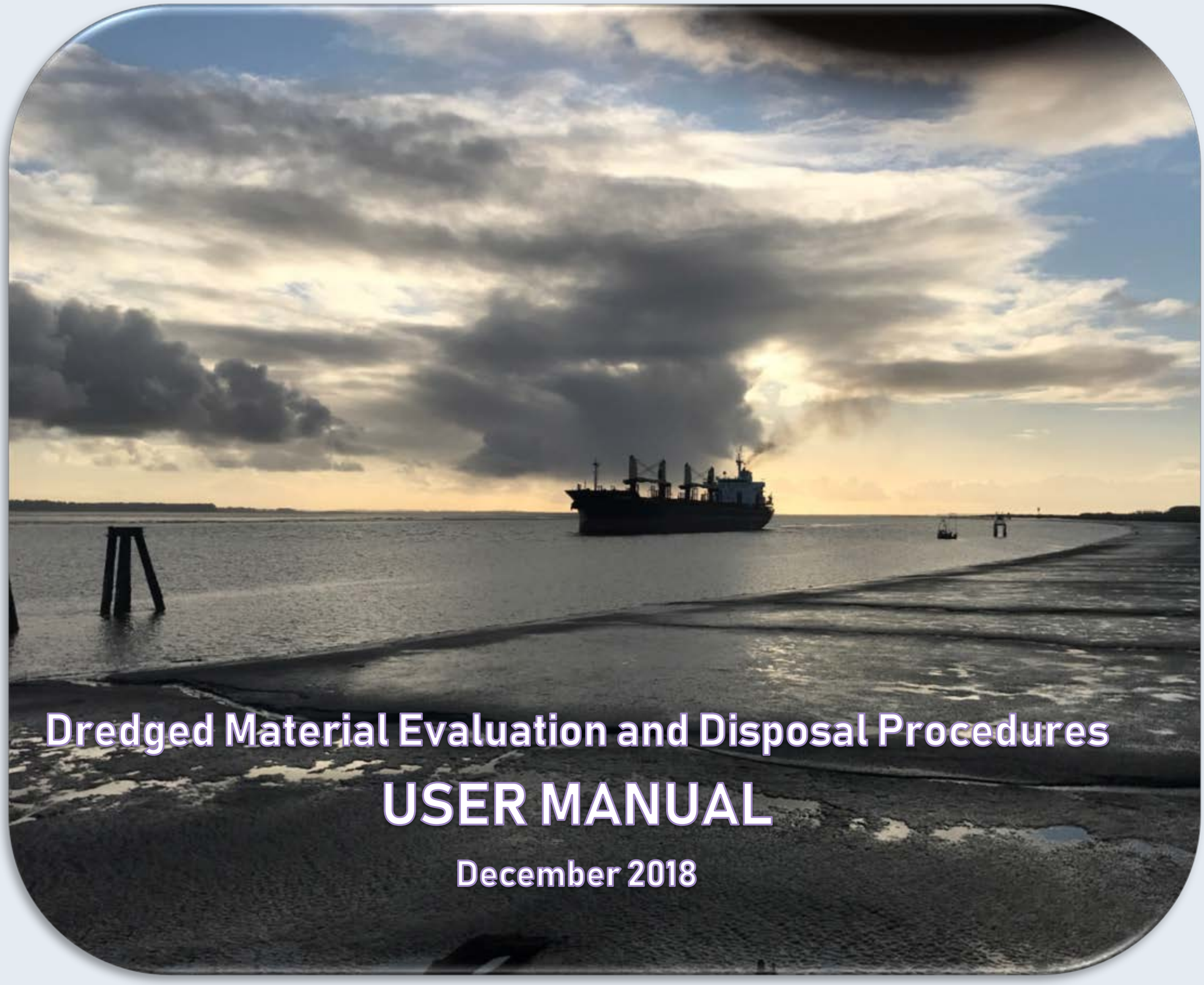

Dredged Material Evaluation and Disposal Procedures

USER MANUAL

December 2018

Dredged Material Management Program

U.S. Army Corps of Engineers, Seattle District
Environmental Protection Agency, Region 10
Washington State Department of Natural Resources
Washington State Department of Ecology

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DEFINITIONS

Acute toxicity: Short-term toxicity to organism(s) that have been affected by the properties of a substance, such as contaminated sediment. The acute toxicity of a sediment is generally determined by quantifying the mortality of appropriately sensitive organisms that are exposed to the sediment, under either field or laboratory conditions, for a specified period.

Advanced Dredging/Advanced Maintenance. Advanced maintenance is dredging to a specified depth and/or width beyond the authorized channel dimensions in critical and fast shoaling areas to avoid frequent re-dredging, and to ensure the reliability and least overall cost of operating and maintaining the project authorized dimensions.

Antidegradation: Policy that seeks to manage "sediment quality so as to protect existing beneficial uses and move towards attainment of designated beneficial uses" of the new surface sediment that would be exposed following dredging (Ecology, 2013). The exposed sediment must meet the SMS antidegradation policy (WAC 173-204-120).

Apparent Effects Threshold (AET): The sediment concentration of various chemicals of concern above which statistically significant adverse biological effects (relative to an appropriate reference condition) are always expected. Theoretically, an AET can be calculated for any chemical and biological indicator.

Aquatic disposal: Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

Aquatic ecosystem: Bodies of water, including wetlands, which serve as the habitat for interrelated and interacting communities and populations of plants and animals.

Beneficial use: Placement or use of dredged material for some productive purpose.

Bioaccumulation: The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

Bioaccumulation Trigger (BT): For bioaccumulative chemicals of concern, the sediment concentration that constitutes a "reason to believe" level that the chemical would accumulate in the tissues of target organisms. Sediments with chemical concentrations above the calculated BT require bioaccumulation testing before suitability for open-water disposal can be determined.

Bioassay: A bioassay is a test using a biological system. It involves exposing an organism to a test material and determining a response. There are two major types of bioassays differentiated by response: toxicity tests which measure an effect (e.g., acute toxicity, sublethal/chronic toxicity) and bioaccumulation tests which measure a phenomenon (e.g., the uptake of contaminants into tissues).

Biomagnification: Bioaccumulation up the food chain. Organisms at higher trophic levels will have higher body burdens than those at lower trophic levels. **Bulking factor:** The ratio of the volume occupied by a given mass of dredged material in either a hopper or bin immediately after deposition by a dredging process, to the volume occupied by the same mass of sediment in situ.

Capping: The engineered placement of a covering or cap of clean material over contaminated material to isolate the contamination from the aquatic environment. A cap is typically designed to remain in place and may require periodic monitoring to ensure continued effectiveness.

Chemical of concern (COC): A chemical present in a given sediment thought to have the potential for unacceptable adverse environmental impact.

Chronic: Involving a stimulus that is lingering or which continues for a long time.

Clay: Soil particle having a grain size of less than 3.9 micrometers.

Coastal zone: Includes coastal waters and the adjacent shorelands designated by a State as being included within its approved coastal zone management program. The coastal zone may include open waters, estuaries, bays, inlets, lagoons, marshes, swamps, mangroves, beaches, dunes, bluffs, and coastal uplands. Coastal-zone uses can include housing, recreation, wildlife habitat, resource extraction, fishing, aquaculture, transportation, energy generation, commercial development, and waste disposal.

Comparability: The confidence with which one data set can be compared to others and the expression of results consistent with other organizations reporting similar data. Comparability of procedures also implies using methodologies that produce results comparable in terms of precision and bias.

Composite: The combination, in a representative manner, of multiple samples from a single DMMU for a single analytical sample.

Confined disposal: A disposal method that isolates the dredged material from the environment.

Confined disposal facility (CDF): An engineered structure for containment of dredged material consisting of dikes or other structures that enclose a disposal area and isolate the dredged material from adjacent surface water during placement. Other terms used for CDFs that appear in the literature include confined disposal area, confined disposal site, and dredged material containment area.

Constituents: Chemical substances, solids, liquids, organic matter, and organisms associated with or contained in or on dredged material.

Confined aquatic disposal: Form of capping which includes the added provision of some form of lateral containment (for example, placement of the contaminated and capping materials in bottom depressions or behind subaqueous berms) to minimize spread of the materials on the bottom.

Contaminant: Chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and is harmful to aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

Contaminated sediment: Sediment that has been demonstrated to cause an unacceptable adverse effect on human health or the environment.

Control sediment: A sediment essentially free of contaminants and which is used routinely to assess the acceptability of a test. Control sediment is typically the sediment from which the test organisms are collected. Test procedures are conducted with the control sediment in the same way as the reference sediment and dredged material. The purpose of the control sediment is to confirm the biological acceptability of the test conditions and to help verify the health of the organisms during the test. Excessive mortality in the control sediment indicates a problem with the test conditions or organisms, and can invalidate the results of the corresponding dredged material test.

Data quality indicators: Quantitative statistics and qualitative descriptors which are used to interpret the degree of acceptability or utility of data to the user; include bias (systematic error), precision, accuracy, comparability, completeness, representativeness and statistical confidence.

Dredged material: Sediment excavated from freshwater, estuarine or marine waters.

Dredged Material Disposal site: Geographic areas in waters of the United States where specific disposal activities are permitted.

Dredged Material Management Unit (DMMU): A manageable, dredgeable unit of sediment which can be differentiated by sampling and which can be separately dredged within a larger dredging area.

EC_{50}: The median effective concentration. The concentration of a substance that causes a specified effect (generally sublethal rather than acutely lethal) in 50% of the organisms tested in a laboratory toxicity test of specified duration.

Ecosystem: A system made up of a community of animals, plants, and bacteria and its interrelated physical and chemical environment.

Effluent: Water that is discharged from a confined disposal facility or water treatment facility during and as a result of the filling or placement of dredged material.

Elutriate: Water derived from mixing a known volume of sediments with site water followed by a settling period.Elutriate water is used for chemical analyses and toxicity testing.

Emergency: In the context of dredging operations, emergency is defined in 33 CFR Part 335.7 as a "situation which would result in an unacceptable hazard to life or navigation, a significant loss of property, or an immediate and unforeseen significant economic hardship if corrective action is not taken within a time period of less than the normal time needed under standard procedures."

Evaluation: The process of judging data in order to reach a decision.

Freshwater sediment: sediments in which the sediment pore water contains less than or equal to 0.5 parts per thousand salinity.

Grain-size effects: Mortality or other effects in laboratory toxicity tests due to sediment granulometry, not chemical toxicity.

Gravel: A loose mixture of pebbles and rock fragments coarser than sand. Specifically, a soil particle having a grain size of greater than 2,000 micrometers.

Habitat: The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

Heterogeneous Sediment: Sediment that is stratified into layers that have potentially different physical or chemical characteristics. Heterogeneous sediments are typically sampled with a coring device that allows for separate sampling and analysis for surface and subsurface sediment layers.

Holding Time: the length of time between sample collection and analysis that is allowed for a given analyte without compromising the validity of the results.

Homogeneous Sediment: Sediment that is well-mixed and deposited over a short time-frame. Homogenous sediments are often found in settling basins or some navigation channels where river flow slows down abruptly. A dredge prism made up of homogenous sediment can be represented with grab samples.

K_{OW}: The octanol-water partition coefficient (K_{ow}) is a measure of the equilibrium concentration of a compound between octanol and water that indicates the potential for partitioning into organic matter (i.e., a high K_{ow} indicates a compound which will preferentially partition into organic matter rather than water). K_{ow} is inversely related to the solubility of a compound in water.

LC_{50}: The median lethal concentration. The concentration of a substance that kills 50% of the organisms tested in a laboratory toxicity test of specified duration.

Leachate: Water or any other liquid that may contain dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. For example, rainwater that percolates through a confined disposal facility and picks up dissolved contaminants is considered leachate.

Loading density: The ratio of organism biomass or numbers to the volume of test solution/sediment in an exposure chamber.

Maximum Level (ML): A guideline value derived for each chemical of concern which represents the highest Apparent Effects Threshold (AET) – a chemical concentration at which biological indicators show significant effects.

Method detection limit (MDL): The minimum concentration of a substance which can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

Open-water disposal: The purposeful placement of suitable dredged material at an approved dispersive, non-dispersive, or flow-lane location.

Overdepth: Paid allowable overdepth dredging (depth and/or width) is a construction design method for dredging that occurs outside the required authorized dredge prism. Paid overdepth is designed to compensate for physical conditions and inaccuracies in the dredging process and to allow for efficient dredging practices.

Pathway: In the case of bioavailable contaminants, the route of exposure (e.g., water, food).

Porewater: The water that fills the area between grains of sediment.

Practicable: Available and capable of being done after taking into consideration cost, existing-technology, and logistics in light of overall project purposes.

QA: Quality assurance; the total integrated program for assuring the reliability of data. A system for integrating the quality planning, quality control, quality assessment, and quality improvement efforts to meet user requirements and defined standards of quality with a stated level of confidence.

QC: Quality control, the overall system of technical activities for obtaining prescribed standards of performance in the monitoring and measurement process to meet user requirements.

Reason to believe: Subpart G of the CWA 404(b) (1) guidelines requires the use of available information to make a preliminary determination concerning the need for testing of the material proposed for dredging. This principle is commonly known as “reason to believe” and is used in Tier I evaluations to determine acceptability of the material for discharge without testing. The decision to not perform additional testing based on prior information must be documented, in order to provide a reasonable assurance that the proposed discharge material is not a carrier of contaminants.

Recency: The duration of time for which chemical and biological characterization of a given dredge prism remains adequate and valid for decision making without further testing.

Reference sediment: A whole sediment used to assess sediment conditions exclusive of the material(s) of interest that is as similar as practicable to the grain size of the dredged material. The reference sediment serves as a point of comparison to identify potential effects of contaminants in the dredged material.

Reference site: The location from which reference sediment is obtained.

Representativeness: The degree to which sample data depict an existing environmental condition; a measure of the total variability associated with sampling and measuring that includes the two major error components: systematic error (bias) and random error. Sampling representativeness is accomplished through proper selection of sampling locations and sampling techniques, collection of sufficient number of samples, and use of appropriate subsampling and handling techniques.

Resource Agencies: State and Federal agencies tasked with regulating, researching and conserving aquatic resources. Including, but not limited to the Washington State Department of Fish and Wildlife, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service.

Salinity: Salt content, usually expressed in grams of salt per kilogram of water.

Sand: Soil particles having a grain size ranging between 62.5 micrometers and 2,000 micrometers.

Screening Level (SL): A guideline value defined for most of the DMMP chemicals of concern that identifies a concentration at or below which there is no reason to believe that dredged material disposal would result in unacceptable adverse effects.

Sediment: Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities such as forest or agricultural practices, or construction activities. The term dredged material refers to material which has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Silt: Sediment having a grain size ranging between 3.9 micrometers and 62.5 micrometers.

Sublethal (chronic) toxicity: Biological tests which use such factors as abnormal development, growth and reproduction, rather than lethality, as end-points. These tests involve all or at least an important, sensitive portion of an organism's life-history. A sublethal endpoint may result either from short-term or long-term (chronic) exposures.

Suspended solids: Organic or inorganic particles that are suspended in water. The term includes sand, silt, and clay particles as well as other solids, such as biological material, suspended in the water column.

Tiered approach: A structured, hierarchical procedure for determining data needs relative to decision-making, which involves a series of tiers or levels of intensity of investigation. Typically, tiered testing involves decreased uncertainty and increased available information with increasing tiers. This approach is intended to ensure the maintenance and protection of environmental quality, as well as the optimal use of resources. Specifically, least effort is required in situations where clear determinations can be made of whether (or not) unacceptable adverse impacts are likely to occur based on available information. Most effort is required where clear determinations cannot be made with available information.

Toxicity: Level of mortality or other end point demonstrated by a group of organisms that have been affected by the properties of a substance, such as contaminated water, sediment, or dredged material.

Toxicity test: A bioassay which measures an effect (e.g., acute toxicity, sublethal/chronic toxicity). Not a bioaccumulation test (see definition of bioassay).

Turbidity: An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. Very high levels of turbidity can be harmful to aquatic life.

Upland environment: The geochemical environment in which dredged material may become unsaturated, dried out, and oxidized.

Water quality certification: A state certification, pursuant to Section 401 of the Clean Water Act, which states that the proposed discharge of dredged material will comply with the applicable provisions of the Clean Water Act and relevant State laws. Typically this certification is provided by the affected State. In instances where the State lacks jurisdiction (e.g., Tribal Lands), such certification is provided by EPA or the Tribe.

Waters of the United States: In general, all waters inland of and including the territorial sea. Specifically, all waters defined in the CWA 404(b)(1) guidelines.

Whole sediment: The sediment and interstitial waters of the proposed dredged material or reference sediment that have had minimal manipulation. For purposes of this manual, press-sieving to remove organisms from test sediments, homogenization of test sediments, compositing of sediment samples, and additions of small amounts of water to facilitate homogenizing or compositing sediments may be necessary to conduct bioassay tests. These procedures are considered unlikely to substantially alter chemical or toxicological properties of the respective whole sediments except in the case of AVS (acid volatile sulfide) measurements (EPA, 1991a) which are not presently required. Alternatively, wet sieving, elutriation, or freezing and thawing of sediments may alter chemical and/or toxicological properties, and sediment so processed should not be considered as whole sediment for bioassay purposes.

Z-sample: A sample from the first two feet below the dredging overdepth, which must be collected during sampling of heterogeneous sediments, to characterize the surface exposed after dredging (Z-layer).

LIST OF ACRONYMS

AET Apparent Effects Threshold
ANOVA Analysis of Variance
ASTM American Society for Testing and Materials
BPJ Best Professional Judgment
BT Bioaccumulation Trigger
CAS Chemical Abstract Service
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act (aka "Superfund")
CFR Code of Federal Regulations
CLP Contract Laboratory Program
COC Chemical of Concern
CSL Cleanup Screening Level
CSO Combined Sewer Overflow
CWA Clean Water Act
CY Cubic Yard
DMMO Dredged Material Management Office
DMMP Dredged Material Management Program
DMMU Dredged Material Management Unit
DNR Washington Department of Natural Resources
DY Dredging Year
EC_{50} Effective Concentration (affecting 50% of test organisms)
EIM Environmental Information Management (Ecology database)
EPA Environmental Protection Agency
EPTA Evaluation Procedures Technical Appendix
ESA Endangered Species Act
FC Full Characterization
FDA Food and Drug Administration
GIS Geographic Information System
GPS Global Positioning System
HPA Hydraulic Project Approval
HPAH High-molecular-weight PAH
IP Individual Permit
JARPA Joint Aquatic Resource Permit Application
K_{OW} Octanol-water partition coefficient
LC_{50} Lethal Concentration (affecting 50% of test organisms)
LOP Letter of Permission
LPAH Low-molecular-weight PAH
ML Maximum Level
MLLW Mean Lower Low Water
MPR Management Plan Report
MPRSA Marine Protection Research and Sanctuaries Act
MTCA Model Toxics Control Act
NAD North American Datum
NEPA National Environmental Policy Act
NFG National Functional Guidelines
NPDES National Pollution Discharge Elimination System
NWP Nationwide Permit Program
ODMDS Ocean Dredged Material Disposal Site
PAH Polycyclic Aromatic Hydrocarbon
PC Partial Characterization
PCBs Polychlorinated Biphenyls
PCDDs Polychlorinated Dibenzodioxins
PCDFs Polychlorinated Dibenzofurans
PSDDA Puget Sound Dredged Disposal Analysis (early version of DMMP)
PSEP Puget Sound Estuary Program
QA/QC Quality Assurance/Quality Control
RGP Regional General Permit
RHA Rivers and Harbors Act
RSET Regional Sediment Evaluation Team
SAP Sampling and Analysis Plan
SEF Sediment Evaluation Framework
SEPA State Environmental Policy Act
SMS Sediment Management Standards (Washington State Guidelines)
SL Screening Level
TBT Tributyltin
TEC Toxic Equivalent Concentration
TEF Toxicity Equivalency Factor
TEQ Toxicity Equivalent
TOC Total Organic Carbon
TVS Total Volatile Solids
USACE U.S. Army Corps of Engineers
USCG United States Coast Guard
VTS Vessel Traffic Service
WDFW Washington Department of Fish and Wildlife
WGS World Geodetic System
WQC Water Quality Certification

1 INTRODUCTION

1.1 OVERVIEW

This *Dredged Material Evaluation and Disposal Procedures User Manual* (User Manual) was prepared by the Dredged Material Management Program (DMMP) agencies. The DMMP is an interagency approach to the management of dredged material in Washington State. The Seattle District of the U.S. Army Corps of Engineers (USACE) acts as the lead agency. Cooperating agencies are Region 10 of the U.S. Environmental Protection Agency (EPA), the Washington Department of Ecology (Ecology), and the Washington Department of Natural Resources (DNR). The DMMP agencies are responsible for evaluating dredged material using the guidelines set out in the User Manual and co-manage the DMMP open-water disposal sites.

1.1.1 Applicability and Limitations

The User Manual provides a framework for:

1. Characterizing proposed dredged material to determine its suitability for unconfined, aquatic disposal, and
2. characterizing proposed post-dredge surface material to determine its compliance with the state of Washington antidegradation policy.

The User Manual may also be useful for the evaluation of dredged material for in-water beneficial use, but decisions regarding beneficial use frequently involve resource agencies or cleanup programs and are not within the purview of the DMMP.

The procedures in this User Manual replace the equivalent guidance in previous versions of the DMMP User Manual[1].

Guidance described in this edition of the DMMP User Manual reflects technical and policy updates that have occurred through the Sediment Management Annual Review Meeting process and public workshops. The User Manual is a living document and is revised periodically as needed to reflect changes made through the public review process.

Geographic applicability. Geographically, these evaluation procedures apply to dredging projects in Puget Sound, on the Washington Coast, for non-port projects on the north side of the Columbia River, and to all other water bodies within the state of Washington.

Guidance vs. Rule. This User Manual is the state of Washington-specific guidance manual for implementation of regional and national sediment testing manuals for material disposed under Section 404 of the Clean Water Act (CWA). This document does not, and is not intended to, impose any legally binding requirements on federal agencies, state agencies, or the regulated public. Nor does the User Manual alter the statutory and regulatory framework for permitting decisions as discussed in 1.2.

[1] Previous versions of the User Manual include the 2000 Puget Sound Dredged Disposal Analysis (PSDDA) Users Manual; and the Grays Harbor/Willapa Bay Users Manual (Dredged Material Evaluation Procedures and Disposal Site Management Manual: Grays Harbor and Willapa Bay, Washington, 1995).

1.2 Regulatory Basis for Sediment Evaluation

Several state and federal entities have regulatory authority governing the management of dredged material in the state of Washington. USACE and EPA share federal responsibility for regulating dredged material within waters of the United States under Section 404 of the CWA. Under Section 401 of the CWA, Ecology must certify that aquatic discharges do not violate state and federal water quality standards. DNR manages the state-owned aquatic lands upon which dredged material disposal sites reside and authorizes placement of dredged material at these sites.

The DMMP Section 404 open-water disposal sites are identified and managed under the federal regulatory authority of the CWA. Washington State's Sediment Management Standards, and other state and local permitting processes are specific to Washington. Ocean disposal sites are designated and managed under the USACE and EPA regulatory authorities under the MPRSA, or Ocean Dumping Act. Currently, there is one ocean disposal site designated in Washington (the "Southwest" or 3.9-mile site off the mouth of Grays Harbor), which is inactive and not available for use.

1.2.1 Clean Water Act

Section 404

The Federal Water Pollution Control Act of 1972 (amended and renamed the Clean Water Act of 1977) governs the discharge of dredged or fill material into waters of the United States (inland of and including the territorial sea). The geographical limits of jurisdiction under the CWA include all waters of the United States as defined at 33 CFR 328.3.

Section 404(b)(1) requires the EPA, in conjunction with the Corps, to promulgate guidelines for the discharge of dredged or fill material to ensure that such proposed discharge will not result in unacceptable adverse environmental impacts--either individually or in combination--to waters of the United States. The Corps and EPA also have authority under the Section 404(b)(1) guidelines to identify, in advance, sites that are either suitable or unsuitable for the discharge of dredged or fill material into waters of the United States. Section 404(b)(1) assigns to the Corps the responsibility for authorizing all such proposed discharges and requires application of the guidelines in assessing the least environmentally damaging practicable alternative to the proposed discharge, including alternatives to disposal into waters of the United States.

Subpart B of the 404(b)(1) guidelines (40 CFR 230.10-230.11) identifies restrictions on the discharges of dredged or fill material into waters of the United States and the factual determinations that must be made in accordance with the restrictions. Subpart G of the 404(b)(1) guidelines (40 CFR 230.60-230.61) identifies regulatory procedures for the general evaluation of discharges; Subpart G also identifies procedures for chemical, biological, and physical evaluation and testing of dredged and fill materials.

In the state of Washington, the DMMP User Manual guidance is designed to help ensure that Corps civil works projects and federal permits comply with the CWA 404(b)(1) guidelines.

Section 401

CWA Section 401 allows states to issue water quality certifications (WQC) with or without conditions, deny certification, or waive certification for any activity that results in a discharge to a water of the United States and requires a federal permit or license. Under the CWA, a "discharge" may include the re-suspension of sediments, the discharge of oils and grease, and/or the discharge of other potential pollutants. Activities that only require a permit under Section 10 of the Rivers and Harbors Act (i.e. activities that do not result in a discharge of dredged or fill material under Section 404 of the CWA) may still require a WQC if Ecology or EPA have determined that there may be "discharges" associated with those activities. A WQC certifies that the activity complies with all applicable federal and state water quality standards, limitations, and restrictions. No license or permit may be issued by a federal agency until the WQC required by Section 401 has been granted. Further, no license or permit may be issued if certification has been denied. In many cases, WQCs have been issued programmatically for general permits (including nationwide permits), and additional review may not be required by Ecology.

In the state of Washington, the EPA has WQC authority in Indian Country[2] for tribes who do not have treatment as a state and on lands with exclusive federal jurisdiction. Tribes with treatment as a state have WQC authority over activities on their respective tribal lands. Ecology makes WQC decisions for activities on all other federal, public, and private lands in Washington State.

1.2.2 Rivers and Harbors Act, Section 10

The Rivers and Harbors Act (RHA) of 1899 was designed to ensure the free flow of interstate commerce on the nation's aquatic "highways." Under the RHA, any project proponent who wishes to build a structure, or perform work in, above, or under navigable waters must receive a permit from the USACE. Navigable waters are identified by Congress after a navigability study (performed by the U.S. Coast Guard), and a list can be found on Corps Regulatory websites. Most Section 10 navigable waters have been defined without change for decades.

Waters are considered navigable if they are: 1) subject to the ebb and flow of the tide, or 2) if they are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce. Navigable waters under the RHA are defined differently than Traditional Navigable Waters under the CWA, though in many cases they overlap.

In most cases if a CWA 404 permit is needed for a discharge of dredged or fill material in navigable waters, the work will also be reviewed under Section 10 for potential impacts to navigation.

1.2.3 Marine Protection Research and Sanctuaries Act

The MPRSA (also called the Ocean Dumping Act, 33 U.S.C. 1401 *et seq*.) governs the transportation of dredged material for the purpose of disposal into ocean waters. The EPA has authority under Section 102 to designate ocean dredged material disposal sites (ODMDSs).

Currently there are two designated ODMDSs off the coast of Washington. The first is the "Southwest" or 3.9-Mile site off Grays Harbor. This site was designated in 1990, remains inactive, and is not available for use. The second is the Shallow Water Site located on the north side of the mouth of the Columbia River. This site was designated in 2005, and is used for the disposal of sandy navigation dredged material at a nearshore location. The Shallow Water Site is managed by EPA Region 10 and the Portland District Corps of Engineers, and is outside the applicability of this User Manual.

Should another ODMDS be proposed and designated in Washington, or should the 3.9-Mile site be re-activated, the DMMP agencies will coordinate with the EPA Region 10 Ocean Dumping Coordinator, and determine sediment characterization requirements at that time. The criteria for

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[2] Indian Country includes reservation lands, trust lands, and Dependent Indian Communities. To date, the EPA has approved treatment as a state to ten tribes within Washington State: Confederated Tribes of the Chehalis Reservation, Confederated Tribes of the Colville Reservation, Kalispel Tribe of Indians, Lummi Nation, Makah Tribe, Port Gamble S'Klallam Tribe, Puyallup Tribe of Indians, Quinault Indian Nation, Spokane Tribe of Indians, Swinomish Tribe, and Tulalip Tribes.

evaluating the environmental impacts of ocean disposal, including disposal of dredged material, is provided in Subpart B of the Ocean Dumping regulations (40 CFR 227.4 to 227.13).

1.2.4 Endangered Species Act

Section 7(a)1 of the Endangered Species Act (ESA) directs all federal agencies to conserve endangered and threatened species and to use their authorities to further the purposes of the ESA in recovering ESA-listed species such that they can be delisted. Section 7(a)2 of the ESA outlines interagency cooperation procedures for federal action agencies to consult with the USFWS and/or NMFS (the Services) to ensure the actions they fund and/or permit do not jeopardize the existence of any ESA-listed species or adversely modify designated critical habitat in the action area of the project.

Upon the receipt of a request to consult from another federal agency, the NMFS and/or the USFWS – the agencies with the legislative mandate to oversee ESA listings and recovery planning – prepare Letters of Concurrence if they agree with the requesting agency that the federal action is *not likely to adversely affect* the subject listed species or its critical habitat.

If the action is considered by the Services to "take" (kill, injure, harass or harm) a listed species or adversely affect its habitat, incidental to the otherwise lawful action, the Services will prepare a biological opinion (Opinion). Opinions provide an exemption for the take of listed species while specifying the extent of take allowed, the reasonable and prudent measures (RPMs) necessary to minimize impacts from the federal action, and the non-discretionary terms and conditions associated with the RPMs to aid in avoiding and minimizing the take identified in the Opinion. In the extreme, some federal actions consulted on are interpreted to jeopardize the continued existence of an ESA-listed species or adversely modify their critical habitat(s). Under such conditions, the Service(s) will issue an Opinion with those findings, and Reasonable and Prudent Alternative(s) to which the action agency will be obligated to implement to ensure the action will not jeopardize the species and/or adversely modify its designated critical habitat.

Consultation with the Services for transport and disposal of dredged material at multiuser disposal sites in Puget Sound and Grays Harbor is conducted by the DMMP. Consultation for individual dredging projects is only needed for the dredging portion of the project. Sediment evaluations (conducted in accordance with the User Manual) provide the Services with data to support evaluation of water quality effects and residuals at the dredge site.

1.2.5 Sediment Management Standards

The Washington State Sediment Management Standards (SMS) are designed to reduce and ultimately eliminate adverse effects on biological resources and significant threats to human health from surface sediment contamination.

For dredging proposed solely for navigation purposes, SMS defers to the DMMP guidelines with respect to evaluation of the dredged material itself. Application of the SMS criteria to dredging projects typically occurs in one of the following scenarios:

1. Antidegradation evaluation of the sediment surface to be exposed by dredging.
2. State cleanup sites in which dredging is a component of the remedial design.

Sediment evaluations conducted in accordance with the User Manual provide Ecology with data to support evaluation of antidegradation. However, the guidance in this User Manual is not designed to support evaluation of state cleanup sites. If your dredging project is within or adjacent to a cleanup site designated by Ecology, additional coordination with Ecology's Toxics Cleanup Program (TCP) is required. ***The DMMP User Manual does not address Model Toxics Control Act (MTCA) sampling and analysis requirements; a dredging project within a MTCA site that only follows this User Manual may be required to perform additional subsequent characterization to fulfill MTCA requirements.***

The Ecology member(s) of the interagency DMMP team can help the project applicant by coordinating DMMP and TCP requirements to ensure that both programs' needs are met.

1.2.6 CERCLA

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), informally called Superfund, authorizes EPA to identify and clean up contaminated sites. Under the Superfund program, EPA can also seek financial reimbursement for the cleanup work from the responsible parties.

Dredging projects that lie within the boundaries of a CERCLA site are subject to additional coordination requirements. The EPA Remedial Project Manager for each Superfund site can best advise dredging project applicants of the necessary requirements. ***The DMMP User Manual does not address CERCLA sampling and analysis requirements; a dredging project within a CERCLA site that only follows this User Manual may be required to perform additional subsequent characterization to fulfill CERCLA requirements.***

The EPA member(s) of the interagency DMMP team can help the project applicant by coordinating DMMP and CERCLA requirements to ensure that both program's needs are met with the most efficient sampling plan possible.

1.2.7 Other Applicable Federal and State Laws and Regulations

Numerous other federal and state laws may pertain directly or peripherally to dredging operations and dredged material/disposal in the state of Washington. See 2.1 for assistance determining which laws/permits may apply to your project.

Federal laws that may pertain to dredging projects include the following:

- National Environmental Policy Act (NEPA)
- "Section 408" (Rivers and Harbors Act, Section 14, codified under 33 U.S. Code 408)
- Fish and Wildlife Coordination Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Public Law 92-583, Coastal Zone Management Act (delegated to state of Washington)
- Section 106 National Historic Preservation Act

State of Washington laws/programs that may pertain to dredging projects include the following:

- State Environmental Policy Act
- Hydraulic Project Approval
- Aquatic Lands Act
- Model Toxics Control Act
- Washington Shoreline Management Act
- Washington State Coastal Zone Management Program
- Public Lands Act (Aquatic Use Authorization for state-owned aquatic lands)

1.3 Dredged Material Management Program

The DMMP is composed of regulatory representatives from four agencies (USACE, EPA, Ecology, and DNR) who are familiar with sediment evaluation procedures, CWA regulations and permitting procedures, and dredging equipment and procedures. The primary role of the members of the interagency DMMP team is to evaluate dredged material using the guidelines in this User Manual and to manage the DMMP multiuser open-water disposal sites.

The DMMP agencies meet monthly to discuss programmatic and project-specific issues. The DMMP agencies operate by consensus in all aspects of the program.

1.3.1 History and Structure

The interagency approach to dredged material management began in 1985 after studies surfaced concerns about environmentally degraded sediment and water quality in Puget Sound. Plunging public confidence in agency management of dredged material led to the loss of shoreline permits for the Elliott Bay disposal site and a halt to much local dredging. This crisis led to the Puget Sound Dredged Disposal Analysis (PSDDA) study, a 4.5 year initiative meant to restore confidence in agency regulation of unconfined open-water dredged material disposal. PSDDA was implemented in two phases, the first in June 1988 for central Puget Sound and second in September 1989 for north and south Puget Sound. The PSDDA effort generated two environmental impact statements that guide the management of Puget Sound open-water disposal sites.

The PSDDA program provided publicly acceptable and environmentally safe regulation of unconfined open-water dredged material disposal, but only for Puget Sound. In 1995 a long-term interagency management strategy was developed and implemented for the coastal estuaries of Grays Harbor and Willapa Bay. In 1998, a long-term interagency dredged material management strategy was also developed and implemented for the lower Columbia River. With the expansion of PSDDA oversight into Washington water bodies beyond Puget Sound, the program name changed from PSDDA to DMMP.

1.3.2 RSET and the SEF

The Regional Sediment Evaluation Team (RSET) is a collaboration of multiple state and federal agencies for the northwestern states of Washington, Oregon, and Idaho. RSET was established in 2002 for the primary purpose of developing and maintaining a regional guidance document called the *Sediment Evaluation Framework for the Pacific Northwest* (SEF) to address dredged material evaluation consistency issues across the northwestern states. Likewise, the SEF is consistent with the guidelines of the national-level sediment assessment manuals.

Relationship between the DMMP User Manual and the SEF

The DMMP User Manual is the implementation manual for dredged material evaluations in the state of Washington. The DMMP agencies ensure that the content of the DMMP User Manual is aligned with the regional SEF through agency participation in regular RSET meetings and involvement in SEF updates. Project proponents in the state of Washington need only refer to the DMMP User Manual when working on projects within the geographic jurisdiction of the DMMP.

1.3.3 The USACE Dredged Material Management Office (DMMO)

As the lead agency for the DMMP, the USACE Seattle District Dredged Material Management Office (DMMO) provides a "one-stop" sediment evaluation location for project proponents. The DMMO is a team within the USACE Operations Division that provides technical support to both the USACE Seattle District's Navigation Section and Regulatory Branch.

The USACE Navigation Section manages federal navigation projects by maintaining channels and other structural features for safe navigation in the Puget Sound region and on the Washington coast. Non-federal navigation projects will interact with the USACE Regulatory Branch for their permitting process. The Seattle District Regulatory Program evaluates applications for permits for proposed activities (including dredging) in "Waters of the United States."

The DMMO coordinates with the USACE Regulatory Branch on dredging projects and provides assistance on sediment quality and dredged material management issues. Dredging project proponents planning to submit an application to the USACE Regulatory Branch and other applicable agencies are encouraged to contact the DMMO beforehand for guidance on the sediment evaluation process. It is recommended that sediment characterization be performed prior to submitting the application so that the public notice and subsequent review can include information about the suitability of sediment to be dredged for open-water disposal and the quality of the sediment surface to be exposed by dredging. This facilitates a more streamlined review. The DMMO coordinates project reviews with the other DMMP agencies and drafts suitability determinations and other documents for DMMP approval. DMMO is responsible for all coordination with the other DMMP agencies during the sediment evaluation process.

In addition to being the lead agency for the DMMP, the DMMO is also responsible for ESA compliance with respect to use of the multiuser open-water disposal sites, including annual reporting to and periodic consultation with the National Marine Fisheries Service and U.S. Fish and Wildlife Service.

1.3.4 U.S. Environmental Protection Agency, Region 10

The primary role of the EPA representative is to evaluate dredged material using the guidelines set forth in the User Manual and to contribute toward management of the DMMP disposal sites. When a proposed DMMP dredging project is located within a CERCLA site, the EPA representative will coordinate with the EPA remedial project manager for that site to ensure that the dredging project and dredged material evaluation are compatible with remedial investigations and remedies. The EPA representative may also be responsible for overall project oversight through the review of NEPA documentation such as public notices and environmental assessments. In some limited circumstances, the EPA representative may also be responsible for the federal Clean Water Act Section 401 water quality certification for a project.

1.3.5 Washington State Department of Natural Resources (DNR)

The DNR representative reviews sediment evaluations and contributes towards the management of the disposal sites. In addition, the DNR representative handles the State's Site Use Authorization program, manages use of disposal sites, and collects revenues that are applied to management of the disposal sites. The DNR representative may advise DNR aquatic land managers, lease managers, and port managers regarding issues related to sediment quality. The DNR representative is also responsible for acquiring and maintaining a shoreline permit for each of the multiuser open-water disposal sites.

1.3.6 Washington State Department of Ecology (Ecology)

The Ecology representative reviews sediment evaluations and contributes to the management of the disposal sites. In some cases the Ecology representative may write the state's Section 401 WQC and Coastal Zone Management (CZM) consistency determination for the project, but in other cases the Ecology representative will advise the Ecology permit manager drafting those decisions. The Ecology representative may also work with the remedial project manager of an adjacent MTCA cleanup site to ensure that the proposed dredging project and dredged material evaluation are compatible with remedial investigations and remedies at the cleanup site. The Ecology representative is responsible for ensuring that DMMP actions and decisions comply with state regulations including the Washington State SMS and Washington State Water Quality Standards.

1.3.7 Multiple Roles of the DMMP Member Agencies.

The USACE DMMO member responsibilities are primarily devoted to DMMP duties; however, as outlined in the preceding sections and in **Table 1-1**, the EPA, Ecology, and DNR representatives often have various additional roles within their respective agencies that may overlap with their DMMP responsibilities. As a result, DMMP representatives have the ability to offer unique insights and advanced coordination with other essential programs within their respective agencies. This early coordination, which may feel like extra work for the applicant initially, can significantly expedite the subsequent permitting process for dredging projects. DMMP representatives who provide non-DMMP advice and information will strive to be as transparent as possible as to their dual roles when the advice provided is outside the scope of the DMMP.

Table 1-1. DMMP Agency Primary and Secondary Roles

Agency	Primary DMMP Role	Secondary Role(s)
DMMO (USACE)	Lead agency	ESA compliance
EPA	Member agency	Superfund coordination & federal-lead Section 401 program
Ecology	Member agency	State Section 401 program, CZMA, MTCA coordination
DNR	Member agency	Site Use Authorization (SUA)

1.3.8 How to Contact Us

DMMO staff are available to answer questions, assist in the development of sediment sampling and analysis plans and help troubleshoot during sediment sampling and testing (see DMMO on **Figures 2-1, 2-2, and 3-1**).

Any questions, problems or issues related to dredged material management should be directed to the DMMO:

Physical Address:	4735 East Marginal Way South Seattle, WA 98134-2385
Mailing Address:	U.S. Army Corps of Engineers, Seattle District ATTN: Dredged Material Management Office, CENWS-ODS-ND P.O. Box 3755 Seattle, WA 98124-3755
E-mail:	cenws-dmmoteam@usace.army.mil
Phones:	206-764-6083 206-764-6945 206-764-6550 206-764-6713

1.4 Public Process to Change the User Manual

Introduction

An important aspect of the User Manual is its ability to continuously evolve. As new information becomes available, the DMMP agencies revise and refine the User Manual content in a publicly coordinated process. The DMMP envisions a biennial cycle for changes to the User Manual and strongly encourages public stakeholders and member agencies to:

- Prepare technical papers and/or provide comments on papers prepared by the DMMP agencies, and
- Present these papers and/or provide comments at the DMMP's Sediment Management Annual Review Meeting (SMARM).

The SMARM is traditionally held on the first Wednesday of May and is a significant forum for the exchange of new information and ideas pertaining to the DMMP. Public input helps strengthen the User Manual and increase its utility for all users.

Who Can Propose a Change?

Any stakeholder, governmental entity or member of the public may propose a change to the User Manual through this public process.

Review Process for Changes to the User Manual

All substantive changes to the DMMP (and this User Manual) are made through the SMARM process: papers proposing updates are presented, public comments are taken, and proposals are then adopted as originally presented, modified based on comments, or not implemented.

DMMP identifies three kinds of papers: Issue, Clarification and Status.

- **Issue** papers propose substantive program-level changes that typically require approval by the directors of all four DMMP agencies in order to implement.
- **Clarification** papers propose updates and modifications to existing guidance that do not substantively change the program or policy.
- **Status** papers are for information only. Status papers may report on current investigations that could eventually result in an Issue or Clarification paper, or they may simply be information of interest to stakeholders.

Public review of proposed changes to the DMMP occur at SMARM and during the subsequent public comment period (typically 30 days). The DMMP agencies will collect, discuss, and address all comments received within the public comment period. After considering all comments, the DMMP agencies will either accept the change, make modifications based on comments received or reject it. Changes made through the annual review process will be documented in the SMARM minutes and incorporated into the next version of the User Manual. The SMARM has been held annually since 1988.

1.5 References (Specific to Chapter 1)

PSDDA, 1989. Management Plan Report, Unconfined Open-Water Disposal of Dredged Material, Phase II. September 1989.

USACE (Northwestern Division; Portland, Seattle, and Walla Walla Districts); EPA Region 10; NMFS; USFWS; Ecology; WDNR; ODEQ; and IDEQ. 2018 *Sediment Evaluation Framework for the Pacific Northwest.*

2 DREDGING PROJECT PERMITTING

Dredging and disposal in the waters of the U.S. require various permits. Evaluation of the proposed dredged material by the DMMP is an integral part of the permitting process. This chapter provides an overview of the permitting process and the role that the sediment evaluation plays in that process.

2.1 REGULATORY PROCESS OVERVIEW AND THE DMMP PROCESS

Prior to dredging, all dredging proponents must obtain the appropriate permits, licenses, or approvals. Depending on the scope and complexity of the project, permits may be required from federal, state, county, city and/or local jurisdictions. To determine which permits may be required for a specific dredging project, we recommend that dredging proponents utilize the state of Washington Governor's Office for Regulatory Innovation and Assistance (ORIA). ORIA's website (**www.oria.wa.gov**) provides basic environmental permitting assistance for both large and small projects located within the state of Washington. Specifically, ORIA's Project Questionnaire can help project proponents identify a list of federal, state, and local permits that may be required for a given project and provides information on how to apply for and obtain each permit.

Some general permitting guidelines for dredging and disposal projects:

- All in-water work requires a **Department of the Army permit**, a federal permit issued by the USACE.
- All dredging projects require a current **DMMP decision document**, which is coordinated through and prepared by the DMMO and is the subject of this User Manual.

For projects within Washington State, the Seattle District Regulatory Program ("USACE Regulatory") issues Department of the Army permits under the CWA, RHA, and MPRSA authorities. The DMMP decision document, prepared by the DMMO, is an integral piece of information used by the USACE Regulatory Project Manager when evaluating permit requests and issuing the Department of the Army permits for dredging projects. Exceptions to this approach are Port projects on the Columbia, which are managed by the Portland District Regulatory Program and receive decision documents through the Portland Sediment Evaluation Team.

While USACE Regulatory and the DMMO are both located within the USACE Seattle District office and coordinate on projects, they are separate groups with unique functions and authorities (see **1.3.3**).

A DMMP decision document is the written outcome of the sediment quality evaluation for a project; types of DMMP decision documents include a Tier 1 Evaluation, Suitability Determination, Antidegradation Determination, Recency Extension or other document related to sediment quality evaluations. It is not the same as the decision document prepared by USACE Regulatory prior to issuing a project permit.

Examples of additional laws, certifications, or permits commonly required for dredging-related projects in Washington State are presented in **1.2.**

2.2 FEDERAL PERMITS

The most well-known of the federal permits for in-water work is the Department of the Army permit. USACE Regulatory can permit dredging projects under two types of permits:

- Individual permit - includes Standard Individual Permits (IP) and Letters of Permission (LOP)
- General Permits – includes Regional General Permits (RGP) and the Nationwide Permit (NWP) Program.

IPs are issued for specific projects whereas General Permits can authorize many projects of a similar nature over a specified region. Typically, IPs undergo the greatest amount of analysis, requiring a public notice comment period as well as consideration for cumulative effects and an alternatives analysis if the project would result in a discharge of dredged or fill material. Letters of Permission, a type of streamlined individual permit, can also be issued for projects that have no more than minor impacts to navigation, such as residential piers and work in navigable waters. In Washington State, LOPs can only authorize Section 10 projects, while Section 404 permits require additional authorization.

General Permits are streamlined for projects that result in no more than minimal adverse environmental effects; compliance with NEPA, cumulative impacts considerations, and alternatives analysis are completed programmatically. NWPs are a type of General Permit issued across the entirety of the U.S. that authorize work with minimal environmental effects.

