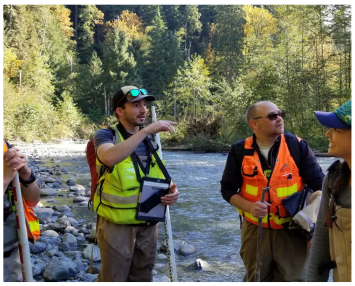
Snohomish County

STATE OF OUR WATERS

Discover the health of your local rivers, lakes and streams

Snohomish County State of Our Waters Quality Assurance Monitoring Plan

Snohomish County Surface Water Management Division



Prepared by:
Snohomish County Surface Water Management (SWM)
Resource Monitoring Team
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May 1, 2020
QA Monitoring Plan
Version 1.0

This Quality Assurance (QA) Monitoring Plan has been prepared according to guidance provided in EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC, March 2001 [Reissued May 2006]) to ensure that environmental and related data collected, compiled, and/or generated for this project are complete, accurate, and of the type, quantity, and quality required for their intended use.

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SECTION A. PROJECT MANAGEMENT

A.1 Approvals – QA Monitoring Plan for: Snohomish County State of Our Waters Monitoring Program

Janell Majewski — 05/05/2020

Janell Majewski, Public Works Supervisor III, Snohomish County Surface Water Management Division — Date

Steve Britsch — 5/20/2020

Steve Britsch, Project Specialist IV, Snohomish County Surface Water Management Division — Date

Frank E Leonetti — 5/27/2020

Frank Leonetti, Project Specialist IV, Snohomish County Surface Water Management Division — Date

Robert Plotnikoff — 05/27/2020

Robert Plotnikoff, Senior Habitat Specialist and QA Manager, Snohomish County Surface Water Management Division — Date

Aaron W Young — 05/28/2020

Aaron Young, QA Manager, Am Test Analytical (Water Quality) Laboratory — Date

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ACRONYMS AND ABBREVIATIONS

Assessment	A sampling program intended to characterize environmental conditions with a single site visit
B-IBI	Benthic Index of Biotic Integrity
BMI	Benthic Macroinvertebrates
°C	degrees Celsius
cm	centimeters
CWA	Clean Water Act
DO	Dissolved oxygen
DQI	Data quality indicators
DQO	Data Quality Objectives
eDNA	Environmental Deoxyribonucleic Acid
EIM	Environmental Information Management
EPA	Environmental Protection Agency
ESA	Endangered Species Act (E&T Species)
g	grams
GMA	Washington State Growth Management Act
GRTS	Generalized Random Tessellation Stratified
m	meter(s)
µS/ cm	micro-Siemens per centimeter
mg/L	milligrams per liter
Monitoring	A program that collects samples on a regular frequency and over the long-term
MS4	Multiple Separate Storm Sewer System
NPDES	National Pollution Discharge Elimination System
NPS	Nonpoint source
PDF	Portable Document Format
QA	Quality assurance
QAM	Quality Assurance Manager
QAMP	Quality Assurance Monitoring Plan
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality control
QCO	Quality Control Officer
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard Operating Procedure
SOW	State of Our Waters Monitoring Program
Survey	A sampling program conducted a single time (see Assessment)
SWM	Surface Water Management (Snohomish County Public Works)
TMDL	Total Maximum Daily Load
WWTP	Waste Water Treatment Plant

A.3 Distribution List

The approved Quality Assurance (QA) Monitoring Plan will be submitted to all project leads and technical staff, the Contract Water Quality Laboratory, and the Contract Taxonomic Laboratory Project Managers. (Table A-1). Laboratory managers are responsible for distributing this QAMP to appropriate personnel within their organization.

Table A-1 Distribution List.

Name/Title	Phone, Fax, E-mail	Mailing Address
Snohomish County Surface Water Management Division		
Janell Majewski Public Works Supervisor III	425-388-6641 (phone) 425-388-6455 (fax) janell.majewski@snoco.org	Physical location: Admin. Bldg. West 3000 Rockefeller Avenue, MS/607 Everett, WA 98201-4046
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Water Quality Laboratory		
Aaron Young Project Manager	425-885-1664 (phone) 425-820-0245 (fax) aarony@amtestlab.com	Am Test Laboratories 13600 NE 126th PL, Suite C Kirkland, WA 98034

Name/Title	Phone, Fax, E-mail	Mailing Address
Snohomish County Surface Water Management Division		
Taxonomic Laboratory		
Wease Bollman Project Manager	406-721-1977 (phone) 406-721-2028 (fax) contact@rhithron.com	Rhithron Associates, Inc. 33 Fort Missoula Rd. Missoula, MT 59804
eDNA Laboratory, Washington Department of Fish and Wildlife		
Sarah Brown Project Manager	360-902-2754 (phone) 360-902-xxxx(fax) sarah.brown@dfw.wa.gov	Washington DFW Natural Resources Bldg. 1111 Washington St. SE Olympia, WA 98501

A.4 Project/Task Organization

The purpose of this document is to present the Quality Assurance Monitoring Plan (QAMP) for conducting:

- Water Quality Monitoring
- Benthic Macroinvertebrate Monitoring
- Continuous Temperature Monitoring
- Threatened and Endangered Species Habitat and Bank Conditions Monitoring
- Fish Use/eDNA Presence
- Hydrology Characterization

Results from the above monitoring programs, collectively referred to as the State of Our Waters Monitoring Program (SOW), will be used to assess status and trends of aquatic resources in streams of Snohomish County. Separately, monitoring of larger rivers will be accomplished by the SOW program and is described in the appendices. This State of Our Waters monitoring program is compliant with the approach of the General Policy Plan concerning in achieving outcomes described in the plan. Some examples of County SWM programs where SOW results may be used include:

- Identification of sensitive and at-risk areas for master drainage planning
- Prioritization of pollution control efforts
- Habitat restoration projects that need prioritization;
- Outreach activities/messaging based on SOW issue/stressor identification; and
- Culvert prioritization based on relative stream health.

This information will also be useful to the Department of Planning and Development Services for compliance with elements of the Growth Management Act, Shoreline Management Act, and the Comprehensive Plan.

The monitoring activities described in this QAMP are driven by goals of the Clean Water Act (CWA), the Endangered Species Act (ESA), Washington State Growth Management Act (GMA), as well as, Snohomish County priorities and to support Public Works - Surface Water Management Division's mission;

> *"Work in partnership with the community to protect and enhance water quality and aquatic habitat, to minimize damage from flooding and erosion, and to preserve water resources for future generations."*

The program is funded by surface water fees collected by Snohomish County Public Works under the authority of the Revised Code of Washington RCW 36.89 and 90.72 and codified in Snohomish County Code Title 25.

This plan is available on Snohomish County's website at:

https://www.snohomishcountywa.gov/DocumentCenter/View/61244/State-of-Waters-

Data for this project will be uploaded to the Surface Water Management Divisions online database http://www.snoco.org/applications/login.html?publicuser=Guest#waterdata/stationoverview

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This QAMP provides general descriptions for in-stream data collection, the objectives to be met, and the procedures that will be used to ensure that the data are scientifically valid and defensible, and that uncertainty has been reduced to a known and practical minimum. The QAMP describes procedures to: 1) prepare for the field effort, 2) conduct field sampling following standard protocols, and 3) post-process field data.

Biological, physical habitat, and water quality data are collected across major land use types (urban, rural, forested, floodplain/upland agriculture) on streams in unincorporated Snohomish County. Status and trends of key variables and identification of relationships between stressors and aquatic life is used to describe watershed health across major land use categories.

The organizational aspects of a program provide the framework for conducting tasks. The organizational structure can also facilitate project performance and adherence to quality control (QC) procedures and QA requirements. Key project roles are filled by those persons responsible for ensuring the collection of valid data and routine data assessment for precision and accuracy, as well as the data users and the person(s) responsible for approving and accepting final products and deliverables. The project organization chart (

Figure A- 1) includes relationships and lines of communication among all participants and data users and Table A-2 summarizes each person's responsibilities and respective authorizations.

Figure A- 1 Organizational Chart.

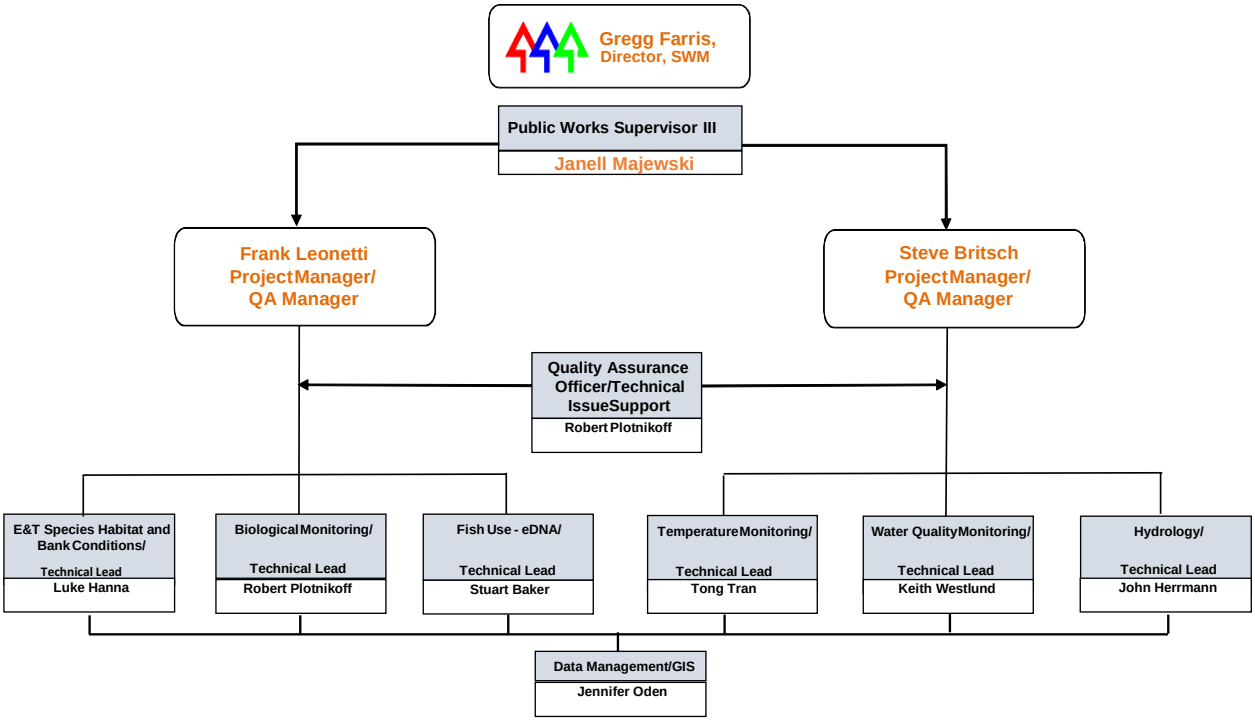


Table A-2 Roles and Responsibilities.

Name	Responsible for:	Authorized to:
Gregg Farris Director, SWM	• Review of project goals and objectives; • Ensure project is meeting high priorities of stakeholders and data users; and • Approval of budget	Revise project direction and budget.
Janell Majewski Public Works Supervisor III	• Updating the management team and acquire feedback on project progress; • Manage overall budget and staffing for State of Our Waters Monitoring Program; • Approving work plans and priorities; • Approving reports and other documents that are created for SOW; and • Providing project oversight in coordination with Project Manager and Project Lead.	Approve work plans, staffing, budgeting and spending. Approve documents as final versions and make technical recommendations for all project work. Represent the State of Our Waters Monitoring Program on SWM's Management Team.

Name	Responsible for:	Authorized to:
Steve Britsch Project Specialist IV/ Quality Assurance Manager	• Acting as Project Manager, in coordination with Project Lead and Supervisor, which includes budgeting, organizing and coordinating work priorities and progress; • Approving water quality monitoring standard operating procedures (SOPs) and relevant QAMP sections; • Coordinating technical products and deliverables with the Project Team; • Prepares technical documents and incorporates suggested revisions by the Quality Assurance/Quality Control scientists; and • Ensuring project deliverables meet deadlines.	Develop annual work plans and budget. Provide technical oversight and data interpretation of water quality monitoring components. Coordinates analysis and reporting.
Frank Leonetti Project Specialist IV/ Quality Assurance Manager	• Acting as Project Lead in coordination with Project Manager and Supervisor; • Approving all pre-monitoring documentation including QAMP and Study Design Plan; • Approving physical habitat SOPs and relevant QAMP sections; • Approving land use SOPs and analyzes; • Providing technical advice for monitoring program design and updates; • Providing technical advice on data analysis; • Developing large river work plan; and • Ensuring project deliverables meet deadlines.	Provide technical oversight of overall project design, physical habitat components, analyzes and data interpretation. Develop and implements land use analyzes and interprets data.
Robert Plotnikoff Senior Habitat Specialist/ QA Officer and Issue Support	• Approving benthic macroinvertebrate SOPs and relevant QAMP sections; • Analyzing and interpreting data; • Providing senior level guidance and review for each of the project deliverables; • Suggesting revisions in the monitoring design; • Providing review of all technical documents for correctness and completeness; • Ensuring that document content and organization meets all the sampling organization's quality control elements; and • Assuring that all products have appropriate documentation to ensure technical credibility.	Provide technical oversight of benthic macroinvertebrate component. Determine aspects of technical documentation that require revisions and updates. Suggest improvements to project process and quality. Assist Project Managers with QA Issues and suggest solutions.
Mike Rustay Senior Habitat Specialist	• Providing technical expertise on physical habitat and fish use components; • Reviewing relevant documentation including QAMP, Study Design Plan, analyzes and reporting; and • Ensuring project deliverables meet deadlines.	Support project as requested by project Manager and Lead. Suggest improvements to project process and quality.

Name	Responsible for:	Authorized to:
Marisa Burghdoff Water Quality Specialist III	• Acting as limnological technical lead; • Assisting with aquatic plant species identification and significance to stream condition; and • Acting as Outreach lead by providing strategy and execution. As such, authorized to update website, create materials.	Provide technical oversight of lake related work. Develop and implement outreach strategy. Support project as requested by Project Manager and Lead. Suggest improvements to project process and quality.
Luke Hanna Biologist	• Developing and implementing GIS technology applications; • Analyzing water quality, physical habitat, land use, fish use and biological information; • Ensuring data quality control; • Implementing E&T Species Habitat and Bank Conditions Monitoring field work; • Providing logistical support to field work; and • Collecting field data per protocols.	Develop and implement DO/temp component. Analyze data and perform QA. Support project as requested by Project Manager and Lead. Suggest improvements to project process and quality.
Stuart Baker Water Quality Analyst	• Acting as Fish Use and eDNA Project Technical Lead. • Implementing water quality field data and sample collection; • Implementing GRTS site selection and landowner permission coordination; • QA and Analysis of water quality information; and • Collecting field data per protocols.	Develop and implement fish use and eDNA components. Analyze data and perform QA. Support project as requested by Project Manager and Lead. Suggest improvements to project process and quality.
Tong Tran Engineering Technician	• Leading Temperature Monitoring data collection lead; • Ensure quality control of temperature data; and • Collecting field data per protocols.	Develop plans for data analysis and determine efficient strategies for field data collection.
Keith Westlund Engineering Technician	• Water Quality Monitoring Field data collection lead; • Ensure quality control of temperature data; and • Collecting field data per protocols.	Develop plans for data analysis and determine efficient strategies for field data collection.
Aaron Young WQ Laboratory Manager	• Primary contact for all water quality reports from the laboratory; • Provides laboratory performance Quality Assurance data; and • Provides explanation of laboratory performance that does not meet stated Quality Objectives.	Upon request, contribute technical explanations addressing QA issues involving laboratory results.

Name	Responsible for:	Authorized to:
Wease Bollman Taxonomic Laboratory Manager	• Primary contact for all benthic macroinvertebrate taxonomic reports from the laboratory; • Provides laboratory performance Quality Assurance data; and • Provides explanation of laboratory performance that does not meet stated Quality Objectives.	Provides high-level quality assurance review for all laboratory results and identifies data that should be flagged from further use.
Sarah Brown WDFW eDNA Project Manager	• Equipment loan and training; and • Sample receipt, analysis and reporting.	Provides high-level quality assurance review for all laboratory results and can qualify data or that limits further use and distribution. Expert in eDNA analysis for target species.

A.5 Problem Definition/Background

A.5.1 Project Objectives

The goals of the project relevant to this QAMP focus on monitoring stream conditions in the landscape settings associated with four major land uses: urban, forested, floodplain/upland agriculture, and rural. Project objectives include:

1) Monitoring to describe current status and detect change in conditions over time (status and trends);
2) Analyze data at different scales in order to address where change is detectable;
3) Monitoring to better understand the process, structure, functions and relationships between human activities and stream health; and
4) Monitoring that is risk- and threat-based; aquatic resources that are at risk from degradation.

A.5.2 Background

Snohomish County Surface Water Management (SWM) provides a variety of services to reduce road and property flooding and preserve and improve the health of Snohomish County's water resources. Focus areas include:

- Drainage and Road flooding
- River flooding
- Aquatic habitat
- Water Quality

The SOW program supports SWM focus areas by providing information that can be used to prioritize water quality, flooding and habitat projects and services. Information provided by the SOW program will include:

- Water quality of lakes, streams, and rivers;
- River conditions and flow patterns;
- Fish habitat, focused on the needs of Endangered and Threatened fish species; and
- Impact of land use changes on lakes, rivers and streams. .

In order to meet technical information needs for these service areas, the SOW study area includes rivers and streams within unincorporated Snohomish County, excluding cities, tribal and forest service lands. The study area is further stratified by four major land use categories including forest, floodplain/upland agriculture, rural and urban. These major land use categories were derived by merging Snohomish County's Future Land Use dataset with land cover.

Land uses (e.g., urban, agricultural, rural, and forested) identified in this monitoring program form distinct areas across the Snohomish County landscape. Each land use type contains unique human activities that can impact stream water quality, habitat condition, and biological communities. Recent studies demonstrate a strong and distinct difference in impacts to water quality and physical condition between urban, rural agricultural, and forested stream settings (Garcia *et al*. 2017). Intensification of these land uses in a similar setting to the Snohomish County landscape resulted in increased nutrient loading

(e.g., agricultural and urban) and decreased biodiversity (urban). Additionally, studies have shown that biotic communities are impacted by availability of a primary food source called fine particulate organic matter that originates from leaves, sticks, and twigs from streamside vegetation. This type of food input has a seasonal effect on the activity and functions in the biotic community based on leaf litter and winds that blow sticks and twigs into the stream.

A.5.3 Description of "Snohomish County State of Our Waters Monitoring Program"

State of Our Waters is an environmental monitoring program that includes the collection of priority data types including:

- Water Quality
- Benthic Macroinvertebrates
- Continuous Temperature
- Threatened and Endangered Species Habitat and Bank Conditions
- Fish Use/eDNA
- Hydrology

The selection of these priority data types was based in part on the identification of goals and key questions below.

Design of SOW was informed through discussion with SWM teams to confirm policy and regulatory drivers and data needs, satisfy business needs, establish goals, describe objectives and develop questions. The goals and study questions for each monitoring element are listed in Table A-3.

Table A-3 Goals and Key Study Questions for each of the Monitoring Elements.

Monitoring Element	Goals	Study Questions
Water Quality	Identify locations and land uses where water quality is or is not supportive of beneficial uses. Evaluate status and trends of core water quality parameters across sites and land use types. Investigate relationships between water quality stressors, habitat, flow, land cover and impacts to aquatic life.	• What are the status and trends for core water quality index (WQI) parameters? • What are monthly and annual flow adjusted WQI scores by site? • Are there trends in WQI scores? • Is WQ meeting standards and supportive of beneficial uses? • Are there bacteria hot spots for targeted source identification and elimination? • Are there relationships between WQ/flow/habitat/BIBI and land cover? • What are the dominant WQ stressors on B-IBI? • Where are the cool-water refuges and are water temperatures approaching 2040/2080 predicted temperatures due to climate change? • What treatments do factorial or stressor ID analysis suggest are needed and where are the opportunities for restoration and protection? • Are aquatic life and or human health based WQ criteria/thresholds exceeded for Cu, Zn in water?
T&E Species Habitat and Bank Conditions and Benthic Macroinvertebrates	Evaluate the integrity of aquatic and riparian habitat and assess functions for salmonids, aquatic life and floodplain ecosystem services	• What is the current status of stream/riparian habitat, bank conditions and aquatic life? • How are conditions changing over time? • What is the overall impact of human activities on stream/riparian habitats, bank conditions and aquatic life? • Where do salmonid habitat deficits and refugia exist and how do they overlap with temperature? • Are there relationships between WQ/summer low flow/habitat/aquatic life/BIBI and land cover? • What are the bank modifications and stressors to aquatic life within each reach/sub-reach? • What stream segments have the highest need and potential for process-based restoration to address deficits? • What treatments do conditions suggest are needed and where are the opportunities for restoration and protection?
Fish Use/eDNA	Evaluate the presence and use of habitats by fish to improve understanding of their geographic extent to support salmon recovery, fish passage and capital programs. Confirmation the project area is being utilized by a target species, or that an existing culvert is a barrier to fish migration will prompt identification of a project. A description of how salmonids are utilizing habitat of various quality will inform restoration or protection projects that conserve these species. Identification of habitat use by various species is especially important where previous records have not verified fish use and this new information expands the known distribution of one or more of the target species.	• Are ESA-listed fish species present upstream of study areas? • What are estimated abundances of target fish upstream of study areas? • How are ESA-listed fish populations currently using the habitat? • Are ESA-listed fish using habitat previously unknown or unreported in current distribution maps? • Are impassable culverts acting as barriers to upstream ESA-listed fish distribution?
Hydrology	Assess the effect of flow on water quality, habitat, and aquatic life to describe watershed health and inform salmon recovery efforts.	• Are high or low flow conditions driving water quality index scores? • Do summer low flow conditions influence water temperature? • What sub-basin factors affect or correlate with low flow? • Do summer low flow conditions limit salmonid rearing habitat and upstream migration to spawning grounds?
Land Cover	Classify major land cover classes by buffer and upstream of study location to characterize conditions and changes to explain factors affecting water quality, habitat, benthic invertebrates and hydrology.	• Is land cover in buffers, floodplains, and watersheds changing over time? • Are there relationships between land cover/use and habitat, aquatic life and water quality conditions? • How does land cover and use affect in-stream physical habitats, aquatic life and water quality?

Environmental policy and regulatory drivers include the:

- Federal Endangered Species Act (ESA);
- Federal Clean Water Act (CWA);
- Washington State Shoreline Management Act (SMA); and
- Washington State Growth Management Act (GMA).

Endangered Species Act

The ESA, enacted in 1973, is designed to protect critically imperiled species, and the ecosystems upon which they depend, from extinction. While the United States Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration Fisheries (NOAA-Fisheries; formerly National Marine Fisheries Service) administer ESA, their efforts do not include long-term monitoring of habitat and other stressors to aquatic life in Snohomish County streams and rivers. At the same time, these administering agencies evaluate factors contributing to on-going listing determinations including the present or threatened destruction, modification, or curtailment of habitat and efforts being made to protect west coast salmonids, such as local watershed initiatives. Understandably, without data and information regarding the status and trends in habitat conditions, de-listing determinations cannot be made nor can conclusions be drawn regarding the value of conservation actions. Moreover, without such information, local management actions cannot be effectively prioritized and implemented to preserve and restore conditions.

Clean Water Act

In 1972, the United States Congress adopted the CWA. Its objective is to restore and maintain the physical, chemical and biological integrity of the nation's waters by preventing point and non-point pollution. The CWA authorized the use of a water quality-based approach, whereby either the Environmental Protection Agency (EPA) or designated states create water quality standards protective of designated uses. Designated uses in Washington State include water supply (domestic, industrial, and agricultural), protection of fish (Salmonid spawning, rearing, and migration), shellfish, wildlife (habitat), as well as recreational, agricultural (stock watering), industrial, commerce and navigation, boating and aesthetic purposes (WAC 173-201A-200, 600 and 602).

The Washington State Department of Ecology (Ecology) has been delegated by the U.S. EPA as the state water pollution control agency, responsible for implementing all federal and state water pollution control laws and regulations. While Ecology implements various water resource and aquatic life monitoring programs on a statewide level, there are gaps at the local level.

State of Our Waters will address elements required under the CWA by implementing a status and trends monitoring program describing water quality conditions throughout the County and comparing them to surface water quality standards. In addition, results will be used to identify the condition of aquatic communities and stressors causing impairment. This data will also be used to identify opportunities for improvement and protection of water quality.

State of Our Waters will not be used to satisfy NPDES requirements for monitoring in sections S8.A or S8.B, but can improve on efficiency of sampling and eliminate the need for additional QAPPs when other monitoring activities are required.

Shoreline Management Act

The Washington State Shoreline Management Act (SMA) of 1972 seeks to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines. The goals of the SMA are to preserve and protect ecological functions and processes necessary to maintain shoreline natural resources, protect public health and preserve beneficial uses of the shorelines. Towards this end, the SMA established a broad policy directive giving preference to shoreline uses that:

- Protect the quality of water and the natural environment;
- Depend on proximity to shoreline ("water dependent uses"); and
- Preserve and enhance public access or increase recreational opportunities for the public along shorelines.

As described in Snohomish County's 2012 Shoreline Management Program, there are 54 lakes and 205 rivers and streams in Snohomish County meeting the shoreline designation. State of Our Waters will provide information on physical, chemical and biological conditions to assist in meeting SMA goals.

Growth Management Act

Snohomish County's Shoreline Management Program is an element of Snohomish County's Growth Management Act (GMA) Comprehensive Plan. The Growth Management Act is a Washington State law requiring state and local governments to manage Washington's growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, preparing comprehensive plans and implementing them through capital investments and development regulations.

Adopted in 2015, Snohomish County's 2035 Comprehensive Plan (The plan) serves as a complete policy document that guides County decisions and services on a wide range of topics including land use, transportation, parks, housing, and capital facilities. The plan consists of five parts; the General Policy Plan, Future Land Use Map, Transportation Element, Capital Facilities Plan, and Parks and Recreation. Of these, the General Policy Plan's natural environment chapter contains goals which overlap with SOW. These include but are not limited to:

- Continue existing and develop new county plans and programs which establish priorities to protect and enhance the natural environment through a coordinated policy framework to maintain and improve the quality of life for Snohomish County residents;
- Monitor elements of the natural environment and use adaptive management strategies to protect the natural environment;
- Protect and enhance natural watershed processes, wetlands, fish and wildlife habitat conservation areas, shorelines, and natural resources with the long-term objective of protecting critical ecological functions and values;
- Provide for the protection and encourage restoration of ecological functions and values across the landscape by coordinating planning efforts among jurisdictions and citizens;
- Improve and protect ecological functions and values of the natural environment through non-regulatory programs;

- Provide incentives for voluntary environmental restoration, enhancement and protection;
- Strengthen the county's ability to adapt to future impacts from climate change; and
- Educate the citizens regarding the natural environment and encourage voluntary environmental protection and stewardship.

While SOW assists in addressing policy and regulatory drivers, it also serves to address several non-regulatory drivers that are also priorities for government. **Non-regulatory drivers** include but not limited to:

- Snohomish-Stillaguamish Local Integrating Organizations Ecosystem Recovery Plan Priorities;
- SWM's Capital Stormwater Facilities and Master Drainage Planning Program needs;
- Snohomish Basin Salmon Recovery Plan;
- Stillaguamish Basin Salmon Recovery Plan;
- Lake Washington Salmon Recovery Plan;
- Snohomish County's Marine Resource Committee
- Snohomish County's Sustainable Lands Strategies Reach Scale Planning;
- SWM's Shellfish Protection Program; and
- Snohomish County Executive Somers' Puget Sound Initiative.

Snohomish-Stillaguamish Local Integrating Organizations Ecosystem Recovery Plan
The Snohomish-Stillaguamish Local Integrating Organization (Sno-Stilly LIO) is one of nine LIO's in the Puget Sound Region. It was established in 2012 to serve as a local forum through which stakeholders can work collaboratively to develop and coordinate actions to improve the health of the Snohomish and Stillaguamish watersheds and advance the broader Puget Sound Action Agenda. The 2016 Draft Ecosystem Recovery Plan identified high priority ecosystem components as primary stressors and strategies for protection. These include but are not limited to:

- Chinook Salmon
- Land Development and Cover
- Summer Stream Flow
- Freshwater Quality
- Shoreline Armoring
- Toxics in Fish

State of Our Waters will generate data that directly evaluates conditions in order to inform strategies for protecting these high priority ecosystem components.

SWM's Capital Stormwater Facilities and Master Drainage Planning Program

SWM's Capital Stormwater Facilities and Master Drainage Planning Programs focus on identifying opportunities to enhance or construct stormwater drainage systems to reduce road flooding, sedimentation and erosion and to improve water quality and fish access to habitat through the removal of blockages.

