Quality Assurance Project Plan

Status and Trends Monitoring of Small Streams in the Puget Lowland Ecoregion for Stormwater Action Monitoring (SAM)

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June, 2020

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2.0 Abstract

This Quality Assurance Project Plan (QAPP) details a long term status and trends monitoring study for small streams in the Puget Lowland as part of Stormwater Action Monitoring (SAM) program. SAM is the regional stormwater monitoring program funded by the Phase I Municipal Stormwater permit and the Western Washington Phase II Municipal Stormwater permit permittees.

This study of small streams in the Puget Lowland Ecoregion (called Puget Small Streams, PSS study, or SAM_PSS study hereafter) is designed to answer the question, "Are regional conditions in receiving water quality and biota improving in concert with broad implementation of required stormwater management practices?"

In 2015, the first round of monitoring evaluated the condition (status) of streams (DeGasperi et al., 2018). Beginning in 2020 and thereafter this study will monitor streams' changes over time in urban, urbanizing and rural areas of the Puget Lowland.

The PSS study design is a random probabilistic survey design, like the previous monitoring in 2015, with some design adjustments to increase statistical power and monitoring efficiency. Beginning in 2020, the core monitoring design has been adjusted as follows:

- Candidate sampling sites (master points) in the Puget Lowland ecoregion have been redrawn using updated high-resolution National Hydrography Dataset (NHD) layer.
- The study area is stratified into four different groups(strata) by percent impervious surfaces cover of contributing watershed to each master point. Sampling sites are selected per each impervious strata separately.
- Sampling will be conducted every year at selected sites. Selected 33 sites each year will be a combination of new and revisited sites to improve status assessment and trend detection power.
- Sampling will be conducted once in summer, which focuses on Watershed Health monitoring with key sediment and water quality parameters.
- Reference condition sites will be monitored every year to establish a better comparison of the results from the annual sampling sites to a ' least disturbed' condition.
- Water level (stage) of each sampling site will be monitored continuously for one water year prior to the summer sampling event.

The PSS will follow the protocols developed for the on-going statewide stream health monitoring program-Status and Trends Monitoring for Watershed Health and Salmon Recovery (WHSR) for physical habitat, biological measurements, except for minor changes to water quality parameters to better capture the stormwater-related chemistry signals. In addition this effort will sample sieved sediments for stormwater-related chemistry signals.

This QAPP ensures quality data collection, analysis, reporting and management of the SAM PSS monitoring study.

3.0 Background

3.1 Introduction

The Phase I Municipal Stormwater permit and the Western Washington Phase II Municipal Stormwater permit, S8. Monitoring and Assessment provides an option for the permittees to commit financially to a collaborative regional stormwater monitoring program (Stormwater Action Monitoring, SAM) to satisfy the permit monitoring requirements. SAM has three focus areas for monitoring: effectiveness studies, source identification projects, and status and trend monitoring of receiving waters of small streams and the marine nearshore.

The purpose of the status and trend monitoring is to answer the question: "Are receiving water quality and biota getting better or worse in response to continuous stormwater discharge and broad implementation of required stormwater management practices?"

Urban development and subsequent stormwater discharge can drastically alter watershed and in-stream physical habitat, stream channels, flow patterns and water chemistry. To date, urban development has resulted, in differing degrees, in degraded conditions of streams in urban or urbanizing areas. The impacts of stormwater on receiving waters in Western Washington vary geographically due to differences in local landuse, watershed forested condition, hydrologic patterns, use of stormwater infrastructure, existing condition, and type of receiving waters.

This monitoring aims to assess unbiased regional status and trends of streams and to identify key stressors driving good or poor stream health across the region. This study will therefore provide feedback and guidance to permittees and the region to improve stormwater management and protect receiving water.

3.2 Study area and surroundings

3.2.1 History of study area

Western Washington, particularly the Puget Lowland ecoregion is experiencing increased human population pressure, landuse changes, and urban development. The Phase I and II municipal stormwater permits (including WSDOT) require flow control and treatment for new and re-development to reduce stormwater runoff and pollutants to receiving waters. Other permit requirements aim to find and control sources of pollutants to the stormwater system. By implementing multiple stormwater management activities, Ecology and the permittees are attempting to reduce stormwater impacts. The Puget Lowland ecoregion captures much of the urban and urbanizing areas within Phase I and II western Washington coverage and is the focus area of this study (Figure 1 and Figure 2). Another small stream status and trend study is being developed for southwest, Lower Columbia River region of Washington that covers the other Phase I and II western Washington permittees.

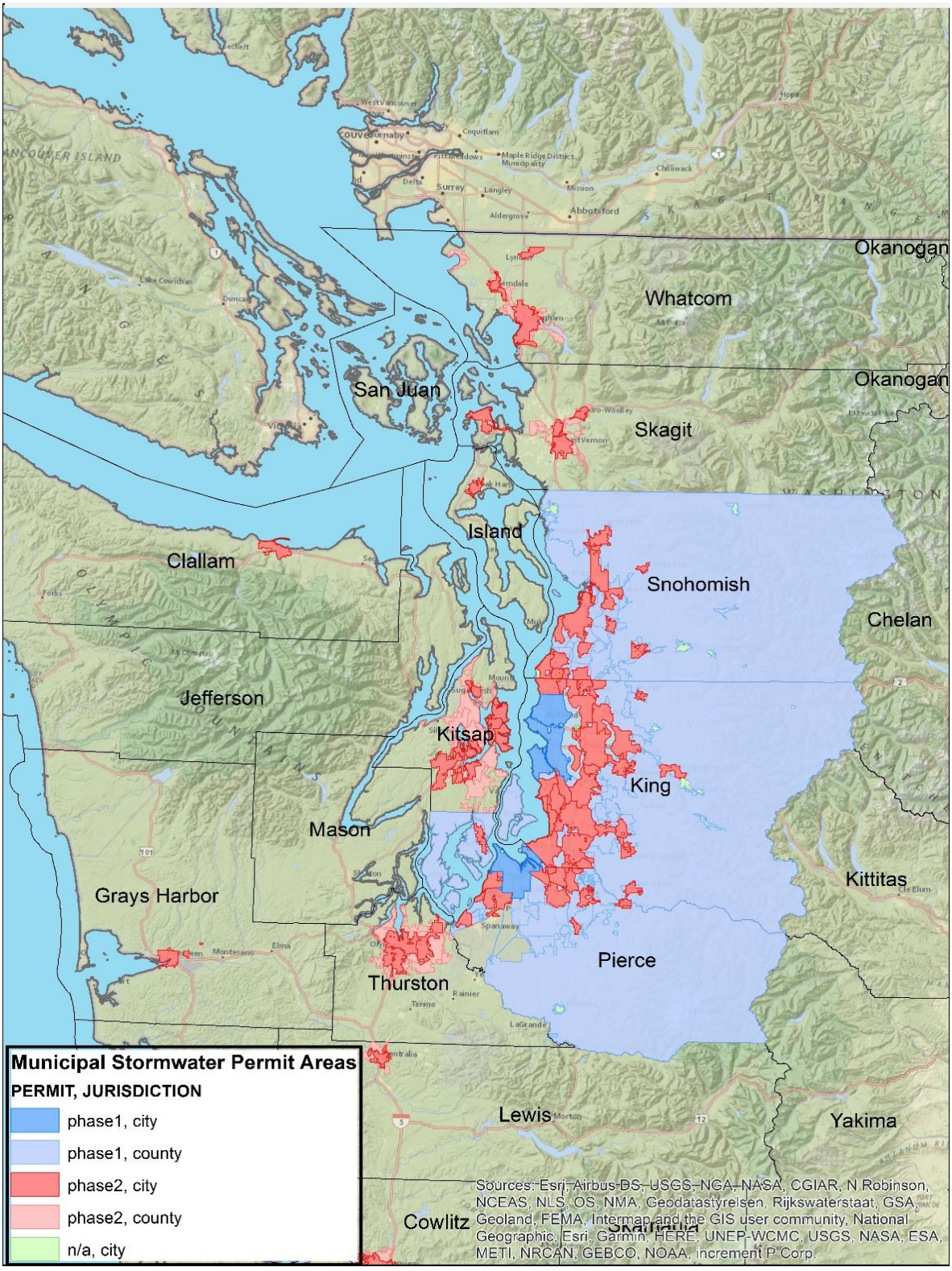

Figure 1. Western Washington Municipal Permit Areas within Puget Sound region

3.2.2 Summary of previous studies and existing data

Under the 2007-2012 Phase I Municipal Stormwater Permit, six permittees and their co-permittees were required to characterize the stormwater quality and quantity from representative municipal stormwater discharges from three urban land uses (commercial, residential and industrial) (Hobbs et al., 2015). The compiled data findings reported high frequencies of detection of conventional parameters, including TSS and nutrients, metals (except mercury), total PAHs, PCB and Bis(2-ethylhexyl) phthalate. Most parameters showed significant concentration differences between those land uses and seasonality with higher concentrations during the dry season (May to September) (Hobbs et al., 2015).

The first year of stream monitoring in 2015 was conducted using a stratified design on inside or outside the Urban Growth Area (UGA) (Lubliner, 2014). In 2015, 105 sites were sampled, representing a total of 1,668 miles (2,685 kilometers) of wadeable streams in the Puget Lowland ecoregion. This first status assessment found that over 80% of the Puget Lowland streams within the UGA had poor stream biological health, indicated by benthic invertebrate index of biotic integrity (B-IBI), a comprehensive stream health indicator. Key stressors driving poor B-IBI scores included watershed-scale tree canopy, riparian scale tree canopy, sediment metal (zinc) concentration, and stream substrate characteristics (DeGasperi et al., 2018).

3.3 Parameters of interest and potential sources

This study monitors stormwater-related parameters and potential indicators or stressors to stream health (Table 1). That includes water and sediment quality, physical stream habitat characteristics, biological communities (benthic macroinvertebrates and periphyton) in streams and landscape metrics in contributing watershed. The general basis for the parameters for this study comes from the experiences of the 2015 study (DeGasperi et al., 2018), Ecology's Watershed Health and Salmon Recovery (WHSR), and the stormwater-related parameters listed in Appendix 9 of the Phase I and Phase II Western Washington Municipal Stormwater Permits (Ecology, 2019a and b).

Table 1. Parameters of interest in this study

Indicator/Parameter	Indicator Type
Temperature	**In-situ**
Stage	
Dissolved Oxygen	
pH	
Turbidity	**Water Quality**
Total Suspended Solids (TSS)	
Dissolved Organic Carbon (DOC)	
Hardness (as $CaCO_3$)	
Chloride (Cl^-)	
Total Nitrogen (TN)	
Nitrate+Nitrite (NO_3^-+NO_2^-)	
Ammonia (NH_4^+)	
Total Phosphorous (TP)	
OrthoPhosphorus (PO_4^{3-})	
Total metals (As, Cd, Cr, Cu, Pb, Zn)	
Dissolved metals (As, Cd, Cr, Cu, Pb, Zn)	
Fecal Coliform	
E.Coli	
Chlorophyll-a	
Grain Size	**Sediment Quality**
Percent Solids	
Total Organic Carbon (TOC)	
Total metals (As, Cd, Cr, Cu, Pb, Zn)	
PAHs[1]	
PBDEs[1]	
Phthalates[1]	
Macroinvertebrate, Periphyton	**Watershed Health**
Physical habitat measurements[2]	**Physical Habitat**

[1] Full list of analytes are listed separately in the Table 2.

[2] Physical habitat measurements include diverse metrics to represent the habitat conditions including bank measurement, substrate and depth measurements, shade measurement, human influence, riparian vegetation structure, thalweg depth measurement, bankfull width, bar width, and wetted width measurements, large wood debris, slope and bearing measurements, and side channel and habitat unit descriptions.

Table 2. Full list of organics analytes

Type of Organics	Individual Compounds
Polycyclic aromatic hydrocarbons (PAH)	1-Methylnaphthalene, 2-Chloronaphthalene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Carbazole, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene, Phenanthrene, Pyrene, and Retene
Polybrominated diphenyl ethers (PBDEs)	Congener number 47, 49, 66, 71, 99, 100, 138, 153, 154, 183, 184, 191 and 209
Phthalates	bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, di-n-octyl phthalate, dibutyl phthalate, and diethyl phthalate

3.4 Criteria and standards for status assessment

Stream conditions will be compared to thresholds based on the condition of least-disturbed reference sites identified in western Washington (Wilmoth et al., 2015) and the State water and sediment standards.