USACE Regulatory determines the type of permit and level of analysis appropriate for the project after reviewing the project impacts. Dredging and disposal projects frequently require a full analysis under the USACE Regulatory IP process due to the amount of work and material discharged.

Section 2.4 outlines the typical regulatory permitting process with an emphasis on interactions with the USACE Regulatory Program.

2.3 STATE PERMITS

Prior to or concurrent with the USACE Regulatory permit process, dredging proponents would be required to obtain permits/approvals from local jurisdictions and/or state agencies.

Typical permits/approvals required in the state of Washington include:

- Shoreline Substantial Development permits
- Hydraulic Project Approval permit
- Section 401 Water Quality Certification
- Coastal Zone Management (CZM) Consistency Review
- Disposal Site Use Authorization (SUA)

Many of these permits are not coordinated by the USACE Regulatory project manager. For example, the SUA (issued by DNR) is required if the project proponent plans to place dredged material at an approved open-water site or if the disposal affects state-owned lands.

2.3.1 Dredging or Placement on State-Owned Aquatic Land

For activities occurring on state-owned aquatic land (for example, sampling, dredging, or placement), authorizations may be required from DNR. The project proponent must check with DNR prior to beginning work. This process should be initiated at the same time that coordination with USACE begins.

2.3.2 DNR Disposal Site Use Authorization

An SUA must be obtained from DNR prior to disposal of dredged material at any of the multiuser open-water disposal sites in Puget Sound, Grays Harbor or Willapa Bay. Some Columbia River sites may also be managed by Washington DNR; the DNR agency representative should be consulted to determine appropriate jurisdiction early in the planning process. Dredging proponents are also encouraged to contact DNR well in advance of dredging (3+ weeks recommended) to avoid delays. DNR maintains updated information on all SUA requirements, including application forms, on its DMMP office web page.

Before DNR will process an SUA application, the applicant must provide a complete application package. A typical application package includes a Site Use Application and copies of all other agency permits required for dredging and dredged material disposal. DNR will not approve use of a disposal site with an incomplete application package.

Copies of the following permits are needed for the application package:

- USACE Regulatory Permit
- Washington Department of Ecology Water Quality Certification
- Washington Department of Fish and Wildlife Hydraulic Project Approval
- Shoreline Substantial Development Permit or Exemption Letter

Application packages must be mailed to DNR's DMMP office at the address listed on DNR's website. Once DNR's DMMP representative receives a completed Site Use Application and all required permits, it will take approximately two to three weeks to process the application and issue an SUA.

2.4 Regulatory Permitting Process

In general, the regulatory permitting process consists of the following steps and is illustrated in **Figure 2-1 and Figure 2-2:**

1. (Optional) The project proponent requests a **pre-application meeting** with USACE Regulatory to discuss the project and outline regulatory issues and processes, data requirements for application submittal, and preliminary permitting time frames.
2. Project proponent submits a complete **permit application** to the appropriate agencies, including USACE Regulatory. In Washington the Joint Aquatic Resource Permit Application (JARPA) is commonly used; however, the USACE Engineering Form 4345 is also accepted. *NOTE: Applicants are responsible for ensuring all relevant agencies receive the application; many project proponents mistakenly believe that submitting a JARPA to USACE Regulatory will fulfil the application requirements for all of the other permitting authorities. The dredging proponent is responsible for submitting the complete application with any additional information required to each of the relevant agencies that are checked in the JARPA. A current DMMP Suitability Determination or other decision document is strongly recommended prior to submission of the permit application.*
3. USACE Regulatory contacts the **DMMO** to discuss the project and ensure that all sediment evaluation requirements have been met.
4. USACE Regulatory, in coordination with Ecology, prepares and distributes a **Joint Public Notice** with a 10 to 30-day comment period.
5. USACE Regulatory completes Endangered Species Act **Section 7** consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (NOAA Fisheries).

6. Ecology issues a **WQC**. In addition, Ecology may also require State Environmental Policy Act (**SEPA**) review and **shoreline permits**.
7. The Washington State Department of Fish and Wildlife issues a **Hydraulic Project Approval**.
8. USACE Regulatory conducts a **public interest review** and incorporates comments from other agencies and the public.
9. USACE Regulatory makes a **permit decision**, and the project proponent signs the permit.
10. Project proponent obtains a DNR **SUA** (**2.3.2**) if open-water disposal at a DMMP site is proposed. Other authorizations may be required for other uses on state-owned aquatic land.
11. Project proponent contacts USACE Regulatory to **schedule a pre-dredge meeting** at least 14 days prior to beginning the work (**Chapter 13**).
12. Project proponent submits a **quality control plan** for dredging and disposal to USACE Regulatory at least 7 days prior to the scheduled pre-dredge meeting (**Chapter 13**).
13. USACE Regulatory conducts a **pre-dredge conference** with the project proponent and approving agencies to review the permitted work and permit conditions, the WQC, DNR's SUA, and the quality control plan (**Chapter 13**)
14. If night disposal is proposed, USACE Regulatory will coordinate with local Tribes prior to commencement of work.

As noted earlier in this chapter, the DMMP sediment evaluation process is an important component of securing permits for dredging and disposal of dredged material.

2.5 Sediment Quality Evaluation Timeline Considerations

When should project proponents conduct the sediment quality evaluation?

Proponents of dredging projects are encouraged to identify the need for a sediment quality evaluation **prior** to submitting a Department of the Army permit application to the Regulatory Program. There are several advantages to this approach:

- Streamlines ESA Section 7 consultation – the NMFS and USFWS commonly need the sediment quality evaluation to complete the ESA consultation.
- Streamlines CWA Section 401 state water quality certification – Ecology typically requires the sediment quality evaluation prior to completing their review and issuing the CWA Section 401 water quality certification.
- Prevents delays in the permit evaluation – The sediment quality evaluation may change the initially conceived project plan. For example, the dredged material disposal site and/or disposal methods may change as a result of the sediment quality evaluation. Also, post-dredge surface management may be necessary. These changes can cause permit processing delays.
- Provides information needed for an informed public interest review – Conducting the sediment quality evaluation prior to release of the public notice ensures that reviewing entities have a better understanding of the project and avoids the need to potentially reissue the public notice should the sediment evaluation result in modification of the proposed project.

How much time is required for the DMMP sediment quality evaluation process?

The time required for the DMMP's sediment quality evaluation can vary significantly depending on the complexity of the proposed dredging project, whether the need for biological testing is triggered, the need for CERCLA coordination and/or any sampling or analytical issues encountered. A typical project that requires characterization may require anywhere from four months to a year or more to complete all of the steps, which include developing a sampling plan, collecting samples, lab analysis, data interpretation, data report preparation, and preparation of the DMMP decision document. Chapter 3 outlines this process in more detail.

Obtaining the Department of the Army permit and the DMMP decision document are two separate, but interdependent, processes. The dredging proponent will need to coordinate with both the Regulatory Branch for a permit, and the Dredged Material Management Office for a DMMP decision document.

2.6 Special Types of Dredging and Permitting/Sediment Evaluation Considerations

2.6.1 New vs Maintenance Dredging

Dredging of areas that have not previously been dredged will always require a new Department of the Army permit. Maintenance dredging, defined as dredging to maintain the required depth of existing channels, harbors, berthing areas, etc., must also have a permit in effect to cover the planned work. If there is an existing permit, check the expiration date and permitted volume. Unless all projected dredging can be completed before the permit expires, a new permit (or extension of an existing permit) is required.

If a new permit is not required, the dredging proponent should check the expiration date and permitted volume of the DMMP suitability determination. If dredging cannot be completed prior to expiration of the suitability determination, the DMMO should be contacted for guidance. A new suitability determination may be needed, which would require additional sampling and testing, or an extension of the recency period may be granted.

2.6.2 Federal Navigation Maintenance Dredging

Federal navigation channel maintenance dredging and civil works projects performed by USACE do not require a Department of the Army permit. However, USACE must still comply with the substantive requirements of the CWA and MPRSA, including the sediment evaluation procedures provided in this User Manual. USACE also obtains a 401 WQC. Public notices are issued by the USACE Navigation office, and the projects must comply with other state guidelines.

2.6.3 Beneficial Use of Dredged Material

The DMMP does not issue beneficial use determinations for dredged material; however, the data generated by the DMMP sediment quality evaluation process are frequently utilized to make final beneficial use determinations. Often, but not always, material proposed for beneficial use will be required to meet DMMP guidelines for open-water disposal and/or Washington State Sediment Quality Standards. Resource agencies or landowners/managers may have even more stringent requirements for sediment characteristics (e.g. grain size), especially for in-water beneficial reuse or habitat creation projects

Applicants considering beneficial use projects are encouraged to coordinate with the DMMO and with other resource agencies early in the dredged material evaluation process. For more information on beneficial uses of dredged material, see EPA's Beneficial Use of Dredged Material page, and the USACE/EPA technical website Beneficial Uses of Dredged Material. If the sediment proposed for beneficial use is state-owned, contact DNR early to determine if additional considerations apply.

2.7 How to Get Help

If you need help characterizing or evaluating your project's proposed dredged material....

- Contact the DMMO (see **Chapter 1** for contact info)

If you have permitting-specific questions about your dredging project (i.e. JARPA, permit status, etc.)...

- Contact the USACE Regulatory Program
  Webpage: http://www.nws.usace.army.mil/Missions/Civil-Works/Regulatory/

If you're not sure whom to contact, feel free to reach out to the DMMO. If the DMMO can't answer your question, they will direct you to the appropriate contact in the USACE Regulatory.

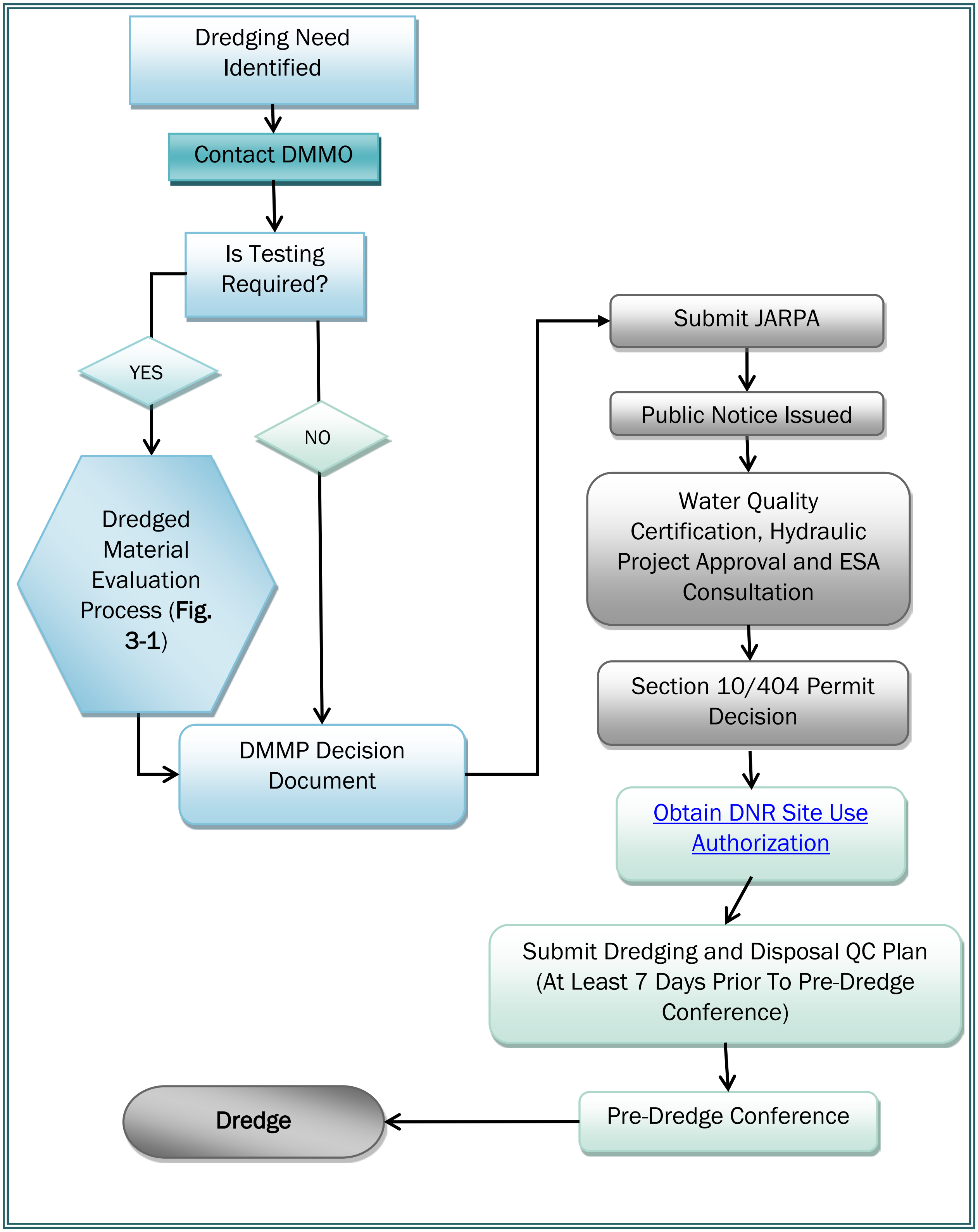

Figure 2-1. DMMP/Regulatory Process (new permit required)

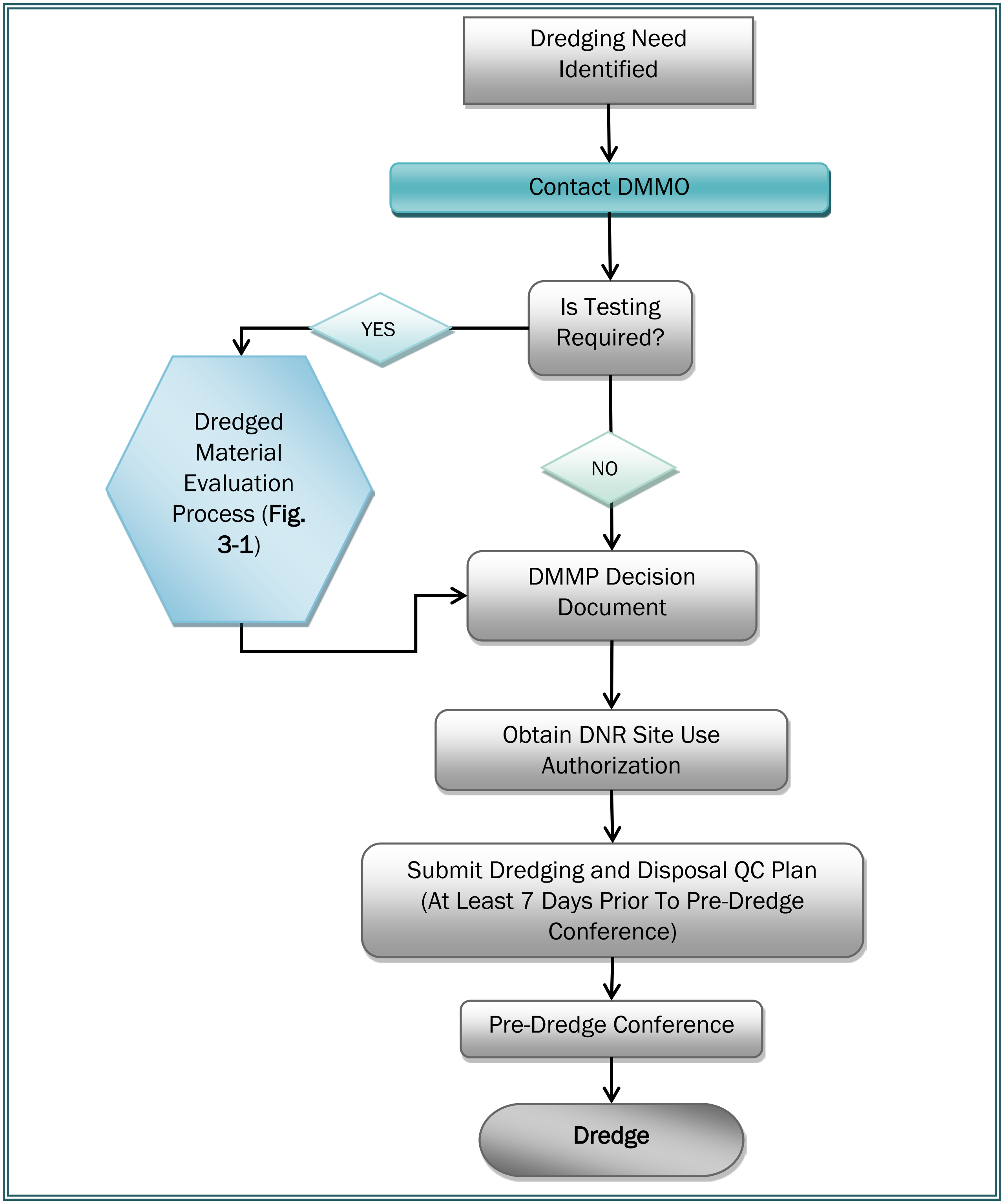

Figure 2-2. Regulatory Process (new permit not required e.g. dredging under an existing multi-year permit)

3 CHARACTERIZING YOUR DREDGING PROJECT

Permits for dredging and disposal are tied to the DMMP decision document prepared for a given project. Major changes in volume, dredge prism, dredge method or disposal site subsequent to DMMP evaluation may result in delayed permitting, additional sediment testing, construction contract issues, or permit enforcement actions. Taking the time to plan a project carefully before proceeding to sediment characterization can save considerable time and money for everyone.

3.1 TYPES OF DMMP DECISION DOCUMENTS

For every project the DMMP writes a decision document consistent with that particular type of project. The major types of decision documents prepared by the DMMP agencies are as follows:

- **Tier 1 evaluation/determination:** A Tier 1 memo is written for projects that don't proceed past the Tier 1 analysis and documents the outcome of that evaluation. More information on Tier 1 evaluations is provided in **Chapter 4**.
- **Suitability determinations:** This is the standard type of decision document and is intended for projects with open-water disposal where some level of Tier 2 and/or Tier 3 testing was completed. This document typically also addresses antidegradation and other project-specific issues such as debris management. Detailed information regarding the evaluation procedures necessary for a suitability determination are included throughout this User Manual.
- **Anti-degradation determinations:** This type of document is prepared for projects for which open-water disposal is not proposed and the sampling is only conducted to determine that the post-dredging sediment surface will not be more degraded than the existing sediment surface. See **Chapter 12** for more information on antidegradation evaluations.
- **Recency determinations:** This type of document is prepared for projects for which existing sediment testing results (typically 2+ years old) are evaluated to verify that they are still "recent" enough to be representative of the project. More information can be found in **5.2**.
- **Volume revisions:** Documents changes in project volume and if/how the previous project documentation applies to the new volume.
- **Special/supplemental determinations:** This type of document is the least common; an example would be a supplement to an original suitability determination due to the availability of new or changed information.

The type of decision document that will be necessary for a project is largely determined by the type(s) of disposal proposed.

3.2 EVALUATING PLACEMENT AND DISPOSAL OPTIONS

Before embarking on the dredged material evaluation process, the proposed final resting place of the dredged material must be determined. Possible placement options will depend on the location of the project, but the two general categories are as follows:

1. In-water
2. Upland

Within each category there are multiple types of disposal options. For in-water disposal, there are existing multiple-use sites in Puget Sound, Grays Harbor, Willapa Bay and the Columbia River for which the agencies perform the required environmental evaluations. More information about the DMMP's in-water disposal sites is in **Chapter 13**. No DMMP-managed in-water disposal sites have been identified in Eastern Washington. In-water disposal in areas where there are no existing multi-user sites is possible if the project proponent conducts the environmental evaluation and permitting.

One common upland disposal location is at a landfill, but other upland disposal locations are available depending on sediment quality and suitability.

Beneficial use can utilize either in-water or upland disposal options. Additional information about beneficial use is in **Chapter 14**.

3.3 The Dredged Material Evaluation Process

The main questions that the DMMP evaluates are as follows:

1. **Is proposed dredged material suitable for open-water disposal?** Open-water disposal can be at one of the approved DMMP sites or in some cases in flow-lane disposal areas.
2. **Is proposed dredged material suitable for in-water beneficial use?** In general, material proposed for beneficial use needs to meet not only DMMP guidelines for open-water disposal, but also the Washington State Sediment Management Standards requirements as well. Fisheries agencies or landowners/managers may require more stringent comparisons, especially with in-water beneficial reuse or habitat creation projects. Certain physical characteristics may also be needed for a given project.
3. **Will the post-dredge surface meet Washington State anti-degradation standards when the project is finished?** In other words, will the sediment surface left behind after dredging be less degraded relative to the sediment surface that existed prior to dredging? This question is often the only applicable question for DMMP consideration if the proposed disposal site is upland with no return water.

To answer these questions, the DMMP uses a tiered approach to sediment characterization. There are four tiers of evaluation:

Tier 1: Site Evaluation and History

Tier 2: Chemical Testing

Tier 3: Biological Testing (bioassay and/or bioaccumulation testing)

Tier 4: Special Studies

Every project is subject to a Tier 1 evaluation, which is a review of historical and ongoing sources of contamination, land use, and any previously collected data (**Chapter 4**). Occasionally a suitability determination can be made using only Tier 1 information. For other projects, Tier 1 informs the characterization required in subsequent tiers. Tier 3 biological testing is invoked if chemicals of concern are present at concentrations that are of potential concern for human health or the environment. Time can be saved by compressing Tiers 2 and 3; that is, by conducting concurrent chemical and biological testing. Tier 4 testing is rarely required by the agencies or pursued by dredging proponents. If Tier 4 testing is needed, it is specially designed in coordination with the DMMP agencies.

It is always the project proponent's decision to proceed to the next tier for further testing; the option of disposing of material in an appropriate upland location rather than pursuing further testing is always available.

The dredged material evaluation process is required for every dredging cycle. In some cases this process will be as simple as checking to see if an existing suitability determination covers the proposed dredging, as might be the case for frequent, routine maintenance dredging. In other cases, Tier 2 and Tier 3 testing may be required. Regardless of the project, DMMP coordination needs to be conducted and documented.

The dredged material evaluation process consists of the following steps (**Figure 3-1**):

1. Dredging proponent defines and submits a conceptual dredging plan and site history (**Tier 1: 3.4** - **3.5** and **Chapter 4**).
2. Dredging proponent (with consultant assistance as needed) determines project-specific sampling and analysis requirements, as stipulated in this User Manual. DMMO may be contacted for assistance, especially for a determination of the appropriate project rank.
3. Dredging proponent develops a sampling and analysis plan (SAP) for sediment evaluation (**Chapters 5 & 6**).
4. Dredging proponent submits SAP to the DMMO.
5. DMMO coordinates review of the SAP by the other DMMP agencies. Proponent may be required to address concerns and re-submit the SAP if it does not meet DMMP requirements.
6. DMMO sends a SAP approval letter or email message to the dredging proponent.
7. A pre-sampling conference call between the DMMP and sampling team may be scheduled prior to the beginning of sampling.
8. Dredging proponent conducts field sampling and laboratory testing.
9. Dredging proponent submits a sediment characterization report to the DMMO for distribution to all DMMP agencies.
10. DMMO coordinates review of the testing data with the DMMP agencies. Proponent may be required to address concerns and re-submit the sediment characterization report if it does not meet DMMP requirements.
11. DMMO drafts and the agencies review and sign a suitability determination for disposal.

Figure 3-2 and Figure 3-4 summarize the tiered testing approach for marine and freshwater sediments, respectively. Figure 3-3 illustrates the specialized dioxin testing procedure for dredging projects in Puget Sound.

3.4 Developing a Conceptual Dredging Plan

Before starting the dredged material evaluation process, the dredging footprint, design depth, overdepth and other characteristics of the dredging project must be determined. While construction-level detail is not required at this point in the process, a realistic conceptual dredging plan will aid in the development of a sampling plan (if needed) and avoid permitting delays and construction issues further along in the process. A project-specific conceptual dredging plan takes into consideration:

- the depth and physical characteristics of the sediment,
- side slopes,
- practicable dredge cut widths and depths,
- physical and logistical constraints,
- dredging priority of various portions of the project,

- available dredging methods and equipment, and
- conventional construction practices at similar dredging projects.

If sampling and testing are anticipated, the conceptual dredging plan should also consider the ramification of various testing outcomes. For example, a decision to create both surface and subsurface dredged material management units (DMMUs; see 5.4.1) may seem appropriate if there are six feet of accumulated sediment at the toe of an under-pier slope, but should the surface DMMU fail and the subsurface DMMU pass, it may be impractical to separate these two units during dredging operations. This topic is addressed in more detail in **Chapter 5**.

3.5 Determining Volume of Material to be Dredged

The physical geometry and volume of sediments proposed for dredging should be determined from a pre-sampling bathymetric survey. The dredging volume calculation should include side slopes, overdepth and sediments anticipated to slough from under piers and wharves. For dredging projects with cuts deeper than four feet and that occur infrequently, the dredging prism can be divided between a "surface" layer (generally two to four feet in depth) and a "subsurface" layer consisting of everything below the surface layer. The volumes comprising each of these layers should be calculated. While the surface and subsurface volumes will be used to calculate the numbers of required samples and dredged material management units for testing, it is not always advisable to carry this distinction forward into the sampling plan[3]. See the example in **Chapter 5**.

Dredging contracts routinely include "overdepth" material that is often one to two feet below the required dredging depth (except for very small projects where it may be decided to minimize overdepth volume for cost control). Overdepth volume will be included in the calculation of the requirements for sampling and analysis.

Volume estimates, including overdepth material, are incorporated into the project permit, water quality certification and site use authorization. Exceedances of permitted volumes may result in fines or work stoppages. Thus it is important to develop an accurate volume estimate of material to be dredged. To reduce the incidence of permit violations, the following guidelines should be followed:

1. Pre-sampling surveys should be taken as close in time as possible to the sampling event to get the best possible bathymetric data for volume estimates.
2. Pre-sampling volume estimates must include allowable overdepth for the entire dredging prism, including side slopes. Technical justification for the selected angle of repose for the side slopes must be included in the sampling and analysis plan.
3. When a box cut is proposed along a pier face, sloughing from under the pier should be anticipated in all cases. Technical justification for the selected angle of repose for side slopes under piers must be included in the sampling and analysis plan. The dredging proponent should ensure that all necessary geotechnical or under-pier survey data be provided to the contractor estimating the dredged material volume.
4. It is highly recommended that presampling estimates of in-situ volume be increased by an uncertainty factor to account for the error inherent in the estimation process - see DMMP 1996a, Dredged Material Volume Estimates. Sampling and testing requirements will be

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[3] See 5.4.2 for more details on delineating surface and subsurface DMMUs, especially for situations in which historical contamination may increase with depth.

based on this adjusted volume. The uncertainty factor must be identified in the sampling and analysis plan along with a technical justification for its selection. It should be noted that the uncertainty factor applies only to estimates of in-situ volume and is not meant to address bulking of sediments during dredging.

5. Some areas, particularly channels and settling basins, are characterized by rapid shoaling during winter storm events. Since sampling and testing are required prior to dredging, not all of the sediment to be dredged will have been deposited at the time of sampling. In such instances, an estimate needs to be made of the additional sedimentation expected between the time of sampling and time of dredging. This contingency volume must be included in the volume to be characterized. Known sedimentation rates for the area, records from previous dredging events, extrapolation from existing conditions, and best professional judgment can be used to estimate the volume of sediments likely to be dredged. The rationale for calculating the contingency volume should be included in the sampling plan. Sampling and testing requirements must include this contingency volume.

3.6 Issue Resolution for DMMP Decision Documents

The DMMP agencies operate by consensus; that is, all four agencies must be in agreement for a given DMMP decision document to be finalized. Project proponents with concerns are encouraged to contact their DMMO point of contact as early as possible to discuss possible outcomes.

Development of a process through which a project proponent can elevate individual project decisions to the management of all four DMMP agencies was recommended by Ecology in a 2017 report to the Washington State Legislature following a management review of the DMMP. The DMMP agencies are developing this process and will present it at the 2019 SMARM (May 1, 2019). The issue resolution process will be available for review on the DMMO website in 2019 and will be incorporated in the next version of the User Manual.

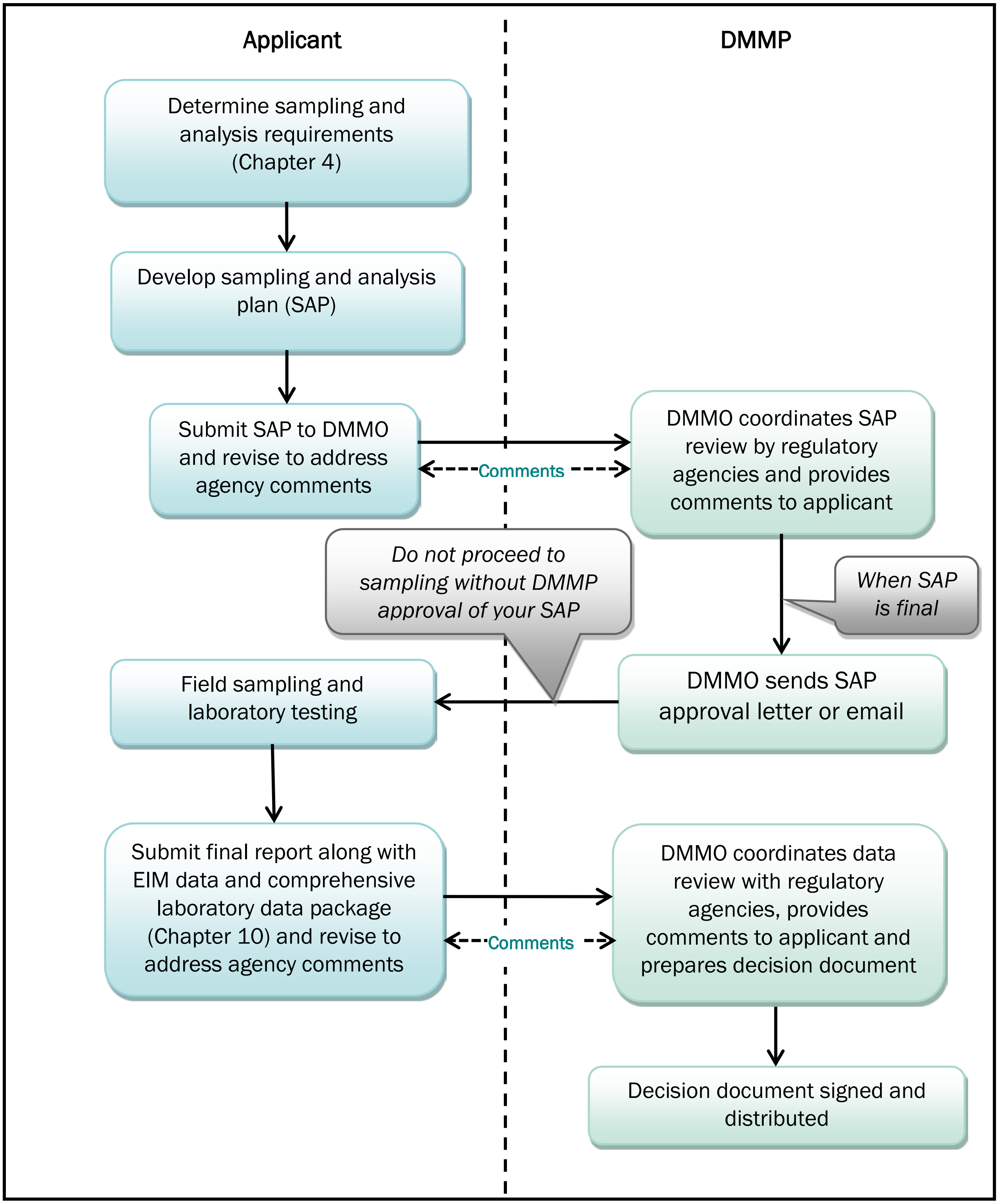

Figure 3-1. Dredged Material Evaluation Process

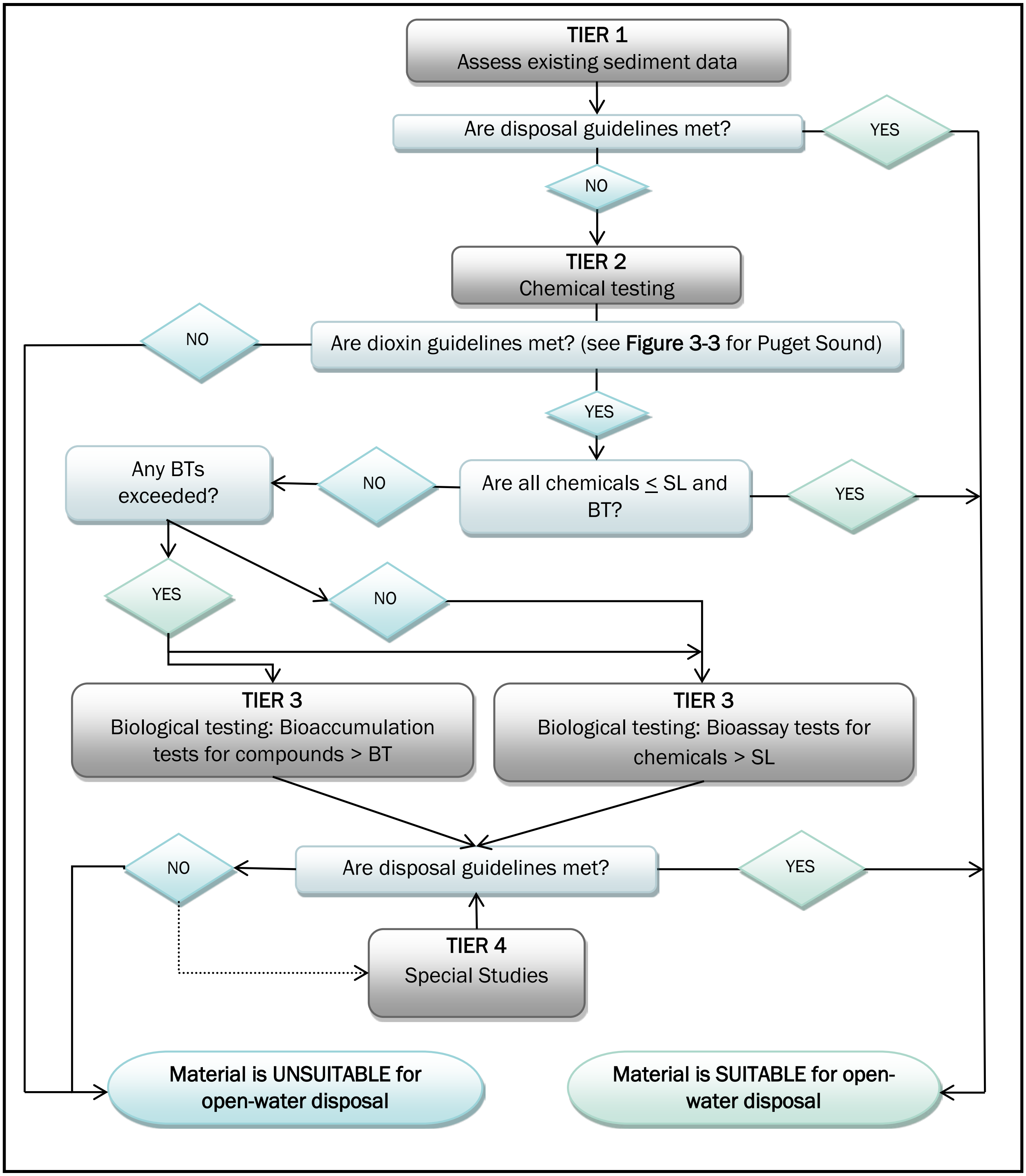

Figure 3-2. Tiered Testing Decision Diagram for Marine Sediment

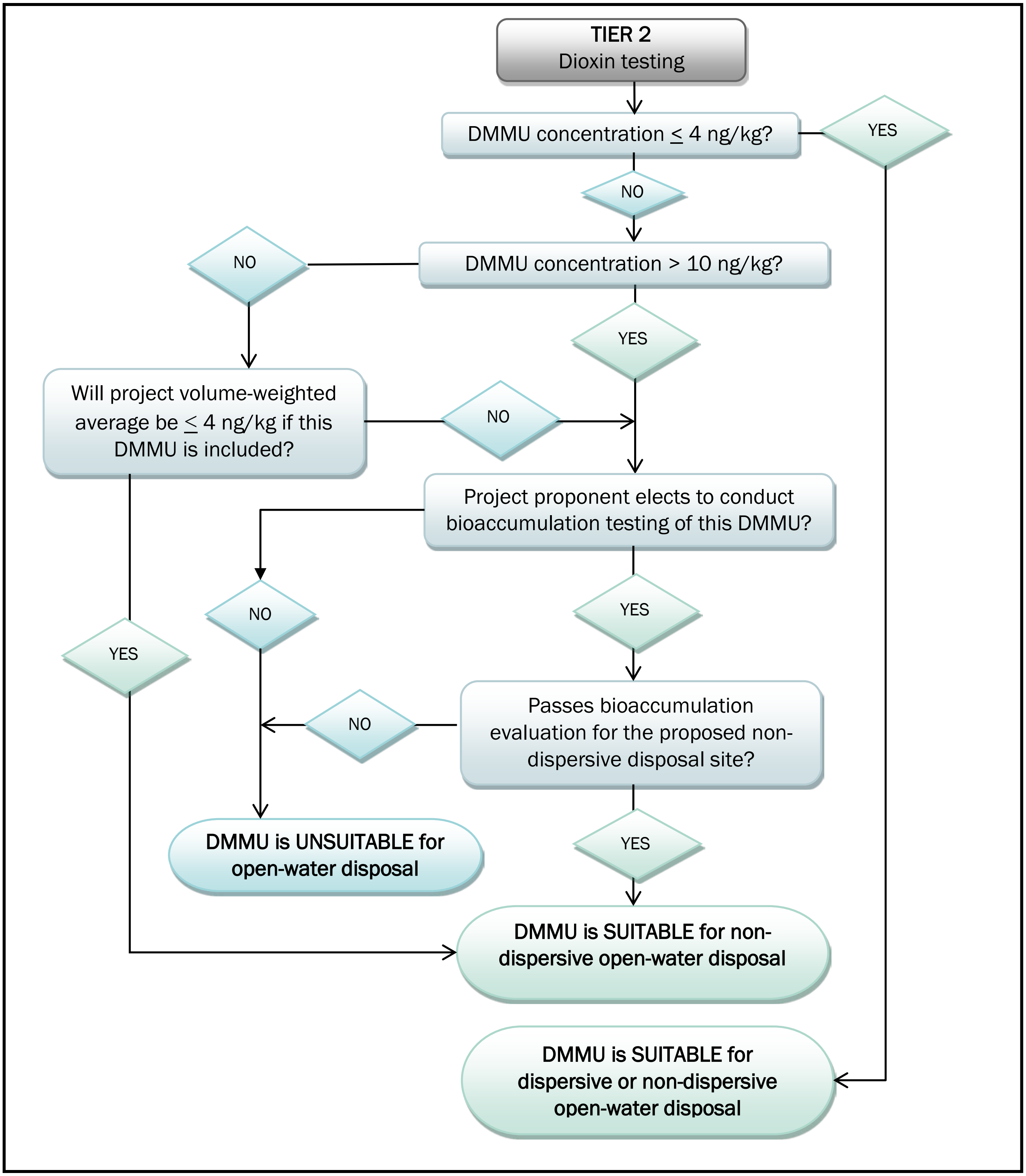

Figure 3-3. Dioxin Testing Decision Diagram for Projects in Puget Sound

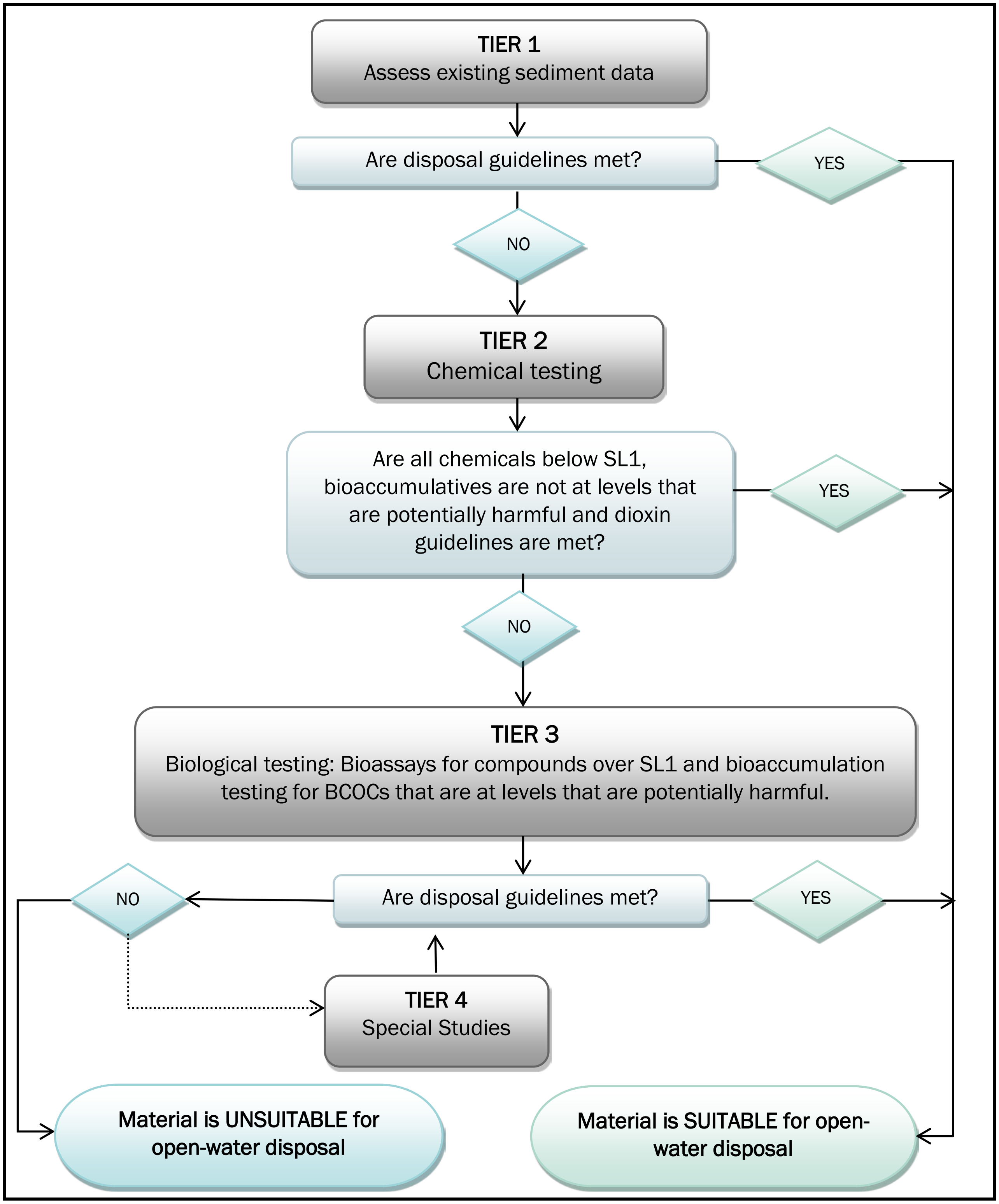

Figure 3-4. Tiered Testing Decision Diagram for Freshwater Sediment

4 TIER 1: EVALUATION/SITE HISTORY

Tier 1 is a comprehensive analysis of all readily available existing information on the proposed dredging project, including a site history and all previously collected physical, chemical and biological data. The type and amount of information required for a Tier I evaluation will vary according to the size and complexity of the project and the history of the dredging site.

A Tier 1 evaluation is necessary to inform the entire sediment evaluation process. It's not necessarily a long or complex process, but it is vital to determining all further steps for a given sediment evaluation. **Providing the Tier 1 information is the responsibility of the project proponent and needs to be included in the project Sampling and Analysis Plan (SAP).**

For a Tier 1 evaluation, the two major components that the dredge proponent (or its consultants) needs to provide to the DMMP are as follows:

- Conceptual dredging plan (see **3.4 – 3.5**)
- Site History (**4.1**)

The site history information requirements are detailed in **4.1.**

4.1 SITE HISTORY

The history of a project area plays a pivotal role in project evaluation and, if needed, the sampling plan development. The purpose of the site history is to document potential past and present sources of contamination to dredged material proposed for open-water disposal. A site history characterizes known activity at the dredging site, in near-shore areas, and on adjacent properties. It identifies past activities and describes the type of contamination that may have resulted from those activities.

The following outline identifies the type of information that may be necessary in a site history for a large, complicated site. Smaller projects in areas of lower concern will require less information. For most projects, site histories do not need to extend beyond two to three pages. A reasonable effort should be made to obtain relevant data. It is recognized that certain types of data may not be readily available but the effort to obtain it should be documented. Previous characterization and dredging in the area should be referenced and summarized to the extent possible. Emphasis should be placed on activities that have occurred since the last dredging cycle. Identify whether the proposed dredging project is within, or adjacent to, an existing or proposed EPA or Ecology-listed CERCLA, RCRA or MTCA site, and the appropriate site manager (if known). In addition to any in-water cleanup sites, this should include upland sites in parcels adjacent to the in-water work area.

The site history should include all the following information that is applicable to the specific project:

1. A map showing the site's location, layout, storm drainage, outfalls, and special aquatic sites such as eelgrass or wetlands.
2. Current site use.
3. Industrial processes at or near the site (and hazardous substances used/generated).
4. Outfall information, such as type, volume, NPDES data.
5. MTCA, CERCLA or site information (including site manager if known), including those on adjacent upland areas (e.g., location of caps, sheet pile containment, use restrictions, etc.).
6. Spill events.

7. History of site ownership and land uses.
8. Adjacent property use, especially those up-gradient or up-current/upstream.
9. Site characteristics that could affect movement of contaminants (e.g. prop wash, ferry traffic).
10. Results of any previous sampling and testing on and around the project site.
11. Presence or absence of invasive species
12. Evidence of the presence/absence of debris in the dredge prism based on previous rounds of dredging or other lines of evidence.

4.1.1 Invasive Species

The project area must be checked against online resources for the known or suspected presence of invasive species, including the invasive New Zealand mud snail. The following WDFW website can be used to check for documented presence of New Zealand mud snails: https://wdfw.wa.gov/ais/potamopyrgus_antipodarum.

