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Addendum: RSMP Streams QAPP

Quality Assurance Project Plan for Status and Trends Monitoring of Small Streams in the Puget Lowland Ecoregion Monitoring

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Introduction

This addendum describes the priority questions, approaches for data assessment, and intended reporting outcomes for the Regional Stormwater Monitoring Program (RSMP) small Puget lowland streams status and trends 2015 monitoring effort. This document is an addendum to the *Quality Assurance Project Plan for Status and Trends Monitoring of Small Streams in the Puget Lowland Ecoregion Monitoring Conducted using Pooled RSMP Funds contributed by Western Washington Municipal Stormwater Permittees* (RSMP Small streams QAPP) (Lubliner, 2014), that had only briefly discussed the data analysis and reporting goals under the section heading on page 53 "Data Analysis and RSMP Small Streams Final Report". This addendum also provides corrections to the RSMP Small streams QAPP, which are described in detail in the last section of this document.

RSMP Puget Lowland Ecoregion Small Streams Data Analysis

The Stormwater Work Group (SWG) convened a subcommittee to develop an addendum to the monitoring QAPP that would describe the approach to data assessment and reporting for answering priority questions for the analysis and interpretation of the RSMP small streams data. These are the priority questions:

Q1:	What percent of streams meet biological, water, and sediment quality standards for beneficial uses within and outside Urban Growth Areas (UGAs)?
Q2:	What natural variables correlate with the status of streams within and outside UGAs?
Q3:	What human variables correlate with the status of streams within and outside UGAs?
Q4:	How does RSMP compare with other monitoring programs in Puget Sound?
Q5:	What water, sediment, biological, and habitat parameters should be carried forward for trend assessment of RSMP stream monitoring in the future, and at what timing and frequency?
Q6:	How does RSMP status and trends monitoring relate to effectiveness monitoring and source control?

Status assessment

Question 1: "What percent of streams meet biological, water, and sediment quality standards for beneficial uses within and outside UGAs?", is the primary status assessment question. To address this question, a regional status evaluation of water, sediment and biological quality will be made for the Puget lowland ecoregion as a whole, and for each assessment strata: within UGAs (WUGA), and outside UGAs (OUGA). The RSMP is monitoring small streams in the Puget Lowlands for monthly water quality and instantaneous discharge and a one-time summer collection of benthic macroinvertebrates, habitat, periphyton and sediment chemistry, spanning the 2015 calendar year. RSMP sites were randomly selected using a Generalized Random Tessellation Stratified (GRTS) survey design from the EPA generated Washington State-Wide Master Sample (Olsen, 2006) , the

details of which can be found on the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) website. The primary reason a randomized study design was selected for the RSMP small streams was to allow for a regional summary assessment of stream condition.

A series of data analysis steps, described below, will answer this top priority question with the data collected for the RSMP small streams effort in 2015.

Relative weights in probabilistic designs

Beyond data quality control (QC) review and verification described in the small streams QAPP, one of the first steps in preparing the data for a regional assessment is to determine the relative weighting of the sampled sites in the context of available sites within the ecoregion. This is called *weighting*. Specifically, weighting will determine the length of stream miles sampled (sample population) out of the total stream miles that also fit the selection criteria (total population). Once the weight of each RSMP small stream monitoring site is determined, the status assessments can be made for each strata and the ecoregion. Status assessment methods are available from EPA's National Wadeable streams report (EPA, 2006), Ecology's Watershed Health Monitoring program (Merritt and Hartman, 2012), and King County's Cedar River (WRIA 8) Status and Trends Assessment (King County, 2015).

Comparison to water quality metrics and standards

Water, sediment and benthic macroinvertebrate data will be used to answer the first question on the status of streams meeting numeric freshwater and sediment Washington state criteria (WAC 173-201A; WAC 173-204-563). This data will be compared at both the individual stream level and "rolled-up" as a categorical group for the assessment strata (within and outside UGAs). Where various designated beneficial uses have multiple water quality standards (e.g. temperature), the analysis will not be done at the reach level, but rather summarized to tell the broader story.

A Water Quality Index (WQI) score (Hallock, 2002) will be calculated at each water quality site. The WQI is typically based on a 5-year moving average, where a value of 80 or greater is considered to meet water quality standards. However, most of these RSMP small stream sites will have only one year of data. Because the RSMP small stream sites will have a short record, the WQI will be calculated using existing standard flow curves where available from state or local governments.

