Revised Monitoring Framework for Puget Sound DMMP Non-Dispersive Disposal Sites

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Introduction

The Puget Sound Dredged Disposal Analysis (PSDDA) was a comprehensive, multi-year, multi-million-dollar public process in the late 1980s that culminated in an interagency program to oversee dredged material management in Washington State. This Dredged Material Management Program (DMMP) brought together the following agencies with roles in management and regulation of dredged material to streamline project evaluation and disposal: the U.S. Army Corps of Engineers, Seattle District (USACE); the U.S. Environmental Protection Agency, Region 10 (EPA); the Washington Department of Ecology (Ecology); and the Washington State Department of Natural Resources (DNR).

The PSDDA study produced three major outcomes:

1. An identified network of eight multiuser open-water dredged material disposal sites in Puget Sound;
2. Evaluation guidelines for dredged material proposed for placement at the disposal sites; and
3. Management goals and an associated disposal site monitoring framework to ensure that the disposal sites continue to meet those goals.

The selected management goal for sediment quality at the disposal sites is called Site Condition II and is broadly defined as “minor adverse effects”. This means no significant acute toxicity and no bioaccumulation levels exceeding human heath tissue guideline values. The disposal site monitoring framework consisted of three basic questions and six hypotheses that have remained nearly unchanged for 30 years. The DMMP is re-visiting and revising the site monitoring framework to reflect lessons learned, incorporate new technologies and approaches, and comply with changes to federal and state regulations.

Purpose

This issue paper documents revisions to the disposal site monitoring framework. It is broken into three parts as follows:

- Part 1 - Origin and Basis for the Revised Disposal Site Monitoring Framework
- Part 2 - Disposal Site Monitoring Sampling Design
- Part 3 - Disposal Site Monitoring Data Interpretation

After the Sediment Management Annual Review Meeting (SMARM) and subsequent public comment period, these changes (and any modifications based on comments) will be incorporated into a new DMMP Disposal Site Monitoring Plan that will replace the Updated Environmental Monitoring Plan (DMMP, 2007).

Part 1: Origin and Basis for the Revised Disposal Site Monitoring Framework

Introduction

Part 1 of this issue paper documents the events, issues and concerns that prompted review of, and proposed revisions to, the original monitoring framework. This paper also briefly outlines the major structural and substantive changes proposed in the revised monitoring framework.

Background

The overall goals of the DMMP disposal site monitoring are to ensure that the targeted disposal site conditions are maintained and that the DMMP program adequately protects the aquatic environment. Disposal site monitoring surveys provide feedback to verify the adequacy of the DMMP dredged material evaluation procedures and management plans. The PSDDA study participants recognized that new technologies, science and information would emerge over time, and encouraged a publicly transparent feedback cycle via annual meetings to enable needed changes.

The original monitoring framework (Table 1-1) consisted of three questions; each question had two hypotheses meant to answer their respective question. The questions are listed below:

1. Does the deposited dredged material stay on site?
2. Are the biological effects conditions for site management [PSDDA-defined Site Condition II (SCII)] exceeded at the site due to dredged material disposal?
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?

For the past 30 years, the original PSDDA monitoring framework was applied to all disposal site monitoring events. Implementation has revealed that some of the monitoring methods were inefficient and/or did not provide optimal information for long-term site management. Examples include:

- In-situ tissue collection and analysis for evaluating off-site effects due to dredged material (Hypothesis 5) required multiple field days to gather sufficient mass yet yielded tissue samples primarily unaffiliated with dredged material.
- Taxonomic evaluation of infaunal community structure was part of the original framework. This evaluation was confounded by the natural variability of benthic community species composition and abundances over time (see Issue Paper Part 2).
- The Chemical Tracking System (CTS) and the temporal trend analysis associated with Hypothesis 2 was not providing useful data in large part due to low chemical concentrations (see Issue Paper Part 3).
- The PSDDA documents acknowledged potential effects of bioaccumulatives, but the original monitoring framework did not include adequate evaluation of on-site bioaccumulative risk (see bioaccumulation section of this paper for more details, and Issue Paper Part 3 for updated bioaccumulation evaluation approach).

Table 1-1. Original Monitoring Framework

Questions	Hypothesis	Monitoring Variable	Interpretive Guideline	Action Item when exceeded
No. 1 Does the deposited dredged material stay on site?	1. Dredged material remains within the site boundary?	SPI On site & Off site	Dredged material > 3cm at the perimeter stations.	Further assessment is required to determine full extent of dredged material deposit.
	2. Chemical concentrations do not measurably increase over time due to dredged material disposal at off-site stations.	Sediment Chemistry Off site	Washington State Sediment Quality Standards and Temporal Analysis.	Post-disposal benchmark station chemistry is analyzed and compared with appropriate baseline benchmark station data.
No. 2 Are the biological effects conditions for site management exceeded at the site due to dredged material disposal?	3. Sediment chemical concentrations at the on-site monitoring stations do not exceed the chemical concentrations associated with PSDDA SCII guidelines due to dredged material disposal.	Sediment Chemistry On site	On-site chemical concentrations are compared to DMMP maximum levels.	PSDDA agencies may seek adjustments of disposal guidelines and compare post-disposal benchmark chemistry with appropriate baseline benchmark station data.
	4. Sediment toxicity at the onsite stations does not exceed the PSDDA SCII biological response guidelines due to dredged material disposal.	Sediment Bioassays On site	DMMP Bioassay Guidelines (Section 401 Water Quality Certification).	Benchmark station bioassays are performed and compared with baseline benchmark bioassay data.
No. 3 Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?	5. No significant increase due to dredged material disposal has occurred in the chemical body burden of benthic infaunal species collected down currentof the disposal site.	Tissue Chemistry Transect	Guideline values Metals: 3x baseline conc. Organics: 5x baseline conc.	Compare post-disposal benchmark tissue chemistry with baseline benchmark tissue chemistry data.
	6. No significant decrease due to dredged material disposal has occurred in the abundanceof dominant benthic infaunal species collected down current of the disposal site.	Infaunal Community Structure Transect	Guideline values Abundance of major taxa < 1⁄2 baseline macrobenthic infaunal abundances.	Compare post-disposal benchmark benthic data with baseline benchmark data.

Washington State's Sediment Management Standards (SMS) rule was first adopted in 1991. At that time, the SMS rule did not explicitly address the effects of bioaccumulatives. In 2013, the SMS Part V Sediment Cleanup Standards were revised, in part, to address risks to both human health and higher trophic level species, particularly due to bioaccumulative chemicals. Starting in 2017, the DMMP embarked on a focused evaluation of DMMP disposal site monitoring and management, particularly with respect to bioaccumulatives, but also with respect to other issues and inefficiencies identified in the original framework over time[1]. The DMMP reviewed PSDDA framework documents, consulted state SMS experts, and held the following public workshops:

- November 1, 2017. Bioaccumulation issues and challenges.
- June 20, 2018. Brainstorming revisions to the disposal site monitoring framework.
- March 7, 2019. Presentation and discussion of proposed revisions to the monitoring framework.

Through these meetings and discussions, it became apparent that the original monitoring framework was no longer adequate to address current issues and concerns. Potential improvements were brainstormed, discussed, and shared. The next section summarizes the major issues identified in the original monitoring framework.

Issues with the Original PSDDA Framework

Multiple issues prompted the revision of the original PSDDA framework. The most significant ones identified by the DMMP were inadequate definition and assessment of bioaccumulation risk/effects, inconsistency with the Washington SMS 2013 revision (Ecology, 2013), and potential for Endangered Species Act (ESA) non-compliance, as summarized below.

