspect data and the data manager will export data files as .dbf files. In the final step, the data manager will import the temperature data .dbf files into Systat 10 for summary and final table/figure creation.

The ERST monitoring program will separate our quality control procedures into discrete steps. We will construct a set of worksheets such that we will check off each step for each file as we progress. Though not required, it's generally most efficient to finish each step before moving on to the next. A methodological summary of our download process through table/figure creation follows:

.dtf File Download

- Attach temperature sensor or shuttle to base station. From Boxcar, select **Logger>Readout** (if downloading temperature sensor directly) or **Logger>Optic Shuttle Readout** (if using the shuttle).
- Boxcar will prompt if you would like to auto save. Select **No** and name each file using the following format: **Serial#_MM-DD-YY.dtf** (serial# and download date as a logger data file).
- Save each .dtf file into a corresponding folder based on site number in an appropriate directory, based on region (Eastside/Westside) and stream type (F or N).

Initial .dtf Inventory

- Using a spreadsheet, compile all download dates against your stations/locations and temperature sensor IDs by matrix type.
- Inventory the .dtf files by checking off each file's download date, confirming location and matrix.
- When downloading temperature sensors, misnaming can occur. It will be important to remain meticulous when naming files.

- Occasionally Boxcar saves .dtf files to its default directory, so missing files may be recovered from there.

.dtf File Review

- Plot each .dtf file in Boxcar.
- Confirm the assigned name of each .dtf file matches the serial number read by Boxcar and that Boxcar displays it above the output graph. Check off confirmation on the QA worksheet.
- Examine file start and end dates and determine if files and field notes agree.
- If a discrepancy occurs, investigate the issue further to determine the cause. Three common errors are: sensor failure, data time shift, and lag between launch and installation. These all may occur in combination.
 - A failed sensor may result in a longer than expected data file. This takes place because; when temperature sensor download ensues overwriting of data occurs instead of deletion. Thus, new data comprises the section of the file up to the failure point, and information from the last download makes up the remaining data. Due to the subtlety of this error, examine files carefully. Track problems in the QA worksheet.
 - Time shifted files become stretched, sometimes 20 years into the future. Time shifted files require factory correction. Track problems in the QA worksheet.
 - Examine each file's leader and tail to identify whether these need editing by comparing .dtf files to install and download datasheets. Track the periods that need clipping in the QA worksheet.
- Check for other problems (gaps, failure to re-launch, partial files, unrealistic data, flat lines, etc.). Track the site, sensor ID#, and problem description in the QA spreadsheet.

Exporting .dtf to .txt

- Build new directories to receive the .txt files based on site number. Name .txt and .dtf directories differently so that they do not overwrite. For consistency, use established naming conventions.
- With a .dtf file open in BoxCar, select **File>Export>Microsoft Excel**. Make sure that you check the “**Include Serial Number in Data Export**” box and select **Export**. Confirm that the serial number on the .dtf file matches all files/folders, and confirm start/end dates as well as total points.
- Save each file in the correct directory and folder as Boxcar may not remember between files. Name each file using the following format: **Serial#_MM-DD-YY.txt** (serial# and download date as a text data file).
- When finished exporting a file, check off each on the QA spreadsheet to confirm successful conversion to .txt file.

Editing .txt Files

- Revise .txt files by clipping pre-installation leaders and download spikes where present. Open a .txt file. Prior to editing notice the .txt file format. The edited file must match this format exactly. Using your QA spreadsheet as a reference, erase those lines in the .txt file that need clipping and resave the .txt file.
- Occasionally, the .txt import process into Access will abort. This occurs as a consequence of editing artifacts left in the file. For example, a blank row between the data arrays and field headers or a stray formatting character at the end of the field header row can cause the import process to fail. Remove these hidden characters by backspacing at the end of the field header row and deleting the last few blank spaces and the final parentheses. Retype the parentheses and try importing again. Lastly, check the beginning and end of the file. It is possible that clipped leaders or tails could have inserted extra return rows at the beginning of the temp data or below the last line. Make sure to delete these lines.
- Update the QA spreadsheet as problems are resolved.
- **NOTE:** Dead temperature sensors often contain useful data but recovery requires factory return of temperature sensors. Use caution when receiving these files, as return may contain ANY data on the temperature sensor. For example, if a temperature sensor failed mid-winter, you may receive data files from the previous winter beyond the failure point. Subtle breaks often occur, so when in doubt, plot data from the previous year. The data pattern will point to the break.

