PSEMP Freshwater Work Group

Monitoring Inventory and Data Gap Analysis

January 31, 2013

Participants

Names and institutions of Puget Sound scientists who contributed their ideas to this document. Participation does not denote approval of document contents. *This is very much a working Draft*.

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Charge to the Freshwater Work Group

The Puget Sound Ecosystem Monitoring Program (PSEMP) was created in response to enabling statute (RCW 90.71.290), the Action Agenda, the Strategic Science Plan and the Biennial Science Work Plan. Creation of PSEMP was supported by the Puget Sound Partnership. The Steering Committee for PSEMP was convened in 2011 and since that time eight Work Groups have been commissioned for Puget Sound resource types. PSEMP's goals are to evaluate progress toward ecosystem recovery, to improve the scientific basis of management actions, and to coordinate monitoring efforts.

Guidance from the Steering Committee directs Work Groups to complete a monitoring inventory and gap analysis (PSEMP, 2011) with tasks that include:

- Identify active, on-going monitoring programs,

- Identify data related to Vital Sign Indicators, regulatory mandates, and the Action Agenda,
- Evaluate gaps in monitoring,
- Develop an approach to prioritize needs, gaps and programs.

Included here are highlights from previous monitoring inventories, descriptions of data and monitoring gaps related to the four freshwater Vital Signs indicators assigned to this work group, descriptions of selected extensive and current freshwater monitoring programs and databases, and outstanding issues from the Freshwater Work Group that will be addressed in consultation with the PSEMP Steering Committee in order to guide work group activities in the coming months. This report documents conversations and meetings with Work Group Participants.

Highlights from Previous Monitoring Inventories

In 2003, Crawford et al. (2003) surveyed and described monitoring programs in Washington as part of the Comprehensive Monitoring Strategy (Monitoring Oversight Committee, 2002). Federal, tribal, state, county, city and volunteer organizations were surveyed. In 2006, the survey was updated (DNR et al., 2006). Detailed descriptions for 145 monitoring programs and databases were provided, including 90 databases for Puget Sound. Several results of that inventory are relevant to PSEMP monitoring.

- Most monitoring programs assess watershed health or salmon recovery (94%).
- Status and trends monitoring most common type (note the scale is typically local rather than regional, that is, targeted rather than probabilistic). Project effectiveness, validation/diagnostic (cause and effect) and compliance (implementation) monitoring were rare.
- Many programs are mandated by federal regulation, tribal law, state law, or local ordinance (66% of programs that collect data). Note: Many local jurisdictions collect data that are not mandated by any laws; for example, B-IBI is not required by law but monitored by numerous counties and cities to evaluate stream condition.
- Minimal redundancy among programs, thus none recommended for elimination (in 2006).
- Most programs are ongoing (89% in 2006). One-half of state programs and one-quarter of county programs have >5 years of data.
- Data content: 50 out of 130 programs collect surface water quality data; 43 have water quantity or hydrology data, 37 collect instream or riparian habitat data.
- Data can be downloaded from the web (35% of reported databases as of 2006).
- Funding: 39% for 2 years or less; 61% is ongoing.
- Note: Since 2006 many monitoring programs have been cut significantly, this summary may not be accurate now in 2013.

See DNR et al. (2006) for details related to the purpose of the monitoring, when the activity started, who uses the information, how often it is accessed, costs, frequency of data collection, geographic location, where the information is stored, and current program status and cost of data storage. See Dzinbal and Butkus (2005) for Ecology's statewide assessment of monitoring.

Data and Monitoring Gaps

An enormous amount of data has been collected and organized into regional databases for freshwaters of Puget Sound including conventional water quality data, benthic invertebrate data, and streamflow data. There are specific monitoring gaps for water quality of lakes, wetlands, and groundwater.

The largest gap identified by the Work Group is an *analysis gap* in that there are extensive opportunities to mine data from large, existing databases and combine with data from other diverse sources (e.g., spatial data) to answer questions about the impact of management actions.

A second gap relates to the lack of statistical sampling designs to leverage data collected at a small spatial scale to answer questions at the WRIA or Puget Sound basin scale. A monitoring design is needed to stitch the various data collection efforts of cities, counties, tribes and other entities into a regional assessment. This could be a probabilistic sampling design or a meta-analysis of existing studies.

A third gap relates to trend detection. Many trend data have been collected, but few trends have been detected for a variety of reasons: 1) change takes time, 2) nothing has happened to cause a change, 3) existing data have not been analyzed, or 4) initial baseline data were collected and follow up data have not been collected yet (reflecting the need for commitment to long-term trend monitoring). Trends for current indicators and current sampling designs are projected to take a relatively long time to detect change, e.g., 10-30 years for WQI and summer low flows. In contrast, information about the impact of management actions is needed for shorter time frames, e.g., 2-5 years. There is a mismatch between the time and scale of monitoring (smaller spatial scale and longer time periods) and the time and scale of management decisions and assessments (larger spatial scale and quicker time periods). Given the enormous amount of data that has already been collected, it's not clear whether additional analyses of existing data would provide better information about trends. In some cases the data legitimately indicate that no trend has occurred, in other cases, alternative analyses of existing data might yield more trend results.

Current Vital Signs Indicators

Four Vital Signs Indicators of freshwater condition are reported by the Puget Sound Partnership: the Water Quality Index (WQI), the Number of Impairments, the Benthic Index of Biotic Integrity (B-IBI, aka the bug index), and summer low flows. All four indicators have extensive regional datasets.

Lacking is a geographically integrated sampling design that can knit together smaller data collection efforts at a regional scale. To meet part of this need, the Stormwater Work Group has proposed a regional, probabilistic sampling design for monitoring small streams and includes WQI and B-IBI (see Regional Stormwater Monitoring Program [RSMP] below).

In general, indicators for freshwater are most responsive to disturbance at smaller spatial scales, e.g., stream segments vs. WRIA, and recovery times are also easier to detect at smaller rather than larger spatial scales. In contrast, for planning and performance analysis, we need feedback at a very large scale (Puget Sound) within a short time period (2020). B-IBI and number of impairments are typically reported at the subwatershed or segment scale. The WQI and summer low flows are reported for large rivers.

The Vital Signs indicators monitor a few types of data for a subset of key ecosystem components of freshwater (Table 1). Several ecosystem components are not currently monitored.

Table 1. Shown are ecological components of freshwater systems and the type of data collected for each component. Shown are active monitoring programs. Grey cells indicate no monitoring. Shown are large, on-going monitoring programs, table does not reflect smaller projects.