Bioaccumulation Guidelines as Defined By PSDDA

The PSDDA study acknowledged that potential ecological effects could occur due to bioaccumulation. However, the decision was made to focus on human health bioaccumulative effects primarily because ecological effects were unknown at the time, and tissue concentrations associated with human health effects could be calculated. The selected disposal site management objective, SCII, is defined in multiple ways in the PSDDA Environmental Impact Statements and supporting documents. In its most general definition, the PSDDA documents define SCII as allowing "minor adverse effects on biological resources" on site but "no significant acute toxicity." The PSDDA Phase I Management Plan Report states that SCII:

> *"…allows, as an upper condition, adverse effects within the site boundaries which are predominantly sublethal and develop only from long-term exposure. In laboratory terms, dredged material creating this condition does not result in significant toxicity to sensitive test species exposed to the sediment to be dredged or significant bioaccumulation. It should be recognized that the bulk of dredged material placed at the disposal sites is expected to produce*

[1] For the 2017 SMARM, a review of the available sediment and tissue chemical bioaccumulation data from disposal site monitoring events found on-site sediment data for bioaccumulative chemicals but little or no tissue data. Tissue chemistry data were available only for off-site locations. The agencies concluded that the existing sediment and tissue chemistry data was sufficient to make conclusions about bioaccumulation risk due to dredged material.

no adverse biological effects due to chemicals. Consequently, actual effects at the disposal site are expected to be less than described for the selected site condition" (PSDDA, 1988)*."*

A 2017 SMARM presentation (DMMP, 2017) distilled the lengthy definitions of SCII "minor adverse effects" from across the PSDDA documents into the following four bullets:

- Some chronic sublethal effects allowed on site
- Potential increase in mortality of more sensitive, but less abundant, crustacean species
- No significant effects off site
- Some bioaccumulation expected on site, but not enough to pose a human health problem

While the definition for SCII is well-defined for benthic toxicity effects, the PSDDA documents were less clear as to what constitutes "minor adverse effects" resulting from bioaccumulation. Many questions were raised during SMARMs and at workshops around the meaning of SCII in the context of bioaccumulation, including: How would we assess chronic sublethal effects for bioaccumulation? What would constitute a significant bioaccumulative effect and how would we measure it?

In summary, SCII as defined by PSDDA does not provide a clear process for evaluating bioaccumulation risk on site, and this was reflected in the original monitoring framework. Because SCII does not provide a clear bioaccumulation evaluation process, the DMMP agencies are evaluating the role of SMS in interpreting and evaluating bioaccumulation risk at the disposal sites.

Role of SMS Parts IV and V

The original framework did not address state SMS requirements because PSDDA preceded the SMS. With the promulgation of the SMS in 1991 and subsequent revisions in 2013, several key state requirements were implemented that are not reflected in the original framework.

SMS Part IV (Sediment Source Control) includes requirements for dredged material and fill discharge activities [WAC 173-204-410(7)] and provides DMMP the ability to manage disposal sites with best available dredged material management guidance. In addition, Part IV defines the applicable upper limit for sediment conditions within the state of Washington:

> *WAC 173-204-410(1)(c): "The department shall implement the standards of WAC 173-204-400 through 420 so as to prevent the creation of new contaminated sediment cleanup sites identified under WAC 173-204-520."*

In plain terms, this means the DMMP must manage sediment at the non-dispersive open-water disposal sites to prevent creation of a cleanup site, as defined in Part V of the SMS.

Part V provides a framework to address bioaccumulative chemicals that incorporates risk, quantitation limits, and background for both the lower Sediment Cleanup Objective (SCO) and the higher Cleanup Screening Level (CSL) [WAC 173-204-560(3) and 173-204-560(4)]. Furthermore, Part V defines the statewide goal for sediment quality at the SCO:

> *WAC 173-204-110(1): "The sediment quality standards of WAC 173-204-300 through 173-204-315, and 173-204-350, and the sediment cleanup standards of WAC 173-204-500 through 173-204-575 shall apply to all surface sediments."*

To comply with the SMS, sediment conditions at the disposal sites must be adaptively managed to protect human health and the environment by:

- Meeting the SCO[2] over the long-term to meet the state-wide sediment quality goal, and
- Not creating a sediment cleanup site.

In response to the state SMS requirements and in consultation with state partners, the DMMP determined that the revised monitoring framework must be expanded to include SMS considerations.

ESA Compliance

The third and final significant issue identified as a driver for revising the monitoring framework is the requirement for ESA compliance. The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) (collectively called the "Services") participated in the early PSDDA work groups. As required by Section 7(c) of the Endangered Species Act of 1973, the DMMP periodically consults with the Services regarding the continued use of these sites. On behalf of the DMMP, the Seattle District USACE prepares Biological Evaluations and consults with the Services. As part of this process, the Services review the findings from the disposal site monitoring events and can make additional recommendations for data collection. The robustness and scientific defensibility of the monitoring framework is key to continued programmatic coverage from the Services.

Since the original PSDDA studies, evaluating ESA compliance has become more complex. Additional marine species have been listed, including rockfish, salmonids and southern resident killer whales. The last two consultation requests, in 2010 and 2015, resulted in biological opinions issued by NMFS that included conservation recommendations associated with bioaccumulative chemicals. In response to these recommendations, the DMMP agencies agreed to continue limited monitoring of polybrominated biphenyl ethers (PBDEs) at non-dispersive disposal sites (NMFS, 2015). The DMMP agencies also evaluated development of a screening level for polycyclic aromatic hydrocarbons (PAHs) for the protection of salmonids and benthic fish based on recommendations from NMFS (DMMP, 2021). With the revised monitoring framework, the DMMP is taking a deliberate and direct approach to addressing bioaccumulation concerns raised by the Services. This helps ensure continued operation of the DMMP disposal sites which, under federal law, remain subject to demonstrated compliance with the ESA.

New Framework

The proposed monitoring framework (Table 1-2) addresses the issues identified during the DMMP's review process. The three original defining questions have been retained largely in their original form, but the rest of the framework has undergone significant changes. The major structural and substantive changes are summarized below:

Routine Monitoring vs Follow-Up Actions & Management Options

The revised monitoring framework (Table 1-2) has been re-organized into two parts to distinguish between Routine Monitoring and Testing (Table 1-2, part 1) and Follow-up Actions and Management

[2] SCO is defined as the highest of risk, natural background, and PQL, where risk is the lowest of the risk-based levels for human health, benthic toxicity, and no adverse effects to higher trophic level species (WAC 173-204-560(3)).

Options (Table 1-2, part 2). This change is designed to simplify the routine monitoring approach while retaining the necessary follow-up actions should routine monitoring identify one or more issues.

The second part of the table includes a dedicated “Management Options” column that links directly back to the DMMP’s primary management goals for the disposal sites: keeping deposited material on site and preventing adverse biological effects in accordance with state and federal environmental regulations.

Previously, three levels of environmental monitoring were possible at the disposal sites: Full, Tiered-Full, and Partial (defined in the UEMP; SAIC, 2007). Full monitoring addressed all three questions in the original framework (Table 1-1) whereas Partial monitoring addressed only questions 1 and 2. In a Tiered-Full monitoring event, questions 1 and 2 were addressed, and samples were collected to answer question 3 but analysis of those samples was contingent upon the answers to the first two questions.

In the revised monitoring framework, all three questions are addressed during Routine Monitoring and Testing (Table 1-2, part 1). If routine monitoring reveals one or more issue(s), then additional actions are triggered in accordance with appropriate Follow-up Actions and Management Options (Table 1-2, part 2). A critical change is that the original monitoring framework included mandatory on-site bioassay toxicity testing; in the revised framework, on-site bioassay testing is only conducted if it is triggered by the chemistry results from routine monitoring. Additionally, Partial monitoring in the original framework implicitly included off-site benthic community monitoring using data from the SPI surveys, although this was not indicated in the original framework. The revised framework explicitly acknowledges the use of SPI (with the addition of plan view [PV]) off site for both identifying the recent dredged material footprint, and for benthic community assessment.

