DEPARTMENT OF ECOLOGY
State of Washington

Preliminary Rule Implementation Plan Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington

Salmon Spawning Habitat Protection Rule

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Preliminary Implementation Plan

Chapter 173-201A WAC

Water Quality Standards for Surface Waters of the State of Washington

Water Quality Program

Washington State Department of Ecology

Olympia, Washington

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Table of Contents

Purpose

The Washington State Department of Ecology (Ecology) provides the information in this implementation plan to meet agency and Administrative Procedure Act (RCW 34.05.328) requirements related to rule adoptions.

Introduction

On October 13, 2021, Ecology proposed amendments to chapter 173-201A WAC Water Quality Standards for Surface Waters of the State of Washington (AO # 19-05). The purpose of this rule implementation plan is to inform those who must comply with chapter 173-201A WAC about how Ecology intends to:

- Implement and enforce the rule.
- Inform and educate persons affected by the rule.
- Promote and assist voluntary compliance for the rule.
- Evaluate the rule.
- Train and inform Ecology staff about the new or amended rule.

Also included in this plan is information about:

- Supporting documents that may need to be written or revised because of the new rule or amended rule.
- Other resources where more information about the rule is available.
- Contact information for Ecology employees who can answer questions about the rule implementation.

Informing and Educating Persons Affected by the Rule

Rule development phase

During the rule development phase of this rulemaking, we reached out to interested parties through emails, water quality listservs, webpage updates, advisory group meetings, and public informational webinars.

Specifically, during this phase we:

- Held two public informational webinars to introduce the rulemaking, provide preliminary rule decisions for feedback, and answer questions
- Presented at the Norwest Indian Fisheries Commission tribal water quality meetings
- Held five Science Advisory Group meetings to discuss the scientific literature and implementation considerations to help inform the rulemaking

Rule proposal phase

During the rule proposal phase, we will hold online public hearings to discuss the proposed rule change and collect formal comments. Public hearings will consist of a presentation of the rulemaking information, after which we would then accept formal testimony on the proposed rule. We will consider and respond to all comments we receive during the CR-102 phase.

Future Outreach

We intend to inform and educate persons affected by the adopted rule by:

- Providing continued opportunities to meet and discuss the implementation of the proposed rule with stakeholders.
- Providing continued opportunities for discussions and government-to-government consultation about the proposed rule with interested tribes.
- Educating Ecology staff on how best to implement the rule in their CWA action work.

For more information on how we intend to train and inform Ecology staff, see the section "Training and Informing Ecology Staff."

Promoting and Assisting Voluntary Compliance

Entities that currently discharge to state waters will need to continue to meet water quality standards. The proposed changes in the DO criteria provide multiple avenues to assess if waterbodies are being protected. The DO criteria will allow for assessment of water column DO levels, percent oxygen saturation, or intragravel DO. This flexibility may assist entities in monitoring and assessing protection of aquatic life. Ecology will assist in providing guidance on new monitoring methods for DO.

The narrative fine sediment criterion will require a multi-parameter approach to water quality monitoring. Ecology will provide guidance on monitoring required to determine if a waterbody is impaired for fine sediment.

Evaluating the Rule

The purpose of the surface water quality standards is to restore and maintain the chemical, physical, and biological integrity of Washington's waters. More specifically, the water quality standards are designed to protect public health, public recreation in the water, and the propagation of fish, shellfish, and wildlife. The numeric and narrative criteria in the water quality standards are intended to protect those beneficial uses.

Ecology will consider if the proposed changes have achieved their purpose to protect the beneficial uses.

Objectively measurable outcomes

Outcomes of the rule can be measured if water quality standards are attained. Ecology monitors surface waters across the state to determine whether water quality conditions support the designated uses set in the standards. Monitoring data (meeting requirements of the Data Quality Act; RCW 90-48-570 to 90-48-590) will be used to determine whether designated uses are met.

Implementation and Enforcement

Implementing changes to permits

Dissolved Oxygen

The majority of permittees do not directly monitor DO in their permits. A select number of facilities have biological oxygen demand limits and dilution factors to ensure compliance with the DO water quality criteria. The Columbia River has a site-specific criterion of 90% oxygen saturation. Some facilities that discharge to the Columbia River already have a 90% oxygen saturation requirement in their permits. Overall, the proposed changes to DO criteria should not affect facilities permit limits unless the receiving waterbody is impaired for DO. The addition of an oxygen saturation criterion to the DO criteria may result in the need to monitor oxygen saturation to ensure compliance with future TMDL requirements.

Fine Sediment

Many facilities are currently required to monitor total suspended solids (TSS) in their permit. We do not anticipate that a narrative fine sediment criterion will affect requirements in permits. If a TMDL is developed in a receiving water, facilities may be required to monitoring discharges for fine sediment based parameters. For example, suspended solids concentrations (SCC) is one of the parameters used to determine a fine sediment based waterbody impairment and may be translated to TSS using site-specific data. If a relationship between SSC and TSS can be established, then more restrictive TSS permit limits could be implemented based on data collected from receiving waters.

Implementing changes to TMDLs

DO TMDLs

Existing DO TMDLs that are approved by EPA are not anticipated to change as a part of this rulemaking. This rulemaking provides additional tools to evaluate DO in waterbodies. Besides a minimum DO level, the addition of an oxygen saturation and intragravel DO criterion allow additional data to be collected that can be used to determine aquatic life protection and to conduct effectiveness monitoring of TMDLs. The proposed criteria could result in additional monitoring and new methods to evaluate oxygen levels in waterbodies.

The addition of an oxygen saturation component to the DO criteria addresses the relationship between DO levels and the temperature of the water. Higher water temperatures are less capable of maintaining DO levels in the water. We currently do not account for DO limitations influenced by water temperature in the water quality standards. The addition of an oxygen saturation component to the criteria accounts for temperature-related effects on DO, which allows us to determine if temperature is driving the DO level. If high water temperature is causing low DO levels, it would not be considered an exceedance since the oxygen saturation represents what the water has the ability to hold.

Current waterbodies identified through the Water Quality Assessment process as impaired for DO may be a result of nutrients or temperature-related DO reductions. The oxygen saturation component will allow the focus of a TMDL to shift towards addressing temperature issues to resolve DO limitations, where needed. The addition of an oxygen saturation component to the DO criteria allows for a more accurate list of DO impairments for nutrients rather than temperature.

Fine Sediment TMDLs

Existing sediment TMDLs are not anticipated to change as a part of this rulemaking. The parameters used to characterize fine sediment may result in additional monitoring and new methods in evaluating sediment and in effectiveness monitoring.

Implementing the new criteria in the Water Quality Assessment (303d/305b Integrated Report)

Dissolved Oxygen

The addition of new parameters to the DO criteria will likely require Ecology to refine the DO impairment listing methodology found in Water Quality Program Policy 1-11, Chapter 1: Washington's Water Quality Assessment Listing Methodology to Meet Clean Water Act Requirements[1]. Currently, the water quality standards for DO only provide water column-based criteria. With this rulemaking, Ecology seeks to add oxygen saturation and intragravel dissolved oxygen criteria. To calculate the oxygen saturation of the water, data on atmospheric pressure[2] and water temperature will be required. The impairment listing methodology will need to include new methodologies for determining impairments using these additional measurements.

