Dredged Material Management Program

Disposal Site Monitoring Plan

Unconfined, Open-Water, Non-Dispersive Dredged Material Disposal Sites in Puget Sound

Version 1

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Prepared by the DMMP Agencies

United States Army Corps of Engineers
United States Environmental Protection Agency
Washington Department of Ecology
Washington Department of Natural Resources

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List of Acronyms and Abbreviations

µg	microgram(s)
ac	acre
AK	Anderson/Ketron Island Disposal Site
aRPD	apparent redox potential discontinuity
BB	Bellingham Bay Disposal Site
BCOC	bioaccumulative chemical(s) of concern
BPJ	Best professional judgment
BT	Bioaccumulation Trigger
CB	Commencement Bay Disposal Site
cm	centimeter(s)
COC	Chemicals of Concern
CSL	Cleanup Screening Level (under Washington State SMS)
CWA	Clean Water Act
cy	cubic yard(s)
DDT	Dichlorodiphenyltrichloroethane
DM	Dredged Material
DMMO	Dredged Material Management Office (in USACE Seattle District)
DMMP	Dredged Material Management Program (includes all four partner agencies)
DMMU	Dredged Material Management Unit
DNR	Washington State Department of Natural Resources
DSMP	Disposal Site Monitoring Plan (this document)
DU	Decision Unit
DU-DIS	Disposal Site Decision Unit
DU-ENV	Environs Decision Unit
DU-NB	Natural Background Decision Unit
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management System (Ecology database)
EPA	Environmental Protection Agency (Region 10)
ERDC	US Army Engineering Research and Development Center
ft	foot
GPS	Global Positioning System
ha	hectare
HCB	Hexachlorobenzene
HPAH	high molecular weight polycyclic aromatic hydrocarbon
ICAP	image collection and analysis plan
ISO	International Standard Organization
LPAH	low molecular weight polycyclic aromatic hydrocarbon
m	meter
MDL	method detection limit
mg	milligram(s)
ML	Maximum Level
MLLW	Mean Lower Low Water
n/a	not applicable
NAD83	North American Datum of 1983
ng	nanogram(s)
NMFS	National Marine Fisheries Service
OC	organic carbon

QA	Quality Assurance
QC	Quality Control
PA	Port Angeles Disposal Site
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	polybrominated diphenyl ether
PCB	Polychlorinated Biphenyl
PG	Port Gardner Disposal Site
ppb	parts per billion
PQL	Practical Quantitation Limit
PSDDA	Puget Sound Dredged Disposal Analysis (precursor to the DMMP)
PSEP	Puget Sound Estuary Protocols
PT	Port Townsend Disposal Site
RB	Regional Background
RL	Reporting Limit
RS	Rosario Strait Disposal Site
RSET	Regional Sediment Evaluation Team (WA, OR and ID interagency team)
SAP	Sampling and Analysis Plan
SCII	Site Condition II
SCO	Sediment Cleanup Objective (for Washington State)
SCUM	Sediment Cleanup User Manual (for Washington State)
SEF	Sediment Evaluation Framework
SEIS	Supplemental Environmental Impact Statement
SL	Screening Level(s)
SMARM	Sediment Management Annual Review Meeting
SMS	Sediment Management Standards (for Washington State)
SPI	Sediment Profile Image
SPI/PV	sediment profile imaging and plan view
SQS	Sediment Quality Standards (for Washington State)
SVOC	Semi-Volatile Organic Compound
SVPS	Sediment Vertical Profiling System (*aka* SPI)
SWI	sediment-water interface
TBD	to be determined
TEQ	Toxicity Equivalents
TOC	total organic carbon
TTL	Target Tissue Level
UEMP	Updated Environmental Monitoring Plan (previous DMMP monitoring manual)
USACE	U.S. Army Corps of Engineers, Seattle District
USFWS	U.S Fish and Wildlife Service
VTS	U.S. Coast Guard Vessel Traffic Service
WDFW	Washington Department of Fish and Wildlife

1 Introduction

1.1 Dredged Material Management Program Disposal Sites

The Dredged Material Management Program (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) is 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). Together the DMMP agencies are responsible for evaluating dredged material and for managing the DMMP disposal sites.

There are eight multiuser open-water disposal sites in Puget Sound managed by the DMMP (Figure 1). Five of these sites are **non-dispersive sites** where dredged material remains in place and which are the subject of long-term monitoring as described in this document. Dredged material placed at any of the three **dispersive sites** - located in areas with strong currents – moves off site quickly and disperses widely.

Establishment and use of all disposal sites is allowed via state and federal environmental laws that permit discharge of dredged material in designated locations, based on extensive studies detailed in Puget Sound Dredged Disposal Analysis (PSDDA) documentation (PSDDA 1988 a,b,c and 1989 a,b,c). The program was designed to adapt over time to changing environmental conditions, scientific understanding, and government regulations. The DMMP went through a multi-year process to review and update the long-term monitoring program to adapt to changes that have occurred over the last 30-plus years.

This Disposal Site Monitoring Plan (DSMP) provides the monitoring framework, procedures, and objectives for future monitoring events at the Puget Sound non-dispersive disposal sites. History, development, and reasoning that underlie this DSMP are detailed in a DMMP Issue Paper finalized in 2022 (DMMP 2022a). That paper, divided into three parts, should be consulted as needed for further information on these topics:

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

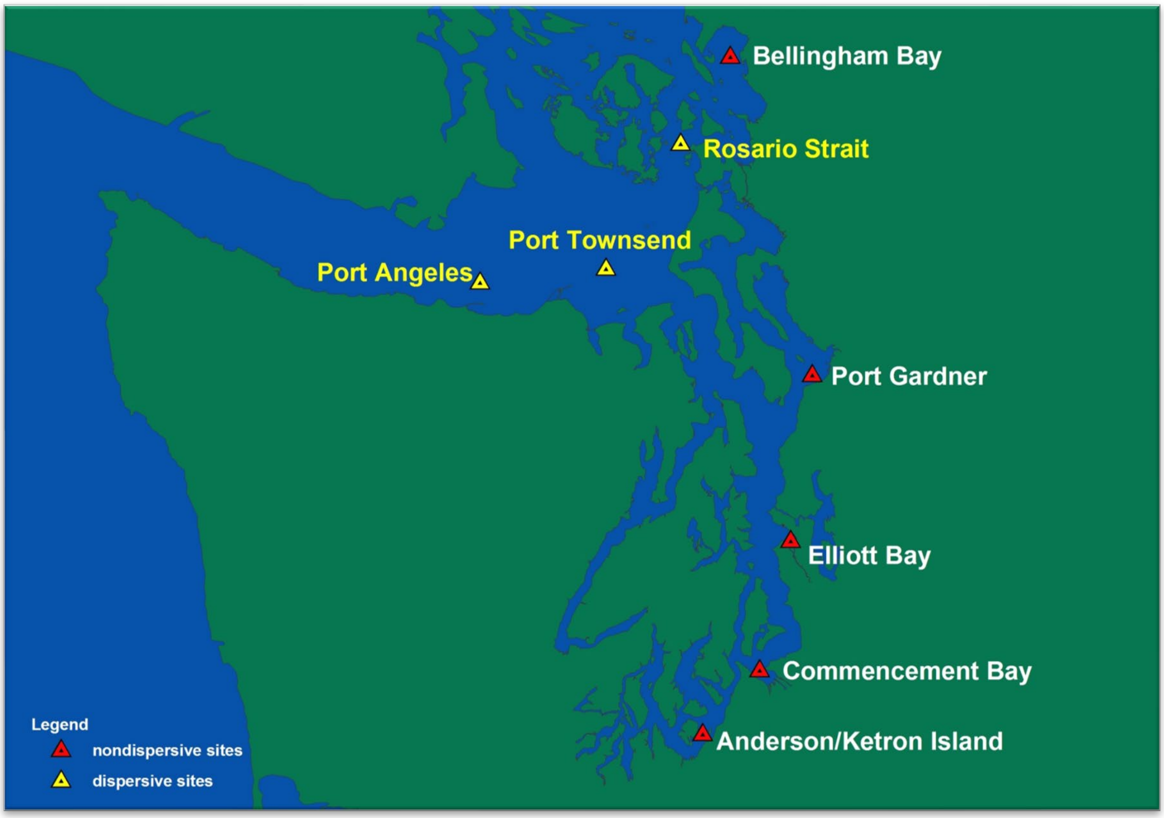

Figure 1. Puget Sound Area Disposal Sites--only non-dispersive sites are the subject of site monitoring

1.2 Program Requirements for Monitoring

Management and monitoring of DMMP disposal sites was developed based on evaluation of the potential effects to biological resources from unconfined, open-water disposal of dredged material in Puget Sound waters (PSDDA 1988b and 1989b). Per those studies (PSDDA 1988c), the primary objectives of monitoring are to:

1. Comply with Section 404(b)(1) of the Clean Water Act (e.g., no "unacceptable adverse impact" to the aquatic environment)
2. Verify predictions of post-disposal conditions
3. Document site conditions and impacts of disposal
4. Provide a basis for annual review and updates to testing

To determine whether material placed at non-dispersive disposal sites complied with the Clean Water Act (CWA), a set of conditions, referred to as "Site Condition II (SCII)", was defined. SCII allows a range of "minor adverse effects" on biological resources that do not rise to the level of "unacceptable adverse impact" under the CWA. Generally, SCII allows:

- short term physical impacts to the benthic community due to burial
- some chronic sublethal effects on site
- potential increase in mortality of more sensitive, but less abundant, crustacean species
- no significant effects off site
- some bioaccumulation on site, but not enough to pose a human health problem

Further description of SCII as well as the history, development, and reasoning that underlie the current monitoring framework and DSMP are detailed in a DMMP Issue Paper finalized in 2022 (DMMP 2022).

1.3 DMMP Non-Dispersive Disposal Sites

The DMMP non-dispersive site locations are described in Table 1. Maps and descriptive information for permitting and site use are available from the current DMMP User Manual.

Table 1. Details for Non-Dispersive Disposal Sites in Puget Sound

Site	Depth[1,2]	Area[2]	Disposal Zone Diameter[2]	Target Area Diameter[2]	Site Shape	Site Dimensions[2]
Anderson/Ketron (AK)	442 ft 135 m	318 ac 128 ha	1,800 ft 549 m (circular)	1,200 ft 366 m (circular)	ellipsoid	4,400 x 3,600 ft 1,341 x 1097 m
Bellingham Bay (BB)	96 ft 29 m	260 ac 105 ha			circular	3,800 x 3,800 ft 1,158 x 1,158 m
Commencement Bay (CB)	540–560 ft 165-171 m	310 ac 125 ha			ellipsoid	4,600 x 3,800 ft 1,402 x 1,158 m
Elliott Bay (EB)	200–360 ft 61-110 m	415 ac 168 ha			teardrop	6,200 x 4,000 ft 1,890 x 1,219 m
Port Gardner (PG)	420 ft 128 m	318 ac 128 ha			circular	4,200 x 4,200 ft 1,280 x 1,280 m

Notes:

ft = feet; m = meters; ac = acres; ha = hectares.

[1] *Approximate depth of disposal zone prior to use for dredged material placement.*

[2] *All dimensions given in both US and metric measurements.*

Each non-dispersive site has a boundary that defines the area of the identified disposal site. In addition, there are sub-areas inside and outside of each site that are used to help guide both disposal and monitoring. These are defined below and shown conceptually in Figure 2.

- **Target Area:** Disposal barges should open within the target area to ensure the material is released within the disposal zone. May change over time to manage mound height or other site management objective.
- **Disposal Zone:** Area within which all material should deposit to ensure it is settled within the site boundary.
- **Site Boundary:** Area within which dredged material should be contained and where Site Condition II (SCII) applies.
- **Site Perimeter:** Line located 0.125 nautical mile outside the site boundary. Used for site management purposes, to determine if material has deposited outside the site boundary.

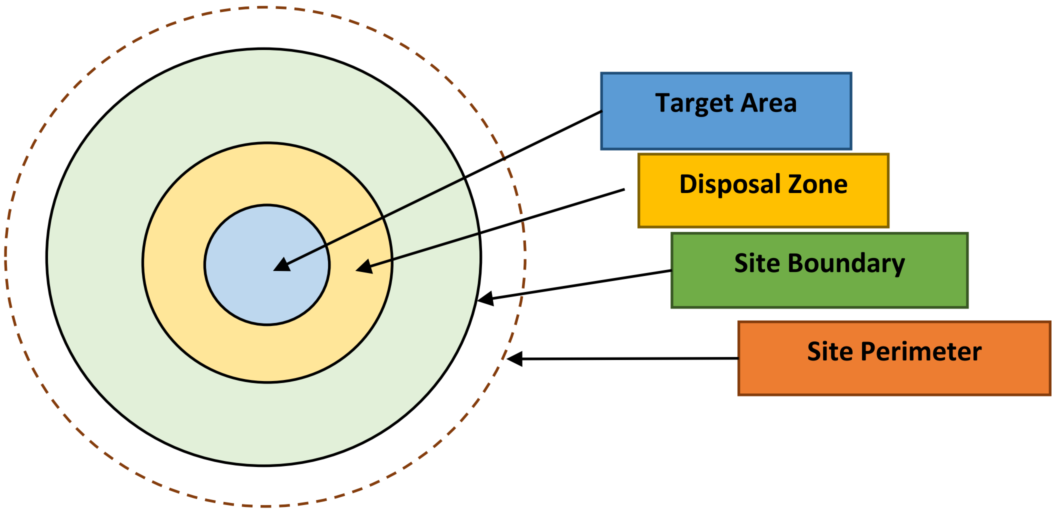

Figure 2. Conceptual Disposal Site Diagram

The distinction between "on site" (within the site boundary) and "off site" (outside the site boundary) is an important distinction under the CWA. Dredged material should be contained on site and should not cause significant impacts off site. However, regional conditions (e.g., urban contaminants) can also affect conditions both on and off site. Distinguishing between regional conditions and any potential adverse impacts from disposal site use is a noteworthy monitoring challenge.

The non-dispersive disposal sites are monitored after reaching pre-established volume triggers. These triggers have evolved over the life of the program based on past site use and monitoring results (DMMP 2021a). Monitoring continues to follow the Management Plan Report guidance (PSDDA 1988c and 1989c) and subsequent updates (DMMP 2007), and includes collecting physical, chemical, and biological data from sites to confirm that program goals are met.

In addition to meeting SCII, an additional objective of monitoring is to assure compliance with Washington State standards for sediment quality (Ecology 2013). Comparing chemical concentrations from on-site and off-site samples to the Sediment Management Standards (SMS) Part V Cleanup Screening Levels (CSL) and SMS Part III Sediment Cleanup Objectives (SCO), respectively, is intended to demonstrate that the DMMP non-dispersive dredged material disposal sites comply with the state sediment goal for reducing and ultimately eliminating adverse effects on biological resources and significant health threats to humans from sediment contamination.

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.

1.4 Limitations of the DSMP

The DSMP replaces all previous monitoring plans. It is intended solely as a guidance document for non-dispersive sites. The only monitoring of dispersive sites is occasional bathymetric surveys to verify that material does not accumulate in the disposal area. No discussion of dispersive sites is included in this document.

2 DMMP Monitoring Framework

2.1 Framework Key Concepts

Central to the DMMP disposal site monitoring framework is harmonization with the Washington State SMS (Ecology 2013) and with updated approaches for assessing bioaccumulation. The following key concepts guided development of the monitoring framework:

- The framework should address the physical placement of dredged material, determine whether there are benthic effects due to dredged material disposal, and determine whether there are bioaccumulative impacts due to dredged material disposal—both on and off the disposal site.
- Site Condition II is a range of "minor adverse effects" as defined by the federal CWA. However, previous monitoring guidance did not adequately address compliance with state sediment management standards. Distinguishing between the federal SCII guidance and state SMS guidance is important to make sure all applicable laws are addressed.
- Disposal of dredged material should not result in identification of the disposal sites as sediment cleanup sites, as defined by SMS. Therefore, conditions within DMMP disposal sites should not exceed the SMS CSL.
- Disposal of dredged material should not cause significant impacts off site. Therefore, conditions off site should not exceed the SMS SCO due to the disposal of dredged material. It is possible, however, that regional background concentrations in sediment may exceed SCO for some chemicals in some areas surrounding the DMMP disposal sites, and/or that the benthic community may be impaired by regional conditions unrelated to dredged material disposal.
- Assessment of benthic toxicity and bioaccumulation will consider both sediment chemical analyses and biological testing.
- Evaluation of benthic toxicity should be conducted on a station-by-station basis, while evaluation of bioaccumulation potential should be conducted on an area-wide basis. Decision Units (DUs) for bioaccumulation testing have been defined for both on-site and off-site areas within which sampling will be conducted and results interpreted, as described in Section 2.2 below.

2.2 Framework Structure

Most disposal site monitoring is routine. It is an important feedback tool that informs site management as well as guidelines for dredging project characterization, per the original program documentation. Over the last three decades monitoring has shown that project evaluation guidelines are working as intended, with no exceedances of SCII found on any disposal site to date. The current monitoring framework was developed to address emerging environmental concerns and updated state sediment standards while discontinuing elements of previous monitoring that were no longer useful.

Monitoring Framework Part 1: Routine Monitoring and Testing (Table 2) defines three specific questions and associated goals for routine monitoring that address whether use of the site continues to meet SCII and thus comply with the CWA. It also documents site conditions and impacts of disposal, verifies predictions of post-disposal conditions, and provides a basis for annual review and updates to testing.

Monitoring Framework Part 2: Follow-up Actions and Management Options (Table 3) is pursued if any Part 1 goal is not met. Part 2 of the framework outlines circumstances that require further investigation while acknowledging that potential findings and commensurate responses can vary widely in magnitude of impact or risk. Because environmental conditions, scientific knowledge, and relevant state and federal laws change over time, Part 2 is intended to maintain enough flexibility to effectively address site-specific issues identified in Part 1. Part 2 is discussed further in Section 5.

In keeping with DMMP policy for transparency, monitoring results are made public, with findings reported at Sediment Management Annual Review Meetings (SMARM) and in Biennial Reports.

2.3 Decision Units (DU)

Decision Units (DUs) are used in the monitoring framework to assess bioaccumulative risk on an area-wide basis. A DU is defined as the smallest area of sediment for which a decision will be made. DUs include an on-site DU identified as the Disposal Site DU (DU-DIS) and an off-site DU identified as the Environs DU (DU-ENV). The Environs DU will be used to account for regional conditions unrelated to dredged material and is particularly important for disposal sites within impacted urban waterways. A Natural Background DU (DU-NB) will be used if SMS natural background is needed to evaluate off-site material. For all DUs, sampling will occur in randomly selected locations from a fixed grid.

2.3.1 Disposal Site DU (DU-DIS)

The DU-DIS is defined as the area within the disposal site boundary. If physical surveys prior to the sampling event find ≥ 10 cm of recent dredged material at or beyond the site boundary, that additional area(s) is included as part of the DU-DIS.

2.3.2 Environs DU (DU-ENV)

The DU-ENV is used to account for regional conditions unrelated to dredged material disposal. It is defined as an area adjacent to but outside the influence of the disposal site. Test results from the composite sample representing the DU-ENV will be compared with that from the DU-DIS to evaluate whether use of the disposal site is adversely affecting on-site and/or off-site biological resources.

2.3.3 Natural Background DU (DU-NB)

The DU-NB is an area representing SMS natural background (e.g., Carr Inlet). Sediments from the DU-NB will only be sampled and tested if off-site material is detected at or beyond a given disposal site's boundary AND if the sediments from the DU-ENV do not represent SMS natural background (see Table 3). In that event, the DU-NB would be needed for interpretation of bioaccumulation data to determine whether off-site material meets SMS under Question 3.

2.4 Framework Part 1: Routine Monitoring and Testing

All monitoring begins with *Part 1: Routine Monitoring and Testing* (Table 2). If an issue is found with any of the routine monitoring questions and goals as listed below, then the monitoring process proceeds to *Part 2: Follow-up Actions and Management Options*. Below, elements of the framework are clarified beyond the contents of the table.

