DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan

Water Quality Monitoring for Best Management Practices Implementation in Spring Flat Creek

By Palouse Conservation District and Alta Science & Engineering

For the Water Quality Program

Washington State Department of Ecology

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Cover photo: Spring Flat Creek in a grazed riparian, photo credits Ryan Boylan.

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WQC-2024-PaloCD-00045

by Ryan Boylan

Published August 2025

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2.0 Abstract

For over 20 years, Palouse Conservation District (PCD) has been working with landowners and operators to install Best Management Practices (BMP) that address water quality issues identified in the Palouse Region. Water quality data have been collected sporadically since 2006, and there is limited information on Spring Flat Creek. Through this study, PCD's Research and Monitoring program will set up four new monitoring locations in addition to the one existing monitoring location to measure changes in water quality parameters associated with BMP implementation. Grab samples will be collected monthly and during peak and base flow events and gauging stations will be installed to create stage-discharge rating curves enabling the calculation of pollutant loads.

The goal of this study is to assess the effectiveness of Best Management Practices (BMPs) in improving water quality within Spring Flat Creek and to establish a baseline for long-term water quality monitoring.

3.0 Background

3.1 Introduction and problem statement

Spring Flat Creek is a tributary to the South Fork Palouse River, located in Whitman County in southeast Washington State (Figure 1). Land use within the Spring Flat Creek watershed is dominated by dryland agriculture and rangeland. Heavy agricultural land use has resulted in degraded water quality in Spring Flat Creek (Ecology, 2024a). The land use change has affected fish, wildlife, and plant populations leading to the listing of several species as endangered by the Washington Department of Fish and Wildlife (WDFW), including the Yellow-billed Cuckoo, Gray wolf, and the Northern leopard frog (WDFW, 2024).

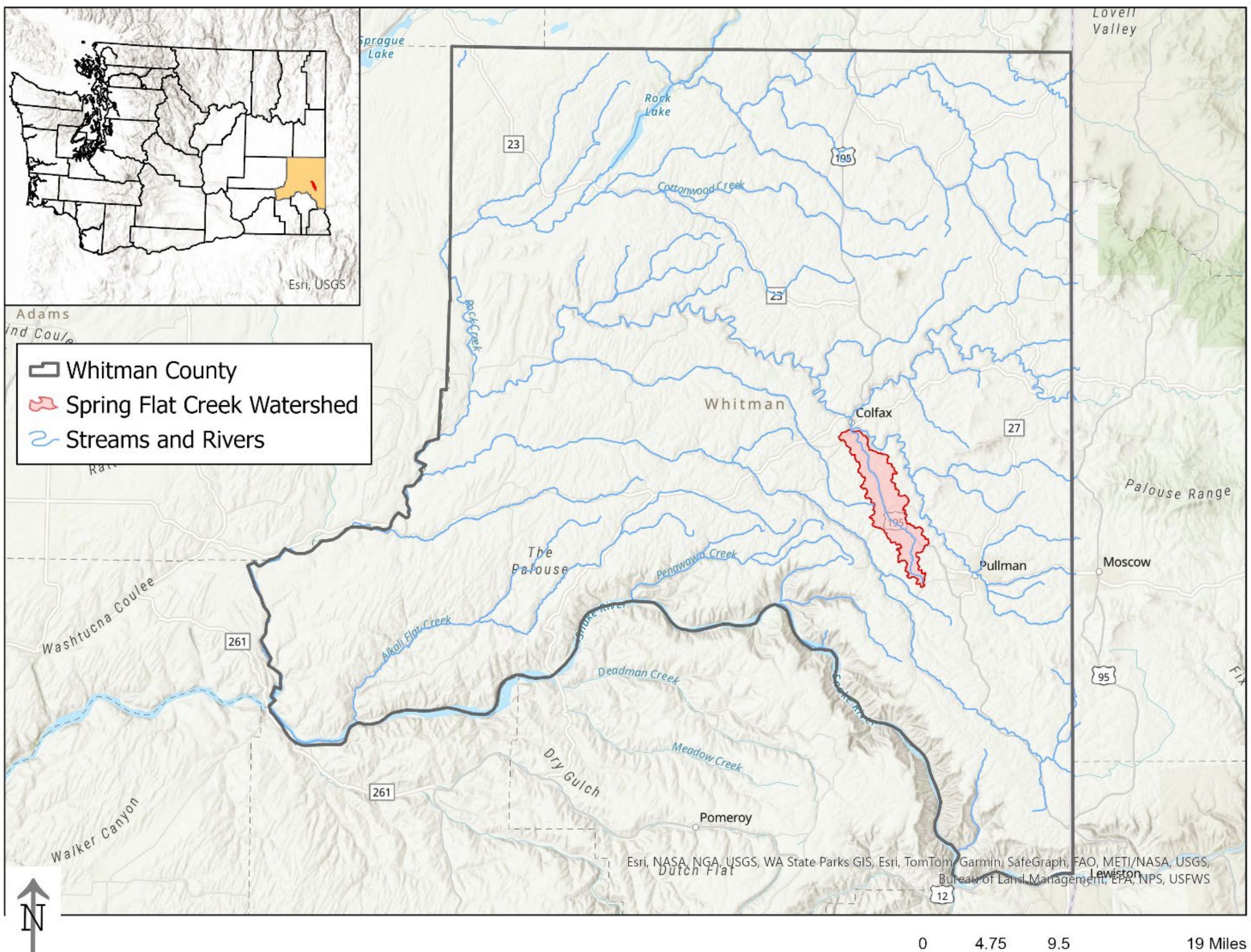

Figure 1. The study location of Spring Flat Creek watershed highlighted in the larger area of Whitman County

Section 303(d) of the Federal Clean Water Act (CWA) requires that states identify waters within their boundaries that are not meeting state water quality standards. The U.S. Environmental Protection Agency (USEPA) requires states to set priorities for cleaning up 303(d) listed waters and to establish a water cleanup plan to address the impairments. Water quality monitoring data show that reaches of the Spring Flat Creek watershed do not meet state water quality standards for temperature (category 5) (Ecology, 2024a). In 2009, A Total Maximum Daily Load (TMDL) for fecal coliform bacteria was developed for the South Fork Palouse River (Ecology, 2009). In this study, fecal coliform samples were collected at the mouth of Spring Flat Creek before it entered the city of Colfax. Results suggested that during the wet season (mid-December through June) fecal coliform concentrations met the geometric mean standard but high variability was a problem, with 25% of the samples greater than 200 cfu/100 mL (Ecology, 2009). Due to the goals of the South Fork TMDL, there is insufficient data to evaluate Spring Flat Creek for DO, pH, and ammonia-nitrogen (USEPA, 2021). Low DO and high pH are also a concern (category 2) (Ecology, 2024a). Ecology is currently pursuing a straight-to-implementation (STI) approach, allowing the implementation of BMPs to improve water quality faster in advance of developing a TMDL.

Recent monitoring efforts indicate DO and pH concerns are worsening and will likely need to be addressed. Therefore, this project is being designed to address temperature, DO, and pH impairments, as well as any future listings for these parameters within this watershed. The STI approach identifies pollution sources and the associated water quality monitoring plan for the BMPs.

Restoration efforts in the Spring Flat Creek watershed will cover approximately 480 acres over ten years. The establishment of riparian buffers reduces streambank erosion, decreases water temperature, increases DO in the stream, reduces fecal coliform inputs in the stream, increases native vegetation, and increases floodplain connection (Ecology, 2024a).

Monitoring in Spring Flat Creek will characterize surface flow and water quality and contribute to identifying and prioritizing locations to implement strategies to improve aquatic ecosystems. The monitoring will provide valuable baseline data before the implementation of the Spring Flat Creek STI Plan.

The Spring Flat Creek watershed has one permitted point-source discharge for a portable rock crusher in an old rock quarry, with no significant effluent violation within the last three years (USEPA, 2021). Nonpoint source pollution is the primary contributor to water quality issues in the Spring Flat Creek watershed. (Ecology, 2024a). To manage nonpoint source pollution, the following land use activities must be considered:

- Agriculture: Livestock feeding and grazing, crop production, non-commercial agriculture
- Atmospheric deposition: Emissions from various sources, wind-borne erosion
- Habitat alteration/ hydromodification: Filling of wetlands and alteration of riparian areas, shoreline development, stream channelization, dikes, dredging, riprap, and dams

A reduction in nonpoint source pollutants is achieved primarily through the implementation of BMPs. PCD has been assisting landowners and operators in implementing BMPs that mitigate nonpoint source pollutants from entering the North and South Fork Palouse Rivers for the last 30 years. This monitoring will evaluate the effectiveness of the BMPs installed by PCD and will assess the effect of riparian buffers on the mainstem of Spring Flat Creek to identify potential hotspots for nonpoint source pollution.

3.2 Study area and surroundings

The Spring Flat Creek watershed (Figure 2) is a tributary to the South Fork Palouse River, located in Whitman County in southeast Washington State. Spring Flat Creek drains approximately 13,200 acres of primarily dryland agriculture and rangeland before discharging into the South Fork Palouse River at its confluence within the city limits of Colfax, Washington. Colfax (approximate population: 3,000) is the only town in the Spring Flat Creek watershed and Spring Flat Creek flows through a small portion on the south side of town. According to the USGS National Hydrography Dataset (NHD), there are approximately 63.7 miles of stream within the watershed (Ecology, 2024a).