Fine Sediment

The addition of a narrative fine sediment criterion will require the development of a methodology to evaluate when the fine sediment standard is being exceeded. Ecology will provide guidance on the parameters used to characterize fine sediment in a waterbody. Subsequently, the listing methodology to determine a fine sediment-based impairment will be developed by the water quality program through a public process. Appendix A provides sampling recommendations and approaches for making a determination of an exceedance of fine sediment criteria. The final methodology for assessing fine sediment will be in a revision to Water Quality Program Policy 1-11.

[1] https://apps.ecology.wa.gov/publications/SummaryPages/1810035.html

[2] To facilitate the use of historic data, the Water Quality Assessment policy update process will explore the option of using site elevation standardized to 1 atmosphere at sea level as a surrogate for atmospheric pressure at the time of sampling.

The rulemaking to propose fine sediment criterion meets a requirement of a stipulated order of dismissal of a past litigation against EPA. The subsequent settlement agreement requires that Ecology complete final guidance regarding a listing methodology for fine sediment within 18 months of this rule adoption.

Implementing new criteria in Ecology's Nonpoint Program

Dissolved Oxygen

Chapter 90.48 RCW serves as the regulatory authority for the nonpoint program to prevent and eliminate pollution and if needed, take actions to minimize pollution. This rule is in alignment with chapter 90.48 RCW, and does not change our implementation of this law. The adoption of oxygen saturation and intragravel DO criteria provides additional tools to characterize DO and nutrient-related impairments. As with the current DO criteria, if a nonpoint source is discharged or has the high likelihood to pollute a waterbody or impact a downstream beneficial use, then best management practices need to be implemented.

Fine Sediment

This rule is in alignment with chapter 90.48 RCW, and does not change our implementation of this law. This rulemaking may provide clarification on specific parameters that can be used to address fine sediment pollution for the nonpoint pollution control program. A review of the available best management practices should be completed to identify best approaches to reduce fine sediment pollution.

Intragravel Dissolved Oxygen Sampling

The addition of intragravel criteria to the DO criteria requires additional guidance on sampling. Intragravel DO can vary based on where the measurement is taken, and depends on site-specific and stream characteristics. The intragravel DO criteria is aimed at protecting early life stages of salmonids, and thus, sampling locations should target riffles and spawning areas in streams to the degree possible. Intragravel DO measurements should be calculated as a spatial median value.

A median spatial value is the middle value of multiple ranked intragravel DO measurements taken within a sampling area. The spatial median value is aimed at determining a representative value for an aquatic habitat area. The measurements within a given habitat sampling area are sorted in ascending or descending order and the middle value is representative of the spatial median. The samples collected within a given sampling area should be spatially representative of the sampling area. A minimum of three samples are required to calculate a median spatial value but more may be required depending on the objectives of the study. When an even number of samples are collected, the middle two values are averaged.

Training and Informing Ecology Staff

A rulemaking requires broad outreach to Ecology permit writers, staff, and management involved with water quality regulation. This will be achieved through meetings, email communication, written guidance, and one-to-one communication. After this rule is adopted, Ecology will notify all Ecology staff who use the criteria or tools. EPA is required to review and approve new rule language before they can be used for Clean Water Act (CWA) purposes. Ecology will notify all Ecology staff after EPA has taken an approval action on its CWA review of the adopted standards. Training on implementation of the revised water quality standards will be provided to Ecology staff upon request.

Below are examples of staff resources to address training and information sharing related to the adopted rule:

National Pollutant Discharge Elimination System permits

The Water Quality Program will provide training for the Ecology permit writers on changes to the rule and associated changes to the Water Quality Program Permit Writer's Manual (Publication 18-10-042, 15 January 2019). The Permit Writer's Manual will be evaluated to determine if updates are needed to implement the proposed rule. Permit writing tools, templates, and forms will be updated to account for provisions in the new rule, and permit writers will be notified of changes. Typically, changes to the Permit Writer's Manual must get approval from the Water Quality Program management team represented by both regional and headquarters managers. Thus, the permit writing staff will also receive reinforcement from their managers regarding use of the new guidance. The Water Quality Program has a Permit Writer's Workgroup that is made up of permit writers who meet quarterly to discuss emerging permit issues and facilitate communication throughout the regions and across other programs. The workgroup provides ongoing support for implementing the water quality standards in permits. Training permit writers will help inform permittees on how to comply with new requirements.

Water Quality Assessment

Staff working with the Water Quality Assessment will help inform any revised methodologies that are needed in order to assess Washington waters for compliance with the final new fresh water dissolved oxygen (DO) and fine sediment criteria.

Total maximum daily loads (TMDL)

Regional TMDL staff will continue to be informed of changes to the standards through TMDL quarterly meetings, workshops and ongoing interactions. TMDL staff have been informed of the proposed rule changes and we will continue to work with staff to get the proposed criteria changes integrated into the TMDL program.

Nonpoint programs

Water quality standards staff are regularly included in nonpoint program staff meetings. Standards staff have discussed this rule and its influence on nonpoint programs and will continue to discuss implementation issues. Additional training on implementation of the revised water quality standards will be provided to Ecology staff upon request.

List of Supporting Documents that May Need to be Written or Revised

We may write or revise the following because of the adopted rule:

- Freshwater monitoring program protocols
- Water quality program policy 1-11
- Permit Writer's Manual

More Information

Rulemaking Website: WAC173-201A-Salmon spawning habitat - Washington State Department of Ecology[3]

[3] https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-201A-Salmon-spawning-habitat

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Appendix A. DRAFT Implementation of the Narrative Criterion for Fine Sediment

Introduction

Purpose of this guidance

This guidance document provides sampling recommendations and approaches for making a determination of an exceedance of the fine sediment criterion. The sampling recommendations are taken from existing methods in Ecology's Watershed Health Monitoring (WHM) program, standardized protocols, or scientific literature. This document is considered draft and will be finalized after rule adoption through a separate process to develop a Water Quality Assessment methodology. However, this draft document provides our initial review of sampling methods to determine an exceedance of the proposed fine sediment narrative criterion.

Exploring multiple methods

We are proposing multiple methods to assess the fine sediment or the impacts of fine sediment to provide flexibility in evaluating the aquatic life and substrates of each unique waterbody. The sediment composition of waterbodies can vary significantly depending on the landscape, geology, and watershed. For example, the assessment of a glacial fed stream will typically be different from a low gradient stream surrounded by grasslands.