Ecosystem Component	Physical Data	Chemical & Water Quality Data	Biological Data
Rain	Gauges	National Deposition Program	Not relevant
Ephemeral streams			
Lakes	Water level data for some lakes	WQ at a ~12 large lakes; historic WQ data for a few more; 17 lakes in Kitsap Co.	Toxic algal blooms at ~50 lakes; weed mngmnt plans
Wetlands	Levels at selected sites	WQ at selected sites	
Ground water	Levels at 100s of wells across multiple local networks	WQ at 100s of wells across multiple local networks	Not relevant
Wadeable streams	Flow gages for ~150 sites; some habitat data for 50-100 sites	WQ data for MANY (1000s?) sites; some could be used to calculate WQI	B-IBI for ~1000 sites
Rivers	Flow gages at downstream locations for most rivers	WQI for downstream sites of many rivers	(Fish monitoring not included here)

Water Quality Index (WQI)

The WQI combines eight measures of water quality of streams and rivers. Expectations for dissolved oxygen, pH, temperature, and fecal coliform bacteria are tied to the State's Water Quality Standards. The other four components measure nitrogen, phosphorus, suspended sediment, and turbidity which do not have numeric standards. WQI values are based on monthly monitoring.

Existing data

Department of Ecology and King County collect data from 55 stations with long-term data. King County plans to increase their 30 stations to 50 in 2013. About 60 additional stations have been sampled during at least one of the last 10 years. Skagit, Pierce, and Thurston Counties also have monitoring programs that could be used to calculate WQI. Many entities collect some components of the WQI. The Regional Stormwater Monitoring Program (RSMP) plans to collect data to calculate WQI (see below).

Monitoring gaps

- Some groups collect the data for WQI, but do not calculate it; some collect WQI data and upload the data to Ecology EIM database, from which WQI could be calculated; some collect data, but not monthly, so WQI cannot be calculated; some groups only collect some of the components. This is an analysis gap.

- Encourage monitoring organizations to provide WQI-relevant data (or calculated WQI scores) in standard formats. Currently Ecology and King Co. are the only organizations that provide data to calculate WQI scores, though other organizations have data available.
- Identify which areas and water body types have and do not have data to calculate WQI.
- Develop quality control procedures, i.e., a Side-by-Side sampling program to ensure data collection and analysis methods are comparable across organizations.
- Develop database procedures to calculate WQI from existing data. It's not clear how much of data collected by cities and counties is in Ecology's regional EIM database or is only available "in house."

Current Funding

The cost to maintain Ecology's existing ambient stations in Puget Sound to support the WQI is about $198,000 per year. Ecology maintains about 30 stations (25 long term + 2 basin + 3 Intensively Monitored Watershed stations for Salmon Recovery). The cost includes data collection, lab analysis, data management, reporting, and other monitoring activities (e.g., continuous temperature and some metals monitoring). Cost estimate is based on statewide network so may not apply to new stations.

Budget estimates for new monitoring

$275,000 – Coordinate reporting and analysis of WQI and expand its use by different monitoring groups.

$55,000 – Data upload.

$137,000 – Freshwater QA Side-by-Side monitoring. Program is designed to facilitate the comparison of data collected by different monitoring groups, such as counties, conservation districts, tribes, consultants, agencies, etc.

$40,000 – Support existing programs to add data missing from WQI.

Number of Impairments

Under the Clean Water Act, states define Water Quality Standards to protect waterbodies. When sample data from a site exceeds the standards, the site is placed on an impairment list (the 303d list). Currently there are 1496 river and stream segments listed as impaired, this number is expected to increase in 2012 after the next water quality assessment. A total of 628 segments have TMDLs or pollution control programs in place; 2685 have insufficient data to determine status. Some of the data used to determine impairment are also included in the WQI.

Existing data

There is an enormous amount of data related to listing rivers, streams and lakes as impaired under the Clean Water Act, literally millions of records in Ecology's EIM database. Freshwater locations are listed for impairment based on Water Quality Standards for bacteria, dissolved oxygen, temperature, toxics or other pollutants. Some of these measures are included in the WQI. In 2012, many more sites are expected to be classified as impaired and added to the 303d list.

Monitoring gaps

- An enormous amount of data is used to evaluate the number of impaired waterbodies and the amount of data is expected to increase. Other summary measures can be derived from these data, e.g., what types of indicators show the most improvement as a result of management actions.
- Moving off the impairment list does not mean the site has recovered. Sites are no longer listed as impaired (Category 5 listing) when a pollution control plan or TMDL is approved; thus, many of the sites that move off the impairment list have not improved in condition. The expectation is that they will recover as the mandatory plans are implemented. We do not have a measure of how these sites are doing, although one could potentially be developed from the extensive data collected from these sites.
- An alternative indicator might be more meaningful, e.g., trend over time for listed sites to summarize whether sites (and watersheds) are improving, declining or stationary.
- Sites take a long time to move from impaired to recovered, i.e., Category 1, meeting water quality standards. There are different reasons, and perspectives, on why this is the case, e.g., recovery takes longer than expected, some standards are unattainable in highly developed areas or unreasonably strict (e.g., for bacteria), and the listing process does not distinguish between sites that are improving and those that only have plans approved but no real recovery efforts implemented.
- Jurisdictions have questions about how the de-listing process works, e.g., how the status review process is initiated.
- Not clear if individual jurisdictions submit data consistently, or if they understand how the TMDL process works.

Benthic Index of Biotic Integrity (B-IBI)

B-IBI, aka the Bug Index, is calculated from 10 measures of the stream invertebrate community including taxa richness of key taxonomic groups, intolerant and long-lived taxa, and percentages of predators, tolerant and dominant individuals. Invertebrates are collected from stream sites with fine-meshed nets and identified in the lab.

Existing data

Invertebrate data are collected by >20 local jurisdictions and tribes and state agencies. Over 3,000 site samples from >1000 sites are stored in a web accessible data base (Puget Sound Stream Benthos, PSSB). The Dept. of Ecology also collects B-IBI data from 50 sites within Puget Sound every four years beginning in 2009.

Monitoring gaps

- Most B-IBI sampling is currently confined to a local scale within a city, county or tribal area. Local jurisdictions do not coordinate sampling to derive regional assessments. Regional status and trend monitoring is addressed by the proposed RSMP and data collected from this program will be used to prioritize management actions for streams and watersheds (but see RSMP and Ecology's Regional Status and Trend Monitoring below).