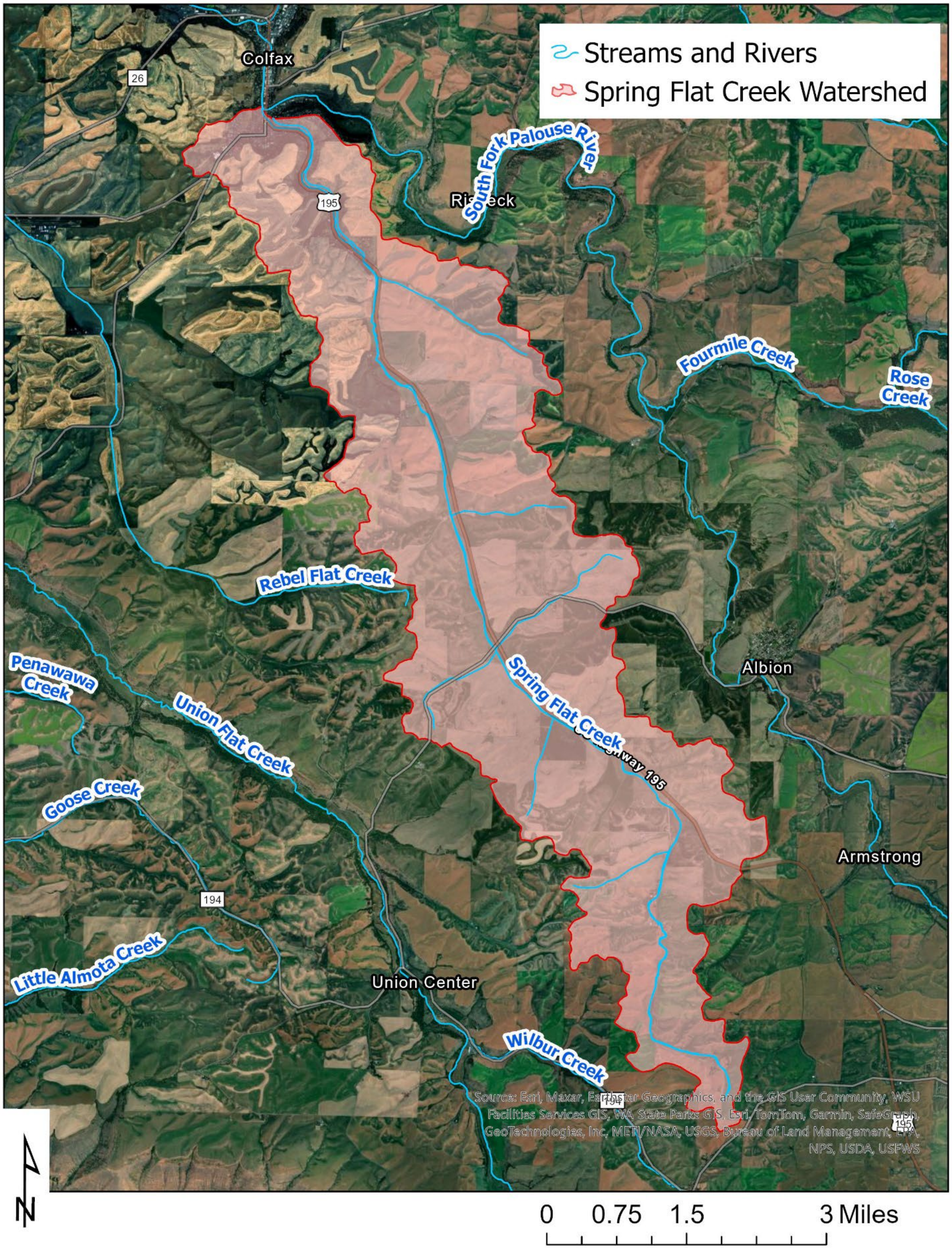

Figure 2. Map showing the boundary of Spring Flat Creek watershed.

Spring Flat Creek watershed has a semi-arid climate. Annual precipitation in the town of Colfax is approximately 19 inches. Precipitation peaks during early winter and falls primarily as snow. Summer precipitation is typically less than an inch per month, with July being the driest month averaging 0.71 inches. Summer precipitation typically falls during intermittent thunderstorms. Summer daily maximum air temperatures can range from the mid-70s to the mid-90s (°F) (around 21°C to 35°C) and occasionally over 100°F (37.8°C) (Ecology, 2024a).

Mainstem Spring Flat Creek generally flows south to north running parallel to State Route 195, in some sections functioning as a roadside ditch. Redirecting the stream into roadside ditches and/or straightening the stream channel is common throughout the watershed to make additional acres available for crop production. During the drier periods from mid-summer to mid-fall, Spring Flat Creek is dry throughout much of its reach. The final 2,200 feet of the Spring Flat Creek mainstem flows through an artificial concrete flood control channel.

Approximately 47 acres of Spring Flat Creek watershed riparian areas are categorized as having predominantly perennial grasses, with no trees or shrubs. These areas negatively affect water quality by lacking the riparian vegetative structure needed to provide adequate riparian function for water quality protection. These areas were likely cleared of riparian vegetation for historical agricultural purposes. Often these areas cannot be effectively farmed due to their hydric soils. Consequently, most of these areas within this land use type are dominated by reed canary grass (*Phalaris arundinacea*), a Class C invasive noxious weed (Ecology, 2024a).

3.2.1 History of study area

Before European settlement, the Palouse watershed consisted of prairie dominated by perennial grasses. In the late 19th century, settlers came to the region to utilize the deep fertile loess soils, blown in after the last ice age. Initially, the settlers used the rolling hills for fruit crops and pasture but soon realized that the highly productive soils were ideal for grain production. Agriculture began to intensify with the development of an extensive railroad network, commercializing wheat and other cereal grains adapted to the steep hillsides and climate. Farming was still incredibly labor intensive and relied heavily on human and horse power and it was common practice to plow up and down the steep slopes. The quest for a less labor-intensive bushel of wheat was accomplished when the Idaho Harvester Company of Moscow, Idaho started to manufacture a small combine that could be used in the hilly terrain of the Palouse (USGS, 1998). By the 1930s, 90% of all wheat was harvested by combine (Williams, 1991). Between 1930 to 1970 agriculture became highly mechanized and industrialized on the Palouse. Advances in petroleum-based technology, wheat breeding, and the introduction of fertilizers following World War II increased crop production by 200-400% (Ecology, 2024a).

The advances in cropping production in the mid-1900s had associated consequences, both environmentally and economically. By the late 1920s, soil erosion became an important issue from continuous moldboard plowing on the steep loess hillsides. It was a concern that if left unchecked, erosion could bring an end to farming on the Palouse. The depression of the 1930s only made the erosion issue more salient. The combination of soil and profits washing away in their literal and figurative streams put Palouse farmers on notice that their ecological and financial futures were at risk (Duffin, 2005). An estimated 40% of the Palouse soils have been lost to erosion and historically the region has had some of the highest erosion rates in the country. The U.S. Department of Agriculture estimates that the average annual soil erosion rate from 1939-1977 in the Palouse River watershed was 14 tons/acre of cultivated cropland (Pimentel et al., 1995; U.S. Department of Agriculture, 1978; Ecology, 2024a).

In addition to excessive soil loss in the region, the rise of mechanized agriculture altered streamflow regimes and channel form and function. As crop production increased, intermittent stream channels were dredged and straightened; wetlands were drained and plowed under; riparian areas, once populated with native grasses, shrubs, and trees, were replaced with cereal grains; and the underlying Grande Ronde and Wanapum aquifers were tapped into and utilized for drinking water as the population centers of Moscow, Idaho and Pullman, Washington increased. These land use changes resulted in higher peak flows, decreased perennial flows, and limited landscape connectivity. Altered flow regimes and historic land use changes, have worsened water quality issues in Spring Flat Creek watershed, contributing to elevated temperature, dissolved oxygen, pH, and fecal coliform/ E. coli (Ecology, 2024a).

3.2.2 Summary of previous studies and existing data

Water quality and land use studies for Spring Flat Creek and associated regions have been conducted from 2006-2022 (Table 1). The following list provides a summary of each study:

1. Washington State Department of Ecology performed a TMDL development study for South Fork Palouse River from 2006-2010. The South Fork has since had a TMDL approved for both ammonia and fecal coliform, with DO, pH, and water temperature currently under development (Table 1, JICA0000).
2. Washington State Department of Ecology performed monitoring across several locations at and near Spring Flat Creek in 2009 to monitor fecal coliform levels (Table 1, JROS0009).
3. A study to determine the effectiveness of BMPs on the tributaries to the North and South Fork Palouse River was also performed by PCD from 2020-2022 (Table 1, WQC-2018-0110).

Table 1. List of previous studies performed within the study area

EIM Study ID	Agency	Location	Description	Collection Date	Parameters Measured
JICA0000	Ecology Environmental Assessment Program	South Fork Palouse River – Station at Spring Flat Creek	Total Maximum Daily Load (TMDL) development	03/29/2006 to 08/18/2010	temperature pH, fecal coliform, e. coli, DO, discharge, ammonia, conductivity, dissolved organic carbon, nitrite-nitrate-N, phosphorous, turbidity, orthophosphate, total suspended sediment, total organic carbon
JROS0009	Ecology Environmental Assessment Program	Several locations at and near Spring Flat Creek	Total Maximum Daily Load (TMDL) effectiveness monitoring	08/12/2009 to 09/01/2009	fecal coliform, discharge
WQC-2018-0110	Ecology Water Quality Program, Eastern Region	Tributaries to the North and South Fork Palouse River	Best Management Practices (BMP) effectiveness monitoring	07/28/2020 to 01/24/2022	orthophosphate as P, suspended sediment concentration, nitrate-nitrite-N, ammonia as N, total phosphorus, mixed forms as P, discharge

3.2.3 Parameters of interest and potential sources

The Spring Flat Creek watershed has one permitted point-source discharge: National Pollutant Discharge Elimination System (NPDES) ID WAG500055. No violations have been identified. Violations of water quality standards are the result of land uses that cause nonpoint pollution (Ecology, 2024a). Water quality parameters of interest and their associated sources for Spring Flat Creek are detailed in the following list:

1. Water temperature
    a. Historically, most trees, shrubs, and herbaceous vegetation in Spring Flat Creek have been cleared for agricultural production. The annual crops of dryland production, such as wheat and lentils, do not provide the adequate riparian structure necessary to shade the stream and protect surface water from solar radiation. Most riparian areas used for livestock grazing and feeding are now comprised of herbaceous non-native grass species. Livestock grazing and trampling within these riparian areas inhibits the generation of native woody vegetation necessary to shade the stream and protect surface water from solar radiation (Ecology, 2024a).
    b. Impervious surfaces and roadways located within the critical riparian zone of a stream do not provide the vegetative structure necessary to shade the stream and mitigate thermal radiation, contributing to increased water temperature (Ecology, 2024a).
2. Dissolved oxygen (DO) and pH
    a. DO and pH are directly influenced by temperature. The lack of riparian structure from dryland crop production, grazing, and trampling in the riparian area reduces the shade needed to achieve natural DO and pH levels and meet state water quality standards (Ecology, 2024a).
    b. DO can also be influenced by stream flow and substrate. Stream channel straightening often reduces turbulence by removing structural diversity and alters curves and riffles in the channel. This may lead to decrease in aeration and the diffusion of oxygen into water (EPA 2024).
3. Suspended sediment concentrations (SSC)
    a. Tillage practices associated with dryland crop production within the riparian areas cause ground disturbance that often results in soil erosion and sedimentation. Sedimentation of a stream can cause it to widen and become shallower (aggradation), which increases the solar input, reduces the area of effective shade, and the shallower water will heat faster and more uniformly than deeper water (Ecology, 2024a).
    b. Livestock hoof action within riparian areas can cause ground disturbance and loosen soils that lead to soil erosion or sedimentation. As with tillage in the riparian area, erosion and sedimentation from livestock activity can cause widening in the stream, and subsequently allows for the shallow water to heat up more quickly (Ecology, 2024a).
4. Nutrients (ammonia, nitrate/nitrite-N, total phosphorous, orthophosphate)
    a. Manure and urine from livestock are a source of nutrients that can be deposited directly into the stream. Furthermore, manure and urine deposited in the riparian area is subject to runoff into the stream from precipitation events and through groundwater

leaching. Nutrients from livestock waste increase algae production, negatively affecting DO and pH (Ecology, 2024a).

b. Some Spring Flat Creek waterways are actively eroding. Often this has a long-term effect of riparian vegetation removal, channel straightening, and land use practices up to the edge of streams. Sediment from eroding stream banks can carry and deposit nutrients in the stream, exacerbating the impacts of algae productivity on DO and pH. (Ecology, 2024a).

c. Fertilizers are commonly applied to dryland crop production in the Palouse watershed. Crops quickly absorb most fertilizer nutrients but excess nutrients remain in the soil. Therefore, erosion from dryland crop production lands can carry nutrients attached to sediment into streams, increasing algae production and negatively affecting DO and pH. Fertilizer may also leach through the soils to groundwater and then flow subsurface to streams (Ecology, 2024a).