Including draft screening levels for methods

Upon review of literature and work that other states are doing, we have developed some screening level thresholds that can be used to evaluate if fine sediment is a pollutant of concern in a waterbody and if further analysis is needed. However, the screening level assessment is not the sole method to determine that a waterbody is impaired or not impaired. If a given waterbody does not exceed screening thresholds, but there is reasonable potential that anthropogenic inputs of fine sediment are negatively affecting the stream, further analysis should occur through other assessment tools. An exceedance of screening levels is an indication that there may be a concern in the waterbody. This should be followed by a waterbody specific analysis of natural occurring sediment, anthropogenic inputs of sediments, and an analysis of the viability of successful salmonid spawning and rearing. A reference site comparison and weight of evidence approach will aid in making a determination on the sediment quality of a waterbody.

Some methods rely on reference site information

The reference site approach compares fine sediment parameters between the waterbody of interest and a site considered to be minimally impacted by anthropogenic influences. The reference site should occur in the same watershed or ecoregion and possess many of the same waterbody characteristics of the waterbody of interest. A statistical analysis of fine sediment parameters collected at the reference site and the site of interest should be used to make a determination of significance. If the site of interest is significantly different for fine sediment parameters at the reference site or thresholds, then additional evaluations need to be made using the weight of evidence approach.

Supporting a final methodology through a weight of evidence approach

A weight of evidence approach uses fine sediment parameters that have been identified to be most useful in evaluating sediment and habitat quality for aquatic life. This approach evaluates whether there is reasonable potential that a waterbody is impaired due to anthropogenic inputs of fine sediment. The weight of evidence approach uses levels of confidence to determine if a water is of concern or if a waterbody is impaired for fine sediment.

Summary of Parameters Used to Characterize Fine Sediment

A summary of the parameters used to characterize fine sediment can be found in Table A-1. Parameters selected are grouped as measures from the water column, streambed, water chemistry, and biomonitoring. The measures include suspended solids, percent substrate (visual), subsurface fines (quantitative), relative bed stability, intragravel dissolved oxygen, and the fine sediment biotic index (FSBI).

The parameters selected to characterize fine sediment have been identified as primary or optional. Primary parameters are considered the parameters of highest priority and importance to making a fine sediment determination. Optional parameters provide key supplemental information that can be used in the weight of evidence approach when determining a fine sediment exceedance.

Table A-1. Summary of parameters used to characterize fine sediment.

Environmental Compartment	Measure	Primary or Optional
Water Column	Suspended Solids	Optional
Streambed	Percent Substrate	Primary
Streambed	Subsurface Fines	Optional (if measuring intragravel dissolved oxygen)
Streambed	Relative Bed Stability	Primary
Chemical	Intragravel Dissolved Oxygen	Optional (if measuring subsurface fines)
Biological	Fine Sediment Biotic Index	Primary

Sampling Recommendations

Sampling Overview

We recommend that water quality sampling for fine sediment follow existing methods established by the WHM program for biological monitoring (Adams, 2010). The WHM is primarily focused on wadeable or “narrow” streams and is based on work by EPA (Kaufmann and Robison, 1998). The WHM program has developed stream monitoring protocols for non-wadeable or "wide" streams as well (Wide and Narrow Protocols[4]). EPA guidance for sampling non-wadeable streams is also available (Kaufmann, 2000). The recommended methods use a randomized, systematic spatial sampling design to minimize bias in the placement and positioning of measurements. Measures are taken over defined channel areas, and sampling locations are systematically spaced proportional to channel width. For purposes of fine sediment analyses, a focus on specific waterbody segments may be more appropriate than randomized systematic sampling.

The WHM is aimed at monitoring streams that are perennial and are representative of each of the 5 Strahler-order based size classes. In the WHM approach, each reach is divided into 11 transects of equal distance per reach (Figure A-1). Since 2009, Ecology methods for sampling the stream invertebrate community are consistent between its two routine monitoring programs (see SOP EAP073[5]). They both randomly select 8 of the 11 habitat transects from across the reach for a reach-wide composite.

Prior to 2009, and prior to WHM's habitat-based routine monitoring, Ecology's Ambient Bioassessment program used a targeted riffle approach, in which all aliquots were collected from riffles. Ecology abandoned this method to improve descriptions for reach-wide biological conditions, the scale upon which WHM habitat metrics are based. Rehn et al. (2007) stated, "Raw data sets and biological indicators derived from targeted riffle and reach wide samples may be generally interchangeable when used in ambient biomonitoring programs." However, many researchers have found that consistently identifying habitat types is difficult because they change with flow. Targeting riffles can introduce sampling error (Poole et al., 1997). For these reasons, investigators use a reach- wide sampling scheme (Hayslip, 2007), as opposed to a targeted "riffle only" sampling scheme (Rehn et al. 2007). In a reach- wide scheme, 11 equidistant transects are established along the stream reach (between 150 m and 2 km in length) and sampling is conducted systematically without consideration for habitat type.

While reach wide sampling is a useful scheme for long-term monitoring projects, special requests for monitoring may require targeted sampling. Noise in signals of impairment is introduced when habitat-wide data are included in a targeted study (Parsons and Norris, 1996). Data collected from habitat specific samples help reduce noise and allow clear and consistent detection of response to pollutants at an impacted site. For example, the use of riffle habitats for targeted studies such as TMDLs capture the composition of more pollution-sensitive communities. Recently, studies have shown that there is no statistical difference between samples collected from riffles only and those collected from reach-wide designs (Kerans et al. 1992; Rehn et al. 2007). Therefore, historical Washington State data collected in riffles only are

[4] https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Standard+Operating+Procedure+(SOP)+%e2%80%94+Watershed+Health+Monitoring&DocumentTypeName=Publication

[5] https://apps.ecology.wa.gov/publications/SummaryPages/1803202.html

useful for describing past and current stream health in streams currently monitored using habitat-wide methods.

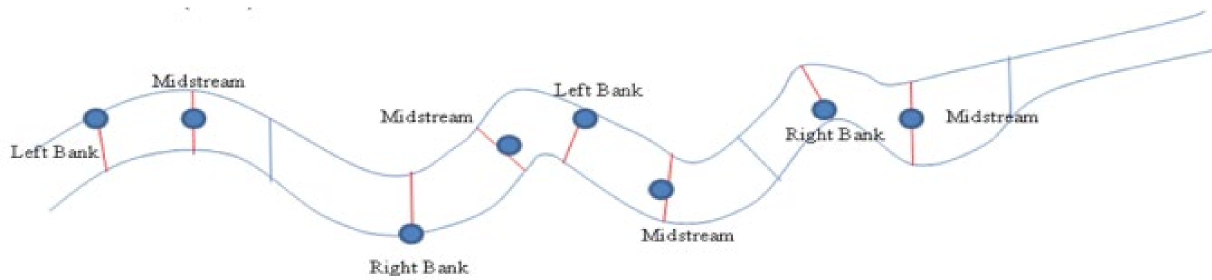

Figure A-1. Reach-wide composite samples from 8 of 11 transects.

