Quality Assurance Project Plan for

Monitoring for Adaptive Management: Status and Trends Monitoring of Aquatic and Riparian Habitats in the Lake Washington/Cedar/Sammamish Watershed (WRIA 8)

Puget Sound Watershed Management Assistance Grant under the
2009 Puget Sound Initiative

November 2010

King County

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and

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Quality Assurance Project Plan for Status and Trends Monitoring in WRIA 8

Date: 1 Dec 2010

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1.0 Background

1.1 Abstract

Monitoring is the cornerstone of adaptive management. Local governments need reliable information to gauge their effectiveness in implementing Puget Sound and salmon recovery plans. Current data are insufficient to assess overall regulatory, incentive and acquisition efforts and to inform future natural-resource planning and protection.

This project will conduct physical, biological and hydrologic monitoring in 50 stream reaches in the Lake Washington/Cedar/Sammamish Watershed (WRIA 8) to: (1) characterize watershed conditions; (2) clarify relationships between development, land and water management, and biological and physical processes in streams; (3) inform adaptive management actions.

The project will extend regional monitoring in Puget Sound to the watershed scale. Climate variability and change will be separated from management activities through linkages with EPA Sentinel Site Monitoring in Puget Sound streams.

Outputs will guide improved land-use and salmon recovery outcomes in the watershed through a robust adaptive management process.

1.2 Project Need

<u>Conservation Issues</u>: Monitoring is a key component of watershed management and is essential for adaptive management. Jurisdictions must monitor changing watershed conditions over time to determine whether or not conservation (regulation and protection) and recovery efforts (restoration) are successful. Local governments throughout Puget Sound are busy implementing a number of plans, including the Puget Sound Action Agenda, *but are not yet adequately monitoring the effects of those efforts, and communicating the results to decision-makers and land managers*. Without monitoring grounded in a scientific framework, decision-makers and recovery planners can only make ‘educated guesses’ about whether they are taking the right actions or protecting the right places.

Significant threats. The most significant threats to natural resources (including endangered salmon) in WRIA 8 are the loss of instream habitat and biological productivity in core spawning and rearing areas as well as in migratory corridors (Tier 1 areas). These threats derive from past, current, and potential future development that encroaches into important aquatic and riparian habitats throughout the watershed. Of immediate concern is ongoing urbanization in those parts of the lower watershed that lie within the UGA (Urban Growth Area) where existing development is concentrated and where future growth must be accommodated. Current data on stream conditions both within and outside the UGA are insufficient to assess the efficacy of existing regulatory, incentive and acquisition efforts and to inform future planning and protection of natural resources.

Development pressures/Prioritization of Threats: An additional 300,000 people are expected to make King County their home over the next decade. Increasing population will intensify pressures on natural resources. Local jurisdictions apply a number of regulations and incentives designed to protect resources including: critical area ordinances to protect habitat and open space; the Public Benefit Rating System tax credit for conservation on private lands; zoning for development; and transfer of development rights to cluster development. Newer techniques, such as Low Impact Development and Green Infrastructure are being tested. The goal of these strategies and techniques are to protect aquatic resources.

Accommodating growth while protecting natural resources is a key priority of King County. The success of King County's Comprehensive Plan depends upon monitoring to understand how well past efforts have succeeded and to direct future efforts to protect and restore natural resources throughout King County. This request is for funding to conduct monitoring to provide the data needed to inform managers if the assumptions in the Comprehensive Plan are correct.

Relevance to Watershed Planning Framework: Through its salmon recovery planning process, WRIA 8 is poised to move into Stage 5 (Adaptive Management) of the Watershed Planning Framework, as described by the Washington Department of Ecology. Without adequate monitoring data and testable hypotheses to inform the process, WRIA 8 will be unable to apply adaptive management principles to improve efficiency in the recovery plan. Jurisdictions need monitoring data gathered from across the watershed over a number of years to assess inter-annual variability in aquatic and riparian conditions; with these data they will be better able to determine how effective current actions are at protecting watershed resources and processes. With data sets tied to land use conditions, jurisdictions can focus their efforts on the most effective approaches to protect those resources most at risk, and focus rehabilitation efforts in the appropriate areas. This project will provide the data needed to model connections between land use and watershed resources for use in adaptive management.

Watershed Planning: Local governments in WRIA 8 have been collaborating on watershed planning for more than a decade. In 2005, the WRIA 8 Chinook Salmon Conservation Plan (King County, 2005) was ratified by 27 local jurisdictions representing more than 97% of the watershed's population. This plan is a chapter of the Puget Sound Salmon Recovery Plan, approved by the NOAA in 2007. Although focused on Chinook recovery, the Plan takes a multispecies approach to restoring the natural processes and functions of the watershed while acknowledging and accommodating current and future development and population growth.

A well-established structure exists to implement the plan, involving local jurisdictions and a collaborative Salmon Recovery Council composed of city and county elected leaders, concerned citizens, scientists, and stakeholder groups. These jurisdictions have jointly funded staff (through an Interlocal Agreement) to work on plan development, implementation, monitoring, and adaptive management. The experience and progress of King County and the WRIA 8 partners towards restoration in a complex urban environment can serve as a model for the region.

1.3 Description of the Study Area

The Lake Washington/Cedar/Sammamish Watershed, Water Resource Area 8 (WRIA 8), is the most populous watershed in Washington State, with 1.4 million people living in 692 square miles (see map, page 19). The watershed is centrally located in Puget Sound and is a vital residential and transportation corridor. Since European settlement began in the early nineteenth century, the area has grown into an important regional, national, and international trading center, and a desirable place to live. Its lower reaches are highly urbanized, but many headwater streams still support significant natural resources. The population of the watershed is projected to increase to 1.7 million by 2020.

Significant natural resources: The watershed is home to Chinook, sockeye, coho, steelhead, bull trout, kokanee, and cutthroat trout—Chinook, bull trout, and steelhead are listed as threatened under the Endangered Species Act, and a petition for kokanee protection is under review by the US Fish and Wildlife Service. Major salmon spawning areas in WRIA 8 include the mainstem of the Cedar River, and in the larger tributaries of the Sammamish basin, particularly Issaquah and Bear Creeks. The watershed also supports a variety of wildlife ranging from protected to common. The red-tailed hawk, bald eagle, great blue heron, northern goshawk, osprey, Townsend's big-eared bat, marbled murrelet, Vaux's swift, peregrine falcon, and northern spotted owl are all protected and found in WRIA 8. Elk are commonly seen in the Issaquah and Cedar River watersheds, and deer, bear and cougars are present throughout the basin. Native freshwater mussels are found in the Bear Creek and Cedar basins. There are a variety of wetland types in the watershed, including large Type I wetlands in the middle to upper portions of basins.

The watershed supplies the region with a number of important ecological services, including drinking water, tourism, recreation and the valuable sport and Tribal fisheries, including the most valuable sport fishery in the state (based upon revenue)—the Lake Washington sockeye fishery.

Watershed Characteristics: The eastern portion of the watershed, about 14% of its total area, lies in the Cascade Range and receives up to 102 inches of precipitation annually. The western portion occupies the Puget Sound Lowland, and receives an average of 38 inches of rain per year. Within the watershed, only the upper Cedar River Basin, relatively high in the Cascade Mountain Range, develops a large annual snowpack. The City of Seattle's water supply facility captures 43% of this runoff; an instream flow plan mitigates the impacts of this diversion. All other watershed streams rely primarily on groundwater to sustain baseflow in the summer and early fall.

Land use varies considerably across the watershed: 13% is classified urban/high density development, with 25% mixed urban/low density and 43% forested. The easternmost land in the Cascade Range is designated for mixed use as State or Federal parkland or private timber lands. Much of the lower/western portion of the watershed is heavily developed, and includes the Cities of Bellevue and Seattle as well as a portion of urbanized south Snohomish County (Kerwin 2001).

Streams in the lower watershed are some of the most modified in the Puget Sound Region, and suffer from the effects of urbanization and development: altered hydrologic regimes, loss of floodplain connectivity, degraded riparian conditions, and poor water quality. The shorelines of the three largest lakes in the watershed are heavily developed, with little natural shoreline remaining. Despite this, salmon and trout are commonly found in urbanized streams, some of which are migratory routes for regionally important salmon runs. In the upper watershed, where development pressures are less, water quality is high and aquatic habitat is excellent.

Efforts to protect watershed resources and processes: Over 100,000 acres in the watershed (over 22%) are protected as forested and recreational lands. More than 1,000 acres have been protected along the lower Cedar River, the highest priority salmon spawning area in the watershed. The upper two-thirds of the Cedar River watershed is protected from development within the City of Seattle's Municipal watershed and is managed for water quality protection. A number of large-scale projects to restore connectivity between the rivers and their floodplains have been conducted, or are in development, along the Cedar River, and habitat improvement projects have been completed in every major stream basin in the watershed. Local governments in the watershed actively collaborate to protect and restore its resources (see Watershed Planning, below).

The WRIA 8 Chinook Salmon Conservation Plan requires monitoring of the status and trends of Chinook salmon, to determine the success of conservation efforts. This monitoring is limited in scope and also by a lack of funding. We need a larger data set, from a range of stream types in the watershed, gathered over a number of years, to determine how effective these efforts have been so that we can focus scarce resources to guide future actions that protect the watershed as population pressures increase. In addition, we need data from multiple land use types to better understand the context and assumptions of stream condition within the watershed.

Description of the Threats or Emerging Problems

Significant threats: The most significant threats to natural resources (including endangered salmon) in WRIA 8 are the loss of instream habitat and biological productivity in core spawning and rearing areas as well as in migratory corridors (Tier 1 areas). These threats derive from past, current, and potential future development that encroaches into important aquatic and riparian habitats throughout the watershed. Of immediate concern is ongoing urbanization in those parts of the lower watershed that lie within the UGA (Urban Growth Area) where existing development is concentrated and where future growth must be accommodated. Current data on stream conditions both within and outside the UGA are insufficient to assess the efficacy of existing regulatory, incentive and acquisition efforts and to inform future planning and protection of natural resources.

Development pressures/Prioritization of Threats: An additional 300,000 people are expected to make King County their home over the next decade. Increasing population will intensify pressures on natural resources. Local jurisdictions apply a number of regulations and incentives designed to protect resources including: critical area ordinances to protect habitat and open space; the Public Benefit Rating System tax credit for conservation on private lands; zoning for development; and transfer of development rights to cluster development. Newer techniques, such as Low Impact Development and Green Infrastructure are being tested. The goal of these strategies and techniques are to protect aquatic resources.

A well-established structure exists to implement the plan, involving local jurisdictions and a collaborative Salmon Recovery Council composed of city and county elected leaders, concerned citizens, scientists, and stakeholder groups. These jurisdictions have jointly funded staff (through an Interlocal Agreement) to work on plan development, implementation, monitoring, and adaptive management. The experience and progress of King County and the WRIA 8 partners towards restoration in a complex urban environment can serve as a model for the region.