Hypotheses become Goals

The use of the term “Hypotheses” has been dropped in favor of “Goals” in the revised framework. The Metrics, Methods, and Goal Achievement Guidelines for each Goal are listed in the subsequent columns of Table 1-2, part 1. Should a Goal not be met for a particular Question, the follow-up action is found in Table 1-2, part 2.

Revisions to Goals & Metrics

The revised framework includes several significant changes to the original hypotheses (now “Goals”). The major changes are summarized below and explained in further detail in Issue Paper Parts 2 and 3.

Question 1 – Does the deposited dredged material stay on site?

> The revised framework uses SPI/PV to make this quantitative assessment and removes off-site chemical concentration temporal trend analysis (Hypothesis 2) which was of limited utility given that significant measurable temporal changes have not occurred or are difficult to measure due to the high prevalence of non-detect and low-concentration data.

Question 2 – Does deposited dredged material cause unacceptable adverse impacts to biological conditions on site?

> The revised framework goals and metrics for this question include consideration of both benthic and bioaccumulation risk. Because SCII is not well-defined for evaluating bioaccumulatives, the

Table 1-2. Revised Monitoring Framework

Part 1: Routine Monitoring and Testing				
Question	**Goal**	**Metric**	**Method**	**Goal Achievement Guideline[3]**
1. Does the deposited dredged material stay on site?	**A.** Dredged material stays within site boundaries	SPI/PV quantitative assessment	Conduct SPI/PV survey of site and surrounding area	< 10 cm at or beyond site boundary OR < 3 cm at or beyond site perimeter
2. Does deposited dredged material cause unacceptable[1,2] adverse impacts to biological conditions on site?	**B.** No long-term adverse effects to on-site benthic biological resources and habitat as defined by SCII	SPI/PV qualitative assessment	Review SPI/PV parameters including successional stage, apparent redox potential discontinuity, and others	Benthic community shows expected levels of recovery based on historical data
		Sediment chemistry	Collect 5 individual 0-10 cm samples from stratified random grid within the Disposal Site DU; analyze for benthic DMMP COC list	All COCs ≤ DMMP SL
		Sediment bioassays (Tiered)	Run on all samples with any COC > SL	No bioassay toxicity test exhibits a 1-hit (major) response or two 2-hit (minor) responses
	C. No long-term adverse bioaccumulative risk to on-site resources as defined by SCII and SMS	Tier 1 analysis	Review existing on-site bioaccumulation data, project data and other relevant data[4]	Sufficient evidence of no bioaccumulative risk > SCII and SMS
		Laboratory bioaccumulation tests (Tiered)	• Composite 20 subsamples from stratified random grid within the Disposal Site DU into a single sample; analyze for sediment chemistry and bioaccumulation • Composite 20 subsamples from random grid within the Environs DU into a single sample; analyze for sediment chemistry and bioaccumulation • Analyze sediment and tissue for relevant DMMP List 1 BCOCs	1. SCII: Sediment BCOCs ≤ DMMP BT; Tissue BCOCs ≤ DMMP TTLs 2. SMS: BCOCs from Disposal Site DU-exposed tissues are ≤ the highest of: • Risk-based values (including relevant TTLs) • Background including Environs DU tissue data • PQLs if available
3. Does use of the disposal site cause unacceptable[1,2] adverse impacts to biological conditions off site?	**D.** No significant decrease in off-site biological conditions due to use of site, either from - indirect effects (no off-site disposal), or - direct effects (off-site disposal)	Indirect impacts: SPI/PV qualitative assessment	Review SPI/PV parameters including successional stage, apparent redox potential discontinuity, and others	Nearby off-site benthic community shows expected levels of habitat quality
		Direct impacts (Tiered) 1. Sediment chemistry/bioassays 2. Laboratory bioaccumulation tests	If Goal A not achieved: 1. Run chemistry analyses and tiered bioassays on individual grab sample(s) collected from any off-site DM 2. Include off-site DM grab sample(s) in Disposal Site DU composite for BCOC sediment analysis and bioaccumulation testing	1. All sediment COCs and bioassay responses ≤ SMS SCO 2. All BCOCs from Disposal Site DU-exposed tissues are ≤ the highest of: • Risk-based values (including relevant TTLs) • Natural background[5] • PQLs if available

Table 1-2. Revised Monitoring Framework

<table>
<tr><th colspan="5">Part 2: Follow-up Actions and Management Options</th></tr>
<tr><th>Question</th><th>Issue Found</th><th>Evaluations Needed</th><th>Potential Evaluation Actions</th><th>Management Options</th></tr>
<tr>
<td>1. Does the deposited dredged material stay on site?</td>
<td>A. DM found ≥10 cm at or beyond site boundary or ≥3 cm at or beyond site perimeter</td>
<td>• Verify extent:
- Where did off-site material end up?
• Consider cause(s):
- Disposal operations?
- Currents, tides, or other localized phenomena?
• Confirm no off-site adverse impacts (Question 3)</td>
<td>• Floating stations added to SPI/PV study to determine extent of off-site DM
• Chemistry (DMMP COC list) and tiered bioassay analysis of individual grab sample(s) collected from off-site DM
• Off-site DM grab sample(s) included in Disposal Site DU composite for BCOC sediment analysis and bioaccumulation testing
• Collect additional sample(s) in off-site DM
• Use sediment from natural background[5] DU for laboratory bioaccumulation tests and tissue comparisons</td>
<td rowspan="4">Prevention of off-site DM:
Prevent future occurrences using disposal management tools, e.g.:
• Disposal target modification
• Timing modifications (e.g. tidal stages)
• Vessel approach/direction modification
Prevention of adverse biological effects:
Prevent future occurrences by modifying project evaluation guidelines, e.g.:
• Additions/modifications to COC list
• Adjust SLs/BTs
• Special studies
Mitigation/Remediation
Mitigate/remediate unacceptable adverse effects on site or off site, e.g.:
• Cover with suitable material
• Monitor for natural recovery
• In-situ remediation
• Temporary site closure</td>
</tr>
<tr>
<td rowspan="2">2. Does deposited dredged material cause unacceptable[1,2] adverse impacts to biological conditions on site?</td>
<td>B. Disposal site sample(s) exceed SL and fail bioassays, thus indicating potential adverse effects on benthic biological resources as defined by SCII</td>
<td rowspan="3">• Verify extent:
- Single sample, or more?
- Benthic and/or bioaccumulation failure?
• Consider cause(s):
- Evidence of recent DM?
- Potential sources?
- Regional conditions?
• Verify impact (per SMS and relevant Site Conditions)
• Determine severity of adverse effect</td>
<td rowspan="3">• Case by case: additional data collection or analyses may be needed</td>
</tr>
<tr>
<td>C. BCOCs in Disposal Site DU sediments or tissues exceed SCII or SMS</td>
</tr>
<tr>
<td>3. Does use of the disposal site cause unacceptable[1,2] adverse impacts to biological conditions off site?</td>
<td>D. Significant decrease in off-site biological conditions due to use of site, either from
- indirect effects (no off-site disposal), or
- direct effects (off-site disposal)</td>
</tr>
</table>

Notes

[1] per Washington State Sediment Management Standards (SMS)

[2] per Site Condition II, based on the Clean Water Act, 404(b)1

[3] If goal not fully achieved, go to Follow-up Actions and Management Options (Part 2)

[4] At least one round of laboratory bioaccumulation tests will be conducted at each disposal site before Tier 1 analyses will be considered sufficient for evaluating on-site bioaccumulation risk

[5] In some instances, the Environs will be used as natural background.