Sampling must occur between July 1 and October 15 of each year following WHM program guidelines. This timeframe was chosen for the following reasons:

- Adequate time has passed for the instream environment to stabilize following natural disturbances (such as spring floods)
- Many macroinvertebrates reach body sizes that can be readily identified
- Representation of benthic macroinvertebrate species reaches a maximum, particularly during periods of pre-emergence, typically from mid-spring to late summer

This time window is largely consistent with "fish windows" for most streams during which early life stages of salmonids are not present. Therefore, we recommend harmonizing fine sediment analyses with the WHM sampling timeframe.

Human Disturbance Evaluation

Sources of suspended sediment can result from:

- Exposed soil (plowing, livestock grazing, devegetated banks, logging roads and trails, construction, road maintenance, landslides, burned forests, erosional rills and gullies, stored soil or waste)
- In-stream processes (gravel mining, vehicle or boat traffic, dredging and trawling, breached impoundments, incised channels, channel modification, eroding stream banks, shallow root systems, fish activity)
- Altered flows (impoundments, upstream scoured streambeds, impervious surfaces, lack of connectivity with floodplain)

EPA developed a simple conceptual model for impacts of sediment inputs on waterbodies (Figure A-2). Generally, examination of the riparian habitat, riverbanks, and nearby surrounding area will provide information regarding sources of fine sediment. Other useful methods may include any available watershed information, an evaluation of natural features in the stream and headwaters, and GIS analyses of landscape level changes and watershed erosion.

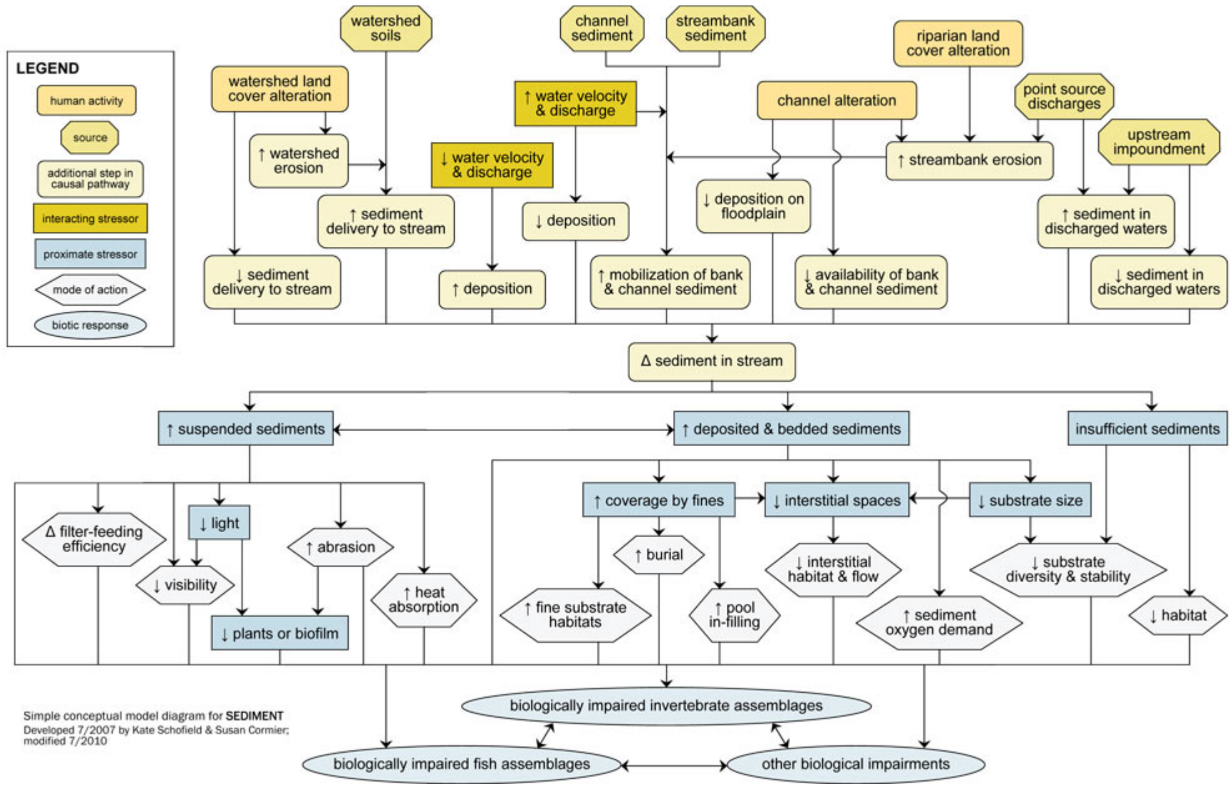

Figure A-2. Simple conceptual diagram depicting human related pathways from sources to sediment impairments (US EPA - Sediments | CADDIS Volume 2 | US EPA[6]).

Field characterization of the presence and proximity of various types of human activities, disturbances, and land use in the river riparian area is adapted from methods developed by Kaufmann and Robison (1998) for wadeable streams and Lazorchak et al. (2000) for non-wadeable streams (Figure A-3). Ecology currently relies on methodology developed for wadeable (Peck et al. 2006) and boatable (Peck et al. 2005) surveys developed by EPA. This information shall be used in combination with riparian and watershed land use information from aerial photos and satellite imagery to assess the potential degree of disturbance of the sample river reaches.

For the left and right banks at each of the 11 detailed Channel/Riparian Cross-Sections, evaluate the presence/absence and the proximity of 11 categories of human influences including:

1) walls, dikes, revetments, riprap, dams
2) buildings
3) pavement
4) roads or railroads
5) inlet or outlet pipes

[6] https://www.epa.gov/caddis-vol2/caddis-volume-2-sources-stressors-responses-sediments#tab-3

6) landfills or trash
7) parks or maintained lawns
8) row crops
9) pastures, rangeland, or hay fields
10) logging
11) mining

Observations are confined to the river and riparian area within 5 m upstream and 5 m downstream from the cross-section transect (narrow protocol) or 10 m up and down (wide protocol). Four proximity classes are used: 1) on the riverbank or in channel; 2) 0 - 10 m; 3) 10 – 30 m; and 4) absent. Ecology's disturbance indexes derived from these data are discussed on pages 96 to 103 of the Habitat Metric Dictionary[7] (Janisch 2013).

[7] https://apps.ecology.wa.gov/publications/documents/1303033.pdf

Category	Left Bank				Right Bank			
Buildings	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Clearing or Lot	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Park/Lawn	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Pasture/Range/Hay Field	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Row Crops	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Pipes (Inlet/Outlet)	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Landfill/Trash	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Logging Operations	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Mining Activity	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Human Foot Path	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Unpaved Motor Trail	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
PavedRoad/Railroad	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank
Wall/Dike/Revetment/Riprap/Dam	Absent	10-30m	0-10m	On Bank	Absent	10-30m	0-10m	On Bank

Figure A-3. Watershed Health Monitoring Program E-form to record human disturbances by category and proximity.

