U.S. Army Corps of Engineers
Seattle District

WASHINGTON STATE DEPARTMENT OF
Natural Resources

REAUTHORIZATION OF DREDGED MATERIAL MANAGEMENT PROGRAM DISPOSAL SITE COMMENCEMENT BAY, WASHINGTON

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

AUGUST 2009

Prepared for the Dredged Material Management Program Agencies

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COMMENCEMENT BAY, WASHINGTON

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Responsible Agencies: The responsible agencies for this action are those constituting the Puget Sound Dredged Material Management Program (DMMP): The U.S. Army Corps of Engineers, Seattle District (USACE); the U.S. Environmental Protection Agency, Region 10 (USEPA); the Washington Department of Natural Resources (WDNR); and the Washington State Department of Ecology (Ecology). USACE is the lead federal agency for this Supplemental Environmental Impact Statement.

Abstract: In 1988 the DMMP agencies prepared an environmental impact statement (EIS) pursuant to the National Environmental Policy Act (NEPA) , entitled "Unconfined, Open-Water Disposal Sites For Dredged Material, Phase I (Central Puget Sound), Puget Sound Dredged Disposal Analysis," to identify unconfined open-water disposal sites for dredged material in central Puget Sound. This document supplements that EIS. In the 1988 EIS, a location in Commencement Bay was identified as a preferred site for dredged material disposal. At that time, based on study of the Commencement Bay environment as well as current dredging activities, the analysis concluded that the site had a capacity of 9 million cubic yards (mcy), and predicted that this volume would be reached in 2028 based on dredging forecasts evaluated for the 1988 EIS. Once 9 mcy of material is placed at the site, the existing shoreline permit expires and disposal at the Commencement Bay open-water site can no longer take place without additional NEPA/State Environmental Policy Act (SEPA) review and analysis. Currently, the Commencement Bay site volume is expected to reach 9 mcy in dredging year 2010 (ending on June 15, 2010). Therefore, the DMMP is proposing to maintain disposal site operation through reauthorization of the Commencement Bay dredged material disposal site. The purpose of this Supplemental Environmental Impact Statement (SEIS) is to support the proposed continuation of disposal site operations through site reauthorization, by updating the original 1988 EIS analysis with more recent relevant environmental information, including the results of pre-disposal and post-disposal environmental monitoring of the site, as well as evaluating any modifications in site management practices that may be necessary. A completely new NEPA EIS analysis is not appropriate since the purpose of the proposed action is predominantly a reauthorization of an ongoing effort; however, since the reauthorization process involves substantial changes in the parameters of the Commencement Bay aquatic disposal site that are relevant to environmental concerns, supplementation of the 1988 EIS is necessary pursuant to 40 CFR 1502.9.

This SEIS evaluates the potential environmental impacts of three alternatives: (1) expand the existing site capacity volume and identify a new cumulative disposal volume ceiling of 23 mcy, formally adopt a provisional shift in the disposal coordinates to the southeast of the

initial site center undertaken in 2007 (at 7.8 mcy), and implement one additional coordinate shift within the existing Target Area southwest of the former site center at 18 mcy; (2) expand the existing site capacity volume and identify a new cumulative disposal volume ceiling of 23 mcy, formally adopt a provisional shift in the disposal coordinates to the southeast of the initial site center undertaken in 2007 (at 7.8 mcy), and implement two additional coordinate shifts within the existing Target Area: one at 13 mcy (to the southwest of the existing site center), and the other at 18 mcy (to the northeast of former site center); and (3) no action (the site would be closed to further disposal upon reaching a cumulative disposal volume of 9 mcy). Both alternatives 1 and 2 would involve application of limited institutional controls applying adaptive management. This SEIS analysis concludes that neither of the action alternatives would result in significant environmental impacts. The selection of the preferred alternative (Alternative 2) is based on the dampening effect on mound growth as a result of two additional shifts in the disposal coordinates all within the existing Target Area , and the alternative's effect in minimizing changes to existing tidal currents in Commencement Bay; Alternative 2 would also institute the use of additional adaptive management measures (e.g., institutional controls) to better manage disposal at the site if future monitoring indicates it is required. The preferred alternative would not generate more than a minimal incremental contribution to cumulative impacts, and would be in compliance with all applicable federal, state and local laws and regulations.

As an analysis of reauthorization of the existing Commencement Bay aquatic disposal site, issues regarding the need for non-dispersive aquatic disposal opportunities for dredged material in southern Puget Sound, and the 1988 siting decision for the Commencement Bay site, are outside the scope of this SEIS.

This document is available online at: http://www.nws.usace.army.mil/ers/envirdocs.html

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AAQS	Ambient Air Quality Standards
AWOIS	Automated Wreck and Obstruction Information System
BCOC	bioaccumulative contaminant of concern
BT	bioaccumulation trigger level
CAA	California Clean Air Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CSL	cleanup screening levels
cy	cubic yards
DAHP	Department of Archaeology and Historic Preservation
DIN	dissolved inorganic nitrogen
DMMP	Dredged Material Management Program
DO	dissolved oxygen
DPS	distinct population segment
DW	dry weight
DY	Dredging Year (June 16 to June 15 of following year; covers 2 calendar years)
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
EIS	environmental impact statement
ESA	Endangered Species Act
FEIS	final environmental impact statement
FR	Federal Register
ha	hectare
HAP	hazardous air pollutant
HPAH	high molecular polycyclic aromatic hydrocarbon
LPAH	low molecular polycyclic aromatic hydrocarbon
LTFATE	long-term fate model
mcy	million cubic yards
MDFATE	Multiple Dump Fate Model
MDL	method detection limits
$\mu g/m^3$	micrograms per cubic meter
mg/L	milligrams per liter
ML	maximum levels
MPN	most probable number
MRL	method reporting limit
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Protection Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NRHP	National Register of Historic Places
NTU	nephelometric turbidity unit
OSI	organism sediment index
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls

ppb	parts per billion
ppm	parts per million
PSAT	Puget Sound Action Team
PSCAA	Puget Sound Clean Air Agency
PSDDA	Puget Sound Dredged Disposal Analysis Program
PSEP	Puget Sound Estuary Program
RCW	revised code of Washington
ROI	region of influence
RPD	redox potential discontinuity
SAIC	Science Applications International Corporation
SEIS	supplemental environmental impact statement
SEPA	State Environmental Protection Act
SHPO	State Historic Preservation Officers
SIP	State Implementation Plan
SL	screening levels
SMA	salmon management area
SMS	Sediment Management Standards
SOx	sulfur oxides
SQS	Sediment Quality Standards
STFATE	short-term fate model
SVPS	Sediment Vertical Profiling System
TBD	to be determined
TBT	tributyltin
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEQ	toxic equivalent quotient
TOC	total organic carbon
TSS	traffic separation scheme
TTL	target tissue level
USACE	U.S. Army Corps of Engineers
USE	Urban Shoreline Environment
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
ZSF	zones of siting feasibility

1.0 Introduction

The Dredged Material Management Program (DMMP) is an interagency forum that is responsible for environmental management of dredged material in Washington State over the past 20 years. The DMMP consists of the U.S. Army Corps of Engineers (USACE: lead agency for implementation), the U.S. Environmental Protection Agency (USEPA), the Washington Department of Natural Resources (WDNR), and the Washington State Department of Ecology (Ecology). The DMMP (originally known as Puget Sound Dredged Disposal Analysis or PSDDA Program[1]) has overseen disposal at the Commencement Bay disposal site, near Tacoma, Washington, since 1988 (Figure 1).

The DMMP (formerly PSDDA) was formally implemented in December 1988 with the USACE/USEPA Record of Decision finalizing the Phase I Central Puget Sound Final Environmental Impact Statement (FEIS). The DMMP process identified eight open-water dredged material disposal sites in Puget Sound, through a 4.5 year, $4.5 million dollar, intense, public interest-stakeholder process. It developed rigorous Site Management Plans and state-of-the art evaluation procedures for evaluating dredged material suitability for unconfined open-water disposal and for conducting environmental monitoring. The 1988 FEIS identified a location in Commencement Bay as a preferred site for dredged material disposal (Figure 1). Each dredging project contemplating open-water disposal undergoes a rigorous sediment testing process. The monitoring conducted at each non-dispersive site provides a direct feedback loop on the adequacy of program characterization of dredging projects documented in suitability determinations.[2] To date, monitoring conducted at the Commencement Bay site and at the other four non-dispersive sites in Puget Sound[3] (Figure 2) has confirmed the adequacy of DMMP program evaluation procedures in characterizing dredging projects. The monitoring plan and evaluation procedures for DMMP testing are updated annually as necessary through the Sediment Management Annual Review Meeting to keep the program current based on the best available science.

1.1 Purpose and Need

The purpose of the proposed action evaluated in this NEPA document is to maintain (through reauthorization) an operating disposal site within Commencement Bay for the disposal of DMMP "suitable" dredged material. This reauthorization is necessary to meet anticipated long-term disposal needs associated with navigation, Port construction activities, and routine maintenance dredging in the Tacoma area. Based on studies of the Commencement Bay environment as well as dredging activities at the time, the 1988 environmental impact statement (EIS) analysis concluded that the site had a minimum capacity of 9 million cubic yards (mcy), and predicted that this volume would be reached in 2028 based on extrapolation

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1 The initial geographic focus of PSDDA was limited to Puget Sound. In 1996 the geographic focus expanded to Grays Harbor and Willapa Bay, and in 1998, further expanded to the Washington side of the Columbia River. The interagency program name changed from PSDDA to DMMP to acknowledge that interagency geographic expansion.

2 Technical Memorandum summarizing the four-agency (USACE, USEPA, Ecology, WDNR) consensus determination on the sediment testing data collected for a given dredged material project for disposal at a DMMP open-water disposal site (http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=SDM`S_BY_YEAR).

3 The DMMP agencies manage 2 types of disposal sites in Puget Sound, non-dispersive and dispersive sites. A site is considered non-dispersive if the peak 1% current speed is less than 25 centimeters per second, and if sediments have a small grain size, with statistically elevated volatile solids, biochemical oxygen demand, and water content (USACE, 1988c). Post-disposal monitoring has verified that the site is non-dispersive, exemplified by the stable mound observed from bathymetric monitoring, which lies concentric within the Disposal Zone (see Figure 7).

from a 15-year forecast of dredging activity, conducted in the 1988 EIS.[4] The 15-year initial forecast of site use in the 1988 EIS, when compared to actual site use, shows that the predictions closely matched what was actually dredged and disposed at the site between 1989 and 2003 (Table 1). However, site use has significantly increased in recent years and disposal volumes are now well beyond what was predicted in the 1988 EIS. At the time of initial implementation, Washington DNR, on behalf of the PSDDA (now DMMP) agencies, applied for a shoreline substantial development permit from Pierce County to begin disposing at the site; the permit established an "established capacity" disposal volume for the site of 9 mcy, at which point the applicant would be required to apply for a new shoreline permit. Once 9 mcy of material is disposed of at the site, the existing shoreline permit would expire and disposal at the site could no longer take place without additional National Environmental Policy Act (NEPA)/State Environmental Policy Act (SEPA) review and analysis. Currently, the Commencement Bay site volume is expected to reach a cumulative disposal volume of 9 mcy in dredging year 2010 (ending on June 15, 2010). Therefore, the DMMP is proposing to maintain operation of the Commencement Bay dredged material disposal site, through reauthorization of the site.

Table 1. Comparison of 15-year (1989-2003) Dredging/Disposal Forecasts to Actual Disposal at the Commencement Bay Disposal Site[5]

Projections	Suitable Volume Disposed (cy)	Unsuitable Volume (cy)	Total
Actual	3,473,266	322,293	3,795,559
Predicted EIS	3,160,000	769,000	3,929,000
% Actual/Predicted	110%	42%	97%

In conjunction with the purpose of evaluating site reauthorization, this SEIS will assess both the efficiency, and the environmental effects, of the alternatives in addressing two conditions identified at the Commencement Bay disposal site: (1) an observed increase in dredged material mound height, beyond levels anticipated in the 1988 EIS; and (2) observed distribution patterns of disposed dredged material that deviate from the expected distribution footprint as reflected in the initial EIS.

An additional need is to reevaluate site management practices to ensure that disposal events, singularly and cumulatively, continue to result in no more than insignificant adverse effects on the aquatic or human environment. To this end, disposal events will continue to be performed in an environmentally responsible manner under DMMP oversight with an approved site management plan that is updated annually as needed after coordinating proposed changes through the Sediment Management Annual Review Meeting public review process (USACE et al. 1988a, 1988b; SAIC 2007). Finally, through the disposal suitability review process, the DMMP will continue to encourage potential site users to consider a clear preference for beneficial uses of this material when such uses are available and feasible. The DMMP agencies and the Puget Sound Water Quality[6] Authority articulated

[4] The initial forecasts in the 1988 EIS preceded the Superfund Cleanups in Commencement Bay Waterways, especially the cleanup of Blair Waterway. Port of Tacoma development accelerated dramatically after the 1994 Superfund Cleanup was completed, and was responsible for the accelerated use of the Commencement Bay Site over the past 13 years, which was not anticipated in the initial EIS.

[5] FEIS, page 2-45, Table 2.4, Alternatives for Commencement Bay Site, Sites 1 and 2, Site Condition II.

[6] The Puget Sound Water Quality Authority subsequently became the Puget Sound Action Team, and this agency sunset in 2007 and was replaced by the Puget Sound Partnership.

sediment management goals in a 1995 Interagency Agreement (Appendix C) to promote and facilitate beneficial uses for dredged material.

This SEIS, prepared pursuant to NEPA and SEPA requirements, describes the environmental impacts of the two reasonable alternatives as input to identifying the alternative that satisfies all needs most effectively while strictly adhering to all federal, state, and local laws and regulations.

Because it constitutes an analysis of reauthorization of the existing Commencement Bay aquatic disposal site, issues regarding the need for non-dispersive aquatic disposal opportunities for dredged material in southern Puget Sound are outside the scope of this SEIS. Similarly, the central management framework of the Commencement Bay site, including application of the Site Condition II management paradigm to dredged materials disposed at this non-dispersive site, is outside the scope of this reauthorization analysis.

As discussed in Section 1.2, the original PSDDA site selection process focused on zones of siting feasibility (ZSFs) with non-dispersive (minimal energy) conditions, that minimized environmental impacts and interference with other uses, and that were a reasonable distance from likely dredging sites. As noted in Section 1.2, there are very limited ZSFs outside the existing disposal site in Commencement Bay meeting the primary non-dispersive siting objectives. The original criteria for selecting the existing Commencement Bay disposal site are still valid and would be used if a new site were to be established. As discussed in further detail throughout this SEIS, the current site is functioning well in terms of environmental effects (see Appendix A, Tables ES-1 and ES-2: Summary of Monitoring findings 1988-2007), and has sufficient physical capacity to accommodate additional dredged material disposal. Switching to a new site would entail more uncertainty regarding potential environmental impacts (limited low-energy areas outside existing disposal site within Commencement Bay) than continuing to use the current site, where monitoring has shown impacts to be minimal and within management criteria. For these reasons, the conclusion of the 1988 EIS as to the siting of the Commencement Bay site was not reevaluated or reconsidered, and establishment of a replacement disposal site in a new location is thus outside the scope and evaluation process of this SEIS.

1.2 Site History

As stated above, disposal of suitable material at the Commencement Bay dredged disposal site began in 1989 after completing a formal NEPA/SEPA EIS, which included a technical site selection review documenting the extensive site selection process followed for this disposal site and other Puget Sound sites (USACE et al. 1988c).[7]

[7] USACE, 1988c: Disposal Site Selection Technical Appendix to the EIS.

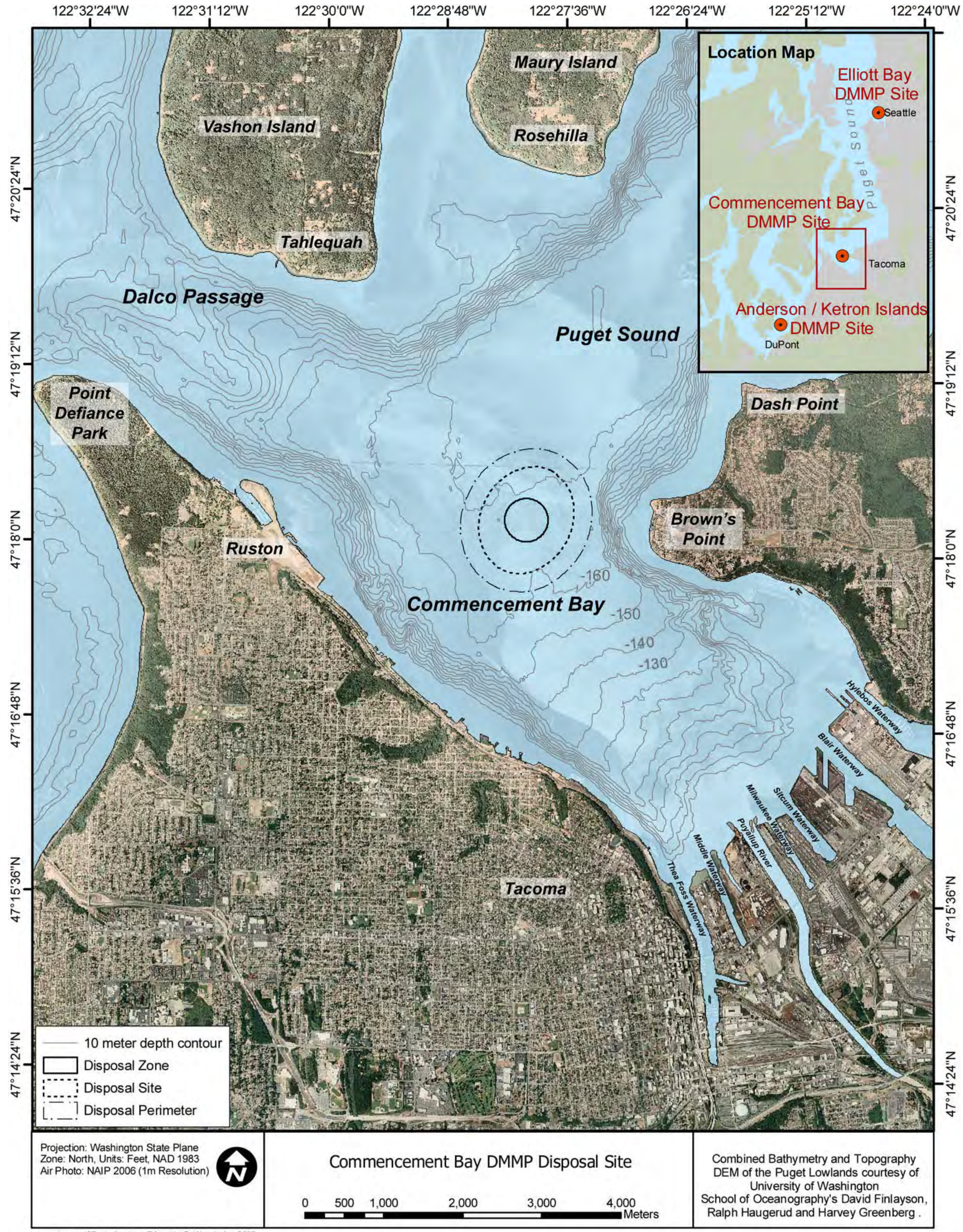
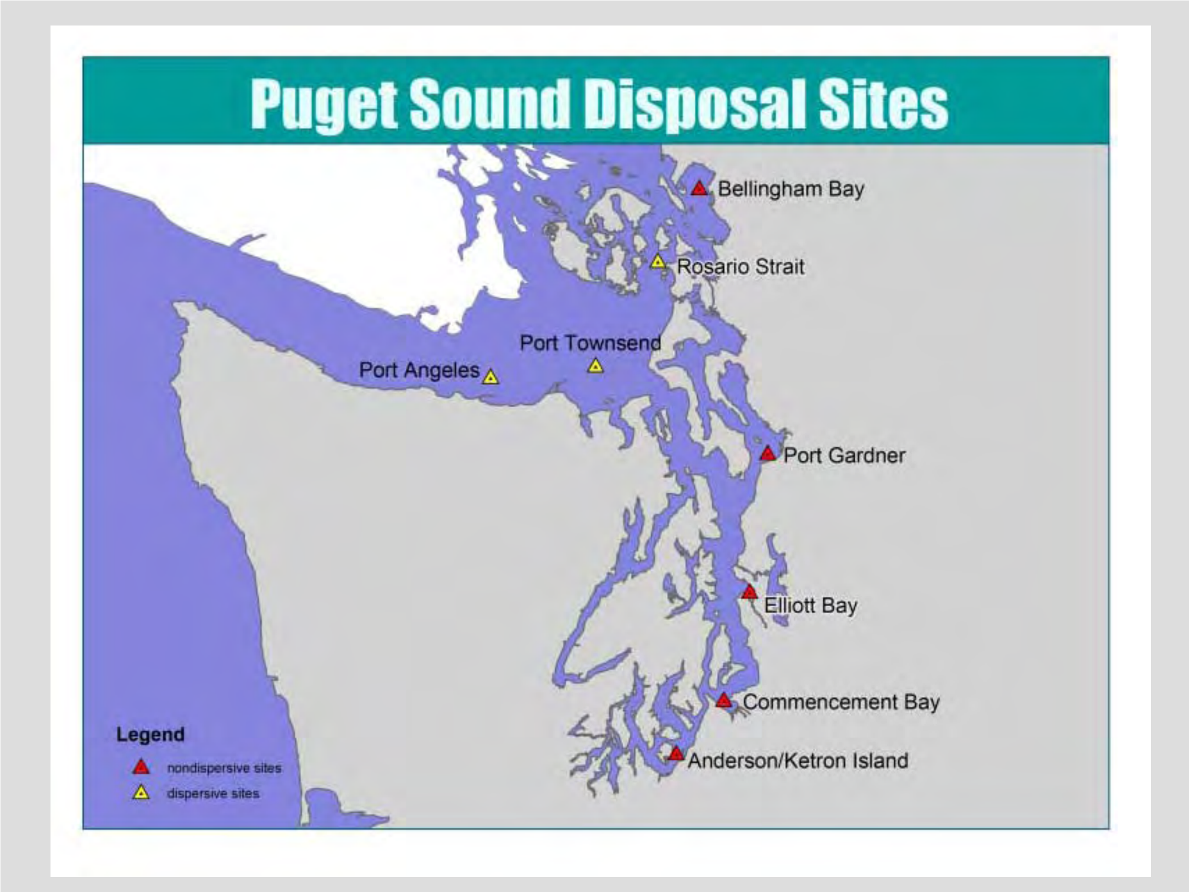


Figure 1. Commencement Bay DMMP Disposal Site



Source: DMMP 2008

Figure 2. Puget Sound DMMP Disposal Sites

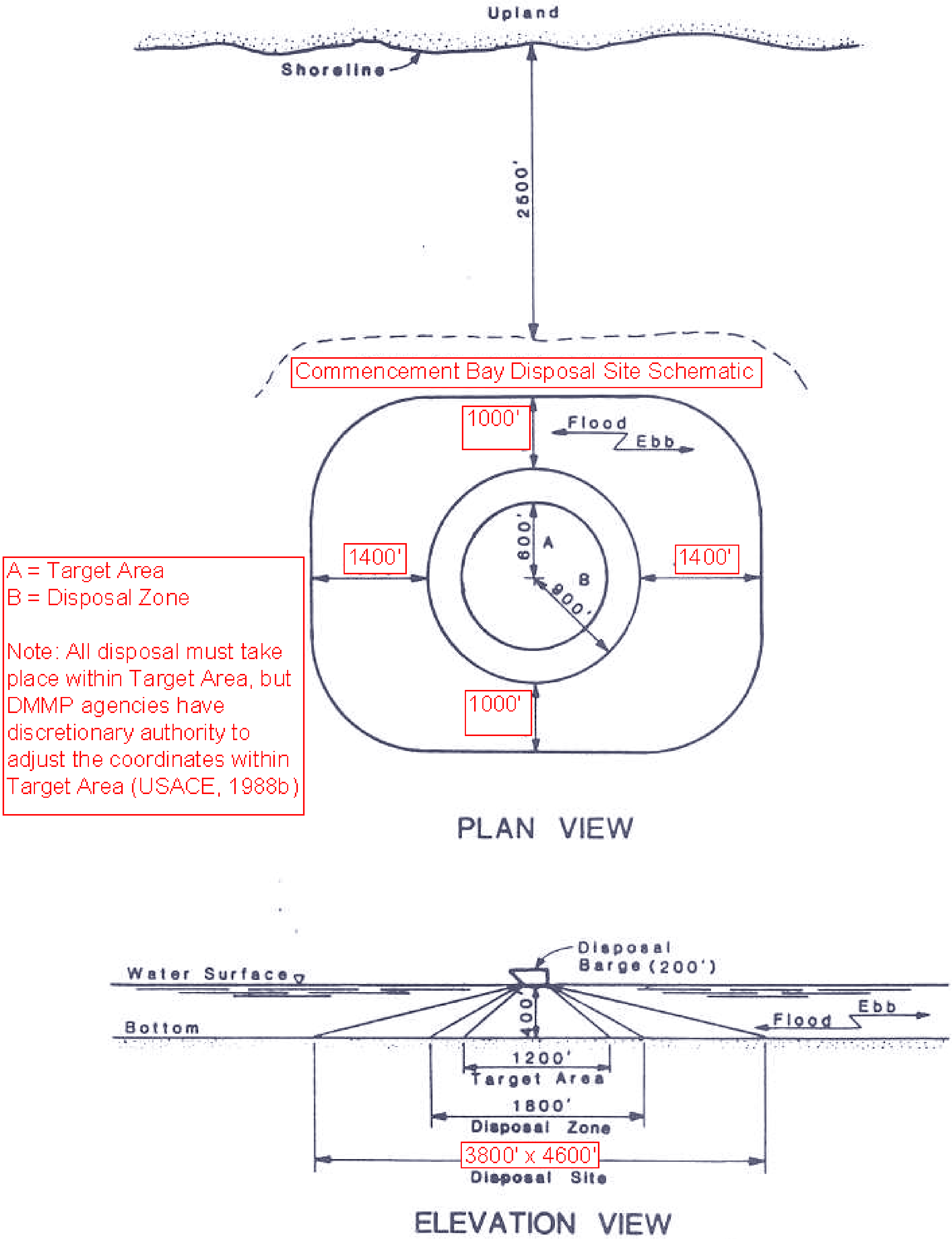
A primary emphasis of the siting process focused on establishing disposal sites in non-dispersive areas of Puget Sound, and the Central Puget Sound Phase I Final EIS established non-dispersive disposal sites in Commencement Bay, Elliott Bay, and Port Gardner. During these disposal site selection evaluations, zones of siting feasibility (ZSFs) were established within areas in proximity to dredging areas in Puget Sound. ZSFs were identified through a mapping overlay process, where key siting factors of concern were minimized. Three general ZSF selection factors were identified to (1) avoid areas of high energy that would disperse dredged material beyond the site; (2) avoid unacceptable adverse impacts on fish, shellfish, marine mammals, and marine birds; and (3) minimize interference with human uses to the lowest extent practicable. Additionally, 19 additional ZSF selection factors (Table 2) were used to identify areas meeting the siting factors that were carried forward for site-specific studies, after applying additional constraints to minimize conflicts. These constraints consisted of locating potential disposal sites a minimum water surface distance of 2,500 feet from adjacent shorelines to act as a buffer from noise and environmental effects on the shoreline. Potential sites were also to be located 2,500 feet from vulnerable biological resources, and at water depths greater than 120 feet and no deeper than 600 feet, outside of the more biologically productive and commercial fish and shellfish areas. Final sites were chosen based on predictions of which sites could receive dredged material without posing a significant threat to the surrounding environment, without disrupting other ongoing activities underway in the area, and without serving as a nuisance to the nearby shoreline.

Table 2. Selection Factors for Zones of Siting Feasibility

1. Navigation activities
2. Recreational uses
3. Cultural sites
4. Aquaculture facilities
5. Utilities
6. Scientific study areas
7. Point pollution sources
8. Water intakes
9. Shoreline land use designation
10. Political boundaries
11. Location of dredging areas
12. Beneficial uses of dredged material
13. Fish/ shellfish harvest areas
14. Threatened and endangered species
15. Fish/ shellfish habitat
16. Wetlands, mudflats, and vegetated shallows
17. Bathymetry
18. Sediment characteristics
19. Water currents

The ZSFs identification effort within Commencement Bay demonstrated that there were only limited areas meeting the site selection factors, and were largely restricted to the two alternatives carried forward for analysis in the 1988 EIS. The preferred site at Commencement Bay was selected because it satisfied all of these requirements to a high degree. Seasonal, site-specific studies verified that existing bottomfish, shellfish, and benthic resources were relatively low in abundance, or absent in the case of Dungeness crab. The site itself is located at 540 to 560 feet in depth, and disposal of material to such depths posed little threat to nearby activities, such as navigation or fishing. Outside of disposal barge operations, there is no noticeable sign of the presence of the disposal site in Commencement Bay.

Figure 3 depicts the site use compliance boundaries, which illustrate that disposal barges must dispose dredged material within the 1,200 ft-diameter Target Area, located within the 1,800 ft-diameter Disposal Zone. Disposal barges/tugs are directed by the U.S. Coast Guard Vessel Traffic Service (VTS) to dispose material at DMMP designated coordinates within the Target Area. DMMP agencies have discretion to make minor site management program adjustments, including modification of site use provisions such as adjustment of the disposal coordinates within the existing Target Area (USACE 1988 and 1988b). From 1989 to 2007 the coordinates for disposal were at the center of the Target Area. In 2007, the coordinates were shifted provisionally 565 feet to the southeast within the Target Area (Wasson et. al. 2007). The reason for this provisional coordinate shift is explained fully in Section 1.2.3. For compliance with the DNR Site Use Authorization (SUA), the disposal barges must be inside the Target Area when discharge is executed.

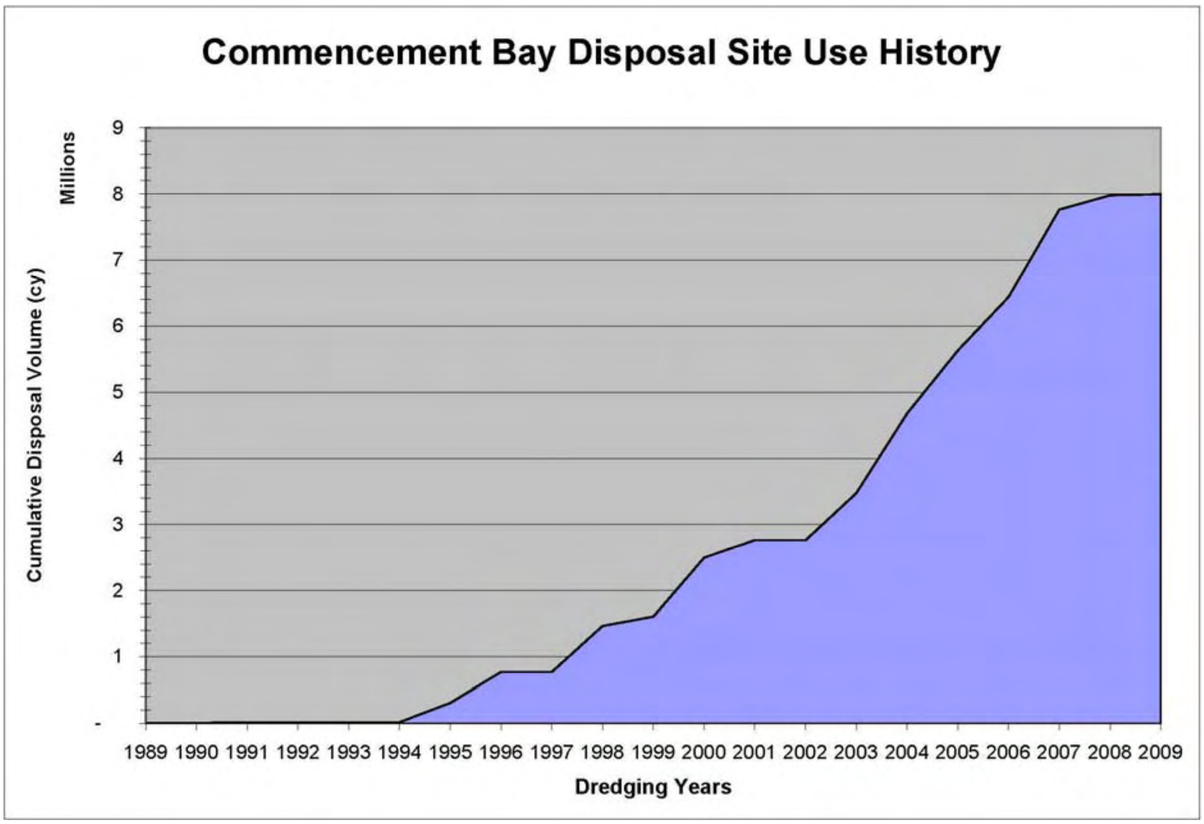


Schematic modified after USACE 1988b

Figure 3. Disposal Site Use Compliance Schematic

Early use of the disposal site was relatively low, with very little disposal occurring through 1994 (cumulative volume between 1989 and 1994 was 17,548 cy). Between 1995 and 2001 (Figure 4 and Table 3), the disposal averaged 457,500 cubic yards per year (cy/year), and between 2003[8] and 2008, disposal at the site increased significantly, averaging 869,363 cy/year. The increase in site use is attributable to Port of Tacoma's expansion and development activities in Blair Waterway, starting in 1995. The Superfund cleanup assessments in Commencement Bay were ongoing and no cleanups were initiated/completed at the time of the 1988 EIS. Therefore, the future Port expansion activities, resulting in increased dredging disposal volumes, in Blair Waterway were not anticipated by the Port of Tacoma and the DMMP agencies at the time the 1988 EIS was completed. The current cumulative site volume after compiling all site disposal completed through February 15, 2009, is close to 8.0 mcy.

In the next few years, two major projects by the Port of Tacoma are expected to result in annual disposal volumes similar to those of 2003 to 2008 (see Section 2.5). In the long term, however, the best projection for annual volumes is expected to be lower, with an average of approximately 700,000 cy. (Brenner 2008). This is the average annual volume used for environmental impact assessment in this SEIS.



Source: DMMP 2008

Figure 4. Cumulative Disposal Site Use History through 2009

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[8] Note the site was not open during 2002, while DMMP agencies conducted a thorough site assessment after monitoring detected an unexpected distribution of a thin layer of dredged material.(see Appendix A for a full discussion of the evaluation conducted).

Table 3. Commencement Bay Disposal Site Use and Monitoring History

Dredging Year	Disposal Volume (cy)	Cumulative Volume (cy)	Monitoring
1988			Baseline
1989	6,648	6,648	
1990	0	6,648	
1991	10,900	17,548	
1992	0	17,548	
1993	0	17,548	
1994	0	17,548	
1995	290,857	308,405	Tiered Full
1996	460,684	769,089	Tiered Partial
1997	0	769,089	
1998	693,540	1,462,629	Sediment Profile Imagery
1999	140,319	1,602,948	
2000	893,776	2,496,724	
2001	265,867	2,762,591	Full, Bathy
2002	0	2,762,591	
2003	710,675	3,473,266	Tiered Full
2004	1,205,993	4,679,259	Tiered Partial, Bathy
2005	949,399	5,628,658	Sediment Profile Imagery
2006	811,000	6,439,658	Multi-beam Survey
2007	1,324,254	7,763,912	Full, Multi-beam Survey, Resource Trawls, Dioxin
2008[9]	214,858	7,978,770	
2009	18,803	7,997,573	

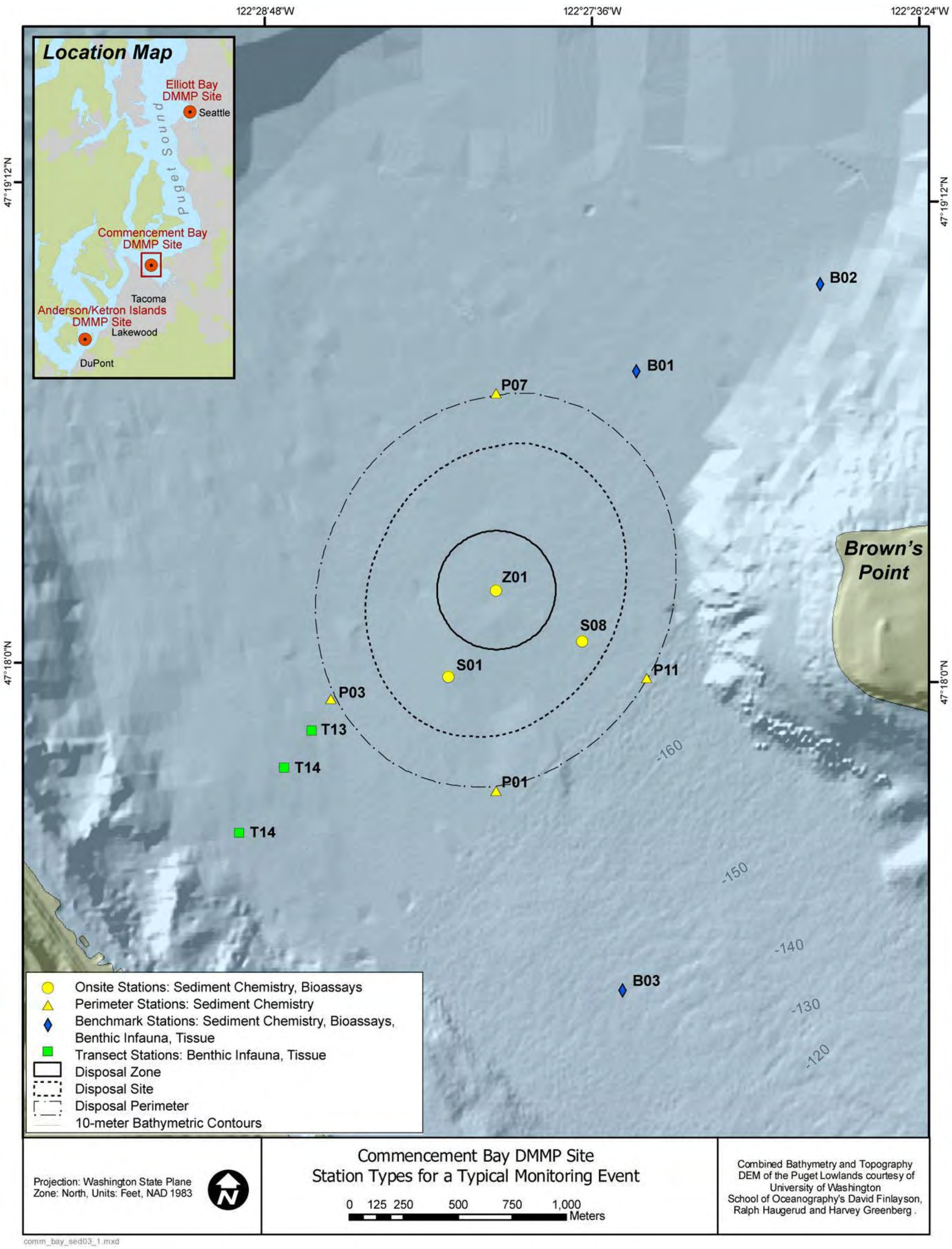
1.2.1 Extensive Monitoring and Successful Outcomes

The DMMP has overseen extensive monitoring activity at the Commencement Bay site throughout its history, making it the most monitored dredged disposal site under DMMP's management authority, and one of the most intensively monitored sites in the country. The Disposal Site Monitoring program collects data at specified monitoring stations (Figure 5, Table 4) to test three basic monitoring questions and six testable hypotheses to verify compliance with site management objectives (Table 5). A complete discussion of monitoring results can be found in Appendix A (Data Summary Report). Since predisposal baseline evaluation of the site in 1988, the Commencement Bay has undergone monitoring in 1995, 1996, 1998, 2001, 2003, 2004, 2005, and 2007 (Table 3). These monitoring activities have provided ongoing in-depth information on the physical, chemical, and biological status of the Commencement Bay site in near real-time to the DMMP agencies. The DMMP has used this information to closely guide management of the site and ensure that disposal operations have

[9] All disposal during DY2008 and DY2009 at Southeast Coordinates

adhered to its strict management, regulatory, and legal guidelines. Over the history of the site, the environmental condition of the site has closely followed what was predicted in the original EIS document and has generally operated effectively within the site management plan objectives for this non-dispersive site (see Appendix A, Table 3-1 for a complete summary of monitoring results relative to site management objectives). As an illustrative example, the monitoring results for 2007 demonstrated full compliance with the site management objectives following the disposal of 1.3 mcy of dredged material during Dredging Year (DY)[10] 2007.

[10] Dredging Year (DY as implemented in DMMP) extends over 2 calendar years and begins on June 16th and extends to June 15th of the following year. DY 2007 began on June 16, 2007 and extended to June 15, 2008.



After SAIC 2003

Figure 5. Commencement Bay Disposal Site Sediment Sampling Locations for a Typical Monitoring Event

Table 4. Station Types and Purpose for Commencement Bay Site Monitoring

Station	Designation Letter	Location	Purpose
Zone	Z	Within disposal target zone.	Assess sediment chemistry and toxicity of dredged material deposited in the target area (Question 2).
Site	S	Within the site boundary but outside of the target zone.	In conjunction with zone data, site station sediment chemistry and toxicity are used to evaluate Question 1.
Perimeter	P	Located 0.125 nautical mile from the site boundary.	Physical and chemical data are obtained to determine if dredged material is present beyond the site boundary and document the chemical character of sediments outside the site boundary (Question 1).
Transect	T	Situated along a radial transect that extends outward from the perimeter line. Located in the direction of dredged material transport.	Sampled for benthic infauna abundance and infauna tissue contaminant body burden to evaluate biological resource impacts off site (Question 3).
Benchmark	B	Located in the vicinity of the disposal site, but beyond the region affected by disposal activity.	Used to identify potential changes in sediment quality that may be unrelated to dredged material disposal. Data are evaluated only if site, perimeter, or transect data indicate that conditions at or adjacent to the site have changed relative to baseline conditions and to test hypotheses that observed changes are due to dredged material disposal.1 Data may be used to evaluate hypotheses 2 through 6.
Central Transect	C	Situated along two perpendicular lines that bisect the disposal site and may extend beyond its boundaries.	Used for physical measurements to map the post-disposal distribution of dredged material (Question 1).
Floating	F	Located in various locations within and outside of the disposal site.	Used to help delineate the extent of the dredged material deposit. Stations are sampled for sediment and benthic infauna analysis, if necessary, to assess dredged material impacts outside of the disposal site.
Reference	R	Located in areas documented to be free of potential sources of contamination (e.g., Carr Inlet). Location is selected on the basis of grain size comparability with the bioassay test sediments.	Sediments used as a control for physical effects in toxicity testing.

1. All data types (physical, sediment chemistry, tissue chemistry, sediment toxicity, and benthic infauna) may be collected. Benchmark sediments are generally archived until disposal site analyses indicate benchmark data are needed for full evaluation. However, benchmark chemical analyses for volatile organics, mercury, sulfides, and ammonia are conducted in conjunction with disposal site sediments due to holding time constraints. In addition, because the freezing of bulk sediment samples may result in structural changes in the sediment, which will alter the availability of tributyltin (TBT), samples to be held for future TBT analysis should have interstitial water extracted prior to freezing (Hoffman 1998).

Table 5. The DMMP Monitoring Framework

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

*To determine if observed changes in chemical conditions or infaunal benthos are due to dredged material disposal, data from the benchmark stations are evaluated. DMMP deliberations also use best professional judgment.

1.2.2 *Shift in Observed Disposed Material Footprint*

Physical surveys of the location of dredged material in 1998 and 2001 showed that a small amount of dredged material had extended beyond the northwest boundary of the Commencement Bay site. The DMMP Management Plan Technical Appendix to the 1988 EIS (USACE 1988b) anticipated that small volumes of dredged material may be observed during routine monitoring outside the disposal site boundary. The management plan established, through interpretive guidelines, a site management trigger of 3 cm of dredged material measured at the Perimeter line, which extends an additional 0.125 nautical mile outside the site boundary (Figure 5). In the event that dredged material exceeds the 3 cm trigger at the Perimeter Line, additional review and assessment by the DMMP agencies is required (Table 5). This review and assessment process involves the application of the DMMP's best professional judgment to determine the ecological significance of, and consequently the ecological risk posed by, the observed conditions. To do so, the DMMP assesses ecological risk significance and risk against the biological effects condition prescribed in the 1988 EIS, to determine whether the observed condition carries more than minor adverse effects. Pursuant to the Management Plan Report and Management Plan Technical appendices to the 1988 EIS, only if more than minor adverse effect is identified does the DMMP determine appropriate site management actions, by applying best professional judgment. Site management measures contemplated in the 1988 EIS as potential adaptive management actions include program adjustment, potentially consisting of modification of disposal site use or amendment of disposal guidelines.

The DMMP agencies elected to place a moratorium on disposal activities in July 2001, to enable a thorough analysis of the offsite thin layer of dredged material. The moratorium lasted until the summer of 2002. During that time, the DMMP agencies evaluated the monitoring observations with a short-term fate (STFATE) analysis to help explain the observed distribution of disposed material and to forecast the effect of future disposal at the site (Nelson 2003[11]). This analysis provided "a plausible explanation of how the finest portion of the disposed material (clay, silt, and fine sand) is being transported off site during the disposal operations" (Nelson 2003, 2006; Michalsen 2008[12]). All potential causes of the observed drift, including disposal at incorrect coordinates, unauthorized dumping, and long-term shifting of material within the disposal boundary, were investigated. After this evaluation, the DMMP concluded that it was very likely that natural factors of Puget Sound, combined with normal disposal operations[13] and the fine-grained nature of the disposed material, led to a small amount of material moving outside of the site perimeter. Because the displaced material was of such small volume (3 to 5 cm in height) the DMMP agencies concluded after careful study that the exceedance of the 3 cm interpretive guidelines triggering threshold, did not constitute more than a minor adverse environmental effect, and posed no threat to the Commencement Bay area and its surroundings. This conclusion was based on extensive survey data collected during the 2001 monitoring effort within the offsite footprint (e.g., chemistry, toxicity data, and benthic infaunal data).

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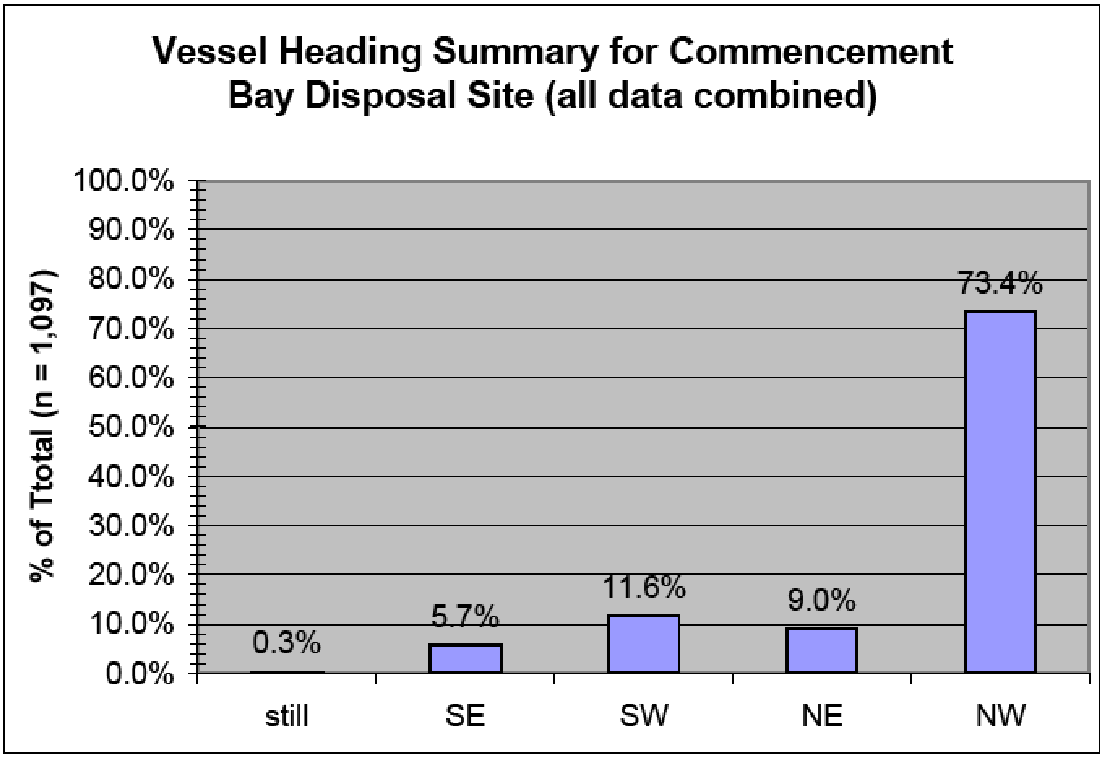
[11] The initial STFATE analysis was conducted in 2001, and the draft 2001 letter report was subsequently finalized in 2003, and the conclusions in the 2001 draft letter report did not change.