Understanding status assessment scores

Questions 2 and 3: "What natural (Q2) and human (Q3) variables correlate with the status of streams within and outside UGAs?", specifically address our desire to learn more than just the assessment score itself. The analysis will investigate what natural and human activity "predictor variables" help explain the scores found at the RSMP small stream sites. Additional data will be gathered and correlated to the RSMP small streams water and biological quality response variables.

Local studies looked at natural and human activity predictor variables. This effort will build on findings of the recent Cedar River (WRIA 8) Status and Trends assessment (King County, 2015); the stormwater retrofit planning project in the Green River (WRIA 9) (http://www.kingcounty.gov/services/environment/watersheds/green-river/stormwater-retrofit-project.aspx); and several others (May et al., 1997; DeGasperi et al., 2009; King County, 2014). Natural predictor variables will include geomorphology, recent climate, flow characteristics, basin size, substrate, habitat metrics, position in the watershed, riparian and forest cover, and likely others. Human activity predictor variables may include land use or land cover (impervious area or road

density) and other readily available, relevant types of data. The available data sets are listed in Table 1. For this effort we will capitalize on previous local efforts to identify key "predictor" variables.

Advanced statistical approaches to evaluate correlations between predictor and response variables will be employed (e.g., relative and attributable risk, or boosted regression trees) for the identified key variables. Correlations for periphyton and additional water or sediment quality variables or use of ancillary data sets will be completed as time and resources allow. Data analysis tools will include the use of R stats, Access, Excel, or other programs to produce summary statistics, graphics (boxplots, charts), and tables.

Table 1. Geographic data sets available for post-stratification analysis

GIS Data Type	Source	Water Qa/Qx	Sediment quality	Biological quality
General geographic info: basin areas, NHD HiRes, REV100kStrahler, salmon regions, ecoregions, cities, gages, permit coverage, water quality assessment areas	Ecology, USGS	x	x	x
Land use/Land Cover: standard categories	National Land Cover Database 2011, Ecology, USGS	x	x	x
Road use density (AADT), stream crossings	Ecology, WSDOT, Counties	x	x	x
Wetlands		x	x	x

NHD = National Hydrography Database
AADT = Annual average daily traffic
Qa/Qx = water quality and water quantity

Comparison to other stream monitoring programs

The purpose of Question 4: "How does RSMP compare with other monitoring programs in Puget Sound?" is to inform future rounds of RSMP sampling and identify efficiencies to be gained in partnering with other monitoring programs.

Programs in Puget Sound using randomized site selection designs

RSMP small streams sites were chosen from the Washington State Master Sample which was created using EPA's generalized random-tesselation stratified (GRTS) design. In the Pacific Northwest, there are several other stream-monitoring programs that use the same randomized study design. Monitoring data can be easily compared among these programs, given there is overlapping geographic domains, and the programs used the same protocols (Larsen, et al. 2007). The SWG and the Freshwater Workgroup (FWG), both committees of the Puget Sound Ecosystem Monitoring Program (PSEMP), recommend comparing results of the RSMP small streams data to the top three existing probabilistic monitoring programs in the following list:

- *Pierce County's Stream Monitoring Program*, which collects small stream data in an identical manner as RSMP streams as a Phase I municipal permit requirement. Site selection was from the same Master Sample but filtered for sites within un-incorporated Pierce County. Therefore, results apply to their jurisdiction.
- *City of Redmond Stream Monitoring Program*, which collects small stream data in an identical manner as RSMP streams as a Phase I municipal permit requirement. Site selection was from the same Master Sample but filtered for sites within the city of Redmond city limits and only include sites in the UGA. Therefore, results apply to their jurisdiction.
- *Ecology's Watershed Health Monitoring Program*, which has strata for Puget, cascades, lower Columbia, Walla Walla, and eastern WA plains ecoregions. Only the Puget region could be compared to the RSMP lowland streams data. However, there is a unique subset of Ecology's sites called the sentinel and reference sites that are sampled annually. These sites are important for the RSMP analysis as they will help quantify inter-annual variability.