Acronyms

BCOC	Bioaccumulative Chemical of Concern
BT	Bioaccumulation Trigger
COC	Chemical of Concern
CSL	Cleanup Screening Level (per SMS)
DM	Dredged Material
DU	Decision Unit
EIS	Environmental Impact Statement
PQL	Practical Quantitation Limit
SCII	Site Condition II (per CWA)
SCO	Sediment Cleanup Objective (per SMS)
SL	Screening Level
SMS	Sediment Management Standards
SPI/PV	Sediment Profile Imaging and Plan View
TTL	Target Tissue Level

DMMP will use an SMS-like approach to evaluate on-site bioaccumulation (see Issue Paper Parts 2 and 3).

Question 3 – Does use of the disposal site cause unacceptable adverse impacts to biological conditions off site?

Hypotheses 5 and 6 in the original framework have been replaced with qualitative assessment of the off-site benthic community using SPI/PV. However, if it is determined that dredged material does not stay within site boundaries, further assessment for impacts to off-site benthos and bioaccumulation risk may be triggered as follow-up actions.

Definition of Off-site Material

The definition of on-site vs off-site material has been updated to focus on accumulation of dredged material at the disposal site boundaries. Question 1 of the original framework (Does the deposited dredged material stay on site?) defined significant off-site material based on observation of 3 cm or more of recently deposited material at the perimeter stations, which are 1/8 of a nautical mile outside the disposal site boundary. The revised monitoring framework retains evaluation of recently deposited material at the perimeter (≥3 cm) to define off-site material and to facilitate temporal comparison and data interpretation congruity. The revised framework adds a definition of off-site material as accumulations ≥10 cm at or beyond the site boundary. A depth of 10 cm was chosen as indicative of a significant accumulation since the entire depth of the biologically active zone (as defined under SMS) would consist of recently deposited dredged material.

Cost Considerations

Costs are a significant factor for any monitoring program. The DMMP devoted considerable effort to evaluating the cost impacts of changing the monitoring framework. A comparison of the overall implementation cost of the revised monitoring framework from the 2020 Port Gardner Pilot Study relative to the 2010 Port Gardner tiered-full monitoring event indicates an approximate 25% cost reduction[3] (Table 1-3). This decrease is driven by reduction in the number of field sampling days required, despite the added cost of adding bioaccumulative analyses. For a tiered-full monitoring under the original framework, analysis of in situ (field-collected) tissue chemistry would only occur if triggered by off-site disposal (which rarely occurred throughout the 30+ years of monitoring and did not occur at Port Gardner in 2010). The revised monitoring framework eliminates all in-situ tissue collection and tissue analyses, and instead utilizes SPI/PV to assess benthic community status. The original framework also required three bioassays; bioassays are no longer automatically conducted in the revised monitoring framework. Finally, the revised monitoring framework significantly reduces the number of samples for sediment chemistry and the frequency of special analyses, which results in significant cost savings. Table 1-3 summarizes the major changes affecting cost.

[3] Assumes 2020 rates and costs applied to both the 2020 and 2010 activities to remove inflation impacts.

Table 1-3. Cost Considerations in the Revised Monitoring Framework

Description of Activity	Cost Changes for 2020 Port Gardner Pilot Study Monitoring relative to 2010 Port Gardner Tiered-full monitoring
Field Operations	
Mobilization/demobilization	No change
No. sampling days	Significant reduction in sampling days (from 13 to 4)
Chemistry	
Sediment Chemistry (inc. QA/QC)	Significant reduction in number (15 to 7) of samples and frequency of special analyses (e.g., D/F, PBDEs, PCB Congeners)
Tissue Chemistry (inc. QA/QC)	Tissue chemistry (26 samples, which includes 6 pre-test samples) added for bioaccumulation testing
Biological testing/Benthic Community Analysis	
Benthic community analysis	No change
Bioassays	Reduction in bioassays (from 3 to 0)
Bioaccumulation	Added two lab bioaccumulation test setups
Data Analysis	
Chemical Tracking System (CTS)	Dropped CTS trend analysis
Overall Cost Savings	~25% reduction in cost for routine monitoring

Summary

With improved knowledge, new regulations, and changing concerns, the DMMP disposal site monitoring program must evolve to meet the needs of the next 30 years (and beyond). The revised monitoring framework (Table 1-2) summarizes the proposed new approach. Parts 2 and 3 of this issue paper provide further details supporting the changes and provide details for implementation.

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Part 2: Disposal Site Monitoring Sampling Design

Introduction

Part 2 of this issue paper discusses sampling design changes to the Dredged Material Management Program's (DMMP) open-water disposal site monitoring framework. The revised monitoring framework is described throughout this issue paper and will serve as the basis for the new Disposal Site Monitoring Plan.

The original disposal site monitoring procedures are outlined in the Updated Environmental Management Plan (UEMP; DMMP, 2007). The "former" sampling design, in the UEMP, incorporates all program updates and revisions since program inception through 2007. The DMMP is making changes to the following elements of the former sampling design for disposal site monitoring: (1) monitored variables, (2) sampling areas, and (3) sampling procedures and analysis. The rationale for and details of these changes are provided below.

Monitored Variables

As summarized in Table 2-1, the former monitored variables required physical surveys (sediment profile imaging [SPI]), sediment chemistry, sediment toxicity (bioassay testing), and analysis of benthic infaunal community structure and in situ benthic infaunal organism tissue. The revised monitoring framework retains physical surveys and sediment chemistry, while tiering sediment toxicity testing, and substituting laboratory bioaccumulation testing for analysis of in situ tissues.

Table 2-1. Former and Revised Monitored Variables

Former Variables	Revised Framework Variable
Physical surveys Sediment chemistry Sediment toxicity Benthic infaunal community structure Tissue analysis of in situ benthic organisms	Physical surveys Sediment chemistry Tiered sediment toxicity Lab bioaccumulation testing

The rationale for retaining, removing, or adding each of these variables is provided below.

- Physical surveys utilizing SPI continue to provide the foundation for the disposal site sampling. In addition to SPI, plan view (PV) imaging has been added to provide additional information about seafloor conditions. The location of sampling stations for physical monitoring have changed to better delineate the 10 cm contour of recent dredged material.
- Sediment chemistry continues to provide critical information; however, the location of sampling stations has been modified (see Sampling Areas section). Consistent with the former sampling design, the testing requirements for sediment and tissue chemistry follow the DMMP User Manual (DMMP, 2021b) except that polybrominated diphenyl ethers (PBDEs) are included in some samples to comply with the biological opinion issued by National Marine Fisheries Service (NMFS; 2015).
- Sediment toxicity testing has been removed as a required variable based on over 30 years of monitoring data in which all bioassays have passed when DMMP chemicals of concern (COC)

concentrations are below screening levels (SL). Under the new framework bioassay testing to assess benthic risks will be tiered and would only be triggered if a COC exceeds an associated SL.