3.2.4 Regulatory criteria or standards

All surface waters in the state include a designated aquatic life use. Based on this use, each water body is assigned numeric criteria to ensure the designated life use is protected. Spring Flat Creek does not appear in the WAC 173-201A table with specific beneficial uses identified. Therefore, the default criteria are applied. Those criteria include salmonid spawning, rearing, and migration; primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values. Standards for Spring Flat Creek's designated aquatic life use can be found below in Table 2.

Table 2. Applicable water quality standards for the study area

Parameter	Measurement	Criteria
Dissolved oxygen	Water Column 1-Day Minimum Milligrams/L	8.0 mg/L
Water temperature	Highest 7-DADMax[1] Degrees C	17.5 Degrees C
pH	Negative logarithm of the hydrogen ion concentration	6.5-8.5 pH units with a human-caused variation within the above range of less than 0.5 units
Turbidity	nephelometric turbidity units or NTUs	5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU

[1]Highest 7-DADMax: 7-day average of the daily maximum temperatures

3.3 Water Quality Impairment Studies

A Total Maximum Daily Load (TMDL) for fecal coliform bacteria was developed for the South Fork Palouse River that included sampling in Spring Flat Creek (Ecology, 2009). Results suggested that during the wet season (mid-December through June) fecal coliform concentrations met the geometric mean standard but high variability was a problem, with 25% of the samples greater than 200 cfu/100 mL (Ecology, 2009).

In addition to the TMDL for fecal coliform bacteria, Palouse Conservation District has collected water quality data in Spring Flat Creek since 2021. These data were part of a larger reconnaissance sampling program to assess the named tributaries within the boundaries of the district. A QAPP was developed (Boylan, 2019) and the data collected was specifically mentioned in the Spring Flat Creek Straight to Implementation Strategy (Ecology, 2024a).

3.4 Effectiveness monitoring studies

This study involves both effectiveness monitoring and the study of water quality impairment. Effectiveness monitoring will include collecting monitoring data upstream and downstream of the BMP implementation site and at the convergence of Spring Flat Creek with the South Fork Palouse River, which can be compared to the upstream site used for water quality impairment monitoring. Water quality impairment monitoring will be performed upstream of the BMP implementation site.

4.0 Project Description

PCD has been working with landowners and operators in Spring Flat Creek to address the issues identified in the TMDLs since 2020. In January 2020, a gauging station was installed with a pressure transducer that collects water level and water temperature measurements every 15 minutes. Additionally, sediment (SSC) and nutrient (nitrate-nitrite-N, total phosphorous, orthophosphate) samples have been collected monthly. Ecology is implementing an STI plan, where the effectiveness of BMPs installed throughout Spring Flat Creek will be assessed. Through this study, PCD will set up four additional monitoring locations to measure changes in water quality parameters linked to the installed BMPs.

A three-tiered sampling approach will be employed to: 1) build upon historic datasets developed in previous water quality studies to assess changes in pH, DO, temperature, sediment, and nutrient levels; 2) install additional gaging stations at the proposed monitoring locations to create stage-discharge relationships enabling calculation of pollutant loading and; 3) employ a reconnaissance sampling strategy to identify "hotspots" of nonpoint source pollution along Spring Flat Creek. The BMP effectiveness studies will be conducted above and below riparian restoration sites on Spring Flat Creek. Data will be used to compare pollutant concentrations with historical data to identify areas where future restoration work could take place. Water quality monitoring will occur in the watershed for a minimum period of one year.

This study will support the work of larger projects including the Palouse Regional Conservation Partnership Program (RCPP). This program is operated through a partnership with Ecology, the Natural Resources Conservation Service (NRCS), and PCD.

The goal of the STI is to restore degraded riparian areas and establish system potential vegetation and shade throughout 100% of the stream corridors in tandem with other BMPs. Implementation of riparian buffers and the land use specific BMPs should, over time, reduce temperature and pH, and increase DO. Progress towards meeting water quality standards will be measured through the monitoring component of the STI plan through the installation of additional water quality monitoring locations.

These data will be used in conjunction with outreach, education, and technical assistance efforts to build public knowledge and awareness to continually address water quality issues in the Spring Flat Creek Watershed.

4.1 Project goals

This project has five main goals:

1. Evaluate BMP Effectiveness – Measure improvements in water quality resulting from BMP implementation.
2. Identify Nonpoint Source Pollution Hotspots – Locate areas contributing to water quality impairments to prioritize future restoration.
3. Track Long-Term Changes – Compare water quality trends with historical datasets to assess progress.
4. Support Data-Driven Decision-Making – Provide essential information for future watershed management and conservation planning.
5. Enhance Public Awareness – Use monitoring results to inform landowners, stakeholders, and policymakers about water quality conditions and BMP impacts.

4.2 Project objectives

The goal for this project will be accomplished by meeting the following objectives:

1. Monitor key water quality parameters (temperature, DO, pH, sediment, and nutrients) at multiple locations.
2. Establish stage-discharge relationships to calculate pollutant loading.
3. Conduct reconnaissance sampling to identify pollution hotspots along Spring Flat Creek.
4. Compare data to historic conditions to assess the impact of BMPs over time.
5. Collect data for at least one year, with the potential for extended monitoring based on findings.
6. Provide baseline data to inform adaptive management and future conservation strategies.
7. Support regional conservation efforts by integrating monitoring with larger initiatives like RCPP.
8. Use monitoring data for outreach and education to promote BMP adoption and water quality improvements.

4.3 Information needed and sources

Meeting these goals and objectives will require PCD to compile historical data collected in Spring Flat Creek watershed. Potential sources for this data will come from Ecology's Environmental Information Management System (EIM), through collaborations with researchers at Washington State University (WSU) and from the U.S. Geologic Survey (USGS). New data to be collected include nutrients, SSC, 15-minute measurements of stage height, water temperature, DO, specific conductivity, pH, and turbidity to establish a baseline for the Ecology STI Plan.

4.4 Tasks required

The following tasks will be performed to meet the goals and objectives of this study:

1. Water quality monitoring locations will be identified, access to monitoring locations will be requested from property owners, and staff gages and pressure sensors will be installed once access is granted.
2. Compile water quality data from EIM, WSU, and USGS into a database.
3. Collect current and historic data on land use change and the BMP locations that will be used to compare changes in water quality.
4. Develop annual stage-discharge rating curves that will be used to estimate sediment, and nutrient loading at ambient monitoring sites.
5. Assess data quality, analyze historic and newly collected data for water quality trends and comparisons to assess the effects of riparian buffers, and write a report.

4.5 Systematic planning process

Not applicable.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 3 shows the responsibilities of those who will be involved in this project.

Table 3. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Ryan Boylan Research and Monitoring Program Manager Palouse Conservation District Phone: (509) 332-4101	Principal Investigator	Assists with writing the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Diana Salguero Research and Monitoring Coordinator Palouse Conservation District Phone: (509) 332-4101 x110	Project Manager	Assists in writing the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
Carson Sass Research and Monitoring Technician Palouse Conservation District Phone: 509-332-4101 x120	Field Technician	Helps collect samples, maintains water quality monitoring stations, and records field information.
Hallie Ladd Department of Ecology Phone: 509-724-6893	Ecology Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves and signs the final QAPP.
Adriane Borgias Department of Ecology Phone: 509-329-3515	Water Quality Section Manager, Eastern Regional Office	Reviews the draft QAPP and signs the final QAPP for approval.
Christina Frans Department of Ecology Phone: 360-519-2067	Quality Assurance Officer	Reviews the draft QAPP and recommends the final QAPP for approval.

QAPP: Quality Assurance Project Plan
EIM: Environmental Information Management database
NEP: National Estuary Program

5.2 Special training and certifications

Key personnel involved in collecting water quality data and interpreting results have extensive experience in similar efforts. The project manager, principal investigator, and field technician of this study have a combined experience of 10 years related to water quality monitoring, hydrological measurements, natural resource science, and conservation science. Continuing education is also encouraged and, if training specific to this scope of work becomes available, key personnel will be encouraged to attend. Relevant SOPs will be reviewed by the project manager, principal investigator, and field technician throughout the study. The relevant Ecology SOPs include:

- Standard Operating Procedures, EAP034, Version 1.5, collection, Processing and Analysis of Stream Samples
- Standard Operating Procedures, EAP042, Version1.2: Measuring Gage Height of Streams
- Standard Operating Procedures, EAP057, Conducting Stream Hydrology Site Visits

- Standard Operating Procedures, EAP070, Minimize the Spread of Invasive Species

Standard Operating Procedures, 019072, Version 2.0: Basic Use and Maintenance of WaterLOG Data Loggers and Peripheral Equipment

- Standard Operating Procedures, EAP080, Version 2.2: Continuous Temperature Monitoring of Freshwater Rivers and Streams
- Standard Operating Procedures, EAP082, Version 1.2: Correction of Continuous Stage Records Subject to Instrument Drift
- Standard Operating Procedures, EAP090, Version 1.2: Decontaminating Field Equipment for Sampling Toxics in the Environment
- Standard Operating Procedures, EAP109, Version 1.1: Watershed Health Monitoring: Standard Operating Procedures for Estimating Stream Discharge (Narrow Protocol)

5.3 Organization chart

See Table 3.

5.4 Proposed project schedule

The proposed schedule for field and laboratory work, data processing, and EIM entry will occur over the span of three years (Table 4). Sampling will begin in June 2025 and will continue monthly through October 2026. Additional sampling may occur during base and peak flow. Scheduling future work will be addressed in addendums to this QAPP before each proposed sampling event. PCD will develop and upload draft annual water quality monitoring reports within 60 days following the monitoring season into Ecology's Administration of Grants and Loans (EAGL) database for review and comment by Ecology's project manager. A draft annual report including a summary of monitoring efforts, quality assurance measures taken, deviations from the QAPP, and any initial results for each of the first two years of monitoring will be submitted to Ecology for review and feedback. A final report is expected to be produced following the completion of the final study at least 30 days before the end date of the agreement on 02/02/2027.

Table 4. Proposed schedule for completing the 2024 – 2027 field and laboratory work, data entry into EIM, and final reporting.

Field and laboratory work	Due date	Lead staff
Begin fieldwork and continue monthly monitoring	Upon QAPP approval (anticipated April 2025)	Ryan Boylan
Fieldwork completed	October 2026	Ryan Boylan
Laboratory analyses completed	All results received by November 2026	Anatek Labs PM
Environmental Information System (EIM) database		
EIM Study ID	WQC-2024-PaloCD-00045	
Product	**Due Date**	**Lead staff**
EIM data loaded	November 2026	Ryan Boylan
EIM data entry review	December 2026	Ryan Boylan
EIM complete	December 2026	Ryan Boylan
Final report		
Author lead / Support staff	Ryan Boylan /Diana Salguero/Carson Sass	
Reporting Schedule		
Draft due to supervisor	November 2026	
Draft due to client/peer reviewer	November 2026	
Draft due to external reviewer(s)	December 2026	
Final (all reviews done) due to publications coordinator	January 2027	
Final report due on the web	February 2027	

5.5 Budget and funding

Ecology's combined water quality assistance program will be used to cover some equipment, travel, laboratory costs, and part of staff salaries. The relevant grant number used is WQC-2024-PaloCD-00045. A breakdown of all costs can be seen in Table 5.