Importing .txt Files into Access

- Create separate databases for each stream type (fish-bearing vs. non-fish-bearing) and region (Westside versus Eastside). This will make data more manageable and assure no violation of data quantity limits exist, which may result in dropped records.
- Import .txt files to Access, file by file, using the **Import** form in each database's list of access objects. Order is not critical, as you can sort the table when you finish importing files. However, it's easiest to work down the QA worksheet.
- You must load **EIM location id** and **study_location_name** into the **user_locations** accessory table prior to importing. Additionally, you will need to enter a list of possible **EIM user study id's** into the **user_study_id's** table. Enter this data into the tables manually or use the corresponding forms in each database.
- Once complete, the user can select the correct site_id, location, and study from drop down menus in the **Import** form. The user will also select the appropriate matrix, or **media**, that corresponds to the particular temperature sensor.
- Select the **import raw data file** button and select a file for import.
- In order to minimize errors, work through all of one matrix before starting another.
- Open each imported file and confirm **location id, study location name, study id, and media**. Get a sense of the number of records per file to assure successful transfer of all records.
- To stay under the record safety limit, partition the data by matrix and other logical breaks as needed. Access has no firm record number limit but will start to drop data if tables get too large. Stay under 750,000 records per table.

- Create master tables that will partition the data by matrix and logger location on the stream. We have already partitioned the data by east/west and stream type, by creation of a database for each of the four domains of the ERST monitoring program.
- After creating the master tables, enter the corresponding table name into the **append daily average-max-min to:** box in **Step 2** on the **Main** form. Then select the **append raw table to another table** button.
- Track all tables appended in the QA spreadsheet to ensure update of all files.
- Confirm appending of each file in the main table by opening the main table and noting the increase in table size.
- Once completion of the import of .txt files to the master tables occurs, delete the temporary Access tables created for each .txt file.
- Track access import via the QA spreadsheet to confirm inclusion of all files.
- Scan each master table for duplicates using a duplicate query. These queries already exist in the database, and you can easily run an update using SQL or query builder.
- Delete duplicate records. These result from Daylight Savings Time (DST). They do not impact daily max or min, but may impact daily average calculations. At the beginning of DST, the creation of records with duplicate date and time occurs. At the conclusion of DST, record elimination from a one hour time span occurs (Table 4).
- Calculate temperature differences due to deletion of DST records.
- As table size grows, MS Access may mix rows from different sites, which renders the data confusing to browse. You may want to insert an auto number field to the far right in your table to aid in browsing/sorting.

Table 4. Beginning and ending dates for Daylight Savings Time (DST) in the Pacific Time Zone from 2007 through 2012.

| Year | DST | |
|------|------------------|----------------|
| | Begins at 2 a.m. | Ends at 2 a.m. |
| 2007 | 11-Mar | 4-Nov |
| 2008 | 9-Mar | 2-Nov |
| 2009 | 8-Mar | 1-Nov |
| 2010 | 14-Mar | 7-Nov |
| 2011 | 13-Mar | 6-Nov |
| 2012 | 11-Mar | 4-Nov |

Editing

Large tables often exceed limits on Access' undo function. Beyond certain size limits you cannot reverse unintended edits because tables immediately update live. Use a conservative approach when deleting records and make copies of tables to assure no data loss. Retain everything in database tables except obvious errors. All data should remain in the database, even

though we may ultimately exclude it from the analyses. This strategy maximizes the number of summary options available and preserves a complete record of the data sets.