- The former sampling design included evaluation of infaunal community structure to assess whether unacceptable adverse impacts are occurring to off-site biological resources. However, the results of over 30 years of environmental monitoring at the disposal sites has shown the difficulty of collecting meaningful data from traditional benthic community evaluations (Striplin, 2002; SAIC and Caenum, 2007; SAIC, 2010). Significant reductions in major taxa abundance observed at the Port Gardner, Commencement Bay, and Anderson/Ketron disposal sites relative to baseline collected decades earlier were determined to be related to changing regional and/or background conditions (e.g., variability of benthic community species composition and abundances over time; Nichols, 2003; Partridge et al., 2018) rather than an impact from dredged material disposal. In light of this information, taxonomic evaluation of infaunal community structure has been removed from the revised framework. Instead, qualitative assessment of benthic community indices derived from SPI/PV (e.g., successional stage, apparent redox potential discontinuity, and others) are included in the revised monitoring framework.
- The former sampling design also evaluated impacts of disposal site use on benthic communities using analysis of COCs in tissue from benthic infaunal organisms. Organisms were collected from off-site locations because it was impractical to collect sufficient tissue mass from post-disposal disturbed conditions on site. The result was that most tissue samples were comprised of a commonly found sea cucumber (*Molpadia* spp.) that was collected from off-site perimeter stations that do not typically contain dredged material. This in-situ tissue analysis, therefore, did not produce empirical evidence required to understand if dredged material was causing adverse impacts to on-site biological resources and has therefore been removed from the monitoring framework. Furthermore, tissue collection required multiple field days to gather sufficient mass.
- Laboratory bioaccumulation testing using standardized test organisms exposed to composited on-site sediments has been added to the revised framework to address the bioaccumulation data gap in the monitoring program. Tissue results are interpreted using the 2013 Washington State Sediment Management Standards (SMS) to determine compliance because SMS provides more guidance than PSDDA Site Condition II (SCII) around risk evaluation, regional background conditions, and practical quantitation limit considerations (see Issue Paper Part 3). Sediment composites and associated tissue samples collected for the bioaccumulation study are analyzed for bioaccumulative COCs (BCOCs) which includes a subset of DMMP COCs plus tributyltin and dioxins/furans (see Table 2-3).

Sampling Areas

A second major revised framework change is to the sampling areas and locations used for monitoring. The former sampling design used station types for defining sampling purpose and locations. Table 2-2 provides the station types historically used and the status of each station type within the revised framework. Several station types were retained for the SPI/PV analysis, while others were removed completely. Revised framework decision units (DUs) have been created and are defined as the smallest area of sediment for which a decision will be made. The revised framework has three DUs:

- The Disposal Site DU is defined as the area within the disposal site boundary (which has not changed).

- The Environs DU is defined as the area just outside the disposal site that excludes trace amounts of dredged material accumulation and known sources of contamination. The Environs DU will be used to account for regional conditions unrelated to dredged material disposal.
- The Natural Background DU is defined as an area representing natural background (e.g., Carr Inlet) and will only be characterized if deposited dredged material is present at or beyond the disposal site boundary (off site) in amounts exceeding interpretive guidelines and the Environs DU does not represent natural background.

This section provides details on how DU boundaries were established and how sampling grids were generated within each of the DUs.

Table 2-2. Changes to Monitoring Framework Sampling Stations

Station Type	Location	Former Framework Purpose (from UEMP)	Revised Monitoring Framework
Zone (Z)	Within disposal target zone.	Assess sediment chemistry and toxicity of dredged material deposited in the target area to evaluate Question 2.	Retained for SPI/PV. Replaced by Disposal Site DU for chemistry and toxicity.
Site (S)	Within the site boundary but outside of the target zone.	In conjunction with zone data, site station sediment chemistry and toxicity data obtained to evaluate Question 2.	Retained for SPI/PV. Replaced by Disposal Site DU for chemistry and toxicity.
Perimeter (P)	Located 0.125 nautical mile from the site boundary.	Physical and chemical data obtained to determine if dredged material is present beyond the site boundary and document the chemical character of sediments outside the site boundary (Question 1).	Retained for SPI/PV. Removed for sediment chemistry.
Transect (T)	Situated along a radial transect that extends outward from the perimeter line. Located in the direction of dredged material transport.	Sampled for benthic infauna abundance and infauna tissue contaminant body burden to evaluate biological resource impacts off site (Question 3).	Retained for use if needed to characterize off-site dredged material. Removed benthic infauna and in- situ tissue evaluation.

Station Type	Location	Former Framework Purpose (from UEMP)	Revised Monitoring Framework
Benchmark (B)	Located in the vicinity of the disposal site, but beyond the region affected by disposal activity.	Used to identify potential changes in sediment quality that may be unrelated to dredged material disposal. Data evaluated only if site, perimeter, or transect data indicate that conditions at or adjacent to the site have changed relative to baseline conditions and to test hypotheses that observed changes are due to dredged material disposal.	Replaced by Environs DU to assess the area just outside the disposal site.
Central Transect (C)	Situated along two perpendicular lines that bisect the disposal site and may extend beyond its boundaries.	Used for physical measurements to map the post-disposal distribution of dredged material (Question 1).	Retained for SPI/PV.
Floating (F)	Located in various locations within and outside of the disposal site.	Used to help delineate the extent of the dredged material deposit. Stations sampled for sediment and benthic infauna analysis, if necessary, to assess dredged material impacts outside of the disposal site.	Retained for SPI/PV. Removed for sediment chemistry and benthic infauna analysis.
Reference (R)	Located in areas documented to be free of potential sources of contamination (e.g., Carr Inlet). Location is selected based on grain size comparability with the bioassay test sediments.	Sediments used as a control for physical effects in toxicity testing.	Retained if off-site material is present in amounts exceeding interpretive guidelines or if bioassays are triggered.

Decision Unit (DU) Boundaries

Determining the location of potential sampling stations for a given DU begins with a systematic selection of the geographic boundaries defining the extent of the DU.

Disposal Site DU

The boundary of the Disposal Site DU is the same as the disposal site boundary. If ≥10 cm of dredged material is measured at or beyond this boundary during a monitoring event, this additional area will be included as part of the Disposal Site DU because 1) their physical, chemical, and biological characteristics are expected to be similar to the dredged material within the disposal site boundaries (i.e., they would not be statistically independent samples) and 2) to provide additional power for the statistical comparison to compliance standards.

Environs DU

The Environs DU is defined as an area immediately adjacent to but outside the influence of the disposal site. The boundary of the Environs DU is based on bathymetry and grain size to best meet the intent of the comparison to the Disposal Site DU. The standard of selection is the bathymetry and grain size at a disposal site's boundary prior to the first use of the site for dredged material disposal. Historical SPI data are used to find the area just outside the disposal site that excludes all areas with trace amounts of dredged material accumulation. In addition, a buffer will be included to ensure that all dredged material is excluded from the Environs DU. For example, for the Port Gardner Pilot Study, a 150-ft buffer based on the cumulative historical trace dredged material footprint was established between the Disposal Site and Environs DUs to ensure that all dredged material was excluded from the Environs DU. Site-specific conditions at the disposal sites (e.g., steeper slopes, bathymetry, currents, off-site sources of sediment, and known sources of contamination) determine the bathymetry and grain size guidelines used to determine the Environs DU.

Natural Background DU

The Natural Background DU will only be sampled if needed (i.e., recent dredged material ≥10 cm in depth extends at or beyond the disposal site boundary) to determine whether adverse benthic effects and/or bioaccumulation risk are occurring off site. Carr Inlet is the most likely location for a Natural Background DU. A boundary for a Carr Inlet DU was defined for the Port Gardner Pilot Study using an approach originally developed to identify natural background sampling locations for the 2008 OSV *Bold* study in Puget Sound. A 500-meter (1,640-foot) buffer was placed around known outfalls or contaminant sources and a 250-meter (820-foot) buffer was placed around points that exceeded one or more DMMP SLs. The outer boundary for the Carr Inlet DU was a 500-meter (1,640-foot) buffer from the shoreline.

DU Sampling Station Grids

Sampling locations within each DU are chosen using systematic random sampling from a grid, the size of which varies depending on the DU, allowing for spatial coverage and (if needed) sample independence.