Table 5. Project budget and funding.

Item	Cost
Salary, benefits, and indirect/overhead	$34,182.00
Equipment	$10,909.00
Travel and other	$2,688.00
Laboratory	$47,290.00
Subtotal	$95,069.00

Parameter	Number of Samples	Number of QA Samples	Total Number of Samples	Cost Per Sample	Lab Subtotal
Water Samples					
Ammonia	110	57	167	$60.00	$10,020.00
Nitrate/Nitrate-N	110	57	167	$55.00	$9,185.00
Orthophosphate	110	57	167	$45.00	$7,515.00
Phosphorous, total	110	57	167	$70.00	$11,690.00
Suspended sediment concentration	110	38	148	$60.00	$8,880.00
				Lab Grand Total	**$47,290.00**

6.0 Quality Objectives

6.1 Data quality objectives

The Data Quality Objective (DQO) for this study is to collect monthly water quality samples, stage height, and discharge measurements on Spring Flat Creek to evaluate the effectiveness of BMP implementations on water quality. The samples will be analyzed for orthophosphate, total phosphorus, nitrate/nitrite, ammonia, and SSC, using standard methods to obtain concentration data that meet measurement quality objectives (MQOs) described below. Annual pollutant loads will be calculated with the LOADEST program, which uses a multiple linear regression approach and provides statistics for model selection (see Section 7.3.1). A minimum of 12 samples per constituent per year are required as inputs to the LOADEST program for annual load estimates.

6.2 Measurement quality objectives

Field sampling procedures and laboratory analyses inherently have associated uncertainty, which results in data variability. MQOs state the acceptable data variability for a project. *Precision* and *bias* are data quality criteria used to indicate conformance with MQOs. Accuracy refers to the combined effects of precision and bias (Lombard and Kirchmer, 2016).

Field sampling precision and bias will be addressed by submitting field replicate and field blank samples. Field replicates and blanks will be collected once a month during each sampling event. Field replicates will be collected at a different monitoring site each month. Anatek Labs will assess precision and bias in the laboratory through the use of lab duplicates and blanks.

Tables 6 and 7 outline the expected precision and bias of sample duplicates as well as method reporting limits or sensitivity. The reporting limits of the methods listed in the tables are appropriate for the expected range of results and the required level of sensitivity to meet project objectives.

Instantaneous measurements of temperature, pH, DO, conductivity/specific conductance, and turbidity will be made with a YSI ProDSS multiparameter water quality meter (or equivalent). Before each site visit, the ProDSS will be calibrated according to the standard operating procedure for calibration of the YSI ProDSS handheld water quality meter developed by the PCD (O'Malley, 2018).

Staff gages and Onset HOBO pressure transducers will be installed at four new sampling locations in addition to the one current sampling location to create stage-discharge rating curves. The rating curves will be used to predict 15-minute discharge and integrated into statistical models to estimate sediment and nutrient loads. All data collected will be housed on a PCD server and organized by sampling location. The MQOs for the creation of stage-discharge rating curves will use primary gauge indexes, station controls, and reference points to assess the precision, bias, and sensitivity of the staff gage readings and pressure sensor data collected. Pressure sensor drift will be assessed and corrected by following the methods outlined in the: *Correction of Continuous Stage Records Subject to Instrument Drift* (EAP082, 2022).

6.2.1 Targets for precision, bias, and sensitivity

The MQOs for project results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in the table below.

Table 6. Measurement quality objectives for laboratory analyses.

MQO	Precision		Bias	Sensitivity
Parameter	Field Duplicates	Lab Duplicates	Matrix Spikes	MDL or Lowest Conc. of Interest
	Relative Percent Difference (% RPD)		Recovery Limits (%)	Concentration Units
Laboratory Analysis				
Phosphorus, Ortho-	≤ 20	≤ 20	10	0.03 mg/L
Phosphorus, Total	≤ 20	≤ 20	25	0.01 mg/L
Suspended Sediment Concentration (SSC)	≤ 20	≤ 20	No Matrix Spike [1]	1 mg/L
Ammonia-N	≤ 20	≤ 20	20	0.01 mg/L
Nitrate/Nitrite-N	≤ 20	≤ 20	10	0.01 mg/L

[1]Note: No suspended sediment concentration (SSC) matrix spike analysis will be performed by the lab due to the inherent difficulties of replicating the natural sediment matrix with spike material that mimics the sediment particles which can vary greatly in size, density, and chemical composition (J. Doty, Anatek, pers. comm., December 18, 2024).

Table 7. Measurement data quality objectives for field water quality and stage height measurements.

Parameter	Equipment/ Method	Bias (median)	Precision-Field Duplicates (median)	Equipment Information			
				Equipment Accuracy	Equipment Resolution	Equipment Range	Expected Range
Water Quality Measurements							
Dissolved Oxygen (DO)	YSI Pro DSS	n/a	5% RSD	± 0.1 mg/L or ±1% of reading w.i.g[a]	0.01 or 0.1 mg/L (auto-scaling)[b]	0 to 50 mg/L	0.1 to15 mg/L
Temperature	YSI Pro DSS	n/a	± 0.2 ºC	± 0.2 ºC	0.1 º C	-5 to 70 ºC	0 to 30 ºC
pH	YSI Pro DSS	n/a	± 0.2 s.u.[c]	± 0.2 s.u.[c]	0.1 s.u.[c]	0-14 s.u.[c]	5.5-10 s.u.[c]
Conductivity/ Specific Conductance	YSI Pro DSS	n/a	5% RSD[d]	± 5 µS/cmor 0.001µS/cm, w.i.g.[a]	0.001µS/cm (range dependent)[e]	0 to 1,000 µS/cm	5 to 1,000 µS/cm
Turbidity	YSI Pro DSS	n/a	15% RSD[d]	0-999 FNU, or ±2% of reading, w.i.g.[a]	0.1 FNU	1 to 4000 FNU	0 to 999 FNU
Stage Height and Flow Measurements							
Discharge	SOP EAP109	n/a	10% RSD[d]	n/a	n/a	n/a	0.01 to 2,000 cfs
Velocity	Hach FH950 Portable velocity meter	<0.03 ft/s	5% RSD[d]	± 2% of reading ±0.05 ft/s through the range of 0 to 10ft/s	.01 ft/s	0 to 20ft/s	0 to 20 ft/s
Water Level/ Temperature	Hobo U20L-04 water level logger	n/a	5% RSD[d]	± 0.1%, 1cm (0.003ft) water/ ±0.44°C	<0.014 kPa/ 0.1°C at 25°C	0 to 145 kPa approx. 0 to 13 ft of water/ -20 to 50°C	0 to 10 ft of water/ 0 to 30°C

[a] w.i.g., whichever is greater

[b] for 1.4 m cables; for 10 m, 20 m, 30 m cables: ±2.0% of the reading or 1.0 µS/cm, whichever is greater

[c] s.u. the standard unit for pH is measured in a logarithmic scale

[d] Relative standard deviation

[e] range dependent, for 0.501 to 50.00 µS/cm: 0.01; for 50.01 to 200 µS/cm: 0.1

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for laboratory duplicate samples will be expressed as relative percent difference (RPD) in Table 6 and relative standard deviation in Table 7.

6.2.1.2 Bias

Bias is defined as the difference between the sample value and the true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures. Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols. Bias is expressed as deviation (units or percentage) in Tables 6 and 7.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit (Table 6) and equipment resolution (Table 7). In a regulatory sense, the method detection limit (MDL) is usually used to describe sensitivity. This should be done in terms of the lowest quantity of a physical or chemical parameter detectable (above background noise) by each field instrument or laboratory method.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability will be achieved by ensuring the same methods and SOPs are used during water quality monitoring. SOPs being referenced are Ecology's EAP numbers 024, 034, 042, 057, 070, 072, 080, 082, and 090 when applicable. All data used in statistical comparisons will be assessed for adherence to MQOs before analysis. If the data quality review rejects any sampling results due to quality criteria, then those data will not be used in the analysis.

6.2.2.2 Representativeness

The study is designed to have enough sampling sites at a sufficient sampling frequency to meet study objectives. Water quality values are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following SOPs and collecting duplicate samples, but natural spatial and temporal factors can contribute greatly to the overall variability of results. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time. Sampling will take place at all sites every month and during peak flow events to capture flow dynamics during all seasons and weather conditions.

6.2.2.3 Completeness

The USEPA has defined completeness as a measure of valid data necessary from a measurement system (Lombard and Kirchmer, 2016). The goal of this study is to correctly collect and analyze 100% of the samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled; thus, a completeness of 90% is acceptable. Potential problems include high water levels, site access problems, equipment failure, and insufficient sample.

6.3 Acceptance criteria for quality of existing data

Palouse Conservation District has been collecting water quality and discharge data at 27 locations for the last eight years. Data collected by PCD through previous monitoring studies have strictly adhered to previously mentioned SOPs to promote comparability over time and have been verified for accuracy by adhering to the targets for precision, bias, and sensitivity outlined in the QAPPs written for these projects (Boylan, 2016a; Boylan, 2016b; Boylan et al., 2022; Bass & Boylan, 2024). New environmental data will be added to existing datasets to observe changes in water quality at the proposed sampling locations. Water quality data must meet MQO standards outlined in Tables 6 and 7 to use the data in analyses. Data that do not meet MQO standards will be excluded from any analyses.

6.4 Model quality objectives

To meet project goals and objectives, model results for nutrient and sediment estimates and stage-discharge rating curves should be compared to models used in other water quality impairment modeling studies. A summary of results for comparison purposes is available in *A Synopsis of Model Quality from the Department of Ecology's Total Maximum Daily Load Technical Studies* (Sanderson and Pickett, 2014). Sensitivity and uncertainty analyses should also be conducted to assess the variability of the model results to specific parameters and the level of confidence in key output values.

Model quality includes the following considerations:

1. **Goodness-of-fit:** The accuracy with which the model can predict observed data. This can be described by (1) precision, using statistics such as Root Mean Squared Error (RMSE), Nash Sutcliffe efficiency coefficient, or simple linear regressions (2) bias, using statistics such as the relative error or percent error, and (3) accuracy, visually using plots of modeled and observed values.

2. **Accurate representation of processes:** Mechanistic models should achieve accurate predictions by invoking correct explanations of observed data and reasonably simulating real-world processes. For example, a model might accurately predict low stream temperatures by incorrectly invoking groundwater instead of shade. Such a model might have good goodness-of-fit, but for the wrong reasons, which is termed "curve-fitting". Selection of model parameters based on physical principles, local knowledge, and careful multi-dimensional analysis of model results should help to ensure that curve-fitting is not occurring.

3. **Sensitivity to key inputs:** Estimates should accurately predict the sensitivity of water body response to key inputs, such as the sensitivity of changes in discharge with winter precipitation, due to the highly flashy nature of the streams on the Palouse.