Project Need: Monitoring is a key component of watershed management and is essential for adaptive management. Jurisdictions must monitor changing watershed conditions over time to determine whether or not conservation (regulation and protection) and recovery efforts (restoration) are successful. Local governments throughout Puget Sound are busy implementing a number of plans, including the Puget Sound Action Agenda, *but are not yet adequately monitoring the effects of those efforts, and communicating the results to decision-makers and land managers*. Without monitoring grounded in a scientific framework, decision-makers and recovery planners can only make 'educated guesses' about whether they are taking the right actions or protecting the right places.

<u>Project Relevance:</u> No jurisdiction in the region, including King County, has consistent habitat and biological data over the appropriate temporal and spatial scales (e.g., individual watersheds over a decade or more) to establish normal variability over time, or to detect trends in watershed health or the ecological effects of climate change. Without these data, we make assumptions regarding the relationship between land use and water management, or impacts to physical habitat and stream biological resources; and decision-makers cannot adapt local planning and management (e.g., to protect critical areas) to avoid or minimize adverse effects of stream flow alteration (Degasperi et al. 2009). While the Washington Department of Ecology and U.S. EPA conduct monitoring programs in the Puget Sound region, the regional scope of those programs is inappropriate for making adaptive management decisions at the watershed scale.

We will develop such a data set in a watershed that covers the range of conditions typical of Puget Sound watersheds—from protected forest lands through rural, suburban, urban and industrial areas. With these data we will begin to detect trends over time and will clarify relationships between land use, hydrology, and biological conditions in streams. This information will then be communicated to the public and to decision-makers to inform and influence change where necessary. The results will be directly transferable to other watersheds in the region to improve monitoring efforts and improve our understanding of aquatic systems.

Connection with other efforts/Interrelated Projects: This project will extend a pilot "Status and Trends" monitoring project, begun in 2009 by King County with WRIA 8 funding, and link it to hydrologic analyses previously undertaken in the watershed to advance both efforts. "Status and Trends" monitoring addresses a number of the priority actions included in the WRIA 8 Chinook Salmon Conservation Plan, the Puget Sound Partnership's Action Agenda, NOAA's Adaptive Management and Monitoring for Salmon Recovery, and the Puget Sound Regional Council's Vision 2040.

Monitoring protocols are based on the *Washington Department of Ecology's Status and Trends* monitoring program (WDOE 2009). Reference sites will include locations sampled as part of *EPA Region 10's Sentinel Monitoring of Puget Sound* to separate climate induced variability and trends from those due to management activities. Since the study design and protocols use Ecology's and U.S. EPA's EMAP guidelines, data and results will feed directly into state and regional efforts.

2.0 Purpose, Goals and Objectives

The goal of this project is to provide information in a Puget Sound Watershed to inform adaptive management. The monitoring data will represent current conditions in the watershed, and provide the ability to understand the relationship between hydrological and physical conditions over time and space. This project will be the first attempt to integrate monitoring results and statistical modeling to begin adaptive management in a Puget Sound watershed. The models and other tools from this project will be exportable throughout the region and across the country.

Our current understanding of the links between land use/land cover (LU/LC), physical habitat, management actions, and watershed biota and processes is limited primarily to connections between impervious surface cover and biological integrity, as measured by the Benthic Index of Biological Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI). While these relationships are statistically significant, they are far from predictive (Morley and Karr 2002; Matzen and Berge 2008).

This study will measure changes in stream hydrology and relate those changes to the amount of impervious surface connected by conveyance networks directly to the stream. To explore these relationships we will collect data on flow, physical habitat, and biota from the same location, or from two places close together (co-locations). We will collect necessary data (flow, physical habitat, fish, and benthic invertebrate data) across a broad range of LU/LC types.

Data collected will be converted into standard biological and physical habitat metrics upon which the status and trend assessment will be based (Kaufmann et al. 1999).

In addition to a summary of yearly status and long-term trends, data and summary indicators will be analyzed to further our regional understanding of the connections between LU/LC, physical habitat, management actions, and the response of biological indicators to these factors. The ultimate goal is to develop predictive models that would be useful for ecosystem management, not just in WRIA 8 but throughout the region.

Climate Change: Hydrologic changes are generally highly variable from year to year, primarily as a result of the seasonal and yearly variability in precipitation. Since we do not have data sets extending over long periods (i.e. decades) we cannot tell for certain what role yearly variability in precipitation plays in the variability we see in other physical and biological data. We need to separate out the effect of this climate variability on streams in the watershed from the effect of management actions. This is particularly important in view of predicted climate change for this region. To address this, we will include a number of relatively undisturbed reference sites (including some from the EPA Region 10 Sentinel Monitoring Program) in the study.

3.0 Organization and Schedule

3.1 Project Staff list and roles

The project involves staff from King County Departments of Natural Resources and Parks (DNRP) with collaborators from the US Fish and Wildlife Service, US Environmental Protection Agency, and Washington Department of Ecology. Detailed roles and responsibilities are:

Core Project Team:

Hans B. Berge–DNRP - Project Manager - responsible for: (1) supervising project implementation; (2) coordinating and tracking work, budgets and personnel; and (3) preparing and presenting presentations and written reports.

Scott Stolnack–DNRP – Core Team Member – Lead team member for identifying and gaining access to sites, developing and implementing project database, liaison with WRIA 8 Salmon Recovery Council, and assisting project manager as directed in all facets of project implementation.

Curtis DeGasperi–DNRP – Core Team Member - Lead team member creating hydrological database, analyzing stream flow data, and assisting project manager as directed in all facets of project implementation.

Dan Lantz–DNRP–Core Team Member - Install and maintain streamflow gaging equipment and provide flow data, assist project manager as directed in all facets of project implementation.

Extended Project Team:

David Funke–DNRP–Supervise and assist stream gaging staff and review and approve final streamflow data product.

Seasonal Hires–DNRP–Collect habitat and fish data, and macroinvertebrate samples from all sites during the summer field season. QA/QC field data sheets and assist project manager as directed.

Cooperators:

Roger A. Tabor–US Fish and Wildlife Service–supervising and training fish collection field crew, and assisting project manager in data analysis and final report preparation.

Lil Herger–US Environmental Protection Agency–share data collected at 10 reference sites using the same protocol and collaborate with data analysis.

Glenn Merritt–Washington Department of Ecology–provides training to field crews in established protocols and coordinates with project manager on data analysis and database sharing.

3.2 Major Activities and Timelines

Table 1 outlines the major project tasks and timelines. Specific tasks are listed under headings of major tasks and each year is separated into quarters.

Table 1. Major activities and timeline.

Project Tasks	Years															
	2010		**2011**				**2012**				**2013**				**2014**	
	Q3	***Q4***	***Q1***	***Q2***	***Q3***	***Q4***	***Q1***	***Q2***	***Q3***	***Q4***	***Q1***	***Q2***	***Q3***	***Q4***	***Q1***	***Q2***
1 Project Management																
Contract Negotiation With EPA	**X**															
Development of QAPP	X	X														
Contract with USFWS and Taxonomic lab	X															
Grant Administration	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2 Field Sampling																
Identify potential sites	X	X														
Gain property access to sites	X	X						X				X				
Coordinate with EPA and DOE for Sentinel site sampling	X	X	X		X	X		X	X			X	X			
Secure sampling permits (WDFW, USFWS, NOAA)	X		X				X				X					
Install flow gauges		X	X	X												
Purchase equipment	X	X		X				X								
Hire Temporary Staff	X	X			X				X				X			
Initial literature Review for modeling work	X	X	X													
Evaluate and select appropriate sampling protocols to detect trends	X	X														
Stream sampling: aquatic and riparian habitat; fish; invertebrates at	X	X			X				X				X			
Flow Sampling at 12 gauges	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Install temperature dataloggers		X			X				X				X			
Download temperature dataloggers			X		X		X				X				X	

3 **Analysis**																
QA/QC Data	X	X	X	X	X	X	X	X	X	X	X	X	X		
Enter data into database and link with GIS	X	X			X			X	X	X			X	X	
Calculate habitat metrics		X				X				X				X	
Analyze data and explore statistical relationships		X	X			X	X	X		X	X	X		X	
Refine Fish-Index-of-Biotic-Integrity			X	X				X	X						
Create multimetric model linking hydrological and biological										X				X	
4 **Outreach**															
Outreach to watershed groups, PSP, and scientific community	X		X		X		X	X			X			X	X
Present findings of work			X					X				X		X	X
Produce Final Report													X	X	X
Prepare manuscript for peer-reviewed article												X	X	X	X

4.0 Quality Objectives

There are two types of quality objectives that need to be identified: Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs). MQOs are "'acceptance criteria' for the quality attributes measured by project data quality indicators. They are quantitative measures of performance…" (USEPA, 2002). MQOs are the targets for precision, bias, and sensitivity against which QC results are compared. Precision is assessed from the results of replicate analyses of samples and standards. Bias is assessed from blanks and check standards and compared to their expected values. Sensitivity is related to the detection and reporting limits for the measurement method used. DQOs are needed in projects where the results are compared to a standard or used to select between two alternative conditions.

Project goals rely upon sampling across areas that represent a gradient of urbanization and reference streams to assess deviation from natural conditions. MQOs will rely upon sound protocols and the use of trained staff in order to collect data in a repeatable and comparable manner in order to assess differences attributed to changes in land use or land cover. In addition, replicate samples are used to better understand how precision and bias may influence data collected by field crews. The project will establish specific MQOs over time as more quality control data have been collected to better define acceptable precision, bias, and accuracy.

4.1 Measurement Quality Objectives

Field crews are responsible for adherence to objectives and following established protocols for habitat, fish, and hydrology across all project sites on an annual basis. King County will be responsible for verifying all MQOs are met.

Precision, Accuracy and Bias

Precision is the agreement of a set of results among themselves and is a measure of the ability to reproduce a result. Accuracy is an estimate of the difference between the true value and the determined mean value. The accuracy of a result is affected by both systematic and random errors. Bias is a measure of the difference, due to a systematic factor, between an analytical result and the true value of an analyte. Precision, accuracy and bias for analytical chemistry may be evaluated by one or more of the following quality assurance/quality control (QA/QC) procedures:

- Collection and analysis of field replicate samples. Ten percent of all field sites will be sampled by both field crews (separately) to identify potential bias.; and
- Up to 5 replicate samples of macroinvertebrates will be collected annually to identify within site variance.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at the sampling point or an environmental condition. This study is designed to collect data from 50 randomly selected stream reaches across a all land use types within a watershed in the Puget Lowlands. These data will be compared with sampling data from the EPA's Sentinel Sites Monitoring Program to establish "reference" conditions and benchmarks.