Percent Surface Substrate (Visual)

Percent substrate field and metric calculation procedures should follow the methods summarized in WHM Standard Operating Procedures[8] and Ecology Publication 13-03-033 (Jansich, 2013). These are derived from EPA methods (Kaufmann et al. 1999; Hillman, 2004; Peck et al. 2005, Peck et al. 2006), but Ecology's methods are from the bankfull channel and involve 11 observations per transect rather than five (231 stations in a waded stream vs 105). These methods

[8] https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods

involve observation of surface particle sizes within a given transect of a stream reach. Generally, substrate can be classified as:

- smooth or rough bedrock (>4 m)
- hardpan (>4 m)
- large boulders (>1 m to 4 m)
- small boulders (250 to 1000 mm)
- cobble (64 to 250 mm)
- coarse gravel (16 to 64 mm)
- fine gravel (2 to 16 mm)
- sand (0.06 to 2 mm)
- fines (≤0.06 mm)

A value of 100 indicates that every station in each transect of the site reach was estimated to be of the same particle diameter category. Percent of other, non-lithic particles can also be reported, but those are less informative and do not factor into the bed stability calculation.

Systematic channel pebble counts can be directly reduced to whole-reach substrate characterizations by calculating percentages of observations within stated size classes. Because the data are systematically spaced, these averages and percentiles are interpreted as unbiased representations of the substrate characteristics measured. Reach level substrate compositions are also evaluated based on various combinations of categories:

- Smooth & Rough bedrock
- Coarse gravel and larger sizes
- Fine gravel and smaller sizes
- Sand and fines
- Small and large boulder

This rule focuses on fine sediment, and thus, the percent sands and fines is of greatest interest for determining a fine sediment exceedance. However, it is helpful to know the distribution of substrate in order to determine trend information and evaluate the impact of restoration efforts on impaired waterbodies.

Percent Subsurface Fines

Percent subsurface fines is not measured in Ecology's WHM, and therefore there are no existing sampling regimes within the Department of Ecology. Subsurface sediment measurements should target riffles and spawning areas in streams with gravel and cobble. Subsurface fines is a mass based measurement that assesses content of surface and subsurface particles. Core sampling methods by Nelson et al. (2002) is recommended by the state of Idaho. Similar methods that entail core sampling may be applicable to subsurface fine collection (Bunt and Abt, 2001). Based on review of literature and research, we recommend a shovel based sampling method that produced comparable results to hollow-core samplers (Grost et al. 1991; Hames et al. 1996; Sutherland et al. 2010). Subsurface samples should be sieved and weighed in the field to determine the mass of the sediment size fractions: >64 mm, >16 mm, and >6.35 mm. Sediment <6.35 mm is typically retained and brought to the lab or be dried, sieved and weighed. At a minimum, particle size fractions of <0.85 mm and <2 mm should be determined.

Relative Bed Stability

Relative bed stability (RBS) involves a series of physical habitat measurements that is expressed as the ratio of the observed substrate median diameter or geometric mean diameter divided by the average critical diameter at bankfull flow (the reach average for the largest particle that is mobile during bankfull flow; Dingman, 1984). RBS values are often expressed as logarithms for comparisons and normalizing variances. As demonstrated in the stepwise equation, the following are required to calculate RBS:

- slope
- mean thalweg depth
- bankfull height
- mean thalweg residual depth
- wood volume per bankfull channel planform area (i.e. wood depth)
- geometric mean bed surface particle diameter measurements

These metrics are collected as part of Ecology's WHM. Ecology has established protocols for collecting the parameters necessary to calculate RBS (Standard Operating Procedures – Watershed Health Monitoring[9]).

Based on review of literature and research, we recommend that RBS and associated parameters used to calculate RBS follow protocols developed in Ecology's WHM (Standard Operating Procedures – Watershed Health Monitoring).

The stepwise methods to calculate RBS and logarithmic RBS (LRBS) are discussed on pages 12 to 21 of Janisch (2013).

Suspended Solids Concentration

Suspended solids concentration (SSC) can vary depending on flow conditions making it difficult to compare to reference conditions. Based on literature and research, we recommend that SSC be measured under average flow conditions (± 20%) for the waterbody of interest for that time of year and should not be collected following a significant rainfall (defined as 0.5 inch or more within 24 hours).

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[9] https://apps.ecology.wa.gov/publications/UIPages/PublicationList.aspx?IndexTypeName=Topic&NameValue=Standard+Operating+Procedure+(SOP)+%e2%80%94+Watershed+Health+Monitoring&DocumentTypeName=Publication

The United States Geological Survey (USGS) standard method for determining suspended solid concentrations is ASTM D 3977-97, Standard Test Methods for Determining Sediment Concentration in Water Samples. This method is reportedly used by all USGS sediment laboratories and cooperating laboratories certified to provided SSC data to the USGS. Studies on the accuracy of the ASTM D 3977-97 have demonstrated accurate measurements of SSC (Gray et al. 2000). Another optional method is EPA method 180.1.

We recommend following ASTM D 3977-97, EPA method 180.1, or updated versions for measuring SSC.

Intragravel Dissolved Oxygen

Intragravel dissolved oxygen (IGDO) can vary substantially depending on site-specific location. To account for spatial variation in a fine sediment assessment, we recommend a representative IGDO measurement should occur at each transect within a given reach, following the sampling regime of the WHM program. Each sampling location should target riffles and spawning areas in streams to the degree possible. For each reach, the spatial median value should be calculated to determine the representative value for a given reach of a waterbody. A minimum of three samples are required within a specified habitat area. Sampling should follow the reach and transect approach described in the "Sampling Overview" section above.

Several methods are available to measure IGDO, with most techniques involving a piezometer or standpipe. The state of Alaska recommends using the technique found in "Variations in the Dissolved Oxygen Content of Intragravel Water in Four Spawning Streams of Southeastern Alaska" (McNeil, 1962). Hoffman (1986) developed the horizontal intragravel pipe that sought to allow significantly more water to be withdrawn for analysis, given that the McNeil method limited samples to about 30 mL. Terhune (1958) developed a standpipe method that measured substrate permeability and IGDO but could not extract a core sample for particle size analysis. Banard and McBain (1994) developed a standpipe method that requires extracting a freeze core to determine permeability, DO, and vertical particle size distribution in gravels. Jeric et al. (1995) developed a method that draws water through a syringe from an intragravel pipe. All of these methods and variations thereof may be applicable to measuring IGDO.

Biomonitoring

Benthic macroinvertebrate community data should be collected and reported in accordance with the "Standard Operating Procedures and Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrate Data in Streams and Rivers" (Larson, 2019), or, using protocols that are at least as rigorous as Ecology standard operating procedures and that produce data to which the Benthic Index of Biological Integrity (B-IBI) and FSBI model can be applied. Ecology currently has a quality assurance monitoring plan for collecting benthic macroinvertebrates as part of the WHM (Adams, 2010). We recommend these methods continue to be used for the purposes of evaluating benthic macroinvertebrate health alongside fine sediment based parameters. Once samples are collected, we recommend that the FSBI be used to compare the health of the benthic macroinvertebrate community to reference sites within the same ecoregion as the waterbody of interest.