The result of this check must be documented in the project documentation or, if testing is required, in the SAP. If the project is located within an area known or suspected of harboring the New Zealand mud snail or other invasive species, project proponents are encouraged to contact WDFW's Aquatic Invasive Species (AIS) group as early as possible in the project planning stages to obtain further guidance. Depending on the project location, design, and AIS involved, transport of dredged material may be prohibited and could significantly impact projects. Regardless of the dredged material's final disposition, projects located within an area known or suspected of harboring the New Zealand mud snail must include standard operating procedures in the SAP for minimizing the spread of this invasive species.

4.2 Sources of Information

There are a wide variety of information sources for site histories. Potential sources include:

1. current and previous property owners
2. aerial photographs (past and present)
3. real estate and Sanborn fire insurance maps
4. zoning, topographic, water resource, and soil maps
5. agency records, such as NPDES permit files, contaminated site lists (state and federal), CERCLA construction completion and long-term monitoring reports, aquatic leases, previous permits, databases, etc.
6. land use records
7. knowledgeable persons at or near the site (managers, employees, adjacent property owners)
8. city atlases (Kroll and Metsker)
9. agency environmental databases (http://www.ecy.wa.gov/cleanup.html, http://www2.epa.gov/cleanups/cleanups-my-community), https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database.
10. spills databases (https://ecology.wa.gov/Spills-Cleanup/Spills)

Not all sources are needed for all projects, and the type and extent of sources consulted will vary. Smaller projects and those with less complicated source histories will generally require less documentation but should always include enough information to enable the agencies to adequately address sampling and testing issues. Dredging proponents can contact the Dredged Material Management Office to determine the level of effort required for their specific project. The DMMO will coordinate with the other agencies as necessary to determine project-specific requirements.

4.3 Testing Exclusions Based on Tier 1 Analysis

Section 404 of the Clean Water Act (CWA) includes provisions for exclusion from testing based on Tier 1 evaluations, as does the Inland Testing Manual guidance document (EPA/USACE, 1998). A project may be given a rank of very low and be excluded from testing under the following conditions:

- Based on the site history information review (Tier 1), the proposed dredged material is sufficiently removed from potential sources of sediment contamination either geospatially or vertically (in the case of native sediment). Bioaccumulative compounds are not likely present at levels of concern based on review of historical data and comparison to DMMP screening levels and bioaccumulation triggers.
- The site is subject to strong current and/or tidal energy and contains coarse-grained sediment with at least 80 percent sand/gravel retained in a No. 230 sieve and total organic carbon (TOC) content of less than 0.5 percent. Typical locations include sand and gravel bars, the main-stem channel of the lower Columbia River, the outer reaches of the Grays Harbor navigation channel, and marina entrance channels subject to deposition of coarse-grained sediment from longshore drift. Grain size and/or TOC analysis may be necessary in some cases to demonstrate that the dredged material meets the numerical guidelines. In other cases, photographic evidence of grain size (e.g., a photo of a gravel or sand bar obstructing navigation) may be sufficient to rank a project "very low" without having the proponent analyze for grain size or TOC.

Testing may also not be necessary "where the discharge site is adjacent to the excavation site and subject to the same sources of contaminants, and materials at the two sites are substantially similar" (40 CFR 230.60(c)). **All testing exclusions are project-specific and may be subject to other regulatory authorities and guidelines.**

4.4 Tier 1 Suitability Determinations

Given the provisions in **4.3**, the DMMP may issue suitability determinations based on a Tier 1 evaluation alone, or based on limited additional testing (see DMMP 2004b). In these situations enough information is available to make a suitability determination call based on Tier 1 information (**3.4, 3.5, 4.1 and 4.2**) alone, and no additional testing is required.

5 DEVELOPING SAMPLING AND ANALYSIS REQUIREMENTS

Once a Tier 1 evaluation is completed and it is determined that additional project characterization is needed, the following steps are followed to determine the requirements for the Tier 2 characterization of project sediments:

1. determine the rank for the project
2. determine the volume of material to be dredged (if not already done)
3. determine required number of dredged material management units (DMMUs) and field samples
4. refine the conceptual dredging plan
5. develop a sampling plan which distributes the DMMUs to reflect the conceptual dredging plan, allocates the required number of field samples, and presents a compositing scheme for combining field samples to represent the DMMUs.
6. determine if any non-standard COCs are required

These steps must be documented in the sampling and analysis plan developed for review by the agencies. Note that if you are within an EPA or MTCA cleanup site, the project proponent should coordinate with the relevant agency early since additional sampling requirements may be required as part of the cleanup programs.

5.1 DETERMINE PROJECT RANK

A dredging area, or a specific project, is typically assigned to one of five possible ranks: *high*, *moderate*, *low-moderate*, *low* or *very low*. These ranks represent a best professional judgment of the level of concern or potential risk *by the agencies*, typically based on a scale of potential for adverse biological effects or elevated concentrations of chemicals of concern. The lower the rank, the less the concern, and the less intense the sampling and testing requirements needed to adequately characterize the dredged material. The ranking system is based on two factors:

1. The available information on chemical and biological-response characteristics of the sediments.
2. The number, kinds, and proximity of chemical sources (existing and historical).

For those dredging projects with sufficient historical data, the assigned ranking is based on the available chemical and biological data for project sediments. For those projects lacking sufficient historical data, the number, kinds and proximity of chemical sources are the major factors driving the assigned rank. Table 5-1 defines the general ranking guidelines.

5.1.1 General Rankings

Certain geographic areas and use activities are assigned a general rank based upon the nature and extent of possible sources of chemicals of concern that could impact sediments needing to be dredged. In the absence of sediment quality data to the contrary, urban and industrialized areas as well as areas located within MTCA or CERCLA cleanup site boundaries are initially ranked ***high***. Marinas, ferry terminals, fueling and ship berthing facilities, construction facilities, and sediments located close to moderate-sized sewer outfalls are initially ranked ***moderate*** (unless located in a high-ranked urban or industrialized area). Areas that are geographically removed from potential sources of chemicals of concern are ranked ***low-moderate***, ***low,*** or ***very low***.

Table 5-1. General Dredged Material Ranking Guidelines

RANK	GUIDELINES
Very Low (VL)	Project is sufficiently removed from potential sources of sediment contamination either geospatially or vertically (in the case of native sediment). Bioaccumulative compounds are not likely present at levels of concern based on review of historical data and comparison to DMMP bioaccumulation triggers. The site is subject to strong current and/or tidal energy and contains coarse-grained sediment with at least 80 percent sand retained in a No. 230 sieve and total organic carbon (TOC) content of less than 0.5 percent.
Low (L)	Few or no sources of chemicals of concern. Data are available to verify low chemical concentrations (below DMMP screening levels and bioaccumulation triggers) and no significant response in biological tests.
Low-Moderate (LM)	Available information indicates a "low" rank, but there are insufficient data to confirm the ranking.
Moderate (M)	Sources exist in the vicinity of the project, or there are present or historical uses of the project site, with the potential for producing chemical concentrations within a range associated historically with some potential for causing adverse biological impacts.
High (H)	Many known chemical sources, high concentrations of chemicals of concern, and/or biological testing failures in one or both of the two most recent cycles of testing. Projects located within or adjacent to a MTCA/CERCLA cleanup site may be subject to project-specific ranking guidelines with higher sampling and testing requirements.

5.1.2 Area-Specific and Project-Specific Rankings

To further facilitate the determination of sampling requirements, rankings for dredging projects in specific geographic areas or with adequate historical testing data were determined using the ranking guidelines in **Table 5-1**. Current rankings for the Puget Sound area are shown in **Table 5-2** and **Table 5-3**; for Grays Harbor and Willapa Bay in **Table 5-4** and in **Table 5-5** for the Columbia River.

5.1.3 Integration of Dioxin Data into Ranking Determinations in Puget Sound

The DMMP uses BPJ to determine ranking relative to dioxin rather than including dioxin in the standardized ranking approach used with other COCs. Where dioxins are either known or suspected to be present, existing sediment dioxin data from the project and vicinity as well as source information will be used to design a sampling density appropriate for the project. This approach is used if elevated dioxin concentrations have limited distribution in a given area; there are demonstrated cases where the higher sampling density required for one portion of a project is not appropriate over the entire area to be characterized.

Table 5-2. Current General Rankings for Puget Sound

High	All urban and industrialized areas except those listed individually
Moderate	All existing fueling and ship berthing or construction facilities
Moderate	All existing marinas except those listed individually
Moderate	All ferry terminals with the exception of Keystone
Low-mod	All other unidentified areas

Table 5-3. Current area and project-specific rankings for Puget Sound

AREA	DETAILS	RANK
Pt. Roberts	Outer Channel Marina	Low Moderate
Blaine	Except marina	Low
Bellingham	Bellingham waterfront, including Inner & Outer Squalicum Boat Harbor and the head of Squalicum Waterway	High
	Squalicum Waterway (except the head)	Low-Mod
	Bellingham Cold Storage	Low-Mod
Anacortes	Cap Sante Boat Haven	High
	Former Scott Paper Mill	High
	Port of Anacortes Pier 2	High
	Cap Sante Waterway	Moderate
	Anacortes waterways, marinas and Guemes Channel	Moderate
Swinomish Channel	Federal Navigation Channel and La Conner Marina	Low
Whidbey Island	Coupeville (Keystone) Ferry Terminal	Low-Mod
	NAS Whidbey Island Fuel Pier	Moderate
Port Susan	West Port Susan, near Cavelero Beach	Moderate
Port Angeles	Inside the harbor	High
Port Townsend	Between Point Hudson and the Port Townsend Boat Haven; and south of Port Townsend Boat Haven	High
	Port Townsend Marina	Moderate
	Oak Bay Channel	Low
Everett/ Snohomish River	East Waterway	High
	Snohomish River: All **intertidal** areas downstream of the upper settling basin	High
	Navigation Channel	Low-Mod
	All other **subtidal** areas of the Snohomish River (through the upper settling basin; excluding cleanup areas)	Low-Mod
	10th Street Boat Launch	Low
	Everett Marina	Variable (based on location and project)
Mukilteo	All projects	High
Edmonds	Edmonds Marina	Moderate
	All other projects	High
Ship Canal/ Lake Washington	Salmon Bay	High
	Lake Washington Ship Canal	High
	Lake Union	High

Table 5-3. Current area and project-specific rankings for Puget Sound

AREA	DETAILS	RANK
Pt. Roberts	Outer Channel Marina	Low Moderate
	Kenmore (north end of Lake Washington)	High
	Lake Washington (except for Kenmore)	Moderate
Elliott Bay	Seattle Waterfront, West Waterway, East Waterway	High
Duwamish River	Navigation Channel, downstream of station 254+00	High
	Navigation Channel, station 254+00 to the turning basin	Moderate
	Turning Basin	Low-Mod
	Delta Marine	Low-Mod
	All other projects downstream of the turning basin	High
Bainbridge Island	Port Madison	Moderate
	Immediately adjacent to Wyckoff	High
	Inner Eagle Harbor (west of Wyckoff west beach)	Low-Mod
Bremerton	Sinclair Inlet	High
	Dyes Inlet	Moderate
Port Orchard	All projects	Low-Mod
Vashon Island	Upper portion Quartermaster Harbor	Moderate
	Outer Quartermaster Harbor	Low-Mod
Gig Harbor	All projects	Moderate
Tacoma	Commencement Bay, except as specifically mentioned	High
	Blair Waterway – federal navigation channel only	Low
	Blair Waterway, except for federal navigation channel	Variable (based on location and project)
	Sitcum Waterway	Low
Shelton	All projects	High
Olympia	Olympia Harbor (except parts of the federal navigation channel)	High
	Lower Budd Inlet, including East Bay and West Bay	High

Table 5-4. Current rankings for Grays Harbor and Willapa Bay

RANK	GRAYS HARBOR	WILLAPA BAY
High	Urban and Industrialized Areas Westport Marina	Urban and Industrialized Areas
Moderate	Westhaven Cove entrance channels (federal maintenance dredging); Marinas, except Westport Marina; Fueling and Berthing Facilities; Construction Facilities Located near moderate-sized sewer outfalls	Other Marinas Fueling and Berthing Facilities Construction Facilities Located near moderate-sized sewer outfalls Nahcotta Boat Basin
Low-Moderate	Rayonier Dock Junction City Dock Weyerhaeuser Bay City Dock	Tokeland Marina

Table 5-4. Current rankings for Grays Harbor and Willapa Bay

RANK	GRAYS HARBOR	WILLAPA BAY
Low	Port of Grays Harbor Terminals 1, 2, 3, 4 Crossover Reach North Reach Hoquiam Reach Cow Point Reach Aberdeen Reach South Aberdeen Reach	Bay Center Inner Channel (both segments of the dog leg) and mooring area Tokeland Entrance Channel
Very Low	Bar Reach Entrance Reach Point Chehalis Reach South Reach	Willapa Bar Bay Center Outer Channel

Table 5-5. Current rankings for projects on the Columbia River and other waterbodies

RANK	COLUMBIA RIVER	OTHER WATERBODIES
High	Typical locations include large urban areas and shoreline areas with major industrial development.	
Moderate	Typical locations include urban marinas, fueling, and ship berthing facilities; areas downstream of major sewer or stormwater outfalls; and medium-sized urban areas with limited shoreline industrial development. Millennium Bulk Terminals – Longview Georgia-Pacific Camas Slough	Quillayute federal boat basin (slip area)
Low-Moderate	Available data indicate a "low" rank may be warranted, but data are not sufficient to validate the low ranking. Weyerhaeuser – Longview	Port of Clarkston Port of Lewiston
Low	Typical locations include areas adjacent to entrance channels, rural marinas, navigable side sloughs, and small community berthing facilities. Kapstone Paper (Longview Fibre)	Snake/Clearwater federal navigation channel Quillayute federal navigation channel and boat basin (non-slip area)
Very Low	Typical locations include gravel bars, mainstem channels such as the lower Columbia River or coastal inlets.	

5.1.4 Outfalls

Some small dredging projects consist of the removal of sediment discharged from an outfall, or located directly adjacent to an outfall, yet fall within a general geographic area ranked low, low-moderate or moderate. However, it is possible that these sediments contain chemicals at a level of concern far greater than the area in general. Therefore, such dredging projects may be given a "high" rank by the DMMP agencies regardless of the rank of the general area. This decision will be made on a case-by-case basis, with consideration given to the type and size of the outfall, the shoaling pattern relative to the outfall, and any other relevant information available to the project proponent, such as catch basin and particulate data associated with the outfall.

5.1.5 Re-Ranking of Areas/Projects/Project Reaches

Modifications of the initial rankings can occur as the result of additional testing. A project area can be ranked higher (e.g., from low-moderate to moderate) based on the results of a single testing period. However, consistent results from two consecutive testing periods are required before a ranking can be lowered (e.g., from high to moderate). Projects may be ranked lower for a one-time dredging event based on the results of a partial characterization (see **5.8**). However, two testing cycles will be required to lower the rank on a longer-term basis.

5.2 Recency Guidelines

Recency guidelines indicate how often a project needs to conduct sediment characterization. Recency guidelines apply to both projects that have been tested but not yet dredged, and to projects that have been maintained with repeated dredging since previous testing. A key consideration in determining whether available data are still representative is the recency of the information. "Recency" guidelines for existing information refer to the duration of time for which chemical and biological characterization of project-specific sediment remains adequate and valid for decision making without further testing. With older data there is increased potential for a "changed condition" that could alter its validity. Data must be sufficiently recent to be considered representative of the material to be dredged.

The ranking system for dredging projects takes into consideration both the sources of contamination and historical chemical and biological testing data (which are considered an integrated reflection of the effects of sources on the project area). Therefore, the recency guidelines are based on the project rank. For high-ranked projects, the recency guidelines allow characterization data to be valid for a period of 3 years (DMMP, 2014). The recency guidelines for moderate, low-moderate, low and very low-ranked projects are periods of 5, 6, 7 and 10 years, respectively (**Table 5-6**).

Table 5-6. Recency Guidelines for DMMP Projects

RANK	RECENCY PERIOD (years)
High	3
Moderate	5
Low-moderate	6
Low	7
Very Low	10

When other permitting requirements prevent a project from being dredged during the recency period, extension of the recency period will be considered on a case-by-case basis. When considering whether existing data continue to adequately characterize sediment from a specific project, the agencies will review previous characterization data, any new data from the dredge site or vicinity, and site use. Based on this review, the agencies may extend the recency determination, typically for one year. This extension may be allowed with no additional testing, or may require some level of additional testing.

The recency guidelines do not apply when a known "changed" condition (e.g., spills or new discharges) has occurred since the most recent samples were obtained. For subsurface sediments, the potential for contamination from groundwater sources must be considered.

Project proponents must request a recency extension from the DMMO if recency guidelines are likely to be exceeded at their project site prior to dredging. The recency extension request should thoroughly evaluate the site for changed conditions, including spills that have occurred in the vicinity since the project was last characterized. The DMMP will respond in writing or by email to the request, and provide a recency extension – if appropriate –after the request has been evaluated.

For projects with upland disposal, DMMP will use BPJ regarding recency.

For further clarification on recency extensions and guidelines, see the DMMP program-level updates entitled, *Recency Guidelines: Program Considerations* (2002b); *Recency Guideline Exceedances: Guidelines for Retesting in High Ranked Areas* (2003b); and *Recency Guideline Modifications* (2014b).

Recency guidelines apply to, and supersede, the concept previously known as "frequency," which referred to the extent of time a given dredging project could be maintained with repeated dredging without further testing.

Two consecutive cycles of sampling and testing for a project or subarea – with all material being found suitable for open-water disposal – are required before the project can be dredged multiple times under a single characterization within the recency guidelines.

5.3 Refine the Conceptual Dredging Plan

A conceptual dredging plan makes a practical project-specific plan for how dredging can be accomplished by taking into consideration several factors, including: the depth and shape of the dredge prism, physical characteristics of the sediment, side slopes, practicable dredge cut widths and depths, available dredging methods and equipment, physical and logistical constraints, and conventional construction practices at similar dredging projects. There is no "one size fits all" approach.

For projects with surface and subsurface DMMUs, an important component of the conceptual dredging plan is to consider how surface and subsurface material will be dredged separately in the event that one or the other is found unsuitable for open-water disposal. A one-foot vertical buffer is typically required when dredging an unsuitable DMMU. This buffer must be considered when developing the conceptual dredging plan. If the resulting layer of suitable dredged material is too thin or patchy to feasibly dredge separately, or consists of a narrow wedge of material at the toe of a slope, then all material should be considered surface material.

Similar consideration must be paid to the division of the dredging area into DMMUs horizontally. If one area (such as an access channel to a marina) is of higher priority for dredging than an adjacent area (such as one or more finger piers), then combining the two areas into one DMMU may lead to adverse consequences if the DMMU be found unsuitable for open-water disposal.

Construction level detail is not needed at this point in the process. However, a realistic conceptual dredging plan will aid in delineating DMMUs and avoiding the situation where a suitability determination negatively impacts the ability to dredge a project.

5.4 Determine the Number of DMMUs and Field Samples

The number of field samples to be taken and the number of laboratory analyses conducted to fully characterize the sediments for any given project must be sufficient to allow for an adequate assessment. The total anticipated dredging volume for the project must be well established; see 3.5 for additional details. The following guidelines specify a maximum volume of dredged material that can be represented by a single field sample and by a single laboratory analysis. They are considered "minimum" requirements in that the dredger may opt for, or regulatory agencies may require, additional samples or analyses if warranted.

Note: The DMMP User Manual does not address sampling and analysis requirements for cleanup sites; projects located within or adjacent to a MTCA/CERCLA cleanup site may be subject to project-specific sampling and testing requirements. Please contact the DMMO early in your project planning process for assistance.

5.4.1 Dredged Material Management Units

A "dredged material management unit" (DMMU) is the smallest volume of dredged material that is truly dredgeable (i.e., capable of being dredged independently from adjacent sediments) and also for which a separate disposal decision can be made by the agencies. **A given volume of sediment can only be considered a DMMU if it is capable of being evaluated, dredged and managed separately from all other sediment in the project.**

All of the field samples taken within a DMMU are composited to provide a single sediment sample for laboratory analysis that is representative of that DMMU. Therefore, the selection of sampling locations and the development of a compositing scheme must provide an accurate representation of the condition of each DMMU. In general, samples should be distributed across the dredging prism so as to target the bulk of the dredge volume. However, special circumstances, such as the presence of sources of contamination, may dictate otherwise. The location of point sources in the vicinity of the project must be taken into consideration when locating field samples, but "worst-case" sampling should *not* be the goal of full characterization (it *is* the goal of partial characterization sampling; see 5.8). Tier I information, including the location of point sources, should be included in the sampling and analysis plan and should support the sampling locations selected to ensure representative sampling of the proposed dredged sediments.

5.4.2 How Many DMMUs?

Sediment in any given project is considered either “heterogeneous” or “homogeneous.” Heterogeneous sediment is known, or presumed, to have different contamination levels in the surface and subsurface sediments. Most projects fall into this category. Heterogeneous sediments are sampled with a core sampling device in order to sample the entire depth of the dredge prism.

To characterize heterogeneous sediments, different sampling intensities are used for the surface and subsurface portions of the dredge prism (Table 5-7). Heterogeneous sediment is usually divided into “surface” (typically 0 to 4 feet of the dredging prism) and “subsurface” (greater than 4 feet below the sediment surface). Using Table 5-7, in a moderate-ranked area with 32,000 cubic yards (CY) of surface material (0 to 4-foot cut depth) and 24,000 CY of subsurface material (at 4-foot cut depth or deeper), a total of three DMMUs are required (two from the surface volume and one from the subsurface volume).

This approach was adopted in the original PSDDA study and assumes that the surface material is more contaminated than the underlying material. It has since been shown that for many sites the opposite is true. Legacy contamination may exist in the deeper sediment and more recently deposited sediment may be relatively uncontaminated. In such cases, Table 5-7 will not apply. The specific conditions for a particular dredging project will dictate the volume limits for DMMUs.

For projects which are dredged frequently due to rapid or routine shoaling, the sediments are expected to be relatively homogeneous and the distinction between surface and subsurface sediments becomes less important. In this case, DMMU volumes may be based on the average of surface and subsurface maximum allowable volumes. The proposed dredging volume may be divided by this average volume to determine the number of DMMUs. Grab samples are usually considered adequate to characterize homogeneous sediments.

The DMMO must be consulted before categorizing a project as "homogeneous" as there are only a small number of cases in which this designation applies. These include -- but are not limited to -- the Duwamish turning basin and adjacent federal navigation channel, Snohomish River federal navigation project, Swinomish Channel federal navigation project and the Grays Harbor federal navigation project.

Table 5-7. Maximum sediment volume represented by each DMMU for projects in Puget Sound, Grays Harbor, Willapa Bay and the Upper Columbia River

PROJECT RANK	HETEROGENEOUS SEDIMENT (contamination level decreases with depth*)		HOMOGENEOUS SEDIMENT (well mixed)
	SURFACE	SUBSURFACE	
Very Low	Not applicable	Not applicable	100,000 CY
Low	48,000 CY	72,000 CY	60,000 CY
Low-moderate	32,000 CY	48,000 CY	40,000 CY
Moderate	16,000 CY	24,000 CY	20,000 CY
High	4,000 CY	12,000 CY	8,000 CY

*If contamination increases with depth or there is no suspected difference between surface and subsurface contamination, project specifics will dictate the appropriate volume limits for the surface and subsurface DMMUs.

*Table 5-8. Maximum sediment volume represented by each DMMU for projects on the Lower Columbia River**

PROJECT RANK	SEDIMENT VOLUME
Very Low	300,000 CY
Low	100,000 CY
Low-moderate	70,000 CY
Moderate	40,000 CY
High	5,000 CY

* Lower Columbia River refers to the portion of the river bordered by Oregon and Washington.

5.4.3 Sampling Intensity

The maximum volume of sediment that may be represented by a single field sample (typically a 4-foot core section) within Puget Sound, Grays Harbor, Willapa Bay and the Upper Columbia varies with project rank and is presented in Table 5-9. For projects in areas ranked low or low-moderate, a single sediment sample should be taken for every 8,000 CY of material to be dredged. For projects in areas ranked moderate or high, a single sediment sample should be taken for every 4,000 CY. Unlike the maximum volume represented by each DMMU, the maximum volume represented by each field sample does not vary with sediment depth. Continuing with the example presented above, a moderate-ranked project with 32,000 CY of surface sediment and 24,000 CY of subsurface sediment would require a total of 14 field samples: eight from the surface volume and six from the subsurface volume, which would be composited respectively to generate two DMMUs (two analyses) for the surface material and a single DMMU (single analysis) for the subsurface material.

Table 5-9. Maximum sediment volume represented by a single field sample for projects in Puget Sound, Grays Harbor, Willapa Bay and the Upper Columbia River

PROJECT RANK	SURFACE	SUBSURFACE
Very Low	Project specific	Project specific
Low	8,000	8,000
Low-moderate	8,000	8,000
Moderate	4,000	4,000
High*	4,000	4,000

*** Projects located within or adjacent to a MTCA/CERCLA cleanup site may be subject to project-specific sampling and testing requirements.**

For projects on the Lower Columbia River, the number of field samples per DMMU is dictated by the predicted heterogeneity within the DMMU and its shape (RSET, 2018).

5.5 Sampling Methods

The goal of sediment sampling for characterization of each individual DMMU is to collect a sample (or a number of composited samples) which will be representative of the DMMU. The minimum sampling requirements discussed above are based on volumetric measurements. The type of sampling required, however, depends on the type of project. The sampling methodology to be used must be presented in the sampling and analysis plan along with the rationale for its use.

5.5.1 Core Sampling

For projects with heterogeneous sediment and for new-work dredging, the proponent will be required to take core samples from the sediment/water interface down to the maximum depth of dredging, including overdepth and Z-samples.

There are numerous gear options available for obtaining core samples. These include impact corers, hydraulic push corers, vibracorers, augers with split spoons or Shelby tubes, sonic corers, etc. The methodology chosen will depend on availability, cost, efficacy, presence of wood waste, debris or rip rap, type of sediment, and anticipated sediment recoveries.

5.5.2 Grab Sampling

Sediments in frequently dredged areas (e.g. Grays Harbor navigation channel) are assumed to be relatively homogeneous. Therefore, for homogenous projects not in high-ranked areas, grab samples will be considered adequate to represent the dredged material, even if shoaling results in sediment accumulation greater than four feet. The minimum number of grab samples required can be calculated from Table 5-7, Table 5-8 and Table 5-9.

5.6 Determining the Chemicals of Concern (COC) list

The standard list of COCs for both marine and freshwater projects can be found in Table 8-3. Tributyltin (TBT) is included on the standard list for freshwater projects, but is required only on a case-by-case basis for marine projects. Note that if the project proponent of a freshwater project can provide compelling evidence that butyltins are unlikely to be present, then butyltins may be dropped as a COC. Dioxins/furans are required on a case-by-case basis for both freshwater and marine projects. Information on when and where analyses of dioxins/furans and TBT are needed can be found in **8.3.1** and **8.4.1**, respectively. Other COCs in limited areas are discussed in **8.4**.

If upland disposal at a landfill becomes necessary, additional COCs may need to be analyzed, specifically barium and volatile organic compounds. Some metals, like chromium, may need different analytical methods. Other tests that may be required are leachate and paint filter testing. It is recommended that applicants check with the landfill to determine if there will be additional testing requirements.

5.7 Special Project Considerations

5.7.1 "No-Test" Volumes for Small Projects

For small projects, the cost of testing must be balanced against the environmental risks posed by disposal of a very small volume of dredged material. Small projects in low, low-moderate and moderate ranked areas represent low potential risk that unacceptable adverse effects will result at the disposal site from the discharge of project material. As a result, with the exception of high-ranked areas, a small volume of sediment to be removed at a dredging site may require no testing or reduced testing.

For projects in very low, low, low-moderate, or moderate-ranked areas, volumes for which no testing need be conducted are shown in **Table 5-10**. For low-ranked areas, the "no test" volume is equal to the maximum volume represented by a single field sample (i.e., 8,000 CY). For low-moderate and moderate rankings, the "no test" volume of 1,000 CY is representative of the capacity of medium-sized barges. For high-ranked areas there is not a "no test" volume and some testing is always required. In addition, the resource agencies may require testing – even for small projects – in areas where dredging could potentially mobilize contaminants in areas important for threatened or endangered species.

Table 5-10. "No Test" volumes for small projects

PROJECT RANK	"NO-TEST" VOLUME
Very Low	Physical testing may be required
Low	Less than 8,000 CY
Low-moderate and Moderate	Less than 1,000 CY
High	Some testing is always required

5.7.2 Reduced Testing for Small Projects Exceeding the "No-Test" Volume

The original PSDDA documents outlined reduced testing requirements for some small projects that exceed the no-test volume (PSDDA 1988). These guidelines have been rarely used during the life of the program. For more information please contact the DMMO office.

To clearly define what constitutes a small project, there are two key qualifiers. First, intentional partitioning of a dredging project to reduce or avoid testing requirements is not acceptable. Second, recognizing that multiple small discharges can cumulatively affect the disposal site, project volumes are defined in as large a context as possible. One example of this latter qualifier is recurring maintenance dredging of a small marina where "project volume" will be the projected dredging volume over the life of the permit.

5.7.3 Reduced Sampling and Testing for Native Material

Projects that involve dredging of native material that has not been exposed to contaminated groundwater may require less sampling and testing than the requirements identified in Table 5-7 and Table 5-8. The agencies will make this determination using best professional judgment on a case-by-case basis using site-specific information.

5.8 PARTIAL CHARACTERIZATION FOR DOWN-RANKING

A dredging proponent may choose to perform a partial characterization (PC) of project sediments. A PC is most frequently done on larger projects and is based on the chemical analysis of a limited number of samples. If the PC data indicate that the project has been over-ranked, then down-ranking may be permitted for a subsequent full characterization (FC). Down-ranking may substantially reduce the overall cost of sampling and testing for a large project.

A PC is designed to be simple and economical. A PC is not a substitute for a full characterization, but is only a means for establishing a "reason to believe" that a lower ranking is appropriate. A PC must provide sufficient information to support a decision to re-rank a project. PC results are used to down-rank a project on a one-time basis only. Two cycles of full characterization are required for longer-term down-ranking and changes to the recency period.

5.8.1 Development of a PC Sampling and Analysis Plan

A sampling and analysis plan must be developed for a PC. The PC plan must be submitted to the DMMO, who in turn will coordinate agency review with EPA, Ecology and DNR representatives.

The following PC guidelines are appropriate for most dredging projects. However, because anomalies may exist for a given project, the agencies reserve the right to depart from these guidelines if conditions so warrant (e.g. complex chemical source environment, ambiguous and/or highly variable characterization data, etc.). As with all aspects of the dredged material evaluation process, professional judgment will be an important factor in the decision-making process. The dredger should coordinate with the DMMO in the development of an adequate PC plan.

5.8.2 Sampling Requirements for Down-Ranking

The number of samples required for down-ranking is based on a percentage of the number of samples that would be required for a full characterization. A dredger may elect to down-rank up to two levels by increasing the sampling intensity. No compositing of samples for a PC is allowed. PC sampling station delineation must be approved in advance by the agencies and should represent "worst-case" sampling relative to the location of local point sources.

For the option of lowering a rank one level, ten percent of the FC minimum surface sample requirement must be analyzed for a PC. A minimum of two samples must be analyzed for this option. For the option of lowering a ranking two levels, 20 percent of the FC minimum surface sample requirement must be analyzed for a PC. At least three samples must be analyzed for this option. A dredger has the option of performing a PC on subareas of a dredging project. Subareas must be selected with the approval of the agencies. A minimum of two samples is required for each subarea. Although a PC is most frequently done on surface sediments, a dredger may be required to perform subsurface sampling and analysis during a PC if there is reason to believe that subsurface sediments are contaminated relative to sediments in the upper four feet of the dredging prism.

Partial characterization data for a given sampling station may also be used, in some limited cases, in partial fulfillment of FC requirements. The strategy for doing so must be clearly stated in the PC sampling and analysis plan and approved by the agencies.

5.8.3 Ranking Guidelines Based on PC Data

PC samples must be analyzed for the full list of chemicals of concern (see **Table 8-3**) and sediment conventionals, including dioxins/furans and TBT if applicable. The down-ranking of a project (or subarea) will be based on the results of the sample having the highest level of chemicals of concern.

PC data may also be used as a "reason to believe" test to screen out some chemicals of concern. If a chemical is not found in the PC and is not available from nearby sources, it may be deleted from the full characterization.

Partial characterization protocols were developed through the PSDDA program for marine sediments. If partial characterization is requested for freshwater projects, the DMMP will utilize BPJ on a case-by-case basis. Additional guidance for partial characterizations can be found in PSDDA (1988).

5.9 Post-Dredge Sediment Surface (Z-Samples)

Dredging alters environmental conditions in the dredging area by exposing new sediments to direct contact with biota and the water column. The sediment exposed by dredging must meet the antidegradation policy (WAC 173-204-120) under the state of Washington Sediment Management Standards (SMS). The “Z-sample” represents the sediment that will be exposed by dredging. Z-samples are typically collected from the **first two feet** below the dredging overdepth and must be collected during sampling for all projects requiring core sampling. Z-sample collection and analysis guidance is as follows:

- Z-samples will be collected and archived for every core sampling location for all projects, regardless of rank. Archived sediment must be maintained at -18° C.
- It is likely that the holding time for mercury will be exceeded prior to any testing of archived Z-sample sediment. If the Z-sample is eventually tested for mercury and more than 28 days have elapsed between sample collection and analysis, the results should be flagged as having exceeded the holding time.
- If an immediately overlying DMMU is found to be contaminated (e.g., unsuitable for unconfined open-water disposal), the associated underlying Z-sample must be analyzed to verify the sediment quality of the Z-layer.
- If there is reason-to-believe that concentrations of chemicals of concern increase with depth, the DMMP agencies may require Z-samples to be analyzed concurrently with analysis of the DMMUs.
- Z-sample analyses will initially consist of sediment conventional and chemical analyses. If the results of these analyses indicate that the sediment to be exposed by dredging will be degraded relative to the existing sediment surface, the dredging applicant may be required to remobilize and resample locations with degraded Z-samples in order to perform required biological testing (bioassays and/or bioaccumulation testing) or the degraded sediment may need to be removed or covered with clean sand.
- For the majority of projects, a decision about Z-sample analysis will be made after review of the chemistry/bioassay data associated with the dredged material. The project proponent always has the option of conducting Z-layer analysis concurrently with the dredge prism.

For further discussion of Z-sample testing and antidegradation evaluations, see **Chapter 12**.

6 PREPARING THE SAMPLING AND ANALYSIS PLAN (SAP)

Once the required numbers of DMMUs and field samples have been calculated and a dredging plan conceived, a sampling and analysis plan (SAP) must be developed. The DMMUs and field samples must be distributed within the actual dredging prism in a manner consistent with the definition of a DMMU and any project-specific constraints. It is not necessary or always desirable to set the volumes characterized by each individual sample or DMMU to the maxima from **Table 5-7, Table 5-8 and Table 5-9**. Best professional judgment is necessary in the allocation of DMMUs and the development of a sampling and compositing plan.

In dividing the proposed dredging volume into DMMUs, it is important to ensure that the DMMUs be fully reflective of the dredging plan and that the management units be truly dredgeable. If an individual DMMU (represented by one or more field samples) is found unsuitable for unconfined open-water disposal, then that DMMU must be capable of being dredged independently from adjacent sediment (remembering that a 1-foot vertical buffer above and/or below the unsuitable DMMU will also be declared unsuitable). Additional DMMUs--beyond the minimum number--may be required to achieve an appropriate dredging plan (e.g., where different sediment types or spatially distinct areas warrant separate DMMUs).

Steps followed in developing characterization requirements must be documented in the sampling and analysis plan developed for review by the agencies.

A well-designed sampling and analysis plan (SAP) is essential when evaluating the potential impact of dredged material discharge on the aquatic environment. The SAP is submitted to the DMMO for coordinated review and approval by the DMMP agencies before any sampling is initiated, as shown in **Figure 3-1**. This coordination, including full and open disclosure of information, reduces the chance of having to repeat costly procedures and assists in keeping projects on schedule.

The SAP must contain the information outlined in the following sections in enough detail to allow the agencies to determine the adequacy of the sampling and analysis program.

6.1 PROJECT DESCRIPTION/CONCEPTUAL DREDGING PLAN

The information outlined below should be provided at the beginning of the SAP. Where appropriate, project details should be presented in tables.

1. Maps of vicinity and project area and plan view of site
2. Project description, recent bathymetric survey data, one or more cross-sections of the dredging prism, dredging depth (MLLW) including overdepth, side-slope ratios, and proposed disposal site
3. Project volume, including sideslopes, overdepth, uncertainty factor and contingency volume (see **3.5**)
4. Proposed disposal location
5. Project schedule – both for sediment characterization and dredging. Describe any tight timeline elements
6. Site history, including past characterization data, past and current site use, identification of potential sources of contamination, and past permitting (including NPDES permits as well as dredging permits) – see **Chapter 4**.

7. The project location must be checked for the presence of invasive species. See **4.1.1** for details.

6.2 Sampling Design

See Chapter 5 for details.

1. Project rank and justification
2. Computation of DMMP sampling and analysis requirements based on surface (0-4 feet) and subsurface (> 4 feet) volumes
3. Project details, as necessary, to justify the design of the DMMUs
4. Map/s of project area with DMMU outlines (including sideslopes) and target sampling locations; cross-sections if necessary
5. Table with DMMU identification, DMMU volume, designation as surface or subsurface DMMU, and number of samples for each DMMU
6. Table of sampling locations including coordinates, mudline elevation (MLLW), design depth, overdepth, Z-depth, and preliminary determination of required core lengths to be assigned to DMMUs and Z-samples
7. Compositing plan, including sampling depths relative to both mudline and MLLW (or other vertical datum as appropriate)
8. Z-sample plan
9. Personnel involved with the project and their respective responsibilities and contact information, including project planning and coordination, field sampling, chemical and biological testing labs, QA management, data validation and final report preparation
10. Signature page for subcontractors – signatures only needed with final SAP

6.3 Sampling Methodology

See Chapter 7 for details.

1. Sampling equipment and capability
2. Horizontal datum – NAD83, HPGN83, HARN83 or WGS84
3. Horizontal positioning system and accuracy of sampling stations (must be <$\pm$ 3 meters); if differential GPS is used, include the make and model of the GPS unit and indicate the differential signal and station that will be used.
4. Method for determining real-time water depths at sampling stations
5. Method for real-time determination of tide levels (e.g. Hazen gauge or tide board), including procedure for establishing or verifying vertical control
6. Sample acceptance criteria (e.g. penetration and recovery criteria for cores)
7. Description of the use of water depths, tide elevations, penetration and recovery data to determine the actual core lengths to be assigned to DMMUs and Z-samples
8. Location where sample processing will occur (i.e. on-board vessel, onshore, laboratory)

9. Decontamination procedures
10. Table of analytical groups (e.g. semivolatiles, metals, bioassays) with planned sample volumes, container sizes and type, holding times and conditions; this table should also include archived samples
11. Sulfides sampling procedure (see **7.5**)
12. Description of entries that will be made in field/sampling logs
13. Description of core logging
14. Chain-of-custody procedures
15. Proposed sampling schedule

6.4 Chemical Analysis

See Chapter 8 for details.

1. Plans for physical and chemical laboratory testing, including grain-size analysis, sediment conventionals and chemicals-of-concern
2. Table(s) of current chemicals of concern, with relevant regulatory limits (DMMP and SMS, marine and/or freshwater) clearly indicated (with correct units of measure), including extraction/digestion methods, analytical methods, method reporting limits and method detection limits for all COCs (estimated detection limits for dioxin)
3. Table(s) of QA parameters, frequency of analysis, and acceptance guidelines
4. (If applicable) Puget Sound Sediment Reference Material (PS-SRM) requirements for dioxin and PCBs; including PS-SRM request procedure and acceptance ranges for Aroclor and dioxin congeners, as needed; see http://www.nws.usace.army.mil/Missions/CivilWorks/Dredging/SRM.aspx
5. Identification of standard reference materials (SRM) to be used for semivolatiles, pesticides and metals, including the SRM certificates and the acceptance ranges the lab plans to use for quality control
6. Dioxin quality assurance and interpretation guidelines, if necessary
7. Validation stage for each analytical group
8. Statement indicating that reporting limits or sample reporting limits must be at or below SLs to avoid bioassays
9. Chemistry lab reporting requirements and case narrative describing analytical problems

6.5 Biological Analysis

See Chapter 9 for details.

1. Selection of tiered or concurrent bioassays
2. Bioassays to be used, species-selection rationale and a brief description of the protocols
3. Decision-making process for determining amphipod species, given project-specific grain size and clay content (i.e. if clay content is greater than 20%, use *Ampelisca abdita*)

4. Decision-making process for determining whether to purge for ammonia or sulfides and/or run an LC_{50} (reference toxicant) test for ammonia
5. Decision-making process for determining whether to use the larval resuspension protocol
6. Statement that larval test will be aerated
7. Water quality monitoring parameters, schedule and acceptance limits
8. Proposed collection location of reference sediments and how reference sediments will be matched to test sediments; the wet-sieving protocol should be included
9. Table with bioassay interpretation and reference/control performance standards
10. List of data to be provided to DMMO in the event that bioassays are needed: grain-size and sediment conventional data (especially ammonia and sulfides) for DMMUs to be tested

6.6 Reporting Requirements

All of the following are required elements of a sediment characterization report and should be listed in the SAP:

1. Explanations of any deviations from approved SAP
2. Sampling equipment and protocols used
3. Procedure used to locate sampling positions
4. Table with coordinates of actual sampling locations, measured water depth at each location, real-time tidal stage at the time of sampling each station, and mudline elevations (tide-corrected to MLLW)
5. Figure showing target and actual sampling locations with DMMU outlines
6. Penetration and recovery data
7. Compositing scheme with actual core lengths and depths (referenced to both MLLW and the mudline)
8. Analytical QA/QC section, including case narrative describing analytical problems
9. Table of analyzed concentrations for all DMMP COCs, lab and validation qualifiers, method reporting limits and method detection limits, with DMMP guideline exceedances highlighted
10. Table of analyzed concentrations for all SMS COCs, lab and validation qualifiers, method reporting limits and method detection limits, with SMS guideline exceedances highlighted
11. PS-SRM required deliverables: data validation report, electronic data deliverable, and SRM sample data summary report.
12. Chemistry QA review and validation results
13. Summary table/s of bioassay results, QA data and interpretation
14. Sampling/field log as an appendix
15. Core logs as an appendix, including any relevant photos
16. Chemistry data report (including a case narrative) as an appendix
17. Bioassay report as an appendix

18. Validation report as an appendix
19. EIM-ready data to be submitted to DMMO for QA review (electronic submittal only)
20. Comprehensive laboratory data package data for Ecology (electronic submittal only)
21. Chain-of-custody forms as an appendix

6.7 Health and Safety Plan

A brief, site-specific health and safety plan (HASP) is recommended as an appendix in the sampling and analysis plan. The HASP should include the following at a minimum:

- safety procedures
- emergency procedures

7 SAMPLING

7.1 TIMING OF SAMPLING

Sampling must be conducted according to a SAP that has been approved by the DMMP agencies. It should be accomplished well in advance of dredging to allow time for testing, data review and permitting.

Areas that receive large volumes of material due to shoaling during winter storm events also need to be sampled prior to dredging. Because these projects are typically dredged within a short time after deposition by winter storms, insufficient time is available to completely characterize all the material that will eventually be dredged. Instead, material that is already in place prior to the winter storm season is sampled and tested. This sampling strategy assumes that sediments deposited annually by winter storms will have a chemical composition very similar to the sediments that are in place at the time sampling and testing is conducted. This strategy is a compromise that includes consideration of the need to provide representative sampling and the need to provide an evaluation process adaptable to the fast shoaling pattern found in these areas. This compromise will also help avoid reliance on “emergency dredging” whereby sediment sampling and testing is not possible prior to dredging. Accordingly, the number of DMMUs and field samples will be based on pre-sampling bathymetric surveys, records from previous dredging events and best professional judgment.

7.2 SAMPLING APPROACH

If full characterization sampling and analysis is required for a project, the applicant will be required to sample the sediment for chemical and, if necessary, biological analyses. There are three sampling approaches that the dredging proponent may take:

1. **Concurrent Testing:** Collect sufficient sediment for all chemical and biological tests potentially required. Run these tests concurrently.
2. **Tiered Testing:** Collect sufficient sediment as above, but archive adequate sediment for biological testing pending the results of the chemical analysis.
3. **Tiered Testing with Resampling:** Collect only enough sediment to conduct the chemical analyses and, if biological testing is required, re-sample the site (chemistry re-analysis required with new sampling).

The proposed sampling approach should be clearly documented in the SAP. The DMMP recommends that sufficient material be collected for tiered bioassays in all projects, especially for projects ranked low-moderate, moderate, or high. The selection of either option 1 or 2 is encouraged because these alternatives provide chemical and biological data on sub-samples of a single homogenized sediment sample. These alternatives are also advantageous because they both preclude the cost involved with collection of additional sediment.

Concurrent testing is the least time consuming, and is likely the most economical when the need for biological testing is expected, because the need to collect additional sediment for bioassays is eliminated. For tiered testing, the sediment to be used for biological testing must be stored in the dark at 4 degrees C with zero headspace (or with headspace purged with nitrogen) while chemical tests are completed. **Maximum holding time for biological testing is 56 days. The 56-day holding time starts the day the first cores or grabs representing a DMMU are collected.**

Tiered testing with re-sampling should only be considered if the need for biological testing is not expected. If bioassay testing is not planned, and one or more chemicals of concern exceed the screening levels, the proponent must either 1) place the material in a (upland) confined disposal facility or 2) collect additional sediment for bioassays and reanalysis of sediment conventional parameters and chemistry. The resampling effort for the biological testing must occur at the same stations as the previous sediment chemistry samples. Even if the new sediment samples show no chemical exceedances, the bioassays must still be conducted, because one or more screening levels were exceeded in the initial chemical analysis.

7.3 Positioning Methods

7.3.1 Horizontal Control

Samples should be obtained as near as possible to the target locations provided in the project sampling plan. A precision navigation system must be used to navigate to and record all sediment sampling locations to a minimum geodetic accuracy of ± 3 meters. Such accuracy can be obtained with a range of positioning hardware, such as differential GPS, real-time kinematic GPS, electronic distance measuring devices, etc. The positioning system to be used and associated QA/QC procedures must be documented in the SAP.