7.0 Study Design

7.1 Study boundaries

The sampling approach aims to evaluate the water quality of Spring Flat Creek and the effects of the installation of riparian buffers. This approach requires the placement of monitoring stations around the areas in which BMPs are implemented. Special emphasis is placed on utilizing historical monitoring data to add to existing datasets.

7.2 Field data collection

At each sampling location, gaging stations will be instrumented with Onset HOBO pressure sensors and staff gages. At each gaging location, reference points will be established, station controls will be assessed and documented, and the gage datum will be recorded. The installation and measurement of gaging stations will follow protocols outlined in the *Standard Operating Procedure for Measuring Gage Height of Streams* (EAP042, 2022) and include both continuous stage and water temperature data. Sampling of sediment, nutrients, DO, pH, specific conductivity, temperature, turbidity, and discharge will occur monthly at all gaging stations and when possible, during base and peak flow events. In addition, to provide quality assurance checks, data will be used to develop estimates of sediment and nutrient concentrations and loading over time. Sampling will follow *Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Samples* (EAP034, 2022) and the installation of staff gages will follow *SOP for Measuring Gage Height of Streams* (EAP042, 2018).

7.2.1 Sampling locations and frequency

The proposed sampling locations are described in Table 8 and displayed in Figure 3 below. As landowners in Spring Flat Creek start to implement riparian restoration projects there is a possibility that the sampling locations may change. If sampling locations move the Ecology Grant Manager will be notified and this QAPP will be amended if necessary.

Table 8. Proposed water quality monitoring sampling locations and recurrence

Site ID	Sampling Recurrence	Description	Latitude	Longitude
SFC00.35	Monthly	Monitoring station already established below the restoration site in the lower watershed	46.873274	-117.35966
SFC03.59	Monthly	Below the restoration site in the middle watershed	46.830431	-117.330055
SFC04.31	Monthly	Above the riparian restoration site in the middle watershed	46.820636	-117.323826
SFC06.48	Monthly	Below the riparian restoration site in the upper watershed	46.790098	-117.310743
SFC07.09	Monthly	Above the riparian restoration site in the upper watershed	46.78304	-117.302237

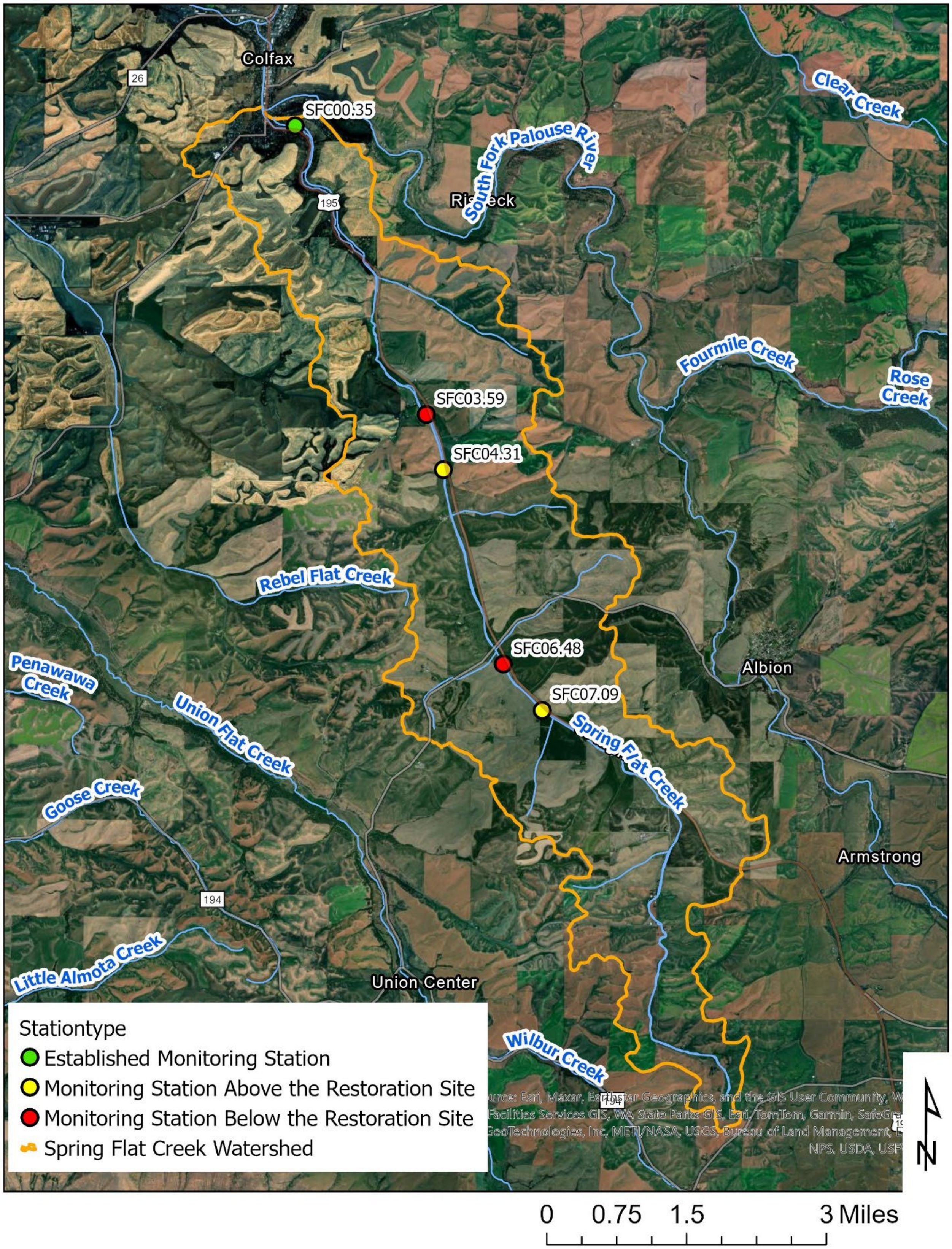

Figure 3. Proposed and existing monitoring stations along Spring Flat Creek.

7.2.2 Field parameters and laboratory analytes to be measured

Water quality parameters measured in the field or the lab include specific conductivity, DO, pH, turbidity, temperature, nitrate/nitrite, ammonia, total phosphorus, orthophosphate, SSC, and discharge. Parameters may be added or removed from the study design as the project progresses as needed; these changes will be addressed through addendums to this QAPP. Table 9 shows the method of collection for each of the parameters to be collected during the study period.

Table 9. Proposed field parameters and laboratory analytes

Parameter	Sensor	Discrete Sample
Ammonia		X
Conductivity	YSI Pro DSS	
Dissolved Oxygen	YSI Pro DSS	
Nitrate/Nitrite		X
pH	YSI Pro DSS	
Phosphorous, total		X
Phosphorous, ortho		X
Suspended sediment concentration		X
Temperature	YSI Pro DSS	
Turbidity	YSI Pro DSS	
Continuous temperature and stage	HOBO Water Level Data Logger	
Velocity	Hach FH950	

7.3 Modeling and analysis design

Because flow and sediment conditions in streams are dynamic, especially during the winter and spring months, this study will assess the relative contribution of sediment and nutrients using continuous monitoring. Continuous flow data will be estimated with stage-discharge rating curves and correlated with discrete measurements of total phosphorus, orthophosphate, nitrate/nitrite, and SSC. The continuous flow will be collected using either existing USGS flow gages or by using stand-alone unvented pressure sensors. Seasonal average loads of total phosphorus, nitrate/nitrite, and SSC will be calculated for each of the ambient monitoring stations.

This will be performed using the following method:

> *Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Stream and Rivers* (Runkle *et al.*, 2004).

Uncertainty analysis will be performed on each of these methods by evaluating the correlations/regressions on which they are based.

7.3.1 Analytical framework

LOADEST is a program developed by the USGS that uses multiple linear regressions to estimate constituent loads in streams and rivers. The load estimation methods used within LOADEST include the maximum likelihood estimation (MLE), adjusted maximum likelihood estimation (AMLE), and least absolute deviation (LAD). The MLE and AMLE methods of load estimation assume that model residuals are normally distributed while LAD estimates are not dependent on the normality assumption (Runkle *et al*. 2004). With several estimation models available it is important to select the appropriate model for the data. Two statistics are built into LOADEST that assist with model selection, the Akaike Information Criterion and the Schwarz Posterior Probability Criterion.

7.3.2 Model setup and data needs

The data needed to set up and run LOADEST is relatively straightforward and will be collected as a part of this project. The data required includes daily discharge data for a specific period, in this case, one and a half years, and at least 12 concentration measurements of constituents of interest. Specific knowledge of statistics, and how LOADEST calculates loads is also necessary to generate accurate results. The staff at PCD have utilized LOADEST in the past to successfully estimate loads for streams in the region (Boylan *et al.,* 2019; Boylan and Bass, 2024).

7.4 Assumptions of study design

This study will assess the water quality of Spring Flat Creek, upstream and downstream of PCD conservation projects to monitor the effects of BMPs. The primary goal of this study is measure changes in key water quality parameters and identify nonpoint source pollution hotspots to guide targeted landowner outreach and assistance. This study operates under the assumption that elevated levels of temperature, nutrients, sediment, or other water quality impairments indicate degraded landscapes. indicate degraded landscapes. Additionally, it assumes that BMP implementation, such as riparian buffers, will lead to measurable improvements in water quality by reducing pollutant loads and enhancing stream health (Bowler *et al*., 2012).

7.5 Possible challenges and contingencies

Challenges always arise when collecting field data. Some of the largest challenges to sampling in the Palouse region are inclement winter weather and high streamflow. As safety is a top priority, monitoring locations may have to be skipped on certain months of the year or potentially moved to facilitate easier access. Remaining flexible, specifically in the first year of data collection, is key to developing a successful long-term monitoring program. As new information and challenges emerge over the study period, sample numbers, timing, frequency, and locations may change. Additional parameters and sampling locations may be sampled as the monitoring priorities and strategy change. Any such changes will be discussed in future addenda to this plan.

7.5.1 Logistical problems

Due to the study area occurring in remote locations and being almost entirely on private property, logistical problems may arise while accessing field sites. All water quality monitoring efforts will require close coordination between PCD and private landowners. Coordination will include obtaining access to field sites, adhering to all site safety procedures, and communicating daily planned activities.

7.5.2 Practical constraints

The QAPP approval process can delay the initiation of the proposed schedule in Section 5.4 (Table 4). Efficient communication and prompt response to edits or modifications to the QAPP between PCD and Ecology should alleviate the impacts of such problems. Seasonality and weather constraints such as snow, frozen channels, hazardous road conditions, and excessive flooding can also present limitations that prevent monitoring efforts. Observation of weather trends and working in safe conditions while monitoring is paramount in successful data acquisition and safety.

7.5.3 Schedule limitations

Potential limitations to the monitoring study schedule include the time it takes for QAPP approval. Any delay in the QAPP approval process will also delay the establishment of hardware on monitoring sites such as survey pins, staff gages, and pressure sensors, and thus reduce the quantity of data collected. Inclement weather can also present challenges to the scheduled data collection, however, flexibility of PCD field personnel while working around inclement weather can prevent the loss of monthly data points.