The group routinely utilizes hydrologic, habitat, benthic macroinvertebrate, fish-use and water quality data to help inform prioritization, planning and implementation of projects.

State of Our Waters may continue to collect site-specific fish use data to support project planning and implementation. Additionally, the collection of heavy metals, hardness, and total suspended solids data is directly tied to water quality facilities planning and prioritization needs.

While these data and others will be collected at randomly selected locations, rather than at site-specific projects, results may be extrapolated to comparable stream settings which, over time, will provide coverage to a broader area. To this extent, SOW will continue to serve capital facilities and master drainage planning program needs.

Snohomish Basin Salmon Recovery Plan

This plan proposes a scientifically based and feasible course of action over the next decade to begin recovering local salmon populations (SBSRF 2005). The plan is based on a careful review of scientific data, historical records, and social and economic considerations. It provides clear direction to local governments, agencies, interest groups, citizens, and other interested parties on recovery actions that will be most beneficial, where they should occur, and when they should happen.

This plan is one part of a regional effort to ultimately recover Chinook salmon populations in Puget Sound, and an important step toward keeping Coho salmon from being listed as a threatened species.

Stillaguamish Basin Salmon Recovery Plan

The overall goal of the Stillaguamish Watershed Chinook Salmon Recovery Plan is to help Chinook salmon populations recover to sustainable and harvestable levels (SIRC 2005). This document recommends an integrated strategy for protecting and restoring Chinook salmon populations, including individual strategies for habitat management, harvest management, and hatchery management, as well as an initial 10-year recovery plan with specific actions for Chinook salmon habitat improvement. The Plan's recommendations include habitat projects to restore watershed processes that affect Chinook salmon populations, protection of existing habitat through regulatory and non-regulatory strategies, stewardship education and outreach, and a monitoring and adaptive management plan.

Lake Washington Salmon Recovery Plan

The Lake Washington/Cedar/Sammamish Watershed, located in western Washington, comprises 692 square miles and includes two major river systems (Cedar and Sammamish) and three large lakes (Union, Washington, and Sammamish). It also includes the marine nearshore and numerous smaller sub-basins that drain directly to Puget Sound from West Point in the City of Seattle northward to Elliott Point in the City of Mukilteo. WRIA 8 is located predominantly in western King County, but about 15 percent extends northward into Snohomish County. However, over 53 percent of the marine shoreline is located within Snohomish County.

The Lake Washington/Cedar/Sammamish Watershed is home to three populations of Chinook salmon: Cedar River, North Lake Washington, and Issaquah. Each year Chinook salmon spawn and rear in the rivers, streams, and tributaries and use the lakes, rivers, estuary, and nearshore to rear and then migrate to the ocean. Development of the WRIA 8 watershed for human use has dramatically altered the habitat salmon need to survive. Chinook salmon in WRIA 8 are in trouble; they are far less abundant now than they were even in recent decades, and all three populations are at high risk of extinction. In March 1999, the federal government listed Puget Sound Chinook salmon as threatened under the Endangered Species Act (ESA).

The WRIA 8 Steering Committee developed this Plan through a multiple stakeholder planning process. The Steering Committee is composed of city and county elected leaders, concerned citizens, scientists, and representatives from business and community groups, water and sewer districts, and state and federal agencies. The WRIA 8 Steering Committee *Proposed Chinook Salmon Conservation Plan* is the result of this collaborative effort. It is a science-based plan containing recommendations for actions to restore and protect salmon habitat, and an approach for implementing these actions over the next ten years. The Plan was developed using the mission and goal statements adopted by the Steering Committee in 1999.

Snohomish County Marine Resources Committee

The Marine Resources Advisory Committee (MRC) is a team of citizen volunteers dedicated to promoting effective stewardship of Snohomish County's marine waters, habitats, species, and shorelines. MRC Committee members are appointed by the County Council to represent diverse local interests. The MRC seeks the best available scientific information and uses it to evaluate, prioritize, and implement strategies for achieving and sustaining a healthy Puget Sound. Through partnerships with native tribes, government, businesses, and non-profit organizations, the MRC protects and restores Snohomish County's marine environment. The SOW program will generate data on shoreline conditions that the MRC could use to prioritize work.

Sustainable Lands Strategies

The Sustainable Lands Strategies (SLS) was established with the intent that fish, farm, and flood management advocates can make more progress working together than alone. https://snohomishcountywa.gov/2194/Sustainable-Lands-Strategy

The SLS was convened in 2010 by Snohomish County, Tulalip and Stillaguamish Tribes, state and federal agencies, and agricultural and environmental stakeholders to improve coordination and promote progress for fish, farm and flood management interests.

The mission for SLS is "To generate net gains in agricultural, tribal cultural, ecological productivity and health in Snohomish County by developing a broadly supported framework of tools, strategies, and policies, including Comprehensive Plan amendments that will drive harmonized sustainable land-use and resource management decisions".

To serve the SLS mission, the executive committee's framework recognized the need for information about ecological conditions on a river reach scale. Four primary reach scale areas have been identified, including the Lower Skykomish, Lower Snohomish, the Snohomish Estuary and the mainstem Stillaguamish. Reach scale reports for these areas will provide information on the water quality, physical habitat and biological health of the areas and will identify project opportunities to generate net gains for floodplain/upland agriculture and fish.

Net gains will be measured in part by improvements to habitat and water quality. Initial habitat and water quality improvement metrics align well with existing Salmon Recovery and LIO goals, of which SOW will serve on a broad scale. Project and site-specific effectiveness monitoring may occur outside of SOW.

SWM's Shellfish Protection Program

The shellfish protection program (closure response plan) is a requirement of RCW 90.72, which is intended to prevent closures of recreational and commercial shellfish beds and to restore marine water quality to allow harvesting. The legislative authority of the county is required to create a shellfish protection district and shellfish protection program within 180 days of a shellfish growing area downgrade or closure caused by nonpoint source pollution. The time period begins when the Washington Department of Health (WDOH) issues the final administrative order reclassifying the growing area. Once the order is issued, growing areas are managed under the requirements of the new classification. The legislative authority of each county is then required to initiate implementation of the shellfish protection program (closure response plan) within 60 days after the Shellfish Protection District was established.

Washington State's 2016 Shellfish Water Quality Memorandum of Agreement (MOA) defines the state partnership between the Departments of Health, Ecology, Agriculture, the Washington State Conservation Commission, and the Puget Sound Partnership (State of Washington 2016). Washington State government uses this partnership to assist local governments during shellfish area downgrades and also helps develop coordinated projects and responses to "threatened" marine water quality. The agreement outlines the general roles, responsibilities, and actions of the agencies in developing a state coordinated response to water quality problems.

Puget Sound Initiative

In May of 2016, Snohomish County Executive Dave Somers announced that expanded efforts to protect and restore Puget Sound would be a center-piece of his Administration. https://snohomishcountywa.gov/3838/Puget-Sound-Initiative

A Snohomish County workgroup was established in 2017 that outlined three phases for the initiative. These phases include:

1. Highlighting what the County is doing to protect and restore Puget Sound – focusing on core areas of water quality, habitat restoration and species vitality;
2. Moving the needle on the County's existing work; and
3. Collaboration and planning for the future.

SWM contributed to the first Puget Sound Initiative report and website content. State of Our Waters Monitoring Program expects to help highlight future efforts to describe water quality and habitat conditions and restoration work.

Figure A- 2 Snohomish County 2018 State of Our Waters Sites and Project Area.

A.6 Project/Task Description

The following is a description of Project Tasks, Schedule, and Deliverables:

Project Tasks

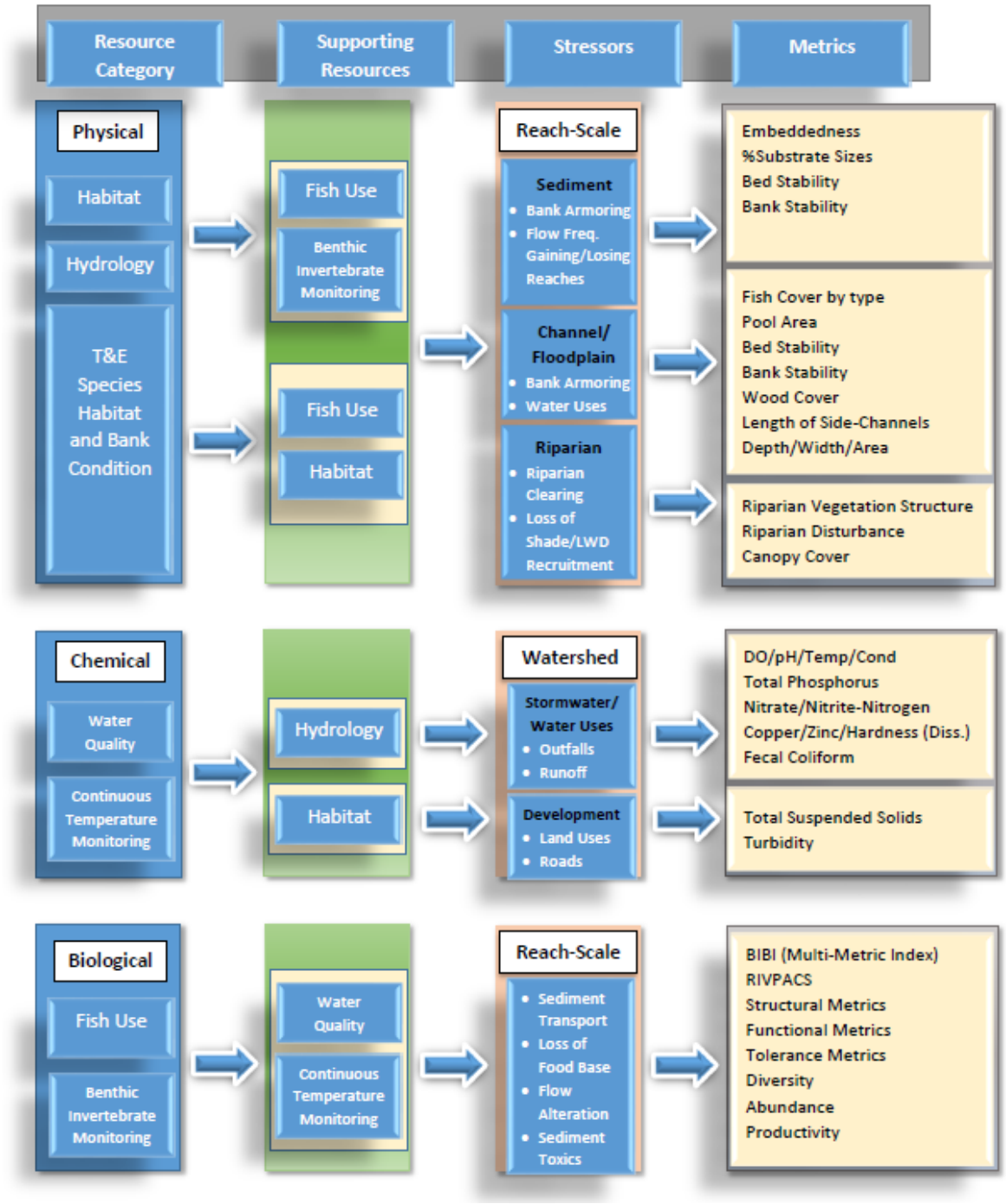
1. In consultation with the SWM leadership, implement a study design to assess the ecological condition of streams in four different land use settings (e.g., urban, forested, rural, and floodplain/upland agriculture);
2. Monitor environmental conditions using a Generalized Random Tessellation Stratified (GRTS)-based design to measuring status and trend of aquatic resources at selected sites;
3. Analyze data using best analytical practices to draw conclusions about quantities, quality, and differences among samples and sites; and
4. Determine the type and source of impairments from pollutants that have diminished the ecological condition of streams in each land use type.
5. Report information to relevant internal and external data users and stakeholders.

Data Analysis Approach; Relationships among State of Our Waters Monitoring Program Elements

State of Our Waters is a robust data gathering effort that addresses several of Snohomish County Public Works SWM and other Division business needs.

A conceptual model for State of Our Waters is described in Figure A- 3. Monitoring program elements are organized by the following categories: physical, chemical, and biological. Interpretation of results generated in each of the monitoring program elements rely on supporting resource data collected in other categories of the monitoring program.

Interpretation of results is focused on identifying the types of stressors that alter lakes, rivers and stream from the natural condition. Metrics that are known to respond to individual (and multiple) stressors in each of the monitoring program elements are used to interpret results.



Interpretation of the Flow Chart:

Resource Category – List of monitoring program types within the State of Our Waters Program.

Supporting Resources – Monitoring program types that generate supporting information for interpreting results.

Stressors – The types of activity that cause changes from the natural condition.

Metrics – Measurements (direct and derived) that reflect environmental conditions and divergence from natural.

Figure A- 3 Conceptual model for the State of Our Waters Monitoring Program.

State of Our Waters will be implemented in stages beginning October 2017. The regularly scheduled work for this monitoring program is included under tasks with associated timelines. Project elements are described by three separate types and are implemented on different timelines. A description of these schedules is provided in the next section.

Deliverables

Five major implementation tasks are addressed throughout the year and reported in Table A-4. These tasks are a combination of administrative support and field tasks representing all major monitoring activities in the State of Our Waters Monitoring Program. Within each of the major tasks are details that describe specific functions and milestones that will be completed within the calendar year.

Additional project deliverables are described in two separate tables. The first of the project deliverables are described in Table A-5 with reporting of data following completion of each monitoring activity. These deliverables include timelines for completion of sample processing, draft report completion and review, and completion of the final reports.

Once data have been finalized from each of the State of Our Waters Monitoring Program activities, data will be incorporated into information management systems that are used to meet environmental reporting requirements. The data used to construct these summaries and reports are on recurring timelines so are commonly prepared on an annual, three-, seven-, and ten-year cycle. Utility of the long-term reporting is to generate description of trends and identify influential factors. This long-term information is valuable as feedback for modifying or enhancing resource management programs.

Table A-4 Tasks and annual schedules for each of the monitoring programs.

Task	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1.0 Project Management												
Workplan and budget			X	X								
Water quality lab contract (Every 3rd year)									X	X	X	X
eDNA lab contract (Every 3rd year)									X	X	X	X
Benthic Invert lab contract (Every 3rd year)									X	X	X	X
Benthic Invert – Scientific collection permit				X	X							
Quarterly Team Meetings			X			X			X			X
2.0 Data Collection												
Bank Conditions				X	X	X	X	X	X	X		
Benthic Macroinvertebrate Sampling[1]						X	X	X	X			
Continuous Temperature Logger (Planning/Placement/Retrieval/Analysis)				X	X	X	X	X	X	X	X	X
Continuous Water Level[2]	X	X	X	X	X	X	X	X	X	X	X	X
Discharge (Flow Monitoring)			X			X			X			X

Task	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Fish Use and eDNA			X	X	X	X						
Habitat – Wadeable Stream Survey							X	X	X			
Summer Low Flow Measurements							X	X	X			
Water Quality Monitoring/Data Management[3]	X	X	X	X	X	X	X	X	X	X	X	X
3.0 Status Site Identification and Access												
Desktop Evaluation of Sites				X	X							
Reconnaissance for Feasibility						X						
Right of Entry						X	X	X				
Finalize Sites									X			
Map Production						X						
4.0 Annual Reporting	X	X	X	X	X	X						

Notes:

[1] Benthic macroinvertebrate monitoring includes one site visit each year, between June and the end of September of each year.

[2] Continuous water level monitoring probes will collect data continuously throughout the year.

[3] Water quality monitoring will include a monthly site visit.

Table A-5 Estimated timeline for anticipated deliverables and annual reports for each of the monitoring programs.

Sampling Routine	Type of Deliverable	Date of Delivery	Internal Client*
Water Quality	Data Review and Finalization (QA Review) Does this one need "Summary of QA Lab Performance accompanies the results"	Ongoing one month from date of collection, Annual QA review.	Resource Monitoring
	Reporting of Water Quality Index (WQI) Scores for all sites; identify reasons for the water quality index result.	Before start of new water year (October 1st).	Surface Water Management
Benthic Macroinvertebrates	a. Complete processing of benthic samples by the taxonomic laboratory b. Summary of QA Lab Performance accompanies the results.	January	Resource Monitoring
	Reporting of Benthic Index of Biotic Integrity (BIBI) Scores for all sites; identify reasons for the water quality index result.	June	Resource Monitoring
Continuous Temperature	Quality Assurance (QA) review of data	February	
	Prepare graphical results to examine annual temperature patterns.	June	
		April	
	a. Report of Results b. Calculate 7-DADMax for each site.	May	Resource Monitoring (placement of probes at trend and status sites)
T&E Species Habitat Use and Bank Conditions	Bank Condition data review and finalization	February	Resource Monitoring
	Habitat Units Review for completeness of data collection and summary of results for reporting.	February	Resource Monitoring

Sampling Routine	Type of Deliverable	Date of Delivery	Internal Client*
Fish Use	a. eDNA results b. Lab performance QA indicators reported with results. c. Include report of fish species presence in site condition narratives for the year.	November (same as the sample collection year)	Resource Monitoring
Hydrology	a. Flow Rating Curves b. Field measurement QA assessment report.	March	Resource Monitoring
	Summer low flow characterization	March	Resource Monitoring
	Pulse Counts Duration/Frequency of Peak Flow	March March	Resource Monitoring (20 trend sites: Impact to BMI Communities)

Note:
* The State of Our Waters Monitoring Program generates data used by internal Snohomish County government clients; deliverables are determined based on specific information needs.

Table 6 Major reports using the State of Our Waters Monitoring Program results and long-term timeline for completion.

Annual		3 Years	7 Years	10 years
SWM On-line/ Stream Health Report Card		Watershed Health Report Card	Shoreline Master Planning (Year 2019, Year 2026)	State of the Watersheds
GIS Layers Updates		WRIA Salmon Reports	Critical Area Regulations	PSP, LIO Targets
		Puget Sound Initiative		Growth Management Act – Comprehensive Plan Update

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A.7 Quality Objectives & Criteria

Data quality objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of the data, define the types of data needed to support the decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error due to uncertainty in the data (if applicable). Data users develop DQOs to specify the data quality and quantity needed to support specific decisions.

A.7.1 Measurement Performance Criteria

Measurement performance criteria are quantitative statistics used to interpret the degree of acceptability or utility of the data to the user. These criteria, also known as data quality indicators (DQIs), include the following:

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability

Precision

Precision is a measure of the scatter in the data due to random error that is expected primarily from sampling and/or analytical procedures. Precision is a measure of internal method consistency. It is demonstrated by the degree of agreement between individual measurements (or values) of the same property of a sample, measured under similar conditions.

Field duplicates are collected for the water quality and benthic monitoring program elements for assessment of precision will be analyzed at a frequency of about 10 percent of the total number of observations (may vary among monitoring elements in State of Our Waters programs). Field duplicates measure random error between collectors, spatial variability, and temporal variability.

For field water quality measurements that exceed a reporting detection limit (RDL), the relative percent difference (RPD) will generally be less than or equal to 20 percent but does vary based on field parameter (see Section B.7). For water quality field results with values less than 5 units, the precision criterion will be less than or equal to 1.5 units rather than the RPD to account for the effect of smaller values on percent differences. No criteria are presented for duplicates which are below the RDL, as these data are provided for informational purposes only. For instance, where one result is below the RDL, professional judgment will be used in determining the compliance of the data to project requirements.

Bias (Accuracy)

Bias provides an indication of the accuracy of the measured data. For water quality in-situ sampling, bias is evaluated by comparing duplicate sets of calibrated multi-parameter probe field measurements. Bias is difficult to measure for some elements of this monitoring program such as for habitat, bank conditions and hydrology when a true value is unknown. Bias is the systematic distortion of a measurement process

that causes errors in one direction, so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value.

Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is a combination of random error (precision) and systematic error (bias), introduced during field sampling measurements (and laboratory sample analysis).

Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures. Procedures for verification of data influence the accuracy of results. Well-trained field staff consistently follow methods and maintenance with equipment that improves accuracy of measurements.

Representativeness

Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition". At one level, representativeness is affected by problems in any or all of the other attributes of data quality.

Sample representativeness will be addressed in the data collection process. During sample collection, the use of generally accepted sampling procedures in a consistent manner throughout the monitoring program will ensure that representative samples are obtained.

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria To ensure completeness, every effort will be made to avoid sample and/or data loss. Accidents during sample handling on-site, or other activities that cause loss of the original samples, may result in irreplaceable loss of data, reducing the ability to perform analyses, integrate results, and prepare reports.

Completeness requirements are established and evaluated from two perspectives. First, valid data for individual indicators must be acquired from a minimum number of site visits, depending on the monitoring program, in order to adequately describe environmental conditions at sites within each land use category (e.g., urban, forested, rural, floodplain/upland agriculture). The objective for sampling completed is 90% (one in ten samples may be compromised or lost). In addition, there are laboratory water quality forms reporting on chemical analysis results as well as physical habitat observations made for each of the sites.

The study area and sampling design presents several constraints that may directly impact the ability to gather, analyze and report on data. The spatial extent of the study area requires work in remote areas which increases drive time and presents potential complications with cell phone or internet connection. These constraints may limit the amount of work conducted during normal hours and cause safety and/or data management issues. Stream reaches needed for collection of habitat and B-IBI data may extend up to 600 meters in length. Much of the lands bordering the reaches are private or state-owned and therefore

require permission for access. Limitations to access may impact the sampling design, cause shifts in sample sites and ultimately impact our ability to meet objectives and answer key questions. Periods of inclement weather, including flooding, may prevent staff from accessing sample sites. Smaller streams may dry during drought periods, preventing sampling opportunities.

These objectives are estimated as the percentage of valid data obtained versus the amount of data expected based on the number of samples collected or number of measurements conducted. Where necessary, supplementary objectives for completeness are presented in the parameter-specific sections of this QA Monitoring Plan.

Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program, and on adherence to accepted sampling techniques, SOPs, and QA (Quality Assurance) guidelines.

Type and Frequency of Field Quality Control Samples

There are several elements for sample or field measurement quality control applicable in this QAMP. Quality control sampling will be conducted prior to, during and after a field sampling event and includes instrument calibrations and checks, field duplicates, and blanks. Type and frequency of quality control elements applicable for water quality samples and field measurements are described in Table A-7. Many of these elements are also applicable to Benthic Macroinvertebrate Monitoring and Threatened and Endangered Species Habitat and Bank Condition Monitoring. All quality control elements in Table A-7 are applicable to Continuous Temperature Monitoring except for collection of field blanks and trip blanks.

Table A-7 Field quality control measurements.

Type of Quality Control Sample	Description
Instrument Calibration	Field instruments are calibrated prior to a field event using standards to manufacturer's specification to assess sensor accuracy. In this case of temperature loggers, calibrations also occur at the end of probe deployment (to adjust results based on instrument drift).
Instrument Calibration Check	Calibration checks on field instruments are conducted after a field event using known standards to assess sensor accuracy over the field event.
in situ Field Measurement Duplicate	A duplicate field measurement taken at the same place and nearly the same time as the original.
Field Duplicate Sample	A sample obtained at the same time and place as the original, labeled in a similar manner as regular samples, submitted to laboratory, and processed in exactly the same manner.

Type of Quality Control Sample	Description
Field Blank	Samples used to determine whether lab or field measurements may have been cross contaminated through sample collection, storage or transport. Ultra-pure water supplied by the laboratory is used for field blanks.
Trip Blank	Samples used to identity contaminant carry over from the time of sample event preparation through sample event and transport.

For all water quality measurements recorded *in-situ*, the frequencies of the quality control samples to be analyzed are summarized in Table A-8.

Laboratory quality control (QC) measurements are used in conjunction with and support of the field quality control measurements. Lab QC elements are used to evaluate lab performance when analyzing water quality samples. They include the following:

- Laboratory Blank Samples - Laboratory blank samples (method and instrument blanks) are laboratory-prepared, analyte-free samples used to detect the introduction of contamination or other artifacts into the laboratory sample handling and analytical process.

- Laboratory Control Samples - Laboratory control samples are used to assess analytical performance under a given set of standard conditions. Synthetic samples, containing some or all of the analytes of interest at known concentrations, are prepared independently from calibration standards.

- Matrix Spike and Matrix Spike Duplicates - Matrix spike samples are actual field samples to which known amounts of select compounds (one, or more, of the analytes of interest) are added. Both spiked and un-spiked aliquots (sample portions) are analyzed.

- Field Duplicate Samples - Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process (i.e., QC purposes).

- Reporting Limits - The reporting limits are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory conditions.

- Data Qualification - Qualifiers will be applied to QC samples when acceptance criteria are not met, and corrective action is not performed or is unsuccessful

- Completeness - Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system.

A complete description for each laboratory quality control measurement is in Section D.2.

Table A-8 *In-situ* Field Water Quality Control samples; parameter type and frequency for duplicate measurement.

Parameter	Matrix	Field	
		Blanks	Duplicates
SURFACE WATER QUALITY			
Temperature	Surface Water	N/A	1 duplicate measurement with a *field meter** at 10% of randomly selected sites per month
Dissolved Oxygen	Surface Water	N/A	1 duplicate measurement with a *field meter** at 10% of randomly selected sites per month
pH	Surface Water	N/A	1 duplicate measurement with a *field meter** at 10% of randomly selected sites per month
Conductivity	Surface Water	N/A	1 duplicate measurement with a *field meter** at 10% of randomly selected sites per month
Turbidity	Surface Water	N/A	1 duplicate measurement with a *field meter** at 10% of randomly selected sites per month

NA ~ not applicable
*A Hydrolab® (or other multi-parameter probe used for continuous monitoring) will be used to make manual measurements at each site.

A.7.2 Project Quality Objectives

The quality of environmental results can be evaluated in three steps: (1) establishing scientific data quality objectives, (2) evaluating program design to determine whether the objectives can be met, and (3) establishing assessment and measurement quality objectives that can be used to evaluate the appropriateness of the methods being used in the program. The quality of a data set is correlated to the types and amount of error associated with the data.

Data, or decision quality objectives, determine when data will be used to select between management alternatives or to determine compliance with a standard. A set of data eventually used to make management decisions will meet various standards or comply with minimum requirements of a statistical evaluation and can distinguish between two or more environmental conditions (e.g., impaired or not-impaired or poor/fair/good) with an acceptable level of uncertainty. The water quality index (WQI) can be used in the county-wide assessment that differentiates five water quality conditions. The benthic macroinvertebrate monitoring program and habitat assessment will be used in the county-wide assessment to distinguish at least five categories of stream condition. Each of the monitoring programs assesses stream condition using an index score that ranges from 0-100 and distinguishes among five condition categories: very poor, poor, fair, good, and excellent.

Sources of error or uncertainty in statistical inference are commonly grouped into two categories:

Sampling error: The difference between sample values and in-situ *true* values from unknown biases due to sampling design. Sampling error includes natural variability (spatial heterogeneity and temporal variability) not specifically accounted for in a non-random site selection monitoring design.

Measurement error: The difference between sample values and in-situ *true* values associated with the measurement process. Measurement error includes bias and imprecision associated with sampling methodology, specification of the sampling unit, sample handling, and instrumentation.

The data requirements for this monitoring program and QAMP minimize errors in data that will be transmitted to future users and is intended to reduce sources of error and uncertainty in use of the data.

A.8 Existing Monitoring Data from Snohomish County Programs

Several types of data collection are completed under the SOW program that includes long-term data collection for description of trends. Historical monitoring data from short-term projects focused on assessment of reach or site-specific conditions is useful for describing range of results expected at Snohomish County river and stream sites. Description of existing monitoring data is useful for determining if results from monitoring and assessment programs are within the range of expectation. The following monitoring programs have generated results for this type of comparison and are in this section.

Water Quality Monitoring

Since 1992, SWM has collected monthly water quality data from over 100 unique locations and across varying land uses. Table A-9 summarizes ranges of conditions for the water quality parameters measured in the State of Our Waters Monitoring Program. Sites included in this Table are typical of the five land use settings identified in this program.

Table A-9 Routine water quality monitoring data ranges at select stations from 2000 to 2014 (Snohomish County, Surface Water Management).