- There are two Action Agenda targets for B-IBI: 1) Develop a plan and cost estimate to restore 30 drainages with "fair" BIBI scores to "good" BIBI scores. Analysis is needed to identify sites and restoration activities to meet the target to restore 30 subwatersheds. 2) Identify sites with excellent B-IBI scores and develop a plan to protect these basins.
- Data analysis gap for B-IBI is to evaluate Status and Trends data from Ecology to determine risk and major threats to stream invertebrates. Probabilistic sampling plan was designed to asses relative risk and the extent of specific risks for Puget Sound streams.
- There is an opportunity to leverage effectiveness monitoring with B-IBI across the region by coordinating sample collection as part of a regional monitoring plan. Individual jurisdictions do not have sufficient resources or sites to collect enough data for testing the impact of management actions at a regional scale. A regional sampling design is needed to do this.
- High elevation areas (>500 m) and large rivers are not typically sampled.

Budget estimates for current and new monitoring

Status and trend monitoring: see RSMP estimates for WQI and B-IBI in wadeable streams.

Identify subwatersheds: 2013 award to King County for $150K.

Actions needed to restore 30 subwatersheds and preserve 'excellent' subwatersheds: no estimate.

Regional effectiveness monitoring: no estimate.

Summer Low Flows (Water Quantity)

Konrad and Voss (2012) developed an inventory of streamflow gage monitoring in the Puget Sound basin. Streamflow data are derived from gages in permanent locations. The Stormwater Work Group is working with regional stakeholders to determine where additional gage data are needed.

Existing data

There are 776 gages in Puget Sound basin, of these, 285 are active and approximately 120 are in King County. Gages cover 74% of the drainage area of Puget Sound basin. Half of the coverage is due to gages on 20 very large rivers. Of these gages, 50 met the criteria for measuring long-term trends and 29 were used to report trends for the 2012 State of the Sound Report. Coverage is uneven, e.g., Bellevue has 17 gages in a 31 mi^2area.

Monitoring gaps

Note: The Stormwater Work Group is also prioritizing gaging gaps and needs. The Freshwater Work Group will coordinate with them.

Gaps in coverage for small streams include:

- Coastal basins with small creeks that drain directly to Puget Sound (e.g., Terrell Creek in Whatcom County, Samish River in Skagit County, Sequalitchew Creek in Pierce County);
- Islands and peninsulas with few streams (e.g., Bainbridge Island, Whidbey Island, Key Peninsula, southwest Kitsap Peninsula, northern coast of Olympic peninsula);

- Large river floodplains and deltas with few streams (for example, Nisqually, Nooksack, Skagit, and Snohomish Rivers) or small streams draining directly to large rivers (for example, Eaton and Yelm Creeks in Thurston County); and
- Urban areas with extensive engineered drainage systems (for example, large portions of Bellevue, Bremerton, Everett, Seattle, and Tacoma).

Data analysis gaps

- Current trend analysis requires that data from gages is relatively complete since 1975. Many more gages could be evaluated if trend indicators could be developed for shorter periods of record. A method is needed to distinguish between short term changes due to climate and changes due to human drivers.
- The current target for summer low flows is based on trend. Need an indicator, and target, to measure whether the current flow is adequate for resource protection during summer low flow. We need a way to identify if the observed flow is 'good' for given the annual climatic variability.
- Note that King County has developed stormwater-related flow metrics that may be relevant.
- Research is needed to understand which drivers (e.g., climate change, rainfall) primarily control streamflow trends, and which drivers could be managed to help meet instream flow targets.
- Need an index of environmental function that measures a variety of hydrologic changes related to watershed health, such as higher peak flows or increased flashiness of flows.

Budget estimates for current and new monitoring

Streamgages cost from $1,000 to $15,000 to install, and about $5,000 to $18,000/year to operate. Assuming 30 new gages are needed (60% of the proposed RSMP network), the installation costs would be on the order of $250,000 and the annual operating costs would be about $300,000.

Other Freshwater Components

Water availability

Originally the Vital Signs water quantity indicator for rivers and streams was meant to include water supply for people and instream flows for salmon and other wildlife. The current Vital Signs indicator only addresses one aspect of instream flow, and the water supply component has been lost. Other streamflow statistics can be calculated from existing stream gage data. Water suppliers coordinate their efforts to monitor municipal supply; but there is no regional program for monitoring water availability. There are some recent and current WRIA-scale groundwater availability assessments in Puget Sound that include monitoring, as described below.

Groundwater

There are no comprehensive regional-scale groundwater monitoring programs in Puget Sound, although there are many smaller-scale less comprehensive monitoring programs, as described below.

An emerging issue for groundwater is the impact of injection wells, very little monitoring or reporting is done although the trend is increasing.

Groundwater levels (an indirect metric for groundwater quantity) are coupled to summer streamflows due to their control over groundwater discharge to surface water, particularly to mid to low elevation rivers and streams that receive few contributions from late season snowmelt or reservoir releases. Groundwater levels and quality are likewise coupled to surface-water quality, with the predominant effects seen during summer baseflow that are predominately sustained by groundwater discharge.

See also "Ambient Groundwater Monitoring Recommendations Report," a 2008 publication by Department of Ecology with specific step and costs for implementing regional groundwater monitoring. Since 2008, efforts have focused on data management and data mining of groundwater information already in EIM even though the program is not directly funded. Data management and analysis tools have been developed to migrate legacy groundwater data into EIM. Current experience with internal data mining efforts has revealed that the level of effort required for this type of work is substantial and was underestimated in the 2008 report.

Contact: Charles Pitz or Kirk Sinclair.

Recent groundwater monitoring inventories

Ecology in 2002 reported on the Status of Active Groundwater Monitoring Programs in Washington State. Their key questions were similar to ours, such as "What is the current state of affairs for long-term ambient groundwater quality and water-level monitoring in the state?" With regard to both groundwater levels and quality, spatial coverage was found to be incomplete and that situation has likely not improved since 2002, and probably deteriorated as many programs have been suspended or reduced. Few local programs were actively collecting and evaluating changes in groundwater quality over time, and much of the systematic public water-supply well chemistry data (such as those from Washington Department of Health) are not tightly coupled to ambient surface-water quality because the wells are generally deep and intentionally installed in uncontaminated aquifers. Ecology conducts the most recurrent groundwater level monitoring in the state, with established water-level networks in areas of high groundwater use or where problems have been identified. Many of the data are from east of the Cascades and not Puget Sound. As with the available groundwater quality data, most groundwater level data have been collected to address groundwater supplies for human use rather than groundwater contributions to streams.