8.0 Field Procedures

8.1 Invasive species evaluation

Field staff will follow Ecology's SOP EAP070 on *Minimizing the Spread of Invasive Species* (Parsons *et al*., 2024). The Spring Flat Creek watershed is not an area of extreme concern. Areas of extreme concern have, or may have invasive species, like New Zealand mud snails and Eurasian watermilfoil, that are particularly hard to clean off equipment and are especially disruptive to native ecological communities. For more information, please see Ecology's SOP on minimizing the spread of invasive species at https://apps.ecology.wa.gov/publications/documents/2403204.pdf

8.2 Measurement and sampling procedures

Field sampling and measurement protocols will follow SOPs developed by Ecology's Environmental Assessment Program and methods determined to be applicable by the PCD (Table 10). The sampling procedures for lab-analyzed samples will follow procedures in EAP034 (EAP034, 2022), modified as necessary by user manuals to account for optical oxygen probes used with the YSI Pro DSS.

For continuous temperature monitoring, Ecology's SOP EAP080 will be used with the only difference being that data will be collected from the HOBO stage and water temperature sensor and not from a HOBO Tidbit datalogger (EAP080, 2022).

Table 10. Field sampling and measurement methods and protocols

Parameter	Measurement/Sample Type	Lab Method	Field Protocol
Synoptic Water Quality Samples (see Table 11 for list)	Grab samples	Table 12	EAP034, 2022
Water Velocity	Instantaneous	NA	EAP109, 2019
Stage Height	Instantaneous	NA	EAP042 2022
Water temperature	Continuous	NA	EAP080, 2022
Stage Height with a Pressure Transducer	Continuous	NA	EAP082, 2022

8.3 Containers, preservation methods, holding times

Field staff will collect grab samples directly into pre-cleaned/sterilized containers supplied by Anatek Labs following sampling instructions found on Anatek's website. Table 11 lists the sample parameters, containers, volumes, preservation requirements, and holding times. Field staff will store samples for laboratory analysis on ice and deliver all sediment and nutrient samples to Anatek Labs within 24 hours of collection via hand delivery.

Table 11. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Ammonia-N	Surface water	125 mL	HDPE	Adjust to pH ≤2 w/ H_2SO_4[1] and cool to ≤ 6°C	28 days
Nitrate/Nitrite-N	Surface water	125 mL	HDPE	Cool to ≤ 6°C	48 hours
Orthophosphate	Surface water	125 mL	HDPE	Filter in the field and cool to ≤ 6°C	48 hours
Phosphorus, Total	Surface water	125 mL	HDPE	H_2SO_4[1] and cool to ≤ 6°C	28 days
Suspended Sediment Concentration	Surface water	1000 mL	HDPE	Cool to ≤ 6°C	7 days

[1]H2S04: sulfuric acid

8.4 Equipment decontamination

Staff will follow all recommended protocols from instrument manufacturers for cleaning and calibrating sensors. For in-situ equipment, staff will follow Ecology's SOP EAP090, *Decontamination of Sampling Equipment for Use in Collecting Toxic Chemical Samples* when cleaning equipment is used for in-situ sample collection and sample preparation (EAP090, 2024). Field staff will also follow gear decontamination protocols outlined in Ecology's SOP EAP070 on *Minimize the Spread of Invasive Species* (Parsons *et al*., 2024).

8.5 Sample ID

All samples will be labeled with station, date, time, parameter, and sample identification numbers. This information will also be recorded electronically on a field tablet once collected. Each lab sample is automatically given a unique identification number once loaded into EIM. This number is transferred to analysis logs (for internal lab samples) or chain of custody forms sent to external labs. All sample bottles are reconciled against lab reports to verify completeness as samples move through the analytical process as described in the Quality Control section of this QAPP.

8.6 Chain of custody

During sample collection, a chain of custody form is generated for samples, based on electronic data logs. Chain of custody logs are delivered to the lab with the corresponding samples for management of sample counts, scheduling, and tracking analysis. Once the samples are delivered, lab personnel log samples and assign a lab number to each, using the sample label number and date. Each laboratory sample number must correspond to a particular date, time, and sampling location.

When sampling results are received from the lab, chain of custody forms are reconciled with data to ensure complete delivery and correct invoicing for all results. If discrepancies exist, research and investigation of the discrepancy are conducted in coordination with the lab until the discrepancy is resolved.

8.7 Field log requirements

A field log is an important component of many projects. It is used to record irreplaceable information, such as:

- Name and location of project
- Field personnel
- Sequence of events
- Any changes or deviations from the QAPP or SOPs
- Environmental conditions
- Date, time, location, ID, and description of each sample
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Unusual circumstances that might affect interpretation of results
- Recommended field log practices include:
    - Use bound, waterproof notebooks with pre-numbered pages.

- Use permanent, waterproof ink for all entries.
- Make corrections with single line strikethroughs; initial and date corrections. Do not use correction fluid such as Wite-Out.
- Electronic field logs may be used if they demonstrate equivalent security to a waterproof, bound notebook.

In-situ measurements collected in surface waters will be either recorded internally within the data logger or collected as water samples and analyzed at the laboratory.

Information on samples will be recorded on a tablet as an electronic field log. The field log form also includes data logger information for data processing, such as start time, file names, replicate cast number, instrument information, and location ID. In addition, any changes or deviations from the sampling plan or unusual circumstances that might affect the interpretation of results are recorded in a notes section.

Collection data sheets will also be generated on each survey to record collected samples being sent to the lab. A paper log is brought along on every survey to use as a backup if the electronic form or device fails. Digital copies of the field and sample logs are stored for analysis on a shared, secure, and frequently backed-up network server. Photos will be taken during each survey to record observations and events. These photos are used to document each sampling site at the time of the survey and for the creation of reports, procedures, and other documents.

8.8 Other activities

The project manager or field personnel for each crew is the designated safety officer for that survey. The safety officer will have the following responsibilities:

- Canceling monitoring events if conditions warrant.
- Complying with field and safety procedures.
- Knowledge of radio/cell phone use.
- Knowledge of the use and location of the safety equipment.
- Sample handling and processing, including chemical safety protocols.
- Emergency procedures.

Technicians are required to read and follow all appropriate guidelines in the PCD Job Hazard Analysis and use good judgment while in the field or the lab (Appendix B).

9.0 Laboratory Procedures

9.1 Lab procedures table

All lab-analyzed samples will be analyzed at Anatek Labs located in Moscow, Idaho. Methods for all lab procedures are described in Table 12. Project QA/QC protocols are discussed in the *Quality Control* section of this plan.

Table 12. Laboratory analytical methods and reporting limits for lab-analyzed samples

Analyte	Sample Matrix	Samples (Number)	Expected Range of Results	Detection or Reporting Limit	Analytical (Instrumental) Method
Ammonia-N	Water	148	0.053-0.25 mg/L	0.00530 mg/L	SM4500 NH3G
Nitrate/Nitrite-N	Water	148	0.77-6 mg/L	0.018 mg/L	EPA 300.0
Phosphorus, Ortho-	Water	148	0.33-2 mg/L	0.030mg/L	EPA 300.0
Phosphorus, total	Water	148	0.00698-0.2 mg/L	0.00698 mg/L	SM 4500-P F
Suspended Sediment Concentrations	Water	148	1 – 20 mg/L	1 mg/L	SM2540D-2015mod

*The modification to SM2504D is that the whole volume will be filtered and analyzed.

9.2 Sample preparation method(s)

Sample preparation methods are listed in SOPs for lab analyses or analytical methods. For analytes and biological samples, preparation methods are determined by Anatek Labs and others. The following SOPs or QAPPs will be employed:

EAP034 *Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Samples* (EAP034, 2022)

9.3 Special method requirements

Not applicable.

9.4 Laboratories accredited for methods

All chemical analyses will be performed at Anatek Labs in Moscow, Idaho which is accredited for all methods (Table 12).

10.0 Quality Control Procedures

The ongoing effort to provide high-quality data occurs in many steps before, during, and after data collection. QA/QC procedures include the following activities:

1. Meeting QA/QC objectives.
2. Calibrating and maintaining equipment.
3. Conducting sensor performance assessment or verification.
4. Evaluating analytical laboratory and field data QA/QC procedures.
5. Performing proper sample custody.
6. Performing proper data and information management.
7. Verifying and validating data through routine data review.
8. Assessing data usability.
9. Conducting field audits.

10.1 Table of field and laboratory quality control

Field quality assurance protocols will follow SOPs developed by Ecology's Environmental Assessment Program and at a frequency of one quality control sample type per month (Table 13). The quality assurance procedures for lab-analyzed samples will follow procedures in section 10.1.2 of *Quality Assurance Monitoring Plan: Statewide River and Stream Ambient Water Quality Monitoring* (Von Prause, 2021). Table 13 presents the quality control samples to be collected in the field and analyzed in the laboratory.

Table 13. Quality control samples, types, and frequency.

Parameter[b]	Field Blanks	Field Replicates	Laboratory Check Standards	Laboratory Method Blanks	Analytical Duplicates	Laboratory Matrix Spikes
Ammonia	1/event[b]	2/event[b]	1/batch[a]	1/batch[a]	1/batch[a]	1/batch[a]
Nitrogen, Nitrate/Nitrite	1/event[b]	2/event[b]	1/batch[a]	1/batch[a]	1/batch[a]	1/batch[a]
Phosphorus, Ortho	1/event[b]	2/event[b]	1/batch[a]	1/batch[a]	1/batch[a]	1/batch[a]
Phosphorus, total	1/event[b]	2/event[b]	1/batch[a]	1/batch[a]	1/batch[a]	1/batch[a]
Suspended Sediment	1/event[b]	2/event[b]	1/batch[a]	1/batch[a]	1/batch[a]	1/batch[a]

[a] A laboratory "batch" is defined as up to 20 samples analyzed together.

[b] A "event" is defined as a sampling event, where all samples are collected at each location identified in Table 8.

10.2 Corrective action processes

QC results may indicate problems with data during the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective actions might include:

1. Retrieving missing information.
2. Re-calibrating the measurement system.
3. Re-analyzing samples within holding time requirements.
4. Modifying the analytical procedures.
5. Requesting additional sample collection or additional field measurements.

If these actions do not correct issues with the data the result will be qualified and deemed as unusable for analysis.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Staff will record all field data on an electronic collection platform. Field notebooks are used as a backup in case of equipment failure with the electronic platform. Before leaving each site, staff will check electronic data forms for missing or inaccurate measurements. Electronic data are stored in Microsoft Excel datasheets and are compiled and backed up on PCD servers upon return from the field. The field assistant will check data for errors and omissions and will notify the project manager of missing or unusual data.

Lab results will be checked for missing and/or inaccurate data. The field lead will check Anatek Labs' data for omissions against the chain of custody forms. The project manager will review data requiring additional qualifiers. Any estimated results will be qualified and their use restricted as appropriate.

In addition, data summaries will be either on PCD's Research and Monitoring website or on Ecology's EIM.

11.2 Laboratory data package requirements

A Microsoft Excel comma-separated value file of the results and a PDF containing a standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

11.3 Electronic transfer requirements

Data and QA/QC information will be emailed to the project manager.