3.4.1 Least-disturbed reference site data

As part of a long-term Ecology monitoring program, WHSR, Ecology samples least-disturbed reference sites in the Puget Lowland ecoregion annually since 2009 (Table 3). GIS data were compiled for all of these sites to provide reference condition levels for land cover data during previous SAM stream monitoring (Sheibley et al., 2017). Urban and agricultural area in the watersheds of reference sites were less than 10 percent of total land cover. Reference site monitoring will follow Ecology monitoring schedule; two to four reference sites will be visited every year. Four sites highlighted in the table are scheduled to be sampled in 2020.

Table 3. List of reference site in Puget Sound region*

Location ID	Longitude	Latitude	County
BIO06600-AUST02	-122.3426	48.7065	Whatcom
BIO06600-BEEF02	-122.7928	47.62859	Kitsap
BIO06600-BIGA02	-122.9514	47.56505	Kitsap
BIO06600-BOYC02	-122.9081	47.60896	Kitsap
BIO06600-CANY02	-123.1398	48.02311	Clallam
BIO06600-CHUC02	-122.4883	48.70185	Whatcom
BIO06600-DEWA02	-123.0257	47.46906	Mason
BIO06600-DUCK01	-123.0205	47.68127	Jefferson
BIO06600-HOLD02	-121.9681	47.43431	King
BIO06600-OYST02	-122.4395	48.61868	Skagit
BIO06600-SEAB02	-122.8372	47.62811	Kitsap
BIO06600-TUMW02	-123.4726	48.09074	Clallam
BIO06600-YOUN02	-121.8251	47.80655	Snohomish
SEN06600-GRIF09	-121.8849	47.60376	King

*Four sites highlighted in the table are scheduled to be sampled in 2020.

3.4.2 State Water and Sediment Standards

In addition to using the reference conditions for the ecological status assessment, the water and sediment quality data will be compared to state standards, including freshwater designated for aquatic life uses (WAC 173-201A-200), toxic substances for aquatic life protection (WAC 173-201A-240), and sediment cleanup levels based on protection of then benthic community in freshwater sediment (WAC 204-563).

4.0 Project Overview

4.1 Project goals

The goal of the SAM stream monitoring is to provide statistically valid estimates of status and trends of chemical, physical and biological conditions in small stormwater receiving streams in the Puget Lowland ecoregion.

The probabilistic study design, selected monitoring parameters and indicators, and frequency of monitoring are designed to develop unbiased regional assessment of stream health in a cost effective way. Findings will inform the permittee's stakeholders, and the public on the urban impact to streams and which stressors are largest so that stormwater management decisions can be adapted and implemented to protect stream health.

The municipal stormwater permittess manage stormwater runoff from new and re-development starting in the late 1990s by controlling stormwater volumes and using best management practices to provide treatment in order to reduce water quality impacts from development and maintain compliance with the permits, water quality standards, and TMDL implementation.

4.2 Project objectives

The objectives of the status and trends program are;

Implement this probabilistic sampling design that can provide strong status and trends of stormwater receiving water in the region.
Set thresholds for status assessment using reference conditions and Washington state standards.
Collect and monitor stormwater-related water and sediment chemistry.
Monitor stream stage and temperature continuously
Assess biological conditions in small streams using B-IBI and periphyton.
Incorporate existing land use information and other existing data into the status and trends assessment.
Identify key drivers affecting integrated stream health indicators

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

The Stormwater Action Monitoring (SAM) program is made up of approximately 1.75 FTE at Ecology, and overseen by a municipal stormwater permit focused stakeholder committee called the Stormwater Work Group (SWG). SWG authorizes the goals and funds for SAM monitoring. To accomplish the scientific objectives of this streams monitoring study the SAM staff formed a stream monitoring team with collaboration from federal, state and local government agencies to conduct the field monitoring, chemical analysis, statistical analysis and reporting. United States Geological Survey (USGS) will lead the field monitoring while statistical analysis and reporting will be shared work between USGS and Ecology (Table 4).

Table 4. Organization of monitoring team members and responsibilities

Staff	Title	Responsibilities
Rich Sheibley USGS Water Quality and Ecosystem Section sheibley@usgs.gov 253-552-1611	Project lead, Data manager	Review QAPP, conduct site evaluation, equipment deployment, field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes, manage and interprets data. Writes the draft report and final report.
Keunyea Song Ecology-WQP Keunyea.Song@ecy.wa.gov 360-407-6158	SAM scientist / Project manager	Manages the study, select sampling sites, write QAPP, and manage stream study related contracts, develop and implement statistical approach for status and trends.
Brandi Lubliner Ecology-WQP Brandi.Lubliner@ecy.wa.gov 360-407-7140	SAM coordinator/ Ecology WQP QA coordinator	Review and approve QAPP, oversee SAM projects
Alan Rue Ecology – EAP Manchester Laboratory Alan.Rue@ecy.wa.gov Phone: 360-871-8801	Laboratory Manager	Review QAPP, coordinate supplies and sample delivery with field staff. conduct and coordinate laboratory analysis, QC and submit results to EIM
Keunyea Song Ecology-WQP Keunyea.Song@ecy.wa.gov 360-407-6158	SAM Data coordinator	Reviews and QAs EIM submitted results
Jack Janisch Ecology-EAP Section Jack.Janisch@ecy.wa.gov Phone: 360-407-6649	Watershed health database coordinator	Reviews and QAs submitted results

EIM: Environmental Information Management database
EAP: Environmental Assessment Program of Ecology
WQP: Water Quality Program of Ecology

5.2 Special training and certifications

The project lead, field crew, and any staff conducting monitoring will participate in the Watershed Health sampling field training designed and provided by Ecology's Environmental Assessment Program. This training involves actual hands-on field monitoring to ensure completeness and comparability of techniques. Also covered is training on the Watershed Health monitoring software, tablets for field monitoring, and data uploading to the Watershed Health portal. This annual training is held in spring each year before the field monitoring in summer.

Any necessary training for statistical tools, analyses and data evaluation can be given by SAM or other approved staff as needed throughout the monitoring period as technology evolves or as staff changes.

5.3 Key monitoring activities and reports

Table 5. Proposed schedule for field and laboratory work, data entry into EIM, and reports

Activities/Reports	Description	Target Date
Site evaluation	Site suitability for sampling including permission, accessibility and other criteria will be evaluated and finalize the sampling site list through GIS image check and site visit.	June-September, a year before the sampling year
Final site list	Memo summarizing site evaluation process and final site list with detailed information including landscape characteristics of each watershed	September-October, a year before the sampling year
Equipment deployment	Pressure transducers to measure stage and temperature at each location will be deployed before the summer sampling event to capture one water year stage data	September-October, a year before the sampling year
Data download and maintenance	Data download and maintenance will be conducted as needed (e.g. quarterly).	Quarterly since deployment for a year (Oct-Sep)
Field work completed	Summer water, sediment chemistry and watershed health monitoring will be conducted between July and October each year	July-October each year
EIM completed	Fully reviewed, if necessary validated, data will be submitted to EIM	November 30, a year after the sampling year, starting from 2021
USGS Data Release completed	Continuous stage and calculated hydrologic metrics submitted to USGS's Science Base	Update the stage data annually, by November, a year after the sampling year, starting from 2021
Annual report (status focused)	Summary of annual monitoring and status assessment results done in previous year	November 30, a year after the sampling year, starting from 2021
4-yr status and trend report	Monitoring and statistical status and trend analyses results based on 4 water years of data and 2015 data; Identification of key stressors to stream health. Interaction between landscape information and stream health.	Spring-Summer of 2024

6.0 Study Design

6.1 Study boundaries

This study targets small (wadeable) streams or rivers in the areas where Puget Lowland ecoregion and Puget Sound Salmon Recovery region intersect (Figure 2). Surface water including stormwater in most of Phase I and II municipal stormwater permitted area flows into the study area. Federal areas are included in this SAM study design.

Figure 2. Study area boundary

6.2 Site Selection

6.2.1 Probabilistic sampling design

The SAM Puget Small Streams (SAM_PSS) study will continue to use EPA's Generalized Random Tessellation Stratified (GRTS) survey design, as was done in 2015, to select spatially-balanced random sampling sites in the study frame. The GRTS study design facilitates unbiased extrapolation of any measured indicator (biological, chemical, and physical) from the sites sampled to estimates of the status of the extent of the whole represented the region, that is, the study area (Figure 2).

Ecology recently (2019) re-generated the Washington State Master sample points using the high-resolution (1: 24k or higher) National Hydrography Dataset (NHD) layer (Figure 3). The master sample points are potential sampling sites generated at every one kilometer in the streamline statewide. In 2015, the SAM streams study used the master sample generated from a medium-resolution DNR generated flow line layer (1:100K).

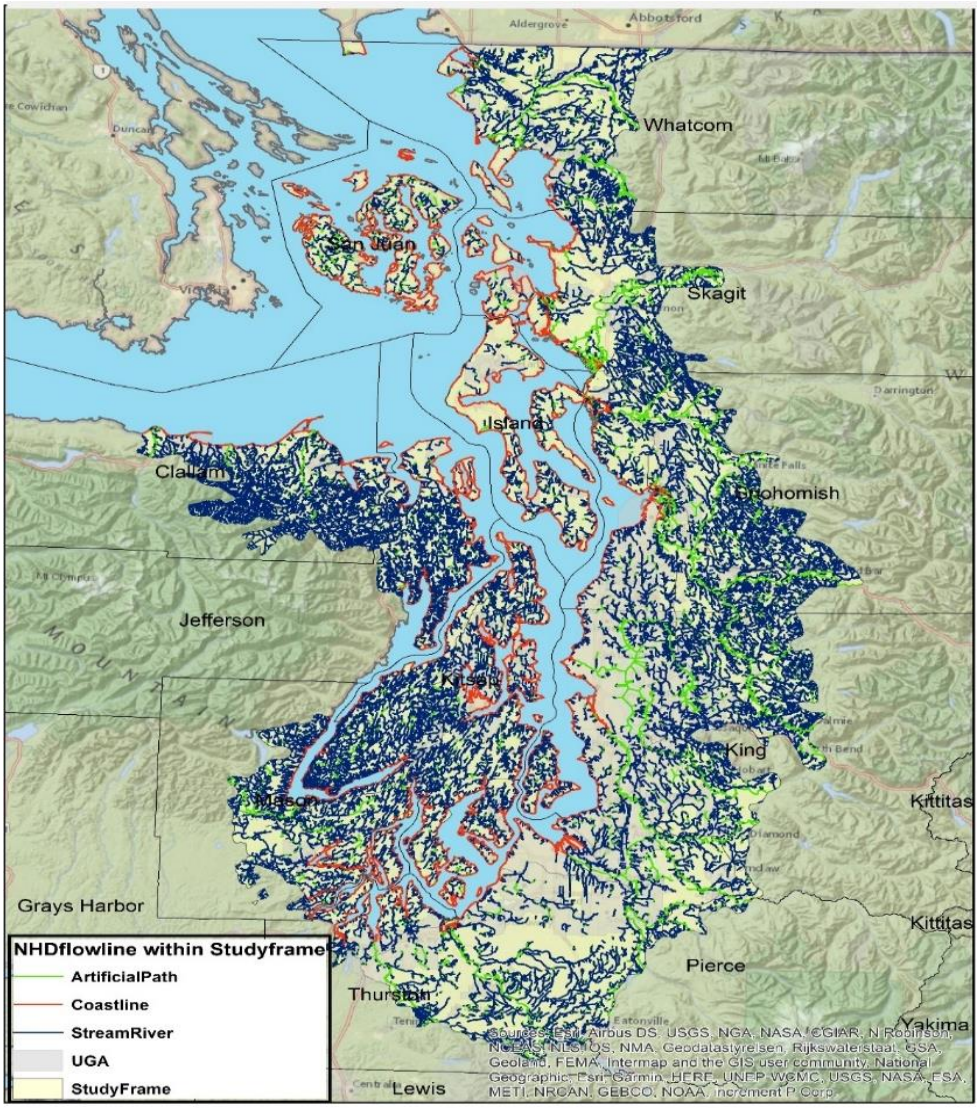

Figure 3. NHD flow line within the study frame

6.2.2 Target Population (Candidate site list selection)

The SAM_PSS study boundary covers 19,970 master sample points. Final target population points were selected by filtering through site selection criteria listed below.