- Plot all .dtf files for a site in a single window within Boxcar. Compare all temperature sensors and determine if any anomalies exist. Additionally, compare data to nearby sites to verify air temperature ranges. Several types of errors may occur. These include data file, calibration, and physical issues. Tie each type of issue and their codes to specific error fields.
- Note the time periods that need to be flagged and their associated physical issues in the QA spreadsheet. We will tie physical errors and issues to the **error3**, **error4**, and, **error5** data fields. We will use the following physical error codes: B= WT sensor buried ≥ 2 cm; D= channel dry; DI= sensor disturbed (animals, high flow, wind throw); E= WT sensor exposed; WS= WT sensor under influence of snow/ice; PE= WT sensor partially exposed; S= AT sensor found submerged; AW= AT under the influence of water; AS= AT sensor likely frozen or influenced by snow/ice; G= AT found on ground; PD= damaged flower pot surrounding sensor; OT= other issues not covered by listed codes.
- Error codes for data file issues correspond to the **error1** data field. We will use the following data file error codes: L= sensor launch error; TC= time correction error. Note the time periods to flag and their associated issues in the QA spreadsheet.
- After post-calibration, enter the corresponding calibration codes into the QA spreadsheet. We will tie post-calibration issues to the **error2** data field. We will use the following calibration codes:
 - For water tidbits: NC (near compliance)= within 0.1 of compliance value, CU (conditional use)= 0.1 - 0.2 of compliance value, EX (exclude)= >0.2 of compliance value
 - For air tidbits: NC (near compliance)= within 0.2 of compliance value, CU (conditional use)= 0.2 - 0.4 of compliance value, EX (exclude)= >0.4 of compliance value
- We will use the **data_use** field to include or exclude data from analyses in Systat. This field can be updated using existing database queries. We will use the following data use codes: 1= use for analyses, 2= do not use for analyses.
- Using update queries to identify the blocks of records to flag for problems and enter their appropriate error codes and timeframes into the corresponding data fields.

Export

Tables are the preferred format for our analysis. MS Access stores its tables inside its database files, rather than as external stand alone .dbfs. If the analysis software being used cannot read the MS Access database directly, you must export tables. This creates a new problem because MS Access generally fails to correctly export one of its native field types, **date_time**, into non-Access table formats. Often we must trick Access into exporting what we want. We will use the following method:

- In your pc **control panel**, select **regional and language options**
 - under **regional** options choose **customize**
 - under the **numbers tab** change **number of digits after decimal** to **7** and **apply**
 - under the **time tab** select **H:mm:ss** as time format and **apply**
 - **close the control panel** and return to MS Access

- Open one of your master tables. Confirm that the 24 hr format time appears and close the table. Open a new database. Copy and paste your table into the new database. Open the table and switch to design view. Change the **date_time** field format to **numeric**. In the first row of **properties**, choose **double** precision. In the second row choose **general number**. Now **export** your table using the **dbf IV** format. Repeat the process for remaining tables as needed. Due to table size and counting of fields by Access, you may need to open a new database for each table you want to export.

Systat Import

You can now import data to Systat as dBase IV (*.dbf) files. We will accomplish import through the use of import commands (.syc) within the Systat program's command pane. Commands using the appropriate syntax enable us to import and manipulate our data into usable tables, and ultimately allow statistical analyses. The complexity of .syc commands results in the possibility that a mistake involving small insertions or deletions may render commands non-functional. We will use several .syc files for the ERST monitoring project.