[12] Nelson, 2006, and Michalsen 2008 provided additional analysis and clarity on the likely causes for the 2001 monitoring observations of offsite drift of small amounts of dredged material outside the site boundary and perimeter line.

[13] Examination of disposal information indicates that there is a strong directional bias during disposal with 73.4 percent of disposal vessels traveling from southeast to northwest, which is the primary direction of offsite footprint (Michalsen 2008).

After completing their evaluation, the DMMP briefed Pierce County and recommended that the site be reopened, to which Pierce County agreed. The site was re-opened and disposal continued shortly thereafter. Additional analysis by Michalsen (2008) indicates an additional contributing factor to the observed offsite drift of a small amount of fine grained material to the northwest is the observed orientation and direction of disposal barges/tugs through the disposal site during disposal, which show a clear bias to the northwest (Figure 6)[14].



Prepared from disposal data from DNR and Port of Tacoma, adapted from Michalsen 2008

Figure 6. Analysis of Vessel Heading Orientation and Direction Bias during Disposal at Commencement Bay Site during 2000 and from 2006 to 2007

1.2.3 Observed Mound Height Growth

An additional issue that the DMMP has examined is the growing height of the mound of dredged material at the site. In the original 1988 EIS, the prediction for the site mound with a 9 mcy volume was a "truncated cone with a base diameter of 4,000 feet (disposal site boundary), a height of 34 feet (3.4 percent angle of repose), and a diameter at the top of the cone equal to 2,000 feet" (USACE et al. 1988a, p. 4-31). Based on surveys over the history of the site, the material has not mounded into a 4,000-foot-wide cone, but rather has remained much more concentrated within the target area (~ 2,400-foot-wide cone) (Figure 7)[15]. As a result, the mound height has increased at a higher rate than was expected

[14] The disposal logs summarized in Figure 4 supporting this conclusion are available at the Seattle District Dredged Material Management Office.

[15] The STFATE modeling inputs for the initial siting of disposal sites in Puget Sound (USACE 1988c, 1989b) assumed characteristics of maintenance dredged material with a higher percent of silts and clays than the bulk of the material disposed at the Commencement Bay site. Because of the completion of Superfund cleanup following promulgation of the 1988 EIS, discussed previously, the aggregate volume of material disposed at the Commencement Bay site has consisted predominantly of new Port construction and native materials, which were the primary reason the mound height and site dimensions predictions were not realized. The model inputs have been subsequently refined to match what has been disposed at the site and repeatedly ground-truthed with bathymetric data in 2001, 2004, 2006, and 2007. The STFATE/ MDFATE model outputs now closely match the actual site disposal mound characteristics.

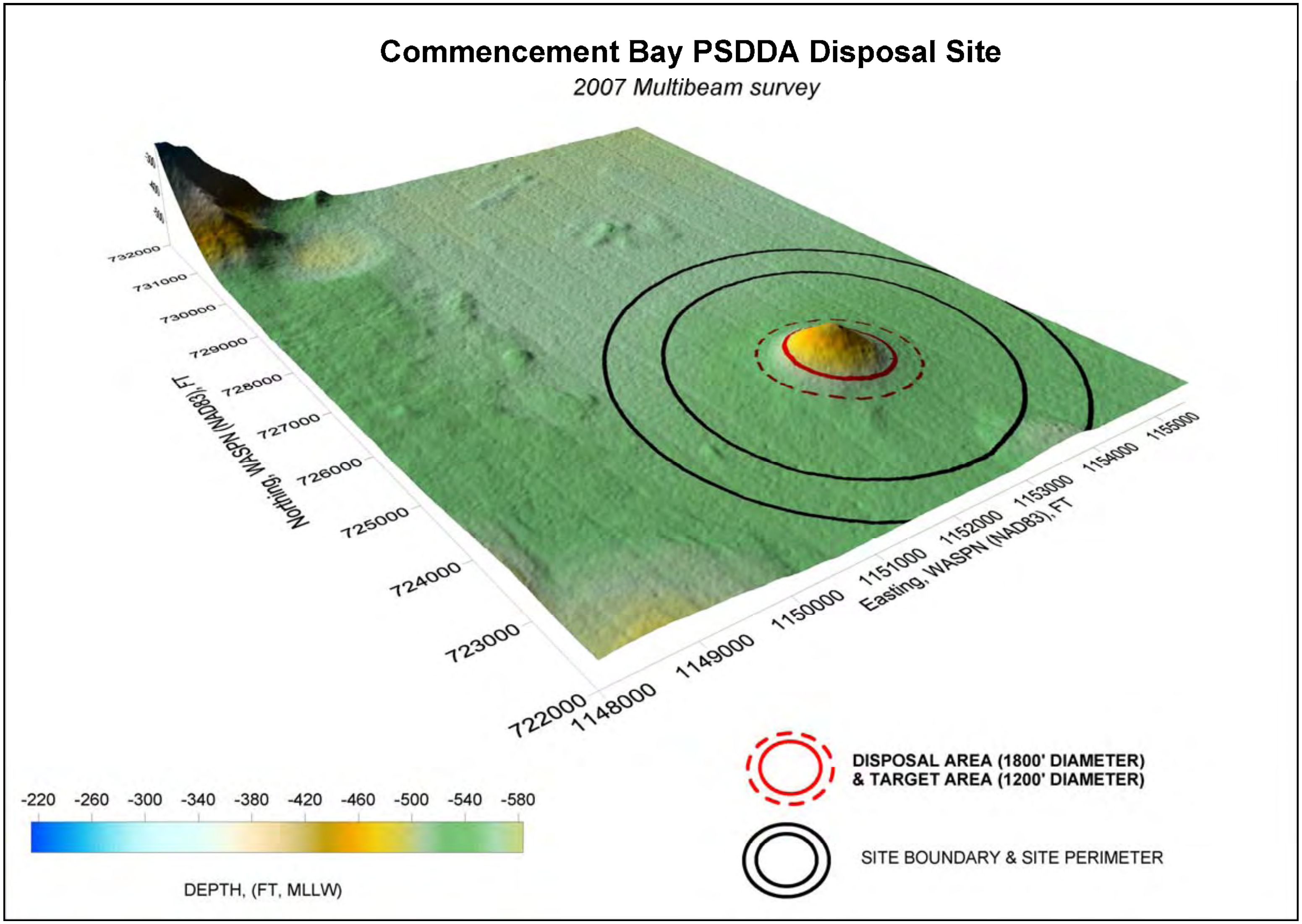
in the 1988 EIS, while remaining more concentrated on a smaller overall area of seafloor within the disposal site boundary. In 2001, the mound height was measured at 48 feet, 80 feet in 2004, 103 feet in 2006, and 121 feet in 2007. While there still remains over 400 feet of water above the mound at its highest point, the DMMP has closely monitored the height of the mound and modeled the future mound height through MDFATE (USACE MDFATE[16] Analyses). The 2006 STFATE analysis (Nelson 2006) concluded that moving the site disposal coordinates within the existing Target Area, 565 feet to the southeast could effect a net reduction in future mound growth of up to 30 percent.

The original DMMP Management Plan Technical Appendix (USACE 1988b) gave wide latitude to use adaptive management as needed to better manage the disposal sites based on site monitoring, and the initial management plan recognized that as new science and information became available the PSDDA (now DMMP) agencies would revise management plans as needed. All changes in the management plan are coordinated through regional stakeholders and the public through the Annual Review Meeting prior to implementation. The DMMP agencies were concerned about mound height growth early during early program implementation, and one of the early 1990 projects disposal of approximately 1 mcy at the Port Gardner disposal site (U.S. Navy Homeport Project) required quadrant dumping (e.g., 4 corners) within the Target Area to spread the dredged material and minimize mound height (Revelas et al. 1991). A similar coordinate shift within the existing Target Area was implemented at the Elliott Bay disposal site in 1991 (Striplin, B. 1991: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/dmmo/pg_eb_91.pdf), where the site center coordinates were moved 300 feet to the south within the Target Zone.

1.3 Authority

USEPA and the federal permitting authority (USACE) are granted joint authority to designate disposal sites within waters of the U.S. in advance of disposal by 40 Code of Federal Regulations (CFR) 230.80, which is part of USEPA's Guidelines for Specification of Disposal Sites for Dredged or Fill Material implementing Section 404(b)(1) of the Clean Water Act. WDNR and Ecology are granted authority to cooperate with the USEPA and USACE in approving such disposal sites by Revised Code of Washington (RCW) 79.105.500 and Washington Administrative Code (WAC) 332-30-166. Pierce County's permitting authority for such sites is also granted by WAC 332-30-166 as well as by the Washington Shoreline Management Act (RCW 90.58 and WAC 173-26).

[16] MDFATE = Multiple Dump Fate Model (Mortiz and Randall 1995). A numerical model that describes short-term and long-term fates of the dredged material following multiple years of site use. MDFATE combines the existing models STFATE and LTFATE (long-term fate) (Scheffner et al. 1995) to predict subaqueous mound configuration over a series of disposal cycles (Moritz and Randall 1995). STFATE was utilized in previous modeling of the site (Nelson 2003, 2006).



Depicts 2007 Southwest Target Zone based on June 2007 Multibeam Bathymetric Survey Data with no Vertical Distortion (after Michalsen 2008)

Figure 7. Existing Dredged Material Disposal Mound at the Commencement Bay Disposal Site

1.4 NEPA and SEPA Requirements

As the lead federal Action Agency for this action, United States Army Corps of Engineers (USACE) is required by NEPA and the associated Council on Environmental Quality implementing regulations (40 CFR § 1500 et seq.) to assess the effects on the human environment from proposed agency actions, determine the significance of those effects, and coordinate with other agencies, tribes, and the interested public in that assessment. USACE implements NEPA through 33 CFR Part 230. The USEPA's NEPA implementing regulations at 40 CFR Part 6, Section 6.101, exempt USEPA from fulfilling NEPA requirements for most actions under the Clean Water Act, including advanced identification of disposal sites, but allow USEPA to conduct a voluntary NEPA analysis when it is beneficial to do so. USEPA has determined that in this case a NEPA analysis is beneficial, because the Commencement Bay disposal site has been operated under cooperative agreements with the state of Washington and USACE since 1988, and because many of the decisions made in the 1988 EIS to originally authorize the Commencement Bay site remain in place. Therefore, it is beneficial for EPA to participate in the preparation and public review of a NEPA document which supplements the original EIS. This SEIS has been prepared according to these regulations and the guidance presented in the Planning Guidance Notebook, ER 1105-2-100. Under SEPA, one agency conducts SEPA environmental review on a proposal for all state/local agencies. DNR, as the SEPA lead agency for this proposal, will determine if adoption of the NEPA document satisfies the requirements of SEPA or whether additional review under SEPA is required. DNR will consult with Ecology and Pierce County as part of that determination.

2.0 Alternatives

This section identifies and describes the reasonable alternatives for addressing the purpose and need underlying reauthorization of the Commencement Bay dredged material disposal site. A proposed action will be selected that best addresses the observed site conditions enumerated in Section 1.2, "Site History": the approach of cumulative disposal volume to the site volume capacity established in the 1988 EIS, or 9 mcy; disposed material footprint expansion; and mound height growth beyond height anticipated in the 1988 EIS. The alternatives selected for detailed analysis are described first, followed by alternatives that were initially considered and then eliminated from detailed evaluation.

2.1 Alternative 1: Expand site cumulative disposal volume ceiling to 23 mcy, with two coordinate shifts within the Target Area at 7.8 mcy and 18 mcy

Under this alternative, cumulative site volume would be increased from 9 mcy to a new cumulative disposal volume ceiling of 23 mcy, based on the MDFATE analysis of Michalsen (2008). Alternative 1 would consist of one additional shift in disposal coordinates (Figure 8). Until a cumulative disposal volume of 18 mcy is reached, all disposal would take place at the disposal coordinates previously implemented provisionally at the beginning of DY 08 (June 2007), after the Commencement Bay site had reached a cumulative disposal volume of 7.8 mcy.

The 2007 coordinates were provisionally placed within the southeast corner of the Target Area (1,200-foot diameter circle located around the 1988 site center coordinates), following the 2007 Sediment Management Annual Review Meeting. As mentioned briefly in Section 1.2, the DMMP agencies relocated, on a provisional basis, the Commencement Bay disposal coordinates within the existing Target Area[17] 565 feet to the southeast from the site center, at the beginning of DY 2008 (June 16, 2007) after the site had reached a cumulative disposal volume of 7.8 mcy. This coordinate shift was undertaken as a prophylactic adaptive management measure to manage the mound height growth, pending full consideration of whether final adoption is warranted upon the comprehensive evaluation conducted in this SEIS. Recent MDFATE analyses modeled additional coordinate shifts within the existing Target Area every additional 5 mcy, and the results of this analysis concluded that future mound height growth could be managed and significantly reduced up to 98 percent by disposing at revised coordinates (Michalsen 2008). Furthermore, the provisional coordinate shift to the southeast will serve the additional purpose of minimizing future material drift off site to the northwest.

This 2007 coordinate shift would be formally adopted. When the Commencement Bay site reaches a cumulative volume of 18 mcy, the site coordinates would shift to the southwest corner of the Target Area (i.e., 565 feet southwest from the initial site center coordinates) and remain at that location through a cumulative disposal volume ceiling of 23 mcy. Expected average annual disposal volumes disposed may be similar to that observed in recent years, approximately 460,000 to 865,000 cy/year, but may also change as regional stakeholder (e.g., Port of Tacoma) development plans change. The long-term average volume is expected to be approximately 700,000 cy/year.

[17]The DMMP agencies drafted a 2007 clarification paper (Wasson et al., 2007: http://www.nws.usace.army.mil/PublicMenu/documents/DMMO/CB-Site-Management-07-Clarification.pdf) justifying the provisional coordinate shift within the Target Area of 565 feet to the southeast.

Accomplishing these two coordinate shifts after 7.8 mcy and 18 mcy, respectively, is expected to result in a mound height of 232 feet after a cumulative disposal volume ceiling of 23 mcy is reached. This would be a net mound reduction of 32.3 percent (i.e., a mound height, measured after a cumulative disposal volume of 23 mcy is reached, is estimated at 307 feet if all disposal were conducted at 2007 coordinates, would be reduced to 232 feet with one additional coordinate shift, at 18 mcy after a cumulative disposal volume of 23 mcy is reached) (Michalsen 2008; Figure 8). Under Alternative 1, the DMMP agencies would establish a mound height site management objective of 250 feet**,** after reviewing the results of the numerical modeling analysis. This objective will minimize the potential effects of the disposal mound on tidal circulation in Commencement Bay, where numerical modeling has shown that there is little effect with a disposal mound of 300 feet or less (Michalsen 2008). Figure 9 (A-D) illustrates the effect of selective coordinate shifts on depressing future mound height growth after a cumulative disposal volume of 23 mcy. Figure 9 (B-D) depicts both undistorted vertical and horizontal scales in three cross-sections through the mound, and also depicts a 10/1 vertical to horizontal aspect ratio, which exaggerates the height of the mound relative to the horizontal scale. Alternatives 1 and 2 would meet the mound height site management objective.

The single additional coordinate shift in Alternative 1 would also adjust the distribution of disposed material within the disposal site boundary and limit the observed drift of dredged material to the northwest.

Disposal would require an average of approximately 1.75 barge trips per day, approximately 210 days per year, for a total of approximately 368 trips per year. Site boundaries would not be changed. The site would continue to be managed according to current practice: stringent monitoring would continue with pre-determined site performance standards. Established DMMP dredged material testing procedures would continue to be used to ensure that only material suitable for open-water disposal is disposed of at the site. The DMMP would continue to actively encourage beneficial uses of dredged material, when available and feasible, as an alternative to open-water disposal.

The DMMP's adaptive management of the site and use of state-of-the-art monitoring tools to manage the site within the site management objectives would continue. This entails ongoing review of the DMMP process for opportunities to improve site management through adoption of best available science and technology, as coordinated through the Sediment Management Annual Review Meeting. Examples include improved techniques for dredged material testing, site monitoring, and disposal operations. The DMMP is also adaptive in its management of the site in response to monitoring results. Examples are the temporary shut-down of the site in 2001 (see Section 1.2.2 for brief discussion of the evaluations during site shutdown; Appendix A provides a complete discussion of this evaluation and conclusion that Commencement Bay and the surrounding environment were not being appreciably adversely affected), and the provisional measure of relocating the disposal coordinates at the Commencement Bay site to dampen mound height and shift the disposed material footprint, pending completion of the full analysis reflected in this SEIS. The DMMP would continue to encourage beneficial use of dredged material as an alternative to open-water disposal, when available and feasible.

2.2 Alternative 2: Expand site cumulative disposal volume ceiling to 23 mcy, with three coordinate shifts within Target Area at 7.8 mcy, at 13 mcy and at 18 mcy (every 5.0 mcy) (Preferred Alternative)

Under this alternative, adaptive management would be exercised to control mound height and dredged material footprint within the site boundary and management areas from 9 mcy up to a cumulative disposal volume ceiling of 23 mcy (Figure 8). The management objective would include having a stronger focus on mound growth management compared to Alternative 1. As with Alternative 1, the DMMP would reserve for future consideration the use of institutional controls[18] for disposal to better manage the site. These criteria will include managing the mound height by formally adopting the provisional shift in disposal coordinates to the southeast, designated at the beginning of disposal year 2008, when the site had reached a disposed volume of 7.8 mcy; by shifting coordinates to the southwest corner of existing target zone after disposal of a cumulative volume of 13 mcy; by a third coordinate shift to the northeast corner of the existing target zone after disposal of 18 mcy; and continued use of adaptive management and updated state-of-the-art monitoring tools to manage the site within the site management objectives.

The MDFATE analysis (Michalsen 2008) conducted by the DMMP agencies evaluated the potential cumulative disposal of an additional 15 mcy beyond the approximately 8 mcy disposed of at the site. The analysis concluded that the existing site could accommodate a cumulative disposal volume ceiling of 23 mcy by carefully managing the disposal at the site with best management practices and adaptive management.

The analysis further evaluated the dampening effect of having provisionally shifted the disposal coordinates before DY 2008 (June 2007) at 7.8 mcy, of shifting the site coordinates again at 13 mcy (to be shifted 565 feet to the southwest from site center coordinates) and again at 18 mcy (to be shifted 565 feet to the northeast from site center coordinates) all within the existing Target Area. This analysis shows that the likely effect of site coordinate shift after every additional 5 mcy is highly significant in reducing and flattening the future mound height growth, as compared to not moving the site coordinates (Figure 8). This analysis predicts that by accomplishing two additional coordinate shifts the future mound height can be reduced by up to 98 percent compared to no coordinate shifts (i.e., Alternative 2 would result in an estimated mound height of 155 feet once a cumulative disposal volume of 23 mcy is reached, as compared with a mound height of 307 feet if all disposal takes place at the 2007 disposal coordinates). As under Alternative 1, the DMMP agencies would establish a mound height site management objective of 250 feet**,** after reviewing the results of the numerical modeling analysis. This objective will minimize the potential effects of the disposal mound on tidal circulation in Commencement Bay, where numerical modeling has shown that there is little effect with a disposal mound of 300 feet or less (Michalsen 2008). Figure 9 (A-D) illustrates the effect of selective coordinate shifts on depressing future mound height growth after a cumulative disposal volume of 23 mcy. Figure 9 (B-D) depicts both undistorted vertical and horizontal scales in three cross-sections through the mound, and also depicts a 10/1 vertical to horizontal aspect ratio, which exaggerates the height of the mound relative to the horizontal scale. Alternatives 1 and 2 would meet the mound height site management objective.

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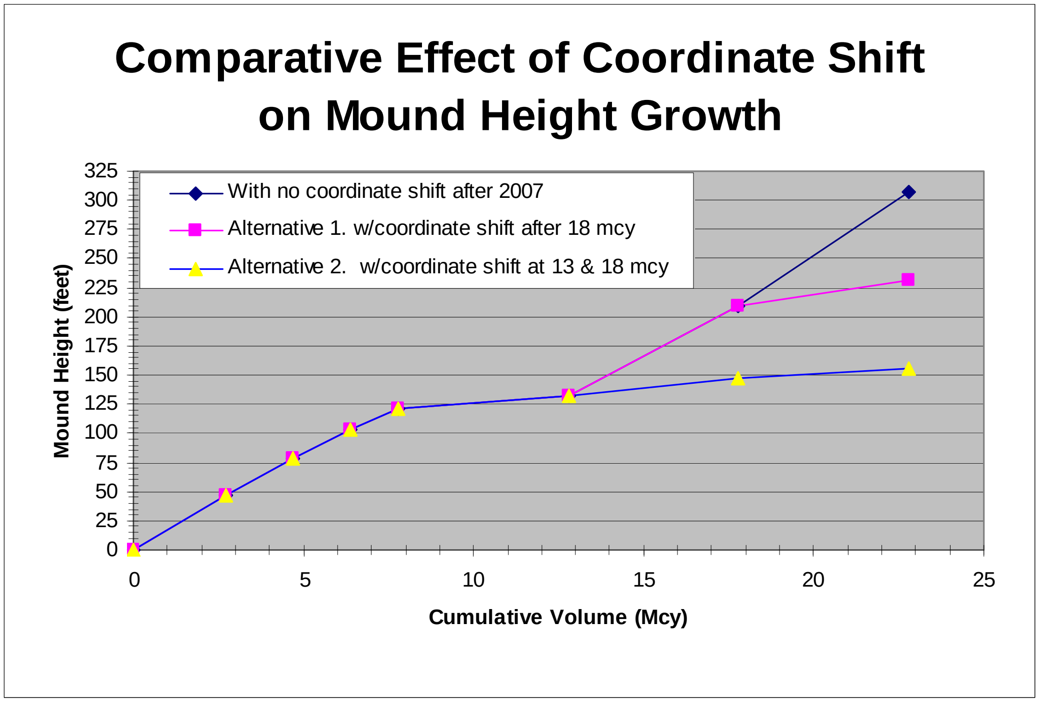
[18] Under consideration by the DMMP agencies would be specific requirements on tug/barge orientation or direction during disposal, and disposal during a specified portion of the tidal cycle (Flood versus Ebb).



Source: Michalsen 2008

Figure 8. Comparative Effect of Coordinate Shift on Mound Height Growth for Alternatives

As with Alternative 1, long-term disposal volume would average approximately 700,000 cy/year, and would require an average of approximately 1.75 barge trips per day, approximately 210 days per year. Site boundaries would not be changed. The site would continue to be managed according to current practice: stringent monitoring would continue with pre-determined site performance standards. Established DMMP dredged material testing procedures would continue to be used to ensure that only material suitable for open-water disposal is disposed of at the site.

The DMMP's adaptive management of the site would continue as described above for Alternative 1, with the additional focus on disposal coordinate shifts at designated volume limits as described above, and considering the implementation of institutional controls to better manage the disposal at the site to control the on/offsite spread of dredged material. The DMMP would continue to encourage beneficial use of dredged material as an alternative to open-water disposal, when available and feasible.

2.3 Alternative 3: No Action

Under the No-Action Alternative, the Commencement Bay site would be closed to disposal once the disposal volume capacity, as designated in the 1988 EIS, of 9 mcy is reached, expected to occur in dredging year 2010 (ending June 15, 2010).

The Port of Tacoma, which has accounted for 98 percent of the material disposed of at the Commencement Bay site to date, expects that site closure would have a significant effect on the rate of dredging by the Port (Brenner 2008, personal communication).

Only small quantities of dredged material could practicably be transported to and disposed of at the Anderson-Ketron or Elliott Bay disposal sites.[19] The Commencement Bay site is approximately 3 miles from the Port area. These alternative sites are at a far enough distance from Commencement Bay (21 miles to Anderson-Ketron and 28 miles to Elliott Bay) to discourage their use as a result of substantial increases in disposal cost, with transportation cost estimates and tipping fees as high as $31.00 per cubic yard (Brenner 2008), as compared to the current estimated cost of $3.00 per cubic yard to dispose of Port of Tacoma material at the Commencement Bay site.

Dredged material also could be transported to an approved upland site or used beneficially.

Potential upland sites available for dredged material are the Rabanco facility near Goldendale, Washington, or the Waste Management facility in Arlington, Oregon. Dredged material would be transported to these facilities by truck or train. Both of these facilities are located approximately 270 miles from Tacoma by truck or train. According to the Port of Tacoma, the primary user of the Commencement Bay site (Brenner 2008), disposal at upland sites would likely only be used for relatively small quantities of the dredged material produced by the Port, because of the high cost of this option (currently $60-$100 cy).

Another option, beneficial uses, would be available as opportunities arise and approved sites could receive dredged material. Beneficial use opportunities could conceivably involve relatively inexpensive disposal costs and could present beneficial environmental impacts. As the opportunities for beneficial use of dredged material depend on a number of factors outside the control of the DMMP – including location and timing of availability of a beneficial use opportunity, compatible with characteristics of dredged material derived from a particular dredging episode – beneficial use alone does not present a comprehensive disposal solution. See the discussion of beneficial use at Section 2.5.

2.4 Alternative Considered But Eliminated from Detailed Analysis

2.4.1 Expand Site Cumulative Disposal Volume Ceiling to 23 mcy, with two coordinate shifts, and Extend Boundary,

This alternative was considered but eliminated from detailed consideration in this SEIS, for the reasons discussed below. This alternative is similar to Alternative 1, except the site boundary would be expanded: the provisional 2007 coordinate shift would be formally adopted, and there would be one additional coordinate shift at 18 mcy within the existing Target Area. As discussed in Sections 1.2 and 3.1 of this SEIS, the current site is performing well in terms of containing the environmental effects of disposal. Although a thin layer of dredged material has at times settled outside the site boundary, the volumes were generally within management predictions as verified by site monitoring and STFATE/MDFATE analyses (Nelson 2003, 2006; Michalsen 2008; also see Updated Monitoring Plan: SAIC 2007, and initial Monitoring Plan (Exhibit I) in USACE 1988b). Subsequent site monitoring has shown no adverse effects demonstrated from sediment chemistry, toxicity testing, or the benthic community within the dredged material footprint evaluated outside the site boundary (SAIC 2008).

In addition, given the current boundaries, the site lies within the Urban Shoreline Environment (USE) as defined by the Pierce County Shoreline Master Plan; the USE is

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[19] Both sites have a 9 mcy capacity limits but are well below the site capacity threshold. The Elliott Bay Site is currently at approximately 2.5 mcy and the Anderson/Ketron Island site has a cumulative disposal volume of approximately 0.15 mcy.

defined as an area supporting high-intensity land use, including commercial and industrial development. The general guideline of the USE encourages water-dependent uses that enhance the success of supported land uses, which includes dredging and thus in-water disposal of dredged material. Expanding the site boundaries would result in the site encroaching into the Conservancy Environment area, which is not zoned for such use. Disposal of dredged material is only authorized in the USE zone. Although the Shoreline Master Plan could be amended to allow such use, expanding the site into the Conservancy Environment area would conflict with current shoreline management policies of Pierce County. Expansion of the site boundary was discussed with Pierce County and they rejected this alternative.

For these reasons, this alternative was not carried forward for detailed consideration in this SEIS.

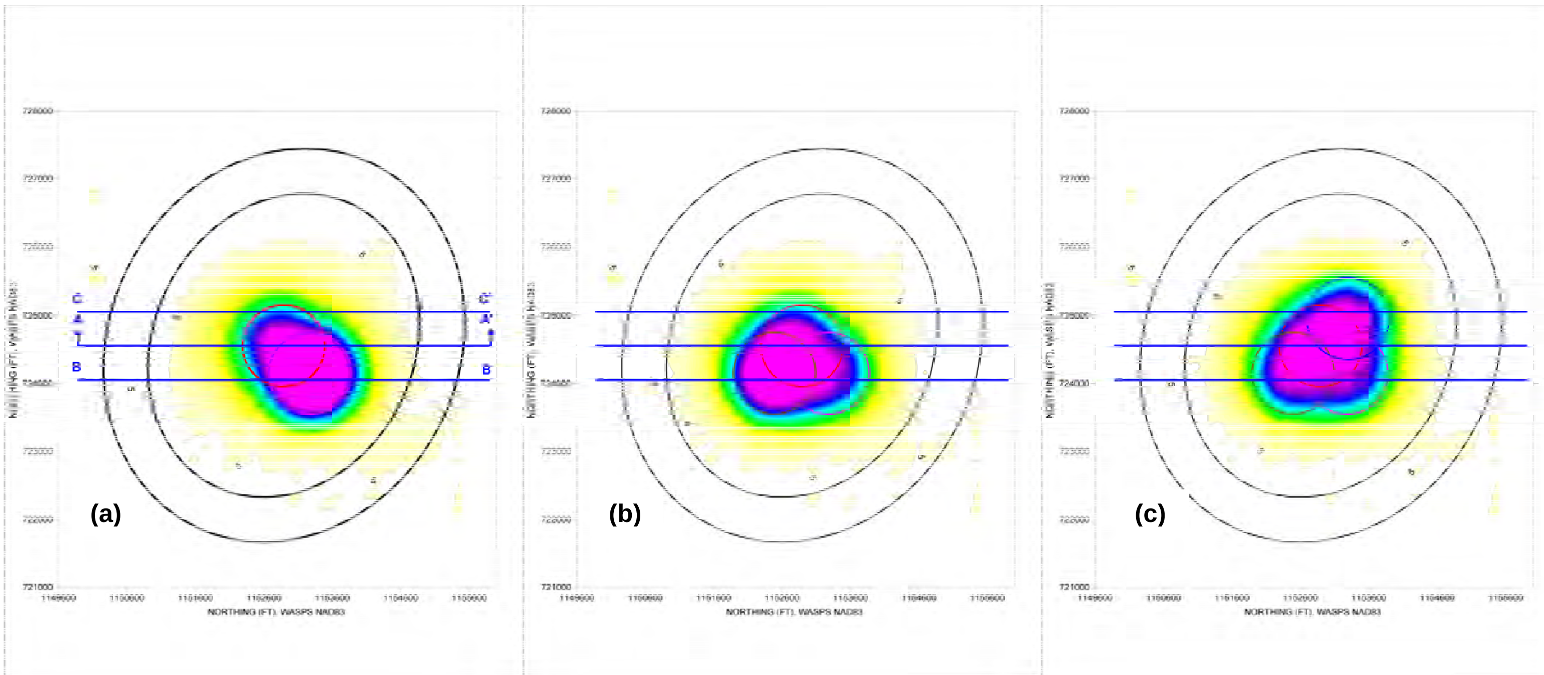
2.5 Beneficial Uses

Beneficial use of dredged material is a programmatic priority and preference of the DMMP. The preference was initially expressed in the original documentation for the Puget Sound Dredged Disposal Analysis (PSDDA) and then further encouraged by the interagency program agreement in 1995 which renamed PSDDA to the DMMP (see Section 1.0). Routinely, DMMP suitability determination documents address the material's suitability for different beneficial use purposes as well as its compliance with the criteria for open-water disposal at the various DMMP disposal sites, including the Commencement Bay site.

The prospect of placement of dredged material in beneficial uses is addressed independently for each dredging project. The opportunity of disposal for beneficial use purposes is the product of a distinct project-by-project analysis of the least environmentally damaging practicable alternatives, and is thus outside the scope of this SEIS for the reauthorization of the Commencement Bay aquatic disposal site.

To the extent that beneficial use of dredged material can occur, beneficial use volumes of sediment are diverted from DMMP disposal sites, reducing capacity demand. Beneficial use by itself, however, is not an alternative to the need for disposal sites. The DMMP experience since 1995 has demonstrated that projects which produce suitable dredged material are infrequently able to deliver this material to beneficial project sites at the moment when these sites are prepared to place the material. Moreover, other than the DMMP suitability determination, agency resources are not available to adequately facilitate coordination of projects requiring clean material with the dredging projects that could provide such material. The DMMP agencies do not have the authority to delay dredging projects or require beneficial use projects. Policies under development by the Puget Sound Partnership to restore and improve aquatic habitats could provide further incentives for beneficial use planning and implementation, and the Partnership may be able to facilitate improved coordination between disposal and habitat projects in the future. The DMMP will continue to act as a clearinghouse to encourage beneficial use of dredged material. However, the limits of the DMMP to identify or create such beneficial use opportunities must be acknowledged. The agencies regulating individual disposal episodes can also be expected to encourage potential site users to consider beneficial uses of material when such uses are available and feasible.

The Port of Tacoma is currently in the planning stages of two beneficial use projects in Commencement Bay. One would use approximately 2.5 mcy of dredged material, and the other would use approximately 400,000 cy of dredged sediments. The future of these projects and their construction timing, if they occur, is uncertain (Refer to Section 6).



Expected mound height with no coordinate shifts; (b) Alt. 1 – SW relocation; (c) Alt. 2 – SW and NE relocation.

For additional information on expected mound thickness reference Figures 11 – 13 (Michaelson 2008)

Figure 9a. Location of Cross-Sections for Alternatives after a cumulative disposal volume of 23 mcy

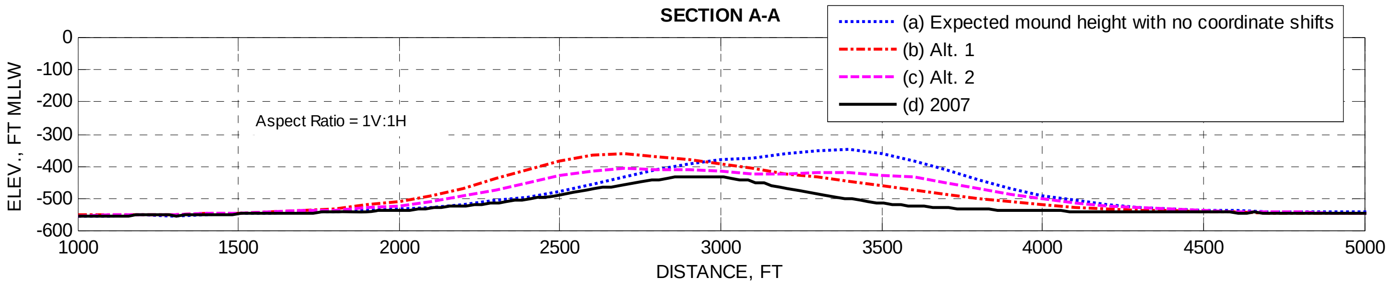


Figure 9b. Cross section A-A' comparing predicted mound thickness for Alternatives (a) Expected mound height with no coordinate shifts; (b) Alt. 1 – SW relocation; (c) Alt.2 – SW and NE relocation; (d) Measured 2007 bathymetry

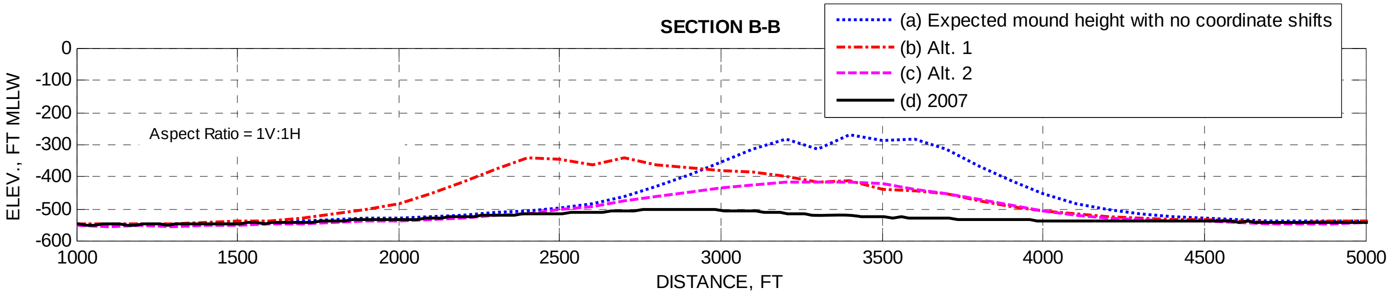


Figure 9c. Cross section B-B' comparing predicted mound thickness for Alternatives (a) Expected mound height with no coordinate shifts; (b) Alt. 1 – SW relocation; (c) Alt.2 – SW and NE relocation; (d) Measured 2007 bathymetry

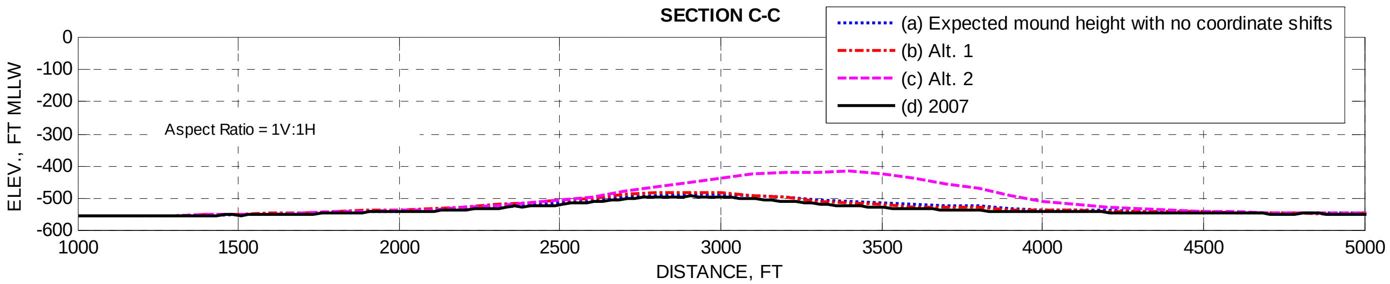


Figure 9d. Cross section C-C' comparing predicted mound thickness for Alternatives (a) Expected mound height with no coordinate shifts; (b) Alt. 1 – SW relocation; (c) Alt.2 – SW and NE relocation; (d) Measured 2007 bathymetry

3.0 Affected Environment

3.1 Physical Oceanography (Bathymetry and Currents)

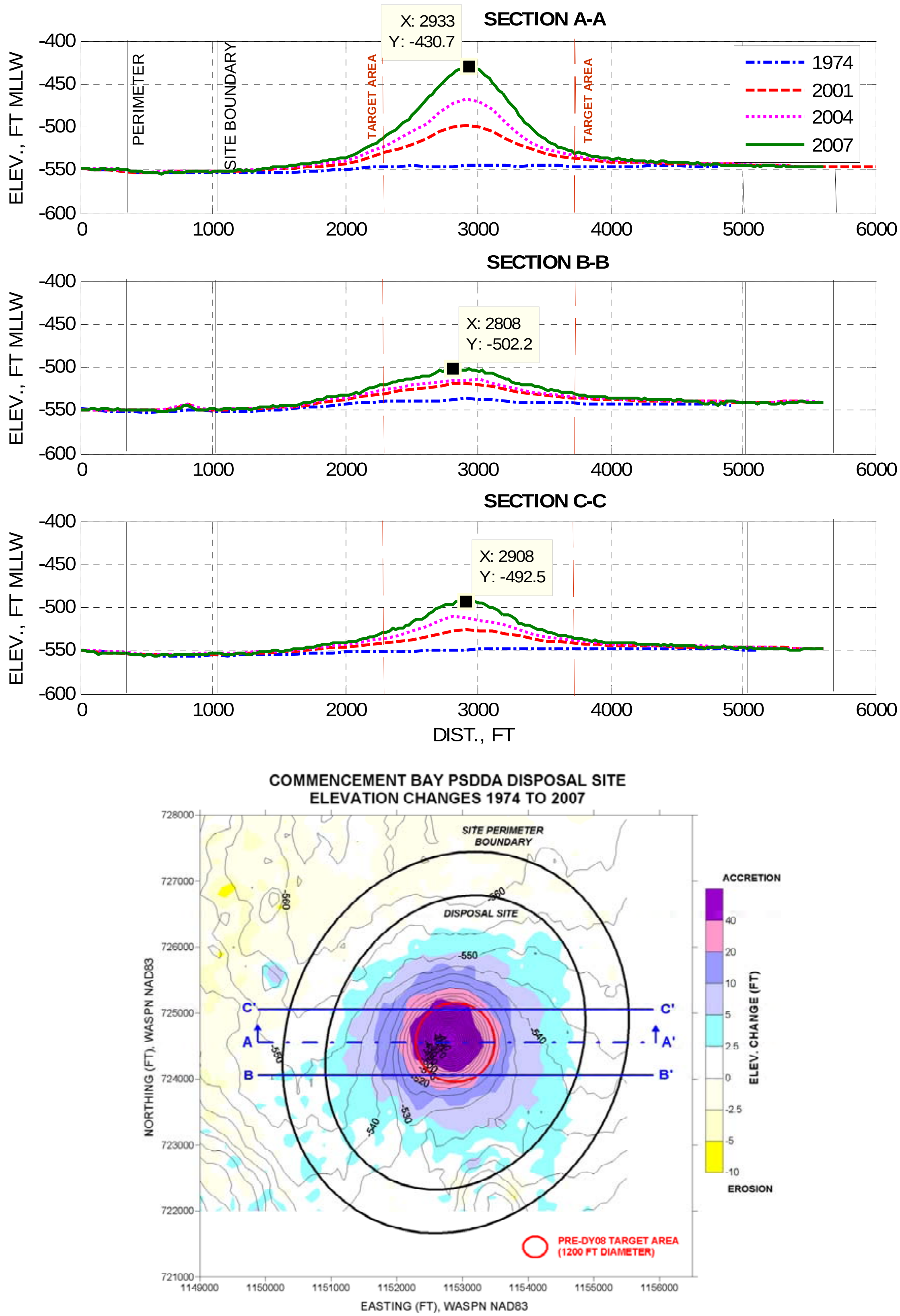
Commencement Bay is located in the southern end of Puget Sound's main basin, south of Vashon and Maury Islands and adjacent to the city of Tacoma (Figure 1). The DMMP disposal site is located in a relatively flat area at the entrance to the bay, with water depth ranging from 530 to 560 feet. Water depths lessen gradually from the entrance of Commencement Bay in a southeast direction to the head of the bay. A number of waterways and the mouth of the Puyallup River are present at the head of the bay. Water depths shoal rapidly near the shorelines to the northeast (Brown's Point) and to the southwest (City of Tacoma shoreline).

Circulation in Commencement Bay is driven primarily by tides and is altered by local winds and flows from the Puyallup River. An eddy-like circulation pattern prevails within the bay based on oceanographic investigations in the early 1980s (USACE et al. 1988a). The bay is subject to deep tidal currents from the northeast-southwest through the main Puget Sound basin (East Passage) and currents from the northwest-southeast through Dalco Passage (Michalsen 2008) (Figure 1). The Puyallup River produces a shallow northwesterly surface layer (lower salinity water occupying the upper 6 feet of the water column) that flows out of the bay. During flood tides, denser, more saline and colder water moves into the bay along the bottom. Stratification is generally greater during flood tides than ebb tides (University of Washington 2003). Residence time for water in the bay is on the order of a few days (Crecelius et al. 1985)

The Puyallup River contributes a substantial sediment load to Commencement Bay. Suspended particulate matter from the river is generally in the surface layer, while suspended particulate matter in bottom water is governed by tidal currents.

Placement of dredged material at the current Commencement Bay DMMP disposal site since 1988 has resulted in the creation of a mound on the seafloor, as described in Section 1.2.3. In 2007, a bathymetric survey at the site measured a mound height of 121 feet with a 2,400-foot-wide cone, and the mound was determined to be confined within the site perimeter (Michalsen 2008) (Figures 7 and 10). The DMMP agencies have closely monitored the mound height and, in 2007, provisionally adjusted the disposal site coordinates to reduce the growth rate of the disposal mound (Wasson et al. 2007). Numerical modeling to project future mound height (USACE STFATE and MDFATE Analyses) has indicated that moving the site disposal coordinates within the Target Zone would reduce mound height growth (Nelson 2006; Michalsen 2008).

During five of the eight environmental site monitoring surveys at the Commencement Bay DMMP site, a small depth of dredged material footprint (generally 3 to 5 cm in thickness) as measured as extending beyond the site perimeter. As discussed in Section 1.2.2, STFATE analysis suggested that offsite deposition of the finest portion of dredged material (clay, silt, and fine sand) was related to natural factors in Commencement Bay circulation (influence of surface currents), combined with normal disposal operations (Nelson 2003, 2006; Michalsen 2008). Intensive physical, chemical, and biological monitoring of the disposal site between 1988 and 2007 found that the dredged material disposal has had minimal impact on the physical and biological resources in Commencement Bay (Appendix A; Sections 3.1 and 3.7).



Note: Vertical scale is exaggerated 30X in cross-sectional plots.
(after Michalsen 2008)

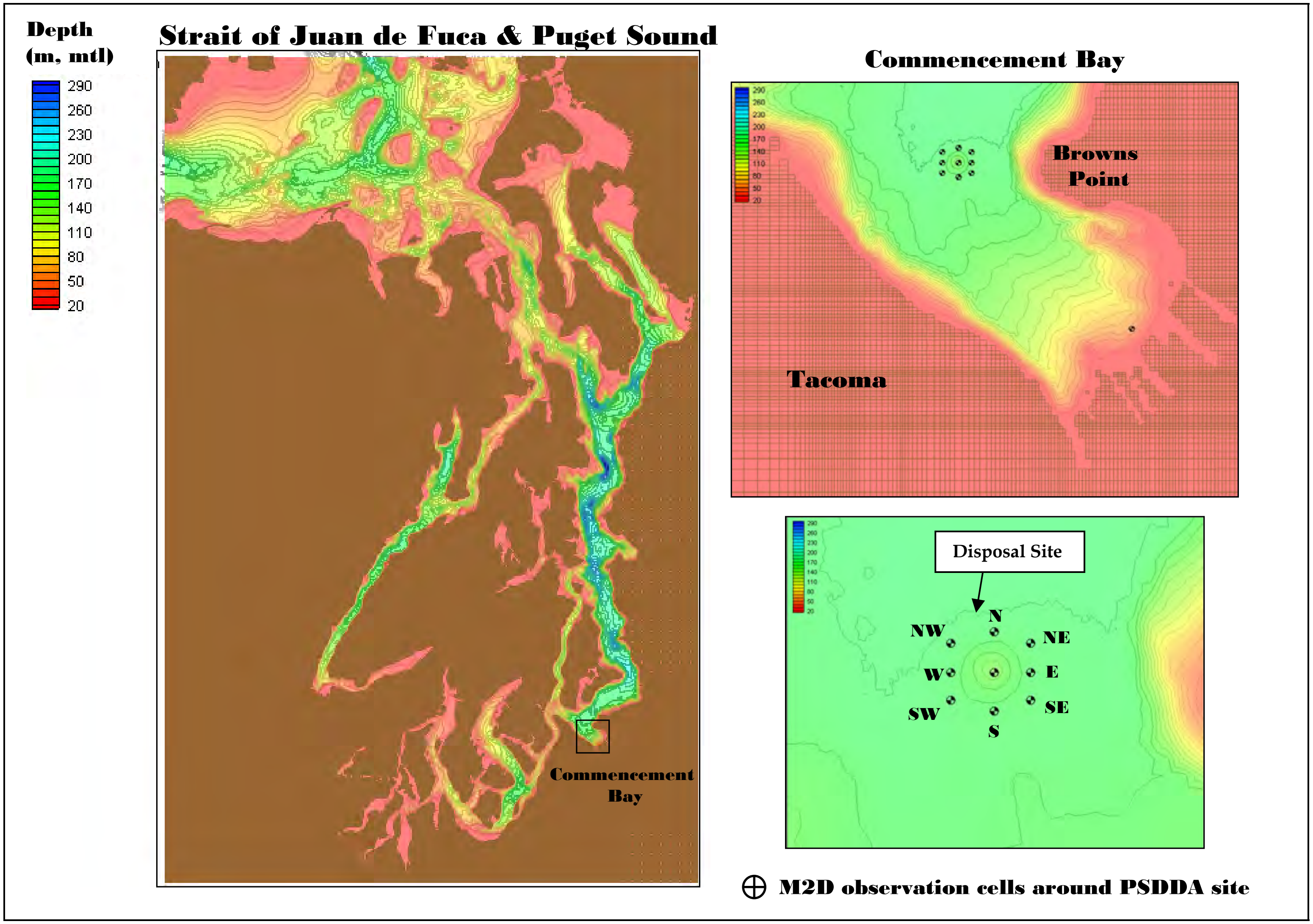
Figure 10. Commencement Bay DMMP Site Elevation Changes from Pre-Disposal to 2007

The DMMP agencies initiated a study to investigate circulation within Commencement Bay and assess the influence of the disposal mound on tidal current patterns. The evaluation included an assessment of the potential for sediment transport at the site for both current and future conditions. A numerical circulation model (CMS-M2D; Militello et al. 2004) was used to simulate tidal currents within Puget Sound and specifically Commencement Bay (Figure 11). This analysis focused on numerical modeling of the current patterns in Commencement Bay using topographic and bathymetric data obtained from the University of Washington Puget Sound Digital Elevation Model (Finlayson 2005) and the NOAA National Geophysical Data Center Coastal Relief Model (Divins and Metzger 2008).