Summary of current groundwater monitoring activities

Groundwater quantity

Long-term monitoring networks. Ecology leads a state-wide groundwater level data compilation to consolidate the independent data collected over the past 30+ years by regional offices of Ecology's Water Resources Program and add data to the EIM database system including water level data for Clallam, Jefferson, Pierce, and Thurston counties. Data are web-accessible through the new EIM Groundwater Data Center (http://www.ecy.wa.gov/eim/groundwater.htm). Migration of the groundwater data from the Northwest regional office of Ecology has not been scheduled.

Unlike their streamflow monitoring network, USGS has only three Puget Sound sites (2 in Pierce County and 1 in Thurston County) where groundwater levels are routinely measured over the long term. All historical water-level data are available in the web-accessible USGS National Water Information System (NWIS) database.

As identified in the 2002 monitoring inventory, the monitoring of ambient groundwater water-levels is largely being conducted at the local level by Counties, PUDs, cities, and others in support of groundwater resource management, e.g., Kitsap County, Vashon Island (9 wells), Bear Creek basin, Bainbridge Island and Island Co. (?).

Synoptic groundwater assessments that include monitoring. USGS has established and operated groundwater level monitoring networks of around 50-150 wells for 2-5 years in support of WRIA-scale or smaller synoptic groundwater resource investigations. Current or recent networks have been on Bainbridge Island, Lower Skagit River, Chambers-Clover Creek, lower Puyallup, Chimacum Creek, and Kitsap County. These recent studies have at least a partial focus on groundwater-surface-water interactions and include groundwater level monitoring near streams and rivers. Active monitoring programs are illustrated online, and all historical water-level data are available in NWIS.

USGS has conducted many previous groundwater resource assessments that included monitoring, and historical data are included with more current data in the recent assessments. There is no established federal program for conducting these assessments and monitoring; rather, new assessments are initiated and at least partially funded by State and local stakeholders including Ecology, Cities, Counties, WRIA watershed Planning Watershed Planning groups, and others. USGS does have a Groundwater Resources Program that funds recurrent (every 5-10 years is the design) groundwater availability assessments in major aquifer systems of the nation, of which Puget Sound is one. The Puget Sound regional aquifer system was last assessed in 1998 under a prior USGS program, but it is relatively low priority for a reassessment under the Groundwater Resources Program because groundwater in Puget Sound is not a predominant water supply for people, agriculture, or industry compared to other parts of the country.

Groundwater quality

Ecology monitors groundwater quality as part of selected groundwater assessments in Puget Sound. Most studies are highly localized and support MTCA or TMDL activities, although they have been conducting a long-term ambient groundwater monitoring program in the Sumas-Blaine surficial aquifer, one of the most broadly contaminated aquifers in Washington State.

The USGS National Water Quality Assessment (NAWQA) Program established two groundwater monitoring networks in Puget Sound in 1996; an "agricultural land use" network in Whatcom County, and an "urban land use" network in Thurston County. Each network includes about 25 wells. Water levels are generally measured annually, and water quality (including nutrients, pesticides and VOCs) has been analyzed in 5 wells every other year, and for all wells every fifth year. Beginning in 2013, the analytes will be more targeted to the land use (e.g. nutrients and pesticides in the ag network and VOCs in the urban network).

The 2002 groundwater monitoring inventory report from Ecology summarizes many other local-scale groundwater quality monitoring programs, as well as the extensive WDOH water quality monitoring of public drinking water supply wells.

Wetlands

Wetland monitoring is conducted by DOT, Army Corps of Engineers, Ecology, consultants and local jurisdictions and is not regionally coordinated. Monitoring is related to construction permits and mitigation. Most monitoring is based on a rating system and if data are uploaded, the raw data are not uploaded, just the category rating. Categories are based on sensitivity to disturbance, whether they can be replaced with mitigation, and 3 functions, hydrologic function, habitat function (can be spp), and water quality function (can be removal of nutrients). The regulatory context relates to Critical Areas Ordinances and mitigation.

However, the data quality is even more mixed and even a simple list of permits from various jurisdictions is difficult to compile. Another challenge is that there are many different types of wetlands.

Ecology has recently completed a GIS inventory (with the help of NOAA and WDFW) and have mapped over 90% of the wetlands that are larger than 1 acre. Contact: Tom Hruby, Department of Ecology

Lakes

The Washington State Academy of Science's recent report on Puget Sound Partnership's indicators recommended specifically that an indicator of freshwater quality for lakes be included as part of the Vital Signs Indicators (Orians et al., 2012). There are thousands of lakes in the Puget Sound basin, e.g., King County alone has >500. Most lakes are small; there are about 100 lakes in Puget Sound with large surface areas and many more that are large enough to be included in the Shoreline Master Program updates (Waters of the State). The statewide lake monitoring program was discontinued in 2000, but a recent proposal has been developed to reinstate the program. WDFW and National Parks Service monitor some high mountain lakes. King County collects conventional water quality measures and nutrients for Lake Union, Lake Washington, and Lake Sammamish. Water quality data are also collected by King County's Lake Stewardship Program funded by small cities from 12 additional lakes with the help of volunteer monitors.

A current concern is that toxic algae blooms may be increasing over time. In five years of sampling, toxic algae have exceeded safe limits at 61 out of 152 lakes sampled statewide, with ~80% of the lakes that were tested located in the Puget Sound basin (WA State Toxic Algae, http://www.nwtoxicalgae.org/Data.aspx). We do not know the immediate causes for toxic blooms, but it is likely that increased nutrients coupled with warm, extended summers are involved. Algal toxins from lakes may also contaminate fish and shellfish. Local jurisdictions are experimenting with different management techniques to control algal blooms as well as invasive milfoil.

A nascent group of individuals from a variety of agencies could use support for meetings and collaboration to strategize approaches to managing toxic algae threats.

Freshwater beaches

Vital Signs indicators currently only include data for marine beaches. However, there may be data for freshwater beaches that could be included. King County monitors swimming beaches of Lake Washington and Sammamish; Pierce County monitors Lake Tapps (?);Snohomish County monitors lakes and beaches; and Kitsap monitor 29 sites on 17 lakes for bacteria. Not sure if this is a water quality issue or a public health issue.