Perennial stream points

The SAM candidate list is a subset of the master sample points to contain primarily perennial flow points. As 'Artificial path' is an unknown or unidentified flow line which could be either perennial or intermittent, they were included in the SAM candidate point list as well.

Contributing watershed delineation and land cover information

USGS delineated contributing watershed for every master point in the study area, a total of 19,970 points.

The 10 meter digital elevation model (DEM) for the study area was preconditioned so all flow lines flow within a delineated channel in the National Hydrography Dataset (NHD) Hi-Resolution network, from high to low regardless of stream capacity, precipitation, etc. This preconditioning involves filling possible sinks to avoid interruptions in the flow path (Lindsey and Creed, 2005) and modifying the landscape to enforce flow within delineated channels using the AGREE, subtraction of the stream raster from the landscape, method (Hellweger, 1997). For each master point, the contribution watershed was delineated as a unique polygon using the Modified New method described in Johnston et al., 2009 using established boundaries of the Watershed Boundary Dataset (WBD) when available.

After watersheds were delineated, the land use characteristics including averaged land cover and averaged impervious cover (%) was determined using 2016 National Land Cover Data (www.mrlc.gov). For this SAM PSS study frame, each master point is linked with delineated contributing watershed to the point and the land use characteristics within that watershed; these are available through USGS ScienceBase (Headman, 2020), a USGS web portal for scientific data and information products.

Contributing watershed outside of the US

In the northern part of Puget Sound, there are some master sample points have part of their watersheds in Canada. Given the lack of permit coverage or potential limits to spatial data for the portion outside of the US, sample points in which the watershed draining to the point crossed international boundaries were excluded. This resulted in removal of total 729 points from the northern boundary.

Watershed size criteria (0.5-70km^2)

SAM PSS focuses on relatively small streams in order to increase the chance of detecting a stronger storm water impact or recovery signal in the receiving waters. In 2015, the master sample list was sorted on stream order to target sites between 0 and 3rd order streams. However, it did not filter out several large streams, because zero-order coded streams were where the size was unknown. For the current study design, instead of stream order, contributing watershed size was used as a means to filter the master sample points with watersheds that are too large (over 70 km^2) or too small (0.5 km^2).

After applying this final set of selection criteria, the total number of SAM candidate sites within the study frame is 6,316 (Table 6).

Table 6. Descriptive summary of watershed size draining to the master points and candidate points within the study area

Watershed size (km^2)	# of points	Min	1st Quantile	Median	Mean	3rd Quantile	Max
All master points	9312	0.00	0.82	3.38	97.61	20.41	4514.32
SAM candidate points (watershed 0.5-70 km^2)	6316	0.50	1.45	3.75	9.86	11.97	69.97

6.2.3 The 2015 sampling site evaluation

Although the 105 sites sampled in 2015 were from a DNR flow line layer with med-resolution, we decided to include as many as possible sites into new study design. Revisiting the 2015 sampling sites improves the trend detection power of the ongoing SAM PSS study. The past sampling sites done in 2015 were evaluated in the same way as described above for candidacy in the new candidate list. Land use and impervious cover of watershed was incorporated using 2016 NLCD for each site, and the watershed size criteria was applied. In the end, 90 out of 105 sites from 2015 met the new criteria and now comprise one panel in the new study design.

6.2.4 Stratification

Impervious surface cover can serve as a reliable indicator of storm water influence to receiving waters. The candidate sites have been stratified into four strata using average percent of total impervious cover of the contributing watershed to better account for the broad range of urban development in the study area.

The four strata for impervious surface cover are:

- Least: 0 to <10 %
- Low: 10 to <20 %
- Medium: 20 to <40 %
- High: 40 to 100 %

This stratification was necessary because most of the study area is still considered undeveloped or has low impervious cover. This characteristic of the study area is due to unique geography of the region, with narrow band of urbanization around Puget Sound combined with large areas of forested and undeveloped areas in the headwaters of the Puget lowland. Using the impervious cover attribute for all the candidate sites we developed four strata as described above to ensure certain number of streams in medium and highly developed areas are sampled every year under this study design (Table 7).

Table 7. Number of candidate sites in each percent impervious surface strata

Strata	0 - <10 %	10 - <20 %	20 - <40 %	40 – <100 %	Total
Number of new SAM candidate points	5142	461	514	199	6316
Carry forward 2015 (past) sampling sites	44	9	23	14	90

6.2.5 Study panel design and site selection

A panel of sites is a set of sites that are all visited in the same year for their initial sampling visit, and then all or a portion of them are revisited in specific years. Each panel will be visited three times on five-year intervals. Each year, new sites (new panel) from the master point list are continually added (Table 8). This panel design provides representativeness of streams in the region because of continuous addition of new sites with keeping high trend detection power by three times revisit of each site over 15 year period.

Table 8. Panel design for the PSS monitoring*

Year	2015	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Panel																					
1	105	33					22					11									
2			33					22					11								
3				33					22					11							
4					33					22					11						
5						33					22					11					
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20																					11

*Each year a total of 33 sites will be sampled. Panel 1 in 2020 is a subset of the sites sampled in 2015. Only subset of panel 1 to panel 5 will be revisited between 2025 to 2034 in order to add new panels for each given year's sampling. Numbers in blue indicate new sites added for sampling whereas numbers in green represent third and last visit of the same panel. Once a site is visited three times, it will be dropped from the study design. Second visit sites are displayed in black.

This panel design process select spatially-balanced sites from each impervious cover-based strata as well as alternative sites (in case selected sites are not suitable or rejected during the candidate site evaluation process).

Panel 1 is a "transition" panel between the prior survey and this new survey. Panel 1 has 33 sites selected from the list of 2015 sites that met the new selection criteria. Having 2015 sampling sites in Panel 1 improves trend estimation from 2015 to 2020. Given that 105 sites sampled in 2015 were also selected using the same GRTS principle and procedure, it is safe to assume that these 33 sites in Panel 1 are still representative of small streams in the region. For spatial weight calculation at data analysis process, Panel 1 will be treated the same way as for other panels. New sites from the 2019 NHD master point list begins in 2021.

6.2.6 Candidate Site Evaluation

Site evaluation for determining the suitability of a GRTS selected candidate site to meet the study goals for SAM_PSS monitoring are described below.

Location Criteria

The following location rules apply such that the site reflects the intended probabilistic stream characteristics. During the site evaluation field visit, the field crew will attempt to access the site at the given coordinates or as nearby as possible, with recognition of the challenges of sampling in urban areas, particularly in gaining access to discretely defined locations. Suitable sampling sites upstream and downstream of the candidate site coordinates must fall within these constraints:

- there are no continuous surface-water inflows in excess of approximately 25 percent of the flow already in the reach
- there is no substantial, abrupt change in adjacent land use such as from residential to industrial, or from native vegetation to developed conditions

Nested watershed

Work from the 2015 study found that the correlation of mean monthly data between nested sites increases as the sites share an increasing percentage of upstream drainage area. Therefore, when GRTS selected sites share the watershed, replace a nested site based on the GRTS selection order with an oversample (alternative) site within the same stratum.

Accessibility Criteria

These criteria concern whether access to a site is permitted by the land owners and if the site can be safely accessed and sampled. A site may also be deemed unsuitable, or impracticable, for sampling if more than one hour is required to access the site from the nearest parking location.

Permission

If a candidate site is not obviously accessible through public property, the private property owners and/or tenants will need to be contacted prior to site evaluation. Parcel information will be researched and a good faith effort to contact owners or tenants will be made. A site will be deemed unsuitable for sampling if permission has been denied by all land owners, tenants, or resource managers along the entire hydrologic reach (see *Location Criteria*, below). No trespassing signs, if posted, will be respected if no contact or authorization is secured for the parcel.

Safety

Overall safety conditions for access and sampling will be assessed during site evaluation based on state and federal law and organizational policy; however, it is ultimately the responsibility of the field crew at each time of arrival for sampling to decide if it is safe to enter the stream to conduct the sampling. Appropriate reasons for disqualifying a site from sampling may include:

flow is too swift or too deep;
route of entry is unstable;
hostile people or animals are present.

Flow, Physical, and Salinity Criteria

These criteria concern the conditions of the stream and streambed with regard to the specific types of data desired for SAM_PSS study. As a suitable sampling site, the waterbody at the candidate site coordinates must be on a stream or river, and not on a lake, pond, wetland, or estuary. Specifically, the waterbody must have:

a net flow of water that is unidirectional;

defined left and right banks readily discernible from mid-stream;

uninterrupted surface-water flow for more than half the length of approximately 20 bankfull widths or a minimum of 150 meters surrounding the candidate site coordinates;

perennial flow (as best as can be determined at the time of the site visit);

flow in a natural channel that might have been highly modified, (converted to a canal, ditch, or culvert) but is not a completely enclosed pipeline or a completely manmade irrigation canal with no historical evidence of a stream;

natural substrate on the channel bottom, for at least some of the reach;

freshwater, as defined by a water column with more than 95 percent of its depth with less than 1 part per thousand salinity at any time during the year. Multiple lines of evidence may be used to make this estimation (*e.g.*, vegetation, proximity to a known estuary, or salinity measurement).

6.2.7 Final sampling site list for 2020 sampling: Panel 1

During the 2015 SAM small streams sampling, several sites had to be dropped because there was no flow present during the summer sampling. A lesson learned was to conduct site selection at the same time the summer sample will take place so the number of sites that might be dropped due to no flow is reduced. Once desktop site evaluation is completed, candidate sites will be visited during summer (August to September) to confirm there will be flow during the time when the sampling will take place the following year. Final sampling sites (Panel 1) for sampling in 2020 is the revisit of 2015 sampling sites listed below. They were confirmed in September 2019 (Table 9 and Figure 4) and called “Past” sites to distinguish them from new master points sites (Starting from Panel 2).

Table 9. Final sampling site list for 2020

No.	Strata	Location ID	Site Name	Longitude	Latitude	Watershed (km^2)	Impervious (%)	County	Past Site ID (2015 list)	USGS Station ID
1	[0,10]	PSS05515-005879	STOSSEL CREEK ABV SWANS MILL POND NR CARNATION, WA	-121.8517	47.7292	6.867	0.163434	King	098-OUGA	12148650
2	[0,10]	PSS05515-000831	CANYON CREEK NEAR SEQUIM, WA	-123.1382	48.0234	29.6469	0.279348	Clallam	009-OUGA	12048050
3	[0,10]	PSS05515-001556	TUMWATER CREEK NEAR PORT ANGELES, WA	-123.4726	48.0907	9.2988	0.410085	Clallam	026-OUGA	12046690
4	[0,10]	PSS05515-000814	STONEQUARRY CREEK NEAR ENUMCLAW, WA	-121.9377	47.2429	0.975535	0.555351	King	008-OUGA	12107850
5	[0,10]	PSS05515-003875	STIMSON CREEK NEAR BELFAIR, WA	-122.9140	47.4237	3.7251	0.700894	Mason	083-OUGA	12065095
6	[0,10]	PSS05515-005892	PEDERSON CREEK NEAR AGNEW, WA	-123.2616	48.0582	7.0425	0.885112	Clallam	093-OUGA	12047595
7	[0,10]	PSS05515-020891	FRENCH CREEK NR 124TH ST SE NEAR MONROE, WA	-121.9879	47.8858	3.105	6.392754	Snohomish	079-WUGA	12151400
8	[0,10]	PSS05515-006227	LITTLE MINTER CREEK NR 144TH ST SW NEAR WAUNA, WA	-122.6814	47.3896	5.7447	7.160426	Pierce	104-OUGA	12073508
9	[0,10]	PSS05515-004239	UNNAMED TRIB TO PILCHUCK R NR 142 NR SNOHOMISH, WA	-122.0398	47.9273	1.9359	8.48768	Snohomish	079-OUGA	12155340
10	(10,20]	PSS05515-010563	LITTLE SOOS CREEK BLW HWY516 NEAR COVINGTON, WA	-122.1258	47.3579	19.4949	10.30299	King	034-WUGA	12109960
11	(10,20]	PSS05515-012807	KIMBALL CREEK BLW SE 76TH ST NEAR SNOQUALMIE, WA	-121.8378	47.5322	21.9915	10.62484	King	040-WUGA	12144475