Model results indicated that the strongest currents around the disposal site occur near the end of the flood tidal cycle (Figures 11 and 12). The direction of the flood current is directed to the southwest, while the direction of the ebb tide is to the northeast, which closely matches the Puget Sound basin geometry north of Commencement Bay (Figure 13). Flood currents initially enter the bay along the western shore and exit the bay along the eastern shoreline along Browns Point (Figure 12). The model simulations indicate the formation of an eddy or gyre near the mouth of the bay during the flood tidal cycle.

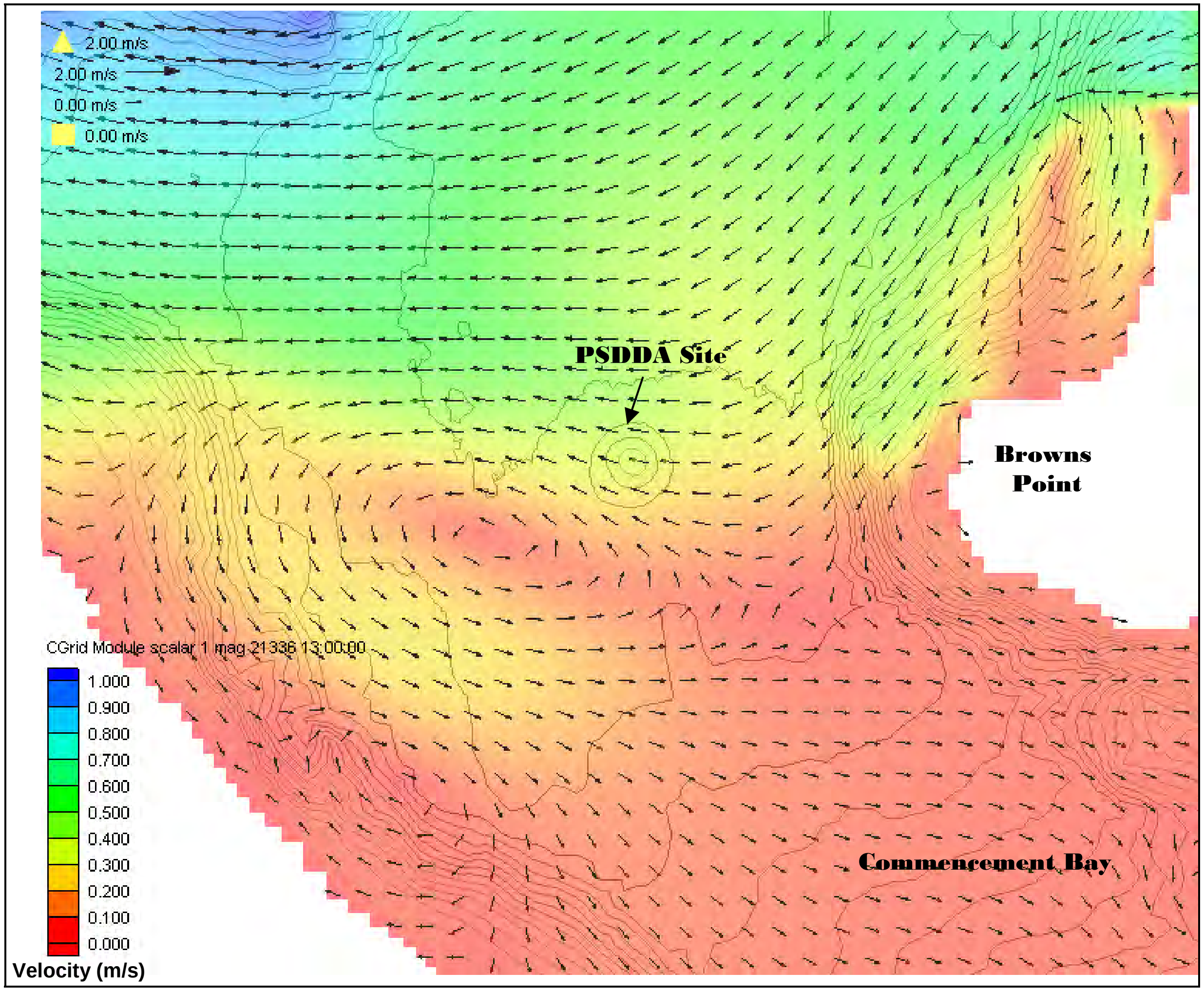
The presence of the DMMP disposal mound may have some influence on the gyre feature within Commencement Bay, but local changes in current magnitude are not evident around the disposal site in its present state. Tidal current magnitudes for nine observation cells around the disposal site under current bathymetric conditions are shown in Figures 11 and 14. The model predicted a peak velocity of 1.1 feet/second (0.35 meter/second) at the northern most observation cell (Michalsen 2008). Under extreme tidal conditions, this peak velocity has the potential to mobilize material with a grain size less than 0.052 mm (silt and clay particles) for short periods of time. However, physical monitoring (bathymetric surveys and Sediment Vertical Profiling System [SVPS] surveys) have confirmed that the overall footprint of the disposal mound is confined within the perimeter of the disposal site. Therefore, peak velocities during extreme tidal conditions do not appear to be a significant mechanism for offsite transport of sediments at the disposal site.

Furthermore, the modeling suggests that the transport of fine sediments outside the site perimeter is a result of surface currents influencing the sediment descent cloud during the disposal process causing materials with lower settling velocities to drift slightly away from the target zone. An examination of recent disposal data indicates that 80 percent of disposal vessel headings were directed to the northwest (traveling from the southeast) during disposal. This bias in vessel course may be a contributing factor to the skewed disposal footprints observed to the northwest during past monitoring surveys.



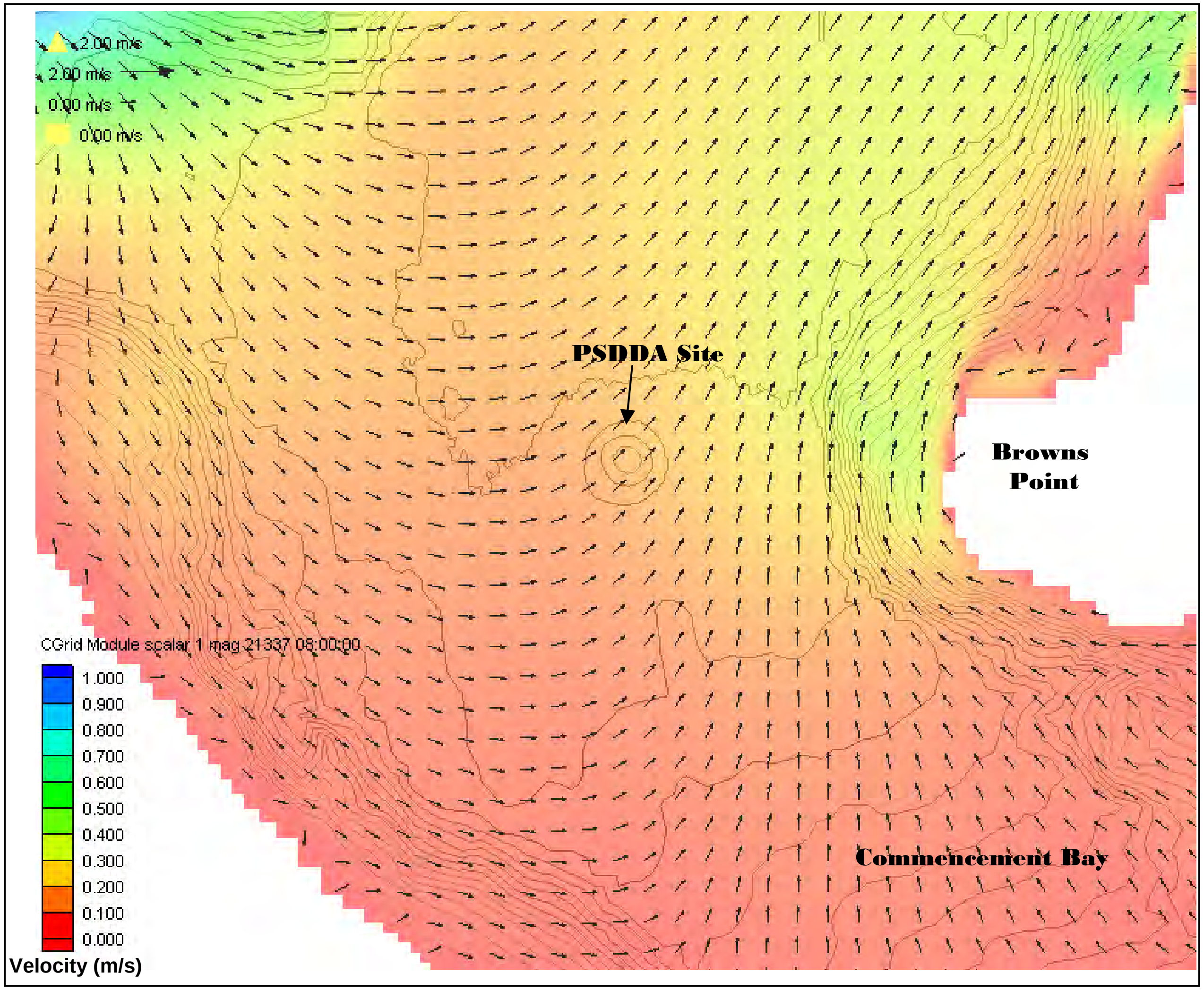
Source: Michalsen 2008

Figure 11. Modeled Domain and M2D Model Observation Cells around the Commencement Bay DMMP Site



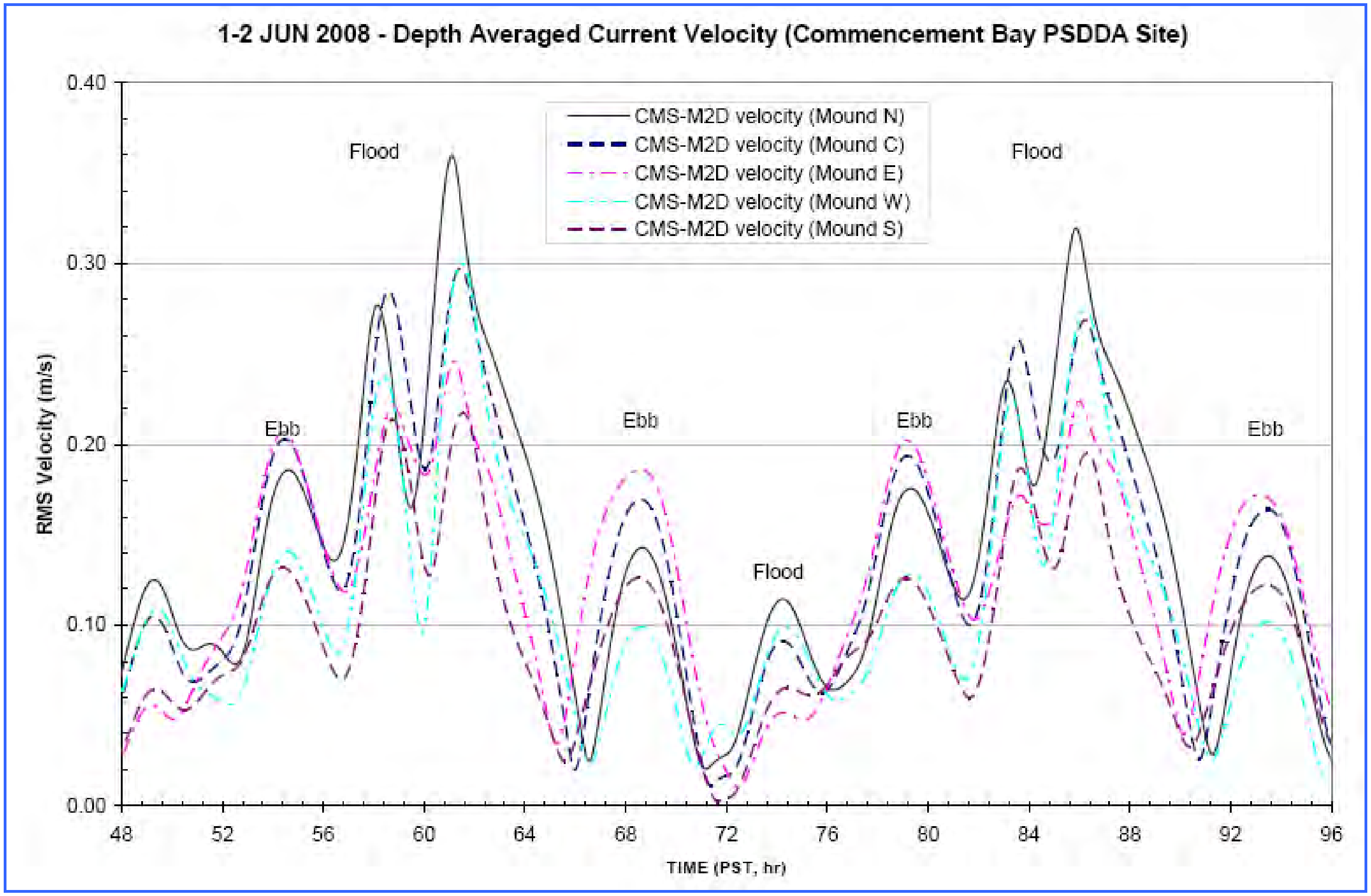
Source: Michalsen 2008

Figure 12. Simulated Flood Tide on 1 June 2008, 1300 PST (near end of flood) under Present Conditions (2007 Bathymetry) showing a Gyre Southwest of DMMP Site



Source: Michalsen 2008

Figure 13. Simulated Ebb Tide on 2 June 2008, 0800 PST under Present Disposal Site Conditions (2007 Bathymetry)



Source: Michalsen 2008

Figure 14. Modeled Depth Averaged Current Magnitude at Observation Cells around the Commencement Bay DMMP Site under Present Conditions (2007 Bathymetry)

3.2 Water Quality

WAC 173-201A establishes water quality standards for surface waters of Washington, consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife, pursuant to the provisions of Chapter 90.48 of the RCW. Designated uses include aquatic life, shellfish harvesting, recreation, and miscellaneous. Specific criteria for each designated use in marine surface waters are summarized in Table 6. Ecology has designated the area of Commencement Bay in which the disposal site is located as an Excellent Quality water body. This designation meets Ecology's goal to provide high quality water sufficient to support salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; and crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

There has been no water quality monitoring focused on the Commencement Bay DMMP site. The closest area regularly monitored by Ecology is Commencement Bay Station CMB003, located approximately 600 meters east-southeast of the disposal site. Of the 39 Washington State marine sites regularly monitored by Ecology, Station CMB003 is one of eight that is considered of high concern because waters in the bay exceed standards for more than one parameter (PSAT 2007a). The most recent Water Quality Assessment lists 76 water bodies in Puget Sound with fecal coliform problems, including Commencement Bay (PSAT 2007b). Low dissolved oxygen (DO) levels (<5 milligrams per liter [mg/L]) were recorded in Commencement Bay between 2000 and 2007. Measurements below 5.0 mg/L were generally made at depths greater than 40 meters (Ecology 2008). Persistent stratification, such as occurs in Commencement Bay, in conjunction with nutrient loading can cause low DO concentrations (Newton et al. 2002). Commencement Bay waters southwest of Browns Point are listed as impaired (Category 5) for DO and fecal coliforms in the most recent water quality assessment (303(d) list) for Washington State (Ecology 2005). Possible sources of fecal coliforms to Commencement Bay include the Puyallup River (Newton et al. 2002). Outmoded waste treatment plants are implicated as a cause of high fecal coliform bacteria in tributary streams to the Puyallup River (Citizens for a Healthy Bay 2004). As discussed in Section 4.1.2, it is unlikely that dredged material disposal contributes to the long-term water quality issues.

Other water quality parameters of concern in Commencement Bay over the 2000-07 period were dissolved inorganic nitrogen (DIN) and ammonium. High ammonium concentrations indicate the presence of a nutrient source. Commencement Bay waters were intermittently highly stratified. Low DO levels, coupled with high DIN and stratification indicate a moderate potential for eutrophication in Commencement Bay (PSAT 2007b). Commencement Bay waters did not exceed the Washington State standard for temperature. Between 2000 and 2007, pH criteria were not met on only three occasions, measuring as low as 6.5 in December 2003 and as high as 8.7 in June 2003 (Ecology 2008). Measurements for water clarity in the Ecology marine dataset are not measured in Nephelometric Turbidity Units (NTUs) but in percent transmission and so are not directly comparable to the applicable criteria.

Table 6. Ecology Marine Surface Waters Designated Uses and Water Quality Criteria

Designated Use	Water Quality Criteria			
Aquatic Life	Temperature[1]	Dissolved Oxygen[2]	Turbidity[3]	pH
Extraordinary Quality	13°C (55°F)	7.0 mg/L	+5 NTU or +10%[4]	7.0 – 8.5[6]
Excellent Quality	16°C (61°F)	6.0 mg/L	+5 NTU or +10%[4]	7.0 – 8.5[7]
Good Quality	19°C (66°F)	5.0 mg/L	+10 NTU or +20%[5]	7.0 – 8.5[7]
Fair Quality	22°C (72°F)	4.0 mg/L	+10 NTU or +20%[5]	6.5 – 9.0[7]
Designated Use	**Coliform Bacteria**			
Shellfish Harvesting	Geometric mean not to exceed 14 MPN/100 mL fecal coliforms[8]			
Recreation				
Primary Contact	Geometric mean not to exceed 14 MPN/100 mL fecal coliforms[8]			
Secondary Contact	Geometric mean not to exceed 70 MPN/100 mL enterococci[9]			

1. One-day maximum (°C). Temperature measurements should be taken to represent the dominant aquatic habitat of the monitoring site. Measurements should not be taken at the water's edge, the surface, or shallow stagnant backwater areas.
2. One-day minimum (mg/L). When DO is lower than the criteria or within 0.2 mg/L, then human actions considered cumulatively may not cause the DO to decrease more than 0.2 mg/L. DO measurements should be taken to represent the dominant aquatic habitat of the monitoring site. Measurements should not be taken at the water's edge, the surface, or shallow stagnant backwater areas.
3. Measured in NTU; point of compliance for non-flowing marine waters; turbidity not to exceed criteria at a radius of 150 feet from activity causing the exceedance.
4. 5 NTU over background when the background is 50 NTU or less; or 10 percent increase in turbidity when background turbidity is more than 50 NTU.
5. 10 NTU over background when the background is 50 NTU or less; or 20 percent increase in turbidity when the background turbidity is more than 50 NTU.
6. Human-caused variation within range must be <0.2 unit.
7. Human-caused variation within range must be <0.5 unit.
8. No more than 10 percent of all samples used to calculate geometric mean may exceed 43 most probable number (MPN)/100 mL; when averaging data, it is preferable to average by season and include five or more data collection events per period.
9. No more than 10 percent of all samples used to calculate geometric mean may exceed 208 MPN/100 mL; when averaging data, it is preferable to average by season and include five or more data collection events per period.

Source: WAC 173-201A as amended in November 2006.

In 1983, seven of Commencement Bay's nine waterways were listed as Superfund sites. The USEPA and Ecology initiated source identification and cleanup efforts in 1989. Nearly 500 point and non-point sources of contamination were identified (USEPA 2007). Ecology concluded in 2003 that enough source control had been completed in order to begin removing contaminated sediments with low risk for recontamination (USEPA 2007).

Cleanups have resulted in substantial water quality improvements in Blair and Hylebos Waterways (both contributors of metals to Commencement Bay) where arsenic and zinc concentrations measured in an Ecology study conducted in the late 1990s were an order of magnitude lower than in the 1980s (Ecology 1999). In the 1990s, metals concentrations measured in surface and deep water samples collected in Commencement Bay in the late 1990s were well within the Washington State acute criteria for protection of aquatic life, and few metals approached the four-day average chronic criteria for the protection of aquatic life (Ecology 1999). The maximum concentrations measured for dissolved cadmium, lead, chromium, and nickel were between 10 and 150 times lower than the chronic criteria. Copper, mercury, zinc, and arsenic were 10 times less than chronic levels.

Approximately 25,000 storm drains in Tacoma flow directly into either Commencement Bay or nearby Puget Sound waters without passing through sewage treatment plants. Stormwater contributes about 7 percent of the total flow from all point and non-point sources but about 60 percent of the total lead, 30 percent of total zinc, and nearly all of the fecal coliform bacteria (Citizens for a Healthy Bay 2004).

3.3 Sediment Quality

Commencement Bay has been characterized as an "urban bay" contaminated with a variety of metals and organic chemicals known to have anthropogenic sources. Elevated levels of polycyclic aromatic hydrocarbons (PAHs), several trace metals, phenols, polychlorinated biphenyls (PCBs), phthalates, hexachlorobenzene, and phenol were found in the Commencement Bay industrial waterways (Long et al. 2003). A joint Ecology/National Oceanic and Atmospheric Administration (NOAA) study, conducted to determine the spatial extent of chemical contamination throughout Puget Sound, found that although samples collected from the industrial waterways were contaminated, those from the deep central and outer reaches of the bay were not (Long et al. 2003).

Within the Commencement Bay disposal site area, located at the mouth of the bay, a number of surveys have been conducted to evaluate the sediment quality at the site. These include a baseline survey conducted in 1988 to document existing conditions at the site and surrounding regions prior to dredged material disposal, and post-disposal full monitoring surveys (1995, 2001, 2003, and 2007), partial monitoring surveys (1996 and 2004), and physical monitoring surveys (1998 and 2005). With the exception of the physical monitoring surveys, sediments were collected and analyzed for sediment conventional parameters and contaminants of concern as specified by the PSDDA/DMMP program. Additional contaminants of concern, including bioaccumulative contaminants of concern (BCOCs) and dioxins, were added in some of the later surveys as the management program developed. Toxicity testing was also conducted to assess the sediment quality of the site. For the physical monitoring surveys, sediment vertical profile imaging gave an indication of the type of sediment present (e.g., ambient, dredged material, grain size characteristics).

For the baseline and monitoring surveys, specific sampling locations were set up in order to monitor the conditions at the disposal site and the surrounding regions. These were to determine if the dredged material remained on site, if biological effects conditions at the site (as defined by the DMMP) were exceeded, or if unacceptable adverse effects on biological resources off site occurred due to dredged material disposal. These sampling locations include onsite (disposal zone and disposal site), perimeter, transect, and benchmark stations (Figure 10). Benchmark stations were included to assess area-wide changes as opposed to those due to dredged material disposal. This monitoring framework involved sediment chemical and conventional analyses at onsite and perimeter stations, as well as benchmark stations if warranted. Toxicity tests were conducted on samples collected on site and, if necessary, samples collected at benchmark stations. Sediment grain size analyses and analysis of total organic carbon (TOC) were also conducted at the transect stations. Sediment vertical profile imaging occurred throughout the area including onsite, offsite, and benchmark locations. The post-disposal monitoring and disposal site use history is summarized in Section 1.2, and a complete description of these surveys can be found in Appendix A. The results of the monitoring surveys are summarized below.

3.3.1 Sediment Conventional Parameters

Baseline surveys, conducted prior to the disposal of dredged material at the current Commencement Bay disposal site, showed that the median sediment grain size was a coarse to fine silt, with the highest levels of clay (15 percent) at the center of the site. This was consistent with a depositional, low-energy current regime. The majority of the other onsite stations sampled showed a high percentage (54 to 92 percent) of fines (silts and clays). However, perimeter stations CBP01 (32 percent) and CBP12 (18 percent) had a lower percent fine fraction and SVPS imaging showed a sand-over-mud stratigraphy due to the presence of historical dredged material. Sand was also present at CBP11 and one site station CBS08. The locations of these stations in the southeastern section of the designated disposal site were consistent with the location of the former disposal site used prior to the DMMP-WDNR disposal site designation. Other baseline conventional parameters were generally similar across the site (SAIC 2008).

In general, the sediment conventional parameters (grain size, total organic carbon, total solids, total volatile solids, ammonia, and total sulfides) measured at site, perimeter, transect, and benchmark stations were comparable throughout the post-disposal monitoring surveys conducted from 1995 to 2007 (Table 7). One exception was total sulfides, which were higher at all locations during 2003 than previous surveys. Sulfide levels were lower during subsequent surveys, with the exception of high concentrations of total sulfides measured at benchmark stations during Phase II of the 2005 monitoring and the 2007 survey (maximum levels of 463 mg/kg and 139 mg/kg, respectively).

Grain size varied at times depending on the dredged material deposited at the site. The SVPS post-disposal surveys conducted from 1995 to 2007 showed the dredged material deposits consisted of very fine “blackish” sands, to reduced fine sandy silts. The disposal site zone station tended to be coarser than other areas, ranging from 5 to 22 percent fines, and exhibited rocks and cobbles with grayish fine sand during the 2004 and 2005 surveys. Other onsite sediments reflected the presence of dredged material, consisting of tan and gray silty fine sand (35 to 65 percent fines). Perimeter and transect stations sediments were finer with up to 92 and 80 percent fines, respectively. Dredged material that extended beyond the site boundaries was a thin layer of silty fine sand (SAIC 2008).

Overall, with the exception of grain size and sulfides concentrations, sediment conventional parameters measured at the disposal site and surrounding areas have been fairly consistent over time. Although grain size has varied within the disposal site and at perimeter stations over time, the infaunal community appears to recover from the changes (Section 3.5). In addition to dredged material disposed of at the site, other sources of sediments in Commencement Bay, which may contribute to variations in grain size and sediment conventionals, include the deposition of sediments carried out to Commencement Bay by the Puyallup River, as well as surface runoff and outfalls. The higher levels of sulfides observed primarily occurred at the benchmark stations, which is indicative of area-wide changes as opposed to effects of dredged material disposal.

Table 7. Post-disposal Summary Averages of Conventional Parameters at Onsite, Perimeter, and Benchmark Stations[20]

Conventionals	Onsite	Perimeter	Benchmark
Total Organic Carbon (% DW)			
Mean	0.7	1.5	1.8
Range	0.17 to 1.5	0.91 to 4.6	1.33 to 2.3
n	14	80	15
Total Sulfides (mg/kg DW)			
Mean*	3.1	15.6	34.0
Range	0.31 U to 20	0.2 U to 180	1.0 U to 463
n	14	80	60
Ammonia (mg-N/kg DW)			
Mean	5.5	9.2	12.4
Range	2.6 to 11	3.8 to 33	4.6 to 34.3
n	14	80	60
Total Volatile Solids (% DW)			
Mean	2.3	4.8	5.7
Range	0.89 to 4.4	2.9 to 6.9	3.8 to 8.24
n	14	80	12
Total Solids (% DW)			
Mean	65.3	45.4	38.2
Range	47.6 to 80	37.8 to 56.4	11.5 to 58.6
n	14	96	72
Fines (%)			
Mean	34.0	71.6	81.3
Range	5.04 to 64.49	50 to 97	66 to 89.9
n	14	80	6

Note: For total sulfides, the mean was calculated using half the detection limit when sulfides were undetected in a given sample.

DW dry weight

3.3.2 Sediment Chemistry

Onsite and perimeter monitoring stations were sampled and analyzed for the DMMP list of chemicals of concern throughout the baseline and monitoring surveys (Figure 14). The current list of chemicals of concern and corresponding screening levels (SL), bioaccumulation trigger levels (BT), and maximum levels (ML) are provided in Table 8. Since 1995, sediment chemistry results were also compared to Washington State's Sediment Management Standards (SMS)-Sediment Quality Standards (SQS). A time-trend analysis of sediment chemistry results at the perimeter was also added to determine if changes in chemical concentrations due to dredged material disposal occurred over time.

[20] As depicted in Figure 13, Onsite Stations are located within the site boundary; Perimeter stations are located 0.125 nautical miles outside the site boundary; Benchmarrk stations are located in the vicinity of the disposal site, but beyond the region affected by disposal activity (see Appendix A, Table 1-3 for more detailed explanation of monitoring station types)

Table 8. DMMP and SMS Conventional Parameters and Chemicals of Concern

Parameter	Prep Method[1]	Analysis[1]	Sediment MDL[2]	DMMP[2]			WA SMS[2]	
				SL	BT	ML	SQS	CSL
Conventionals								
Total Solids (%)	---	PSEP	0.1	---	---	---	---	---
Total Volatile Solids (%)	---	PSEP	0.1	---	---	---	---	---
Total Organic Carbon (%)	---	PSEP	0.1	---	---	---	---	---
Total Sulfides (mg/kg)	---	PSEP	1	---	---	---	---	---
Ammonia (mg/kg)	---	Plumb 1981	1	---	---	---	---	---
Grain Size	---	PSEP	---	---	---	---	---	---
Metals (parts per million [ppm])								
Antimony	3050B	6020	2.5	150	---	200	---	---
Arsenic	3050B	6020	2.5	57	507.1	700	57	93
Cadmium	3050B	6020	0.3	5.1	11.3	14	5.1	6.7
Chromium	3050B	6020	0.5	---	267	---	260	270
Copper	3050B	6020	15.0	390	1027	1300	390	390
Lead	3050B	6020	0.5	450	975	1200	450	530
Mercury	7471A	7471A	0.02	0.41	1.5	2.3	0.41	0.59
Nickel	3050B	6020	2.5	140	370	370	---	---
Selenium	7740	7740	0.2	---	3	---	---	---
Silver	3050B	6020	0.2	6.1	6.1	8.4	6.1	6.1
Zinc	3050B	6020	15.0	410	2783	3800	410	960
Butyltins								
Porewater Butyltins (µg/L)	Michelsen et al. 1996 Hoffman 1998	Michelsen et al. 1996 Hoffman 1998	0.025–0.050	0.15	0.15	---	---	---
Organics (parts per billion [ppb] DW)							SMS**	
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH): ppb DW							ppm Carbon	
Naphthalene	3550B	8270C	20	2100	---	2400	99	170
Acenaphthylene	3550B	8270C	20	560	---	1300	66	66
Acenaphthene	3550B	8270C	20	500	---	2000	16	57
Fluorene	3550B	8270C	20	540	---	3600	23	79
Phenanthrene	3550B	8270C	20	1500	---	21000	100	480
Anthracene	3550B	8270C	20	960	---	13000	220	1200
2-Methylnaphthalene	3550B	8270C	20	670	---	1900	38	64
Total LPAH*				5200	---	29000	370	780
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH): ppb DW							ppm Carbon	
Fluoranthene	3550B	8270C	20	1700	4600	30000	160	1200
Pyrene	3550B	8270C	20	2600	11980	16000	1000	1400
Benzo(a)anthracene	3550B	8270C	20	1300	---	5100	110	270
Chrysene	3550B	8270C	20	1400	---	21000	110	460
Benzofluoranthenes (b + k)	3550B	8270C	20	3200	---	9900	230	450
Benzo(a)pyrene	3550B	8270C	20	1600	---	3600	99	210

Parameter	Prep Method[1]	Analysis[1]	Sediment MDL[2]	DMMP[2]			WA SMS[2]	
				SL	BT	ML	SQS	CSL
Indeno(1,2,3-c,d)pyrene	3550B	8270C	20	600	---	4400	34	88
Dibenzo(a,h)anthracene	3550B	8270C	20	230	---	1900	12	33
Benzo(g,h,i)perylene	3550B	8270C	20	670	---	3200	31	78
Total HPAH				12000	---	69000	960	5300
Chlorinated Hydrocarbons: ppb DW							ppm Carbon	
1,3-Dichlorobenzene	5030B	8260B	3.2	170	---	---	---	---
1,4-Dichlorobenzene	5030B	8260B	3.2	110	---	120	3.1	9
1,2-Dichlorobenzene	5030B	8260B	3.2	35	---	110	2.3	2.3
1,2,4-Trichlorobenzene	3550B	8270C	6	31	---	64	0.81	1.8
Hexachlorobenzene	3550B	8270C	12	22	168	230	0.38	2.3
Phthalates: ppb DW							ppm Carbon	
Dimethyl phthalate	3550B	8270C	20	71	---	1400	53	53
Diethyl phthalate	3550B	8270C	20	200	---	1200	61	110
Di-n-butyl phthalate	3550B	8270C	20	1400	---	5100	220	1700
Butyl benzyl phthalate	3550B	8270C	20	63	---	970	4.9	64
Bis(2-ethylhexyl)phthalate	3550B	8270C	20	1300	---	8300	47	78
Di-n-octyl phthalate	3550B	8270C	20	6200	---	6200	58	4500
Phenols: ppb DW							ppb DW	
Phenol	3550B	8270C	20	420	---	1200	420	1200
2 Methylphenol	3550B	8270C	6	63	---	77	63	63
4 Methylphenol	3550B	8270C	20	670	---	3600	670	670
2,4-Dimethylphenol	3550B	8270C	6	29	---	210	29	29
Pentachlorophenol	3550B	8270C	61	400	504	690	360	690
Miscellaneous Extractables: ppb DW							ppb DW	
Benzyl alcohol	3550B	8270C	6	57	---	870	57	73
Benzoic acid	3550B	8270C	100	650	---	760	650	650
Miscellaneous Extractables: ppb DW							ppm Carbon	
Dibenzofuran	3550B	8270C	20	540	---	1700	15	58
Hexachloroethane	3550B	8270C	20	1400	---	14000	---	---
Hexachlorobutadiene	3550B	8270C	20	29	---	270	3.9	6.2
N-Nitrosodiphenylamine	3550B	8270C	12	28	---	130	11	11
Volatile Organics: ppb DW								
Trichloroethene	5030B	8260B	3.2	160	---	1600	---	---
Tetrachloroethane	5030B	8260B	3.2	57	---	210	---	---
Ethylbenzene	5030B	8260B	3.2	10	---	50	---	---
Total Xylene (sum of o-, m-, p-)	5030B	8260B	3.2	40	---	160	---	---
Pesticides: ppb DW							ppm Carbon	
Total DDT	---	---	---	6.9	50	69	---	---
P,p'-DDE	3550B	8081A	2.3	---	---	---	---	---
P,p'-DDD	3550B	8081A	3.3	---	---	---	---	---
P,p'-DDT	3550B	8081A	6.7	---	---	---	---	---

Parameter	Prep Method[1]	Analysis[1]	Sediment MDL[2]	DMMP[2]			WA SMS[2]	
				SL	BT	ML	SQS	CSL
Aldrin	3550B	8081A	1.7	10	---	---	---	---
Chlordane	3550B	8081A	1.7	10	37	---	---	---
Dieldrin	3550B	8081A	2.3	10	---	---	---	---
Heptachlor	3550B	8081A	1.7	10	---	---	---	---
Lindane	3550B	8081A	1.7	10	---	---	---	---
Total PCBs	3550B	8082	67	130	38**	3100	12	65
Dioxins/Furans								
Total Polychlorinated Dibenzo-p-Dioxins/Furans	---	1613B	---	---	---	---	---	---

* Total LPAH does not include 2-Methylnaphthalene.

** Total PCBs BT value is ppm carbon-normalized. In addition, Sediment Management Standards (SMS) organics values are ppm carbon-normalized except for phenols, benzyl alcohol, and benzoic acid (ppb dry weight).

1. Sample preparation and analytical methods (3000, 5000, 6000, 7000, 8000, and 9000 series) are from SW-846, Test Methods for Evaluation Solid Waste Physical/Chemical Methods, USEPA 1986 and updates. http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm
2. Method detection limits (MDL), SLs (except tributyltin [TBT]), MLs, and BTs (except PCBs and TBT), SQS, and cleanup screening levels (CSL) are on a dry weight basis.
3. Recommended Protocols for Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program (PSEP), March 1986 with minor corrections April 2003.
4. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment, and Tissue Samples – Appendix D, Puget Sound Estuary Program, 1997b.
5. Procedures for Handling and Chemical Analysis of Sediment and Water Samples, Russell H. Plumb, Jr., USEPA/ USACE, May, 1981.
6. Analysis of dioxins/furans is necessary for establishing baseline conditions at each non-dispersive site and may be required as part of regular monitoring at the discretion of the DMMP.

Source: DMMP 2008

During the 1988 baseline surveys, sediment concentrations of several DMMP metals and organic chemicals of concern exceeded the existing 1988 guidelines (refer to Appendix A). However, with the exception of hexachlorobutadiene, the 1988 sediment chemical concentrations compared to current guidelines do not exceed the DMMP guidelines. Hexachlorobutadiene was detected at 44 µg/kg, which is above the current DMMP SL guideline of 29 µg/kg. TBT was detected at a concentration of 42 µg/kg at station CBP11, which was 10 times higher than all other Commencement Bay stations sampled (mean of 2.4 ± 0.8 µg/kg).

In general, the stations with chemical concentrations that exceeded the 1988 screening levels were located in the central and southern half of the Commencement Bay site. Asphalt particles and an oily sheen were observed in grab samples collected in this region (CBP01, CBP02, CBP11), which is consistent with the presence of PAH contamination (PTI 1988). These observations may have been related to the existence of a former disposal site that was used prior to the designation of the current disposal site. This former site was located at the southeast corner of the perimeter line of the current site (Brenner et al. 2003; PSDDA 1988).

Over the duration of the DMMP monitoring program (1988 to 2007), a total of six post-disposal monitoring surveys have been conducted to assess onsite chemistry. In each monitoring year, the onsite chemistry did not exceed the DMMP SL guidelines or the Washington State's SMS- SQS criteria (WAC 173-204). Metals (Table 9) and organic compounds measured at the onsite stations were well below the DMMP SL). In 2007, 1,2,4-trichlorobenzene was undetected at onsite station CBZ01, but the carbon normalized detection limit (1.0 U mg/kg TOC) slightly exceeded the SQS of 0.83 mg/kg TOC.

Table 9. Metals Concentrations at Onsite Stations in Commencement Bay

Monitoring Year	DMMP SL	DMMP ML	Baseline 1988	Post-disposal Monitoring Summary		
Metals in mg/kg DW				Mean	Range	Number
Onsite Stations						
Antimony	150	200	0.55	0.55	0.02 U – 1.8	n = 14
Arsenic	57	700	11.4	4.64	1.24 – 10.0	n = 14
Cadmium	5.1	14	0.18	0.12	0.026 - 0.229	n = 14
Chromium	--	--	--	15.62	5.57 - 24.9	n = 7
Copper	390	1300	45	21.81	8.8 – 37	n = 14
Lead	450	1200	29.7	18.34	1.43 – 53	n = 14
Mercury	0.41	2.3	0.16	0.04	0.06 U - 0.1	n = 14
Nickel	140	370	29	17.74	5.15 - 33.6	n = 14
Selenium	--	--	--	0.13	0.1 U - 0.3	n = 7
Silver	6.1	8.4	0.36	0.19	0.02 - 0.66	n = 14
Zinc	410	3800	72.3	44.11	12 – 84.6	n = 14

A total of eight monitoring surveys have included perimeter chemistry monitoring. With the exception of monitoring years 2003 and 2004, perimeter chemistry did not exceed the Washington State SQS. In 2003, perimeter station chemistry exceeded the SQS for butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and phenol. However, it was determined that the phthalate compounds detections were most likely an artifact of the laboratory analyses. Phenol results (440 BE to 480 BE) slightly exceeded the SQS criteria and DMMP SL (both SQS and DMMP SL = 420 µg/kg) in two replicate samples at station CBP01 and one replicate at CBP03. However, the phenol results were also qualified due to low-level method blank contamination.

In 2004, all chemical concentrations at perimeter stations were below the SQS with the exception of hexachlorobenzene. This compound was undetected, but the reported detection limit exceeded the SQS criterion at CBP11 due to low TOC concentrations. The detection limit was well below the DMMP SL.

In general, perimeter sediment chemistry monitoring has shown that detected chemical concentration in offsite areas has not exceeded the Washington State SQS with the exception of phenol during 2003. The source of the phenol measured during the 2003 survey is unknown. Several natural pathways (e.g., conifer needles, wood particles, natural degradation of various organic materials) may exist for phenol to accumulate in sediments (SAIC 2005a). **The statistical time trend analysis has shown that the majority of the chemical compounds measured at perimeter stations have exhibited a decreasing trend since the 1988 baseline survey.**

3.3.3 Sediment Toxicity

Toxicity testing conducted at the Commencement Bay disposal site during the 1988 predisposal baseline and monitoring surveys found toxicity in the amphipod bioassay test at the onsite center and at one benchmark station[21], but no toxicity in the other bioassays (Sediment Larval bioassay, saline *Microtox* bioassay[22]). The amphipod species used during the initial baseline (*Rhepoxinius abronius*) has been shown to be sensitive to high silt-clay fractions, and the high clay-silt contents of sediments at these two stations (>60 percent) may have contributed to the toxicity observed. The DMMP subsequently substituted alternative amphipod species (*Eohaustorius estuarius* or *Ampelisca abdita*), which are less sensitive to silt-clay fractions for DMMP testing in the Monitoring Program (Kendall 1993). Toxicity has not been observed in bioassay tests conducted on sediments collected from the disposal site since the 1988 survey using the DMMP Site Condition II interpretation guidelines (Appendix A for details).

Onsite sediment toxicity test results have met DMMP Site Condition II biological response guidelines for all post-disposal monitoring surveys (e.g., 1995, 1996, 2001, 2003, 2004, 2007) conducted at Commencement Bay. Therefore, toxicity due to dredged material disposal at the site has not occurred. See the Technical Appendix attached to this SEIS (Appendix A) for a complete summary of information on each monitoring event.

3.3.4 Dioxins/Furans in Sediment and Tissues

The DMMP is currently reviewing the regulatory framework for managing dioxin/furan contamination in dredged material sediments. In order to gather further information on current levels of dioxins and furans at the Puget Sound disposal sites, the 2007 monitoring survey included high resolution dioxin/furan analysis of surface sediments (0–10 cm) and tissues from onsite, perimeter, transect, and benchmark stations. Tissues sampled included polychaete worms (Glyceridae, Maldanidae, and Travisia), the clam *Compsomyax subdiaphana*, and the demersal fish English sole (*Parophrys vetulus*).

The results of these analyses are summarized in Table 10. Dioxin/furan congeners are normalized to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) using toxic equivalent factors updated by the World Health Organization in 2005 and published in 2006 (Van den Berg et al. 2006). The toxic equivalent quotient (TEQ) is equivalent to the sum of the concentrations of individual congeners multiplied by the toxic equivalent factor (potency relative to 2,3,7,8-TCDD). The DMMP is currently undergoing an involved stakeholder process to develop a dioxin/furan regulatory framework for evaluating dredging projects with dioxin/furan concerns that provides appropriate levels of protection to aquatic resources and human health.

The highest levels of dioxins and furans in the sediments observed at the Commencement Bay disposal site appeared to be in the site center (CBZ01). However, sediment TEQ levels at the other two onsite locations (CBS01 and CBS08) were comparable to those at the perimeter, transect, and benchmark stations. All sediment values were within the then-current

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[21] This amphipod toxicity was found in comparison to the Port Susan reference sample. Toxicity was not found in comparison to the Carr Inlet reference sample, which is considered the more appropriate reference (Appendix A). Nevertheless, this was an issue of concern. In addition to changing the test species for this test, the reference sample has been collected from Carr Inlet since the baseline survey.

[22] The *Microtox* bioassay using the saline extraction method was initially included among the DMMP suite of bioassay tests and used during the baseline surveys, but it is no longer used to evaluate the toxicity of sediments for the monitoring program and was not used for the monitoring surveys conducted from 1995 to 2007. Note that the Neanthes 20-day growth bioassay was implemented in the DMMP program in 1992 and added to post-disposal monitoring toxicity test suite.

management framework for dioxins; namely, no greater than 5 ng/kg 2,3,7,8-TCDD, and no greater than a sum of 15 ng/kg TEQ to 2,3,7,8-TCDD. Note that this management guideline is currently being reevaluated. Tissue results are discussed in Section 3.5, Benthic Community.

Table 10. Dioxin/Furan Concentrations[1] in Sediments and Tissue in the Vicinity of the Commencement Bay Disposal Sites (after SAIC 2008b)

Sample	Dioxin/Furan Concentrations (ppt DW TEQ) Average (range), n = number of analyses	TOC/Lipid Concentrations (%) Average (range), n = number of analyses
Sediment		TOC
Onsite	5.3 (1.1 – 14.3), n = 3	0.46 (0.37 – 0.55), n = 3
Offsite	2.5 (1.28 – 5.2), n = 7	0.99 (0.85 – 1.18), n = 7
Benchmark	2.1 (0.96 – 4.1), n = 3	1.2 (1.12 – 1.31), n = 3
Tissue		Lipids
Annelids		
Glyceridae	0.38 (0.26 – 0.56), n = 7	1.30 (1.0 – 1.88), n = 7
Maldanidae	0.35 (0.23 - 0.43), n = 4	1.08 (0.86 – 1.45), n = 4
Travisia sp.	0.85 (0.66 - 1.07), n = 4	0.46 (0.35 – 0.54), n = 4
Bivalves		
Compsomyax sp.	0.08 (0.06 - 0.09), n = 2	0.23 (0.2 – 0.25), n = 2
Fish		
English Sole (*Parophrys vetulus*) (whole body)	0.66 (0.49 - 0.92), n = 3	2.72 (2.1 – 3.1), n = 3

1. Undetected congeners summed in TEQ at half the detection limit

3.4 Plankton/Neuston

Plankton are single-celled algae and multi-cellular animals that reside in the water column and form the foundation of the marine food web. Phytoplankton (planktonic algae) and zooplankton (planktonic animals) are critical components of Puget Sound's food web, but their abundance and distribution are not well known or characterized (PSAT 2007b). Populations fluctuate both seasonally and annually and are affected by climate, rainfall, cloud cover, wind, upwelling, tides, current, and nutrients (Newton and Mote 2005). Geographically, locations are influenced by wind, tides, currents, and freshwater sources (Boesch et al. 1997; PSAT 2007b). Many species of plankton exhibit diel vertical migration, which is the marked upward migration of organisms to the surface at night and a downward movement to deeper waters during the day.

The diverse community in Puget Sound includes phytoplankton diatoms and dinoflagellates, as well as zooplankton including decapods; crustacean larvae; small crustaceans such as calanoid copepods, hyperiid amphipods, and euphausiids (krill); and fish larvae and eggs (called ichthyoplankton) (Schreiner 1977; Simenstad and Kinney 1978; Salo et al. 1980; Ecology 1998; Llansó 1999). Phytoplankton and zooplankton populations are directly correlated. For example, small crustaceans (zooplankton), predominantly copepods, may increase in abundance during algal blooms as their food base increases (PSAT 2007b).

Phytoplankton and zooplankton communities are ubiquitous throughout Puget Sound. However, very little plankton data are available that are specific to Commencement Bay.

Therefore, plankton are discussed in the context of seasonal and geographic fluctuations and relative abundance in Puget Sound in the following sections.

3.4.1 Neuston

Neuston include those species that inhabit the uppermost few millimeters of the surface water. Phytoneuston in this layer are marked by higher abundances, lower diversity, greater absolute biomass, and more variable productivity than the plankton community below. The zooneuston comprise a rich layer and include bacteria, protozoa, metazoans, and fish eggs, larvae, and fry. The surface microlayer is an important region for productivity and an important interface for the exposure of marine organisms to physical and chemical disturbances (Word et al. 1986).

3.4.2 Phytoplankton

Phytoplankton are microscopic algae that consume nutrients in the water column and contain chlorophyll for use in photosynthesis, the process of drawing energy from sunlight. In Puget Sound, phytoplankton are comprised mainly of diatoms (unicellular algae with silica shells) and dinoflagellates (microscopic organisms with self-propulsion) (Strickland 1983). Although diatoms are unicellular, some form chains or small colonies. Most dinoflagellates are capable of photosynthesis but do not fall strictly within the plant or animal kingdoms (Strickland 1983). Sampling conducted at a depth of 10 meters in Commencement Bay by the University of Washington in May 2003 documented several types of diatoms (chains, disks, spirals, and pennate) and three dinoflagellate genus (*Noctiluca*, *Peridinum*, and *Ceratium*) (University of Washington 2003).

While phytoplankton are present throughout the year in Puget Sound, under ideal conditions of increased nutrient and light availability, blooms (larger accumulations of phytoplankton) can occur and may last from days to weeks. Blooms are typically caused by an increase of nutrients, such as nitrogen-rich freshwater influx from streams or rivers during warm sunny periods, or areas of poor water circulation. Diatoms dominate phytoplankton populations in fall and winter and during spring blooms. After spring blooms decrease, nutrients are reduced and diatoms then reproduce more slowly in the following summer months (Snow et al. 2005). Dinoflagellates compete with diatoms, thrive in warmer temperatures, and become more abundant in late spring and summer when the diatoms decrease (Spitale et al. 2005; PSAT 2007b).

