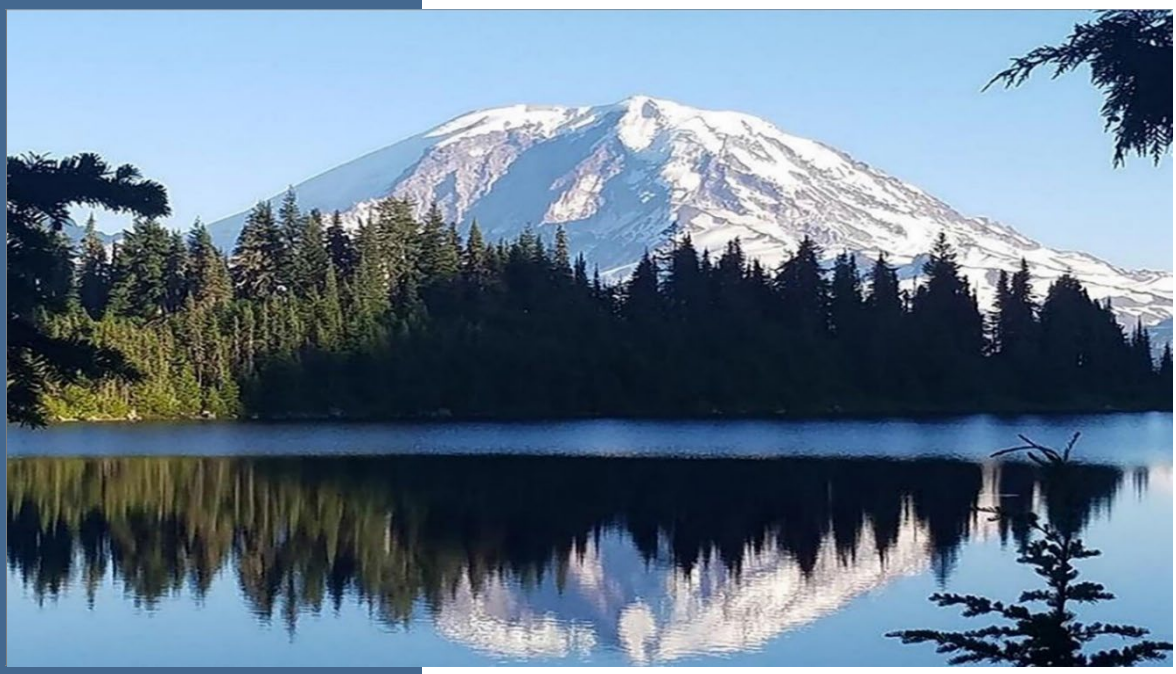

A Performance-Based Approach for Developing Site-Specific Natural Conditions Criteria for Aquatic Life in Washington

Water Quality Program

Washington State Department of Ecology

Olympia, Washington

May 2024, Publication 24-10-017

DEPARTMENT OF ECOLOGY
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Contact Information

Water Quality Program

P.O. Box 47600
Olympia, WA 98504-7600
Phone: 860-407-6600
Website[1]**:** Washington State Department of Ecology

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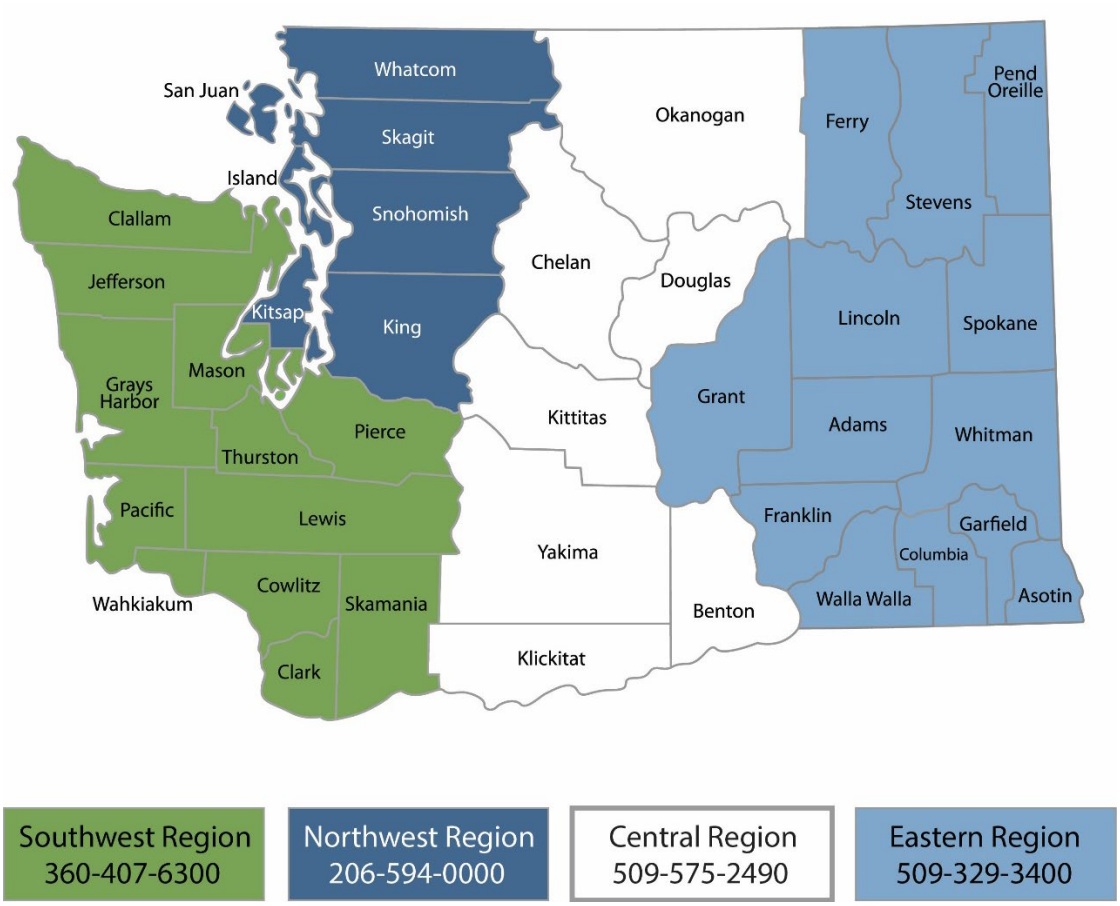
Map of Counties Served



Southwest Region 360-407-6300	Northwest Region 206-594-0000	Central Region 509-575-2490	Eastern Region 509-329-3400

Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

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Introduction and Background

Introduction and purpose

This publication is part of Chapter 173-201A Washington Administrative Code (WAC) Water Quality Standards for Surface Waters of the State of Washington.