Monitoring Site Locations						**Most Stringent Water Quality Standard & Designated Uses**
Location Name		**Portage Creek Lower @ 212th St NE**	**NA**	**French Creek- Upper @ 167th FCLU**	**North Creek @ County Line NCLD**	
Land Use Category		**Floodplain Agriculture**	**Forested**	**Rural**	**Urban**	
Date Collected		**2000-2014**		**2000-2014**	**2000-2014**	
Analyte	**Units**					
Water Temperature (grab samples - may underestimate maximums)	ºC	1.3 – 19.89		0.1 – 16.6	2.34 – 20.5	Instantaneous or Seven Day Average of Daily Maximum not to be exceeded 12-20 ºC [growth and propagation of fish and shellfish, other aquatic life and wildlife; aquaculture] 12 ºC [Char spawning and rearing 16 ºC [Core summer salmonid habitat] 17.5 ºC [Salmonid spawning, rearing, and migration 18 ºC Non-anadromous Interior Redband Trout 20 ºC Indigenous warm water species

Monitoring Site Locations						**Most Stringent Water Quality Standard & Designated Uses**
Location Name		**Portage Creek Lower @ 212th St NE**	**NA**	**French Creek- Upper @ 167th FCLU**	**North Creek @ County Line NCLD**	
Land Use Category		**Floodplain Agriculture**	**Forested**	**Rural**	**Urban**	
Date Collected		**2000-2014**		**2000-2014**	**2000-2014**	
Analyte	**Units**					
Dissolved Oxygen	mg/L	1.01 – 12.18		8.59 – 15.33	8.06 – 13.9	Lowest 1 day minimum 6.5 – 9.5
pH	Standard Units	5.68 – 9.93		5.48 – 7.91	6.45 – 8.66	6.5-8.5 pH units (and ≤0.5 from natural)
Turbidity	NTUs	0.01 – 88.3		0.01 – 53.5	0.01 – 44.9	Natural 5 NTUs [Char spawning and rearing; Core summer salmonid habitat; Non-anadromous Interior Redband Trout; ≤ 10% increase with background > 50 NTU] Natural 10 NTUs [Salmonid rearing and migration; Indigenous warm water species; ≤ 20% increase when background > 50 NTU]
Conductivity	µmhos/cm	54.9 – 227.2		29.8 – 100.9	40.4 – 204.8	N/A

Monitoring Site Locations						**Most Stringent Water Quality Standard & Designated Uses**
Location Name		**Portage Creek Lower @ 212th St NE**	**NA**	**French Creek- Upper @ 167th FCLU**	**North Creek @ County Line NCLD**	
Land Use Category		**Floodplain Agriculture**	**Forested**	**Rural**	**Urban**	
Date Collected		**2000-2014**		**2000-2014**	**2000-2014**	
Analyte	**Units**					
Fecal Coliform	cfu/100ml	1 – 2,800		1 – 6,600	2 – 2,700	Extraordinary primary contact recreation; Geometric mean of ≤ 50 cfu/100mL and Not more than 10% of samples > 100 cfu/100mL Primary contact recreation; Geometric mean of ≤ 100 cfu/100ml and Not more than 10% of samples > 200 cfu/100ml
Total Suspended Solids	mg	1 - 50		1 - 220	1 – 51	N/A
Nitrate + Nitrite as Nitrogen, Total	mg/L	0.129 – 2.11		0.06 – 1.57	0.719 – 1.2	10.0 mg/L [contact recreation; drinking water supply]
Total Phosphorus	mg/l	0.012 – 2.9		0.0016 – 0.110	0.005 – 0.35	Stream Criteria Not Available
Copper	ug/l	0.19 – 12		0.07 – 12.5	0.44-17	Criteria is hardness dependent
Zinc	ug/l	1 - 73		1 - 37	1 - 62	Criteria is hardness dependent

Benthic Macroinvertebrate Monitoring

Since 1994, SWM has collected benthic macroinvertebrate data to assess community condition using B-IBI scores that describe stream health and the overall effectiveness of habitat restoration projects. Following initial benthic monitoring beginning in 1994, a comprehensive status and trends benthic macroinvertebrate sampling scheme was implemented between 2005 and 2014 (Table A-10). The program goals were to gain a better understanding of the status and trends of benthic invertebrate communities in County watersheds. This monitoring effort consisted of a rotating basin panel design that targeted roughly 30 status (randomly selected) and trend (stationary) sites each year within one of the three main basins or Water Resource Inventory Areas (WRIAs) in the County: the Stillaguamish, Snohomish, or Lake Washington/Cedar/Sammamish Basins.

Benthic Monitoring as part of the State of Our Waters Monitoring Program will use companion data from the Habitat Use and Bank Condition, Water Quality, and Flow Monitoring Programs to identify physical and chemical conditions that impact the biological community. Factors that impact the community are known as "stressors" and are the focus for evaluation of how stream reaches can be restored, conserved, and protected.

The benthic monitoring program includes collection of physical habitat data at site-specific sample locations within a reach. The Habitat Use and Bank Condition monitoring program measures physical habitat characteristics at the reach-scale. Figure A- 3 describes how multiple monitoring elements supplement the primary benthic monitoring effort to identify stressors on aquatic biological communities. The State of Our Waters Monitoring Program plan shares field effort and expands the ability to interpret biological conditions and identify stressors by using data collected through multiple monitoring programs.

Table A-10 Status and Trends Benthic Macroinvertebrate Monitoring Program: Conditions (based on the 100-Point Scale) from WRIAs and Select Sites in Snohomish County (2005 through 2014).

Location: Sub-Basin	Dominant Land Use	Period of Record	Range of B-IBI Scores (2005-2014)	Number of Total Site Visits	Condition Category
WRIA 5				**40**	
Portage Creek Sub-Basin	Floodplain Agriculture/ Residential	2007-2014	57.3 - 78.7	4	Fair-Good
Lower Canyon Creek	Forested/Residential	2011	59.4	1	Fair
Church Creek		2007-2014	35.1 - 69.2	7	Poor-Good
WRIA 7				**37**	

May Creek	Forested	2010-2013	43.5 - 99	2	Fair-Excellent
Woods Creek	Forested	2005-2013	47.5 - 87.3	13	Fair-Excellent
Dubuque Creek	Forested	2006-2013	50 – 69.8	3	Fair-Good
WRIA 8				**44**	
Little Bear Creek	Forested/Residential	2005-2014	18.6 - 73.2	24	Very Poor-Good
North Creek	Urban	2005-2012	3.8 - 54.6	19	Very Poor-Fair

Freshwater Mussel Detection and Identification

Recently, freshwater mussel species have been identified as uncommon native species by the Washington Department of Natural Resources (http://www.dnr.wa.gov/sites/default/files/publications/aqr_aamt_freshwater_id.pdf) and are protected in several aquatic reserves throughout the state. When freshwater mussels are collected (or identified in the reach) during benthic macroinvertebrate sampling, population characteristics will be estimated and physical and chemical variables support the population will be characterized. Since many of the freshwater mussel populations known to inhabit stream reaches in Snohomish County have unknown population characteristics (e.g., age-class distribution) the SWM Team is incorporating these collection protocols to learn the general condition and health of the species. Presence of healthy freshwater mussel populations in Snohomish County are strong indicators of stability and resiliency of our rivers and streams from short-term impacts due to human activity (e.g., road-building, residential development, and expansion of the urban areas).

Continuous Temperature Monitoring

SSWM deploys temperature loggers each summer to monitor habitat conditions during the summer critical periods for salmonid populations. Locations for loggers have been selected by SWM staff to provide coverage throughout the County, particularly on fish-bearing streams. This site selection strategy differed than the current site selection process using the GRTS design for site selection. SWM temperature monitoring in 2015 provides a good example of historical efforts. Many sites selected for sampling in 2015 had been previously visited during wetter years. Sites were distributed throughout the county during 2015, with coverage in all WRIAs and major sub-basins (Figure A- 4). Particular emphasis was placed on the Pilchuck River, to inform on progress of a TMDL under development for the watershed. Additionally, a reach of the Lower Skykomish River had a higher density of temperature probe deployment to assess effectiveness of recently completed fish habitat improvement projects. As 2015 was a drought year, this provided a good contrast for effect of low flow on surface water temperature during an extreme climatic event (Baker 2019).

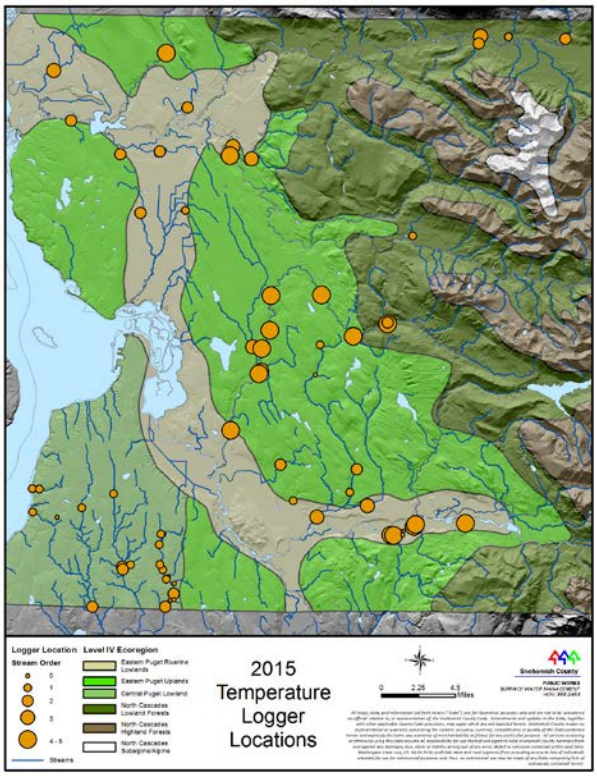

Figure A- 4 Temperature probe deployment at 2015 locations (including Strahler Stream Order and Ecoregions).

Deployment of temperature data loggers were sometimes placed at a site for one-year and other times for eleven-years in a row. Only one site had a temperature data logger placed for all eleven years whereas as seventy-three sites had temperature data loggers placed for only a single year (Table A-11).

Table A-11 Number of years of historical continuous temperature data at sites in Snohomish County 1995 -2015

			Site Visit Frequency (1-year to 11-years)										
WRIA	**Total sites**	**Total data sets**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
5	**146**	**354**	73	28	10	12	8	9	1	2	1	1	1
7	**169**	**305**	108	30	9	9	6	5	2				
8	**72**	**146**	52	3	1	3	7	5		1			
Total	**387**	**805**	233	61	20	24	21	19	3	3	1	1	1

Continuous temperature monitoring of sites throughout Snohomish County were compared against salmonid temperature thresholds (WDOE 2002). The 7DADMax (seven day average daily maximum) temperature was calculated for each of the streams monitored during the low flow period of 2015 and organized from lowest 7DADMax temperature and within each of the County WRIAs (WRIA 5, WRIA 7, and WRIA 8) (Figure A- 5).

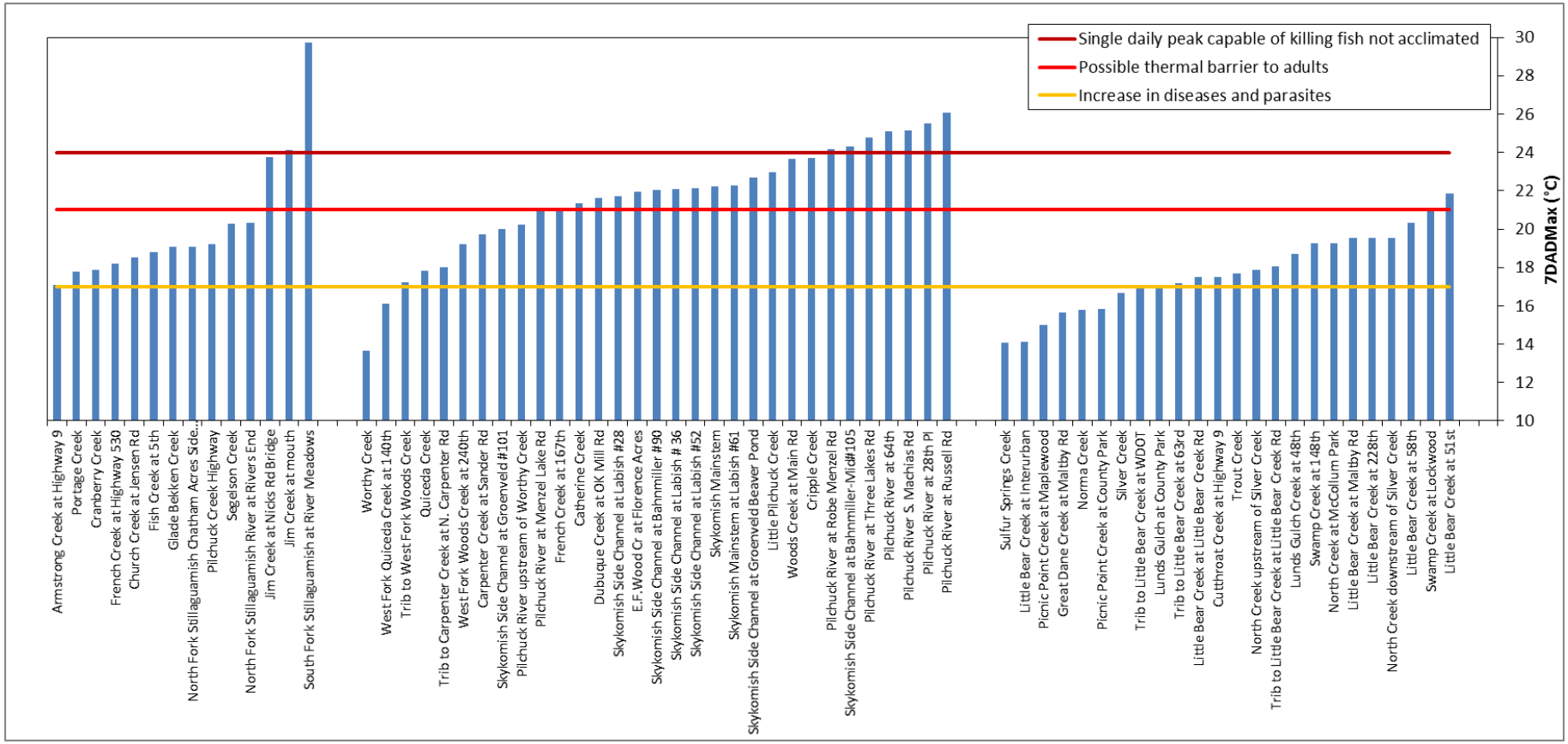

Figure A- 5 7DADMax for Snohomish County continuous monitoring sites visited in 2015 (groupings above appear in this order: WRIA5, WRIA 7, WRIA 8).

Surface water 7DADMax temperatures ranged from above 13ºC to about 26ºC. Streams maintaining lowest 7DADMax temperatures were dominated by groundwater and protected from direct sunlight with undergrowth and/or overhead canopy in riparian margins.

Threatened and Endangered Species Habitat and Bank Conditions

Instream physical habitat and bank conditions were described for 2007 at sites selected randomly throughout the Snohomish River Basin (WRIA 7; Leonetti et al. 2008). Site selection was based on the GRTS randomized design enabling comparison with future data sets generated from site visits in the Snohomish River Basin. The primary purpose for this monitoring program was to describe status and identify trends in salmon recovery based on the Plan (NOAA 2007). Future comparison of physical habitat and riparian conditions in this basin will measure progress of implementation of the Salmon Recovery Plan's Goals.

Physical habitat data was characterized by habitat units and at the reach-scale (measurements along transects). The same protocols and assessment techniques were used for generating this historical data set as those used currently. Land use types were designated as either forested or non-forested. Ten habitat metrics were assessed and reported as number of sites in poor/fair/good condition of the total number visited in 2007 (Table A-12). Future results from this monitoring program will include assessment of indicator habitat metrics in Table A-13. These indicator metrics will be used to determine if stream characteristics known to support salmon populations are helping reach salmon recovery goals.

Table A-12 Condition of habitat characteristics in Snohomish watershed streams assessed in 2007 (percent of streams in each condition category).

	Functional Condition		
Physical Habitat Metric	**Poor**	**Fair**	**Good**
Bank Stability	18%	26%	56%
Bank Modifications	7%	43%	50%
Mid-channel Canopy Cover	67%		33%
Fox and Bolton's (2007) LWD frequency criteria	90%	10%	0%
Number of pieces per 100m of Channel Length	100%	0%	0%
Pool Area, % (WFPB 1997)	43%	30%	27%
Pool Frequency, Pools/CW (WFPB 1997)	33%	50%	17%
Pool Frequency, Pools/mile (NMFS 1996)	30%	NA	70%
Pool Depth (NMFS 1996) – Sufficient deep pools > 1m	83%	NA	17%
Exceed 25% composition in fines and sand (<2mm)	50%	NA	50%

Some of the streams assessed in 2007 will be revisited and habitat indicators examined for any change over the past >10 years. This comparison will help learn if changes in some of the habitat indicators are beneficial for salmon recovery goals.

Table A-13 Threatened and Endangered Species Habitat and Bank Conditions: Performance Indicators for Habitat Metrics.

Indicator	Criteria	Metric	Source
Woody Debris	80 Pieces (≥15m length and ≥ 0.6m diameter)	Frequency (pieces/mile)	NMFS (1996)
	2 Pieces (≥ 2m length and ≥0.1m diameter)	Frequency (pieces/channel width)	WFPB (1997)
	Key Pieces		
	>0.3 (0 -10m BFW)	Frequency	
	>0.5 (10 - 20m BFW)	(pieces/channel width)	
	Woody Debris Volume	Volume (m^3/ 100m of channel length)	WFPB (1997)
	>99 m^3 / 100m CL (<30mBFW)		
	>317 m^3 / 100m CL (>30mBFW)		Fox and Bolton (2007)
	Predicted mean LWD pieces/CW	$Y=0.22x^{1.26}$	

Indicator	Criteria	Metric	Source
Pool	Channel width - # pools/mile 1.5m - 164 3m - 96 4.5m - 70 6m - 56 7.6m - 47 15m - 26 23m - 23 30.5m - 18	Frequency (pools/Mile)	NMFS (1996)
	<2 channel widths per pool	Frequency (channel width/pool)	WFPB (1997) WFPB (1997)
	Percent pool > 55%	Percent (% pool)	NMFS (1996)
	Sufficient deep pools >1m deep with good cover and cool water	Count (pool)	WFPB (1997)
Substrate	Sand is never dominant or subdominant	Ranking (substrate size class)	WFPB (1997)
	Fines < 0.85 mm in spawning gravel are <12% good (12-17% fair, >17% poor)	Percent composition	NMFS (1996)
Stream-bank condition	> 90% Stable, <10% actively eroding banks	Percent (% stable or % eroding banks	NMFS (1996)
	>95% unarmored	Percent (natural banks)	NOAA (2003)

Indicator	Criteria	Metric	Source
Off – Channel	Off-channel areas are frequently hydrologically linked to main channel; over bank flows occur and maintain wetland functions, riparian vegetation and succession.	No metric	NMFS (1996)
Cover	Suitable cover ≥90% for bank cover; suitable center-channel cover for shading varies as a function of BFW dimension; 90-50% for increasing elevation (to 2000ft)	Percent cover or percent view-to- sky	WFPB (1997) Ecology (2007)

Fish Use/eDNA

Mapping of the distribution of salmon and steelhead species in rivers and streams throughout Snohomish County helps resource managers understand the extent of fish use in freshwaters. Several mapping tools that report distribution of species presence in stream reaches provide the current status of habitat use. Snohomish County's eDNA monitoring program confirms or documents the known use by salmon species and is a forward-looking tool for verifying success in opening habitat where barriers (e.g., culverts) previously existed.

Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP)

Several databases reporting on salmon and steelhead distribution are hosted by Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (NWIFC). The Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) shares responsibility for delineating WRIAs into discrete stream segments, identification of current and potential fish distribution, quantification of obstructed and degraded habitat, and quantification of historical habitat. Assessments are partitioned based on Water Resource Inventory Area (WRIA) with NWIFC maintaining information and assessment for WRIAs 1 through 23 and the WDFW maintaining assessments for WRIAs 24 through 62.

Information for historical and current conditions in WRIAs 5, 7, and 8 have been reported in State of Our Watersheds 2016 Report. The following are web links to report chapters that describe current conditions, progress in restoration and conservation, and progress in meeting goals:

Stillaguamish Basin (WRIA 5)
https://geo.nwifc.org/sow/SOW2016_Report/Stillaguamish.pdf

Snohomish Basin (WRIA 7)
https://geo.nwifc.org/sow/SOW2016_Report/Tulalip.pdf

Lake Washington Basin/Cedar-Sammamish (WRIA 8)
https://geo.nwifc.org/sow/SOW2016_Report/Muckleshoot.pdf

The following web link (https://geo.nwifc.org/swifd/) accesses an integrated map that enables search of:

- Fish Distribution (Salmon and Steelhead Stocks)
- Proposed Natural Barriers
- Proposed Distribution Changes
- River Miles
- Roads
- Boundaries

Salmonscape

General data available in Salmonscape (http://apps.wdfw.wa.gov/salmonscape/) include specific fish and habitat data and information about stock status and recovery evaluations. Salmonscape's basemap (http://apps.wdfw.wa.gov/salmonscape/map.html) can zoom in to specific areas like Snohomish County in order to rapidly search for several types of important scientific information that assists in on-the-ground salmon recovery projects. The basemap includes the following data features:

- Facilities (Hatcheries and Rearing, Fish Traps, and Major Dams)
- Fish Distribution (Species and Stocks)
- ESA Listing Units
- Hydrography
- Boundaries (Township and Range, WRIAs, Counties)
- Basemap

Hydrology: Current and Historical Records

Snohomish County has operated a water level gaging system for over 20 years. Currently, the water level gaging system with real-time data records is available on line (https://snohomish.onerain.com/home.php). The purpose for this site is to report real-time river level and precipitation data in for the purpose of warning Snohomish County residents about water level and flood risk to private property.

Additionally, historical records are accessible through the following web address:

http://www.snoco.org/applications/login.html?publicuser=Guest#waterdata/stationoverview

These historical data for 61 stations throughout Snohomish County provide continuous water level data for wadable streams throughout most of the County. Depending on the site, data available may include continuous water level, precipitation totals, and water temperature. Data records are also available in a variety of time series (e.g., hourly, daily average, etc.).

A.9 Documents & Records

Thorough documentation of all field sample collection is necessary in each of the monitoring programs for proper processing of data and ultimately, for interpreting study results. Field sample collection can be documented in writing, on forms, or recorded in electronic format on an iPad®. Additional forms and labels that could be used for recording of field data, depending on the monitoring program, include the following:

- A field notebook for general observations and notes;
- A Field Data Record Form that contains information about observations and measurements made and samples collected at the site (see Section B.2.3)
- Checklists for each sampling event, sampling point, and sampling time.

Non-transitory project documents and vital records including, but not limited to, contracts, calibration logs, field forms, lab reports, and project reports, will be maintained, as appropriate, in hardcopy and/or electronic form at the SWM office or County archive in a manner consistent with State and County records retention requirements. Project leads will supervise the use of materials in the project files to ensure the location and organization is maintained.

As appropriate for the SOW monitoring program, copies of calibration logs, field data sheets, and laboratory results will be collated into binders by sample event. Data are verified for credibility and used in formal reports. Formal reports generated from the data will be subject to technical and editorial review and will be maintained by the SOW Monitoring Program Technical Leads in the central file (electronic and hard copy). The formal reports will include a summary of the types of data collected, sampling dates, and any problems or anomalies observed during sample collection.

When visiting a sampling station, the sample collector will record the following information on water-proof field sheets or an electronic iPad®. Detailed information on field observations should consider the following:

- Date
- Time
- Names of sampling personnel
- Number/type of samples collected
- Weather
- Descriptions of any field photographs
- On-site field measurement (e.g., temperature, water level)
- Color of water (Water Quality and Benthic Monitoring only)
- Unusual conditions (changes in land uses, presence of oil sheens, odors).

If any change(s) in this QAMP are required during program activities, a memorandum will be sent to each person on the distribution list describing the change(s), following approval by the appropriate persons. The memos will be attached to this QAMP.

A.10. Safety

Persons involved with sample collection, hydrology measurements, or habitat and bank condition surveys could be subjected to unsafe conditions. Hazards include, but are not limited to, heavy sample coolers, roadside traffic, boating accidents, slips, trips, falls, stream wading, drowning, heat and cold stress, air quality problems or exposure to chemical and biological pathogens. Washington State Department of Labor and Industries requires employers provide a safe work environment through communicating hazards and providing adequate training. Health and Safety guidelines based on recommendations and requirements of the SWM Safety Committee are found in Appendix I.

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SECTION B. DATA GENERATION & ACQUISITION

B.1. Sampling Process Design (Experimental Design)

Snohomish County Public Works, Surface Water Management Division is designing and implementing a monitoring program using current technology for measuring ecological condition of streams and identifying factors causing degradation to habitat, water quality, and biological communities. Several types of data are collected and synthesized in a way that enables scientists to interpret how conditions could impact human health, limit use of aquatic resources, and effect aquatic communities. This type of information used for assessing stream conditions on a countywide scale directly or indirectly reflects cumulative influences at sample site locations whether those degrade or enhance several beneficial uses. In some discrete cases, those may be locations that have undergone projects that restore, protect, and\or enhance aquatic resources. Three secondary benefits of the State of Our Waters Monitoring program are expected to be: 1) understanding of improvements in ecological condition at restored sites, and 2) using monitoring results to direct projects to locations in Snohomish county watersheds where improvements are feasible, and 3) identifying locations that, because of their excellent conditions, could be protected.

B.1.1 Sampling Design and Rationale

The sampling design and rationale presented support each of the objectives for the State of Our Waters Monitoring Program:

1) Describe current condition of the wadeable streams in Snohomish County;
2) Determine if conditions are improving or declining;
3) Identify factors that are causing conditions to change; and
4) Identify the optimal locations to implement restoration and protection strategies.

The monitoring design is consistent with the Washington Department of Ecology Status and Trends Monitoring Program and the Regional Stormwater Monitoring Program (now known as “Stormwater Action Monitoring”). These monitoring designs select stream sites randomly from throughout target areas like statewide, natural regions (ecoregions), or Urban Growth vs. non-Urban Growth Areas. The purpose for establishing this type of monitoring program is to assess large areas containing many streams without having to sample every stream, but rather, infer ecological condition for all stream miles by conducting a probability-based sample of the entire population. This type of sampling strategy, or sampling frame, is accompanied by challenges in the design phase on how to divide the landscape into fragments that have similar characteristics and that influence small streams.

The State of Our Waters Monitoring Program sample frame is inclusive of unincorporated Snohomish County, excluding City, Tribal and Forest Service lands. Interviews with SWM staff combined with a gaps analysis and review of drivers resulted in a focus on small freshwater streams within the sample frame and each land use type. Small, freshwater streams included in the selection process were limited to Strahler stream order 2 through 4. The reason for inclusion of these sites is that there are a greater number

of stream miles when these stream orders are combined and so our effort will assess most of the stream miles within unincorporated Snohomish County.

The stream settings in our sampling area of Snohomish County can be partitioned into groups that are naturally distinct or have been altered from human disturbance for a prolonged period of time. Biological expectations for each of the groups (e.g., natural settings or human disturbance) may be different depending on the type and intensity of impact each type of factor presents. The GRTS sample design enables partitioning of streams into categories and requires far fewer sites to accurately describe the range of conditions that occur. We identified several types of land uses in Snohomish County that can have distinct impacts to chemical, physical, and biological conditions of streams. Those land uses are: floodplain/upland agriculture, forested, rural, and urban.

It is acknowledged that over time, the total number of sites and subsequently those within each land-use designated status and trend are subject to budgetary and/or constraints due to ongoing access to sites. However, those principal design decisions are program cornerstones to which adherence is important.

Data describing stream conditions for each land use type will be examined for: 1) representation of a range of stream conditions in a land use type (variance of signals from repeated measures at sites within the stratification level, and 2) strength of signal from impacts to biology, physical habitat, and water quality. Examination of variance at the land use level versus the “reach” level will be one of the tools used to examine utility of indicators for determining factors that impair the stream health.

As the program progresses through time , an adequate amount of data will have been collected to determine if the sample design can determine current conditions of streams by land use of unsampled stream sites, if stream characteristics change over time, the direction of change, and how to improve conditions. This analysis will include a description of the limitations of the design with current number of sites, method for sampling, and time taken to detect change for the indicators. This analysis will require multiple years of data collection.

GRTS Sampling Design

Random selection of stream sites within the sample frame is achieved through use of an EPA-developed set of master sample sites referred to as Generalized Random Tessellation Stratified (GRTS) linear survey sites. Use of these linear stream sites provides a spatially-balanced, true random probability site selection design process. This means that selection of sites on a random basis is made from a grid and avoids bias within the sampling area (or sampling frame). The independence of sites within this spatial grid encourages an equal probability a site will be selected. These features of the GRTS sampling design minimize bias in representing range of ecological condition of sites at a single period of time.

The GRTS sample design is appropriate for characterizing condition of aquatic resources over large portions of the landscape for two reasons: 1) it generates an accurate description of environmental resource condition without having to sample every stream reach in Snohomish County, and 2) sites can be partitioned prior to data analysis using several classification variables (e.g., land use, stream size, or natural regions). Adjusting the scale for analysis of data enables broader use of this monitoring information by our internal clients in Surface Water Management and those external to this Division of the Public Works Department.

B.1.2 Sample Frame and Site Selection Considerations

Monitoring describes water quality conditions, physical habitat, and biological community conditions through implementation of six primary monitoring programs listed in Section A.5.1. The following description of the site selection process based on the GRTS design and finalization of the annual sampling effort is presented in the following sections.