Sampling station grid spacing within the Disposal Site DU does not require sample independence, as most disposal site stations would be expected to have potential impacts from dredged material disposal. For the Port Gardner Pilot Study, a grid spacing of 125 meters (410 feet) was determined to be appropriate, to provide a higher density grid to characterize the Disposal Site DU and avoid unintentional overlap between sampling areas that could be created by the Van Veen grab wire angle during sediment sampling activities at this deep-water site. The sampling station grid will remain fixed and a subset of 20 randomly selected samples will be collected to characterize the DU. If SPI/PV surveys identify recent dredged material ≥10 cm in depth extending at or beyond the disposal site boundary ("off-site material"), the Disposal Site DU sampling station grid will be extended to include those areas.[4]

A 500-meter grid spacing for the Environs DU was used in the Port Gardner Pilot Study based on an analysis of autocorrelation conducted for the Port Gardner Bay Regional Background Study (Ecology, 2013), which determined a minimum distance of 500 meters (1,640 feet) was needed to ensure sample independence. This sampling station grid provides spatial coverage and enough locations for a systematic spatially balanced random sample design. As with the Disposal Site DU, a subset of 20 randomly selected samples will be collected to characterize the DU. An Environs DU 500-meter grid spacing will be used at the other disposal sites unless reevaluation of sample independence is warranted.

If ≥10 cm of off-site dredged material is observed, 20 stations may also be collected from a Natural Background DU, to evaluate whether impacts from dredged material at or beyond the disposal site boundary exceed the SMS Sediment Cleanup Objective (SCO). Similar to the Environs DU, the Carr Inlet DU sampling station grid spacing requires sample independence. A minimum distance of 500-meters (1,640 feet) was determined during the Port Gardner Bay regional background study to ensure sample independence (Ecology, 2013); however, for the Carr Inlet DU, a 1,000-meter (3,281-foot) grid spacing was applied to reduce the number of potential stations over the large area of the inlet.

Sampling Procedures and Analysis

Sampling procedures have been updated in the revised framework to be more representative of the disposal site and surrounding area. The former sampling procedure required that sediment chemistry be conducted on individual samples from the Zone, Site, and Perimeter stations. The stations were designed to be consistent within disposal sites for each monitoring event to try to capture changes over time. However, low level detections (J-qualified data), changes to analytical methods, regional impacts and seasonal variability were confounding factors that made data interpretation difficult. Additionally, the overall representativeness was lacking due to the limited number of stations sampled during each event. Using DU's with randomly selected sampling stations, rather than targeting a small number of fixed locations, captures both recently deposited dredged material and dredged material deposited in years between monitoring events.

Analytical testing is consistent with the DMMP User Manual (DMMP, 2021). Table 2-3 summarizes the testing parameters for bioaccumulation composites and discrete grab samples.

DU Sediment Compositing and Analysis

For the Disposal Site and Environs DUs (and Natural Background DU, if needed), the sampling station grid will remain fixed, and a subset of 20 sampling stations for each monitoring event will be selected randomly from among the sampling station grid locations. The revised framework uses industry standard geostatistical software to select spatially balanced sampling locations from within the sampling station grid established for each DU. The 20 subsamples from each DU will be composited into their

[4] In this case, an additional buffer will be included to ensure that all dredged material is excluded from the Environs DU.

respective DU sample composites. The composited bioaccumulation sediment samples will be analyzed for the DMMP List 1 BCOCs and PBDEs (Table 2-3), and bioaccumulation tissue testing will be conducted.

Discrete Grab Sampling and Analysis and Tiered Bioassay Testing

Within the Disposal Site DU, five of the twenty sampling stations will be randomly selected for chemical analysis and potential (tiered) benthic testing. If off-site material ≥10 cm is observed at or beyond the disposal site boundary, the sampling grid will be extended into those areas. If a large off-site excursion of dredged material is present, the DMMP agencies will consider whether modifications to the benthic testing sampling design may be needed beyond the 5 stations specified here. Discrete samples will be collected and analyzed from each of the 5 stations. Samples will initially be analyzed for conventionals and the DMMP benthic toxicity COC list. If any SL in any given sample is exceeded, the full suite of marine bioassay tests will be conducted on that sample and interpreted according to current DMMP marine bioassay evaluation guidelines.

Table 2-3. Sample Testing Parameters

	Bioaccumulation Composites (Marine)		**Discrete Grabs (Marine)**
Analyte	**Tissue BCOCs DMMP User Manual Table 10-1**	**Sediment BCOCs DMMP User Manual Table 10-1**	**Sediment Benthic Toxicity COCs DMMP User Manual Table 8-3**
Conventionals			
Total solids	X	X	X
Total volatile solids (TVS)	--	X	X
Grain size	--	X	X
Total organic carbon (TOC)	--	X	X
Total sulfides	--	X	X
Ammonia	--	X	X
Lipids	X	--	--
Metals			
Antimony	--	--	X
Arsenic	X	X	X
Cadmium	--	--	X
Chromium	--	--	X
Copper	--	--	X
Lead	X	X	X
Mercury	X	X	X
Selenium	X	X	X
Silver	--	--	X
Zinc	--	--	X
Organometallic Compounds			
Tributyltin ion (bulk)	X	X	--
Polycyclic Aromatic Hydrocarbons			
Total LPAHs	--	--	X
Naphthalene	--	--	X

	Bioaccumulation Composites (Marine)		Discrete Grabs (Marine)
Analyte	**Tissue BCOCs DMMP User Manual Table 10-1**	**Sediment BCOCs DMMP User Manual Table 10-1**	**Sediment Benthic Toxicity COCs DMMP User Manual Table 8-3**
Acenaphthylene	--	--	X
Acenaphthene	--	--	X
Fluorene	--	--	X
Phenanthrene	--	--	X
Anthracene	--	--	X
2-Methylnaphthalene	--	--	X
Total HPAHs	--	--	X
Fluoranthene[1]	--	X	X
Pyrene[1]	--	X	X
Benz(a)anthracene	--	--	X
Chrysene	--	--	X
Benzofluoranthenes (b,j,k)	--	--	X
Benzo(a)pyrene	--	--	X
Indeno(1,2,3-c,d)pyrene	--	--	X
Dibenz(a,h)anthracene	--	--	X
Benzo(g,h,i)perylene	--	--	X
Chlorinated Hydrocarbons			
1,4-Dichlorobenzene	--	--	X
1,2-Dichlorobenzene	--	--	X
1,2,4-Trichlorobenzene	--	--	X
Hexachlorobenzene (HCB)	X	X	X
Phthalates			
Dimethyl phthalate	--	--	X
Diethyl phthalate	--	--	X
Di-n-butyl phthalate	--	--	X
Butyl benzyl phthalate	--	--	X
Bis(2-ethylhexyl) phthalate	--	--	X
Di-n-octyl phthalate	--	--	X
Phenols			
Phenol	--	--	X
2-Methylphenol	--	--	X
4-Methylphenol	--	--	X
2,4-Dimethylphenol	--	--	X
Pentachlorophenol	X	X	X
Miscellaneous Extractables			
Benzyl alcohol	--	--	X
Benzoic acid	--	--	X
Dibenzofuran	--	--	X

	Bioaccumulation Composites (Marine)		Discrete Grabs (Marine)
Analyte	**Tissue BCOCs DMMP User Manual Table 10-1**	**Sediment BCOCs DMMP User Manual Table 10-1**	**Sediment Benthic Toxicity COCs DMMP User Manual Table 8-3**
Hexachlorobutadiene	--	--	X
N-Nitrosodiphenylamine	--	--	X
Pesticides			
Aldrin	--	--	X
4,4'-DDD	X	X	X
4,4'-DDE	X	X	X
4,4'-DDT	X	X	X
Total 4,4'-DDX (calculated)	X	X	X
cis-Chlordane	X	X	X
trans-Chlordane	X	X	X
cis-Nonachlor	X	X	X
trans-Nonachlor	X	X	X
Oxychlordane	X	X	X
Total Chlordane (calculated)	X	X	X
Dieldrin	--	--	X
Heptachlor	--	--	X
PCB Aroclors	--	X	X
PCB Congeners	X[2]	X	--
Dioxins/Furans	X	X	--
PBDE Congeners	--	X[3]	--

Notes:

1 -Not required for tissue analysis because there is no completed exposure pathway for cPAHs in disposal site sediments to humans (DMMP, 2021a)

2 -Recommended based on DMMP User Manual Table 10-1.