Washington Department of Ecology (Ecology) recognizes that in some portions of some water bodies, the assigned aquatic life criteria may not be met due, in part, to the natural conditions of the water body, as acknowledged in EPA memorandum and guidance (Davies, 1997; EPA 2015). Therefore, if these natural climatic or landscape attributes are preventing attainment of applicable numeric aquatic life criteria, then the natural conditions of the system constitute the water quality criteria (see WAC 173-201A-260(1)(a)).

When the natural conditions of a waterbody are used to establish aquatic life water quality criteria, criteria values may be determined by use of various approaches, including the performance-based approach (see DRAFT WAC 173-201A-470).

When the performance-based approach is chosen to establish aquatic life water quality criteria for natural condition scenarios, development of these criteria values must follow the procedures in this document as per DRAFT WAC 173-201A-470. This performance-based approach can only be used for the following water quality parameters:

- Dissolved oxygen (DO; fresh water and marine water)
- pH (fresh water)
- Temperature (fresh water and marine water)

If the determination of aquatic life criteria values cannot meet the requirements set forth in this document, then alternative approaches, such as site-specific criteria, may be considered.

Regulatory information

Federal

The Clean Water Act requires states to adopt water quality standards that consist of designated uses, water quality criteria, and an antidegradation policy. Section 303(c)(2)(A) of the Clean Water Act gives the responsibility for adopting water quality standards to states and authorized Tribes, and that these standards will protect the public health or welfare, enhance the quality of water, and serve the purposes of the Act.

40 CFR 131.3(b) defines criteria as elements of the water quality standards (expressed as constituent concentrations, levels, or narrative statements) that represent a quality of water that supports a particular use such that when criteria are met, water quality will generally protect the designated use.

States and authorized Tribes must adopt water quality criteria that protect these designated uses (see 40 CFR 131.11). States and authorized Tribes may adopt, where appropriate, other criteria that differ from EPA's recommendations, so long as the criteria are:

- Based on sound scientific rationale,
- Contain sufficient parameters or constituents to protect the designated use or uses, and
- Support the most sensitive designated use of the waterbody.

States and authorized Tribes can adopt criteria that are modified to reflect site-specific conditions (see 40 CFR 131.11(b)(1)(ii)), so long as they are based on sound scientific rationale and protect designated uses. EPA has provided guidance for derivation of site-specific criteria outlined in *Water Quality Standards Handbook Chapter 3: Water Quality Criteria* (USEPA, 2023).

In 1997, EPA's Director of Office of Science and Technology Tudor T. Davies released a memo entitled *Establishing Site Specific Aquatic Life Criteria Equal to Natural Background* (Davies, 1997). In this memo, EPA recognized that naturally occurring concentrations of pollutants may exceed national criteria recommendations published under Section 304(a) of the Clean Water Act. EPA described how states and authorized Tribes may establish site-specific numeric aquatic life water quality criteria for waterbodies by setting the criterion value equal to natural background. Natural background was defined as "background concentration due only to non-anthropogenic sources; i.e., non-manmade sources" (Davies, 1997).

The memorandum recommends that the following elements should be included, at minimum, in a state's or tribe's water quality standards when setting criteria equal to natural background:

- A definition of natural background that states natural background is defined as the background concentration due only to non-anthropogenic sources, i.e., non-manmade sources.
- A provision that states site-specific criteria may be set equal to natural background.
- A procedure for determining natural background or a reference in the water quality standards to another document describing the binding procedure that will be used.

EPA has also developed additional documentation to provide clarity and direction for establishing site-specific criteria for temperature, dissolved oxygen, and pH (USEPA, 2015). This document provides a framework that includes recommendations for developing natural conditions criteria, including when using a performance-based approach for determining criteria values.

State

Water pollution control in the State of Washington is regulated under Chapter 90.48 Revised Code of Washington (RCW). This includes 90.48.010 RCW which declares that it is the public policy of the state to maintain the highest possible standard to ensure purity of waters consistent with public health, public enjoyment, and propagation and protection of wildlife, birds, game, fish, and other aquatic life.

90.48.035 RCW establishes the rule-making authority for the Department to promulgate rules and regulations necessary to carry out the provisions of Chapter 90.48, including water quality standards for the state.

Chapter 173-201A Washington Administrative Code (WAC) is the Water Quality Standards for Surface Waters of the State of Washington. This chapter establishes standards for public health and public enjoyment of waters in the State and for propagation and protection of fish, shellfish, and wildlife. The Water Quality Standards include, but are not limited to, the following sections regarding natural conditions criteria:

- WAC 173-201A-020 Definitions
    - Defines natural conditions or natural background levels, which means surface water quality present before any human-caused pollution.
- WAC 173-201A-260(1) Natural conditions and other water quality criteria and applications
    - Recognizes that portions of water bodies cannot meet the assigned aquatic life criteria due to natural conditions. When this occurs, this section establishes that the natural conditions constitute the water quality criteria.
- WAC 173-201A-430 Site Specific Criteria
    - Lists the requirements for determining site-specific criteria, which includes conducting development of such criteria that are scientifically justifiable.
- DRAFT WAC 173-201A-470 Performance-based approach
    - Lists the requirements for determining site-specific criteria using a performance-based approach. Criteria developed under this approach must be derived using procedures found in this document, which is adopted by reference into regulation.

Performance-Based Approach Use

Overview

Use of the performance-based approach may be considered when developing site-specific natural conditions criteria when all applicable and prerequisite state and federal regulations are met. This includes, but is not limited to, the natural conditions provision at WAC 173-201A-260(1)(a) and the performance-based approach at DRAFT WAC 173-201A-470.