Over 5,000 original GRTS points falling within the sample frame were organized by SITEID and evaluated in a Geographical Information Systems (GIS) exercise to refine the selection of points to exclude those:

- with Strahler stream orders of ≥5 and <2,
- on Tribal, city, or USDA Forest Service Land,
- not meeting required sampling conditions, or
- considered unsafe to sample.

The remaining GRTS points were evaluated again in order of SITEID against County future land use data and NOAA's 2015 Coastal Change Analysis land cover dataset to ensure GRTS points were representative of each land use. For example, a GRTS point might conceivably be located in an urban land use area, but drains from a forested or rural area.

Field reconnaissance was conducted to confirm safe and manageable access, and that streams had perennial flow. Additionally, bankfull width was estimated using GIS hydrology data layers to determine the total reach length needed for habitat assessments, and to inform parcel selection for right of entry requests.

Up to fifty sites were identified from the initial screening process including a field evaluation and this list was submitted to the Snohomish County Public Works Department, Engineering Services, Right of Way Group for verification of ownership, if private, and to gain permission to access for current and future monitoring visits. Once final selections were made for sites that were accessible for sampling, were recorded using geospatial coordinates.

Following the initial year of monitoring in State of Our Waters program, twenty trend sites were identified for subsequent visits. Even though permission was granted for access to the original twenty trend sites, property owners are re-contacted before any data collection is initiated in subsequent years. This process for annual site selection is repeated.

From the set of year 1 sites (Table B-1), 20 trend sites were selected based upon the following assumptions and criteria;

- Budgetary constraints allowed monitoring of up to 35 locations in 2019 of which 20 represents 60% of total – in conformance with design decisions
- Wadable stream from which collection of habitat and benthic macroinvertebrate data was feasible and in alignment with standard operating procedures
- Willing landowners
- Known or expected presence/importance for fish
- Collection of water level feasible in adherence with water level site selection criteria and in alignment with standard operating procedures (flow estimate applies to a single location within the reach)
    - No backwatering
    - Stable stream channel – limited migration with uniform shape
    - Defined edges on banks
    - Free of large boulders and cobble (prevents laminar flow near the bottom of the reach)
    - Depths greater than 0.5ft
    - Velocities greater than 0.5ft/sec

Data collected from each of the sites are described in Section A.5.1 and implemented at different times during the year (see Section B.2-1).

Post hoc Evaluation of State of Our Waters Monitoring Program Results: Determining Number of "GRTS" Sites Allocated to Each Land Use Type

Site selection for the State of Our Waters Monitoring Program is proceeding with the sampling frame defined by land use types: urban, rural, forested, floodplain agriculture and upland agriculture. The number of sites visited in each land use type in the future will be influenced by: 1) an adequate representation of stream conditions throughout a land use type, 2) sites that represent a reasonable number of stream kilometers, and 3) enough sites to adequately represent the variety of stream types in each land use category. The goal for a *post hoc* analysis of Year 2 (Panel 2) State of Our Waters Monitoring Program data will be to determine the number of GRTS sites that will be located in each of the land use categories previously listed in future sampling of the remaining years.

Thirty-three sites were selected for sampling during the 2018 season (Table B-1). In some cases sample location for: water quality, stream temperature logging, and water level logging did not correspond to the randomly selected site shown in Figure A- 2. Rather, markers with colors like red, blue, green, yellow, and purple were offset from the GRTS point based on issues due to accessibility (usually related to an access issue during high flow months) or deployment of equipment (finding and obscure location for prevention of theft or damage).

Table B-1 GRTS Design Sample Locations (Panel 1; Year 2018).

Land Use Category • Urban • Agriculture • Rural • Forested	**Trend Site**	**Site Name**	**Latitude** (Decimal Degrees)	**Longitude** (Decimal Degrees)	**Description of Site**
Rural		**PILR Pilchuck River**	47.918313	-122.083181	Pilchuck River off Menzel Lake Road
Mixed*		**SULT Sultan River**	47.860805	-121.821084	Upstream of SR2 Bridge (right bank sample)
Mixed*		**SKYR Skykomish River**	47.860536	-121.819127	Downstream of confluence with the Sultan River (right bank sample)
Urban	**X**	**CRYL Crystal Creek**	47.77626675	-122.2470582	Crystal Creek at Lockwood
Rural		**OSMR Old Snohomish Munroe Rd**	47.87602466	-122.0492123	Unnamed Creek at Old Snohomish Monroe Road
Urban	**X**	**TMBK Tambark Creek**	47.83822216	-122.1830592	Tambark Creek Park at South Bridge
Rural		**PILT Tributary to Pilchuck Creek**	48.236062	-122.189024	Tributary to Pilchuck Creek at Tronson Road
Rural	**X**	**SCTT Scott Creek**	47.9456915	-122.0662235	Scott Creek off 123rd Avenue
Upland Agriculture		**FRDM Freedom Creek**	48.25405237	-122.3065059	Freedom Creek at Village Road

Land Use Category • Urban • Agriculture • Rural • Forested	**Trend Site**	**Site Name**	**Latitude** (Decimal Degrees)	**Longitude** (Decimal Degrees)	**Description of Site**
Urban		**LLRB Unnamed Tributary (Lowell/Larimer Rd)**	47.90697096	-122.1727637	Unnamed Creek at East Lowell/Larimer Road at the Red Barn
Rural	**X**	**FCSP French Creek Tributary**	47.917511	-121.990525	Tributary of French Creek at Spada Road
Urban		**GRDN Garden Creek**	47.87985764	-122.122074	Garden Creek at East Lowell/Larimer Road
Urban		**CCMU Cripple Creek**	47.88679078	-121.9880679	Cripple Creek upstream of 124th ST SE
Rural	**X**	**TBRD Unnamed Creek at Thunderbird RV Park**	47.846658	-121.873884	
Forested	**X**	**WDOP East Fork Woods Creek**	47.90150473	-122.8753901	EF Woods Creek at Old Pipeline Road
Urban	**X**	**SULFUR Sulfur Creek**	47.81468562	-122.2013918	Sulfur Creek at Griffins Community
Upland Agriculture		**OSOT Unnamed Creek on Oso Loop Rd**	48.26439598	-121.9256908	Tributary to NF Stillaguamish R at Oso Loop Rd
Urban	**X**	**DOUG Douglas Creek**	48.25262003	-122.3540779	Douglas Creek at Pioneer Highway
Urban		**TCCC Thomas Creek**	47.871311	-122.138792	
Rural	**X**	**JRDN Jordan Creek**	48.14727415	-122.0354226	Jordan Creek at Jordan Creek Road

Land Use Category • Urban • Agriculture • Rural • Forested	**Trend Site**	**Site Name**	**Latitude** (Decimal Degrees)	**Longitude** (Decimal Degrees)	**Description of Site**
Rural		**PRML Pilchuck River**	48.018679	-121.9148	Pilchuck River off Menzel Lake Road
Rural	**X**	**WDRD West Fork Woods Creek**	47.90227676	-121.9079949	WF Woods Creek at Woods Creek Road
Forested		**PLCK Pilchuck Creek Bridge at SR-9**	48.2644996	-122.1665913	Pilchuck Creek at Highway 9 Bridge
Urban	**X**	**LBWM Little Bear Creek**	47.78557288	-122.1451194	Little Bear Creek at 233rd Street
Upland Agriculture	**X**	**TRFT Trafton Creek**	48.242872	-122.059156	Tributary to NF Stillaguamish at Trafton
Urban		**NCCW North Creek (Clear Water School)**	47.82019794	-122.2121462	North Creek at Clearwater
Urban	**X**	**PCNC Picnic Point Creek**	47.88026248	-122.3311714	Picnic Point Park; east end of parking lot
Rural		**DBQC Dubuque Creek**	48.005344	-121.995089	Dubuque Creek at 9th PL
Forested	**X**	**BNSN Benson Creek**	48.09057227	-121.778299	Benson Creek at Mountain Loop Highway
Rural	**X**	**CNYN Canyon Creek**	48.12147269	-121.82734260	Canyon Creek at River-N-Forest Estates
Forested	**X**	**SQCR Squire Creek**	48.27016935	-121.6713435	Squire Creek at Squire Creek Park nr Group Area

Land Use Category • Urban • Agriculture • Rural • Forested	**Trend Site**	**Site Name**	**Latitude** (Decimal Degrees)	**Longitude** (Decimal Degrees)	**Description of Site**
Upland Agriculture	**X**	**MCGV McGovern Creek**	48.26898753	-122.0050266	McGovern Creek at Whitehorse Trail and Cicero Pond
Forested	**X**	**OLNY Olney Creek**	47.92786054	-121.7203029	Olney Creek
Floodplain Agriculture		**PORL Portage Creek (Bridge on 212th St NE)**	48.189124	-122.233168	Portage Creek at Sill Road
Forested	**X**	**BLDR Boulder River**	48.27789267	-121.7810904	Boulder River at SR 530
Floodplain Agriculture		**PRTU Portage Creek (Log Farm Bridge)**	48.183782	-122.232133	Log Farm Bridge

Note:

*Mixed land use is characteristic of the large basins like the Sultan River and Skykomish River. These sites represent influence from a variety of land uses in varying proportions.

Additional Tables will be added to this QAMP in subsequent years containing sites visited in succeeding years (Year 2 through Year 5).

B.1.3 Order (Timing) of Sampling

The following are then sampling periods, or the time frame when samples are collected, and frequency of data collection during the sampling period, for satisfying study objectives:

GRTS Design Monitoring

a. Water Quality Monitoring

- Sampling period: water year, October of the previous year through September of the following year
- Frequency of site visits: Monthly; sequence of site visits will be maintained during each month (visit times will be within a two-hour interval during a site visit the previous month)

b. Benthic Macroinvertebrate Monitoring

- Sampling period: June – October 15 of each calendar year
- Frequency of site visits: once per year during the Index Period (see Sampling Interval above).

c. Continuous Temperature Monitoring

- Sampling period: June through September of the same year for status sites and year round at trend sites.
- Frequency of data logging: 15-minute intervals with data downloaded on approximately a monthly basis.

d. Threatened and Endangered Species Habitat and Bank Conditions

- Sampling period: June through September of the same calendar year.
- Frequency of sampling: once per year per site, in some cases surveys may require more than one visit to complete all tasks.

e. Fish Use/eDNA

- Sampling period: April through September of the same calendar year.
- Sampling period may change depending on existing data that describes timing of fish use in each stream.
- Frequency of sampling: One time annually.

f. Hydrology

- Sampling period: water year, October of the previous year through September of the following year.
- Frequency of water level data logging: 15-minute intervals with data downloaded on approximate monthly basis.

- Discharge measurements occur during flows representative of low to high flows throughout the year.
- Staff gauge readings occur approximately on a monthly schedule.

Since there are several monitoring program elements in this QAMP and each requires environmental measurements collected during a specific time of the calendar year, data collection is staggered in order to meet monitoring schedule and resource limits.

B.2. Sampling Methods

Sections B.2 – B.10 summarize water quality, benthic macroinvertebrate, continuous temperature, threatened and endangered species habitat and bank condition, eDNA/fish use, and hydrology sample collection periods, methods, handling, identification, quality control and data management procedures.

B.2.1 Rationale for Sampling Schedule

State of Our Waters is implemented on a schedule with the new water year beginning October 1st during the calendar year. Each of the monitoring programs is implemented on a unique schedule that satisfies data needs and address project goals (see Table B-2).

Water Quality Monitoring

The water quality monitoring element is active throughout the water year (October 1st through September 30th of the following calendar year), generating data on a monthly basis to capture seasonal patterns and meet data requirements for the calculation of a water quality index. The water quality index (WQI) is the tool used to describe overall water quality conditions in relation to water quality standards. The WQI incorporates results from seven water quality parameters and converts them to scores that are summed to derive a total score for the site.

Data collection for year 1 (2018) began in February of 2018 so does not conform to the October 1st, 2017 start date for generation of an annual WQI score. Monthly WQI scores can be calculated for the months of Year 2018 with additional data collected through September 2019 to calculate the annual WQI score.

Benthic Macroinvertebrate Monitoring

The Benthic Macroinvertebrate monitoring element is operated during an Index Period and is a timeframe chosen for the following reasons:

- Stream flow stabilizes following the storm season (fall and winter);
- Later aquatic life stages (instars) for each species result in macroinvertebrate body size with recognizable taxonomic features;
- Maturity of the benthic macroinvertebrate community reaches a maximum prior to emergence from the stream which typically occurs by mid-October; and
- While the typical Index Period starts July 1st, flows showing a reduction in volume earlier than expected in Snohomish County streams, sampling may begin toward the end of June instead of July 1 of that year.

Continuous Temperature Monitoring

Although continuous temperature monitoring focuses on the core summer salmonid habitat window (from June 15 – September 15) as described in Washington State Water Quality standards (WAC173-201A), temperature logging is conducted at each of the sites year around. The core summer salmonid window is the low flow “critical period” important for identifying areas of heating and cooling during salmonid spawning or emergence, adult holding, or rearing and migration.

Threatened and Endangered Species Habitat and Bank Conditions

Threatened and Endangered Species habitat and bank conditions monitoring focuses on salmon habitat indicators and occurs during low flow portions of the year. This monitoring effort is located in mainstem and side channel portions of wadeable streams and river (see Appendices) that are primarily accessible to field crews during the low flow portion of the year, when many physical features of these waterbodies can be seen and safely sampled. Monitoring for salmon habitat at this time during the year is typical of most monitoring programs in the Pacific Northwest.

SWM's habitat monitoring element focuses on trend detection to assess long-term changes in habitat quantity and quality; specifically to evaluate whether habitat conditions in Snohomish County streams are meeting salmon recovery goals and targets.

The Habitat and Bank Condition monitoring element is implemented annually from June through October of the same calendar year.

Fish Use/eDNA

Sampling of select stream sites is completed during April and March for Year 1. Results from Year 1 sampling guides timing for future monitoring. We may, as time and budget permits, visit eDNA sites more than once in a year to determine how timing of eDNA sampling effects detection of salmon and char species presence.

Several goals are identified that require assessment of fish presence at waterways where the County is planning or has completed fish habitat restoration or culvert replacement. This will allow for confirmation that the project area is being utilized by the target species, or that an existing culvert is a barrier to fish migration and should be replaced. An understanding can then be developed of how salmonids are utilizing habitat of various quality, which may inform restoration or protection to conserve these species. Identification of species use is especially important where previous records have not verified fish use and new information expands the distribution of one or more of the target species.

Several target species are identified for analysis of eDNA samples. These salmonid species include: Chinook salmon (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), rainbow trout (*O. mykiss*), and bull trout (*Salvelinus confluentus*).

Hydrology

Hydrology monitoring involves development of flow-rating curves. Continuous in-stream water level is collected year round and in-stream flow measurements are performed periodically through the year to capture low, medium and high flows. The flows determined from flow-rating curves are used to calculate expressions of intensity and frequency of water level fluctuations. These fluctuations have a direct effect on condition of the benthic macroinvertebrate community as well as an influence on concentrations of select water quality parameters. The flow metrics calculated from this data also have an influence on habitat and bank condition and is one the monitoring elements that has direct influence on several elements in the State of Our Waters monitoring program.

Timing and frequency of sampling collection for each of the State of Our Waters Monitoring elements is summarized using a visual format in Table B-2. The information contained in this Table provides a basis for planning level of field effort.

Table B-2 Monitoring schedule and timing/frequency for collection of samples.

Sampling Routine	January	February	March	April	May	June	July	August	September	October	November	December
Water Quality	X	X	X	X	X	X	X	X	X	X	X	X
Benthic Macroinvertebrates							X	X	X			
Continuous Temperature Monitoring	X	X	X	X	X	X	X	X	X	X	X	X
T&E Species Habitat and Bank Conditions						X	X	X	X	X		
Fish Use (eDNA)				X	X		*X	*X		*X	*X	
Hydrology	X	X	X	X	X	X	X	X	X	X	X	X

Note:
* Discretionary eDNA sampling period beyond April/May timeframe (determine if fish spp. present at other times).

B.2.2 Sample Collection and Handling

Water Quality

Recommended sample sizes, containers, preservation techniques, and holding times for measurement of the conventional water quality parameters are listed in Table B-3. Sample containers will be kept closed until each set of sample containers is filled. All samples will be immediately placed in a cooler and kept cool and dark until delivered to the lab.

Water samples will be collected using equipment and laboratory supplied bottles to ensure samples are representative and reliable. Sampling methods will minimize the potential for cross contamination or spread of invasive species, and enable safe collection. The following collection devices and locations for sampling will be used:

1. Surface water grab sampling using a pole to obtain representative sample, minimize spread of invasive species, and limit contact with sediment. Obtained from bank or while standing downstream of the sample collection location; or

2. Surface water grab sampling using a Van Dorn samplers from a bridge (if present/feasible) to obtain a representative sample on large rivers. Attempt to obtain samples from the upstream side of the structure.

Lab results from samples exceeding holding times are rejected unless exceedance is minimal and does not affect result integrity. Data Management Section B.10 further outlines how to record variation from QA Project Plan protocol or DQOs (Data Quality Objectives).

Instantaneous Field Water Quality Measurements

In-situ field data measurements will be recorded immediately following collection, primarily in electronic form (stored within the Hydrolab® Surveyor) and, transferred to an electronic field form. If necessary, a hardcopy field datasheet will be used. Data are routinely transferred to the County computer network for verification and load to the WISKI database.

Table B-3 Containers, preservation techniques, and holding times for measurement of water quality parameters.

Parameters	Sample Container	Sample Volume	Preservation	Recommended Holding Time
Instantaneous Field Measurements				
Temperature	*In-situ*	NA	NA	Instantaneous
Dissolved Oxygen	*In-situ*	NA	NA	Instantaneous
pH	*In-situ*	NA	NA	Instantaneous
Conductivity	*In-situ*	NA	NA	Instantaneous
Turbidity	*Polyethylene*	1L/25ml aliquot	NA	ASAP after collection
Flow	*In-situ*	NA	NA	Instantaneous
Surface Water Samples				
Hardness	Wide-Mouth Polyethylene	250mL	HNO3 to pH<2 3, Cool to ≤6°C	6 months
Total Phosphorus	Polyethylene	250 ml	H_2SO4 to pH<2 Cool ≤ 4ºC	28 days
Nitrate+Nitrite-N	Polyethylene	250 mL	H_2SO4 to pH<2 Cool ≤4ºC	28 days
Total Persulfate Nitrogen	Polyethylene	250 mL	H_2SO4 to pH<2 Cool ≤4ºC	28 days
Totals Suspended Solids	Polyethylene	500 mL	Cool ≤4ºC	7 days
Fecal Coliform/*E.coli*	Sterile Polyethylene	250mL	EDTA/Sodium Thiosulfate and Cool, 0° C - 10° C	24 hours

Metals (Dissolved*) (Surface Water Samples)				
Parameters	**Sample Container**	**Sample Volume**	**Preservation**	**Recommended Holding Time**
Dissolved Copper*	HDPE	125mL	HNO_3 to pH<2 Cool to≤6°C	Lab filtered within 24hrs of sampling 6 months
Dissolved Zinc*	HDPE	125mL	HNO_3 to pH<2 Cool to≤6°C	Lab filtered within 24hrs of sampling 6 months

NOTES:
NA ~ not applicable
TBD ~ to be determined
Sample transport at ≤ 4ºC may be relaxed to ≤ 10ºC if data used for non-regulatory purposes
* Dissolved metals samples will be filtered in lab within 24hrs of being sampled

Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate samples will be collected and stored in Nalgene® containers supplied by the taxonomic laboratory. Periodically, sample volume (including detritus and sediment) is large and will fill more than one sample jar. In these cases, labeling on the jars will indicate the total number that will be submitted to the laboratory from a site (e.g., Jar 1 of 2, Jar 2 of 2).

Alternate sample vessels can include one-gallon heavy duty freezer bags that are resistant to degradation from the ethanol preservative used with benthic samples. This is an alternate strategy for storing samples should sample jars be unavailable. A freezer bag is used to hold all sample material from the Surber sampler. A label is added inside the freezer bag along with enough preservative to cover the sample. A second freezer bag is used to ensure that any leakage is contained.

Samples are stored in coolers while in transit to sites and between sites during each field day. Storage in coolers minimizes the potential for damage or cross-contamination of other samples from leaking vessels (Nalgene® jars or Ziploc® Freezer Bags). Jars can be stacked to maximize the number that can be stored in a cooler. Freezer bags with the benthic samples should be stored in rows in a water tight container like a cooler. Stacking could cause damage to invertebrates in sediment and prevent identification by laboratory taxonomists. The continual movement of sediment within a bag caused by vibration of the moving field vehicle can “grind” tissue on benthic macroinvertebrate bodies obscuring important taxonomic features.

Benthic macroinvertebrate samples will be collected using standard protocols developed by the Surface Water Management group. The protocols are consistent with other biomonitoring efforts implemented by State and local government agencies. A detailed description of the benthic macroinvertebrate protocols are described in the SOP (Standard Operating Procedures) and can be found in Appendix D. A description of both field collection techniques and taxonomic laboratory processing methods that outline the type of information eventually used to evaluate ecological condition of communities are included.

Continuous Temperature Monitoring

Temperature sampling is completed with an electronic probe that is calibrated using a NIST thermometer (National Institute of Standards and Technology) and is automatically measured in fifteen-minute intervals. There are no physical samples collected for temperature measurements so storage and handling of samples does not exist for this monitoring element.

Threatened and Endangered Species Habitat and Bank Conditions

Observations and measurements are made for a variety of physical habitat characteristics (Table B-4) and are collected at either equally spaced transects or continuously along the surveyed stream. Transect sampling supports reach-scale characterization and continuous monitoring characterizes discrete conditions across the entire survey. The data are collected at these scales using network-enabled iPads for real-time cloud storage using ArcGIS.

Table B-4 Physical habitat measurement categories and description for how this information will be used.

Habitat Parameter	Scale	Description
Bankfull Width (BFW) and Depth (BFD) – BFW measured to nearest 1 cm. BFD measured to nearest 1 cm	11 transects	Bankfull Width measures the channel size most often influenced by channel forming flow (approximately 2-year recurrence interval) delivered from the watershed upstream. It is the primary measure used to determine channel size and minimum size of functioning pools along a reach. BFW scales habitat conditions and characteristics in order to evaluate results based on summarized data. The width/depth ratio is a metric used to characterize channel shape as flow varies).
Stream Bank Condition – measured to nearest 10 cm.	Continuous	Inventory of the length of bank modifications (human-made), such as placed rip-rap and assessment of bank erosion within a surveyed stream or river segment.
Canopy Cover (%)	11 transects	Vegetative cover that provides shade, stabilization of soils, and contribution of organic matter to the stream measured with densitometer. Measurements made in 4 directions at center of channel and at stream bank facing bank.

Habitat Parameter	Scale	Description
Instream Wood Pieces – count and frequency by survey length	Continuous	Measurement of characteristics and quantity of instream wood. Instream wood provides habitat complexity, cover, and hydraulic roughness. All wood larger than two meters length and 10 cm diameter is counted. Wood characteristics include wood length class, diameter class, wood type (conifer/deciduous), decay class (young, med, old). Values establish a baseline LWD size and density for the reach for future comparison and to assess LWD enhancement needs in certain cases.
Instream Wood Jams – count and frequency by survey length	Continuous	Measurement of wood jams include jam type based on position within the channel, visually averaged jam length, jam width, and jam height. All wood larger than two meters length and 10 cm diameter is counted.
Habitat Units (riffle/glide/pool) – area to 0.01 m2; depth to nearest 1 cm.	Continuous	Assessment of total habitat area (total length and visually averaged width) and composition among types. For pools, residual pool depth and pool forming function according to: • Riprap • Bedrock • Wood • Beaver Activity • Free Form • Boulder
Side-Channel Habitat	Continuous	Quantification of side channel length, width, and habitat composition and area.
Substrate – measured at B-axis to nearest 1 mm.	11 transects	Size distribution of surface substrate particles in a stream reach using pebble count technique – 10 pebbles per transect; serves as important living space in each habitat type (e.g., silt, sand, small gravel, large gravel, small cobble).
Channel Gradient	3 transects	Measurement of water surface elevation differences between transects establishes the reach gradient using the average slope among 3 transect pairs. Results are used to bin streams by gradient category and interpret habitat results. Data used to ground-truth the LiDAR-derived stream gradients for evaluation of remote-sensing.

Equipment used to make these measurements include the following:

- Hand-held rangefinder (metric)
- Stadia rod (metric)
- iPad loaded with electronic field forms
- Convex spherical densiometer (modified per Lazorchak et al. 1998)
- Calipers
- Pea level
- Handheld tally counter

Fish Use/eDNA

eDNA Field Collection Methods:

Water sampling is conducted with the Smith-Root ANDe™ water sampling backpack (https://www.smith-root.com/edna/ande). Before sampling begins at a site, all equipment (water sampling backpack, filter holding wand, water bottles, etc.) is wiped down with or submerged in a 50% bleach solution (Kemp & Smith 2005; Champlot et al. 2010), and subsequently rinsed with DI water, to prevent contamination. At each site, up to one liter of stream water is filtered through a 1.0 µM pore size filter. In order to detect potential contamination, 500 ml of sterile water is filtered at each site, as an equipment control. Equipment controls are extracted only if the paired sample has a positive detection, to ensure the result is not due to contamination (Jerde *et al*. 2013). Filters (stored in 100% ethanol in 2 mL tubes) are stored in the laboratory at -20ºC until DNA extraction.

Hydrology

Sites will be monitored for water level every 15 minutes using Onset HOBO MX2001 or Onset Hobo U20 level-loggers. Data will be downloaded monthly at a minimum of nine sites. Additional hydrology sites may be added to the network based on the discretion of the Hydrology Technical Lead and budgetary constraints.

In situ flow will be measured at each site up to six times per year using an OTT MF Pro mounted to a wading rod. Measurements will be made using methods consistent with the existing SWM gaging program and the USGS document "Discharge Measurements at Gauging Stations."

Decontamination of Field Equipment for Aquatic Invasive Species

Special care must be taken to prevent the spread of aquatic invasive species (AIS) between sites when wading in streams. Three problem species have been tentatively or definitively identified in western Washington watersheds. These include *Didymopsphenia geminata* (Didymo), New Zealand Mud Snail (*Potamopyrgus antipodarum*), and the amphibian African Clawed Frog (*Xenopus laevis*). Areas of Snohomish County affected by these species include all tributaries to Lake Washington and those in the Snohomish River estuary. Since there are areas of Snohomish County are considered as high level of concern for spread of these AIS species, decontamination procedures will be used as described in Appendix B.

B.2.3 Field Recording Methods

Field notebooks and sample custody forms will be maintained by the Technical Lead for each monitoring element. Where applicable, field data will be entered into iPads with programmed electronic forms. The nature of collected samples will differ among data types and monitoring elements.

Forms contain different types of information for each of the State of Our Waters Monitoring Program elements. Additional notes may be recorded about a site and site visit in the case collected data does not capture observations made by the professional field scientists.

Water samples and benthic macroinvertebrate samples will be handled differently from field to laboratory. The quantity of preservative used in benthic samples increases complexity of shipping requirements to the taxonomic laboratory as ethanol is considered a hazardous material when shipping. To minimize risk and cost for shipping of hazardous materials to the taxonomic processing laboratory, ethanol preservative is drained from the sample container, the container re-sealed, and the sample shipment completed. In order to use this procedure, samples collected from the field should be preserved in ethanol following collection for at least one-month prior to shipping. Preservative permeates and displaces most of the water in macroinvertebrate tissue in this time period and will limit (or prevent) macroinvertebrate tissues from bacterial degradation.

General information is periodically recorded on water proof field sheets and then transferred to the iPad in electronic form or is directly recorded in electronic form. Information common to all field visits including:

- Date of sample collection or field measurement
- Time of sample collection or field measurement
- Names of sampling personnel collecting field data and samples
- Number/type of samples collected
- Weather at time of sampling (recorded under “Notes”)
- Descriptions of any photographs taken at sampling sites (recorded under “Notes”)
- On-site field measurement (e.g., temperature, water level)

Data is stored electronically in an iPad® form; fields with categorical data have drop-down boxes so that a selection is made by the recorder. Fields that require measurements of distance or counts require entry of numerical data into the electronic iPad® field form. The field form is reviewed at the end of the sampling reach for completeness, all remaining field entries finalized, and then data uploaded to the server from the iPad so that two copies of data are stored; a local copy on the iPad® and a permanent copy on the server.

Field forms in electronic form have designated information that must be entered before data collection at a site is considered complete. A review of all cells for entries in the electronic field form will indicate when site data collection is complete. Once an electronic field form is completed, it is submitted for upload to the server and then is “synced” so that all data collected from the same site are viewable on the same electronic page and color-coded based on type of monitoring element (e.g., water quality, benthic macroinvertebrates, habitat measurements; transects and habitat units).