11.4 EIM/STORET data upload procedures

All water quality data will be entered into EIM, following all existing Ecology business rules and the *EIM User's Manual* (Ecology, 2024) for loading, data quality checks, and editing. The method used by PCD for data management and upload to EIM is outlined in Appendix A.

11.5 Model information management

Modeling information will be managed in a database housed on PCD's internal servers. Quality-controlled data will be appended to previously collected data at monthly intervals. The final dataset will be formatted for LOADEST model upload upon completion of this proposal's field data collection. This dataset and all model outputs are expected to be less than 50 gigabytes, easily housed and processed on PCD servers. Iterations of the model will be mapped according to their version number and model input settings.

12.0 Audits and Reports

12.1 Audits

Field audits will be conducted annually for all technical staff by the Research and Monitoring Coordinator at PCD. The audit aims to improve fieldwork consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen our data QA process. Additional audits will be conducted on any data manually entered into the database. A senior staff member will review manually entered data quarterly.

12.2 Responsible personnel

The project manager conducts audits of all data and works with field and lab technicians to complete audits. The senior field lead participates in quality control of data before it is finalized and made public.

12.3 Frequency and distribution of reports

See Section 5.4 for a timeline of interim and final report submissions.

12.4 Responsibility for reports

Given the nature of the study, the dataset will be extensive. Analyzing and interpreting data results requires an intensive team approach. The project manager leads reporting on the status and trends of various products and the presentation of results. All members of the research and monitoring program assist in data collection, management, and analysis for the production of reports and presentations.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Data verification and review are conducted by the project manager and the field lead by examining all field- and laboratory-generated data to ensure:

1. Specified methods and protocols were followed.
2. Data are consistent, correct, and complete, with no errors or omissions.
3. Data specified in the *Sampling Process Design* section were obtained.
4. Results for QC samples, as specified in the *Measurement Quality Objectives* and *Quality Control*, accompany the sample results.
5. Established criteria for QC results were met.
6. Data qualifiers (QC codes) are properly assigned.

Throughout field sampling, the field lead and all crew members are responsible for carrying out station positioning, sample collection, and sensor deployment procedures as specified. Additionally, technicians systematically review all field documents (such as field logs, chain-of-custody sheets, and sample labels) to ensure data entries are consistent, correct, and complete, with no errors or omissions. A second staff person always checks the work of the staff person who primarily collected or generated data results.

After data entry and data verification tasks are completed, all field and laboratory data will be uploaded into the EIM system annually. Before uploading the data to EIM, the entire dataset will be independently reviewed by a different staff member to check for errors. If significant entry errors are discovered, a more intensive review will be undertaken.

13.2 Laboratory data verification

Laboratory data are verified at the laboratory by lab personnel

13.3 Validation requirements, if necessary

All laboratory data that have been verified by Anatek staff will be reviewed by a PCD staff member following the verification, requirements, and responsibilities outlined in section 13.1 above. Field data that was verified by a staff member will be validated by a different staff member.

13.4 Model quality assessment

Constituent loading will be modeled for each monitoring and sampling location using discrete grab sample concentrations and discharge estimates generated from rating curves. Constituent loads in streams and rivers will be estimated for total nitrogen, total phosphorus, and SSC using the USGS LOADEST program. Transformed regression models allow for approximation of total load in monitored streams.

13.4.1 Calibration and validation

Model calibration for LOADEST requires a time series with 12 or more uncensored and nonzero data points for each constituent being modeled. This calibration assists in the development of model coefficients through ordinary least squares regression. LOADEST calibration will be conducted in accordance with the guidance in Runkle et al, 2004. Additionally, PCD will review the LOADEST constituent and residual output files for identification of potential load bias.

13.4.1.1 Precision

The precision of the model is approximated using residual errors generated from regression equations. The residual error is calculated for each data point and is equal to the difference between the observed and estimated load when comparing the calibration data with the complete dataset. Additionally, r-squared values, residual variance, serial correlation of residuals, and probability plot correlation coefficients will be generated to inform the precision of model estimates.

13.4.1.2 Bias

Model bias is addressed as a function of model inputs where LOADEST applies bias correction factors depending on dataset completeness and the regression type selected. Bias diagnostics include load bias (%), partial load ratios, and Nash Sutcliffe Efficiency Index. A complete description of bias correction factors is described in Runkle et al., 2004.

13.4.1.3 Representativeness

The study is designed to have enough sampling sites at sufficient sampling frequency to meet study objectives. Model inputs will include monthly and high-flow event constituent samples and discharge values, which should capture a representative dataset to input into LOADEST. Explanatory factors for load depend on the constituent and the hydrologic system being modeled. Proper regression selection will determine the explanatory variable influence on the constituent of interest.

13.4.1.4 Qualitative assessment

Graphical representation of estimated load over the study period will be compared to manual calculations of instantaneous load to assess the comparability of model estimates. This goodness-of-fit evaluation will also provide insight into the model's sensitivity to variations in stage and discharge.

13.4.2 Analysis of sensitivity and uncertainty

Uncertainty analysis will be performed on model outputs by evaluating the correlations and regressions on which they are based.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

After all laboratory and field data are verified and validated, the field lead or project manager will thoroughly examine the dataset, using statistics and professional judgment, to determine if MQOs have been met. The project manager will examine the entire dataset to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the field lead and project manager will decide if the affected data should be accepted or rejected based on the decision criteria in the QAPP. The project manager will decide how any qualified data will be used in the technical analysis.

The sampling design will be considered successful if the project objectives outlined in the QAPP are met.

14.2 Treatment of non-detects

Data results or concentrations of all analytes reported between the MDL and reporting limit are quantified and annotated with a "J" qualifier (estimated concentration); this indicates a higher level of uncertainty in the quantitative value. Statistical evaluations of data whose uncertainties are "high" can lead to erroneous conclusions, especially if the sample populations are limited in size or have high percentages of non-detect data, where analytes are not present at detectable concentrations.

Analytes reported at the detection limit will receive the "U" qualifier and will be considered a non-detect. Due to the timing and objectives of this study, all non-detects will be reported with the appropriate qualifier. Non-detect data will be replaced by half the method detection limit. Treatment of non-detects in this way assumes on average that all values between the MDL and zero could be present and that the average value could be as high as half the MDL.

14.3 Data analysis and presentation methods

Data analysis consists of comparing results to water quality standards and detecting changes in monitoring parameters over time. Procedures comparing results to water quality standards are defined in Ecology's Water Quality Program Policy 1-11 (https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d/Assessment-policy-1-11), and Ecology's *Guidance for Effectiveness Monitoring of Total Maximum Daily Loads in Surface Waters* (Collyard and Onwumere, 2013).

14.4 Sampling design evaluation

The project manager will decide whether the dataset meets the MQO criteria for completeness, representativeness, and comparability and whether meaningful conclusions (with enough statistical power) can be drawn from the results and analysis. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

In the technical report, the project manager will include a summary of the data quality assessment findings. This summary will be included in the data quality section of the report.

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16.0 Appendices

Appendix A. Palouse CD Standard Operating Protocol for Environmental Information Management (EIM) Submittal through Washington State Department of Ecology

PCD Data Management

Gabby Hannen, Ryan Boylan, Nick Harris. Updated

2023

- Open File Explorer and navigate to the *R Scripts* folder (R:\Research_and_Monitoring_04_Project_Data\R\EIM)
- Find and open the R project *EIM,* then the script *WQ_EIM_Formatting*
    - Once open, note that the R Script contains all the required packages for the script to run properly.

If all packages are NOT installed on your computer, an exception will be thrown, and the script will not run

- There are three sections to this code, the first formats Anatek data, the second formats Anatek replicate sample data, and the third formats discrete sensor data such as ProDSS data. All files in the Anatek data folder will be read in and can then be filtered by date; **ensure you change the filter dates.**
- Note the comment *# Run EIM Transformation.* To run the *EIM Transformation Function*, **ensure the correct input, output, and site_ID values** are entered into the function.
    - Input = input directory from the Anatek Lab data. Select the folder for the directory, not individual files.
    - Pattern = ".xls", unless another file type is used for Anatek Lab data.
    - Output = the directory for which the EIM will be exported. It should be the outputs folder withing the EIM folder.
    - Study_ID = the Ecology study ID, this can be found in the EIM database if you are unsure.

- Once all three fields are entered, run the lines of cleaning code and then the function by hitting CTRL + Enter.
- A message will appear in the console indicating a successful transformation or a warning/failure.
    - If there is a failure or a warning, use the *Show Traceback* feature within the console to track the error. Indicate that the input, output, and site_ID are all spelled correctly.
    - Another common error could be with the quotations around each directory. In R, retype the quotation marks. Make sure all the strings are **green**, not black font.
- Navigate to the appropriate destination in File Explorer and open the newly created file to check all data has been formatted correctly.

Submittal Through Access Washington

- Navigate to secureaccess.wa.gov and sign into your Secure Access Washington account.
- Go to EIM Loader and select "Access".
- If starting a new study, click on "Add new Study" on the right-hand side.
    - If study is already created, click "Edit Study".
- Fill sheet out accordingly
    - *Study ID*
    - *Study Name*
        - Refer to QAPP for the project
    - *Study Type*
        - Typically, TMDL effectiveness monitoring, but can vary. Refer to QAPP and chose the most appropriate type
    - *Study Purpose*
        - Refer to QAPP for the project
    - *Ecology Contact*

        - Kristin Slodysko, but this may change in the future
    - *Ecology Program*
        - Ecology Water Quality Program, Eastern Region
    - *Study QA Planning Level*
        - Level 4: Approved QAPP or SAP
    - *Study QA Project Plan Description*
        - You can leave this blank
    - *Study QA Assessment Level*
        - Level 2: Data Verified
    - The rest of the fields can be left blank. Check once more that the information above would meet the criteria for the project you are submitting an EIM for.
- To submit the data associated with this project, go back to the EIM Loader home page and click “Result” under the Submit Template Data section on the right-hand side.
- Choose “EIM Result Template” and chose the EIM file you created in the first section of this SOP.
- From here, the data will be validated. Using the “Check Data” function, you can see whether or not the data will be accepted. Make any necessary changes if needed, otherwise you can proceed to contacting EIM coordinator.
- Next, you will need to see if a Location Template is needed. You can use the “EIM Search” function to find the locations of your sites to see if they have been used before by PCD or another agency.
    - By going to the homepage of EIM Search, you can click the map on the right-hand side that is captioned “Click to search by map”.
    - Here, you can zoom to the locations of your sites.
    - Check to see if there are any data points at the location of your monitoring site. If there is, you can use the “Identify” function.
    - When you click on the point, check to see if the description of the point on the

location details relates to your monitoring locations. For example, if there are similar sample sources.

    - If you find these locations on EIM Search, then you can use the Location IDs in your EIM in lieu of creating a location template. If you submitted the EIM before changing the Location IDs, you can simply change them and reupload the EIM.

- Once all the data is submitted, you should be contacted by your EIM Coordinator or someone else from Department of Ecology regarding the status in the process of your EIM submittal. Follow the critiques, if any. Once edits are made, the EIM submittal process should be completed and the data will be publicly available.