Aquatic life water quality criteria values developed using the performance-based approach are applicable to the waterbody immediately following the performance-based approach derivation process, so long as all requirements set forth in this document are met. This document serves to meet the minimum recommendations in EPA's 1997 Memorandum that recommends water quality standards include a binding procedure that will be used for determining natural background (Davies, 1997).

Applicable parameters

Use of the performance-based approach is limited to the following parameters:

- Dissolved Oxygen, Fresh Water
- Dissolved Oxygen, Marine Water
- pH, Fresh Water
- Temperature, Fresh Water
- Temperature, Marine Water

Other parameters

This performance-based approach can only be used to establish natural conditions aquatic life criteria for water quality parameters listed in the above "Applicable Parameters" section. Natural conditions aquatic life criteria for other water quality parameters may be developed using alternative approaches specified at WAC 173-201A-260(1)(a), as applicable, and must follow all state and federal rulemaking regulations prior to becoming effective for state and federal Clean Water Act actions.

Natural conditions water quality criteria are appropriate only for the protection of aquatic life uses, not human health uses.

Process-Based Modeling Approach

Introduction

The process-based modeling approach characterizes the natural water quality for a parameter of interest through application of tools such as a water quality model. The water quality model determines the water quality dynamics for the parameter observed at the site of interest under current and natural conditions. This approach will allow quantification of effects at a site on the parameter of interest from both human sources and natural sources.

This approach can be used when there are indications that nonattainment of water quality criteria is due in part to natural processes. This approach can be used regardless of the level of human disturbance to the water body being evaluated, so long as the natural conditions for the parameter and site of interest can be quantified via the approach (i.e., the performance-based approach can be followed in its entirety).

In this approach, developing the natural conditions criteria consists of:

1. Defining where natural conditions will apply (site boundary).
2. Compiling existing, readily available, and credible current and historical water quality and site data.
3. Developing a Quality Assurance Project Plan (QAPP).
4. Obtaining new field data, if required in the QAPP.
5. Compiling, reviewing, and assessing any new field data to ensure it meets quality assurance (QA) / quality control (QC) goals.
6. Developing and calibrating a predictive model of the existing conditions of the waterbody or watershed, including defining temporal and spatial boundaries.
7. Evaluating model performance.
8. Determining whether nonattainment of numeric water quality standards is due, in part, to natural processes.
9. Calculating the natural conditions criteria values by removing known and estimated human-caused impacts from the predictive model.

The analysis of data and development of the criteria values must be documented. If the developed criteria values are used in subsequent state or federal Clean Water Act actions, then: (a) this documentation must be included with the documentation for the CWA action; and (b) the criteria values must be accessible to the public.

Define site boundaries

The first step in developing natural conditions criteria using this approach is defining site boundaries. The boundaries of the site of interest must be defined and documented. Boundary information should include geospatial information. The site boundary consists of the entire model domain, which may include multiple assessment units of interest to the project. Natural

conditions criteria for each assessment unit will be derived based on the resolution of the model and the spatial and temporal variability of its predictions.

Project Quality Assurance Project Plan requirements

The next step in developing natural conditions criteria using this approach is developing the project Quality Assurance Project Plan (QAPP). Data quality objectives and measurement quality objectives must be established within the QAPP to ensure proper model calibration and evaluation such that, once met, the output of the model could be used to inform the selection of appropriate natural conditions criteria. Additional programmatic, departmental, or other requirements may exist for inclusion in any project QAPP.

The project QAPP must provide:

1. Key objectives, goals, and questions that are to be addressed by this project.
2. Observational data quality objectives.
3. Description of the data to be used, identified data needs, and data sources.
4. Model capability descriptions or references, including identification of key processes that drive water quality.
5. Model peer-review approach and/or documentation.
6. How spatial and temporal variability will be addressed in any model or models to ensure that natural condition estimates protect designated and existing uses.
7. Model approaches and key assumptions, which may include boundary conditions and associated determinations, initial or existing conditions, model resolution, inflow loads, or watershed inputs.
8. Description of the computational setup.
9. Model quality objectives, including how model calibration performance and model skill will be evaluated using both quantitative statistics, skill metrics, and qualitative methods.
    a) Model segment or grid size descriptions and rationale as to appropriateness linked to (4).
    b) Description of reasonable fit or other statistics between model-estimated and measured conditions following model calibration.
    c) Performance goal targets.
    d) Any model limitation, uncertainties, and assumptions, and how these could impact (if applicable) the reasonableness to meet the goals and objectives of the project.
    e) Quality Assurance and Quality Control considerations, such as adherence to the Department's programmatic QAPP for assessing impaired waters.

Data sources

All existing, readily available, and credible water quality and site characterization data for the site of interest and waters that affect the site of interest must be considered. Credible water quality data are defined by Washington's Water Quality Data Act in RCW 90.48.585 and

discussed in Water Quality Policy 1-11 Chapter 2, Ecology publication 21-10-032. Waters that affect the site of interest include upstream waters (e.g., tributaries), groundwater, oceanic inputs, and waters outside the jurisdiction of the State of Washington (e.g., waters from another state or country) where relevant. The description of the data compiled and data sources must be documented in the project QAPP.

Water quality data

Water quality data must include data for the parameter(s) of interest in natural condition criteria value development. Additional water quality data may be necessary (e.g., salinity, ambient air temperature) to further demonstrate that nonattainment of an aquatic life criterion is due, in part, to natural causes or to characterize the site of interest. These data requirements will be detailed in the QAPP as they are project specific. For these data, including initial conditions data for model setup, the data must be from a range of years that encompasses the natural variability of a site, waterbody type, and parameter of interest.

Sources of readily available data include state and federal water quality databases. Washington maintains the Environmental Information Management[2] (EIM) database, which contains environmental monitoring data collected by Ecology scientists and partners. Federal water quality data includes data in the Water Quality Portal[3], which integrates data from the United States Geological Survey (USGS), EPA, and other state, federal, tribal, and local agencies. Other sources of information could include datasets related to forests and grasslands (such as from the United States Department of Agriculture Forest Service), water quality data collected by the United States Army Corps of Engineers, United States Department of Interior (including the Bureau of Reclamation) data, other state water quality databases, tribal water quality data, or other credible water quality data from outside the United States.