B.2.4 Sampling Identification and Custody

Water Quality Monitoring

Each sample bottle will have a waterproof sample identification label or tag. All sample bottles will be labeled with an indelible marker before or during the time of collection. Sample labels will include station designation, date, time, and type of sample (analyte). Special analyses to be performed and any pertinent remarks will also be recorded on the label.

All water quality samples will be delivered by courier to the contract commercial laboratory. Samples will be accompanied by the chain of custody (COC) with sample numbers, requested analyses, number of bottles, bottle sizes and contact information. An example of the COC form used for tracking water quality samples is presented in Appendix A.

Water samples will be collected in the labeled transfer bottles, and delivered to the laboratory as soon as possible following collection. Bottle ware for each parameter, including the container types and preservatives, will be supplied by the contract laboratory and used to collect samples. Handling requirements for samples collected as part of this water quality monitoring program will also be provided by the laboratory. The samples taken for laboratory analysis will be stored in coolers containing bags of ice. The temperature inside the coolers and acid preservation for samples will be verified by the receiving laboratory as a component of field quality control.

All samples will be transferred to the receiving analytical laboratory using COC forms. The COC form acts as a record of sample shipment and a catalog of the contents of each shipment (coinciding with information on the field record), in addition to maintaining a complete record of evidentiary custody transfer. It will contain the following, at a minimum:

- Project name
- Contact person
- Chain of Custody Number
- Temperature upon receipt
- Sample ID (facility name, waste stream, sampling point)
- Collection date and time
- Matrix
- Number of containers
- Type of analysis required
- Sample collected/relinquished by signature / date and time
- Laboratory recipient signature
- Laboratory receipt date and time

Staff notify the contract laboratory of a pick-up at the County campus such that custody is transferred on same day as the sample event and within the shortest holding time for individual analytes.

Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrate samples collected from the field are stored in 95% ethanol (anhydrous) that is decanted from a source container purchased from a local supply company licensed to dispense this preservative. An identification label for the sample is placed within the Nalgene® plastic sample container and fixed on the outside of the container with clear packing tape. The following is an example of the label placed both on the inside and outside of the sample container.

SNOHOMISH COUNTY
SURFACE WATER MANAGEMENT

BENTHIC INVERTEBRATE SAMPLE
SAMPLE ID:_____
DATE:_____
CONTAINER ____ OF ____

Information on the label is also recorded on the Chain-of-Custody Form for sample pickup and transport (see Table Appendix A-3) to the taxonomic laboratory.

Continuous Temperature Monitoring

Data are identified though use of established Site ID's and descriptions included on the placement and retrieval field form. Collection of continuous temperature data is normally downloaded in the office by physically connecting via a data-shuttle. The data file at water level monitoring sites will be downloaded using a Bluetooth wireless connection and will include both water level readings as well as temperature readings. These temperature loggers are located at a select number of sites each year.

Threatened and Endangered Species Habitat and Bank Conditions

Habitat assessments do not generate transportable samples to office or a laboratory. Data recorded from field observations are described in B.2.3. Any missing fields are identified and data collection resumes at a site until all fields have been filled where required in the iPad application.

Fish Use/eDNA

Samples (eDNA) are collected on a filter and is carefully folded and inserted into a sample jar filled with preservative. The sample jar is labelled with the following:

- Site Name
- Site ID
- Date of Sample Collection
- Sampling Staff

The hardcopy field form is prepared on rite-in-the-rain© paper that includes several types of information used to ensure an adequate water sample was collected for analysis of eDNA for salmonid and char species present. That information includes the following:

- Site Name
- Site ID
- Date and time sample was collected
- Volume of surface water filtered

Hydrology

Site ID is entered into the handheld electronic data gathering unit as a component of the flow monitoring device. This Site ID then associates the flow estimate with a site that can be retrieved at a later date. Additionally, the flow estimate generated by the flow monitoring equipment is transferred to the iPad® field form used to record the physical habitat data.

Continuous water level records are associated with the Site ID, date and time collected, and logging device identification number. This identification number is initially noted on the deployment record form so that at retrieval, identity of the device is verified. This is part of the chain-of-custody procedure for the hydrology monitoring element; quality of the data is, in part, determined by verification of equipment deployed and retrieved.

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B.3 Sampling Handling & Custody

B.3.1 Field Data Recording

Water Quality Monitoring

Each sample bottle will have a waterproof sample identification label, tag, or permanent marker identification. All sample bottles will be labeled with an indelible marker or ballpoint pen before or during the time of collection. Sample labels will include, date, time, sample ID, collector's initials, and sample/analysis type. Special analyses to be performed and any pertinent remarks will be recorded on the label as space allows. Sample sets from a site are placed in a one-gallon freezer bag before storing in a cooler with cube ice. This ensures samples from the same site stay together during transport and the laboratory easily locates all samples from a site for check-in when delivered.

Benthic Macroinvertebrate Sampling

Companion physical habitat information collected with benthic samples are fines present in the sampling area and the intermediate axis diameter of twenty-five substrate particles within the benthic sampling area. Up to twenty-five observations for fine sediment (sand and smaller) are recorded either in hardcopy on rite-in-the-rain© paper by field staff or in the iPad® application. The sampling grid has twenty-five cross-hairs and the estimate of fine sediment presence is based on a fraction of these twenty-five potential observations for fine sediment.

The intermediate axis diameter for twenty-five substrate particles are measured with a micrometer to the nearest millimeter and recorded for each of the eight benthic sampling areas. These data are recorded either in hardcopy on rite-in-the-rain© paper by field staff or in the iPad® application. The measurements of substrate characteristics within each sampling reach result in a total of two hundred observations for fines and for substrate particle intermediate axis size.

Additional field observations may be recorded for each of the sites in the "Notes" section of the data entry page on the iPad®. Additional information describes site physical conditions, human activity, physical changes from previous monitoring visits (trend sites only), and presence of salmonids including species identification, when possible.

Continuous Temperature Monitoring

Periodic visits to temperature-logger locations are made during deployment periods and to make sure that equipment remains submerged and in a representative location as well as performing data downloads. If the logger needs to be moved or is missing and needs to be replaced, then appropriate action is taken, and new remarks and notes entered on the survey form (**Error! Reference source not found.**).

Prior to temperature logger downloading, the computer atomic clock time is set for the Pacific Time Zone. The manufacturer's downloading procedures are followed. The data is saved as text files that can be opened in Excel or another type of spreadsheet software.

Continuous Temperature Survey Forms are used to document the deployment and retrieval information for a station (Appendix E). Field forms are completed while in the field, organized and stored in binders for use in long-term recordkeeping.

Standard data processing and analysis sheets are used to trim, process and analyze data. Data is then uploaded to the WISKI7® database (see Section B.10).

Methods for acquisition of continuous temperature data is described further in Standard Operating Procedures (Appendix E).

Threatened and Endangered Species Habitat and Bank Conditions

Sampling handling and custody are not applicable with this type of monitoring data. Field data recording of habitat information for transects and habitat unit parameters are described in Section B.2.2.

Fish Use/eDNA

Data collected while in the field are recorded in an iPad® and stored electronically as a local file and uploaded to the server from the sample location (when an available signal enables connection). Data in Table B-5 are recorded while on site and sample collection is occurring.

Table B-5 Data fields from eDNA sample collection at State of Our Waters Monitoring sites.

Data Field	Description
Date	Date sample is collected
Sampler 1	Three letter initials of the first field staff
Sampler 2	Three letter initials of the second field staff
Site	Abbreviation of site name; 4-6 capital letters unique to the site (e.g., PCNC)
Description	Descriptive location of the site; reference to Rd names, Park names, etc.
Latitude	Recorded as decimal-degrees; use six significant figures
Longitude	Recorded as decimal-degrees; use six significant figures
Sample ID	Site abbreviation + Replicate No. (E.g., PCNC-1)
Blank ID	Site ID + Blank designation (e.g., PCNC-Blank)
Sample Volume (L)	Volume of stream sample passed through the filter (in Liters)
Blank Volume (L)	Volume of de-ionized water passed through the filter (in Liters)
Decontamination	Decontamination procedure of the sample equipment observed between sites (Y/N)
Blank	Blank sample collected at a site (Y/N)
Filter	Filter collected and preserved at a site (Y/N)
Turbidity (NTU)	Turbidity measurement made on-site (Nephelometric Turbidity Units)
Notes	Site notes including description of sample location, flow conditions, water color

In addition, a diagram of the sample site is constructed, and location of the sample indicated on the diagram. The diagram is recorded in pencil on Rite-in-the-Rain© paper.

B.3.2 Sample Packaging and Shipping Requirements

Water samples for laboratory analysis will be collected in containers appropriate for the analytes of interest, filtered if necessary and will be properly preserved until delivery to the analytical laboratory. All samples will be immediately placed in coolers and packed with gel ice after sampling and will remain chilled to 0 - 10°C (±2°C) during transportation to the contract laboratory. All samples will be accompanied with completed chain-of-custody forms when shipped, and coolers will be kept in a secure location.

Benthic samples for taxonomic laboratory analysis will be collected in containers appropriate for storage of sediment and sample preservative (90% Ethanol).

Sample packaging and shipping do not apply to the Continuous Temperature Monitoring program, Threatened and Endangered Species Habitat and Bank Conditions program, and Hydrology program. Data collected with automated temperature monitoring devices and recording of observations onto hardcopy forms or into iPad® Tablets serve as the equivalent to water or benthic samples and do not require shipping and handling.

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B.4 Analytical Methods

Water Quality Monitoring

All sample analysis methods used for this project are approved use by the EPA and Ecology (Table B.4-1) and are classified as an EPA Method or as Standard Methods (Rice et al. 2012).

The contracted laboratory for the program must be Ecology-accredited, and unless subcontracting is necessary, this lab will perform all other physicochemical analyses for this study. The contract laboratory QMP (Quality Management Plan) must be on file with Ecology detailing their quality assurance procedures.

Laboratory turnaround times must be within 7 to 10 working days. Any issues regarding analytical data quality will be resolved by the sampling organization Project Managers.

Laboratory analytical procedures will follow U.S. EPA (1983, 1991) or APHA et al. (2005) methods. Detection limits and methods are summarized in Section B.4 and in Table B-

Water quality field instrument sensors employ methods conforming to guidelines for establishing test procedures for pollutants in 40 Code of Federal Regulations Part 136.

Benthic Macroinvertebrate Monitoring

Analytical methods include extraction and identification by a certified taxonomic benthic macroinvertebrate laboratory. A sub-sample of 500 or more organisms are picked from each benthic sample using the Caton Sub-sampling device. If less than 500 organisms are picked from a full sample then additional information about the physical attributes of the sample are noted like substrate size and composition. Usability of the data is determined by the technical lead (see Table A-1) who determines if the reach was recently disturbed by catastrophic flows or other disturbance that reduces the density of invertebrates in a reach. Samples with less than 300 sub-sampled organism counts will be flagged and usability of the data determined on a case-by-case basis. Normally, fewer than 300 organisms sub-sampled from a site sample are not unusable when generating BIBI scores as the WQI was developed using 300 or more organisms from sub-sampling of a whole site sample.

Data reported by the laboratory as part of the analytical process are divided into two types:

Sample and Processing Information:

- Laboratory Name/Taxonomist;
- Integrated Taxonomic Information System (ITIS) Taxa Number;
- Scientific name of taxa;
- Collection date;
- Sampling device;
- Habitat sampling scheme (reach wide or targeted);
- Collection protocol used (narrow protocol; wadeable streams <25m bankfull width);
- Number of organisms identified;

- Density of taxa per meter square;
- Number of each taxa by life stage;
- Report number of damaged taxa and indicate if unable to identify to lowest level;
- Report taxa uniqueness for non-specific identifications (to estimate diversity);
- Presence of invasive species including the New Zealand Mudsnail (*Potamopyrgus antipodarum*).

Sample Taxonomic Information:

- Raw data will be submitted in an Excel file and include the lowest taxonomic level identifications as well as the parent taxonomic names including the following: Order, Family, Genus, and Species (at a minimum, the Fine STE (Standard Taxonomic Effort) (King County 2014);
- Spreadsheet tables will include the following information under column headings: parent taxonomic names, scientific name (genus and species) under separate columns, site name (separate column for each site), density estimates of taxa for each site, and functional feeding designation using current technical literature.

Data is entered onto bench sheets; data includes the taxonomic name of the organism (usually genus or species), the count, life stage, indications about whether the taxon is unique to the sample and qualifiers that explain cases where the target taxonomic resolution was not achievable. For a detailed account of laboratory procedures, see Appendix D (SOPs for Benthic Macroinvertebrate Monitoring).

A minimum of 10% of identified samples are fully re-identified and re-enumerated by a second taxonomist. The individual samples to be checked are randomly chosen before a project begins and taxonomists do not know which samples have been selected for quality checking. The second taxonomist performs a blind quality check; that is, the taxonomic and count data generated by the first taxonomist are not made available to the QA taxonomist. Results from the 2 identifications are compared by means of the Bray-Curtis similarity calculation, which combines taxonomy and enumeration into a single conservative statistic, maximizing potential error. The Lead Taxonomist, assisted by the Chief Biologist, oversees the application of QA/QC protocols, tracks statistics for individual taxonomists and for projects, and institutes corrective actions.

Continuous Temperature Monitoring

Continuous Temperature Monitoring data is collected using the same protocol as the Washington Department of Ecology (EAP080).
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_Cont_Temp_Mon_Ambient_v2_0EAP080.pdf

Temperature monitoring data is useable once evaluated using specific equipment performance checks and identification of data segments that increase abruptly, indicating exposure to air temperatures resulting from water levels that drop below the elevation of the temperature logger. Analysis of temperature data involves several steps including:

- Post-deployment accuracy Checks; and
- Examination of data that does not fit the expected pattern (e.g., abrupt increases indicating exposure to air temperature).

Temperature criteria for protection of aquatic life in WRIA 5 (Stillaguamish Basin), WRIA 7 (Snohomish Basin) and WRIA 8 (Lake Washington-Cedar-Sammamish Basin) use the 7-day average of the daily maximum temperatures (Ecology 2016). The 7-DADMax is calculated using continuous temperature monitoring records using data from three days prior- and three days following a date in order to calculate the average daily maximum for a seven-day interval. More detailed discussion of these analytical procedures are found in Section B.5.8.

Threatened and Endangered Species Habitat and Bank Conditions

Physical habitat monitoring has two levels of characterization; reach-scale habitat description and continuous streambank, habitat unit, and wood quantities or description. The methods used for assessing habitat condition (banks and wood recruitment) do not have laboratory analytical methods. Rather, field measurements and desktop analysis of data are analogous to laboratory analysis of samples. Habitat indicators generated from the physical habitat assessments are listed in Table A-13. More detailed explanation and methods for data collection are provided in Appendix F.

The reach-scale habitat description is based on measurements at eleven transects and that are combined to derive a total or averaged single value for each of the data types (e.g., canopy cover, wetted width, bankfull width, bankfull depth, and substrate size distribution (e.g., % Sand)) and includes a measure of variance for each. Measurements of continuously variable indicators are generally made at the point of observation or represent individual observations (e.g., count of wood) or lengths (e.g., pool length, riffle length) within the total length of the survey. Results are summarized by total count or the average of discrete observations (e.g., average pool depth), but also are summarized in terms of total reach length (i.e., frequency or density per unit reach length) or total survey area.

These resulting habitat metric values are used to generate quantitative or qualitative expressions of habitat suitability for salmonids (e.g., good, fair, poor) either using individual indicators compared to regional habitat criteria or combined into a Habitat Quality Index (HQI) that uses multiple indicators in a semi-quantitative way. The development of an HQI will follow examples from Snohomish County Surface Water Management (2002) and Leonetti et al. (2005). Results will be used to measure status of sites and to compare repeated visits in a time series analysis for detection of trends.

Handling of data is by electronic methods in a database application that is stored on the iPad. Eventual storage of all data as part of the State of Our Waters Monitoring Program will be in WISKI7®; Snohomish County Surface water Managements local data management system.

Fish Use/eDNA Sample Analysis Methods

In eDNA analysis of aquatic organisms, water is typically collected and filtered. DNA is then extracted from the filter and amplified using species-specific primers to determine if the species of interest is present or absent. Quantitative Polymerase Chain Reaction (qPCR) is used to detect minute levels of DNA, using species-specific primers, and a fluorescently labeled reporter molecule (probe), which yields increased fluorescence with an increasing amount of product DNA (**Error! Reference source not found.**). A sample is determined “positive” or “negative” for target species based on whether or not the sample crossed the threshold (dashed line in **Error! Reference source not found.**). When a sample

crosses the threshold, this is referred to as the C_T, "Cycling Threshold." Samples with higher concentration of DNA typically cross the threshold earlier in the cycling (~cycle 20-30) than samples with lower concentration (~ cycle 31-40).

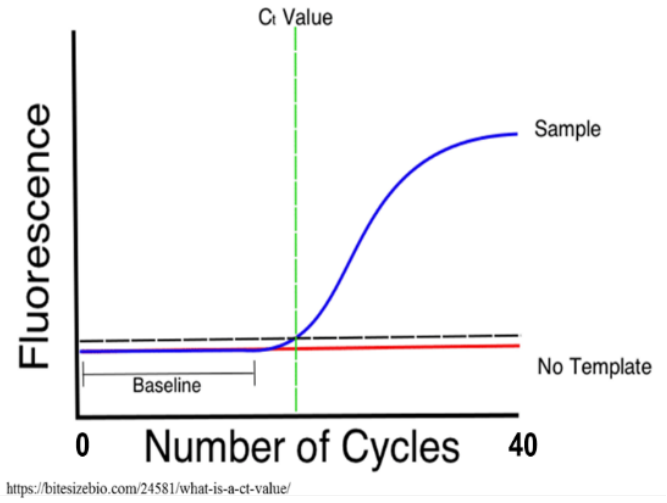

Figure B- 1 Diagram of qPCR real-time output. A sample replicate is deemed Detection, if the sample (blue line) crosses the threshold (dashed line), before the termination of thermal cycling. The point at which the sample crosses the threshold is referred to as CT.

All laboratory work is performed in an AirClean 600 Work Station (ISC Bioexpress, Utah, USA), which is equipped with HEPA air filters and UV lights. All work surfaces are decontaminated with 50% bleach, and exposed to UV light for at least one hour before analytical work begins. DNA extraction is performed on half of the filter sample, using the Qiagen DNeasy Blood & Tissue and Qiashredder kits (Qiagen, Inc.), as per Pilliod *et al*. (2013). The other half of the filter is stored for potential future use. Post-extraction, each filter sample is processed in triplicate.

Samples will be tested for the presence of Chinook salmon (*O. tshawytscha*), Coho salmon (*O. kisutch*), rainbow trout (*O. mykiss*), and bull trout (*S. confluentus*). Mitochondrial COI species specific qPCR primers (C. Ostberg, USGS, unpublished) will be used. qPCR products will be obtained by amplifying DNA in 10µl reaction volumes, containing 5 µl of Taqman gene expression master mix, 0.5 µl of 20X primer/probe mixture, 1.5 µl of molecular grade water and 3 µl of DNA. Cycling conditions will consist of 2 minutes at 50ºC, then 95 ºC for 10 minutes, followed by 45 cycles of 95 ºC for 15 seconds, and 60 ºC for 1 minute. To quantify DNA, and assess the performance of qPCR reaction, samples will be run alongside an eight-level standard curve serial dilution of either Chinook salmon, Coho salmon, rainbow trout or bull trout DNA extracted from fin tissue.

Filter samples will be considered positive for detection if two out of three triplicate qPCRs per filter result in a positive amplification (e.g. C_T of 45 or below), as per Turner et al. (2014). If qPCR samples are positive for only one of three replicates, the samples will be re-amplified, in triplicate. If the results from that amplification are still ambiguous, the paired equipment blank that is extracted and amplified, will be tested for contamination.

Hydrology

Analytical methods for hydrology are field-based versus in the laboratory. Several of the data types collected for the discharge estimate are analyzed to calculate total flow. Specific analytical methods for calculating flow are described in Section B.4.1.

B.4.1 Field Instrument and Laboratory Analysis Procedures

Procedures describing water quality field sampling technique for each parameter are in Appendix C. Laboratory and field instrument analysis procedures are described in Table B-. All water sample analyses except the field measurements of temperature, DO (dissolved oxygen), conductivity, pH and turbidity will be completed by fully qualified contract laboratories. The analytical chemistry methods to be used, as well as the sample volume requirements, detection limits, and holding times, will be consistent with the laboratory's QA and QC plans and SOPs.

Table B-6 Field Instrument and laboratory analysis of surface water samples.

Analyte	Sample Matrix	Expected Range of Results	Reporting Limit (RL)	Analytical[a] (Instrument) Method
Temperature	Water	0-25ºC	0.1 ºC	SM2550B-F
Dissolved Oxygen	Water	RL to 18 mg/L	0.1 mg/L	ASTM D888
pH	Water	pH 3-10	0.01 Standard Units	SM4500H+B
Conductivity	Water	RL to 1000 µS/cm	0.1 µS/cm	SM2520B
Turbidity	Water	RL to 1000 NTU	0.01 NTU	EPA - 180.1
Flow	Water	unknown	± 2 -4 % of current velocity reading depending on velocity	OTT MF Pro – Magnetic Inductive
	Water	Unknown	±1% of water velocity relative to ADCP, ±2mm/s	Stream Pro Acoustic Doppler Profiler
Surface Water: Laboratory				
Hardness	Water	RL to 100 mg/L	2.0 mg/L as $CaCO_3$	EPA 200.7, SM2340B, or SM2340C

Analyte	Sample Matrix	Expected Range of Results	Reporting Limit (RL)	Analytical[a] (Instrument) Method
Total Phosphorus	Water	RL to 3	0.01 mg/l	EPA 365.3, 365.4, SM4500PE or SM4500PF
NO3+NO2-N	Water	RL to 6	0.1 mg/l	EPA 353.2 or SM4500NO3E
Total Suspended Solids	Water	RL to 1000	1 mg/l	SM2540B or D
Fecal Coliform/E.coli	Water	RL to 50,000	1 cfu/100 mL	SM9222D/SM9222G1
Copper (Dissolved)	Water	RL to 100	1.0 µg/L	EPA 2007, 200.8 or SM3125
Zinc (Dissolved)	Water	RL to 100	1.0 µg/L	EPA 2007, 200.8 or SM3125

a. All Standard Methods are from Standard Methods for the Examination of Water and Wastewater, 21st Edition, American Public Health Association, 2005

Continuous Temperature Monitoring protocols that include calibration, deployment, retrieval, and data download are fully described in Appendix E. The Hobo ProV2® monitoring devices are calibrated in the office prior to deployment and log data on 15-minute intervals during the entire deployment period. Downloading of data is usually completed in the field using a Data Shuttle® so that results can be reviewed for determination of properly functioning equipment. Alternate Tidbit monitoring devices can replace any malfunctioning equipment in order to succeed in collecting data for the remainder of the planned deployment period.

Threatened and Endangered Species Habitat and Bank Conditions monitoring protocols include two approaches for measuring physical characteristics of a reach that influence aquatic life (Appendix F). One of the monitoring approaches is a transect-based approach that describes the “reach” level condition for substrate particle distribution and canopy cover conditions. Field instruments include the following; laser rangefinder, stadia rod, pea gun/hand level, convex spherical densitometer, hand calipers, and manual tally counter. Prior to field use the laser rangefinder is tested against an object with known distance (measured with reel tape). The hand level is evaluated for level in an office setting by comparing measured height of hand level (on monopod) to the measured level height at a 10 meter distance. If hand level height and distance level height are different (by +/-3cm), then hand level is re-calibrated.

Fish Use monitoring protocols are focused on identification of presence in stream segments through eDNA analysis (Appendix G). Field sampling protocol and sample interpretation is described in Section B.2.2 using the Smith-Root eDNA™ water sampling backpack. Samples are contained on filters that are folded and inserted into a collection vial that is preserved and contained for future analysis. This specialized sampling technique enables the identification and confirmation of select salmonid species

presence prior to visiting the reach. Detection of salmonid species verifies distribution and expands known distribution, where previously unknown.

Hydrology monitoring protocols are comprised by several components that ensure collection of data with known quality (Appendix H). The components of the Hydrology Monitoring protocols include:

- General Instrument Set-Up;
- Measurement Pre-planning;
- Discharge Measurement;
- Records Management; and
- Quality Control and Quality Assurance.

General set-up involves parameterization of the monitoring instrument so that the correct units are recorded for each of the data points, the velocity measurement is collected in a consistent way among all of the annual monitoring sites, date/time settings are correct, and flow is estimated at the end of each transect characterization.

The discharge measurement includes several steps that result in a flow estimate for the cross-section. The first step is in identifying the cross-section and determining the wetted width. A tape is anchored on both banks perpendicular to the direction of flow. This is important for determining the number of depth and current velocity observations needed to complete a reasonable flow estimate of each stream size. The edge measurements are determined based on how water meets shoreline (e.g., stream cross-section shape: inverse trapezoid, rectangular, or trapezoidal). Records collected from the measurements along the cross-section tape are downloaded and stored in a server location designated for use by the State of Our Waters Monitoring Program. These records include distance, depth, velocity, flow estimate, cross-section area for each cell, and channel cross-section profile. The flow estimate is uploaded to the WISKI7® database.

B.4.2 Calibration of Equipment

Care will be taken to ensure that field instruments are calibrated and adjusted prior to sampling. The multi-parameter probes will be calibrated following the manufacturer’s designated procedures. Field measurements that exceed the normal range of values for each parameter will require that a calibration check of the instrument be completed upon return from the field. If the calibration check falls outside the acceptable calibration limits, the instrument will be re-calibrated and a new field measurement will be taken at the site. All calibration checks and remediation actions taken will be recorded in calibration logs and be available upon request.

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B.5 Quality Control

Sources of error and uncertainty in environmental data are addressed by evaluating quality control results for both field collection and laboratory performance. Each of the monitoring elements in this program have unique environmental variables that are measured using SOPs (See Appendix C through Appendix H). Data quality is addressed, in part, by consistent performance of valid procedures documented in SOPs. It is enhanced by the training and experience of project staff (Table A-2) and documentation of project activities (Section A.9).

Annual training for habitat and bank condition and benthic invertebrate monitoring occurs prior to the field season. Training consists of a one-day orientation and actual data collection on a stream reach selected for sampling that year. All staff must attend and are trained on each aspect of monitoring activities. This training session provides the opportunity to review monitoring protocols, re-familiarize with data collection, and ask questions. Interns and temporary staff are included in these training sessions and mentored during the early part of the season with each of the monitoring leads (Figure A-1).

Similarly, training for the continuous temperature monitoring element and the hydrology monitoring element focus on mentoring staff and temporary employees/interns during site visits. Training requires that the technical lead beginning the training process and evaluates performance of the staff/intern during successive site visits. The Technical lead will determine when trainees are ready to assume field duties and data collection.

This QA Monitoring Plan and other supporting materials will be distributed to all sampling personnel. Data type leads will ensure that samples are taken according to the established protocols and that all forms, checklists, and measurements are recorded and completed correctly during the sampling event.

The following describe Quality Control (QC) elements for this monitoring program. Examples for how each of the following QC elements are described for the monitoring elements (e.g., water quality, benthic macroinvertebrates, temperature monitoring, T&E species habitat use and bank condition, fish use/eDNA, and hydrology) beginning in Section B.5.6.

B.5.1 Precision

Precision is a measure of internal method consistency. It is demonstrated by the degree of mutual agreement between individual measurements or enumerated values of the same property of a sample, usually under demonstrated similar conditions. Precision of sampling methods is estimated by taking duplicate samples at the same sampling station at approximately 10 percent of sites for water quality, benthic macroinvertebrates, and eDNA monitoring elements. Duplicate sampling for the State of Our Waters Monitoring program, due to impairment status of some randomly selected sites, might result in significant variability for some parameters due to the nature of sources for impairment. The usability assessment will include consideration of this condition in evaluating field duplicates as a measure of the entire measurement system.

This QC calculation also addresses uncertainty due to natural variation and sampling error. Precision is calculated from two duplicate samples by RPD as follows:

$$RPD = \frac{|C1 - C2|}{\frac{C1 + C2}{2}} \times 100$$

where C_1 = the first of the two values and C_2 = the second of the two if precision is to be calculated from three or more replicate samples (as is often the case in laboratory analytical work), the relative standard deviation (equation B.5-2) will be used and is calculated as

$$RSD = \frac{s}{\bar{\chi}}$$

Where $\bar{\chi}$ is the mean of the replicate samples, and *s* is the standard deviation and is determined by the following equation:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}\left(\chi_i - \bar{\chi}\right)^2}{n-1}}$$

where χ_i is the measured value of the replicate, $\bar{\chi}$ is the mean of the measured values, and *n* is the number of replicates.

For this monitoring program, duplicate field samples will be collected to assess sampling precision and field blanks for the water quality monitoring element will accompany samples to assess the potential for contamination in the sample collection process.