Completeness

Completeness is defined as the total number of samples analyzed for which acceptable analytical data are generated, compared to the total number of samples submitted for analysis. Sampling at stations with known position coordinates in favorable conditions, along with adherence to standardized protocols will aid in providing a complete set of data for this project. The goal for completeness is 100%.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through using the same or very similar equipment and following established protocols, along with standardized data validation and reporting procedures. The equipment and protocols used in this study follow those adopted by Ecology and EPA, making the data comparable. Annual training of field data collection protocols by of all field staff will occur in Lacey, and be given by Ecology to ensure consistency across years.

5.0 Sampling Process Design (Experimental Design)

5.1 Sampling Design and Rationale:

We propose a comparative study of ecological responses to different degrees of urban development across a watershed (Table 2). Our primary assumption is that, habitat conditions, hydrology, and the diversity of aquatic organisms are influenced by urbanization. This assumption is based upon data we have collected previously (Matzen and Berge 2008; DeGasperi et al. 2009) using a known indicator of urbanization, total impervious area (TIA; Figure 1).

Table 2. Study design

Category	Current level of urbanization	Future development
Reference (n = 10*)	None to very low	Little or none
Treatment (n = 50)	Low to high	Potentially extensive

* Sites are selected from EPA's Sentinel Sites

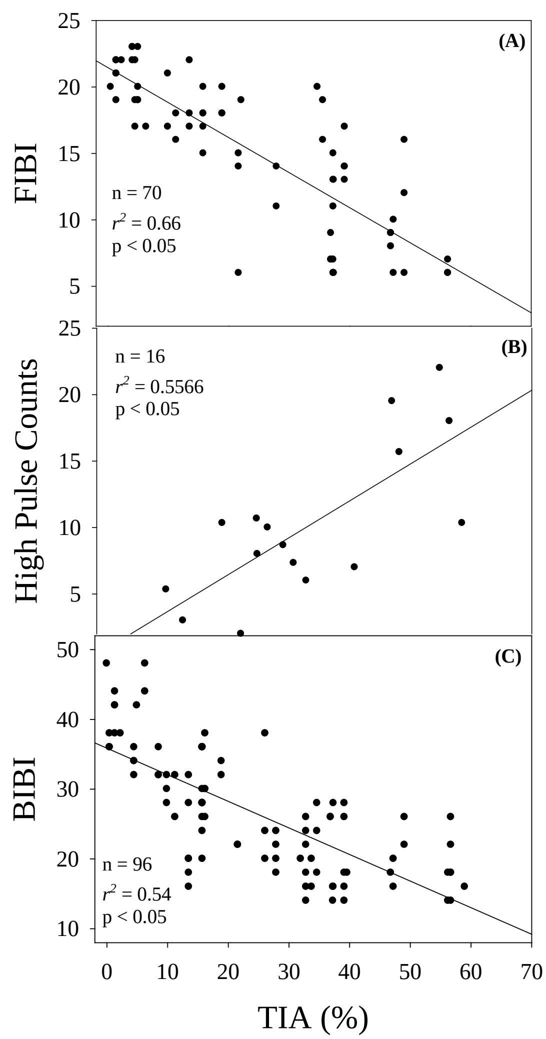

Figure 1. Biological (panels A and C) and hydrological (panel B) response to total impervious area (TIA) (modified from Matzen and Berge 2008 and DeGasperi et al. 2009).

Sampling sites were selected using a stratified random design with a database from the Washington Department of Ecology's stream database within WRIA 8 (Figure 2). An additional 10 reference sites throughout the Puget Lowlands will also be surveyed to account for regional climate trends in collaboration with Ecology and EPAs Sentinel Sites Monitoring Program.

Data collected includes important stream characteristics such as the number and depth of pools, channel width and depth, vegetative cover along the stream, aquatic species composition (vertebrates and invertebrates), and detailed profiles of a 150m reach at each site (e.g., cross-sections, thalweg profiles, pool frequency, riparian cover, etc.). Monitoring protocols are based on the *Washington Department of Ecology's Status and Trends* monitoring program. Reference sites will include locations sampled as part of *EPA Region 10's Sentinel Monitoring of Puget Sound* to separate climate induced variability and trends from those due to management activities. Since the study design and protocols use Ecology's and U.S. EPA's EMAP guidelines, data and results will feed directly into state and regional efforts.

Connection to land use: Our current understanding of the links between land use/land cover (LU/LC), physical habitat, management actions, and watershed biota and processes is limited primarily to connections between impervious surface cover and biological integrity, as measured by the Benthic Index of Biological Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) (Figure 1). While these relationships are statistically significant, they are far from predictive. This project focuses around several major hypotheses:

> H_1: If effective impervious cover influences hydrology, then urbanized streams with impervious cover connected to streams will experience higher peak flows than systems with less connected impervious area.
>
> H_2: If hydrology influences biological conditions in streams, then the BIBI and FIBI metrics will be lower in streams that exhibit flashy flows caused by more connected impervious cover.
>
> H_3: If land use type influences fluvial geomorphology, then the frequency of pools will be different in each land use type.
>
> H_4: If the salmon recovery plan in WRIA 8 is successful, then the pool frequency will increase in basins where restoration actions are prescribed.

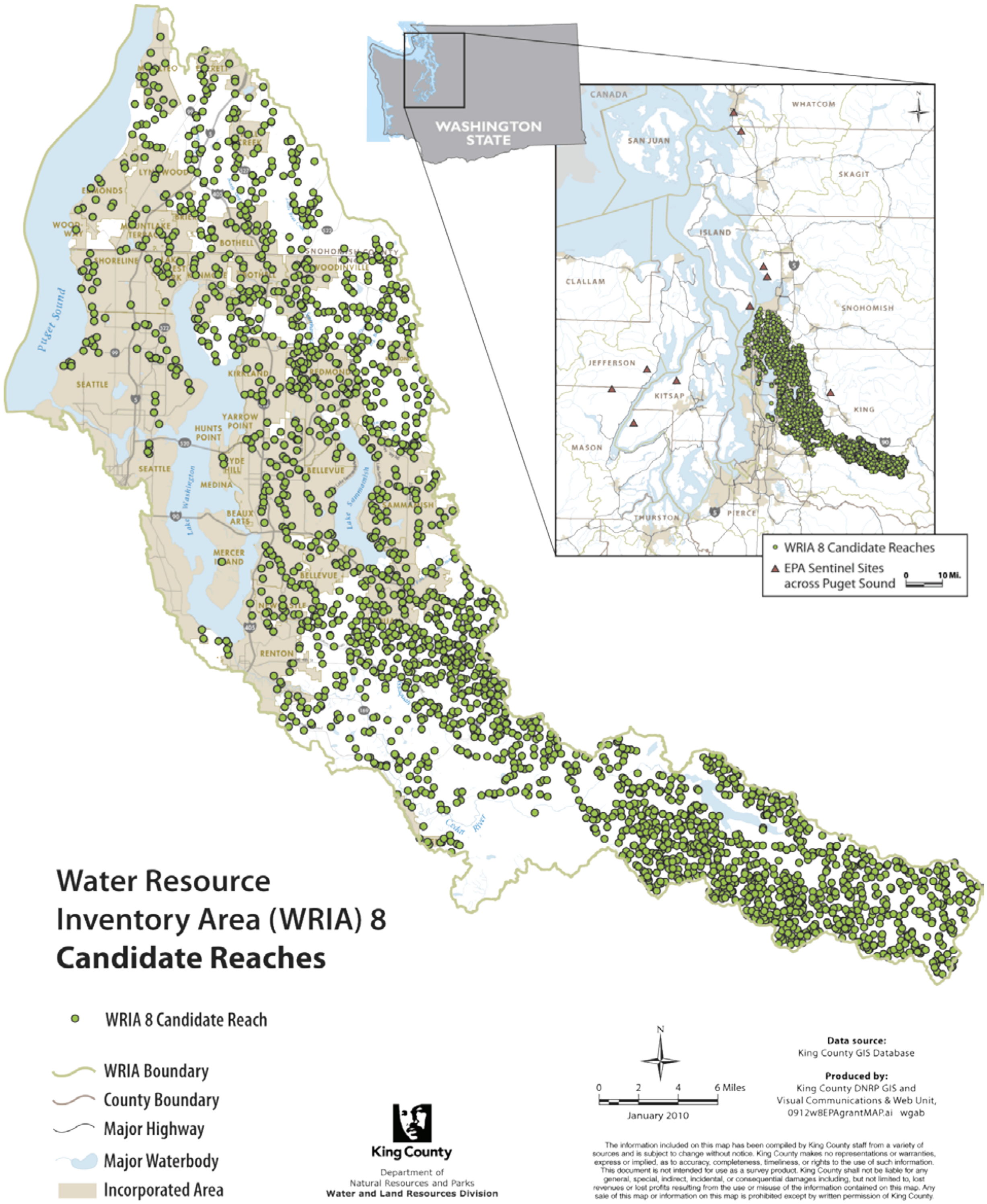

Figure 2. Candidate sample sites from Ecology's stream database in WRIA 8.

To explore these hypotheses explicitly, we will collect data on flow, physical habitat, and biota from the same location, or from two places in close proximity (co-locations). We will collect necessary data (flow, physical habitat, fish, and benthic invertebrate data) across a broad range of LU/LC types. Data collected will be converted into standard biological and physical habitat metrics upon which the status and trend assessment will be based (Kaufmann et al. 1999).

In addition to a summary of yearly status and long-term trends, data and summary indicators will be analyzed to further our regional understanding of the connections between LU/LC, physical habitat, management actions, and the response of biological indicators to these factors. The ultimate goal is to develop predictive models that would be useful for ecosystem management throughout the Puget Sound region.

Climate Change: Hydrologic changes are generally highly variable from year to year, primarily as a result of the seasonal and yearly variability in precipitation. As we do not have data sets extending over long periods (i.e. decades) we cannot tell for certain what role yearly variability in precipitation plays in the variability we see in other physical and biological data. We need to separate out the effect of this climate variability on streams in the watershed from the effect of management actions. This is particularly important in view of predicted climate change for this region. To address this, we will include a number of relatively undisturbed reference sites (including some from the EPA Region 10 Sentinel Monitoring Program) in the study.

5.2 Variables to be measured at each sampling location

The project will measure land use and land cover throughout the study reaches and, concomitantly, a suite of environmental “response” variables considered likely to change as environmental degradation of sampling sites occurs. Land cover will be classified by surface condition, ranging from forested (conifer, deciduous, mixed), non-forested (grass, scrub/shrub), bare soil, and several types and levels of development (agriculture, rural, urban). Response variables to be monitored are benthic invertebrate diversity indicators (e.g., B-IBI or similar scoring methods), Fish (FIBI), stream habitat condition (e.g., pool frequency, large woody debris density, embeddedness), and hydrology (e.g., high pulse count).

6.0 Sampling Procedures

6.1 Procedures for collecting samples

Except for where noted, sampling and measurement procedures will closely follow standard methods developed and used by King County and the Washington State Department of Ecology. Stream habitat sampling protocols are taken directly from WDOE (2009) and summarized in section 6.1.1- below.