- **ERM_import.syc**: used to import and convert raw database files to raw Systat files (.syd) containing appropriate date_time format.
 - By using the find/replace command (or manually) you can designate what file to import, its location, where to save the new .syd file, and what to name the new .syd file.
- **WF08_LOG.syc** (WN08_LOG.syc, etc.): used to merge sensor data by site, apply error and data validity codes, drop insufficient or undesired data from analyses, calculate temperature statistics, and generate and manipulate temperature data figures.
 - By using the find/replace command (or manually) you can designate what file to import, its location, where to save the new .syd file, and what to name the new .syd file.
- Before importing habitat data into Systat, you must convert the access tables to .txt or .xlsx files. Conversion to .txt files seems the most reliable, with few formatting errors occurring. Systat has trouble with the new Excel .xlsx file format. If utilizing Excel, use the earlier .xls file format.
 - Convert the desired Access tables to .txt files, making sure to select **Delimited** and check the **Include Field Names on First Row** box. If field names do not appear, you will have to manually add these to the .txt file before importing to Systat.
- **WF_ERM_phys_var.syc** (WN_ERM_phy_var.syc, etc.): used to import or merge physical habitat data (in .txt format) into a manageable table, drop insufficient or undesired data from analyses, calculate habitat statistics, and generate and manipulate habitat data figures.
 - By using the find/replace command (or manually) you can designate what file to import, determine its location, where to save the new .syd file, and what to name the new .syd file.

The Environmental Information Management (EIM) database system is the major environmental data repository for Ecology. Due to the immense quantity of temperature data produced by this study, complete data entry into EIM is currently impractical and improbable. Therefore, only summary information will be included in the system.

Data Analysis

The principal investigator, project manager, and field/data manager will perform our data analyses. They will work collaboratively to generate draft and final summary reports estimating the current status of type F/S and type Np streams and associated riparian zones across the FFR lands of Washington State.

Summary statistics and frequency distribution plots will be used to describe current status. Changes between years in Phase I will be assessed using a paired t-test or comparable nonparametric procedure.

Using a simple Pearson correlation analysis with a Bonferroni adjustment for multiple comparisons we will reveal any significant correlations between the variables. We will then use step-wise multiple linear regressions to identify any factors involved with the discovered relationships and create simple corresponding models. Additionally, we will evaluate each site descriptor variable for inclusion in the model based upon squared partial correlation coefficients (r^2). In effect, we will determine which variable added the greatest amount of explanatory power to the initial model, add that term to the model, and repeat the process for all remaining descriptor variables until $p < 0.05$.

To analyze and present all tables and figures, including summary statistics, we will use Systat 10. We will graphically represent each parameter, visually describing estimates and ranges of the data sets.

Because Phase I (current status) of the projects will guide Phase II (trend monitoring), we will not discuss trend method analyses in this document.

Audits and Reports

A series of audits and reports will ensure correct implementation of our QA Project Plan, quality of our data, and timely implementation of any required corrective actions. Audits and reports enable tracking of project progression and validity as a project develops. This will enable us to modify any procedures not functioning as envisioned before data collection concludes, develop precision acceptance criterion, and ensure adherence to QA Project Plans.

Audits

Early on we will develop a technical systems audit to assess the qualitative value of conformance to the QA Project Plan. Our goal for this initial audit involves the exposure of any existing issues with protocols or data viability and immediate enactment of corrective actions if such concerns exist. We will also develop an audit to determine QA threshold limits. This will establish acceptance limits for precision, bias, sensitivity, representativeness, comparability, and completeness. Our project and field/data managers will implement each audit.

Reports

At the conclusion of each field season and following data download and review, our principal investigator, project manager, and field/data manager will prepare a progress/draft report for CMER. When final entry of all data from each of the four project domains and QA procedures conclude, we will prepare an all-encompassing final project report. Phase I of the ERST program will guide the design of the trend monitoring scheduled for Phase II of this project. Each Phase I report shall include an assessment of data accuracy and completeness, QA problems and corrective measures taken, and summary figures describing present conditions of assessed sites across lands subject to forest practice rules.

Each of the final Phase I reports for the four Extensive Riparian Status and Trends (ERST) domain reports, as well as the final report, shall undergo scientific review by staff with appropriate expertise who are not directly connected with the project. These peer reviews will ensure proper documentation and technical soundness. Ecology's intranet site provides guidelines for technical document review.