Appendix B. Job Hazard Analysis for Water Quality Monitoring

Job Hazard Analysis: Water Quality Sampling		
Required Standards and General Notes:	Work will involve driving on rough terrain and in inclement weather, crouching, doing repetitive tasks for long periods, wading in streams and rivers, handling chemicals, walking over rough terrain, and bending over and light lifting.	
Personal Protective Equipment:	Sturdy boots with ankle support are highly recommended; long pants are required and a long-sleeve shirt to reduce scratches from plants & insect bites are optional. Waders and wading boots are required for water quality measurements. Gloves, insect repellant, sunscreen, & first aid kit are also recommended.	
Tools and Equipment:	Wading rod, survey equipment, blow torch, soldering iron, hand saws, shovels, hammers, cordless drills, other hand tools, brush cutters, gas and manual powered augers, Polaris Ranger UTV, and other pieces of small equipment.	
Tasks/Procedures	**Potential Hazards**	**Safe Action or Procedure**
Attitude about work and physical limits	Pride/Ego over-ruling good judgment	Avoid letting pride/ego push you harder than you can go. Try not to become competitive. Look out for coworkers.
Drive to/from work site	Traffic, mud/rocks, off-road driving hazards	Obey all traffic laws. Do not speed and adjust MPH based on weather conditions. Always wear seatbelts Use lights whenever it is dark, there is poor visibility, or windshield wipers are in use. Drivers should use spotters when driving off-road in areas of poor visibility, questionable stability/clearance, and while reversing, Follow laws and PCD policies on using phones while driving. Properly secure all equipment in the truck.
Using hand tools	Injury due to misuse of tools and/or injury to other crew members	Handle/carry all tools safely. Maintain appropriate spacing from other workers. Always be aware of your surroundings and activities.

Hiking to/from sites	Uneven surfaces, downed trees, slippery logs and soil, mud, standing water, loose leaves, steep slopes, rocks, fording, rock hopping across streams, and other natural or manmade hazards may be encountered.	Move at speeds reasonable for the conditions. Wear sturdy well-fitted waterproof boots. Exercise care in crossing logs or other obstructions. Avoid hazards by taking alternative routes. Pay attention to stream/river edges that can be loose. Never proceed if it appears to be dangerous. When crossing streams, angle the body upstream and move one foot at a time. Cross streams in areas where it is widest as this is more likely to have lower flows. Fording will be avoided if flows are too high. Only rock hop if the rocks are near enough to each other, beware of slippery rocks or loose banks.
In-site travel	Tripping, heat-related illness, back strain from bending/lifting, wet feet, blisters, insect bites (including ticks), and plants (i.e. nettles, roses, hawthorn, etc.) that could scratch or irritate exposed skin.	Wear sturdy well-fitted waterproof boots with ankle support. Wear long pants and long sleeves. Dress for the weather. Bring adequate drinking water and drink it frequently. Rest as needed. Lift using leg muscles; comfortable haul weight, make as many trips as necessary to set up and take down. Wear work gloves. Use insect repellant and sunscreen. Upon return thoroughly wash exposed areas & treat all scratches with appropriate first aid.
Weather	Sun damage, heat illness, and hypothermia	Wear SPF 30-50 sunscreen including lip salve. Wear long sleeves, long pants, wide-brimmed hats, and sunglasses with dark UV protection to protect as much of your body from sun damage as possible. Use aloe vera for burns. Take breaks as needed when it becomes too hot. Stay hydrated, seek shade as necessary, and do not overexert yourself. Avoid drinking overly cold beverages. Wear the proper layers of clothing to prevent hypothermia. Stay moving to generate body heat.

All duties	Animals of concern: Biting/stinging insects Coyotes Plants of concern: Poisonous (poison hemlock, etc.), thorny (thistle, rose, teasel, etc.), rash (stinging nettle, etc.)	Avoid the use of perfumed cosmetics and personal care items. Wear insect repellent. Pay attention to insect behavior (i.e. swarming) that may indicate the presence of a nest & avoid area. Wear light-colored long sleeves/pants. Tuck the shirt into your pants, and tuck your pants into socks, preferably nylon socks. Treat clothing with insect repellant like permethrin. Remove ticks with tweezers, making sure to pull out the entirety of the mandible. Do not feed wildlife. Shout or throw something at coyotes, do not run away to avoid looking like prey. Give wild animals their space. Always wear work gloves when dealing with plants to avoid unwanted injuries/contact with possibly harmful fluids. Wear long clothing to prevent contact with plants which may cause reactions. Avoid said plants if you are overly sensitive to them. Do not consume any wild plant unless you are 100% sure of its identification.
Wading in streams and creeks	Slip and fall, hypothermia, and drowning	Use the proper PPE for wading such as chest waders, wading boots, and/or hip waders. If possible, use a wading staff or rod for support while wading Be sure foot placement is secure when wading especially when the water is murky Use best judgment, if the current is swift or weather conditions do not permit safe wading conditions, avoid monitoring.
Proximity to potential hantavirus, rabies, or other vector-borne diseases	Various organisms (mammals, insects, etc.) may be vectors for pathogens	Be aware of the sources and symptoms of infectious pathogens potentially present in the working environment- seek medical attention if infection is suspected. Be aware of signs of mice, packrats, and other rodents, and avoid contact with them, their excrement, or nests. Avoid all contact with any strange-acting mammals such as bats, skunks, coyotes, feral dogs, and others, and be aware of the possibility of rabies in such animals.
Avoid confrontation with ungulates	Working in proximity to cattle, pigs, deer, etc.	If you come across an animal that seems threatened, give it space. Do not approach from behind, separate a mother from the calf, make quick movements, or make loud noises. Be aware of ungulate behavior.

Avoid UTV/ATV damage and injury	Open configuration and use of off-road vehicles pose hazards	Drivers shall receive training before using the equipment. Have a spotter determine a safe route in questionable terrain, signaling where hazards are. Properly secure tools/equipment. Wear proper PPE, including seatbelts.
Avoid cut/abrasion	Sharp or abrasive objects in the field (barbed wire, thorns, etc.)	Beware of plants that have thorns, sharp edges, or still branches. Avoid them if possible. Wear protective clothing and beware of loose/baggy clothing when traveling through narrow areas where it might catch on something. Wear gloves whenever handling sharp equipment. Properly store equipment. Be cautious of broken glass, aluminum cans, barbed wire, and other potentially dangerous objects found in the field.
Handing chemicals for water quality sampling	Caustic and corrosive chemicals	Use the proper PPE for handling chemicals such as eye, hand, and skin protection. Refer to MSDS for the chemicals being handled, understand how to respond to chemical exposure Work in well-ventilated areas to avoid inhalation Store and transport chemicals in appropriate containers for that chemical .
Falling objects	Uncontrolled falling of limbs, cones, or other objects	Be aware of any trees, objects, or people that are above you and might cause a hazard. Use caution if moving things above the head. Do not cut things down that are directly overhead- use caution when cutting anything down.
Losing communication between crew members	Splitting up a crew can leave some without guidance or help in case of an emergency	Always have at least one working cell phone with each part of the crew. If there is limited cell service, utilize walkie-talkies to maintain contact. .
Working during hunting season	Stray bullets or being mistaken as game	Be aware of white sites allow hunting or if there is hunting happening nearby. Wear orange vests in sites where hunting may be occurring or may be occurring nearby.

Appendix C. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

Anthropogenic: Human-caused.

Bankfull stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Dilution factor: The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100.
http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-020

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day and falls during the night).

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Effluent: An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Near-stream disturbance zone (NSDZ): The active channel area without riparian vegetation that includes features such as gravel bars.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Synoptic survey: Data collected simultaneously or over a short period of time.

System potential: The design condition used for TMDL analysis.

System-potential channel morphology: The more stable configuration that would occur with less human disturbance.

System-potential mature riparian vegetation: Vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System-potential riparian microclimate: The best estimate of air temperature reductions that are expected under mature riparian vegetation. System-potential riparian microclimate can also include expected changes to wind speed and relative humidity.

System-potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system-potential condition uses best estimates of mature riparian vegetation, system-potential channel morphology, and system-potential riparian microclimate that would occur absent any human alteration.

Thalweg: The deepest and fastest moving portion of a stream.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

1-DMax or 1-day maximum temperature: The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

303(d) list: Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days before and the three days after that date.

90th percentile: An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

Acronyms and Abbreviations

BMP	Best management practice
DO	Dissolved oxygen
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GPS	Global Positioning System
MQO	Measurement quality objective
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SSC	Suspended sediment concentration
TMDL	Total Maximum Daily Load
TSS	Total suspended solids
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WQA	Water Quality Assessment

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cms	cubic meters per second, a unit of flow
dw	dry weight
ft	feet
g	gram, a unit of mass
kcfs	1000 cubic feet per second
kg	kilograms, a unit of mass equal to 1,000 grams
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters
L/s	liters per second (0.03531 cubic foot per second)
m	meter
mm	millimeter
mg	milligram
mgd	million gallons per day
mg/d	milligrams per day
mg/kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mg/L/hr	milligrams per liter per hour
mL	milliliter
mmol	millimole or one-thousandth of a mole
mole	an International System of Units (IS) unit of matter
ng/g	nanograms per gram (parts per billion)
ng/kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)

psu	practical salinity units
s.u.	standard units
µg/g	micrograms per gram (parts per million)
µg/kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
µM	micromolar (a chemistry unit)
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data (Kammin, 2010). For Ecology, it is defined according to WAC 173-50-040: "Formal recognition by [Ecology] that an environmental laboratory is capable of producing accurate and defensible analytical data."

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USEPA, 2014).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: Discrepancy between the expected value of an estimator and the population parameter being estimated (Gilbert, 1987; USEPA, 2014).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 2014; USEPA, 2020).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 2014; USEPA 2020).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: The process of determining that the data satisfy the requirements as defined by the data user (USEPA, 2020). There are various levels of data validation (USEPA, 2009).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 2014).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS)/LCS duplicate: A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. Monitors a lab's performance for bias and precision (USEPA, 2014).

Matrix spike/Matrix spike duplicate: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias and precision errors due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (USEPA, 2001).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): The minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results (USEPA, 2016). MDL is a measure of the capability of an analytical method of distinguished samples that do not contain a specific analyte from a sample that contains a low concentration of the analyte (USEPA, 2020).

Minimum level: Either the sample concentration equivalent to the lowest calibration point in a method or a multiple of the method detection limit (MDL), whichever is higher. For the purposes of NPDES compliance monitoring, EPA considers the following terms to be synonymous: "quantitation limit," "reporting limit," and "minimum level" (40 CFR 136).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$RPD = [Abs(a-b)/((a + b)/2)] * 100\%$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Relative Standard Deviation (RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$RSD = (100\% * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Reporting level: Unless specified otherwise by a regulatory authority or in a discharge permit, results for analytes that meet the identification criteria (i.e., rules for determining qualitative presence/absence of an analyte) are reported down to the concentration of the minimum level established by the laboratory through calibration of the instrument. EPA considers the terms "reporting limit," "quantitation limit," and "minimum level" to be synonymous (40 CFR 136).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1992).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 2014).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 2014).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

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