Phytoplankton are sensitive to changes in temperature and cloud cover; increased rainfall, water circulation, and exchange; increased turbidity; decreases in nutrients; and grazing by zooplankton (Strickland 1983; PSAT 2007b). Phytoplankton have profound effects on DO levels. Live phytoplankton expire oxygen and enrich DO levels (Newton and Mote 2005). When blooms die off and decay, they contribute to low DO as bacteria consume oxygen to break down the masses of organic material resulting from dead, sinking phytoplankton (Newton and Mote 2005).

3.4.3 Zooplankton

The most abundant types of zooplankton in Puget Sound are crustaceans, including various types of copepods, amphipods, ostracods, isopods, shrimp, cumaceans, and crustacean larvae (Simenstad and Kinney 1978; Strickland 1983). Some of these organisms spend their entire life as planktonic organisms (resident plankton). Organisms that spend only a portion of their life cycle as plankton are classified as planktonic larvae (or meroplankton). In the Puget Sound region, meroplankton typically include the eggs and larvae of fish (ichthyoplankton), crustaceans, molluscs, and annelids, with crustacean larvae being the most abundant type (Strickland 1983; WDFW 2000a; Snow et al. 2005). Other zooplankton in Puget Sound include coelenterata or cnideria (the small jellyfish medusae), ctenophore (the combjelly Pleurobrachia), and planktonic mussels (Limacina and Clione). Some marine species of rotifera also occur in Puget Sound (Synchaeta sp, etc.) (Strickland 1983). Zooplankton do not occur in blooms, but their populations increase with phytoplankton abundance (PSAT 2007b).

Zooplankton are dependent on the availability of phytoplankton as a food source, which fluctuates seasonally, annually, and geographically (PSAT 2007b). Ichthyoplankton are abundant during the winter and spring months (Strickland 1983). Copepods, small crustaceans less than 0.25 inch in length, are consumed by fish, jellyfish, larval fish, and filter-feeders, such as barnacles. Sampling conducted at a depth of 10 meters in Commencement Bay by the University of Washington in May 2003 documented several types of zooplankton including copepods, euphasiids, and naupli (the free swimming stage of crustaceans such as crabs) (University of Washington 2003). Forage fishes (such as herring, sand lance, and smelt), as well as juvenile salmonids (including Chinook, chum, pink, and coho salmon, steelhead, and cutthroat trout), depend upon zooplankton as a primary food source, often forming dense schools at tidal fronts where plankton are concentrated (Simenstad and Kinney 1978; Strickland 1983; PSAT 2007b).

3.5 Benthic Community

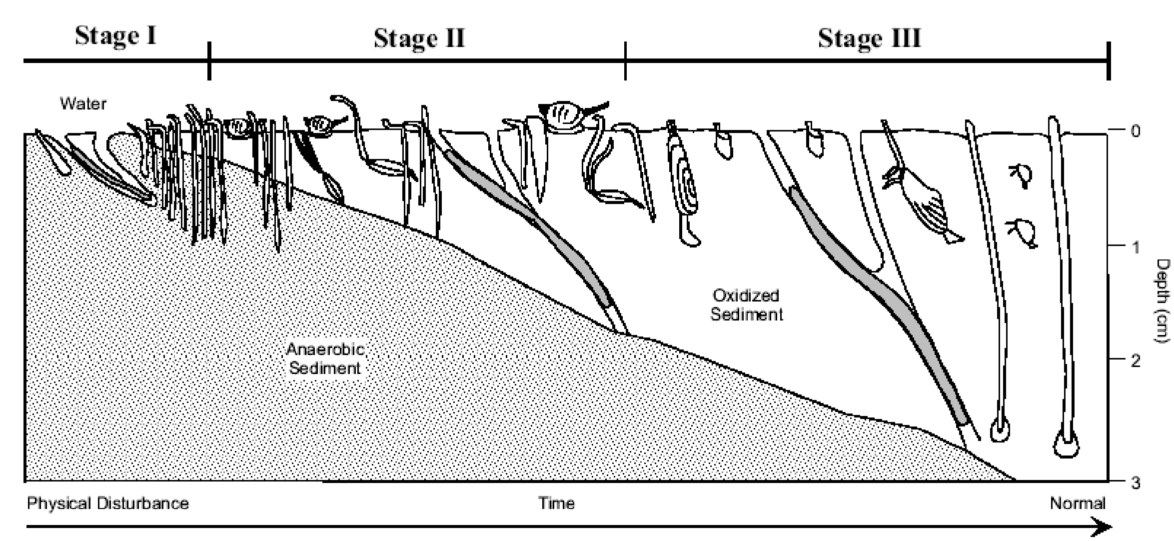
The benthic community assemblages occurring at the Commencement Bay disposal site were evaluated during the baseline and monitoring surveys in order to evaluate potential effects on benthic communities attributable to dredged material disposal occurring off site. Similarly, tissues of the sea cucumber, *Molpadia intermedia*, were collected and analyzed to determine if an increase in the chemical body burden of benthic species down current of the disposal site occurred following dredged material disposal. In addition to assessing and mapping the dredged material footprint, the sediment vertical profile imaging results provide a qualitative assessment illustrating the type of benthic community present and the observed habitat quality. The results of the SVPS monitoring, benthic community analyses, and tissue chemistry analyses are discussed below.

3.5.1 Sediment Vertical Profiling System

SVPS photography was conducted during the 1988 baseline survey and each of the eight subsequent monitoring surveys performed from 1995 to 2007. In addition, SVPS imaging was utilized for a comprehensive study of floating stations conducted in 2001 to aid in determining of the extent of dredged material that appeared outside the site boundary, and to determine any potential impacts to the biological community associated with the dredged material offsite. Biological parameters measured (Table 11) include the depth of the apparent Redox Potential Discontinuity (RPD), infaunal successional stage, and Organism Sediment Index (OSI), a numerical index to characterize habitat quality (Rhoads and Germano 1982, 1986). The apparent RPD depth estimates the depth of oxygenation in the upper sediment column and can be considered the biological mixing depth by infaunal organisms. Following a disturbance of the seafloor, such as dredged material disposal, benthic infaunal communities generally follow a three-stage succession (Pearson and Rosenberg 1978; Rhoads and Germano 1986). These stages, shown in Figure 15, range from opportunistic organisms consisting of small tubicolous, surface-dwelling polychaetes (Stage I) to long-lived, infaunal deposit-feeding organisms that feed at depth (Stage III). Stage II communities are considered transitional communities and typically consist of tube-dwelling amphipods or shallow-dwelling bivalves.

Table 11. Calculation of the Organism-Sediment Index

Choose One Value:		
	Mean RPD Depth Classes	**Index Value**
	0.00 cm	0
	> 0 - 0.75 cm	1
	0.76 - 1.50 cm	2
	1.51 - 2.25 cm	3
	2.26 - 3.00 cm	4
	3.01 - 3.75 cm	5
	> 3.75 cm	6
Choose One Value:		
	Successional Stage	**Index Value**
	Azoic	- 4
	Stage I	1
	Stage I - II	2
	Stage II	3
	Stage II - III	4
	Stage III	5
	Stage I on III	5
	Stage II on III	5
Choose One or Both if Appropriate:		
	Chemical Parameters	**Index Value**
	Methane Present	- 2
	No/Low Dissolved Oxygen	- 4
Organism-Sediment Index =		**Range: - 10 + 11**



Source: Pearson and Rosenberg 1978

Figure 15. Idealized Development of Infaunal Successional Stages

The OSI values range from -10 to +11. The lowest value is given to bottoms, which have low or no DO in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment. The highest value is given to an aerobic bottom with a deep apparent RPD, evidence of a mature macrofaunal assemblage, and no apparent sedimentary methane. OSI values greater than +6 are generally considered indicative of undisturbed, healthy benthic conditions.

1988 baseline SVPS images showed a well established benthic community and healthy habitat conditions. The apparent RPD depth was relatively well developed throughout the site, with a mean of 4.33 cm for the entire site (Figure 16). Extensive burrows and feeding voids visible in the images were indicative of large, head-down deposit feeding infauna (Stage III taxa). A mean OSI value of +10 throughout the site indicated a healthy habitat (SAIC 1988, 2008).

A complete description of the post-disposal monitoring survey results and distribution of successional stages, OSI values, and other parameters may be found in Appendix A. The post-disposal monitoring surveys have generally shown that within the dredged material site center, Stage I or Stage II taxa were present and OSI values tended to be less than +6 (Figure 16). This is consistent with predicted effects of recent physical disturbance/ displacement by dredged material deposition. Stage III infauna, in conjunction with a Stage I assemblage, were observed throughout the disposal site and surrounding offsite areas, although Stage III infauna tended to be absent around the disposal site center during the earlier surveys (1995, 1996, 1998). Stage I communities and lower OSI values were also observed in the sandy, ambient sediments to the northwest of the disposal site during the 2003 monitoring survey. Stage III organisms tend to prefer softer, muddier sediments (SAIC 2008).

Four of the SVPS surveys (1998, 2003, 2004, and 2005) showed the presence of thin bands (<5 cm) of recent dredged material beyond the northwest perimeter of the disposal site, and accumulations observed were greater than 5 cm only during the 2001 survey and floating station study. A review of apparent RPD depths, infaunal successional stages, and OSI values within the offsite dredged material lobes observed during the surveys, indicated that the thin layer of dredged material accumulation did not adversely impact benthic habitat quality (Table 12). The majority of the stations showed the presence of Stage III infauna, particularly during the 2004 and 2005 surveys, although a higher proportion of Stage I communities were present during the 2001 survey. However, the benthic infauna community data from offsite and benchmark evaluations showed area-wide changes in the benthic community structure during 2001, which probably accounted for the changes observed. In addition, SVPS results from subsequent monitoring surveys (2003 to 2007) showed that any impacts were relatively short-lived, because subsequent monitoring surveys showed the benthic community structure had recovered (SAIC 2008).

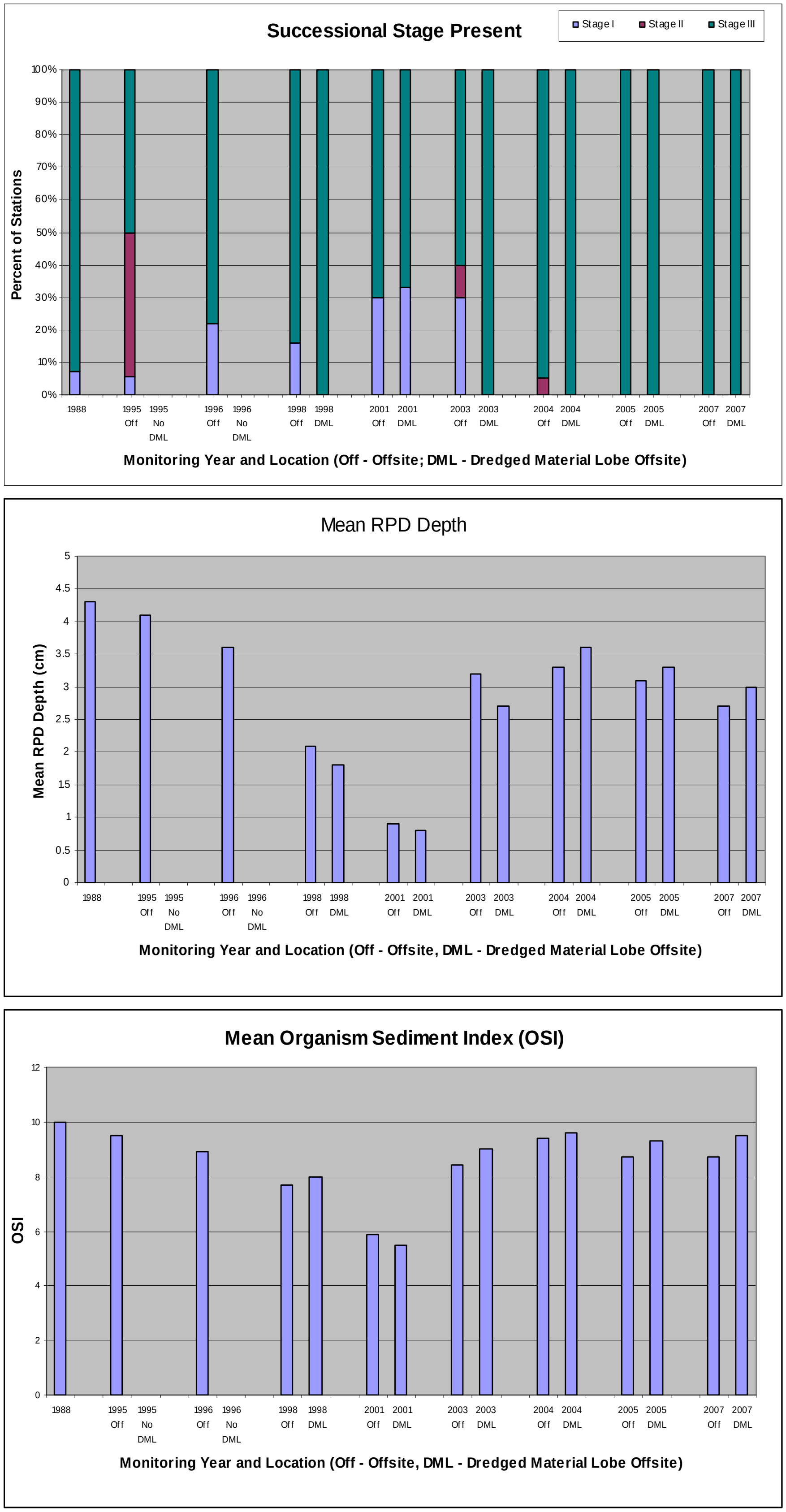


Figure 16. SVPS Biological Parameters in Offsite Areas

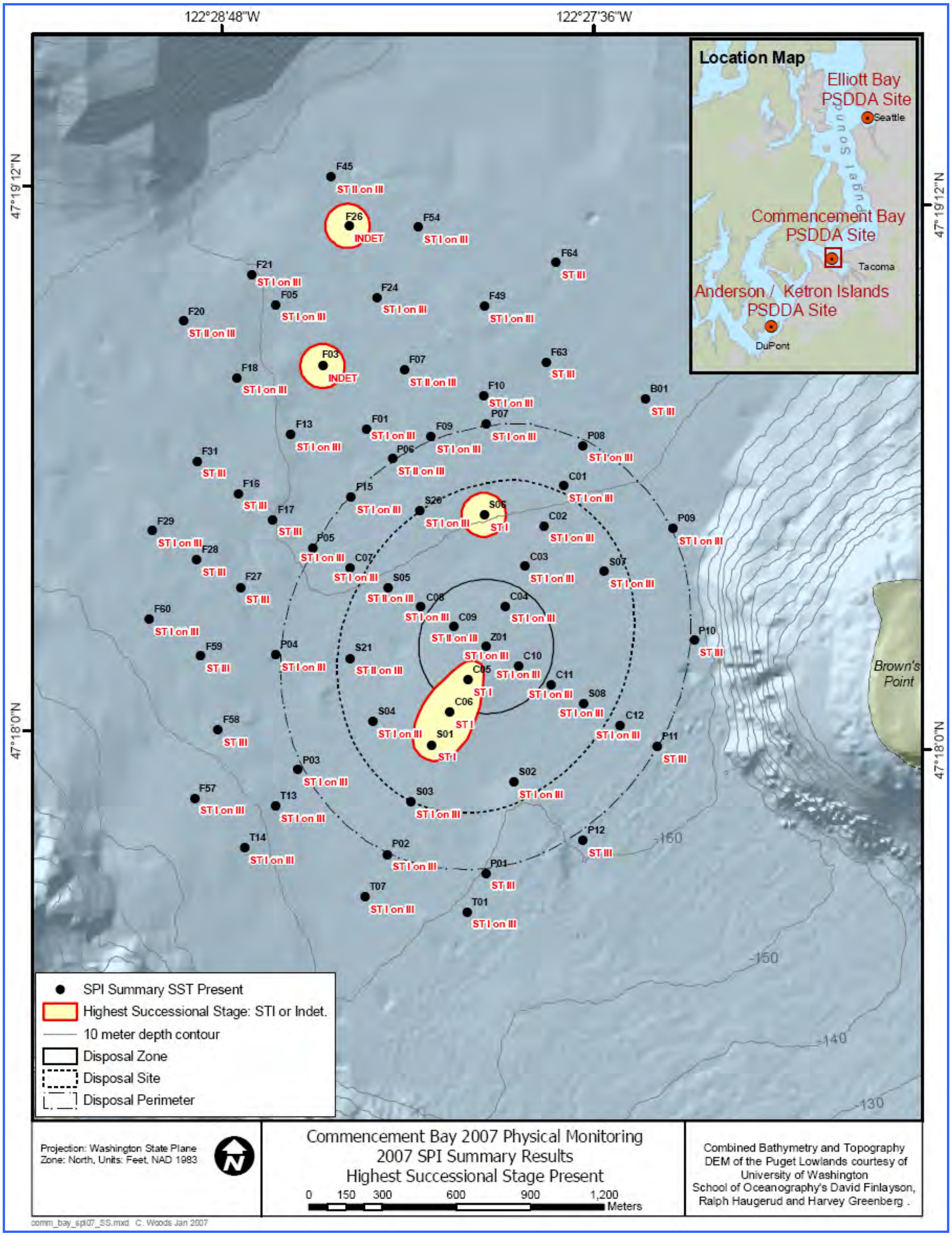
During the most recent survey (2007), Stage III benthic communities were observed at every SVPS station sampled, with the exception of four stations within the site boundary (CBC05, CBC06, CBS01, and SBS06) and two stations to the north (CBF03 and CBF26) where the successional stage was indeterminate (Figure 17). OSI values also tended to be lower (less than +6) where the Stage I or indeterminate benthic communities were present (Figure 18). Other stations located within the disposal site showed the presence of Stage III infauna, which indicate that thin layers of "suitable = clean" dredged material do not displace the Stage III community inhabitants, and they are able to re-establish their burrows.

Overall, SVPS monitoring has found well-developed benthic communities and undisturbed benthic habitat conditions during post-disposal monitoring surveys in surrounding offsite areas. Parameters measured from SVPS images showed that long-term adverse impacts to benthic habitat quality due to dredged material accumulation have not occurred in the offsite areas.   The benthic community appears to be resilient and adaptable to the incremental disposal of thin layers of dredged material. This is supported by the wide distribution of Stage III infaunal communities and high OSI values observed within the disposal site during the post-disposal surveys, and in areas where the thin layer of dredged material were detected to have occurred offsite (Figure 18).

Table 12. Summary of SVPS Biological Parameters in Offsite Areas

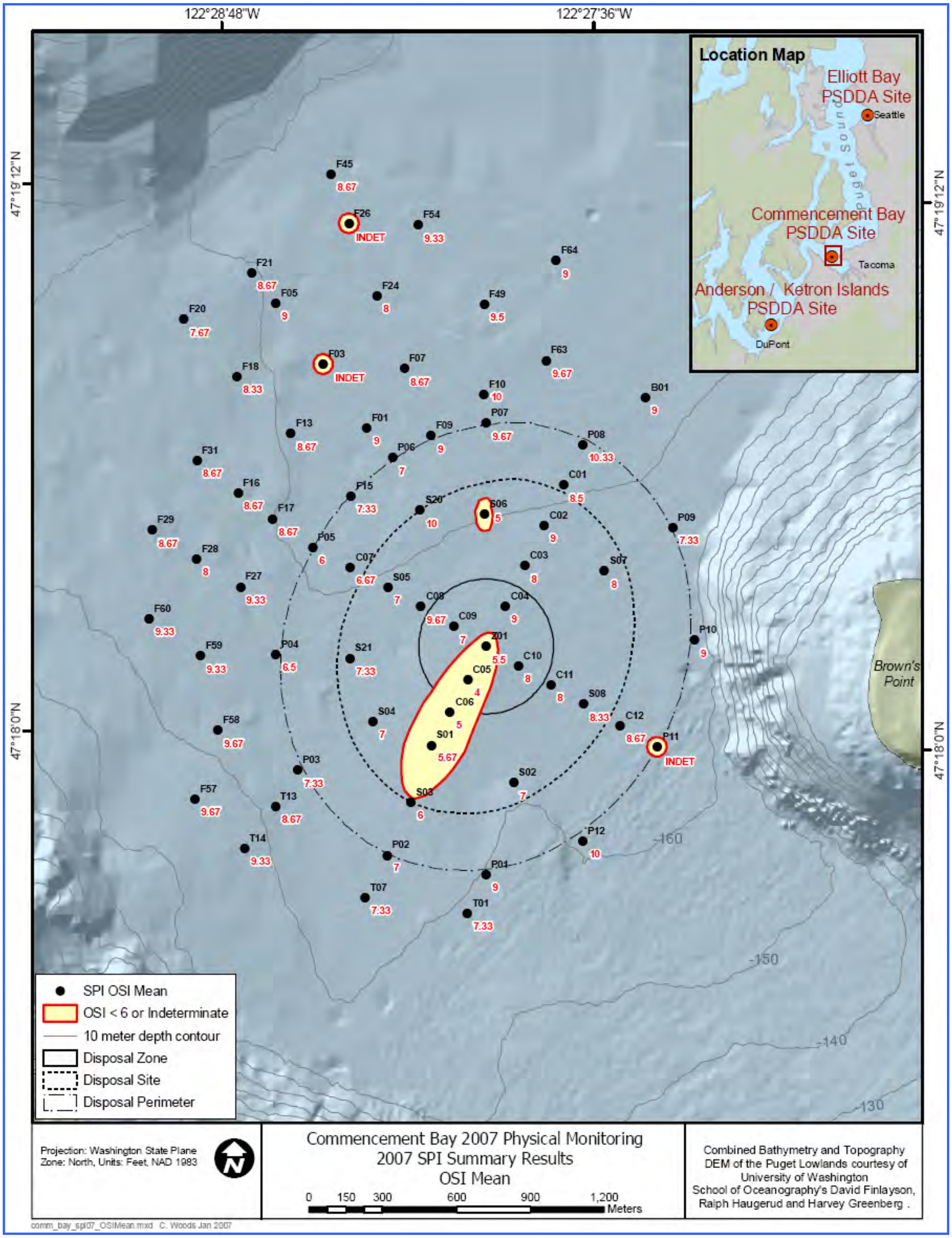
Monitoring Year	Area[1]	Number of Stations	Highest Successional Stage Present (% of Stations)			RPD Depth (cm)			OSI[2]		
			Stage I	Stage II	Stage III	Min	Max	Mean	Min	Max	Mean
1988	Baseline Survey	30	7	0	93	2.0	6.3	4.3	6	11	10
1995	Offsite	19	6	47	53	2.6	5.4	4.1	7	11	9.5
	Dredged Material Lobe[3]	0									
1996	Offsite	24	22	0	78	2.0	9.7	3.6	5	11	8.9
	Dredged Material Lobe[3]	0									
1998	Offsite	38	16	0	84	0.9	3.4	2.1	4	10	7.7
	Dredged Material Lobe	4	0	0	100	1.2	2.8	1.8	7	9	8
2001	Offsite	27	30	0	70	0.6	1.7	0.9	3	8	5.9
	Dredged Material Lobe	42	33	0	67	0	2	0.8	2	7	5.5
2003	Offsite	30	30	10	60	1.8	4.6	3.2	4	11	8.4
	Dredged Material Lobe	3	0	0	100	1.8	4	2.7	8	11	9
2004	Offsite	41	0	5	95	1.9	4.3	3.3	4.7	11	9.4
	Dredged Material Lobe	4	0	0	100	3.1	4.1	3.6	7.3	10.3	9.6
2005	Offsite	15	0	0	100	1.7	4.3	3.1	4.5	10.7	8.7
	Dredged Material Lobe	14	0	0	100	2.7	3.8	3.3	7	10.3	9.3
2007	Offsite	27	0	0	100	2.1	5.8	2.7	7.3	9.7	8.7
	Dredged Material Lobe	4	0	0	100	2.5	3.6	3.0	8.7	10	9.5

1. Offsite – offsite areas (beyond the site perimeter) where dredged material was not observed. Dredged Material Lobe – offsite areas where dredged material was present.
2. OSI values greater than or equal to +6 are generally considered indicative of undisturbed benthic habitat quality.
3. Offsite dredged material not observed.



After SAIC 2007

Figure 17. 2007 Infaunal Successional Stage Distribution



After SAIC 2007

Figure 18. 2007 Organism Sediment Index (OSI) Distribution

3.5.2 *Benthic Infauna Analysis*

The potential effects of dredged material on the benthic community structure down current of the disposal site were addressed only during post-disposal full monitoring surveys in 1995, 2001, 2003, and 2007 (SAIC 1995; SEA 2001; SAIC 2003; SAIC 2007). Benthic infauna samples were also collected at transect and benchmark stations prior to dredged material disposal at the site (1988 baseline survey) to evaluate the existing conditions prior to site use. Transect stations sampled were based on the direction of offsite dredged material deposition. To maintain comparability between years, the DMMP agencies established in 1990 a protocol to make comparisons more uniform between years and stations, which specified processing sample through a 1.0 mm sieve, and only analyzing the top 10 cm of each box core sample[23]. However, it should be noted that during the 1988 baseline survey, the entire box core was collected and analyzed, and therefore subsequent post-disposal comparisons with the 1988 baseline were problematic[24]. The abundance of dominant taxa (polychaetes, molluscs, crustaceans, and miscellaneous taxa) measured at offsite transect stations were compared to guideline values derived from baseline abundance values. Benchmark data were evaluated if taxa abundances at the transect stations were less than half of the baseline and statistically significant, in order to determine if the decreases were related to dredged material disposal or due to temporal changes or regional factors.

During the 1988 baseline survey, samples were collected from transect stations and identified and enumerated to major taxa groups only. Molluscs were the most abundant group during this survey, followed by crustaceans and polychaetes. A similar distribution of major taxa abundance was observed in the 1988 benchmark stations. The biological community present was typical of many deepwater Puget Sound habitats.

Post-disposal monitoring of the benthic infauna in 1995, 2001, and 2007 showed a significant decrease (>50 percent compared to baseline) in molluscan abundance at some of the offsite transect locations sampled, and in arthropod abundance in 2007 (refer to Appendix A for specific details). However, abundances of infaunal organisms were higher at the floating stations sampled for the 2001 special study than at the transect stations. Based on the other data collected (e.g., no dredged material present, perimeter chemistry was below biological effects criteria, no appreciable bioaccumulation of chemicals of concern in sea cucumbers collected from transect stations, and a similar decline in molluscan abundance at the benchmark stations, it was determined that the decrease in mollusc abundance was not due to dredged material disposal. The results suggested that the reductions observed at the transect stations were probably due to regional changes in benthic community structure that were unrelated to the dredged material disposal (SEA 2001; SAIC 1995; SAIC 2007).

During the 2003 survey, the abundance of major benthic taxa at all three transect stations sampled increased relative to the 2001 survey. Nearly all major taxa group abundances were greater in 2003 than the 1995 baseline data. The benthic communities in 2003 tended to be dominated by molluscs, followed by crustaceans. This observation helps to demonstrate that benthic community structure is variable and subject to change over time, as has been documented in long-term benthic studies in Puget Sound (Nichols 2003; Partridge et al. 2005).

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[23] The >10 cm depth fraction of each box core is sieved through 1.0 mm sieve and archived pending analysis results of the overlying 10 cm deep sample.

[24] The DMMP agencies concluded after the 1995 monitoring survey that the 1995 benthic data would be the new baseline for postdisposal evaluations

Dominant species observed during the post-disposal monitoring surveys included the bivalve *Axinopsida serricata*, the cumaceans *Eudorellopsis integra* and *Eudorella* nr. *pacifica*, and the ostracod *Euphilomedes producta* (SAIC 2003). The bivalve *Macoma carlottensis* was also among the most abundant species observed at the site in 2001 and 2003. The dominant species observed during the previous surveys were among the top ten most abundant species observed at the three transect stations in 2007. However, there were significant decreases in the abundance of *Axinopsida serricata*, *Eudorella pacifica*, and *Euphilomedes producta*. The polychaete *Spiophanes berkeleyorum* and amphipod *Heterophoxus conlonae* were among the top five dominant species at the transect stations studied. The amphipod *Anchicolurus occidentalis*, which was among the dominant species present in 1995, was absent in samples collected in 2007.

The benthic infauna community at the offsite areas appears to have fluctuated greatly over time. Based on comparisons to benchmark data, the variability within the community structure observed during post-disposal monitoring surveys does not appear to be related to dredged material disposal. Similar changes in benchmark taxa abundance suggested other naturally-occurring factors may have contributed to the changes. Similar to the 2007 survey, the 2001 benthic infauna analysis showed a decrease in benthic infauna abundance, particularly mollusc abundance. The benchmark station evaluation suggested this was due to area-wide changes in benthic conditions. In addition, a station added as a reference site for the 2001 monitoring, located to the north of the dredged material footprint (Seahurst Station CBDP01), also exhibited changes in community structure, including a decrease in crustacean abundance (SEA 2001). Furthermore, all major taxa groups had increased abundances during the subsequent 2003 monitoring survey.

Other studies within Puget Sound have shown temporal variability in the benthic community structure that appeared to be related to natural cycles. Reductions in mollusc and arthropod abundance compared to baseline conditions were also observed during monitoring surveys of the Port Gardner and Anderson/Ketron disposal sites. These appeared to be related to basin-wide changes and not due to dredged material disposal (SEA 2002; SAIC and Caenum 2006). Studies by Nichols (2003) and the Puget Sound Ambient Monitoring Program (Partridge et al. 2005) have measured benthic community temporal fluctuations in various parts of Puget Sound. Some of the fluctuations in the biological communities were complex and difficult to relate to physical and sediment chemical parameters, and some may have been related to naturally occurring cycles (e.g., variable planktonic larvae recruitment, interspecific competition, predation pressure, etc.) within the invertebrate communities (Partridge et al. 2005).

3.5.3 Tissue Chemistry

A component of the monitoring of dredged material disposal is to evaluate bioaccumulation of DMMP chemicals of concern by determining if there are significant increases in the chemical body burden of benthic infauna species collected down current of the disposal site. The target benthic infaunal species used to assess chemical body burden in Commencement Bay is the sea cucumber, *Molpadia intermedia*. The concentrations of DMMP bioaccumulative chemicals of concern in the tissue of sea cucumbers are measured at both transect stations (down current of the dredged material disposal) and benchmark stations. Table 13 provides the sediment bioaccumulation trigger (BT) and target tissue levels (TTL) for bioaccumulative chemicals of concern. Similar to sediment chemistry, bioassay testing, and benthic infaunal analyses, benchmark tissue stations are only evaluated if transect tissue station data also exhibit a significant increase in tissue chemistry. Chemical body burden was assessed during the initial baseline and full or tiered-full monitoring surveys in 1988, 1995, 2001, 2003, and 2007 (see Appendix A for a detailed discussion).

Molpadia intermedia were collected from three benchmark and nine transect stations for the 1988 baseline survey. These tissue samples exhibited low concentrations of metals, and the only organic compounds detected were HPAH (CBB03) and phenol (CBB01). Low concentrations of metals were also observed in tissues collected from transect stations during the 1995 survey. Tissue chemistry compared to baseline values showed that all chemicals were below the guideline (less than five times the baseline concentration for organics, three times for metals) with the exception of bis(2-ethylhexyl)phthalate. This contaminant is a common analytical contaminant and the detection was thought to be a laboratory artifact (SAIC 1995). The 1995 values were later adopted as new baseline values for Commencement Bay, due to differences in tissue collection and processing methods for the sea cucumber, and differences in the analytical chemistry methods used between the 1988 and 1995 surveys.

For the 2001, 2003, and 2007 post-disposal monitoring surveys conducted, tissue levels observed compared to baseline, met guideline levels with a few exceptions. Mercury, copper, and phenol exceeded the guidelines in some tissue replicates collected in 2001. However, benchmark data also exhibited elevated concentrations of tissue metals (copper and nickel) and phenol, which suggested that the increase at the transect stations reflected area-wide changes and therefore were not likely attributable to dredged material disposal. In addition, mercury exceeded the guideline in only one replicate and the level observed (0.069 J mg/kg wet weight) was below the current DMMP TTL for mercury (1.0 mg/kg wet weight).

Cadmium was detected at low concentrations that exceeded the guideline values (less than 3 times the baseline) during the 2003 survey, but was undetected in 2007 tissue samples. There is not an established DMMP TTL at this time. A similar decrease in cadmium in sediments was also observed in 2007, suggesting a correlation between cadmium concentrations in tissues and sediments. However, the increases in cadmium observed in 2003 were very low, and the 2007 tissue concentrations reflect a reduction in this chemical.

All other BCOC metals, except silver, were detected below guideline values during 2007. Arsenic levels exceeded the BCOC target tissue levels (TTL) in 2003 and 2007, although these levels were below the baseline and thus guideline values. Silver was undetected during both surveys, but the 2003 detection limit exceeded the very low guideline value.

Overall, the chemical analysis of *Molpadia intermedia* tissue samples collected in offsite areas of Commencement Bay has shown that the chemical body burden of offsite biological resources has not increased due to dredged material disposal.

In addition to the sea cucumber tissue collections, the 2007 full monitoring survey included high resolution dioxin/furan analysis of tissues collected from three types of polychaete worms (Glycerid, Maldanid, and *Travisia*), and the clam *Compsomyax subdiaphana*. These analyses were conducted to provide additional information for the DMMP during their broad stakeholder/interagency review to develop a regulatory framework for managing dioxin/furan in dredged material. The results of these analyses are summarized in Table 8, and showed generally low dioxin/furan concentrations in the tissues of the collected species.

Table 13. Bioaccumulative Chemicals of Concern

Chemical	Bioaccumulation Trigger (BT) mg/kg dry weight[1]	Target Tissue Level (TTL)[2] mg/kg wet weight	Analysis Method
List 1 (Required for Analysis)			
Arsenic	507.1	10.1	6020
Cadmium	11.3*	TBD	6020
Chlordane	0.037	0.3	8081A
Chromium	267*	TBD	6020
Copper	1027*	TBD	6020
Dioxins/furans[4]	TBD	n/a	1613B
Fluoranthene	4.6	8400	8270
Hexachlorobenzene	0.168	180	8081A
Lead	975*	TBD	6020
Mercury	1.5	1.0	7471A
Nickel	370	20000	6020
Pentachlorophenol	0.504	900	8270
Pyrene	11.98*	TBD	8270
Selenium	3*	TBD	7740
Silver	6.1	200	6020
TBT (porewater)	0.15 µg/L	0.6[5]	Michelsen et al. 1996
Total Aroclor PCBs	38 mg/kg organic carbon normalized	0.75[5]	8082
Total DDT	0.05	5.0	8081A
Zinc	2783*	TBD	6020
List 2 (Strong Concern and Priority for Study)			
1,2,4,5-Tetrachorobenzene	TBD	TBD	8270C
4-Nonylphenol, branched	TBD	TBD	8270C
Benzo(e)pyrene	TBD	TBD	8270C
Biphenyl	TBD	TBD	8270C
Chlorpyrifos	TBD	TBD	8141
Chromium VI	TBD	TBD	7196A or 7199
Dacthal	TBD	TBD	8081A
Diazinon	TBD	TBD	8141
Endosulfan	TBD	TBD	8081A
Ethion	TBD	TBD	8141
Heptachloronaphthalene	TBD	TBD	8270C
Hexachloronaphthalene	TBD	TBD	8270C
Kelthane	TBD	TBD	8081A
Mirex	TBD	TBD	8081A
Octachloronaphthalene	TBD	TBD	8270C
Oxadiazon	TBD	TBD	8141
Parathion	TBD	TBD	8141
Pentabromodiphenyl ether	TBD	TBD	8270C
Pentachloronaphthalene	TBD	TBD	8270C

Chemical	Bioaccumulation Trigger (BT) mg/kg dry weight[1]	Target Tissue Level (TTL)[2] mg/kg wet weight	Analysis Method
Perylene	TBD	TBD	8270C
Tetrachloronaphthalene	TBD	TBD	8270C
Tetraethyltin	TBD	TBD	Michelsen et al. 1996
Trichloronaphthalene	TBD	TBD	8270C
Trifluralin	TBD	TBD	8081A

* Interim BT value

TBD To be determined

1. Except where noted otherwise.
2. The TTLs are chemical concentrations in tissues used to interpret the results of bioaccumulation testing (Hoffman 2003).
3. Interim bioaccumulation trigger level.
4. DMMP dioxin/furan regulatory guidance will be forthcoming, developed through a series of DMMP-convened stakeholder workshops.
5. Target tissue level is based on site-specific considerations for the Elliott Bay disposal site. Separate TTLs may need to be developed for other sites.

3.6 Fish and Shellfish

The Commencement Bay disposal site was selected in 1988 in an area that was determined to be of little or no commercial value to fishermen (Dinnel et al. 1986; USACE et al. 1988a). Biological studies, which were conducted in 1986 to help guide the selection of the preferred and alternative disposal sites, found low populations of shrimp and bottom fish. The 1986 trawl studies at the disposal site were conducted to survey species that may be of commercial value: Dungeness crab (*Cancer magister*), pandalid shrimp, and bottom fish (especially flatfish, Pacific hake, cod, and rockfish). A 7.6-meter otter trawl was used to sample shrimp and bottom fish during June and September 1986. No Dungeness crabs were caught in the trawls at the site (Dinnel et al. 1986). The abundance, biomass, and species diversity of juvenile and adult flatfishes sampled at the site were relatively low. Dominant species caught were ratfish (*Hydrolagus colliei*), Dover sole (*Microstomus pacificus*), and slender sole (*Lyopsetta exilis*). Moderate populations of sidestripe shrimp (53.3 shrimp/ hectare [ha]) and pink shrimp (306.4 shrimp/ha) were found at the site, while low numbers of pink shrimp and spot shrimp were caught. None had populations that would be significant as a commercial or sport fishery (Dinnel et al. 1986).

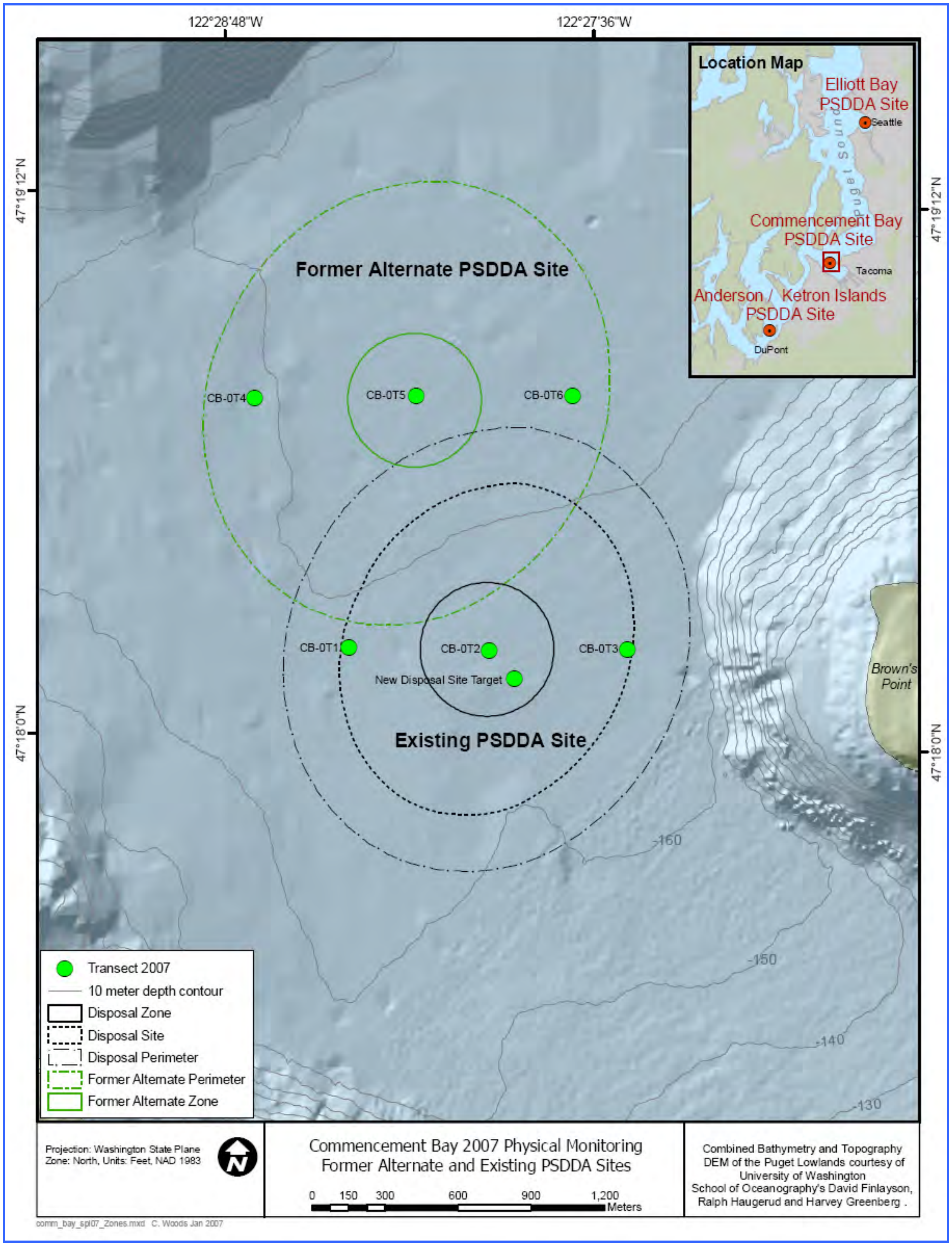
In 1986, a Benthic Resource Assessment Technique evaluation, which estimates the relative amount of trophic support or feeding potential of a given soft-bottom habitat, was used to assess bottomfish habitat values at the alternate disposal sites. The study determined that the selected disposal site provided less trophic support to demersal, bottom-feeding fish than the alternate disposal site (USACE et al. 1988a; Clarke 1986). Trophic support for a soft-bottom habitat is based on the benthic biomass in terms of size and vertical distribution in a selected area (i.e., prey size and distribution within the sediment). This was compared to the foraging depth and prey size exploitation pattern of demersal fishes at the alternate disposal sites. Estimates of trophic support for bottom-feeding fish increased with increasing total benthic biomass in the area. The Commencement Bay disposal site chosen was recommended in part because of the lower biomass and low potential to support demersal fishes (USACE et al. 1988a).

A trawling evaluation was conducted in 2007 revisited previous trawling stations occupied in 1986 to update the evaluation of demersal fishery resources at the disposal site and alternative site to evaluate whether the sites are serving as “attractive nuisance” (Figure 19). These investigations were conducted with USACE and USACE-contractor scientists, who have considerable expertise in fisheries and invertebrate biology. A 7.6-meter otter trawl was again used to sample the fish population at the site. Three target shrimp species of commercial value were collected during the sampling: pink shrimp (*Pandalus borealis*) at 3.5 shrimp/ha, smooth pink shrimp (*P. jordani*) at 2.8 shrimp/ha, and sidestripe shrimp (*Pandalopsis dispar*) at 8.4 shrimp/ha. The numbers of sidestripe shrimp and pink shrimp caught were much lower than those obtained during the 1986 surveys (Figure 20). The number of smooth pink shrimp caught in 2007 was slightly higher than that observed in 1986 (2.8 shrimp/ha and 0.8 shrimp/ha, respectively). The overall population of shrimp encountered during the 2007 surveys (14.7 shrimp/ha) was much less than that observed in 1986 (362 shrimp/ha). Therefore, these populations are not expected to be significant as a commercial or sport resource. Non-target shrimp species included Crangon shrimp (*Crangon* sp.), slender-blade shrimp (*Spirontocaris holmesi*), and glass shrimp (*Pasiphaea pacifica*).

Fish of commercial or recreational value caught within the 2007 trawls included English sole (*Parophyrs vetulus*) and slender sole. These two species were found in similar quantities (4.2 fish/ha and 4.9 fish/ha, respectively). Dover sole, which was the dominant species caught during both 1986 trawl surveys, was absent in the 2007 trawl catches. Fewer flatfish were caught in the July 2007 trawls (9.1 flatfish/ha) than in either month in 1986, although the abundances were more comparable to the June 1986 trawls than September (Figure 21). Other fish species caught in low abundances in the 2007 trawls included spotted ratfish, Pacific hake (*Merluccius productus*), and walleye pollock (*Theragra chalcogramma*).

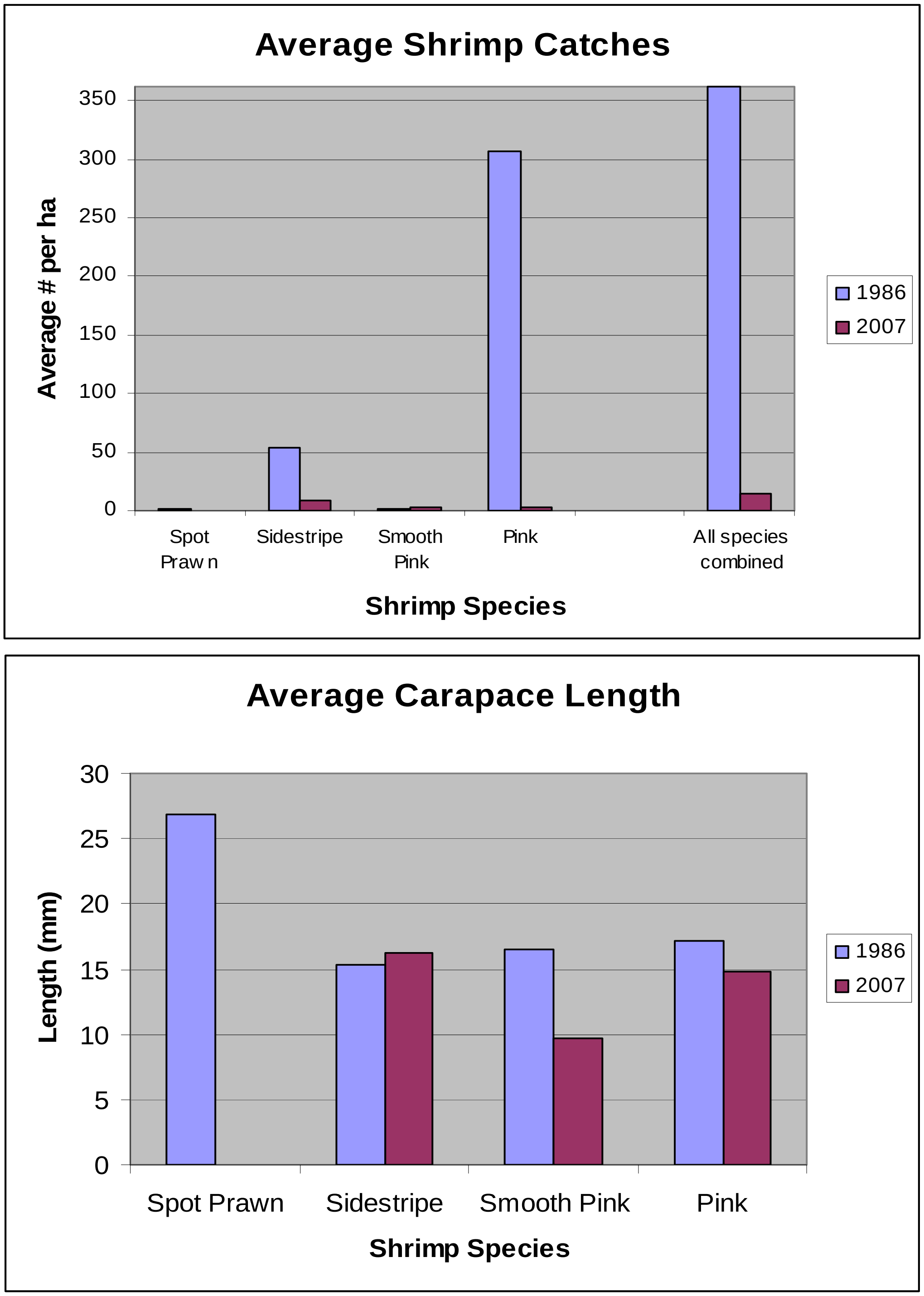
Overall, the densities of shrimp and flatfish were less than those found in 1986. Similar to the 1986 trawl surveys, no Dungeness crabs were encountered in the 2007 trawl surveys. The conclusions reached during the 1988 EIS were thoroughly vetted through resource agencies during the public interest review and substantiated the conclusion in the FEIS that “viable fishery resources” are not supported at the site or alternative site. The absence of Dungeness crab and low abundances of pandalid shrimp and bottom fishes were consistent with the 1986 studies, and 1988 FEIS assessment. The results of the 2007 trawl survey supported the conclusion that the Commencement Bay site was designated in an area that did not have abundant fish or shellfish populations that could support commercial fisheries.