Programs outside Puget Sound using randomized site selection designs

The recommendations for future RSMP stream sampling (Question 5) that will come out of the answer to Question 4 will also be informed by looking at key programs outside of Puget Sound. The SWG and FWG also recommend learning from other programs, and in particular the first program in the list below:

- *Lower Columbia Habitat Status and Trends Monitoring* (LC HSTM) is a coordinated monitoring program under development in the Lower Columbia ecoregion of Washington State. The sites to be monitored to answer stormwater-related status and trends assessment questions came from the master sample framework, but with basin drainage area criteria applied to screen sites for suitability under this program (Stillwater 2015). No data have yet been collected; however, a comparison with and consideration of the LC HSTM study design, and in particular (1) the site selection and confirmation approach, and (2) the selected indicators, will inform recommendations for future RSMP stream monitoring.
- *Other States* probabilistic programs are available for 13 states (Arizona, California, Florida, Iowa, Kansas, Missouri, New Hampshire, New Jersey, South Carolina, South Dakota, Tennessee, Vermont, Wyoming) http://ofmpub.epa.gov/waters10/attains_status.state_status. Comparison with these programs may also be considered for further analysis.

Initial steps to compare probabilistic monitoring programs will include a high-level comparison of site selection methods and sampling protocols. Where found comparable, the data from RSMP small streams can be compared to the previously listed programs, or the data combined to extend the time range and investigate similarities or differences in the data sets. The Pacific Northwest Aquatic Monitoring Partnership (PNAMP) Monitoring Resources tool will be used to store and compare RSMP methods, protocols, and site design to other programs (https://www.monitoringresources.org/).

For example, this analysis will also allow us to compare the status of streams in the Puget Sound Lowland ecoregion, both within and outside UGAs, to Ecology's sentinel and reference site results. This will provide a meaningful assessment of change over very long timeframes, and the ultimate gage of impact due to cumulative long-term pressures such as climate and land use changes in the last 100 years. Another intended evaluation between these programs is to evaluate if as a region we can

combine our data, cooperate for more efficient monitoring, and share data among agencies and programs.

Programs in Puget Sound using targeted site selection designs

RSMP small streams monitoring randomized design was chosen so that the results represent the entire Puget Lowlands ecoregion and the lowlands portion of the Puget Sound Salmon Recovery Region. Targeted (non-randomized) stream monitoring programs also exist in this same region, and the comparability of these programs to the RSMP is unknown. Some local jurisdictions collect extensive stream datasets, and in terms of methods and protocols may be very similar to the RSMP.

Primary data sources for comparison of targeted monitoring programs to the RSMP will be Puget Sound counties and cities. An evaluation of the comparability or usability of larger-scale targeted stream monitoring programs will be conducted within a reasonable effort and given the resources available. Water quality, benthos, or sediment data from a select set of Puget Sound cities' and counties' targeted stream monitoring programs will be solicited, and if provided in compatible formats, compared to the RSMP stream data if time and resources allow.

The approach to the analysis is to create four groups within UGA, outside UGA, and a random versus targeted data set. Key response metrics, including benthos and selected water quality and sediment quality variables, will be compared for each of the four groups. Correlations with predictor variables identified in Q2 and Q3, as well as with seasonality, will be evaluated as time and resources allow.

Comparison to a status and trend effectiveness monitoring program design

The city of Redmond developed a study design for long-term monitoring of urban watersheds to assess the effectiveness of intensive stormwater system retrofits and in-stream restoration at improving key indicators of stream health. We will review the study design and consider their metrics and approach in making recommendations for future RSMP stream monitoring.

Trend monitoring recommendations for RSMP small streams

Question 5 is "What water, sediment, biological, and habitat parameters should be carried forward for trend assessment of RSMP stream monitoring in the future, and at what timing and frequency?" The 2015 RSMP small streams data collection effort captures a wide range of parameters. The SWG seeks feedback on what are the recommended adaptive management changes to and targeted focus of the streams monitoring effort to become more relevant, efficient and purposeful in answering stormwater management impact questions.

In particular, results from comparisons to standards, relative risk/attributable risk effort, signal to noise analyses, and comparisons to other probabilistic or targeted programs will be discussed. The goal will be to discern valuable parameters for the future RSMP small streams trend program. Recommendations for parameters, and also frequency of the various RSMP small stream monitoring components (flow, bug, water quality, sediment quality), will be made to both the Stormwater Work Group and Freshwater Work Group.