6.1.1 Site Layout and Verification

The crew first navigates to the site using the coordinates provided by the Master Sample. They then verify that they are at the correct location and determine if the site is suitable for sampling. Next, they define the upper and lower boundaries and they define the transects within the site.

Establish the Data Collection Event

Enter the SITE_ID portion of the DCE using a number 2 pencil. Enter the Master Latitude and Master Longitude as listed on the Master Sample file. Navigate to the site using the GPS receiver. Upon arrival, record the date (MMDD) and time (military) portion of the DCE. Record the GPS-measured coordinates for the Index Station. Identify the bank at which these coordinates were measured (left and right are interpreted when facing downstream). Also note the precision of the GPS measurement. Other notes on location can also be recorded. Record the turn-by-turn directions taken to reach the site's access point.

Note: Sometimes streams have re-routed after production of the map from which the Master coordinates were generated. In these cases navigate to the closest (most representative) point onthe stream.

Determine Site Suitability

After arrival and recording the DCE, determine whether the site is suitable for sampling. Verify that conditions at the site are truly suitable for sampling during the day of arrival. Complete the appropriate fields in the top third of the front side of the *SiteVerification Form,* indicating whether the site is being sampled. The site should not be sampled if it is deemed:

Unsafe to enter

To have permission denied by land owners

Not a stream or river (e.g. a wetland, lake)

Not freshwater

Within an artificial channel (e.g. canal or ditch)

Not perennial

Not with surface flow for more than 50% of the length.

Record Event Information

Next, on the *Site Verification Form*, record the information below about the data collection event.

Crew

Record the names of those who are in the crew. Also note the organization that each staff represents. The crew lead will be recorded in column 1. Staff sampling roles can be recorded later, after the day is done, by using the check boxes provided on the form.

Site

Bankfull Stage

Near the Index Station (X), visually estimate the bankfull stage.There are at least three good on-line sources of training materials for identifying bankfull stage:

1. http://preview.tinyurl.com/8aabbm (Buffington, 2007)

2. http://www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv

http://www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv (Grizzel, 2008)

3. http://www.stream.fs.fed.us/publications/bankfull_west.html (Leopold et al, 1995)

Bankfull stage height is *not* a value that gets recorded on the *Site Verification Form*. The crew merely uses their visual estimate to help understand where to measure bankfull width.

Bankfull Width

Using the estimated bankfull level, measure the channel width at each of 5 transects near the Index Station:

1. The Index Station (X)
2. 1 bankfull width upstream from X
3. 2 bankfull widths upstream from X
4. 1 bankfull width downstream from X
5. 2 bankfull widths downstream from X

Record the average (nearest meter) of these 5 bankfull width measurements on the *Site Verification Form*. Width measurements can be made using either a 50-m tape, a measuring rod, or (if the channel is wide) with a laser rangefinder.

Site Length

Sites will be 150 m, and follows the main flow of the stream. Record the site length on the *Site Verification Form*.

Relative position of the Index Station (X) within the site

The index station (X) is normally located at the middle of the site (i.e. at major transect F). On the *Site Verification Form*, record the distance (tenths of meters) from X to the bottom of the site (i.e., to major transect A) and the distance from X to the top of the site (i.e., to major transect K). This distance is measured along the thalweg channel. Unless there is a reason to adjust the position of X, the distance will be equal to half the site length, in each direction. The relative position of X can be adjusted for reasons such as to keep the top or bottom of the site in lands where permission has not been denied, or to keep from changing Strahler stream order (at the 1:100,000 scale), or to account for barriers such as lakes.

The location of the Index Station's coordinates can never be changed. These are pre-defined by the survey design. Although the site position can change relative to X (called "sliding" the site), the site must always contain X.

Bed Form

Assess the site for its predominant reach type according to Montgomery and Buffington (1993, 1997). First decide whether the site is predominated by a reach that is colluvial, alluvial, or bedrock. Colluvial streams have a low chance of being sampled by this Status and Trends program, because we are limiting our sample to perennial streams. Bedrock streams are confined locations with little depositional material present. Most streams sampled will be alluvial. Next, if the site is predominantly alluvial, decide which one of the following subclassifications can be used to describe the site.

- cascade
- step-pool
- plane-bed
- pool-riffle
- regime
- braided

Place an X in the appropriate box of the *Site Verification Form* to describe the predominant bed form within the site.

Layout the Reach

There are 3 types of transects that define the stream site: thalweg transects, major transects and minor transects.

Thalweg Transects

Conceptually divide the stream site length using 101 transects which are perpendicular to the thalweg. These are called Thalweg Transects. They occur at regular intervals (1.5 m). Thalweg transects, except for those that are also major transects (see below), do not need to be marked. Thalweg transects are useful in concept for describing relative positions

within the site.

Major transects

Use orange flagging and a permanent marker to mark each of the 11 equidistant major transects. The lowest is *transect A0*, the highest is *transect K0*. Measure the distance between transects using either a 50-m tape or a measuring rod, by following the thalweg of the stream. The distance between flags should be 15 m (1/10th of the site length).

Minor Transects

Ten minor transects occur mid-way between the 11 major transects. The distance between major and minor transects is 7.5 m. Minor transects

don't need to be marked.

Record Coordinates

Refer to *GPS Positions Form*. Record the GPS-measured coordinates at the bottom of the site (transect A0), and at the top of the site (transect K0). Note the bank at which the GPS was used and the accuracy of the measurements.

References

Armantrout, N.B., compiler: 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, MD.

Buffington, J.M. 2007. Identifying Bankfull Elevation. Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Watershed Monitoring Workgroup meeting attachment for 1 February 2007. http://www.pnamp.org/web/Workgroups/documents.cfm?strWGShort=WM

Grizzel, J. 2008. Washington State Department of Natural Resources, Forest Practices Board. Olympia, WA. Identifying Bankfull Channel Edge (Parts 1 (1 min 52 sec) and 2 (9 min 6 sec)). http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx.

Leopold, L.B. W.W. Emmett, H.L. Silvey, and D. L. Rosgen. 1995. A Guide for Field Identification of Bankfull Stage in the Western United States. Online video (31 minutes, closed captioned). Stream Systems Technology Center USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. http://www.stream.fs.fed.us/publications/videos.html#eastandwest

Montgomery, D.R., and J.M. Buffington. 1993. Channel Classification, Prediction of Channel Response and Assessment of Channel Condition, Washington State. TFW-SH10-93-002.

http://www.krisweb.com/biblio/gen_wadnr_montgomeryetal_1993_tfwsh1093002.pdf

Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, 109(5):596-611. http://www.esm.ucsb.edu/academics/courses/235/Readings/Montgomery+Buffington%201997%20GSA.pdf

Montgomery, D.R., and J.M. Buffington, 1998, Channel processes, classification, and response, in River Ecology and Management, edited by R. Naiman and R. Bilby, Springer-Verlag, New York, NY, pp. 13-42. http://www.fs.fed.us/rm/boise/publications/watershed/rmrs_1998_montomeryr001.pdf

6.1.2 Bank Measurements at Major Transects in Waded Streams

Summary of Procedure

At each of the major Transects (A0-K0), assess the main channel. Measure these channel characters: bankfull width, wetted width, bar width, bankfull height, and bank instability. Describe flags.

Channel Dimensions

Bankfull Stage

At the transect, visually estimate the bankfull stage.

There are at least four good on-line sources of training materials for identifying bankfull stage:

1. http://preview.tinyurl.com/8aabbm (Buffington 2007)

2. http://www.dnr.wa.gov/Publications/fp_bfw_video_pt1.wmv

http://www.dnr.wa.gov/Publications/fp_bfw_video_pt2.wmv (Grizzel 2008)

3. http://www.stream.fs.fed.us/publications/bankfull_west.html (Leopold et al 1995)

4. http://www.fgmorph.com/fg_3_5.php (Endreny 2009)

Use this visual estimate to help understand where to measure *bankfull width* and *bankfull height*.

Bankfull Width

After locating the bankfull stage at each bank, measure the ***bankfull width*** to the

nearest tenth of a meter. Record this value on the *Major Transect Data Form*. Width measurements can be made using either a 50-m tape, a measuring rod, or (if the channel is wide) with a laser rangefinder.

Wetted Width

Observe the wetted margins of the channel. On the *Major Transect Data Form*, record the ***wetted width*** (or horizontal distance between these margins) to the nearest tenth of a meter. Do *not* subtract for bars.

Bar Width

Using the measuring rod, measure the width of each bar within the wetted channel. Record the sum (nearest tenth of a meter) for ***bar width***.

Bankfull Height

Bankfull height is measured using a surveyor's rod with hand level or clinometer. On the *Major Transect Form*, record bankfull height data in whole centimeters. Record the ***right***

bankfull height and ***left bankfull height***.

Bank Instability

For waded streams, evaluate how much of a 10-m length of each bank (centered on the primary transect) is unstable. Limit your observations of bank stability to the portion of the bank at and below the bankfull stage.

A bank is unstable if it has eroding or collapsing banks. It may have the following characteristics:

- sparse vegetation on a steep surface
- tension cracks
- sloughing

On the *Major Transect Form*, record ***right bank instability*** (%) and ***left bank***

instability (%).

References

Buffington, J.M. 2007. Identifying Bankfull Elevation. Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Watershed Monitoring Workgroup meeting attachment for 1 February 2007. http://www.pnamp.org/web/Workgroups/documents.cfm?strWGShort=WM

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Grizzel, J. 2008. Washington State Department of Natural Resources, Forest Practices Board. Olympia, WA. Identifying Bankfull Channel Edge (Parts 1 (1 min 52 sec) and 2 (9 min 6 sec)). http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx

Leopold, L.B. W.W. Emmett, H.L. Silvey, and D. L. Rosgen. 1995. A Guide for Field Identification of Bankfull Stage in the Western United States. Online video (31 minutes, closed captioned). Stream Systems Technology Center USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. http://www.stream.fs.fed.us/publications/videos.html#eastandwest

Small, J. and M. Witherick. 1986. *A Dictionary of Modern Geography*. Edward Arnold Publishers, Baltimore, Maryland. 233 pp. Page 88 – *DRAFT*

6.1.3 Substrate and Depth Measurements at Major Transects in Waded Streams

Summary of Procedure

Refer to the *Major Transect Data Form*. At each of the major Transects (A0-K0), assess the main channel (channel number 0). Record these characters at each of 11 equidistant stations across the bankfull width:

wetted depth

bankfull depth

substrate type code

embeddedness.

Station Location

Identify the position along the transect. Example stations along a transect would be:

1. **left bank** – at the left bankfull stage
2. **.1** – 10% distance across the channel
3. **.2** – 20% distance across the channel
4. **.3** – 30% distance across the channel
5. **.4** – 40% distance across the channel
6. **.5** – half way across the channel
7. **.6** – 60% distance across the channel
8. **.7** – 70% distance across the channel
9. **.8** – 80% distance across the channel
10. **.9** – 90% distance across the channel
11. **right bank** – at the right bankfull stage

On the Major Transect Form, insert data for depths, substrate type and embeddedness next to each station code. Describe flags.