Sampling location data will be entered into Ecology's Environmental Information Management (EIM) system referenced to North American Datum of 1983 (NAD 83) or the World Geodetic System 1984 (WGS 84). If sampling locations are referenced to a local coordinate grid, the local grid should be tied to NAD 83 or WGS 84 to allow conversion to latitudes and longitudes. The North American Datum of 1927 (NAD 27) is outdated and should not be used. **Table 7-1** outlines the required level of accuracy.

Table 7-1. Required accuracy for sample positioning

Coordinates in:	Level of Accuracy
Degrees Minutes Seconds	2 decimal places
Degrees Minutes	4 decimal places
Decimal Degrees	6 decimal places
State Plane	Nearest foot
UTM	meters, with 1 decimal place

7.3.2 Vertical Control

Accurate vertical measurement/calculation of sampling depths is required to ensure that the designated DMMU(s) and Z-layer(s) are sampled as planned. Tidal fluctuations, river flows and changing reservoir (lake) levels can complicate depth interval calculations. A variety of tools are available to establish vertical control and make accurate depth determinations possible. These include – but are not limited to – tide boards, nearby NOAA harmonic stations, electronic tide gauges calibrated to MLLW, and real time kinematic global positioning system (RTK GPS) instrumentation.

Predicted tide elevations from NOAA subordinate stations are generally not acceptable because actual tide elevations can deviate significantly from predicted elevations depending on such factors as river flow, storm surge and barometric pressure. Observed tide elevations from NOAA harmonic stations are acceptable if the station is relatively near the project site.

The coordinate system for reporting vertical sampling data will vary based on location and project specifics. Commonly used datums include the following:

- Marine waters – MLLW
- Lake Washington – Lake Washington Low Water (LWLW)
- Columbia River – Columbia River Datum (CRD)
- Other lakes and rivers – North American Vertical Datum of 1988 (NAVD88)

The SAP must clearly describe which tools and procedures will be used to ensure accurate vertical measurements.

7.4 Sample Collection and Handling Procedures

Proper sample collection and handling procedures are vital for maintaining the integrity of the sample. If the integrity of the sample is compromised, the analysis results may be unacceptable. Procedures for decontamination, sampler deployment, sample logging, sample extrusion, compositing, sample transport, chain of custody, archiving and storage should be discussed in the SAP.

7.4.1 Sediment Volume Requirements

In general, seven (7) liters of composited and homogenized sediment will be needed to provide adequate volume for physical, chemical and standard biological analysis (7.4.6). Bioassay analysis requires a minimum of five (5) liters while physical and chemical analysis requires approximately one (1) liter of sediment. The additional liter should be archived for possible chemical retesting. Additional sample volume may be necessary for analysis of additional special COCs – such as porewater TBT.

Bioaccumulation testing requires a minimum of 15-20 liters of sediment beyond the amount needed for standard testing. Because of the large volume required for bioaccumulation testing, most dredging proponents do not collect this additional material during the initial sampling event, but wait to see if any bioaccumulation triggers are exceeded. In the event that bioaccumulation testing is triggered, a second round of sampling would become necessary, along with physical and chemical re-testing of the DMMU(s) in question. For all projects where samples are taken with coring devices, sediment that will be exposed by dredging must also be sampled. Please refer to 5.9 (Z-samples).

7.4.2 Decontamination Procedures

It is recommended that sampling containers be decontaminated by the laboratory or manufacturer prior to use. All sampling equipment and utensils such as spoons, mixing bowls, extrusion devices, sampling tubes and cutter heads, etc., should be made of non-contaminating materials and be thoroughly cleaned prior to use. The intention of these procedures is to avoid contaminating the sediments to be tested, since this could possibly result in dredged material, which would otherwise be found acceptable for open-water disposal, being found unacceptable. While not strictly required, an adequate decontamination procedure is highly recommended. Typical decontamination procedures for sampling equipment include the following steps:

- Remove excess sediment with a brush and *in situ* water
- Clean with a phosphate-free detergent solution (such as Liquinox)
- Rinse equipment thoroughly with clean *in situ* water
- Triple rinse with analyte-free de-ionized water

The dredging proponent assumes a higher risk of sample contamination by not following an established protocol. Additional decontamination steps such as a solvent rinse or dilute acid rinse may be necessary for contaminated sites or sites with a higher possibility of encountering contamination. Consult the Puget Sound Protocols and Guidelines for more specific guidance.

After decontamination, sampling equipment should be protected from recontamination. Any sampling equipment suspected of contamination should be decontaminated again or removed from use. During core sampling, extra sampling tubes should be available on-site to prevent interruption of operations should a sampling tube become contaminated. Sampling utensils should be decontaminated again after all sampling has been conducted for a given DMMU to prevent cross-contamination. Disposable gloves are typically used and disposed of between DMMUs.

7.4.3 Sample Collection

Sampling procedures and protocols will vary depending on the sampling methodology chosen. Whatever sampling method is used, measures should be taken to prevent contamination from contact with sources of contamination such as the sampling platform, grease from winches, engine exhaust, etc. Core sampling methodology should include the means for determining when the core sampler has penetrated to the required depth. If the core is driven deeper than required, field records and core logging must be adequate to allow the proper core section(s) to be taken post-sampling for inclusion in the sample composite(s), as well as for the Z-sample. The sampling location must be referenced to the actual deployment location of the sampler, not to another part of the sampling platform such as the bridge of a sampling vessel.

7.4.4 Core Penetration and Percent Recovery

In order for the samples collected to be a good representation of the DMMU, each core collected needs to be representative of the sediment column being characterized. The criteria that will be used to determine if a core is acceptable for use need to be outlined in the SAP. At a minimum these should include acceptance criteria for core penetration and percent recovery.

The core should penetrate deeply enough to reach the lower limit of the Z-sample. If refusal occurs prior to reaching this depth – due to woody debris, gravel, deep sand deposits or dense native material – at least two more attempts must be made within 10 feet of the target coordinates in an effort to reach the lower limit of the Z-sample. If, after three attempts, full penetration has not been achieved, DMMO must be contacted and a path forward determined.

Percent recovery is defined as the length of the sediment core retrieved divided by the depth of core penetration. Under ideal conditions percent recovery would be 100%, but due to variability in sediment type and coring conditions this is rarely the case. In order to assure that the dredge prism is being adequately characterized, **the recommended core acceptance criterion for percent recovery is at least 75%. If project specifics dictate that a 75% recovery may not be possible, justification for use of a different percent recovery threshold must be decided in coordination with the DMMO.**

If the recovery criterion is not met during the first sampling attempt, at least two more attempts must be made within 10 feet of the target coordinates. If, after three attempts, the recovery criterion has not been achieved, DMMO must be contacted and a path forward determined. If less than the recommended 75% recovery is obtained, then careful consideration must be made regarding whether to recovery correct the core depths. Dense sandy material is unlikely to compact, so it is more likely that either bypass or loss of material from the bottom of the core occurred. If recovery fails to meet guidance (>75%), DMMO should be contacted regarding whether to assume compaction (correct for recovery) or loss/bypass (do not correct for recovery).

7.4.5 Sampling Logs

As sediment is collected, whether by core or grab, sampling/field logs must be completed. The following should be included in this log:

1. Date and time of collection of each sediment sample.
2. Names of field supervisors and person(s) collecting and logging in the sample.
3. Weather conditions.
4. The sample station number and individual designation numbers assigned for individual core sections.
5. Penetration depth of each coring attempt and notation of any resistance of the sediment column to coring.
6. Percent recovery of each coring attempt and percent recovery calculations.
7. The outcome of each coring attempt – either 'accepted' or 'discarded'.
8. The measured water depth at each sampling station and (for marine projects) the real-time tidal stage at the time of sampling at each station. The mudline elevation, referenced to mean lower low water (MLLW), must then be calculated by subtracting the tidal stage from the measured water depth. The method/procedure used to determine the real-time tidal stage should be documented in the log.
9. For grab samples: physical sediment description, including type, density, color, consistency, odor, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features.
10. Any deviation from the approved sampling plan.

7.4.6 Extrusion and Core Logging

Sample extrusion and core logging can occur either at the sampling site (e.g., on board the sampling vessel), on-shore or at a remote facility. If cores are to be transported to a remote facility for processing, they should be stored upright on ice onboard the sampling vessel and during transport. The cores should be sealed in such a way as to prevent leakage and contamination. If the cores will be sectioned at a later time, thought needs to be given to core integrity during transport and storage to prevent loss of stratification. For cores or split-spoon sampling, the extrusion method should include procedures to prevent contamination.

Core logging can provide valuable information, not only for sediment characterization, but also for the dredging contract itself. It is recommended that core logging be conducted using the Unified Soil Classification System. The core logs must include a qualitative physical description, including sediment type, density, color, consistency, odor, stratification, vegetation, debris, biological activity, presence of an oil sheen or any other distinguishing characteristics or features. If native sediment is encountered, it is useful to note the point of contact on the core log. Finally, the core logs should also record the penetration, recovery, and indicate the core sections representing the DMMUs and Z-samples. If core lengths are corrected for percent recovery, the core depths should be logged based on collected depths prior to any corrections being made. Core sections collected from elevations deeper than the lower limit of the Z-sample are discarded and recorded as such in the core logs.

7.4.7 Compositing and Sub-sampling

For composited samples, representative volumes of sediment are removed from each core section or grab sample comprising a composite. For core samples, sediment is collected from along the entire length of each core section. The composited sediment should be thoroughly mixed to a uniform color and consistency, and should occasionally be stirred while individual samples are taken of the composite. This will ensure that the mixture remains well mixed and that settling of coarse-grained sediments does not occur.

After compositing and sub-sampling are performed, the sample containers must be refrigerated or stored on ice until delivered to the analytical laboratory. Each sample container must be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book.

7.4.8 Sulfides Sampling

The DMMP now recommends analyzing total bulk sulfides on composited sediment, rather than on sediment from a single core, prior to compositing (DMMP, 2015b). This change will provide a more realistic assessment of the concentration of total sulfides in sediment archived for bioassays. Exceptions to this procedure for total sulfides might need to be made for sediment testing performed for both cleanup and DMMP characterization; and for projects where wood waste in new surface material may be an issue. In those cases, total sulfides should continue to be performed on single cores.

For sulfides sampling, 5 milliliters of 2 Normal zinc acetate per 30-g of sediment are placed in a 4-ounce sampling jar. It is recommended that jars containing the zinc acetate be prepared in advance in order to reduce the possibility of zinc cross-contamination in the field. The sulfides sample sediments are placed in the jar, covered, and shaken vigorously to completely expose the sediment to the zinc acetate.

The sulfides sampling jars should be clearly labeled with the project name, sample/composite identification, type of analysis to be performed, date and time, and initials of person(s) preparing the sample, and referenced by entry into the log book. The sulfides sampling jars should indicate that zinc acetate has been added as a preservative.

7.4.9 Preservation and Holding Times

After compositing and sub-sampling are performed, the sample containers must be refrigerated or stored on ice until delivered to the analytical laboratory.

The holding time is the length of time allowed between sample collection and analysis. The holding time differs for different analytes and test types. Holding times for the standard list of DMMP COCs is in Table 7-2.

For some large projects, many cores are collected and composited together to form an analytical sample. Sometimes cores are collected over multiple days and stored over ice or in a refrigerated room until all cores to be composited for a DMMU are collected. **In this situation, the holding time for the composited sample begins on the day that the first core is collected.** Cores should be held for the minimum time possible before processing. All sample material must be preserved according to the temperature requirements in Table 7-2.

Samples reserved for bioassays are stored in the dark at 4 degrees C in containers or polyethylene bags with zero headspace, or with headspace purged with nitrogen, for **up to 56 days** pending initiation of any required biological testing.

Table 7-2. Sample storage criteria

SAMPLE TYPE	HOLDING TIME	TEMP [2]	SAMPLE SIZE [1]	CONTAINER
Particle Size	6 Months	4 ± 2 degrees C	100-200 g (75-150 ml)	16 oz. Glass or HDPE
Total Solids	14 Days	4 ± 2 degrees C	125 g (100 ml)	8 oz. Glass or HDPE
	6 Months	-18 ± 2 degrees C		
Total Volatile Solids	14 Days	4 ± 2 degrees C	125 g (100 ml)	
	6 Months	-18±2 degrees C		
Total Organic Carbon	14 Days	4 ± 2 degrees C	125 g (100 ml)	
	6 Months	-18±2 degrees C		
Metals (except Mercury)	6 Months	4 ± 2 degrees C	50 g (40 ml)	4 oz. Glass
	2 years	-18±2 degrees C		
Mercury	28 Days	≤ 6 degrees C	50 g (40 ml)	
Semi-volatiles, Pesticides And PCBs	14 Days until extraction	4 ± 2 degrees C	150 g (120 ml)	SVOC: 8 oz. Glass Pesticides/PCBs: 8 oz. Glass
	1 Year until extraction	-18±2 degrees C		
	40 Days after extraction	4 ± 2 degrees C		
Total Petroleum Hydrocarbons	14 Days	4 ± 2 degrees C	100 g	8 oz. Glass
Ammonia	7 Days	4 ± 2 degrees C	25 g (20 ml)	4 oz. Glass
Total Sulfides	7 Days	4 ± 2 degrees C [3]	50 g (40 ml)	4 oz. Glass
Tributyltin (porewater)	7 Days	4 ± 2 degrees C [4]	Sediment sufficient to collect 200-500 ml of porewater	(2) 32 oz. Glass
Tributyltin (bulk sediment)	6 Months	-18 ± 2 degrees C	50 g (40 ml)	4 oz. Glass
Dioxins/Furans	14 days until extraction	4 ± 2 degrees C	100 g (80 ml)	8 oz. Amber Glass Jar
	1 year until extraction	-18 ± 2 degrees C		
Bioassay	8 Weeks	4 ± 2 degrees C [4]	5 liters	(5) 1 liter Glass or HDPE Jars or Polyethylene Bags
Bioaccumulation	8 Weeks	4 ± 2 degrees C [4]	variable [5]	Glass or HDPE
Archive	Variable	-18 ± 2 degrees C	1 liter	min. 16 oz. Glass

[1]Recommended minimum field sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retests.

[2] During transport to the lab, samples will be stored on ice. The mercury and archived samples will be frozen immediately upon receipt at the lab. Jars to be frozen must include headspace to prevent breakage.

[3]The sulfides sample will be preserved with 5 ml of 2 Normal zinc acetate for every 30 g of sediment.

[4]Headspace purged with nitrogen.

[5] See **Table 10-4**

7.4.10 Sample Handling, Transport and Chain of Custody Procedures

Sample transport and chain-of-custody procedures should follow the PSEP protocols, which include the following guidelines:

- If sediment cores are taken in the field and transported to a remote site for extrusion and compositing, chain-of-custody procedures should commence in the field for the core sections and should track the compositing and subsequent transfer of composited samples to the analytical laboratory. If compositing occurs in the field, chain-of-custody procedures should commence in the field for the composites and should track transfer of the composited samples to the analytical laboratory.
- Samples should be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173.24.
- Individual sample containers should be packed to prevent breakage and transported in a sealed ice chest or other suitable container.
- Blue ice is recommended; if ice is used it should be double-bagged and well-sealed.
- A temperature blank should be included in each cooler.
- Each cooler or container containing sediment samples for analysis should be delivered to the laboratory within 24 hours of being sealed.
- A sealed envelope containing chain-of-custody forms should be enclosed in a plastic bag and taped to the inside lid of the cooler.
- Signed and dated chain-of-custody seals should be placed on all coolers prior to shipping.
- The shipping containers should be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the container and consultant's office name and address) to enable positive identification.
- Upon transfer of sample possession to the analytical laboratory, the chain-of-custody form should be signed by the persons transferring custody of the sample containers. The shipping container seal should be broken, and the condition of the samples should be recorded by the receiver, including the temperature of the temperature blank.
- Chain-of-custody forms should be used internally in the lab to track sample handling and final disposition.

7.5 Field Sampling Checklist

The following checklist is intended to guide the sampling event. This checklist is by no means complete; some of the items listed below may not be necessary for every sampling event. Sampling staff are encouraged to adapt this list, in part or entirely, to meet their field sampling needs:

Paperwork

- ☐ SAP (approved by the DMMP)
- ☐ Field checklist
- ☐ Field map(s) with recent hydrosurvey and target field sample locations

- ☐ Sample summary table/compositing scheme
- ☐ Waterproof field log book
- ☐ Waterproof grab and/or core sample log forms (with known fields completed)
- ☐ Chain of custody forms
- ☐ Laboratory address(es)
- ☐ Shipping forms for cooler shipment
- ☐ Cooler labels for dry ice (if used as a sample preservative)

Sampling Equipment

- ☐ Sediment sampler
- ☐ Generator/power supply for powered samplers
- ☐ Contingency grab sampling (for core sampling in sand)
- ☐ Extra parts/sampler repair kit
- ☐ Core liner (or sacrificial aluminum cores)
- ☐ Core catchers
- ☐ Core caps
- ☐ Duct tape
- ☐ Tools for core setup and processing (core samplers only)

Horizontal and Vertical Positioning Equipment

- ☐ GPS and onboard chart plotter
- ☐ Depth finder (and measurement of sensor below waterline)
- ☐ Lead line
- ☐ Smartphone or onboard computer with access to tides or river levels
- ☐ Staff gauge or electronic gauge vertical datum information

Decontamination Equipment

- ☐ Distilled, deionized water (at least 3 gallons)
- ☐ Phosphate-free, laboratory-grade decontamination soap
- ☐ Brushes and pole-brush (for cores and core-liners)
- ☐ Primary wash bucket
- ☐ Stainless steel wash/rinse pans(s)

Sample Processing and Handling

- ☐ Boxes of latex-free, nitrile gloves (multiple sizes)
- ☐ Hand sanitizer
- ☐ Paper towels
- ☐ Stainless steel bowls/utensils/trays for sample processing and compositing
- ☐ Aluminum foil
- ☐ Pre-labeled sample jars (checked against SAP) and extras (in case of breakage)
- ☐ Jar labels, extras
- ☐ Jars preloaded with zinc acetate for sulfide samples
- ☐ 1-gal. Ziploc bags (physical samples only)
- ☐ Duct tape
- ☐ Camera
- ☐ Wet-sieving equipment

Sample Packing and Shipping

- ☐ Coolers
- ☐ Sample preservative (wet, blue, or dry ice)
- ☐ Completed chain of custody forms
- ☐ Custody seals for coolers
- ☐ Copy of SAP tables summarizing
  - o List of analytes
  - o sample quantitation limits and screening levels
  - o Compositing scheme and instructions (for samples composited in the lab)
- ☐ Photocopy or photograph of completed chain of custody forms
- ☐ 1 gal. Ziploc storage bag for chain of custody forms and copy of SAP tables
- ☐ Temperature blank
- ☐ Retained copy of shipping form or courier receipt

Tools

- ☐ Screwdriver
- ☐ Pliers
- ☐ Pipe wrench
- ☐ Crescent wrench
- ☐ Hack saw
- ☐ Box cutters and/or knife
- ☐ Circular saw (with jig) or power shears (for splitting core linters)
- ☐ Wire cutters
- ☐ Hammer
- ☐ Rubber mallet
- ☐ Tape measure

Personal Equipment

- ☐ Personal Flotation Device (life vest or coat)
- ☐ Hard hat
- ☐ Steel toed boots or shoes
- ☐ Leather or rubber work gloves
- ☐ Rain gear (jacket and pants)
- ☐ Cold weather gear
- ☐ Drinking water
- ☐ Field food
- ☐ Hat and/or sun protection
- ☐ First Aid kit

7.6 Pre-Sampling Conference Call

A pre-sampling conference call with the dredging proponent's sampling team may be required by the DMMP agencies. The pre-sampling call will include: review of project sampling details, establishment of vertical control and adjustment of sampling depths for changes in mudline elevation, and coordination with DMMP during the sampling event.

8 TIER 2: CHEMICAL TESTING

Chemical testing of the dredged material is often required after an assessment of existing information for a project during the Tier 1 phase. Chemical analysis includes both the measurement of "conventional" parameters and the measurement of concentrations of chemicals which have been identified by DMMP as chemicals of concern (COCs) for the project.

8.1 SEDIMENT CONVENTIONAL PARAMETERS

Sediment conventionals provide information about the physical nature of the dredged material and aid in interpreting chemical and biological test results. These analyses should be performed on all test sediments, as well as on bioassay reference sediments. **Table 8-1** lists the conventional parameters required for analysis and the recommended analytical methods.

Table 8-1. Sediment Conventionals and Recommended Analytical Methods

SEDIMENT CONVENTIONAL	ANALYSIS METHOD
Total solids	PSEP (1986)/SM2540G
Total volatile solids (TVS)	PSEP (1986)/SM2540G
Grain size	PSEP (1986)/ASTM D-422[4] (modified)
Total organic carbon (TOC)	SM 5310B/EPA 9060 (modified for sediments)
Total sulfides	PSEP (1986)/Plumb (1981)
Ammonia	Plumb (1981)

Grain size may be determined using either PSEP (1986) or ASTM Method D-422 (modified), which subdivide the silt-clay fraction by pipette and hydrometer respectively. One of the following sieve series must be used: 1) Modified EPA - sieve numbers 4, 10, 18, 35, 60, 120, 230 or 2) Modified ASTM - sieve numbers 4, 10, 20, 40, 60, 140, 230. The fine-grained fraction must be classified by phi size (+5, +6, +7, +8, >8). The delineation of sand vs. gravel fractions is achieved through use of the #10 sieve (2 mm). Similarly, the delineation of fines (silt and clay) vs. sand is achieved through use of the #230 sieve (62.5 microns). It is therefore critical that these two sieve sizes be used in analyzing grain size. The following general classifications are used in the DMMP:

- **Gravel: >2,000 microns (2 mm)**
- **Sand: 62.5 to 2,000 microns**
- **Silt: 3.9 to 62.5 microns**
- **Clay: 0 to 3.9 microns**

TOC is a key index parameter that affects the adsorptive capacity and bioavailability of organic contaminants and some metals in sediments. Sediment TOC analysis should follow PSEP (1986) for sample preparation (i.e. sample drying, homogenization, and acidification to remove inorganic

[4] ASTM D-422 has been replaced by ASTM D-6913 (sieve) and D-7928 (hydrometer), but may continue to be used for DMMP sediment characterization.

carbon), with modifications suggested by Bragdon-Cook (1993) and Appendix D of PSEP (1997b) for high-temperature combustion followed by non-dispersive infrared detection (NDIR). Acidification, combustion and NDIR analysis should be conducted according to the instrument manufacturer's instructions, as specified in Standard Method (SM) 5310B and EPA Method 9060A.

8.2 Standard List of Chemicals of Concern

Chemicals of concern generally have the following characteristics:

- A demonstrated or suspected effect on ecological receptors or human health.
- One or more present or historical sources, resulting in high concentration when compared to natural conditions, and of sufficient magnitude to be of concern.
- A potential for persisting in a toxic form for long periods in the environment.
- A potential for entering the food web (bioavailability).

Chemicals of concern that have been shown to be widespread in the environment are included on the standard list of DMMP COCs. Chemical testing, when required, will involve analysis of these COCs.

Table 8-3 lists these chemicals and presents the currently used marine and freshwater guideline values for each chemical.

Freshwater guidelines apply only to sediments in which the sediment pore water contains less than or equal to 0.5 parts per thousand salinity. The marine guidelines apply to all other sediments. Selection of the appropriate suite of chemical analyses is based on the location at which sediment toxicity is being evaluated. The surface exposed by dredging will be evaluated using the COCs appropriate for the dredge site; the effects of open-water disposal of dredged material will be evaluated using the COCs appropriate for the disposal site. General guidelines for several major rivers in Washington State are presented in **Table 8-2**. The DMMP agencies will determine which set of chemical analyses (freshwater or marine) will be used to evaluate the dredging project; in some cases, both the freshwater and marine COCs may need to be analyzed (e.g., a dredging project in Lake Washington using the open-water disposal site in Elliott Bay).

Table 8-2. Marine and freshwater classifications by water body and river mile (RM) in Washington State

Water Body	Location	Marine/Freshwater Classification
Duwamish River	Upstream of RM 10	Freshwater
	RM 6.5 to 10	Marine unless evidence indicates otherwise
	Downstream of RM 6.5	Marine
Columbia River	Upstream of RM 20	Freshwater
Snohomish River	Upstream of RM 9.3	Freshwater
	RM 6.2 to 9.3	Marine unless evidence indicates otherwise
	Downstream of RM 6.2	Marine

Table 8-3. DMMP COCs And Regulatory Guidelines

	CHEMICAL	CAS[1] NUMBER	USE FOR MARINE PROJECTS			USE FOR FRESHWATER PROJECTS WITHIN DMMP JURISDICTION	
			DMMP MARINE GUIDELINES			**SMS FRESHWATER**	
			SL	**BT**	**ML**	**SL1**	**SL2**
STANDARD CHEMICALS OF CONCERN	METALS (mg/kg dry weight)						
	Antimony	7440-36-0	150	---	200	---	---
	Arsenic	7440-38-2	57	507.1	700	14	120
	Cadmium	7440-43-9	5.1	--	14	2.1	5.4
	Chromium	7440-47-3	260	--	---	72	88
	Copper	7440-50-8	390	--	1,300	400	1,200
	Lead	7439-92-1	450	975	1,200	360	> 1,300
	Mercury	7439-97-6	0.41	1.5	2.3	0.66	0.8
	Nickel	7440-02-0	---	---	---	38[2]	110
	Selenium	7782-49-2	---	3	---	11	>20
	Silver	7440-22-4	6.1	--	8.4	0.57	1.7
	Zinc	7440-66-6	410	--	3,800	3,200	>4,200
	ORGANOMETALLIC COMPOUNDS[3]						
	Tributyltin ion (interstitial water; ug/L)	36643-28-4	---	0.15	---	---	---
	Tributyltin ion (bulk; ug/kg)[4]	36643-28-4	---	73	---	47	320
	Monobutyltin ion (bulk; ug/kg)	78763-54-9	---	---	---	540	>4,800
	Dibutyltin ion (bulk; ug/kg)	10-53-502	---	---	---	910	130,000
	Tetrabutyltin ion (bulk; ug/kg)	1461-25-2	---	---	---	97	>97
	PAHs (µg/kg dry weight)						
	Naphthalene	91-20-3	2,100	---	2,400	---	---
	Acenaphthylene	208-96-8	560	---	1,300	---	---
	Acenaphthene	83-32-9	500	---	2,000	---	---
	Fluorene	86-73-7	540	---	3,600	---	---
	Phenanthrene	85-01-8	1,500	---	21,000	---	---
	Anthracene	120-12-7	960	---	13,000	---	---
	1-Methylnaphthalene[5]	90-12-0	---	---	---	---	---
	2-Methylnaphthalene[5]	91-57-6	670	---	1,900	---	---
	Total LPAH	—	**5,200**	—	**29,000**	---	---
	Fluoranthene	206-44-0	1,700	4,600	30,000	---	---
	Pyrene	129-00-0	2,600	11,980	16,000	---	---
	Benz(a)anthracene	56-55-3	1,300	---	5,100	---	---
	Chrysene	218-01-9	1,400	---	21,000	---	---
	Benzofluoranthenes (b, j ,k)	205-99-2 205-82-3 207-08-9	3,200	---	9,900	---	---
	Benzo(a)pyrene	50-32-8	1,600	---	3,600	---	---
	Indeno(1,2,3-c,d)pyrene	193-39-5	600	---	4,400	---	---
	Dibenz(a,h)anthracene	53-70-3	230	---	1,900	---	---

Table 8-3. DMMP COCs And Regulatory Guidelines

	CHEMICAL	CAS[1] NUMBER	USE FOR MARINE PROJECTS			USE FOR FRESHWATER PROJECTS WITHIN DMMP JURISDICTION	
			DMMP MARINE GUIDELINES			SMS FRESHWATER	
			SL	BT	ML	SL1	SL2
STANDARD CHEMICALS OF CONCERN	Benzo(g,h,i)perylene	191-24-2	670	---	3,200	---	---
	Total HPAH	**—**	**12,000**	**—**	**69,000**	---	---
	Total PAHs[6]	—				**17,000**	**30,000**
	CHLORINATED HYDROCARBONS (µg/kg dry weight)						
	1,4-Dichlorobenzene	106-46-7	110	---	120	---	---
	1,2-Dichlorobenzene	95-50-1	35	---	110	---	---
	1,2,4-Trichlorobenzene	120-82-1	31	---	64	---	---
	Hexachlorobenzene (HCB)	118-74-1	22	168	230	---	---
	beta-Hexachlorocyclohexane					7.2	11
	PHTHALATES (µg/kg dry weight)						
	Dimethyl phthalate	131-11-3	71	---	1,400	---	---
	Diethyl phthalate	84-66-2	200	---	1,200	---	---
	Di-n-butyl phthalate	84-74-2	1,400	---	5,100	380	1,000
	Butyl benzyl phthalate	85-68-7	63	---	970	---	---
	Bis(2-ethylhexyl) phthalate	117-81-7	1,300	---	8,300	500	22,000
	Di-n-octyl phthalate	117-84-0	6,200	---	6,200	39	>1,100
	PHENOLS (µg/kg dry weight)						
	Phenol	108-95-2	420	---	1,200	120	210
	2-Methylphenol	95-48-7	63	---	77	---	---
	4-Methylphenol	106-44-5	670	---	3,600	260	2,000
	2,4-Dimethylphenol	105-67-9	29	---	210	---	---
	Pentachlorophenol	87-86-5	400	504	690	1,200	>1,200
	MISCELLANEOUS EXTRACTABLES (µg/kg dry weight)						
	Benzyl alcohol[7]	100-51-6	57	---	870	---	---
	Benzoic acid	65-85-0	650	---	760	2,900	3,800
	Dibenzofuran	132-64-9	540	---	1,700	200	680
	Hexachlorobutadiene	87-68-3	11	---	270	---	---
	N-Nitrosodiphenylamine	86-30-6	28	---	130	---	---
	Carbazole	86-74-8				900	1,100
	PESTICIDES & PCBs (µg/kg dry weight)						
	4,4'-DDD 4,4'-DDE 4,4'-DDT sum of 4,4'-DDD, 4,4'-DDE, 4,4'-DDT	72-54-8 72-55-9 50-29-3 ---	16 9 12 ---	--- --- --- 50	--- --- --- 69	---	---
	2,4'-DDD and 4.4'-DDD 2,4'-DDE and 4,4'-DDE 2,4'-DDT and 4,4'-DDT	--- --- ---	---	---	---	310 21 100	860 33 8,100
	Aldrin	309-00-2	9.5	---	---	---	---

Table 8-3. DMMP COCs And Regulatory Guidelines

	CHEMICAL	CAS[1] NUMBER	USE FOR MARINE PROJECTS			USE FOR FRESHWATER PROJECTS WITHIN DMMP JURISDICTION	
			DMMP MARINE GUIDELINES			SMS FRESHWATER	
			SL	BT	ML	SL1	SL2
	Total Chlordane (sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane)	5103-71-9 5103-74-2 5103-73-1 39765-80-5 27304-13-8	2.8	37	---	---	---
	Dieldrin	60-57-1	1.9	---	1,700	4.9	9.3
	Heptachlor	76-44-8	1.5	---	270	---	---
	Endrin ketone	53494-70-5	---	---	---	8.5	>8.5
	Total PCBs (Aroclors)	---	130	38 (8)	3,100	110	2,500
	BULK PETROLEUM HYDROCARBONS (mg/kg)						
	TPH – Diesel	---	---	---	---	340	510
	TPH – Residual	---	---	---	---	3,600	4,400
CASE-BY-CASE COCs (9)	DIOXINS/FURANS						
	Total TEQ (ng/kg dry weight)	---	Puget Sound: see **8.3.2** Grays Harbor: see **8.3.3** Other Waters: see **8.3.4**			See **8.3.4**	

(1) Chemical Abstract Service Registry Number
(2) The Nickel SL1 value is based on the 90th percentile of soil background data from WA state (Ecology, 1994), and was adopted by the DMMP agencies at the 2014 SMARM (DMMP/RSET, 2014b)
(3) TBT and dioxins/furans are not standard COCs for marine projects. They may be required on a case-by-case basis (see **8.3 and 8.4**). All butyltins are required for freshwater projects.
(4) Bulk sediment measurement of TBT is recommended for dredged material and Z-sample evaluations, although porewater TBT remains an option. See **8.4.2** for further details.
(5) 1-Methylnaphthalene and 2-Methylnaphthalene are included in the summation of total PAH for freshwater projects. 2-Methylnaphthalene is analyzed for marine projects but is not included in the summation for total LPAHs. 1-Methylnaphthalene is not analyzed for marine projects.
(6) Total PAHs for freshwater projects include the sum of all PAHs listed.
(7) DMMP agencies will use best professional judgment to determine the need for biological testing for projects in which benzyl alcohol is the only COC present in project sediments (DMMP, 2016a).
(8) This value is normalized to total organic carbon, and is expressed in mg/kg carbon.
(9) Analyses required only when there is sufficient reason-to-believe for presence in a given project or location.
Analytes printed in blue apply ONLY to freshwater.

8.2.1 Chemical Evaluation Guidelines

Apparent Effects Threshold values (AETs) were the main basis for establishing DMMP evaluation guidelines for marine sediment. For freshwater sediment, the floating percentile method (FPM) was used. For details regarding AETs, see PSDDA, 1988. For details regarding FPM, see SAIC and Avocet, 2003 and Ecology, 2011. The Department of Ecology adopted new freshwater sediment standards in February 2013. These new standards were adopted after SMARM 2014 and are now reflected in the freshwater standards shown in **Table 8-3**. For more information, see the implementation information in DMMP/RSET 2015, Proposal to Revise Freshwater Sediment Screening Levels.

8.2.1.1 Marine Screening Levels and Maximum Levels

The "screening level" (SL) is defined as the chemical concentration at or below which there is no reason to believe that dredged material disposal would result in unacceptable adverse effects to benthic species. For most COCs, the SL is set equal to the lowest Apparent Effects Threshold (LAET). DMMUs with chemical concentrations present at levels above the SL require biological testing before a decision can be made on the suitability for unconfined, open-water disposal.

The "maximum level" (ML) is equal to the highest Apparent Effects Threshold (HAET) – a chemical concentration at which all biological indicators with AETs show significant effects. The ML values are no longer used by the DMMP agencies as pass/fail indicators, but rather serve to provide valuable information to project proponents regarding the likely outcome of bioassays. While some DMMUs with ML exceedances have passed biological testing, the majority have failed. By comparing sediment chemical data to the MLs, a dredging proponent can better judge how to proceed with the project, i.e., whether to invest more time and money into further testing for unconfined, open-water disposal, or to rechanneled that effort into other disposal options and testing for those options (e.g., leachate tests for upland disposal).

With regard to the SLs and MLs, the following scenarios are possible:

1. All chemicals are **at or below their SLs**: no biological testing is needed; the DMMU is considered suitable for unconfined, open-water disposal at any DMMP marine site.
2. One or more chemicals are present at levels **between SL and ML**: standard bioassay testing is needed (see **Chapter 9**).
3. One or more chemicals are present at levels above the ML: standard bioassay testing may still be pursued but there is a high probability that the dredged material will fail Tier 3 bioassay testing.

8.2.1.2 Marine Bioaccumulation Triggers

Bioaccumulation trigger (BT) values are used as guidelines to determine when bioaccumulation testing is required. If any chemical of concern exceeds the bioaccumulation trigger guideline value, additional information gained via bioaccumulation testing will be required in order to determine whether dredged material is suitable for unconfined, open-water disposal. Discussion on bioaccumulation testing is presented in **Chapter 10**.

8.2.1.3 Freshwater Screening Levels

Freshwater screening levels were adopted in 2014 following promulgation of the Washington State Sediment Management Standards (SMS) for freshwater sediments.

The "screening level 1" (SL1) is defined as the chemical concentration at or below which there is no reason to believe that dredged material disposal would result in unacceptable adverse effects. The SL1 is set equal to the Sediment Cleanup Objective (SCO) which represents a no adverse effects level. The SCO/SL1 is the state goal for freshwater sediments for the protection of benthic communities. DMMUs with chemical concentrations present at levels above the SL1 require biological testing before a decision can be made on the suitability for unconfined, open-water disposal in freshwater.

The "screening level 2" (SL2) is equivalent to the Cleanup Screening Level (CSL), which corresponds to a concentration above which more than minor adverse effects may be observed in benthic organisms; in Table 8-3, the ">" symbol indicates that the toxicity threshold is unknown but above the listed concentration. Chemical concentrations at or below the SL2 but greater than the SL1 correspond to sediment quality that may result in minor adverse effects to the benthic community. The CSL/SL2 is used to define potential cleanup sites. Similar to the ML for marine sediments, the SL2 values are not used by the DMMP agencies as pass/fail indicators, but rather serve to provide valuable information to project proponents regarding the likely outcome of bioassays.

With regard to the SL1 and SL2, the following scenarios are possible:

1. All chemicals are at or below their SL1s: no biological testing is needed; the DMMU is considered suitable for unconfined, open-water disposal at an approved freshwater site.
2. One or more chemicals are present at levels between SL1 and SL2: standard biological testing is required (see Chapter 9).
3. One or more chemicals are present at levels above the SL2: standard biological testing may still be pursued but there is a high probability that the dredged material will fail Tier 3 testing.

8.2.1.4 Freshwater Bioaccumulation Triggers

There are currently no BTs for characterization of freshwater sediment. The need for bioaccumulation testing for freshwater projects will be determined on a case-by-case basis. Factors that may be considered include, but are not limited to, 303(d) listings; regional background concentrations of BCOCs; presence of ESA-listed species, etc.

8.2.2 Analytical Methods

There are no required analytical methods for standard chemicals of concern in the Dredged Material Management Program. Any established and well-documented method that is capable of meeting the QC requirements outlined in this chapter may be used. The Puget Sound Estuary Program protocols should be consulted for sample cleanup procedures and method modifications. The methods to be used for a project must be clearly articulated in the SAP and approved by the DMMP agencies prior to testing. Table 8-4 lists the most commonly used sediment methods for the standard COCs.

Table 8-4. Analytical Methods for Standard COCs

CHEMICAL Standard Chemicals of Concern	PREP METHOD	ANALYSIS METHOD
METALS		
Antimony, Arsenic, Cadmium, Chromium, Copper, Lead, Silver, Zinc	EPA 3050B	EPA 6010/6020
Selenium	EPA 3050B	EPA 6020/7740/7742
Mercury	CLP-M-245.5	EPA 7471
PAHs	EPA 3541/3550	EPA 8270D
CHLORINATED HYDROCARBONS		
1,2-Dichlorobenzene, 1,4-Dichlorobenzene, 1,2,4-Trichlorobenzene	EPA 3550	EPA 8260B/8270D
Hexachlorobenzene (HCB)	EPA 3540/3550	EPA 8270D/8081
PHTHALATES	EPA 3550	EPA 8270D
PHENOLS	EPA 3550	EPA 8270D
MISCELLANEOUS EXTRACTABLES		
Benzyl alcohol, Benzoic acid, Dibenzofuran, N-Nitrosodiphenylamine	EPA 3550	EPA 8270D
Hexachlorobutadiene	EPA 3540/3550	EPA 8270D/8081
PESTICIDES & PCBs		
Pesticides	EPA 3540/3541/3550	EPA 8081
PCB Aroclors	EPA 3540/3550	EPA 8082
TOTAL PETROLEUM HYDROCARBONS	NWTPH-Dx[1]	NWTPH-Dx[1]

Notes:
[1] Total Petroleum Hydrocarbons by GC/FID – Analytical Methods for Petroleum Hydrocarbons, Ecology 1997.
Other methods may be used with DMMP approval.
Selected ion monitoring (SIM) may be used in the event that reporting limits cannot be brought below SL.

8.2.3 Summing PAHs, Benzofluoranthenes, DDT, Chlordane and PCBs

For comparison to SL, BT and ML values, a group summation is performed for the following families of chemicals using all detected concentrations. Non-detect results are not included in the sum. Estimated values between the method detection limit and the laboratory reporting limit (i.e., J-flagged values) are included in the summation at face value and the sum is also J-flagged. Values that are J-flagged due to minor quality control deviations are also to be handled in this way (DMMP, 2015a). If all constituents of a group are undetected, the group sum is reported as undetected, and the single highest laboratory reporting limit of all the constituents is reported as the group sum.

- (Marine only) LPAH is the sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and anthracene.

- (Marine only) HPAH is the sum of benzofluoranthenes, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene and benzo(g,h,i)perylene.
- (Freshwater only) Total PAHs are the sum of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, 1-methylnaphthalene, 2-methylnaphthalene, anthracene, benzofluoranthenes, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenz(a,h)anthracene and benzo(g,h,i)perylene.
- Benzofluoranthenes are the sum of the b, j and k isomers.
- For marine guidelines, total DDT is the sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT.
- For freshwater guidelines, DDT, DDD and DDE values are the sum of both the 2,4'- and 4,4'-isomers
- Total chlordane is the sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor and oxychlordane.
- Total PCBs include the sum of the following Aroclors: 1016, 1221, 1232, 1242, 1248, 1254, and 1260. If present, Aroclor-1262 and 1268 should be reported but not included in the total PCB summation.

The group sums, as well as the concentrations of individual constituents, must be included in the sediment characterization report.

8.3 Dioxins

Polychlorinated dibenzo-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs) are commonly referred to together as "dioxins," or simply "dioxin." Dioxins are a group of 210 chlorinated organic compounds (congeners) with similar chemical structures. The toxicity of the various congeners varies considerably. The 17 congeners that have chlorine atoms located in the 2,3,7,8 positions (e.g., 2,3,7,8-TCDD or 1,2,3,7,8-PeCDF) are the dioxins of known concern for health effects in fish, wildlife, and humans. Of these, 2,3,7,8-TCDD is considered the most toxic and is used as a benchmark for estimating the toxicity of the other 16 congeners; as such, it is assigned a toxic equivalency factor (TEF) of 1.0. Table 8-5 provides the human/mammalian TEFs for all 17 congeners of regulatory concern. The Toxicity Equivalence (TEQ) is calculated by multiplying the TEF of each congener by the concentration of the congener, and summing the results. The resulting TEQ is used in evaluating the suitability of dredged material for open-water disposal.

Dioxins are produced by natural events and are also unintentional byproducts of certain industrial processes. Natural events include forest fires or volcanic activity. Industrial processes include incomplete combustion of materials in the presence of chloride, such as burning of fuels, municipal and domestic waste incineration, as well as chlorine bleaching of pulp and paper, and creosote and chlorinated pesticide manufacturing. Structural fires may also be a source of dioxins.

Like the standard DMMP chemicals of concern, dioxins are widespread in the environment. However, due to the cost of analysis, dioxin analysis is only required when there is a reason to believe dioxins might be present at a project site at concentrations above natural background.

Table 8-5. Toxicity Equivalency Factors (TEFs) for PCDDs and PCDFs

	CONGENERS / ISOMERS	TOXIC EQUIVALENCY FACTOR (TEF)[1]
Dioxins	2,3,7,8-TCDD	1
	1,2,3,7,8-PeCDD	1
	1,2,3,4,7,8-HxCDD	0.1
	1,2,3,6,7,8-HxCCD	0.1
	1,2,3,7,8,9-HxCDD	0.1
	1,2,3,4,6,7,8-HpCDD	0.01
	OCDD	0.0003
Furans	2,3,7,8-TCDF	0.1
	1,2,3,7,8-PeCDF	0.03
	2,3,4,7,8-PeCDF	0.3
	1,2,3,4,7,8-HxCDF	0.1
	1,2,3,6,7,8-HxCDF	0.1
	2,3,4,6,7,8-HxCDF	0.1
	1,2,3.7,8,9-HxCDF	0.1
	1,2,3,4,6,7,8-HpCDF	0.01
	1,2,3,4,7,8,9-HpCDF	0.01
	OCDF	0.0003

[1] World Health Organization Human and Mammalian TEFs, from van den Berg et al (2006)

8.3.1 Dioxin Reason-to-Believe Guidelines

Testing for dioxins and furans is required on a case-by-case basis in areas where there is reason to suspect presence of these chemicals. Significant factors which can trigger a "reason-to-believe" that dioxin may be present and thus result in the requirement for dioxin testing include the following:

- Location within an urban bay and having no historical data showing that dioxin is below the 2010 guidelines.
- Proximity to current or historical point sources, such as outfalls.
- Proximity to chlor-oxide bleach process pulp mills, chlor-alkali or chlorinated solvent manufacturing plants, former wood treatment sites, phenoxy herbicide manufacture and/or use and handling areas.
- Proximity to areas with high polychlorinated biphenyl (PCB) concentrations.
- Proximity to former hog fuel burners/boilers and areas with previous structural, vessel or other fires or incineration sources.
- Proximity to areas previously sampled that showed elevated levels of dioxin.

Dioxin testing will be required for all projects meeting one or more of the reason-to-believe factors described above. Deeper underlying sediments, which are confirmed as "native," may be exempt from testing. Native material within the dredge prism, and lying directly under sediment that is being tested for dioxins, should be archived for possible dioxin analysis.

8.3.2 Guidelines for Dioxin Evaluation in Puget Sound

The DMMP agencies have developed and implemented dioxin evaluation guidelines for dredging projects in Puget Sound (DMMP, 2010a; 2016b). The guidelines include a Disposal Site Management Objective of 4 pptr TEQ, which was derived from data on background concentrations of dioxins in the Sound. Due to differences in the nature of dispersive and non-dispersive disposal sites, separate guidelines were developed to achieve the Site Management Objective at the two types of sites.

Dispersive Sites: Dredged material placed at dispersive sites does not stay on site, but is rapidly dispersed with the tides. Post-disposal monitoring is not possible. Therefore, only DMMUs meeting the Disposal Site Management Objective of 4 pptr TEQ may be placed at dispersive sites.

- The Puget Sound dispersive-site guidance applies to the Port Angeles, Port Townsend and Rosario Strait disposal sites.

Non-dispersive Sites: Dredged material placed at non-dispersive sites stays on site, and sequential disposal events result in a combination of mixing with, and burial of, previously-placed dredged material. This mixing and burial allowed the DMMP agencies to adopt more flexible guidelines for non-dispersive disposal, while still achieving the Disposal Site Management Objective of 4 pptr TEQ in surface sediment. Further, periodic post-disposal monitoring provides the feedback necessary to ensure that the Disposal Site Management Objective is being met.