Climate Change impacts

We did not address which potential indicators or additional data are needed to track climate change impacts. Additional work would be needed to identify the best indicators for detecting emerging impacts. A report published in 2012, "Preparing for a Changing Climate – Washington State's Integrated Climate Response Strategy," discusses research and monitoring needs (http://www.ecy.wa.gov/climatechange/ipa_responsestrategy.htm#REPORT).

New Monitoring Programs Proposed to Fill Gaps

Regional Stormwater Monitoring Program (RSMP)

RSMP is a new monitoring program funded by western Washington municipal stormwater permittee contributions. The Stormwater Work Group is a diverse set of regional stakeholders spearheading this effort. In December 2013 municipalities will decide whether they will opt in with their contributions to a regional monitoring plan or opt out and conduct their own permit monitoring to complement the RSMP.

The Freshwater Work Group recognizes the proposed RSMP as a multi-stakeholder, regional effort to collaborate across agencies and support integrated monitoring that will yield relevant data at multiple spatial scales. The Freshwater Work Group recommends that any additional proposed monitoring should complement this design. The probabilistic framework adopted in the RSMP is flexible in that additional sites can be added, e.g., to focus on a specific watershed or evaluate the effectiveness of specific management actions. Additional water body types, e.g., lakes or large rivers, could also be added to this statistical design. The statistical sampling design does not address long-term, site specific changes, e.g., TMDL assessment. However, the design could be applied to evaluating these sites at a regional scale.

In short, the expectation is that any monitoring recommended by the Freshwater Work Group should build on this design as funding sources become available. Another option would be to make recommendations to the Stormwater Work Group regarding additional monitoring, realizing that any changes would need to occur within the context of the 5-year permit.

Status and Trend monitoring. Draft monitoring plans (Quality Assurance Project Plans - QAPPs) are being written for small streams (first to third order), nearshore sediment chemistry and nearshore mussel and bacteria monitoring. QAPPs for opt-out monitoring will be available August 2013. For streams, 100 randomly selected sites will be sampled during the 4-5 years of the permit cycle; 50 sites will be inside Urban Growth Areas (UGAs) and 50 outside. Data for the WQI, B-IBI, sediment, habitat data, and stream flow data will be collected. For nearshore areas, fecal coliform data will be collected monthly at 50 sites in the UGAs, sediment chemistry every five years at 50 sites in UGAs (to compare with PSAMP locations outside UGAs), and Mussel Watch data at 30-50 sites near stormwater outfalls (to be compared with Mussel Watch sites away from outfalls).

Effectiveness monitoring. A prioritized list of recommended study topics has been created and a literature review is under way to refine the list of questions to be completed in spring 2013. RFPs expected to go out in early 2014.

Web page: http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp.html.

Puget Sound Habitat Status and Trend Monitoring

The PSEMP Salmonid Work Group is working to define elements of a comprehensive monitoring strategy for salmon habitat. This is based on multiple existing programs conducted by many different agencies and using diverse methods such as remote sensing, on the ground monitoring of habitat in streams, nearshore, and estuarine areas using a probabilistic design, and intensive habitat monitoring for specific watersheds to complement existing monitoring for salmon and steelhead. Also, a coordinated monitoring and adaptive management framework has been developed by the Puget Sound Salmon Recovery Implementation Technical Team (RITT) to be implemented at a watershed scale. Together, these efforts are intended to integrate and economize on monitoring efforts across federal, tribal, state and local governments. Water quality and water availability are important components of salmon habitat.

Both the RSMP and the habitat monitoring plan are based on random sampling and include data collection for habitat. Efforts are underway to coordinate the activities of the Salmonid workgroup with that of the RSMP and the Freshwater workgroup.

Collaboration is also ongoing among EPA, Ecology, King County and Tulalip Tribes to identify and monitor habitat in reference (sentinel) sites.

Contact: Bruce Crawford, NOAA

Data Inventory Template

The Puget Sound Ecosystem Monitoring Program (PSEMP) Steering Committee provided a template for the survey of active monitoring programs for Work Groups to use in creating an inventory. Because of the enormous amount of data collected for rivers, streams and lakes in the Puget Sound, the Freshwater Work Group opted to start with a narrative description of active databases and include active monitoring programs as appropriate. Note that much of the detail for the programs below can be found in DNR et al. (2006).

Database and Monitoring Program Summaries

Federal Programs

National Rivers and Streams Assessment, (NRSA) US Environmental Protection Agency

This program is the national version of the original regional EMAP studies (Environmental Monitoring and Assessment Program). During 2008-2009, 1924 rivers and stream sites within the continental U.S. were sampled for biological, chemical, and physical measures. NRSA provides standardized protocols for data collection, a regional baseline for expectations of stream condition, and protocols for data analysis such as risk analysis based on the probabilistic data derived from these types of surveys. Ecology's state status and trends monitoring program is modeled on this design and the entire state is surveyed every 4 years (see below).

US Geological Survey – National Water Information System (NWIS)

The Washington District of the USGS is responsible for the collection, compilation, and publication of hydrologic data, including records of stream discharge. Data are collected as part of statewide, countywide, or local networks. Surface-water stations provide data on stream discharge and stage, and reservoir and lake elevation and storage; some data are reported by satellite-telemetry.

Flow data are collected for streams and rivers and water level is monitored in streams, rivers, lakes, and reservoirs; groundwater levels in wells; and chemical and physical data for streams, lakes, springs, wells are also collected.

Konrad and Voss (2012) evaluated the streamflow-gaging network in the Puget Sound basin for its capacity to monitor stormwater in small streams. The active gaging network covers much of the Puget Lowland largely by gages located at sites on larger streams and rivers. Monitoring that emphasizes small streams in combination with approaches for estimating streamflow at ungaged sites provides an alternative to expanding the current gaging network that can improve the spatial resolution of streamflow information in the region. The highest priority gaps in the gaging network are low elevation basins close to the Puget Sound shoreline and sites that share less than 10 percent of the drainage area of an active gage.

USGS Water Resources Links for Puget Sound: http://water.usgs.gov/lookup/getwatershed?17110019

National Water Quality Assessment (NAWQA), US Geological Survey

The Puget Sound NAWQA program investigates fresh water quality in both surface and ground-water flow systems and begins with a retrospective analysis of existing data to assess current status, and identify water quality constituents of concern in addition to identification of areas worthy of more intensive study.