Figure 22 shows forage fish habitat areas in the vicinity of Commencement Bay. Due primarily to water depth at the site, there are no key forage fish habitats in the immediate vicinity of the DMMP site that could be affected by disposal. Figure 23 shows shellfish harvest areas in the Commencement Bay vicinity. There are no shellfish harvest areas in the immediate vicinity of the DMMP site that could be affected by disposal.



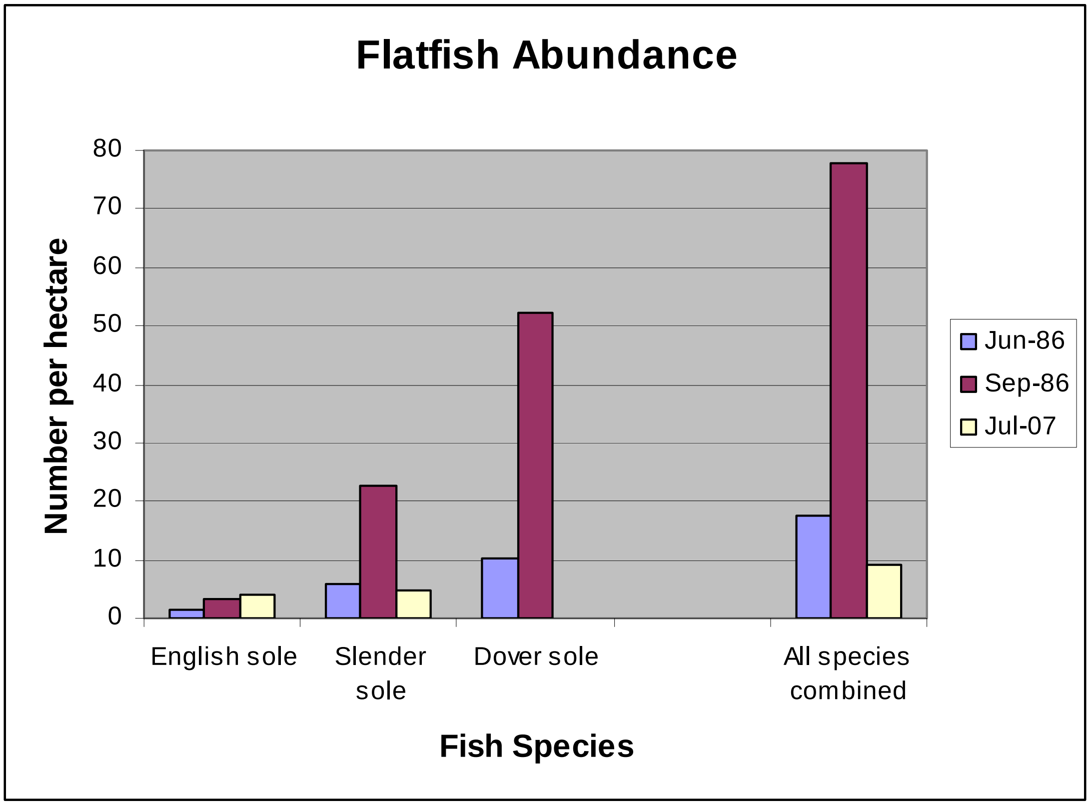
After SAIC 2007

Figure 19. 2007 Commencement Bay Site Otter Trawl Stations



After SAIC 2007

Figure 20. Average Shrimp Catches and Lengths for all Shrimp Caught by Otter Trawl in Commencement Bay

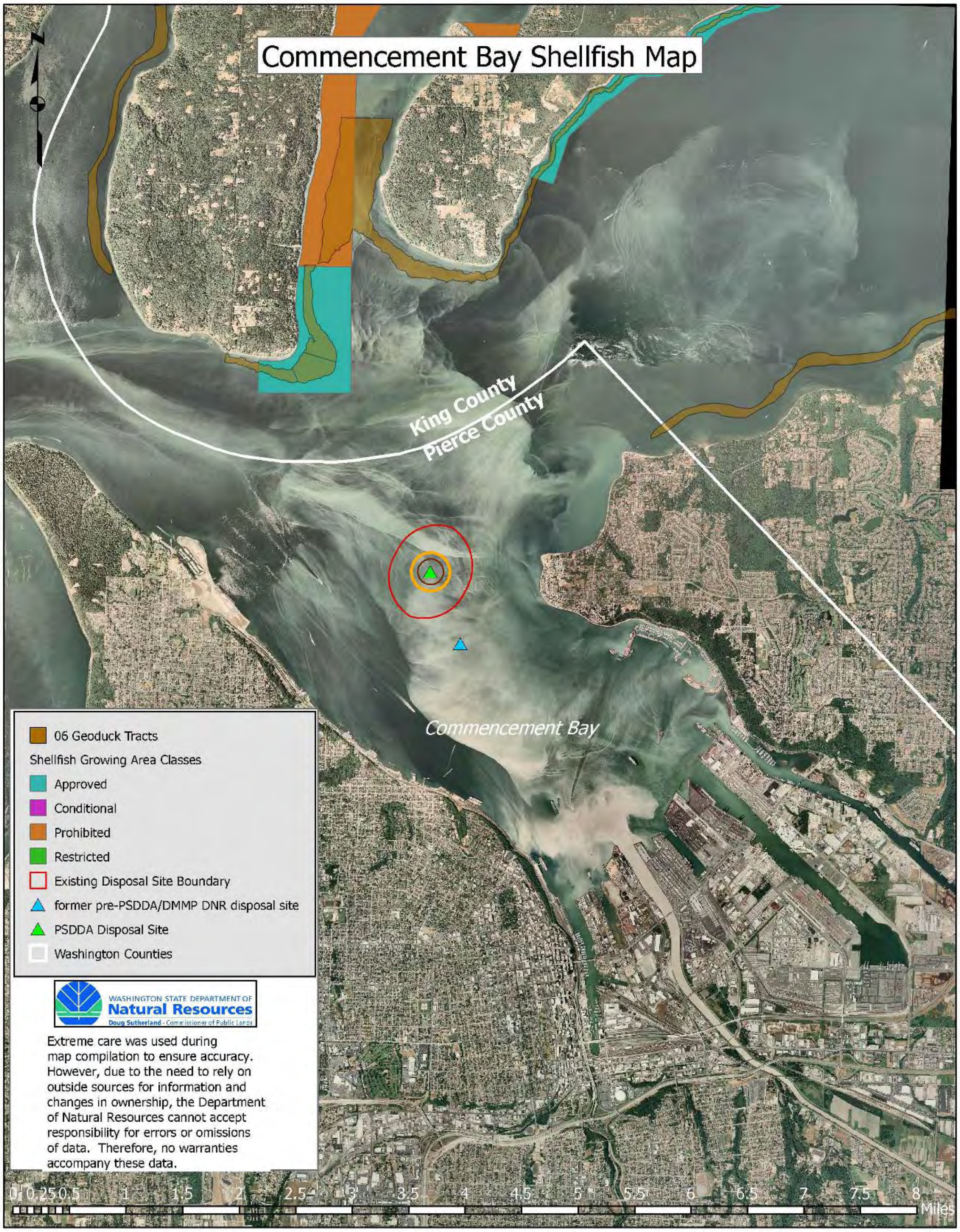


After SAIC 2007

Figure 21. Abundance (Number) of Flatfish Caught by Otter Trawl in Commencement Bay

Source: DNR 2008

Figure 22. Forage Fish Habitats in the Commencement Bay Vicinity



Source: DNR 2008

Figure 23. Shellfish Harvest Areas in the Commencement Bay Vicinity

3.7 Birds

Commencement Bay is a stopover point for marine birds and shorebirds during migration and supports many overwintering species. Species that occur in deeper water are mostly mid-water or surface feeders, often found in large flocks that concentrate at productive sites such as convergences or "tide rips" in channels and passages (Johnson and O'Neil 2001). The Tacoma Narrows is a nearby example of such an area. Species that use Puget Sound deepwater habitats for foraging and resting include the groups listed in Table 14, with the exception of the shorebirds, dabbling ducks, and geese, which occupy nearshore habitats. The marbled murrelet, discussed in Section 3.9.2, is a federal- and state-listed threatened species. Commencement Bay is within the range of fish-eating raptors (bald eagle and osprey), but these species feed less frequently in deepwater marine habitat. Peregrine falcons may use the area but are more likely to prey on shorebirds in the nearshore zone. Species most likely to occur at the disposal site include marine waterfowl such as western grebe, red-necked grebe, Barrow's goldeneye, common goldeneye, white-winged scoters, and surf scoter; and seabirds such as common murre, rhinoceros auklet, double-crested cormorant, glaucous-winged gull, Bonaparte's gull, and Caspian tern.

Table 14. Marine Birds and Shorebirds of Puget Sound

Marine Bird Grouping	Marine Bird Families	Season(s) of Occurrence
Shorebirds	Plovers, sanderlings, dowitchers, sandpipers, yellowlegs, and phalaropes	Killdeer: year-round Spotted sandpiper: summer Phalaropes: during migration All other species: winter and during spring and/or fall migration
Marine Waterfowl	Dabbling ducks, geese Diving ducks: scaup, goldeneye, scoters, bufflehead, canvasback Sea ducks: oldsquaw, scoters Mergansers Grebes, loons	Canada goose, common and hooded mergansers, and some dabbling ducks: year-round Surf and white-winged scoters: winter and non-breeding flocks during summer All other species: winter and/or during migration (spring and/or fall migration)
Seabirds	Pursuit divers: auklets, murres, murrelets, guillemots, and cormorants Surface feeders: gulls and terns, parasitic jaeger	Gulls: glaucous-winged gulls: year-round; Ring-billed gull: summer and during migration; Bonaparte's gull: fall and spring migrant; other species: winter Terns: Caspian terns: summer; common tern: fall migrant Parasitic jaeger: fall migrant (follows the common tern) All other species: year-round
Raptors	Fish-eaters: bald eagle, osprey	Bald eagle: year-round Osprey: spring, summer, early fall

Sources: Smith et al. 1997; Opperman 2003; Larsen et al. 2004; WDFW 2005a: Nysewander et al. 2005.

Most marine bird species listed above are migrants or winter residents. In winter, resting flocks of western grebe, most of the loon species, and other sea birds use protected and semi-protected deeper waters (Washington Sea Grant Program 2000). Resident breeding species observed in the vicinity of Commencement Bay include pigeon guillemot, Barrow's goldeneye, glaucous-winged gull, and osprey (Smith et al. 1997). Some resident species, including most of the alcids, Barrow's goldeneye, and the cormorant species, are uncommon in this area during the breeding season because of the distance to suitable nesting areas. Pigeon guillemots are known to nest in cliff burrows adjacent to the bay. Caspian terns nested at the Asarco site on Commencement Bay from 1999 to 2000 (Collis et al. 2002) but no longer breed there.

3.8 Marine Mammals

Deepwater habitats in Puget Sound are used primarily as foraging areas for 10 species of marine mammals (Table 15). The Steller sea lion, humpback whale, and killer whale are federally listed under the Endangered Species Act, and are described in Section 3.9.3.

Table 15. Marine Mammals of Puget Sound

Species	Stock(s)[1]	Relative Occurrence	Season(s) of Occurrence
Gray whale	Eastern North Pacific stock	Rare to occasional use	Year-round
Minke whale	California/Oregon/ Washington stock	Rare to occasional use	Spring, summer, and fall
Humpback whale	Eastern North Pacific stock	Rare to occasional use	Spring/fall
Killer whale	Eastern North Pacific Southern Resident	Common	Year-round
Dall's porpoise	California/Oregon/ Washington stock	Common	Year-round
Harbor porpoise	Washington inland waters stock	Rare to occasional use	Year-round
Harbor seal	Washington inland waters stock	Common	Year-round;
Northern elephant seal	California breeding stock	Occasional use	Summer/fall
California sea lion	U.S. stock	Common	Fall to late spring
Steller sea lion	Eastern U.S. stock	Rare to occasional use	Year-round

Sources: Osborne et al. 1988; Calambokidis and Baird 1994; Osmek et al. 1998; Jeffries et al. 2000; Jeffries 2006, personal communication; Laake 2006, personal communication; and NMFS marine mammal stock assessment reports (Carretta et al. 2007a, 2007b), accessed online: http://www.nmfs.noaa.gov/pr/sars/species.htm

Resident species most likely to use Commencement Bay include Dall's porpoise, killer whale (Southern Resident stock), and harbor seals. Harbor porpoise were relatively abundant in northern Puget Sound aerial surveys in the 1990s (Osmek et al. 1998), although the National Marine Fisheries Service (NMFS) (Carretta et al. 2007a) noted a significant decline in harbor porpoise sightings in southern Puget Sound since the 1940s. A few observations were reported by Nysewander et al. (2005) in the Tacoma Narrows in annual surveys conducted between 1992 and 1999. The abundance of Dall's porpoise has increased in Puget Sound in recent decades (Osmek et al. 1995; Calambokidis et al. 1997) but no surveys have been conducted since 1996 (Carretta et al. 2007b). In south Puget Sound, they were reported by Nysewander et al. (2005) in surveys conducted from 1993 to 1999 in Carr Inlet and Colvos Passage. Harbor seals are abundant throughout Puget Sound (Jeffries et al. 2003; Carretta et al. 2007a). In Commencement Bay they haul out on buoys, floats, and log booms.

The other marine mammals listed in Table 15 are seasonally present in south Puget Sound. Male California sea lions are seasonally abundant in Puget Sound during the fall and winter (Jeffries et al. 2000). In Commencement Bay they haul out on buoys and floats. Minke whales have been observed near the San Juan Islands (Calambokidis and Baird 1994; Osmek et al. 1998), but inland marine habitat is not considered to be a preferred habitat type for the species (Reeves et al. 2002). The northern elephant seal is an occasional visitor to Puget Sound in spring and summer (Jeffries et al. 2000) and feeds on benthic invertebrates and fishes (Reeves et al. 2002). Other marine mammals that may occasionally enter Puget Sound in any season include the Steller sea lion, discussed in Section 3.9.3, and the gray whale. A small number of gray whales have been reported at irregular intervals in various years in south Puget Sound (Calambokidis et al. 1994, 1999, 2000), including Commencement Bay (Orca Network dates various).

3.9 Threatened and Endangered Species

In accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, federally funded, constructed, permitted, or licensed projects must take into consideration impacts to federally listed and proposed threatened or endangered species. Species listed as either threatened or endangered potentially found in Commencement Bay are discussed below.

3.9.1 Puget Sound Salmonids

Puget Sound Chinook Salmon

The Puget Sound ecologically significant unit of Chinook salmon was listed as federally threatened under the ESA in 1999 (64 Federal Register [FR] 14308), with the threatened listing reaffirmed in 2005 (70 FR 37160). Critical habitat was designated for Puget Sound Chinook shortly thereafter in 2005 (70 FR 52685). The draft recovery plan for Puget Sound Chinook is currently available (70 FR 76445). The Puyallup River basin supports two populations of Chinook salmon: the early returning White River Chinook, which spawn in the upper and lower White River, and the late returning Chinook population that spawns in the Carbon River, Puyallup River, and associated tributaries. Estimated abundances of these Chinook are 200 for the Lower White River, 500 for the Upper White River, and 1,300 for the Puyallup River.

Juvenile Chinook are present in the bay from April to late July and primarily use shallow nearshore waters during outmigration (Dames and Moore 1981, as cited in USACE et al. 1988a). Juveniles would not be expected at the depths found at the project location. No adults were collected during bottom surveys with otter trawls conducted in 2007 (SAIC 2008); however, adults could occur in Commencement Bay in the disposal area when returning from the ocean to spawning rivers.

Puget Sound Steelhead

The Puget Sound steelhead DPS (distinct population segment) was listed in May 2007 under the ESA as a threatened DPS (72 FR 26772). Steelhead exhibit the most complex life history of any species of Pacific salmonid. Steelhead can be anadromous (referred to as steelhead) or freshwater residents (referred to as rainbow trout), and, under some circumstances, they can yield offspring of the alternate life history form (72 FR 26772). Steelhead may spawn more than once during their life span, whereas Pacific salmon species generally spawn once and die. Both the White River and Puyallup River winter steelhead stocks were classified as depressed in the 2002 Washington State Department of Fish and Wildlife (WDFW) stock assessment while both were considered healthy in the previous assessment conducted in 1992 (WDFW 2002). The Puyallup River winter steelhead run size has declined steadily since the 1980s (NMFS 2005).

Juvenile steelhead would not be expected at the depths found at the project location. No salmonids have been collected during bottom surveys of the disposal site conducted in the 1980s or most recently in 2007 (Dames and Moore 1981, as cited in USACE et al. 1988a; Donnelly et al. 1986; SAIC 2008). Adult steelhead could occur in Commencement Bay in the disposal area when returning from the ocean to spawning rivers or on their return to the ocean from the rivers if they survive spawning.

3.9.2 Birds

Marbled Murrelet

The Pacific coast population of marbled murrelets south of the Canadian border was listed as threatened under the federal ESA (57 FR 45328) in 1992. Critical habitat was designated for the marbled murrelet 4 years later (61 FR 26256) in 1996. The state of Washington also lists the marbled murrelet as threatened (WDFW 2007a). The federal listing decision was based on the determination that the marbled murrelet was threatened from loss and modification of nesting habitat, primarily due to commercial timber harvesting of older forests, mortality associated with gillnet fisheries off the Washington coast, and mortality resulting from oil pollution (61 FR 26256). Marbled murrelets are pursuit divers that feed on small fish and invertebrates and tend to forage in waters less than 30 meters deep (Sealy 1975; Strachan et al. 1995). Marbled murrelets may use Commencement Bay waters when feeding (USFWS 2006) but would be unlikely to feed in the deep waters at the disposal site.

Bald Eagle

The bald eagle was delisted as threatened under the ESA on August 8, 2007 (50 FR 37346), but it remains protected under the federal Bald and Golden Eagle Protection Act and is still listed as threatened under Washington State law (Bald and Golden Eagle Protection Act, RCW 77.12.655) Both federal and state law focus on protection of nesting and roosting habitat. State law requires the establishment of rules defining buffer zones around bald eagle nest and roost sites. WDFW identified 1,125 bald eagle territories in Washington in 2005, of which 75 percent were occupied (WDFW 2007b). Several bald eagle nesting territories occur within foraging distance of Commencement Bay (e.g., Browns Point and Point Defiance) and these birds are known to occur year round in the vicinity of Commencement Bay. However, bald eagles tend to forage in nearshore areas and are more common along streams in winter where they feed on salmon (USACE 2005).

3.9.3 Marine Mammals

Killer Whale

The Southern Resident killer whale was listed as endangered under the federal ESA in November 2005 (70 FR 69903). A combination of natural factors, including the impact of El Niño and La Niña oceanic conditions, reductions in prey populations, disturbance from vessel traffic, and toxins, most likely contributed to the Southern Resident's decline. A recovery plan was published in January 2008, and critical habitat (including most of Puget Sound and the Strait of Juan de Fuca) was designated by NOAA in November 2006. The killer whale is also a state-endangered species (WDFW 2007a). Killer whales are top-level predators that feed high on the aquatic food chain. The diet of Southern residents is not well studied, but feeding records indicate that they primarily eat salmon (Chinook 78 percent and chum 11 percent of the diet), with a small percentage of other fish such as herring and rockfish (review in NMFS 2008). In contrast to transient species, which feed on marine mammals such as sea lions and seals, Southern residents have been seen to kill marine mammals, but do not eat them (review in NMFS 2008).

The Southern Resident stock occurs in Puget Sound, including Commencement Bay, from late spring to early autumn (May to September) (NMFS 2008). The summer range of Southern resident pods is fairly well defined as Haro Strait, the southern Strait of Georgia, Boundary Passage, and the eastern Juan de Fuca Strait (Heimlich-Boran 1986; Krahn. et al. 2002). The range of Southern Resident pods throughout the rest of the year is less well known, but J pod in particular includes Puget Sound in its range, probably to take advantage of chum and Chinook salmon runs (Heimlich-Boran 1986; Osborne 1999; The Whale Museum 2003, as cited in NMFS 2008). Sightings of Southern Residents in south Puget Sound are irregular in occurrence but have occasionally included Commencement Bay and the surrounding waters (Heimlich-Boran 1986; Nysewander 2005; Orca Network dates various).

Steller Sea Lion

The Steller sea lion was listed as threatened under the ESA in 1990 (55 FR 49204), and critical habitat was designated 3 years later (58 FR 45269). The state of Washington also lists the species as threatened. This species is classified into two DPSs; the eastern population is more likely to occur in Puget Sound (NMFS 2007). The eastern DPS has continuously increased at an annual rate of 3 percent over the past 30 years in southeast Alaska and British Columbia. Steller sea lions have been observed occasionally at the Toliva Shoals Buoy haul-out site in south Puget Sound (Jeffries et al. 2000). There are no breeding sites or designated critical habitat for Steller sea lions in Washington, although immatures and non-breeding individuals may be present during fall and winter months in the Strait of Juan de Fuca and the trans-boundary area (Calambokidis and Baird 1994; NMFS 2007). Therefore, the potential for this species to occur at the disposal site is low.

Humpback Whale

Humpback whales were listed as endangered in 1970 (35 FR 8491) and a recovery plan was finalized in November 1991 (NMFS 1991). Whaling depleted this species to approximately 10 percent of historic levels worldwide (Reeves et al. 2002). Several stocks are recognized for this species; the eastern North Pacific stock is seasonally present in Washington coastal waters during migration. Humpback whales occasionally enter Washington inland waters and one was sighted in the south Sound in May to June 2004 (Falcone 2005; Orca Network dates various). Therefore, the potential for this species to occur at the disposal site is very low.

3.10 Fishing

This section describes the existing use of the area around the dredged disposal site for Tribal and non-Tribal commercial and non-commercial fishing. There are no data available for fishing at the site itself, so information is presented for the fishery management units that include the site.

3.10.1 Tribal Fishing

Tribes are recognized by the federal government as sovereign nations with fishing rights at all "usual and accustomed [fishing] grounds and stations." The term "usual and accustomed" was used in treaty language and refers to those areas where tribes traditionally fished at and before treaties were made with the federal government. Only the Confederated Tribes and Bands of the Yakama Indian Nation and the Puyallup Indian Tribe currently possess adjudicated fishing rights in Commencement Bay (some tribes such as the Samish Indians are involved in ongoing litigation to determine their usual and accustomed fishing areas, which may include Commencement Bay). Thus, these tribes have commercial fishing rights for salmon, shellfish, and non-salmon fish resources, as well as rights to harvest fish and shellfish for ceremonial and subsistence purposes.

The harvest amounts and open fishing dates for the commercial salmon fishery are negotiated yearly by WDFW and the treaty tribes. The commercial salmon fishing season is split up by the type of salmon species (for example, coho and chum) and open dates typically alternate between Tribal and non-Tribal commercial fishermen. The fishing season generally runs from mid-September to early October for coho and October through November for chum.

For the purposes of WDFW, Puget Sound is split up into designated Salmon Management Areas (SMAs), which are used to track and manage the salmon fishery. Commencement Bay is designated by WDFW as SMA 11A (Figure 24). SMA 11A includes those waters of Puget Sound southerly of a line projected 259 degrees true from Browns Point (northerly point) to landfall on the opposite shore of Commencement Bay (southerly point). The Commencement Bay dredged disposal site is located within SMA 11A and SMA 11.

SMA 11A has been closed to non-Tribal commercial fishing since 1981, and for the past several years Tribal commercial fishing has mostly been voluntarily suspended by the tribe to allow greater salmon escapement. However, SMA 11A was open to Tribal fishermen in November and December of 2007 to fish for chum salmon (Phinney 2008). Since 2001, Tribal fishing in SMA 11A occurred in 2001, 2004, 2007, and 2008. The total number of fish caught has ranged from 239 (all chum salmon) in 2008 to 2,704 (mostly coho salmon) in 2007 (Table 16).

SMA 11 is located just outside Commencement Bay and includes those waters of Puget Sound located between the northern tip of Vashon Island and the Tacoma Narrows Bridge, excluding Commencement Bay. SMA 11 has been open to commercial Tribal and non-Tribal fishermen for coho and chum salmon (in 2003 the Chinook fishery was also open). Table 17 shows the fishing that has occurred since 2001 by Tribal fishermen in SMA 11 and the number and species of salmon caught. The main species of salmon caught by commercial Tribal fishermen was chum salmon, which ranged from 121 to 7,557 fish caught during the 2001 to 2008 period. The 8-year average total salmon catch for commercial Tribal fishermen was 4.491 fish.

There is no information available on Tribal fishing at the disposal site itself. Considering that the site represents a small fraction of the area of SMAs 11 and 11A, it is expected that relatively little of the Tribal catch described above was obtained at the site.

Table 16. Commercial Tribal Fishing in SMA 11A

Year	Chinook	Chum	Coho	Pink
2001	148	--	167	4
2002	--	--	--	--
2003	--	--	--	--
2004	--	257	--	--
2005	--	--	--	--
2006	--	--	--	--
2007	45	60	2,599	--
2008	--	239	--	--

Table 17. Commercial Tribal Fishing in SMA 11

Year	Chinook	Chum	Coho
2001	--	2,439	91
2002	--	6,621	--
2003	1	121	15
2004	--	4,162	129
2005	--	1,307	--
2006	--	3,727	54
2007	4	6,519	651
2008	6	7,163	388

Source: WDFW 2008a.

The Puyallup Tribe harvests shellfish, such as Dungeness crab, rock crab, shrimp, scallops, sea urchins, sea cucumbers, and squid. They also harvest geoducks, clams, and oysters, but for the purpose of this section, these species are not addressed in detail because they are located in shallow zones well away from the dredged disposal site. Non-salmon resources such as Dungeness crab, shrimp, geoduck clams, and sea cucumbers are co-managed by WDFW and the tribes. Sampling at the disposal site in 1986 and 2007 yielded no Dungeness crab (Dinnel et al. 1986; Appendix A), indicating very low or zero crab abundance at the site. This, in conjunction with the considerable water depth at the site, suggests that Tribal and non-Tribal shellfishing at the site is likely to be minimal.

3.10.2 Non-Tribal Fishing

This section describes non-Tribal commercial and recreational fishing in the vicinity of the proposed project.

Commercial Fishing

As discussed above under Section 3.10.1, there has been no non-Tribal commercial fishing allowed in SMA 11A since 1981. However, commercial fishing is allowed in SMA 11 and the results of that fishing are shown in Table 18. Similar to the commercial Tribal fishery, chum salmon was the main species caught. Between 2001 and 2008, the catch for chum salmon ranged from 68,109 (2008) to 274,656 (2004); catch generally declined over this period. The 8-year average total salmon catch for commercial fishermen was 180,547 fish.

Table 18. Commercial Non-Tribal Fishing in SMA 11

Year	Chinook	Chum	Coho
2001	--	2,439	91
2002	--	6,621	--
2003	1	121	15
2004	--	4,162	129
2005	--	1,307	--
2006	--	3,727	54
2007	4	6,519	651
2008	6	7,163	388

Source: WDFW 2008a.

As discussed above for Tribal fishing, commercial crab fishing and other shellfishing are expected to be minimal at the disposal site.

Recreational Fishing

WDFW tracks the recreational catch of salmon and other sport fish in Puget Sound in designated Catch Record Card Areas. One of these areas (Area 11) includes the area of Puget Sound from the northern tip of Vashon Island to the Tacoma Narrows Bridge including Commencement Bay. The annual sport salmon catch in Area 11 was 23,146, 17,272, 14,517, 14,212, and 27,761, respectively, for the years 1997 to 2001 (WDFW 2005b). The types of salmon caught in 2001 were 14,128 Chinook, 12,472 coho, 448 chum, 708 pink, and 5 sockeye salmon. The majority of the salmon were caught in July (4,950), August (13,293), and September (5,674) of 2001 in Area 11. Other sport fish that are taken by recreational fishers include flatfish, lingcod, rockfish, Pacific cod, surf perches, sculpins, spiny dogfish, and other bottom fish. In 2001, there were 6,739 bottom fish caught in Area 11.

As discussed above for Tribal and commercial fishing, recreational crab fishing and other shellfishing are expected to be minimal at the disposal site.

3.11 Marine Transportation

Commencement Bay is used by a variety of vessels including cargo and container ships, tugs and barges, fishing boats, recreational sail and motor vessels, and other ships. Marine shipping is a major industry and the Port of Tacoma is one of the region's leading ports. The Port of Seattle, combined with the Port of Tacoma, makes up the third largest container port in the United States (PSRC 2008). The Port of Tacoma reported that 1,172 container and bulk carriers visited the Port's facilities in Commencement Bay in 2007 (Port of Tacoma 2008).

Barges have been used to dispose of dredged material at the Commencement Bay dredged disposal site in 11 of the 16 years (1989 to 2005) that the site has been authorized for use. In some of the later years of data, 471 barge loads were disposed of at the site in 2004 and 436 barge loads in 2005 (USACE 2006).

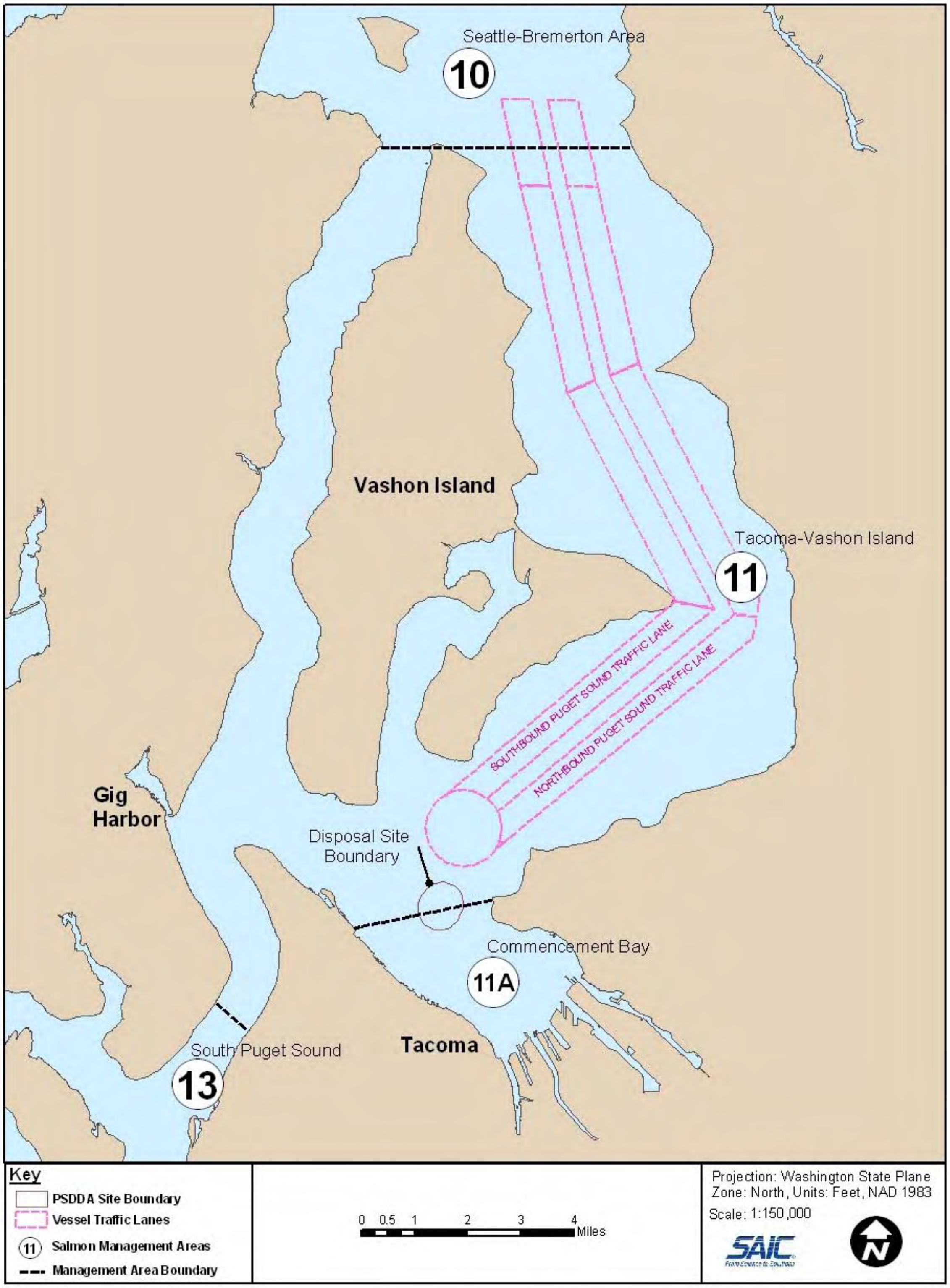
Private boats make up a large share of marine transportation in the area. There are approximately 2,300 recreational boating slips located in 11 marinas in the vicinity of Commencement Bay (Eastside Boat Manager 2008). Five yacht clubs are also located in the Commencement Bay area including the Tacoma, Corinthian, Fircrest, Totem, and Viking yacht clubs (Yacht Clubs of Washington 2008).

The Port of Tacoma reported that there have been no conflicts between marine shipping using Port facilities and barges that are offloading dredged material at the dredged disposal site in Commencement Bay.

Puget Sound waters are heavily traveled by vessels; because of the high number and concentration of vessels, all of Puget Sound is a regulated navigation area for commercial vessels (33 CFR 165). A regulated navigation area is a water area within a defined boundary for which there are regulations for vessels navigating within that area. Regulations for vessels traveling within the regulated navigation area are found in 33 CFR 165, subpart F.

Large commercial vessels are directed through Puget Sound to Commencement Bay by the Puget Sound Vessel Traffic Service, operated by the U.S. Coast Guard. This system comprises several elements that promote safe navigation by reducing the likelihood of groundings and collisions. The system is made up of three parts: (1) a vessel movement reporting system, (2) a traffic separation scheme (TSS), and (3) surveillance of ship traffic by radar, an automatic identification system, and closed circuit television.

The TSS provides vessel separation in Puget Sound through the use of directional commercial vessel traffic lanes. These lanes are located near the center of Puget Sound and extend from the entrance to the Strait of Juan de Fuca to Tacoma. In the central Puget Sound, there is a southbound lane on the west side and a northbound lane on the east side of the sound (Figure 24).



After SAIC 2008

Figure 24. Vessel Traffic Lanes and Salmon Management Areas Near the Commencement Bay Site

Each lane is approximately 1,000 yards wide with a separation zone of 500 feet between the traffic lanes. All vessels traveling within the TSS must follow TSS rules found in the U.S. Coast Guard's Puget Sound Vessel Traffic Service Users Manual.

Large vessels entering Commencement Bay from the north travel south on the inbound (western) traffic lane, which ends just north of Browns Point. There is a precautionary area (2,500 yards in radius) at the end of the traffic lanes. Vessels within the precautionary area must keep the center of the precautionary area to port.

During night hours, vessels in the precautionary zone traveling to the Port of Tacoma use the three-way flashing light on the Blair Waterway to help direct them to the Port of Tacoma facilities. This light appears to be green, white, or red depending on the ship's location. The white light indicates the ship is on course. If the light appears green or red then the ship is slightly off course (either north if green or south if red). Ships aligned with the white or green light would pass to the north of the Commencement Bay dredged disposal site. Ships aligned with the red light would pass within the northern edge of the dredged disposal target area.

3.12 Air Quality

Air quality in Commencement Bay and the surrounding region would be affected by emissions from the project alternatives. The following section describes the existing air quality resource within the proposed region of influence (ROI).

Air quality in a given location is defined by the concentration of various pollutants in the atmosphere, generally expressed in ppm or micrograms per cubic meter ($\mu g/m^3$). The significance of a pollutant concentration is determined by comparing it to national and/or state ambient air quality standards. These standards represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare with a reasonable margin of safety. The national standards are established by the USEPA and termed the National Ambient Air Quality Standards (NAAQS). The NAAQS are defined as the maximum acceptable ground-level concentrations that may not be exceeded more than once per year except for annual standards, which may never be exceeded. Ecology has also established state standards that are at least as restrictive as the NAAQS. The national and Washington ambient air quality standards are shown in Table 19.

3.12.1 Region of Influence

The area affected by the proposed emission sources would mainly include the Commencement Bay disposal site. However, use of alternative disposal sites would extend the ROI to eastern Washington and Oregon. Specifically identifying the ROI for air quality requires knowledge of (1) the types of pollutants being emitted, (2) emission rates of the pollutant source, (3) the proximity of an emission source to other emission sources, and (4) meteorological conditions. The ROI for inert pollutant emissions (pollutants other than ozone and its precursors) is generally limited to a few miles downwind from the source. Ozone is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants called precursors. The ROI for ozone generally extends much farther downwind than for inert pollutants. In the presence of solar radiation, the maximum effect of precursor emissions on ozone levels usually occurs several hours after their emission and many miles from the source, depending on the wind conditions.

Table 19. National and Washington State Ambient Air Quality Standards

Air Pollutant	Averaging Time	Washington/PSCAA AAQS[a]	NAAQS	
			PRIMARY[A,B,C]	SECONDARY[A,B,C]
Carbon Monoxide	8-Hour 1-Hour	9 ppm 35 ppm	9 ppm 35 ppm	-- --
Nitrogen Dioxide	Annual	0.05 ppm	0.053 ppm	0.053 ppm
Sulfur Dioxide	Annual 24-Hour 3-Hour 1-hour[e]	0.02 ppm 0.10 ppm -- 0.40 ppm	0.03 ppm 0.14 ppm -- --	-- -- 0.5 ppm --
Total Suspended Particulates	Annual 24-Hour	60 µg/m³ 150 µg/m³	-- --	-- --
Respirable Particulate Matter (PM_{10})	Annual 24-Hour	50 µg/m³ 150 µg/m³	-- 150 µg/m³	-- 150 µg/m³
Fine Particulate Matter ($PM_{2.5}$)[d]	Annual 24-Hour	-- --	15 µg/m³ 35 µg/m³	-- --
Ozone[e]	1-Hour 8-Hour	0.12 ppm --	0.12 ppm 0.075 ppm	0.12 ppm --
Lead and Lead Compounds	Calendar Quarter	--	1.5 µg/m³	1.5 µg/m³

AAQS = Ambient air quality standards.

a. National and Washington State standards, other than those based on annual or quarterly arithmetic mean, generally are not to be exceeded more than once per year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is less than or equal to one.

b. The NAAQS and Washington State standards are based on standard temperature and pressure of 25ºC and 760 millimeters of mercury, respectively. Units of measurements are ppm and µg/m³.

c. National Primary Standards: The levels of air quality necessary to protect the public health with an adequate margin of safety. Each state must attain the primary standards no later than 3 years after the state implementation plan is approved by the USEPA.

d. Not to be exceeded more than twice in seven consecutive days. PM2.5 is particulate matter smaller than 2.5 microns and PM10 is particulate matter smaller than 10 microns (also called fugitive dust).

e. Not to be exceeded more than once per year throughout the state of Washington and never to be exceeded within the PSCAA region.

Source: Ecology 2009.

3.12.2 Baseline Air Quality

The USEPA designates all areas of the United States as having air quality better than (attainment) or worse than (nonattainment) the NAAQS. A nonattainment designation generally means that a primary NAAQS has been exceeded more than once per year in a given area. Former nonattainment areas that the EPA designates as having attained the NAAQS are called maintenance areas. Pierce County is presently designated as in attainment of all NAAQS.

The Tacoma area historically did not attain the NAAQS for PM_{10}. Due to reductions in emissions from wood stoves and fireplaces, prohibitions of outdoor burning in urban areas, and an inspection program for diesel trucks and buses, the region has attained the PM_{10} standard since 1992 (PSCAA 2001). The region was re-designated to attainment of the PM_{10} NAAQS by the USEPA in 2001, and it is now considered a maintenance area for PM_{10}.

Recent ambient monitoring data show that the Tacoma area does not attain the NAAQS for PM2.5. The Puget Sound Clean Air Agency (PSCAA) submitted a request to designate the area as a PM2.5 nonattainment area to Ecology in November 2007. Ecology submitted its recommendation to the Governor, followed by the Governor submitting her recommendation to EPA (PSCAA 2008). EPA signed the nonattainment rule for this area in December 2008 and it is expected that they will publish the final rule in the Federal Register in the near future (personal communication with John Anderson, PSCAA).

Ozone concentrations are generally the highest during the summer months and they coincide with the period of maximum insulation. Maximum ozone concentrations tend to be regionally distributed, since precursor emissions become homogeneously dispersed in the atmosphere. Inert pollutants, such as carbon monoxide (CO), tend to have the highest concentrations during the colder months of the year, when light winds and nighttime/early morning surface-based temperature inversions inhibit atmospheric dispersion. Maximum inert pollutant concentrations are usually found near an emission source.

3.12.3 Regional Climate

Climate is important to air quality, because weather conditions determine the potential for the atmosphere to disperse emissions of air pollutants. The climate of the project region is maritime, characterized by mild summers and winters, small diurnal ranges in temperature, considerable cloudiness, and abundant rainfall during much of the year. Due to its location in the mid-latitude, the region experiences a high frequency of polar storm systems. These storms are the strongest and most common during the winter months. During the summer, the storm track weakens and shifts to the north, but storm systems can still bring cloudiness and light rain to the region. Since the majority of storms move into the region from the northern Pacific Ocean, a large percentage of precipitation falls first in the Olympic Mountains, to the west of the project site. This creates a rain shadow to the east and lessens the amount of precipitation that would otherwise fall within the project region. The presence of the Pacific Ocean and Puget Sound waters help to moderate temperatures in the region. The Cascade Mountains to the east often shield the region from the effects of cold continental air masses during winter months.

3.12.4 Applicable Regulations and Standards

The federal Clean Air Act (CAA) and its subsequent amendments form the basis for the national air pollution control effort. The USEPA is responsible for implementing most aspects of the CAA. Basic elements of the act include the NAAQS for major air pollutants, hazardous air pollutant standards, attainment plans, motor vehicle emission standards, stationary source emission standards and permits, acid rain control measures, stratospheric ozone protection, and enforcement provisions.

The CAA delegates the enforcement of the federal standards to the states. In Washington, Ecology administers the State of Washington Pollution Program (Chapter 43.21A Revised Code of Washington). Ecology has in turn delegated to local air agencies the responsibility of regulating stationary emission sources. In the Counties of King, Kitsap, Pierce, and Snohomish, the PSCAA has this responsibility. In areas that exceed the NAAQS, the CAA requires preparation of a State Implementation Plan (SIP), detailing how the state will attain the standards within mandated time frames. The CAA identifies emission reduction goals and compliance dates based upon the severity of the ambient air quality standard violation within a region.

The following is a summary of the state and local air quality regulations that would apply to the project alternatives.

3.12.5 Federal Regulations

Section 176(c) of the CAA, as articulated in the USEPA General Conformity Rule, states that a federal agency cannot issue a permit for or support an activity unless the agency determines that it will conform to the most recent USEPA-approved SIP. This means that projects using federal funds or requiring federal approval must not (1) cause or contribute to any new violation of a NAAQS, (2) increase the frequency or severity of any existing violation, or (3) delay the timely attainment of any standard, interim emission reduction, or other milestone. Since the Tacoma area is a maintenance area for PM_{10}, the USACE must determine whether emissions from the proposed action would conform to the most recent federally approved Washington SIP. If project emissions of PM_{10} are less than 100 tons per year, the action would conform to the goals of the SIP. Section 4.2.12 of this SEIS presents the conformity applicability analysis for the proposed action.

3.12.6 State Regulations

The Washington Clean Air Act and the General Regulations for Air Pollution Sources, Chapter 173-400 of the WAC, outline the state air regulations. Ecology oversees preparation of the Washington SIP and is responsible for its timely submittal to the USEPA. Ecology also administers the Prevention of Significant Deterioration regulations for major sources of air pollution at the state level.

3.12.7 Local Regulations

The PSCAA has developed rules to regulate stationary sources of air pollution in Kitsap, Pierce, King, and Snohomish Counties (PSCAA 2009). Sources associated with the project alternatives would comply with all applicable PSCAA rules and regulations.

3.13 Historical and Cultural Resources

3.13.1 Introduction

Cultural resources are historic districts, sites, buildings, structures, or objects considered important to a culture, subculture, or community for scientific, traditional, religious, or other purposes. They include archaeological resources, historic architectural or engineering resources, and traditional resources. Cultural resources that are eligible for listing in the National Register of Historic Places (NRHP) are called historic properties. Historic properties are evaluated for potential adverse impacts from an action. In addition, some cultural resources (such as American Indian sacred sites or traditional resources) may not be historic properties but are evaluated under NEPA for potential adverse effects from an action. These resources are identified through consultation with appropriate American Indian or other interested groups.

Chief among the laws, regulations, and executive orders governing cultural resources is the National Historic Preservation Act (NHPA) of 1966, as amended. Section 106 of the NHPA requires federal agencies to identify historic properties that have the potential to be affected by an undertaking, to determine the effect of the undertaking, and to consult with the Washington Department of Archaeology and Historic Preservation (DAHP) State Historic Preservation Officers (SHPO) to identify and implement ways to avoid or minimize any adverse effects on these historic properties. The NHPA includes submerged or marine resources, as well as archaeological, historical, and traditional resources found on land. In addition to federal laws, federal agencies also comply with other laws, regulations, and executive orders as appropriate.

To be considered eligible for inclusion in the NRHP, cultural resources must be determined to be significant by meeting one or more of the criteria outlined in 36 CFR 60.4. A historic resource must also possess integrity of location, design, setting, materials, workmanship, feeling, or association. A historic property must usually be more than 50 years old, although exceptions can occur. For example, more recent historic resources on a military installation may be considered significant if they are of exceptional importance in understanding the Cold War.

The interagency DMMP coordinates Section 106 compliance with the Washington DAHP SHPO. They completed consultation for the 1988 PSDDA EIS.

The region of influence for cultural resources is the area within which any of the action alternatives has the potential to affect archaeological, architectural, or traditional cultural resources. For this project, this includes the existing disposal site and its immediate surroundings. For the No-Action Alternative, the region of influence consists of the existing location of the DMMP Disposal Site and the Anderson-Ketron and Elliott Bay DMMP sites, as well as the landfills, and the train and truck routes to those landfills. For all alternatives, the region of influence also includes potential, as yet unidentified, beneficial use sites where sediment would be used for habitat enhancement.

3.13.2 Absence of Cultural Resources in the Deep Waters of Commencement Bay

While there are numerous archaeological sites (both American Indian and historic) and features of the built environment on the landforms surrounding Commencement Bay, the disposal site is located at a depth far too deep to have supported human activities. Despite the tectonic activity of the general Puget Sound region that might change exposure of sites along the coastlines in the region, the Commencement Bay disposal site is located at a depth that has never been exposed to habitation during human occupation of the region.

Cultural resource investigations conducted in support of the 1988 PSDDA EIS, utilizing side scan survey and archival historical information, found no historically significant shipwrecks in the vicinity of the Commencement Bay disposal site (Evans Hamilton 1988; USACE et al. 1988a, Appendix C). A search of the National Register Information Service, which lists places and objects listed on the NRHP (National Park Service 2008), also revealed no documented historical shipwrecks in the project vicinity. Finally, a recent check of the NOAA Coast Survey database (NOAA 2008a) and the Automated Wreck and Obstruction Information System (AWOIS) Shipwrecks and Submerged Obstructions (NOAA 2008b) reinforced these findings; their database did not indicate the recording of submerged features in the Commencement Bay DMMP site vicinity.

Any locations identified for receipt of dredged materials for beneficial uses would require assessment in coordination with the Washington SHPO and disposal in such areas would need to be in compliance with Section 106 of NHPA.