Station Depth

For each station, record depth in whole centimeters. This should be the easiest to measure of either ***wetted depth*** or ***bankfull depth***. The bankfull depth equals the wetted depth plus average bankfull height. Therefore, if you know one type of depth and the mean bankfull height, you also know the other type of depth.

Substrate Type

After recording depth, estimate the substrate particle type at the front of the measuring rod,

where it rests on the surface of the streambed. Estimate the size class of that particle based on the intermediate axis length. Record the ***substrate type code***. For fine gravel, coarse gravel and cobble use calipers to measure the intermediate axis length of the particle and confirm your estimate of size. For larger sizes, use the measuring rod to confirm your estimate.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point.

All particles within the ring are evaluated for size and embeddedness, not just the point. Record

the estimated average for surface substrate within the ring.

CODE TYPE SIZE RANGE SIZE GUAGE

RS Bedrock (smooth) > 4 m larger than a car

RR Bedrock (rough) > 4 m larger than a car

RC Concrete/Asphalt > 4 m larger than a car

XB Large Boulder 1-4 m meter stick to car

SB Small boulder >250 mm – 1 m basketball to meter stick

CB Cobble >64 mm – 250 mm tennis ball to basketball

GC Gravel, coarse >16 mm to 64 mm marble to tennis ball

GF Gravel, fine >2 mm to 16 mm ladybug to marble

SA Sand (2-16 mm) >0.06 mm to 2 mm gritty to ladybug

FN Fines (silt/clay/muck) < 0.06 mm non gritty

HP Hardpan - hardened fines any size

WD Wood any size

OT Other (doesn't fit choices above) any size

Embeddedness

At each station, touch the nearest particle to foot of the measuring rod then look at it. Estimate ***embeddedness*** (%). This is the fraction of a particle's surface that is surrounded by (embedded in) sand or finer sediments (≤ 2 mm). By default, sand or fines are 100% embedded. By default, bedrock is 0% embedded.

Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

References

Bain, M.B. 1999. Substrate. Pages 95 to 103 *in* M.B. Bain and N.J. Stevenson, editors. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Harrelson, C.C, C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p. http://www.fs.fed.us/rm/pubs_rm/rm_gtr245.pdf Page 94 – *DRAFT*

6.1.4 Shade Measurements at Major Transects in Waded Streams

Summary of Procedure

Refer to the *Major Transect Form*. At each of the major Transects (A0-K0), assess the main channel (channel number 0). Use a convex densiometer (Lemmon, 1957) that has been modified according to Mulvey *et al* (1992); it has 17 intersections.

Record how many of the 17 cross-hairs have shade over them. Do this for each of six directions on the major transect (Figure J-3):

Facing the left bankfull stage

Facing the right bankfull stage

Bankfull channel center, facing upstream

Bankfull channel center, facing right

Bankfull channel center, facing downstream

Bankfull channel center, facing left

At each wetted station, hold the densiometer 30 cm above the water. At each dry station, hold the densiometer 30 cm above the ground. Bank readings should be able to detect shade from riparian understory vegetation such as ferns.

References

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Lemmon, P.E. 1957. A New Instrument for Measuring Forest Overstory Density. Journal of Forestry. 55(9):667-668.

Mulvey, M, L. Caton, and R. Hafele. 1992. Oregon Nonpoint Source Monitoring Protocols and Stream Bioassessment Field Manual for Macroinvertebrates and Habitat Assessment, Draft. Oregon Department of Environmental Quality, Portland, Oregon. Page 98 – *DRAFT*

6.1.5 Estimating Fish Cover at Major Transects in Waded Streams

Summary of Procedure

This method is derived from that of Peck *et al.* (2006). Within the main channel, evaluate 11 plots with these characteristics: Centered at each major transect Extends 5 meters upstream of each transect Extends 5 meters downstream of each transect Beneath the wetted surface Visually assess the percentage of the water surface that has fish cover provided by each of 10 cover types. Refer to the *Major Transect Form*. Circle the cover code that best characterizes each cover type.

References

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf Page 102 – *DRAFT*

6.1.6 Human Influence at Major Transects in Waded Streams

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007). Refer to the *Major Transect Data Form*. At each of the major Transects (A0-K0), assess the main channel. Record the appropriate ***influence proximity code*** for each of 13 human ***influence types*** relative to riparian plots on each bank of the transect. Influence proximity codes are:

0 = absent

1 = beyond the plot, but within 30 meters of the bankfull margin.

2 = within the 10 meter by 10 m riparian plot.

3 = at least partially within the bankfull channel.

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocolsfieldmanualdraft070615.pdf

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

6.1.7 Riparian Vegetation Structure at Major Transects in Waded Streams

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007). Refer to the *Major Transect Data Form*. On each major transect of the main channel, assess a plot on each bank. Each plot extends 5 meters downstream, 5 meters upstream, and 10 meters back from the bankfull margin. The riparian plot dimensions can be estimated rather than measured. On steeply sloping channel margins, plot boundaries are defined as if they were projected down from an aerial view. Conceptually divide the riparian vegetation into three layers:

Canopy (> 5 m high),

Understory (0.5 to 5 m high),

Ground Cover layer (< 0.5 m high).

Within each layer, consider the type of vegetation present and the amount of cover provided. Do this independently of what is contained in higher layers. Cover quantity is coded on the field form as follows:

0 - absent

1- sparse (< 10% cover)

2 - moderate (10-40% cover)

3 - heavy (40-75% cover)

4 – very heavy (> 75% cover)

The maximum cover in each layer is 100%, so the sum of the cover for the combined three layers could add up to 300%.

Canopy

On the *Major Transect Form*, circle the appropriate vegetation **type code** (D, C, E,

M, or N). Type codes are defined on the form. Then circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 2 classes:

Big trees – trees having trunks larger than 0.3 m diameter (at breast height)

Small trees– trees having trunks smaller than 0.3 m diameter (at breast height)

Understory

On the *Major Transect Form*, circle the appropriate vegetation **type code** (D, C, E,M, or N) for any *woody* vegetation that might be present. Then circle the appropriate cover

quantity code (0, 1, 2, 3, or 4) for each of 2 classes:

Woody vegetation - such as shrubs or saplings

Non-woody vegetation - such as herbs, grasses, or forbs

Ground Cover

Circle the appropriate cover **quantity code** (0, 1, 2, 3, or 4) for each of 3 classes:

Woody (living)

Non-woody (living)

Bare dirt (or decomposing debris)

The sum of cover quantity ranges for these 3 types of ground cover should include 100%.

References

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitat-protocolsfieldmanualdraft070615.pdf

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency,

Washington, D.C.
http://www.epa.gov/wed/pages/publications/authored/EPA620R06003EMAPSWField-OperationsManualPeck.pdf

6.1.8 Measuring Thalweg Depth in Waded Streams

Summary of Procedure

This procedure is derived from Peck et al. (2006) and Moberg (2007).

Refer to the *Thalweg Data Form*.

A portion of the *Thalweg Data Form*, with example data. While walking up the main channel, measure thalweg depth (cm) at each of 101 thalweg transects. To reference location:

Record the letter code for the lowest major transect referenced (e.g. A). Record depth and occurrence data into the appropriate thalweg transect row (e.g. .0). These thalweg stations are located 0.2 bankfull widths apart from each other; bankfull width is based on an estimate made during the site layout. While measuring thalweg depth, also evaluate whether each of these features is present at each thalweg transect:

- bar
- edge pool
- Circle “Y” for “yes” and “N” for “no”.

References

Armantrout, N. B., Compiler. 1998. Glossary of Aquatic Habitat Inventory Terminology. American Fisheries Society, Bethesda, Maryland

Endreny, T.A. 2009. *Fluvial Geomorphology Modules*, State University of New York College of Environmental Science and Forestry, National Oceanic and Atmospheric Administration, and the University Corporation for Atmospheric Research. www.fgmorph.com

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration’s Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocols-fieldmanualdraft070615.pdf

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Streamnet, 2002. Public Education Glossary of Habitat Related Terms. Last Updated March 5, 2002 http://www.streamnet.org/pub-ed/ff/Glossary/glossaryhabitat.html

6.1.9 Large Woody Debris Tally for Waded Streams of Western Washington

Summary of Procedure

This procedure is derived from Peck et al (2006) and Moberg (2007). One person, while walking upstream, counts the number of pieces of large woody debris (LWD), that are (at least partially) within the bankfull channel of each stream segment (e.g. A0 to B0) in the main channel. Pieces are tallied according to 12 size classes (4 diameter classes for each of 3 length classes).

Size Classes

Diameter:

Diameter 1: 10 to 30 cm

Diameter 2: > 30 to 60 cm

Diameter 3: > 60 to 80 cm

Diameter 4: > 80 cm

Length:

Length 1: 2 to 5 m

Length 2: > 5 to 15 m

Length 3: > 15 m

Considering taper

Wood pieces have a taper. The diameter of a log is based on the thickest end. The length of a log only counts the portion that has a diameter of more than 10 cm.

Record

Refer to the *Thalweg Data Form*. Identify and tally LWD pieces that lie in the bankfull channel. After tallying, sum the marks separately for each size class and enter the number into the corresponding box for each class.

References

Moberg, J. 2007. A field manual for the habitat protocols of the Upper Columbia Monitoring Strategy. Prepared for and funded by Bonneville Power Administration's Integrated Status and Effectiveness Monitoring Program. Terraqua, Inc. Wauconda, WA http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/docs/isemphabitatprotocols-fieldmanualdraft070615.pdf

Peck, D.V., Herlihy, A.T., Hill, B.H., Hughes, R.M., Kaufmann, P.R., Klemm, D.J., Lazorchak, J.M., McCormick, F.H., Peterson, S.A., Ringold, P.L., Magee, T., and Cappaert, M.R. 2006. Environmental Monitoring and Assessment Program-Surface Waters, Western Pilot Study, Field Operations Manual for Wadeable Streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C. http://www.epa.gov/wed/pages/publications/authored/EPA620R-06003EMAPSWFieldOperationsManualPeck.pdf

6.1.10 Habitat Unit Descriptions Along the Main Channel Thalweg

Summary of Procedure

This procedure is derived from Moberg (2007). Refer to the *Thalweg Data Form*. Identify and code habitat units consecutively during the walk upstream. A separate Thalweg Data Form is recorded for sets of observations that span between major transects. Data will include: type code, unit identity (number), pool forming code, and depths (for pools).