No.	Strata	Location ID	Site Name	Longitude	Latitude	Watershed (km^2)	Impervious (%)	County	Past Site ID (2015 list)	USGS Station ID
12	(10,20]	PSS05515-032304	PADDEN CREEK ABOVE 24TH ST AT BELLINGHAM, WA	-122.4817	48.7153	11.7297	14.95143	Whatcom	102-WUGA	12201902
13	(10,20]	PSS05515-016983	YARROW CREEK NR NE 34TH ST NEAR BELLEVUE, WA	-122.1858	47.6401	2.4588	15.95461	King	055-WUGA	12119815
14	(10,20]	PSS05515-000391	COAL CREEK BLW COAL CRK PKWY NEAR BELLEVUE, WA	-122.1701	47.5599	14.0841	17.8097	King	001-WUGA	12119690
15	(10,20]	PSS05515-027812	BELL CREEK AT SEQUIM, WA	-123.0691	48.0845	16.8606	17.90776	Clallam	087-WUGA	12049195
16	(20,40]	PSS05515-256359	UNNAMED TRIB TO WILLOWS CRK NEAR REDMOND, WA	-122.157	47.686	0.522	20.30172	King	814-WUGA	12125150
17	(20,40]	PSS05515-024158	SULLIVAN GULCH CREEK NEAR WOLLOCHET, WA	-122.5814	47.2857	2.6226	21.15271	Pierce	376-OUGA	12072688
18	(20,40]	PSS05515-019815	NF ISSAQUAH CREEK BLW 224TH AVE SE AT ISSAQUAH, WA	-122.0420	47.5461	12.1761	21.67086	King	082-WUGA	12121580
19	(20,40]	PSS05515-009831	STEEL CREEK NEAR GLUDS POND NEAR BROWNSVILLE, WA	-122.6324	47.6508	4.9563	25.84547	Kitsap	030-WUGA	12070220
20	(20,40]	PSS05515-007726	WAPATO CREEK AT 12TH ST E IN FIFE, WA	-122.3704	47.2453	15.16605	31.31818	Pierce	023-WUGA	12102510
21	(20,40]	PSS05515-000859	NORTH CREEK NR 242ND ST SE NR BOTHELL, WA	-122.1880	47.7798	69.2523	35.83934	Snohomish	003-WUGA	12126110
22	(20,40]	PSS05515-013054	LAKOTA CREEK BELOW UNNAMED TRIB NEAR TACOMA, WA	-122.3655	47.3224	8.6364	36.56461	King	042-WUGA	12103206

No.	Strata	Location ID	Site Name	Longitude	Latitude	Watershed (km^2)	Impervious (%)	County	Past Site ID (2015 list)	USGS Station ID
23	(20,40]	PSS05515-001454	WEST TRIB TO HYLEBOS CR UPS OF I-5 NR MILTON, WA	-122.3335	47.2535	24.1794	38.13117	King	005-WUGA	12103008
24	(20,40]	PSS05515-026139	SHELL CREEK AT EDMONDS, WA	-122.2990	47.8841	2.3526	39.27467	Snohomish	068-WUGA	12128100
25	(20,40]	PSS05515-029907	HONEY CREEK NEAR RENTON, WA	-122.1792	47.5134	2.9718	39.48698	King	093-WUGA	12119450
26	(40,100]	PSS05515-003691	SWAMP CREEK NEAR ALDERWOOD MANOR, WA	-122.2553	47.8256	27.5157	40.17192	Snohomish	009-WUGA	12126800
27	(40,100]	PSS05515-000451	MCSORLEY CREEK NEAR DESMOINES, WA	-122.3151	47.3753	6.6969	40.58137	King	002-WUGA	12103218
28	(40,100]	PSS05515-050295	PETERS CREEK ABV 151ST AVE NE NEAR REDMOND, WA	-122.141	47.683	5.2362	42.91045	King	158-WUGA	12125130
29	(40,100]	PSS05515-023787	BOEING CREEK AT SHORELINE, WA	-122.3649	47.7542	4.4541	46.24449	King	074-WUGA	12128075
30	(40,100]	PSS05515-027199	JAPANESE GULCH CREEK NEAR MOUTH NEAR MUKILTEO, WA	-122.2933	47.9499	4.5639	47.49675	Snohomish	065-WUGA	12128450
31	(40,100]	PSS05515-015067	SCRIBER CREEK NEAR MOUTH NR MOUNTLAKE TERRACE, WA	-122.2631	47.8035	14.7708	49.70016	Snohomish	048-WUGA	12126904
32	(40,100]	PSS05515-015391	POWDER MILL GULTCH CREEK NEAR MUKILTEO, WA	-122.2748	47.9409	4.6278	50.24543	Snohomish	050-WUGA	12128485
33	(40,100]	PSS05515-030323	DES MOINES CREEK AT DES MOINES, WA	-122.3244	47.4104	13.2282	50.60471	King	095-WUGA	12103322

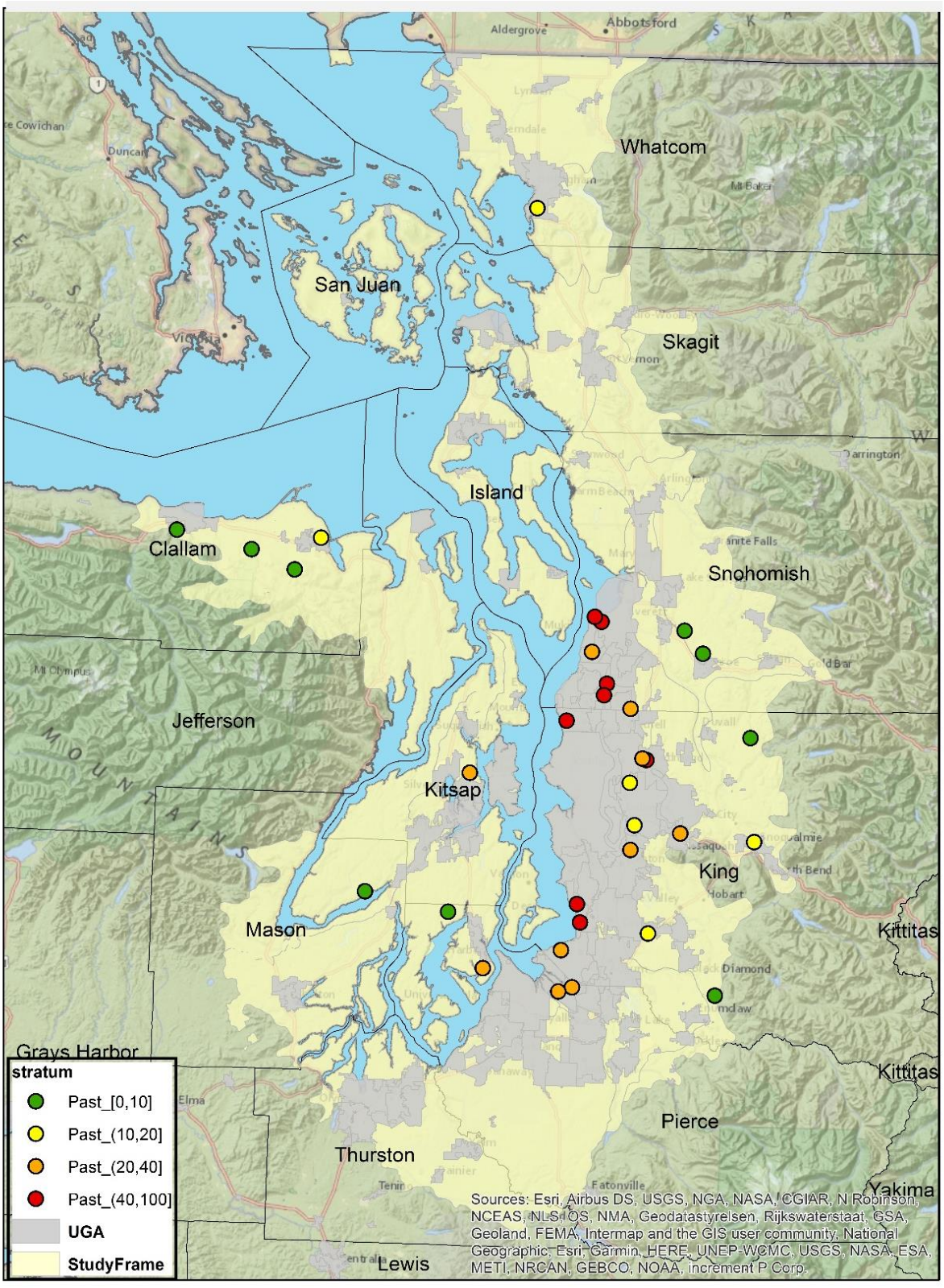

Figure 4. Final sampling site location in 2020

6.2.3 Candidate site list for sampling from 2020 to 2039 (Panel 01-20)

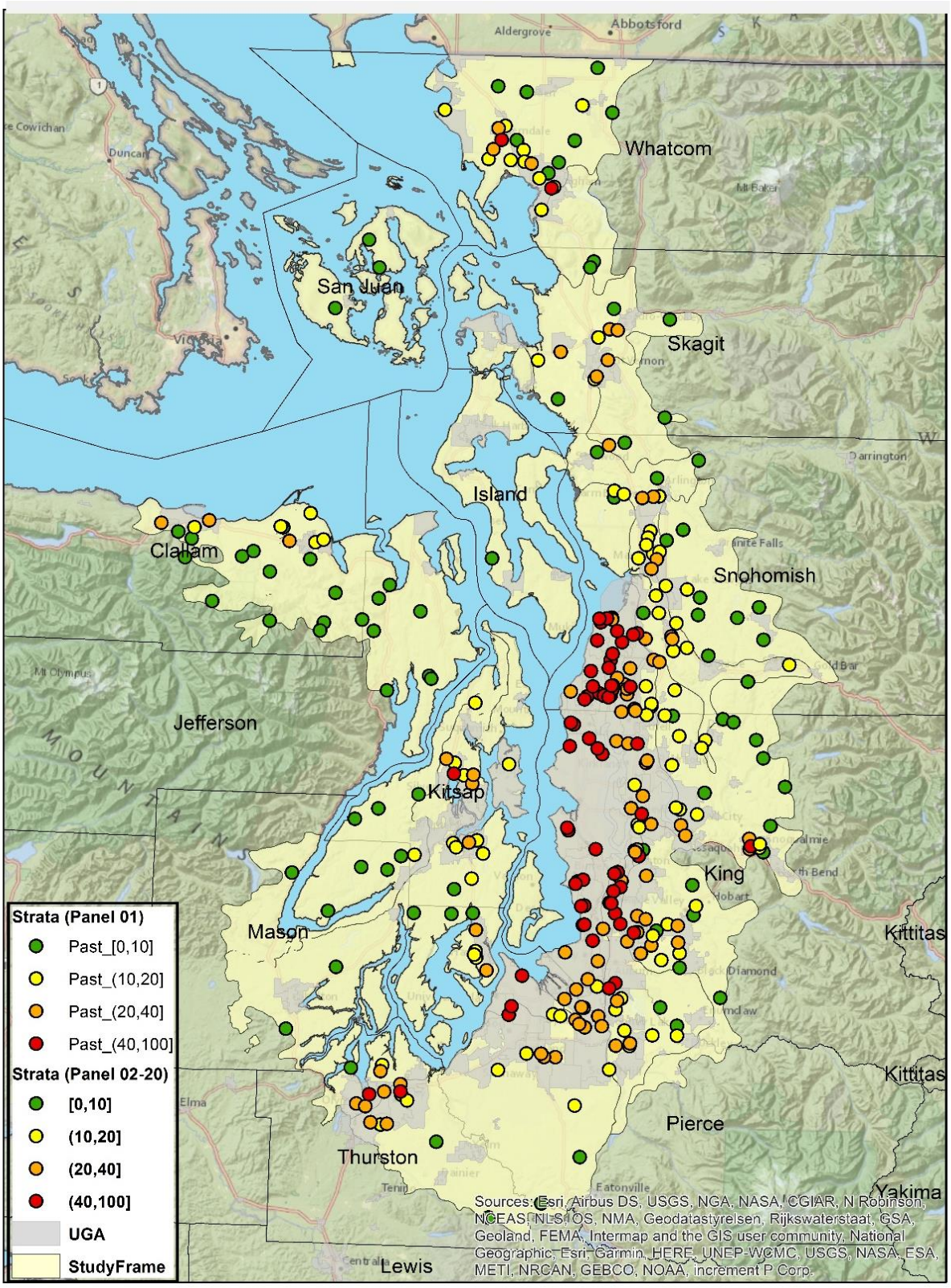

Figure 5. Candidate sites for sampling from 2020 to 2039

6.3 Sampling parameters and frequency

6.3.1 Field and laboratory sampling parameters

Water level and water temperature will be monitored continuously using Data loggers at each sampling site while the rest of parameters listed in Table 10 will be measured once in summer.