4.0 Environmental Effects of the Alternatives

4.1 Alternative 1: Expand site cumulative disposal volume ceiling to 23 mcy, with two target coordinate shifts within the existing Target Area at 7.8 mcy and at 18 mcy

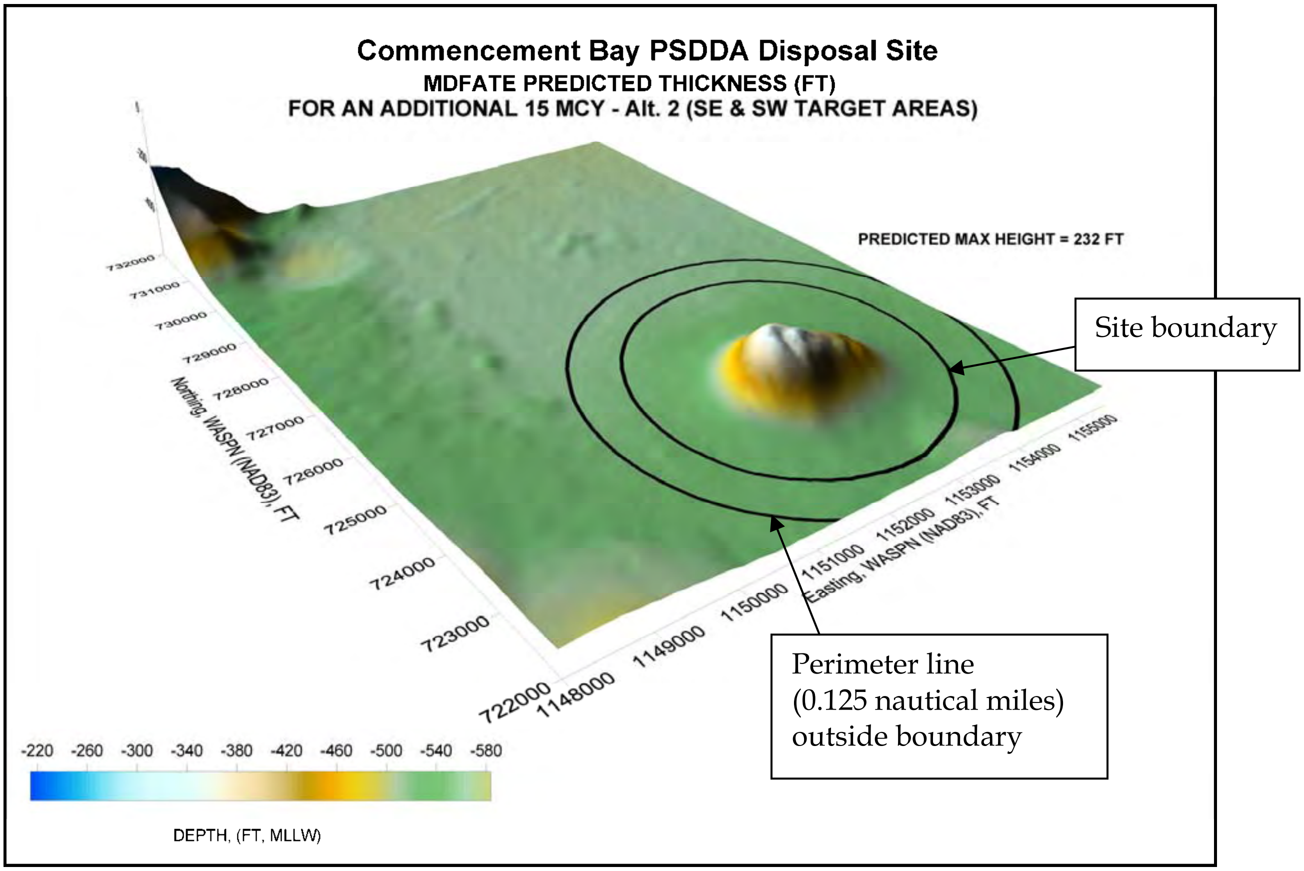
4.1.1 Physical Oceanography

For Alternative 1, the Commencement Bay disposal site boundary would remain the same. The cumulative disposal volume ceiling would be increased from 9 mcy to 23 mcy. Alternative 1 would consist of two shifts in disposal coordinates: the adoption of a shift in disposal coordinates, provisionally designated at the beginning of DY 2008 (June 2007), when the Commencement Bay disposal site had reached a cumulative disposal volume of 7.8 mcy, to a location 565 feet southeast of the initial site center within the existing Target Area; and an additional disposal coordinate shift, when the site reaches a cumulative disposal volume of 18 mcy, to a location 565 feet southwest of the initial site center and within the existing Target Area (see Figures 7, 8). Based on heavily field verified modeling under these conditions, the projected mound height would be 232 feet after 23 mcy of cumulative disposal (Figure 25; compare to Figure 7). Without these two coordinate shifts, the mound height would be expected to grow to 307 feet after 23 mcy of cumulative disposal. Therefore, Alternative 1's series of two coordinate shifts to the southeast and southwest, respectively, is expected to result in a net reduction in mound height of 75 feet after 23 mcy (32.3 percent). Alternative 1 would incorporate a site management goal of <250 feet for the Commencement Bay disposal mound. This goal was established by the DMMP agencies after review of the results of the numerical modeling analysis (Michelson, 2008). The coordinate shift would enable the DMMP agencies to meet this management objective, while remaining in the disposal site boundary outlined in the 1988 FEIS, as referenced in the existing shoreline permit (SD-18-04). The projected footprint of the disposal mound would be approximately 215 acres[25] after 23 mcy (Figure 26), which is similar to Alternative 2 (Figure 27). Further institutional controls for disposal at the site would be evaluated if the dredged material footprint exceeds the designated perimeter management boundary (>3 cm).

The DMMP agencies conducted a circulation study within Commencement Bay using the CMS-M2D numerical model to assess the influence of the disposal mound on tidal current patterns (Section 3.1). Under Alternative 1, the projected mound height would be 232 feet following the cumulative disposal of 23 mcy of dredged material. Depth averaged current velocities determined using the CMS-M2D numerical model at the center of the mound, to the north of the mound, and to the east of the mound are provided in Figures 28, 29, and 30, respectively. Overall, the 232-foot disposal mound has very little impact on tidal currents in Commencement Bay. The largest, but still minor, increase in maximum current velocity would occur at the center of the site, increasing from 1.0 foot/second (0.31 meter/second) to 1.1 feet/second (0.38 meter/second) (Figure 28. North of the disposal mound, the maximum current velocity (1.1 feet/second or 0.35 meter/second) remains unchanged relative to all of the proposed alternatives (Figure 29). In all cases, the maximum current velocities are less than the critical velocity required to initiate bedload transport for the majority of sediments disposed of at the site, according to sediment transport theory. This is further corroborated

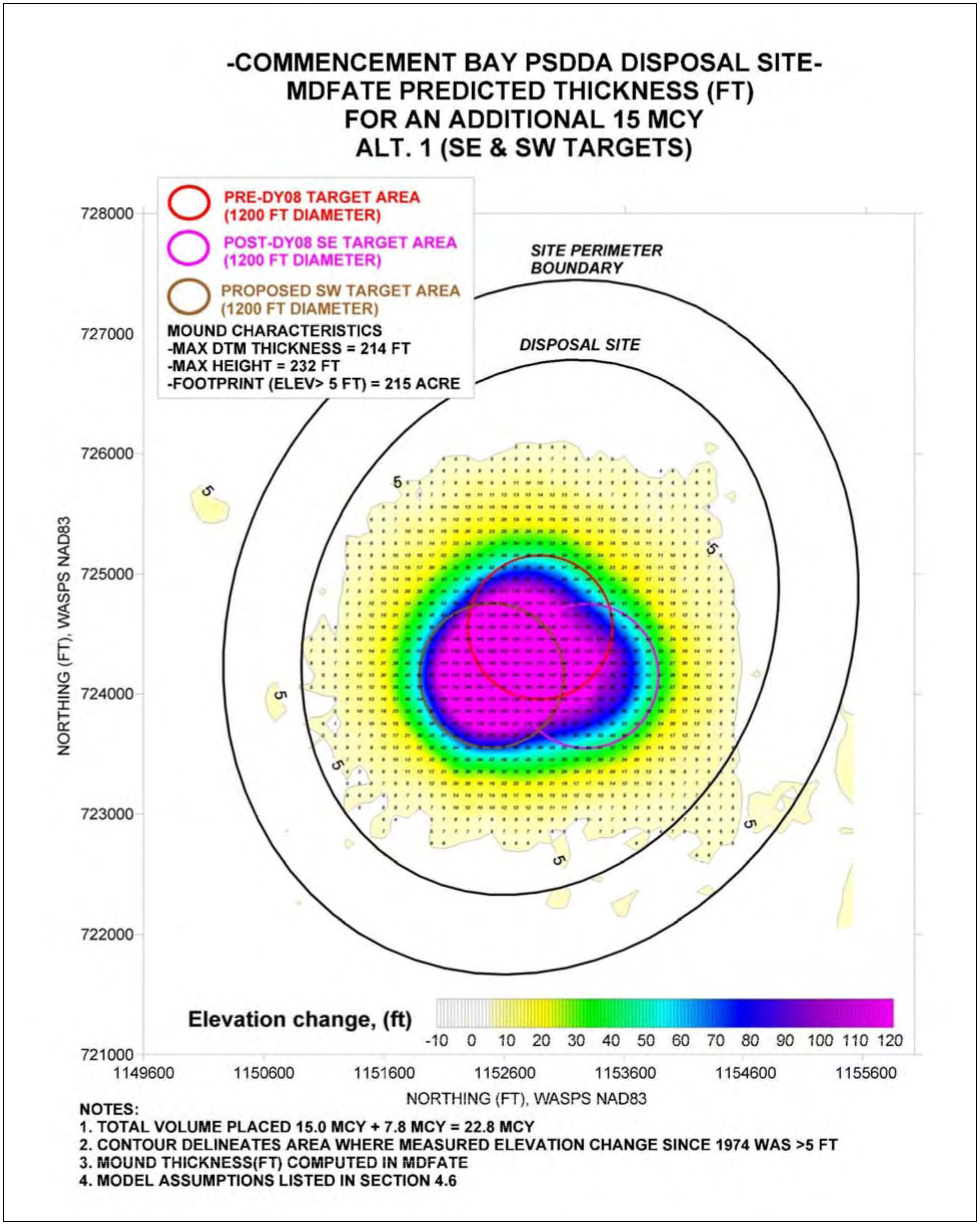
[25] The 1988 EIS (USACE, 1988a) designated this site as an ellipsoid with site boundary dimensions of 4,600 ft by 3,800 feet (310 acres) (see Figure 3).

by empirical monitoring data showing very little material deposited outside the site perimeter boundary. As a result, there would be no significant impact on physical oceanography.



After Michalsen 2008

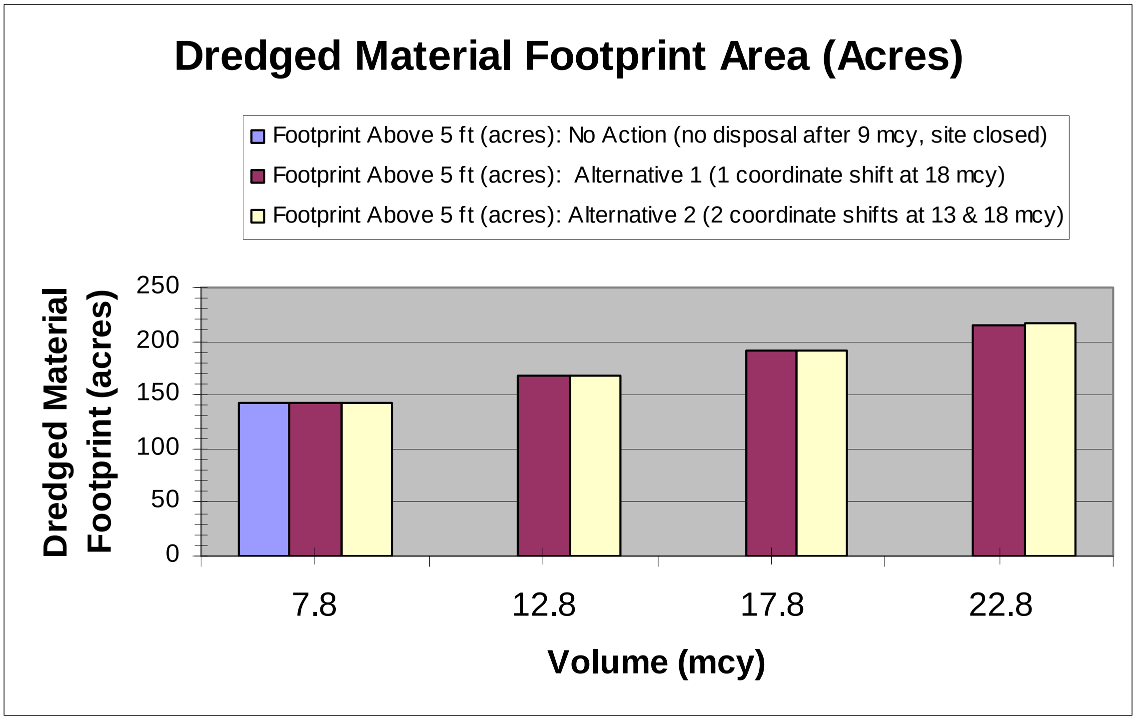
Figure 25. Alternative 1 Disposal Mound and Mound Height MDFATE Prediction After 23 mcy with One Coordinate Shift after 18 mcy with No Vertical Distortion



The maximum thickness of the mound is averaged within a 100 feet by 100 feet cell of model grid.

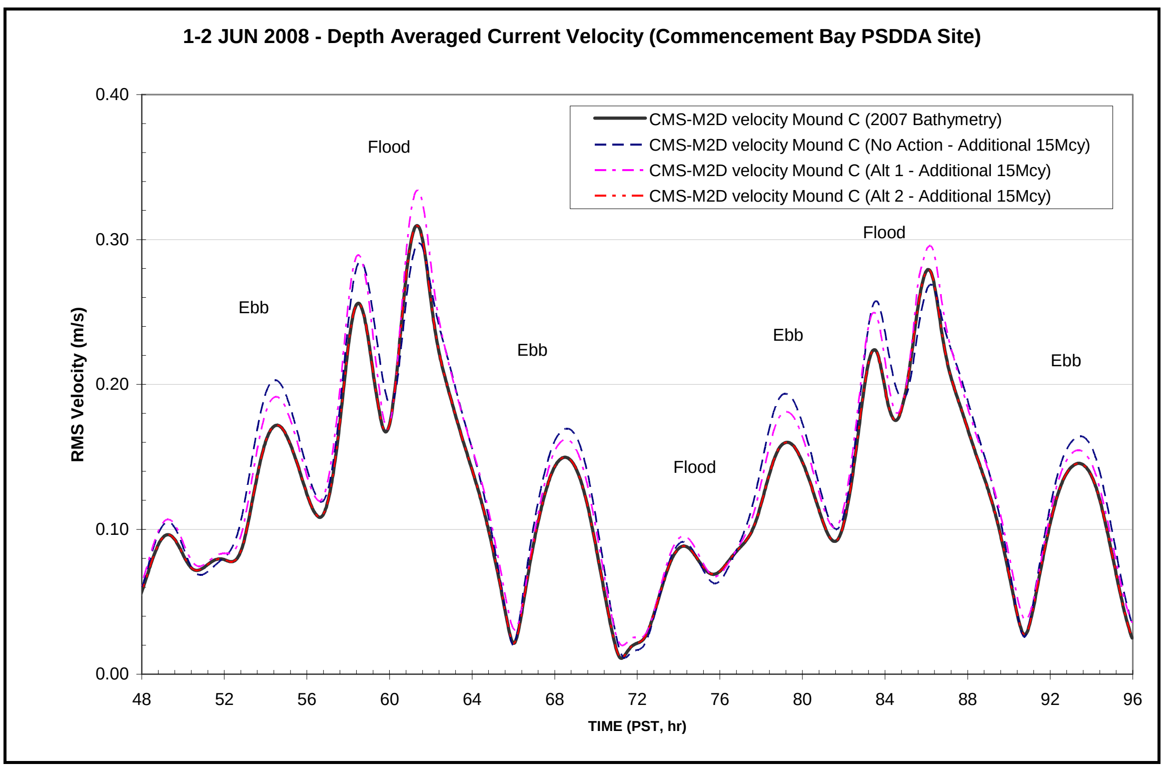
After Michalsen 2008

Figure 26. Alternative 1 MDFATE Predicted Mound Thickness and Footprint Area at a Cumulative Volume of 23 mcy with an Additional 15.0 mcy of Material Placed



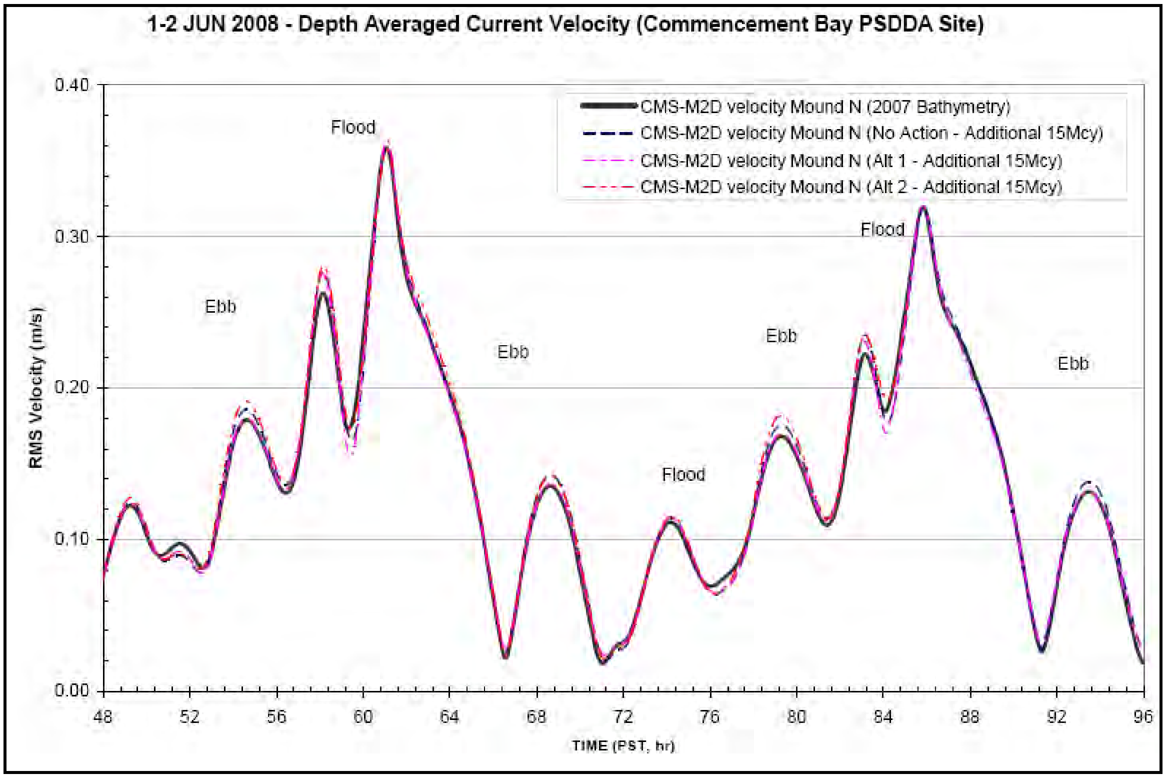
After Michalsen 2008

Figure 27. Comparative Present and Predicted Dredged Material Footprint



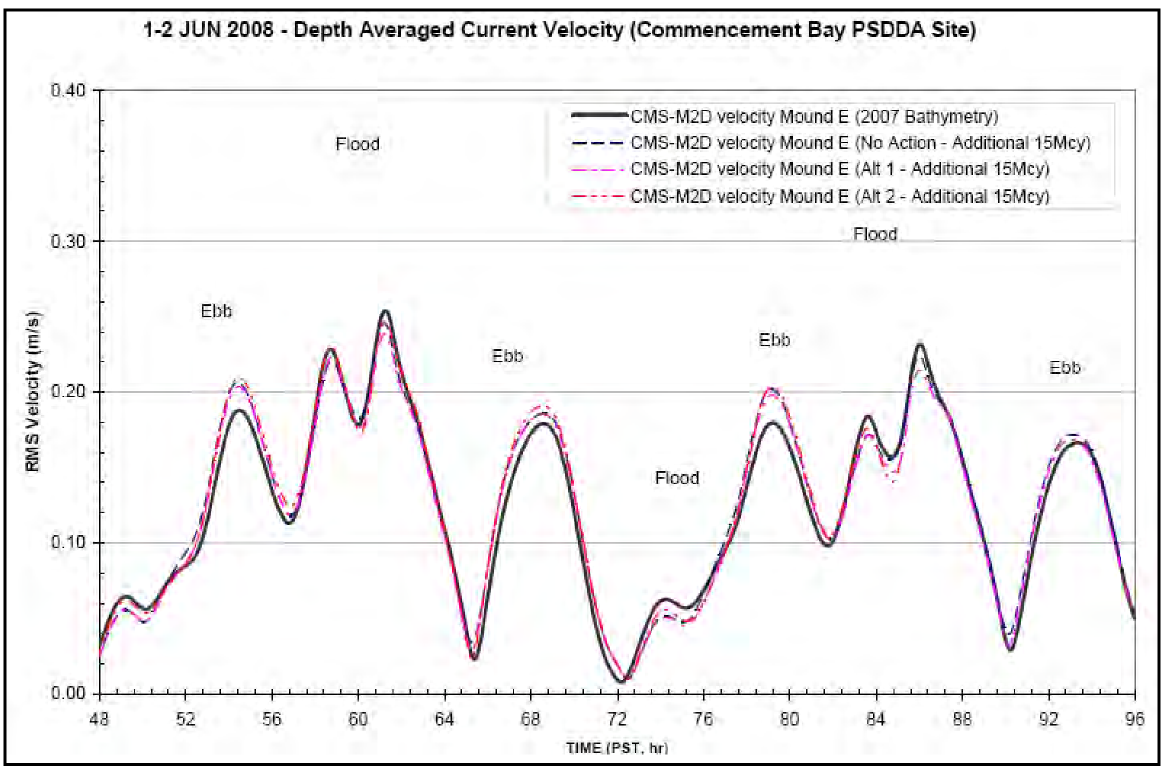
After Michalsen 2008

Figure 28. Depth Averaged Current Magnitude Computed in M2D at Observation Cell "Mound Center (C)" of the Disposal Site



After Michalsen 2008

Figure 29. Depth Averaged Current Magnitude Computed in M2D at Observation Cell "Mound North (N)" of the Disposal Site



After Michalsen 2008

Figure 30. Depth Averaged Current Magnitude Computed in M2D at Observation Cell "Mound East (E)" of the Disposal Site

4.1.2 Water Quality

Disposal of dredged material at the Commencement Bay non-dispersive site would result in elevated turbidity levels on a localized and temporary basis. During monitoring at other disposal sites across the country, maximum concentrations of suspended sediments observed during disposal activities were less than 1,000 mg/L (Pequegnat 1983). Truitt (1986) found that very little suspended sediment persists near the surface or midwater during dredged material disposal. The highest concentrations of suspended sediments tend to occur in near-bottom waters and are typically much lower (less than 200 mg/L) in mid and upper water depths. Based on predictive modeling studies[26], and field verified observations, approximately 95 percent of dredged material deposited at non-dispersive sites settles within a few minutes (Johnson et al., 1999; Moritz et al., 1999; Revelas et al, 1991; USACE Portland District, 1995; USACE et al. 1988a, 1988c; Nelson 2003, 2006; Michalsen 2008).

Monitoring of experimental disposal sites in Elliott Bay during and up to 9 months after disposal showed no significant long-term impacts to water quality (USACE et al. 1988a).

Sediment-bound contaminants associated with suspended sediments may dissolve in the water column and result in localized and temporary impacts to water quality. However, sediments are rigorously tested for chemicals of concern and for biological effects[27] before they are determined to be suitable for disposal at DMMP sites (USACE et al. 1988a). In addition, monitoring of dredged material deposited at the site has indicated no significant increases in toxic chemicals in sediments or tissues, and no toxic effects to the benthic community (Sections 4.1.3 and 4.1.5). Likewise, no effects on toxic chemicals in the water column are expected. Nutrients could be released into the water column during disposal actions; however, any increases would be temporary, localized, and insignificant relative to the high nutrient concentrations in Commencement Bay waters (PSAT 2007b). Implementation of Alternative 1 would present no appreciable change in effects on water quality, as compared with the effects analyzed in the 1988 EIS. Continuation of dredged disposal at the Commencement Bay site would not be expected to affect other water quality parameters such as DO, temperature, or nutrient loading.

Continued use of the disposal site for dredged material disposal would have temporary and localized, but no long-term, effects on water quality at the site. Once deposited at the disposal site, material is rarely resuspended into the water column by disposal activities. No toxic effects are expected from material suspended in the water column. Increasing the total volume at the site and extending the duration of use would not increase the risk of resuspension or degrade water quality or toxicity. The impacts of this alternative to existing and future water quality would be not significant.

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[26] The predictive capabilities of the MDFATE and STFATE rely on site specific data. When the model is appropriately calibrated the model has been demonstrated to be valid for managing open-water disposal sites. Example applications include, Port Gardner, Elliot Bay PSDDA sites (Revelas et al. 1991), the Mouth of the Columbia River (Moritz, Kraus, and Siipola 1999), Coos Bay, Oregon (USACE, Portland District 1995), Chesapeake Bay (Johnson et al. 1999).

The accuracy as a predictive tool for determining mound thickness and areal footprint at Commencement Bay is demonstrated in the Michalsen report (see Table 4.1). Through these model calibration tests, the confidence of predicting future mound configuration is acceptable. Still, it is acknowledged that uncertainties in future physical and operational variables can result in deviations from the predicted mound configuration. Thus, the DMMP actively collects disposal log data, sediment classification, bathymetry, and SPI data to determine if previous assumptions employed in the model remain valid.

[27] Biological effects testing and/or bioaccumulation testing required when any chemical exceeds an SL or BT.

4.1.3 *Sediment Quality*

Disposal of dredged material has resulted in changes in grain size and sediment conventional parameters (e.g., TOC), with the onsite material changing from a finer texture (mean of 76 percent fines, range of 72 to 79 percent fines) to a coarser texture (mean of 34 percent fines, range of 5 to 65 percent fines), and monitoring has confirmed a general improvement in sediment quality (e.g., low concentrations in chemicals). There have been no increases in sediment chemistry attributable to disposal. If allowed to occur, elevated chemistry in dredged material could result in toxicity to biological organisms living within or on the surface of the sediment. It could also lead to the bioaccumulation of contaminants within tissues of organisms in direct contact with the sediments or from consuming organisms that live within the sediments. However, none of these "potential" impacts have occurred at the Commencement Bay site, because of the stringent protocols in place for determining suitability of sediment for open-water disposal. The CB site is the most monitored disposal site in the nation. These potential impacts to the biological community (e.g., exceedance of Site Condition II Guidelines[28]) are described further in Section 4.1.5, but they have a low risk of occurring. If, after a monitoring event, the sampling results reflect any one of the adverse effects listed above, the DMMP agencies would deliberate and decide on a course of action to further assess the impacts using adaptive management (2007 UEMP, see SAIC 2007). If data results find any adverse impacts occurring, the DMMP could close the site pending further assessment. A good example would be the 2001 monitoring year when a thin layer of disposed material was located outside the perimeter line. The site was closed until all four DMMP agencies fully evaluated the effects of the offsite material, and concluded that these sediments were well below all chemical guidelines of concern (SQS), exhibited no toxicity, and showed no impacts to benthic communities or elevated tissue chemistry that could be attributed to dredged material disposal (Striplin 2001).

Under this alternative, average annual disposal volumes would be similar to volumes disposed of at the site in recent years (approximately 700,000 cy/yr). As mentioned before, only dredged material determined to be suitable for open-water disposal would be disposed of at the site (DMMP 2008 Users Manual. The DMMP would continue to monitor and manage the site, and since sediment volumes disposed of under Alternative 1 would be similar to those already disposed of at the site, any impacts to sediment quality would be expected to be comparable to those observed during the past post-disposal monitoring conducted at the site, and thus would not be significant. Implementation of Alternative 1 would present no appreciable change in effects on sediment quality, as compared with the effects analyzed in the 1988 EIS.

As described in Section 3.3, a total of eight post-disposal surveys have been conducted to monitor the disposal site conditions from 1995 to 2007. To date, onsite chemical monitoring and toxicity testing have confirmed that DMMP Site Condition II (minor adverse effects on biological resources due to sediment chemicals; SAIC 2008) chemical and biological guidelines have not been exceeded since disposal operations began.

Onsite monitoring results from the post-disposal surveys (1995 to 2007) provide positive evidence of the adequacy of the DMMP evaluation procedures in properly characterizing dredging projects over the life of the dredged material management program. Adaptive

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[28] By definition an exceedance of Site Condition II could result in "minor adverse effects, due to chemicals of concern in dredged material, on biological resources" at the disposal site (EPTA, 1988). Minor effects are defined as potential sublethal chronic effects, but no significant acute toxicity effects within the site, or its dilution zone (MPR, 1988, Chapter 7).

management as a key monitoring strategy has ensured that any impacts to the site have been minimal. Therefore, impacts to sediment quality due to dredged material disposal for Alternative 1 are not expected to be significant.

4.1.4 Plankton/Neuston

As described in Section 4.1.2, Water Quality, disposal of dredged material would result in elevated turbidity levels for a few hours on a localized and temporary basis. The potential for exposure of plankton to contaminants would be minimal. Because disposal occurs from bottom dumped barges, where most of the material enters the water column below the water surface, any potential effects on neuston in the sea surface microlayer are therefore sharply reduced. Very little suspended sediment persists near the surface or midwater during dredged material disposal (Truitt 1986). Effects on phytoplankton, zooplankton, and neuston from deposition usually result from material in the water column, which occurs only during and immediately following disposal and is limited to a small area around the disposal site. Dredged material could temporarily inhibit photosynthetic processes for phytoplankton, and interfere with feeding by zooplankton. Once deposited, material at the disposal site has stayed in place on the disposal mound, with very minimal resuspension. Increased site volume is not expected to increase resuspension, and short-term effects are expected to continue to be minimal.

As described in Section 4.1.2, nutrients released into the water column during disposal actions would be rapidly diluted and dispersed. The continued use of the disposal site would not increase the frequency of phytoplankton blooms in Commencement Bay. Implementation of Alternative 1 would present no appreciable change in effects on plankton and neuston, as compared with the effects analyzed in the 1988 EIS. Disposal is not expected to result in significant levels of contaminants in the sea surface microlayer and would have no significant impacts to neustonic organisms associated with the microlayer.

4.1.5 Benthic Community

Impacts to the benthic community due to disposal of dredged material depends on the type and amount of material being deposited, the rate of accumulation and burial time, the frequency of disposal, and the type of organisms present at the disposal site. For Alternative 1, the frequency and annual volume of disposal is expected to be comparable to that of recent years. Dredged material would be disposed of within the same disposal zone, although the disposal site target was shifted within the zone in 2007 to dampen the mound height, with an additional target shift planned with this alternative after 18 mcy of cumulative disposal. DMMP's adaptive disposal site management would continue, so that the observed minimal impacts to the benthic community would not be expected to increase. The types of impacts expected are limited to chemical and physical impacts. Due to the rigorous testing on all dredged material, chemical impacts have not occurred and are not expected in the future. Therefore, the impacts to benthic communities are limited to temporary physical impacts from each disposal event. The general results of observed monitoring surveys conducted at the site since 1995 are described below.

Physical impacts to the benthic community include burial and smothering of existing species. Suspension and surface deposit feeders would be the most susceptible to burial. Mobile infaunal deposit feeders would be more likely to survive burial by their ability to burrow upward through the newly deposited material. Based on various studies of critical burial depths for different benthic organisms, critical burial depths appeared to range from 5 cm for suspension and surface deposit feeders, to 30 cm for active burrowers (Nichols et al. 1978;

Maurer et al. 1978). Significant mortality could result in thicknesses greater than the 5 to 30 cm depth. The thinner the disposal layer (e.g., <10 cm), the more likely the organisms will be able to survive. Burial impacts would be expected to be greatest at the site center where the dredged material is released, and would be less towards the edges of the disposal site. Post-disposal monitoring has shown that the incremental impacts from each discrete disposal event did not result in dredged material layers greater than 10 cm over most of the disposal site, and, therefore, impacts to the benthic organisms were minimized.

With time, in areas where the benthic community has been physically displaced due to disposal, Stage I, and later Stage II and higher order successional Stage III deposit feeding invertebrates will recolonize the site, depending on the frequency of disturbance and characteristics of the disposed dredged material. It is expected that the benthic community may not fully recover within the immediate disposal target zone, while dredged material disposal is actively ongoing. The benthic community may also vary within the disposal site depending on the characteristics of the sediment deposited at the site (e.g., sediments at the site center are coarser than the sediments in adjacent areas). Sediment vertical profile image monitoring at the disposal site conducted from 1995 to 2007 has shown Stage I communities at the site center as predicted. However, Stage II and Stage III species were also observed within the disposal site area during these surveys, suggesting that at the periphery of the disposal mound vertical migration through thin layers of dredged material (<10 cm) is actively occurring as is recolonization at the site during periods of disposal inactivity. The benthic community appears to be resilient and adaptable to the disposal of dredged material. This is supported by the wide distribution of Stage III infaunal communities and high OSI values observed within the disposal site during the post-disposal surveys. Even in 2007, the year in which the greatest volume of dredged material was disposed of at the site (1.3 mcy), there were Stage III organisms present at most locations both on and off site, and mean OSI values (>+7) were relatively high throughout the disposal site area. This implied that the high frequency of site use and physical impacts of dredged material disposal did not have long term detrimental effects on the resident benthic community, except at the site center.

The results of the monitoring surveys (1995, 2001, 2003, 2007) have shown that the benthic infauna community at the offsite Transect Stations fluctuated greatly over time, and the results suggested other naturally occurring factors (e.g., interspecific competition, predation pressure, variable recruitment of planktotrophic larvae, etc.) may have contributed to the changes observed, and that the changes were not attributable to dredged material disposal. Several studies have shown that interspecific competition (e.g., including competition for space, food, and interference from sediment destabilization), changes in patterns of abundance due to adult-larval interactions, changes in population dynamics due to seasonal trends, predation pressure on other organisms, and other factors can have a major effect on the existing benthic community. One example is the tube-dwelling amphipod *Ampelisca abdita*, which has been shown to hinder populations of the mud snail *Nassarius* sp. as its mats of tubes hinder the feeding of the snail. This in turn would reduce the predation pressure on other organisms by the mud snail (Mills 1969; Gray 1981). Deposit feeders can change the sediment with their reworking activities. Patterns of abundance can be affected by adult-larval interactions of particular assemblages (Gray 1981; Woodin 1976). For example, depositing feeders feed at the surface layers where larvae of other organisms may be feeding. Zajac and Whitlatch (1982) as well as other studies (McCall 1976, 1978; Rhoads et al. 1978) found differences in recolonization and ambient benthic infaunal population dynamics related to seasonal trends. Population densities tended to be higher in the spring. Studies within Puget Sound have also identified temporal variability in the benthic community structure that appear to be related to natural cycles or interspecific competition, and the population dynamics were complex and difficult to relate to physical and chemical sediment parameters (Nichols 2003; Partridge et al. 2005).

Impacts to the benthic community off site are expected to continue to be minor, and long-term impacts are not expected to be significant due to continued dredged material disposal at the site.

Another potential impact to benthic infauna could be toxic effects from the dredged material disposed of at the site or the accumulation of contaminants within their tissues, which could result in biomagnification in organisms, such as fish, that consume them. However, sediments disposed of at the site have all met DMMP screening and bioaccumulation trigger levels, and Washington State SQS criteria (i.e., have been determined to be suitable for open-water disposal). Thus, the sediments disposed of at the site would not be expected to contain levels of contaminants that would have biological effects on the organisms living in the vicinity of the disposal site. Post-disposal sediments sampled on site have always met Site Condition II guidelines, which confirms that dredged material taken to the site has met DMMP suitability guidelines. Therefore, because of the generally low concentrations of bioaccumulative chemicals, it is unlikely that these contaminants would bioaccumulate within tissues of organisms on site. Furthermore, toxicity tests conducted on samples collected within the disposal site have shown that organisms exposed to the dredged material have not exhibited toxic responses to the sediments disposed of at the site.

Monitoring of *Molpadia intermedia* (sea cucumber) tissues collected off site and evaluated for the potential for bioaccumulation of BCOCs has shown that the overall chemical body burden in this species has not increased as a result of dredged material disposal (Section 3.5 and Appendix A). Mercury, copper, and phenol exceeded guidelines during one survey (2001), but this was either attributed to area-wide changes (e.g., a similar increase in benchmark samples) or levels were below the current bioaccumulative chemicals of concern TTL. Arsenic exceeded the TTL in both 2003 and 2007, but levels were below baseline levels, suggesting the dredged material disposal did not contribute to the arsenic levels observed in the tissues. Therefore, the bioaccumulation of chemical contaminants in benthic organisms occurring off site in the vicinity of the disposal site has not been found to be significant over all the post-disposal monitoring surveys (1995, 2001, 2003, 2007), where benthic tissue was evaluated.

In conclusion, the continued use of the dredged material disposal site, with similar annual volumes of dredged material being disposed of through the use of adaptive management practices as proposed for Alternative 1, is not expected to have significant impacts on the benthic community of the site. The community within the target zone would experience the greatest impacts due to smothering at the center of the target zone, with effects diminishing toward the periphery of the dredged material footprint. Toxic effects on site have not been demonstrated since disposal operations began in 1988. The benthic community off site where a thin layer of dredged material extended beyond site boundaries is indistinguishable from prevalent adjacent communities in the site vicinity, and significant bioaccumulation of contaminants in site vicinity benthic organisms has not been demonstrated during post-disposal monitoring.

4.1.6 Fish and Shellfish

Potential impacts to fish at the Commencement Bay disposal site due to dredged material disposal are not expected to be significant, may include minor impacts such as temporary respiratory function impairment from exposure to elevated suspended sediments, and could include burial within the target zone of the disposal site. Other potential impacts could include the bioaccumulation of contaminants when ingesting prey species exposed to the dredged material sediments or directly from exposure to the dredged material. However, these types of impacts are expected to be minimal for several reasons, including stringent evaluation of all sediments proposed for disposal at this site, resources that are not abundant at or in the vicinity of the disposal site due to the rigid site selection process outlined in the FEIS, and frequent site monitoring conducted to evaluate potential disposal impacts have not documented contaminant bioaccumulation concerns (2007 UEMP).

For Alternative 1, the disposal of dredged material would occur within the same site boundaries, which have been used since site designation. Dredged material disposed of at the site would likely bury some of the flatfish, shrimp, and crabs within the target zone. Fish and shellfish outside the target zone may escape burial, but suspended sediments of the dredged material plume could cause impaired oxygen exchange due to reduced gill function. Increased suspended sediment could also result in reduced food availability due to burial of benthic organisms and reduced visibility for foraging activities (O'Connor 1991). However, the sediment vertical profile imaging conducted during monitoring also showed that Stage I and II communities dominated the site, with the implication that a food source remained available for fish species or recovered rapidly. In addition, the reduced visibility is relatively short-lived. Most fish species would be expected to avoid this stress by temporarily moving out of the area while the dredged material plume persists, so that the effects of turbidity would be negligible. Since low numbers of bottom fish were found at the disposal site during the 1986 and 2007 surveys, direct effects of burial and suspended particulates on fish would not be expected to be significant. Similarly, only low levels of various shrimp species and no Dungeness crabs were observed during all previous surveys conducted at the disposal sites. Impacts on these species would thus be expected to be minor. Since volumes of dredged material annually disposed of at the site are expected to be similar to disposal volumes of recent years, the impacts are expected to be comparable and continue to be minor.

Bottom fish feed on polychaetes and bivalves living within the sediments. Within the target impact zone, benthic communities may be temporarily lost or reduced as a result of burial but can recover from thin layers of overlain dredged material. Benthic communities are completely displaced in only a relatively small area within the target zone and will recover from adjacent migration and recolonization. Demersal fish species may leave the area until the benthic community recovers. The feeding area of the demersal fish would change, but the behavior would not change as a result of temporal changes in their food resources. The displaced fish would simply move and feed in adjacent areas. Since the disposal site area generally has not appeared to be a significant feeding habitat area for bottom fish, the potential impact of a small portion of the target zone to fish resources as feeding habitat is not expected to be significant (USACE et al. 1988a). In addition, benthic resources are expected to quickly recover during periods of disposal inactivity, so that the initial loss of food resources would be temporary. Post-disposal monitoring data have confirmed that the benthic community impacts have not been significant within the disposal site and have been relatively short-lived as evidenced by the dominant Stage III/I community and high OSIs observed.

Another potential impact to fish could be the bioaccumulation of contaminants from foraging on opportunistic benthic infaunal species living within the disposal site. Bottom-dwelling fish also burrow within the sediment and could directly accumulate contaminants through their skin and gill membranes. However, all dredged material disposed of at the site has been found to be suitable for open-water disposal and has met stringent sediment quality guidelines for disposal. Monitoring surveys have shown that in general metals and organics concentrations both on site and off site were well below the DMMP screening and bioaccumulation trigger levels, including the Washington State SQS, and statistical time trend analysis showed the majority of the chemical compounds measured at perimeter stations have exhibited a decreasing trend since the 1988 baseline survey. Thus, concentrations of contaminants that were detected within sediments that could be bioaccumulated or cause direct toxic effects were very low. Sea cucumber tissue samples collected in offsite areas of Commencement Bay have shown that the chemical body burdens of offsite biological resources have not increased due to dredged material disposal. In addition, the disposal site only represents a small portion of the foraging habitat for bottom-dwelling fish in Commencement Bay. Therefore, bioaccumulation of contaminants in fish at the disposal site as a result of consuming organisms exposed to the dredged material has not been found to be significant and would not be expected to be significant as a result of disposal in the future. For Alternative 1, only sediments evaluated as suitable for disposal at Puget Sound nondispersive disposal sites would continue to be disposed of at the Commencement Bay site, so that the potential for bioaccumulation of contaminants in fish, either directly or through consumption of prey species, would remain low and would not be expected to be significant.

Impacts to other fish that may be found within the disposal site either migrating through the area or foraging for food in the vicinity of the disposal site are expected to be negligible. These fish would be able to avoid the area as the dredged material is being disposed of at the site. In order for non-demersal fish to absorb chemicals from suspended particulates through their gills, they would have to remain within the dredged material plume for extended periods of time, which is unlikely. Since monitoring surveys have shown that the sediments at the site have met Site Condition II guidelines (no more than minor sublethal chemical effects within the site), continuing diligent dredged material evaluations and disposal management practices would ensure that physiological effects due to dredged material disposal are not expected to occur.

In conclusion, for Alternative 1, impacts such as loss of food or habitat for fish are expected to be localized and temporary. Because turbidity conditions are temporary, the disposal should not interfere with any possible migratory species (e.g., salmon), and any changes in the fish community are expected to be temporary. Because of the ability of fish to avoid the dredged material plume, the relatively low fish and shellfish populations at the disposal site, and the insignificant potential to bioaccumulate contaminants from the "suitable" dredged material, the impacts of dredged material on fish are expected to be minimal and not significant. Implementation of Alternative 1 would present no appreciable change in effects on fish and shellfish, as compared with the effects analyzed in the 1988 EIS. Stringent monitoring and management of the site would continue, thus further ensuring that impacts to the fish and shellfish communities remain not significant.

4.1.7 Birds

Continued use of the Commencement Bay disposal site could potentially affect waterfowl and seabirds through their prey base (primarily forage fish, juvenile salmonids, schooling fish, and molluscs). Increased water turbidity immediately following each disposal event could interfere with feeding and photosynthesis processes of plankton on the site, which in turn could reduce foraging opportunities for fish. However, fish populations in the vicinity of the disposal site are sparse (SAIC 2008). The site lacks habitat structure or tidal currents that would attract or concentrate zooplankton or fish (USACE 2007), there is no spawning habitat for forage fishes, and the site is not in the migration routes for anadromous fish populations (WDNR 2007). The original analysis of the site indicated that the value of Commencement Bay for marine birds lies in the nearshore zone, not in deepwater habitats (USACE et al. 1988a). Water depth is far greater at this site (540 to 560 feet) than typical foraging depths of pursuit-diving seabirds, and therefore benthic organisms would not be available for foraging waterfowl. Relative to other nearby areas, such as the shorelines of Vashon and Maury Island, and the Tacoma Narrows, which are used by larger numbers of marine birds (Nysewander et al. 2005), feeding opportunities are poor at the disposal site for forage fish and shellfish. Continued use of the disposal site is not expected to have a widespread or long-term reduction in the abundance and distribution of vital prey species or foraging habitat for marine birds in Commencement Bay. Moreover, the disposal site is not an area of concentration for resting marine birds. Therefore, the increased height of the dredged material mound at the site (estimated to grow from 121 feet at 8 mcy [2007], to 132 feet at 13 mcy, 209 feet at 18 mcy, and 232 feet at 23 mcy) would have no effect on use of the site by marine birds.

The number of vessel/barge trips to the disposal site varies by project, but in recent years it has typically been two to five discharges per day while a dredged disposal project is active. It is expected that a similar level of activity will continue with Alternative 1. The temporary turbidity that follows disposal would limit visibility and make feeding difficult, with the result that marine birds and their prey would be likely to avoid the turbidity plume and move elsewhere. The materials deposited at this site typically drop quickly, with turbidity levels in the mid- to upper water column returning to ambient levels in less than 20 minutes. During periods of high activity, daily exposure to elevated turbidity and potential contaminants could range up to 2.5 hours (USACE 2007). This level of exposure, in the unlikely event that any marine birds remained in the turbidity plume, is not considered significant exposure to contaminants. Moreover, the affected area is about 310 acres in size (USACE 2005), which is relatively small compared to more productive foraging areas in central Puget Sound. The activity and noise that accompany disposal would likely cause marine birds to avoid the area while the vessels are present. DMMP would continue adaptive management of the site, with opportunities for improved testing, monitoring, and disposal procedures; the possibility of beneficial use of dredged materials elsewhere will continue to be explored under this alternative. As discussed in Section 3.3, Sediment Quality, past monitoring of the disposal site and the dredged materials has demonstrated very little potential for bioaccumulation of contaminants in the benthic community, including bottom fish. Marine birds are more likely to consume pelagic fish at this site, and as discussed in Section 4.1.6, the potential for these species to accumulate contaminants from this site is also remote. Implementation of Alternative 1 would present no appreciable change in effects on birds, as compared with the effects analyzed in the 1988 EIS. In conclusion, no significant impacts on marine birds or their habitats are expected with continued use of the Commencement Bay disposal site under Alternative 1.

4.1.8 Marine Mammals

No marine mammals are abundant in Commencement Bay, with the exception of harbor seals. Much of the discussion above on marine birds, especially with regard to prey base, exposure to contaminants, and responses to vessel traffic noise and disturbance, applies to marine mammals. The dredged disposal site is not a productive foraging area for marine mammals because fish populations are relatively low. Continued use of the disposal site is not expected to have a widespread or long-term reduction in the abundance or distribution of contaminant loads of most prey species. There are no available features suitable for haul-out sites for pinnipeds, which would therefore be present only while foraging. The few cetacean sightings in the vicinity appear to have been animals transiting through (i.e., these animals did not remain to feed in this location). The increased height of the dredged material mound (estimated to grow from 121 feet at 8 mcy [2007], to 132 feet at 13 mcy, 209 feet at 18 mcy, and 232 feet at 23 mcy) at the site would have no effect on movement through the site by marine mammals.

The noise and disturbance from vessel and barge traffic, and temporary turbidity after each disposal project, described above for marine birds would likely also cause marine mammals to avoid the disposal site during disposal operations. The potential for significant exposure to the turbidity plume is not great because of the relatively small area involved, the relatively brief duration of the turbidity in mid- to upper waters, and the likelihood that marine mammals would avoid the disturbance. As discussed in Section 3.3, Sediment Quality, past monitoring of the disposal site and the dredged materials has demonstrated very little potential for bioaccumulation of contaminants in the benthic community, including bottom fish, and the potential for pelagic fish species to accumulate contaminant is very low. Implementation of Alternative 1 would present no appreciable change in effects on marine mammals, as compared with the effects analyzed in the 1988 EIS. In conclusion, no significant impacts to marine mammals are expected with continued use of the Commencement Bay disposal site.

4.1.9 Threatened and Endangered Species

Puget Sound Salmonids

Adult Chinook and steelhead salmon may occur in the disposal area but they would be unlikely to congregate there because it is not preferred habitat for either species. As described in Section 3.9.1, Puget Sound Salmonids, juveniles would be very unlikely to occur in the disposal area because they prefer nearshore habitats and because disposal would not occur during the peak juvenile migration period. Disposal of dredged material would result in elevated turbidity levels on a localized and temporary basis and the potential for exposure to contaminants would be negligible and insignificant (Section 4.1.2). If a Chinook or steelhead were to be in the area during a disposal event, the fish would migrate from the area affected by the discharge and recover relatively quickly from effects caused by increased suspended sediments. Both Chinook and steelhead adults and subadults are primarily pelagic feeders, feeding mostly on forage fish. Therefore, foraging habitat would not be adversely affected for these species, except that the disposal plume would cause temporary and localized displacement of prey fish (both prey fish and adult salmon would avoid the plume). Forage fish would tend to actively avoid sediment plumes and would not be adversely affected by extension of the volume or duration of use of the disposal site (Section 4.1.6). Therefore, extension of disposal operations under Alternative 1 may affect, but is not likely to adversely affect, threatened and endangered Puget Sound salmonids.