Type Code

With each step up the thalweg, evaluate the wetted channel for conformity to the Hawkins *et al.* (1993). We are focusing on Level II designations. The main division is between slow water (pools) and fast water (e.g., cascades, riffles, or runs). All habitat units (except plunge pools or dry channels) must be at least as long as half the wetted width. All pools have specific depth criteria: the maximum depth must be at least 1.5 times the depth at the pool crest. Record the unit type code (Table U-2) on the *Thalweg Data Form*

Unit Type Description

FT Fast Turbulent (riffle, cascade, waterfall)

FN Fast Non-Turbulent (sheet, run)

PS Scour pool

PD Dammed pool

PP Plunge pool

DC Dry channel

Unit Number

After you designate the habitat unit type, assign a habitat unit number. These are consecutive number counts for the whole stream site. For each form, record data for any new habitat units that appear since the last encountered major transect. For example, if habitat units numbered 1, 2, and 3 were recorded between major transects A and B, then new units encountered between B and C would begin with habitat unit number 4.

Pool Forming Code

On the *Thalweg Data Form*, record the pool forming code to describe the obstruction that led to pool formation. Assign “N” for habitat units other than pools. If pool formation could be associated with two types (e.g boulder *and* large wood), use both columns on the form, with one code per column.

Pool Forming Code Description

N Not a pool

W Large Woody Debris

R Rootwad

B Boulder/Bedrock

F Fluvial (non-specific stream process)

Habitat Unit Width

Estimate the average wetted width (nearest tenth of a meter) of the habitat unit for the full course of its length. Record this value on the *Thalweg Data Form*. A measurement is not required. Just consider the relative width compared to the width measurements performed at nearby major transects and minor transects.

Pool Depths

With a measuring rod, measure water depth (cm) in each of two locations in the thalweg of pools: at the crest at maximum depth.

Crest depth is measured differently, depending upon the pool type. For scour pools and plunge pools, the crest depth is measured where water exits the pool. For dammed pools, the crest depth is measured where water enters the pool. Record crest depth and maximum depth on the *Thalweg Data Form* (Figure P-2). No data need to be recorded for non-pool habitat units.

Position

After identifying and describing habitat units, record the position of each habitat unit relative to thalweg stations.

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6.1.11 Side-Channel Descriptions

Summary of Procedure

This procedure is derived from Moberg (2007). Refer to the *Thalweg Data Form*. Identify and count side channels occurring within the length of the sample site. Estimate their widths.

Identify and count

Identify and code side channels consecutively for the entire streams site. Number them as encountered while walking upstream. Note their presence for each of the 101 Thalweg Transects of the stream site. This will require 11 *Thalweg Data Forms* to complete (A-K).

Estimate Width

For each channel, estimate wetted width (nearest tenth of a meter). Make at least one representative measurement (in a notebook) between each major transect then visually estimate an average value for the length of the side-channel. Record this channel average on the *Thalweg Data Form*. In your width estimate, do *not* include portions of the channel that occur below transect A0 or above transect K0.

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6.1.12 Width and Substrate Measurements at Minor Transects in Waded Streams

Summary of Procedure

Measure the channel width and then make observations about substrate size at 11 equidistant stations across the minor transect.

Widths

At each minor transect, measure distance (tenth of meters) for: bankfull width wetted width total bar width (sum for all bars). Record these widths on the *Thalweg Data Form:*

Station Location

Identify the ***Transect Station LeftRight***. Example stations for minor transect A5 would be:

12. **A500** – at the left bankfull stage
13. **A501** – 10% distance across the channel
14. **A502** – 20% distance across the channel
15. **A503** – 30% distance across the channel
16. **A504** – 40% distance across the channel
17. **A505** – half way across the channel
18. **A506** – 60% distance across the channel
19. **A507** – 70% distance across the channel
20. **A508** – 80% distance across the channel
21. **A509** – 90% distance across the channel
22. **A510** – at the right bankfull stage

Substrate Type

Hold the measuring rod vertically and rest it on the substrate at each station. Estimate the substrate particle type at the front of the measuring rod, where it rests on the surface of the streambed. Estimate the size class of that particle based on the intermediate axis length. Record the ***substrate type code*** (Table R-1) on the Thalweg Data Form (Figure R-2) for each station. For coarse gravel and cobble, use calipers to measure the intermediate axis length of the particle and confirm your estimate of size. For larger sizes, use the measuring rod to confirm your estimate. Particles smaller than 100 mm are evaluated using a 10 cm ring surrounding the sample point. All particles within the ring are evaluated for size and embeddedness, not just the point. Record the estimated average for surface substrate within the ring.

CODE TYPE SIZE RANGE SIZE GUAGE

RS Bedrock (smooth) > 4 m larger than a car

RR Bedrock (rough) > 4 m larger than a car

RC Concrete/Asphalt > 4 m larger than a car

XB Large Boulder 1-4 m meter stick to car

SB Small boulder >250 mm – 1 m basketball to meter stick

CB Cobble >64 mm – 250 mm tennis ball to basketball

GC Gravel, coarse >16 mm to 64 mm marble to tennis ball

GF Gravel, fine >2 mm to 16 mm ladybug to marble

SA Sand (2-16 mm) >0.06 mm to 2 mm gritty to ladybug

FN Fines (silt/clay/muck) < 0.06 mm non gritty

HP Hardpan - hardened fines any size

WD Wood any size

OT Other (doesn’t fit choices above) any size

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6.1.13 Measuring Slope and Bearing in Wadeable Streams

Summary of Procedure

A two-person crew performs this procedure incrementally, once for each of at least 20 segments of the main channel for the entire site. Segments evaluated are normally between major and minor transects (e.g A5-A0), but intermediate measurements may be used if necessary (e.g. due to thick vegetation or sharp bends in the channel). There should be no space between segments and no overlap of segments. The crew can either work moving up the stream or down, depending on efficiency of overall work flow. We will describe the technique for working from the top of the stream, downward. This method is based on modifications of Peck et al (2006) and Moberg (2007).

Slope

The *sighter* stands at the water's edge of a transect at a higher elevation. This person will sight downstream toward a measuring rod at a lower transect. Use a monopod to rest the hand level at a fixed eye height. The *rodder* holds the measuring rod vertically, with its base at the surface of the water. The *rodder* can assist by pointing to the numbers on rod and adjusting up or down as directed by the *sighter.* Record these things on the Slope and bearing Form:

Identity of transect where the *sighter* stands

Identity of transect where the *rodder* stands

Eye height (cm)

Level Height (cm)

Note: Sometimes it is easier to sight in the wetted channel rather than the edge, to avoid vegetation. If the monopod or measuring rod rest below the surface of the water, subtract that depth from the eye height or level height.

Bearing

The *sighter* stands at a transect at a higher elevation. This person will sight downstream toward the *rodder* at a lower transect. The *sighter* will then point the compass toward the *rodder* and parallel to the thalweg. On the Slope and Bearing Form, record the bearing (magnetic north) of the thalweg between the top and bottom of the segment. NOTE: If sighting from bottom to top, record the bearing south.

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6.1.14 Sampling the Vertebrate Assemblage in Wadeable Streams

Summary of Procedure

To preserve sample integrity, vertebrate sampling is conducted after sampling for chemistry and invertebrates. The crew first prepares their fishing equipment to best suit the stream conditions and minimize fish injuries. They then walk up through the stream site to perform a single-pass electrofishing sample. Peck et al (2006) and AREMP (2006) served as a basis for much of this method.

Pre-sampling Preparations

Carefully read the sampling permits and NOAA (2000) guidance to determine special requirements. The Scientific Collection Permit from the Washington State Department of Fish and Wildlife is likely to stipulate persons to be contacted prior to each sampling event (e.g. regional biologists). It is also likely to include restrictions from sampling in warm water. The crew members should each be trained in both electrofishing roles. Practice sessions should be performed prior to sampling, at a location external to the range of threatened or endangered species.

Absence of spawning fish

Prior to sampling verify that there are no salmonids present in spawning condition. Pre-season research on the timing of runs can help. During the site layout the crew should also perform a visual confirmation.

Electrofisher Log

Complete an electrofisher log to determine that the instrument settings will maximize capture efficiency and minimize harm to aquatic vertebrates. The electrofisher log will also help to keep track of settings that work well for each type of stream. Try low intensity settings to start, and increase intensity as needed to find a response. Try to stay below 60 Hz, 35% duty cycle and 600 V settings, although at times these might be required. The United States Department of Interior (Brenkman and Connelly, 2008; Connelly and Brenkman, 2008) uses settings of 60 Hz and 400–600 v where this is necessary to find an effective response in National Parks of the Northwest.

Water temperature

Prior to electrofishing, measure and record water temperature (˚C). Check permit restrictions to see if fishing can proceed.

Ambient conductivity

Prior to electrofishing, measure specific conductivity (i.e., the value recorded in $\mu S \cdot cm^{-1}$ at 25˚ C during *in situ* chemistry sampling). Record this on the electrofisher log, to the left of the value for the observed water temperature. Convert this into an estimated ambient conductivity value ($\mu S \cdot cm^{-}$), by dividing the specific conductivity by the "denominator" (D) value in the column to the right of water temperature.

Testing

Test the operation of the electrofisher while situated well downstream from the bottom of the sample site (Transect A0). Evaluate settings to ensure that the audio and light signals are emitting at a standard pace. Also check to see that fish are attracted to the anode with the least possible application of electrical intensity. When ambient conductivity is approximately 100 $\mu S \cdot cm^{-1}$ (about the same as fish flesh), little power is required to effectively fish. For lower conductivity water, higher voltage will be needed. For higher conductivity water, more current will be needed. Details on set-up and testing can be found in Smith-Root (2007). If captured fish demonstrate signs of injury, lower the settings.

Vertebrate Assemblage Sampling

The crew wades upstream sampling all available habitats equally, spending no more than about 20 minutes in each segment (or 3.5 hours total). One person operates the electrofisher while another nets the vertebrates. Vertebrates collected in slow and fast water habitats are kept separate.

Electrofisher Operation

Operate the electrofisher according to manufacturer's instructions (e.g. Smith-Root 2007). At the bottom of the site (transect A0), reset the timer. Tell all staff nearby that you are ready to begin electrofishing. Before you start, they should acknowledge to you that they understand and that they are ready. Then start. Sampling is complete when reaching the top of a habitat unit that is nearest to transect K0. Tell the data recorder the following information:

- *on-button* time (seconds) in the display
- clock time (minutes) elapsed during sampling
- distance (m) travelled up the length of the stream

Netting

If working in open sunlight, netting must be performed while wearing polarized sun glasses and a brimmed cap. The netter captures vertebrates that move toward the anode. They then place the animals into a bucket (live-well) of fresh stream water. Specimens can be protected from harm by carefully performing these duties:

- Net the fish away from the electrodes
- Do *not* net fish unless your net is empty
- Minimize animals' exposure to air and sunlight
- Pass specimens off for processing quickly
- Do not crowd the live-well
- Keep fresh water in the live well

Processing the Sample

Processing includes data recording. The person processing receives animals from the netter and then completes the Vertebrate Collection Form. Representative photographs should be taken of each *species-life stage*. After processing, in most cases, live animals are released in quiet water at a location well below samplers. A few select hard-to-identify fish specimens (e.g., lampreys, sculpins, or dace) may be retained for later identification in a laboratory or by a professional taxonomist. Be sure to examine all animals for electrofishing-induced injuries. If you observe injury (e.g., bruising or branding), tell the electrofisher operator to adjust the settings accordingly.