- For non-dispersive sites, DMMUs with dioxin concentrations below 10 pptr TEQ will be allowed for disposal as long as the volume-weighted average concentration of dioxins in material from the entire dredging project does not exceed the Disposal Site Management Objective of 4 pptr TEQ. Where possible, disposal of DMMUs is sequenced such that those with higher dioxin concentrations are disposed before those with lower concentrations.

- Case-by-case decisions to allow disposal of material not meeting these guidelines may be made by the DMMP agencies based on the overall goal of meeting the Disposal Site Management Objective. Case-by-case considerations will include the following: (a) material placement sequencing; (b) consideration of the possible cumulative effects of other bioaccumulative compounds within the project sediments; and (c) the frequency of disposal site use.

- When the sediment dioxin concentration in a dredging unit exceeds 10 pptr and the dredging unit is found unacceptable for non-dispersive disposal under case-by-case decision-making, the dredging proponent will have the option of pursuing bioaccumulation testing to determine whether or not individual DMMUs could qualify for open-water disposal. Bioaccumulation testing may also be pursued if the volume-weighted average for the project exceeds 4 pptr TEQ.

- Small businesses[5] with total dredged volume less than 4,000 cubic yards may not be required to meet the volume-weighted average concentrations of 4 pptr if dioxin in all suitable

[5] "Small business" means any business entity, including a sole proprietorship, corporation, partnership, or other legal entity, that is owned and operated independently from all other businesses, and that has fifty or fewer employees. (RCW Chapter 19.85)

DMMUs is less than 10 pptr TEQ and DMMP review determines that the Disposal Site Management Objective of 4 pptr will likely be met on an annual average basis, based on knowledge of other anticipated use of the identified disposal site.

- The Puget Sound non-dispersive-site guidance applies to the Bellingham Bay, Port Gardner, Elliott Bay, Commencement Bay and Anderson-Ketron disposal sites.

8.3.3 Guidelines for Dioxin Evaluation in Grays Harbor

Dioxin evaluation guidelines in Grays Harbor are based on a risk assessment conducted for a navigation improvement project in the early 1990's (USACE, 1991). For the dispersive sites in Grays Harbor, each disposed DMMU must have a 2,3,7,8-TCDD concentration less than or equal to 5 pptr dry wt and a TEQ of less than or equal to 15 ng/kg. DMMUs with concentrations above these levels would be required to undergo bioaccumulation testing in order to qualify for open-water disposal.

8.3.4 Guidelines for Dioxin Evaluation in Other Areas of Washington State

Dioxin evaluation guidelines have not been developed in other areas of Washington State. Dioxin results for areas outside of Puget Sound and Grays Harbor will be evaluated on a case-by-case basis. For non-Port projects on the Washington side of the Columbia River, dioxin concentrations in dredged material have been compared to background values for sediment samples taken downstream of Puget Island, which ranged from 0.65 to 2.89 pptr TEQ as of 2009.

8.3.5 Dioxin Analysis and Reporting

Specifying data analysis procedures for PCDD/F is considerably more difficult than for other chemicals in the DMMP list. The DMMP clarified preferred analysis methods at the 2010 SMARM, in *Polychlorinated Dioxins and Furans (PCDD/F): Revisions to the Supplemental Quality Assurance Project Plan* (DMMP, 2010b) and *Revised Supplemental Information on Polychlorinated Dioxins and Furans (PCDD/F) for use in Preparing a Quality Assurance Project Plan (QAPP)* (DMMP, 2010c). **Please refer to the full documents for complete guidance.** In summary, for dioxin analysis, the DMMP requires:

Analytical Method. The identification of PCDD/F congeners at low concentrations is difficult, and there is significant possibility of interfering compounds (such as chloro-diphenyl ethers) causing the reporting of artificially elevated values. The DMMP agencies recommend EPA Method 1613B: Tetra-Through Octa-Chlorinated Dioxins and Furans by Isotope Dilution High Resolution Gas Chromatography/High Resolution Mass Spectrometry as the most suitable method for sediment.

Puget Sound Sediment Reference Material (PS-SRM). The PS-SRM must be extracted and analyzed alongside dioxin samples. This is a requirement of all DMMP projects, both marine and freshwater. See **8.5.6** for more information on the PS-SRM analysis and reporting requirements.

Data Validation. At a minimum, Stage 2 data validation is required for dioxin analysis. However, because of the complexity of the method, the extremely low reporting limits, and the high potential for interfering compounds such as chloro-diphenyl ethers, Stage 4 data validation by an experienced independent validator is highly recommended.

If the applicant chooses not to validate the data using Stage 4 validation, the DMMP agencies will review the results of the Stage 2 validation, as well as the PS-SRM testing results. The DMMP may also compare the analytical results against the Method 1613B acceptance limits and the dioxin QC performance criteria in **8.5.5**. If data anomalies or QC deficiencies are found, Stage 4 validation of the dioxin raw data may be required. Should the DMMP require Stage 4 validation, the project proponent must provide it, using a person with demonstrated experience accomplishing validation for PCDD/F. The raw data associated with the analysis of dioxins must be made available to the DMMP agencies upon their request.

Data Reporting. The laboratory shall report each of the 2,3,7,8-chlorine substituted PCDD/F congeners on a dry-weight basis. Estimated detection limits (EDLs) and reporting limits shall be reported for each of these congeners. The 17 congeners of interest shall be tabulated as TEQ, both with nondetected values (U) = ½ EDL and with U = 0. (The difference between these values gives data reviewers an idea of how much the EDL substitution affects the TEQ summation Details regarding EDLs are as follows:

Estimated Detection Limit

The estimated detection limit is a sample- and analyte-specific detection limit that is based on the signal-to-noise ratio present in the sample for each analyte at the time of analysis. This is the best value to use to get the lowest defensible TEQ values.

The estimated detection limit is defined as follows:

$$\mathrm{EDL} = \frac{2.5 \times \mathrm{H}_x \times \mathrm{Q}_{is}}{\mathrm{H}_{is} \times \mathrm{W} \times \overline{\mathrm{RF}}_n}$$

where:

EDL = estimated detection limit for homologous 2,3,7,8-substituted PCDDs/PCDFs.

H_x = sum of the height of the noise level for each quantitation ion for the unlabeled PCDDs/PCDFs.

H_{is} = sum of the height of the noise level for each quantitation ion for the labeled internal standard.

W = weight, in g, of the sample.

$\overline{\mathrm{RF}}_n$ = calculated mean relative response factor for the analyte (with n = 1 to 17 for the seventeen 2,3,7,8-substituted PCDDs/PCDFs).

Q_{is} = quantity, in pg, of the internal standard added to the sample before extraction.

Estimated Maximum Possible Concentration (EMPC). The EMPC qualifier is applied when both quantitation ions are detected with a signal to noise ratio of at least 2.5 to 1, but where the ion abundance ratio does not meet the criteria for positive identification. For the purpose of TEQ summations, concentrations with EMPC qualifiers will be treated as non-detects and included in the TEQ summations as U = ½ EMPC and U = 0.

Reporting Requirements for Dioxin Data Validation:

- **Case narrative** per batch of samples, including: a summary of samples received and samples analyzed; list of analytical methods used and modifications; samples requiring dilutions and re-analysis and reasons; description of any problems encountered during sample shipment, extraction and/or analysis; corrective actions taken and any data limitations; list of manually integrated peaks with the original and manually reintegrated peak areas;, and definitions of all laboratory qualifiers applied.

- PCDD/PCDF Data
- Summary of analytical results arranged in chronological order. Example calculations. Tabulated analytical results (identification and quantitation) of the specified target analytes, mass-ion ratios and recoveries of the associated labeled compounds. Include lab name, lab sample ID, lab file ID, sample prep method, date received, date extracted, date analyzed, sample matrix, amount of sample extracted, dilution factor (if any), injection volume, final extract volume, and sample specific EDLs and RLs. For solids, reporting units and concentrations need to be identified on a dry weight basis (include percent moisture).
- Toxicity Equivalence Summary - Tabulated adjusted concentrations for the target analytes based on toxicity equivalent factors. PCDD/PCDF toxicity of the 17 congeners of interest shall be calculated and tabulated as TEQs, using the product of the TEFs with (1) non-detected values (U) = ½ EDLs and (2) with non-detected values (U) = 0. Table 8-5 presents the specified mammalian TEFs for each of the 17 congeners. Tabulated total homologue concentrations shall be completed for each sample, blank, and Quality Control (QC) sample analyzed. EMPC values shall be flagged "*", and the Estimated Detection Limit (EDL) shall be qualified "U" on the form.
- Complete data system report, including but not limited to quantitation reports and area summaries, selected ion current profile (SICP) for each sample including dilution and re-analysis. SICPs must be presented so the two major quantitation ions, the relevant labeled compounds and chlorinated diphenyl ether (CDPE) interferences are on one page. The internal standards can be presented on another page. The SICPs must show the full retention time window scanned for each ion. Enlarge any SICP peak for any 2,3,7,8-substituted congener present below the signal-to noise (S/N) ratio of 10 or below the RLs.
    - The following information shall be included in all laboratory "raw data sheets": sample number, date and time of analysis, retention time or scan number of the identified target compound, ions used for quantitation with measured areas, area table, on-column concentration including units, S/N ratios, lab file ID, Analyst ID.
    - In all instances where the data system report has been edited, or where manual integration or quantitation has been performed, the HRGC/HRMS operator shall identify the changes made to the report, by initialing and dating all handwritten changes, and shall include the integration scan range. In addition, a hardcopy printout of the chromatogram displaying the manual integration shall be included in the raw data.
    - Second column confirmation is required for all samples in which 2,3,7,8-TCDF is positively identified at, or above, the RLs by analysis on a DB-5 (or equivalent) HRGC column, or if 2,3,7,8-TCDF is reported as an Estimated Maximum Possible Concentration (EMPC) at, or above, the RL.
- Quality Control and Supporting Data

- Instrument Performance Check
- Window Defining Mix Summary
- Chromatographic Resolution Checks
- Analytical Sequence Summary Checks
- Fortified blank (LCS) recovery results (1 per batch)
- SRM run and recovery results
- Method blanks and list of samples associated with the method blanks
- Initial calibration summary and raw data
- Calibration verification summary and raw data
- Miscellaneous Data
- Copy of laboratory's method SOP
- Sample receipt documentation and sample control
- Extraction, extract clean-up, and instrument run logs
- Standard Traceability documentation
- Communication logs

8.4 Chemicals/Constituents of Concern for Limited Areas

In addition to the standard list of standard chemicals of concern, there are COCs that may be required for analysis by certain dredging projects based on site-specific conditions. The need for adding any non-standard chemicals to a project's COC list will be determined in coordination with the DMMP agencies. These chemicals include those from the following list, which are further discussed below.

- Tributyltin (standard for freshwater; non-standard for marine)
- Wood waste

Other COCs may need to be analyzed for specific projects depending on site-specific information.

8.4.1 Tributyltin

Tributyltin (TBT) is a standard COC for freshwater projects, but is a non-standard COC for marine projects.

Tributyltin (TBT) testing in marine sediments is indicated in areas near current or historic marinas, boatyards, shipyards, combined sewer overflows (CSOs), treatment plant outfalls and in urban areas, especially Commencement Bay, Elliott Bay, Duwamish River, Lake Washington ship canal, Salmon Bay and Lake Union.

Measurement of TBT (and other butyltins) in freshwater sediment is by bulk analysis. Bulk sediment TBT data will be evaluated against the SL1 of 47 ug/kg for freshwater projects. If the bulk TBT concentration of a DMMU exceeds 47 ug/kg, bioassay testing must be conducted. Similar comparisons to SL1 are made for monobutyltin, dibutyltin and tetrabutyltin.

Measurement of TBT in marine sediments by bulk analysis (in lieu of porewater analysis) is now recommended and accepted for most dredging projects (DMMP, 2015d). Bulk sediment TBT data will be evaluated against the bioaccumulation trigger of 73 ug/kg. If the bulk TBT concentration of a DMMU exceeds 73 ug/kg, bioaccumulation testing must be conducted unless porewater (also known as "interstitial water") data are available.

Porewater TBT data is considered a better approximation of the bioavailable fraction and porewater analysis remains an option for marine projects in addition to, or instead of, bulk analysis, at the discretion of the project proponent. In cases where the applicant chooses to collect porewater TBT data, the suitability of the dredged material for open-water disposal will be determined by comparison to the existing bioaccumulation trigger of 0.15 ug/L. In the event that paired bulk and porewater TBT data are collected for a sample, the porewater results will be used to determine suitability of the dredged material for open-water disposal.

Centrifugation is preferred for collecting sediment porewater – for detailed guidance on porewater collection and sample handling refer to DMMP, 1998 - Tributyltin Analysis: Clarification of Interstitial Water Extraction and Analysis Methods - Interim. Alternative porewater extraction methods may be used in cases where centrifugation is not an effective technique, (e.g., for very sandy sediments) and will be decided on a case-by-case basis by the DMMP agencies.

Acceptable methods for measuring TBT involve tropolone/methylene chloride extraction, followed by Grignard derivitization and analysis by GC/MS (e.g., Krone *et al*., 1989), GC/MS SIM (e.g., PSEP, 1997b), or GC/FPD (e.g., Unger *et al*., 1986).

For marine projects, if the TBT concentration in the porewater of a DMMU is above 0.15 ug TBT/L or if the bulk TBT concentration (in the absence of porewater data) exceeds 73 ug/kg, bioaccumulation testing must be conducted using the DMMP bioaccumulation guidelines in effect at the time of testing. If unacceptable tissue concentrations are measured at the end of the bioaccumulation test, the sediment will be found unsuitable for open-water disposal. It should be noted that standard toxicity bioassays (amphipod mortality, larval development, and *Neanthes* growth tests) are not triggered by exceedances of TBT thresholds, as these bioassays have been shown to be ineffective in the evaluation of TBT toxicity (PSDDA/SMS, 1996).

8.4.2 Wood Waste

Wood waste can range in size from intact logs down to fine bark and sawdust. The DMMP program requires logs and large woody debris to be removed prior to disposal. Effective June 16, 2016, no debris (wood or otherwise) greater than 12 inches in any dimension is allowed at the open-water disposal sites (see 13.4). Projects containing large pieces of wood debris must remove it prior to open-water disposal of dredged material using a clamshell bucket or by passing the dredged material through a 12" X 12" screen. The quantity of wood debris that would pass through a 12" X 12" screen must be visually assessed during field collection of sediments. If a project's sediments contain a significant quantity of smaller wood debris, the sediments must be analyzed in the laboratory to quantify the wood fraction.

The wood fraction can be quantified in the laboratory on either a volume or a weight-specific basis. While quantifying wood debris in sediments on a volumetric basis may be more ecologically meaningful, it is much more difficult and less accurate than quantifying it on a weight-specific basis.

Therefore, dredged material assessment of wood debris will be accomplished on a dry-weight basis, then converted to a volumetric basis by multiplying the weight-based number by two (example: 25% by weight ≅ 50% by volume). The dry-weight fraction of debris is estimated by quantifying the organic fraction. Dredged material containing an organic fraction greater than 25% dry weight will be required to undergo biological testing to assess the suitability of the material for unconfined open-water disposal. Likewise, dredged material containing an organic fraction less than 25% dry weight will be considered suitable for unconfined open-water disposal without further testing unless one or more chemicals of concern exceed chemical screening levels.

One method for determining the dry-weight fraction of wood waste is quantification by ASTM D-2974 Method C, with the sample size increased to 100-300 grams. Other methods may be proposed by the applicant in lieu of this approach, but must be included in the SAP and approved by the DMMP agencies.

For additional information see DMMP/SMS, 1997 - Management of Wood Waste under DMMP and SMS Cleanup Program.

If bioassays are triggered by wood waste, additional information must be obtained in preparation for biological testing. Sediment grain size is an important consideration when selecting the species to be used in the amphipod test and choosing appropriate reference sediments. However, the presence of wood waste in the sediment sample would bias the results of standard grain-size analysis. Therefore, in addition to the standard grain-size testing, applicants should conduct grain-size analysis on the residue left over after the wood-waste analysis. This “organic-free” grain-size distribution should be used in conjunction with the standard grain-size distribution in selecting the appropriate amphipod species and reference sediment.

8.5 Sediment Data Quality

The quality of chemical data submitted to characterize dredged material proposed for open-water disposal at a DMMP site must be assessed before it may be used for regulatory decision-making. This section provides general quality assurance (QA) guidelines, as well as guidelines specific to the analysis of tributyltin and dioxin.

8.5.1 Laboratory Accreditation

Laboratories are required to be accredited by the Department of Ecology for sediment methods used to generate chemical and biological data for DMMP projects. A current list of accredited labs may be found at https://fortress.wa.gov/ecy/laboratorysearch/.

8.5.2 Sample Detection Limits and Reporting Limits

Ideally, the reporting limits (*aka* limits of quantification or practical quantification limits) for all COCs will be below the SLs. If this is not possible - due to matrix interference or sample dilution - it is imperative that sample detection limits be below the SLs. **Failure to bring reported nondetects for an analyte below the SL could result in the agencies requiring the re-extraction and re-analysis of archived sediment, or biological toxicity testing, to verify the suitability of sediments for open-water disposal.**

The following guidelines must be followed when reporting results of chemical analysis:

- Laboratories must report estimated concentrations that fall between the sample detection limit and reporting limit. Such estimated concentrations should be accompanied by a "J" qualifier.
- Laboratories must report both the reporting limit and the sample detection limit for any COC concentration that is accompanied by a "U" flag.
- For mixtures of chemicals, such as Total PCBs, the reported values of detected constituents - including "J" values falling between the sample detection limit and the reporting limit - will be summed. In the event that all constituents are undetected, the single highest constituent's detection limit will be used as the value for the mixture in a given sample and will be accompanied by a "U" qualifier.

The following scenarios are possible and need to be understood and handled appropriately:

- One or more chemicals-of-concern (COC) have nondetects exceeding screening levels while all other COCs are quantitated or reported as nondetects at or below the screening levels: the requirement to conduct biological testing will be triggered solely by the nondetects. In this case the chemical testing subcontractor should do everything possible to bring sample detection limits down to or below the screening levels, including additional cleanup steps, re-extraction, etc. Selected ion monitoring or other more sensitive analytical methods may be used, if necessary. All such actions must be documented in the lab report. In the event that nondetects cannot be brought below the SLs, the Dredged Material Management Office must be contacted immediately. Failure to do so could result in the need to collect new field samples for analysis or trigger bioassays, an expensive endeavor.
- One or more COCs are reported as nondetects above the SLs for a lab sample, but below respective bioaccumulation triggers (BT), and other COCs have quantitated concentrations above screening levels: The need to do bioassays is based on the detected exceedances of SLs and the nondetects above SL become irrelevant. No further action on the part of the chemical testing subcontractor is necessary.
- One or more COCs are reported as nondetects above the SL and BT, and other COCs have quantitated concentrations above screening levels: the need to do bioassays is based on the detected exceedances of SLs but all other nondetects must be brought below BTs to avoid the requirement to do bioaccumulation testing. As in scenario "1" above, everything possible should be done to lower the sample detection limits.

In all cases, to avoid potential problems and leave open the option for retesting, sediments or extracts should be kept under proper storage conditions until the chemistry data are deemed acceptable by the regulatory agencies.

8.5.3 Data Quality Objectives

Data quality objectives are the quantitative and qualitative terms used to describe how good the data needs to be in order to meet the project's objectives. Typical data quality objectives include precision, accuracy, representativeness, comparability and completeness.

Precision: The precision is evaluated using the Relative Percent Difference (RPD) values between duplicate sample results and/or matrix spike duplicates.

$$\text{RPD} = \frac{\text{ABS}(\text{R1} - \text{R2})}{\left(\frac{\text{R1} + \text{R2}}{2}\right)} \times 100$$

R1 = Recovery for MS or duplicate 1

R2 = Recovery for MSD or duplicate 2

Accuracy: For parameters analyzed in the laboratory, accuracy will be evaluated using percent recovery (%R) of the target analyte in spiked samples and, where applicable, also the recoveries of the surrogates in all samples and QC samples.

$$\%\text{Recovery} = \frac{\text{SSR - SR}}{\text{SA}} \times 100$$

SSR = Spiked Sample Result

SR = Sample Result

SA = Spike Added

Representativeness is the degree to which data from the project accurately represent a particular characteristic of the environmental matrix which is being tested. Representativeness of samples is ensured by adherence to standard field sampling protocols and standard laboratory protocols. The design of the sampling scheme and number of samples should provide representativeness of each matrix being sampled.

Comparability is the measurement of the confidence in comparing the results of one sampling event with the results of another achieved by using the same matrix, sample location, sampling techniques and analytical methodologies.

Completeness: Completeness is the percentage of valid results obtained compared to the total number of samples taken for a parameter. %Completeness may be calculated using the following formula:

$$\%\ \text{Completeness} = \frac{\#\ \text{of valid results}}{\#\ \text{of samples taken}} \times 100$$

8.5.4 General Quality Assurance Guidelines

The chemistry QA/QC requirements summarized in Table 8-6 must be met to ensure data quality and usability for dredged material characterization and suitability determinations. Due to analytical complexity, dioxin QA is covered in 8.5.5.

Table 8-6. Laboratory QA/QC Requirements for Conventionals and COCs

Analysis Type	Method Blanks[1]	Replicates[1]	Triplicates[1]	CRM/RM	MS/MSD[1]	Surrogates[2]
Semivolatiles[3,4]	X[5]	X[6]		X	X	X
Pesticides[3,4]	X[5]	X[6]		X	X	X
PCBs[3,4]	X[5]	X[6]		X[7]	X	X
Metals	X	X		X	X	
Ammonia	X		X			
Total Sulfides	X		X			
Total Organic Carbon	X		X	X		
Total Solids			X			
Total Volatile Solids			X			
Grain Size			X			
Tributyltin	X	X[6]			X	X
Dioxins/Furans	See **Table 8-8**					

Notes:

CRM = Certified Reference Material; RM = Reference Material; MS/MSD = matrix spike/matrix spike duplicate

[1] Frequency of Analysis (FOA) = 5 percent or one per batch, whichever is more frequent.

[2] Surrogate spikes required for every sample, including matrix spiked samples, blanks, and reference materials.

[3] Initial calibrations required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria.

[4] Ongoing calibration required at the beginning of each work shift, every 10–12 samples or every 12 hours (whichever is more frequent), and at the end of each shift.

[5] FOA = one per extraction batch.

[6] Matrix spike duplicates may be used.

[7]The Puget Sound Sediment Reference Material must be used for projects in Puget Sound.

Laboratories performing DMMP chemical analyses (with the exception of dioxins/furans) must follow the standard quality control procedures published in the respective method. Alternatively, or in addition to standard published laboratory methodology, laboratories may utilize the EPA Contract Laboratory Program (CLP) National Functional Guidelines (NFG) to evaluate data quality and determine when corrective action is necessary. Laboratory method accreditation by Ecology is required. Dioxin/furan laboratory quality control procedures must follow the guidelines provided in **8.5.5**.

The DMMP agencies recommend that all chemistry data undergo a minimum of Stage 2b validation to ensure that all chemistry QA/QC requirements are met and to assign appropriate final data validation flags consistent with Ecology reporting requirements. As defined by EPA (2009), a stage 2b validation consists of verification and validation based on completeness and compliance checks of sample receipt conditions and both sample-related and instrument-related QC results. As discussed in **8.3.5**, Stage 4 validation is strongly recommended for dioxin data.

A minimum of Stage 2b validation is required when reporting dioxin/furan and PCB results from the analysis of the PS-SRM (**8.5.6**).

8.5.5 Dioxin QC Performance Criteria

QC performance criteria for the analysis of dioxins must be presented in the sampling and analysis plan and approved by the DMMP agencies. Laboratories will be required to meet these performance criteria as well as take the specified corrective action if performance criteria are not met. Example criteria and corrective actions are provided in **Table 8-7** and **Table 8-8.** These tables of QC requirements are not all-inclusive of method 1613B requirements. Other method-required QC checks, criteria and corrective actions can be found in the EPA *National Functional Guidelines for Chlorinated Dioxin/Furan Data review* (EPA, 2011) and must also be followed.

It is critical for reporting limits to be sufficiently low when analyzing dredged material for dioxin. Target reporting limits for DMMP projects are presented in **Table 8-9.**

All projects will be required to analyze the Puget Sound Sediment Reference Material (PS-SRM) for dioxin/furans with each analytical batch. Acceptance criteria for the reference material must be included in the sampling and analysis plan (**Table 8-10**). If results fall outside the acceptance range, the laboratory may be required to reanalyze.

Table 8-7. Summary of Dioxin Quality Control Procedures

QC Check	Minimum Frequency	Acceptance Criteria	Laboratory Corrective Action*
Ongoing Precision and Recovery	1 per analytical batch (≤ 20 samples)	Recovery within acceptance criteria in **Table 8-8** of the QAPP guidance document	1. Check calculations 2. Reanalyze batch
Stable-isotope-labeled compounds	Spiked into each sample for every target analyte	Recovery within limits in **Table 8-8**	1. Check calculations 2. Qualify all associated results as estimated
		Ion abundance ratios must be within criteria in Table 9 of method 1613B	1. Reanalyze specific samples. 2. Reject all affected results outside the criteria 3. Alternatively, use of secondary ions that meet appropriate theoretical criteria is allowed if interferences are suspect. This alternative must be approved by the DMMP agencies.
Laboratory duplicate	5% or 1 per batch (≤ 20 samples)	Relative percent Difference ≤ 30%	1. Evaluation of the homogenization procedure and evaluation method 2. Reanalyze batch
Method blank	1 per analytical batch (≤ 20 samples)	Detection ≤ minimum level in Table 2 of Method 1613B	1. If the method blank results are greater than the reporting limit, halt analysis and find source of contamination; reanalyze batch.

Table 8-7. Summary of Dioxin Quality Control Procedures

QC Check	Minimum Frequency	Acceptance Criteria	Laboratory Corrective Action*
			2. Report project samples as non-detected for results ≤ to the reported method blank values
GC/MS Tune	At the beginnings of each 12 hour shift. Must start and end each analytical sequence.	>10,000 resolving power @ m/z304.9825 Exact mass of 380.9760 within 5 ppm of theoretical value.	1. Re-analyze affected samples 2. Reject all data not meeting method 1613B requirements
Initial Calibration	Initially and when continuing calibration fails.	Five point curve for all analytes. RSD must meet Table 4 requirements for all target compounds and labeled compounds. Signal to noise ratio (S/N) >10. Ion abundance (IA) ratios within method specified limits.	
Window Defining/Column Performance Mix	Before every initial and continuing calibration.	Valley <25% for all peaks near 2378-TCDD/F peaks.	
Continuing Calibration	Must start and end each analytical sequence.	%D must meet Table 4 limits for target compounds & labeled compounds. S/N >10. IA ratios within method specified limits.	
Confirmation of 2,3,7,8- TCDF	For all primary-column detections of 2,3,7,8-TCDF	Confirmation presence of 2,3,7,8-TCDF in accordance with method 1613B requirements	Failure to verify presence of 2,3,7,8-TCDF by second column confirmation requires qualification of associated 2,3,7,8-TCDF results as non-detected at the associated value.
Sample data not achieving target reporting limits or method performance in presence of possibly interfering compounds	Not applicable	Not applicable	Rather than simply dilute an extract to reduce interferences, the lab should perform additional cleanup techniques identified in the method to insure minimal matrix effects and background

Table 8-7. Summary of Dioxin Quality Control Procedures

QC Check	Minimum Frequency	Acceptance Criteria	Laboratory Corrective Action*
			interference. Thereafter, dilution may occur. If re-analysis is required, the laboratory shall report both initial and re-analysis results.
Puget Sound Sediment Reference Material	One per analytical batch	Result must be within acceptance ranges (**Table 8-10**)	1. Extraction and analysis should be evaluated by the lab and re-analysis performed of the entire sample batch once performance criteria can be met. 2. If analysis accompanies several batches with acceptable PS-SRM results, then the laboratory can narrate possible reason for PS-SRM outliers.

* If re-analysis is required, the laboratory shall report initial and re-analysis results

Table 8-8. QC Acceptance Criteria for PCDD/F

	Test Conc., ng/mL[1]	IPR[2]		OPR[3] (%)	I-CAL[4] %	CAL/VER[5] (%) (Coeff. of Variation)	Labeled Compound % Recovery in Sample	
		RSD (%)	Recovery				Warning Limit	Control Limit
Native Compound								
2,3,7,8-TCDD	10	28	83-129	70-130	20	78-129	-	-
2,3,7,8-TCDF	10	20	87-137	75-130	20	84-120	-	-
1,2,3,7,8-PeCDD	50	15	76-132	70-130	20	78-130	-	-
1,2,3,7,8-PeCDF	50	15	86-124	80-130	20	82-120	-	-
2,3,4,7,8-PeCDF	50	17	72-150	70-130	20	82-122	-	-
1,2,3,4,7,8-HxCDD	50	19	78-152	70-130	20	78-128	-	-
1,2,3,6,7,8-HxCDD	50	15	84-124	76-130	20	78-128	-	-
1,2,3,7,8,9-HXCDD	50	22	74-142	70-130	35	82-122	-	-
1,2,3,4,7,8-HxCDF	50	17	82-108	72-130	20	90-112	-	-
1,2,3,6,7,8-HxCDF	50	13	92-120	84-130	20	88-114	-	-
1,2,3,7,8,9-HxCDF	50	13	84-122	78-130	20	90-112	-	-
2,3,4,6,7,8-HxCDF	50	15	74-158	70-130	20	88-114	-	-
1,2,3,4,6,7,8-HpCDD	50	15	76-130	70-130	20	86-116	-	-
1,2,3,4,6,7,8-HpCDF	50	13	90-112	82-122	20	90-110	-	-
1,2,3,4,7,8,9-HpCDF	50	16	86-126	78-130	20	86-116	-	-
OCDD	100	19	86-126	78-130	20	79-126	-	-
OCDF	100	27	74-146	70-130	35	70-130	-	-
Labeled Compounds								
$^{13}C_{12}$-2,3,7,8-TCDD	100	37	28-134	25-130	35	82-121	40-120	25-130
$^{13}C_{12}$-2,3,7,8-TCDF	100	35	31-113	25-130	35	71-130	40-120	24-130
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100	39	27-184	25-150	35	70-130	40-120	25-130
$^{13}C_{12}$-1,2,3,7,8-PeCDF	100	34	27-156	25-130	35	76-130	40-120	24-130
$^{13}C_{12}$-2,3,4,7,8-PeCDF	100	38	16-279	25-130	35	77-130	40-120	21-130
$^{13}C_{12}$-1,2,3,4,7,8-HxCDD	100	41	29-147	25-130	35	85-117	40-120	32-130
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100	38	34-122	25-130	35	85-118	40-120	28-130
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	100	43	27-152	25-130	35	76-130	40-120	26-130
$^{13}C_{12}$-1,2,3,6,7,8-HxCDF	100	35	30-122	25-130	35	70-130	40-120	26-123
$^{13}C_{12}$-1,2,3,7,8,9-HxCDF	100	40	24-157	25-130	35	74-130	40-120	29-130
$^{13}C_{12}$-2,3,4,6,7,8-HxCDF	100	37	29-136	25-130	35	73-130	40-120	28-130
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100	35	34-129	25-130	35	72-130	40-120	23-130
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	100	41	32-110	25-130	35	78-129	40-120	28-130
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	100	40	28-141	25-130	35	77-129	40-120	26-130
$^{13}C_{12}$-OCDD	200	48	20-138	25-130	35	70-130	25-120	17-130
Cleanup Standard								
$^{37}Cl_4$-2,3,7,8-TCDD	10	36	39-154	31-130	35	79-127	40-120	35-130

(Table shown with permission from AXYS Analytical Services LTD (2005), Vancouver, BC, Canada. *Analysis of Polychlorinated Dioxins and Furans by Method 1613B* -- MSU-018 Rev. 5, 07-Jun-2005)

[1] QC acceptance criteria for IPR, OPR, and samples based on a 20 µL extract final volume
[2] IPR: Initial Precision and Recovery demonstration
[3] OPR: Ongoing Precision and Recovery test run with every batch of samples.
[4] Initial Calibration
[5] CAL/VER: Calibration Verification test run at least every 12 hours

Table 8-9. Target Reporting Limits for Dioxins/Furans

Dioxins and Furans	Reporting Limit (ng/kg dry wt)
2,3,7,8-TCDD	1.0
1,2,3,7,8-PeCDD	1.0
1,2,3,4,7,8-HxCDD	2.5
1,2,3,6,7,8-HxCDD	2.5
1,2,3,7,8,9-HxCDD	2.5
1,2,3,4,6,7,8-HpCDD	2.5
OCDD	5.0
2,3,7,8-TCDF	1.0
1,2,3,7,8-PeCDF	2.5
2,3,4,7,8-PeCDF	1.0
1,2,3,4,7,8-HxCDF	2.5
1,2,3,6,7,8-HxCDF	2.5
1,2,3,7,8,9-HxCDF	2.5
2,3,4,6,7,8-HxCDF	2.5
1,2,3,4,6,7,8-HpCDF	2.5
1,2,3,6,7,8,9-HpCDF	2.5
OCDF	5.0

8.5.6 Puget Sound Sediment Reference Material

The Puget Sound Sediment Reference Material (SRM) has been developed to help evaluate measurement accuracy and monitor laboratory performance when analyzing for chlorinated dioxins, furans, and biphenyl compounds in sediment samples collected from the Puget Sound area. The SRM is currently available free of charge, though recipients must pay shipping costs.

The guidance document provides instructions for obtaining, analyzing, and reporting on the SRM. The guidance and procedures are intended to ensure that SRM users:

- Report methods used for analysis
- Report QA/QC procedures used to verify and validate results, and
- Report results that can be included in periodic recalculations of acceptance limits

In addition to the reporting requirements outlined in the guidance document, all PS-SRM users must ensure proper reporting of the SRM bottle # used, the date on which the SRM was received by the lab, and the date on which the lab analyzed the SRM.

The Puget Sound SRM has been established for chlorinated dibenzo-p-dioxins/chlorinated dibenzofurans (CDD/CDF) and/or chlorinated biphenyl (CB) congener analysis using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) methods. This SRM is also suitable for Aroclor analysis using gas chromatography/electron capture detection (GC/ECD) methods. Use of the SRM **requires** submittal of data per the guidance document. The SRM may be requested through DMMP website.

To ensure analytical quality of the SRM data, all results from the analysis of the SRM are **required** to undergo Stage 2b validation. The data validator should review the SRM data like any other sample; final data validation qualifiers must be provided. Final validated SRM data must be provided in the final characterization report along with validated field sample data. An EDD with PS-SRM data must also be provided as part of the sediment characterization report.

When certified reference materials (CRMs) other than the PS-SRM are used, the certified acceptance limits should be used as an objective evaluation tool. The acceptance range for Aroclor 1260 in the PS-SRM is 41-180 µg/kg. Acceptance limits for dioxin/furans are listed in **Table 8-10**.

Table 8-10. CDD/CDF Acceptance Limits for Puget Sound SRM

Acceptance Limits Source	Analyte	CAS No.	Avg. Conc. (ng/kg)	Action Low -50%	Action High +50%
± 50 Percent	2,3,7,8-TCDD	1746-01-6	1.05	0.525	1.57
	1,2,3,7,8-PeCDD	40321-76-4	1.08	0.542	1.63
	1,2,3,4,7,8-HxCDD	39227-28-6	1.59	0.797	2.39
	1,2,3,6,7,8-HxCDD	67653-85-7	3.88	1.94	5.82
	1,2,3,7,8,9-HxCDD	19408-74-3	3.04	1.52	4.55
	1,2,3,4,6,7,8-HpCDD	35822-46-9	90.6	45.3	136
	OCDD	3268-87-9	811	406	1217
	2,3,7,8-TCDF	51207-31-9	1.11	0.557	1.67
	1,2,3,7,8-PeCDF	57117-41-6	1.23	0.613	1.84
	2,3,4,7,8-PeCDF	57117-31-4	1.07	0.533	1.60
	1,2,3,4,7,8-HxCDF	70648-26-9	3.02	1.51	4.53
	1,2,3,6,7,8-HxCDF	57117-44-9	1.09	0.545	1.64
	2,3,4,6,7,8-HxCDF	60851-34-5	1.83	0.917	2.75
	1,2,3,7,8,9-HxCDF	72918-21-9	0.511	0.255	0.77
	1,2,3,4,6,7,8-HpCDF	67562-39-4	18.7	9.36	28.1
	1,2,3,4,7,8,9-HpCDF	55673-89-7	1.63	0.815	2.44
	OCDF	39001-02-0	58.4	29.2	87.6

9 TIER 3 BIOLOGICAL TESTING: BIOASSAYS

Tier 3 biological testing of dredged material is required when chemical testing results indicate the potential for unacceptable adverse environmental or human health effects. Results of bioassay tests are considered to be more informative of potential resource impacts than exceedance of numeric chemical sediment standards (DMMP/RSET 2015). Thus bioassay results always take precedence over chemical results. Biological testing could include:

Bioassays (sometimes called "toxicity tests") – used to evaluate potential toxicity effects on benthic invertebrates – discussed in this chapter.

Bioaccumulation tests – used to evaluate the bioavailability of certain chemicals which are known or suspected agents affecting human or ecological health in the marine environment– discussed in **Chapter 10**.

The standard suite of bioassays for either marine or freshwater sediment in Tier 3 evaluations is triggered by **exceeding** one or more screening levels for chemicals of concern in the dredged material (see **Table 8-3**).

Laboratories providing biological effects data for DMMP projects must be accredited by the Department of Ecology for the methods used to produce the data. Additional information related to bioassay testing under the DMMP can be found on the DMMO website.

9.1 BIOASSAY TESTS: MARINE

A suite of three bioassays is used in the DMMP program to characterize toxicity of whole sediment and includes both acute and chronic tests. Bioassays used for marine/estuarine evaluations, with recommended species, are shown in **Table 9-1**. **If recommended species are not available, please contact the DMMO prior to initiating testing with a non-recommended species.**

The protocols for the required bioassays can be found in the Puget Sound Protocols and Guidelines (PSEP, 1995), with updates since 1995 found on the DMMP Program Updates web page. The protocols describe field collection and processing methods, bioassay specific QA/QC, and data reporting procedures.

Table 9-1. Marine bioassay tests and recommended species. Choice based on availability and sediment characteristics. See text for further details.

Test	10-Day Amphipod Mortality Test	20-Day Juvenile Infaunal Growth Test	Sediment Larval Development Test
Tests for	acute toxicity	chronic toxicity	acute larval toxicity
Species	• *Eohaustorius estuarius* • *Ampelisca abdita* • *Rhepoxynius abronius*	• *Neanthes arenaceodentata* (Los Angeles karyotype)	• *Mytilus galloprovincialis* • *Dendraster excentricus*

9.1.1 10-day Amphipod Mortality Test

This bioassay is an acute test that measures survival of infaunal amphipods to evaluate the toxicity of sample sediments.

The DMMP generally recommends using *Eohaustorius estuarius*, as this species is relatively insensitive to salinity changes and grain size effects, except for high clay (>20%) content. *Ampelisca abdita* is also relatively insensitive to the effects of grain size and is the recommended species when testing sediments with relatively high clay content (>20%). *Rhepoxynius abronius* has shown sensitivity to high percent fines in sediments, particularly high clay content sediments, and has exhibited mortalities greater than 20 percent in clean, reference area sediments (DeWitt *et al*., 1988; Fox, 1993). It should only be selected when testing coarser sediments (<60% fines). *Eohaustorius estuaries* can generally tolerate the widest range of salinities (2 to 28 ppt), whereas *A. abdita and R. abronius* prefer salinities of 28 ± 1 ppt.

Proposed species must be coordinated through the DMMO, and the rationale for species selection must be documented in the sampling and analysis plan for the proposed dredging project. Appropriate negative control sediment must be used for the test species selected. More information on amphipod species selection can be found in DMMP 1999.

9.1.2 20-day Juvenile Infaunal Growth Test (*Neanthes*)

This bioassay is a sublethal bioassay, testing for chronic rather than acute (lethal) toxicity to the nereid worm *Neanthes arenaceodentata.* The growth of this worm is used as an indication of sublethal toxicity. Testing results must be reported on an ash-free dry-weight (AFDW) basis. The AFDW procedure eliminates weight from sediment in the gut, thereby providing a more accurate measurement of the change in biomass during the exposure period.

9.1.3 Sediment Larval Development Test

The sediment larval test uses the planktonic larval form of a benthic invertebrate to test for acute toxicity to this life stage. Larvae are introduced into chambers of test sediment and overlying water directly after fertilization. Development and survival are tracked for the 48 to 60 hours of larval growth.

This test uses larvae of either an echinoderm or bivalve species. *Dendraster excentricus* is the recommended echinoderm species and *Mytilus galloprovincialis* is the recommended bivalve species. If both of these species are unavailable, laboratories may propose use of alternative species such as the bivalve *Crassostrea gigas.* **Use of alternative species should proceed only after DMMP coordination and approval.**

Because the larval stage is a sensitive one, care must be taken during the test to insure that non-treatment factors for larval survival and development are controlled. The PSEP Protocols must be followed carefully to insure that useable data are collected.

For the sediment larval test, adults must be collected in spawning condition or must be induced to spawn in the laboratory. Therefore, seasonality plays a role in selecting a test organism for this bioassay. Viable test organisms are most difficult to obtain in the fall and early winter and the probability of performance problems increases during that time. The DMMP agencies recommend that biological testing be avoided late in the calendar year if at all possible.

When testing dredged material with high concentrations of fines, wood waste or other flocculent material, applicants may elect to use the resuspension protocol (see DMMP, 2013) in lieu of the standard PSEP protocol termination procedure, in order to reduce false positives from normally developing larvae being entrained in the flocculent material. The decision to use the resuspension protocol must be made in coordination with the DMMP agencies for approval before use. For routine testing of sediments with lower fractions of fines, wood waste or flocculent material, the standard PSEP protocol should be used.

9.2 Quality Assurance/Quality Control in Marine Bioassays

The following QA/QC guidelines apply to the standard suite of marine bioassays.

9.2.1 Replication

For marine bioassays, five (5) replicates are run for each test sediment, as well as for the control and reference sediments.

9.2.2 Negative Control and Reference Samples

For the amphipod and juvenile infaunal species biological tests, a negative control sediment is run with each test batch. The negative control sediment for the amphipod test is taken from the test organism collection site (see additional information in 9.2.2). The juvenile infaunal growth test, using laboratory-cultured *Neanthes arenaceodentata*, requires collection of negative control sediment from an appropriate area such as West Beach, Whidbey Island. For the sediment larval test, a negative seawater control is required. The negative control provides an estimate of test organism general health during the test exposure period.

In addition to the negative control, at least one reference sediment must be run with each test batch for each bioassay. The primary purpose of the reference sediment is to control for non-treatment effects due to grain size. Reference sediment is collected from one of the reference sediment collection sites in Puget Sound, Grays Harbor or Willapa Bay (Table 9-3 and Table 9-4). The fines content (silt + clay) of the reference material should ideally fall within 10% of the fines content of the test sediments. For dredged material with relatively coarse-grained sediments (> 80% sand), the dredger can opt to rely solely on the control sediment (see guidance below on when it is appropriate to use control sediments as a reference).

9.2.3 Selection of Negative Control Sediments

An appropriate negative control sediment must be used for the amphipod mortality and *Neanthes* growth tests. All bioassays must be conducted using well-established negative (clean) controls. Such controls are clean, nontoxic seawater and/or sediment samples taken from outside each study area. *Rhepoxynius abronius* and *Eohaustorius estuarius* typically inhabit well-sorted, fine sand while *Ampelisca abdita* is a tube-dwelling amphipod found mainly in protected areas and is often abundant in sediments with a high organic content. *Ampelisca* generally inhabits sediments from fine sand to mud and silt without shell, although it can also be found in relatively coarser sediments with a sizable fine component (PSEP, 1995).

The best way to ensure a good negative control is to collect the control sediment from the same location at which the test organisms are collected. *Neanthes arenaceodentata* is cultured in the lab rather than field-collected. However, PSEP (1995) states that, "For the *Neanthes* bioassay, sand should be used as the control sediment." West Beach of Whidbey Island is most often used as a collection site for clean control sediment. From PSEP (1995), "*Neanthes* maintained in West Beach sand exhibited low mortality and high percentage increases in biomass during the exposure period, indicating that West Beach sand is a suitable material for a control sediment."

Sediments proposed for use as negative controls must be approved before bioassays commence. If an area without a proven track record is proposed for collection of negative control sediment, sufficient data (such as grain size, organic carbon content, chemical data, bioassay results) must be submitted before its use can be approved by the regulatory agencies.

9.2.4 Use of Control Sediments as Reference Sediments

When reference sediment fails to meet its performance standard, and more than one reference has been collected, DMMP/SMS (1996) provides procedures for statistical comparisons. If no reference sediments meet performance standards, or if the control sediment is closer in grain size to one or more stations being evaluated than any of the remaining reference sediments, the control sediment could be considered an acceptable substitute for the reference sediment and the data interpreted accordingly.

If a control sediment is substantially dissimilar to the site stations and a failed reference sediment in its physical characteristics (e.g., >25% difference in fines), it may still be used as a substitute for the reference station if both the agencies and the project proponent agree that this is appropriate. Otherwise, the data will be considered unusable and data from the bioassay(s) in question will need to be rejected and tests possibly rerun.

9.2.5 Quality Control Limits for the Negative Control

All three bioassays have negative control performance standards (see Table 9-2). In the amphipod and juvenile infaunal bioassay tests, control mortality over the exposure period must be less than or equal to 10 percent. This represents a generally accepted level of mortality of test organisms under control conditions, in which the bioassay (in terms of test organism health) is still considered a valid measure of effects of the test treatments. If control mortality is greater than 10 percent, the bioassay test will generally have to be repeated, although that determination must be made in consultation with the agencies through the DMMO. Additionally, for the *Neanthes* 20-day growth bioassay there is a negative control performance guideline of greater than 0.72 mg/individual/day as a target growth rate, with negative control growth rates below 0.38 mg/individual/day considered a QA/QC failure. Laboratories failing to achieve a control growth rate greater than 0.38 mg/individual/day may be required to retest. For the sediment larval test, the performance standard for the seawater negative control combined endpoint (mortality + abnormality) is 30 percent or less.