One such area of focus is flow characteristics. The report will highlight this data element, characterize what is collected in RSMP small streams and compare that to what other flow data exists. The recent USGS lowland stream gaging reports (Konrad and Voss, 2012 and Konrad and Sevier, 2014) identified all gages in the Puget Lowlands. Where possible, the report will provide recommendations on improving the flow variable usefulness for the next round of small streams monitoring.

Relating status and trends to effectiveness monitoring and source control

The purpose of Q6: "How does RSMP status and trends monitoring relate to effectiveness monitoring and source control?" is to reflect back on the overall scientific framework for the RSMP and connect the results and findings of the separately implemented RSMP components. This task question is not yet scoped for contracting, but the intent is described here for a future effort.

Citizens and governments residing in the Puget Lowlands ecoregion employ a myriad of efforts to identify and eliminate pollutants, restore and enhance habitat, and reduce stormwater impacts to receiving waters. It is generally agreed that, collectively, these actions should have a positive impact on water and habitat quality and on the status and trends results at the RSMP stream monitoring locations.

However, it is unknown how informative tracking and inventorying these actions within the immediate drainage area to RSMP stream monitoring sites can be to interpreting status and trends assessment results. Conversely, it is unknown how much regional status and trends can inform adaptive management strategies at the local level. A more in-depth effort to understand effectiveness of stormwater, source control, or restoration activities at small sub-basin scales may be plausible with multiple sources of data including RSMP stream results.

The following approach may be used to help understand or explain results from the RSMP results, given as time and resources allow.

1. Conduct a discovery survey of existing data related to implementation and monitoring of restoration and management actions. The goal is to assess which of these actions are tracked and whether they are tracked in a format that can be used by RSMP (e.g., using a spreadsheet, database, or GIS). This task could be a survey to Ecology, municipalities and other agencies.

2. Match restoration and management actions to potential data sources with relevant information to assess the implementation, scale, local effectiveness, and regional effectiveness of the actions. The outcome would be an understanding of what are the major types of actions being implemented to reduce the impacts of stormwater. Note, such a list or summary may already exist; members of the SWG should be queried first about summary information before conducting a broader summary. Primarily these actions include source control actions, municipal stormwater/sanitary sewer system actions, BMP implementation projects, and restoration activities in areas that have before and after sampling form the RSMP status and trends program or other monitoring programs (Table 2).

3. There is a potential to conduct a risk assessment to identify key parameters and corresponding actions that are useful for informing local adaptive management. EPA developed a statistical

method for ranking the relative risk associated with various stressors, using probabilistic sampling data. King County has applied this approach to evaluate relative risks to stream invertebrates of various regional stressors. This analysis should be taken further to evaluate the primary stressors to a variety of endpoints we care about, e.g., stream invertebrates, mussels, and fish. These data are available but have not been analyzed in this way, and would provide insight into where we should focus, or management actions and evaluate their impact.

4. As data and results from RSMP effectiveness studies become available, the relevance of local studies need to be made relevant to the regional recovery effort. Depending on the study, some modeling of potential impact may be needed. Results from studies and regional modeling need to be summarized and communicated to people making decisions on related topics.

5. A process to develop logic models will be needed to refine our questions for monitoring. The goal for monitoring is to connect actions to outcomes and identify what is known, what is not known, and what we can measure at each step from implementation of actions, to reduction of environmental pressures, to recovery of biological endpoints. Any outcomes need to be carefully vetted by municipalities to ensure that the questions asked are relevant to their work. For example, tracking a variable we cannot change is not helpful; in contrast, determining which actions are most cost effective at a regional scale is helpful.