Header Information

Begin recording data by completing header information on the Vertebrate Collection Form. This includes temperature and conductivity data (from the electrofisher log) and your opinion on water visibility (clarity). When sampling is done, record on-button time (seconds), *fishing+processing* time (minutes), and sample distance (m) along the thalweg.

Count and Presence

1) Identify specimens to species using taxonomic keys, e.g.

a. Corkran and Thoms (1996)

b. Jones *et al* (2005)

c. Leonard *et al* (1993)

d. Page and Burr (1991)

e. Pollard *et al* (1997)

f. Stebbins (2003)

g. Wydoski and Whitney (2003).

2) Each new life stage (juvenile or adult) per species encountered is assigned a sequential Tag Number. For each tag number, record the designated **common name**. Check "J" for juvenile or "A" for adult.

3) Record a tally mark for each new observation per *species-life stage*. Sum these to complete the "Total Count" column when sampling is complete.

4) Fill in the circle for each segment where a member of a *species-life stage* is observed.

5) Keep track of how many animals die during collection and processing. Record totals in the "Mortality" column of the form.

6) Count the number of animals in each species-life-stage that are retained for later taxonomic analysis. These totals are recorded in the "Voucher Count" column.

7) Make a note (using the flag and comments fields) of any abnormalities observed on animals. This includes deformities, lesions, tumors, fin erosion, or other notable features.

Animal Lengths

Record the minimum and maximum length (mm) of each *species-life stage* for the DCE. Measure the total length for every *species-life stage*, except for adult frogs. These are measured from snout to vent. Do not measure all individuals, only those that are smaller or larger than those already observed.

Voucher specimens

Voucher specimens will be obtained for all species captured, to verify field identifications. In the large majority of cases the voucher will consist of photographs from representative specimens using guidelines of Stauffer *et al* (2001) and AREMP (2007). Record an audio tag to each photograph with a description of each specimen, location, and date. Try to capture the relevant features that distinguish species. For example, for suckers, not only capture a lateral view, but also try to capture a ventral image of the head and jaw. In a few cases, hard-to-photograph specimens (e.g. small individuals) of fishes may be preserved in a labeled polyethylene jar. Fill each jar with ethanol by diluting a 95% stock solution (2:1) in water including the fish (Bean, 1882). After a day or two, replace this with a stronger ethanol solution (3:1of ethanol to water). This should preserve the fish for a few months for more close examination in the laboratory. Complete 2 tags on Write-In-Rain paper. Insert one inside the jar; tape the other to the outside. Keep species separated.

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6.1.2 Benthic Invertebrates

Summary of Procedure

Invertebrate sampling is one of the first methods to be performed on-site, after site verification and layout. It starts concurrently with water sampling, with initial components of the benthos sample collected downstream of the water sample. One Surber sample (1 ft^2) is collected at each of 8 transects and added to the composite sample for the site. This method is taken from Hayslip (2007) with some details provided by Peck et al (2006).

Choose transects

Randomly choose 8 transect stations out of these 11:

A0

B0

C0

D0

E0

F0

G0

H0

I0

J0

K0

Identify sampling stations

Start at the lowest transect and work upstream. At each transect, visually estimate the distance

from left to right where the stream bottom will be sampled. Half the stations are in mid-channel. Half are in margins. If the water is too deep to sample at any station, collect the

sample from the nearest feasible location. The surber normally allows sampling up to about 50

cm depths.

Surber Stations

Distance across wetted channel

(left to right)

1st 25%

2nd 50%

3rd 75%

4th 50%

5th 25%

6th 50%

7th 75%

8th 50%

Once the Surber station is determined, place the net opening into the face of flow. Position the net quickly and securely on the stream bottom to eliminate gaps under the frame. Collect benthic macroinvertebrates from a 1ft² (0.9 m²) quadrat located directly in front of the frame mouth. Work from the upstream edge of the quadrat backward and carefully pick up and rub stones directly in front of the net to remove attached animals. Quickly inspect each stone to make sure you have dislodged everything and then set it aside. If a rock is lodged in the stream bottom, rub it a few times concentrating on any cracks or indentations. After removing all large stones, keeping the sampler securely in position, starting at the upstream end of the quadrat, stire the top 4 to 5 cm of the remaining finer substrate within the quadrat for 30 seconds using a garden spade. Pull the net up out of the water. Immerse the net in the stream several times or splash the outside of the net with stream water to remove fine sediments and to concentrate organisms at the end of the net. After completing the sample, hold the net vertically and rinse material to the bottom of the net.

After taking a sample, examine the contents of the net. Pick out coarse rocks and sticks. Closely examine them for clinging organisms; pick these animals off of the debris and place them into the sample jar. Discard the debris and empty the net's remaining contents into the sample jar. Add enough ethanol to the sample jar so that the resulting solution consists of 1/3 sample and 2/3 ethanol (by volume). Add benthos label to the inside of the jar and place a label on the outside of the jar. Cover the label on the outside of the jar with clear tape. The label should include the DCE, which includes the Site_ID, and site arrival time (year, month, day, hour, and minute). It should match the DCE recorded on the Site Verification Form. Be sure to note which transects were sampled.

Laboratory Analysis

Upon arrival at the taxonomic laboratory, each sample will be assigned a unique internal tracking number that will be based on the DCE, and that number will remain with the sample permanently.

A Caton gridded tray will be used to subsample at least 525 organisms from each sample. Using this subsampling procedure, each sample will be distributed evenly across a 30-square wire-mesh tray. Individual squares to be selected will be done at random and the contents removed and placed into a Petri dish. Macroinvertebrates will be removed from the sample material under a dissecting microscope. This process will be repeated until a minimum count of 525 is achieved. The remainder of the sample (the unsorted fraction) will then inspected for large or rare taxa that are not encountered during the subsampling procedure; these "large/rare" taxa will be recorded on the laboratory bench sheet as such and placed in separate vials. The following products will result from the sample sorting procedure:

1) 525-550 macroinvertebrates sorted into a series of small vials by order, class, and/or phylum.

2) A separate vial containing organisms found during the large-rare search

3) Sorted residue – material from which the 525organisms were sorted.

4) Unsorted fraction – portion of the original sample that was not sorted.

QA/QC will be done on the unsorted fraction to determine whether macroinvertebrate sorts were attaining 95% efficacy. Sorted residues will be saved until quality control results are reviewed and approved. All identification work will follow taxonomic standards established by the Northwest Biological Assessment Workgroup and Jeff Adams of the Xerces Society. Taxonomic literature sources used to aid in the identification of project specimens are found below.

Following identification, all raw data will be entered into Excel spreadsheets and crosschecked against paper copies of the data for errors and omissions before the data are analyzed. Electronic data will be checked for outliers and other errors using summary statistics and graphic

analyses. Following QA/QC, data will be uploaded into the regional macroinvertebrate database for subsequent analysis (http://pugetsoundstreambenthos.org).

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6.2 Streamflow

We will use a SOP for continuous measurement of discharge developed by King County to meet NPDES monitoring requirements. (**http://green.kingcounty.gov/wlr/waterres/hydrology/-NPDES-SOP.doc**). The methods closely flow guidance provided by WDOE (Butkus 2005; **http://www.ecy.wa.gov/pubs/0503204.pdf**).

This SOP applies to the collection of continuous discharge data at monitoring sites on streams, stormwater conveyance systems and BMPs. It describes equipment and site selection factors, installation, operation, and field measurement techniques. A continuous flow monitoring station is commonly called a stream gage or gaging station.

The NPDES municipal stormwater permit calls for permittees to develop and implement a comprehensive long term water quality monitoring program. The monitoring program has two elements: stormwater and receiving water monitoring, and BMP effectiveness monitoring. Both elements require the production of continuous records of discharge in the stream channel, stormwater conveyance system, or BMP. The equipment and methods used must enable the collection of flow-weighted composite storm samples, base flow samples, and the production of a time series data set of flow rate. From the flow data set flow durations and volumes can be calculated and hydrographs produced.

Each monitoring site will have individual characteristics that require a specific configuration of equipment and installation that best enables the collection of accurate flow data. A successful location for continuous flow monitoring features stable hydraulics and either a convenient place to directly measure discharge or the ability to install a primary flow measuring device such as a flume or weir.

Continuous flow monitoring generally involves using electronic equipment to measure and record water level in a stream or other conveyance. A programmable data logger operates a water level sensor and records measured values at time increments. The data logger may process the measured values and signal other devices. A relationship between the water surface elevation and the flow rate (stage-discharge relationship) is developed using various generally accepted techniques. The stage-discharge relationship represents the sum of the various forces that make water move or resist movement, primarily gravity and channel friction. It is expressed as an array or a mathematical function. Continuous streamflow is calculated by using the stage-discharge relationship to match a specific water level with a corresponding rate of flow. In certain situations, equipment that measures water velocity as well as water level can be used to determine flow rate. The automatically calculated flow rate may be adequate for producing flow weighted composite samples, but post processing is usually necessary to produce an accurate flow record and may involve using velocity as an index of flow.

The procedures and tasks involved with a stream gage are designed to accurately measure and record water level and determine the stage-discharge relationship at the site.

6.3 Procedure for assessing land cover and land use

Changes in land cover and land use will be assessed using digitized versions of orthophotographs. Photographs are currently available for the following years: 1996, 1998, 2000, 2002, 2005, 2007, and 2010 (note: a series of 1936 photos is also available but only for a limited number of the study catchments). Resolution ranges from 3.0 foot pixels (nine square feet in area) for 1995 and 1998 photos to 0.5 feet – for study catchment areas – for the 2007 and 2010 photos. New orthophotos with resolution similar to 2010 photos are planned for 2012. Starting with the 2000 series, and earlier if time permits, these photos will be used to create digitized land cover and land use classifications including forest cover (conifer, deciduous and mixed, clear-cut and re-growing), scrub/shrub, grass, pastures, tilled fields, pavement, rooftop, bare soil, and water. Additional classes may be added as needed.

7.0 Measurement procedures

7.1 Streamflow Gages

Gages are maintained and calibrated periodically, especially following major flow events, by King County gaging technicians using SOPs described in **http://green.kingcounty.gov/wlr/waterres/hydrology/-NPDES-SOP.doc**.

7.2 Land Cover and Land Use

Orthophotos (see section 6.3) will be digitized using "heads-up" digitizing methodology, in which a person visually identifies and delineates objects directly from photos onto a digitizing pad. Orthophoto visual interpretations require consistent scale of projection and clear and consistent application of criteria for identification of an object or patch.

8.0 Quality Assurance and Control

Quality assurance and control will be provided by project manager oversight, project staff training, and adherence to a combination of laboratory and field procedures.