Existing, available, and credible data may also be found in academic and literature sources, and these published data from reputable research journals must be obtained and considered. Additional sources of data may include data collected under state or federally approved quality assurance project plans, private and public facilities (e.g., data collected as part of National Pollutant Discharge Elimination System, or NPDES, permits), and utilities (e.g., drinking water facilities).

Finally, Ecology has gathered relevant external data sets useful and applicable for water quality impairment studies. A list of these data sources, quality assurance information, and links to data are available in Appendix A of Ecology's Programmatic QAPP[4] (Ecology, 2017). This programmatic QAPP references data sets for water quality process-based modeling which are used to develop natural conditions aquatic life criteria. Data used should follow the quality objectives outlined in the section "Quality Objectives" of the above-referenced document.

[2] https://apps.ecology.wa.gov/eim/search/default.aspx
[3] https://www.waterqualitydata.us/
[4] https://apps.ecology.wa.gov/publications/SummaryPages/1703107.html

Site characterization data

In addition to water quality data, additional data must be identified to characterize the site of interest using all existing, readily available, and credible data. These data must also be sourced for waters that affect the site of interest (e.g., tributaries, upstream waters). These data may be necessary to characterize the site of interest and the application of the model (e.g., model validity), or data may be necessary to assist with other processes (e.g., modeling hydrodynamics, thermodynamics). Specific data needs must be addressed in the project specific QAPP.

Site characterization data information includes, but is not limited to, the following (required unless marked as optional):

- Data characterizing the boundary and initial conditions of the site.
    - Include data for any relevant or appropriate headwaters, tributaries, and groundwaters.
    - This may include applicable water quality data (e.g., dissolved oxygen, sediment characteristics, turbidity). This may also include information regarding nutrient fluxes (e.g., phosphorus, nitrogen, dissolved organic carbon), sediment fluxes, site alkalinity, or planktonic data.
    - Data should be from a range of conditions, both current and natural, encompassing the expected natural and impacted variability of a site and parameter of interest.
        - Conservative assumptions reflective of natural conditions will be made based upon sensitivity (range) testing.
    - Data gaps may be present. See the section “Data Gaps” below on how data gaps are addressed.
- Description of surrounding vegetation and riparian conditions.
    - This may include, but is not limited to, tree canopy cover data, system shade potential, any applicable stream buffer zones, or estimates of the fraction of solar radiation reaching the water surface.
- Waterbody morphology.
    - This includes size, shape (such as measured by shoreline development factor), and connectivity (such as via intersection with surface flow lines).
- Hydrodynamics and physical properties.
    - Including, but not limited to, density, salinity, and tidal attributes (where relevant).
- Light availability.

    - Data characterizing light availability throughout the water column.
- Sediment mobilization and concentrations in the water column.
- Bio-geochemical concentrations and characteristics.
    - Includes relevant water quality and related parameters such as dissolved oxygen, nutrients, photosynthetic pigments, carbonate system concentrations, and metals.
- Sources of groundwater connected to the surface waters of interest.
    - Data could include groundwater quality data and characterization, flow rates, and sources of withdrawal or recharge.
- Hydrological modifications.
    - This may include identification of dams or impoundments, channelization (e.g., dredging, bank erosion) information, impacts to natural flow regimes, and evaluations of bottom roughness and gradient.
- Point source discharges.
    - Identification of all point-source discharges, including NPDES permits. Information related to the discharge should be sourced, such as effluent characteristics, discharge locations, and mixing zone boundaries.
- Non-point source discharges.
    - Identification of all known non-point sources, including those discharges within and upstream of the site of interest.
    - This includes runoff from all sources present that could impact the site, which includes all human activities including but not limited to: agriculture activities; septic systems; mining; presence of non-native vegetation; impervious surfaces; and forestry activities.
        - This could also include surface and groundwater non-point source load information.
    - Provide estimations for nutrient and organic carbon loads for dissolved oxygen and pH natural conditions calculations.
    - This includes water quality data associated with the non-point sources, volume of water from these discharges, and distance between runoff and the site of interest.
- Meteorological data.

    - This includes data such as ambient air temperature, precipitation, humidity, or wind as required by the modeling platform selected (refer to model documentation).
    - These data should capture the expected natural and impacted variability.
- Atmospheric deposition data.
    - Include information relevant to parameters of interest (e.g., nutrient deposition, inorganic carbon or sulfur deposition).
- Other climatic data.
    - This includes long-term data (collected or estimated through climatic models) that describe how humans have impacted the site from a global scale (e.g., watershed temperature increases due to emissions).
- Kinetic and physical rates and ratio data.
    - This includes, but is not limited to, attributes of a site such as primary production rates, aeration, organic carbon decomposition rates, and nutrient limitation rates.
    - Natural conditions parameterization of rate process and kinetic functions must rely on site-specific data, if available.
    - Kinetic and physical rates and ratio values must be consistent with model literature and understanding of natural dynamics for the site and parameter of interest.
- Invasive species.
    - Invasive species information should be sourced, including known habitat.
- Biological indices or other measures (optional).
    - Collect any available information regarding previously reported, scientifically applicable biological indices or other measures that characterize aquatic life health of the system. Indices or measures should be: published in reputable scientific journals or by local, state, tribal, or federal agencies; and peer reviewed.

Types of data

Data sourced for water quality and site characterization is not limited to numeric datasets. In addition to numeric data, all existing, readily available, and credible data could include, but is not limited to, data in the form of:

- GIS data (e.g., maps).

    - Such as maps of the site of interest and surrounding area, including upstream, that indicates historical and current land cover or land use.
- Site-survey data.
    - Data in, near, and around the site of interest, including road coverage and density, hydrological alterations, or other human-constructed structures.
- Site photographs.
    - These could show the presence or extent of riparian vegetation, tree canopy, and waterbody morphology.
- Records from relevant state or federal agencies.
    - This may include information such as historic or current mining activities, forest logging, or other major human actions (e.g., NPDES permits) within or upstream of the site.
- Cultural histories, interviews, or other tribal information of the watershed.
    - This could be used to demonstrate historical uses of the waters.