Table 10. Parameters and sampling frequency

Indicator Type	Indicator/Parameter	Sampling Frequency
Field In-situ	Stage	Continuous (Data logger) for a year (Oct-Sep)
	Temperature	
	Temperature	Field measurement in summer (July-Sep)
	DO	
	pH	
	Conductivity	
Water Quality	Turbidity	Grab sample in summer (July-Sep)
	Hardness (as $CaCO_3$)	
	Total Suspended Solids (TSS)	
	Dissolved Organic Carbon (DOC)	
	Chloride (Cl^-)	
	Total Persulfate Nitrogen (TPN)	
	Nitrate+Nitrite (NO_3+NO_2)	
	Ammonia (NH_4^+)	
	Total Phosphorous (TP)	
	Orthophosphate (PO_4^{3-})	
	Total metals (As, Cd, Cr, Cu, Pb, Zn)	
	Dissolved metals (As, Cd, Cr, Cu, Pb, Zn)	
	Fecal Coliform	
	E-coli	
	Chlorophyll-a	
Sediment Quality	Grain Size	Sample in summer (July-Sep)
	Percent Solids	
	Total Organic Carbon (TOC)	
	Total metals (As, Cd, Cr, Cu, Pb, Zn)	
	PAHs[1]	
	PBDEs[1]	
	Phthalates[1]	
Watershed health	Benthic macroinvertebrates	Sample in summer (July-Sep)
	Periphyton	
	Physical habitat measurements[2]	Field measurement in summer (July-Sep)

[1]List of individual compounds is in the Table 2.
[2]Field habitat measurements include bank measurement, substrate and depth measurements, shade measurement, human influence, riparian vegetation structure, thalweg depth measurement, bankfull width, bar width, and wetted width measurements, large wood debris, slope and bearing measurements, and side channel and habitat unit descriptions.

6.3.2 Field data collection and frequency

Continuous data collection

Data loggers will be deployed at the 33 sampling sites to collect continuous temperature and stream stage, at the start of the water year (October) before the summer sampling date. Loggers will be deployed for only one year at each site and then move to the next panel sites. Measurements will be collected at 15 min intervals and all sites will be visited quarterly for continuous data retrieval and any necessary equipment maintenance.

Watershed health monitoring

Benthic macroinvertebrates and physical habitat indicators will be collected once annually at each of the 33 sampling sites between July 1 and September 30. The same Watershed health monitoring procedure used in the previous SAM streams monitoring program in 2015, developed by Environmental Assessment Program (See section 7.0).

Scientific collection permit

The necessary permits for sampling macroinvertebrates will be obtained from the Washington Department of Fish and Wildlife. The USGS will obtain a permit every year before the summer sampling.

Sediment and water quality monitoring

Sediment and water samples will be collected annually during the summer sampling period to measure chemistry parameters indicative of stormwater impacts and stream health; these include metals and organic contaminants (PAHs, PBDE and phthalates) concentrations. Opportunistic parameters are possible based on available future funding and would follow the same collection procedures, lab accreditation requirements and data review.

6.3.3 Landscape information

Environmental characteristics describing physical and anthropogenic characteristics of the study region will be identified in the watershed and riparian zone around each sampling site. These variables include basin geology, watershed size, slope, land cover, elevation, urbanization-population density, impervious surface, road density, and other applicable or available landscape information in the delineated watershed draining to the sampling areas. Landscape information will be updated every 5 years (e.g. www.mrlc.gov).

6.3.4 Potential short-term or less frequent measurements

There may be opportunities to incorporate “add-on” monitoring into the SAM_PSS study. Add-on studies may include: 1) adding parameters into the study one time or with less frequent interval, 2) exploring new or alternative methods to determine if new method could improve parameter detection, or 3) conducting additional in-depth data analysis.

Potential parameters for add-on studies include microplastics in either water column or sediment tire-rubber related chemicals such as Hexa(methoxymethyl)melamine HMMM), dephenylguanidine, Heptapropylene glycol, dicyclonexylurea, or, contaminants of emerging concern (CEC) such as perfluoroakyl substances (PFAS). New or alternative methods to examine pollutants include using passive samplers for organics and metals, or using biofilms chemical analysis.

Additional in-depth data analysis may include developing structural equation models to identify key stressors associated with stream health, developing predictive mapping model of the stream conditions, developing overall stream quality indicator that can capture water and sediment quality as well as biotic conditions.

All of these listed measurements and analyses will be done only if the SAM status and trends budget allows and when Stormwater Work Group approves of any add-on studies proposed by the SAM status and trends subgroup. The QAPP will be amended for any add-on studies if and when confirmed.

7.0 Field Sampling Procedures

7.1 Field Equipment handling and maintenance

7.1.1 Field equipment handling and decontamination

Field equipment will be cleaned to prevent the spread of invasive species. Staff practices and equipment that contact multiple surface waters will, at a minimum, be cleaned according to Ecology's standard operating procedure (SOP) EAP070, *Minimizing the Spread of Aquatic Invasive Species* (Table 11). These procedures will be followed at the end of each work day or upon leaving a water body before entering another. This information may be updated at any time and the study lead and project manager will update the field crews on areas of extreme concern.

Data loggers

Continuous in-situ data loggers (Hobo U20L-04, Onset Computer Corp.) for water temperature and stage will be checked under controlled conditions in the laboratory and cleaned prior to deployment and checked for functionality and biofouling during quarterly site visits using the manufacturer's recommended protocols. Each deployment location will be photographed and have site-specific survey information documented.

The field crew will conduct any necessary cleaning during the maintenance visit by rinsing the loggers, outside casing, the circulation holes and the optical eyes using a pipe cleaner and rising with fresh running water, distilled water or instrument specific cleanser.

In-situ water quality measurements and water sampling

Dissolved oxygen, conductivity, pH and temperature will be measured using a multi-parameter water quality sonde (YSI EXO2 or InSitu AquaTroll 100). All in-situ measurements will be done at the beginning and at the end of sampling, preferably in the exact same location. The time and the closest transect the in-situ measurements are taken will be recorded. Some probes take time to stabilize and readings will be recorded after sensors are stabilized (within $\pm$ 5 %). Water samples will be taken in the pre-cleaned bottles provided by the lab with preservatives. Sample bottles will be sotred in bags and weighed down in the stream in order to maintain cool temperature until the sampling is done.

Sediment sampling

Equipment and supplies for collecting and processing stream bed-sediment samples for analyses of trace elements and organic contaminants are listed in Table 11. The use of each is explained in the following discussions of preparation for sampling, sampling procedures, and sample processing.

Table 11. Equipment and supplies for collecting and processing bed sediment samples

Sampling and Processing
Bowl, glass, flat bottom, approximately 5 L, 12-in diameter
Sieve, stainless steel, 2.0 mm, 3" diameter (for organics sample)
Sieve Frame, Nylon, 8" diameter (for metals sample)
Nylon sieve cloth, 63 micron (for metals sample)
Funnel, polyethylene, 8" diameter
Policeman, Teflon (to aid sieving)
Spatula, scoop, and spoon, all Teflon
Syringe, plastic, 50ml
Wash bottle (labeled) with Liquinox or Alconox
Wash bottle (labeled) with acetone (pesticide grade)
Wash bottle (labeled) with 10% nitric acid
Wash bottle, plastic 500-ml
Wash bottle, Teflon 500-ml
Deionized water
Personal protective gear as specified by the MSDS
Sample containers (analytical laboratory will supply) – see Table 12
Miscellaneous
MSDS
Gloves - Non-powdered nitrile
Cooler and Ice
Polyethylene bags
Foam sleeves for shipping
Ice
5-gallon plastic bags
Sample Tags/bottle labels (with laboratory-assigned sample numbers)
Aluminum foil

Use uncolored or white non-metallic sieve and utensils to process bottom material for samples that will be analyzed for metals. Use a stainless steel sieve and polyfluorocarbon (Teflon) utensils to process bottom material for samples that will be analyzed for organic compounds. Brass is acceptable but not recommended.

7.1.2 Pre-sampling preparation

Sample Numbers, Jars, and Tags

Prior to sampling, staff will obtain sample identification numbers, sample jars, and labels from laboratories conducting the analysis.

Cleaning

Prior to sampling, the field crew will clean necessary sampling tools (including spares). These cleaning steps are based on USGS procedures for each reusable piece of sampling equipment that comes in contact with the sediment sample (Wilde et al., 2014):

1. Washing in non-phosphate detergent and hot tap water
2. Rinsing with hot tap water
3. Soak nonmetal parts for 30 mintes in 5% HCL solution
4. Rinsing with deionized water three times
5. Rinsing with methanol for organic analyses
6. Air drying in clean area free of contaminants and bag until use

After drying, equipment will be wrapped in aluminum foil (shiny side out) and stored in polyethylene bags until used in the field. Cleaned sampling equipment will be used at only one site and then will be stored for re-cleaning.

7.2 Measurement and sampling procedures

7.2.1 The order of field procedures

Field procedures will be conducted in the following order to avoid any damage or disturbance to benthic invertebrates and other samples:

1. Site verification and layout,
2. Instantaneous stream flow measurement at the lower end of the sampling reach,
3. In-situ water measurements at the lower end of the sampling reach,
4. Water sample collection upstream of location where flow and in-situ disturbance occurred,
5. Benthic macroinvertebrate at major transects,
6. Sediment chemistry sample collection in depositional areas of the hydrologic reach,
7. Physical habitat condition.

7.2.2 Watershed Health monitoring procedures

Watershed Health monitoring will follow standard operating procedures for field measurement and sampling as listed in Table 12.