For streamflow, trained and qualified gaging technicians will install, maintain, and extract data from gages. Gaging technicians will maintain and calibrate according to procedures to provide high quality data and gaging technicians or project staff will periodically (about every two weeks at minimum) visit the gage site to ensure proper working condition. All data are reviewed, rated for accuracy, and approved by a County gaging supervisor before being submitted as a final product.

For stream habitat surveys, only trained individuals will participate in the surveys. Each survey crew will have a crew leader that has at least one year's worth of experience in all sampling protocols. Each survey crew will have one member that is certified in operation of electrofishing equipment. In addition, replicate samples will be collected from five randomly selected sampling sites to identify any sampling bias between survey crews.

For benthic invertebrates, a series of measures will be used for quality assurance and control. First, all samplers will be trained in established sampling protocol. Second, a core project team member will accompany and assist in all sampling to ensure consistent and common application of protocol. Third, to reduce the chance of organisms being lost during sampling all rocks and nets will be thoroughly examined before being discarded or stored. Fourth, three replicates will be collected from sites at random to better understand within site variability. Finally, only recognized taxonomic labs, which have their respective quality control procedures (see for example http://abrinc.com/services/macroinvertebrate_subpage.htm), will be used for sample taxa ID and census, and data will be entered into a common database.

For tracking land cover and land use changes, all digitized products will be reviewed and compared against orthophotos by a master GIS technician and the Project Manager or one of the project core team members.

9.0 Data Management Procedures

Except where noted otherwise, all field data and associated observations will be recorded on standardized field sheets (physical or electronic). Data forms will be checked for errors and scanned into Ecology's database (Teleform). Other project data will be stored in WLRD benthic macroinvertebrate database, WLRD hydrology database, and WLRD GIS database for subsequent analysis.

Stream gaging staff will collect and store streamflow data in the WLRD Hydrologic Information database (http://green.kingcounty.gov/wlr/waterres/hydrology/). After QA review, streamflow data will be made publicly accessible

Stream habitat data will be maintained in a relational database, built by Ecology, and accessible to the public. Outputs of these data will be in a format compatible with STORET. Until the database is completed sometime in early 2011, data will be stored in spread sheets. The database will contain (at minimum) the following types of information:

- Site name
- Sample date and time
- Watershed
- Catchment
- Geographic location, including GPS coordinates
- Unique sampling and site condition data for each variable
- Data collected in each collection event

The Project Manager will provide supervision of all data acquisition and management activities. Project staff will enter all other data manually into datasheets (Appendix A) or download from electronic field sheet (e.g., gauging data). A County database manager will ensure data are stored into project-specific database compatible with other county environmental databases.

10.0 Audits and Reports

As per the USEPA's contract requirements, semiannual project reports will be provided to the USEPA by the Project Manager. The report will include a description of project activities and status including an overview of data collected, field and data problems encountered and solutions applied, and changes in schedule, measurements, database, and analysis.

11.0 Data Verification and Validation

All data will be subject to verification by project staff responsible for collection and validation by the Project Manager before use in data analysis, distribution to an outside party (i.e., not part of the King County or USEPA project team) or posting to a publicly accessible database. Prior to such use, the Project Manager will contact the appropriate project staff and field technicians responsible for collecting data to verify procedures were followed and the data were checked for errors. To provide a third-party review, at least one project team member (not project manager or technician involved in data collection) will review the data and collection procedures before data are committed to use in analysis or disseminated outside of the project team.

12.0 Data Analysis

Data quality will be evaluated against the objectives set in this document for precision. The data will also be evaluated for obvious errors, such as incorrect units. Data collected at replicate sites will be compared to assess variability between observers (stream habitat) and method (e.g., macroinvertebrates) for a given site. The data will also be evaluated against the objectives set for representativeness and completeness.

The usability of the data will be confirmed by using it in the models we develop demonstrating the relatedness between land use/land cover, hydrology, physical habitat, and biological response variables (B-IBI and FIBI). Exploratory analyses will follow similar procedures as outlined in Degasperi et al. (2009), Matzen and Berge (2008), and Kauffman et al. (1999).

12.1 Reconciliation with User Requirements

Reports generated for this study will include identification of any data limitations determined through application of the Data Quality Objectives described in this project plan. This information will be communicated initially through annual project reports and will be mirrored in subsequent project reports that rely on data with known limitations, including, but not limited to, modeling reports and reports containing recommended updates to decision makers that update the King County Comprehensive Plan.

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APPENDIX A

Field Forms for Washington Status and Trends

There are 7 data forms that will be scanned using into Ecology's database (Teleform) to enter data into the Status and Trends system. These are:

GPS Positions Form

Site Verification Form

Site Diagram

Major Transect Form

Thalweg Data Form

Slope and Bearing Form

Vertebrate Collection Form

Except for the 2-sided *Vertebrate Collection Form,* these occur back-to back.

Reviewed by (Initials):________

Status and Trends Program - Site Verification Form 2009

	Site Number	YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 -	- D C E - 2 0	-	- :

DCE Start Date	/ / 2 0 0 9	**DCE End Date**	/ / 2 0 0 9

Water Name:

Waterbody Type: Saltwater/Brackish ☐ River/Stream ☐ Canal/Ditch ☐ Wetland ☐ Reservoir ☐ Lake ☐ Other ☐

Safe to Sample?:	Y N	If not sampled, why not?
Permission?:	Y N	
Sampled?:	Y N	
Wade or Raft?:	W R	

Crew		**1 (Leader)**		**Crew Member 2**		**Crew Member 3**		**Crew Member 4**	
First Name	Last Name:								
Organization:									
Habitat:		☐		☐		☐		☐	
Water:		☐		☐		☐		☐	
Sediment:		☐		☐		☐		☐	
Invertebrates:		☐		☐		☐		☐	
Fishing:		☐		☐		☐		☐	

Other People?

Montgomery & Buffington Reach Type	**Bankfull Width** Estimate near Index Station (avg. of 5) (m)	**Site Length** 20 x BFW but between 150-2000 (m)
	Downstream Thalweg Distance (X to A) (m.x)	**Upstream Thalweg Distance** (X to A) (m.x)

Colluvial ☐
Alluvial:Braided ☐
Alluvial:Regime ☐
Alluvial:Pool-Riffle ☐
Alluvial:Plane Bed ☐
Alluvial:Step Pool ☐
Alluvial:Cascade ☐
Bedrock ☐

General Notes

Draft

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by wading within one day? Y N

Is the site unsafe to access, or with barriers that prevent access (round trip) and sampling by raft within one day? Y N

Why is it inaccessible?

SITE DIAGRAM

Provide North Arrow

Draft

Thalweg Data Form

Reviewed by (Initials): ____

	Site Number		YY	MMDD	HH : MM
DCE:	W A M 0 6 0 0 -	- D C E - 2 0	-	-	:

Transect ☐	Thalweg Depth (cm)	Bar? (circle)	Edge Pool? (circle)	Habitat Unit Number	Side Channel Numbers					Wet Width (m.x)	BF Width (m.x)	Bar Width (m.x)
.0		Y N	Y N									
.1		Y N	Y N									
.2		Y N	Y N									
.3		Y N	Y N									
.4		Y N	Y N									
.5		Y N	Y N									
.6		Y N	Y N									
.7		Y N	Y N									
.8		Y N	Y N									
.9		Y N	Y N									

Thalweg Notes:

Substrates at 5	LB	01	02	03	04	05	06	07	08	09	RB

Substrate Notes:

Habitat Unit Number	Habitat Unit Type FT, FN, PS, PD, PP, DC	Pool Forming Code (N, W, R, B, F) Code 1	Code 2	HU Width (m.x)	Max Pool Depth (cm)	Crest Pool Depth (cm)	Channel Unit Notes:

Side Channel Number	Width (m.x)	Side Channel Notes:

LWD Count

Example: 𝍸 | 6

Check box if all are zero ☐

	2-5 m	5-15 m	>15 m	Flag
10-30 cm				
30-60 cm				
60-80 cm				
>80 cm				

LWD Notes:

Draft

Reviewed by (Initials):___________

Status & Trends - Slope and Bearing Form

DCE: W A M 0 6 0 0 - _ _ _ _ _ _ _ - D C E - 2 0 _ _ - _ _ _ _ - _ _ : _ _

Site Number / YY / MMDD / HH : MM

Top Transect* LEVEL, COMPASS	Bottom Transect* ROD	Segment Length (m.x)	Eye Height on Level (cm)	Level Height on Rod (cm)	Bearing (deg)	Flag	Comment

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*Normally sight between major and minor transects: K0 to J5, J5 to J0, J0 to I5, etc, unless there is a need for intermediate measurements. For intermediate measurements, always sight to/from a transect station 0-9 (for example K0 to J7 and J7 to J5). Bearings are magnetic north facing downstream (not adjusted).

Reviewed by (Initials):________

Status and Trends Program - GPS Positions Form

DCE: W A M 0 6 0 0 - ________ - D C E - 2 0 __ - ____ - __ : __

(Site Number; YY; MMDD; HH : MM)

Station	Bank (circle one)	Master Lat dec deg e.g. 47.123456	Master Lon dec deg e.g. 120.123456	GPSlatDD e.g. 47.123456	GPSLonDD e.g. 120.123456	Accuracy	Accuracy Units (ft, EPE, etc.)	Flag
INDEX STATION	L R							
A0	L R							
B0	L R							
C0	L R							
D0	L R							
E0	L R							
F0	L R							
G0	L R							
H0	L R							
I0	L R							
J0	L R							
K0	L R							
PUTIN	L R							
TAKEOUT	L R							

ALL COORDINATES TO BE RECORDED IN NAD83

Position comments including accuracy

Directions to access point

22965

Reviewed by (Initials): ________

Vertebrate Collection Form - Streams/Rivers

DCE: W A M 0 6 0 0 - ____ (Site Number)	- D C E - 2 0 __ (YY) - ____ (MMDD)	- __ : __ (HH : MM)	
FPARS Type ____	FPARS FLAG ____	Fished: Y N	Verts Detected: Y N
Not Fished FLAG ____			
On Button Time (sec) ____	Fishing+Processing Time (min) ____	Sample Distance (m) ____	
Gear: ☐ Backpack ☐ Raft	FLAG for other Sampling Information ____	Water Visibility ☐ Good ☐ Poor	Water Temp (c) ____ Cond (cm) ____
Volts: ____ Frequency: ____ Hz Duty Cycle: ____ %	Notes regarding electrofisher operation:		

Jar No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)* Min	LENGTH (mm)* Max	Mortality	Flag	SEGMENTS
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

Flag	Comment

Draft

Page ____ of ____

K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium.

Tag No.	COMMON NAME	A	J	Tally	Total Count	Voucher Count	LENGTH (mm)*		Mortality	Flag	SEGMENTS
							Min	Max			
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J
											○A ○B ○C ○D ○E ○F ○G ○H ○I ○J

Flag	Comment

Draft

Page ______ of ______

K = No measurement made, U = Suspect measurement, F1, F2, etc. = flags assigned by each field crew

LENTH* - Enter single fish as minium.