Data timeframe and metadata requirements

There are no restrictions or limits on obtaining applicable data other than those previously identified (i.e., all existing, readily available, and credible data). Ideal datasets will include long-term data[5] for the water quality parameter(s) of interest and data that represents pre-industrial periods or before large-scale human impacts.

If combining data across multiple time frames to estimate natural conditions, the methodology used in combining data sets must be documented and will be appropriately conservative to capture the range of conditions that protect existing and designated uses across the scales of aggregation.

All associated metadata must be included alongside the sourced water quality and site characterization data. This includes any quality assurance or quality control information, geospatial information, and data collection information (e.g., time of collection, depth).

Data gaps

Any data gaps in the data compilation should be identified. If data gaps are filled (such as through estimation), or any data are estimated for the project, the process for doing so must be described in the project QAPP and final report, and its use must be supported with best professional and scientific judgement.

[5] Defined as data collected regularly (e.g., monthly) over at least ten years.

Model development and requirements

The process-based modeling approach considers the use of a model or models to estimate natural conditions of a system, which can be used to determine appropriate natural conditions criteria for the site of interest. Any models used in this approach must follow the requirements set forth in the project QAPP as well as the following requirements:

- The model must allow for reproducibility of results.
    - This means the model code should be open source, with existing and reference input and output files, alongside data sources, and made available to the public.
- The model framework, including the model code, will have undergone a formal peer-review process before application, or be recognized as widely-used code in the published literature, if not peer reviewed previously and fully documented.
    - Documentation of the peer-review process must be described in the project QAPP or final report associated with this approach.
- Model selection will be from a set of best available modeling tools applicable for the specific purpose to estimate natural conditions based on the project requirements and best professional judgement.
- The model or models chosen must be able to simulate all key processes and sources affecting the parameters of interest.
- Calibration of the model must be done using reasonable adjustments of model parameters, as defined using best professional judgement and comparison to typical parameter ranges documented in literature, peer-reviewed reports, and other similar studies, to achieve a reasonable fit between model-estimated and measured conditions based upon the peer review of the individual model, or by comparing to documented model fit statistics from other similar applications using the same model.
    - The quality of the model calibration must be documented and include both qualitative and quantitative evaluations.
- The model should be able to recreate the existing condition scenarios with the quality specified in the project QAPP.
    - Model calculated outputs must be compared with measured data at calibration locations. A sufficient number of calibration locations will be defined and identified prior to model application.
    - Modeled hydrodynamics and relevant parameters (e.g., DO, temperature, pH) for all waterbody types simulated must be evaluated.
- Model documentation should information about and what are the unknowns and uncertainties in model outputs.
- The model must have sufficient resolution (and such resolution is documented) to:
    - Predict horizontal and vertical variations in water quality (e.g., tributary confluences, varied depths in stratified reservoirs). These predictions must be generated on least an hourly basis.

    - Capture the impacts to all designed uses, including the most sensitive designated use, and provide rationale for this determination in the project QAPP or final report.
    - Identify criteria outcomes that are fully protective of the designated or existing uses.
- The model domain must be large enough to encompass the entire system of interest while sufficiently accounting for boundary conditions.
- All model parameter values must be documented.
- The flow and water quality information for any groundwater, tributaries, upstream inflows, and open boundary inflows must be set at estimated natural conditions of those waters based on readily available and credible information.
    - The methods used and assumptions made must be documented.
- Sensitivity testing must be conducted on the means and ranges on parameters which affect the natural condition outcome.

All technically feasible steps to improve model performance and representativeness of the model, based on available information, must be taken prior to model acceptance and use to estimate natural conditions.

Determining that nonattainment is due, in part, to natural processes

Introduction

Use of the process-based modeling approach must include an evaluation that determines the extent of how the nonattainment of the applicable water quality criteria is due to a natural process or variation. In this determination, use of this approach must consider all required elements listed in this section during site characterization and evaluation. If any required element is not applicable or relevant to a site (e.g., there are no hydromodifications within or upstream of the site of interest), then its non-applicability or non-relevancy must be justified using firm scientific rationale or professional judgement.

Due to hydrological differences, required elements are split between fresh waters and marine waters. Use WAC 173-201A-260(3)(e) to determine whether fresh water or marine water criteria apply to the site of interest.

Accounting for human-caused impacts and pollution

In the process for determining the extent of natural conditions' impact on nonattainment of the applicable water quality criteria, analysis of the various elements will include factors related to human-caused impacts to surface water quality. Ultimately, these impacts will need to be accounted for and removed in the natural condition estimation.

Specifically, human-caused sources of pollution originating within the boundaries of the State of Washington impacting surface waters of the State must be accounted for and removed in the

natural condition mechanistic model. This includes accounting for all known sources of heat, oxygen-demanding pollutants, and pH-altering pollutants, including but not limited to those listed within each element.

All other human-caused sources of pollution that impact the site must be accounted for as best as possible using existing, readily available, and credible information (e.g., global climate change, boundary inputs from sources outside the United States). These sources can be excluded from the model if it is not feasible to model it, but the impact of these sources must be estimated outside the model before deriving the final criteria values. While data used to address these other sources of pollution must meet credibility requirements, it may not meet other resolution or frequency requirements established in the project QAPP. Further, these data may range in database size and complexity, from simple numeric datasets to complex models that have previously been developed to estimate human impacts to water quality on a global scale.

Any source or stressor that are not part of any model used in this approach must have a rationale for exclusion. These sources must not affect the parameter or site of interest.

Any final natural conditions criteria values used for further state and federal Clean Water Act actions must represent the natural conditions of the water of interest as defined in WAC 173-201A-020: that the natural conditions reflect the water before any human-caused pollution.

Human structural changes

The performance- based approach may not be used to derive criteria for specific assessment units of waters that contain human structural changes that cannot be effectively remedied (see WAC 173-201A-260(1)(b)). In these situations, alternative criteria may be developed (e.g., site-specific criteria, through a use attainability analysis).

The performance-based approach, however, may be used for other assessment units that are impacted by a waterbody containing human structural changes (as per WAC 173-201A-260(1)(b)), so long as the regional natural condition values with an underlying scientific basis defined in the project-specific QAPP or relevant documentation are used to remove the potential impacts of the irreversible structural changes.