Data include pesticides, nutrients, toxics, and traditional water quality measures of groundwater and surface water; and macroinvertebrates. Prior to 2013, fixed stations were located near the mouths of the larger rivers draining to the Puget Sound, the Green-Duwamish, Nooksack, and Skokomish, and selected tributaries to these rivers. For NAWQA Cycle 3 beginning in 2013, the baseline station on the North Fork Skokomish River will be the only river monitored. Continued groundwater monitoring is described in the previous section on groundwater quality monitoring. All Puget Sound NAWQA data are in NWIS and the NAWQA Data Warehouse.

STORET, US Environmental Protection Agency

For Puget Sound Watershed, ~93,000 observations from 1871 sites, mostly EPA and tribal water quality data. Data includes water quality parameters such as PCBs, metals, habitat, nutrient, pesticides, and microbiological in addition to physical habitat and biological data collected from the EMAP and NARS monitoring mentioned above.

Surf Your Watershed for the Puget Sound, HUC 17110019.
http://water.usgs.gov/lookup/getwatershed?17110019

EPA STORET Watershed Summary Report for Puget Sound:
http://ofmpub.epa.gov/apex/STORETSummary/f?p=WatershedUI:1:3503185304607001::::P1_ORG_CHAR,P1_HUC:1,17110019

Federal Energy Regulatory Commission (FERC) Projects/National Parks

State Programs

Environmental Information Management System (EIM), Department of Ecology

EIM is a very large database that includes data from numerous programs and many, many studies across the state. Conventional water quality measures are the most common data for surface waters, and include millions of measurements of temperature, dissolved oxygen, pH, fecal coliform, turbidity, flow, conductivity, nutrients. Also included are chemical measurements such as metals and toxics; biological measurements of fish, invertebrates, plants and bioassays; habitat data; and descriptions of studies and locations. Although studies may collect different types of data, standardization is not required for comparing results across studies, e.g., meta-analysis may be used to evaluate effectiveness of management actions across studies.

A search within Puget Sound found hundreds of studies that yield monitoring data for rivers and streams. Some are ongoing, some are related to impairment listings and TMDLs, and others are part of larger ongoing regional efforts. TMDL studies conducted by Ecology since 2000 are in EIM and some of the major TMDLs completed in the 1990s. Water Quality Program grant funded study data have been included since about 2004. Data are collected by Ecology and local jurisdictions.

Table 2. Types and numbers of studies in Puget Sound basin found in the EIM database.

Number of Studies	Project Type Code
1010	GenEnvironmentalStudy
525	SiteInvestigation
418	FinalCleanupMonitoring
298	SedDredgingStudy
228	RoutineMonitor
197	PostCleanupMonitoring
197	InitialInvestigation
161	SourceControl
66	TmdlDev
54	InterimCleanupMonitoring
42	BmpMonitor
39	TmdlMonitor
27	BioaccumulationStudy
21	HabitatMonitoring
15	SedDisposalSiteMonitor
6	MuniStormwater
1	StressorIdentification
1	VCP

WA Ambient Monitoring

The department of Ecology has been monitoring conventional water quality monthly at targeted stations since the 1950s. There are currently 25 stations in PS monitored every year, mostly on major rivers intended primarily to assess long-term trends. There are a small number of stations monitored for a single year only in support of Clean Water Act requirements. Since 1994, when the current program stabilized, 142 stations have been monitored in PS. Metals are sampled every other month at a few stations each year.

WA Department of Ecology Status and Trend Monitoring

This program grew out of the EPA's EMAP program and uses similar data collection protocols for fish, invertebrates, habitat, and chemistry. Sites are selected from the region using a probabilistic design. Sites are visited in a rotating panel with the state divided into 8 status and trend regions with 2 areas sampled each year. The first sampling event for Puget Sound basin was in 2009, and the next event will be in summer 2013 when 50 randomly selected river and stream sites will be evaluated, and then every four years.

Coordination with RSMP: The probabilistic sampling designs used by both projects are entirely compatible and flexible. Ecology's sampling design includes larger streams and all non-federal land in the Puget Sound Basin, thus the sample population is somewhat larger than the lowland areas sampled by the proposed RSMP. One original proposal was to sample the same year with Ecology's sites in the lowlands paid for by Ecology and permittees funding monitoring of additional sites. The 4-year cycle for Ecology's statewide sampling does not align well with the 5-year permit cycle for stormwater sampling. The permit runs from 2013-2018 with RSMP sampling proposed to begin in 2015 or 2016. The Stormwater Work Group will decide how best to coordinate with Department of Ecology Status and Trend sampling in terms of which year to begin sampling and the frequency of sampling.

Status and Trends: Riverine Ecology and Assessment Monitoring (STREAM), Ecology

The STREAM database is a new component to the EIM database that includes habitat data for state, county and tribal organizations. Currently included are data collected since 2009 for ~125 locations and multiple projects in Puget Sound (EPA sentinel sites, WHSR, Ecology ambient sampling, Puyallup Tribe, and WRIA 8).

https://fortress.wa.gov/ecy/eimreporting/search.asp.

Effectiveness Monitoring

A variety of programs and groups collect data to test whether changes in fish, water quality or invertebrates are associated with management or restoration activities. There are many projects throughout the Puget Sound basin; one question is whether these various data sources from individual projects can be leveraged as part of a meta-analysis for a regional scale assessment to compare the relative effectiveness of the different approaches.

At Ecology, the three major state funding sources require effectiveness monitoring (Revolving fund, Centennial, and Section 319). To date there has been little effort to track implementation or effectiveness across these programs. Several monitoring programs collect data related to effectiveness at the project level scale and possibly at the programmatic scale (Ecology, 2005). These include:

- River and Stream Water Quality Monitoring Program
- River and Stream Flow Monitoring
- Intensively Monitored Watersheds
- Stream Biological Monitoring
- Status and Trends for Watershed Health and Salmon Recovery
- Aquatic Plant Monitoring
- BEACH Program
- Marine Water Quality Monitoring
- Marine Sediment Monitoring
- Washington State Toxics Monitoring
- Washington's State Effectiveness Monitoring

Contact: Scott Collyard, TMDL Effectiveness Monitoring, Dept. of Ecology. http://www.ecy.wa.gov/programs/eap/tem/index.html.

The WA Salmon Recovery Funding Board (SRF Board) sets aside 10% of funding for restoration projects to evaluate the implementation and effectiveness of the projects. Reach scale effectiveness monitoring has been ongoing since 2003. Experimental design and sampling protocols were developed to evaluate the effectiveness of fish passage, riparian plantings, instream structures, livestock exclusions, constrained channels, reconnected channels, gravel placement, and diversion screening restoration projects. The intent of the monitoring is to test whether habitat targeted for restoration has been improved, and which project types are most cost effective.