3- Included pursuant to NMFS EFH Conservation Recommendations (NMFS, 2015).

Summary

The disposal site monitoring program has evolved over time to assure that disposal sites are being managed effectively and efficiently. The revised monitoring framework sampling design provides the information needed to assess compliance with the original goals of the PSDDA program and current Washington State standards. The inclusion of bioaccumulation testing also addresses current and anticipated ESA concerns. Part 3 of this issue paper provides the data interpretation protocols that will be used to assess the bioaccumulation composites and discrete grab samples.

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Part 3: Disposal Site Monitoring Data Interpretation

Introduction

Part 3 of this issue paper provides updates to the approach for interpreting sediment and tissue chemistry data from disposal site monitoring. Data interpretation updates include (1) discontinuing the Chemical Tracking System (CTS), and (2) aligning risk interpretation guidelines for on-site and off-site dredged material with the Sediment Management Standards (SMS) sediment risk evaluation framework (Ecology, 2013).

Discontinuing the Chemical Tracking System (CTS)

The CTS was a statistical time trends analysis that tracked concentrations of all the Dredged Material Management Program (DMMP) chemicals of concern (COCs) measured in samples from the perimeter stations around each disposal site (SAIC and MWLS, 1996). The purpose of the CTS was to provide an early warning of adverse impacts to the area just outside the disposal site by identifying trends of increasing chemical concentrations over time, even if concentrations were below DMMP screening levels (SLs).

CTS is being discontinued from disposal site monitoring for several reasons. The CTS was designed to determine if dredged material at or beyond the disposal site boundary (at perimeter stations) was adversely impacting off-site sediment chemistry. However, because the perimeter stations were at fixed locations and did not target dredged material found at or beyond the disposal site boundary, there is no ability to link chemical concentrations at the perimeter stations with off-site dredged material.

Additionally, trend analysis is difficult when dealing with low chemical concentrations. Many chemical groups have insufficient detections to report trends, as observed at the Port Gardner monitoring event in 2010. While CTS did report some statistically significant trends for chemicals over time, the observed trends were often based on estimated concentrations (below quantitation limits) that were well below DMMP SLs. Statistically significant trends based on estimated values are not dependable metrics. Phenol (with an SL of 420 ug/kg) is an example of this issue. While phenol had previously been undetected (28U ug/kg in 1990, 12U ug/kg in 2006), a statistically significant, large (140% per year) trend was identified by CTS at Port Gardner in 2010 (SAIC, 2010), driven by a single replicate with an estimated value of 43J ug/kg. Other apparent trends, such as an apparent doubling of cadmium at CBP03 (NewFields, 2018), are reported for values that are all below Ecology-established natural background values and should not be considered early warnings of impacts due to dredged material.

In summary, the DMMP has determined that the CTS early warning system did not function as intended and was a costly, ineffective aspect of the original monitoring framework. Changes in low-level chemical concentrations below Sediment Cleanup Objective (SCO), SL and/or natural background concentrations are not a concern, and the disconnect between sampling locations and presence of dredged material invalidates the assumption that changing concentrations are the result of dredged material disposal. Therefore, CTS will be discontinued.

Updated On-Site Risk Interpretation

The original monitoring approach ensured that on-site material met Site Condition II (SCII), which considered thresholds for benthic risk, as defined by the DMMP SLs, along with bioaccumulative risk, as defined by DMMP sediment Bioaccumulation Triggers (BTs). However, many of the existing BTs were formulaically calculated using the SL and Maximum Level (ML) rather than risk-based, and thus are not consistent with the current SMS risk-based approach described below.

Ecology promulgated changes to the SMS in 2013 and included an updated framework for sediment risk evaluation (Ecology, 2013). The updated SMS sediment risk evaluation framework considers background, risk (benthic, human, higher trophic levels, and other applicable rules), and Practical Quantitation Limits (PQLs) (Figure 3-1). For disposal sites, the on-site sediment goal is to not exceed SMS sediment Cleanup Screening Levels (CSLs), which can incorporate SCII as an "other applicable rule" (Figure 3-1A). The goal for the bioaccumulation testing tissue results from the Disposal Site DU is to not exceed the on-site compliance-based Target Tissue Levels (TTLs) (Figure 3-1B).

On-site Sediments

The SMS CSL paradigm defines the sediment CSL as the HIGHEST value of background, risk, or PQL (Figure 3-1A).

The CSL allows use of regional background (Sediment Cleanup User's Manual [SCUM] Table 10-2) as an upper limit (Ecology, 2021). For locations and chemicals that do not have established regional background values, the DMMP is using the Environs DU composite data as a surrogate for regional background. This approach is protective, because it uses the mean of the Environs DU data which would be lower than a value based on an upper percentile statistic (Ecology-developed regional background values using the 90th upper tolerance level of the 90th percentile of the data).

For the CSL risk component, the LOWEST applicable risk value for benthic, higher trophic levels, and human risks is retained. For the purposes of the disposal site monitoring, the DMMP SCII benthic risk has been incorporated into the tiered SMS CSL framework (Figure 3-1A), as a site-specific additional applicable criteria[5].

Sediment screening values that address specific bioaccumulative exposure pathways (e.g., human health risks and higher trophic levels) require development of site-specific BTs, typically through a biota sediment accumulation factor (BSAF) approach that converts a TTL to a sediment screening level. These have not been developed for higher trophic levels and human risk, which are instead considered under the tissue bioaccumulation evaluation. In the series of public meetings preceding the development of the revised monitoring framework, the DMMP agencies determined that insufficient data were available to determine whether or not existing DMMP sediment BTs were sufficiently protective[6]. The revised monitoring framework currently requires bioaccumulation testing that will provide information to assess bioaccumulative risks.

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[5]Note that for both SCII and SMS CSL, bioassay over-ride is allowed if benthic risk sediment values are exceeded. While SMS would allow the CSL bioassay definition as an upper limit, the more protective SCII must also be met, so any bioassays triggered by exceeding benthic SLs would be evaluated using the DMMP bioassay interpretive guidelines.

[6] Many of the BTs were formulaically calculated using the SL and ML, which are based on benthic risk toxicity testing (not bioaccumulative risk).