- **Question 1. Does the deposited dredged material stay on site?**
  - ***Goal A. Dredged material stays within disposal site boundaries.***

Goal A is not achieved if dredged material accumulation ≥3 cm is observed at or beyond the perimeter line OR if dredged material accumulation ≥10 cm is observed at or beyond the disposal site boundary.

The presence of dredged material will be monitored by sediment profile imaging (SPI), with mapping of both the 3 cm and 10 cm contours relative to the perimeter and site boundary lines, respectively. The SPI data will also be used to identify the overall footprint of observable dredged material and to inform DMMP decisions regarding disposal site management and Environs sampling. In addition, SPI images and plan view images (SPI/PV) will be interpreted to evaluate benthic habitat conditions both quantitatively and qualitatively.

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

  - ***Goal B. No long-term adverse effects to on-site benthic biological resources and habitat as defined by SCII.***

    Question 2, Goal B will be addressed by collecting sediment from five discrete sampling locations within the DU-DIS. Stratified random selection of stations will be used to assure that some samples are within the recent dredge footprint.

    Analysis of these samples is tiered, with sediment chemistry results providing a first tier of information on the health of benthic resources, and sediment bioassays used as a second tier to directly test sediments that indicate potential toxicity if exceeding DMMP Screening Levels (SLs).

    If DMMP SL chemistry guidelines are exceeded in any discrete sample, bioassay tests will be conducted on that sample and interpreted according to the DMMP interpretation guidelines (DMMP 2021b).

    Additionally, SPI/PV images will be used to qualitatively review site conditions including the presence of benthic organisms, successional stage, and other SPI/PV metrics.

  - ***Goal C. No long-term adverse bioaccumulative risk to on-site resources as defined by SCII and SMS.***

    Question 2, Goal C will be first addressed by a Tier 1 analysis that considers whether enough information already exists to evaluate this goal for a given site and monitoring event. It is expected that a Tier 1 analysis will not be sufficient until at least one round of on-site bioaccumulation data is collected from a given site. If the Tier 1 analysis indicates that bioaccumulation tests are required, it will also determine which bioaccumulative chemicals of concern (BCOCs) are of concern for the given monitoring event.

    If a Tier 1 analysis indicates that more data are required, laboratory bioaccumulation tests will be conducted and evaluated.

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

  - ***Goal D. No significant decrease in off-site biological conditions due to use of site, either from:***
    1. ***Indirect effects (always evaluated)***

2. ***Direct effects (only evaluated when dredged material is found off site such that Goal A is not met)***

Evaluating Indirect Effects. This evaluation is to determine whether there are any adverse impacts to off-site resources as defined by SMS that are NOT caused by off-site dredged material. SPI/PV survey data are used to qualitatively evaluate dredged material distribution, ambient sediment characteristics, infaunal successional stage and other physical and biological features to determine whether off-site benthic habitat quality has been adversely affected by placement of dredged material within the disposal site. Regional conditions may also contribute to off-site benthic habitat quality.

Evaluating Direct Effects. If physical monitoring finds off-site dredged material, an evaluation of direct effects to off-site biological conditions is triggered as part of the tiered metric for evaluating Question 3. The risks for both benthic impacts (tested via sediment chemistry/bioassays) and bioaccumulation (tested via laboratory bioaccumulation tests) must be evaluated. For all tests, the DU-DIS will be expanded to incorporate any off-site area with ≥10 cm of dredged material.

2.5 Framework Part 2: Follow-up Actions and Management Options

If goals for one or more routine monitoring questions are not met, some level of follow-up action must occur. *Monitoring Framework Part 2: Follow-up Actions and Management Options* outlines potential approaches for addressing unmet goals from *Part 1: Routine Monitoring* – but does not prescribe specific elements or magnitude of response. This structure requires transparent action and reporting but maintains flexibility for a wide variety of potential issues and solutions.

Part 2 is discussed more thoroughly in Section 5: Data Interpretation, Follow-up Actions and Site Management Options.

Table 2. Part 1 of Disposal Site Monitoring Framework

<table>
<tr><th colspan="5">PART 1: ROUTINE MONITORING AND TESTING</th></tr>
<tr><th>QUESTION</th><th>GOAL</th><th>METRIC</th><th>METHOD</th><th>GOAL ACHIEVEMENT GUIDELINE[3]</th></tr>
<tr><td>1. Does the deposited dredged material stay on site?</td><td>A. Dredged material stays within site boundaries</td><td>SPI/PV quantitative assessment</td><td>Conduct SPI/PV survey of site and surrounding area</td><td>< 10 cm at or beyond site boundary OR < 3 cm at or beyond site perimeter</td></tr>
<tr><td rowspan="6">2. Does deposited dredged material cause unacceptable[1,2] adverse impacts to biological conditions on site?</td><td rowspan="3">B. No long-term adverse effects to on-site benthic biological resources and habitat as defined by SCII</td><td>SPI/PV qualitative assessment</td><td>Review SPI/PV parameters including successional stage, apparent redox potential discontinuity, and others</td><td>Benthic community shows expected levels of recovery based on historical data</td></tr>
<tr><td>Sediment chemistry</td><td>Collect 5 individual 0-10 cm samples from stratified random grid within the Disposal Site DU; analyze for benthic DMMP COC list</td><td>All COCs ≤ DMMP SL</td></tr>
<tr><td>Sediment bioassays (Tiered)</td><td>Run on all samples with any COC > SL</td><td>No bioassay toxicity test exhibits a 1-hit (major) response or two 2-hit (minor) responses</td></tr>
<tr><td rowspan="2">C. No long-term adverse bioaccumulative risk to on-site resources as defined by SCII and SMS</td><td>Tier 1 analysis</td><td>Review existing on-site bioaccumulation data, project data and other relevant data[4]</td><td>Sufficient evidence of no bioaccumulative risk > SCII and SMS</td></tr>
<tr><td>Laboratory bioaccumulation tests (Tiered)</td><td>• 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</td><td>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</td></tr>
<tr></tr>
<tr><td rowspan="2">3. Does use of the disposal site cause unacceptable[1,2] adverse impacts to biological conditions off site?</td><td rowspan="2">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)</td><td>Indirect impacts: SPI/PV qualitative assessment</td><td>Review SPI/PV parameters including successional stage, apparent redox potential discontinuity, and others</td><td>Nearby off-site benthic community shows expected levels of habitat quality</td></tr>
<tr><td>Direct impacts (Tiered)
1. Sediment chemistry/bioassays
2. Laboratory bioaccumulation tests</td><td>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</td><td>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</td></tr>
</table>

Table 3. Part 2 of Disposal Site 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	PQL	Practical Quantitation Limit
BT	Bioaccumulation Trigger	SCII	Site Condition II (per CWA)
COC	Chemical of Concern	SCO	Sediment Cleanup Objective (per SMS)
CSL	Cleanup Screening Level (per SMS)	SL	Screening Level
DM	Dredged Material	SMS	Sediment Management Standards
DU	Decision Unit	SPI/PV	Sediment Profile Imaging and Plan View
EIS	Environmental Impact Statement	TTL	Target Tissue Level

3 Physical Monitoring

Physical monitoring of non-dispersive sites helps indicate where dredged material has accumulated and whether a given site is performing as expected. It includes bathymetric surveys and sediment profile imaging (SPI) and plan view (PV) surveys.

Aspects of physical monitoring help address all three questions in the framework Part 1: Routine Monitoring and Testing, as well as providing relevant information for Part 2: Follow-up Actions and Management Options. The quantitative and qualitative analyses made from the SPI/PV images provide important information for interpreting other sediment chemical and biological data. In addition, PV images complement the SPI images in characterizing benthic habitat quality and providing an overview of recently deposited dredged material. Physical monitoring thus provides the foundation upon which all other monitoring evaluations are dependent.

3.1 Routine Physical Monitoring

The specific purposes of the routine SPI/PV surveys are:

1. **Quantitative assessment (Question 1, Goal A)**: Map recently deposited dredged material to determine if the goal of keeping dredged material on site is achieved.
2. **Qualitative assessment (Question 2, Goal B and Question 3, Goal D)**: Evaluate benthic community parameters to determine if expected levels of recovery are apparent.

The SPI images are used as the primary tool to identify the presence and thickness of deposited dredged material. SPI photographs a cross-sectional image of surface sediments in profile, to a depth of up to 20 cm below the sediment/water interface (Figure 3). The area surveyed includes the disposal site and adjacent seafloor. SPI images are analyzed using a computer-based image analysis system. Characteristics measured include the thickness of the dredged material layer, major mode and range of grain sizes, roughness of the surface boundary layer, the depth of the apparent Redox Potential Discontinuity (RPD), and infaunal successional stage (Rhoads and Germano, 1982; 1986).

PV images are collected synoptically with SPI to provide qualitative information on landscape ecology and sediment topography in areas where SPI is obtained. PV images add information about surface conditions, including documenting any debris, anthropogenic or otherwise.

SPI/PV surveys should be conducted as soon as possible after the close of a given dredge window to be able to identify recently placed dredged material as accurately as possible. Benthic colonization and bioturbation have been shown to begin soon after placement, making recently placed dredged material increasingly difficult to distinguish over time. Though historical dredged material can sometimes be identified in SPI/PV photos, only recently disposed dredged material (within several months, with decreasing confidence even during that time frame) can be accurately identified and measured. For this reason, the entire area of the disposal site is considered impacted over time even when recent dredged material is not identified in all areas.

3.1.1 SPI/PV Station Locations and Sampling Requirements

SPI/PV images are collected from up to about 90 stations at and near each disposal site. A typical SPI/PV survey is expected to take two to four field days.

SPI/PV sample location names are used to designate groups of sample types that can be replicated across disposal sites to standardize the survey approach. The target sampling locations include many that have been used in past monitoring events, with some modifications (Table 4, Table 5). Site-specific maps as well as tables of fixed target locations are found in Section 6.

Table 4. Sample Types in SPI/PV surveys

Station Type	Fixed/ Unfixed[1]	Description	Notes
Zone (Z)	Fixed	Within disposal zone; one sample near center of target area	At the CB site, the target area is shifted within the disposal zone to manage mound height (SEIS 2009)
Site (S)	Fixed	Within site boundary but outside target zone	Number of S stations varies by site
Central Cross (C)	Fixed	Along two perpendicular lines that bisect disposal site and may extend beyond site boundary	Number of C stations varies by site
Perimeter (P)	Fixed	Along site perimeter line	P stations are roughly evenly spaced along the perimeter line around the entire site
Floating (F)	Unfixed	As-needed samples within, along, and outside of disposal site boundary	Varies by site and conditions. Floating stations will be used as necessary to define ≥ 3 cm and ≥ 10 cm contours of recent dredged material, and to evaluate benthic community health

[1] *Coordinates of fixed stations listed in Section 6; unfixed stations used as necessary for a given event.*

Table 5. Number of fixed stations per site.

Site	Zone	Site	Central Cross	Perimeter	Total
Anderson/Ketron (AK)	1	13	10	16	**40**
Bellingham Bay (BB)	1	7	8	8	**24**
Commencement Bay (CB)	1	10	12	12	**35**
Elliott Bay (EB)	1	21	8	13	**43**
Port Gardner (PG)	1	13	13	15	**42**

The use of floating stations is expected to fill in necessary site-specific and event-specific information and are intended to maximize flexibility. The standard sampling approach is to first occupy the perimeter, central cross, and zone stations to determine the overall trend of the recent dredged material deposit. Subsequent sampling stations are then used to delineate the edges of the deposit. If a wider distribution of dredged material is expected at a site, a low-density survey grid can be used during the first survey day that spatially covers the expected dredged material footprint.

At each station, the SPI/PV camera will be deployed for a minimum of three replicate drops to obtain three, analyzable SPI images and at least one analyzable PV image. Those stations for which less than three analyzable SPI images are obtained must be re-occupied as it is the SPI imagery that provides the key information of presence and thickness of deposited dredged material. Up to three replicate PV images will be analyzed per station.

3.1.2 SPI/PV Sampling Vessel and Navigation

SPI/PV survey operations need to be conducted by a vessel equipped to deploy and recover the SPI/PV camera system at disposal site depths (100 - 560 feet; 30.5 – 171 meters). Positioning and navigation systems used must be capable of the following:

1. Horizontal datum: NAD83, HPGN83, HARN83 or WGS84
2. Horizontal positioning system and accuracy of sampling stations must be <± 3 meters
3. 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. Quality control procedures for navigation and positioning must be designed to maintain records and accuracy throughout the field operations

3.1.3 SPI/PV Camera Operations and Image Analysis

The SPI system used must be capable of obtaining a cross-sectional image of surface sediments in profile to a depth of approximately 20 cm below the sediment/water interface. System deployment is illustrated in Figure 3.

Image analysis should include the following variables:

- optical prism penetration depth
- presence/absence of dredged material
- thickness of dredged material layer
- sediment grain size major mode and range
- surface boundary roughness
- presence and characteristics of mud clasts
- apparent redox potential discontinuity (RPD) depth
- infaunal successional stage
- organic loading (indicated by such features as methane gas, thiophilic bacterial colonies, and extremely dark [sulfide-rich] sediment)
- biological structures (e.g., burrows, fecal pellets, feeding voids, burrows, tubes)
- classification of surface type and grain size characteristics
- presence/absence of anthropogenic debris
- identification and enumeration of flora and fauna visible on the seafloor
- an overall assessment of benthic habitat quality at the disposal site

3.1.4 SPI/PV Image Interpretation

Quantitative assessment (Question 1, Goal A): Mapped accumulations of recent dredged material will include trace amounts (no measurable layer, but evidence of dredged material such as clasts or partially mixed sand), 3 cm, and 10 cm layers. Goal A is not achieved if dredged material accumulation ≥3 cm is observed at or beyond the perimeter line or if dredged material accumulation ≥10 cm is observed at or beyond the disposal site boundary. If Goal A is not achieved, monitoring must proceed to Part 2: Follow-Up Actions and Management Options.

Qualitative assessment (Question 2, Goal B and Question 3, Goal D): Analysis of physical and biological parameters in the SPI/PV images provides an important assessment of benthic habitat quality at and around the disposal sites. SPI/PV is used to verify the prediction that recolonization of dredged material deposits occurs within expected timeframes, and that re-established habitat conditions (where there has been dredged material accumulation) eventually become similar to nearby areas. "Expected time frames" are not defined here due to the nature of site use: benthic habitats are disrupted whenever disposal takes place, which varies greatly both within and between sites. "Similar to nearby areas" is used to account for area-wide influences such as changes in weather, climate, or the nearby built environment. This qualitative assessment is a weight-of-evidence approach based on assessment of the following key SPI/PV parameters:

- **Apparent Redox Potential Discontinuity (aRPD).** The aRPD visually estimates the depth of oxygenation in the upper sediment column and can be considered the depth to which biological mixing by organisms and/or physical mixing are most prevalent.
- **Infaunal Successional Stage.** Infaunal succession following a major seafloor disturbance initially involves pioneering populations (Primary or Stage I succession) of very small organisms that live at or near the sediment/water interface (Rhoads and Germano 1986). In the absence of further disturbance, infaunal deposit feeders eventually replace these early successional assemblages. The start of this "infaunalization" process is designated as Stage II. Large, deep-burrowing infauna (Stage III taxa) represents a high order successional stage typically found in areas of low disturbance.
- **Methane Gas or Reduced Sediment.** Any evidence of organic enrichment as indicated by the presence of subsurface methane gas or extremely dark (sulfide-rich) sediment.
- **Biological Structures.** Presence of biological sediment surface structures (fecal pellets, tubes, pits, and mounds) and subsurface structures (infaunal structures, burrows, and oxic voids).

Other SPI parameters analyzed and reported include sediment grain size (major mode and range), optical prism penetration depth, surface boundary roughness, and presence and characteristics of mud clasts, as follows:

- **Sediment Grain Size.** The sediment grain size major mode and range, in phi units, are visually determined from the SPI images by comparison with grain size scales. The most common grain size comparator is a series of seven Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes): ≥ 4 phi (silt/clay), 4 to 3 phi (very fine sand), 3 to 2 phi (fine sand), 2 to 1 phi (medium sand), 1 to 0 phi (coarse sand), 0 to -1 phi (very coarse sand), and < -1 phi (gravels). The lower limit of optical resolution is about 62 µm, allowing recognition of grain sizes equal to or greater than coarse silt.
- **Prism Penetration Depth.** The prism penetration depth is determined by measuring both the largest and smallest linear distance between the sediment-water interface and the bottom of the SPI image. Observations regarding the nature and condition of the sediment-water interface are recorded. Comparative penetration depths from stations of similar grain size give an indication of relative sediment water content and shear strength.
- **Surface Boundary Roughness.** Surface boundary roughness is determined by measuring the vertical distance (parallel to the image border) between the highest and lowest points of the

sediment-water interface. The origin of this small-scale topographic relief is sometimes evident and can be recorded. In most cases, this is either biogenic (mounds and depressions formed by bioturbation or foraging activity), or relief formed by physical process (ripples, scour depressions, rip-ups, mud clasts, etc.) or presence of shell fragments or lag deposits.

- **Mud Clasts.** When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging), intact clumps of sediment are often scattered about the seafloor. Following dredged material disposal, relict sediment clumps may also be present on the seafloor. Mud clasts may be moved about and broken by bottom currents and/or animals (macro or meiofauna) (Germano 1983). The abundance, distribution, oxidation state, and appearance of mud clasts can be used to make inferences about the recent pattern of seafloor disturbance.

Plan view images provide useful information on the landscape ecology and sediment topography in areas where SPI is obtained and assist in characterizing benthic community response. Plan view images will be evaluated for evidence of physical disturbance (e.g., ripples, irregular or chaotic surface from recent dredged material disposal), biological features (e.g., burrows, feeding structures), classification of surface type and grain size characteristics, presence of anthropogenic debris, and identification and enumeration of flora and fauna visible on the seafloor. Underwater scaling lasers allow for density counts (number per square area) of burrows, tracks/trails, tubes, epifaunal organisms, and other features not always captured in SPI. Information on sediment transport dynamics and bedform wavelength can also be determined using plan view image analysis. Water clarity is extremely important for plan view image collection and can vary widely from site to site.