9.2.6 Quality Control Limits for the Reference Sediment

Performance guidelines for reference sediments are listed in Table 9-2. The mean amphipod test mortality for the reference sediment must not exceed 20 percent absolute over the mean negative control sediment mortality. For the juvenile infaunal growth test, the reference sediment mean mortality must be less than or equal to 20 percent at the end of the exposure period, and the mean growth rate must be greater than or equal to 80 percent of the control sediment's mean growth rate. The seawater-normalized combined endpoint (mortality + abnormality) observed in the reference sediment for the sediment larval test must not exceed 35 percent. Failure to meet the reference sediment performance standard for a bioassay may require that the bioassay be rerun with a new reference sediment. If a performance guideline is not met for reference sediment, the DMMO should be contacted as soon as possible to coordinate with the agencies regarding a retest.

9.2.7 Positive Control - Reference Toxicant

An appropriate reference toxicant must be run with each batch of test sediments as a positive control to assess the test organism sensitivity. The LC_{50} or EC_{50} must be within the 95 percent confidence interval of responses expected for the toxicant used.

9.2.8 Water Quality Monitoring

Temperature, aqueous salinity, pH, and dissolved oxygen should be monitored on a daily basis for the amphipod and sediment larval tests, and every three days for the 20-day *Neanthes* growth test. Total sulfides and ammonia should be measured at least at test initiation and termination for all three tests (See **9.9** for a discussion of non-treatment effects). Interstitial salinity should be measured prior to test initiation. The test protocols for each of these bioassays specify acceptable ranges for these parameters. Water quality data can be critical in the interpretation of bioassay results.

9.3 Marine Ammonia and Sulfide Non-Treatment Effects

Ammonia and sulfide can adversely affect test organisms in both marine and freshwater bioassays. Because most bioassays run in the DMMP program are for marine waters, protocols for addressing non-treatment effects from ammonia and sulfide are more established for marine bioassays, as addressed in the following DMMP clarification papers:

- DMMP (1993) - The *Neanthes* 20-day Bioassay – Requirements for Ammonia/Sulfides Monitoring and Initial Weight
- DMMP (2001b) - Reporting Ammonia LC50 data for Larval and Amphipod Bioassays
- DMMP (2002a) - Ammonia and Amphipod Toxicity Testing
- DMMP (2004a) - Ammonia and Sulfide Guidance Relative to *Neanthes* Growth Bioassay
- DMMP (2015b) – Modifications to Ammonia and Sulfide Triggers for Purging and Reference Toxicant Testing for Marine Bioassays

The 2015 clarification paper addresses data gaps and inconsistencies in the previous guidance and should be consulted for further details and background information on this topic. In summary, triggers for purging bioassay containers in order to reduce ammonia and/or sulfides prior to testing are given in **Table 9-2**. The trigger for purging was set to be equal to the No Observed Effects Concentration (NOEC) for the most toxic forms of ammonia and sulfides--unionized ammonia and hydrogen sulfide. Unionized ammonia and hydrogen sulfide concentrations must be derived from measurements of total ammonia and sulfides using test-specific pH, temperature, and salinity measurements. For ammonia, the trigger for conducting Reference Toxicant testing (Ref Tox) is set at half the lowest NOEC. Reference toxicant testing is not required for sulfides.

Table 9-2. Reference Toxicant and Purging Triggers for Marine Bioassays

Trigger	Bedded sediment tests				Larval tests	
	Neanthes	*Ampelisca*	*Eohaustorius*	*Rhepoxynius*	Bivalve	Echinoderm
Unionized Ammonia (mg/L) Ref Tox	0.23	0.118	0.4	0.2	0.02	0.007
Unionized Ammonia (mg/L) Purge	0.46	0.236	0.8	0.4	0.04	0.014
Hydrogen Sulfide (mg/L) Purge	3.4	0.0094	0.122	0.099	0.0025	0.01

9.3.1 Determining the Need for Purging or Ref Tox Testing:

These guidelines are only for bioassays on marine sediments; no similar guidance for bioassays in freshwater sediment have been developed to date in the DMMP.

The need for purging or Ref Tox testing should be determined PRIOR to the commencement of actual bioassay testing. The following summarizes the recommended procedure (See DMMP, 2015b for details):

- **Measure bulk ammonia and sulfides in sediment.** Bulk ammonia and bulk sulfides measurements should be measured by the chemistry lab on composited sediment representing each DMMU. Exceptions to this procedure for total sulfides may be considered for sediment testing performed for both cleanup and DMMP characterization; and for projects where wood waste in new surface material may be an issue. In those cases, total sulfides should be performed on single cores.

- **Measure ammonia and sulfides in bioassay medium of exposure.** For those DMMUs that will undergo bioassays, ammonia and sulfides must be measured in the medium of exposure prior to running the bioassays. While bulk measurements made by the analytical laboratory can provide an early warning of potential non-treatment effects in bioassays, these measurements are not always predictive of the ammonia and sulfide concentrations to which bioassay organisms will actually be exposed. Aqueous concentrations measured by the bioassay lab are more meaningful in this regard.

  For bedded sediment tests using *Neanthes*, *Eohaustorius* and *Rhepoxynius*, porewater is the medium of exposure. For the tube-building amphipod *Ampelisca*, as well as the bivalve and echinoderm species used in the larval development test, the overlying water is the medium of exposure.

  Measurement of ammonia and sulfides in the medium of exposure can be accomplished by the bioassay lab by making measurements on two beakers for each DMMU, the first of which is set up in the manner that would be done for the amphipod bioassay and the second of which is set up as would be done for the larval bioassay. Since the juvenile infaunal bioassay is set up in the same way as the amphipod bioassay, the amphipod beaker is also predictive of ammonia/sulfides in the juvenile infaunal bioassay. In addition to ammonia and sulfides, pH is also measured. Unionized ammonia and hydrogen sulfide concentrations are calculated using the measured pH, plus the temperature and salinity that will be maintained during the bioassays.

- **Prepare bioassays without purging.** If unionized ammonia and hydrogen sulfide concentrations are below the purging triggers in **Table 9-7**, or if any of the chemicals of concern exceeding SL are subject to significant loss or alteration of bioavailability during purging (to be determined in consultation with the DMMP agencies), set up the bioassays normally, without sacrificial beakers or purging. Run the ammonia reference toxicant test concurrently with a bioassay if the Ref Tox trigger is exceeded for the test organism being used.
- **Prepare bioassays with purging.** If a purging trigger is exceeded for the species being used – and contaminant loss or alteration of bioavailability due to purging has been determined not to be a significant issue – prepare for purging. If the purging trigger for ammonia is exceeded, run the ammonia reference toxicant text concurrently.

9.3.2 Purging methods

For sediment toxicity testing, there are a variety of approaches used by regulatory agencies, project proponents and laboratories to purge samples. Purging is most often performed either by replacing overlying water twice a day plus continuous aeration, or by aeration alone. Once the unionized ammonia and/or hydrogen sulfide concentrations are below the trigger levels in **Table 9-2** for all test samples (labs should use the minimum purging required to bring concentrations below the trigger levels), the bioassay may be initiated. Each batch of test sediments must have associated and similarly purged control and reference sediments.

For further information on recommended purging methods and reporting of data see DMMP (2015b).

9.3.3 Case-by-case Determination to Allow Purging

The purging process may cause loss of more volatile/less hydrophobic COCs while less volatile compounds with a higher log K_{ow} remain associated with particles and dissolved organic matter. In addition, metals bioavailability and toxicity can be influenced by purging. Limited testing provided evidence that contaminant loss due to volatilization may not be an issue for the purging methods described above (DMMP, 2015b). The DMMP agencies will therefore continue to consider the specific contaminants triggering biological testing in decisions regarding purging. If contaminants may potentially be lost or their toxicity altered while purging for ammonia or sulfides, then purging may be disallowed or restricted in duration. Also, in some cases, ammonia or sulfides themselves may be contaminants of concern (e.g. new surface material containing wood waste) and purging may not be allowed. Purging is also not allowed for cleanup evaluations. For projects that include both cleanup and DMMP evaluation, side-by-side testing of both purged and non-purged sediments may be required.

9.3.4 Application of Purging Recommendations

The dredging proponent assumes the risk of dredged material being found unsuitable for open-water disposal if potential effects of ammonia and sulfides are not proactively addressed. Proactively addressing ammonia and sulfides requires advanced planning. Sufficient volumes of sediment must be collected for sacrificial beakers; the pretesting and purging procedures must be included in the sampling and analysis plan; and holding times must be considered. The dredging proponent will need to balance the cost of these procedures against the cost of upland disposal of dredged material that fails toxicity testing due to non-treatment effects from ammonia/sulfides.

Ammonia and sulfides are more likely to be present in deeper sediments or sediments containing a significant fraction of organic material such as wood waste. Therefore, the type of sediment being tested will need to be assessed to determine the likelihood for elevated ammonia and sulfides. Initial bulk ammonia and sulfides testing by the analytical lab will also provide valuable information in this regard.

Alternative procedures from those described in this user manual may be proposed on a project-specific basis. Justification for the selected procedures must be clearly articulated in the sampling and analysis plan.

Close coordination with the DMMP agencies must be maintained throughout the process, from development of the pre-bioassay testing procedures in the sampling and analysis plan, to decision-making about purging and details of the purging procedure itself. All procedures must be approved by the agencies before the procedures may be performed.

9.4 Marine Bioassay Interpretive Criteria

The response of bioassay organisms exposed to the sediment sample representing each DMMU will be compared to the response of these organisms in both control and reference treatments. This comparison will determine whether the material is suitable for unconfined, open-water disposal.

The determination of an environmentally significant response involves two conditions: first, that the response in the tested DMMU must be greater than 20 percent different from the control response; and, second, that a comparison between mean test and mean reference responses be statistically significant. For the latter determination, the following guidelines are to be followed:

1. Multiple comparison tests (e.g., ANOVA, Dunnett's) are not to be used.
2. A null hypothesis shall be selected that reflects the one-tailed t-test approach and the type of endpoint being evaluated.
3. Bioassay data expressed in percent should be transformed prior to statistical testing using the arcsine –square-root transform to stabilize the variances and improve the normality of the data. *Neanthes* growth data may require a square root or log transformation.
4. Bioassay data should then be tested for normality and homogeneity of variances, using the Shapiro-Wilk test (W test) and Levene's test, respectively.
5. Bioassay data passing both tests should be tested for statistical difference using a one-tailed Student's t-test.
6. Data passing the W test but failing Levene's test should be tested for statistical difference using the approximate t-test.
7. Data failing the W test but passing Levene's test should be tested for statistical difference using the non-parametric Mann-Whitney test.
8. Data failing both the W test and Levene's test should be converted to ranks and tested with a t-test.

Seattle District has developed statistical analysis software called BioStat to facilitate bioassay statistical comparisons with appropriate reference sediments. Submittal of screen shots or statistical reports from BioStat will provide the documentation necessary to support summarized interpretations of bioassay data in the sediment characterization report.

9.4.1 One-hit failure

When any one biological test exhibits a test sediment response that exceeds the bioassay-specific guidelines (below) relative to the negative control and reference, and which is statistically significant in comparison to the reference, the DMMU is judged to be unsuitable for unconfined open-water disposal (see Table 9-3).

10-day Amphipod Mortality. For the amphipod bioassay, mean test mortality greater than 20 percent absolute over the mean negative control response, and greater than 10 percent (dispersive) or 30 percent (non-dispersive) absolute over the mean reference sediment response, and statistically significant compared to reference (alpha = 0.05), is considered a "hit" under the “single-hit” guidelines.

20-day Juvenile Infaunal Growth. Juvenile infaunal growth test results that show a mean individual growth rate (AFDW) less than 80 percent of the mean negative control growth rate, and less than 70 percent (dispersive) or 50 percent (non-dispersive) of the mean reference sediment growth rate, and statistically significant compared to reference (alpha = 0.05), constitute a hit under the single-hit rule.

Sediment Larval Development. For the sediment larval bioassay, test and reference sediment responses are normalized to the negative seawater control response. This normalization is performed by dividing the number of normal larvae from the test or reference treatment at the end of the exposure period by the number of normal larvae in the seawater control at the end of the exposure period, and multiplying by 100 to convert to percent. The normalized combined mortality and abnormality (NCMA) is then 100 minus this number. If the mean NCMA for a test sediment is greater than 20 percent, and is 15 percent (dispersive) or 30 percent (non-dispersive) greater than the mean reference sediment NCMA, and statistically significant compared to reference (alpha = 0.10), it is considered a hit under the single-hit rule.

9.4.2 Two-hit failure

When any two biological tests (amphipod, juvenile infaunal growth or sediment larval) exhibit test sediment responses which are less than the bioassay-specific reference-comparison guidelines noted above for a single-hit failure, but are statistically significant compared to the reference sediment (and less than 70 percent of the mean reference sediment growth rate for the *Neanthes* bioassay for non-dispersive sites), the DMMU is judged to be unsuitable for unconfined open-water disposal.

Table 9-3. Marine Bioassay Performance Standards and Evaluation Guidelines

<table>
<tr><th rowspan="2">Bioassay</th><th rowspan="2">Negative Control Performance Standard</th><th rowspan="2">Reference Sediment Performance Standard</th><th colspan="2">Dispersive Disposal Site Interpretation Guidelines</th><th colspan="2">Non-dispersive Disposal Site Interpretation Guidelines</th></tr>
<tr><th>1-hit rule</th><th>2-hit rule</th><th>1-hit rule</th><th>2-hit rule</th></tr>
<tr><td rowspan="2">Amphipod Mortality</td><td rowspan="2">$M_C \leq 10\%$</td><td rowspan="2">$|M_R - M_C| \leq 20\%$</td><td colspan="4">$|M_T - M_C| > 20\%$
and
M_T vs. M_R SD (p=.05)
AND</td></tr>
<tr><td>$M_T - M_R > 10\%$</td><td>NOCN</td><td>$M_T - M_R > 30\%$</td><td>NOCN</td></tr>
<tr><td rowspan="2">Larval Development</td><td rowspan="2">$N_C \div I \geq 0.70$</td><td rowspan="2">$N_R \div N_C \geq 0.65$</td><td colspan="4">$N_T \div N_C < 0.80$
and
N_T/N_C vs. N_R/N_C SD (p=.10)
AND</td></tr>
<tr><td>$N_R/N_C - N_T/N_C > 0.15$</td><td>NOCN</td><td>$N_R/N_C - N_T/N_C > 0.30$</td><td>NOCN</td></tr>
<tr><td rowspan="2">Neanthes Growth</td><td rowspan="2">$M_C \leq 10\%$
and
$MIG_C \geq 0.38$</td><td rowspan="2">$M_R \leq 20\%$
and
$MIG_R \div MIG_C \geq 0.80$</td><td colspan="4">$MIG_T \div MIG_C < 0.80$
and
MIG_T vs. MIG_R SD (p=.05)
AND</td></tr>
<tr><td>$MIG_T/MIG_R < 0.70$</td><td>NOCN</td><td>$MIG_T/MIG_R < 0.50$</td><td>$MIG_T/MIG_R < 0.70$</td></tr>
</table>

M = mortality
N = normal larvae
I = initial count
MIG = mean individual growth rate (mg/individual/day)
SD = statistically significant difference
NOCN = no other conditions necessary

Subscripts:
R = reference sediment
C = negative control
T = test sediment

9.5 REFERENCE SEDIMENT COLLECTION SITES - MARINE

Bioassays must be run with a reference sediment with physical characteristics (grain size and organic carbon) that as closely as possible matches the test sediment. **Table 9-3** contains information about each of the Puget Sound sites that are recommended for use. **Table 9-4** contains information about reference sites for Grays Harbor and Willapa Bay. Other reference areas may be utilized with DMMP review and approval if:

- biological tests are initially run using the proposed reference area along with an already recognized reference area.
- chemical (DMMP contaminants of concern) analysis is performed for the proposed area.

Table 9-4. Reference Sediment Collection Areas for Puget Sound.

	CARR INLET	SAMISH BAY	HOLMES HARBOR	SEQUIM BAY
Fines (%)	5-85	11-96	3-96	19-85
TOC (%)	0.2-11.8	0.4-29.0	0.2-31.0	2.3-2.7
Reference	PTI, 1991; SAIC, 2001	PTI, 1991; SAIC, 2001	PTI, 1991; SAIC, 2001	DAIS

Table 9-5. Reference Sediment Collection Sites for Grays Harbor and Willapa Bay

PARAMETER	STATION					
	3.9 MILE ODMDS	**WBS5**	**WBS7**	**GHS4**	**GHS6**	**GHS7**
Location	SE of 3.9 Mile Site[1]	Grassy Point	Bay Center	Stearns Bluff	Elk River	North Bay
GPS Latitude (WGS84)	46° 51.00'	46° 38.04'	46° 37.90'	46° 55.73'	46° 52.52'	47° 00.35'
GPS Longitude (WGS84)	124° 13.73	124° 01.78'	123° 56.80'	123° 59.03'	124° 04.78'	124° 05.79'
Fines (%)	10	0	35-52	12	2	7-9
TOC (%)	0.10	0.02	0.51-1.0	0.25	0.06	0.15 - 1.1

Table adapted from *Grays Harbor and Willapa Bay Dredged Material Management Study: Expanded Reference Area Sediments* final report (SAIC, 1993)

[1] Station 4 from the 3.9-Mile ODMDS site.

The sampling protocol used for the collection of reference sediment can affect its performance during biological testing. The following guidelines should be followed when collecting reference sediments:

- Use experienced personnel
- Follow PSEP protocols
- Sample from biologically active zone
- Avoid anoxic sediment below the Redox Potential Discontinuity (RPD) horizon
- Use wet-sieving method in the field to target appropriate grain sizes
- Fix sulfides sample(s) with zinc acetate

Wet-sieving in the field is imperative for finding a good grain-size match with the test sediment. Wet-sieving is accomplished using a 63-micron (#230) sieve and a graduated cylinder; 100 ml of sediment is placed in the sieve and washed thoroughly until the water runs clear. The volume of sand and gravel remaining in the sieve is then washed into the graduated cylinder and measured. This represents the coarse fraction; the fines content is determined by subtracting this number from 100. Because of the wide heterogeneity of grain size in the reference areas, it may be necessary to perform wet-sieving in several places before a reference sediment with the proper grain size is found. It is important that the sediment sample analyzed by wet-sieving is representative of the sediment that will be used for bioassays. Homogenization of the sediment prior to wet-sieving is recommended.

It should be noted that wet-sieving results will not perfectly match the dry-weight-normalized grain size results from the laboratory analysis, but should be relatively close (generally within 10%). It is requested that wet-sieving results be submitted along with the laboratory data so that a regression line for each embayment can be developed which more accurately predicts the dry-weight fines fraction from the wet-sieving results found in the field. Reference station coordinates should also be reported, with an accuracy of ± 3 meters.

In addition to wet-sieving in the field, reference sediments must be analyzed in the laboratory for total solids, total volatile solids, total organic carbon, grain size, ammonia and sulfides. The methods and QA guidelines used for analysis of sediment conventionals in test sediments should also be used for reference sediments.

9.6 Bioassay Tests: Freshwater

Freshwater bioassay tests must meet the requirements of the state of Washington's Sediment Management Standards as updated in 2013. These methods are similar to those in the RSET's Sediment Evaluation Framework. To evaluate freshwater toxicity both acute and chronic assays are required, as follows.

1. Two different test species: *Hyalella azteca* and *Chironomus dilutus*
2. A total of three endpoints:
    a. One chronic test: 20-day *Chironomus* or 28-Day *Hyalella*
    b. One sublethal (growth) endpoint

Table 9-6. Freshwater biological tests, species and applicable endpoints.

Species, biological test, and endpoint	Acute effects biological test	Chronic effects biological test	Lethal effects biological test	Sub-lethal effects biological test
Amphipod: *Hyalella azteca*				
10-Day mortality	X		X	
28-Day mortality		X	X	
28-Day growth		X		X
Midge: *Chironomus dilutus*				
10-Day mortality	X		X	
10-Day growth	X			X
20-Day mortality		X	X	
20-Day growth		X		X

Bioassays conducted on freshwater sediments must follow the protocols specified below. These tests and parameters were developed based on the most updated American Society for Testing and Materials protocols.

Acute Effects Tests

- *Hyalella azteca* 10-day mortality: ASTM E1706-05 (2010)/EPA Method 100.1 (EPA, 2000)
- *Chironomus dilutus* 10-day mortality: ASTM E1706-05 (2010)/EPA Method 100.2 (EPA, 2000)
- *Chironomus dilutus* 10-day growth: ASTM E1706-05 (2010)/EPA Method 100.2 (EPA, 2000)

Chronic Effects Tests

- *Hyalella azteca* 28-day mortality: EPA Method 100.4 (EPA, 2000)
- *Hyalella azteca* 28-day growth: EPA Method 100.4 (EPA, 2000)
- *Chironomus dilutus* 20-day mortality: EPA Method 100.5 (EPA, 2000)
- *Chironomus dilutus* 20-day growth: EPA Method 100.5 (EPA, 2000)

9.7 Quality Assurance/Quality Control in Freshwater Bioassays

9.7.1 Quality Control for Negative Control and Use as Reference Sediment

Negative control sediments are used in bioassays to check laboratory performance. Negative control sediments are clean sediment in which the test organism normally lives and which are expected to produce low mortality.

All freshwater bioassays have negative control performance standards that must be met (see Table 9-6). In the 10-day and 28-day *Hyalella* bioassay tests, mortality of the test organisms during the entire exposure period must be less than or equal to 20 percent. For the *Chironomus* 10-day test, mortality over the exposure period must be less than or equal to 30%, and less than or equal to 32% for the 20-day test. This represents a generally accepted level of mortality of test organisms under control conditions, indicating that the bioassay (in terms of test organism health) is considered a valid measure of effects of the test treatments. If control mortality is greater than the performance criteria, the bioassay test will generally have to be repeated, although that determination must be made in consultation with the agencies through the DMMO. Additionally, there are negative control performance criteria for the *Hyalella* 28-day and *Chironomus* 10-day and 20-day growth bioassays (see Error! Reference source not found.). Laboratories failing to achieve the control growth rate performance criteria may be required to retest. Since the negative control is used for test comparisons with freshwater bioassays, it is also advised to compare the grain size distribution of the control sediments to the test sediments.

9.7.2 Replication

For freshwater bioassays, eight replicates are run for each test sediment, as well as for the control and/or reference sediment.

9.7.3 Positive Control

A positive control, or reference toxicant test, will be run for each bioassay. Positive controls are chemicals known to be toxic to the test organism. The positive control provides an indication of the sensitivity of the particular organisms used in a bioassay. Positive controls are performed on freshwater spiked with the reference toxicant and compared with historical laboratory reference toxicity test results.

9.7.4 Water Quality Monitoring

Water quality monitoring of the overlying water should be conducted for freshwater bioassays. Daily measurement of temperature and dissolved oxygen should be conducted for the amphipod and midge tests. Conductivity, hardness and alkalinity should be measured at test initiation and termination for the amphipod and midge tests. Monitoring of ammonia and total sulfides should be measured at test initiation and termination if either of these chemicals is suspected as being a problem (Ecology, 2008). Ammonia and sulfides values developed by Ecology as part of the Floating Percentile Model for freshwater sediment guidelines are used by the DMMP only to inform the need for bioassay purging. These values are:

- Ammonia: SL1/SQS=230; SL2/CSL = 300
- Total Sulfides: SL1/SQS= 39; SL2/CSL = 61

If ammonia and sulfides exceed these levels, the project proponent should coordinate purging and reference toxicity tests protocols with the DMMP (see 9.9).

9.8 Freshwater Bioassay Interpretive Criteria

Freshwater biological tests are based on a comparison to control sediments, so it is not necessary to collect a reference sediment. This is primarily due to a lack of established reference sediment sites in freshwater areas of Washington State. Dredging projects wishing to use a reference sediment must have the location approved by the DMMP agencies prior to collection of the reference sediment.

The response of bioassay organisms exposed to composited sediment representing each DMMU will be statistically compared to the response of these organisms in the control sediment. Table 9-6 specifies the bioassay performance criteria used for freshwater bioassays. These interpretive criteria were adopted at SMARM 2014 and revised at SMARM 2015 (DMMP, 2015c).

When any biological test exhibits a test sediment response that fails to meet the SL1/SCO criteria, the DMMU is judged to be unsuitable for unconfined open-water disposal in freshwater (see Table 9-6). The "one-hit/two-hit" interpretive criteria associated with marine sediments do not apply to freshwater sediments.

Freshwater disposal sites are primarily dispersive. If non-dispersive disposal sites become available, the DMMP may evaluate sediments that fail SL1 criteria but pass SL2 criteria for in-water placement in a managed disposal site on a case-by-case basis.

Table 9-7. Freshwater biological criteria (performance standards) for each biological test.

Biological Test/ Endpoint [a]	Performance Standard[b]		Screening Level 1 (SL1)	Screening Level 2 (SL2)
	Control[c]	Reference		
Hyalella azteca				
10-day mortality	$M_C \leq 20\%$	$M_R \leq 25\%$	$M_T - M_C > 15\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 25\%$ and M_T vs M_C SD ($p \leq 0.05$)
28-day mortality	$M_C \leq 20\%$	$M_R \leq 30\%$	$M_T - M_C > 10\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 25\%$ and M_T vs M_C SD ($p \leq 0.05$)
28-day growth	$MIG_C \geq 0.15$ mg/ind	$MIG_R \geq 0.15$ mg/ind	$(MIG_C - MIG_T)/MIG_C > 0.25$ and MIG_T vs MIG_C SD ($p \leq 0.05$)	$(MIG_C - MIG_T)/MIG_C > 0.40$ and MIG_T vs MIG_C SD ($p \leq 0.05$)
Chironomus dilutus				
10-day mortality	$M_C \leq 30\%$	$M_R \leq 30\%$	$M_T - M_C > 20\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 30\%$ and M_T vs M_C SD ($p \leq 0.05$)
10-day growth	$MIG_C \geq 0.48$ mg/ind	$MIG_R/MIG_C \geq 0.8$	$(MIG_C - MIG_T)/MIG_C > 0.20$ and MIG_T vs MIG_C SD ($p \leq 0.05$)	$(MIG_C - MIG_T)/MIG_C > 0.30$ and MIG_T vs MIG_C SD ($p \leq 0.05$)
20-day mortality	$M_C \leq 32\%$	$M_R \leq 35\%$	$M_T - M_C > 15\%$ and M_T vs M_C SD ($p \leq 0.05$)	$M_T - M_C > 25\%$ and M_T vs M_C SD ($p \leq 0.05$)
20-day growth	$MIG_C \geq 0.60$ mg/ind	$MIG_R/MIG_C \geq 0.8$	$(MIG_C - MIG_T)/MIG_C > 0.25$ and MIG_T vs MIG_C SD ($p \leq 0.05$)	$(MIG_C - MIG_T)/MIG_C > 0.40$ and MIG_T vs MIG_C SD ($p \leq 0.05$)

Notes:

M = Mortality; C = Control; R = Reference; T = Test; F = Final; MIG = Mean Individual Growth at time final; ind = individual; mg = milligrams; SD = statistically significant difference.

[a] These tests and parameters were developed based on the most updated American Society for Testing and Materials protocols.

[b] Reference performance standards are provided for sites where the department has approved a freshwater reference sediment site(s) and reference results will be substituted for control in comparing test sediments to criteria.

[c] The control performance standard for the 20 day test (0.60 mg/individual) is more stringent than for the 10 day test and the agencies may consider, on a case-by-case basis, a 20 day control has met QA/QC requirements if the mean individual growth is at least 0.48 mg/individual.

9.9 ELUTRIATE BIOASSAY TESTING

The Tier 3 evaluation of dredged material in some cases may include bioassay testing of dredging elutriates to estimate water quality impacts (RSET, 2018). Elutriate testing for biological effects is not routinely required for regulated or federal dredging projects evaluated under CWA Section 404 for DMMP disposal. This test is conducted only when the Washington Department of Ecology requires it for assessment of potential water column toxicity effects relative to a particular chemical of concern.

In the event that elutriate testing is required for marine sediments at the dredging site, the echinoderm/bivalve larval test will be conducted to evaluate water column effects. The appropriate assessment is described in the Sediment Evaluation Framework (SEF). More specificity on the serial dilution bioassay tests performed on the elutriate water can be found in the Inland Testing Manual (EPA/USACE, 1998, Sections 6.1 and 11.1). In the event that freshwater sediments at the dredging site require elutriate testing, and where salmonid species are present, elutriate testing should be conducted with rainbow trout (*Oncorhynchus mykiss*). The following species may be used for the larval water column bioassay test:

- Echinoderm: *Dendraster excentricus* (marine)
- Bivalve: *Mytilus galloprovincialis* (marine)
- Rainbow trout: *Oncorhynchus mykiss* (freshwater)

10 Tier 3 biological testing: Bioaccumulation

Bioaccumulation is the accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material. Tier 3 bioaccumulation testing of dredged material is required when results of sediment chemical analysis for bioaccumulative chemicals of concern (BCOCs) indicate the potential for unacceptable adverse ecological or human health effects.

The potential for adverse effects is screened for in DMMP through the use of bioaccumulation triggers (BTs) for BCOCs. Exceedance of one or more BTs results in a requirement to conduct bioaccumulation testing. **Currently, BTs only exist for projects in marine waters. The chemicals to be evaluated for bioaccumulation potential in freshwater vary based on location (RSET, 2018).**

When bioaccumulation testing is conducted, the tissue concentrations of BCOCs resulting from laboratory exposure of test organisms to dredged material are assessed for potential human- and ecological-health related effects. This assessment is done through the use of target tissue levels (TTLs) and a statistical comparison to tissue residues resulting from exposure to reference sediment. The purpose of the reference sediment in bioaccumulation testing is to represent relatively uncontaminated sediments that are unimpacted by previous discharges of dredged material (EPA/USACE, 1998). Important elements of the Tier 3 testing process and data interpretation are described in this chapter.

If results of the bioaccumulation testing in Tier 3 are found to be equivocal, or there is a concern that steady-state body burdens in test organisms were not achieved and/or cannot be estimated, further testing may be required in Tier 4 before a regulatory decision can be made on the suitability of the dredged material for unconfined open-water disposal.

10.1 Bioaccumulative Contaminants of Concern (BCOCs) and Triggers for Bioaccumulation Testing in marine waters

In 2003, the DMMP agencies conducted a systematic review of potential BCOCs for marine systems that considered multiple lines of evidence for determining the bioaccumulative risk posed by these chemicals (DMMP, 2003c). Additional work was accomplished in 2007 and 2009 (DMMP, 2007; 2009). Chemicals were placed on one of four lists, which are described below.

List 1: Primary Bioaccumulative Chemicals of Concern. Chemicals on this list meet the DMMP's weight-of-evidence criteria for defining a bioaccumulative contaminant to be of concern. List 1 includes 13 chemicals (or groups of chemicals) for marine waters. Analysis of 11 of the 13 chemicals on List 1 is required to determine dredged material suitability for all marine projects. Analysis of the other two chemicals – TBT and dioxins/furans – is required on a case-by-case basis for marine projects.

List 2: Candidate Bioaccumulative Chemicals. List 2 defines chemicals of potential concern for bioaccumulative effects but for which definitive data are still lacking; analysis of these chemicals is not routinely required. Analysis of List 2 chemicals will be decided on an as-needed basis depending on the specifics of the project.

List 3: Potentially Bioaccumulative Chemicals. List 3 chemicals have been identified in the scientific literature as potentially bioaccumulative but their toxicity to humans and/or ecological receptors is unknown or poorly documented. Analysis of these chemicals is not routinely required; List 3 chemicals will only be considered for analysis if there is a project-specific reason to believe that they may be present.

List 4: Not Currently Considered Bioaccumulative. List 4 includes chemicals that are not likely to bioaccumulate due to their chemical properties, or that regional data have shown to rarely (if ever) occur in sediments and tissues at levels of toxicological relevance. In 2009, six metals (cadmium, chromium, copper, nickel, silver, and zinc) that were originally placed on List 1 (DMMP, 2003c) were moved to List 4 because they do not have methylated or organic forms, making them unlikely to biomagnify (DMMP, 2009b).

List 1 chemicals for marine projects are presented in **Table 10-1**. List 2, 3, and 4 chemicals follow the table.

When measured sediment concentrations of the List 1 contaminants exceed the BT values presented in **Table 10-1**, bioaccumulation testing must be performed before suitability of the test sediment for open-water disposal can be determined. The BT is set at a sediment concentration that constitutes a “reason to believe" that the chemical would accumulate in the tissues of target organisms. As a general approach, BTs were established for human health COCs at concentrations in the upper 30th percentile of the concentrations allowable for unconfined, open-water disposal (i.e., 70 percent of the difference between the SL and ML) (PSDDA, 1988). The 2003 revisions to the BCOC list did not involve revisions to existing BT values, but interim BT values were developed for new List 1 chemicals using the same algorithm described above.

List 1 chemicals that do not follow this algorithm for bioaccumulation triggers include PCBs, TBT, selenium and dioxins/furans. The BT for PCBs is carbon-normalized and was established using a TTL and biota-sediment accumulation factor (PSDDA, 1989). The BT for TBT was established on a porewater basis (PSDDA/SMS, 1996), but is typically used now on a dry-weight basis (DMMP, 2015). For selenium the BT was developed in consideration of sediment concentrations reported in the literature to be associated with adverse ecological effects from bioaccumulation (DMMP, 2003c). The BT for dioxins/furans was adopted as an element of the updated dioxin guidelines in 2010 (DMMP, 2010).

Table 10-1. List 1 Bioaccumulative Chemicals of Concern for Projects in Marine Waters

CHEMICAL	METHOD INFORMATION	LOG K_{ow}[1]	BT (dry wt[2])	BT Basis
METALS				
Arsenic	SW846 M.6010/6020	N/A	507.1 mg/kg	0.7*(ML-SL)+SL (PSDDA, 1989)[10]
Lead	SW846 M. 6010/6020/7421	N/A	975 mg/kg	0.7*(ML-SL)+SL (DMMP, 2003c)
Mercury	SW846 M.7471	N/A	1.5 mg/kg	0.7*(ML-SL)+SL (PSDDA, 1988)[9]
Selenium	SW846 M. 6010/6020/7740	N/A	3 mg/kg[3]	Ecological effects (DMMP, 2003c)
ORGANOMETALLIC COMPOUNDS				
Tributyltin (interstitial water) (bulk sediment)	Krone/Unger	3.7-4.4	0.15 ug/L 73 ug/kg	Sediment value - interim SL based on BPJ (PSDDA, 1989; DMMP, 2015d); Porewater value - estimated from sediment value using K_{oc} and TOC (PSDDA/SMS, 1996).
ORGANICS				
Fluoranthene	SW846 M.8270	5.12	4,600 ug/kg	0.7*(ML-SL)+SL (PSDDA, 1988)[9]
Pyrene	SW846 M.8270	5.11	11,980 ug/kg	0.7*(ML-SL)+SL (PSDDA, 2003[c])
CHLORINATED HYDROCARBONS				
Hexachlorobenzene (HCB)	SW846 M.8081	5.89	168 ug/kg	0.7*(ML-SL)+SL (PSDDA, 1989)
PHENOLS				
Pentachlorophenol	SW846 M.8270	5.09	504 ug/kg	0.7*(ML-SL)+SL (PSDDA, 1989) [10]
PESTICIDES/PCBs				
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	SW846 M.8081	(5.7 - 6.0)[4]	50 ug/kg	0.7*(ML-SL)+SL (PSDDA, 1988)[9]
Chlordane[5]	SW846 M.8081	(5.5 – 6.4)[4]	37 ug/kg	7.3*SL (PSDDA, 1988)[8,9]
Dioxins/Furans	EPA 1613	5.5-13.9	10 ng/kg[6]	Dioxin special study (DMMP, 2010)
Total Aroclor PCBs	SW846 M.8081/2	(3.6-11)[7]	38 mg/kg OC	TTL and BSAF (PSDDA, 1989)

1 Octanol/Water Partitioning Coefficients (log K_{OW}) for organic chemicals of concern for bioaccumulation in Puget Sound.
2 Except where noted otherwise
3 Based on review of sediment effect values from the literature and best professional judgment.
4 Range of individual chemicals making up the total.
5 Chlordane includes cis-Chlordane, trans-Chlordane, cis-Nonachlor, trans-Nonachlor, and oxychlordane. Components of chlordane were clarified at the 2007 SMARM.
6 The BT for Puget Sound established with implementation of new dioxin guidelines in 2010.
7 Range of individual congeners making up the total.
8 This chemical did not have an ML value. Therefore the BT concentration was computed as ((10SL-SL)*0.7+SL=7.3*SL
9 The BT was calculated using older (1988) SL and ML values from the Phase I MPR (PSDDA, 1988). SL/MLs have since been updated, but BT was left unchanged pending more information.
10 The BT was calculated using older (1989) SL and ML values from the Phase II MPR (PSDDA, 1989). SL/MLs have since been updated, but BT was left unchanged pending more information.

List 2: Candidate Bioaccumulative Chemicals

1,2,4,5-Tetrachlorobenzene
4-Nonylphenol, branched
Benzo(e)pyrene
Biphenyl
Chromium VI
Chlorpyrifos
Dacthal
Diazinon
Endosulfan
Ethion
Heptachloronaphthalene
Hexachloronaphthalene
Kelthane
Mirex
Octachloronaphthalene
Oxadiazon
Parathion
Pentabromodiphenyl ether
Pentachloronaphthalene
Perylene
Tetrachloronaphthalene
Tetraethyltin
Trichloronaphthalene
Trifluralin

List 3: Potentially Bioaccumulative Chemicals

1,2,3,4-Tetrachlorobenzene
1,2,3,5-Tetrachlorobenzene
1,2,3-Trichlorobenzene
1,3,5-Trichlorobenzene
1-methylnaphthalene
1-methylphenanthrene
2,6-Dimethyl naphthalene
2-methylnaphthalene
4,4'-Dichlorobenzophenone
4-bromophenyl phenyl ether
Acenaphthene
Acenaphthylene
Aldrin
Alpha-BHC/Alpha-benzene hexachloride
Anthracene
Antimony
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(g,h,i)perylene
Bis(2-ethylhexyl) phthalate
Butyl benzyl phthalate
C1-chrysenes/benzo(a)anthracene
C1-dibenz(a,h)anthracene
C1-fluoranthene/pyrene
C1-fluorenes
C1-naphthalenes
C1-phenanthrene/anthracene
C2-chrysenes/benzo(a)anthracene
C2-dibenz(a,h)anthracene
C2-fluorenes
C2-naphthalenes
C2-phenanthrene/anthracene
C3-chrysenes/benzo(a)anthracene
C3-dibenz(a,h)anthracene
C3-fluorenes
C3-naphthalenes
C3-phenanthrene/anthracene
C4-chrysenes/benzo(a)anthracene
C4-naphthalenes
C4-phenanthrene/anthracene
Chrysene
Dibenzo(a,h)anthracene
Dibenzothiophene
Dieldrin
Di-n-butyl phthalate
Di-n-octyl phthalate
Endosulfan sulfate
Ethoxylated nonylphenol phosphate
Fluorene
Gamma-BHC/Gamma-hexachlorocyclohexane
Heptachlor epoxide
Hexachlorobutadiene
Indeno(1,2,3-c,d)pyrene
Methoxychlor
Nonylphenol
Pentachloroanisole
Phenanthrene
Polybrominated terphenyls
Polychlorinated alkenes
Polychlorinated terphenyls
Pronamide
Tetradifon
Toxaphene

List 4: Not Currently Considered Bioaccumulative Chemicals

1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Bromoxynil
Cadmium
Chromium
Copper
Dicamba
Dichlobenil
Dimethyl phthalate
Diuron
Endrin
Ethylbenzene
Fenitrothion
Guthion
Heptachlor
Hexachloroethane
Methyl parathion
Methyltin trichloride
Naphthalene
Nickel
N-nitroso diphenylamine
Phenol
Silver
Tetrachloroethene
Trichloroethene
Triphenyltin chloride
Zinc

10.2 Bioaccumulation Test Species Selection

Selection of appropriate species is an important consideration for bioaccumulation tests. Studies have shown that the time required for any given species to achieve a steady-state tissue concentration of a chemical of concern may vary (see **Table 10-3**) or is not well known (Windom and Kendall, 1979; Rubenstein, Lores, and Gregory, 1983). As such, for a given chemical triggering a Tier 3 bioaccumulation test, the applicant should consider selecting species that will assimilate the target chemical near its steady-state concentration (if known) within the exposure period or consider extending the exposure period. The Inland Testing Manual requires bioaccumulation testing with species from two different trophic niches, including: 1) a suspension-feeding/filter-feeding organism and 2) a burrowing deposit-feeding organism (USEPA/USACE, 1998). In the Pacific Northwest, the Tier 3 marine bioaccumulation test is usually conducted with both an adult bivalve (*Macoma nasuta*) and an adult polychaete (*Nephtys caecoides*). For recommended freshwater species, consult the RSET SEF (RSET, 2018).

10.3 Bioaccumulation Test Protocol

The standard Tier 3 bioaccumulation test utilizes the EPA protocol (Lee et al. 1989) and a 28-day exposure period, after which a chemical analysis is conducted of the tissues to determine the concentration of bioaccumulative chemicals of concern identified in the sediments. Protocols for tissue digestion and chemical analysis will follow the PSEP-recommended procedures for metals and organic chemicals. **Table 10-2** contains information on recommended tissue analytical methods and sample quantitation limits for bioaccumulation testing.

For many chemicals in **Table 10-1**, it was originally assumed that the standard 28-day exposure would be sufficient for a steady-state tissue concentration to be reached. However, after examining the observed steady state exposures depicted in **Table 10-3**, the DMMP agencies deemed it unlikely that steady state will have been reached after 28 days for some chemicals. The DMMP agencies addressed this issue for those BCOCs that had previously been subjected to bioaccumulation testing by increasing the exposure time from 28 to 45 days for PCBs, TBT, DDT, Hg and fluoranthene (DMMP, 2009c). Failure to reach steady state was also observed for 2,3,7,8-TCDD and 2,3,7,8-TCDF in *Nereis virens* (Pruell et al. 1990). Therefore, a 45-day exposure is also required for dioxins/furans. If bioaccumulation testing is conducted for any other BCOC, the DMMP agencies will evaluate the need to extend the exposure period beyond 28 days. For 45-day tests, supplemental additions of 175 ml of sediment will need to be made once a week to each test chamber, including all test, reference and control replicates.

Given the holding time limitations (8 weeks) and the large volume of sediment required, it is typically necessary to resample project sediments in order to conduct bioaccumulation testing. Under these circumstances, it is necessary to also reanalyze the newly collected sediment for the chemicals of concern that originally triggered the requirement for bioaccumulation testing. If the chemical concentration(s) found in the bioaccumulation test sediment is less than that measured in the original sediment analyzed, the DMMP may require that the measured tissue concentrations of that chemical be mathematically adjusted to reflect the bioaccumulation that may have resulted from exposure to the original sediment sample.

Table 10-2. Recommended Tissue Analytical Methods and Sample Quantitation Limits

CHEMICAL	PREP METHOD	ANALYSIS METHOD	SAMPLE QUANTITATION LIMITS (SQL)[1,2]
METALS (mg/kg)			
Arsenic	EPA 3035B/PSEP	EPA 6010/6020	0.05-0.2
Lead	EPA 3035B/PSEP	EPA 6010/6020/7421	0.05-0.2
Mercury	EPA 7471	EPA 7471	0.01-0.02
Selenium	EPA 3035B/PSEP	EPA 6010/6020/7740	0.05-0.2
ORGANOMETALLIC COMPOUNDS (μg/kg)			
Tributyltin (bulk sediment)	EPA 3550B or NMFS	Krone/Unger	10
POLYCYCLIC AROMATIC HYDROCARBONS (μg/kg)			
Fluoranthene	3540C, 3541, or 3550B	EPA 8270	1-5
Pyrene	3540C, 3541, or 3550B	EPA 8270	1-5
MISCELLANEOUS SEMIVOLATILES (μg/kg)			
Hexachlorobenzene (HCB)	3540C, 3541, or 3550B	EPA 8081	1
Pentachlorophenol	3540C, 3541, or 3550B	EPA 8270-SIM/8270	25
Pentachlorophenol	3540C, 3541, or 3550B	EPA 8151	5
PESTICIDES (μg/kg)			
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	3540C, 3541, or 3550B	EPA 8081	2
Chlordane[3]	3540C, 3541, or 3550B	EPA 8081	2
PCBs (ng/kg)			
PCB congeners	EPA 1668C	EPA 1668C	2-20
Dioxin-like PCB Congeners (sum TEQ)	EPA 1668C	EPA 1668C	1
DIOXINS/FURANS (ng/kg)			
Dioxin/Furan congeners	EPA 1613B	EPA 1613B	0.5-5
Dioxin/Furans (sum TEQ)	EPA 1613B	EPA 1613B	1

mg/kg = milligrams per kilogram; μg/kg = micrograms per kilogram; ng/kg = nanograms per kilogram

[1] All sample quantitation limits are expressed on a wet-weight basis

[2] SQLs are highly dependent on sample size; details should be confirmed with the laboratory

[3] Chlordane compounds include cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; in samples with interference from PCBs, the SQLs for cis- and trans-nonachlor and oxychlordane may be elevated

A considerable volume of sediment would be required to test species individually (Table 10-4). Therefore, to conserve laboratory space and reduce the volume of sediment required, applicants may expose *Macoma nasuta* and *Nephtys caecoides* together in the same test chambers (DMMP, 1996b). The total sediment requirement for co-testing is 30 liters.

The EPA protocol requires monitoring of survival, moisture and lipid content to assess the general health of the test organisms. In addition, for DMMP bioaccumulation testing, the wet-weight biomass (of a subset of 10 individual organisms per replicate) should be measured at the beginning and end of the bioaccumulation exposure period for each test, control and reference sample. This data can be used to calculate net individual growth during the exposure period, which provides an additional metric to evaluate the health of the test animals (DMMP, 2009c).