Elements – fresh waters

Each element contains a description of the information to be evaluated in the model. The use of each of these elements and subsequent analyses based on corresponding data should be documented in the final report.

Boundary and initial conditions of site

The boundary or initial conditions of the site includes any relevant or appropriate headwaters, tributaries, and groundwaters. These site conditions are used to define flow, water quality concentrations (including but not limited to nutrients, carbon, dissolved oxygen, and temperature), and other biological, chemical, and physical parameters in the spatial area of

interest for the model. Boundary conditions must be set at estimated natural conditions of these waters, based on readily available and credible data. All methods used and assumptions made in setting boundary conditions for natural condition predictions must be documented in the final report. This documentation must include rationale for boundary siting within the model domain as well as water quality conditions.

Impacts by humans on boundary or initial conditions of the site must be accounted for and removed in the natural condition estimation. This includes but is not limited to:

- Any impacts by humans on tributaries which influence the site of interest.
- Loss of stream baseflow or other flow changes (e.g., stagnant conditions)
- Decreased groundwater availability due to human withdrawals.
- Human recharge to groundwater that results in discharges that affect DO levels and nutrient concentrations in streams.
- Increased sedimentation, including fine sediment.
- Changes to benthic submerged aquatic vegetation.
- Changes in residence time of the system.

All methods and procedures to characterize how these will be accounted for and removed will be included in the QAPP and documented in the application of the PBA.

Hydrologic or hydraulic modifications

Hydrologic or hydraulic modification data are evaluated to understand how modifications to the site have changed over time, regardless of whether anthropogenically or naturally caused. This information will be used to:

- Demonstrate changes in the water compared to historical records, including identification where and when major hydrological projects occurred.
- Estimate natural channel widths to system potential shade calculations.
- Model water system changes with the removal or alteration of any hydrological or hydraulic modifications (i.e., dams, culverts, and other modifications removed in the natural simulation).
- Demonstrate the impact of groundwater fluxes into the system including groundwater restoration in the natural simulation.
- Account for withdrawals or pumping outside of boundary conditions and adjust inflow accordingly such that it reflects natural flows.
- Explicitly model surface withdrawals as point abstractions in current conditions flow balance then remove withdrawals for natural condition determinations.

Impacts to water quality must be accounted for and removed in the natural conditions' estimation, and the process for doing so must be in the project specific QAPP. This includes:

- Upstream and downstream impacts from dams.
    - Stream temperature impact, including but not limited to timing and depth changes of seasonal thermoclines.

    - Dissolved oxygen impacts, including but not limited to releases of water with low DO concentrations and changes in primary productivity and respiration.
    - pH impacts, including but not limited to impacts during water thermal stratification and changes in primary productivity and respiration.
- Loss of channel complexity.

See "Human Structural Changes" for additional information.

Riparian conditions

Data regarding the riparian conditions of the site must be reported and analyzed. Riparian differences between existing conditions and natural conditions may be a driver in impact of solar radiation on the water body of interest. This information could be used in:

- System potential shade estimations.
- Comparison of vegetation height or density to applicable reference sites.
- Making historic tree height comparisons.
- Perform analyses using tree diameter data, which is used to estimate tree heights using known species-specific relationships.

The loss of riparian shade or other vegetation impacts along the shoreline due to human actions must be accounted for and removed in natural condition estimations.[6] The methods used must be documented.

Meteorological conditions

Applicable meteorological conditions and data must be reported and evaluated based on the project requirements. Analyses of meteorological conditions will be used to:

- Develop hydrodynamic and thermodynamic simulations based on a range of conditions.
- Investigate differences between current and unaltered habitats.
- Demonstrate how reduction of air temperatures could reflect small changes in riparian climates.
- Measure climate change impact on the natural conditions of a system over time.

Impacts must be accounted for and removed (e.g., climate change impacts on air temperature). As these impacts will vary by project and possibly over time, the specific impacts identified, accounted for, and removed must be documented and provided in the final report.

Point source discharges

Impacts by all point source discharges within and upstream of the site of interest must be documented and evaluated. This information may be useful to:

[6] For example, determine system potential tree height based on General Land Office survey bearing tree records converted to tree heights using known species-specific relationships between diameters and height.

- Model how removal or reduction of a pollutant in discharged effluent would affect the water quality parameters of interest.
- Demonstrate how effluent flow rate adjustments would influence the system under evaluation.

These impacts from discharges (e.g., NPDES permitted discharges, wastewater, stormwater outfalls) must be accounted for and removed in natural condition estimations.[7] This includes but is not limited to:

- Accounting for impact of point source effluent on dissolved oxygen, including biochemical oxygen demand and nutrient loads.
- Discharge impacts on water temperature.
- Effects on pH (including changes or increases in pH range or extremities).

Non-point source discharges

All readily available non-point source discharges within and upstream of the site of interest must be evaluated for impact to the site of interest. This includes surface and groundwater non-point source loads. This element is to understand the pollutants entering the site waters dispersed from any land-based or water-based activity that is not otherwise regulated under a state surface water discharge permit or NPDES permit. This information will be used to:

- Demonstrate how alterations or reductions of these discharges could influence water quality of the site.
- Compare data to reference sites to estimate non-point impact.
- Develop a reference natural condition land-use condition for further analysis in any developed water quality model.

Any impacts from non-point source discharges, including human development in the watershed, must be accounted for, and removed, when estimating natural conditions of the site.[8] This includes accounting for impact of non-point source discharge on the biochemical oxygen demand, dissolved oxygen, nutrients, temperature, and pH of the water. All processes and methods used must be included in documentation and the final report.

Kinetic and physical rates and ratios

Kinetic and physical rates and ratios relate to temporal or speed attributes at which chemical, biological, or physical reactions or processes take place. The values assigned to rates are estimated in the model calibration process. If there is information indicating that a rate or ratio is impacted by human-caused factors, these impacts to the rates or ratio must be accounted for and removed when estimated natural conditions.

[7] No discharges allowed in natural condition estimations.
[8] For example, using a reference natural condition land use condition.