Data Verification

Assessment involves data examination and evaluation to varying levels of detail and specificity. It includes verification and data quality assessment. Data verification requires examination of data for errors or omissions as well as inspection of results for compliance with QC acceptance criteria.

Prior to departure from a sample site, we will screen field datasheets for completeness and errors. This will allow field crews to immediately assess any questionable figures, eliminating incomplete datasets and additional site visits.

Following field verification, we will perform an in-office review of datasheets to ensure data correctness, consistency, completeness, and lack of errors or omissions. We will then enter data into corresponding databases. Following entry, different individuals will compare the database data to the original datasheets to ensure no entry errors occurred. With this additional review we expect our data entry errors will be minimized. As mentioned previously, we have yet to establish our QC acceptance criteria. As they materialize, we will compare our data to these threshold limits to determine if we met QC goals and used appropriate methodologies.

For quality control, we will duplicate habitat data collection procedures at a minimum of 10% of our sites. After data collection and duplicate sample data compilation, our project manager and principal investigator will make a final determination as to our data's usability.

Data Quality (Usability) Assessment

The meaningfulness of data quality relates to their *intended* use. Following data verification and validation, we will perform a Data Quality Assessment (DQA) or Usability Assessment (UA). DQAs determine whether you have answered your study questions and made necessary decisions with desired confidence. We cannot fully discuss the usability of our temperature data until we have firmly established our measurement quality objectives (MQOs). If we meet our MQOs, we will have quality temperature data that meets project objectives. If we do not meet our MQOs for temperature data, we will need to determine if the data is usable. Additionally, we will determine if the data set quantity meets project objectives by assessing whether we have met our requirements for representativeness and comparability.

If we collect complete data sets from less than our target of 50 sites, we will assess the effect on the estimates of our parameters of precision using a chi-square test. With alpha equal to 0.10, we can compare the 90% confidence ranges to determine the effect on the parameter estimates.

Due to the straightforwardness of our sampling design, others can use it over a wide range of possible outcomes. We expect that we will obtain quality data, which will accurately characterize the status of Type F/S and Np streams in relation to temperature across lands subject to forest practice rules in Washington State. We propose continuation of the ERST monitoring program through implementation of Phase II (trend monitoring).

References

- Clinton, C., 2009. Standard Operating Procedure for Measuring Sediment Size and Channel Dimensions: 11-Count Method Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP063. www.ecy.wa.gov/programs/eap/quality.html.
- Diaz-Ramos, S., D.L. Stevens, Jr., and A.R. Olsen, 1996. EMAP Statistical Methods Manual. EPA/620/R-96/XXX. Corvallis, OR: U.S. Environmental Protection Agency, Office of Research and Development, National Health Effects and Environmental Research Laboratory, Western Ecology Division. www.epa.gov/nheerl/arm/documents/intro.pdf.
- Ecology, 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Washington State Department of Ecology, Olympia, WA. Publication No. 93-e04. www.ecy.wa.gov/pubs/93e04.pdf.
- FFR, 1999. Forest and Fish Report. April 29, 1999. www.dnr.wa.gov/Publications/fp_rules_forestsandfish.pdf.
- Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy, 1994. Stream channel reference sites: an illustrated guide to field technique. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-245, Fort Collins, CO. www.stream.fs.fed.us/publications/PDFs/RM245E.PDF.
- Kennedy, K., 2009. Standard Operating Procedure for Counting Large Woody Debris for the Extensive Riparian Status and Trends Monitoring Program Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP065. www.ecy.wa.gov/programs/eap/quality.html.
- Lombard, S. and C. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030. www.ecy.wa.gov/biblio/0403030.html.
- MDT, 2002. Monitoring Design for the Forestry Module of the Governor's Salmon Recovery Plan. Monitoring Design Team. www.dnr.wa.gov/Publications/fp_am_mdt_report_20020718.pdf.
- Montgomery, D.R. and J.M. Buffington, 1997. Channel-reach Morphology in Mountain Drainage Basins. Department of Geological Sciences, University of Washington. Geological Society of America Bulletin, May 1997, Volume 109, p. 596-611.
- Onset Computers, 2004. 470 MacArthur Blvd., Bourne, MA 02532. www.onsetcomp.com/files/manual_pdfs/3050_H_MAN_TBI32.pdf.
www.onsetcomp.com/products/data-loggers/tbi32-0537.
www.onsetcomp.com/products/data-loggers/tbi32-2050.