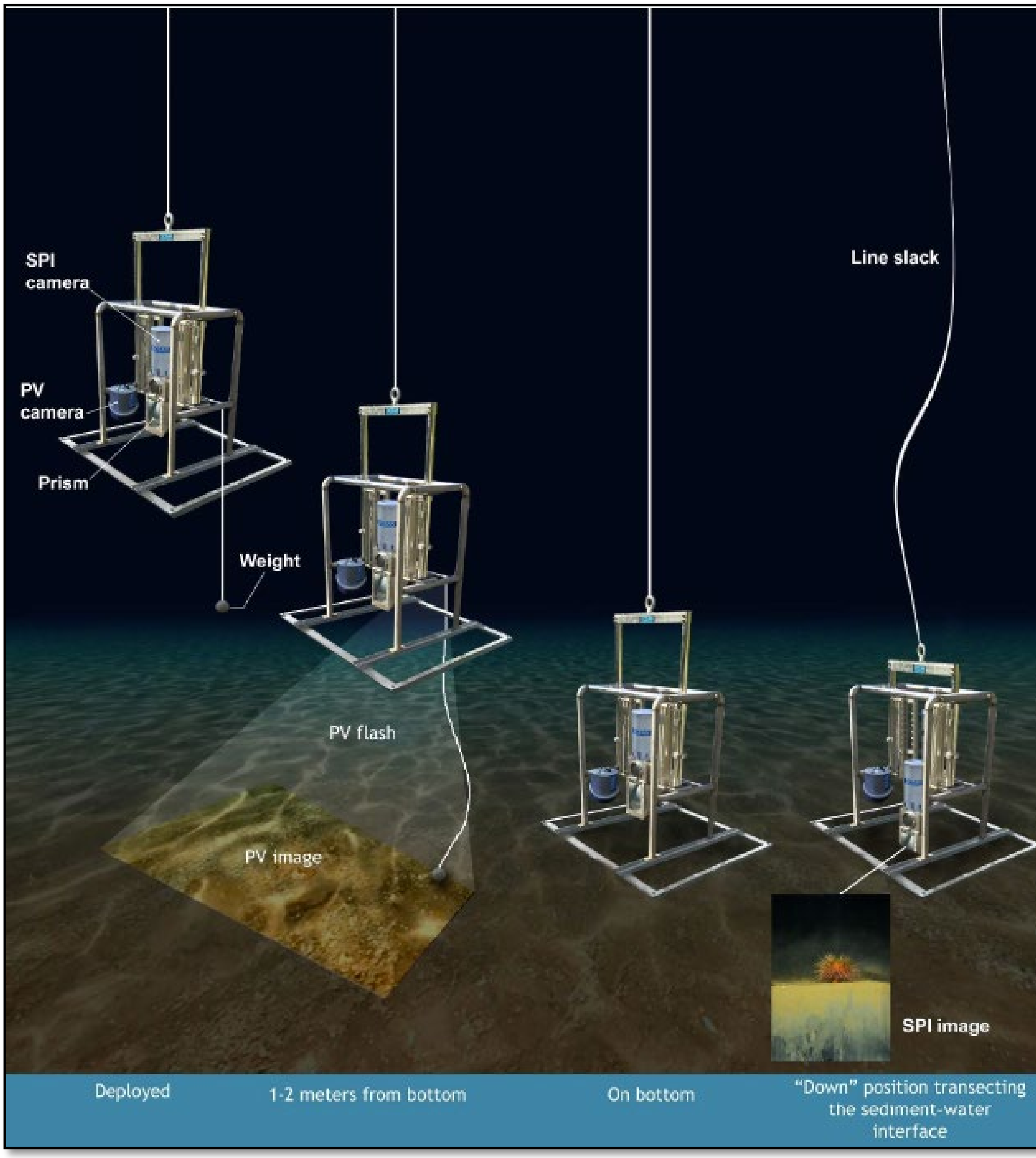

Figure 3. Illustration of SPI/PV Deployment (from Integral and EcoAnalysts 2020)

4 Chemical and Biological Monitoring

Chemical and biological methods are used to address monitoring Questions 2 and 3 in the framework Part 1: Routine Monitoring and Testing. These questions ask whether deposited dredge material causes unacceptable adverse impacts to biological conditions **on site** (Question 2), and whether use of the disposal site causes unacceptable adverse impacts to biological conditions **off site** (Question 3).

4.1 Routine Chemical and Biological Monitoring

The specific purposes of the routine chemical and biological monitoring methods are:

1. **Benthic Evaluation (Question 2, Goal B and Question 3, Goal D if there is off-site material such that Goal A is not met)**: Test sediments from the DU-DIS to determine whether there is unacceptable toxicity to benthic resources.
2. **Bioaccumulative Risk Evaluation (Question 2, Goal C and Question 3, Goal D if there is off-site material such that Goal A is not met)**: Test sediments and tissues from the DU-DIS to determine whether there is unacceptable bioaccumulative risk to biological conditions.

Sediment sampling required for a given monitoring event should occur after SPI/PV surveys but prior to any further disposal.

4.1.1 Sampling Approach

The sediment sampling design for the monitoring framework is based on the development of a sampling station grid within designated DUs. Systematic grid sampling is used for this monitoring plan to designate sample locations that ensure uniform coverage of DUs while keeping some consistency over time. Randomized sampling within a grid provides statistically unbiased estimates of mean and variability.

For benthic evaluations, five DU-DIS discrete samples are tested for toxicity with a tiered approach: sediment chemistry is analyzed first to determine if any DMMP chemicals of concern (COCs) exceed program SLs. If so, those samples are then subjected to bioassay testing for a second-tier evaluation of benthic toxicity. If possible, at least two of the five discrete benthic samples should be in recent dredged material.

For bioaccumulative risk evaluations, one composite sediment sample from 20 stations in each DU is collected for both chemical and biological tests. The composite sediment samples are tested to determine levels of any BCOCs. They also are used for laboratory bioaccumulation tests, which use test sediments as substrate for holding benthic invertebrates in the laboratory for up to 45 days. Tissues are collected from both test and pre-test organisms and submitted for chemical analysis for DMMP BCOCs. Pre-test organisms are a subset of the population of test organisms that are not exposed to test sediments.

4.1.2 Sampling Methods

The 0.2-m^2 double van Veen or equivalent will be the primary sediment sampler for the monitoring program. If the substrate is unconsolidated and too soft for the van Veen sampler, a 0.06-m^2 Gray O'Hara box-corer is a suitable alternative sampler. Surface sediment sampling will target the top 10 cm of sediment.

Sample collection procedures will follow standard Puget Sound Estuary Program (PSEP) guidelines (PSEP 1997a, b, 1998) with applicable DMMP updates as described in the current DMMP User Manual. Additional factors and logistical considerations in applying the updated DMMP disposal site monitoring framework are discussed below.

4.1.3 Defining Decision Unit Boundaries

Disposal Site DU (DU-DIS). In general, the boundary of the DU-DIS is the same as the boundary of the disposal site historically used (Figure 1). If ≥10 cm of dredged material is measured beyond this boundary during a monitoring event, this additional area will be included as part of the DU-DIS, in order to: 1) comply with bioaccumulation goals as an area-weighted average comparison, and 2) to provide additional power for the statistical comparison to compliance standards.

DU-DIS sampling station grids, which identify all possible random station locations at a given site, have been defined by the DMMP agencies and remain fixed. The DU-DIS samples/composite is made up of random samples whose locations are chosen from the given station grid for each sampling event.

Maps of site-specific DUs are provided in Section 6.

Environs DU (DU-ENV). Delineation of the DU-ENV boundary should follow the guidelines listed below (Table 6). However, site-specific conditions at the disposal sites (e.g., bathymetry, currents, and off-site sources of sediment) could warrant adjustments to the boundary determination. Some areas may be excluded if they represent outliers to Environs conditions (e.g., cleanup sites, sediment cap locations, river delta material, etc.). Other environmental data may indicate areas unsuitable for inclusion in an DU-ENV, including locations of potential contaminant sources.

It is expected that the DU-ENV will be established for each site prior to its first monitoring under this framework and will also be used for subsequent monitoring events at a given site. However, new information, changes in applicable state or federal regulations, movement of dredged material off site, or influence of other environmental conditions may necessitate future adjustments. The DU-ENV for Port Gardner and Elliott Bay have been determined and are included in the site-specific information in Section 6. Once established for other sites, DU-ENV figures and sample station coordinates will be added to Section 6.

Natural Background DU (DU-NB). A DU-NB has been defined in Carr Inlet (Figure 16) though other DU-NBs could be defined in the future. The boundary of the DU-NB in Carr Inlet followed the boundary parameters used to evaluate background dioxin/furan and PCB congeners in Carr Inlet sediments during the Ocean Survey Vessel (OSV) *Bold* study in Puget Sound (DMMP 2009). A 500-meter (1,640-foot) buffer was placed around known outfalls or known contaminant sources and a 250-meter (820-foot) buffer was placed around points that exceeded DMMP screening level guidelines. The boundary for the Carr Inlet DU was a 500-meter (1,640-foot) buffer from the shoreline.

Table 6. Steps for Defining an Environs Decision Unit

Action	Details
Define Depth Boundaries	To approximate similar habitat and sedimentation, depth boundaries should not vary too widely from those found on the disposal site. Depth range should not vary more than about 50 feet (15 meters) deeper than the deepest point of the original disposal site boundary and 50 feet (15 meters) shallower than the shallowest point of the original site boundary. See Table 1 for original site depths.
Define Inner Boundary	To avoid potential influence of dredged material, incorporate a minimum 150-foot (46-meter) buffer around the site boundary. In addition, allow a similar buffer around the cumulative footprint of any trace dredged material outside the site boundary. This buffer corresponds to the assumed van Veen wire angle for sampling in 420-foot (128-meter) deep water, adjustments to the buffer will be needed for deeper disposal sites.
Define Outer Boundary	The DU-ENV should be entirely within the same water body as the DU-DIS.
Define Exclusions	In addition to depth and waterbody boundaries, avoid other point sources or conditions. These could include defining buffers around shorelines, river deltas, cleanup sites at any stage of remediation, legacy disposal areas, known “hot spots,” or other sources of contamination or sediment input.
Overlay Sampling Grid	A sampling grid that allows for sample independence is placed over the DU-ENV, with a target sample location defined in the center of each grid square. Samples from 20 different grid squares are required for an DU-ENV sample; at least 30 grid locations are recommended for a sampling grid.

4.1.4 Defining DU Sampling Station Grids

Disposal Site DU. Sampling station grid spacing within the DU-DIS does not require sample independence, as most disposal site stations are expected to have potential impacts from dredged material disposal activities. To provide a grid that avoids overlap between sampling areas that could be created by a van Veen grab wire angle during sediment sampling activities, a grid spacing of 125 meters (410 feet) was selected. This spacing also results in a reasonable number (68 – 106, depending on the disposal site) of locations available for selection of a random subset of 20 actual sampling stations.

If excursions of recent dredged material ≥10 cm in depth extend beyond the disposal site boundary, the DU-DIS will be extended to include those areas. Selection of potential sample areas within the off-site material will be made depending on site, extent of off-site material, and other project-specific variables.

Environs DU. Sampling station grid spacing for the DU-ENV should allow for sample independence and a minimum of 30 total potential stations from which to select a random subset of 20 actual sampling stations. A grid using a specified distance of 250 to 500 meters (820 to 1,640 feet) between sample locations should be used in the Environs area, with target sample locations placed at the center of each cell. Grid spacing will vary depending on DU-ENV boundaries and space limitations and will be determined by the DMMP agencies using best professional judgment (BPJ). If a target sample location falls within the DU-ENV boundary, that sample may be included even if the entire grid cell is not within the DU-ENV boundary.

Once the sampling station grid is established it will remain fixed.

Natural Background DU. If dredged material is observed off site such that Goal A is not achieved, sediments may also be collected from a DU-NB. Data from the DU-NB will be used to evaluate whether impacts from dredged material beyond the disposal site boundary exceed the SMS SCO. Like the DU-ENV, the DU-NB sampling station grid spacing requires sample independence. A Carr Inlet DU-NB has been defined, but others may be defined as needed for future monitoring. For the Carr Inlet DU-NB, a 1,000-meter (3,281-foot) grid spacing was applied. This grid spacing maintained sample independence and resulted in 56 sampling station locations available for random selection of 20 stations within the DU-NB boundary (Figure 16).

4.1.5 Sampling for Bioaccumulative Risk Evaluation

Bioaccumulation sampling requires a composite of sediment from 20 locations from a DU sampling grid. Stations should be selected from a given DU using a method that balances random selection with spatial balancing.

For the Port Gardner pilot monitoring event stations were randomly selected from the station grids using the ArcGIS Geostatistical Analyst tool “Create Spatially Balanced Points” to select spatially balanced sampling locations. This or similar equivalent method may be used.

The method chosen should specifically accommodate potential changes in the dredged material footprint by allowing for adjustment to individual cell probabilities in the sample selection process. A cell probability adjustment maintains the randomness of selection while insuring spatial balance in the distribution of the randomly selected sample locations.

From each DU, twenty subsamples will be collected during each monitoring event, randomly selected from the available sampling locations on the site grid. The method chosen for sampling station selection should be spatially weighted to ensure representativeness of the area sampled.

For the DU-DIS, on-site subsample locations will be selected regardless of the presence or absence of dredged material. If there is off-site material with ≥10 cm of dredged material, potential sample locations will be added to the pool of DU-DIS stations with at least one of the 20 selected as part of the DU-DIS composite sample. The method for selecting potential off-site stations will incorporate sample spacing guidelines but otherwise will be dependent on a BPJ evaluation of extent and location of material.

The 20 subsamples within each DU will be composited following procedures from the current DMMP User Manual. The composited bioaccumulation sediment sample will be analyzed for conventionals and the DMMP List 1 BCOCs as well as PBDEs, as shown in Table 7. Bioaccumulation and subsequent tissue testing will be conducted as outlined in Section 4.1.8.2.

4.1.6 Sampling for Benthic (Toxicity) Evaluation

Five sampling stations will be selected within the DU-DIS for tiered benthic testing. These stations will be selected from the 20 bioaccumulation sampling stations and, if possible, should include at least two stations within recent dredged material (determined by SPI). Discrete sediment samples will be collected from each of the 5 selected stations. Up to three field samples will be collected for compositing at each station to insure there is sufficient sediment if bioassay testing is required.

Samples will initially be analyzed for the DMMP COC list (Table 8). If any SL in any given sample is exceeded, bioassay tests will be conducted on that sample.

If bioassay testing is required, reference sediment sample(s) will be collected from an approved DMMP reference area. Selection of reference samples will be based on comparable grain sizes to the on-site benthic samples. Bioassay results from on-site material are interpreted according to DMMP guidelines as defined in the current User Manual.

If one or more lobes with ≥10 cm of dredged material are observed beyond the disposal site boundary, the DU-DIS will be extended into those areas. A total of five benthic samples will still be collected, but at least one sample will be collected from the off-site area. If any SL is exceeded in sample(s) from the off-site area, bioassay tests will be conducted for those samples and interpreted according to the SMS SCO interpretive criteria. If a very large lobe area is present, the DMMP agencies will consider whether modifications to the sampling design may be needed.

4.1.7 Sampling Sediment Compositing and Volumes

Sample homogenization procedures will follow PSEP and DMMP guidelines (PSEP 1997 a,b and DMMP 2021 or current User Manual).

Sample compositing methods and processing location (e.g., vessel or laboratory) will be determined as part of the site-specific SAP, once the sampling vessel and laboratory are selected. In general, it is expected that compositing in the laboratory may be preferred for sediments collected for bioaccumulation testing due to the large volumes of sediment involved. The proposed homogenization tools and their applications based on anticipated sediment volumes should be presented in the site-specific SAP.

4.1.7.1 Bioaccumulation Testing Compositing and Volume

Sample compositing for bioaccumulation testing will follow an incremental approach, in which an equal volume of sediment is collected from each station location within a DU and combined into one composite sample for that DU. This method of compositing ensures that each point sample is equally represented within the DU composite and provides a concentration that represents the mean of the area sampled.

For laboratory bioaccumulation testing, a minimum of 73 liters for each composite sample is required. Composite volumes needed are:

- Bioaccumulation testing (assume up to 45-day test duration) – 71 liters
    - Volume based on exposure of two species in separate test chambers with five replicates each. Includes volume for weekly sediment addition.
- Bioaccumulation sediment chemistry – 2 liters

4.1.7.2 Benthic Toxicity Testing Compositing and Volume

A minimum of 9 liters are needed from each of the 5 discrete benthic toxicity station, for use as follows:

- Sediment chemistry – 3 liters
- Bioassay testing – 6 liters (initially archived; only used if tiered testing required)

4.1.8 Sediment Chemical and Biological Testing and Analytical Methods

4.1.8.1 Physical and Chemical Analyses

All physical and chemical analyses will be carried out in accordance with DMMP guidance (DMMP 2021b or current User Manual). Analyses required for this DSMP are detailed in the following tables:

- Sediment (bioaccumulation and benthic) and tissue target analyte lists - Table 8
- Sediment sample analytical methods and volumes - Table 9
- Tissue sample analytical methods and volumes - Table 10

The *minimum* sample volumes in Tables 9 and 10 represent the amount that the laboratory would need to meet project detection limits below screening levels for one analytical run on one sample, providing that significant matrix interferences are not present. The *target* sample volumes listed in Tables 9 and 10 account for additional volume that may be required to resolve matrix interferences, meet project detection limits, and run project-specific laboratory quality control samples.

4.1.8.2 Bioaccumulation Testing

The composite sediment samples from relevant DUs are used for both sediment laboratory analysis and as the exposure medium for laboratory bioaccumulation testing. Laboratory bioaccumulation tests will use both a suspension-feeding/filter-feeding organism and a burrowing deposit-feeding organism in accordance with DMMP guidance, with modifications as discussed below.

Sediment Laboratory Analysis. The composited bioaccumulation sediment samples from all DUs will be analyzed for conventionals and BCOCs[1] listed in Table 7.

Laboratory Bioaccumulation Testing. The DMMP recommends using the polychaete *Alitta virens* as the deposit-feeding organism for monitoring bioaccumulation tests, rather than *Nephtys caecoides*, the burrowing organism typically recommended for DMMP project evaluation bioaccumulation tests. This is because the amount of tissue needed for analysis of all BCOCs is much greater than that needed for a typical project evaluation test, where tissue analysis is needed only for those BCOCs which exceeded a sediment BT. The bivalve *Macoma nasuta* is the recommended filter-feeding organism. Use of other species could be considered if approved by the DMMP.

Macoma and *Alitta* should be exposed in separate chambers. Use of either static renewal or flow-through water circulation systems is acceptable. If a flow-through system is used, 4-6 water circulation exchanges per 24-hour period is recommended. Any deviation from these protocols could be considered but would need to be proposed and explicitly approved by the DMMP prior to sampling.

Bioaccumulation Tissue Analysis. For monitoring purposes, tissues from both exposed and pre-test organisms will be analyzed for the list of BCOCs identified in the Tier 1 evaluation.

To provide sufficient tissues for these analyses, as well as for total solids and lipids, a minimum of 64 g of wet tissue is needed from *each replicate for each species*. Pre-test tissues (pre-exposure) from the same population as those used for exposure tests are required, in triplicate. Modifications to these requirements can only be made by specific approval from the DMMP prior to testing.

[1] PCB congeners in sediment are analyzed in addition to PCB Aroclors for comparison to tissue concentrations (which are only measured as congeners).

At least one round of monitoring at each disposal site will analyze tissues for all List 1 BCOCs (as listed in Table 7).

4.1.8.3 Bioassay Testing

Material collected for bioassays is archived until sediment chemical analysis results are received, and the benthic COC SL comparisons made. Bioassays are conducted if chemical analysis of a given benthic sediment sample (of the five benthic samples randomly chosen from the DU-DIS) results in detected or non-detected exceedances of any benthic COC SL.

For bioassays conducted under this framework, the standard DMMP suite of three bioassays will be used to characterize the benthic toxicity of whole sediments: a 10-day amphipod acute test, a sediment larval test, and the 20-day Neanthes growth test. For the amphipod test, *Eohaustorius estuarius* is the recommended test species when clay content is less than 20 percent, and *Ampelisca abdita* is the recommended test species when clay content is greater than 20 percent. For the sediment larval test, the sand dollar *Dendraster excentricus* or the bivalve *Mytilus galloprovincialis* are the recommended test species. Bioassay testing procedures should follow PSEP (1995) with modifications as specified by the DMMP in the current User Manual.

Reference sediments for bioassay tests are collected from one of the reference sediment collection sites in Puget Sound (usually Carr Inlet). The fines content (silt + clay) of the reference material should fall within 10% of the fines content of the test sediments.

Bioassay test sediments will always be from the DU-DIS but may not always be from within the disposal site boundary. If there is off-site material, and if the benthic sample from the off-site material has an exceedance of a DMMP SL, then bioassays will be used to determine benthic toxicity in the off-site area. In this case, results will be compared with Ecology SMS benthic guidelines to determine whether material meets the SCO state-wide sediment quality objective.

Table 7. DMMP List 1 Bioaccumulative Chemicals of Concern (BCOCs)

Chemical	BT (dry wt[1])
Arsenic	507.1 mg/kg
Lead	975 mg/kg
Mercury	1.5 mg/kg
Selenium	3 mg/kg
Tributyltin (bulk sediment)[3]	73 ug/kg
Fluoranthene	4,600 ug/kg
Pyrene	11,980 ug/kg
Hexachlorobenzene (HCB)	168 ug/kg
Pentachlorophenol	504 ug/kg
Total DDT (sum of 4,4'-DDD, 4,4'-DDE and 4,4'-DDT)	50 ug/kg
Chlordane[2]	37 ug/kg
Dioxins/Furans	10 ng/kg
Total PCBs	38 mg/kg OC

Notes:

[1] Except as noted otherwise.