Table 2. Ancillary data sets that may be needed for relational analysis

Other relevant stream monitoring	Source Control Actions	Municipal Stormwater/Sanitary Sewer Actions	Restoration Actions
Environmental Groups (Ex Stream Team)	Industrial, commercial, agricultural, and residential inspections/technical assistance	MS4 cleaning and vactoring, street/parking lot sweeping, pond maintenance, treatment and flow control inspections, ditch maintenance, road repair	Stream habitat restorations and enhancements
Local land trusts	Confirmed toxic spills (toxic cleanup)	IDDE: spills/illicit connections that resulted in a discharge to a receiving water (S4F notification)	Culvert replacement/removal/ drainage improvements
Watershed Councils	Confirmed Failed Septic Systems (replacement or maintenance)	ERTS: spills that resulted in a discharge to a receiving water	MS4 Retrofits (including LID)
Citizen science	Confirmed food/haz waste handling violations (corrections)	CSOs	BMP effectiveness monitoring (inside and outside RSMP)

Other relevant stream monitoring	Source Control Actions	Municipal Stormwater/Sanitary Sewer Actions	Restoration Actions
Local Health Districts and Washington Dept. of Health			

Reporting and Communication Strategy

The technical analytical team for Questions number 1 through 5 will be made up of experts at the U.S. Geological Survey, Ecology, King County and the Puget Sound Partnership. A series of communication products (presentations, short summaries, and factsheets for each question) will be developed to communicate among team members, between agencies and for the PSEMP workgroups (particularly SWG and FWG). These products will present findings as they relate to the five priority questions introduced at the beginning of this addendum. A final technical report will be prepared by the team members.

Corrections to the RSMP Smalls Streams QAPP

This section describes corrections or updates to the RSMP Small streams QAPP (Lubliner, 2014).

Item	Location	Notes for correction
1	Throughout	The URL for the RSMP website was updated to www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/status.html
2	Pg 11	Amend the first sentence of the 4th paragraph on the page. The sentence will now read: "Candidate sites for evaluation were selected from the Master Sample Sites list generated for the EPA 'Puget Lowland' ecoregion streams that are also contained within the 'Puget Sound' salmon recovery region."
3	Pg. 14 and 15	Update the titles of Table 3 and Figure 1 to read "candidate sites" in place of "sites".
4	Pg 14-21	The list of sites in Tables 3, 4, and 5 and Figure 1 sampled for water quality and watershed health have changed slightly due to permissions or suitability conditions (e.g. dry in the summer). For the most up to date lists of sites check the RSMP Website.
5	Pg 25	The protocol for cleaning sediment sampling equipment is amended for step #3 to allow for the use of 5%HCl or 10% nitric acid; and step #6 to allow for Rinsing with pesticide-grade acetone or methanol.
6	Pg 27	Table 8, Amend the TOC entry to add "(both sieved fractions)".

Item	Location	Notes for correction
7	Pg 27	Table 8. Amend the title of the table to be "Chemistry Parameters for watershed health monitoring" and add a series of rows to include the water parameters.

Water Parameters
Dissolved oxygen (by meter)
pH (by meter)
Conductance (by meter)
Temperature (by meter)
Chloride
Total nitrogen
Total phosphorus
Total suspended solids

8	Pg 33	Table 14. Chlorophyll A will be replicated in the field 10% of the total samples as well.
9	Appendix A	Assumptions underlying the design section should also contain the following information on the data layers used to select for the RSMP small stream sites. Added text:

> Each of the 387,237 points contained in the study areas on the Washington Master Sample shapefile (http://www.ecy.wa.gov/services/gis/data/enviro/mastersample.htm) was evaluated to generate a list of candidate sampling sites within the assessment regions. Master sample sites were statistically chosen from the lines on a 1:24,000-scale hydrography frame (*WDNR watercourses, February 2005).*
>
> The final assessment area was determined by three geographic areas in the Puget Sound watershed. The first was the EPA Ecoregion level III designated as the "Puget Sound" ecoregion. The second was the Washington State Salmon Recover Region designated as "Puget Sound". The RSMP small stream sites are those Master Sample sites that were contained by both the Puget Lowlands Ecoregion within the Puget Sound Salmon Recovery Region (PLSRR). The two evaluation strata for the RSMP small streams monitoring design are the PLSRR stream reaches that fall *within* and *outside* of the designated Urban Growth Areas as defined by the Growth Management Act. The sources of the geographic information used include:
>
> - www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm#Level%20III
> - www.rco.wa.gov/salmon_recovery/regions/regional_orgs_map.shtml
> - http://www.ecy.wa.gov/services/gis/data/data.htm

All three layers (Ecoregion, Salmon Recovery and UGA) are available from Ecology's GIS and were used for the RSMP small streams list.

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