Overton, W.S., Stevens, D.L., and White, K., 1990. Design Report for EMAP Environmental Monitoring and Assessment Program. EPA/600/3-91/053. U.S. Environmental Protection Agency, Washington, D.C.

Palmquist, R., 2003. Type N Stream Demarcation Study Phase I: Pilot Results. Cooperative Monitoring and Effectiveness Monitoring Committee. Northwest Indian Fisheries Commission. Olympia, WA. www.dnr.wa.gov/Publications/fp_am_pipfinalreportv7.5.pdf.

Peck, D., J.M. Lazorchak, and D.J. Klemm (ed.), 2003. Environmental Monitoring and Assessment Program – Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Western Ecology Division, Corvallis, OR. www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/ewwsm01.pdf.

Rao, J.N.K. and J.E. Graham, 1964. Rotation designs for sampling on repeated occasions. Journal of the American Statistical Association, 59: 492-509.

RCW 77.15.290. Unlawful transportation of fish or wildlife -- Unlawful transport of aquatic plants. Washington Department of Fish and Wildlife, Olympia, WA. <http://search.leg.wa.gov/pub/textsearch/ViewRoot.asp?Action=Html&Item=2&X=903123125&p=1>

Roberts, T., 2009. Standard Operating Procedure for Assessing Storm Damage for the Extensive Riparian Status and Trends Monitoring Program Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP068. www.ecy.wa.gov/programs/eap/quality.html.

Schuett-Hames, D., N. Sturhan, K. Lautz, R. McIntosh, M. Gough, and C. Rodgers, 1996. Proposal for a TFW monitoring strategy to determine the effectiveness of forest practices in protecting aquatic resources. Timber/Fish/Wildlife Rep. No. TFW-AM9-96-007. Washington State Department of Natural Resources, Olympia, WA. www.dnr.wa.gov/Publications/fp_tfw_am9_96_007.pdf.

Schuett-Hames, D., A.E. Pleus, E. Rashin and J. Matthews, 1999a. TFW Monitoring Program manual for the stream temperature survey. Timber/Fish/Wildlife Rep. No. TFW-AM9-99-005. Washington State Department of Natural Resources, Olympia, WA. www.ecy.wa.gov/pubs/99e01.pdf.

Schuett-Hames, D., A.E. Pleus, J. Ward, M. Fox, and J. Light, 1999b. TFW Monitoring Program method manual for the large woody debris survey. Timber/Fish/Wildlife Rep. No. TFW-AM9-99-004. Washington State Department of Natural Resources, Olympia, WA. www.dnr.wa.gov/Publications/fp_tfw_am9_99_004.pdf.

Skalski, J.R., 1990. A design for long-term status and trends in monitoring Journal of Environmental Management, 30: 139-144.

Topping, B.J.D, T.L. Nadeau, and M.R. Turaski, 2009. Oregon Streamflow Assessment Method Interim Version. Public Notice release date, 6 March 2009. <http://yosemite.epa.gov/R10/ecocomm.nsf/wetlands/oregonstreamflow>.

WAC 173-201A. Water Quality Standards for Surface Waters in the State of Washington WAC 173-201A. Washington State Department of Ecology, Olympia, WA.
<http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A>.

Washington State Department of Ecology, 2008. Washington State's Water Quality Assessment [303(d)]. www.ecy.wa.gov/programs/wq/303d/introduction.html.