Birds

The disposal site is not preferred foraging habitat for either marbled murrelets or bald eagles (Section 3.9.2). Both of these species prefer to forage in nearshore environments, and the deeper waters of the disposal site are unlikely to attract these species because their prey are scarce. The preferred prey of marbled murrelets and bald eagles (forage fish) would tend to avoid sediment plumes and would not be adversely affected by extended use of the disposal site (Section 4.1.6). The area affected by the plume would be a very small part of the birds' foraging habitat, and therefore temporary avoidance of the plume would not affect foraging adversely. The potential for toxic effects of contaminants released from discharged sediments would be negligible and insignificant (Section 4.1.2). Moreover, bald eagles are accustomed to vessels of all sizes on Puget Sound, and continued use of barges and tugboats to unload dredged material would not be expected to disturb them. Therefore, extension of disposal operations under Alternative 1 may affect, but is not likely to adversely affect, listed birds.

Marine Mammals

As described in Section 3.9, Threatened and Endangered Species, occurrence of either Steller sea lions or humpback whales in the disposal site is unlikely. Southern resident killer whales also rarely use the waters of Commencement Bay. Marine mammals, including threatened and endangered species, would likely avoid disposal vessels and disposal sediment plumes, thereby minimizing effects. However, should a threatened or endangered marine mammal coincidentally be present in the disposal area during a discharge event, it could experience a short period of non-lethal effects such as irritation due to high suspended sediments in the water column (Section 4.1.2). The potential for exposure to contaminants in the water column would be minimal, as described in Section 4.1.2. The preferred prey of marine mammals (primarily forage fish in the case of sea lions and salmon in the case of orcas) would tend to avoid sediment plumes and would not be adversely affected by expanded use of the disposal site (Section 4.1.6). Humpback whale feeding grounds are located off of the Pacific coast. Therefore extension of disposal operations may affect, but is not likely to adversely affect, threatened and endangered marine mammals.

As described in Section 3.9, southern resident killer whales are top-level predators that feed high on the aquatic food chain. Rigorous monitoring screens of dredged materials for BCOCs against screening criteria are conducted to prevent bioaccumulation of these chemicals to harmful levels in fish and invertebrates (Section 4.1.6). Monitoring at the various disposal sites in Puget Sound confirms that bioaccumulation of BCOCs has not been significant in benthic invertebrates. Therefore, continuance of disposal operations would not adversely impact BCOC levels in prey species for southern resident killer whales.

The size and height of the disposal mound would be managed by the DMMP, and would not be expected to have any adverse impacts on marine mammals, as it would remain at least 300 feet below the water surface at its highest point. Therefore, expansion of disposal site volume may affect, but is not likely to adversely affect, listed marine mammals.

4.1.10 Fishing

The effects of dredged material disposal at the Commencement Bay site on Tribal commercial salmon fishing practices have been minimal over time. There have been no known conflicts between Tribal commercial fishing and dredged material disposal activities. Use of the site for dredged material disposal is regulated by the Washington State Department of Natural Resources (WDNR)'s permitting authority, which permits when disposal can occur. There is also USACE's regulatory authority that requires consultation with potentially affected Tribes to avoid conflicts with Tribal fishermen as a standard USACE permit condition. Thus, disposal operations can be timed so that they avoid open Tribal salmon fishing and non-ceremonial periods. If disposal activities were to occur during an open Tribal fishing period, then Tribal fishing, particularly drift gillnet fishing, would be displaced from the immediate area (disposal would be unlikely to damage fishing gear). However, the disposal target area is relatively small in comparison to the area available for fishing, and thus this displacement would be expected to be very minor in effect.

There have been no known conflicts between use of the site for dredged material disposal and non-Tribal commercial or recreational fishing. For non-Tribal commercial fishing, this could be partly due to the closure of SMA 11A (which encompasses a portion of the site) to commercial fishing since the 1980s. Even though there have been no conflicts, it is likely that some commercial and recreational fishing activities have been displaced by dredged material disposal in the past (although it is more likely that recreational fishing has been periodically displaced from the disposal target area than commercial fishing). While there is some long-term potential for displacement of fishing from the disposal target area, this area is relatively small in comparison to the area available for fishing. Thus, any interference from dredged material disposal on fishing activities would be expected to be very minor.

4.1.11 Marine Transportation

The current water depth at the disposal site is greater than 400 feet. Even though additional dredged material would be disposed of at the site up to 23 mcy, the water depths would still be greater than 300 feet at the highest portion of the mound after a cumulative volume of 23 mcy. Therefore, there would be no potential for any vessel to become grounded on the dredged material mound.

The only potential effect on navigation could occur when a barge is offloading dredged material over the site. At these times, other vessels would need to avoid the disposal barge. Typically, collisions are more likely to occur when two vessels are underway and headed in opposing directions, and the disposal barge is relatively stationary when offloading. The potential for a collision would be slightly exacerbated during foggy weather or evening hours because of more limited visibility. However, vessels in these conditions use lighting, horns or bells, and radar to warn and/or locate other boat traffic.

The dredged disposal activity has been ongoing for close to 20 years at the Commencement Bay site and all disposal activity is monitored by the U.S. Coast Guard through their Vessel Traffic Service; the Port of Tacoma reports that there have been no known collisions between container ships, bulk carriers, or other ships entering and leaving the Port with a dredged disposal barge, nor have there been conflicts with navigation (Brenner 2008). This is likely because dredged disposal is a known activity; the Port of Tacoma harbormaster warns ships; night lighting (red-green-white flashing light) at the Port facilities directs ships past the dredged disposal site on the north side; and larger vessels are equipped with radar and Loran to locate other boat traffic. With continued use of the site, this lack of conflict would be expected to continue, with no adverse impacts to marine transportation. Implementation of Alternative 1 would present no appreciable change in effects on marine transportation, as compared with the effects analyzed in the 1988 EIS.

4.1.12 Air Quality

Air pollutant emissions produced from each project alternative were estimated and then compared to the criteria identified below to determine their significance. Emission sources associated with the project alternatives include diesel-powered equipment involved in dredged material transport and handling.

Criteria to determine the significance of air quality impacts are based on federal, state, and local air pollution standards and regulations. To assess the significance of project air quality impacts for NEPA purposes, proposed emissions would be potentially significant if they exceed the thresholds that require an operating permit under PSCAA Regulation I, Article 7, including (1) 100 tons per year of a regulated pollutant, such as volatile organic compounds (VOCs), CO, nitrogen oxides (NO_x), sulfur oxides (SO_x), and PM_{10}; (2) 10 tons per year of a hazardous air pollutant (HAP); or (3) 25 tons per year of combined HAPs (PSCAA 2009b). This approach is conservative, as these thresholds are designed to assess the potential for stationary sources to impact a localized area and contribute to an exceedance of an ambient air quality standard (see Table 19). However, all proposed emissions would occur from mobile sources that would spread impacts over the Eastern Puget Sound region between Tacoma and Seattle.

If proposed emissions exceed a significance threshold described above, further analysis of the emissions and their consequences would be performed to assess whether there was a likelihood of a significant impact on air quality. The nature and extent of such an analysis would depend on the specific circumstances. The analysis could range from simply a more detailed and precise examination of the likely emitting activities and equipment, to air dispersion modeling analyses (or air quality impact assessment). If project emissions were determined to increase ambient pollutant levels from below to above a national or state ambient air quality standard, these emissions would be significant.

Air quality impacts from Alternative 1 would occur from combustive emissions due to the use of diesel-powered dredging equipment and tugboats. Factors needed to estimate dredging equipment emissions were obtained from the USEPA NONROAD emissions model for nonroad equipment (USEPA 2005). Factors needed to estimate tug boat emissions were obtained from special studies on vessel emissions (Entec UK Limited 2002). Appendix B includes data and assumptions used to calculate air emissions from Alternative 1.

Table 20 summarizes the annual emissions of criteria pollutants that would occur from the following scenarios under Alternative 1: (1) the projected average annual disposal volume of 700,000 cy (Brenner 2008) and (2) the high range annual disposal volume of 869,000 cy that occurred in recent years (Section 1.2). A dredge material barge with a capacity of 1,900 cy would transport dredge material to the Commencement Bay disposal site under each scenario. This would result in 368 or 455 annual barge trips under the average and high range scenarios, respectively. The data in Table 20 show that emissions from either scenario under Alternative 1 would remain below the NEPA annual emission significance thresholds.

Table 20. Annual Air Emissions Associated with Alternative 1

Scenario/Activity	Annual Air Pollutant Emissions (tons)					
	VOC	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
700,000 Cubic Yards per Year						
Dredging	1.60	7.62	23.35	2.56	1.47	1.42
Barge Transport of Dredged Material	0.27	0.60	7.17	0.01	0.37	0.35
Annual Emissions	1.87	8.22	30.52	3.11	1.96	1.87
869,000 Cubic Yards per Year						
Dredging	1.97	9.42	28.85	3.17	1.82	1.75
Barge Transport of Dredged Material	0.34	0.74	8.87	0.68	0.60	0.56
Annual Emissions	2.31	10.16	37.73	3.84	2.42	2.31
NEPA Significance Thresholds	100	100	100	100	100	100

Dredging equipment and tug boats that operate under Alternative 1 would emit HAPs that could potentially impact public health. HAPs generally are subsets of VOC and PM_{10} emissions. Under the high range annual scenario, Alternative 1 would produce a combined total of 4.73 tons of VOC and PM_{10} emissions and therefore would not exceed 10 tons per year of a HAP or 25 tons per year of combined HAPs. Implementation of Alternative 1 would present no appreciable change in effects on air quality, as compared with the effects analyzed in the 1988 EIS. Therefore, Alternative 1 would produce less than significant air quality impacts with regard to levels of HAPs or criteria pollutants.

4.1.13 Historical and Cultural Resources

Under federal law, impacts to cultural resources may be considered adverse if the resources are listed in, or are eligible for listing in, the NRHP, or are important to traditional cultural groups, such as American Indians. An NRHP-listed or eligible resource is a historic property. An action results in an impact to a historic property when it alters the resource's characteristics, including relevant features of its environment or use, so as to affect its qualification for listing on the NRHP. Impacts to traditional resources are identified in consultation with affected American Indian or other traditional groups.

Analysis of potential impacts to cultural resources considers both direct and indirect impacts. Direct impacts may occur by physically altering, damaging, or destroying all or part of a resource; altering characteristics of the surrounding environment that contribute to the resource's significance; introducing visual or audible elements that are out of character with the property or alter its setting; or neglecting the resource to the extent that it deteriorates or is destroyed. Direct impacts can be assessed by identifying the types and locations of proposed activities and determining the exact location of cultural resources that could be affected. The PSDDA/DMMP conducted a cultural resources evaluation based on side scan sonar survey information and archival historical information (Evans Hamilton 1988), and concluded that no historically significant shipwrecks appear to lie in Commencement Bay. Indirect impacts generally result from the effects of project-induced population increases and the need to develop new housing areas, utility services, and other support functions to accommodate population growth. These activities and the subsequent use of the facilities can impact cultural resources.

Effects on a traditional resource may occur if the resource itself is impacted, or if there is a change in access to the resource. The Confederated Tribes and Bands of the Yakama Indian Nation and the Puyallup Indian Tribe have adjudicated fishing rights in Commencement Bay, while other tribes may gain such rights in the future (e.g., the Samish Indians). Actions that change access to these rights would be considered to have impacts. DMMP continues to consult with appropriate tribes, in part to ensure tribes will continue to have access to their traditional resources.

The volume expansion and extended time of use under Alternative 1 would have no effect on cultural resources. No historic properties, such as shipwrecks, have been identified at the disposal site, and the depth of the sea floor means that there is no likelihood of deposits that could have one time been on land. Beneficial use of dredged material would be subject to compliance with Section 106 of the NHPA, so that if a new location were identified for receipt of material the regulatory permit applicant for a specific project would consult with the Washington DAHP SHPO (or the DAHP SHPO of another state, if necessary) regarding the presence of cultural resources (Reference Section 3.13.2).

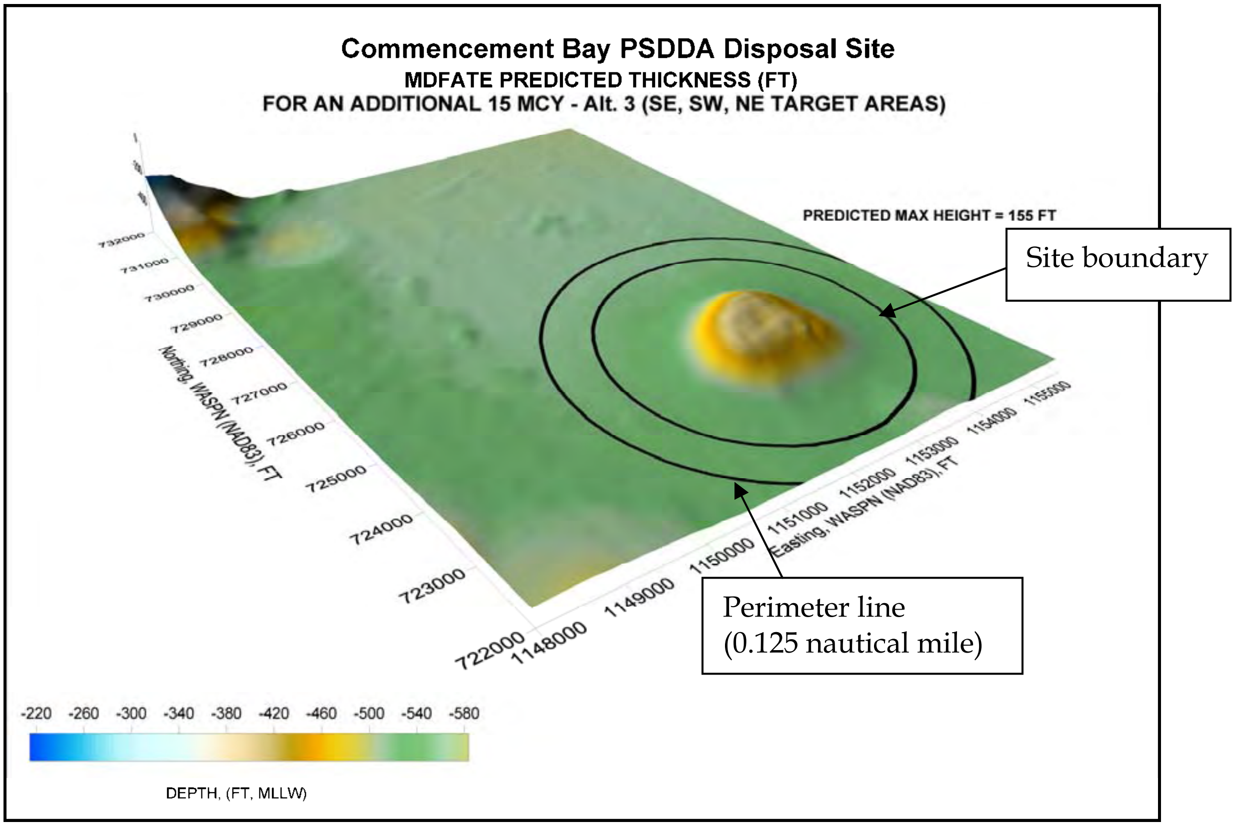
Traditional Tribal fishing is not expected to be significantly affected by Alternative 1, so overall no impacts on traditional cultural resources would be expected.

4.2 Alternative 2: Expand site cumulative disposal volume ceiling to 23 mcy, with three target coordinate shifts within the existing Target Area at 7.8 mcy, at 13 mcy and at 18 mcy (every 5.0 mcy) (Preferred Alternative)

4.2.1 Physical Oceanography

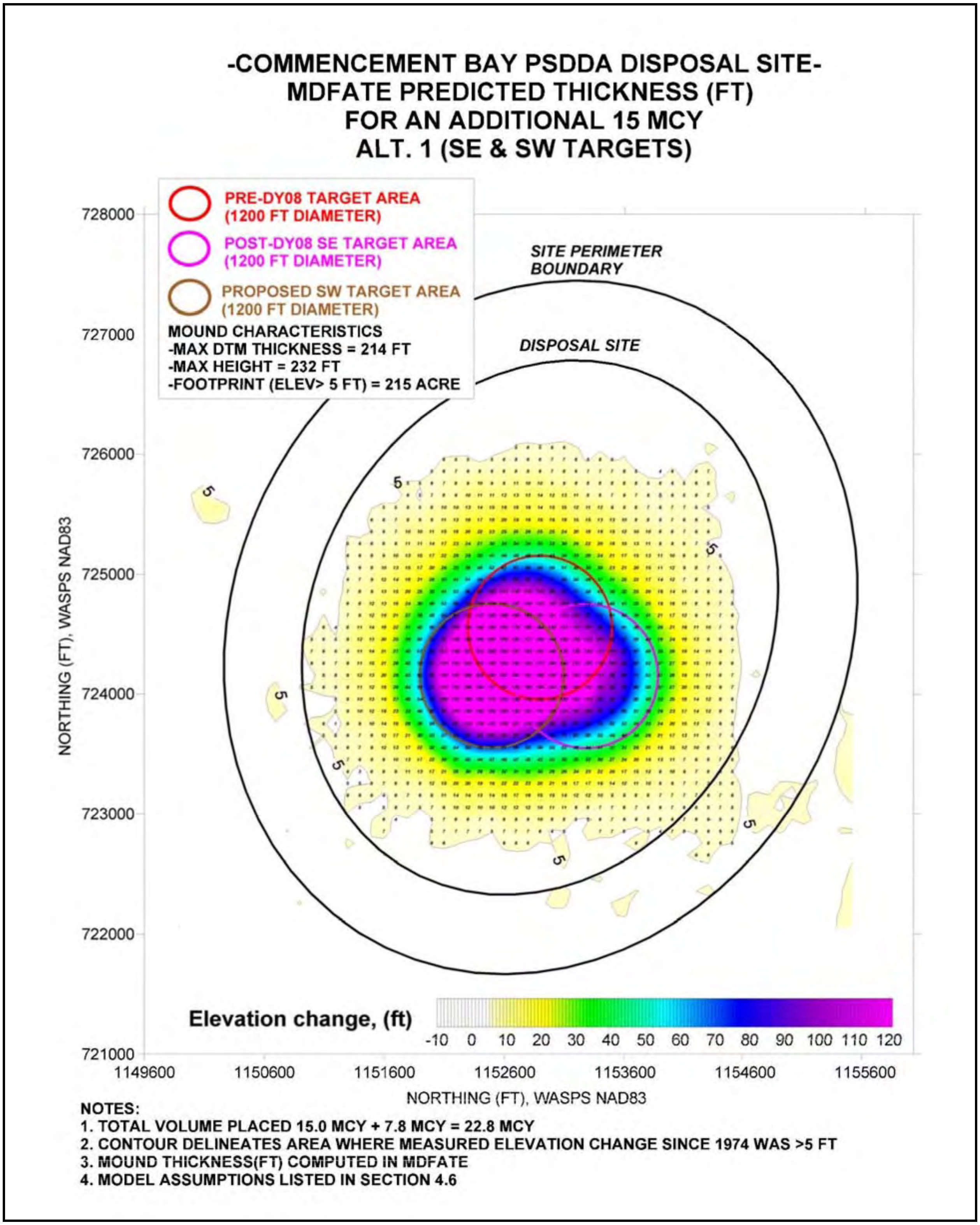
Under Alternative 2, the Commencement Bay disposal site boundary would remain the same. The cumulative disposal volume ceiling would be increased from 9 mcy to 23 mcy. Alternative 2 would consist of three shifts in disposal coordinates: the adoption of a shift in disposal coordinates, provisionally designated at the beginning of DY 2008 (June 2007), after the Commencement Bay disposal site had reached a cumulative disposal volume of 7.8 mcy, to a location 565 feet southeast of the initial site center and within the existing Target Area; an additional disposal coordinate shift, when the site reaches a cumulative disposal volume of 18 mcy, to a location 565 feet southwest of the initial site center, and within the Target Area; and a third coordinate shift 565 feet to the northeast of the existing site center, within the Target Area, after reaching a cumulative disposal volume of 18 mcy. Under Alternative 2, there would be a stronger focus on managing the disposal mound growth by the additional coordinate shift at 18 mcy (northeast corner of target zone) (see Figures 7, 8). The mound height estimated from the MDFATE analysis (Michalsen 2008) is expected to be 132 feet at 13 mcy, 147 feet at 18 mcy, and 155 feet at 23 mcy (Figure 31; compare to Figures 7 and 25). With the three coordinate shifts all within the existing Target Area, the DMMP agencies would be able to significantly reduce the future mound growth compared to Alternative 1, effecting a net reduction in mound height of 77 feet compared to Alternative 1, which is 95 feet under the 250-foot site management objective (see Section 1.2.3). Figure 32 depicts the predicted dredged material footprint area and mound within the disposal site with additional disposal through 23 mcy for the preferred Alternative 2. The projected footprint of the disposal mound at 23 mcy would be approximately 217 acres (Figure 32), which is very similar to projections under Alternative 1 (215 acres). Additionally, Alternative 2 would consist of institutional controls on disposal to counteract identified directional bias in disposal and thus minimize the dispersal of dredged material within the site. The DMMP would continue to use adaptive management of the site. Further institutional controls for disposal at the site would be evaluated if the dredged material footprint exceeds the designated perimeter management boundary (>3 cm).

Circulation modeling in Commencement Bay for Alternative 2 found even less impact, as compared with Alternative 1, to tidal circulation from the predicted 155-foot disposal mound after reaching the cumulative disposal volume ceiling of 23 mcy of dredged material. Depth-averaged current velocities determined using the CMS-M2D numerical model at the center of the mound, to the north of the mound, and to the east of the mound are provided in Figures 28, 29, and 30, respectively. Similar to Alternative 1, the maximum current velocity north of the disposal mound (1.1 feet/second; 0.35 meter/second) remains unchanged. At the center of the site, the maximum current velocity also remains unchanged (1.0 foot/second or 0.31 meter/second). The maximum current velocities are less than the critical velocity required to initiate bedload transport for the majority of sediments disposed at the site. Therefore, impacts to physical oceanography would not be significant.



After Michalsen 2008

Figure 31. Preferred Alternative 2 MDFATE Prediction of Disposal Mound and Height After a Cumulative Disposal Volume of 23 mcy with No Vertical Distortion



The maximum thickness of the mound is averaged within a 100 feet by 100 feet cell of model grid.

After Michalsen 2008

Figure 32. Alternative 2 MDFATE Predicted Mound Thickness at 23 mcy with an Additional 15.0 mcy of Material Placed

4.2.2 *Water Quality*

Impacts to water quality would be the same as described for Alternative 1 (Section 4.1.2). As with Alternative 1, disposal of materials would result in temporary and localized increases in suspended sediments and insignificant increases in nutrients and sediment-associated contaminants. Implementation of Alternative 2 would present no appreciable change in effects on water quality, as compared with the effects analyzed in the 1988 EIS. Therefore, there would be no significant long-term adverse effects on water quality from Alternative 2.

4.2.3 *Sediment Quality*

Under Alternative 2, the existing site boundary would remain the same as that which currently exists. Annual volumes disposed of at the site are estimated to range from 470,000 cy to 1,170,000 cy. Therefore, in some years smaller volumes would be disposed of at the site than have occurred annually, and in other years, more material may be disposed of at the site.

The types of impacts that could occur to the sediment quality would be similar to those described for Alternative 1 in Section 4.1.3. The bottom area affected (footprint) by deposition of disposed material would be similar to Alternative 1 (Figure 27). For Alternative 2, the monitoring requirements for the site would be at least as stringent as those which currently exist. Dredged material would continue to be tested prior to dredging and disposal operations and only sediments determined to be suitable for open-water disposal would be disposed of at the site. Implementation of Alternative 2 would present no appreciable change in effects on sediment quality, as compared with the effects analyzed in the 1988 EIS. Due to the careful management of the site as described in Section 4.2.1, impacts to the sediment quality are expected to be comparable to or less than what has been observed over the eight monitoring surveys, and consequently are not expected to be significant.

4.2.4 *Plankton/Neuston*

Impacts to plankton and neuston would be the same as described for Alternative 1. As with Alternative 1, disposal of materials would result in temporary and localized increases in suspended sediments and insignificant increases in nutrients and sediment-associated contaminants. Implementation of Alternative 2 would present no appreciable change in effects on plankton and neuston, as compared with the effects analyzed in the 1988 EIS. Therefore, there would be no significant long-term adverse impacts to plankton and neuston from Alternative 2.

4.2.5 *Benthic Community*

Impacts to the benthic community would be essentially the same as for Alternative 1 (minimal; Section 4.1.5), and the area affected by disposal (footprint) would be very similar to Alternative 1 (Figure 27). One of the main impacts to the benthic community would be burial and smothering of existing species, but this would be largely restricted to a relatively small portion of the target zone and disposal zone where dredged material is released. The greater the frequency of disposal, the greater the impact would likely be. For Alternative 2, at times the frequency and annual volume of disposal is expected to be comparable to or less than that of recent years. During these years, impacts to the site would be expected to be similar to those described for Alternative 1. Should the disposal volume be greater than the current average volume (700,000 cy), the benthic community may show a greater disturbance within the target zone; Stage III species would be replaced with Stage I communities consisting primarily of opportunistic species initially recolonizing the site. However, past monitoring surveys have shown that the benthic community can continue to develop and recover within the disposal site, as evidenced by the presence of higher ordered Stage III benthic infauna and higher OSI values (>+6) at most locations within the disposal site. In addition, Stage III infauna were observed throughout the disposal site during 2007 and within the site, but mainly outside of the site zone during the 2004 surveys, after the disposal of total volumes of 1,324,254 to 1,205,993 cy of material, respectively. These volumes are expected to be comparable to the upper range of volumes disposed of for this alternative. The SPI imagery results during both of these high disposal years, demonstrate the resiliency of the benthic community observed within the dredged material lobe to recover from each incremental disposal event, when the dredged material cover is less than 10 cm, with high order benthic community structure (Stage III/I) and high OSIs (9.6 and 9.5 respectively).

Similar to Alternative 1, the disposal site boundaries would remain the same for Alternative 2. Monitoring surveys have shown that impacts to the biological community off site have not been demonstrated in areas where the dredged material extended off site, and the benthic community quickly recovered to a healthy state following the disturbance. Since only dredged material determined to be suitable for disposal at the site will be disposed of at the site, toxic responses to the sediments and bioaccumulation of contaminants would not be expected to be significant.

The DMMP's adaptive disposal site management would continue, so that impacts to the benthic community would continue to be minimized. Physical impacts to the biological community on site where disposal of sediments is occurring are expected, with recovery occurring quickly when disposal ceases. However, if monitoring surveys were to show impacts to the biological community off site (e.g., reduced abundances in major taxa that are not corroborated by changes in abundance at benchmark stations, or increased chemical body burdens of BCOCs that exceed target tissue levels), the DMMP would act to remedy the impacts, which might result in altered site use practices, and increased testing and monitoring of the site and adjacent areas to address the problem. It is important to note that over the entire post-disposal monitoring of this site, no significant impacts to the biological communities have been recorded off site. The use of adaptive management practices would continue to ensure any impacts due to dredged material disposal would be negligible. Therefore, for Alternative 2, impacts to the benthic community are not expected to be significant.

4.2.6 Fish and Shellfish

Impacts to fish at the Commencement Bay disposal site under Alternative 2 would be expected to be comparable to those discussed for Alternative 1 in Section 4.1.6. For both Alternative 1 and 2, the disposal of dredged material would occur within the same site boundary as has been used since site designation. Disposal volumes and footprint would be essentially the same under both alternatives (Figure 27). Volumes of dredged material disposed of at the site would vary annually. Greater impacts would likely occur when larger volumes are disposed of at the site. Although some flatfish, shrimp, and crabs may be buried within the disposal zone, many would be able to avoid the dredged material plume so that effects of burial and turbidity would be minimal. Impacts such as loss of food or habitat for fish are expected to be localized and temporary. Since turbidity conditions are temporary, the disposal should not interfere with any possible migratory species (e.g., salmon), and any changes in the fish community are expected to be temporary. In addition, disposal would not occur during major periods of outmigration of salmon or forage fish spawning periods

(March 15 to August 15), so that impacts on salmon due to disposal would be minor. Implementation of Alternative 2 would present no appreciable change in effects on fish and shellfish, as compared with the effects analyzed in the 1988 EIS. Because of the ability of fish to avoid the dredged material plume, the relatively low fish and shellfish populations at the disposal site, and the low possibility of bioaccumulation of contaminants, the impacts of dredged material on fish are expected to be minimal and not significant. Monitoring and management of the site under Alternative 2 would continue, and may be altered by the agencies if warranted. This would further ensure that impacts to the fish and shellfish communities remain minor and not significant.

4.2.7 Birds

Under Alternative 2, impacts to birds would be the same as described for Alternative 1 (Section 4.1.7). Impacts would be minimal and not significant.

4.2.8 Marine Mammals

Under Alternative 2, impacts would be the same as for Alternative 1 (Section 4.1.8). Impacts would be minimal and not significant.

4.2.9 Threatened and Endangered Species

Puget Sound Salmonids

Impacts to Puget Sound salmonids would be the same as described for Alternative 1 (Section 4.1.9), except that reducing the mound height through periodic site coordinate shifts could further reduce effects on these species as compared to Alternative 1. Therefore, Alternative 2 may affect, but is not likely to adversely affect, threatened and endangered salmonids.

Birds

Impacts to Puget Sound listed birds would be the same as described for Alternative 1 because the Commencement Bay disposal site is not preferred habitat for bald eagles or marbled murrelets. Changes in size and height of the disposal mound would not affect these species or their forage base. Therefore, Alternative 2 may affect, but is not likely to adversely affect, listed birds.

Marine Mammals

Impacts to threatened and endangered marine mammals would be the same as described for Alternative 1. Coordinate shifts and monitoring would ensure that the disposal mound does not elevate to a height that would be disruptive to marine mammals. Therefore, Alternative 2 may affect, but is not likely to adversely affect, threatened and endangered marine mammals.

4.2.10 Fishing

Potential effects on Tribal and non-Tribal commercial or recreational fishing would be the same as for Alternative 1 (Section 4.1.10): minimal and not significant.

Potential Tribal concerns related to effects on water quality and fish resources are addressed in Sections 4.2.2 and 4.2.6, respectively.

4.2.11 Marine Transportation

Compared to Alternative 1 (Section 4.1.11), the height of the dredged disposal mound under Alternative 2 would be significantly dampened. The mound height would be expected to remain at 132 feet through 13 mcy, increase to 147 feet after 18 mcy, and increase to 155 feet after 23 mcy. This would represent a significant reduction in mound growth compared to Alternative 1, and would certainly not cause any potential for vessel grounding.

Under Alternative 2, disposal-related vessel traffic would be the same as for Alternative 1, and the potential for collisions is considered very remote based on no reported incidents between ship traffic and dredged disposal barges over the past 20-year period. Therefore, there would be no adverse impact on marine transportation.

4.2.12 Air Quality

Air quality impacts from Alternative 2 were evaluated for the same average annual and high range annual scenarios proposed under Alternative 1. Implementation of Alternative 2 would present no appreciable change in effects on air quality, as compared with the effects analyzed in the 1988 EIS. Therefore, air quality impacts would be considered not significant, which is the same as described for Alternative 1 (Section 4.1.12).

Conformity Applicability Analysis

Table 20 presents estimations of annual PM_{10} emissions generated by Alternative 1, which are equal to those that would occur from Alternative 2. These data show that for either the average annual or high range annual scenario, the Preferred Alternative would produce annual PM_{10} emissions that would be substantially less than the PM_{10} conformity threshold of 100 tons per year for PM_{10} maintenance areas. Therefore, the Preferred Alternative would conform to the Washington SIP.

As stated in Section 3.12.2 of this SEIS, the PSCAA and EPA are in the process of redesignating the Tacoma area from attainment to nonattainment of the $PM_{2.5}$ NAAQS. Activities associated with the proposed action would occur within this area. This current attainment designation precludes the need for federal agencies to perform conformity analyses for proposed $PM_{2.5}$ emissions within this area at this time. Nevertheless, as shown in Table 20, $PM_{2.5}$ emissions from Alternatives 1 and 2 would be well below the $PM_{2.5}$ conformity threshold of 100 tons per year.

4.2.13 Historical and Cultural Resources

Impact analysis for Alternative 2 follows the same protocol as described for Alternative 1 (section 4.1.13). As with Alternative 1, there would be no effects on cultural resources as a result of expanding the site volume and managing the disposal site. No archaeological, architectural, or submerged cultural resources are present, and there would be no effect on traditional fisheries.

4.3 Alternative 3: No Action

Under the No Action Alternative, the Commencement Bay DMMP Site would eventually not be available, and dredged material disposal could occur at either the Anderson-Ketron DMMP site, the Elliott Bay DMMP site, or an approved upland disposal site (Section 2.3). Beneficial re-use would also be considered if feasible. In addition, dredging volumes in the Tacoma/Commencement Bay region would be expected to be considerably lower than under the Preferred Alternative, because of the higher cost of disposal (Section 2.3).

4.3.1 Physical Oceanography

Under Alternative 3, the site would be closed to disposal at a cumulative disposed volume of 9 mcy. Michalsen (2008) concluded that at that time the disposal mound would be approximately 125 feet (Figure 7) and the footprint size would be approximately 150 acres, both of which are considerably smaller than for Alternatives 1 and 2 (see Section 1.2.3, Figure 4). This would be 125 feet below the DMMP site management goal of <250 feet for the Commencement Bay disposal mound.

Under this alternative, currents at the site would be similar to existing conditions, as described in Section 3.1, because the mound would be only slightly larger than at present. The disposal mound is not having a significant effect on currents (Michalsen 2008). Maximum current velocities are less than the critical velocity required to initiate bedload transport for the majority of the sediments at the site. Monitoring has shown that currents do not appear to be a significant mechanism for offsite transport of site sediments (Section 3.1). At the Elliott Bay and Anderson-Ketron DMMP sites, smaller disposal mounds would develop. These mounds would also not affect current patterns, and offsite transport of disposed material would be unlikely (see next section, Water Quality). Therefore, impacts to physical oceanography would not be significant.

4.3.2 Water Quality

There would be no changes to existing water quality at the Commencement Bay disposal site. Both of the alternative disposal sites are in deep, non-dispersive areas. The Elliott Bay site is approximately 300 to 360 feet deep and the Anderson-Ketron site is approximately 442 feet deep. Both sites are at least 3,000 feet from the nearest shore areas.

Impacts to water quality at either alternative disposal site would be similar to those described for Alternative 2, Section 4.2.2. The impacts would be somewhat less under this alternative, because a smaller volume of material would disposed of at the sites than at the Commencement Bay site under Alternatives 1 or 2. Disposal of dredged material at either alternative site would result in elevated turbidity levels on a localized and temporary basis, with most of the materials depositing within a few minutes. Dredged materials would continue to be tested for chemicals of concern before disposal at the alternative sites. Therefore, any contaminants or nutrients introduced to the water column would be insignificant. The peak current speed on the bottom at the Elliott Bay site is less than 15 cm/second, well below the 25 cm/second threshold required to resuspend fine sediments. Although current speeds at depths 15 meters (49 feet) or more above the bottom at the Anderson-Ketron site are at or greater than the critical speed for fine sediment transport (about 25 cm/sec), bottom conditions indicate that this is a depositional site (USACE et al. 1989). The depositional nature of both sites has been further corroborated by post-disposal monitoring. Therefore, there would be no significant impacts to water quality at the Elliott Bay or Anderson-Ketron disposal sites under the No-Action Alternative.

4.3.3 Sediment Quality

Under the No-Action Alternative, the sediment quality at the Commencement Bay disposal site is expected to remain comparable to the current conditions at the disposal site. Dredged material would no longer be disposed of at the site, so the existing high sediment quality demonstrated through active site monitoring at the site would not change. However, since only suitable material is currently disposed of at the site according to stringent management practices, the sediment chemistry has consistently met site condition guidelines during monitoring surveys. In onsite areas, the sediment would be reworked by benthic organisms, increasing the RPD somewhat (RPD is already high at 9.5 onsite in the dredged material footprint) and with sediment grain sizes gradually getting finer over time on the disposal mound through deposition from sediment sources (e.g., Puyallup River).

No additional dredged material would travel outside the disposal site perimeter under this alternative. Therefore, changes in sediment quality in areas adjacent to the disposal site as a result of dredged material disposal would not occur. There may be natural changes in sediment quality or grain size characteristics due to input from the Puyallup River, including increases in fines material deposited or wood debris.

For the No-Action Alternative, in-water dredged material disposal would occur at either the Anderson-Ketron or Elliott Bay disposal sites. The sediment quality observed during monitoring surveys at these sites was acceptable. Monitoring at the Anderson-Ketron site conducted in 2005 has shown that dredged material has remained on site. Similarly, surveys conducted at the Elliott Bay disposal site have shown that dredged material has remained on site or within the site perimeter. The thickest accumulations were within the site center.

Monitoring surveys have indicated that no significant impacts to sediment quality at the Anderson-Ketron and Elliott Bay disposal sites have occurred due to dredged material disposal. Although there were some DMMP screening level exceedances observed during surveys at the Elliott Bay disposal site (e.g., mercury, PCBs, total DDT, chlordane), onsite chemistry results for surveys conducted at both Anderson-Ketron and Elliott Bay disposal sites met DMMP Disposal Site Condition II guidelines. No onsite bioassay test results exceeded the Site Condition II Biological Response guidelines. Statistical time-trend analyses indicated no significant increases in chemical concentrations off site since 1988 baseline surveys at the Elliott Bay site. There were also no apparent increases in chemical concentrations off site at the Anderson-Ketron site.

Based on the results of the monitoring surveys conducted at the Anderson-Ketron, Elliott Bay, and Commencement Bay disposal sites, impacts associated with disposal of Commencement Bay sediments on the sediment quality at these alternate disposal sites are expected to be comparable to those described for Alternative 1 (Section 4.1.3), except that impacts would be reduced commensurate with the smaller disposal volumes under this alternative. Grain size on site may vary depending on the nature of the sediment deposited. Dredged material has remained on site according to surveys conducted at the Anderson-Ketron and Elliott Bay sites. Should any dredged material extend beyond the site, it is likely that this area would recover relatively rapidly. Only dredged material determined to be suitable for open-water disposal will be disposed of at the site. The DMMP would continue to monitor and manage the site. To date, onsite chemical monitoring and toxicity testing have confirmed that DMMP Site Condition II chemical and biological guidelines have not been exceeded at these sites. Therefore, impacts to sediment quality due to dredged material disposal for Alternative 3 are not expected to be significant.

4.3.4 Plankton/Neuston

Impacts to plankton and neuston would be similar to those described for Alternative 1, but of a smaller scale due to the smaller volume of materials expected to go to the Elliott Bay or Anderson-Ketron disposal sites. Effects from localized changes in water quality during disposal would be temporary and insignificant. There would be no significant adverse impacts to plankton and neuston from upland disposal of dredged materials at the landfills in eastern Washington or Oregon. There would be no adverse impacts to plankton or neuston at the Commencement Bay disposal site under the No-Action Alternative when disposal operations cease.

4.3.5 Benthic Community

Disposal of dredged material at the Commencement Bay disposal site would cease under the No-Action Alternative once the disposal site has reached capacity. Once disposal operations stop, impacts such as burial and smothering of benthic organisms within the disposal site would no longer occur. The benthic infauna would continue to recolonize the onsite areas and would be expected to be fully restored to a Stage III community over the entire disposal mound to a higher-order successional stage species, such as invertebrates or deeper burrowing deposit feeders.

Monitoring surveys have shown that off site and most of the onsite benthic community is healthy. Under the No-Action Alternative, this community would be expected to remain healthy. The results of the surveys showed that the benthic infauna community at the offsite areas fluctuated greatly over time; these changes were not attributed to dredged material disposal but to area-wide changes (e.g., species recruitment, interspecific competition, predation, etc.). There may continue to be fluctuations within the community structure as a result of temporal changes or other sources of sediments being deposited in the area (e.g., deposition of sediments carried by the Puyallup River, surface runoff, or outfalls).

As part of the No-Action Alternative, some of the dredged material from Commencement Bay dredging projects would be disposed of at the Anderson-Ketron and Elliott Bay disposal sites. Impacts to these sites on the benthic community would likely be comparable to previous impacts at these sites and at the Commencement Bay disposal site, except that impacts would be reduced commensurate with the smaller disposal volumes under this alternative. SVPS surveys had shown that the biological communities at the Elliott Bay and Anderson-Ketron disposal sites were relatively healthy, with Stage III organisms observed at many stations, including the onsite stations. OSI values were relatively high throughout the sites. Monitoring surveys at the Elliott Bay and Anderson-Ketron disposal sites have shown fluctuations in benthic infaunal abundance at transect stations off site, including decreases in arthropod abundance (both sites) and mollusc abundances (Elliott Bay). Based on comparisons to benchmark data at these sites and changes in abundances at other locations (e.g., decreased arthropod abundances at the Commencement Bay site), it was concluded that the observed changes were more likely due to region-wide changes and not due to dredged material disposal (SEA 2002; SAIC 2005b; SAIC and Caenum 2006). However, during the 2000 Elliott Bay survey, very fine sediments with relatively high clay contents from the PitCAD site in Sinclair Inlet deposited at the Elliott Bay site may have contributed to toxic responses observed in the amphipod bioassay (*Eohaustorius estuarius*), which has been shown to exhibit a sensitivity to clay content in sediments (SAIC 2000). Retesting later with the same species and another amphipod species (*Ampelisca abdita*) found no toxicity to these sediments. It is also possible that an apparent reduction in arthropods (e.g., crustacean) observed at the transect stations in 2000 may have been a result of the fine-grained sediments from the Pit-CAD disposal at the site (SAIC 2002).

Bioaccumulative chemicals of concern were below TTLs and met guidelines for the clam (*Compsomyax subdiaphana*) and sea cucumber (*Molpadia intermedia*) species tested at these sites. This indicated that there was no significant increase in the chemical body burden of benthic infaunal species collected down current of the disposal site due to dredged material disposal.

Based on post-disposal site monitoring survey results at the Anderson-Ketron and Elliott Bay disposal sites, impacts at the Anderson-Ketron or Elliott Bay disposal sites would be expected to be comparable to those discussed for Commencement Bay in Section 4.1.5. The greatest disturbance to the infaunal community would be at the disposal release site within the disposal zone. Monitoring surveys at Commencement Bay have shown that the benthic community begins to recolonize the disposal site rapidly. Should the dredged material extend beyond the disposal site perimeter, the benthic community would be expected to recover and develop to a healthy community. The recovery would likely be more rapid if the dredged material layer is thin (< 10 cm). Because only dredged material determined to be suitable for open-water disposal at the sites would be disposed of, bioaccumulation and toxic effects on the benthic community are not expected to be significant. The adaptive management and monitoring program in place for these sites would further ensure that effects of disposal of sediments that would have gone to the Commencement Bay site would be negligible.

4.3.6 Fish and Shellfish

Impacts to fish at the Commencement Bay disposal site due to dredged material disposal, such as burial within the disposal zone or impaired respiratory function due to suspended sediments during disposal operations, would not occur once dredged material disposal ends under the No-Action Alternative. Although the disposal site area generally has not appeared to be a significant feeding habitat area for bottom fish, benthic food resources are expected to recover as benthic organisms continue to recolonize the site. The potential for bioaccumulation of contaminants from foraging on opportunistic benthic infaunal species living within the disposal site or from direct exposure to the sediments would remain low.

The Commencement Bay disposal site was designated in an area that did not have abundant fish or shellfish populations that could support commercial fisheries. Densities of shrimp and flatfish would be expected to remain low for the No-Action Alternative. There may be temporal changes in fish populations at the site, such as exhibited by differences in shrimp and fish abundances during the 1986 June and September trawls. However, these seasonal abundances would likely be low overall. Impacts at the Commencement Bay disposal site due to the cessation of disposal of dredged material at the site would not be significant.

Impacts at the Anderson/Ketron and Elliott Bay disposal sites would be expected to be comparable to those described for Commencement Bay under Alternative 1 (Section 4.1.6), except that impacts would be reduced commensurate with the smaller disposal volumes under this alternative. Impacts such as loss of food or habitat for fish, due to smothering and burial of fish and prey species, are expected to be localized and temporary. Increased turbidity conditions would be temporary, and the disposal should not interfere with any possible migratory species (e.g., salmon) moving through the area. Disposal operations would not occur during the salmon outmigration period (March 15 to August 15). Any changes in the fish community are expected to be temporary. Because of the ability of fish to avoid the dredged material plume, and the low possibility of bioaccumulation of contaminants, the impacts of dredged material on fish are expected to be minimal and not significant. Stringent monitoring and management of the site would continue, thus further ensuring that impacts to the fish and shellfish communities remain minor or not significant.

4.3.7 Birds

Under the No-Action Alternative, the Commencement Bay site would likely be closed to disposal sometime during 2009 or 2010. There would be no further impacts on the prey base for marine birds, and vessel traffic and associated disturbance at the site would decrease. Marine bird use of the site, however, would not be expected to increase significantly because prey resources and foraging habitat there, which were unfavorable prior to disposal activities, would be unlikely to improve.

In all probability, much reduced quantities of dredged material produced by the Port of Tacoma would be disposed of at the next closest deepwater nondispersive disposal sites in Elliott Bay or Anderson-Ketron Island in South Puget Sound due to much longer barge travel distances and resulting high transportation expenses (see Section 2.3). Both sites are more than 3,000 feet from the nearest nearshore habitat, similar to the Commencement Bay site, and no impacts to important marine bird or shorebird habitats are expected. Waterfowl and seabirds most frequently seen in Elliott Bay include scoter species, goldeneye species, western grebes, common loon, gull species, and double-crested cormorants (Nysewander et al. 2005). However, the disposal site here is deeper than ordinary foraging depths of these bird species, and they are likely to avoid the site during disposal activities. The Anderson-Ketron disposal site hosts most of these species and wintering alcids, but like the other sites it is much deeper than the preferred foraging habitats of marine birds. Disposal of dredged materials from Commencement Bay at either of these alternative sites is unlikely to affect local marine bird populations.

Potential transportation and disposal of small quantities of dredged material at upland waste management sites in eastern Washington or Oregon would have no effect on marine birds or mammals, and it is expected that transport to and use of these approved sites would have no effect on upland wildlife species.

4.3.8 Marine Mammals

For the same reasons discussed above in Section 4.3.7, Birds, no impacts on marine mammals in Commencement Bay are expected with the No-Action Alternative. Marine mammal use of the site is not expected to change with this alternative.

Harbor seals are the only marine mammals regularly seen in Elliott Bay or the channel between Anderson Island and Ketron Island, and California sea lions may be present in the winter. At both alternate disposal sites, foraging marine mammals are likely to avoid the noise, disturbance, and turbidity during project activities. Elliott Bay has several haul-out sites used by California sea lions, including buoys off West Point and Alki Point (Jeffries et al. 2000). The Alki Point buoy is along the route that tugs and barges would follow from Commencement Bay to the Elliott Bay disposal site, but these animals are habituated to high levels of ship traffic and are unlikely to be disturbed by project-related traffic. The closest haul-out sites used by pinnipeds in the vicinity of the Anderson-Ketron disposal site are about 4 miles away in the Nisqually River delta (Jeffries et al. 2000), and disposal actions would not affect animals resting at these sites.

4.3.9 Threatened and Endangered Species

Puget Sound Salmonids

In all probability, much reduced quantities of dredged material produced by the Port of Tacoma would be disposed of at the next closest deepwater nondispersive disposal sites in Elliott Bay or Anderson-Ketron Island in South Puget Sound due to much longer barge travel distances and resulting high transportation expenses (see Section 2.3). Minor quantities of dredged material could be transported to and disposed of in upland facilities. Obviously, there would be no adverse impacts to Puget Sound Salmonids from upland disposal of dredged materials at the landfills in south-central Washington or Oregon. There would be no impacts to threatened and endangered salmonids at the Commencement Bay disposal site under the No-Action Alternative. The Commencement Bay disposal site would continue to be non-preferred habitat for adult and juvenile Chinook and steelhead salmon. Also, both the Elliott Bay and Anderson-Ketron disposal sites are in deep waters more than 3,000 feet from nearshore areas preferred by juvenile salmonids. As with the Commencement Bay site, adults could occur in these disposal areas when returning from the ocean to spawning rivers or on their return to the ocean from the rivers if they survive spawning (steelhead only). Temporary and localized changes in water quality immediately after disposal, as described in Section 4.1.2, would not significantly affect threatened and endangered salmonids. Therefore, this alternative may affect, but is not likely to adversely affect, threatened and endangered salmonids.