Table 12. Standard Operation Procedures for watershed health monitoring

Standard Operation Procedures	Ecology Publication No.
Standard Operating Procedure EAP109, Version 1.1: Watershed Health Monitoring: Estimating Stream Discharge (Narrow Protocol)	19-03-226
Standard Operating Procedure EAP122, Version 1.1: Measuring Stream Slope (Narrow Protocol)	19-03-218
Standard Operating Procedure EAP123, Version 1.1: Measuring Compass Bearings (Narrow Protocol)	19-03-217
Standard Operating Procedure EAP112, Version 1.1: Assessing Bank Erosion Vulnerability	19-03-215
Standard Operating Procedure EAP121, Version 1.1: Watershed Health Monitoring: Standard Operating Procedures for Counting Large Woody Debris.	19-03-214
Standard Operating Procedure EAP095, Version 1.2: Collecting Water Samples for Watershed Health Monitoring	19-03-216
Standard Operating Procedure EAP073, Version 2.3: Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrates in Streams and Rivers	19-03-211
Standard Operating Procedure EAP111, Version 1.14: Periphyton Sampling, Processing, and Identification in Streams and Rivers	19-03-207
Standard Operating Procedure EAP108, Version 1.10: Collecting In Situ Water Quality Data	19-03-206
Standard Operating Procedure EAP107, Version 1.0: Measuring Transect Coordinates with a Global Positioning System (GPS)	18-03-230
Standard Operating Procedure EAP114, Version 1.3: Standard Operating Procedure for Estimating Substrate Sizes and Embeddedness at Major Transects	18-03-229
Standard Operating Procedure EAP106, Version 1.8: Standard Operating Procedures for Verification and Layout of Sites (Narrow Protocol)	18-03-226
Standard Operating Procedure EAP120, Version 1.3: Standard Operating Procedure for Quantifying Habitat Units	18-03-225
Standard Operating Procedure EAP118, Version 1.3: Standard Operating Procedure for Visual Assessment of Human Influence	18-03-224
Standard Operating Procedure EAP119, Version 1.3: Standard Operating Procedure for Thalweg Profiling	18-03-223
Standard Operating Procedure EAP117, Version 1.2: Standard Operating Procedure for Assessing Riparian Vegetation Structure	18-03-222
Standard Operating Procedure EAP115, Version 2.1: Standard Operating Procedure for Measuring Riparian Cover Using a Convex Densiometer	18-03-220
Standard Operating Procedure EAP113, Version 1.7: Watershed Health Monitoring: Measuring Channel Dimensions	18-03-219
Standard Operating Procedure EAP070, Version 2.2: Minimize the Spread of Invasive Species	18-03-201
Sediment sampling*	Described below section 7.2.3.

*Sediment sampling will follow USGS SOP.

7.2.3 Sediment Sampling

The sediment sampling and sieving follows the USGS National Field Manual (USGS, 2005) and National Water-Quality Assessment protocols (USGS, 1994).

This sampling can be performed by one person in the field, but is more efficiently done by a two-person team during a day-long Watershed Health Sampling event. Pre-sampling cleaning activities should be performed by staff familiar with MSDS and safety procedures. Staff collecting sediments should not use sunscreen and mosquito repellent until finished collecting the samples.

Use clean equipment at each site. Collect the composite sample by sampling quiescent sediment from a minimum of three locations at each site. A suitable location will have these characteristics:

Surface sediment is dominated by particles < 2 mm diameter (coarse sand or smaller),

Water depth above the sediment is < 30 cm,

The station is always under water throughout the day.

Anywhere within 10 bankfull widths (upstream or downstream) of the index station.

Upstream from where staff have entered the stream channel.

Using a Teflon spoon, scoop, or spatula, carefully collect the top 2 cm of sediment and place it into a glass mixing bowl. The spatula can remove thin layers of surficial sediments, and the scoop or spoon can remove the bed material from between rocks and debris. Sieving is easier if the sandy material is avoided. Care must be taken to prevent the fine sediments from being washed away by the stream when bringing the sample to the surface. Collect a total of about 1.5 L of wet sediment. Sediment grab samples from the hydrologic reach are composited and processed into a single sediment sample.

Prepare the sample processing area:

1. Isolate the sample-processing area from potential contaminants such as nearby road(s) as possible and turn off motor (road dust and vehicle emissions can contaminate samples).
2. Set up field-processing area. Preferable areas would be in a van or a building located near the sampling site. If not available, a foldable table can be used onsite.
    a. Spread a large, uncolored or white plastic (non-metallic) sheet over the area where inorganic sample processing is taking place.
    b. Use heavy-duty aluminum sheeting over the area where organic sample processing is taking place.
    c. Keep sample-processing equipment covered (when not processing sample), and keep all sample containers covered or capped.

3. Field rinse processing equipment with native stream water to ensure that all cleaning solution residues are removed, and to equilibrate equipment with sampling environment.
4. Wear powderless, disposable gloves while processing sample. Avoid contact with any potential source(s) of contamination. For example, keep gloved hands off any reactive (metal or plastic) objects when processing samples.

Mixing

Wear nitrile gloves and thoroughly mix (homogenize) the composite sample in the glass bowl using the Teflon spatula until a uniform color and texture is achieved. Decant excess water from sample into an appropriate, nonreactive wash bottle, being careful not to lose fine material.

The homogenized sediment sample will be split into portions for further processing. One sub-sample will be sieved to less than 63 µm and analyzed for metals. A second sub-sample will be sieved to less than 2.0 mm and analyzed for multiple organic compounds and total-organic carbon. The third sub-sample also will be sieved to less than 2.0 mm and analyzed for percent particle-size distribution.

Sieving

Two different sieves are required to process the sample for metals and one for organic contaminants. A 63-µm mesh nylon-sieve cloth held in a plastic frame is used for sieving sediment samples for metals analyses, and a 2.0-mm stainless-steel sieve is used for processing samples for organic-contaminants analyses.

Note: If the field sampling got delayed for any reason, 63-µm mesh nylon-sieving and the following procedures for trace-metals analyses can be done in the lab within 24 hours from the sampling.

<u>Metals samples</u>

- Stretch the 63-µm mesh nylon-sieve cloth over the plastic-sieve frame and attach retaining ring. Assemble in series the 63-µm mesh nylon cloth sieve and the plastic funnel over a 500-mL plastic sample container.
- Place a small amount of composite sample onto the 63-µm mesh nylon cloth with the spatula. Apply ‘dunking’ method. For this method, a glass bowl with native stream water will be used to filter out the fines by dunking. The cloth is twisted to gently squeeze out the fines into the glass bowl and then dunked and squeeed repeatedly until no more fines come through. The material is discarded and repreat the process until enough material is collected. This material is then transferred to the sample bottle for analysis.
- An alternative method will be to "Pressure sieve" the sample using native water that has been collected directly from the stream into the 500-mL plastic-wash bottle. The fine sediments pass through the sieve into the sample container with the stream of water delivered by the wash bottle.

- Work small amounts of bed material through the sieve at a time, discarding the material remaining on the sieve. It is not necessary to sieve all the material that is less than 63 µm in each aliquot.

  NOTE: Shaking the sieve aggressively will help separate the fines.

- If additional wash water is needed, allow the sieved sediment/native water to settle several minutes and decant only the native water back into the wash bottle for reuse. Continue to reuse the native water until the necessary amount of sediment sample is obtained (a depth of approximately 1 cm in the sample container).
- The specific analytical laboratory can tell you how much sample material is needed for the analyses of inorganic constituents; typically that will be about 10 g (dry weight) of sieved sediment.

Organics samples

Place the 2.0-mm stainless-steel sieve over a 500-1,000-mL glass sample container. Gently work an aliquot of the sample through the sieve with a teflon policeman or spatula. Do not use water. The bottom of the sieve may require periodic removal of the material that adheres to it. Fill the sample container approximately half full or until an adequate amount of sample material has been collected; about 500 mL of wet sediment is typically needed for analyses of organic contaminants and TOC.

Particle size samples

Using the same 2.0-mm sieve described above, sieve until approximately 2 cm of wet sediment accumulates into a 500-1,000-mL plastic sample container.

Reserve a scoop of the homogenized sample for conducting an estimate on the physical composition of the sediment. Gravel should never be a dominant component of the sample. Sand is gritty to the touch. Fines are not. Record percent gravel, percent sand, and percent fines on the field form. Field-determined grain size estimation is categorized as follows: gravel (>2 mm), sand (2-16 mm), and fines (silt/clay/muck).

Labeling, storage, and shipping

For all samples, label each jar, place into polyethylene bags, and store in a small portable cooler of ice. Record sample information including number of jars representing each sample on a field form.

7.3 Field quality control procedures

7.3.1 Containers, preservation methods, holding times

To ensure the quality and consistency of sample collections, protocols including preservation methods, containers and holding times will be followed (Table 13 and Table 14).

Sample containers will be sent from the laboratory to the field team before each sampling event. Samples will be transported or sent by the field team to the analytical laboratory or a secure transfer station. At the laboratory, samples may be further divided for analysis and storage.

Sample holding time is the maximum allowable length of time between sample collection and laboratory analysis. If necessary, field crew will coordinate with the analytical laboratory to ensure samples can be transported and processed during non-business hours.

Table 13. Water Sample containers, preservation, and holding times

Parameter	Container	Preservative	Holding Time
Turbidity	500 mL w/m poly bottle[1]	Cool to ≤6°C	48 hours
Hardness (as $CaCO_3$)	125 mL w/m poly bottle[2]	1:1 H_2SO_4 to pH <2; Cool to ≤6°C	6 months
Total Suspended Solids (TSS)	1000 mL w/m poly bottle[3]	Cool to ≤6°C	7 days
Dissolved Organic Carbon (DOC)	125 mL n/m poly bottle[2], 0.45 um pore size filters	Filter in filed with 0.45 um pore size filter; 1:1 HCL to pH<2; cool to ≤6°C	28 days
Chloride (Cl^-)	500mL w/m poly bottle[3]	Cool to ≤6°C	28 days
Total Persulfate Nitrogen (TPN)	125 mL clear n/m poly bottle[2]	1:1 H2SO4 to pH<2; Cool to ≤6°C	28 days
Nitrate+Nitrite (NO_3+NO_2)	125 clear w/m poly bottle[2]	1:1 H_2SO_4 to pH <2; Cool to ≤6°C	28 days
Ammonia (NH_4)	125 mL clear w/m poly bottle[2]	1:1 H_2SO_4 to pH <2; cool to ≤6°C	28 days
Total Phosphorous (TP)	125 mL clear n/m poly bottle[2]	1:1 HCl to pH<2; Cool to ≤6°C	28 days
Ortho Phosphorus (PO_4)	125 mL amber w/m poly bottle, 0.45 um pore size filters for dissolved OP	Filter in field with 0.45 um pore size filter; Cool to ≤6°C	48 hours
Total metals (As, Cr, Cd, Cu, Pb, Zn)	500 mL HDPE bottle[4]	5 ml of 1:1 HNO_3 to pH<2	6 months
Dissolved metals (As, Cr, Cd, Cu, Pb, Zn)	500 mL HDPE bottle[4]	Filter within 15 minutes of collection then add 5ml of 1:1 HNO_3 to pH<2; Cool to ≤6°C	6 months
Fecal Coliform	250 glass/ polypropylene autoclaved bottle[5]	Filter the bottle to the shoulder; Cool to ≤10°C	24 hours

Parameter	Container	Preservative	Holding Time
E.Coli	250 mL glass/polypropylene autoclaved bottle	Filter the bottle to the shoulder; Cool to ≤10°C	24 hours
Chlorophyll-a	1000 mL amber poly bottle	Cool to ≤6°C If filtered in the field: freeze filters in acetone at -20°C	24hrs to filtration, 28 days after filtration

[1]Do not comfine Alkalinity with patermaters that must be shaken (turbidity, TSS and other solids tests); May be able to analyze several general chemistry parameters from the same container.
[2]Container is sent by lab with preservative in it.
125 mL poly: 0.25 mL 1:1 H_2SO_4;
125mL poly: 0.25 mL 1:1 HCl
500 mL, 5mL 1:1 HNO_3
[3]May be able to analyze several general chemistry parameters from the same container.
[4]Containers cleaned as per OSWER Cleaning Protocol #9240.0-05
[5]If chlorine is suspected in sample, then request bottle with thiosulfate preservative in it.

Table 14. Sediment sample containers, preservation, and holding times

Parameter	Container	Preservative	Holding Time
Grain Size	8oz plastic jar	Cool to ≤6°C	6 months
Percent Solids	2oz glass jar	Cool to ≤6°C	7 days
Total Organic Carbon	2oz glass jar	Cool to ≤6°C; PSEP: may freeze at -18°C	14 days, 6 months if frozen
Total metals (As, Cr, Cd, Cu, Pb, Zn)	4oz glass jar[1]	Cool to ≤6°C	6 months
PAHs	8oz glass jar	Cool to ≤6°C; or freeze at -18°C	14 days; 1year if frozen,
PBDEs	8oz glass jar[2]	Cool to ≤6°C; or freeze at -18°C	14 days; 1year if frozen,
Phthalates	8oz glass jar	Cool to ≤6°C; or freeze at -18°C	14 days; 1year if frozen,

[1]Containers cleaned as per OSWER Cleaning Protocol #9240.0-05
[2]Organic free with Teflon lined lids

7.3.2 Field blank

Blanks serve as field audits to ensure procedures to prevent or reduce contamination are working. A field blank sample will not be processed for sediment parameters.