Table 10-3. Percent of Steady-State Tissue Residues of Selected Metals and Neutral Organics from 10 and 28-day Exposures to Bedded Sediment

COMPOUND	% OF STEADY STATE[1,2] TISSUE RESIDUE		SPECIES	EST. BY	REFERENCES[3]
	10-DAY	28-DAY			
METALS					
Copper	75	100	*Macoma nasuta*	G[5]	Lee (unpublished)
Lead	81	100	*Macoma nasuta*	G	Lee (unpublished)
Cadmium	17	50	*Callianassa australiensis*	G	Ahsanulla et al., 1984
Mercury	ND[4]	ND[4]	*Neanthes succinea*	G	Kendall, 1978
PCBs					
Aroclor 1242	18	87	*Nereis virens*	G	Langston, 1978
Aroclor 1254	12	82	*Macoma balthica*	G	Langston, 1978
Aroclor 1254	25	56	*Nereis virens*	K[6]	McLeese et al., 1980
Aroclor 1260	53	100	*Macoma balthica*	G	Langston, 1978
Total PCBs	21	54	*Nereis virens*	G	Pruell et al., 1986
Total PCBs	48	80	*Macoma nasuta*	G	Pruell et al., 1986
Total PCBs	23	71	*Macoma nasuta*	G	Boese (unpublished)
PAHs					
Benzo(a)pyrene	43	75	*Macoma inquinata*	G	Augenfield et al., 1982
Benzo(b,k)fluoranthene	71	100	*Macoma nasuta*	G	Lee (unpublished)
Chrysene	43	87	*Macoma inquinata*	G	Augenfield et al., 1982
Fluoranthene	100	100	*Macoma nasuta*	G	Lee (unpublished)
Phenanthrene	100	100	*Macoma inquinata*	G	Augenfield et al., 1981
Phenanthrene	100	100	*Macoma nasuta*	G	Lee (unpublished)
Pyrene	84	97	*Macoma nasuta*	G	Lee (unpublished)
TCDD/TCDF					
2,3,7,8-TCDD	6	22	*Nereis virens*	G	Pruell et al., 1990
2,3,7,8-TCDD	63	100	*Macoma nasuta*	G	Pruell et al., 1990
2,3,7,8-TCDF	43	62	*Nereis virens*	G	Pruell et al., 1990
2,3,7,8-TCDF	92	100	*Macoma nasuta*	G	Pruell et al., 1990
MISCELLANEOUS					
4,4-DDE	20	50	*Macoma nasuta*	G	Lee (unpublished)
2,4-DDD	31	56	*Macoma nasuta*	G	Lee (unpublished)
4,4-DDD	32	60	*Macoma nasuta*	G	Lee (unpublished)
4,4-DDT	17	10	*Macoma nasuta*	G	Lee (unpublished)

Table 10-4. Percent of Steady-State Tissue Residues of Selected Metals and Neutral Organics from 10 and 28-day Exposures to Bedded Sediment

Notes:

[1] This table is modified from ASTM E1688-00a, Standard Guide for Determination of the Bioaccumulation of Sediment-Associated Contaminants by Benthic Invertebrates

[2] Steady-state values are estimates, as steady-state is not rigorously documented in these studies.

[3] See Boese and Lee (1992) for complete citations.

[4] ND = Not Determined. Observed AFs (accumulation factors) for field tissue levels compared with sediment levels (normalized to dry weight) averaged 4 for this species, but ranged from 1.3 to 45 among other benthic macroinvertebrate species. Laboratory 28-day exposures to bedded sediment indicated uptake fit a linear regression model over the exposure period and experimental conditions and did not approach a steady-state condition. Tissue levels observed (*N. succinea)* at 28 days amounted to only 2.5 % of the total sediment-bound Hg potentially available.

[5] G = Steady-state residue estimated by visual inspection of graphs of tissue residue versus time.

[6] K = Steady-state residue estimated from a 1st-order kinetic uptake model.

Table 10-5. Species-specific sediment volume requirements for marine bioaccumulation testing

SPECIES	MINIMUM SEDIMENT REQUIREMENT
Macoma nasuta	250-400 ml per beaker x 10 beakers per replicate x 5 replicates = **12.5-20 liters**
Nereis virens	200 ml per worm x 20 worms per replicate x 5 replicates = **20 liters**
Arenicola marina OR *Abarenicola spp.*	500 ml per beaker x 4 beakers per replicate x 5 replicates = **10 liters**
Co-testing*: Macoma/Nephtys*	4 liters per replicate x 5 replicates = **30 liters**

10.4 Bioaccumulation Test Interpretation

NOTE: DMMP guidelines for the interpretation of bioaccumulation data are currently being revisited. The guidelines provided in this section are those that have been used historically in DMMP. For projects requiring bioaccumulation testing, the interpretive framework for evaluating the analytical results will be determined by the DMMP agencies prior to testing and on a case-by-case basis in coordination with the project proponent.

The interpretive approach used by DMMP includes an evaluation of both human health and ecological effects. These effects are evaluated through comparison of tissue concentrations resulting from exposure to dredged material to target tissue levels (TTLs) and to tissue concentrations resulting from exposure to a reference sediment. Decision-making is also informed by consideration of practical quantitation limits (PQLs), in-situ tissue data from disposal site environs and the effect of non-detects on statistical comparisons.

Ten of the 13 BCOCs on List 1 have a TTL against which the analytical results of tissue samples are compared. A TTL is defined as the tissue concentration of a BCOC, measured in the tissues of the bioaccumulation test organisms, above which potential harm to the target organism (via bioaccumulative effects) is inferred. The DMMP TTLs (Table 10-5) were derived from human-health risk assessments, Food and Drug Administration (FDA) action levels, or (in the case of TBT) ecological effects thresholds derived from the scientific literature.

For those BCOCs with a TTL, tissue residues from bioaccumulation testing are compared to the TTL. In addition, for all BCOCs except TBT, a comparison is also made to the tissue residues from a reference sediment exposure to assess potential ecological effects. For TBT, the ecological risk-based TTL is considered a sufficient benchmark for the assessment of potential ecological effects and a comparison to reference is not necessary.

Table 10-6. Target Tissue Levels for Chemicals of Concern

CHEMICAL	TTL (mg/kg ww)		Source	Reference
	For Protection of Human Health	For Protection of Ecological Effects		
Arsenic	10.1	---	Human Health	EPTA, 1988
Chlordane [1]	0.3*	---	FDA Action Level (fish)	FDA, 2000
Dioxins/Furans	---	---	---	---
Fluoranthene	8400	MBD	Human Health	EPTA, 1988
Hexachlorobenzene	180	---	Human Health	EPTA, 1988
Lead	MBD	MBD	---	---
Mercury	1.0*	MBD	FDA Action Level (fish, shellfish, crustaceans)	FDA, 2000
Pentachlorophenol	900	MBD	Human Health	EPTA, 1988
Pyrene	MBD	MBD	---	---
Selenium	MBD	MBD	---	---
Silver	200	---	Human Health	EPTA, 1988
TBT	---	0.6 [2]	Benthic Eco-Risk at Harbor Island/Elliott Bay	EPA, 1999
Total PCBs	0.75 [3]	---	Human Health Risk at Elliott Bay	DMMP, 1999
Total DDT [4]	5.0*	---	FDA Action Level (fish)	FDA, 2000

Legend:
ww = wet weight; dw = dry weight
*FDA Action Level
MBD = may be determined on a project-specific basis.
[1] Chlordane includes the chlordane isomers and metabolites cis-Chlordane, trans-Chlordane, cis-Nonachlor, trans-Nonachlor, and oxychlordane
[2] The target tissue level for TBT was derived from a CERCLA risk assessment and is based on site-specific considerations of ecological risk for benthos found in the Harbor Island/Elliott Bay area, but the DMMP concluded it is appropriate for use at other DMMP disposal sites.
[3] The target tissue level for PCBs is based on site-specific considerations of subsistence human exposure in Elliott Bay and may not be appropriate for all disposal sites.
[4] Total DDT is determined by summing the p,p'- isomers of DDT and its metabolites (DDD and DDE).

10.4.1 Human Health Effects

Most of the human-health based TTLs were developed during the PSDDA study for deep-water disposal sites, using consumption rates of bottom fish by recreational anglers, the home range of bottom fish and the size of the Elliott Bay disposal site (EPTA, 1988). For those chemicals with FDA action levels lower than the risk-based concentrations, the FDA action levels were adopted. The TTL for total PCBs was revised in 1999 based on an updated human-health risk assessment that considered subsistence seafood ingestion rates of Native American and Asian/Pacific Islander groups (DMMP, 1999). Table 10-5 shows the current TTLs used by the DMMP for suitability determinations. Interpretation of bioaccumulation test results is accomplished by a statistical comparison of the mean tissue concentration of contaminants in animals exposed to dredged material to the TTL. The statistic employed is the one-tailed one-sample t-test (alpha level of 0.05):

$$t = \frac{\bar{x} - TTL}{\sqrt{\frac{s^2}{n}}}$$

where "$\bar{x}$", "s^2", and "n" refer to the mean, variance, and number of replicates associated with a contaminant's tissue concentrations from bioaccumulation testing of the proposed dredged material. For undetected chemicals, a concentration equal to one-half the detection limit will be used in the statistical analysis.

Use of the one-sample t-test is necessary to allow experimental results for bioaccumulation testing to be compared to the TTLs, which are constants. A one-*tailed* t-test is appropriate since there is concern only if bioaccumulation from the dredged sediment is not significantly less than the TTL. The null hypothesis in this case is that the tissue concentration **is greater** than or equal to the TTL.

If the mean tissue concentration of one or more contaminants of concern is greater than or equal to the TTL, then no statistical testing is required. The conclusion is that the dredged material is not acceptable for open-water disposal. If the mean tissue concentration of a chemical of concern is less than the applicable TTL, a one-tailed one-sample t-test is conducted and the dredged material is considered acceptable for open-water disposal if the null hypothesis is rejected.

Dioxins/furans are BCOCs for human health, but a TTL has not yet been established. In the absence of a TTL, comparison to a reference sediment is required. Bioaccumulation testing for dioxins/furans is generally necessary to allow consideration of the disposal of material with dioxin levels higher than 10 pptr TEQ or where the volume-weighted average for project DMMUs is greater than 4 pptr TEQ (DMMP, 2010a). While the testing approach would be similar to that described for ecological effects in the next subsection, the evaluation of testing results is complicated by the fact that 17 congeners are involved and tissue concentrations may be at or below practical quantitation limits. A weight-of-evidence approach was used to evaluate tissue data from dioxin/furan bioaccumulation testing for the Port of Everett Marina (DMMP, 2017). The weight-of-evidence approach included consideration of practical quantitation limits, the effect of non-detects on statistical comparisons, the magnitude of bioaccumulation, and a comparison to tissue concentrations in comparable species in the vicinity of the Port Gardner disposal site.

10.4.2 Ecological Effects

Bioaccumulation testing results for all BCOCs – including those with human-health based TTLs – are also assessed for potential ecological effects.

TBT is the only BCOC with a TTL based on protection of ecological effects. If bioaccumulation testing is conducted for TBT, the test tissue results are compared to the TTL as described in the previous section. A comparison to reference is not needed for TBT.

For all other BCOCs, an evaluation of the ecological effects of bioaccumulation is accomplished by comparing the test tissue results to the reference tissue results for statistical significance. Statistically significant bioaccumulation resulting from exposure to dredged material may demonstrate the potential for food-web effects. For non-detects, a concentration equal to one-half the detection limit will be used in the statistical analysis (project proponents may also propose a non-substitution method for non-detects where appropriate). If the results of a statistical comparison show that the tissue concentration of the chemical(s) of concern in test sediments is statistically higher (one-tailed t-test, alpha level of 0.1) than the reference sediment, the dredged material will be evaluated further to determine the potential ecological significance of the measured tissue residues.

The factors summarized below will be reviewed as part of the suitability determination process when the difference between the tissue concentration of one or more BCOCs resulting from exposure to dredged material and the tissue concentration resulting from exposure to a reference sediment is statistically significant. In reviewing these factors, the best available regional guidance will be used to assess the relative importance of each factor to the regulatory decision.

1. How many contaminants demonstrate bioaccumulation from dredged material relative to reference sediments?
2. What is the magnitude of the bioaccumulation from dredged material compared to reference sediments?
3. What is the toxicological importance of the contaminants (e.g., do they biomagnify or have effects at low concentrations?). In assessing the toxicological importance, ecologically-based TTLs may be established on a project-specific basis by the regulatory agencies based on a review of the current residue-effects literature. A statistical comparison will be made to ecologically-based TTLs using the one-sample t-test described under human-health effects.

   One exception to the project-specific nature of ecologically-based TTLs is the TTL for TBT (Table 10-5), which was adopted from a CERCLA risk assessment (EPA, 1999) for Harbor Island/Elliott Bay that used a weight-of-evidence approach. The TBT TTL represents a residue that is associated with reduced growth in a number of invertebrate species including polychaetes and crustaceans and is, therefore, broadly applicable.
4. What is the magnitude by which contaminants found to bioaccumulate in laboratory test tissues exceed the tissue burdens of comparable species found at or in the vicinity of the disposal site?
5. Are detected concentrations above or below established PQLs?
6. Are the number of non-detects such that the statistical comparison between test and reference concentrations affected by artificially low variance?

10.5 Bioaccumulation Reporting Requirements

In addition to the reporting requirements listed in Reporting Requirements, the following are requirements for reporting bioaccumulation results:

1. Day 0 tissue concentrations
2. Tissue concentrations resulting from exposure to test, reference and control sediment
3. Statistical comparison of tissue results to TTLs (for those BCOCs with TTLs)

4. Statistical comparison of test tissue results to reference tissue results
5. Tissue concentrations of comparable species found in the vicinity of the disposal site
6. Evaluation of tissue concentrations relative to PQLs
7. Evaluation of the role of non-detects on statistical comparisons
8. Bioaccumulation laboratory report
9. Evaluation of indicators of test organism health, including biomass and mortality
10. Summary of water quality data
11. Discussion of any other factors that may have affected the bioaccumulation testing results

11 TIER 4 EVALUATIONS

If standard chemical and/or biological evaluations of dredged material are unable to determine suitability of dredged material, a Tier 4 assessment may be required. A Tier 4 assessment is considered a special, non-routine evaluation and will require discussions among the agencies and the dredging proponent to determine the specific testing or assessment requirements. Alternative analyses that may be conducted in this tier may include any or all of the following.

11.1 STEADY STATE BIOACCUMULATION TEST

In a Tier 4 evaluation, bioaccumulation testing may be necessary to determine, either by time-sequenced laboratory bioaccumulation testing (Lee *et al*., 1989) or by collection of field samples, the steady state concentrations of contaminants in organisms exposed to the dredged material as compared with organisms exposed to the reference material. Tier 4 evaluations of data collected would follow the interpretation guidance specified in Chapter 10.

11.1.1 Time-Sequenced Laboratory Testing

As an alternative to accepting the 45 day exposure as a reflection of steady state conditions, an applicant may elect to conduct a time-sequenced bioaccumulation test. If organisms are exposed to biologically available contaminants under constant conditions for a sufficient period of time, bioaccumulation will eventually reach a steady-state in which maximum bioaccumulation has occurred, and the net exchange of contaminant between the sediment and organism is zero. By testing tissue residues periodically over the course of exposure, this steady-state concentration can be determined more accurately than relying on a single exposure period.

The necessary species, apparatus and test conditions for laboratory testing are the same as those utilized for the Tier 3 bioaccumulation test. Tissue sub-samples taken from separate containers during the exposure period provide the basis for determining the rate of uptake and elimination of contaminants. From these rate data, the steady state concentrations of contaminants in the tissues can be calculated, even though the steady state may not have been reached during the actual exposure. For the purposes of conducting this test, steady state is defined as "the concentration of contaminant that would occur in tissue after constant exposure conditions have been achieved."

An initial time-zero sample is collected for each species for tissue analysis. Additional tissue samples are then collected from each of the five replicate reference and dredged-material exposure chambers at intervals of 2, 4, 7, 10, 18, and 28 days. Alternative time intervals may be proposed by the agencies. It is critical that sufficient tissue is available to allow the interval body burden analyses at the specified detection limits for the chemical(s) of concern.

Calculating steady-state concentrations following time-sequenced testing should follow data analysis procedures outlined in the USACE/EPA Inland Testing Manual (Appendix D, Paragraph D3.2.1, pages D-47 to D-51). Bioaccumulation data are very expensive to obtain, because of the extensive number of chemical analyses required, and the data should be carefully and correctly analyzed.

11.1.1.1 Field Assessment of Steady State Bioaccumulation

Measuring concentrations in field-collected organisms may be considered as an alternative to laboratory exposures. A field sampling program designed to compare dredging and reference tissue levels of the same species allows a direct comparison of steady state contaminant tissue levels. The assessment involves measurements of tissue concentrations from individuals of the same species collected within the boundaries of the dredging site and a suitable reference site. The difficulty in collecting sufficient numbers of individuals of the same relative size ranges and biomass of the same species to enable tissue analyses at the reference and dredging site can make this type of assessment problematic. A determination is made based on a statistical comparison of the magnitude of contaminant tissue levels in organisms collected within the boundaries of the reference site, compared with organisms living within the area to be dredged.

11.1.1.2 Human Health/Ecological Risk Assessments

When deemed appropriate by the agencies, a human health and/or ecological risk assessment may be required to evaluate a particular chemical of concern, such as dioxin, mercury, PCBs, etc. In the case of chemicals like dioxin, national guidance is in a rapid state of flux, and project-specific risks to human health or ecological health should be evaluated using the best available technical information and risk assessment models.

11.2 Other Case-Specific Studies

Biological effects tests in Tier 4 should only be used in situations that warrant special investigative procedures. To address unique concerns, special studies not formally approved for use may be recommended to evaluate a specific dredged material issue. The nature and details of these studies would have to be worked out on a case-by-case basis through discussions with the DMMP agencies.

Tests considered may include chronic/sublethal tests, field studies such as benthic infaunal studies, experimental studies such as *in situ* toxicity tests or toxicity identification evaluations (TIE procedure; see Ankley *et al*, 1992), and/or no effects levels for aquatic life. In such cases, test procedures have to be tailored for specific situations, and general guidance cannot be offered. Such studies, when conducted, require design and evaluation specific to the need arising, with the assistance of administrative and scientific expertise from the agencies and other sources as appropriate.

Prediction of the movement of contaminants from sediment into and through pelagic food webs is technically challenging and should only be dealt with in a Tier 4 evaluation, if deemed necessary. General approaches may be explored which bracket likely concentrations of specific contaminants at different trophic levels based on an empirical model derived from a variety of marine food webs (Young, 1988, Lachmuth *et.al*., 2010). Other methods may be recommended, such as bioenergetic-based toxicokinetic modeling, if deemed appropriate to address a particular concern.

12 ANTIDEGRADATION EVALUATIONS

As part of each sediment characterization that includes core sampling, the DMMP agencies require the collection and archiving of a sample (Z-sample) from each core, consisting of the first two feet of material extending beyond the proposed project overdepth (**5.9**). These samples represent the post-dredge sediment that would be exposed following dredging. The exposed sediment must meet the SMS antidegradation policy (WAC 173-204-120), which seeks to manage "sediment quality so as to protect existing beneficial uses and move towards attainment of designated beneficial uses" (Ecology, 2013).

Antidegradation evaluations are site-specific and often require best professional judgment on the part of the DMMP agencies. There have been a number of guidance documents written by the DMMP agencies to address testing of Z-samples and evaluation of the data for compliance with the antidegradation policy (PSDDA, 1988; DMMP 2001a, 2008a, 2010d). This chapter provides a summary of those documents.

12.1 WHEN TO ANALYZE Z-SAMPLES

Chemical analysis of Z-samples is required if:

1. the testing results for the overlying dredged material are found to be unsuitable for unconfined aquatic disposal, or
2. any other project in the vicinity has shown evidence of subsurface sediments with greater contamination than surface sediments, or
3. there is any other site-specific reason to believe that the sediment to be exposed by dredging may fail to meet the antidegradation policy.

In a small number of cases, where there is reason-to-believe that concentrations of chemicals of concern increase with depth, the DMMP agencies may require Z-samples to be analyzed concurrently with analysis of the dredged material; or the dredging proponent may opt for concurrent testing to save time. However, for the majority of projects, a decision about Z-sample analysis will be made after review of the chemistry/bioassay data associated with the dredged material.

12.2 DETERMINING ANALYSIS REQUIREMENTS

Z-sample analyses will initially consist of sediment conventional and chemical analyses. At a minimum, the conventionals to be analyzed include grain size, total organic carbon, total solids and total volatile solids. If there is a possibility that bioassays may need to be run, then ammonia and sulfides data will also be important. As for chemicals-of-concern, typically only those chemicals that were elevated in the overlying dredged material will need to be tested in the Z-samples. However, the overall data set will need to be taken into consideration in making this call. For example, if two adjacent DMMUs are found unsuitable for open-water disposal, one due to elevated PCBs and the other due to elevated TBT, then the DMMP agencies could require the Z-samples underlying both DMMUs to be tested for both PCBs and TBT.

Bioassays may become necessary if chemistry testing alone does not provide enough information for the antidegradation evaluation. For example, there have been cases in which DMMUs with no SL exceedances have failed biological testing. In such cases it might be necessary to run bioassays on the Z-samples to test for toxicity not predicted by the chemistry results. Due to holding time constraints (56 days for bioassays), the Z-samples may need to be recollected before bioassays can be run.

Bioaccumulation testing of Z-samples may also be necessary in some situations. However, it is anticipated that bulk sediment concentrations (or optional porewater results in the case of TBT) could be used in most cases to determine the bioaccumulation potential of the Z-samples relative to the overlying dredged material. If the calculated bioaccumulation potential exceeds acceptable limits, the dredging proponent always has the option to conduct bioaccumulation testing to determine the actual bioaccumulation potential.

12.3 Evaluating Compliance with the Antidegradation Policy

As indicated previously, antidegradation evaluations can be complicated and often require best professional judgment on the part of the DMMP agencies. DMMP (2008a) should be referenced for more detail, but the following guidelines are expected to cover the majority of antidegradation evaluations for marine projects:

- If the post-dredge sediment meets the SMS Sediment Quality Standards (SQS), it is generally also compliant with the antidegradation policy. Exceptions include chemicals without numeric SQS values, such as dioxin and tributyltin.
- Post-dredge sediment may not exceed the SMS Cleanup Screening Levels (CSL) or DMMP MLs unless they pass bioassays.
- If chemical concentrations are higher in the Z-samples than in the overlying dredged material and exceed SQS (or SL for COCs with no numeric SQS), then bioassays might be required to evaluate the material for toxicity. Toxicity would need to be below SQS in order to meet the antidegradation guidelines.
- If chemical concentrations are lower in the Z-samples than in the overlying dredged material, but still exceed SQS (or SL for COCs with no numeric SQS) and/or BT, the DMMP agencies will review the bioassay and/or bioaccumulation results from the overlying dredged material before requiring the Z-samples to be tested biologically.
- Dioxin concentrations will be evaluated using the following guidelines:
    - TEQs less than 4 pptr meet the antidegradation standard
    - TEQs greater than 10 pptr generally do not meet the antidegradation standard, but will be evaluated on a case-by-case basis

TEQs between 4 and 10 pptr will be compared to concentrations in the overlying dredged material.

Antidegradation guidelines for freshwater projects are similar to those for marine projects, with the SCO (SL1) replacing SQS. Dioxin will be addressed on a case-by-case basis.

If a project, either marine or freshwater, is within an EPA or MTCA cleanup site, further coordination on antidegradation will be required.

12.4 What Happens if the Sediment is not Compliant?

If the sediment to be exposed by dredging does not meet the antidegradation standard, there are two options available:

- Dredge deeper until acceptable material is reached
- Overdredge and place a clean sand cover over the area

12.5 Other Considerations

The complexity of dredging projects varies considerably. Following are additional considerations for Z-sample collection and analysis:

- Multiple Z-layers might need to be collected depending on anticipated conditions at the project site. For example, if there is a high probability of encountering elevated chemical concentrations in the newly exposed sediment, the dredging proponent might want to collect Z-samples from 0-2, 2-4 and 4-6 feet beyond the planned overdepth in order to reach uncontaminated native material. In other areas, samples may need to be collected from adjacent side slopes that may slough subsequent to dredging.
- Projects with planned upland disposal might not ordinarily be required to test the dredged material for DMMP disposal. However, an antidegradation evaluation will still be required by the Department of Ecology. This evaluation could involve sampling and testing of the sediment that will be exposed by dredging.
- In those cases where the sediment to be exposed by dredging is resampled to collect sediment for biological testing, the resampled sediment must undergo DMMP chemical testing to provide a synoptic dataset.
- Due to time or monetary constraints the dredging proponent may desire to forego biological testing of the Z-layer and proceed directly to overdredging and/or placement of a clean sand layer over the new sediment surface.

12.6 Post-Dredge Evaluations

In certain situations, the post-dredge sediment surface (top 10 cm) may be subject to sediment quality evaluation at the discretion of the DMMP agencies. This may be necessary if pre-project Z-samples could not be collected due to the presence of rip rap; where under-pier sloughing occurs and the under-pier sediment could not be evaluated prior to dredging; in cases of dredging violations where material that has not been approved for open-water disposal is dredged; or where dredging residuals are of concern. Post-dredge evaluations will be conducted on a case-by-case basis.

13 DREDGING AND DISPOSAL

13.1 DREDGED MATERIAL DISPOSAL

Disposal options for dredged material depend upon project location, type of dredging, and results of sediment evaluation. There are eight dredged material disposal sites around Puget Sound (three dispersive and five non-dispersive) and two dispersive estuarine sites each in Grays Harbor and Willapa Bay. The DMMP agencies collectively evaluate the suitability of dredged material for disposal at these sites. As owner of the state's aquatic lands, DNR manages the disposal sites and is responsible for environmental monitoring of all nondispersive disposal sites. **Only material found suitable for open-water disposal may be placed at one of these sites.**

Dredged material placed at *non-dispersive sites* remains on-site and is the subject of long-term monitoring. Non-dispersive sites are managed to allow minor adverse effects such as sub-lethal effects to some species after long-term exposure.

Dredged material placed at d*ispersive sites*--which are located in areas with strong tidal currents--disperses quickly. No adverse effects are allowed at dispersive sites, so dredged material must meet more stringent evaluation guidelines to be eligible for disposal at these sites.

In-water disposal of suitable dredged material is not limited to DMMP sites: other types of open-water placement include "flow-lane disposal" (used in parts of the Lower Columbia River and Willapa Bay), and "beneficial use" placement such as contaminated material capping, beach nourishment, or habitat creation. **Please note: though the DMMP evaluates sediment for suitability for open–water disposal at a DMMP site, we do NOT approve material for any given beneficial use. See Chapter 14 for more information.**

Material found to be unsuitable for open-water disposal must be placed at an Ecology-approved upland disposal site.

13.2 PREPARING TO DREDGE

Once all necessary permits are obtained, planning for dredging and disposal can proceed. Only bottom-dump barges are authorized at DMMP non-dispersive sites. On a limited basis flat top barges may be authorized **at dispersive sites only** with prior review and approval (DMMP, 2008a). Hydraulically dredged material may not be disposed at DMMP non-dispersive disposal sites. Dredgers must coordinate as follows:

- Applicant should apply for DNR Site Use Authorization (SUA) at least three weeks prior to the pre-dredge meeting to allow adequate SUA processing time (see DMMP, 2009).
- At least 14 days prior to the beginning of dredging and disposal work, notify the USACE Regulatory Branch, at (206)764-3495.
- Submit a Dredging and Disposal Quality Control Plan for distribution to agencies, including DMMP representatives, at least 7 days prior to scheduled pre-dredge conference.
- Attend a pre-dredge conference (see **13.3**) at least 7 days prior to the start of dredging.

Please note that some permits may have additional requirements or earlier plan submission requirements. Applicants should carefully read conditions of other permits to determine if earlier submittals are required.

13.3 Dredging and Disposal Quality Control Plan (QCP)

This document helps ensure that the dredging and disposal are in compliance with the DMMP suitability determination and permits, that the necessary coordination has been done, and that reporting procedures are in place. It is submitted at least 7 days prior to the pre-dredge conference and reviewed carefully at the conference. The QCP should provide the following information:

1. Project description; including project and vicinity maps, in-situ volume estimate, and bulking factor (see 13.5).
2. Figures showing the area to be dredged, dredging depths (including overdredge), side slopes and disposal site.
3. Dredging and disposal vessels and equipment.
4. Schedule of dredging and disposal activities, and the allowable work windows for the dredging and disposal sites
5. Dredging/disposal personnel, responsibilities, and contact information
6. Dredging method and procedures, including:
    - measures to control or minimize potential water quality impacts
    - separation of contaminated material from sediments suitable for open-water disposal
    - decontamination of dredging equipment, if required
    - plan for removal and disposal of floatable and non-floatable debris (see 13.4)
    - horizontal and vertical controls during dredging (see 13.5)
    - real-time dredged volume estimation method, such as barge measurement or daily bathymetry
    - debris control plans
7. Disposal method and procedures, including:
    - names, types (e.g. bottom dump) and capacities of barges and dump scows (see 13.5)
    - identification of tow boats (by name and call letters)
    - tug operator's name and telephone number
    - target disposal coordinates
    - navigation equipment and positioning protocol for disposal, including communication with the Coast Guard's Vessel Traffic Service for DMMP disposal sites in Puget Sound
    - procedure for initiation of dump sequence when on site
    - disposal data recording and reporting procedures
    - disposal site, whether it be in-water or upland
8. Water quality monitoring plan and contingencies for water quality exceedances

9. Coordination procedures with the regulatory agencies, including contact information and notification requirements
10. Tribal coordination for nighttime disposal
11. Spill control and response measures
12. Post-dredge hydrographic survey

The dredging and disposal quality control plan must be approved by the DMMP agencies prior to commencement of open-water disposal.

13.4 Pre-Dredge Conference

Most regulated projects that are evaluated under DMMP are required to have a pre-dredge conference with the regulatory agencies prior to the initiation of dredging. For projects in Puget Sound, a physical meeting is generally required, but for projects involving routine maintenance dredging over several cycles, a conference call may be substituted for a meeting on a case-by-case basis. For projects in Grays Harbor, Willapa Bay, coastal Washington or the Columbia River basin, conference call pre-dredge meetings are generally accepted in lieu of meetings due to logistical considerations. Beneficial use projects may also require a pre-dredge conference or call depending on the size, complexity and project-specific considerations. The need for, and type of, pre-dredge conference will be determined by the DMMP agencies for each project and dredging cycle using best professional judgment.

The meeting (or conference call) will be coordinated by the USACE Regulatory Branch. Attendees will include, at a minimum, the applicant, the dredging contractor, and representatives from USACE, DNR and Ecology. EPA and WDFW may also choose to attend. The meeting will be used to review the disposal locations, water quality certification, dredging QCP, DNR site use authorization and any other permit conditions. Completion of the pre-dredge conference will be documented as part of the Regulatory Branch permit file.

Modifications to the QCP that are made at the predisposal conference must be incorporated into a final control plan and submitted to the agencies for approval prior to dredging A predisposal dry run may be required by USACE. At the discretion of the USACE, the regulatory project manager may ride out to the disposal site during the predisposal dry run or any disposal run to verify positioning accuracy.

13.5 Debris Management

In general, debris is not allowed to be disposed at the DMMP open-water sites. This includes all floatable debris, large non-floatable debris such as logs, piling, rip rap and concrete, and all solid waste (e.g., tires, rebar, garbage). Occasionally, suitable dredged material may include smaller non-floatable woody debris such as sawdust, bark or wood chips, which are inseparable from the sediment and represent less than half of the dredged material by volume. In cases where a heterogeneous mix of smaller woody debris and sediment exists, which otherwise meets DMMP disposal guidelines, open-water disposal may occur as long as none of the woody debris measures more than 12 inches in its longest dimension. As described in the 2015 DMMP Clarification on Debris Screening Requirements effective June 16, 2016 (DMMP, 2015e), all projects must use a 12-inch x 12-inch screen to remove debris unless it can be demonstrated that debris is unlikely to be present or that the debris present is large woody debris that can be easily observed and removed by other means during dredging. It is the responsibility of the applicant to provide adequate information to the DMMP to support the determination for an exemption from screening. Examples of project characteristics and/or information that can be provided to demonstrate that debris is unlikely to be present in project sediments are given in the 2015 Clarification paper. The determination of whether or not a grid will be required for a given project will be documented in the DMMP Suitability Determination.

13.6 Dredged Material Volume Estimates for Open Water Disposal

Exceedances of permitted dredging volumes at the open-water disposal sites may result in monetary fines or work stoppages. In addition to the guidance provided in Chapter 3, the following guidelines should be followed to reduce the potential for permit violations:

- Additional shoaling may occur between the time of sampling and dredging. It is the project proponent's responsibility to identify the need for a volume adjustment as a result of any post-sampling shoaling. Volume adjustments should be made prior to issuance of the public notice. If significant shoaling occurs after the public notice has been issued, written requests for permit revisions must be made to the permitting agencies as early as possible and before dredging commences.
- An estimate of the bulking factor, and a justification for its selection, must be included in the QCP.
- A description of the barge measurement method for volume must be included in the QCP.
- A description of the procedures to ensure vertical and horizontal dredging control must be included in the QCP. Such procedures prevent over-dredging and may reduce the need for confirmatory surveys in areas where suitable and unsuitable dredged materials are in close proximity.
- Once dredging has begun, if the dredging proponent or contractor determines that significant dredging has occurred outside the permitted dredging prism, vertical and horizontal control must be re-established immediately and DNR, Ecology and USACE contacted as soon as possible.
- When the daily barge estimates, corrected for bulking, tally to fifty percent of the permitted in-situ volume, the dredging contractor must confer with USACE, Ecology, DNR and the dredging proponent. Based on the experience of the dredging contractor during the first half of the project, a correction in the bulking factor will be made if necessary. Dredging progress (based on condition surveys or spatial coverage) will then be compared to the corrected barge measurements (using the revised bulking factor) as a check on the adequacy of the permitted in-situ volume. A decision will be made by the DMMP as to whether permit revisions for an increased volume will be necessary. Details of this coordination procedure must be included in the QCP.
- As dredging proceeds, the contractor must closely monitor dredging progress and notify the agencies as soon as possible if an exceedance of the permitted volume appears likely. Revision of the permits may be made as necessary. Dredging must stop when the sum of the daily barge estimates, corrected for bulking using the revised bulking factor, reaches the permitted in-situ volume. DNR and USACE (and Ecology is a WQC has been issues) must be

notified at this time. If the dredging has not been completed, a determination will be made as to the cause of the impending volume exceedance and permit volumes revised as appropriate.

- Post-dredge surveys will be reviewed by the agencies, as necessary, to ensure that the dredging plan has been followed.

13.7 Post-Dredging Requirements

For all dredging projects, actual volumes of disposed material must be reported to the Regulatory PM and DMMO. This applies to both in-water and upland placement, as the DMMP tracks both types of disposal. As necessary, post-dredge surveys will also be reviewed by the agencies to ensure that the dredging plan was followed.

13.8 Dredging and Disposal Closures

13.8.1 WDFW Closures

The Washington Department of Fish and Wildlife (WDFW) establishes closure periods in various parts of Puget Sound to protect aquatic resources. In-water work, including dredging and disposal, cannot be conducted during closed periods. WDFW Habitat Managers should be contacted directly to determine the closure periods for dredging and disposal of specific projects.

WDFW requires additional closures at three of the Puget Sound disposal sites to protect resources (**Table 13-1**). Routine in-water work windows for ESA listed species generally apply for the disposal sites as depicted in **Table 13-2**. Dredging site closures are more variable and are established for each dredging action during endangered species act (ESA) consultation for each Section 10/404 permit to protect outmigrating salmonid juveniles and bull trout, and in Grays Harbor, there is additional consideration for green sturgeon and eulachon.

Table 13-1. Puget Sound DMMP Site Closure Periods (Non ESA)

Disposal Site	Disposal Site Closure Period	Reason
Port Townsend	September 1 to November 30	Fall shrimp closure
Port Angeles	September 1 to November 30	Fall shrimp closure
Bellingham Bay	November 1 to February 28	Crab/shrimp closure

13.8.2 Native American Fisheries

The following special site-use condition will be specified by USACE in all permits that include open-water disposal:

Disposal operations must not interfere with Indian treaty fishing at the disposal site, including gill nets and other fishing gear. The permittee must coordinate any nighttime disposal with the USACE Seattle District Regulatory Branch Project Manager. Approval must be received from the District Engineer prior to conducting nighttime disposal.

13.8.3 Endangered Species Act

Under the Endangered Species Act (ESA), all in-water projects are evaluated for impacts to listed species. USACE Seattle District undergoes formal consultation under Section 7 of the ESA to address the potential use effects of the DMMP disposal sites on federally listed species. The most recent consultation--conducted in 2015--provides programmatic coverage through 2046 in the absence of the listing of new species or designation of critical habitat that may be affected by use of the disposal sites, or program modifications that may result in effects not covered by the consultation. Current and past programmatic Biological Evaluations, Biological Opinions and concurrence letters are posted on the DMMP website.

Table 13-2. In-water Disposal Windows (including ESA and non-ESA requirements)

Site	Type	Disposal Window	Comments
Puget Sound			
Anderson/Ketron Island	Non-dispersive	Jul 16 - Feb 15	no forage fish at site
Bellingham Bay (Inactive)	Non-dispersive	Jul 16 - Oct 31	no forage fish at site; includes non-ESA closure for pandalid shrimp, Dungeness crab and spawning flatfish
Commencement Bay	Non-dispersive	Aug 16 - Feb 15	no forage fish at site
Elliott Bay	Non-dispersive	Jul 16 - Feb 15	no forage fish at site
Port Gardner	Non-dispersive	Jul 16 - Feb 15	no forage fish at site
Port Angeles	dispersive	Jul 16 - Aug 31 Dec 1 - Feb 15	no forage fish at site; includes non-ESA closure for pandalid shrimp
Port Townsend	dispersive		
Rosario Strait	dispersive	Jul 16 - Feb 15	no forage fish at site
Grays Harbor			
Point Chehalis	dispersive; estuarine	Jul 16 - Feb 15	Also open Apr 1-Jun 30 for USACE hopper dredging
South Jetty	dispersive; estuarine	Jul 16 - Feb 15	Also open Apr 1-May 31 for USACE hopper dredging
Half Moon Bay	beneficial use	Apr 1 - Jun 30	Used for USACE hopper dredging only
South Beach	beneficial use	Apr 1 - May 31	Used for USACE hopper dredging only
3.9-Mile SW	dispersive; Section 102 ocean site	none	site inactive
Willapa Bay			
Cape Shoalwater	dispersive; estuarine	Jul 16 - Feb 15	Assumes no forage fish at site
Goose Point	dispersive; estuarine	Jul 16 - Feb 15	Assumes no forage fish at site
Flow-lane Disposal	dispersive; estuarine	Jul 16 - Feb 15	Assumes no forage fish at site

Notes: 1) A July 16 – February 15 disposal window means that disposal may occur between July 16 at 12:01am until February 15 at 11:59pm; 2) Disposal windows include both the non-ESA closures shown in Table 13-1 and the approved work windows presented in *Approved Windows for Fish Protection* (USACE, 2017).

13.9 DISPOSAL SITE INFORMATION

Table 13-3 and **Table 13-4** contain descriptive information about the DMMP disposal sites. **Figure 13-1** is a schematic delineating the target area and disposal zone within a generic non-dispersive disposal site. In the non-dispersive sites the disposal barges should open within the target area to ensure dredged material is released within the disposal zone. The zone allows for some difficulties in maneuvering. For dispersive sites, the target area and the disposal zone are one and the same. **Figure 13-2** shows an overview of dredged material disposal sites in Western Washington. **Figure 13-3** through **Figure 13-11** show detailed drawings of each disposal site and are suitable drawings for public notices.

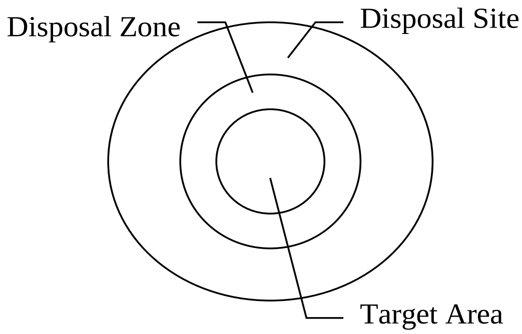

Figure 13-1. Disposal Zone vs. Target Area

13.10 Disposal Positioning

13.10.1 Coast Guard Notification and VTS Monitoring

The United States Coast Guard (USCG) must be notified by email at D13-PF-LNM@uscg.mil at least 14 days prior to commencing dredging operations, so the project information can be issued in the Local Notice to Mariners. Dredging operations north of a line between Bush Point on Whidbey Island and Nodule Point on Marrowstone Island must monitor VHF-FM Channels 13 and 5A. Dredging operations south of this line must monitor VHF-FM Channels 13 and 14.

For projects using the DMMP disposal sites in Puget Sound, the USCG Puget Sound Vessel Traffic Service (VTS) also known as “Seattle Traffic” must be contacted by radio prior to each disposal for positioning and verification of location within the disposal site target area. Disposal may not commence until verification is received from the USCG. Information required by the USCG must be provided for recording of the disposal.

Use of the Port Angeles dispersive site will require special coordination with VTS because the disposal site is located within the shipping lanes into Port Angeles Harbor. Applicants using this disposal site will be required to follow the Port Angeles VTS Coordination Operations Plan.

13.10.1.1 Dump-Site Position Recording Equipment

Projects using hopper dredges are required to use monitoring equipment from the National Dredging Quality Management (DQM) program, administered by USACE. This equipment utilizes differential global positioning to provide a record of disposal events.

For more information about DQM, see http://dqm.usace.army.mil

13.10.1.2 Flow-lane Disposal

This alternative is generally used for dispersive disposal within the Columbia River and has been used selectively in Willapa Bay since 2009. The DMMP agencies will generally require a simulation of flow-lane disposal based on the characteristics of the fine grained material proposed for dredging using the USACE DREDGE model to evaluate total suspended solids (TSS) relative to the plume as compared to background observed at a distance of approximately 1,000 ft. from the discharge point. The DMMP agencies review the characteristics of the material and the results of the DREDGE model analysis to determine whether flow-lane disposal would be authorized or not on a project-specific basis.

Table 13-3. Puget Sound Disposal Site Descriptions

Site	Area (acres)	Depth (ft)	Disposal Zone diameter (ft)	Target Area diameter (ft)	Disposal Site Dimensions (ft)	Disposal Coordinates (NAD83: Lat/Long)	Positioning VTS/ DGPS
Anderson/Ketron Island (non-dispersive)	318	360-480	1,800 (circle)	1,200 (circle)	4,400 x 3,600 (ellipsoid)	Lat: 47° 09.42’ Long: 122° 39.47’	VTS (AIS)*
Bellingham Bay (inactive) (non-dispersive)	260	96	1,800 (circle)	1,200 (circle)	3,800 x 3,800 (circular)	Lat: 48° 42.82’ Long: 122° 33.11’	VTS (AIS)
Commencement Bay (non-dispersive)	310	420-560	1,800 (circle)	1,200 (circle)	4,600 x 3,800 (ellipsoid)	Lat: 47° 18.145’ Long: 122° 27.815’	VTS
Elliott Bay (non-dispersive)	415	210-390	1,800 (circle)	1,200 (circle)	6,200 x 4,000 (Tear drop shape)	Lat: 47° 35.91’ Long: 122° 21.45’	VTS
Port Gardner (non-dispersive)	318	420	1,800 (circle)	1,200 (circle)	4,200 x 4,200 (circular)	Lat: 47° 58.85’ Long: 122° 16.74’	VTS
Port Angeles (dispersive)	884	435	3,000 (circle)	none	7,000 x 7,000 (circular)	Lat: 48° 11.67’ Long: 123° 24.94’	VTS
Port Townsend (dispersive)	884	361	3,000 (circle)	none	7,000 x 7,000 (circular)	Lat: 48° 13.61’ Long: 122° 59.03’	VTS
Rosario Strait (dispersive)	650	97-142	3,000 (circle)	none	6,000 x 6,000 (circular)	Lat: 48° 30.87’ Long: 122° 43.56’	VTS

VTS = USCG Vessel Traffic Service; **DGPS** = Differential Global Positioning System; **AIS** = Automatic Identification System

*Automatic Identification Systems (AIS) are designed to be capable of automatically providing information about a ship to other ships as well as to coastal authorities.