[2] Chlordane includes cis-Chlordane, trans-Chlordane, cis-Nonachlor, trans-Nonachlor, and oxychlordane.

[3] Porewater may need to be analyzed if TBT contamination is suspected.

Table 8. Sediment and Tissue Analytes for Monitoring

	Bioaccumulation Composites		Discrete Grabs
Analyte [1]	**Tissue BCOCs [2]**	**Sediment BCOCs [2]**	**Sediment Benthic Toxicity [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

	Bioaccumulation Composites		Discrete Grabs
Analyte [1]	Tissue BCOCs [2]	Sediment BCOCs [2]	Sediment Benthic Toxicity [3]
Zinc	--	--	X
Organometallic Compounds			
Tributyltin ion (bulk)	X	X	--
Polycyclic Aromatic			
Total LPAHs[7]	--	--	X
Naphthalene	--	--	X
Acenaphthylene	--	--	X
Acenaphthene	--	--	X
Fluorene	--	--	X
Phenanthrene	--	--	X
Anthracene	--	--	X
2-Methylnaphthalene	--	--	X
Total HPAHs	--	--	X
Fluoranthene [4]	--	X	X
Pyrene [4]	--	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			

	Bioaccumulation Composites		Discrete Grabs
Analyte [1]	**Tissue BCOCs [2]**	**Sediment BCOCs [2]**	**Sediment Benthic Toxicity [3]**
Benzyl alcohol	--	--	X
Benzoic acid	--	--	X
Dibenzofuran	--	--	X
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 [5]	X	--
Dioxins/Furans	X	X	--
PBDE Congeners	--	X [6]	--

Notes:

[1] Not all analytes will necessarily be analyzed for during every monitoring event.

[2] From DMMP 2021 User Manual Table 10-1.

[3] From DMMP 2021 User Manual Table 8-3.

[4] These PAHs have bioaccumulation triggers in sediments but there is no completed exposure pathway for human health risk from tissues at disposal sites, so tissue analysis not required (DMMP 2021a).

[5] Recommended based on DMMP 2021 User Manual Table 10-1.

[6] Included pursuant to NMFS Essential Fish Habitat Conservation Recommendations (NMFS 2015).

[7] 2-methynaphthalene is not included in the LPAH summation.

Table 9. Sediment Sample Analytical Methods and Volumes[1]

Chemical Analyses	Analytical Method[4]	Min. Sample Size[2] (wet wt)	Target Volume[3] (Full Suite)	Benthic Toxicity	Bio-accumulation
Chemical/Conventional Testing					
Grain size	PSEP/ASTM Mod	150 g	500 mL	X	X
Total sulfides	SM 4500-S2	5 g	60 mL	X	X
Total solids and total volatile solids	SM 2540 G	20 g	250 mL	X	X
Ammonia	SM 4500-NH3	8 g		X	X
Total organic carbon	9060 Mod	6 g		X	X
Metals	EPA 6020	22 g	125 mL	X	X (As, Pb, and Se only)
Mercury	EPA 7471	0.4 g		X	X
Organotins (bulk)	Krone *et al.* 1989	10 g	500 mL	X	X (125 ml)
Semivolatile Organic Compounds	EPA 8270	40 g		X	X
Pesticides	EPA 8081	25 g		X	X
PCB Aroclors	EPA 8082	25 g	250 mL	X	--
High-Resolution Analyses					
PCB Congeners	EPA 1668	30 g	250mL	--	X
Dioxins/Furans	EPA 1613			--	X
PBDE Congeners	EPA 1614			--	X
Archive	--	--	500 mL	X	X
Biological Testing					
Bioassay testing/archive	PSEP 2005; DMMP 2021	3 Liters	6 Liters	X	--
Bioaccumulation testing	USEPA 1993; ASTM E-1688-10; DMMP 2021	71 Liters	71 Liters	--	X
Total Sediment Sample Volume Target				***9 Liters***	***73 Liters***

Notes:

[1] Analyte groupings for sample containers are laboratory specific and should be identified in the SAP.

[2] Minimum field sample sizes for one laboratory analysis (based on lab minimum dry weight requirements; assuming minimum of 50% percent solids).

[3] Adjusted to provide additional volume for laboratory QA/QC and potential re-runs, if necessary.

[4] Analytical methods in the User Manual should be used. Other methods must be approved by the DMMP.

Table 10. Tissue Sample Analytical Methods and Volumes

Parameter	Method	Minimum Sample Size[1] (wet weight)	Target Sample Size[2] (wet weight)
Conventionals			
Total solids	SM 2540 G	5 g	10 g
Percent lipids	Bligh & Dyer	5 g	10 g
Metals			
As, Pb, Hg, and Se	EPA 6020; EPA 7471 (Hg)	3.5 g	7 g
Organotins	Krone/Unger	5 g	10 g
SVOCs			
Hexachlorobenzene	EPA 8270	10 g	20 g
PAHs			
Pentachlorophenol			
Pesticides + Hexachlorobenzene			
DDTs	EPA 8081	15 g	30 g
Chlordanes			
High-Resolution Analyses			
PCB congeners	EPA 1668	20 g	40 g
Dioxins/furans	EPA 1613		
Total Tissue Volumes		***63.5 g***	***125 g***

Notes:

[1] *Minimum volume required by analytical laboratory for one analysis.*

[2] *Adjusted to provide additional volume for laboratory QA/QC and potential re-runs, if necessary.*

5 Data Interpretation, Follow-up Actions and Site Management Options

If routine monitoring reveals one or more issue(s), then additional actions are triggered, as outlined in the Monitoring Framework *Part 2: Follow-up Actions and Management Options*. This section clarifies elements of Part 2 beyond the contents of the framework table.

The “issue Found” column of Part 2 specifies the criteria for meeting each goal. Part 2 also 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.

5.1 Issue Found: Proceeding to Part 2

5.1.1 Question 1, Goal A - Off-site Material Identified?

If physical monitoring identifies dredged material at a thickness of ≥10 cm at or beyond the site boundary, or ≥3 cm at or beyond the site perimeter line, Goal A is not met, and further evaluations are needed. Physical monitoring (SPI/PV surveys) map trace, 3 cm and 10 cm contours of recent dredged material. Because physical monitoring is not done after every dredging year this mapping may not find all off-site material. However, the SPI/PV surveys also map benthic habitat indicators that may provide indirect indicators of previous off-site material.

Per Section 2.3.1, only off-site material ≥10 cm will be included in the Disposal Site Decision Unit (DU-DIS). Off-site material < 10 cm thickness is excluded because sediment grab sampling targets the top 10 cm of sediment; if native material is included in that sample, results may be biased.

5.1.2 Question 2, Goal B - Toxicity in DU-DIS Discrete Sediment Sample(s) Identified?

Goal B concerns benthic toxicity in the DU-DIS. For discrete sediment samples taken within the site boundaries, the standard for meeting Goal B is SCII, and exceedance of one or more DMMP SL(s) triggers bioassays. Results from those bioassays are interpreted per DMMP guidelines.

Results are also evaluated for compliance with SMS CSL (Ecology 2013) to ensure that benthic toxicity does not exceed the maximal allowed biological response.

If any discrete sample is from off-site material, the standard for meeting Goal B is SMS SCO. In this case the sediments are tested for the same standard set of DMMP COCs that is used for on-site material but interpreted via SMS under Question 3, Goal D.

Because sediment toxicity may be localized, follow-up actions to identify sources will be very site- and project-specific.

5.1.3 Question 2, Goal C - Bioaccumulation Risk in DU-DIS Sediment or Tissue Sample(s) Identified?

Goal C concerns bioaccumulation risk in the DU-DIS. Initially, a Tier 1 evaluation looks at project data, disposal history, or other data sources to determine whether laboratory bioaccumulation tests are needed to address Goal C. It will also determine which BCOCs are of concern for tissue analysis. The DU-DIS sediment samples will always be analyzed for all current BCOCs.

Bioaccumulation data from the DU-DIS will be interpreted via SCII guidelines. Goal C is not met if 1) any BCOC from the DU-DIS sediment sample exceeds the DMMP Bioaccumulation Trigger (BT), and/or 2) any BCOC from DU-DIS tissues exceed DMMP Target Tissue Levels (TTL; DMMP 2021b).

5.1.4 Question 3, Goal D - Decrease in Off-Site Biological Conditions Identified?

5.1.4.1 Indirect Effects.

For interpretation of bioaccumulation data, sediment composites and laboratory tissue chemistry results from within the DU-DIS will be compared to the highest of 1) natural background (represented by tissues from the DU-ENV or DU-NB composite sample, whichever is determined to be appropriate), 2) risk-based values such as TTLs, and 3) practical quantitation limits (PQLs). DMMP will apply best professional judgment to interpret the results in the context of regional regulations.

5.1.4.2 Direct Effects.

To determine whether a given sample must undergo bioassays, all results for analytes on the SMS SCO list will be compared to those guidelines. This may require converting result data from a dry weight basis to organic carbon normalized. If any SMS SCO guideline(s) are exceeded, the sample must undergo bioassays. Those bioassays will be interpreted per SMS (Ecology 2013).

5.2 Evaluations Needed

Documentation of findings and follow-up actions are required whenever a routine monitoring goal is not achieved. Follow-up evaluations are always determined by specifics of the issues found. If any Goal is not achieved, Part 2 of the framework outlines a general process that must be followed. The extent and details of that process will always be very site- and project-specific. Any action by the DMMP will be based on careful evaluation of the monitoring results and an interpretation of these findings relative to potential ecological significance (PSDDA, 1988a).

5.2.1 Goal A Not Achieved – Evaluations Needed

Should Goal A not be achieved, Part 2 of the framework requires addressing the extent, causes, and impacts of off-site material, per the following outline:

1. What is the extent of off-site material?
    a. Addressed as part of SPI/PV survey mapping of trace, 3 cm and 10 cm contours. Mapping of benthic habitat indicators can assist in evaluating extent of off-site adverse impacts.
    b. Do physical parameters such as grain size indicate the potential source of the material?
2. What are potential causes of off-site material?
    a. Were there known releases of material outside the target area?
    b. Do physical parameters such as grain size indicate whether material drifted from the target area, or if material was deposited outside the target area?
    c. Are there local conditions that could have carried material off site, such as currents or tidal fluctuations?

5.2.2 Goals B, C or D Not Achieved – Evaluations Needed

If Goals B, C or D are not met during routine monitoring, then follow-up actions are required. The monitoring framework describes explicitly what guidelines must be met to achieve a given goal – but follow-up actions are entirely based on the specific issue found.

The outline for addressing all these questions is the same, though details may again be very different for any given monitoring event:

1. Identify type and extent of impact (e.g., benthic sample failure, or bioaccumulation DU-DIS risk exceeds DU-ENV risk)
    a. Were adverse effects localized?
    b. What was the severity of adverse effects?
2. Identify potential causes of adverse impact(s)
    a. Were effects potentially caused by a specific project (e.g., evidence of recent DM associated with impact?)
    b. Are there indications that project evaluation did not adequately assess risk?
3. Determine severity of adverse impact
    a. Are more data needed to assess impact?

5.3 Site Management Options

5.3.1 Prevention of Off-Site Material

Prevention of off-site material is central to the DMMP disposal site management. Some options for prevention of off-site drift of dredged material include:

- Modification of disposal site target area
- Limiting disposal during times of high tidal exchange or currents
- Directing vessel approach direction or transit speed

5.3.2 Prevention of Unacceptable Adverse Impacts

Identification of potential preventative measures is dependent on the identified cause and extent of unacceptable adverse impacts. If there are indications that current project evaluation guidelines are not sufficient maintenance of SCII at the disposal site, or of SMS off the site, then modifications to those guidelines should be considered. These could be modifications to the COC lists, adjustments to guideline levels (SLs or BTs), or adjustments to project rank or sampling density guidelines. It is likely that additional studies would be necessary before appropriate project guidelines could be made.

5.3.3 Mitigation or Remediation of Unacceptable Adverse Impacts

In extreme cases, mitigation or remediation of unacceptable adverse impacts may be necessary either on or off the site. Possibilities such as cover with suitable material, specialized monitoring, or temporary site closure may be considered. These measures would be fully coordinated and communicated per DMMP reporting requirements.

6 Site-Specific Monitoring Plans

The general monitoring plan is adapted to each of the disposal sites based on physical and biological conditions at the site, anticipated annual loading, and proximity of potential contaminant sources to the disposal site (PSDDA 1988a). This DSMP was also informed by site-specific use and monitoring results from 1989 – 2021 that were compiled into a status paper in 2022 (DMMP 2022b); those details are not repeated in this document.

Further modifications to the site-specific monitoring plans may be adopted by the DMMP as site use or environmental conditions change over time.

The DMMP uses volume-based monitoring triggers for all five non-dispersive open-water disposal sites in Puget Sound. When the cumulative dredged material volumes placed at a given site since the last monitoring approaches the volume trigger, a monitoring event is scheduled. These are "soft" triggers that may be adjusted based on project status, funding, or other programmatic considerations.

- Anderson/Ketron: 150,000 cy
- Bellingham Bay: 150,000 cy
- Commencement Bay: 500,000 cy
- Elliott Bay: 500,000 cy
- Port Gardner: 500,000 cy

6.1 Anderson/Ketron Disposal Site

The Anderson/Ketron Islands disposal site is in southern Puget Sound, situated between Anderson and Ketron Islands, and is the only site located south of the Tacoma Narrows. The disposal site is in a relatively flat non-dispersive area with an average depth of approximately 420 feet (120 meters). Bottom current measurements during the disposal siting studies indicated moderate currents that tended to flow from north to south (PSDDA 1989a).

6.1.1 AK SPI/PV Map and Locations

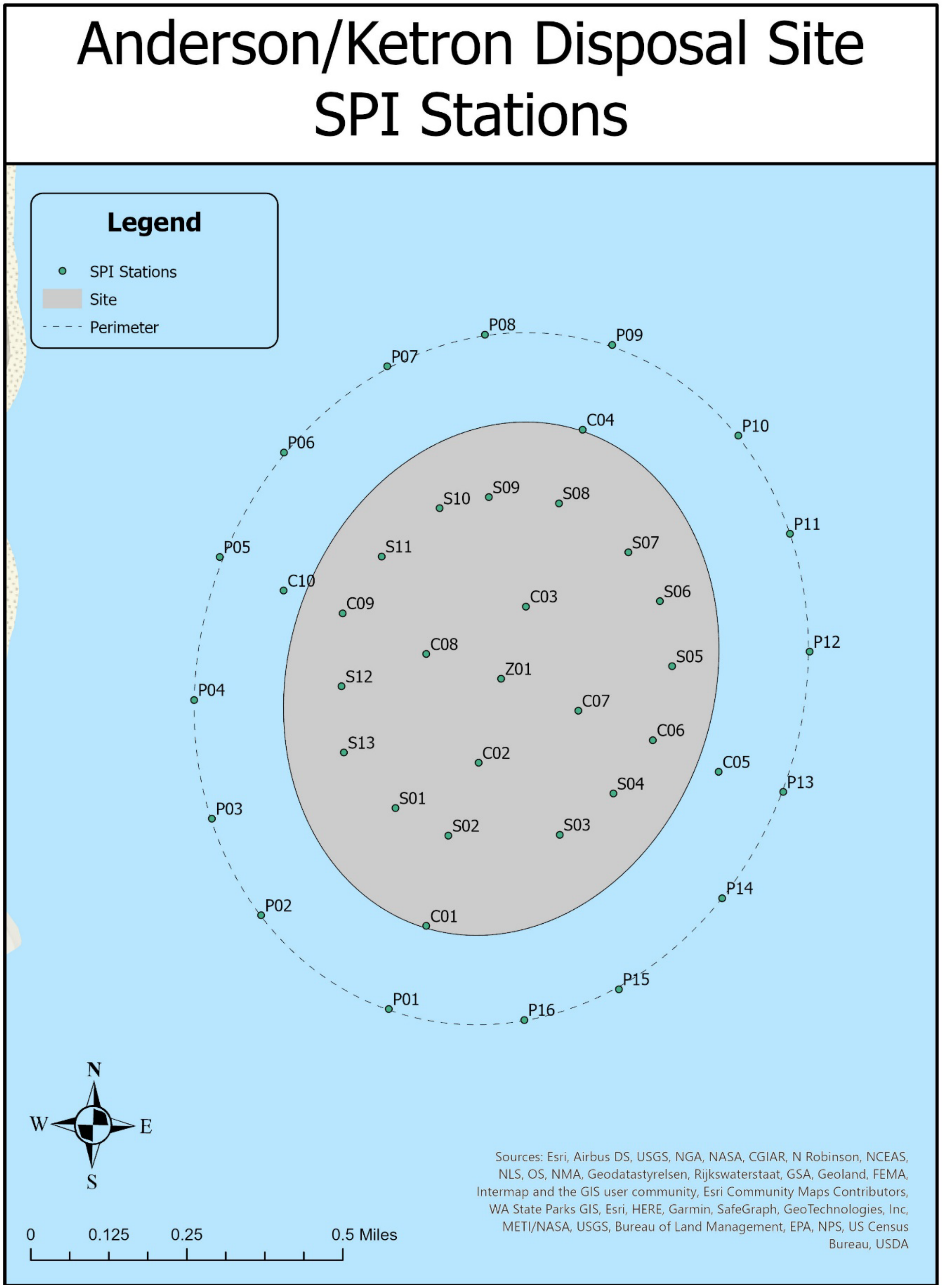

Figure 4. Anderson/Ketron SPI/PV Fixed Sample Location Map

Table 11. Anderson/Ketron SPI/PV Fixed Sample Coordinates

Anderson Ketron SPI/PV Location Coordinates			
Station ID	**Station Type**	**Latitude N (NAD83)**	**Longitude W (NAD83)**
AKZ01	Zone	47.156986	-122.657907
AKS01	Site	47.153930	-122.661400
AKS02	Site	47.153319	-122.659574
AKS03	Site	47.153403	-122.655790
AKS04	Site	47.154386	-122.654007
AKS05	Site	47.157369	-122.652107
AKS06	Site	47.158869	-122.652573
AKS07	Site	47.159986	-122.653690
AKS08	Site	47.161086	-122.656090
AKS09	Site	47.161186	-122.658474
AKS10	Site	47.160902	-122.660140
AKS11	Site	47.159752	-122.662074
AKS12	Site	47.156719	-122.663324
AKS13	Site	47.155186	-122.663191
AKP01	Perimeter	47.149268	-122.661458
AKP02	Perimeter	47.151369	-122.665874
AKP03	Perimeter	47.153582	-122.667627
AKP04	Perimeter	47.156324	-122.668330
AKP05	Perimeter	47.159652	-122.667574
AKP06	Perimeter	47.162112	-122.665478
AKP07	Perimeter	47.164163	-122.662033
AKP08	Perimeter	47.164955	-122.658740
AKP09	Perimeter	47.164786	-122.654407
AKP10	Perimeter	47.162752	-122.650048
AKP11	Perimeter	47.160506	-122.648210
AKP12	Perimeter	47.157781	-122.647451
AKP13	Perimeter	47.154515	-122.648237
AKP14	Perimeter	47.152019	-122.650218
AKP15	Perimeter	47.149853	-122.653657
AKP16	Perimeter	47.149090	-122.656852
AKC01	Cross	47.151213	-122.660251
AKC02	Cross	47.155024	-122.658612
AKC03	Cross	47.158674	-122.657121
AKC04	Cross	47.162803	-122.655338
AKC05	Cross	47.154946	-122.650442
AKC06	Cross	47.155645	-122.652701
AKC07	Cross	47.156287	-122.655266
AKC08	Cross	47.157516	-122.660471
AKC09	Cross	47.158416	-122.663353
AKC10	Cross	47.158909	-122.665373