An equipment blank (field filter) and a single transfer blank for water-based parameters will be collected early in the monitoring program. These samples will be labeled with unique numbers, and will accompany samples to the laboratory.

- The field filter blank will be collected from the filtration apparatus using DI or RO water.
- The transfer blank will be collected by pouring lab-provided deionized (or RO) water into a clean sample bottle to determine whether field contamination (including DI water contamination) is present, unrelated to the equipment.

Other field blank samples may be collected as needed for determining a contamination source. If field blank contamination is discovered, additional field blank samples may be used to determine the source of the contamination. Field blank samples collected to determine the contamination source may include:

A field trip blank collected by transporting unopened bottles containing organic and metal-free, certified clean water from the laboratory into the field, and then returned it to the laboratory (bottles are not opened in the field). Trip blanks are used to determine whether any contamination occurs while traveling from field to laboratory.

7.3.3 Field log requirements

A field log with appropriately detailed notes will be used to record irreplaceable information for each site visit. The information collected during each field visit, whether for sampling location confirmation or for monitoring activities. Field form entries will include but are not limited to:

- Name and location of activity
- All field personnel, and specifying the recorder's name
- Sequence of events
- Any changes or deviations from the QAPP
- Environmental conditions at time of monitoring activity
- Date, time, location, ID, and description of each sample
- Field instrument calibration procedures and documentation
- Field measurements
- Type and number of QC samples collected
- Unusual circumstances that might affect data validation and interpretation of results

Forms will include the station visit/maintenance sheet, meter calibration, and chain-of-custody forms. All errors or typos will be crossed out and rewritten by the technician who recorded the data. All corrections will be initialed and dated when made. Do not use correction fluid or tape. Paper documents will be stored in an organized central filing location at the USGS office in Tacoma.

Watershed Health monitoring software includes electronic field forms for use by computer tablets.

Table 15. Field quality control samples and QC procedures

Field Sample Collected	Frequency	Control Limit	Corrective Action
Grab water and sediment field replicate	10% of total samples	Assess representativeness, comparability, and field variability.	Review procedures; alter if needed
Field equipment /filter blank	At least once a year	Analyte concentration should be below the reporting limit	Compare equipment/filter blanks for analyte to determine whether the sampling process is the source of contamination; re-evaluate decontamination procedures; evaluate results greater than 5x blank concentrations
Transfer blank	At least one sample a year	Blank analyte concentration should be below the reporting limit	Compare blanks for analyte to determine whether the sampling process is the source of contamination; re-evaluate decontamination procedures; evaluate results greater than 5x blank concentrations
Other blank samples for determining a contamination source	As needed	Blank analyte concentration should be below the reporting limit	Compare results from separated blanks to isolate the source of contamination; evaluate results greater than 5x blank concentrations

7.4 Chain-of-custody

Chain of custody (COC) procedures are necessary to ensure through documentation of handling for each sample, from field collection to laboratory analysis. The COC provided by laboratory will include sample location, sampling time and analyses to be performed. Field staff will fill the COC form at the field.

7.5 Laboratory Notification

The field lead will notify the laboratories 24 to 72 hours before the sampling to schedule the sample submittal and analysis. For fecal coliform and *E.coli*, field staff are responsible for notifying the laboratory and make sure the samples to be picked up and processed within 24 hours holding time.

8.0 Laboratory Procedures

All chemical analyses should be done by Washington State accredited labs for the particular parameters.

8.1 Lab measurements

Table 16. Measurement methods (laboratory)

Analyte	Sample Matrix	Sample Prep Method	Analytical (Instrumental) Method	Method Detection Limit
Turbidity	Water	NA	SM 2130 B	0.1049 NTU
Hardness (as $CaCO_3$)	Water	NA	SM 2340 B	0.067 mg/L
Total Suspended Solids (TSS)	Water	NA	SM 2540 D	NA
Dissolved Organic Carbon (DOC)	Water	NA	SM 5310 B	0.111 mg/L
Chloride (Cl^-)	Water	NA	EPA 300.0	0.0051 mg/L
Total Persulfate Nitrogen (TPN)	Water	NA	SM 4500-N B	0.01296 mg/L
Nitrate+Nitrite (NO_3+NO_2)	Water	NA	SM 4500 NO_3	0.0025 mg/L
Ammonia (NH_4)	Water	NA	SM4500-NH3H	0.004 mg/L
Total Phosphorous (TP)	Water	NA	SM 4500 PB	0.0063 mg/L
Ortho-Phosphate (PO_4)	Water	NA	SM 4500 PG	0.00174 mg/L
Total metals (As, Cd, Cr, Cu, Pb, Zn)	Water	EPA 200.2	EPA 200.8	0.030, 0.011, 0.084, 0.182, 0.017, 1.66 µg/L
Dissolved metals (As, Cd, Cr, Cu, Pb, Zn)	Water	NA	EPA 200.8	0.013, 0.007, 0.013, 0.052, 0.015, 0.760 µg/L
Fecal Coliform	Water	NA	SM 9222 D	NA
E.Coli	Water	NA	SM 9222G1	NA
Chlorophyll-a	Water	NA	SM 10200 H3	NA
Grain Size	Sediment	NA	PSEP 1997	NA
Percent Solids	Sediment	NA	SM 2540 G	NA
Total Organic Carbon	Sediment	NA	EPA440.0	NA
Total metals (As, Cd, Cr, Cu, Pb, Zn)	Sediment	EPA 3050B	EPA 6020 B	0.014. 0.014, 0.02, 0.01, 0.011, 1.8 µg/kg
PAHs	Sediment	SW3541	EPA 8270 E SIM	0.07-0.94 µg/kg
PBDEs	Sediment	SW3541	EPA 8270 E	0.041-0.115 µg/kg
Phthalates	Sediment	SW3541	EPA 8270 E SIM	2.02-5.71 µg/kg

8.2 Laboratory quality control procedures

This section discusses the laboratory quality control (QC) procedures that will be implemented to provide high quality data. Laboratory procedures will help identify problems or issues associated with data collection, data analysis while the project is underway.

8.2.1 Water and sediment samples QC procedures

Laboratory QC procedures and results will be closely monitored throughout the project period. QC samples includes;

Blanks and standards

Laboratory blanks are useful for instrument calibrations and method verifications, as well as for determining whether any contamination is present in laboratory handling and processing of samples.

Laboratory standards

Laboratory standards (reference standards) are solid, powdered, or liquid substances often purchased from an outside accredited source to determine high-level or low-level quantities of a specific analyte. These standards are accompanied by acceptance criteria and are used to test the accuracy of the laboratory's methods. Laboratory standards are typically added after calibration of an instrument and prior to sample analysis.

Method blanks

Method blanks are designed to determine whether contamination sources may be associated with laboratory processing and analysis. Method blanks are prepared in the laboratory using the same reagents, solvents, glassware, and equipment as the field samples. These method blanks will accompany the field samples through analysis.

Matrix spikes and matrix spike duplicates

Matrix spike samples are triple-volume field samples (per parameter tested) to which method-specific target analytes are added or spiked into two of the field samples, and then analyzed under the same conditions as the field sample. Matrix spikes can be analyzed in duplicate (matrix spike/matrix spike duplicate [ms/msd]) to determine method accuracy and precision. Matrix spikes will be prepared and analyzed at a rate of 1 /20 (five percent) samples collected or one for each analytical batch, whichever is most frequent. Use of ms/msd at the frequency of 5% of the total number of samples is common practice.

Laboratory Duplicate/splits

Laboratory duplicate or "split" sample will be analyzed regularly to verify that the laboratory's analytical methods are maintaining their precision.

Some parameters may require a double volume for the parameter to be analyzed as the laboratory duplicate. Matrix spike duplicates may be used to satisfy frequencies for laboratory duplicates. A laboratory duplicate is typically prepared for each batch of samples.

Lab Control Sample (LCS) and lab control sample duplicate (LCSD)

LCS and LCSD is a reference matrix blank spiked with known amounts of target analytes. LCS/LCSD is prepared and analyzed at a minimum frequency of one per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. The LCS/LCSD sample is prepared and analyzed in exactly the same manner as the method blank and field samples.

The percent recovery of the target analytes in the LCS/LCSD is compared to established control limits and assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit in relatively clean matrix without interferences.

Surrogates and internal standards

Surrogate standards are used to process and analyze extractable organic compounds. A surrogate standard is added before extraction and it monitors the efficiency of the extraction methods.

Internal standards are added to organic compounds and metal digests to verify instrument operation when using inductively coupled plasma mass spectrometry (ICP-MS) analysis and gas chromatography-mass spectrometry (GC-MS) analyses. Extracted Internal Standards are isotopically labeled analogs of the target analytes and are added to the sample prior to extraction. Physical and chemical properties of each labeled compound are virtually the same as its unlabeled "native" analog. Thus, any losses of the target compound that may occur during sample preparation or determinative steps will be mirrored by a similar loss of the labeled standard. This assumption, termed recovery correction, allows for correction to observed concentrations of the target compound relative to its labeled counterpart. Built-in recovery is one of the principal advantages of isotope dilution method. The added cost of isotopically labeled compounds is a disadvantage, but can be offset by higher quality data.

Table 17. Laboratory quality control samples and QC procedures

Quality Control Sample[1]	Analysis Type	Frequency[2]	Corrective Action
Laboratory Duplicates[3]	Conventional	5% of total samples or 1 per batch (method-specific)	Evaluate procedure; reanalyze or qualify affected data
	Organics		
	Microbiology		
Matrix Spike (full constituent list)	Metals	5% of total samples or 1 per batch	Evaluate procedure and assess potential matrix effects; evaluate and qualify affected data
	Conventional	5% of total samples or 1 per batch	
	Organics	5% of total samples or 1 per batch	Evaluate duplicates and surrogate recoveries and assess matrix effects; evaluate and qualify affected data
Matrix Spike Duplicates[3]	Metals and Organics	5% of total samples or 1 per batch	Evaluate procedure and assess potential matrix effects; evaluate and qualify affected data
Method Blanks	Metals	5% of total samples or 1 per batch (method-specific)	Blank concentration may be used to define a new reporting limit. Evaluate procedure; ID contaminant source; reanalyze samples if blanks are within 10x concentration. No action necessary if samples are >10x blank concentrations
	Conventional		
	Organics		
	Microbiology		
Lab control sample	Metals	5% of total samples or 1 per batch (spiked blank).If available, solid batches only: LCSs at 10% of total samples or 2 per batch	Evaluate lab duplicates/matrix spike recoveries; assess efficiency of extraction method; evaluate or qualify affected data
	Conventional	5% of total samples or 1 per batch	
	Organics	5% of total samples or 1 per batch (spiked blank; LCS/LCSD). If available, solid batches only: SRMs at 10% of total samples or 1 per batch	
Surrogates	Organics	Surrogates frequency is 100%	Evaluate results; qualify or reanalyze or re-prep/reanalyze samples.
Internal Standards	Metals and Organics	Internal standard frequency is 100% for GC/MS and ICPMS methods	Evaluate results; dilute samples, or flag data.
Extracted Internal Standards	PAHs	100% frequency	Qualify, reanalyze or re-prep samples.

[1]Quality control samples may be from different projects for frequencies on a per-batch basis.
[2] Frequencies may be determined from the study number of samples collected.
[3]The lab may use either a matrix spike duplicate or laboratory duplicate to evaluate precision based on the method.

9.0 Measurement Quality Objectives

9.1 Data quality objectives

Data quality objectives (DQOs) establish acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data. These criteria are known as performance or acceptance criteria, or DQOs. DQOs represent the overarching quality objectives of the study, including that collected data meet measurement quality objectives (MQOs).

9.2 Measurement quality objectives

MQOs for this study include data quality indicators of precision, bias, sensitivity, representativeness, comparability, and completeness. The MQOs for the data to be collected in the program are provided in this section.

9.3 Targets for precision, bias, and sensitivity

The MQOs for this study results, expressed in terms of acceptable precision, bias, and sensitivity, are summarized below (Table 18, 19 and 20).