Approaches to Fine Sediment Assessments

Threshold Approach

A threshold approach may be employed as a screening level tool to determine if there is excess fine sediment that could result in adverse effects to aquatic life. In some circumstances, substantially high exceedances of single parameter thresholds should be considered in determining an exceedance of the fine sediment criterion. Relationships between fine sediment based parameters and biological responses are generally poorly understood. However, for some metrics, thresholds have been determined that are indicative of negative impacts to salmonid spawning and rearing.

Composite samples for a stream reach or waterbody segment may be appropriate to evaluate sediment quality. Composite samples may be presented as a mean or median value for each metric (i.e. percent substrate, LRBS, subsurface fines, IGDO, SSC, FSBI) for a given waterbody or waterbody segment. Where applicable, the variability around the statistic should be reported. Fine sediment quality may be of concern when a particular parameter exceeds screening level thresholds developed based on literature or reference site information gathered within Washington State (Table A-2).

Table A-2. Thresholds for fine sediment based parameters.

Parameter	Threshold
Percent Substrate	If >20% fines (<2 mm), then do full characterization of fine sediment and proceed to comparison with reference site
Subsurface Fines	If >20% fines (< 2 mm), then do full characterization of fine sediment and proceed to comparison with reference site If >10% fines (< 0.06 mm), then characterize fine sediment and proceed to comparison with reference site
LRBS	In the absence of ecoregional reference values, LRBS should be greater than -1. If LRBS is -1 or lower, then do full characterization of fine sediment and proceed to comparison with reference site. Lower 25th percentile within given ecoregion: Coast Range: To be determined Puget Lowlands: To be determined

Parameter	Threshold
	North Cascades: To be determined Cascades: To be determined Columbia Plateau: To be determined Northern Rockies: To be determined Willamette Valley: To be determined Blue Mountains: To be determined
Fine Sediment Biotic Index	If the 10%tile of ecoregional reference values are exceeded, then do full characterization of fine sediment and proceed to comparison with reference site. Coast Range: 89 Puget Lowlands: 89 North Cascades: 89 Cascades: 89 Columbia Plateau: 8 Northern Rockies: 79 Willamette Valley: 89 Blue Mountains: 79
Intragravel dissolved oxygen	If < 6.0 mg/L, then proceed to full characterization of fine sediment, and proceed to reference site comparisons
Suspended solids concentration	If >20% percent increase in SSC over natural or instream background conditions, then proceed to full characterization of fine sediment, and proceed to reference site comparisons

Percent Substrate and Subsurface Fines

The threshold approach for percent substrate and subsurface fines is set at 20% sand/fines at particle sizes less than 2 mm. Additionally, subsurface fines threshold for particle sizes less than 0.85 mm is 10% fines. This threshold is based on multiple peer-reviewed articles that indicate at percent fine levels greater than the thresholds recommended results in adverse effects to early life stages of salmonids (Bryce et al. 2010; CDPHE, 2002; Table A-3, Table A-4).

Table A-3. Optimum sediment tolerance values and medians for areal percentage fines (≤0.06 mm) and areal % sand and fines (≤2 mm) for selected sediment-sensitive species. Percent fines for salmonids were first presented in Bryce et al. (2008). This table was adapted from Bryce et al. 2010.

Taxon	**% Fines (≤0.06 mm)**	**% Sand / Fines (<2 mm)**
Sediment-sensitive salmonids		
Chinook salmon	4	11
Bull trout	6	11
Rainbow trout	7	16
Cutthroat trout	8	19
Sediment-sensitive amphibians		
Foothill yellow-legged frog	2	11
Tailed frog	3	7
Pacific giant salamander	9	14
Rough-skinned newt	9	14
Red-legged frog	10	17
Cascades frog	11	15
Sediment-sensitive macroinvertebrates		
Trichioptera (*Ecclisomyia sp.*)	1.6	7.3
Ephemeroptera (*Epeorus grandis*)	1.7	9.1
Ephemeroptera (*Caudatella hystrix*)	2.5	12.3
Plecoptera (*Pteronarcys sp.*)	2.6	8.2
Trichoptera (*Oligophlebodes sp.*)	3.0	8.8
Trichoptera (*Arctopysche grandis*)	3.6	10.2
Ephemeroptera (*Epeorus longimanus*)	3.9	11.4
Plecoptera (*Megarcys sp.*)	4.3	11.4

Table A-4. Summary of the effects of particle size on salmonid spawning and rearing (adapted from CDPHE, 2002).

Reference	Species	Endpoint Evaluated	Study Location	<Particle Size (mm)	% Fines Threshold
Bennett et al. (1993)	Chinook salmon	Emergence success	WA, ID, Lab	6.4	24
Bjornn (1969)	Steelhead trout and Chinook salmon	Embryo survival and emergence success	Lab	6.35	20
Burton et al. (1990)	Chinook salmon	Embryo survival	ID	6.03	20
Canadian Council of Ministers of the Environment (2002)	Salmonids	Results in 80% embryo survival	CAN	<2 3 6.3	10 19 25
Chapman (1988)	Coho salmon Chinook salmon and steelhead trout Rainbow trout	Embryo survival	Lit Review	0.85 6 6-12	20 20 10
Hausle and Coble (1976)	Brook trout	Embryo survival and emergence success	Lab	1-3	20
Jensen et al. (2009)	Pacific salmon	Embryo survival	Lit Review	0.85 6.4	10 20
Kondolf (2000)	Trout: bull, brook, cutthroat, steelhead, rainbow Salmon: coho, Chinook, chum, Kokanee	Results in 50% emergence success	Lit Review	2 3.35 6.35 9.5	10 30 30 28
McHenry et al. (1994)	Coho salmon and steelhead trout	Embryo survival		0.85	10
Phillips et al. (1975)	Coho salmon and steelhead trout	Emergence success	Lab	1-3 (sand)	20
Sowden and Power (1985)	Rainbow trout	Embryo survival	Ontario	2	25
Tappel and Bjornn (1983)	Steelhead trout and Chinook salmon	Embryo survival	Lab	0.85 9.5	<12 <35
Weaver and Fraley (1993)	Westslope cutthroat trout	Emergence success	MT	6.35	20
Witzel and MacCrimmon (1983)	Brook trout and brown trout	Survival and emergence	Lab	2	<20
U.S. FWS Habitat Suitability Index Models (1982, 1984, 1986)	Brook trout, brown trout, cutthroat trout, and rainbow trout	Survival and emergence	Lit Review	3	5-30%

In other studies, Hall (1986) found survival of egg to emergence of coho, chinook, and chum salmon to be 7-10% when fines composed 10% of the substrate at particle sizes of <0.85 mm compared to 50-75% survival with no fines <0.85 mm. Reiser and White (1988) found little survival of steelhead and Chinook salmon eggs beyond 10-20% fines <0.84 mm. In artificial redds, Bjornn et al. (1998) reported a significant reduction in fry survival when fines <0.25 mm comprised 5% of the substrate in the egg pocket. Three tiers of subsurface sediment conditions were developed for the Clearwater River drainage that included good conditions for embryos at <20% subsurface fines (<6.3 mm), marginal conditions from 20 to 27% fines, and improbable survival above 27% fines (Rowe et al. 2003). The Forest Service and the Bureau of Land Management developed guidelines based on the Clearwater and Nez Perce National Forests and Cottonwood (Idaho) area that indicated high levels of habitat conditions when fines were less than 20% (<6 mm) at depth, while >25% fines was considered poor habitat conditions (USDA-FS et al. 1998).