6.1.2 AK Disposal Site Decision Unit Map and Locations

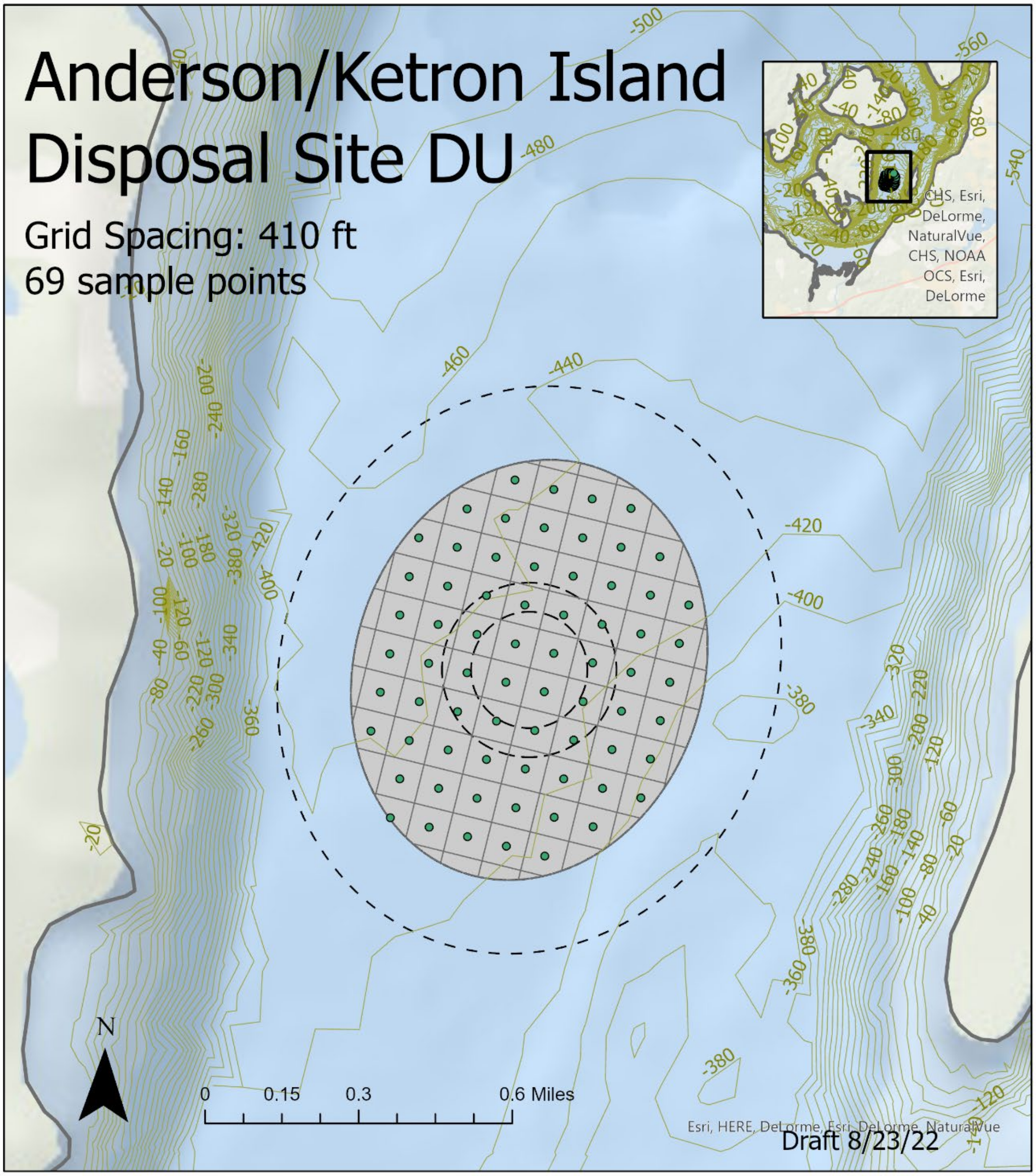

Figure 5. Anderson/Ketron Disposal Site Decision Unit Map

Table 12. Anderson/Ketron Disposal Site Decision Unit Sample Coordinates

Anderson Ketron Disposal Site DU Sample Location Coordinates		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
AK-1	47.152704	-122.663494
AK-2	47.152464	-122.661884
AK-3	47.152223	-122.660275
AK-4	47.151983	-122.658665
AK-5	47.151742	-122.657055
AK-6	47.153802	-122.663142
AK-7	47.153562	-122.661532
AK-8	47.153322	-122.659922
AK-9	47.153081	-122.658312
AK-10	47.152841	-122.656703
AK-11	47.152600	-122.655093
AK-12	47.155141	-122.664399
AK-13	47.154901	-122.662789
AK-14	47.154660	-122.661179
AK-15	47.154420	-122.659570
AK-16	47.154179	-122.657960
AK-17	47.153939	-122.656350
AK-18	47.153698	-122.654740
AK-19	47.153457	-122.653131
AK-20	47.156239	-122.664046
AK-21	47.155999	-122.662437
AK-22	47.155758	-122.660827
AK-23	47.155518	-122.659217
AK-24	47.155277	-122.657607
AK-25	47.155037	-122.655997
AK-26	47.154796	-122.654388
AK-27	47.154556	-122.652778
AK-28	47.157337	-122.663694
AK-29	47.157097	-122.662084
AK-30	47.156856	-122.660474
AK-31	47.156616	-122.658864
AK-32	47.156375	-122.657255
AK-33	47.156135	-122.655645
AK-34	47.155894	-122.654035
AK-35	47.155654	-122.652425
AK-36	47.158435	-122.663341
AK-37	47.158195	-122.661732
AK-38	47.157954	-122.660122
AK-39	47.157714	-122.658512
AK-40	47.157473	-122.656902
AK-41	47.157233	-122.655292
AK-42	47.156992	-122.653682
AK-43	47.156752	-122.652072

Anderson Ketron Disposal Site DU Sample Location Coordinates		
Station ID	**Latitude N (NAD83)**	**Longitude W (NAD83)**
AK-44	47.159533	-122.662989
AK-45	47.159293	-122.661379
AK-46	47.159052	-122.659769
AK-47	47.158812	-122.658159
AK-48	47.158571	-122.656549
AK-49	47.158331	-122.654939
AK-50	47.158090	-122.653330
AK-51	47.157850	-122.651720
AK-52	47.160632	-122.662636
AK-53	47.160391	-122.661026
AK-54	47.160151	-122.659417
AK-55	47.159910	-122.657807
AK-56	47.159670	-122.656197
AK-57	47.159429	-122.654587
AK-58	47.159188	-122.652977
AK-59	47.158948	-122.651367
AK-60	47.161489	-122.660674
AK-61	47.161249	-122.659064
AK-62	47.161008	-122.657454
AK-63	47.160768	-122.655844
AK-64	47.160527	-122.654234
AK-65	47.160287	-122.652624
AK-66	47.162347	-122.658711
AK-67	47.162106	-122.657101
AK-68	47.161866	-122.655491
AK-69	47.161625	-122.653881

6.2 Bellingham Bay Disposal Site

The Bellingham Bay disposal site is in a relatively flat, nondispersive area of Bellingham Bay, with weak northwest to southeast currents (PSDDA 1989a). It has not been used since 1994 (DMMP 2022b).

6.2.1 BB SPI/PV Map and Locations

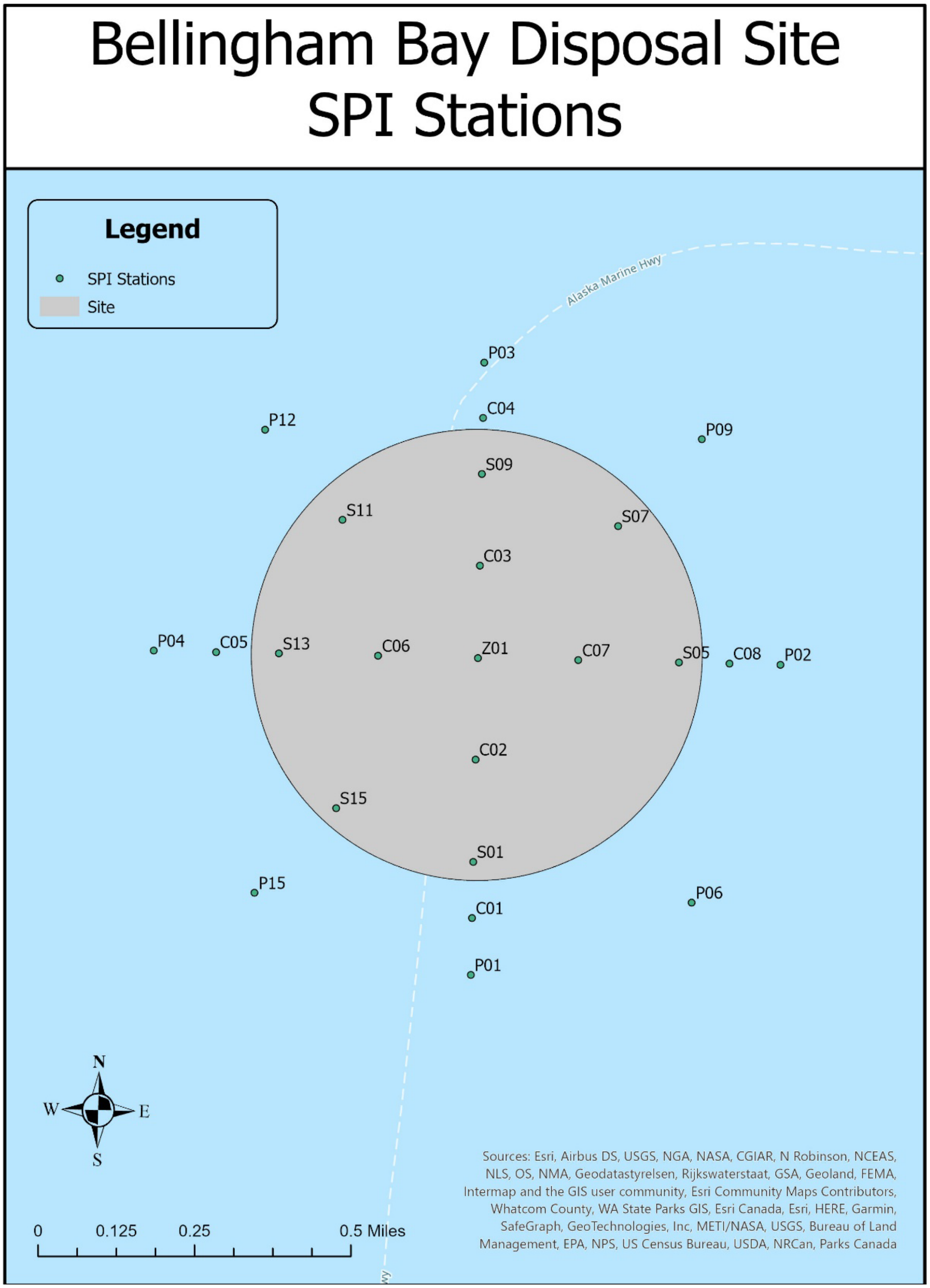

Figure 6. Bellingham Bay SPI/PV Fixed Sample Location Map

Table 13. Bellingham Bay SPI/PV Fixed Sample Coordinates

Bellingham Bay Site SPI/PV Coordinate Locations			
Station	**Type**	**Latitude N**	**Longitude W**
BBZ01	Zone	48.713594	-122.551747
BBS01	Site	48.708878	-122.551747
BBS05	Site	48.713594	-122.544714
BBS07	Site	48.716714	-122.546947
BBS09	Site	48.717844	-122.551747
BBS11	Site	48.716714	-122.556581
BBS13	Site	48.713594	-122.558697
BBS15	Site	48.710047	-122.556581
BBP01	Perimeter	48.706261	-122.551747
BBP02	Perimeter	48.713594	-122.541161
BBP03	Perimeter	48.720428	-122.551747
BBP04	Perimeter	48.713594	-122.563081
BBP06	Perimeter	48.708047	-122.544078
BBP09	Perimeter	48.718764	-122.544081
BBP12	Perimeter	48.718764	-122.559364
BBP15	Perimeter	48.708047	-122.559364
BBC01	Cross	48.707578	-122.551747
BBC02	Cross	48.711244	-122.551747
BBC03	Cross	48.715728	-122.551747
BBC04	Cross	48.719144	-122.551747
BBC05	Cross	48.713594	-122.560897
BBC06	Cross	48.713594	-122.555231
BBC07	Cross	48.713594	-122.548231
BBC08	Cross	48.713594	-122.542944

6.2.2 BB Disposal Site Decision Unit Map and Locations

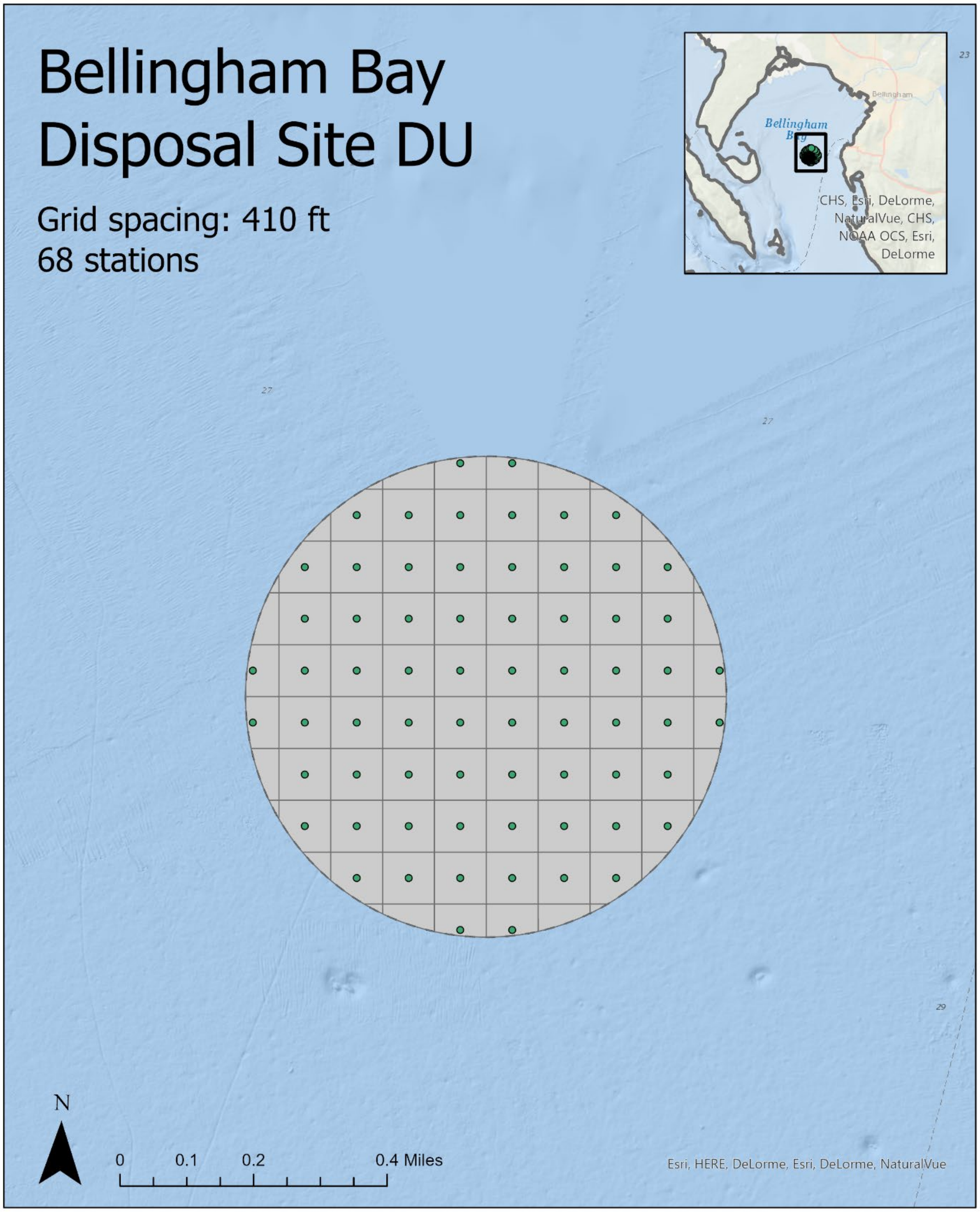

Figure 7. Bellingham Bay Disposal Site Decision Unit Map

Table 14. Bellingham Bay Disposal Site Decision Unit Sample Coordinates

Bellingham Bay Disposal Site DU Stations		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
BB-1	48.708600	-122.552420
BB-2	48.708629	-122.550724
BB-3	48.709664	-122.555857
BB-4	48.709693	-122.554161
BB-5	48.709723	-122.552465
BB-6	48.709752	-122.550768
BB-7	48.709781	-122.549072
BB-8	48.709810	-122.547375
BB-9	48.710758	-122.557598
BB-10	48.710787	-122.555902
BB-11	48.710816	-122.554205
BB-12	48.710845	-122.552509
BB-13	48.710875	-122.550812
BB-14	48.710904	-122.549116
BB-15	48.710933	-122.547419
BB-16	48.710962	-122.545723
BB-17	48.711880	-122.557642
BB-18	48.711910	-122.555946
BB-19	48.711939	-122.554249
BB-20	48.711968	-122.552553
BB-21	48.711997	-122.550856
BB-22	48.712026	-122.549160
BB-23	48.712056	-122.547463
BB-24	48.712085	-122.545767
BB-25	48.712974	-122.559383
BB-26	48.713003	-122.557687
BB-27	48.713032	-122.555990
BB-28	48.713061	-122.554294
BB-29	48.713091	-122.552597
BB-30	48.713120	-122.550901
BB-31	48.713149	-122.549204
BB-32	48.713178	-122.547507
BB-33	48.713207	-122.545811
BB-34	48.713237	-122.544114
BB-35	48.714096	-122.559427
BB-36	48.714126	-122.557731
BB-37	48.714155	-122.556034
BB-38	48.714184	-122.554338
BB-39	48.714213	-122.552641
BB-40	48.714243	-122.550945
BB-41	48.714272	-122.549248
BB-42	48.714301	-122.547552
BB-43	48.714330	-122.545855

Bellingham Bay Disposal Site DU Stations		
Station ID	**Latitude N (NAD83)**	**Longitude W (NAD83)**
BB-44	48.714359	-122.544158
BB-45	48.715248	-122.557775
BB-46	48.715278	-122.556079
BB-47	48.715307	-122.554382
BB-48	48.715336	-122.552685
BB-49	48.715365	-122.550989
BB-50	48.715395	-122.549292
BB-51	48.715424	-122.547596
BB-52	48.715453	-122.545899
BB-53	48.716371	-122.557819
BB-54	48.716400	-122.556123
BB-55	48.716430	-122.554426
BB-56	48.716459	-122.552730
BB-57	48.716488	-122.551033
BB-58	48.716517	-122.549336
BB-59	48.716546	-122.547640
BB-60	48.716576	-122.545943
BB-61	48.717523	-122.556167
BB-62	48.717552	-122.554470
BB-63	48.717582	-122.552774
BB-64	48.717611	-122.551077
BB-65	48.717640	-122.549380
BB-66	48.717669	-122.547684
BB-67	48.718704	-122.552818
BB-68	48.718733	-122.551121

6.3 Commencement Bay Disposal Site

The Commencement Bay site, located in Tacoma, WA, is a relatively flat, non-dispersive area with water depths varying from 540 to 560 feet (165 to 171 meters) with northwest to southeast currents (PSDDA 1988a).