Table 18. Measurement quality objectives for field measurements

Parameters	Analysis methods in Water	Accuracy (deviation between measurements)	Precision (%)	Bias (% deviation from true value)
Stage	Data logger	Typical error: ±0.1%; 0.4 cm (0.013 ft) water Maximum error: ±0.2%; 0.8 cm (0.026 ft) water	±0.1 feet	within 0.1 ft of known depth of lab water tank
Temperature	Data logger	Between -5 and 50 °C, resolution 0.001 °C ±0.01 °C.	Within ±0.5 degree C	Within ±0.2 °C of NIST calibrated thermistor
Temperature	Multiparameter sonde	Between -5 and 50 °C, resolution 0.001 °C ±0.01 °C.	Within ±0.5 degree C	Within ±0.2 °C of NIST calibrated thermistor
DO	Multiparameter sonde	0 and 50 mg/L, resolution 0.01 mg/L ±0.1 mg/L or 1%, whichever is greater.	±0.3 mg/L or less than 5%	Within ±0.3 mg/L or less than 5% of theoretical saturation value at calibration temperature and pressure
pH	Multiparameter sonde	0 and 14 units, resolution 0.01 unit ±0.2 unit.	Within ±0.2 pH unit	Within ±0.2 pH unit of at least 2 standards that bracket known range of field measurements. A third standard is used to check the calibration.
Conductivity	Multiparameter sonde	Between 0 and 200 mS/cm, resolution 0.001 mS/cm ±0.5% of reading.	± 5 uS/cm or ± 3%	Within 5% of standards below 100 uS/cm or within 3% of standards above 100 uS/cm.

Table 19. Measurement quality objectives for water quality

Parameters	Reporting Limit	Field Replicate (RPD, %)	Lab Control Recovery (%)	Lab Control Duplicate (RPD, %)	Matric Spike Recovery (%)	Matric Spike Duplicate (RPD, %)	Lab Duplicate (%)
Turbidity	0.5 NTU	20	90-110	20	NA	NA	NA
Hardness as $CaCO_3$	0.3 mg/L	20	85-115	20	75-125	20	NA
Total Suspended Solids (TSS)	1 mg/L	20	NA	NA	NA	NA	20
Dissolved Organic Carbon (DOC)	0.5 mg/L	20	80-120	NA	75-125	NA	20
Chloride (Cl^-)	0.1 mg/L	20	90-110	NA	75-125	20	20
Total Persulfate Nitrogen (TPN)	0.025 mg/L	20	80-120	NA	75-125	NA	20
Nitrate+Nitrite (NO_3+NO_2)	0.01 mg/L	20	80-120	NA	75-125	NA	20
Ammonia (NH_4)	0.01 mg/L	20	80-120	NA	75-125	NA	20
Total Phosphorous (TP)	0.01 mg/L	20	80-120	NA	75-125	NA	20
Ortho-Phosphate	0.003 mg/L	20	80-120	NA	75-125	NA	20
Total metals (As, Cd, Cr, Cu, Pb, Zn)	0.1, 0.1, 0.2, 0.4, 0.05, 5.0 ug/L	20	85-115	20	75-125	20	NA
Dissolved metals (As, Cd, Cr, Cu, Pb, Zn)	0.1, 0.02, 01, 0.1 0.02, 1.0 µg/L	20	85-115	20	75-125	20	NA
Fecal Coliform	1 cfu/100mL	50	NA	NA	NA	NA	20
E.Coli	1 cfu/100mL	50	NA	NA	NA	NA	20
Chlorophyll-a	0.1 ug/L	25	NA	NA	NA	NA	20

Table 20. Measurement quality objectives for sediment samples

Parameters	Reporting Limit	Field Replicate (RPD, %)	Lab Control Recovery (%)	Lab Control Duplicate (RPD, %)	Matric Spike Recovery (%)	Matric Spike Duplicate (RPD, %)	Lab Duplicate (%)
Grain Size	NA	40	50-150	40	50-150	40	40
Percent Solids	NA	20	NA	NA	NA	NA	NA
Total Organic Carbon	0.1 %TOC	20	80-120	NA	NA	NA	20
Total metals (As, Cd, Cr, Cu, Pb, Zn)	0.1 except Zn, 5.0 µg/kg	20	85-115	20	75-125	20	NA
PAHs	1-5 µg/kg	40	50-150	40	50-150	40	40
Phthalates (Bis(2-Ethylhexyl)-, Butyl benzyl-, Di-N-Oxtyl)	25 µg/kg	40	50-150	40	50-150	40	40
Phthalates (Diethyl-, Dimethyl-, Di-N-Butyl-)	10 µg/kg	40	50-150	40	50-150	40	40
PBDEs (47, 49, 66, 71, 99, 100)	0.4 µg/kg	40	50-150	40	50-150	40	40
PBDEs (138, 153, 154, 183, 184, 191)	0.8 µg/kg	40	50-150	40	50-150	40	40
PBDE 209	2 µg/kg	40	50-150	40	50-150	40	40

10.0 Data Management Procedures

10.1 Data recording

Management of all field and continuous monitor data will follow established USGS data management procedures (Conn et al., 2019). These procedures outline methods for storing, reviewing, checking data quality, and release of all data collected by the Washington Water Science Center.

Field forms will be completed in the field during sampling and maintenance visits. The completed field form will be reviewed by the USGS program lead after each sampling, scanned, and an electronic version stored on internal servers that are backed up nightly.

Continuous monitoring data will be downloaded approximately quarterly from data loggers and stored in site specific electronic field folders and backed up nightly. Continuous data will be reviewed before or during uploading to Ecology's EIM database. Review and approval of continuous data will follow USGS's continuous records process and include a primary reviewer, approver and a final audit check (Wagner et al., 2006; Conn et al., 2017; Mastin 2017)

Watershed health data will be filled in the Ecology's provided electronic field form.

Laboratory data will be electronically sent to the USGS project lead and SAM study manager by each laboratory following completion of each set of analyses for a sampling event. Reporting times may vary depending on holding time and analytical methods but should not exceed eight months from the documented sampling date.

Laboratory data will be reviewed first by the USGS project lead for errors, missing data, and adherence to measurement quality objectives. The project lead will implement corrective actions if needed with the assistance from the Laboratory. At the end of each year's data collection effort the complete dataset will be reviewed by the SAM PSS study manager for adherence to completion and data quality objectives.

10.2 Electronic transfer requirements

Field measurements including continuous data will be loaded to USGS Science Base and Ecology's EIM database annually by the project lead with the assistance from SAM PSS study manager. Any calculated hydrologic metrics are not required to be loaded to EIM. The project lead will submit the calculated hydrologic metrics in an excel file to SAM PSS study manager annually.

Watershed health field form will be submitted to Ecology's watershed health database directly after the sampling using the electronic field form and will go through Ecology watershed health data review process and overseen by the SAM PSS study manager.

Finalized laboratory data will be loaded and submitted to Ecology's EIM database by SAM PSS study manager with the assistance of the project lead and Water Quality Program EIM coordinator in Ecology. The SAM PSS study manager will conduct the final data review and verification process using EIM submitted data.

Macroinvertebrate and periphyton data will be submitted to Puget Sound Stream Benthos (PSSB) database (https://pugetsoundstreambenthos.org/) by the laboratory manager. Ecology Environmental Assessment Program (EAP) staff will retrieve the data from PSSB and submit them to EIM regularly.

10.3 Data storage

All field forms, photographs, electronic data, and laboratory data will be stored by the project lead in an organized filing system for electronic and paper files. All raw data including continuous data, chemistry and biotic data will be stored and available in EIM. Key deliverables, reports and summary results will be posted on the SAM status and trends webpage.

10.4 Data reporting requirements

The project lead will submit reports as deliverables to SAM PSS project manager. The stream monitoring reports will include a complete discussion of the monitoring effort. The table (Table 5) provides a list of reports and target dates.

11.0 Data Verification and Usability

Data verification involves examining the data for errors, omissions and compliance with quality control (QC) acceptance criteria. The project lead will verify the data during and after data collection. SAM stream study manager and project lead will conduct final data review and verification during and after the data submittal to EIM.

11.1 Data verification, requirements, and responsibilities

11.1.1 Field data verification

Field staff will verify field results after measuring and before leaving the site.
They will keep field notes to meet the requirements for documentation of field measurements.
The field lead will ensure;

- Field-collected data are consistent, correct, and complete with no errors or omissions.
- Instrument measurement and converted values are within the acceptable instrumentation error limits and expected range of values.
- Methods and protocols specified in this QAPP were followed.
- Field QC process specified in this QAPP were followed.
- For continuous parameters, if identified discrepancies are found that indicate sensor or data-logger malfunction, a site visit to correct the problem must occur as soon as possible. Suspect data prior to that time should be flagged in the database and not be used in subsequent analyses.

11.1.2 Laboratory data verification

Project lead will verify the laboratory data to ensure;

- Results of laboratory QC samples accompany the sample results
- Field QC samples met the established criteria
- Data qualifiers are properly assigned where necessary
- Methods and protocols specified in this QAPP were followed.
- Laboratory QC frequency and corrective actions were properly done as described in this QAPP

If lab suspect field blank contamination, the labs will notify the project lead and SAM PSS study manager. The sample results will be then reviewed to determine if samples associated with the field blanks should be qualified based on the contamination.

Manchester laboratory will conduct standard QC process, which is equivalent to an EPA level 2A data verification process. The lab will also qualify data using the data qualifiers, which is ususally added during a Level 4 data validation.

Laboratory manager at the taxonomic laboratory will verify all taxonomic results, and Ecology EAP staff will verify all taxonomic data and then submit them into EIM.

Statistical data verification

As part of data verification, the project lead and SAM PSS study manager will consider using a statistical data review procedure to identify any abnormalities in the data.

11.2 Data usability

Data usability assessment

Data verification and validation, the variability, accuracy, and precision of the collected data will be compared with project objectives established at the beginning of the project. If the results do not meet those criteria, this will be explicitly stated in the annual reports. The lab will qualify results according to SOPs. Data will be reviewed through statistical and descriptive analyses to determine the data usability-if the sampled values represent the regional status of stream health, and all measured results met the QC criteria.

If data met all requirements and QC criteria, and followed the methods and documentation process properly, data will be accepted. If data met most of the requirement, but not all with minor issues, and SOPs were followed with little modifications, then the data will be qualified and may be used for subsequent data analysis. If data does not meet some or most of the requirements and QC criteria, and there were critical issues during sampling or chemical analyses or documentation processes, the results would be not usable.

Data analysis and presentation methods

Descriptive statistics summary: Describe basic features of the data, distribution and frequency of values, differences between groups, detection frequency of each parameter including stage-derived flow indicators.

Explanatory variables assessment: Exploratory data analysis will be conducted to investigate what natural and human factors/stressors correlate streams indicators.

Multivariate statistical analyses: Multiple statistical analyses will help to identify key drivers of status and trends of stream health.

Status assessment: The assessment of stream condition will be conducted either by developing thresholds or by comparing to known criteria such as Properly Functioning Conditions, state water or sediment quality standards, and sediment screening level.

Data from this study will be used to provide a regional scale status assessment. Calculation of spatial weights and status assessment will be presented through Cumulative Distribution Frequency (CDF) analysis, and it should be applied in both status and trend analysis using statistical software, such as the ‘spsurvey’ package in R.

Trend assessment: trend assessment will be done in two ways: annual CDF pattern changes and conventional trend analysis. Signal to noise analysis for each parameter will be updated each year to help distinguish true trend versus annual variations.

12.0 Adaptive management of this QAPP

If a need is identified for adaptive changes to the monitoring protocols or data analysis approaches specified in this QAPP, the proposed revision(s) to this QAPP must be detailed in a separate memo. The memo will provide justification for the change(s) and the expected results and impacts to data usability for the monitoring that has been conducted to date and that will be conducted in the future. Any proposed changes must be approved by the SAM Scientist prior to implementation. At the discretion of the SAM Scientist, the approval process for substantive changes to this QAPP may include discussion(s) with the Stormwater Workgroup or Status & Trend Subgroup and other interested parties.

13.0 References

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