These data are hosted by Recreation and Conservation Office in a searchable online database with two parts: a grant tracking system and a database for stream and fish indicators. There are 4395 grant projects in Puget Sound, including 658 restoration projects; data from PS Nearshore Restoration Project (PSNERP) restoration is also included. Contact: Greg Tudor, PRISM (Project Information System), http://www.rco.wa.gov/prism/ProjectSearch.aspx.

Results of effectiveness monitoring: http://www.rco.wa.gov/doc_pages/other_pubs.shtml#monitoring.

Intensively Monitored Watersheds (IMW). (Department of Fish and Wildlife?)

The IMW project is a joint effort of the Washington Departments of Fish and Wildlife and Ecology, NOAA Fisheries, EPA, Lower Elwha Klallam Tribe and Weyerhaeuser Company and is financially supported by the WA SRF Board. To test for cause and effect relationships between restoration and management activities and salmon production, a selection of sites were monitored with more intensive data collection. These include ten streams in three small stream complexes: Hood Canal IMW, 4 streams; Strait of Juan de Fuca IMW, 3 streams, and Lower Columbia IM, 3 streams that focus on coho, steelhead, and cutthroat monitoring; and two larger basins that focus on Chinook in the Skagit and Wenatchee.

Hydraulic permit compliance monitoring (HPA) – Department of Fish and Wildlife (WDFW)

The purpose of the monitoring program is to determine if persons working within the waters of the state are in compliance with the provisions of their permit and have implemented the project as designed and approved. The program protects stream riparian zones and instream habitat. The HPA

program protects fish and fish habitat. Thousands of HPAs are issued annually in Washington for work that impacts habitat. Database contains permit information (http://wdfw.wa.gov/licensing/hpa/).

Washington Department of Transportation

Conservation Districts

Northwest Water Quality Exchange

Contact: John Tooley ECY

Counties, Cities and Local Jurisdictions

Many local jurisdictions collect ambient data on water resources. A brief summary of some of the data collected is provided in Appendix 1. Jurisdictions collect data in support of basin planning, to comply with Clean Water Act monitoring requirements, to protect public health beneficial uses (such as shell fishing and swimming), and to communicate resource condition to planners and stakeholders.

Watershed Monitoring for Salmon Recovery

In WRIA 8, a probabilistic design was used to select ~60 sample sites were sampled each year from 2010 to 2012 to evaluate the impact of restoration and management actions in the watershed. Benthic invertebrates, fish, temperature, and habitat data are collected at every site; flow is collected at a subset of sites.

For WRIA 7, water quality data was summarized from local jurisdictions to create a watershed-scale assessment. *Snoqualmie Watershed Water Quality Synthesis Report, 2009* http://www.govlink.org/watersheds/7/plans-studies/water_quality_synthesis_report.aspx.

Other WRIAs collect data related to a variety of projects. Monitoring is typically not coordinated across WRIAs.

Puget Sound Stream Benthos (PSSB), King County

Invertebrate samples collected from stream benthos are uploaded by >20 entities in Puget Sound and the Dept of Ecology. Data are publicly available and downloadable data include lists and abundances of invertebrate taxa and total B-IBI scores and individual metric scores. The data can be uploaded from PSSB to Ecology's EIM database and used in Ecology's Water Quality Assessment process for defining the 303d list of impaired state waters. King County maintains the database which is freely available on the web; participants pay a fee for data management. Data date to 1994 for some projects, but most data are from 2005 to present.

Laboratory Information Management System (LIMS)

LIMS is used by King County (and other jurisdictions?) to manage water quality and toxics data. Data are uploaded in support of CWA listing requirements every four years and are not publicly available. For King Co, most of these data end up in EIM.

Road Services Division Monitoring Program, King County

The King County Road Services Division conducts field studies before, during, and after road projects. They monitor water quality, macroinvertebrates, and habitat condition within the road right of way. All of the monitoring is required to meet various state, federal and local permits. Invertebrate monitoring no longer happening.

Water supply projects

Prioritizing Monitoring Needs based on Conceptual Model(s)

PSEMP Work Groups have been asked by the PSEMP Steering Committee to prioritize monitoring needs. As a first step, the Freshwater Work Group has identified data gaps, gaps in the analysis of existing data, and gaps in the statistical design for data collection for the Vital Signs Indicators. Data gaps also exist for other freshwater resources such as lakes, groundwater and water supply, all of which are critical for supporting human health and well-being as well as wildlife.

Work Group members have asked which criteria should be used in the prioritization process. Using a conceptual model has been proposed as an approach to prioritization; this work is ongoing. Examples of conceptual models include Open Standards, DPSIR, and the Water Cycle. PSEMP Steering Committee will provide additional guidance to Work Groups on how to approach prioritization in early 2013.

Outstanding Issues from Freshwater Work Group

The following questions are posed to the PSEMP Steering Committee. The Freshwater Work Group is interested in consulting with the SC on these issues to better guide our activities in the coming months.

- What are the priority questions for freshwater? Are they only those specified in the current Action Agenda?
- What are goals of the PSEMP monitoring program? What questions should we be answering to facilitate Puget Sound recovery?
- What is PSP/PSEMP guidance to workgroups about adaptive management? What decision makers are we supporting? What types of decisions are being supported and on what time frames?
- Fork in the road: Do we need more data for indicators, or, do we need to develop different indicators? Second fork in the road: Do we need new data or do we need time to interpret data we have?
- Should additional indicators be focused on the condition of the resource or the pressures on the resource, or both?

References

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PSEMP (Puget Sound Ecological Monitoring Program). 2011. Steering Committee Guidance to Workgroups: March-December, 2012. https://sites.google.com/a/psemp.org/psemp/home/workplan-and-guidance.

Appendix 1. Active, salmon-related monitoring programs in Puget Sound basin.

Name of monitoring program, geographic location of data collected, description of the sample design and objectives, location of data, and types of data collected or index calculated (and protocol used). Information derived from interviews conducted by Bruce Crawford (NOAA) during Summer 2012. Primary purpose of interviews was to assess regional salmonid monitoring, therefore, monitoring information is not necessarily complete for all data and all programs.