6.3.1 CB SPI/PV Map and Locations

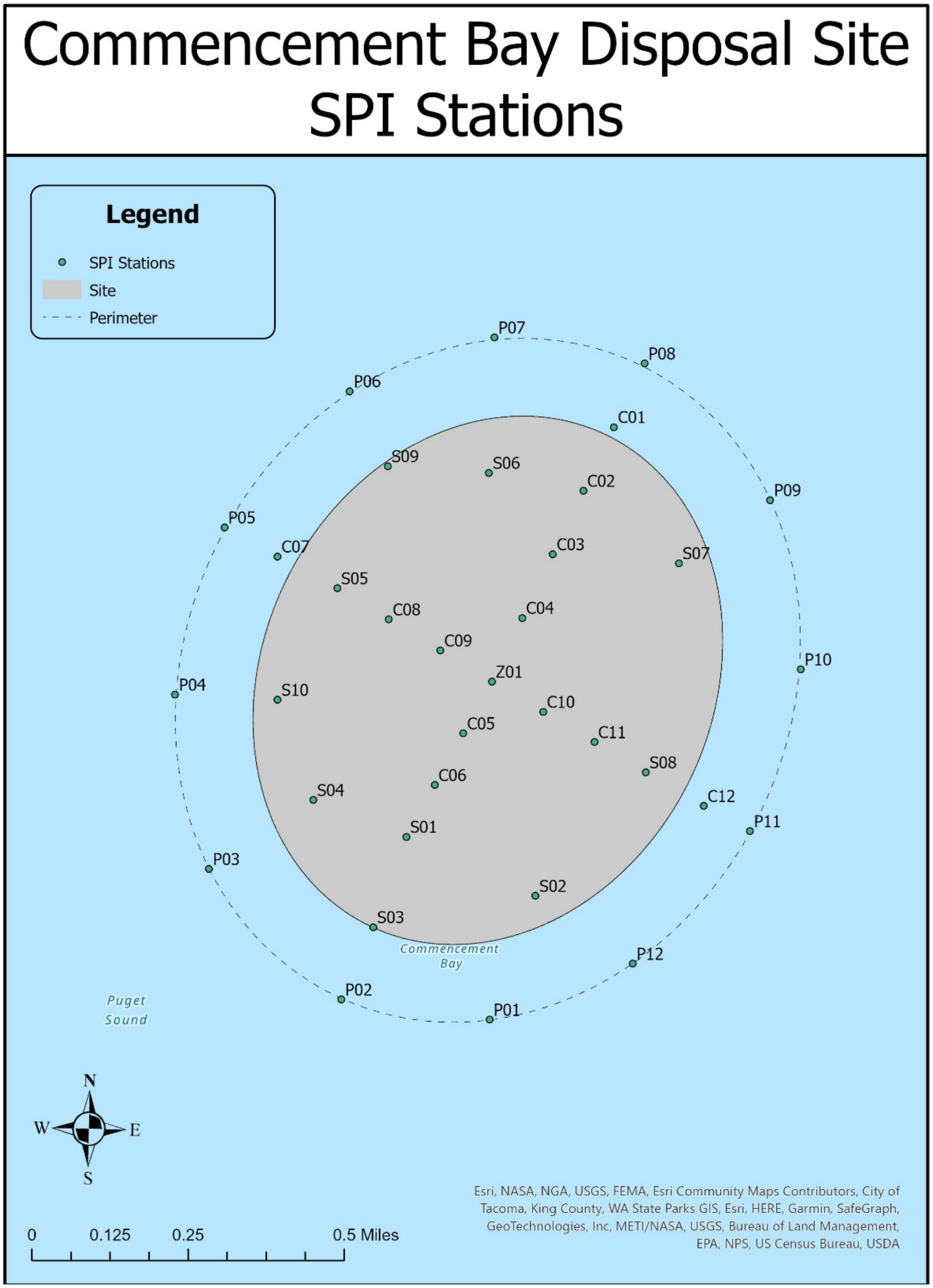

Figure 8. Commencement Bay SPI/PV Fixed Sample Location Map

Table 15. Commencement Bay SPI/PV Fixed Sample Coordinates

Commencement Bay SPI/PV Station Locations			
Station	Type	Latitude N	Longitude W
CBZ01	Zone	47.303460	-122.465097
CBS01	Site	47.299822	-122.467903
CBS02	Site	47.298517	-122.463458
CBS03	Site	47.297711	-122.468958
CBS04	Site	47.300628	-122.471097
CBS05	Site	47.305545	-122.470430
CBS06	Site	47.308294	-122.465347
CBS07	Site	47.306294	-122.458819
CBS08	Site	47.301433	-122.459793
CBS09	Site	47.308400	-122.468802
CBS10	Site	47.302933	-122.472383
CBP01	Perimeter	47.295628	-122.464926
CBP02	Perimeter	47.296020	-122.469996
CBP03	Perimeter	47.298978	-122.474597
CBP04	Perimeter	47.303002	-122.475880
CBP05	Perimeter	47.306900	-122.474316
CBP06	Perimeter	47.310117	-122.470148
CBP07	Perimeter	47.311434	-122.465261
CBP08	Perimeter	47.310905	-122.460127
CBP09	Perimeter	47.307801	-122.455751
CBP10	Perimeter	47.303895	-122.454588
CBP11	Perimeter	47.300122	-122.456198
CBP12	Perimeter	47.296993	-122.460096
CBC01	Cross	47.309417	-122.461122
CBC02	Cross	47.307928	-122.462117
CBC03	Cross	47.306440	-122.463112
CBC04	Cross	47.304950	-122.464106
CBC05	Cross	47.302247	-122.466036
CBC06	Cross	47.301037	-122.466970
CBC07	Cross	47.306253	-122.472486
CBC08	Cross	47.304850	-122.468653
CBC09	Cross	47.304156	-122.466875
CBC10	Cross	47.302783	-122.463331
CBC11	Cross	47.302108	-122.461561
CBC12	Cross	47.300683	-122.457794

6.3.2 CB Disposal Site Decision Unit Map and Locations

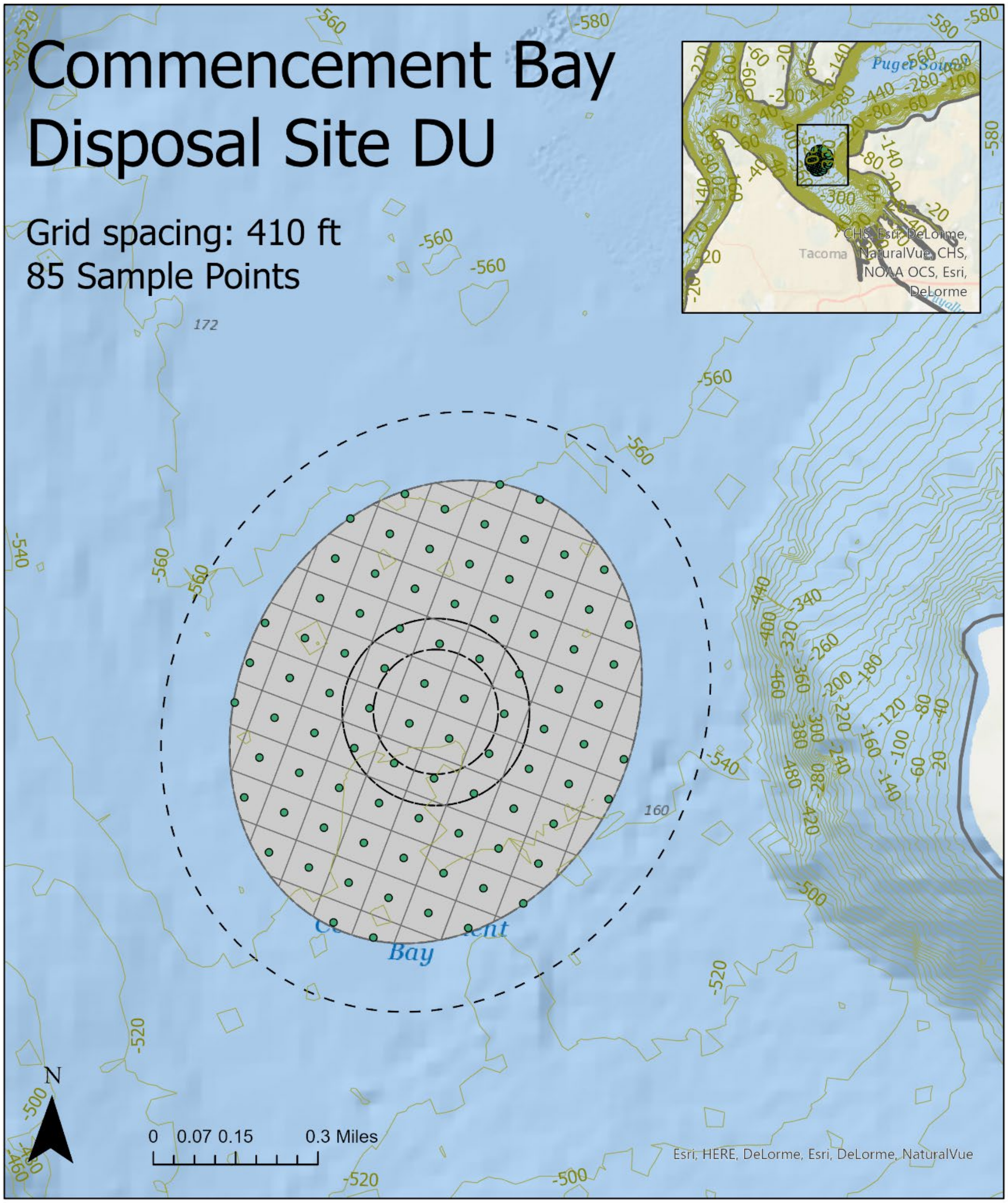

Figure 9. Commencement Bay Disposal Site Decision Unit Map

Table 16. Commencement Bay Disposal Site Decision Unit Sample Coordinates

Commencement Bay Disposal Site DU Stations		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
CB-1	47.297861	-122.468998
CB-2	47.297488	-122.467439
CB-3	47.299667	-122.471567
CB-4	47.299294	-122.470008
CB-5	47.298921	-122.468450
CB-6	47.298548	-122.466891
CB-7	47.298176	-122.465332
CB-8	47.297803	-122.463773
CB-9	47.301101	-122.472578
CB-10	47.300728	-122.471019
CB-11	47.300355	-122.469460
CB-12	47.299982	-122.467901
CB-13	47.299609	-122.466342
CB-14	47.299236	-122.464784
CB-15	47.298863	-122.463225
CB-16	47.298490	-122.461666
CB-17	47.302161	-122.472030
CB-18	47.301788	-122.470471
CB-19	47.301415	-122.468912
CB-20	47.301042	-122.467353
CB-21	47.300669	-122.465794
CB-22	47.300296	-122.464235
CB-23	47.299923	-122.462677
CB-24	47.299550	-122.461118
CB-25	47.303594	-122.473040
CB-26	47.303221	-122.471481
CB-27	47.302849	-122.469922
CB-28	47.302476	-122.468364
CB-29	47.302103	-122.466805
CB-30	47.301730	-122.465246
CB-31	47.301357	-122.463687
CB-32	47.300984	-122.462128
CB-33	47.300611	-122.460570
CB-34	47.304655	-122.472492
CB-35	47.304282	-122.470933
CB-36	47.303909	-122.469374
CB-37	47.303536	-122.467815
CB-38	47.303163	-122.466256
CB-39	47.302790	-122.464698
CB-40	47.302417	-122.463139
CB-41	47.302044	-122.461580
CB-42	47.301671	-122.460021
CB-43	47.301298	-122.458462

Commencement Bay Disposal Site DU Stations		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
CB-44	47.305715	-122.471944
CB-45	47.305342	-122.470385
CB-46	47.304969	-122.468826
CB-47	47.304596	-122.467267
CB-48	47.304223	-122.465708
CB-49	47.303850	-122.464149
CB-50	47.303477	-122.462590
CB-51	47.303104	-122.461031
CB-52	47.302731	-122.459473
CB-53	47.302358	-122.457914
CB-54	47.306403	-122.469837
CB-55	47.306030	-122.468278
CB-56	47.305657	-122.466719
CB-57	47.305284	-122.465160
CB-58	47.304911	-122.463601
CB-59	47.304538	-122.462042
CB-60	47.304165	-122.460483
CB-61	47.303792	-122.458924
CB-62	47.307463	-122.469288
CB-63	47.307090	-122.467729
CB-64	47.306717	-122.466170
CB-65	47.306344	-122.464611
CB-66	47.305971	-122.463052
CB-67	47.305598	-122.461493
CB-68	47.305225	-122.459935
CB-69	47.304852	-122.458376
CB-70	47.308523	-122.468740
CB-71	47.308150	-122.467181
CB-72	47.307777	-122.465622
CB-73	47.307404	-122.464063
CB-74	47.307031	-122.462504
CB-75	47.306658	-122.460945
CB-76	47.306285	-122.459386
CB-77	47.305912	-122.457827
CB-78	47.309211	-122.466633
CB-79	47.308838	-122.465074
CB-80	47.308465	-122.463515
CB-81	47.308092	-122.461956
CB-82	47.307719	-122.460397
CB-83	47.307346	-122.458838
CB-84	47.309525	-122.462966
CB-85	47.309152	-122.461407

6.4 Elliott Bay Disposal Site

The Elliott Bay site, located in Seattle, WA, is a gently sloping area in the center of Elliott Bay at a depth ranging from 200 feet (61 meters) at the south edge of the site to 360 feet (110 meters) at the north edge. Currents at the disposal site location were found to be weak and variable (PSDDA 1988a).

6.4.1 EB SPI/PV Fixed Station Map and Locations

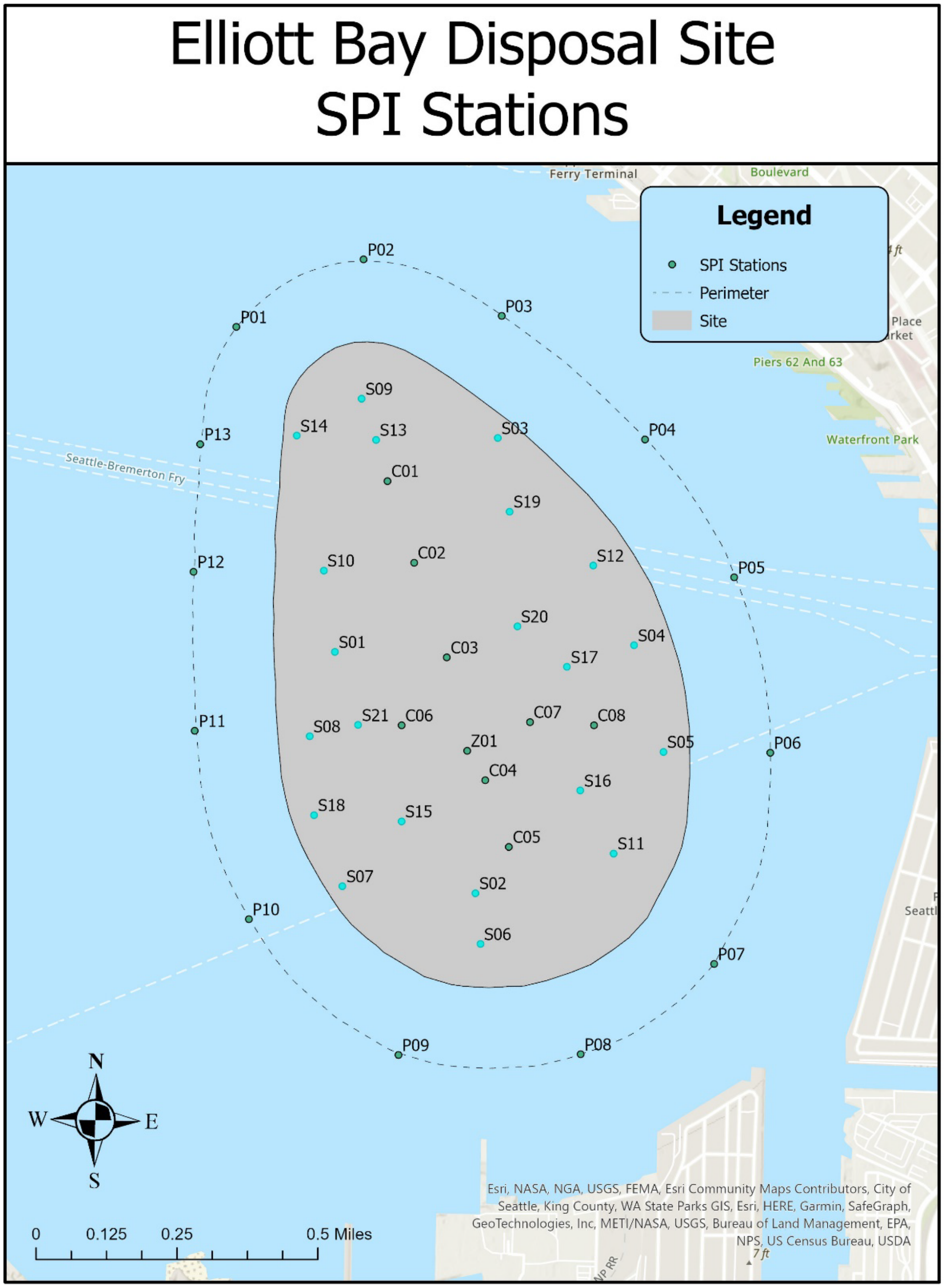

Figure 10. Elliott Bay SPI/PV Fixed Sample Location Map

Table 17. Elliott Bay SPI/PV Fixed Sample Coordinates

EB SPI/PV Sample Locations			
Station	Type	Latitude N	Longitude W
EBZ01	Zone	47.59850000	-122.3575000
EBS01	Site	47.60096944	-122.3625889
EBS02	Site	47.59484722	-122.3570722
EBS03	Site	47.60654167	-122.3565722
EBS04	Site	47.60129167	-122.3512389
EBS05	Site	47.59856944	-122.3500444
EBS06	Site	47.59354167	-122.3568500
EBS07	Site	47.59495833	-122.3621278
EBS08	Site	47.59879167	-122.3634889
EBS09	Site	47.60748611	-122.3617667
EBS10	Site	47.60305278	-122.3630778
EBS11	Site	47.59593611	-122.3518556
EBS12	Site	47.60331944	-122.3528556
EBS13	Site	47.60643611	-122.3611889
EBS14	Site	47.60650278	-122.3642056
EBS15	Site	47.59665278	-122.3599389
EBS16	Site	47.59753611	-122.3531722
EBS17	Site	47.60070278	-122.3537722
EBS18	Site	47.59676944	-122.3632556
EBS19	Site	47.60466195	-122.3560632
EBS20	Site	47.60171944	-122.3556889
EBS21	Site	47.59910278	-122.3616556
EBP01	Perimeter	47.60926389	-122.3665722
EBP02	Perimeter	47.61106241	-122.3617964
EBP03	Perimeter	47.60968056	-122.3565167
EBP04	Perimeter	47.60658031	-122.3509865
EBP05	Perimeter	47.60308324	-122.3474907
EBP06	Perimeter	47.59860211	-122.3459952
EBP07	Perimeter	47.59315013	-122.3479642
EBP08	Perimeter	47.5907624	-122.3529599
EBP09	Perimeter	47.59065278	-122.3598778
EBP10	Perimeter	47.59406263	-122.3656571
EBP11	Perimeter	47.59887354	-122.3678461
EBP12	Perimeter	47.60295668	-122.368016
EBP13	Perimeter	47.60623602	-122.3678562
EBC01	Cross	47.60538611	-122.3607222
EBC02	Cross	47.60330278	-122.3596556
EBC03	Cross	47.60088611	-122.3583389
EBC04	Cross	47.59775278	-122.3567889
EBC05	Cross	47.59605278	-122.3558389
EBC06	Cross	47.59911944	-122.3600056
EBC07	Cross	47.59926944	-122.3551389
EBC08	Cross	47.59921944	-122.3527056