Invasive species

Information regarding invasive species should be provided and evaluated. In the context of this approach, "invasive species" refers to non-native plants or animals that have been introduced into the site of interest since the start of the industrial era, or native plants or animals that have hyper-aggressively propagated due to human-conditioned environments. This information may be used to:

- Demonstrate the impact that invasive species have on shade changes over time in shade analyses.
- Demonstrate impact to water quality with reduction or removal of invasive species.

Impacts of invasive species must be accounted for and removed in natural condition estimations. This may include evaluating impact of invasive species on lower trophic level organisms or aquatic life (e.g., benthic vegetation) and how invasive species may have caused changes in water quality. Methods and data sources for invasive species and methods for capturing return to non-invasive status must be documented and included in final report.

Elements – marine waters

Each element contains a description of the information to be evaluated as well as examples of how analysts may use this information. The use of each of these elements and subsequent analyses based on corresponding data should be contained in the final report.

Boundary and initial conditions of site

The boundary or initial conditions of the site includes any relevant or appropriate headwaters, tributaries, and groundwaters. These site conditions are used to define flow, water quality concentrations, and other biological, chemical, and physical parameters in the spatial area of interest for the model. These must be set at estimated natural conditions of these waters, based on readily available and credible data. All methods used and assumptions made in setting boundary conditions for natural condition predictions must be documented in the final report.

Impacts by humans on boundary or initial conditions of the site must be accounted for and removed in the natural condition estimation.

Hydrologic or hydraulic modifications

Hydrologic or hydraulic modification data are evaluated to understand how modifications to the site have changed over time, regardless of whether anthropogenically or naturally caused. This information could be used to:

- Demonstrate changes in the water compared to historical records, including identification where and when major hydrological projects occurred.
- Model water system changes with the removal or alteration of any hydrological or hydraulic modifications.
- Account for withdrawals or pumping outside of boundary conditions and adjust inflow accordingly.

Impacts to water quality must be accounted for and removed in the natural conditions' estimation. See "Human Structural Changes" for additional information.

Meteorological conditions

Applicable meteorological conditions and data should be reported and evaluated based on the project requirements. Analyses of meteorological conditions may be used to:

- Investigate differences in these conditions between current and unaltered habitats.
- Evaluate scale-appropriate inputs that influence factors such as algal photosynthesis, productivity, mixing, or stratification.

When using this element in the mechanistic approach, generally use the same meteorological observational or model-based meteorological files for natural conditions as existing conditions, unless specified otherwise in the project QAPP or there exists a firm scientific basis.[9]

In estimating natural conditions criteria, impacts must be accounted for and removed, and the methods and process must be included in documentation and the final report.

Point source discharges

Impacts by all point source discharges within and upstream of the site of interest must be documented and evaluated. This information may be useful to:

- Model how removal or reduction of a pollutant in discharged effluent would affect the water quality parameters of interest.
- Demonstrate changes in water quality if effluent concentrations into marine or brackish waters (including those from freshwater systems) were set to natural ambient levels.

These impacts from discharges (e.g., NPDES permitted discharges, wastewater, stormwater outfalls) must be accounted for and removed in natural condition estimations. Methods and process for doing so must be included in documentation and the final report. This includes but is not limited to:

- Accounting for impact of point source effluent on the biochemical oxygen demand.
- Discharge impacts on water temperature outside mixing zones.
- Effects on pH (including changes or increases in pH range or extremities).

Non-point source discharges

All non-point source discharges must be evaluated for impact to the site of interest. This element is to understand the pollutants entering the site waters dispersed from any land-based or water-based activity that is not otherwise regulated under a state surface water discharge permit or NPDES permit. This information may be used to:

[9] For example, some projects may have this element based on published literature and will not be modeled.

- Demonstrate how alterations or reductions of these discharges could influence water quality of the site.
- Make comparisons to reference sites to estimate non-point impact.

Any impacts from non-point source discharges, including human development in the watershed, should be accounted for, and removed, when estimating natural conditions of the site. This includes accounting for impact of non-point source discharge on the parameter of interest, such as biochemical oxygen demand, temperature, and pH of the water. The methods and process for doing so must be included in documentation and in the final report.

Kinetic and physical rates and ratios

Kinetic and physical rates and ratios relate to temporal or speed attributes at which chemical, biological, or physical reactions or processes take place. This information may be used in:

- Model calibration process.
- Specify rates or ratios for natural conditions when there is a scientific basis to do so.

Impacts to these rates and ratios must be accounted for and removed when estimating natural conditions. The methods and process for doing so must be included in documentation and in the final report. This includes:

- Evaluating the ability of the water to hold dissolve oxygen, and subsequently, determining loss of that ability based on increases of water temperature due to human-caused impacts.
- Analyzing changes to algal and plant photosynthetic rates due to eutrophication driven by human causes (e.g., point- and non-point loading of nitrogen and phosphorus).
- Evaluation of human-driven changes in biological productivity.

Determining natural conditions criteria values

Criteria magnitude

The process-based modeling approach uses a model to estimate natural conditions of a system, which can be used to determine appropriate natural conditions criteria for the site of interest. Development of the applicable natural condition criteria magnitudes must consider all existing, readily available, and credible data for the site of interest. Any biogeochemical and physical relationships used for determining natural conditions must be established based upon known relationships for pristine or pre-anthropogenic conditions.

Natural condition criteria magnitude estimations must reflect the natural conditions of the system without any human impacts. See “Accounting For Human-Caused Impacts and Pollution” for additional details.

Modeling outputs and subsequent analysis must include a demonstration of the natural extent of the parameter.[10] This includes:

- Describing long term (multi-week to inter-annual) range and variation in the parameter.
- Calculations of summary statistics, including low or high percentiles, as appropriate, of the natural condition estimations.
- Demonstration of how input variability (e.g., flows, temperatures) impacts the magnitude of the parameter(s) under investigation.

Determination of the natural condition criteria magnitudes must be done on a specified cell by cell or node by node (depending upon the model) basis. The basis for these decisions must be documented, and the resulting criteria values must provide protection for all designated and existing aquatic life uses. Natural conditions criteria cannot be developed for areas where reliable estimates of the natural conditions cannot be produced.