B.5.2 Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference or true value. Accuracy is determined by using a combination of random error (precision) and systematic error (bias) due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. EPA now recommends that the term *accuracy* not be used and that *precision* and *bias* be used instead.

Because accuracy is the measurement of a parameter and comparison to a *truth* condition, and the true values of environmental physicochemical and biological community characteristics cannot be known, use of a surrogate is required. Accuracy of field measurements will be assumed to be determined through use of precision. In the case of laboratory chemical measurements from the water quality monitoring element, accuracy will be determined by analysis of matrix spikes and matrix spike duplicates, laboratory control samples (fortified blanks), and other method-specified QC samples. Analyses for specific nutrients will include the use of spiked samples or certified standard reference materials, where appropriate, to

determine percent recovery. In the absence of manufacturers' certified range, the recoveries for spiked analytes are contained in Table B-. Bias is assessed in terms of recovery of a known value for control samples and matrix spikes and is calculated as follows:

% Recovery (LCS)*:*

$$\%Recovery = \frac{analyticalresult}{truevalue} \times 100\%$$

% Recovery (MS):

$$\%Recovery = \frac{(spikedsampleresult - sampleresult)}{amountspiked} \times 100\%$$

B.5.3 Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represents a characteristic of a population, parameter, and variations at a sampling point, a process condition, or an environmental condition. It therefore addresses the natural variability or the spatial and temporal heterogeneity of a population. The number of sampling points and their location is intended to represent the range of conditions of streams within each land use type.

B.5.4 Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. To achieve this objective, every effort is made to avoid accidental or inadvertent sample or data loss. Accidents during sample transport or lab activities that cause the loss of the original samples can result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Samples will be stored and transported in unbreakable (plastic) containers wherever possible. All sample processing (sub-sampling, sorting, identification, and enumeration) will occur in a controlled environment within the laboratory. Field personnel will assign a set of continuous identifiers to a batch of samples.

Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C = \frac{V}{T} \times 100\%$$

where V = the number of measurements judged valid and T = the total number of measurements planned. For this project, sampling will be considered complete when no less than 90 percent of the samples collected during a particular sampling event are judged valid.

Samples that are not collected for the following reasons will not be included in calculating the "Completeness" expression for any of the monitoring programs:

1. Access denial to a site is beyond Snohomish County SWM control;
2. Drought years that result in loss of flow in previously perennial streams; and
3. Loss of site(s) to annexation by Cities within Snohomish County.

4. Inability to access a location when collecting water quality samples or making flow measurements due to snow or ice.

B.5.5 Comparability

Two data sets are comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability is dependent on the proper design of the sampling program and on adherence to accepted sampling techniques, SOPs, and QA guidelines.

Combining data sets is sometimes necessary when evaluating trends in environmental condition and over a long time period. What often is the case, a single agency is not committed to long-term monitoring and so similar data from other agencies is sought and combined. This is more common with water quality data, but is increasingly being done with benthic macroinvertebrate data. Alternatively, elements of a monitoring program may change over time most commonly by use of a different laboratory service (e.g., water quality or taxonomic consulting service).

In order to combine data sets, an evaluation for similarity of data is necessary and accomplished by comparing Data Quality Objectives (DQOs) for each data set. Ideally, data sets should have the same performance expectations in laboratory sample analysis and field sample collection. Some minor differences for generating high quality data may exist, but data sets are still considered comparable.

Data Quality Objectives (DQOs) include precision, accuracy, and representativeness of data obtained from the sampling effort. Three types of QA and QC samples will be analyzed during each sampling event: field blanks/trip blanks, sample QC, and laboratory QC.

B.5.6 Water Quality Monitoring QC

Water Quality Field Measurement Accuracy

The accuracy of field equipment for the measurement of temperature, DO, conductivity, salinity, and pH will be determined at a minimum of two points that span the expected range of values for these parameters (two-point calibration; except for LDO). Instruments used and procedures for determining accuracy include the following.

Hydrolab® Multi-parameter water quality sensor accuracy and acceptance will be ensured by twice per day (pre and post-sampling) calibration and standard checks. Accuracy for temperature is determined annually through factory calibrations. Table B-7 includes accuracy acceptance criteria.

Table B-7 Data Quality Objectives water quality sensor accuracy and data acceptance

Parameter	Units	Accept	Qualify	Reject
pH *	std. units	< or = ± 0.25	> ± 0.25 and < or = ± 0.5	> ± 0.5
Conductivity*	µS/cm	< or = ± 5%	> ± 5% and < or = ± 15%	> ± 15%
Dissolved Oxygen	% saturation	< or = ± 5%	> ± 5% and < or = ± 10%	> ± 10%
Turbidity	NTU	< or = ± 5%	> ± 5% and < or = ± 10%	> ± 10%

* Criteria expressed as a percentage of readings; for example, buffer = 100.2 µS/cm and Hydrolab = 98.7 µS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%. Calibration checks for pH and

conductivity are conducted using two point checks. Conductivity and pH standard values change with temperature. Calibration checks take this into consideration.

Precision of water quality field measurements will also be assessed through evaluation of field duplicate measurements, where the relative standard deviation (RSD; Section B.5.1)) should not exceed 20% for any parameter. Acceptance limits (RSD) for measuring accuracy of each parameter using field instrumentation or duplicates results from the laboratory will be refined over time.

Field Blanks/Trip Blanks will be collected for 10 percent of the samples during each sampling event for all the chemical parameters listed in Section B.2.2 to ensure that no contamination was introduced during sample collection, preservation, and handling. At the same time samples are collected, field blanks will be prepared by running analyte-free deionized water through the same equipment used to collect the samples, collecting it in the appropriate sample containers, and preserving it with the same procedures used to preserve the samples. The field blanks will be collected, stored, shipped, and analyzed with the associated samples. In addition, trip blanks will be included once per quarter to determine if cross-contamination among samples occurs. If target analyte concentrations are detected in field or trip blanks, results will be examined to determine the source of contamination.

Analyte concentrations measured in samples collected during the event will be considered valid when no corresponding field blank analyte concentrations are detected or when the sample analyte concentrations are up to10 times the field blank analyte concentrations (parameter dependent).

Sample QC samples will be collected for 10 percent of the water quality samples obtained each month. The additional volumes collected for analytical QC are used to perform duplicate and spiked sample analyses or matrix spike and matrix spike duplicate analyses, depending on method requirements. For the purpose of this collection, sample QC will be evaluated using the criteria established in Table B- (Target analytes, analysis methods, reporting limits and laboratory quality control sample limits), and as detailed in the laboratory analysis methods and the laboratory QA Plan. Any results noted as deviating from program or laboratory QC acceptance criteria require immediate investigation and thorough documentation as detailed in the assessment and response actions of this QA Monitoring Plan. Corrective actions might vary widely from re-preparation and reanalysis to disqualification of sample data for use. Under no circumstances will outlying sample or QC results be submitted without a detailed explanation. The Project Manager should be contacted immediately regarding deviations for which there is not a suitable analytical corrective action due to holding time or other restrictions, so that recollection can be requested, if possible.

In addition, laboratory QC analyses will be performed concurrently with sample preparation and analysis. Laboratory QC includes analysis of appropriate reagent or method blanks for each analytical method or technique, as well as analysis of laboratory control sample or certified standard reference materials as appropriate (Table B-8). Method and reagent blanks should be free from analytes of interest at levels above the project quantitation limits.

Table B-8 Water Quality Laboratory Quality Control Sample Limits

Parameter	Lab Method Blank	Lab Duplicate % Difference	Matrix Spike% Recovery	Matrix Spike Duplicate % Recovery	Standard Reference Materials % Recovery
Fecal Coliform	Non-detect	0 – 50	NA	NA	NA
Total Suspended Solids	Non-detect	0 – 50	NA	NA	81 - 122
Nitrate – Nitrite as Total Nitrogen	Non-detect	0 - 20	90 - 110	NA	90 - 110
Total Persulfate Nitrogen	Non-detect	0 - 20	90 - 110	NA	90 - 110
Total Phosphorus	Non-detect	0 - 20	85 - 115	NA	90 - 110
Dissolved Copper	Non-detect	NA	70 - 130	0 - 25	90 - 110
Dissolved Zinc	Non-detect	NA	70 - 130	0 - 25	90 - 110

Field duplicate sample precision is assessed and compared to expectations in Table B-9. Duplicate and original sample results for the site where samples were obtained are qualified accordingly (Table B-).

Table B-9 Individual Water Quality Field Duplicate Limits and Associated Qualifiers

Parameter	Field Duplicate% Difference	Qualifier
Fecal Coliform Means ≤ 20 Colonies	< 50 %	Sample result is accepted without qualification
	≥ 50% < 75%	Sample result is an estimate
	≥ to 75%	Sample result is rejected

Parameter	Field Duplicate% Difference	Qualifier
Fecal Coliform Means > 20 Colonies	< 20%	Sample result is accepted without qualification
	≥ 20% < 50%	Sample result is an estimate
	≥ 50%	Sample result is rejected
Total Suspended Solids < 5 x's MDL	< 50%	Sample result is accepted without qualification
	≥ 50% and < 75%	Sample result is an estimate
	≥ to 75%	Sample result is rejected
Total Suspended Solids > 5 x's MDL	< 20 %	Sample result is accepted without qualification
	≥ 20% < 50%	Sample result is an estimate
	≥ 50%	Sample result is rejected
Total Phosphorus Means ≤ 1	≤ 25	Sample result is accepted without qualification
	≥25 and < 75	Sample result is an estimate
	≥ 75	Sample result is rejected
Total Phosphorus Means ≥ 1	≤ 25	Sample result is accepted without qualification
	≥25 and ≤ 50	Sample result is an estimate
	≥ 50	Sample result is rejected

Table B-10 Individual Water Quality Field Duplicate Limits and Associated Qualifiers

Parameter	Field Duplicate% Difference	Qualifier
Nitrate+Nitrite-N and Total Persulfate Nitrogen <1	<25	Sample result is accepted without qualification
	>25 and <75	Sample result is an estimate
	>75	Sample result is rejected
Nitrate+Nitrite-N and Total Persulfate Nitrogen >1	<25	Sample result is accepted without qualification
	>25 and <50	Sample result is an estimate
	> 50	Sample result is rejected
Dissolved Copper and Zinc ≤ 1	<25	Sample result is accepted without qualification
	>25 and <75	Sample result is an estimate
	>75	Sample result is rejected
Dissolved Copper and Zinc ≥ 1	<25	Sample result is accepted without qualification
	>25 and <50	Sample result is an estimate
	> 50	Sample result is rejected

Water quality data are considered representative if they are:

- collected from a location representative of the site and associated land use (or as close as possible to the target location given right-of-way issues);
- collected at mid-depth from well-mixed, flowing waters; and
- collected throughout seasons to represent varying conditions.

QC for laboratory analyses of water quality samples will be analyzed according to methods reported in Table B- and collected at the frequency described in Table B-0 (conventional surface water analytes) and Table B-1 (metals in surface water).

Table B-11 Laboratory Quality Control samples; sample types and frequency (conventional surface water analytes).

Parameter	Matrix	Laboratory (%)			
		Lab Control Sample	**Method Blanks**	**Analytical Duplicates**	**Matrix Spikes**
Laboratory Parameters					
Hardness	Water	10% of samples	One per analysis batch of 10 or fewer samples	NA	10% of samples
Total Phosphorus	Water	10% of samples	One per analysis batch of 10 or fewer samples	10% of samples	10% of samples
Nitrate+Nitrite-Nitrogen and Total Persulfate Nitrogen	Water	10% of samples	One per analysis batch of 10 or fewer samples	10% of samples	10% of samples
Totals Suspended Solids	Water	10% of samples	One per analysis batch of 10 or fewer samples	10% of samples	NA
Fecal Coliform/*E.coli*	Water	NA	One per analysis batch of 10 or fewer samples	10% of samples	NA

Table B-12 Laboratory Quality Control samples; sample types and frequency (metals in surface water).

Metals (Dissolved)					
Parameter	**Matrix**	**Laboratory (%)**			
	Water	**Lab Control Sample**	**Method Blanks**	**Analytical Duplicates**	**Matrix Spikes**
Copper	Water	10% of samples	One per analysis batch of 10 or fewer samples	NA	10% of samples
Zinc	Water	10% of samples	One per analysis batch of 10 or fewer samples	NA	10% of samples

B.5.7 Benthic Macroinvertebrate Monitoring QC

Similarly, QC for benthic macroinvertebrate (BMI) samples (field replicates and laboratory performance) will be evaluated against performance criteria established in Section B.5. Two sources of variability will be identified from BMI results; the first is variability of the BMI community within a sampling reach and the other is characterization of the taxonomic analysis by the qualified laboratory and repeatability of results (laboratory performance).

Quality control procedures for taxonomic determinations of invertebrates involve checking accuracy, precision and enumeration (Appendix D). Two samples are randomly selected and all organisms are re-identified and counted by an independent taxonomist within the same laboratory. Taxa lists and enumerations are compared by calculating a Bray-Curtis similarity statistic (Bray and Curtis 1957), Percent Taxonomic Disagreement (PTD) and Relative Percent Difference (RPD; Section B.5.1) in enumeration for each selected sample. Routinely, discrepancies between the original identifications and the QC identifications are discussed among the taxonomists and necessary revisions to the data are made. Discrepancies that cannot be rectified by discussions are routinely sent out to external (to the laboratory) taxonomic specialists for identification.

Evaluation of field replicates (side-by-side samples) and BIBI scores for each sample set are evaluated using relative percent difference (RPD). This should be ≤ 20% before a quality control issue is declared. Generally, replicates that do not meet this standard are an issue for the individual sample site. Reasons for failure to meet this QC standard are explained by patchiness of the benthic macroinvertebrate community due to, but not limited to, one of several factors (e.g., severe degradation, availability of marginal riffle habitat, or experience of sample collectors).

Re-collection of benthic macroinvertebrate (BMI) samples is not normally possible nor required following processing, especially if past the Index Period. Since community characterization is unique for samples collected from a site, taxonomic analysis of communities relies on measures of repeatability for correct identification and enumeration of specimens. Sample processing of BMI samples in the laboratory is the focus for QC evaluation and remedial actions/decisions should QA objectives not be met.

Representativeness of the benthic community at a site is based on adherence to collection in riffle habitat at eight different locations within a reach. Riffle habitat is targeted for characterization of the benthic community so that site comparisons can be made during analysis of the results. Benthic communities are markedly different in riffle versus pool habitat and are considered not comparable, therefore information collected for benthic communities is limited to riffle habitat. Sites with non-riffle habitat are flagged and use of analytical tools restricted when analyzing data. Analytical tools used for describing community condition are calibrated from data collected in riffle habitat and use is not appropriate for benthic data collected from non-target habitat.

B.5.8 Continuous Temperature Monitoring QC

Continuous Temperature Monitoring data is collected using the SOP from Washington Department of Ecology (EAP080). The calibration procedure and QC evaluation for temperature probe is fully described in Section 6 of the EAP080 SOP document at the following web address:
http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_Cont_Temp_Mon_Ambient_v2_0EAP080.pdf

Post-deployment accuracy checks are made during retrieval of the equipment. Detailed description of the pre- and post-deployment calibration check is found in Section 6 of the Standard Operating Procedure (Appendix E). Analysis of accuracy includes: 1) immersion in each of an ice and water bath, 2) compared against the NIST certified thermometer, and 3) determine if result is equal to or less than the manufacturer stated accuracy ±0.2°C for a water-temperature logger. The original result is verified with a second check. Temperature loggers that have a mean difference greater than 0.44°C fail this post-deployment calibration test. A follow-up test can be performed, if passed, can reinstate data usability.

If a follow-up calibration check result confirms a consistent bias above the stated accuracy, then the raw data should be adjusted by the mean difference of the pre- and post-calibration check results to correct for the logger bias (Schuett-Hames *et al.* 1999).

Data proofing procedures use data from temperature loggers that met the calibration-check accuracy requirement. These data are proofed/trimmed by charting the records (plotting on a graph) to identify times when the logger may have been exposed to air temperatures as a result of water levels that fall below expected. A secondary evaluation of potential temperature logger exposure to air is to search data points above 20ºC. All data suspected of recording air temperatures may be omitted from the data set, provided that the justification remark(s) is inserted on the station Continuous Temperature Station Survey Form and in the electronic record for the data (electronic data in the database or on a spreadsheet). Similarly, all explainable climatic caused data spikes (i.e. - rain events) should also be noted in these same two records. Rain events during the summer season is known to increase surface water temperature in nearby streams. Runoff from summer rain events is heated by warmer impervious

surfaces and can noticeably change stream temperatures during times of day when expected to decline. Upon completion of QC, data are analyzed to determine the 7DADMax and other metrics such as the percentage of the monitoring period that each location exceeds its designated 7DADMax temperature. This helps determine where temperatures are a limiting factor for salmonids.

B.5.9 T & E Species Habitat Use and Bank Condition QC

Ten percent of the total number of sites (or three sites; one from each of three land use types) are re-visited during each monitoring year with a different crew from the initial visit of the site. Both the reach-scale and habitat unit measurements are evaluated twice during a monitoring year and physical habitat parameters compared between both data sets. The replicate survey ideally is completed shortly after the initial survey (days), before any flow-induced changes can occur.

Initial habitat surveys were implemented beginning in 2000 by Snohomish County as a response to the Federal Listings under the Endangered Species Act of Chinook salmon (*Oncorhynchus tshawytscha*) and bull trout char (*Salvelinus confluentus*) of Puget Sound. Habitat results generated from the 2000-2002 physical habitat assessments are listed in Table A-13 and were evaluated for their precision and repeatability (Snohomish County SWM 2002). These metrics are similar to the individual values that will be evaluated for precision under this new State of our Waters monitoring program. Results from this report demonstrated repeatability of most habitat metrics in wadeable streams based on collection of data from independent field crews (Snohomish County staff and Contractor staff). Though, the precision analysis demonstrated lower precision and repeatability for wood characterization and surface fine sediments (Snohomish County SWM 2002). Precision and repeatability was again evaluated using habitat data from 2006 and 2007 that demonstrated similar results (Leonetti et al. 2008). As mentioned, methods training and adherence to protocols are used to minimize observation or measurement error. Thresholds for moderate to high precision performance are included in Table B-13.

Habitat use and bank condition data are considered representative if they are:

- collected from within the randomly identified survey reach
- collected during the low flow window (July – September)
- are complete with respect to full collection of data input
- collected from a survey length of approximately 20 times the bankfull channel width, where survey length (m) = BFW (m) x 20.

B.5.10 Fish Use/eDNA QC

Detection of target species using eDNA technology in freshwater rivers and streams is influenced by several factors. Identifying presence of salmonids like Coho, Chinook, steelhead/rainbow trout, and char (bull trout) can be influenced by magnitude of flow in a stream and time of year peak and low flows occur.

As an example for how timing of aquatic species presence and flow in streams are related, Ostberg *et al.* (2018) described presence of Pacific Lamprey (*Entosphenus tridentatus*) in a greater number of Puget Sound streams during spring than in the fall months. High flows during the fall months (October/November) was isolated as an obvious factor distinguishing the two seasons and detection rates.

In contrast, spring (May-June) had the most detections of Pacific Lamprey at a greater number of the study sites. *E. tridentatus* is present in the same sampled streams year-round, but detected at lower rates during high flow conditions. Many of the streams were larger rivers in contrast to those surveyed in this monitoring program.

Collection of eDNA samples will be implemented up to twice per year at select sites. Some of these sites have continuous flow monitoring (water level loggers) and will be evaluated for detection rate of four fish species (e.g., Chinook, Coho, rainbow/steelhead, and bull trout). Streams sampled in this program are much smaller than those in the Puget Sound study by Ostberg *et al.* (2018). Differences in magnitude of flow may be smaller than fluctuations in larger streams. The State of Our Water Monitoring Program will contrast seasonal differences using flow available at select sites with frequency of target fish species detection to determine if flow levels explain detection rate success.

B.5.11 Hydrology Monitoring QC

Water level loggers are checked monthly against staff plate readings to determine if the sensor has drifted. If the sensor has drifted, the staff plate reading will be used to apply an offset to the period of record to correct the data. Additional information for evaluating quality of data is provided in the SOP (Appendix H).

The staff plate will be surveyed against a benchmark three times per year to ensure that the staff plate has not moved and is accurate. If the staff plate has moved, the difference between the original elevation and the new elevation will be calculated and applied to the data for the period of record.

The flow meter uses internal software that calculates total discharge at a site based on multiple measurements taken along a transect established across the stream and perpendicular to flow. The flow meter will be checked annually for software updates.

Measuring accuracy in flow measurements can be accomplished when estimating average daily discharge. Grover and Hoyt (1916) described several factors used to estimate sources of error for estimating average daily discharge. The following factors are used to achieve accuracy of average daily discharge and is possible with select sites identified for continuous flow monitoring in this program:

1. Permanence of the stage-discharge relation.

2. Precision with which the discharge rating curve is defined.

3. Refinement of gage readings.

4. Frequency of gage readings.

5. Methods of applying the daily gage heights to the rating table to obtain the daily discharge.

A description of how accuracy is described from continuous stream flow records by Grover and Hoyt (1916) is included almost verbatim, with minor editorial:

> "Studies of the accuracy of stream-flow data serve to determine the methods to be followed in their collection so that the records may meet the requirements of the proposed uses. Notes on accuracy that accompany stream-flow records should give, first, information by which the *scientist* may study the records and judge their accuracy, and, second, information by which both the general and the technical user may judge the reliability of the records without making a study (*launching a separate project*). These two uses should be kept in mind in preparing the data as well as the notes. Consideration of the accuracy of records to be collected at any station should begin with the reconnaissance for the site and continue through the selection, establishment, maintenance, and preparation of the station, the computation and interpretation of the data, and the preparation of the records for publication. In other words, records should be collected with the desired degree of accuracy in view instead of leaving it to be determined after the field data are collected and estimates have been made (*evaluate accuracy early in the data collection effort*).
>
> In this discussion of accuracy, it has been assumed that personal or instrumental errors (mentioned in Ecology's SOP and ours; SWM-RM-003), both in field and office, are reduced to a negligible amount. In order that this assumption may be true, however, all operations connected with the work must be carefully conducted and instruments must be kept in proper working order. The conditions affecting accuracy may introduce errors that may be consistently compensating, consistently cumulative, or alternately compensating and cumulative. Therefore, care must be taken to determine the way in which the incidental errors affect the results."

The message from these early pioneers in flow monitoring remains the same today:

1. Examine data records early in the collection effort;
2. Calibrate and maintain equipment; and
3. Examine precision of flow records using staff gages calibrated against repeated checks at a regular frequency.

These elements are included in Snohomish County's SOP (Appendix H).

Discharge/Water level measurements are considered representative if they are:

- collected from a location within the randomly selected survey reach;
- discharge measurements are made at several water levels within the dry portion of the year (June through October) and during the wet portion of the year (November through May);
- flow measurements during or shortly following rain events are collected.

B.5.12 Summary of Measurement Performance Criteria for All Monitoring Elements

Measurement performance criteria for data collected in all monitoring elements of the State of Our Waters Program are reported in Table B- 13. These performance criteria are important for determining the validity of measurements that will be used to determine condition of each stream reach sampled or if data have restricted use when not meeting measurement performance criteria.

Table B- 13 Data Quality Objectives for Components of the State of Our Waters Monitoring Program.

Monitoring Program	Data Type	Measurement Performance Criteria			
		Precision	Accuracy	Representativeness	Completeness
Benthic Macroinvertebrates	B-IBI Scores	≤ 20%	N/A	100%	≥ 90%
	Sample Sorting and Enumeration	< 5% Difference	≥ 95%	N/A	N/A
	Taxonomic Identification	< 15% Disagreement	100%	N/A	≥ 95% (to Fine STE)
Continuous Temperature	Instrument Calibration	±0.2ºC	±0.2ºC	-20 ºC to +50 ºC	100%
	Replicate Logging Results	±0.2ºC	±0.2ºC	N/A	≥ 90%
	Record of Monitoring	N/A	N/A	Placement in appropriate locations in the stream channel.	≥90%
T&E Species Habitat and Bank Condition	Bankfull Width, m	1.4 (<1.75)	N/A	100%	≥90%

Monitoring Program	Data Type	Measurement Performance Criteria			
		Precision	Accuracy	Representativeness	Completeness
(Precision Reported as RMSE, Leonetti et al. 2008); Values in parentheses are high to moderate repeatability (RMSE) as selected by Roper et al. 2010	Riffle Wetted Width, m	1.3	N/A	100%	≥90%
	Pool Count	1.4	N/A	100%	≥90%
	Pool Frequency (per km)	5.7 (<10)	N/A	100%	≥90%
	Pool Area (wetted percent)	4.2 (<10)	N/A	100%	≥90%
	Pool Area (Functional Percent)	2	N/A	100%	≥90%
	Small Woody Debris Frequency (pieces/km)	56.5 (<50)	N/A	100%	≥90%
	Large Woody Debris Frequency (pieces/km)	8.5	N/A	100%	≥90%
	Fine Sediment, %	17.2 (<10)	N/A	100%	≥90%
	Pool Depth, Residual (cm)	10 (<10)	N/A	100%	≥90%

Monitoring Program	Data Type	Measurement Performance Criteria			
		Precision	Accuracy	Representativeness	Completeness
	Bank Instability,%	4.5	N/A	100%	≥90%
Fish Use/eDNA	Site Sampling			100%	≥90%
	Laboratory Analysis			100%	≥90%
Hydrology	Flow Estimate	Numerical Expectations Established for Individual Stream Sites.	Numerical Expectations Established for Individual Stream Sites.	Selection of appropriate cross-section without obstructions and braided channel.	≥90%

*King County. 2014. Recalibration of the Puget Lowland Benthic Index of Biotic Integrity (B-IBI). Prepared by Jo Opdyke Wilhelm, (Water and Land Resources Division [WLRD]); Leska Fore (Statistical Design), Deb Lester (WLRD), and Elene Dorfmeier (WLRD), Seattle, WA.

N/A ~ Not Applicable

Following data entry operations, all spreadsheets or database printouts will be proofread using the original handwritten field and laboratory data sheets, where available. Someone other than the data entry specialist will conduct this review as a component in finalization of field data collection for each of the monitoring programs.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Periodic regular inspection of equipment and instruments is needed to ensure the satisfactory performance of the systems. Equipment to be used for each of the State of Our Waters Monitoring program elements during a sampling event are listed in the appropriate SOPs. Before any piece of sampling or measurement equipment is taken into the field, it will be inspected to ensure that the equipment is appropriate for the task to be performed, all necessary parts of the equipment are intact, and the equipment is in working order. In addition, the equipment will be visually inspected before its use. Broken equipment will be labeled “DO NOT USE” and returned to Surface Water Management offices to receive necessary repairs or will be disposed if irreparable. Backup field equipment will be available during all field activities in the event of equipment failure.

The objective of preventive maintenance is to ensure the availability and satisfactory performance of the measurement systems. All field measurement instruments will receive preventive maintenance in accordance with the manufacturer’s specifications.

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B.7 Instrument/Equipment Calibration and Frequency

Calibrated field instruments will be used for in-field instantaneous measurement of temperature, DO, conductivity, pH and turbidity. Flow monitoring instruments will be used to measure stream velocity and depth. Continuous temperature monitoring probes will be deployed during the critical summer period at status sites and year round at trend sites. Instruments used in the field will be calibrated in accordance with manufacturer's specifications. SOPs for instrument checks and calibration have been prepared in and are complimentary to those used by state regulatory agencies and federal monitoring agencies. The MQOs cited in Table A-7 will be used as criteria for determining proper functioning of monitoring equipment beyond which equipment adjustment described in SOPs will be completed. The SOPs will include pre- and post-calibration verification on each sampling date.

The calibration of temperature, DO, conductivity, and pH probes will be checked before and after each sampling event, or as deemed necessary by the multi-probe's manufacturer, using certified standard solutions. Any field calibrations that may be necessary will be recorded in the field sampling log book. Section B.5.2 and Table B-9 contain the data quality objectives for calibration of water quality field instruments.

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B.8 Inspection/Acceptance of Supplies & Consumables

Supplies and consumables are those items necessary to support the sampling and analysis operation. They include bottles, calibration solutions, hoses, decontamination supplies, preservatives, and various types of water (e.g., potable, deionized, organic-free). Upon delivery of supplies, the sampling organization will ensure that types and quantities of supplies received are consistent with what was ordered and with what is indicated on the packing list and invoice for the material. If any discrepancies are found, the supplier will be contacted immediately.

While preparing for specific sampling events, the field sampling Technical Leads will be responsible for acquiring and inspecting materials and solutions that will be used for obtaining the samples for field measurements or for preservation of biological samples. Other materials must also meet specific requirements as indicated by the appropriate manufacturer; for example, only certified standard solutions will be used for the multi-probe calibration. Buffers and standards will be checked for expiration dates and appearance (correct color).