6.4.2 EB Disposal Site Decision Unit Map and Locations

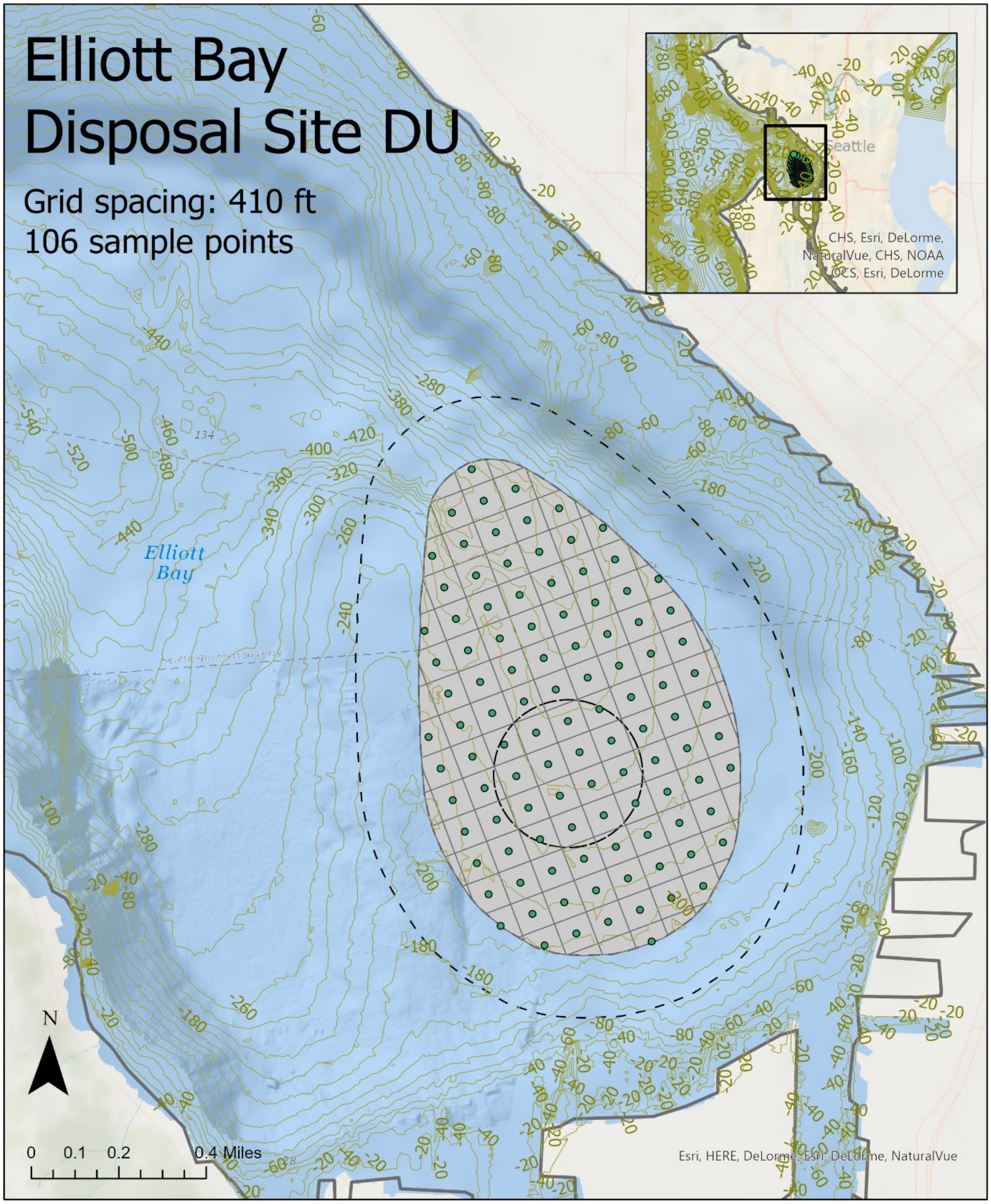

Figure 11. Elliott Bay Disposal Site Decision Unit Map

Table 18. Elliott Bay Disposal Site Decision Unit Sample Coordinates

Elliott Bay Disposal Site DU Stations		
Station ID	**Latitude N (NAD83)**	**Longitude W (NAD83)**
EB-1	47.592969	-122.353210
EB-2	47.592743	-122.358453
EB-3	47.593165	-122.356913
EB-4	47.593588	-122.355374
EB-5	47.594010	-122.353834
EB-6	47.594432	-122.352294
EB-7	47.594855	-122.350755
EB-8	47.593362	-122.360617
EB-9	47.593784	-122.359077
EB-10	47.594207	-122.357538
EB-11	47.594629	-122.355998
EB-12	47.595052	-122.354458
EB-13	47.595474	-122.352919
EB-14	47.595896	-122.351379
EB-15	47.596319	-122.349839
EB-16	47.594404	-122.361242
EB-17	47.594826	-122.359702
EB-18	47.595248	-122.358162
EB-19	47.595671	-122.356623
EB-20	47.596093	-122.355083
EB-21	47.596516	-122.353543
EB-22	47.596938	-122.352003
EB-23	47.597360	-122.350463
EB-24	47.595445	-122.361866
EB-25	47.595867	-122.360326
EB-26	47.596290	-122.358787
EB-27	47.596712	-122.357247
EB-28	47.597135	-122.355707
EB-29	47.597557	-122.354167
EB-30	47.597979	-122.352628
EB-31	47.598402	-122.351088
EB-32	47.598824	-122.349548
EB-33	47.596487	-122.362491
EB-34	47.596909	-122.360951
EB-35	47.597331	-122.359411
EB-36	47.597754	-122.357871
EB-37	47.598176	-122.356332
EB-38	47.598599	-122.354792
EB-39	47.599021	-122.353252
EB-40	47.599443	-122.351712
EB-41	47.599866	-122.350172
EB-42	47.597528	-122.363115
EB-43	47.597950	-122.361576

Elliott Bay Disposal Site DU Stations		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
EB-44	47.598373	-122.360036
EB-45	47.598795	-122.358496
EB-46	47.599218	-122.356956
EB-47	47.599640	-122.355416
EB-48	47.600063	-122.353876
EB-49	47.600485	-122.352337
EB-50	47.600907	-122.350797
EB-51	47.598570	-122.363740
EB-52	47.598992	-122.362200
EB-53	47.599414	-122.360660
EB-54	47.599837	-122.359121
EB-55	47.600259	-122.357581
EB-56	47.600682	-122.356041
EB-57	47.601104	-122.354501
EB-58	47.601526	-122.352961
EB-59	47.601949	-122.351421
EB-60	47.599611	-122.364365
EB-61	47.600033	-122.362825
EB-62	47.600456	-122.361285
EB-63	47.600878	-122.359745
EB-64	47.601301	-122.358205
EB-65	47.601723	-122.356665
EB-66	47.602146	-122.355125
EB-67	47.602568	-122.353585
EB-68	47.602990	-122.352045
EB-69	47.601075	-122.363449
EB-70	47.601497	-122.361910
EB-71	47.601920	-122.360370
EB-72	47.602342	-122.358830
EB-73	47.602765	-122.357290
EB-74	47.603187	-122.355750
EB-75	47.603609	-122.354210
EB-76	47.604032	-122.352670
EB-77	47.602116	-122.364074
EB-78	47.602539	-122.362534
EB-79	47.602961	-122.360994
EB-80	47.603384	-122.359454
EB-81	47.603806	-122.357914
EB-82	47.604229	-122.356374
EB-83	47.604651	-122.354834
EB-84	47.605073	-122.353294
EB-85	47.603158	-122.364699
EB-86	47.603580	-122.363159
EB-87	47.604003	-122.361619

Elliott Bay Disposal Site DU Stations		
Station ID	Latitude N (NAD83)	Longitude W (NAD83)
EB-88	47.604425	-122.360079
EB-89	47.604848	-122.358539
EB-90	47.605270	-122.356999
EB-91	47.605693	-122.355459
EB-92	47.604622	-122.363784
EB-93	47.605044	-122.362244
EB-94	47.605467	-122.360704
EB-95	47.605889	-122.359164
EB-96	47.606312	-122.357624
EB-97	47.606734	-122.356084
EB-98	47.605663	-122.364408
EB-99	47.606086	-122.362868
EB-100	47.606508	-122.361328
EB-101	47.606931	-122.359788
EB-102	47.607353	-122.358248
EB-103	47.607127	-122.363493
EB-104	47.607550	-122.361953
EB-105	47.607972	-122.360413
EB-106	47.608591	-122.362578

6.4.3 Elliott Bay Environs Decision Unit

The EB DU-ENV was defined in the 2023 Elliott Bay Site monitoring event. Map and station location coordinates of the DU-ENV are included below.

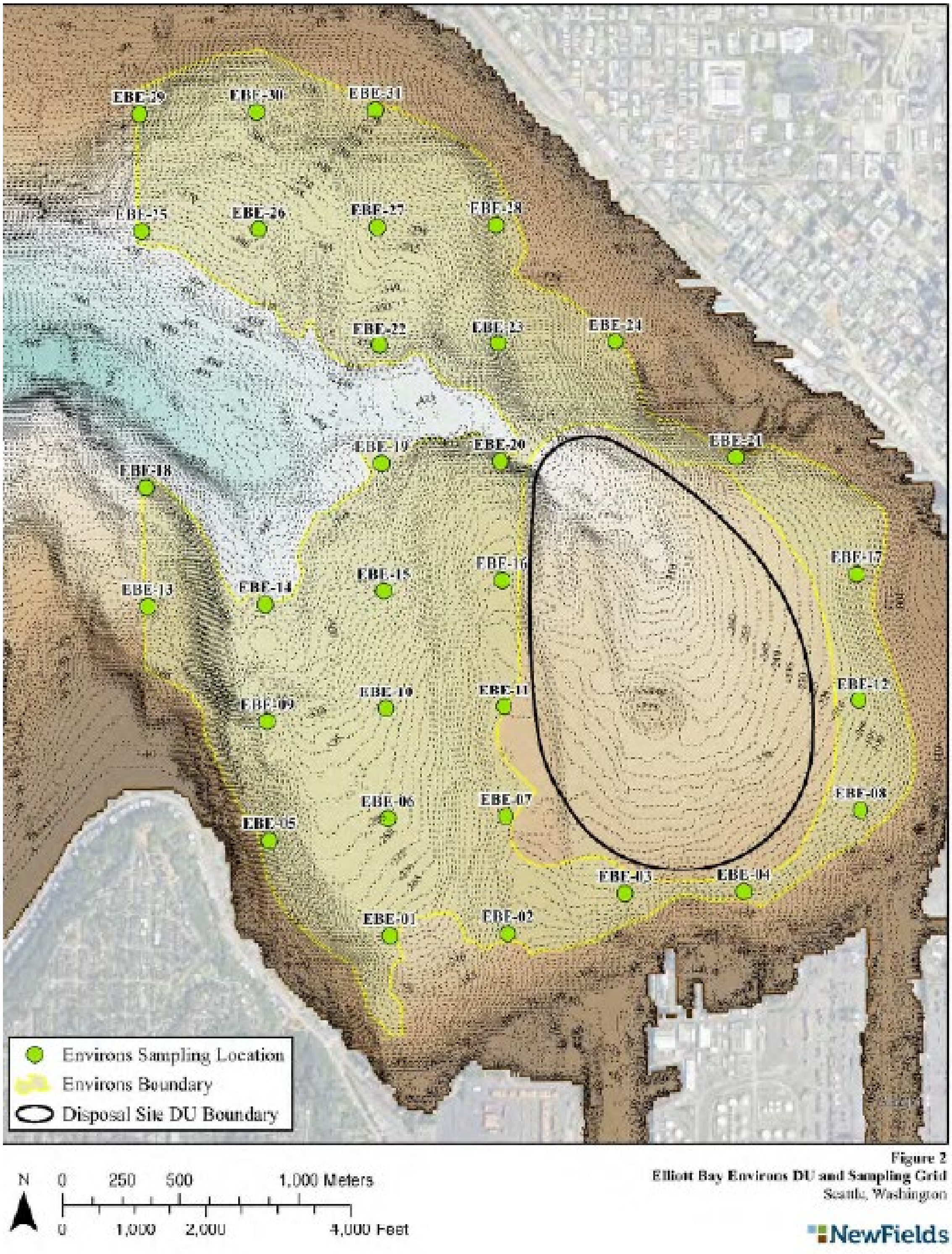

Figure 12. Elliott Bay Environs Decision Unit Map

Table 19. Elliott Bay Environs Decision Unit Sample Coordinates

Elliott Bay Environs Decision Unit Grid Center Coordinates		
Station ID	**Latitude**	**Longitude**
EBE-01	47.589845	-122.372774
EBE-02	47.589935	-122.366127
EBE-03	47.591467	-122.359523
EBE-04	47.591556	-122.352877
EBE-05	47.593501	-122.379531
EBE-06	47.594342	-122.372907
EBE-07	47.594431	-122.366260
EBE-08	47.594698	-122.346319
EBE-09	47.597997	-122.379665
EBE-10	47.598514	-122.373030
EBE-11	47.598604	-122.366383
EBE-12	47.598871	-122.346440
EBE-13	47.602403	-122.386447
EBE-14	47.602493	-122.379799
EBE-15	47.603010	-122.373163
EBE-16	47.603424	-122.366525
EBE-17	47.603691	-122.346580
EBE-18	47.606899	-122.386581
EBE-19	47.607831	-122.373306
EBE-20	47.607920	-122.366657
EBE-21	47.608099	-122.353360
EBE-22	47.612327	-122.373439
EBE-23	47.612417	-122.366790
EBE-24	47.612506	-122.360140
EBE-25	47.616642	-122.386872
EBE-26	47.616733	-122.380222
EBE-27	47.616823	-122.373572
EBE-28	47.616913	-122.366922
EBE-29	47.621139	-122.387006
EBE-30	47.621229	-122.380356
EBE-31	47.621319	-122.373705

6.5 Port Gardner Disposal Site

The Port Gardner disposal site, located in Everett, WA, is a relatively flat, non-dispersive area with weak currents that generally flow southeast to northwest at depth (PSDDA 1988a). The average depth at the site is approximately 420 feet (128 meters).

6.5.1 PG SPI/PV Map and Locations

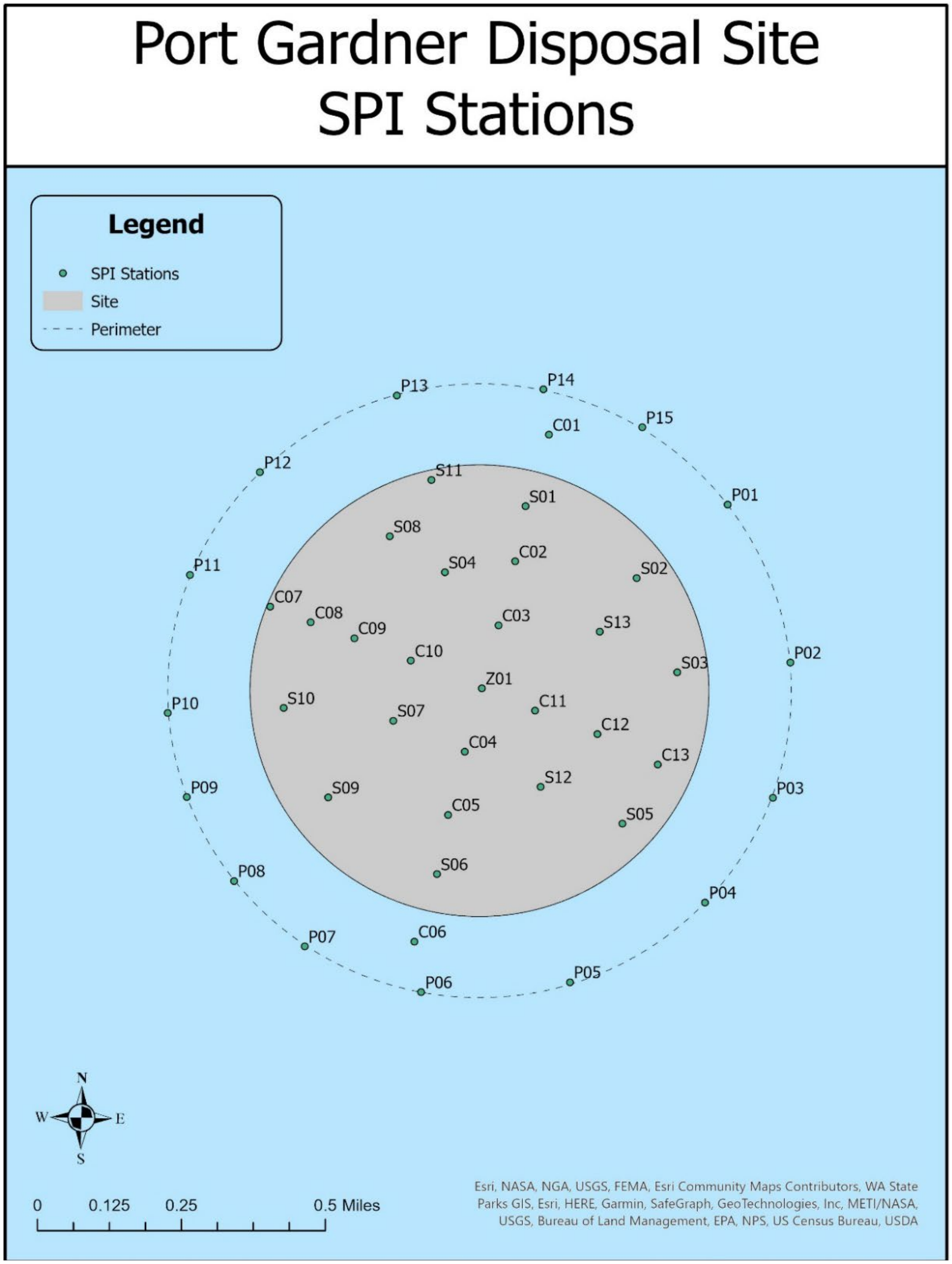

Figure 13. Port Gardner SPI/PV Fixed Sample Location Map

Table 20. Port Gardner Site SPI/PV Fixed Sample Coordinates

Port Gardner SPI/PV Station Coordinates			
Station	Type	Latitude N	Longitude W
PGZ01	Zone	47.980878	-122.278997
PGS01	Site	47.985544	-122.277497
PGS02	Site	47.983767	-122.273275
PGS03	Site	47.981378	-122.271692
PGS04	Site	47.983821	-122.280468
PGS05	Site	47.977489	-122.273636
PGS06	Site	47.976114	-122.280547
PGS07	Site	47.980011	-122.282281
PGS08	Site	47.984717	-122.282553
PGS09	Site	47.978017	-122.284669
PGS10	Site	47.980283	-122.286406
PGS11	Site	47.986175	-122.281025
PGS12	Site	47.978392	-122.276720
PGS13	Site	47.982376	-122.274622
PGP01	Perimeter	47.985688	-122.269920
PGP02	Perimeter	47.981681	-122.267471
PGP03	Perimeter	47.978219	-122.268026
PGP04	Perimeter	47.975517	-122.270486
PGP05	Perimeter	47.973417	-122.275486
PGP06	Perimeter	47.973092	-122.281046
PGP07	Perimeter	47.974206	-122.285442
PGP08	Perimeter	47.975844	-122.288131
PGP09	Perimeter	47.977961	-122.289959
PGP10	Perimeter	47.980098	-122.290741
PGP11	Perimeter	47.983638	-122.290002
PGP12	Perimeter	47.986291	-122.287453
PGP13	Perimeter	47.988317	-122.282381
PGP14	Perimeter	47.988537	-122.276902
PGP15	Perimeter	47.987617	-122.273183
PGC01	Cross	47.987383	-122.276669
PGC02	Cross	47.984133	-122.277836
PGC03	Cross	47.982494	-122.278419
PGC04	Cross	47.979250	-122.279586
PGC05	Cross	47.977633	-122.280169
PGC06	Cross	47.974383	-122.281336
PGC07	Cross	47.982867	-122.286969
PGC08	Cross	47.982480	-122.285443
PGC09	Cross	47.982100	-122.283803
PGC10	Cross	47.981550	-122.281669
PGC11	Cross	47.980333	-122.276986
PGC12	Cross	47.979767	-122.274636
PGC13	Cross	47.979017	-122.272358