Model outputs that estimate natural conditions represent the system potential conditions of the site. The model output resolution will vary by project design (as described in the QAPP), data availability, and model choice. The highest resolution model outputs that represent the natural conditions criteria magnitudes of the site must:

- Meet the precision and accuracy requirements set forth in the project QAPP,
- Reflect the parameter (DO, temperature, pH) biologically based numeric criteria metrics,
- Abide by the data and modeling requirements in this performance-based approach, and
- Protect designated and existing uses by removing all human-caused impacts and pollution to the water of interest.

If various model outputs are used in analysis (such as from using multiple model runs across different years), then the model run(s) chosen must best reflect the long-term natural condition of the system and capture the range of long-term conditions.

If aggregating estimated natural condition criteria values to "simplify" the final natural conditions criteria,[11] then criteria values must be aggregated in such a way that:

- Any aggregated groupings (e.g., water assessment units) are scientifically or professionally justifiable.
- The natural condition criterion value determined post-aggregation is fully protective of aquatic life across the entire grouping.[12]

[10] Such as the range of magnitude of the parameter.
[11] Such as determining a single criterion value that applies to two assessment units.
[12] For example, consider a temperature determination scenario aggregating two assessment units that are abutting in a freshwater stream. If the natural condition criterion value determined for one assessment unit is estimated to be 16.2°C and the other assessment unit criterion value is estimated to be 16.8°C, then the final aggregated natural condition temperature criterion value that protects aquatic life across the grouping would be 16.2°C.

This process of aggregation, support for the groupings used, and calculations for the natural condition criteria values must be documented and have a firm scientific basis. Further, these criteria values must fully protect designated and existing uses.

Finally, criteria magnitudes determined may reflect a singular or combination of values[13], and these values must protect designated and existing uses based on the chosen statistical metrics (e.g., 7-DADMax, no more than one exceedance in a 10-year period).[14] This includes protections against acute and chronic impacts of the parameter on aquatic life.

Criteria duration and frequency

Any developed natural conditions criteria must include duration and frequency components. In estimation of the natural conditions, the statistical metric will be the biologically based numeric criteria for each parameter simulated. The duration and frequency of these natural condition estimates should match the duration and frequency requirements of the applicable biologically based numeric aquatic life criteria within WAC 173-201A.[15]

Criteria evaluation and application

Developed natural conditions criteria must include the periods of the year when the criteria values apply, if applicable. For example, the criteria might only be applicable for the summer period or during low flow conditions. If natural conditions criteria were calculated using such restrictions (e.g., seasonal boundaries), then any developed natural conditions criteria values have the same restrictions. The period of application for natural conditions criteria will not include times or conditions where limited or no data are available; the existing biologically based numeric criteria would continue to apply during these times or conditions.

Site-specific numeric aquatic life criteria derived in accordance with the performance-based approach are the applicable numeric aquatic life criteria for the site (as identified in "Define Site Boundaries" upon derivation). This includes times or conditions where analysis demonstrates that the natural conditions criteria are more stringent than the existing biologically based numeric criteria. Further, criteria values developed using the performance-based approach must protect existing and designated uses in downstream waters and must not cause degradation of downstream receiving waters.

[13] This determination is project specific. For instance, the final natural conditions criteria magnitudes could be a singular value that applies across the entire year, or the final criteria could be multiple values with each singular value representing a seasonal criterion. The determination of the criteria magnitudes and any restrictions for when they apply (e.g., seasonal) must be documented and provided in the final report.
[14] See "Criteria Duration and Frequency."
[15] For example, if developing natural conditions criteria for temperature in a riverine system that cannot meet the applicable biologically based criteria in Table 200(1)(c), the natural conditions criteria determined in this process would have calculated magnitude values that are 7-DADMax criteria not to be exceeded at a probability frequency of more than once in ten years.

Documentation and use

Once the natural conditions criteria values (including magnitude, duration, frequency) are determined, these values can be used for state and federal Clean Water Act actions, such as for Water Quality Assessments or in Total Maximum Daily Load development. If using this value for these state and federal actions, then all evaluation, analyses, data, and decision points from this process-based modeling approach must be documented and reported, and this must be provided alongside the calculated values and project QAPP. The report format should follow accepted agency templates or protocols.

The final report must include sources of model uncertainty in summarized form. The report will also include how the model output was used to establish natural conditions criteria, identifying outcomes for each site-specific determination as applicable. This will include documentation on how model outputs and external jurisdictional data were analyzed to calculate the natural conditions criteria values.

The report must also include information on natural condition estimates, including but not limited to:

- Summary tables
- Cumulative relative frequency tables
- Natural variation and central tendencies for simulated waters
- Spatial and temporal considerations
- Changes from the project QAPP
- An appendix that includes all sources of data, approaches, and references not previously documented and used in the analysis

This report will undergo agency peer review through established departmental processes with a specific mention for reviewers to focus on the natural conditions analyses. This peer review must be completed prior to the use of these natural condition criteria values in further state and federal Clean Water Act actions (e.g., TMDLs, NPDES permits, CWA 401 certifications).

All documentation (including, but not limited to the project specific QAPP, final report, and criteria) must be made available to the public if using the natural condition criteria values in further state and federal Clean Water Act actions.

Appendix A. References

Davies, Tudor T. 1997. Establishing Site Specific Aquatic Life Criteria Equal to Natural Background. Memorandum to Water Management Division Directors, EPA Regions 1-10, and State and Tribal Water Quality Management Program Directors. Dated 5 November 1997. Office of Water, Office of Science and Technology. Washington, D.C.

United States Environmental Protection Agency (USEPA). 2015. A Framework for Defining and Documenting Natural Conditions for Development of Site-Specific Natural Background Aquatic Life Criteria for Temperature, Dissolved Oxygen, and pH: Interim Document. Office of Water, Office of Science and Technology. Washington, D.C. EPA 820-R-15-001.

United States Environmental Protection Agency (USEPA). 2023. Water Quality Standards Handbook Chapter 3: Water Quality Criteria. Office of Water, Office of Science and Technology. Washington, D.C. EPA 823-B-23-001.

Washington State Department of Ecology (Ecology). 2017. Programmatic Quality Assurance Project Plan. Water Quality Impairment Studies. Olympia, Washington. Publication No. 17-03-107.