Benthic Macroinvertebrates

Ecology has developed B-IBI thresholds for indicating degraded biological integrity and diagnostic metric thresholds for the FSBI by ecoregion (Table A-5). The B-IBI thresholds are derived from 10,000 bootstrap replications for reference site scores within the various ecoregions of Washington using data through 2016.

Table A-5. B-IBI and fine sediment biotic index thresholds for different ecoregions in Washington State using data through 2016.

EPA Level III Ecoregion	B-IBI (0-100 scale) 10th Percentile	Fine Sediment Biotic Index[2]
North Cascades	63	89
Cascades	72	89
Coast Range	62	89
Puget Lowland	65	89
Willamette Valley[1]	65	89
Eastern Cascades Slopes & Foothills	54	79
Northern Rockies	60	79
Blue Mountains	68	79
Columbia Plateau	39	8

[1]The threshold for the Puget Lowland ecoregion also applies to the small portion of the Willamette Valley Ecoregion in Washington for Water Quality Assessment purposes.

[2]Scores less than these values indicate sediment pollution. These numbers are based on the 10th percentile of Fine Sediment Biotic Index values at reference sites in western Washington, eastern Washington, and the Columbia Plateau.

Relative Bed Stability

Currently, Ecology does not have LRBS reference values for ecoregions within Washington State. However, data exists within the Environmental Information Management database to develop thresholds or reference values. EPA outlines methods for developing reference values for LRBS (US EPA, 2020). The development of LRBS reference values may be completed in the future. In the absence of LRBS waterbody specific or ecoregional reference values, literature may be used to develop screen level thresholds. A study conducted by Kaufmann et al. (2008) in the Pacific Northwest found that sites in the upper quartile of human disturbance and riparian area had LRBS values ranging from -1.1 to -4.2. We have used this information to determine a threshold of less than -1 for LRBS.

Intragravel Dissolved Oxygen

As previously discussed, IGDO levels can vary temporally and spatially. Research has suggested that early life stages of salmonids require IGDO levels of 8.0 mg/L (Hicks, 2002; EPA, 1986). However, it is recognized that the salmonid redd excavation process can contribute to higher levels of IGDO by removal of fines resulting in increased water flow and permeability (Groves and Chandler, 2005). When measuring IGDO levels using a piezometer or other instruments, it is unlikely that redds would be targeted due to the risk of injuring the embryos. Therefore, water quality monitoring of IGDO will likely occur at locations that may not be subject to the improvements made by spawning adult salmonids. We are recommending IGDO levels at a minimum level of 6.0 mg/L as a screening level threshold for which levels should not fall below. The 6.0 mg/L level aligns with current Idaho water quality criteria for IGDO and accounts for environmental variables that may result in slight reductions in DO in the absence of early life stages of salmonids. At a spatial median IGDO value of 6.0 mg/L and below, we have reasonable certainty that the water quality may be limited due to fine sediment.

Suspended Solids Concentration

SSC thresholds are based on an increase in the suspension of particles relative to background conditions under average flow conditions. An increase in 20% of SSC over background concentrations provides reasonable assurance that inputs of fine sediment are contributing to a reduction in sediment quality in the streambed. The 20% increase in SSC is based on a similar criterion that Washington has for turbidity. SSC is more specific than turbidity for measuring solid-phase particles in surface waters.

Reference Site Approach

To determine if a waterbody contains excessive fine sediment, the metrics used to characterize fine sediment should be compared to historical background conditions, upstream-of undisturbed sites, or reference sites within the same watershed or ecoregion. We suggest that if background information exists from historical monitoring of a waterbody, that it be compared to recent data to determine if significant sediment related changes have occurred within the waterbody. However, it is unlikely that historical information will be available for all metrics and therefore, other options will need to be utilized for reference conditions.

If anthropogenic inputs of sediment are identified at specific locations or segments of a waterbody, then undisturbed upstream sites may be used for comparison. Upstream sites should not be used if there is evidence of anthropogenic inputs of fine sediment or significant alteration in the landscape that may affect the metrics being measured in the evaluation of fine sediment. Upstream sites should be minimally impacted to serve as a reference condition. Given that many of Washington's waterbodies have been impacted in upper watersheds from historical logging practices, other options may need to be used for a reference condition.

In the absence of in-stream background conditions identified from historical monitoring data or at upstream-undisturbed sites for a waterbody, we suggest that a reference site be used. Reference sites should be within the same watershed or ecoregion. If reference sites are unavailable within the same watershed or other waterbodies do not share similar geomorphological characteristics, then reference sites should be selected according to ecoregion. Since inception, Ecology's routine stream habitat-based monitoring programs (Watershed Health Monitoring and Biological Monitoring Programs) have sampled 117 reference sites across eight Level 3 ecoregions of the state (Table A-6). Ecoregional reference values have been developed for some parameters (e.g. RBS, percent surface substrate, FSBI) used for sediment characterization and may be used in a reference site comparison.

Some of these sites assessed are considered sentinel sites, which are sampled annually and others are considered reference sites based on limited human disturbance. The sentinel site studies aim to investigate long-term patterns in stream health at 'least disturbed' sites to determine the impacts of natural shifts in climate, environment, and habitat without the influence of human interference. Some reference sites have been monitored for over a decade and represent a baseline for fine sediment at relatively undisturbed sites. These least disturbed sites may be used for reference sites on a site-specific or ecoregion level. The "reference condition" is the physical, chemical, and biological condition of a class of streams with little or no human-induced degradation. High road densities and the presence of other human activities in Washington State require the definition of minimally disturbed conditions or least disturbed for reference. Minimally disturbed conditions reflect sites that have experienced very little human activity. Least disturbed conditions are based on measurements from best available streams given today's state of the landscape (Stoddard et al. 2006). Data collected from reference sites may be used for comparison in the evaluation of fine sediment.

In 2003 to 2006, prior to habitat-based monitoring, Ecology staff collected annual invertebrate samples from riffles (fast flowing water) of 12 wadeable reference streams among five of the 1986 edition level III ecoregions in Washington: Coast Range, Puget Lowlands, Cascades, Columbia Plateau, and Northern Rockies (Figure A-4; Omernik and Gallant, 1986). The number of ecoregions has expanded to eight (Table A-6).