6.5.2 PG Disposal Site Decision Unit Map and Locations

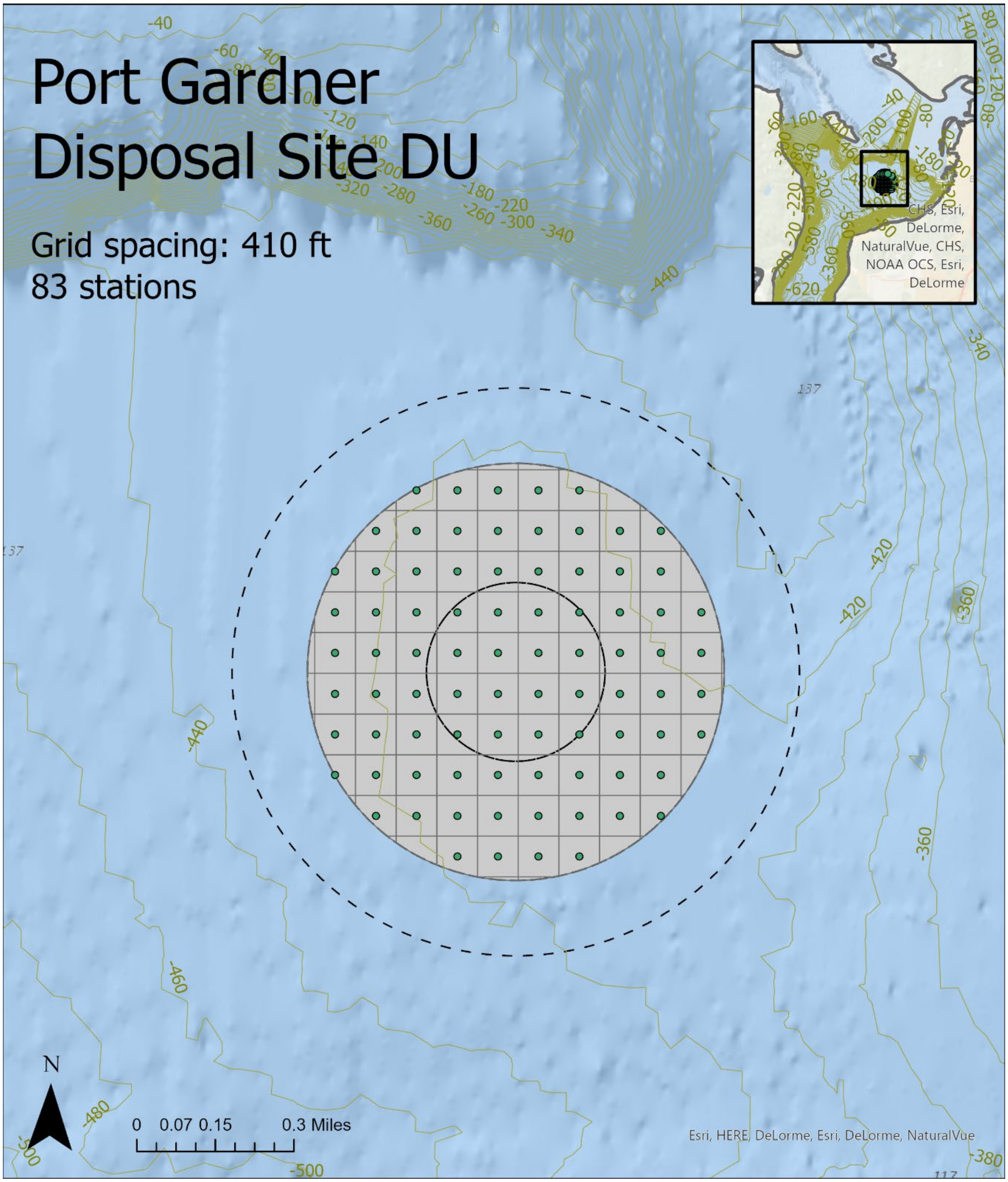

Figure 14. Port Gardner Disposal Site Decision Unit Map

Table 21. Port Gardner Disposal Site Decision Unit Sample Coordinates

Port Gardner Disposal Site DU Stations		
Station ID	**Latitude N (NAD83)**	**Longitude W (NAD83)**
PG-1	47.975685	-122.281319
PG-2	47.975711	-122.279646
PG-3	47.975736	-122.277973
PG-4	47.975761	-122.276300
PG-5	47.976758	-122.284703
PG-6	47.976783	-122.283030
PG-7	47.976809	-122.281357
PG-8	47.976834	-122.279684
PG-9	47.976859	-122.278011
PG-10	47.976885	-122.276338
PG-11	47.976910	-122.274664
PG-12	47.976935	-122.272991
PG-13	47.977856	-122.286414
PG-14	47.977881	-122.284741
PG-15	47.977907	-122.283068
PG-16	47.977932	-122.281395
PG-17	47.977958	-122.279721
PG-18	47.977983	-122.278048
PG-19	47.978008	-122.276375
PG-20	47.978033	-122.274702
PG-21	47.978059	-122.273029
PG-22	47.978979	-122.286452
PG-23	47.979005	-122.284779
PG-24	47.979030	-122.283106
PG-25	47.979056	-122.281432
PG-26	47.979081	-122.279759
PG-27	47.979106	-122.278086
PG-28	47.979132	-122.276413
PG-29	47.979157	-122.274740
PG-30	47.979182	-122.273067
PG-31	47.979207	-122.271393
PG-32	47.980103	-122.286490
PG-33	47.980128	-122.284817
PG-34	47.980154	-122.283143
PG-35	47.980179	-122.281470
PG-36	47.980204	-122.279797
PG-37	47.980230	-122.278124
PG-38	47.980255	-122.276451
PG-39	47.980280	-122.274777
PG-40	47.980306	-122.273104
PG-41	47.980331	-122.271431
PG-42	47.981226	-122.286528
PG-43	47.981252	-122.284854

Port Gardner Disposal Site DU Stations		
Station ID	**Latitude N (NAD83)**	**Longitude W (NAD83)**
PG-44	47.981277	-122.283181
PG-45	47.981302	-122.281508
PG-46	47.981328	-122.279835
PG-47	47.981353	-122.278162
PG-48	47.981378	-122.276488
PG-49	47.981404	-122.274815
PG-50	47.981429	-122.273142
PG-51	47.981454	-122.271469
PG-52	47.982349	-122.286566
PG-53	47.982375	-122.284892
PG-54	47.982400	-122.283219
PG-55	47.982426	-122.281546
PG-56	47.982451	-122.279873
PG-57	47.982476	-122.278199
PG-58	47.982502	-122.276526
PG-59	47.982527	-122.274853
PG-60	47.982552	-122.273179
PG-61	47.982578	-122.271506
PG-62	47.983473	-122.286603
PG-63	47.983498	-122.284930
PG-64	47.983524	-122.283257
PG-65	47.983549	-122.281584
PG-66	47.983574	-122.279910
PG-67	47.983600	-122.278237
PG-68	47.983625	-122.276564
PG-69	47.983650	-122.274890
PG-70	47.983676	-122.273217
PG-71	47.984622	-122.284968
PG-72	47.984647	-122.283295
PG-73	47.984672	-122.281621
PG-74	47.984698	-122.279948
PG-75	47.984723	-122.278275
PG-76	47.984749	-122.276601
PG-77	47.984774	-122.274928
PG-78	47.984799	-122.273255
PG-79	47.985770	-122.283333
PG-80	47.985796	-122.281659
PG-81	47.985821	-122.279986
PG-82	47.985847	-122.278312
PG-83	47.985872	-122.276639

6.5.3 Port Gardner Environs Decision Unit

The PG DU-ENV was defined in 2020 when the Port Gardner Site was used as a pilot project for testing the current monitoring framework. Map and station location coordinates of the DU-ENV are included below.

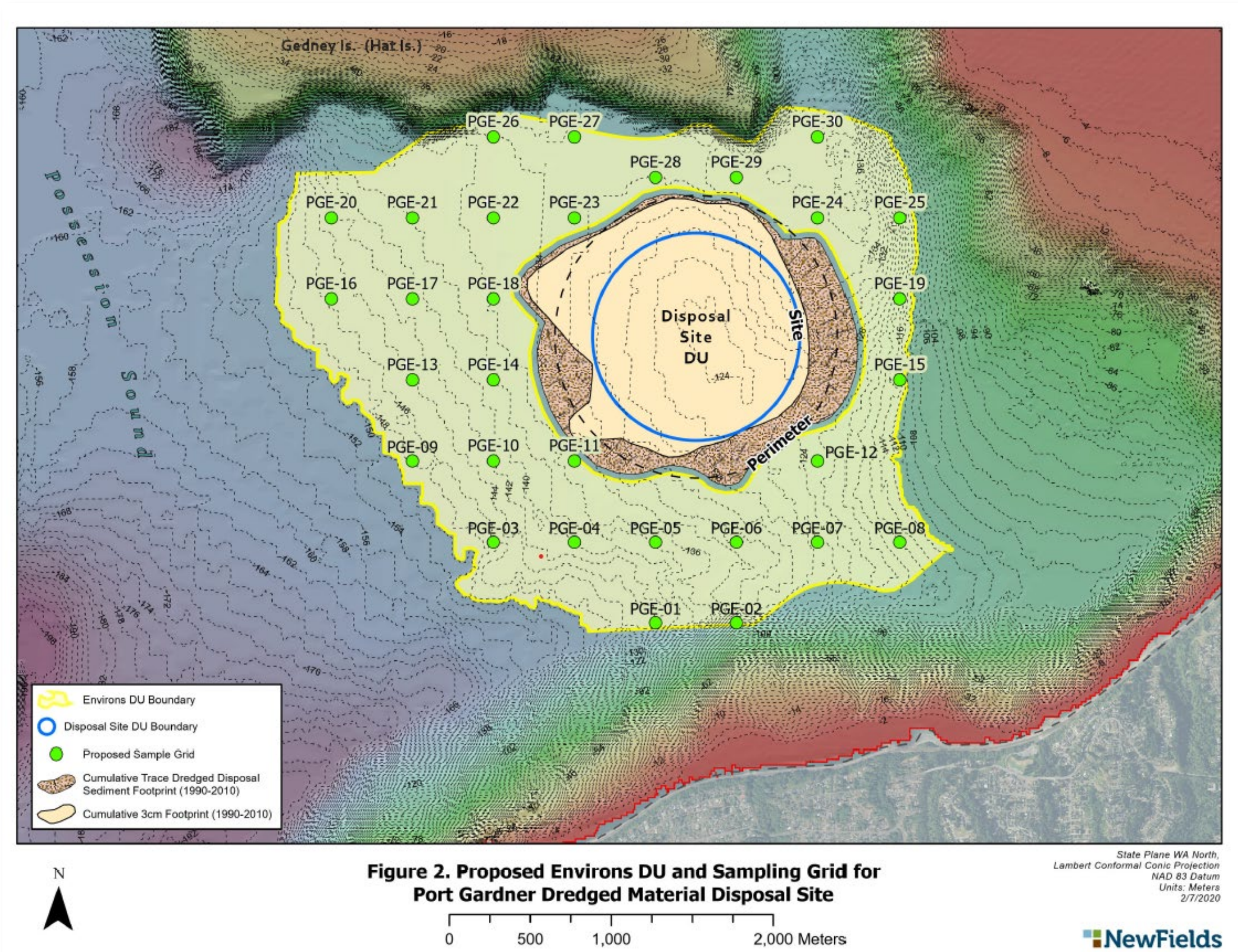

Figure 15. Port Gardner Environs Decision Unit Map

Table 22. Port Gardner Environs Decision Unit Sample Coordinates

Port Gardner Environs Decision Unit Grid Center Coordinates		
Station ID	**Latitude**	**Longitude**
PGE-01	47.964950	-122.281920
PGE-02	47.965035	-122.275225
PGE-03	47.969277	-122.295437
PGE-04	47.969362	-122.288741
PGE-05	47.969447	-122.282046
PGE-06	47.969531	-122.275351
PGE-07	47.969615	-122.268655
PGE-08	47.969699	-122.261960
PGE-09	47.973687	-122.302260
PGE-10	47.973773	-122.295564
PGE-11	47.973858	-122.288868
PGE-12	47.974111	-122.268780
PGE-13	47.978183	-122.302388
PGE-14	47.978269	-122.295691
PGE-15	47.978691	-122.262208
PGE-16	47.982594	-122.309213
PGE-17	47.982680	-122.302516
PGE-18	47.982765	-122.295819
PGE-19	47.983188	-122.262333
PGE-20	47.987090	-122.309341
PGE-21	47.987176	-122.302643
PGE-22	47.987262	-122.295946
PGE-23	47.987347	-122.289248
PGE-24	47.987600	-122.269155
PGE-25	47.987684	-122.262457
PGE-26	47.991758	-122.296073
PGE-27	47.991843	-122.289375
PGE-28	47.989680	-122.282614
PGE-29	47.989764	-122.275916
PGE-30	47.992097	-122.269280

6.6 Carr Inlet Natural Background Decision Unit

A Natural Background Decision Unit in Carr Inlet was defined by the DMMP agencies in 2020, in preparation for a pilot monitoring event at the Port Gardner Disposal Site. While ultimately not sampled for the Port Gardner event, Carr Inlet is a commonly used reference area in south Puget Sound with existing data supporting Natural Background DU status. Though other DU-NBs may be defined, this DU-NB is documented here for use as needed.

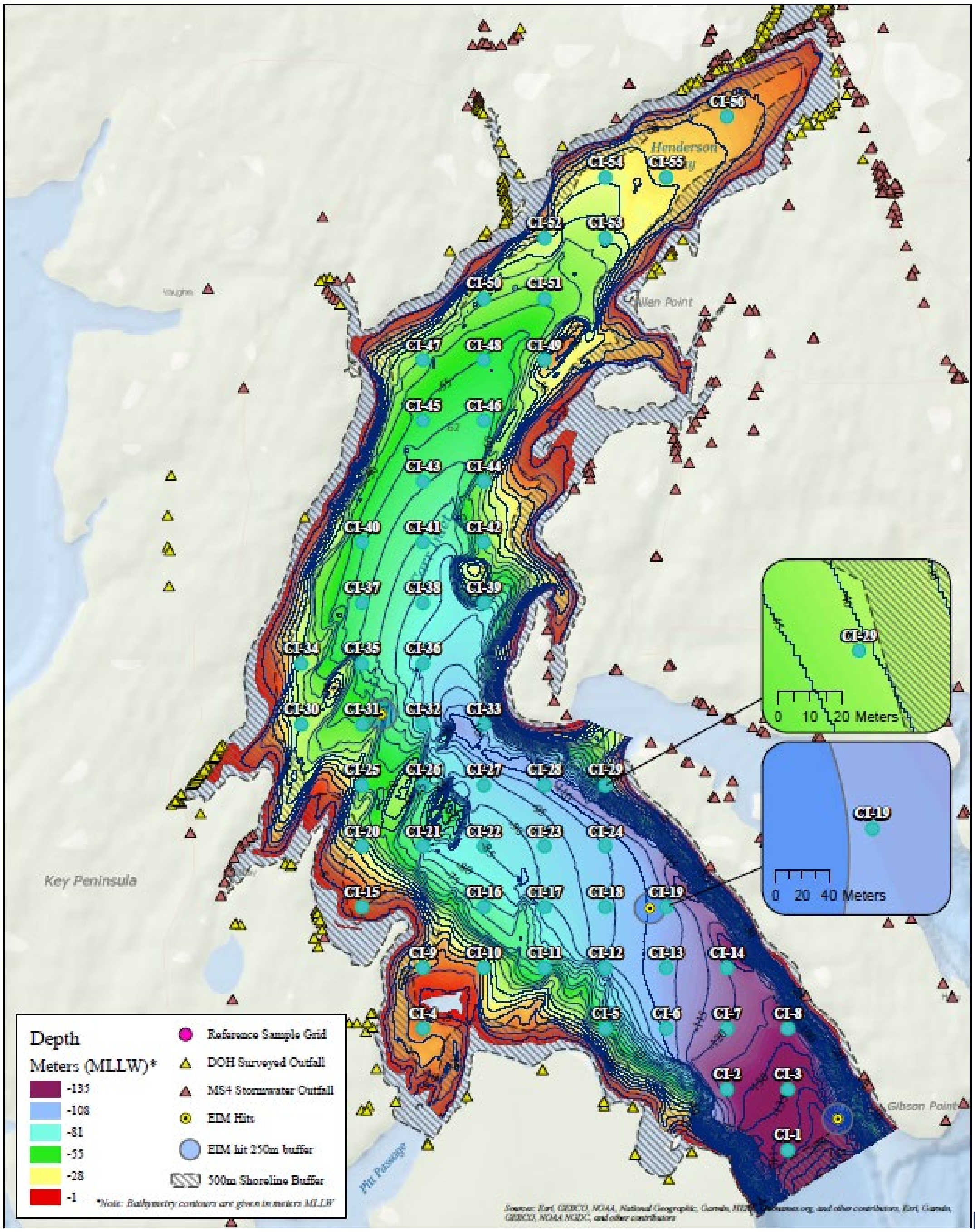

Figure 16.

Figure 16. Carr Inlet Natural Background Decision Unit Map

Table 23. Carr Inlet Natural Background Decision Unit Sample Coordinates

Carr Inlet Natural Background Decision Unit Grid Samples			
Station ID	Latitude N (WGS84)	Longitude W (WGS84)	Depth MLLW (m)
CI-01	47.216493	-122.636000	143
CI-02	47.225533	-122.649147	126
CI-03	47.225492	-122.635938	136
CI-04	47.234714	-122.715143	10
CI-05	47.234609	-122.675510	49
CI-06	47.234571	-122.662299	106
CI-07	47.234531	-122.649087	120
CI-08	47.234490	-122.635876	128
CI-09	47.243712	-122.715095	18
CI-10	47.243679	-122.701882	20
CI-11	47.243644	-122.688668	65
CI-12	47.243607	-122.675455	95
CI-13	47.243569	-122.662241	108
CI-14	47.243529	-122.649028	120
CI-15	47.252743	-122.728263	8
CI-16	47.252677	-122.701831	72
CI-17	47.252642	-122.688616	91
CI-18	47.252605	-122.675400	98
CI-19	47.252567	-122.662184	108
CI-20	47.261741	-122.728217	29
CI-21	47.261709	-122.714999	66
CI-22	47.261675	-122.701781	84
CI-23	47.261640	-122.688563	91
CI-24	47.261604	-122.675345	100
CI-25	47.270739	-122.728171	48
CI-26	47.270707	-122.714950	65
CI-27	47.270674	-122.701730	92
CI-28	47.270638	-122.688510	104
CI-29	47.270602	-122.675290	41
CI-30	47.279768	-122.741347	36
CI-31	47.279738	-122.728125	50
CI-32	47.279705	-122.714902	82
CI-33	47.279672	-122.701680	99
CI-34	47.288766	-122.741303	35
CI-35	47.288736	-122.728078	64
CI-36	47.288704	-122.714854	84
CI-37	47.297734	-122.728032	63
CI-38	47.297702	-122.714805	76
CI-39	47.297668	-122.701578	71
CI-40	47.306732	-122.727986	58
CI-41	47.306700	-122.714757	71
CI-42	47.306666	-122.701528	44
CI-43	47.315698	-122.714709	64

Carr Inlet Natural Background Decision Unit Grid Samples			
Station ID	**Latitude N (WGS84)**	**Longitude W (WGS84)**	**Depth MLLW (m)**
CI-44	47.315664	-122.701477	46
CI-45	47.324696	-122.714660	56
CI-46	47.324663	-122.701426	61
CI-47	47.333694	-122.714612	45
CI-48	47.333661	-122.701376	55
CI-49	47.333625	-122.688140	25
CI-50	47.342659	-122.701325	44
CI-51	47.342624	-122.688087	49
CI-52	47.351622	-122.688034	29
CI-53	47.351585	-122.674793	33
CI-54	47.360583	-122.674738	29
CI-55	47.360545	-122.661496	24
CI-56	47.369503	-122.648193	17

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