Monitoring Entity	Location	Sample design and objectives	Data housed here	Data collected
WA Department of Ecology Long term Freshwater River and Stream Ambient Monitoring Program	WRIA 1-19	Assesses water quality at selected non-random river and stream sites throughout Puget Sound	WA Ecology	Monthly FC, temp, pH, oxygen, percent oxygen saturation, TSS, turbidity, nutrients (5), and conductivity, and WQI
WA Department of Ecology Stream Flow Monitoring Program	WRIA 1-19	Measures stream flow and specific sites throughout the Puget Sound basin	WA Ecology	pH (AREMP), Do, P, N, CI, sed. Contam., flow, fish, phab
WA Department of Ecology and Department of Fish and Wildlife Toxic Pollution Studies	WRIA 1-19	Monitor and assess water, sediment, soil, and fish/shellfish tissue in Puget Sound basin to determine toxic burdens		
USGS Washington Water Science Center Stream gauging	WRIA 1-19	Collects compiles and publishes stream discharge from gauging stations located throughout Puget Sound	USGS NWIS	river or lake stage, stream discharge; temperature, turbidity, continuous water quality (selected sites)
USGS Washington Water Science Center—groundwater levels	Various WRIAs	WRIA or smaller scale networks of 50-150 wells operated for 2-5 years designed to characterize groundwater availability for people and ecosystems.	USGS NWIS	Groundwater levels
Puget Sound Stream Benthos (PSSB)	Various	Regional data contributed by >20 jurisdictions and tribes	King County	B-IBI
Kitsap County	WRIA 15	54 BIBI sites, 25 annually; 50 sites on 31 streams monthly for fecal coliform, >600 fecal samples annually in clean up areas; 9 major stream continuous flow gages; 3-6 lakes for nutrients on a rotating annual basis, 28 stations at 17 lakes for E. coli and toxic algae.		B-IBI
Jefferson County	Monitor WQ in		WA Ecology	B-IBI

Conservation District	east Jefferson County			
City of Port Townsend		Watershed Monitoring and Monitor WQ in water supply		pH (AREMP)
City of Arlington	Portage and Prairie Creeks (trib)	Water quality monitoring		flow, DO, Temp, Conductivity
Stillaguamish Tribe	WRIA 14-17	Water quality monitoring program to create a baseline for trend and restoration effectiveness, Don Kopfer		Inverts (TFW) pH (TFW)
Snohomish County Surface Water Management Water Quality Ambient Monitoring	WRIA 5, 7, 8	March 2012 began monthly water quality monitoring at 41 sites on 30 streams and rivers in the county	Ecology EIM	Grab sampling DO, Cont Temp, pH, Fecal Coliform, Turbidity, Conductivity, TSS, NO Nutrients (collected from 1995 – 2009 at various sites), NO Copper or Zinc (collected from 1995 – 2009 at various sites)
Snohomish County Surface Water Management BIBI Monitoring Program	WRIA 5,7,8	Rotating basin sampling scheme w/ 15 fixed locations and 15 random locations (each monitoring episode)	Snohomish County, recent data in PSSB	B-IBI, No stream flow, No DO, No Temp, No pH, No Fecal Coliform, No Turbidity, No COND, No TSS, No Nutrients, No Copper, Zinc, No PCB, PBT
King County Road Maintenance		Monitors water quality, macroinvertebrates, and habitat conditions within the road right of way in unincorporated King County. Project related to permit requirements	Inverts to PSSB; WA Ecology	B-IBI (program cut in 2011)
City of Lake Forrest Park	McAleer and Lyon Creeks, WRIA 15	Streamkeepers Volunteer stream monitoring. Quarterly monitoring	PSSB	physical conditions, temperature, pH, DO, turbidity, B-IBI DO, Temp
City of University Place	Leach Creek and Chambers Creek in Pierce county		WA Ecology	B-IBI
Thurston County Surface Water Quality		Collects some surface water chemistry and data specific to grant requirements		pH (AREMP)
Thurston County Environmental Health Division Surface WQ ambient monitoring program	Streams and lakes in Thurston County	Used for status/trends		B-IBI, Stormwater flows, DO pH, Fecal Coliform, Turbidity, Nutrients, Copper, Zinc

City of Lacey	Woodland Creek	Complements monitoring by Thurston County		Monthly monitoring of flow, pH, temperature, DO, conductivity, turbidity, coliform, nitrate, nitrite. Also Copper, Zinc
City of Olympia	WRIA 7	Conduct ambient monitoring of surface and ground waters		
Thurston County Basin Monitoring Program	Basins in county	Precipitation, stream flows, and groundwater monitoring		
Snohomish Conservation District		Riley Slough Water Quality Monitoring Project		
City of Redmond		Monitoring of stormwater and flow, benthic and water quality. Daren Baysinger	WA Ecology	B-IBI
City of Auburn		Water quality of water resources, stormwater and drinking water		pH (AREMP)
City of DesMoines	Des Moines, Massey, Barnes, and McSorley Creeks	New 5-year monitoring program testing normal flows and storm flows to develop a baseline for WQ monitoring		B-IBI, Stormwater flows, DO, fecal coliform, nutrients, turbidity
City of Normandy Park	Miller, Walker, and DesMoines creeks, WRIA 14-17	Monitoring WQ		DO, Temperature, pH, Turbidity Copper, Zinc
US Coast Guard Benchmark NPDES Monitoring Program	WRIA 7	Monitor stormwater runoff from Piers 36 and 37 in Seattle		
City of Bremerton	Port Washington narrows, Anderson Cr, Gorst Cr. And Union River	Compliance with regulations related to waters system development		Fresh WQ, groundwater, and marine estuarine and nearshore WQ
Pierce County Surface Water Mngmnt	26 basins in County	Monitoring flow and water quality and salmonid passage.		B-IBI
NWIFC water quality data exchange network	WRIA 1-19	Tribal water quality data part of NW Data Exchange Network	WA Ecology	B-IBI
SWAMPPS Regional	Puget Sound Watershed	Monitoring will include status and trends, effectiveness studies, and	WA Ecology	Mussel Watch, B-IBI,

Stowmater Monitoring Plan (RSMP)		source control. Technical assistance for the SWG Effectiveness Study Selection Subgroup to (1) synthesize information from the literature review for the highest-ranked topics in a format that is useful to local governments and (2) identify gaps to address in RSMP studies (~ $40-75K)		
King County Long Term WQ Monitoring	WRIA 7-9	Non-random sites chosen for major tributaries and incoming waters		WQ (monthly); B-IBI (WRIAs 8 & 9), temperature, conductivity, and others
King Co Lakes				Phytoplankton and zooplankton data fofr Lakes WA and Sammamish