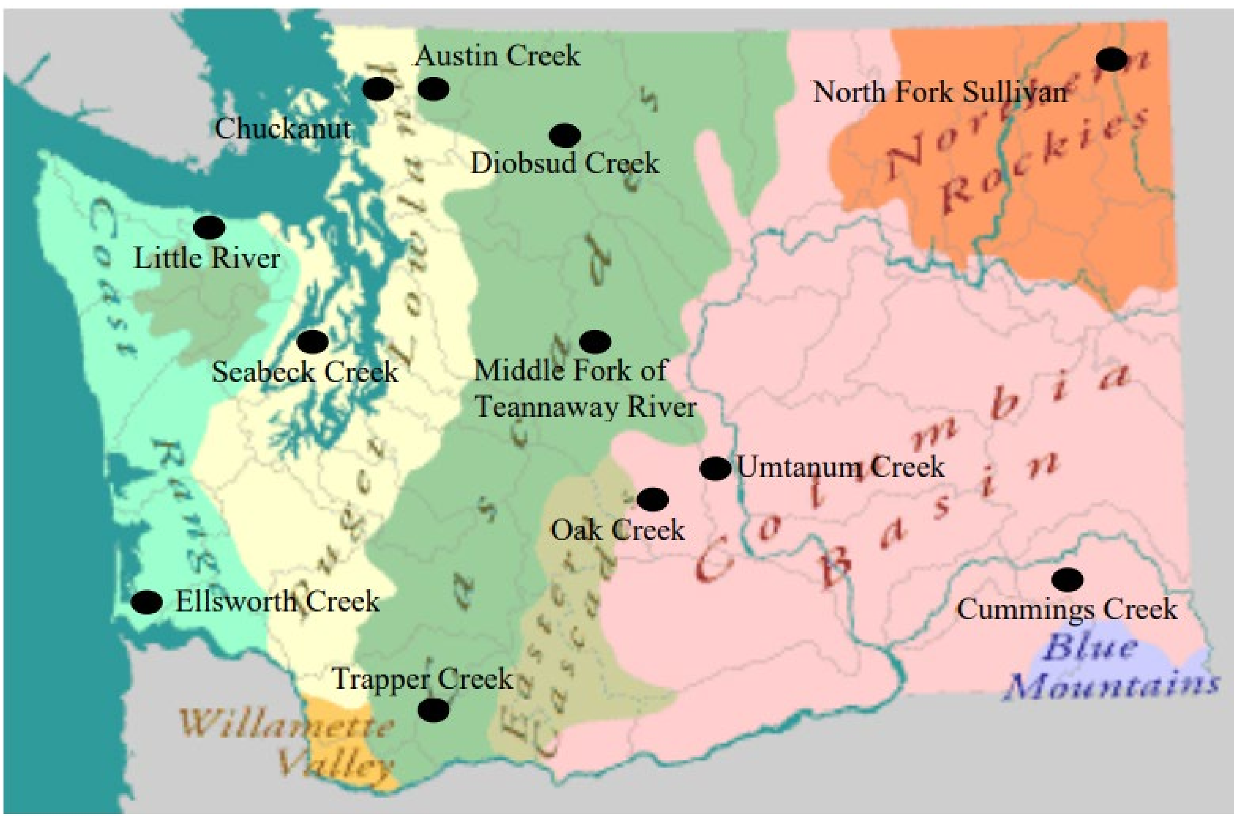

Figure A-4. Washington State Ambient Biological Field Sites (1993-2006) and Ecoregions as defined by Omernik and Gallant (1986).

Table A-6. Number of reference sites sampled by Ecology's routine habitat-based monitoring programs through 2020, by latest Level 3 Ecoregion[10]

Level 3 Ecoregion	**Reference Sites**
North Cascades	20
Cascades	14
Coast Range	16
Puget Lowland	15
Willamette Valley	0
Eastern Cascades Slopes & Foothills	13
Northern Rockies	16
Blue Mountains	8
Columbia Plateau	15

Weight of Evidence Approach

The methods to determine a fine sediment impairment for purposes of the Clean Water Act Section 303(d) will be finalized in Ecology's Water Quality Policy 1-11, Chapter 1. However, the following recommendations may be useful in developing an approach to determining a fine sediment exceedance. We recommend that a weight of evidence approach be established that is not dependent on a single metric or threshold, but rather, multiple metrics that provide support that anthropogenic inputs of fine sediment are excessive.

First, a statistical (i.e., mean or median) value should be calculated for each metric (i.e., percent substrate, LRBS, subsurface fines, IGDO, SSC, FSBI) for the reach, segment, or entire waterbody of interest. Data may be compiled for several reaches within a waterbody segment or for an entire waterbody, or both. Where applicable, the variability (e.g. standard error) around the parameter measured should be reported. We recommend a statistical approach be used, similar to the state of Montana, to compare if metrics for the assessed waterbody differs significantly from the same metrics for the reference condition. In these situations, the statistical value (mean or median) for a given metric in an assessed stream is compared to reference conditions and a determination of significance or non-significance is made. Non-parametric statistical tests are recommended to compare waterbodies to reference conditions for fine

[10] https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

sediment based parameters due to the distribution of data. Statistical methods recommended for comparisons include the 1-Sample Wilcoxon Signed Rank Test (less than 4 sampling events) and the Mann-Whitney U Test (≥ 4 sampling events). If statistical testing reveals statistically significant differences that indicate or support higher levels of excess sediment at the assessed waterbody, then that metric is considered one line of evidence towards determining a fine sediment exceedance. The statistical tests should be conducted for each required metric.

Once statistical comparison tests have been conducted, a determination of exceedance may be determined through the weight of evidence approach. We recommend four primary parameters (percent substrate, LRBS, FSBI, and subsurface fines or IGDO) for a fine sediment determination and two optional parameters (SSC and subsurface fines or IGDO). We recommend that a weight of evidence of ≥75% be used to determine if anthropogenic inputs of fine sediment are in excess. The 75% thresholds assumes reasonable assurance that the site is impaired for fine sediment and that fine sediment presence is not naturally occurring. For example, after evaluating the four required parameters, if one or two parameters out of four are significantly different from reference conditions, the waterbody is not considered impaired (Table A-7). However, if three or four out of four parameters are significantly different from reference conditions, then the waterbody may be considered impaired for fine sediment (Table A-7). If additional fine sediment measures are used, then the ≥75% weight still applies but the number of parameters used would be a total of five or six (Table A-7). If the line of evidence is between ≥50% and <75%, the water may be of concern and sampling should be monitored. The thresholds for the weight of evidence approach will be further reviewed by the water quality assessment program and are subject to change.

Table A-7. Example of a weight of evidence approach for determining a fine sediment exceedance.

Statistically Significant Impairment	Exceedance Determination
1 out of 4 parameters	No exceedance
2 out of 4 parameters	No exceedance
3 out of 4 parameters	Exceedance
4 out of 4 parameters	Exceedance
3 out of 5 parameters	Water of concern
4 out of 5 parameters	Exceedance
5 out of 5 parameters	Exceedance
3 out of 6 parameters	No exceedance
4 out of 6 parameters	Water of concern
5 out of 6 parameters	Exceedance
6 out of 6 parameters	Exceedance

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