Table 13-4. Grays Harbor and Willapa Bay Disposal Site Descriptions

Area	Site (Dispersive)	Area (acres)	Depth (ft)	Disposal Zone	Disposal Site Dimensions (ft)	Site Coordinates (NAD83) (Latitude/Longitude)		Positioning VTS/DGPS
GRAYS HARBOR	Point Chehalis (Estuarine)	229.6	>50 ft	Within rectangle, partitioned into 3 cells (2,000 x 5,000 ft)	2,000 x 5,000 ft. (rectangle)	46°55’00.51”	124°08’06.94”	DGPS
						46°55’04.49”	124°07’50.66	
						46°55’10.46”	124° 07’26.23”	
						46°55’17.09”	124°06’59.10”	
						46°54’41.91”	124°07’57.26”	
						46°54’45.90”	124°07’40.98”	
						46°54’51.87”	124° 07’16.55”	
						46°54’58.50”	124°06’49.42”	
						(Corners of 3 cells within rectangle)		
	South Jetty (Estuarine)	55.1	>50 ft	Within rectangle (800 X 3,000 ft)	800 X 3,000 ft. (rectangle)	46°54’34.82”	124°09’30.67”	DGPS
						46°54’32.06”	124°08’47.65”	
						46°54’26.96”	124°09’31.74”	
						46°54’24.20”	124°08’48.72”	
						(4 corners of rectangle)		
	3.9-Mile SW Ocean Site (inactive)	58.4 (circle) 1056.6 (parallelogram)	>120 ft	1,800 ft diameter circle within parallelogram	6,000 x 8,000 ft. (parallelogram)	Site presently inactive		DGPS
						46°51’55.68	124°14’40.53	
						(center of circle)		
						46°51’56.19”	124°15’03.91”	
						46°52’57.51”	124°13’51.34”	
						46°52’08.67”	124° 13’02.50”	
						46°51’07.35”	124°14’15.06”	
						(4 corners of parallelogram)		
WILLAPA BAY	Cape Shoalwater (Estuarine)	178.9	5-19 ft	3,000 x 5,196 x 6,000 ft. triangle	3,000 x 5,196 x 6,000 ft. triangle	46°42’09.84	124°01’14.70”	USCG Entrance Light 13
						(coordinates for Entrance Light 13)		
	Goose Point (Estuarine)	58.4	30-48 ft	1,800 ft diameter circle	1,800 ft diameter circle	46°39’27.60”	123°59’46.04”	DGPS
	Flow-lane disposal	Contact DMMP for details						

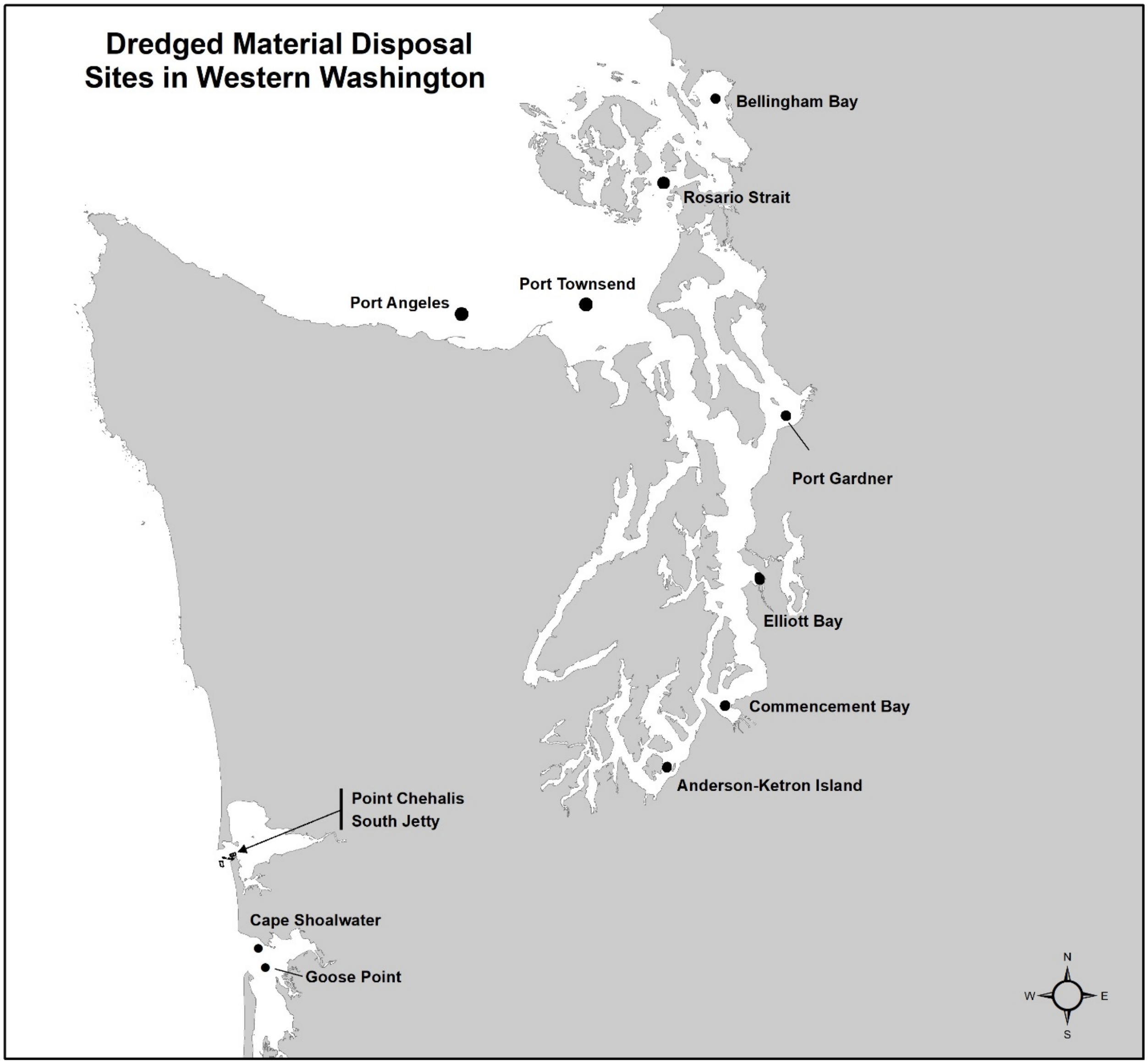

Figure 13-2. Dredged Material Disposal Sites in Western Washington

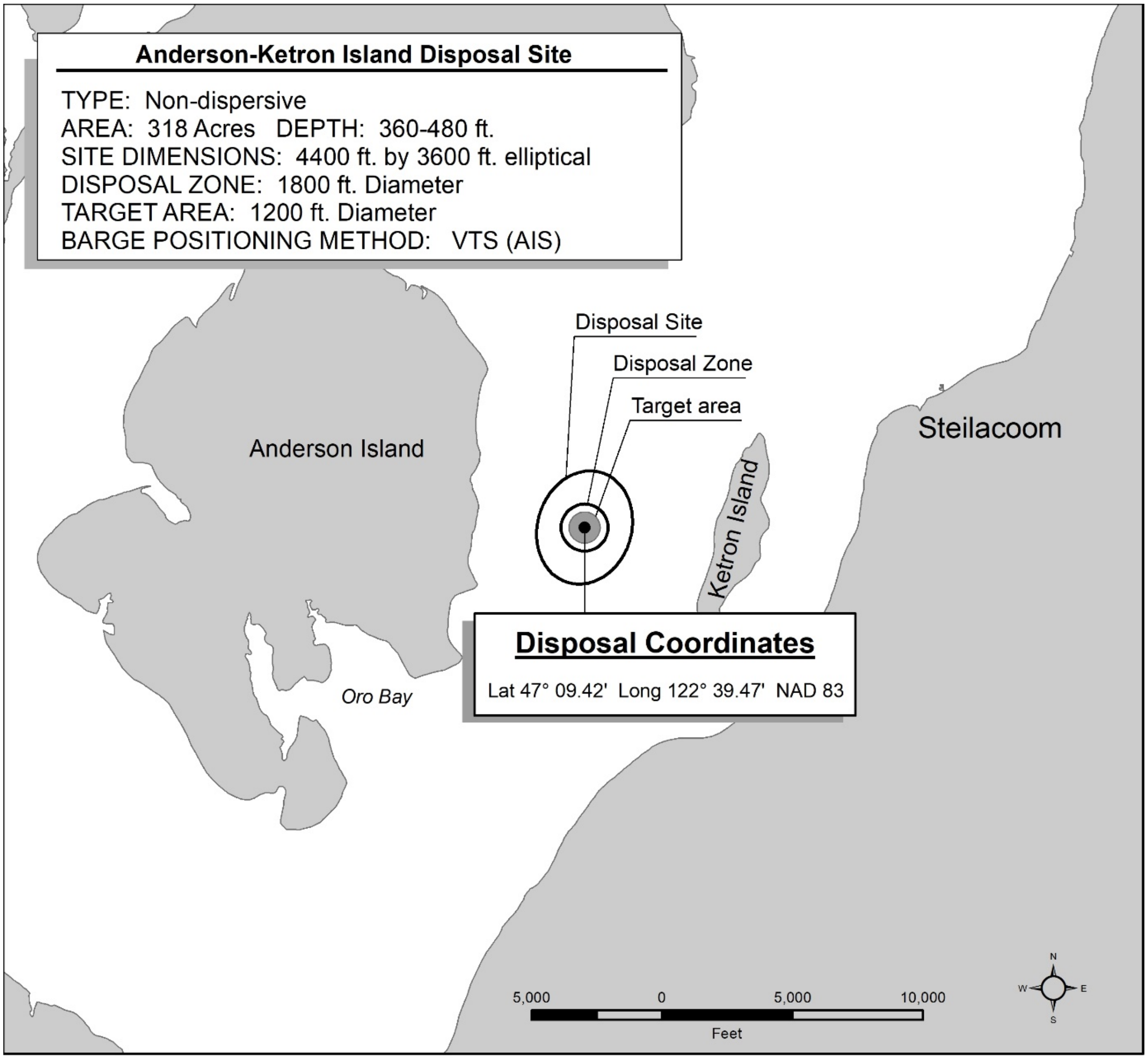

Figure 13-3. Anderson-Ketron Non-Dispersive Disposal Site

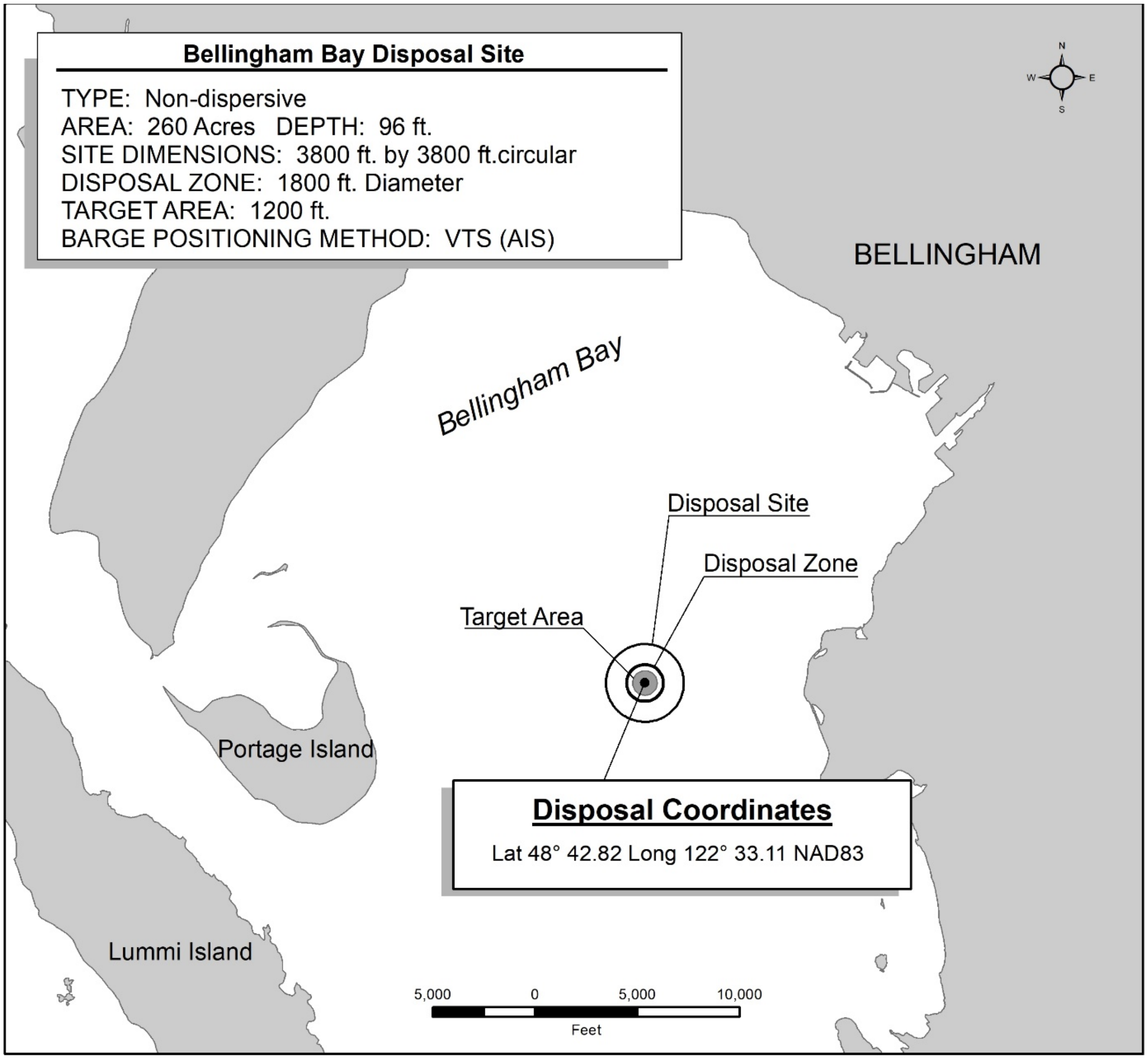

Figure 13-4. Bellingham Bay Non-Dispersive Disposal Site (Inactive)

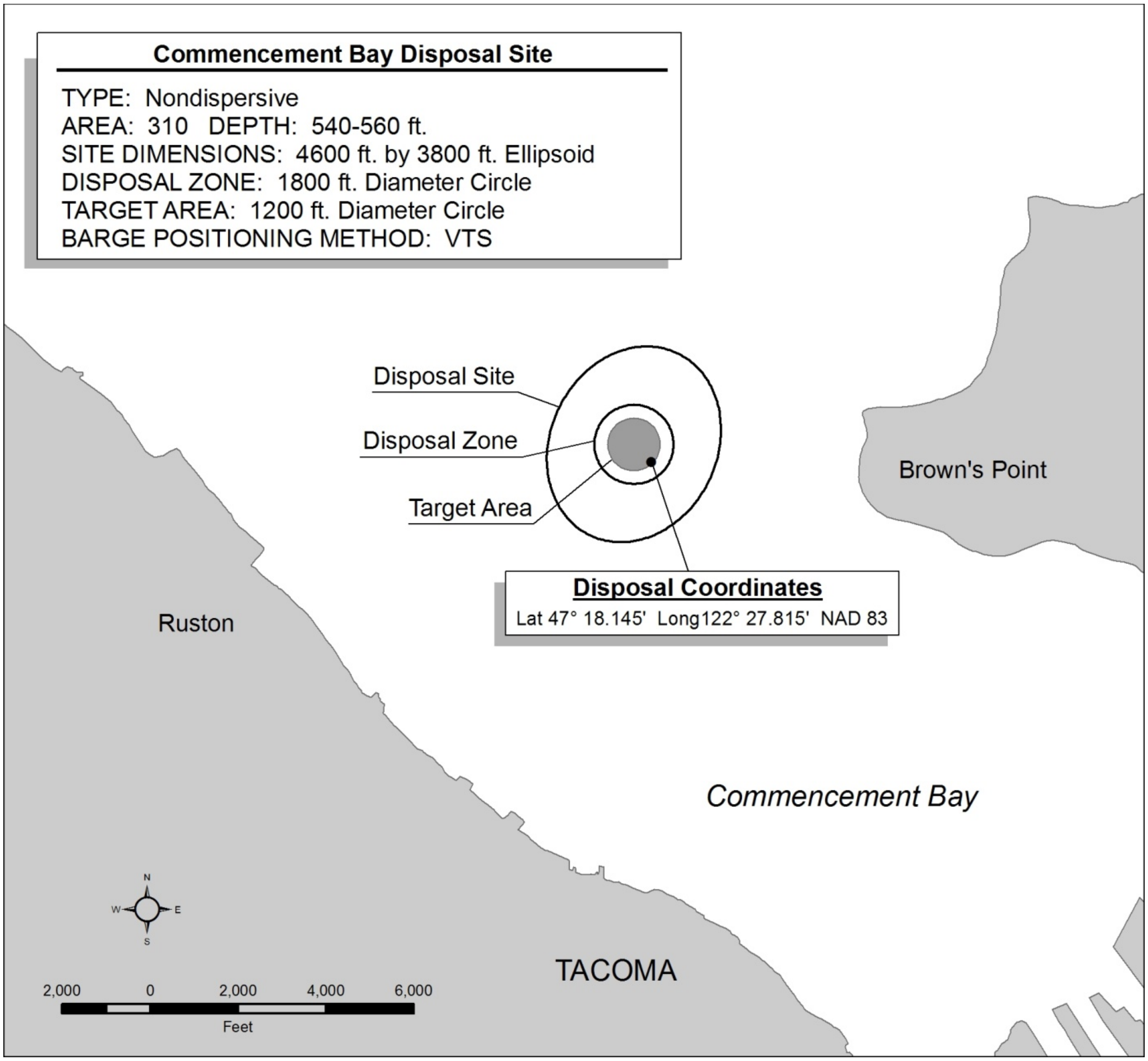

Figure 13-5. Commencement Bay Non-Dispersive Disposal Site

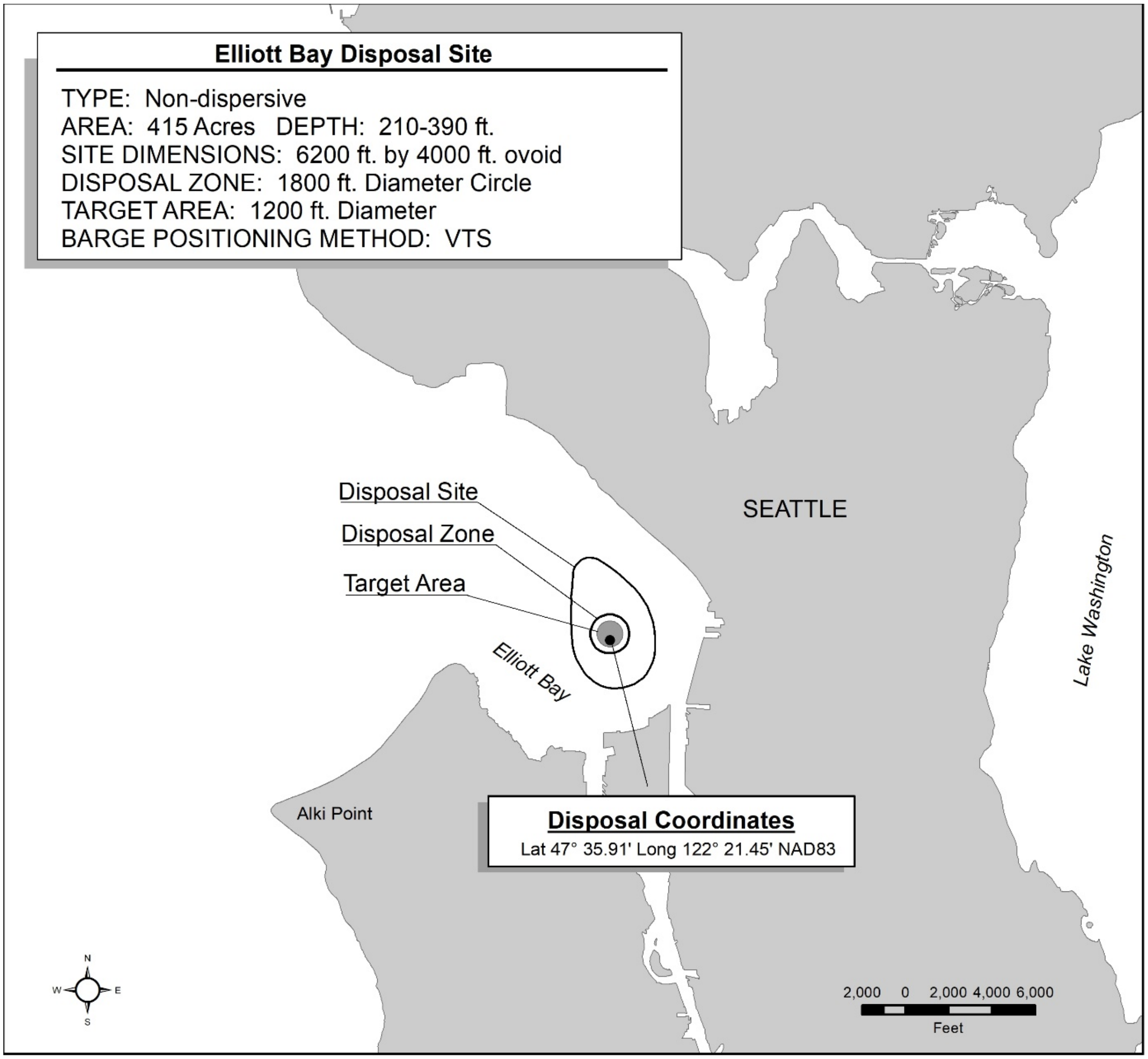

Figure 13-6. Elliott Bay Non-Dispersive Disposal Site

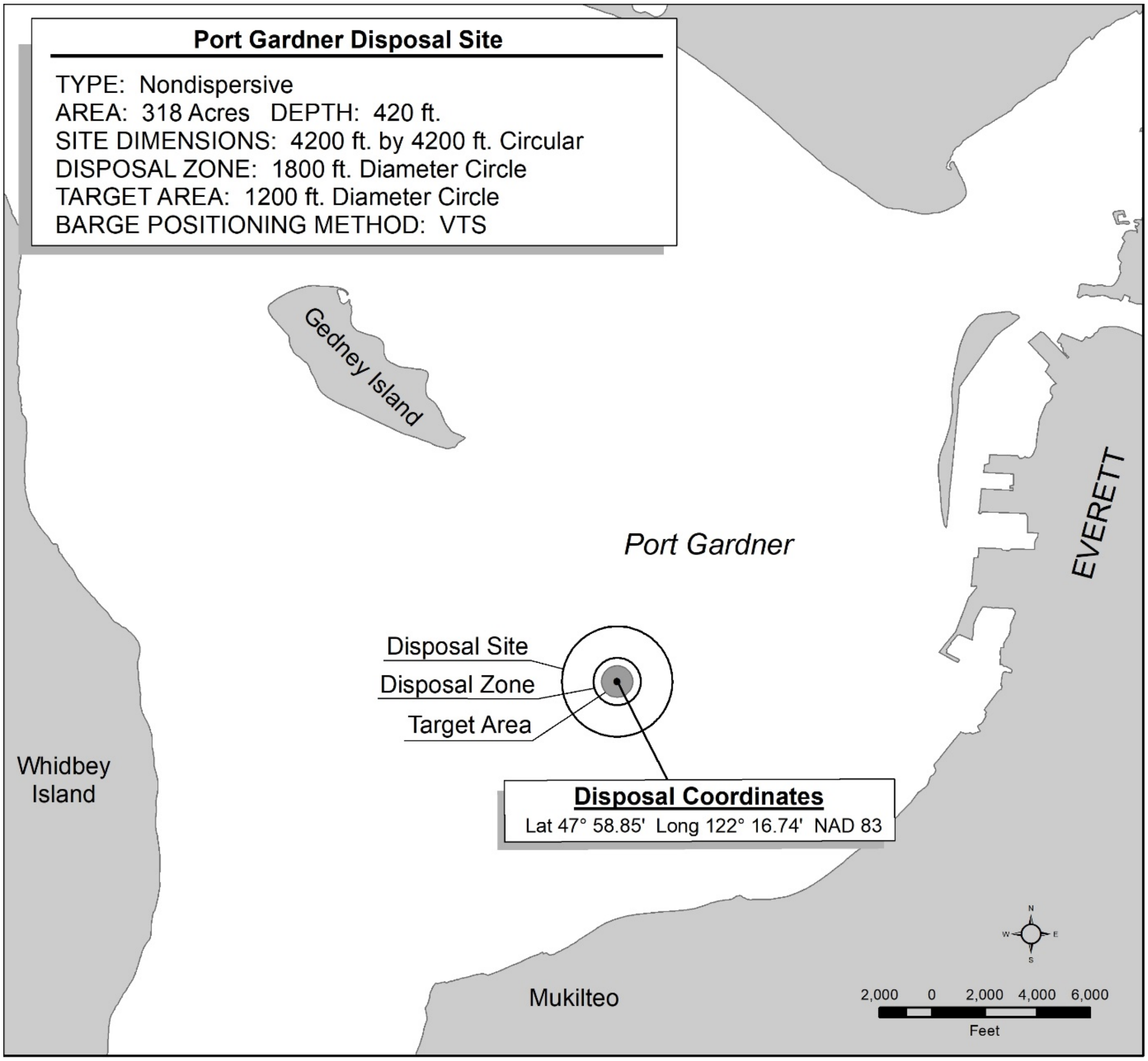

Figure 13-7. Port Gardner Non-Dispersive Disposal Site

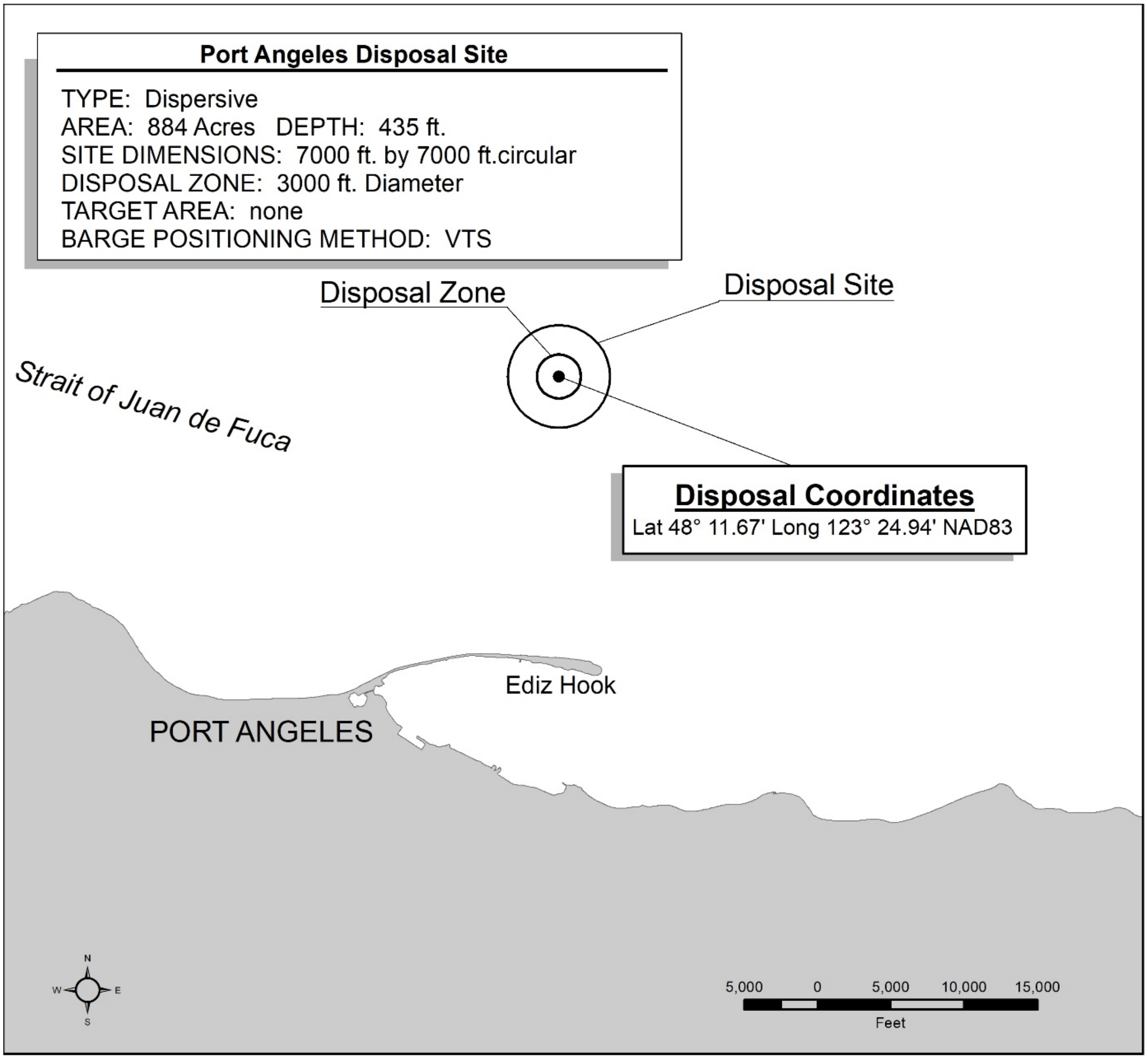

Figure 13-8. Port Angeles Dispersive Disposal Site

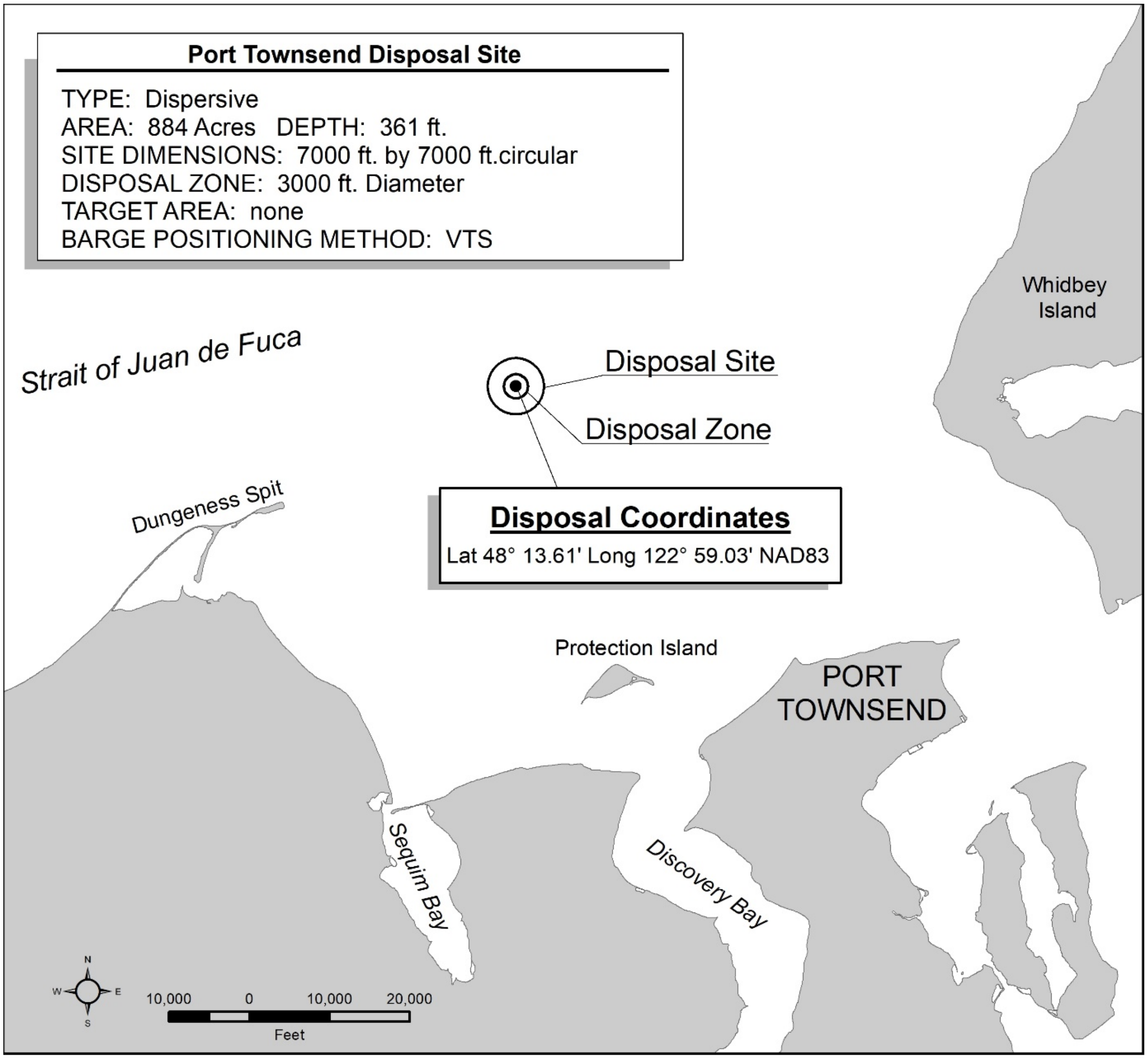

Figure 13-9. Port Townsend Dispersive Disposal Site

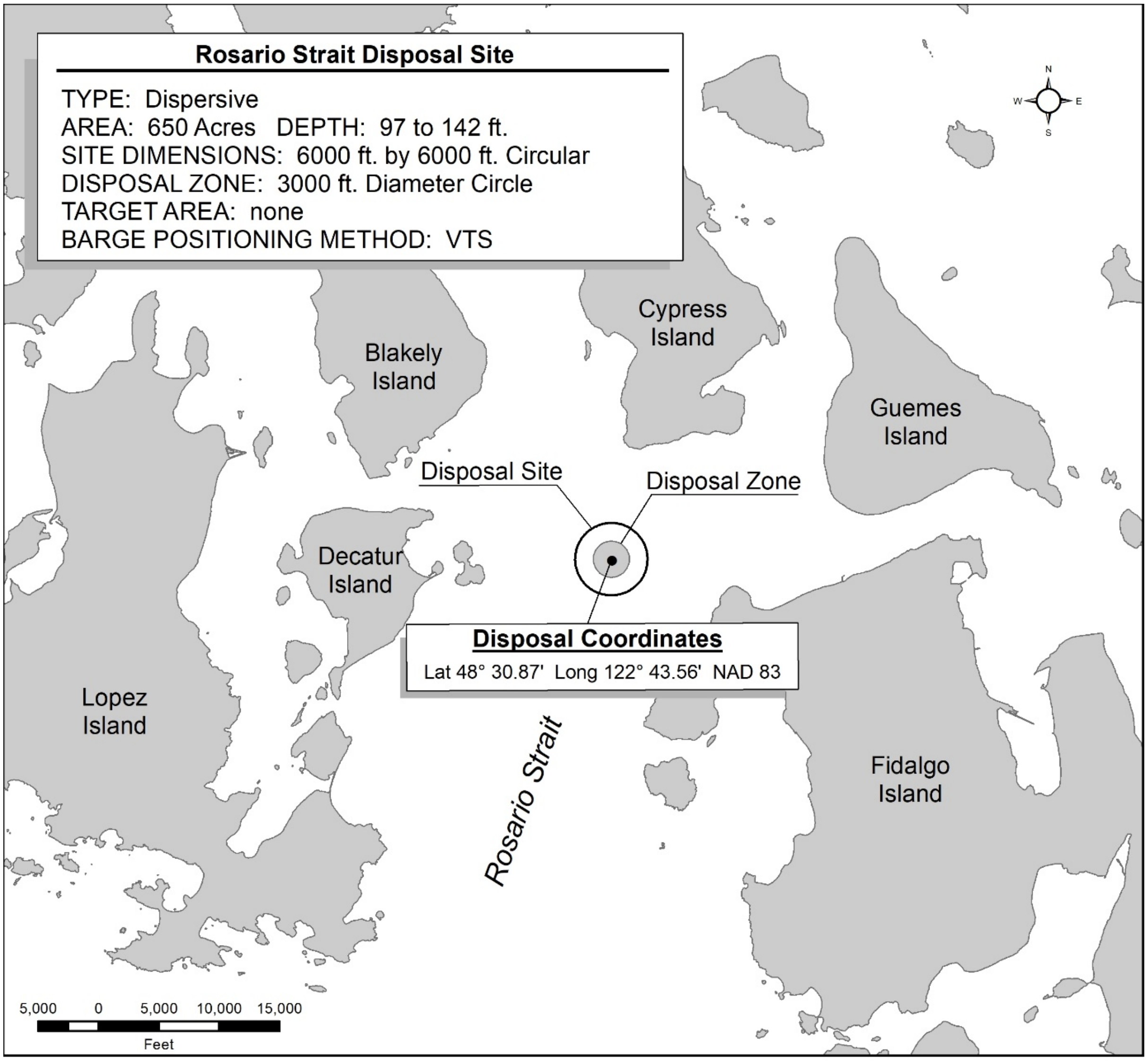

Figure 13-10. Rosario Strait Dispersive Disposal Site

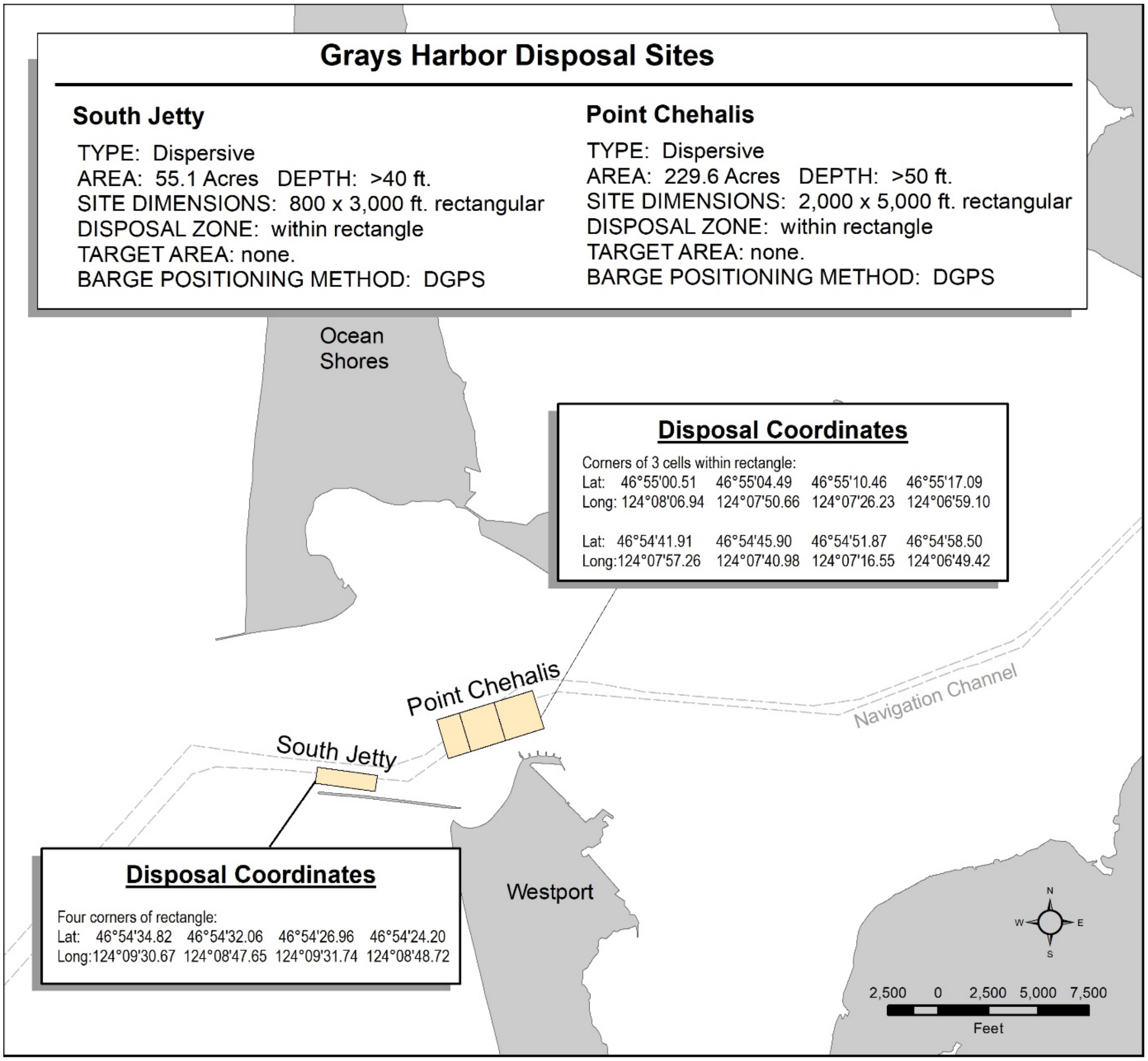

Figure 13-11. Grays Harbor Dispersive Disposal Sites

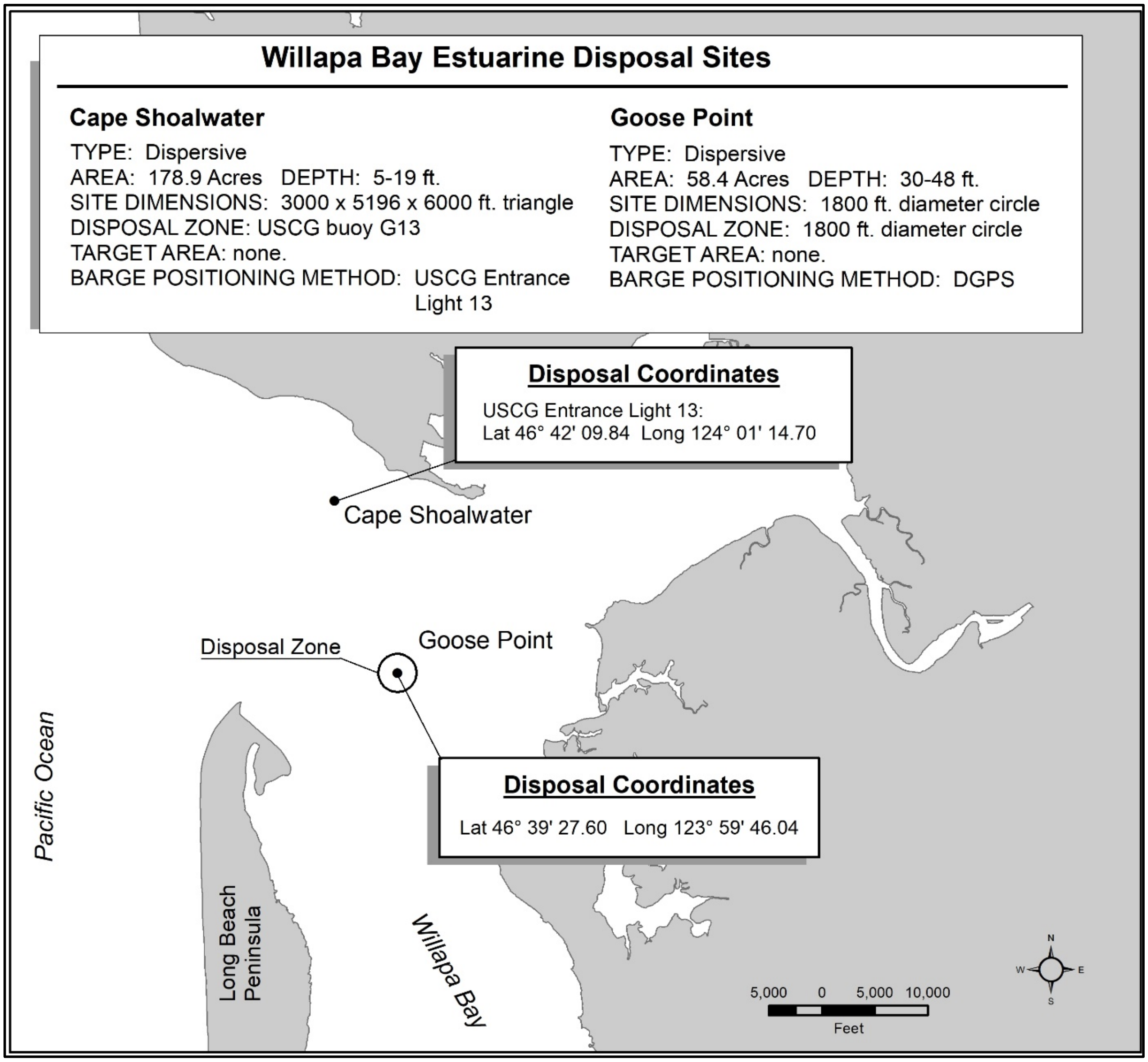

Figure 13-12. Willapa Bay Dispersive Disposal Sites

14 BENEFICIAL USE

14.1 BENEFICIAL USES GUIDELINES

"Beneficial use" is the placement or use of dredged material for some productive purpose. While the term "beneficial" indicates some "benefit" is gained by a particular use, the term has come to generally mean any "reuse" of dredged material. As part of overall sediment management in Washington, the regulatory agencies responsible for sediment management support the productive reuse of dredged material.

Applicants considering beneficial use projects are encouraged to coordinate with the DMMO and with other resource agencies early in the dredged material evaluation process. For more information on beneficial uses of dredged material, see EPA's Beneficial Use of Dredged Material page, and the USACE/EPA technical website Beneficial Uses of Dredged Material. If the sediment proposed for beneficial use is state-owned, contact DNR early to determine if additional considerations apply.

To ensure a beneficial use project's viability, evaluation of the proposed dredged material is required. **Please note: standard DMMP characterization may or may not be sufficient for the proposed beneficial use.** Other permitting agencies may require additional testing to insure the material is suitable for the proposed use. For example, NMFS or WDFW may require additional chemical or biological analyses as part of the project's ESA consultation.

14.2 SEDIMENT CHARACTERIZATION OF BENEFICIAL USE MATERIAL

Unconfined aquatic projects (such as beach nourishment, habitat restoration, and in-situ capping) are projects where dredged material may come directly into contact with the surrounding aquatic environment. For most projects, detected chemicals of concern must fall below SQS (Sediment Quality Standards) levels and any bioassays must pass SQS criteria. Material that has levels of chemicals greater than SQS but lower than CSL (Cleanup Screening Level) may be appropriate for beneficial use on a case-by-case basis after consideration of site-specific factors and coordination with landowners and/or resource agencies. For other projects, additional chemicals may need to be analyzed, or alternative screening levels may be requested by another agency. DMMP Suitability Determinations will document the sediment quality of each project relative to SMS SQS and CSL criteria, and provide a preliminary assessment of a project's suitability for in-water beneficial use based on this analysis. As always, best professional judgment may need to be applied in making case-by-case determinations. Dredged material proposed for beneficial use must be approved by the entity receiving the material. Additional coordination with resource agencies may be required.

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APPENDIX A: NOTABLE UPDATES TO THE 2018 EDITION OF THE DMMP USER MANUAL

THIS LIST WILL BE UPDATED IF / WHEN ADDITIONAL CHANGES ARE MADE PRIOR TO PRODUCTION OF THE NEXT EDITION, SCHEDULED FOR 2020.

Chapter 1 - Introduction

Chapter 1 was significantly expanded. Major additions include

- Added a Applicability and Limitations section that defines DMMP jurisdiction
- Added a section that describes the regulatory basis for sediment evaluations
- Defined the role of the DMMP and its member agencies, including any secondary roles that some agency members may share
- Documented the public process to change the User Manual
- Added a chapter-specific references section

Chapter 2 – Dredging Project Permitting

- Clarified the roles of USACE Regulatory and DMMP
- Added information about the different types of USACE Regulatory permit
- Defined the difference between of new vs maintenance dredging
- Added subsections for federal navigation maintenance dredging and beneficial use

Chapter 3 – Characterizing your Dredging Project

Chapter 3 was significantly expanded and now has a new title. Major additions include:

- Added a section that define the types of DMMP decision documents
- Reviewed possible placement & disposal options
- Reviewed the basic development of a conceptual dredging and volume of proposed dredged material (these sections were previously in Chapter 5)
- Described the issue resolution process for DMMP decision documents

Chapter 4 – Tier 1: Evaluation/Site History

- Clarified the components for a Tier 1 evaluation
- Added invasive species information

Chapter 5 – Developing Sampling and Analysis Requirements

- Updated project-specific rankings
- Added “very low” rank and guidelines

Chapter 7 – Sampling

- Added a new sub-section outlining vertical positioning control requirements

Chapter 9 – Tier 3 Biological Testing: Bioassays

- More introductory language

Chapter 10 – Tier 3 Biological Testing: Bioaccumulation

- Add the basis for the marine bioaccumulation triggers listed in Table 10-1

Chapter 11 – Tier 4 Evaluations

- Revised the Bioaccumulation Test Interpretation section for improved clarity
- Added a new section that details bioaccumulation reporting requirements

Chapter 13 - Dredging and Disposal

- Added a new general dredged material disposal introductory section
- Added the Willapa Bay sites to Table 13-2; updated the disposal windows for Grays Harbor sites
- Added site map and disposal site descriptions for Willapa Bay disposal sites

Chapter 14 – Beneficial Use

- Minor editorial revisions; added links to EPA's beneficial use website