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B.9 Data Acquisition Requirements for Non-Direct Measurements

Data acquisition applicable for use in this project include: GRTS points from the Washington State Master Sample Draw, NHD Plus data layer, land cover (LULC), precipitation records (past and current), and discharge measurements reported by the U.S. Geological Survey. Past and current data generated by other organizations are used for selecting sites and for planning visits. Logistical issues in site access are informed by the acquisition of non-direct measurements, like Google Earth© imagery, acquired in this monitoring program.

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B.10 Data Management

Water Quality and Benthic Macroinvertebrate Monitoring programs will generate samples during site visits. Samples will be documented and tracked on hardcopy field data forms or in electronic format, Sample Identification labels, and Chain of Custody records (Appendix A). The Technical Lead for each monitoring element will be responsible for ensuring that these forms are completed and reviewed for correctness and completeness by the designated field QC Officer (to be identified for one or more of the technical areas by the Project Managers). The sampling organization will maintain copies of these forms in the project files. Another person will manually check data entered into any spreadsheet or other format against the original source to ensure accurate data entry, when applicable. If there is any indication that requirements for sample integrity or data quality have not been met (for samples or measurements collected by the sampling organization), the Monitoring Element Leader will be notified immediately (with an accompanying explanation of the problems encountered).

Other monitoring programs will generate observations from instrument readings that will be recorded on hardcopy field data forms or in iPad® electronic forms. The Field Task Leader for each of the programs (Continuous Temperature Monitoring, Threatened and Endangered Species Habitat and Bank Conditions, Fish Use, and Hydrology) will ensure that all information is collected while in the field by examining completeness of the forms.

All data will eventually be stored in WISKI7® database. This is a commercial, relational database that enhances collection, management, reporting, and storage of multiple types of data such as those collected under each of the monitoring elements in this monitoring program. Results from two or more of the monitoring elements are used to identify stressors that explain water quality and benthic macroinvertebrate conditions (see Table A-3) for unique combinations of data queried from WISKI7® database. A full description of the WISKI7® relational database can be found at the following address: https://www.kisters.net/NA/products/wiski/.

Laboratory data will be managed in accordance with established protocols. The data will be retained by Surface Water Management in hard copy and in electronic database format (Excel spreadsheet) for addition to a WISKI7® database. The electronic data will be submitted in a format to be negotiated with the lab. At a minimum, the electronic data files are reviewed for outliers, checked for conformance with lab contract requirements, and verified for usability. Lab reports will include the date and time of sample/observation collection, date received, date of preparation or analysis, requested parameter, analytical batch ID, results, and data qualifiers. Electronic data will be provided for all samples and QC, including laboratory blanks, control samples, duplicates, and spiked samples analyzed in a format compatible with the requirements of Surface Water Management's(or contractor) statistical and modeling software routines.

In the event hard copies are made containing results from any of the monitoring programs, data packages are provided by the taxonomic laboratory and the water quality laboratory. Data records from the other monitoring elements (e.g., continuous temperature, hydrology, habitat use and bank condition, eDNA) are stored in WISKI7® and are downloadable in hardcopy form. These are fully validated raw data packages that include an analytical narrative and are compliant with this QA Monitoring Plan. Copies of Chain of

Custody forms are retained for water quality monitoring and benthic macroinvertebrate sample shipment to the laboratory.

All computer files associated with the project will be stored in a project sub-directory by the technical leads (or appointed technical staff) and are subject to regular system backups. Data from all elements of the State of Our Waters Monitoring Program will be stored indefinitely on the Snohomish County's server system and backed up off-site at routine time intervals.

Data obtained during sampling activities may be entered into field notebooks. The field notebooks will be retained and stored by each of the Technical Leads for future reference in the case there is any question about data quality or original entries from field observations.

The following is a list of data information that will be kept by each of the technical leads for the State of Our Waters Monitoring Program as well as the contract water quality laboratory for future review:

- Field equipment and chemicals maintenance, cleaning and calibration records;
- Field notebooks;
- Sample Data Sheets;
- Photographs of sampling stations and events;
- Chain-of-Custody forms;
- Laboratory equipment maintenance, cleaning and calibration records;
- Laboratory bench sheets, control charts, and SOPs;
- Records of QA/QC problems and corrective actions (field and/or laboratory);
- Laboratory data QC records;
- Records of data review sheets;
- Duplicate, performance evaluation records and other QA/QC control records (field and laboratory); and
- Data review, verification and validation records.

Data handling equipment will include computer software applications such ArcGIS Survey 123®, Microsoft Excel® or Microsoft Word® or others as necessary prior to load to the designated database.

Field notebooks will be filled out using *rite-in-the-rain*® ink or pencil and will not be erased. Changes will be made by crossing out errors, initialing, and adding correct information. Field notebooks will be bound with numbered pages.

Laboratory data results (water quality and benthic macroinvertebrates) will be recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check-in of equipment, equipment parts and chemicals will be kept on file at the laboratory.

Any procedural or equipment problems will be recorded in the field notebooks. Any deviation from this State of Our Waters Monitoring Program workplan SOPs will also be noted in the field notebooks. Data results will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to the contract laboratory will be the standard ten calendar days (unless analysis is sub-contracted to another laboratory or other circumstances affect this timeline).

Chain-of-custody forms will be kept with sample batches during transport (Water Quality and Benthic Macroinvertebrate Monitoring) and will accompany data results when returned to Technical Leads and State of Our Waters Project Managers. Training records and data review records will be kept on file at Surface Water Management Division offices and be available on request. All sample analysis records and documents are kept at the contract laboratory and will be available for inspection at any time. In addition to any written report, data collected for the project can be provided electronically.

All records will be retained by the contract laboratory for five or more years. All project records kept by the Surface Water Management Division will be retained permanently.

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SECTION C. ASSESSMENT AND OVERSIGHT

C.1 Assessments and Response Actions

The QA program under which the State of Our Waters Monitoring Program will operate includes technical system audits, with independent checks of the data obtained from sampling, analysis, and data-gathering activities. This process is illustrated in Figure C- 1 as an example for how QA decision-making progresses. Surface Water Management Project Managers and the Quality Assurance Officer will review QA programs that all project technical staff follow to ensure similar levels of QA and QC are attained. The system audit will evaluate project performance using a list of requirements (where applicable) to evaluate adherence to protocols and procedures in each of the State of Our Waters Monitoring Program elements (Appendix J). The essential steps in the QA program are as follows:

- Identify and define the problem
- Assign responsibility for investigating the problem
- Investigate and determine the cause of the problem
- Assign and accept responsibility for implementing appropriate corrective action
- Establish the effectiveness of and implement the corrective action
- Verify that the corrective action has eliminated the problem

Many of the technical problems that might occur can be solved on the spot by the field staff and technical team leads; for example, by modifying the technical approach, repairing instrumentation that is not working properly, or correcting errors or deficiencies in documentation. Immediate corrective actions form part of normal operating procedures and are noted in records for the project. Problems not solved this way require more formalized, long-term corrective action. If quality problems that require attention are identified, the field technical lead will determine whether attaining acceptable quality requires short- or long-term actions. If a failure in an analytical system occurs (e.g., performance requirements are not met), the appropriate SOW Project Manager will be responsible for corrective action and will immediately inform the Quality Assurance Officer (QAO), as appropriate. Subsequent steps taken will depend on the nature and significance of the problem, as illustrated in Figure C- 1.

The SOW Project Managers have primary responsibility for monitoring the activities of this monitoring program and identifying or confirming any quality problems. These problems will also be brought to the attention of the State of Our Waters Monitoring Program QAO, who will initiate the corrective action system described above, document the nature of the problem, and ensure that the recommended corrective action is carried out. The State of Our Waters Monitoring Program QAO has the authority to stop work on the project if problems affecting data quality require extensive effort to resolve and are identified.

The SOW Program Managers and Technical Project Managers will be notified of major corrective actions and stop work orders.

Corrective actions might include the following:

- Re-emphasizing to field staff the project objectives, the limitations in scope, the need to adhere to the agreed-upon schedule and procedures, and the need to document QC and QA activities
- Securing additional commitment of staff time to devote to the project
- Changing procedures
- The State of Our Waters Monitoring Program QA Officer is responsible for overseeing work as it is performed and periodically conducting checks during the data entry and analysis phases of the project. As data entries, calculations, or other activities are checked, the person performing the check will sign and date a hard copy of the material or complete a review form, as appropriate, and provide this documentation to the sampling organization Project Manager for inclusion in the project files. Field audits and technical system audits may be conducted on part or all of the field activities during a monitoring year depending on detection of chronic quality assurance issues.

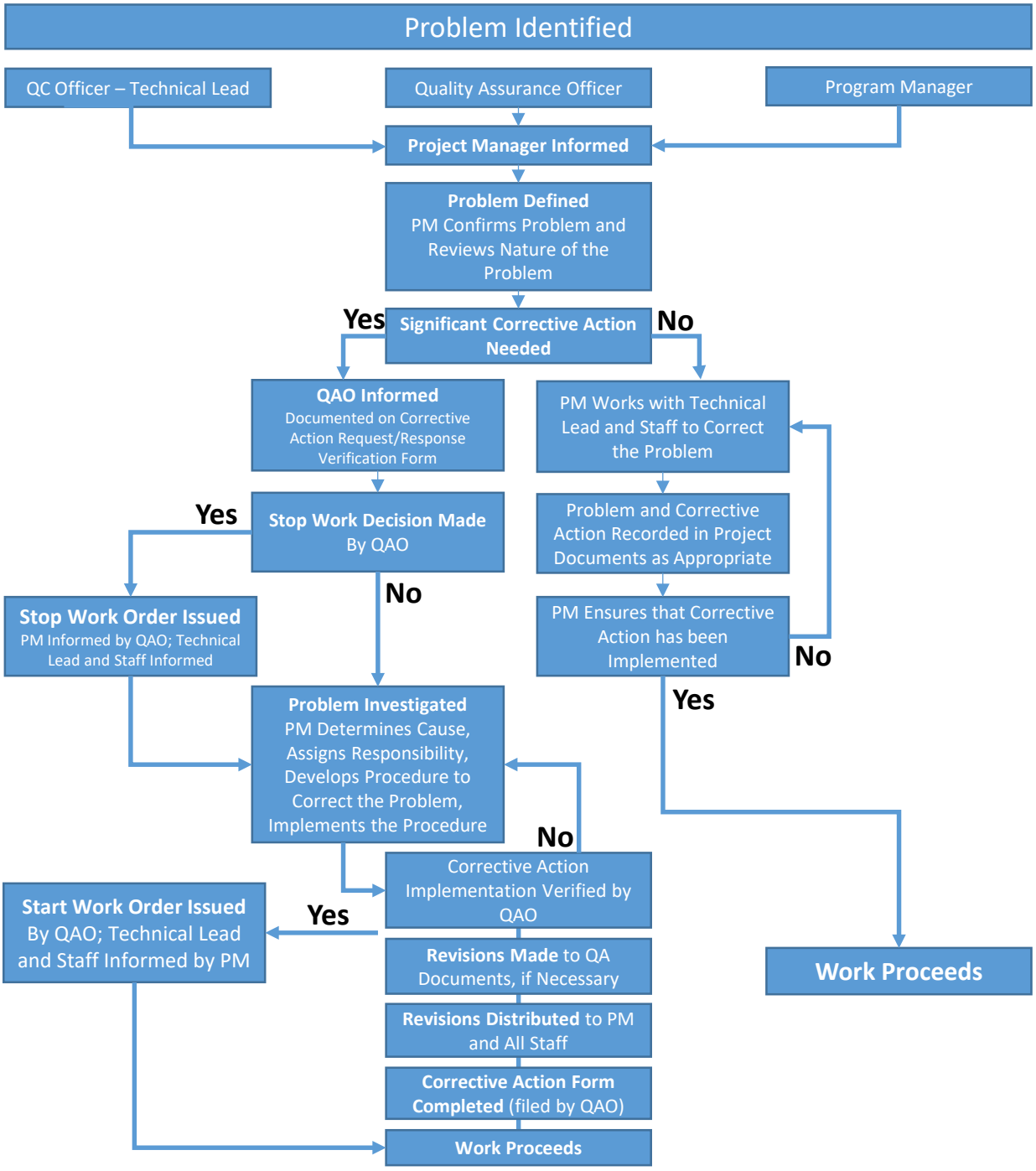

Figure C- 1 Example for problem assessment and corrective operations.

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C.2 Reports to Management

Upon completion of sampling activities, the Surface Water Management field team leads will summarize sampling team progress in updates at the State of Our Waters monthly meetings. Following completion of field sampling, the sampling teams will ensure that a detailed listing of all sampling participants, sampling locations, and specimens collected are available for review in electronic form by the Project Managers.

Following the completion of each data quality assessment, the State of Our Waters Monitoring Program Quality Assurance Officer (QAO) or designee will present Data Quality Assessment issues at the routine meetings for consideration by the monitoring team and Project Managers. The data quality assessment will include decisions by the Project Managers for any required qualification of data based on observations, field QC analyses, or other observations that might affect data quality.

When required, direction from Project Managers summarizing incidents of technical direction requests from field staff, required corrective actions, and any other issues affecting data quality or usability will be distributed to Technical Leads. Sampling method consistency and adherence to SOPs (Standard Operating Procedures) will be periodically assessed by the field team lead and documented in a Field Sampling QA Report included as part of the aggregated year end data analysis and interpretation report that includes information from all monitoring in State of Our Waters program. In the event a field audit identifies problems requiring attention, the Project Managers will immediately consult with the Technical Leads.

These observations will be compiled and reported to the monitoring team, where warranted, and document in routine monitoring program meeting notes for access by the Project Managers. These annual QA report summaries and memoranda (optional), along with a routine review of data quality assessments performed throughout the data collection period will be the basis of an annual QA assessment for this collection effort.

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SECTION D. DATA VALIDATION AND USABILITY

D.1 Data Review, Verification, and Validation

A formal process for review of data is primarily focused on the water quality monitoring program, benthic macroinvertebrate monitoring program, and Fish Use/eDNA monitoring program. The U.S. EPA review protocol applies to these three monitoring elements in the State of Our Waters Monitoring Program. Remaining monitoring elements (e.g., Continuous Temperature, Habitat Use/Bank Condition, and Hydrology Monitoring) data are subject to a data review that identifies missing data, results that are outside of expected ranges, and results that don't follow expected patterns (e.g., extreme shifts in temperature).

Analytical results from water quality monitoring, benthic macroinvertebrate monitoring, and Fish Use/eDNA monitoring will be reviewed and validated in accordance with EPA documents, including the *USEPA Guidance on Environmental Data Verification and Validation* (EPA QA/G-8), 2002b; the USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-94/012), 1999; and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), 1994b. The Technical Leads will conduct data review and validation, when applicable, using the following methods on 10% of the primary project samples, including their associated field and lab quality control samples.

- A review of sample handling and analytical and field data for completeness, accuracy, holding time compliance, and quality control (QC) sample frequency compliance (Water Quality Monitoring).
- Evaluation of laboratory blank samples (Water Quality Monitoring).
- Evaluation of the accuracy and precision of field duplicate samples (Water and Quality and Benthic Macroinvertebrate Monitoring), laboratory control samples (LCS), and matrix spike/spike duplicate (MS/MSD) samples (Water and Quality Monitoring).
- Assignment of data qualifiers, when necessary, to reflect limitations identified in the data assessment process (Water Quality, Benthic Macroinvertebrates and eDNA).

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D.2 Estimation of completeness (all monitoring programs); Verification and Validation Methods

The following procedures will be used to determine if data meets the measurement and data quality objectives and criteria specified in Section A.7 (Quality Objectives and Criteria). If data QA/QC procedures do not meet the specified criteria, the Quality Control leads will review all field and laboratory records to determine the cause. If equipment failures are limiting the usability of the data, calibration and maintenance procedures will be reviewed and changed as needed. If sampling or analytical procedures are the source of failures, methods will be reviewed to resolve the errors. Any changes or modifications to quality control procedures will be approved by the Project Managers prior to inclusion in the QA Monitoring Plan.

Review of Sample Handling

Proper sample handling techniques are required to ensure sample integrity. During data review, the sample handling procedures identified below are evaluated to determine potential effects on data quality.

- Review of field sample collection and preservation procedures to determine whether they were completed in accordance with the requirements specified by the analytical methods.
- Review of chain-of-custody documentation to ensure control and custody of the samples was maintained.
- Review of sample holding times between sample collection, extraction, and analysis (see Table B-3 in Section B.2).
- Review of sample conditions upon receipt at the contract laboratory.
- Review of Quality Assurance/Quality Control (QA/QC) Samples. Specific procedures for review of QA/QC samples are included in the sections below.

Laboratory Blank Samples

Laboratory blank samples (method and instrument blanks) are laboratory-prepared, analyte-free samples used to detect the introduction of contamination or other artifacts into the laboratory sample handling and analytical process. These blanks play an especially important role in sampling programs involving trace-level analyses or analytes that are common solvents found in a laboratory. None of the analytes of concern for this project are common laboratory contaminants. Use of samples results based upon contamination of lab method blanks is conducted on a parameter by parameter basis.

Laboratory Control Samples

Laboratory control samples are used to assess analytical performance under a given set of standard conditions. Synthetic samples, containing some or all of the analytes of interest at known concentrations, are prepared independently from calibration standards. The samples consist of laboratory control samples (LCS) and laboratory control sample duplicates (LCSD). Laboratory control samples will be analyzed with each analytical batch. LCS may be used to estimate analytical accuracy and precision by comparing measured results to actual concentrations. LCS/LCSD percent recoveries will be checked on laboratory reports to ensure they are within the limits set by the EPA and/or Standard Methods listed in Table B-8. .

LCS are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess the laboratory's internal precision. The analytical precision is expressed by the relative percent difference (RPD) (equation B.5-1). Analytical precision and accuracy should meet the method criteria listed in in Section B.4.

Matrix Spike and Matrix Spike Duplicates

Matrix spike samples are actual field samples to which known amounts of select compounds (one, or more, of the analytes of interest) are added. Both spiked and un-spiked aliquots (sample portions) are analyzed. The difference between the concentration of the spike compound(s) in the spiked and un-spiked aliquots is compared to the amount of spike added before the extraction process. Since actual samples are used for the recovery determination, the matrix effects can be evaluated. Usually expressed as a percentage of the mass of the spiked amount, spike recovery is the measurement of accuracy anticipated for the sample matrix. Percent recoveries will be compared to method specific recoveries in Table B-9.

Matrix spike samples are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess sample reproducibility and the laboratory's internal precision. The analytical precision is expressed by the RPD between the measurement results of the two duplicate samples. Analytical precision and accuracy should meet the criteria provided in Table B-. MS/MSD samples will be run on each batch of samples.

Field Duplicate Samples

Field duplicate samples will be collected simultaneously with a primary project sample. Duplicates are treated in the same manner as the primary sample during all phases of sample collection, handling, and analysis. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process (i.e., QC purposes). Field duplicates are collected and submitted to the laboratory for 10% of those collected.

Analytical results will be reviewed for agreement with each other or their respective reporting limits and evaluated for comparability. Estimated results quantified below the reporting limit and qualified with a "J" flag are not considered significant for the purpose of data agreement. The comparison between project and field duplicate sample results should meet RSD (relative standard deviation) criteria for each method listed in Equation B.5-2.

Reporting Limits

The reporting limits are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory conditions. For many analytes, the reporting limit analyte concentration is selected by the laboratory as the lowest non-zero standard in the calibration curve. Sample reporting limits vary based on sample matrix and dilution of the samples during analysis. Reporting limits should be equal to or below the PQLs (Practical Quantitation Limits) provided in Table B- for each method.

Data Qualification

Qualifiers will be applied to QC samples when acceptance criteria are not met, and corrective action is not performed or is unsuccessful (Table D-1). These same qualifiers will be applied to the associated laboratory data, as defined in the following table.

Table D-1 Lab Data Qualifiers.

QC Category	Quality Control Condition	Qualifier Code	Comment
Non Detect	Result is non-detect	U	Target analyte was not detected at a level above the Method Detection Level (MDL)
Hold Time	Method Specific Hold Time Not Met	REJ	Sample analysis performed past the method specific hold time; sample result is unusable
Hold Temp	Hold Temperature Not Met	J	Sample exceeded method specific hold temperature upon receipt of laboratory; sample result is an estimate
	Hold Temperature Unknown	J	Method specific hold temperature for sample is unknown, sample result is an estimate
COC Actions	Sample Not Analyzed with Method On COC	J	Sample was analyzed with a method that differs from the dataset; methods are comparable and sample result is an estimate
	Sample Not Analyzed with Method On COC	UJ	Sample was analyzed with a method that differs from the dataset; methods are comparable and sample result is non-detect and considered an estimate
	Sample Not Analyzed with Method On COC	REJ	Sample was analyzed with a method that differs from the dataset; methods are not comparable and sample result is unusable
	Sample Date/Time Does Not Match the COC	J	Date and/or time information for sample collection does not match the COC; sample result is an estimate
	Sample Date/Time Does Not Match the COC	UJ	Date and/or time information for sample collection does not match the COC; sample result is non-detect and considered an estimate
Lab Duplicate	Lab Dup RPD Outside Acceptance Limits	J	Laboratory Duplicate RPD exceeds acceptance limits; sample result is an estimate
Lab Matrix Spike	Matrix Spike Recovery Outside Acceptance Limits	J	Matrix Spike recovery is outside acceptance limits; sample result is an estimate
Lab Matrix Spike Duplicate	Matrix Dup RPD Outside Acceptance Limits	J	Matrix Spike duplicate RPD exceeds acceptance limits; sample result is an estimate
Lab Standard Reference Material	Standard Reference Material Outside Acceptance Limits	REJ	Standard reference material recoveries are outside acceptance limits; sample is unusable
Laboratory Method Blank	Detection in method blank, sample non-detect	U	Target analyte was detected in the method blank; sample result is non-detect and data is not impacted
	Detection in method blank, sample is >10x detection	J	Target analyte was detected in the method blank and the sample result is greater than or equal to 10x the blank result; sample result is an estimate
	Detection in method blank, sample is < 10x detection	REJ	Target analyte was detected in the method blank and the sample result is less than 10x the blank result; sample result is unusable
Lab Surrogate	Surrogate Recoveries Outside Acceptance Limits	J	Surrogate recoveries are outside acceptance limits; sample result is an estimate
	Surrogate Recoveries Outside Acceptance Limits	REJ	Surrogate recoveries are below minimum acceptance limits; sample result is non-detect and considered unusable
Field Blank	Detection in the field blank	J	Target analyte was detected in the field blank; sample result is an estimate
	Detection in the trip blank	J	Target analyte was detected in the trip blank; sample result is an estimate

Completeness

Completeness is calculated after the QC data have been evaluated and the qualifiers have been applied to the sample data. Invalid results, broken or spilled samples, and samples that are unable to be analyzed for other reasons are included in the assessment of completeness. The criteria and calculation to determine completeness are provided in Section B.5-4. If data cannot be qualified to meet completeness goals, a Project Manager will determine if additional sampling should be performed to meet data quality objectives.

D.3 Reconciliation with User Requirements

The technical leads will review all data deliverables upon receipt from the lab. Laboratory results will be checked for data qualifiers entered by the lab to ensure that sample collection and preservation procedures were adequate and that laboratory analysis procedures met quality assurance objectives. Any outstanding issues will be addressed immediately with the lab and/or sampling staff to ensure that project quality assurance objectives are met.

The Project Managers will review and validate data during interim reporting to management and final reporting stages of the project. If there are any problems with quality sampling and analysis, these issues will be addressed immediately and methods will be modified to ensure that data quality objectives are being met. Modifications to monitoring will require notification of the appropriate Project Manager and subsequent edits to the approved QA Monitoring Plan.

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SECTION E. REFERENCES

APHA (American Public Health Association). 1998. *Standard Methods for the Examination of Water and Wastewater, 20th ed.* American Public Health Association, Washington, DC.

APHA. 2005. Standard Methods for the Examination of Water and Wastewater, 21st Edition. American Public Health Association Press, Washington, D.C.

Baker, S. 2019. Snohomish County Summer Stream Temperatures; Placing the 2016 Drought in Context. Snohomish County Surface Water Management Division, Everett, WA. *In prep*

Baldwin, N. L, R.E. Millemann, and S.E. Knapp. 1967. "Salmon poisoning" disease. III. Effect of experimental *Nanophyetus salmincola* infection on the fish host. J. Parasitol. 53(3):556-564.

Bray, J. R. and J. T. Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. Ecological Monographs 27:325-349.

Champlot, S., C. Berthelot, M. Pruvost, EA Bennett, T. Grange, and E.M. Geigl. 2010. An efficient multi-strategy DNA decontamination procedure of PCR reagents for hypersensitive PCR applications. PLOS|One Vol 5(9):

Ecology (Washington State Department of Ecology). 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Environmental Assessment Program, Olympia, WA. Publication No. 04-03-030. 100p.

Ecology (Washington Department of Ecology). 2016. Water Quality Standards for Surface Waters of the State of Washington. Olympia, WA. Publication No. 06-10-091.

EPA (United States Environmental Protection Agency). 1990. Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region. Prepared by Tetra Tech, Inc. Bellevue, WA for the USEPA Region X Office of Puget Sound, Seattle, WA.

EPA (United States Environmental Protection Agency). 1998. EPA Guidance for Quality Assurance Project Plans (EPA QA/G-5). Office of Research and Development, EPA/600/R-98/018. Washington, D.C. 136p.

EPA (United States Environmental Protection Agency). 2001. *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency (EPA), Quality Assurance Division, Washington, DC.

EPA (United States Environmental Protection Agency). 2002. *EPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review,* OSWER 9240.1-35, EPA 540-R-01-008. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

Foot, J.S., D. Free, W. Talo and J.D. Williamson. 1997. FY96 Investigational Report: Physiological Effects of *Nanophyetus* Metacercaria Infection in Chinook Salmon Smolts (Trinity River). US Fish and Wildlife Service, California – Nevada Fish Health Center, Anderson, CA.

Fox, M.J. and S. Bolton. 2007. A Regional and Geomorphic Reference for Quantities and Volumes of Instream Wood in Unmanaged Forested Basins of Washington State. North American Journal of Fisheries Management 27:342–359.

Garcia, L., W.F. Cross, I. Pardo, and J.S. Richardson. 2017. Effects of land use intensification on stream basal resources and invertebrate communities. Freshwater Science (36)3: 609-625.

Grover, N.C. and J.C. Hoyt. 1916. Accuracy of Stream Flow Data. Contributions to Hydrology of the United States (USGS). pp. 53-59.

Herrera Environmental Consultants, Inc. 2005. Year 2003 Water Quality Data Report, Green-Duwamish Watershed Water Quality Assessment. Report prepared for King County Department of Natural Resources and Parks in association with Anchor Environmental, LLC and Northwest Hydraulic Consultants, Inc.

Kemp, B.M. and D. G. Smith. 2005. Use of bleach to eliminate contaminating DNA from the surfaces of bones and teeth. *Forensic Sci. Intl.* 154:53–61.

Jerde, C.L., W.L. Chadderton, A.R. Mahon, M.A. Renshaw, J. Corush, M.L. Budny, S. Mysorekar, and D.M. Lodge. 2010. Detection of Asian carp DNA as part of a Great Lakes basin-wide surveillance program. Canadian Journal; of Fisheries and Aquatic Science Vol 70(4): 522-526.

Kerwin, John and Nelson, Tom S. (Eds.). December 2000. Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)." Washington Conservation Commission and the King County Department of Natural Resources.

King County. 1989. Water and Land Resources Division, Bear Creek Basin Current and Future Conditions Analysis.

King County July 1990. Water and Land Resources Division, Bear Creek Basin Plan.

King County. 2012. Stream Report for Soos Creek (A320). Available at: http://green.kingcounty.gov/wlr/waterres/streamsdata/watershedinfo.aspx?locator=A320

King County. 2014. Recalibration of the Puget Lowland Benthic Index of Biotic Integrity (B-IBI). Prepared by Jo Opdyke Wilhelm, (Water and Land Resources Division [WLRD]); Leska Fore (Statistical Design), Deb Lester (WLRD) and Elene Dorfmeier (WLRD). Seattle, Washington.

WRIA 8 Steering Committee. 2005. Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan (Vol. 1, 2, and 3). King County DNRP, Seattle, WA.

Lazorchak, J.M., Klemm, D.J., and D.V. Peck (editors). 1998. Environmental Monitoring and Assessment Program –Surface Water: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. EPA/620/R-94/004F. U.S. Environmental Protection Agency, Washington, D.C.

Leonetti F, K. Paulson and B. Murray. 2005. Watershed evaluation and identification of Chinook salmon Tier 1, 2, and 3 sub-basins supporting salmon conservation planning in WRIA 8. Prepared for Greater Lake Washington (WRIA 8) Steering Committee. Appendix C-2 in Volume III, Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan. July 2005.

Leonetti, F.E., A.C. Thomas, B. Gaddis, M.D. Rustay, and A.D. Haas. 2008. Snohomish Basin 2007 Status and Trend Monitoring of Physical Habitat for Fish. Snohomish County, Public Works, Surface Water Management, Everett, WA.