Washington Forest Practices Board, 2001. Washington Forest Practices Rules, Board Manual, Forest Practices Act. Washington State Department of Natural Resources, Forest Practices Division, Olympia, WA.
www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx.

Werner, L., 2009. Standard Operating Procedure for Determining Canopy Closure using a Concave Spherical Densimeter – Model C for the Extensive Riparian Status and Trends Monitoring Program Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP064. www.ecy.wa.gov/programs/eap/quality.html.

Werner, L., 2009. Standard Operating Procedure for Establishing a Reach Length for the Extensive Riparian Status and Trends Monitoring Program Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP066.
www.ecy.wa.gov/programs/eap/quality.html.

Werner, L., 2009. Standard Operating Procedure for Visual Characterization of Riparian Vegetation Structure for the Extensive Riparian Status and Trends Monitoring Program Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP EAP067.
www.ecy.wa.gov/programs/eap/quality.html.

Appendix. Glossary, Acronyms, and Abbreviations

Glossary

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Accuracy: An estimate of the closeness of a measurement result to the true value.

Bias: The difference between the population mean and the true value.

Calibration: The process of establishing the relationship between the response of a measurement system and the value of the parameter being measured.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters.

Data validation: A sample-specific process that extends the evaluation of data beyond data verification to determine the analytical quality of a specific data set. It involves a detailed examination of the data package using professional judgment to determine whether the MQOs for precision, bias, and sensitivity have been met.

Data verification: Examination of the data for errors or omissions and of the QC results for compliance with acceptance criteria.

Duplicates: Two samples collected or measurements made at the same time and location, or two aliquots of the same sample prepared and analyzed in the same batch.

Federal Endangered Species Act: The 1973 Endangered Species Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend.

Measurement quality objectives (MQOs): The performance or acceptance criteria for individual data quality indicators, including precision, bias, and sensitivity.

Measurement result: A value obtained by carrying out once the procedure described in a method.

Method: A set of written instructions completely defining the procedure to be used.

Parameter: A specified characteristic of a population or sample.

Perennial: Continual existence throughout an entire year.

Population: The hypothetical set of all possible observations of the type which is being investigated.

Precision: A measure of the variability in the results of replicate measurements due to random error.

Quality assurance (QA): Adherence to a system for assuring the reliability of measurement data.

Quality assurance project plan (QA Project Plan): A document that describes the objectives of a project and the procedures necessary to acquire data that will serve those objectives.

Quality control (QC): The routine application of statistical procedures to evaluate and control the accuracy of measurement data.

Replicates: Two or more samples collected or measurements made at the same time and place.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Standard operating procedure (SOP): A document that describes in detail the approved way of performing a routine procedure.

Type F/S Water: For purposes of this report, all potentially fish-bearing perennial waters across Washington State

Type Np Water: All segments of natural waters within the bankfull width of defined channels that are perennial non-fish habitat streams. Perennial streams are flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and Abbreviations

| | |
|----------|---|
| BFW | Bankfull Width |
| CMER | Cooperative Monitoring, Evaluation and Research Committee |
| EAP | Environmental Assessment Program |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management database |
| EPA | U.S. Environmental Protection Agency |
| ERST | Extensive Riparian Status and Trends |
| F or F/S | Fish-bearing/Shoreline |
| FFR | Forest and Fish Report |
| GIS | Geographic Information System |
| LWD | Large Woody Debris |
| NIST | National Institute of Standards and Technology |
| Np | Non-fish-bearing Perennial |
| Ns | Non-fish-bearing Seasonal |
| QA/QC | Quality Assurance / Quality Control |
| RVA | Riparian Vegetation Assessment |
| SOP | Standard Operating Procedures |
| WAC | Washington Administrative Code |
| WDNR | Washington State Department of Natural Resources |
| WFPB | Washington Forest Practices Board |
| WW | Wetted Width |
| RCW | Washington Administrative Code |

Units of Measurement

| | |
|----|--------------------|
| °C | degrees centigrade |
| cm | centimeter |
| m | meter |