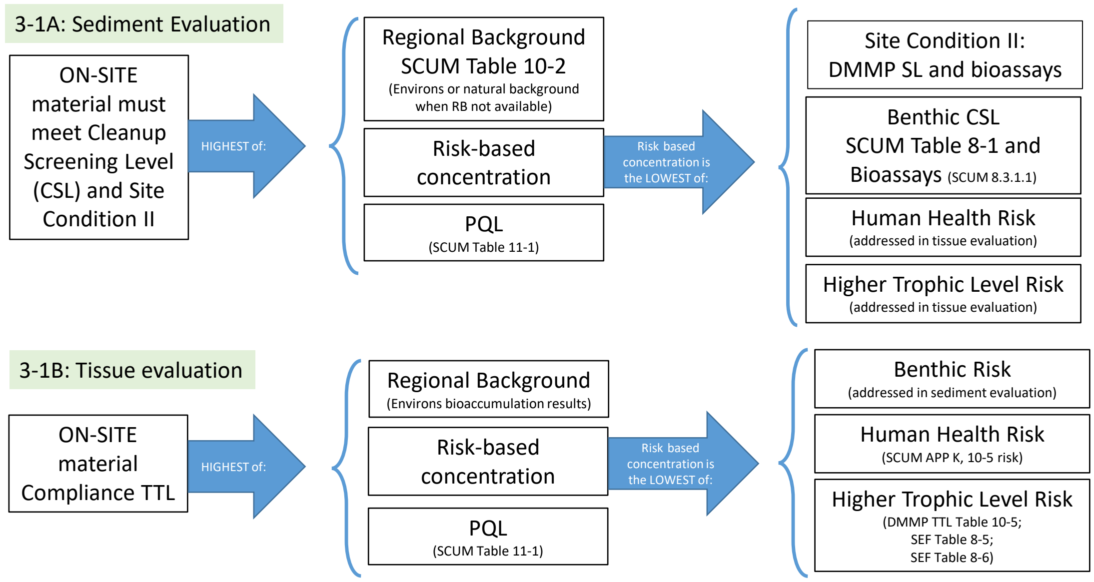

Figure 3-1. On-site SMS framework for disposal site monitoring. 1A: Tiered sediment framework. 1B: Tiered Target Tissue compliance.

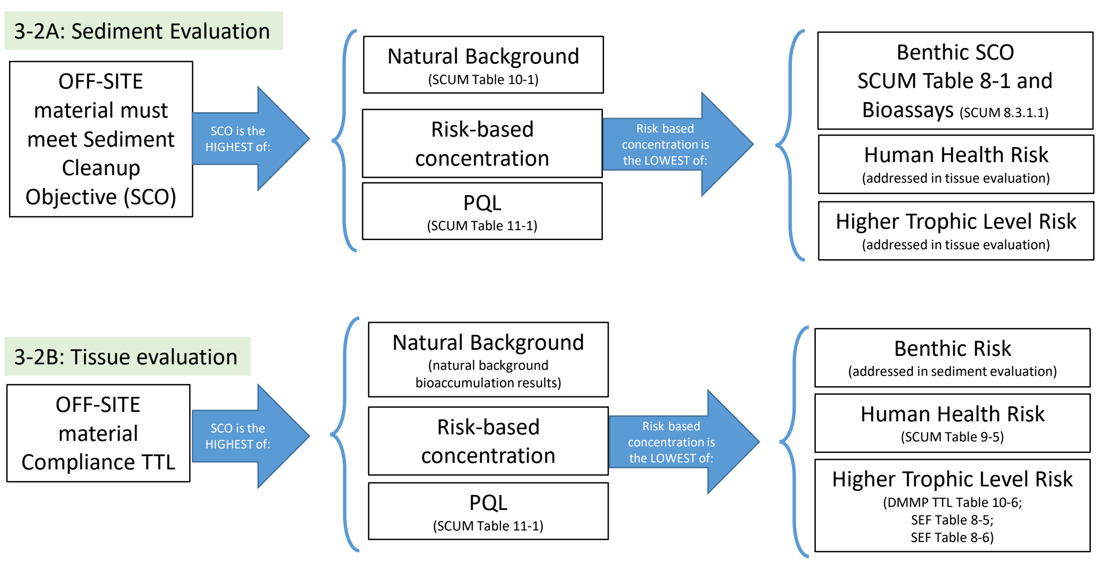

Figure 3-2. SMS framework for DMMP site monitoring if sediments present off site (more than 10 cm). 2A: CSL for off-site material evaluation. 2B: TTL for off-site material evaluation.

Ecology's PQLs (SCUM Table 11-1) are used when available (Ecology, 2021). Where not available and needed for the evaluation, DMMP may develop PQLs using approaches similar to those used by Ecology.

On-site Tissues

Evaluation of tissue data reflecting exposure to on-site sediment is a significant new element of the revised monitoring framework. Tissue chemistry data are generated from organisms exposed to on-site sediment including deposited dredged material in laboratory-based bioaccumulation testing.

For disposal site monitoring of on-site material, SCII does not include a quantitative approach for evaluating bioaccumulation results, but rather relies on a narrative interpretation (minor adverse effects) that is not well defined. The DMMP has risk-based TTLs for a few compounds which are incorporated into the compliance TTL framework described below.

The 2013 SMS allows the use of tissue chemistry for compliance purposes but not for setting cleanup standards, so the TTLs developed for disposal site monitoring evaluation are referred to as "Compliance TTLs," not tissue CSL values. For the purposes of the DMMP disposal site monitoring bioaccumulation tissue data interpretation, the DMMP is applying the SMS sediment framework approach that selects the highest of background, risk, and PQL (Figure 3-1B).

Ecology has not developed tissue background levels, so DMMP is using the Environs DU bioaccumulation data as a surrogate for regional background.

For risk, the LOWEST of applicable TTLs is selected. Risk-based values included in the evaluation were TTLs from the DMMP User Manual Table 10-5 (DMMP, 2021), the Sediment Evaluation Framework (SEF) Table 8-5 (protection of aquatic life, Species Sensitive Distribution values), SEF Table 8-6 (protection of deep-water species populations) (RSET, 2018), and human health TTLs developed from SCUM Appendix K (Ecology, 2021), using appropriate Tribal consumption rates and a risk of 1x10E-5, as allowed under SMS CSL.

Ecology's PQLs (SCUM Table 11-1) are used when available (Ecology, 2021). Where not available and needed for the evaluation, DMMP may develop PQLs using approaches similar to those used by Ecology.

Updated Off-Site Risk Interpretation

If Sediment Profile Imaging/Plan View (SPI/PV) indicates that ≥10 cm of recent dredged material is at or beyond the site boundary or ≥3 cm is at or beyond the site perimeter, then at least one discrete grab sample and at least one Disposal Site DU sediment composite subsample must be located in the off-site dredged material.

Off-site material should not exceed the SMS SCO (Figure 3-2). The goal for off-site sediments is defined by the highest of natural background, risk (benthic SCO only; human risks and higher trophic levels are addressed in tissue evaluation), and PQLs, in a similar framework as described for on-site risk interpretation (Figure 3-2A). For tissues, the approach is similar to that of the on-site TTL selection, replacing the Environs DU bioaccumulation results with bioaccumulation results from material considered representative of natural background, and using a more stringent human risk level of 1x10-6 instead of 10-5 (Figure 3-2B) as allowed under the SMS SCO.

Summary

The revised monitoring interpretation framework described in this paper includes discontinuation of elements that have not proven to be useful (e.g., time trend analysis) and modifications to on-site and off-site risk interpretation to improve consistency with SMS updates. This framework will be applied consistently for monitoring evaluation for all non-dispersive disposal sites, although each site will have site-specific data provided by the Environs DU chemical and bioaccumulation testing.

The 2020 Port Gardner Pilot Study is the first DMMP disposal site monitoring conducted under the revised monitoring framework. The foreword to the final data report provides an example of how the tiered evaluation described in this issue paper is applied (NewFields, 2021).

The DMMP agencies recognize that work is still needed to develop an approach consistent with Ecology's approach for determining PQLs for COCs that are not included in Ecology's SCUM Table 11-1. Additionally, the DMMP agencies recognize the need to develop an alternative to using the average Environs DU chemistry and bioaccumulation data (central tendency metric) to be more consistent with the upper percentile metric (90/90 UTL) used by Ecology for sediment background development.

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