Milleman, R.E. and S.E. Knapp. 1970. Pathogenicity of the "salmon poisoning" trematode *Nanophyetus salmincola* to fish. Pages 209-212. In: S.F. Snieszko, ed. A symposium on diseases of fishes and shellfishes. Special Publication No. 5, American Fisheries Society, Washington D.C.

Murphy, P.J. and D.B. Hicks. 1986. In-situ method for measuring sediment oxygen demand. In Hatcher, K.J. (ed.) Sediment oxygen demand-Process, modeling and measurement. University of Georgia, Institute of Natural Resources, Athens, GA. P.307-322.

National Marine Fisheries Service (NMFS). 1996. Coastal salmon conservation: working guidance for comprehensive salmon restoration initiatives on the Pacific Coast. USDC-NOAA, NMFS, Portland, OR. Report dated September 15, 1996.

NOAA 2003. HCD Stormwater Online Guidance. ESA Guidance for Analyzing Stormwater Effects. Habitat Conservation Division. NOAA-Fisheries Northwest Region. March 2003.

NOAA (National Marine Fisheries Service). 2007. Recovery Plan for the Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*): Final Supplement. National Marine Fisheries Service, Northwest Region. Seattle, WA.

Newcomb, T.W., G.A. Snell, and F.W. Wknitz. 1991. Survival of Coho Salmon smolts in salt water following exposure to cercaria of the salmon poisoning fluke, *Nanophyetus salmincola*. Proceedings of 42nd annual Northwest Fish Culture Conference. Redding, CA.

Ostberg, C.O., D.M. Chase, M.C. Hayes, and J.J. Duda. 2018. Distribution and seasonal differences in Pacific Lamprey and *Lempetra* spp. eDNA across 18 Puget Sound Watersheds. PeerJ 6:e4496: DOI 10.7717/peerj.4496.

Pilliod, D.S., C.S. Goldberg, R.S. Arkle, and L.P. Waits. 2013. Estimating occupancy and abundance of stream amphibians using environmental DNA from filtered water samples. Canadian Journal of Fisheries and Aquatic Science 70(8):1123-1130.

Rice, E.W., R.B. Baird, A.D. Eaton, and L.S. Clesceri (Eds.). 2012. Standard Methods for the Examination of Water and Wastewater, 22nd Edition. American Public Health Association, American Water Works Association, and Water Environment Federation. New York, NY. 1496 p.

Roper, B.B., and 14 co-authors. 2010. A Comparison of the Performance and Compatibility of Protocols Used by Seven Monitoring Groups to Measure Stream Habitat in the Pacific Northwest. North American Journal of Fisheries Management 30:565-587.

Rustay, M.D., Leonetti, F.E., Haas, A.D., Purser, M.D. and B. Gaddis. 2008. Snohomish County wadeable stream habitat survey protocol for status and trend monitoring. Snohomish County, Public Works, Surface Water Management, Everett, WA.

Schuett-Hames, D., A. E. Pleus, E. Rashin, and J. Matthews, 1999. TFW Monitoring Program Method Manual for the Stream Temperature Survey. Washington State Department of Natural Resources and NW Indian Fisheries Commission publication #TFW-AM9-99-005.

SBSRF (Snohomish Basin Salmon Recovery Forum). June 2005. Snohomish River Basin Salmon Conservation Plan. Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA.

Snohomish County Public Works, Surface Water Management (SWM). 2002. Aquatic Habitat Summary: A Regional Summary of the DNR Habitat Survey of Urban and Urbanizing Streams of Snohomish County. Snohomish County, Public Works, Surface Water Management, Everett, WA. December 2002.

Snohomish County SWM. 2002. Precision and Repeatability of Wadeable Stream Habitat Survey Methods. Snohomish County Publics Works, Surface Water Management Division. Project No. 236. Everett, WA. 22p.

Simpson, T., J. Deatrick, and H. Johnson. 2016. Field specific conductance measurement. U.S. Environmental Protection Agency, Science and Ecosystem Support Division (Region 4). Athens, GA. 9 p.

Stillaguamish Implementation Review Committee (SIRC). 2005. Stillaguamish Watershed Chinook Salmon Recovery Plan. Published by Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA.

Turner, C. R., Barnes, M. A., Xu, C. C. Y., Jones, S. E., Jerde, C. L., & Lodge, D. M. (2014). Particle size distribution and optimal capture of aqueous macrobial eDNA. bioRxiv. doi:10.1101/001941

United States Environmental Protection Agency (USEPA). 1990. Recommended Protocols for Measuring Conventional Water Quality Variables and Metals in Fresh Water of the Puget Sound Region. Prepared by Tetra Tech, Inc. Bellevue, WA for the USEPA Region X Office of Puget Sound, Seattle, WA.

Urquhart, N.S. and T.M. Kincaid. 1999. Designs for Detecting Trend from Repeated Surveys of Ecological Resources. *Journal of Agricultural, Biological, and Environmental Statistics*, 4(4):404-414.

USEPA (U.S. Environmental Protection Agency). 2002. *USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review,* OSWER 9240.1-35, EPA 540-R-01-008. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

Washington State Department of Ecology. 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Environmental Assessment Program, Olympia, WA. Publication No. 04-03-030. 100p.

Washington State Forest Practices Board (WFPB). 1997. Watershed Analysis Manual, v. 4.0. Olympia, WA.

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SECTION F. APPENDICES

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APPENDIX A

Chain-of-Custody Forms

Laboratory Chain-of-Custody form for water quality sampling.

AMTEST LABORATORIES

AmTest Chain of Custody Record
13600 NE 126th PL, Suite C, Kirkland, WA 98034
Ph (425) 885-1664 Fx (425) 820-0245
www.amtestlab.com

Chain of Custody No. 7983

Client Name & Address:	Invoice To:
Contact Person:	Invoice Contact:
Phone No:	PO Number:
Fax No:	Invoice Ph/Fax:
E-mail:	Invoice E-mail:
Report Delivery: (Choose all that apply) Mail / Fax / Email / Posted Online	Data posted to online account: YES / NO Web Login ID:

Special Instructions:

Requested TAT: **(Rush must be pre-approved by lab)** Standard RUSH (5 Day / 3 Day / 48 HR / 24 HR) | Temperature upon Receipt:

Project Name:

Project Number:

AmTest ID	Client ID (35 characters max)	Date Sampled	Time Sampled	Matrix	No. of containers	Analysis Requested									QA/QC

Collected/Relinquished By:	Date	Time	Received By:	Date	Time
Relinquished By:	Date	Time	Received By:	Date	Time
Relinquished By:	Date	Time	Received By:	Date	Time

COMMENTS:

Chain of Custody form with list of samples and number of jars associated with 2018 State of Our Waters benthic macroinvertebrate samples.

Packing Container	Site Code	Sample Code	Sample Date	# Jars per Sample	Notes
1	CRYL	109051	07/19/2018	1	
1	OSMR	000891	07/05/2018	1	
1	TMBK	017179	07/10/2018	2	
1	PILT	020180	07/11/2018	1	
1	SCTT	020287	07/17/2018	1	
1	LLRD	041551	07/18/2018	2	
1	FCSP	008335	07/24/2018	1	
1	CCMU	020891	07/31/2018	1	
1	TBRD	025099	08/10/2018	1	
1	WDOP	031259	08/01/2018	1	
1	SULFUR	052587	08/07/2018	2	
1	DOUG	087176	07/25/2018	1	
1	TCCC	109083	08/09/2018	1	
1	JRDN	005780	09/05/2018	1	
1	PRML	009135	08/15/2018	1	
1	WDRD	015355	08/16/2018	1	
1	PLCK	028776	07/11/2018	1	
1	LBWM	046555	08/24/2018	2	
1	TRFT	063252	08/14/2018	2	
1	PCNC	126779	08/02/2018	1	
1	BNSN	002948	08/30/2018	1	
1	CNYN	007700	08/30/2015	1	
1	SQCR	008180	09/06/2018	2	
1	SQCR-DUP	008180D	09/06/2018	2	
1	MCGV	010228	08/29/2018	2	
1	OLNY	013455	08/28/2018	1	
1	PORL	015780	TBD (09/17/2018)	2	
1	PRTU	088100	TBD (09/17/2018)	2	
1	BLDR	031252	TBD (09/17/2018)	2	

CHAIN OF CUSTODY RECORD											
Relinquished By:	Received By:	Yr		Mo		Day		Hr		Min	

APPENDIX B

State of Our Waters Monitoring Program: Aquatic Invasive Species Decontamination Plan

Special care must be taken to prevent the spread of aquatic invasive species (AIS). Two problem species have been tentatively or definitively identified in western Washington watersheds. These include *Didymopsphenia geminate* (Didymo) and New Zealand Mud Snail (*Potamopyrgus sp.*).
Ecology currently defines problem invasive species areas into two categories: Areas of Extreme Concern and Areas of Moderate Concern. Watersheds with New Zealand Mud Snails are Extreme Concern Areas. Staff must follow these standard operating procedures as adapted from (Parsons et al., 2012).

Staff designing studies in the greater Puget Sound watershed will evaluate two potential sampling sites for the likely presence of mud snails (see Ecology's Invasive Species webpage at www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html and the USGS Nonindigenous Aquatic Species webpage at http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008) and contact Jesse Shultz (Washington Department of Fish and Wildlife Invasive Aquatic Species Unit) or Jenifer Parsons (EAP Central Regional Office) with questions that arise.

Any sampling done in a watershed contributing to Lake Washington should be followed by decontamination procedures for Areas of Extreme Concern.

- Sampling will be done in these watersheds using a pole, if feasible, and avoiding contact with wet streamside soils.
- Sampling will proceed from upstream to downstream.
- Between sampling sites, boots that have contacted stream water or wet streamside soils during sample collection will undergo decontamination procedures using chemicals or heat, especially when cold treatment (4hrs at -40C) or drying (48 hours to fully dry) cannot be completed in time.
- Wearing short rubber boots will simplify decontamination, while wearing felt-soled boots will make decontamination more difficult.

New Zealand Mud Snails

New Zealand Mud Snails have been found in numerous areas of Washington State, where they can potentially cause tremendous environmental and economic impacts. These areas are now considered to be of Extreme Concern. In western Washington they include Marathon Park, Capital Lake (Olympia), and Kelsey and Thornton Creeks in the Seattle area, and Union Slough in the lower Snohomish River (Figure F-1).

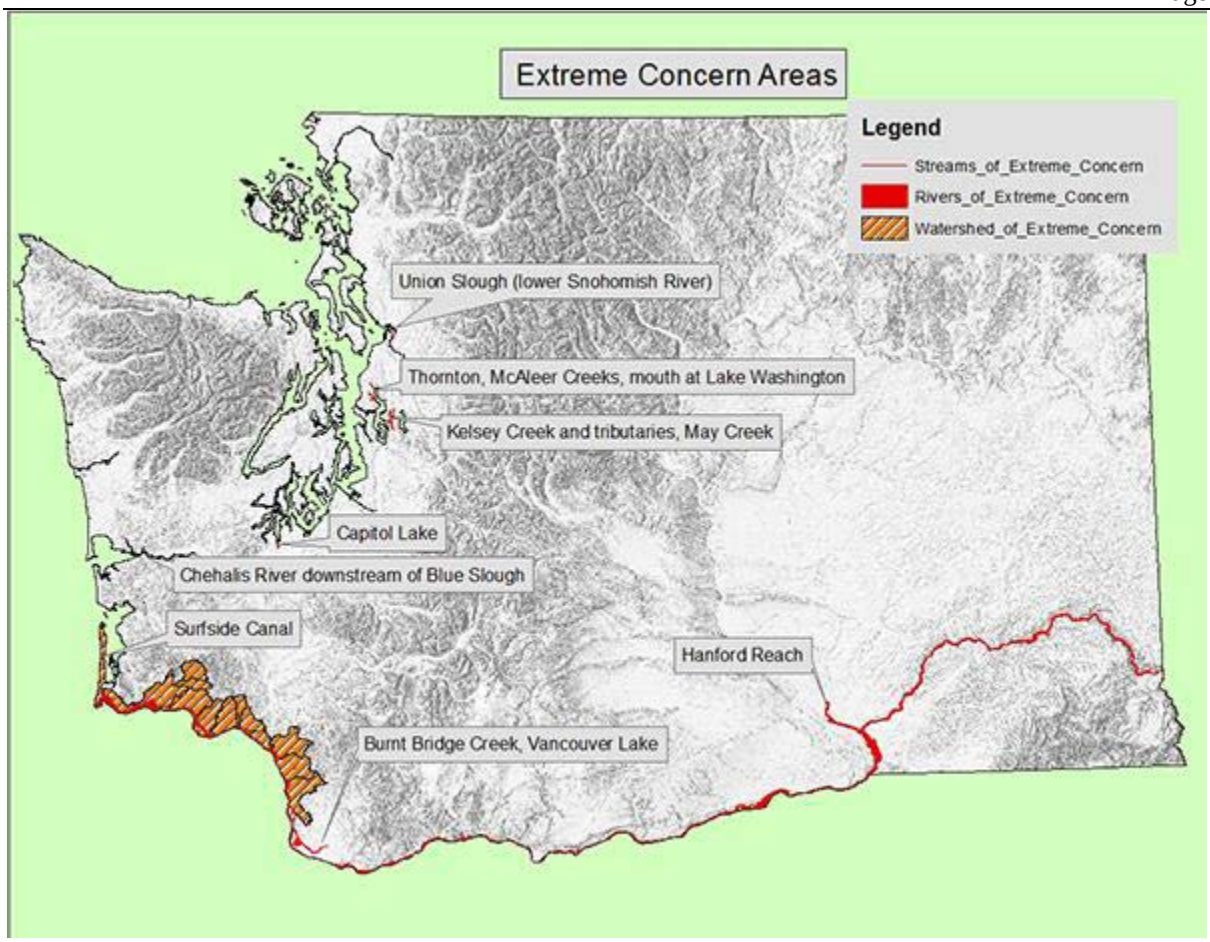

Figure F-1. Aquatic Invasive Species Distribution in Washington State.

Specialized Sampling Devices to Reduce Contamination Risk

A sampling extension pole may be used to collect stream samples where feasible. Use of the sampling pole can reduce overall disturbance of the stream and riparian zone, help prevent the spread of New Zealand mud snails, and help ensure a representative sample is collected where wading would be dangerous. The use of a sampling pole can also speed up sample collection times and increase overall staff safety. When using a sampling pole, caution should be taken to prevent the pole from collecting water internally and spilling into the sample bottle. Similarly, if the previous sampling site is suspected to have very high bacteria levels, the end of the pole should be rinsed prior to taking a sample at the next location to avoid contamination.

Sampling and Decontamination Procedures

The following is modified language from Ecology's Approved Standard Operating Procedure SOP070 that addresses decontamination procedures in Areas of Moderate Concern and Areas of Extreme Concern.

Prior to field work

- Check if the sampling will take place in an area of extreme concern – maps at this link: www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html
- Plan field activities to minimize contact between equipment and potential sources of invasive species, particularly aquatic plants and sediment.

After conducting field work

- **Inspect and clean** all equipment. Remove any visible soil, vegetation, vertebrates, invertebrates, aquatic plants, algae or sediment. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean. **Drain** all water in bilges, samplers or other equipment that could harbor water from the site. This step should take place before leaving the sampling site or at an interim site. If cleaning after leaving the sampling site, ensure that no debris will leave the equipment and potentially spread invasive species during transit or cleaning.
- **Additional Requirements for felt sole waders used anywhere in the state and equipment that contacted sediment, aquatic vegetation or fish in areas of extreme concern**:
    - **Smooth surfaced sampling equipment that can be easily and fully wiped down – wipe until dry**. The equipment must be smooth enough so there are no cracks or crevices that could harbor a sand-grain-sized juvenile New Zealand mud snail while being wiped dry.
    - **For all other equipment, use one of the decontamination treatments found in the table below**. Conduct decontamination where the procedure can be carried out effectively and safely. Wash and rinse water must not drain to surface water, and all chemicals must be disposed of to a sanitary sewer.
    - **Dry** – Between field sites and upon returning from the field, when cleaning and decontamination requirements are complete store gear to facilitate drying.

Table C-1. Decontamination Options.

Treatment	Concentration or Temperature	Exposure Time	Comments
Hot water wash or soak	60° C (140° F)	5 min for felt-soled boots and nets; 10 sec for all other equipment	Ensure all parts of the equipment reach temperature for the full exposure time
	49° C (120° F)	10 min for felt-sole boots and nets; 5 min for other equipment	Ensure all parts of the equipment reach temperature for the full exposure time
cold	-4° C	4 hours minimum	Time starts after the equipment reaches -4 °C

Treatment	Concentration or Temperature	Exposure Time	Comments
drying	low humidity, in sunlight is best	48 hours	Time starts after the equipment is thoroughly dry
Formula 409 All-Purpose Cleaner[1]	100% (full strength)	10 min	Follow proper procedures for storage and handling.
Sparquat 256[2]	3.1% or higher	10 min	Follow proper procedures for storage and handling.
Quat 128	4.60%	10 min	Follow proper procedures for storage and handling.
Hydrogen peroxide[3]	30,000 ppm (3%)	15 min	Spray on until soaked, then keep damp for contact time (cover or place gear in a dry bag)
Virkon Aquatic®	2%	20 min	Must soak (not spray on) Follow proper procedures for storage and handling[4]

[1] Must be antibacterial (make sure it has quaternary ammonia, otherwise it is ineffective).
[2] Sparquat 256 is corrosive; read the MSDS and use with caution.
[3] May be corrosive; read the MSDS and follow safety precautions.
[4] Rinse gear after soak to prolong life. Solution degrades, lasts up to 7 days, best if mixed fresh.

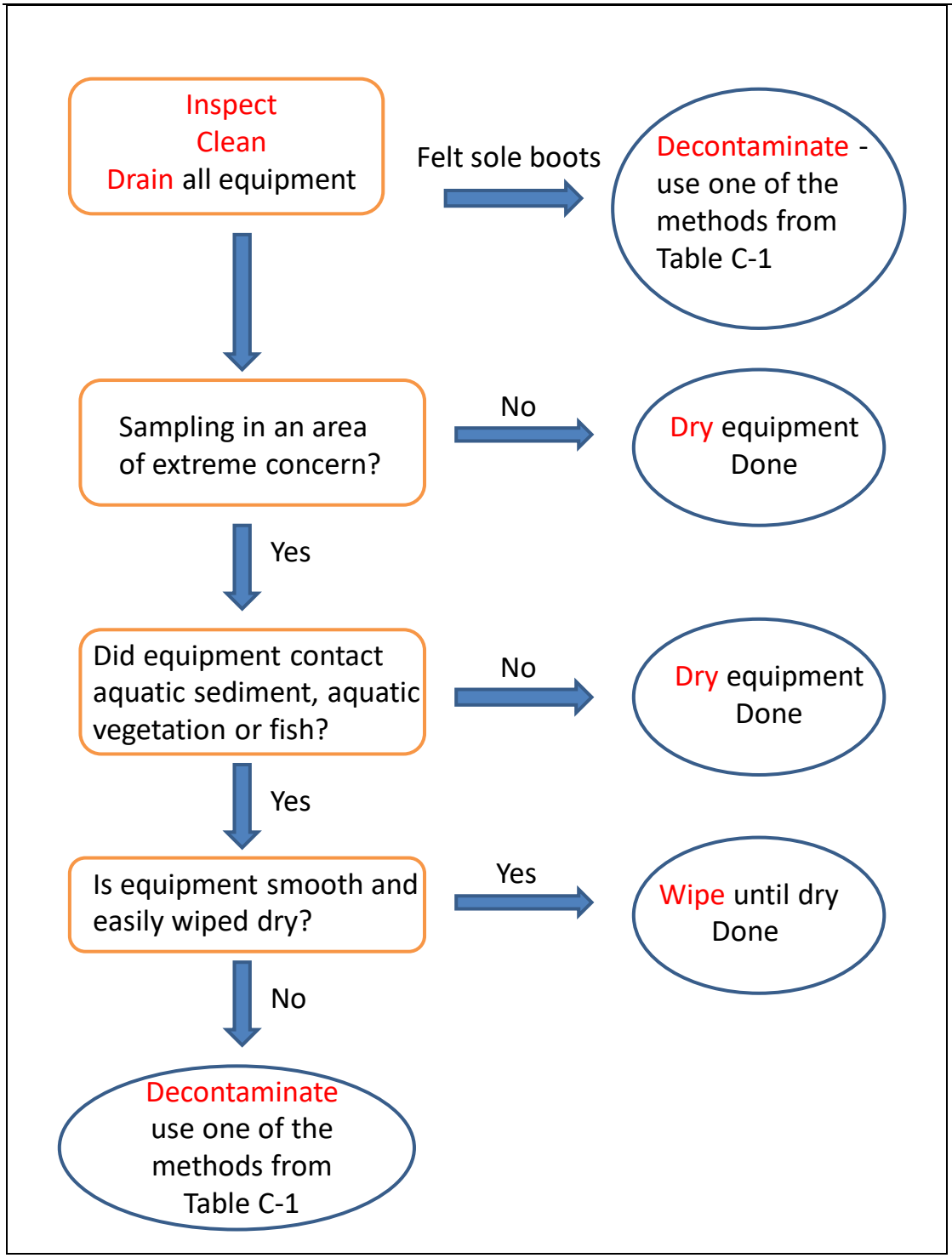

Figure C-1. Invasive Species Decontamination Summary Flow Chart.

APPENDIX C

Standard Operating Procedures for Water Quality Monitoring

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

APPENDIX D

Standard Operating Procedures for Benthic Macroinvertebrate Monitoring

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

APPENDIX E

Standard Operating Procedures for Continuous Temperature Monitoring

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

Temperature Logger Field Form

Snohomish County SWM Temperature Logger Field Form

SWM Probe #: _____

Probe Serial #: _____

Logger Placement

Personel: _____ Date/Time: _____

Program (circle): CAR, Ambient, Proj Effect, Grant

Water Body: _____ Air _____ Water _____

Site ID # _____

Stream Name _____ Temperature: _____

Easting (DD/MM/SS.#): _____ Northing: _____

State Plane Coordinate System _____ GPS Unit Used _____

Township/Section/Range (E.g., N38W22S18): _____

Flow: _____ BFW: _____ WW: _____

Site Description _____

Canopy Cover: _____

Habitat unit (pool, riffle, glide): _____

Landmark: _____

Notes: _____

Site Sketch or Photo

Retrieval Date: _____ Time: _____ Temperature: _____

Condition/Notes: _____

APPENDIX F

Standard Operating Procedures for Wadeable Stream Habitat Surveys for Status and Trends Monitoring

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

APPENDIX G

Standard Operating Procedures for Fish Use/eDNA

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

APPENDIX H

Standard Operating Procedures for Hydrology

Please contact Steve Britsch for State of Our Waters SOP's: **Steve.Britsch@snoco.org** or 428-262-2656

APPENDIX I

Health and Safety Guidelines

Persons involved with State of our Waters could be subjected to unsafe environments. Hazards include, but are not limited to roadside traffic, slips, trips, falls, drowning, heat and cold stress, exposure to chemicals and biological pathogens. Washington State Department of Labor and Industries requires the employers provide a safe work environment through communicating hazards and providing adequate training.

Staff are provided appropriate personal protective equipment (PPE) to minimize hazards. Using proper PPE and sampling procedures can also help limit potential for cross contamination of samples. Staff carrying out work under this QAPP, are encouraged to receive vaccinations for Hepatitis A and B and are provided hazard communication and training in the following areas;

- Proper sign in/out procedure (job sites on which this procedure is required; e.g., Hydro Projects, Logging Access Roads, *et al.*)
- Fire extinguisher use
- Roadway Hazard and Safety Training
- Chemical Hygiene/Laboratory Safety
- Biological Hazards
- Confined Space Entry
- Defensive Driving
- Swiftwater Rescue Training
- Heat and Cold Stress
- Hazard Communications through 24hr Hazardous Materials Training

Each training emphasizes the identification and use of PPE to minimize hazards. Staff are encouraged to identify potential deficiencies in PPE or unsafe work conditions and report them to the project manager, supervisor or safety office so needs may be addressed.

General guidelines that water quality monitoring team members should follow include:

- Sign in and out of office according to SWM procedure;
- Carry a cell phone with you at all times;
- Check to ensure your PPE (boots, high visibility clothing, eye safety, ear protection, personal floatation device, gloves etc.) are adequate;
- Be aware of rising water levels and road closures due to heavy rain/flooding;
- Always wear appropriate PPE when working near surface waters and the roadway;
- Watch out for slippery surfaces, especially while accessing or leaving sample stations;
- Never enter a confined space, unless you have received confined space entry and followed all applicable county/state safety policies;
- Do not work in the railroad right of way, unless trained and certified to do so and proper notifications have been made and permissions onto private property acquired;
- Do not touch your hands or sampling equipment to your face or mouth during the course of the day, and immediately wash your hands after sampling is finished; and
- Always ask the project manager if unsure about field or laboratory safety.

In case of an emergency, field personal should call 911 or have injuries treated by the nearest hospital. Hospitals have been identified for each of the major watersheds in which work will be conducted.

Stillaguamish Watershed:

- Cascade Valley Hospital
  330 S Stillaguamish Ave
  Arlington, WA 98223
  (360) 435-2133

- Skagit Valley Hospital
  9631 269th St, Stanwood
  WA, 98292
  (360) 629-5800

Snohomish Watershed:

- Valley General Hospital
  14701 179th Ave SE, Monroe
  WA 98272
  (360) 794-7497

- Providence Regional Medical Center – Everett
  1321 Colby Ave Everett
  Everett, WA, 98201
  (425) 261-2000

Lake Washington Watersheds (Little Bear Creek, North Creek and Swamp Creek):

- Providence Regional Medical Center – Mill Creek Campus
  12800 Bothell-Everett Highway
  Everett WA 98208
  (425) 316-5000

- University of Washington Medicine – Woodinville Clinic
  17638 140th Ave. N.E.
  (425) 485-4100

APPENDIX J

State of Our Waters Monitoring Program System Audit Forms

Program Systems Audit – Sample Collection and Site Set-Up	
Program Name	
Site Name (as appropriate for audit of sampling procedures)	
Date of Audit	
Auditor	
Project Manager	
Field Staff Audited	

Resources	**Yes**	**No**	**N/A**	**Comment/Answer**
Are field staff familiar with established protocols for the activity being audited?				
Does the field notebook or QAPP include site safety documents and nearby hospital locations?				
Does the field staff know where to find copies of the QAPP and defining established protocols?				
Additional Auditor Notes				
Field Instrument Calibration	**Yes**	**No**	**N/A**	**Comment/Answer**
Field instruments calibrated/checked in accordance with QAPP prior to and after sampling?				
Were calibration methods followed?				
Is a calibration log available in the appropriate notebook?				
Additional Auditor Notes				
Sample Collection and Handling	**Yes**	**No**	**N/A**	**Comment/Answer**
Sample bottles stored in a clean area with lids on?				

Field staff handling sample bottles and clean lids wearing new, clean Nitrile gloves?				
Field instrument placed downstream of grab sample location to minimize re-suspension/cross contamination?				
Field samples gathered in accordance with QAPP?				
Field samples preserved in accordance with QAPP?				
Field measurements gathered in accordance with QAPP?				
Trip blanks filled w/ultra clean de-ionized water prior to leaving county offices?				
Field blanks obtained at the correct randomly selected site?				
Field duplicates obtained in the same manner and time as the original sample?				
Sample bottles handled properly (sampler did not touch inside of bottle or lid, lid was not placed inside down on contaminating surface, etc.)				
Sample bottle labels filled out correctly and completely?				
Samples placed on ice after collection?				
Field sheet thoroughly followed and filled out completely? Was it reviewed by field personnel for accuracy/completeness?				
Equipment decon to minimize spread of invasive species?				
Additional Auditor Notes				
Laboratory Delivery	**Yes**	**No**	**N/A**	**Comment/Answer**
Was the sample COC filled out completely? Was it reviewed by both field personnel for accuracy and completeness?				

Were all samples under the custodian's care or kept in a secure location during the entire sampling event or prior to delivery to the analytical lab?				
Were the samples delivered to the analytical lab prior to the time noted on the COC?				
Did the analytical lab's custodian sign and date/time the COC? Was a copy of the COC provided to the field staff?				
Additional Auditor Notes				
Post Sampling (Complete Approximately 30 days after sampling)	**Yes**	**No**	**N/A**	**Comment/Answer**
Were calibration records, field sheets and lab reports filed in appropriate folders?				
Were electronic copies of lab results copied to the County network?				
Were field and lab data verified for usability?				
If the program uses a post sampling checklist was it completed appropriately?				
Are records available for a minimum 5 year period?				
Additional Auditor Notes				

Additional Notes from the Auditor	
Issues Defined	**Comments/Corrective Actions Taken**