Birds

Impacts to Puget Sound threatened and endangered birds would be similar to those described for Alternative 1, but of a smaller scale due to cessation of disposal in Commencement Bay and, at most, only minor and infrequent disposal events that might be expected at either the Elliott Bay or Anderson-Ketron disposal site. Effects from localized changes in water quality during disposal would be temporary and insignificant. There would be no adverse impacts to threatened and endangered birds from upland disposal of dredged materials at the landfills in eastern Washington or Oregon. There would be no impacts to threatened and endangered birds at the Commencement Bay disposal site under the No-Action Alternative. The Commencement Bay disposal site would continue to be non-preferred habitat for these species. The deep waters of the Elliott Bay and Anderson-Ketron disposal sites are not preferred habitat for bald eagles or marbled murrelets. Both sites are at least 3,000 feet from the closest nearshore areas that would be more preferable foraging habitat for either species. Changes in size and height of the disposal mound would not affect these species or their forage base. Therefore, the No-Action Alternative may affect, but is not likely to adversely affect, threatened and endangered birds.

Marine Mammals

Impacts to Puget Sound threatened and endangered marine mammals would be similar to those described for Alternative 1, but of a smaller scale due to cessation of disposal in Commencement Bay and, at most, only minor and infrequent disposal events that might be expected at either the Elliott Bay or Anderson-Ketron disposal site. Effects from localized changes in water quality during disposal would be temporary and insignificant. There would be no adverse impacts to threatened and endangered marine mammals from upland disposal of dredged materials at the landfills in eastern Washington or Oregon. There would be no adverse impacts to threatened and endangered marine mammals at the Commencement Bay disposal site under the No-Action Alternative. This area would continue to be visited only rarely by these species. Continued adaptive management and rigorous monitoring of dredged materials would reduce the potential impact of BCOCs to marine mammal prey. Due to the low probability of threatened and endangered marine mammal species coming in contact with the Elliott Bay or Anderson-Ketron disposal sites affected by disposal activities, the infrequent and short-lived nature of disposal events, and the ability of these mobile species to quickly leave the affected area, this alternative may affect, but is not likely to adversely affect, threatened and endangered marine mammal species.

4.3.10 Fishing

Under the No-Action Alternative, the disposal site would be shut down in the near future. Once this occurred, there would be no further effects on commercial or recreational fishing by Tribal or non-Tribal fishermen in Commencement Bay. Compared to Alternatives 1 and 2, this would reduce the potential to displace commercial or recreational fishing in Commencement Bay.

There is potential for displacement of fishing activities to occur at the Anderson-Ketron Islands dredged disposal site, if dredged material that would have gone to the Commencement Bay site is disposed of at this site instead. This would increase the frequency of dredged disposal activities at the Anderson-Ketron site. However, the target area for dredged disposal is relatively small in comparison to the area available for fishing within SMA 13, and there have been no known past conflicts between fishing and dredged material disposal. (Note: The Elliott Bay site is within SMA 10A, which is closed to commercial fishing.)

4.3.11 Marine Transportation

Under the No-Action Alternative, the site would close to further dredged material disposal. It is anticipated that the water depth would be over 400 feet when the site closed; thus, there is no concern for grounding of vessels on the disposal mound at the project site. The DMMP agencies would consider site coordinate shifts at either the Anderson-Ketron Island or Elliott Bay disposal sites to manage the mound height growth at either site with increased site use as part of an adaptive management strategy.

Dredged material that would have been disposed of at the Commencement Bay site could then be placed at either of two other approved in-water sites mentioned above. These sites are also located in deep water, and additional material at these sites would not result in mounding that would create water depths shallow enough to ground a vessel. Two other options to the available approved in-water sites would be to haul the dredged material by train to the Rabanco site near Goldendale, Washington, or to place it in beneficial use areas.

Since the Commencement Bay site would be closed, there would be no effects on navigation or potential for vessel collisions with dredged disposal barges in Commencement Bay. Compared to Alternatives 1 and 2, the potential for collisions in Commencement Bay would be reduced under the No-Action Alternative.

Elliott Bay or Anderson/Ketron Islands would probably be used more frequently for dredged material disposal since the Commencement Bay site would close under this alternative. There would remain an ongoing potential for a collision between a disposal barge and other vessels at these sites. However, there have been no reported incidents at any of the eight DMMP disposal sites over the 20 years of disposal activity, and therefore a collision is considered a remote possibility. No adverse impact on marine transportation would be expected.

4.3.12 Air Quality

Air quality impacts from Alternative 3 were evaluated for the same average annual and high range annual scenarios proposed for Alternative 1. Air quality impacts from Alternative 3 would occur from combustive emissions due to the use of diesel-powered dredging equipment, tug boats, equipment used to unload barges, and dredged material transport trucks. Factors needed to estimate source emissions were the same as those used in the analyses of Alternatives 1 and 2. In addition, factors needed to estimate truck emissions were obtained from the USEPA MOBILE6 emissions model for on-road vehicles (USEPA 2003). Appendix B includes data and assumptions used to calculate emissions from Alternative 3.

Table 21 summarizes the annual emissions of criteria pollutants that would occur from the No-Action Alternative under the average annual and high range annual scenarios. The analysis presented is a worst case analysis, assuming no reduction in dredge volumes under this alternative; actual emissions are likely to be less but cannot be quantified at present. Emissions from this alternative are based upon 45 percent of the annual disposal volume sent to each marine disposal site and 10 percent of annual disposal volume sent to upland disposal sites. The data in Table 21 show that emissions from either scenario under the No-Action Alternative would exceed the NEPA NOx emission significance threshold and would remain below all other NEPA emission significance thresholds.

The No-Action Alternative would generate annual NOx emissions of up to 136.9 tons per year under the high range annual scenario. These emissions would occur from (1) dredge and marine disposal activities within an approximate 40-mile stretch of southern Puget Sound and (2) truck transport of dredge material to an upland disposal site in Eastern Washington. Therefore, proposed NOx emissions would occur over a substantial region and would not be expected to significantly impact the project area air quality.

Table 21. Annual Air Emissions Associated with the No-Action Alternative

Scenario/Activity	Annual Air Pollutant Emissions (tons)					
	VOC	CO	NOx	SOx	PM10	PM2.5
700,000 Cubic Yards per Year						
Dredging	1.60	7.62	23.35	2.56	1.47	1.42
Barge Transport of Dredged Material	2.00	4.40	52.85	4.02	3.59	3.33
Upland Disposal of Dredged Material	1.20	7.51	34.80	0.39	1.01	0.88
Annual Emissions	4.80	19.54	111.00	6.97	6.08	5.63
869,000 Cubic Yards per Year						
Dredging	1.97	9.42	28.85	3.17	1.82	1.75
Barge Transport of Dredged Material	2.47	5.44	65.23	4.96	4.44	4.11
Upland Disposal of Dredged Material	1.48	9.24	42.82	0.48	1.24	1.08
Annual Emissions	5.92	24.09	136.90	8.61	7.50	6.94
NEPA Significance Thresholds	100	100	100	100	100	100

The No-Action Alternative would emit HAPs, which can impact public health. HAPs generally are subsets of VOC and PM10 emissions. Under the high range annual scenario, the No-Action Alternative would produce a total of 5.9 and 7.5 tons of VOC and PM10 emissions, respectively, and therefore would not exceed 10 tons per year of an individual HAP or 25 tons per year of combined HAPs. Therefore, the No-Action Alternative would produce less than significant air quality impacts with regard to levels of HAPs or criteria pollutants.

4.3.13 Historical and Cultural Resources

Under the No-Action Alternative, when the Commencement Bay location ceases operation as scheduled, the disposal activity would move to the existing Anderson-Ketron and Elliott Bay DMMP sites, as well as upland locations. Total dredge/disposal volumes are expected to be lower to some degree than under Alternatives 1 and 2. All are operating disposal locations that have been evaluated for the presence of historic properties. Because no cultural resources were identified at the Anderson-Ketron locale (USACE et al. 1988), no effects on historic properties would be expected as a result of the No-Action Alternative.

Potentially significant (i.e., eligible for the NRHP) shipwrecks identified at or near the Elliott Bay location were investigated, documented, and addressed by a Memorandum of Agreement between the DMMP and the DAHP SHPO, making the location available for disposal use (USACE et al. 1988a; Attachment C).

The upland disposal sites in Washington and Oregon are also functioning facilities where no impacts to cultural resources are expected. If additional disposal facilities were identified, either upland or in-water, then DMMP would comply with Section 106 of NHPA by consulting with the appropriate DAHP SHPO to determine the presence of and possible effect on historic properties, followed by the development of a mitigation plan, if necessary.

5.0 Mitigation

The management of the DMMP disposal sites includes important components to minimize the environmental impacts of disposal. Material proposed for disposal at the DMMP sites, including the Commencement Bay site, is tested to determine its suitability for open-water disposal. DMMP sites are monitored on a prescribed regular basis to ensure that disposal is not having unacceptable impacts on the marine environment.

In addition, the conservation measures included in the programmatic Biological Evaluation under the ESA (USACE 2005) for current and continued use of the PSDDA/DMMP disposal sites apply to the Commencement Bay site:

- Consider beneficial-use disposal sites for appropriate dredged material.
- Consolidate dredged material disposal sites to minimize the area and locations affected by dredged material disposal.
- Site dredged material disposal sites in areas of relatively low habitat value or low use by biota (distance offshore, depth, areas with low known resource value).
- Time dredging and disposal events to avoid overlap with sensitive migration of life history periods of salmon (March 15 to August 15 for the Commencement Bay site).
- Use updated state-of-the-art dredged material testing protocols to ensure the suitability of materials for unconfined, open-water discharge.
- Conduct site monitoring activities (physical, chemical, and biological) to determine if unacceptable impacts are occurring at disposal sites.
- Perform annual review of monitoring results.
- Use adaptive management of the DMMP by multiagency task force.

For future site use, the DMMP would also implement Institutional Controls[29] on site use to minimize the spread of dredged material during disposal and ensure that the site management objective is achieved (<3 cm of dredged material at the perimeter line).

The DMMP addresses all recommended conservation measures put forth by the Pacific Fisheries Management Council in their management plans for Pacific salmon, coastal pelagic species, and Pacific coast groundfish species (PFMC 2003, 2006a,b).

The DMMP would continue to regulate the timing of dredged disposal activities to avoid periods of Tribal commercial fishing.

In consideration of the minimal environmental impacts remaining after application of the above measures, no additional mitigation measures are needed or proposed.

[29] Evaluation of recent disposal data indicate that 80 percent of disposal vessel headings through the Commencement Bay site were directed to the northwest from the southeast. The strong vessel bias through the site may be contributing to the skewed disposal footprint observed during previous monitoring surveys (e.g., 1998, 2001, 2004, etc.) to the northwest. The DMMP agencies' provisional coordinate shift in 2007, which would be formally adopted as an element of the preferred alternative, to the southwest corner of the target zone, was undertaken in part to dampen the northwest drift outside the perimeter line. The DMMP agencies could implement stricter disposal site vessel orientation recommendations in the future to minimize this bias if monitoring shows offsite drift outside the perimeter line.

6.0 Cumulative Impacts

This section considers cumulative impacts that could result from the preferred alternative's incremental impacts (and also those of Alternative 1) when these impacts are added to the impacts of similar past, present, and reasonably foreseeable future actions. In evaluation of impacts in a cumulative sense, the following aspects have been considered (USEPA 1999):

1. **The proximity of the disposal site and vicinity to other relevant projects, either geographically or temporally.** The disposal site is not proximate to other projects with similar impacts, but there are other projects affecting the same environmental system (see next item).
2. **The probability of site use affecting the same environmental system as other related actions, especially systems that are susceptible to development pressures.** Multiple past, present, and reasonably foreseeable future actions have affected or will affect the marine environment of Commencement Bay. Although continued use of the disposal site would have minimal (temporary and localized) environmental impacts, other projects affecting the sediments and benthic community of Commencement Bay are most relevant to an analysis of cumulative impacts. These are summarized below.
3. **The likelihood that site use will lead to a wide range of environmental effects or to a number of associated projects (indirect cumulative impacts).** The preferred alternative would not lead to a wide range of environmental effects. However, the Port of Tacoma, the primary user of the disposal site, has indicated that having the Commencement Bay disposal site available would result in more dredging and port development than if the site were not available (No Action alternative), because of the significantly higher cost of disposal under the latter scenario (Brenner 2008, personal communication). This cumulative impacts analysis describes qualitatively the indirect cumulative impacts of this level of dredging and port development under the preferred alternative.
4. **Whether the effects of other projects are similar to those of the site use.** There are no other projects of a like nature (unconfined dredged material disposal) in the Commencement Bay area. Other actions, including confined fill, affecting the sediments and benthic community of Commencement Bay are summarized below.

Since the late 1980s and early 1990s there has been ongoing shoreline cleanup, restoration, and redevelopment on a number of sites in and along Commencement Bay and on the nearshore tideflats encompassed by the Hylebos, Middle, Sitcum, Blair, St. Paul, Puyallup, Wheeler Osgood, and Thea Foss (City) waterways. A good example is development near the city center that was spearheaded by the Thea Foss Development Authority. Thea Foss and Wheeler Osgood waterways have been remediated and almost completely redeveloped with mixed uses that include marinas, commercial and office space, open areas, and residences.

There have been several cleanup actions on USEPA-designated National Priority List sites, which have required dredging, underwater capping in place, containment, and/or natural resource restoration. Some the major projects include cleanup of the Asarco site in Ruston, and dredging and sediment containment or capping at eight sites in the St. Paul, Sitcum, Hylebos, Thea Foss, Wheeler Osgood, and Middle waterways. Many of these projects will continue into the future as monitoring may indicate that additional actions such as dredging or capping may be required.

The Port of Tacoma has several waterfront projects in process or planned that focus on the Blair Waterway. Construction began in August 2007 on a new $31.6 million wharf adjacent to the 96-acre former Kaiser Aluminum Smelter site on the Blair Waterway. The 1,200-foot wharf and adjacent Kaiser Site are part of the future East Blair Waterway marine terminal development.

The Port of Tacoma is also coordinating with the Puyallup Indian Tribe and several commercial entities to develop another future marine container terminal on the Blair Hylebos Peninsula. The project will include land exchanges and dredging and widening of Blair Waterway at the terminal location.

There is also a proposal by the Port of Tacoma to improve a pier and stabilize the shoreline at their North Schuster Parkway facility. The project involves removing existing timber piers and replacing these with concrete and steel structures, as well as utilities such as sewer, water, and electricity. The project would allow for berthing of two bulk carriers.

There are also several recent restoration projects that have been undertaken by the City of Tacoma around Commencement Bay. These projects include:

- Middle Waterway—A 1.85-acre piece of land next to Middle Waterway was cleaned of its contaminated materials and reconstructed into an intertidal salt marsh. Construction was completed in 2000, planting was completed in 2001, and monitoring took place from 2000 to 2005.
- Tahoma Salt Marsh—Located next to the Ruston Way shoreline, a bowl-shaped salt marsh and upland areas were created with construction completed in 2003. The site will be monitored from 2004 to 2009.
- Hylebos Marsh—Marsh land was re-created near the mouth of Hylebos Creek. Construction was completed in 2007 with monitoring scheduled for 2008 to 2013.

The following resource-specific cumulative impact evaluations consider the impacts of the above projects and future similar projects in conjunction with the impacts of the preferred alternative. They also consider the potential for the preferred alternative to contribute to general past and ongoing environmental trends and effects in the Commencement Bay region.

6.1 Physical Oceanography

Past sediment cleanup and port development projects in the Commencement Bay area have included dredging, capping, and filling, as would future cleanup and development projects. These types of actions result in changes to bottom contours and bathymetry, which in turn result in very localized changes in circulation and currents. As discussed in Sections 4.1.1, 4.2.1, and 4.3.1, the disposal mound at the Commencement Bay disposal site is affecting currents minimally and on a very localized basis, and would continue to do so in the future. No major dredging, capping, or filling projects have occurred in the vicinity of the disposal site, and the same is expected to be true in the future. (The disposal site is located approximately 2 miles from the locations of past and likely future projects of these types.) Considering this distance, the very localized effects of disposal and of the other dredging, capping, and filling projects, there is essentially no potential for cumulative impact contributions on physical oceanographic conditions. Dredging and port development as an indirect effect of continued availability of the Commencement Bay PSDDA site would affect physical oceanography on a very localized basis at the site of any dredging for channel or berth deepening, or any fill for Port development.

6.2 Water Quality

Development and industrialization of Commencement Bay shorelines and lower tributaries over the past 150 years caused extensive sediment and water contamination. Impaired water quality was a direct result of development activities. Past dredged disposal events in Commencement Bay would have resulted in temporary and localized impacts to water quality but no long-term impacts.

Stormwater runoff from urban development continues to be the major contributor of nonpoint source pollution to Puget Sound. Stormwater runoff can carry contaminants, such as heavy metals, oils, nitrogen, fecal contamination, and phosphorus, into the water, often coinciding with storm events. The contaminants from stormwater runoff can adversely affect DO, biochemical oxygen demand, pH, and other water quality parameters in localized areas. Overall DO concentrations in Puget Sound appear to be continuing a downward trend. Currently, Commencement Bay waters are occasionally impaired by low DO and high fecal coliform concentrations. Measures of dissolved inorganic nitrogen and ammonium indicate the continued presence of nutrient sources to the bay (PSAT 2007b). The Puyallup River continues to contribute substantial amounts of suspended sediments to the bay.

USEPA and Ecology cleanup efforts of the Superfund sites along the bay and tributaries have eliminated some sources of contamination to Commencement Bay waters. Contaminated sediments in several of the waterways at the end of the bay have been dredged and capped to reduce sources of ongoing contamination to the bay. These efforts will be continuing into the near future (USEPA 2007). Although there will be localized and temporary impacts to turbidity, the proposed continued use of the Commencement Bay disposal site would not introduce contamination to the bay or result in long-term reduction of water quality.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in increased turbidity and related availability of sediment-associated contaminants at the dredging site. These effects, which would be repeated with any subsequent maintenance dredging, would be reduced through the use of clean dredging techniques such as “closed” buckets or other “environmental” dredging equipment, and silt curtains. Port development could result in the potential for stormwater discharge impacts as described above; up-to-date stormwater BMPs would be implemented to minimize the resulting water quality impacts.

Overall, continued use of the disposal site would not contribute substantively to cumulative impacts on water quality.

6.3 Sediment Quality

Cumulative impacts to sediment quality as a whole within Commencement Bay, due to dredged material disposal at the Commencement Bay disposal site, are not expected to be significant. There are no other known impacts on sediments in Commencement Bay deepwater environments and the disposal site is only 1.1 percent of the total deepwater environment area (defined as that bay area between 120 and 600 feet in depth). Only sediment determined to be suitable for disposal at non-dispersive open-water disposal sites in Puget Sound would be placed at the site, and thus should not contribute to the further degradation of sediments within Commencement Bay. Long-term post-disposal monitoring at the Commencement Bay site has shown that impacts to the sediment quality at the site and adjacent areas are not significant. Onsite chemical monitoring and toxicity testing results have met DMMP Site Condition II chemical and biological guidelines since disposal operations began (Technical Appendix; Tables 1-5 and 1-6). Due to the DMMP's continued adaptive management and monitoring of the site, effects on sediment quality would continue to be minimal and very localized, with no potential to overlap with the impacts of other projects or actions on sediment quality.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in resuspension and settling of sediments at the dredging site, potentially resulting in changes in grain size and levels of sediment-associated contaminants at the sediment surface. These effects would be repeated with any subsequent maintenance dredging. As with water quality, these effects would be reduced through the use of clean dredging techniques such as "closed" buckets or other "environmental" dredging equipment, and silt curtains. Port development could result in the potential for stormwater discharge impacts as described above, which could affect sediment quality as well as water quality. Up-to-date stormwater BMPs would be implemented to minimize the resulting sediment quality impacts.

Overall, the preferred alternative would make no substantive contribution to cumulative impacts on sediment quality.

6.4 Plankton/Neuston

As described in Section 6.2, Water Quality, past development and industrialization of Commencement Bay shorelines and lower tributaries caused extensive water contamination. Phytoplankton abundance in the bay will likely continue to be influenced by the high nutrient levels in the bay (PSAT 2007b). The proposed continued use of the Commencement Bay disposal site would not increase the frequency of phytoplankton blooms in Commencement Bay. Disposal is not expected to result in increased levels of contaminants in the sea surface microlayer, so there should be no cumulative impacts specific to neuston. Dredging and port development resulting from the continued availability of the Commencement Bay DMMP site could affect, through dredging turbidity and port development stormwater effects, plankton and neuston on a localized and temporary (for dredging) basis. Such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, effects on the presence and distribution of plankton at the disposal site due to disposal operations would be minimal, and when added to other projects in the bay would make no substantive contributions to cumulative impacts.

6.5 Benthic Community

Cumulative impacts to the overall benthic community within Commencement Bay, as a result of continued dredged material disposal at the Commencement Bay disposal site, are not expected to be significant. Monitoring surveys at the site have shown that no significant impacts to the biological community off site have occurred due to dredged material disposal. Although the biological community structure is affected to a limited extent on site, surveys have shown that the existing benthic community is able to recover from thin layers (<10cm) of dredged material after each discrete disposal event, and also there is active recolonization of benthic species taking place in physically impacted areas with displaced communities. Because the disposal site is located within deep-water habitat, no impacts to the nearshore intertidal communities would be expected. Given the DMMP's adaptive management practices and continued monitoring of the site, effects on the benthic community would continue to be minimal and very localized, with no potential to overlap with the impacts of other projects or actions on the benthic community.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in temporary loss of the benthic community in dredged areas, which would be repeated with any subsequent maintenance dredging. Any fill for port development would result in loss of the benthic community in the filled area. The area affected by dredging and filling is expected to be small relative to the total seafloor area of Commencement Bay. Stormwater impacts to water and sediment quality from port development would affect the benthic community; such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, the preferred alternative would make no substantive contribution to cumulative impacts to the benthic community.

6.6 Fish and Shellfish

Studies of fish populations within south Puget Sound have shown declines in certain groundfish species (e.g., rockfish, Pacific cod, Pacific whiting, and walleye pollock) and some forage fish species such as herring. However, other fish populations are in above average condition in south Puget Sound (e.g., English sole) and northern anchovy abundances appear to be expanding. Puget Sound Chinook salmon stocks are listed as threatened (PSAT 2007b).

Cumulative impacts to these fish and shellfish populations within Commencement Bay and Puget Sound overall, due to dredged material disposal at the Commencement Bay disposal site, are not expected to be significant. The Commencement Bay disposal site is located within an area that has shown low populations of fish and shrimp, and no Dungeness crabs were observed in surveys conducted at the site. Impacts to these populations due to dredged material disposal are expected to be localized and temporary. Dredged material disposal would not occur during periods of outmigration of salmon, so that impacts to salmon due to dredged material disposal would be minor. Toxic or bioaccumulative effects on fish or shellfish species are not expected, since only sediment determined to be suitable for open-water disposal would be placed at the site. Continued monitoring of the site would further ensure that any cumulative impacts to fish and shellfish communities within Commencement Bay would not be significant. Given the DMMP’s adaptive management practices and continued monitoring of the site, effects on fish and shellfish would continue to be minimal and very localized, with no potential to overlap with the impacts of other projects or actions on fish and shellfish.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in temporary loss of the shellfish community in dredged areas, and would affect fish and shellfish through the temporary water quality impacts of dredging. These effects would be repeated with any subsequent maintenance dredging. Any fill for port development would result in loss of fish habitat and the shellfish community in the filled area. The area affected by dredging and filling is expected to be small relative to the total seafloor area of Commencement Bay, and to be of relatively low habitat value due to its proximity to industrial development and activity. Stormwater impacts to water and sediment quality from port development would affect the fish and shellfish communities; such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, the preferred alternative would make no substantive contribution to cumulative impacts on fish and shellfish.

6.7 Birds

Overall, state-wide marine bird populations have declined by 27 to 47 percent since the 1970s (PSAT 2007b). Of the 30 most common species, 19 have declined by 20 percent or more. A variety of factors may have played a role in marine bird population declines, including chemical contamination; reduced prey availability; derelict fishing gear; gillnet fishing practices; loss of foraging, breeding, and resting habitat; collisions with manmade structures; impacts of non-native species; and climate change.

However, the site is not a high-value area for birds at past or current levels of disposal activity, dredged material releases are unlikely to increase sediment contaminant loads, and the area impacted is very small in comparison to surrounding waters that would not be affected by the disposal actions. No other project activities are anticipated in the vicinity of the disposal site.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in temporary loss of the marine bird foraging habitat in dredged areas, and could affect birds through food-chain effects of temporary water quality impacts of dredging. These effects would be repeated with any subsequent maintenance dredging. Any fill for port development would result in loss of marine bird foraging habitat in the filled area. The area affected by dredging and filling is expected to be small relative to the total seafloor area of Commencement Bay, and to be of relatively low habitat value due to its proximity to industrial development and activity. Stormwater impacts to water and sediment quality from port development could affect birds through food-chain effects; such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, continued use of the disposal site with either action alternative would not make a significant contribution to cumulative impacts on marine birds resulting from other uses of Puget Sound waters.

6.8 Marine Mammals

Harbor seal populations have increased from low levels in the 1970s and have been stable since the mid 1990s in inland Washington waters (Carretta et al. 2007a; PSAT 2007b). California sea lion numbers have increased in Puget Sound but aggregations vary depending on prey fish abundance. Other marine mammals such as harbor porpoise have declined in Puget Sound, likely due to traffic, entanglement in fishing nets, and contaminants (PSAT 2007b). Marine mammals are particularly vulnerable to contamination by PBTs; PBDE concentrations in Puget Sound harbor seals have increased exponentially in recent years (PSAT 2007b). However, continued use of the Commencement Bay disposal site is not expected to contribute significantly to this trend or any marine mammal population declines, for reasons similar to those stated above in Section 6.7, Birds. In fact, years of monitoring have shown concentrations of toxic chemicals decreasing at the site over time (Section 3.2.3). Disposal would not affect marine mammals in other ways.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in temporary loss of the marine mammal foraging habitat in dredged areas, and could affect marine mammals through food-chain effects of temporary water quality impacts of dredging. These effects would be repeated with any subsequent maintenance dredging. Any fill for port development would result in loss of marine mammal foraging habitat in the filled area. The area affected by dredging and filling is expected to be small relative to the total seafloor area of Commencement Bay, and of relatively low habitat value due to its proximity to industrial development and activity. Stormwater impacts to water and sediment quality from port development could affect marine mammals through food-chain effects; such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, continued use of the site would make no substantive contribution to cumulative impacts on marine mammals.

6.9 Threatened and Endangered Species

Past development and industrialization of Commencement Bay shorelines and lower tributaries caused extensive contamination of Commencement Bay and loss of nearshore natural habitats. Federal and state agencies are restoring habitats along Commencement Bay nearshore areas and tributaries, which would improve foraging habitat for marbled murrelets and bald eagles, and foraging and migratory habitats for juvenile and adult Chinook and steelhead.

Past dredged disposal events in Commencement Bay would have resulted in temporary and localized impacts to water quality but no long-term impacts to threatened and endangered species, as described in Section 4.9. Steller sea lions only rarely occur in Commencement Bay and humpback whales are very unlikely to occur in the disposal area. No adverse effects on Puget Sound Chinook salmon and steelhead, bald eagles, and marbled murrelet are expected because the dredged disposal would not occur in preferred habitat for these species. The major threats to Southern resident killer whales in Washington State are declines in their salmonid food base, pollutants, noise and disturbance from boats, and oil spills (PSAT 2007b). Continued use of the disposal site would not adversely affect salmonids or introduce contaminants to Commencement Bay. Boat trips to and from the disposal site would not increase significantly over the current condition.

Dredging resulting from the continued availability of the Commencement Bay DMMP site would result in temporary loss of salmonid habitat and foraging habitat for marbled murrelets, bald eagles, and killer whales in dredged areas, and could affect listed species through food-chain effects of temporary water quality impacts of dredging. These effects would be repeated with any subsequent maintenance dredging. Any fill for port development would result in loss of salmonid habitat and foraging habitat for marbled murrelets, bald eagles, and killer whales in the filled area. The area affected by dredging and filling is expected to be small relative to the total seafloor area of Commencement Bay, and of relatively low habitat value due to its proximity to industrial development and activity. Stormwater impacts to water and sediment quality from port development could affect listed species through food-chain effects; such effects would be reduced through BMPs as described in Section 6.2, Water Quality, above.

Overall, continued use of the site would make no substantive contribution to cumulative impacts on threatened and endangered species.

6.10 Fishing

According to the State of the Sound Report (PSAT 2007b), over-fishing has been one of the causes of depressed salmon and bottom fish stocks. Recent trends show continued decline in salmon stocks. However, there have been some slight improvements in some species of bottom fish stocks over the past 4 years (Section 6.6). The Commencement Bay disposal site is not a productive area for bottom fish of commercial or recreational interest based on past and recent trawling studies at the site. Disposal to date has not affected fishing in the Commencement Bay area and this is not expected to change in the future. Dredging and port development resulting from the continued availability of the Commencement Bay DMMP would have little effect on fishing because the areas affected by dredging and port development are unlikely to be valuable fishing areas. As discussed above under Fish and Shellfish (Section 6.6), dredging and port development are not expected to result in significant cumulative impacts to fish. Therefore, continued use of the site would make no substantive contribution to cumulative impacts on fishing.

6.11 Marine Transportation

Dredged material disposal at the Commencement Bay site has been ongoing for 20 years and would continue into the future until a maximum of up to 23 mcy of material was placed at the approved site with roughly the same site use frequency. At approximately 368 barge trips per year, disposal-related vessel traffic makes up approximately 24 percent of commercial vessel traffic in the Commencement Bay area. Current marine traffic levels, including disposal-related traffic, in the Commencement Bay area are not having an adverse effect on marine transportation, or significant environmental impacts. Measures are in place to minimize the potential for oil or fuel spills and to maximize the effectiveness of cleanup in the unlikely event of a spill. These conditions would not be expected to change with continued use of the disposal site. Dredging and port development resulting from continued availability of the Commencement Bay DMMP site would result in increased commercial vessel traffic. Although these increases cannot be quantified at present, considering the minimal effects of current marine traffic, they are unlikely to be sufficient to result in marine traffic conflicts or significant environmental impacts. Therefore, the preferred alternative would make no substantive contribution to cumulative impacts on marine transportation.

6.12 Air Quality

Air quality impacts resulting from the proposed dredged disposal activities would be additive to those from other shipping operations and other activities that emit air pollutants in the bay. As discussed in Section 4.1.12, however, emissions from disposal activities would remain well below the EPA annual emission significance thresholds. Additionally, due to the mobile and intermittent nature of proposed emission sources, project operational emissions would not produce substantial ambient impacts in a given locality. As a result, air emissions from proposed operational activities, in combination with reasonably foreseeable future project emissions, would not exceed any ambient air quality standard. Dredging and port development resulting from continued availability of the Commencement Bay DMMP site would result in increased air pollutant emissions from dredging and construction equipment (temporary during construction) and upland and marine traffic related to port development (long term). It is not possible at present to quantify these emissions, but they would contribute to some degree to existing adverse air quality conditions in the region (Section 3.12). The percentage contribution to regional emissions is likely to be small. Therefore, the preferred alternative *per se* would make no substantive contribution to cumulative impacts on air quality.

6.13 Historic and Cultural Resources

Because the proposed project would have no effect on historic properties or other cultural resources, there would be no contribution to cumulative effects on these resources. No shipwrecks are located in the vicinity of the Commencement Bay disposal site, there is no probability that archaeological sites would be present in these deep waters, and no traditional resources, including traditional fisheries, would be significantly affected (see Section 3.13). Dredging and port development resulting from the continued availability of the Commencement Bay DMMP is unlikely to affect cultural resources because the areas affected by dredging and port development are unlikely to contain any valuable cultural resources. Any increased dredging or port development is also unlikely to adversely affect Tribal fish resources or fishing areas (Sections 6.6 and 6.10).

7.0 Coordination and SEIS Review Process

Representatives of the DMMP met with representatives of Pierce County in August 2007, and again in April 2008, to discuss the County's concerns about the preferred alternative. The county provided comments on a preliminary draft of the SEIS that were evaluated and incorporated as appropriate into this draft SEIS. Representatives of the DMMP coordinated with representatives of the following agencies and entities to collect information for preparation of the draft SEIS.

- Port of Tacoma
- Washington Public Ports Association
- Puyallup Tribe
- Northwest Inter-Tribal Fish Council

This draft SEIS was made available to the public for a 45-day public review period (April 24, 2009, to June 9, 2009). Comments were received from the Port of Tacoma and the Environmental Protection Agency, and responses to these comments are provided in Appendix E. The Notice of Availability of the final SEIS will be filed by the Environmental Protection Agency in August 2009. This event will commence after a thirty (30) day "wait period" per NEPA regulations. Following the "wait period," the SEIS will be revised as necessary and used as the basis for preparation of the Record of Decision (ROD). The ROD will be signed by the USACE District Engineer and the EPA Regional Administrator. The state of Washington is then expected to conduct an independent environmental review per SEPA, and this process is expected to be completed by Fall 2009.

8.0 Environmental Compliance

8.1 National Environmental Policy Act

Sections 1500.1(c) and 1508.9(1) of the regulations implementing the National Environmental Policy Act of 1969 (as amended) require federal agencies to "provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact" on actions authorized, funded, or carried out by the federal government to ensure such actions adequately address "environmental consequences, and take actions that protect, restore, and enhance the environment." This SEIS is necessitated by the fact that the evaluation process reflects substantial changes in the parameters of the designated Commencement Bay aquatic disposal site, that are relevant to environmental concerns, pursuant to 40 CFR 1502.9(c). This SEIS evaluates environmental consequences from the proposed reauthorization of the Commencement Bay dredged material disposal site, and would, after public comment and finalization, satisfy the appropriate sections of the Act.

8.2 State Environmental Policy Act

The State Environmental Policy Act, Chapter 43.21c RCW, is modeled after the federal National Environmental Policy Act, and is intended to ensure that the full extent of potential environmental impacts of a preferred alternative are considered by state and local government entities when evaluating project proposals. SEPA requires the consideration of environmental impacts of a preferred alternative, including those adverse impacts that cannot be avoided, as well as possible alternatives to the action. SEPA also requires recognition of the relationship between short-term uses and long-term environmental outcomes of the preferred alternative, as well as irreversible commitment of the state's natural resources if the action were implemented. The SEPA Rules (Chapter 197-11 WAC) were adopted to implement SEPA and to establish uniform requirements and guidance for compliance with SEPA.

In certain instances, SEPA Rules allow for the adoption of federal NEPA documents, often an environmental assessment or EIS, to satisfy the state's SEPA requirements (WAC 197-11-610). This allows SEPA lead agencies to avoid duplication of efforts by using existing federal documents and their analyses, when appropriate. When federal agencies produce NEPA documents, the designated state or local SEPA lead agency performs an independent evaluation and concludes if the NEPA analysis meets their responsibilities under SEPA. If the SEPA agency determines the NEPA analysis satisfies SEPA requirements, they then make their own separate determination on the environmental significance of the proposed project. While the SEPA lead agency may use NEPA documents for the basis of their final conclusions under SEPA, they will reach those conclusions independently of the findings of the federal NEPA process.

8.3 Clean Water Act

The Clean Water Act requires federal agencies to protect waters of the United States. Section 404 regulates the discharge of dredged or fill material into waters of the United States, and Section 404(b)(1) defines conditions that must be met by federal agencies before they make such discharges. Compliance with Section 404(b)(1) is required for specific dredging and disposal projects, not designation of a site for potential disposal as in the currently preferred alternative. As discussed in Section 1.3, federal authority for designation of dredged material disposal sites is granted by 40 CFR 230.80, which is part of USEPA's Section 404(b)(1) guidelines. If USEPA and USACE determine at the conclusion of the NEPA process that a reauthorization of the Commencement Bay disposal site is warranted, an updated notice of advanced identification under Section 230.80 would be published and circulated to the public. Section 401 of the Act requires federal agencies to receive certifications from the applicable state that a proposed federal action involving a discharge into the waters of the U.S. will comply with state water quality standards. Again, such certifications are required for specific dredging and disposal projects, not site designation.

8.4 Rivers and Harbors Act of 1899

The Rivers and Harbors Act of 1899 regulates structures or work in or affecting navigable waters of the United States including discharges of dredged or fill material into waters of the United States. Structures include without limitation, any pier, boat dock, weir, revetment, artificial islands, piling, aid to navigation, or any other obstacle or obstruction. The preferred alternative would not result in significant impacts to navigation; interference with vessel traffic would be minimal and the depth of the disposal sites precludes any channel depth-related effects on navigation.

8.5 Endangered Species Act

The Corps, in consultation with the DMMP agencies, initiated consultation with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act (ESA) during March 2005 relative to the Puget Sound PSDDA sediment disposal sites after updating the existing programmatic biological evaluation (USACE 2005). The findings of NMFS and USFWS in their respective concurrence letters (June 15, 2005 and May 17, 2005) found that disposal of dredged material at the five non-dispersive disposal sites and three dispersive sites "may affect, but are not likely to adversely affect" the listed species.

In 2007, the DMMP agencies re-initiated consultation with the NMFS for Puget Sound Steelhead (*Oncorhynchus mykiss*) and Southern resident (SR) killer whales (*Orcinus orca*) and SR killer whale critical habitat (USACE 2007), and received concurrence letters (June 26, 2007, and August 21, 2007) on both species, that the sites "may affect", but are "not likely to adversely affect" for both PS steelhead and SR killer whales. NMFS also analyzed the potential impacts of the projects on SR killer whale critical habitat and determined that effects on that habitat will be insignificant.

The proposed reauthorization of the Commencement Bay disposal site would represent no change to the determination of effect under the current programmatic consultation for endangered species for the Puget Sound dredged material disposal sites.[30] First, the disposal site and perimeter locations would remain unchanged, and the DMMP agencies must continue to ensure that all dredged material disposal at the site would still remain within the same boundary and essentially within the same footprint as before. Second, site permitting would remain the same; all potential site users would be required to meet general and special conditions for use as determined by USACE under a Section 404 permit and WDNR under a site use authorization. Third, the DMMP agencies would continue to apply the same interpretative standards for sediment chemistry and biological effects to all dredged material proposed for disposal at the site. Finally, all of the existing site condition requirements

[30] USACE on behalf of the DMMP agencies has initiated additional consultation with NOAA on the 2005 concurrence, regarding the accommodation of a cumulative volume up to 23 mcy within the original EIS site boundaries. The Draft SEIS will be amended as necessary after consultation has been completed.

would remain in place, and the same site monitoring regime would be implemented to ensure the required site condition is met. Thus, the DMMP agencies have concluded that reinitiating Endangered Species Act consultation under the existing programmatic biological assessment is not required.

8.6 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 USC 470) requires that wildlife conservation receive equal consideration and be coordinated with other features of water resource development projects. The SEIS analysis concludes that the preferred alternative would not have adverse effects on fish or wildlife and requires no further action under this Act.

8.7 Coastal Zone Management Act

The Coastal Zone Management Act of 1972, as amended (with implementing regulations at 15 CFR 923), requires federal agencies to carry out their activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of the approved Washington Coastal Zone Management Program. Continued designation and use of the dredged material disposal sites in Puget Sound is consistent to the maximum extent practicable with the Washington State Shoreline Master Program. In considering whether to issue a permit for the preferred alternative, Pierce County will determine whether the preferred alternative is consistent with the Pierce County Shoreline Master Program.

8.8 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to consult with NMFS regarding actions that may adversely affect Essential Fish Habitat (EFH) for Pacific coast groundfish, coastal pelagic species, and Pacific salmon. The programmatic DMMP Biological Evaluation addressed the potential effects of the program on EFH. Based on the analysis in this SEIS, it is concluded that the preferred alternative would not adversely affect EFH and would require no further coordination under this Act.

8.9 Clean Air Act

The Clean Air Act requires states to develop SIPs for eliminating or reducing the severity and number of violations of the NAAQS while achieving expeditious attainment of the NAAQS. The Act also requires federal actions to conform to the appropriate SIP. An action that conforms with a SIP is defined as an action that will not: (1) cause or contribute to any new violation of any standard in any area, (2) increase the frequency or severity of any existing violation of any standard in any area, or (3) delay timely attainment of any standard or any required interim emission reductions or other milestones in any area. USACE has determined that emissions associated with this project will not exceed USEPA's *de minimis* threshold levels (100 tons/year for carbon monoxide and 50 tons/year for ozone), and that a conformity determination is thus not required.

8.10 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (36 CFR Part 800) requires that the effects of proposed actions on sites, buildings, structures, or objects included or eligible for the NRHP must be identified and evaluated. The preferred alternative would not affect such resources. As required under Section 106 of the NHPA, USACE is coordinating with the Washington DAHP, Puyallup Tribe, and Northwest Intertribal Fish Council.

8.11 Treaty Rights

In the mid-1850s, the United States entered into treaties with a number of American Indian tribes in Washington. These treaties guaranteed the signatory tribes the right to “take fish at usual and accustomed grounds and stations…in common with all citizens of the territory” [U.S. v. Washington, 384 F. Supp. 312 at 332 (WDWA 1974)]. In U.S. v. Washington, 384 F. Supp. 312 at 343 - 344, the court also found that the Treaty tribes had the right to take up to 50 percent of the harvestable anadromous fish runs passing through those grounds, as needed to provide them with a moderate standard of living (Fair Share). Over the years, the courts have held that this right comprehends certain subsidiary rights, such as access to their “usual accustomed” fishing grounds. More than *de minimis* impacts to access to usual and accustomed fishing area violates this treaty right [Northwest Sea Farms v.Wynn, F.Supp. 931 F.Supp. 1515 at 1522 (WDWA 1996)]. In U.S. v. Washington, 759 F.2d 1353 (9th Cir 1985) the court indicated that the obligation to prevent degradation of the fish habitat would be determined on a case-by-case basis. The Ninth Circuit has held that this right also encompasses the right to take shellfish [U.S. v. Washington, 135 F.3d 648 (9th Circ 1998)].

The preferred alternative has been analyzed with respect to its effects on the treaty rights described above. As substantiated in this SEIS:

1. The work would not interfere with access to usual areas.
2. The work would not cause the degradation of fish runs, accustomed fishing grounds, fishing activities or shellfish harvesting, or habitat.
3. The work would not impair the Treaty tribes’ ability to meet moderate living needs.

9.0 Climate Change

Currently, there are concerns that continued increases in greenhouse gas emissions resulting from human activities contribute to climate change. Effects of climate change may include changes in hydrology, sea level, weather patterns, precipitation rates, and chemical reaction rates. Therefore, the cumulative effects analysis in this supplemental SEIS, should include changes to resources that can reasonably be anticipated due to climate change that may have bearing on aspects of the project (e.g., changes in hydrology that may increase sediment). Therefore, the following analysis considers how resources affected by climate change could potentially influence the proposed reauthorization and use of the Commencement Bay disposal site.

Climate change is currently predicted to have impacts to a number of environmental resources in the Commencement Bay area. Most important to the proposed action are changes forecast to the hydrologic regime: to sea level rise, increases in air and sea surface temperatures, peak flows from rain and snowmelt runoff, water temperatures, and possibly direct increases in precipitation resulting from alterations to air circulation and storm patterns in the eastern Pacific. Climate change may also have an effect on both horizontal and vertical ocean circulation patterns, and could also speed up chemical processes in the water column and sediment.

Sea level rise, while expected to be a global process, would also have a direct impact to the Commencement Bay area. Sea level rise in Puget Sound has been predicted to range from 1 to 22 inches by the middle of this century, and to continue rising to from 13 to 50 inches by the year 2100. The mid-range sea-level rise would deepen Commencement Bay waterways and slips by approximately 12 inches, potentially reducing the frequency of navigation maintenance dredging. The worst-case scenarios of sea-level rise could reduce the need for maintenance dredging, while the lower ranges of estimated sea-level rise would have a smaller and negligible reduction in the need for maintenance dredging. Thus, predicted sea level rise would not likely result in an increase in dredging requirements regionally, nor would there be an increase in the use of the Commencement Bay disposal site.

An increase in sea surface temperatures could change temperature stratification of marine waters and cause changes to cold water upwelling patterns, increasing the frequency and intensity of low dissolved oxygen events. Such events appear to be on the increase regionally (e.g., northern Oregon coast). An increase in freshwater input to Commencement Bay from the Puyallup River could lead to some stratification near the Puyallup River delta, although there has been no known stratification documented in the vicinity of the Commencement bay disposal site. Therefore, this potential concern would have no impact to site reauthorization, use, or management of the site in the future.

Chemical processes and reactions in water and sediment could conceivably accelerate with warmer air and water temperatures. However, measurable effects would be limited to intertidal or shallow subtidal areas, and would not extend to the deepwater disposal site environment. There currently are no known predictive tools to conclude whether this would occur in Commencement Bay with the presently forecast temperature increases during the 21st century. The DMMP imposes strict guidelines for sediment characterization, which determine whether dredged material is suitable for open-water disposal, and 20 years of monitoring data demonstrate that DMMP standards are protective of the marine environment. In the event that accelerated chemical processes result in unacceptable concentrations of chemicals of concern in sediments bound for the disposal site, the DMMP would not allow these sediments to be disposed of at the site. Therefore, there are no anticipated impacts to the Commencement Bay site from potential changes in chemical processes.

Increases in air temperatures are expected to affect precipitation patterns, which ultimately affect the amount of sediment delivery to the Commencement Bay waterway. Most surface water entering Commencement Bay falls during winter months as snow at higher elevations in the Cascade mountain range. Higher air temperatures would cause more precipitation to fall as rain. This is of particular importance in the Puget Sound region, where surface air temperatures are commonly at or just below the freezing level during winter snowfall events. More rain would also change both the quantity and the timing of peak river runoff events in drainages discharging into Commencement Bay, potentially causing more and larger post-storm runoff events over short time periods, such as hours to a few days, and a reduction in spring freshet or snowmelt events, which typically span as much as several weeks. An increase in storm runoff peak flow events could deliver more sediment to Commencement Bay and potentially increase the need for dredging, while decreased spring snowmelt would reduce delivery of sediments to the bay, offsetting this increase.

In considering the impacts of altered runoff volumes and periodicity in Commencement Bay and their possible effects on sediment deposition, it is important to understand the character of waterways flowing into it. The dominant drainage discharging into Commencement Bay is the Puyallup River, which accounts for the vast majority of runoff volume entering the bay. A great deal of runoff in the Puyallup originates as snowfall in the Cascade Mountains. There are two small local drainages, Hylebos and Wapato Creeks, which discharge relatively small volumes of runoff into the bay. In these basins most precipitation falls as rain. The Puyallup River enters the bay south of the major industrial waterways where navigation dredging may occur. Thus, most of the sediment bedload in the river discharges south and west directly into the bay itself, bypassing the waterways.

Figure 22 (page 63) depicts a plume dispersing northwest from the mouth of the Puyallup River, carrying most of the suspended sediment away from the dredged waterways and toward deeper water in Dalco Passage. EPA collected water current and turbidity data in 2006 and 2007 at Point Rustin, several miles west of the mouth of the Puyallup River in Commencement Bay. This area frequently has strong longshore currents that flow west. The data showed that high runoff volumes from the Puyallup River carried sediment past the Point Rustin site causing a marked increase in ambient turbidity. These data support a conclusion that the plume visible in Figure 22 represents part of the normal circulation condition and that sediment does not accumulate in large quantities in the maintained waterways of Commencement Bay.

Finally, the historical dredging data further support that the Commencement Bay commercial waterways are stable and do not experience appreciable deposition of sediments over time. Since first use of the Commencement Bay disposal site in 1989, very little of the dredge material disposed there is from maintenance dredging in the waterways. Of just under 8 mcy of material disposed at the site, only about 176,000 cy, or 2.2 percent of the total volume, has been contributed by maintenance dredging projects. Rather, most disposed dredge material has originated from Port of Tacoma projects to widen and deepen existing channels such as Blair Waterway, by excavating both laterally and deeper into native material. Table 3 and Figure 4 show a sharp increase in dredging and disposal, which followed the 1994 CERCLA cleanup in Blair Waterway, thereby allowing opportunities for widening/deepening projects in the Blair Waterway.

In conclusion, there is no evidence from current hydrologic conditions or the historical record of dredging and disposal to indicate that climate change would result in an appreciable increase in the need for dredging in Commencement Bay waterways and increased disposal at the Commencement Bay site.

10.0 Conclusion

This SEIS was prepared pursuant to NEPA and examined in detail pertinent aspects of the Commencement Bay aquatic environment and the environmental impacts to that environment that could potentially result from the reauthorization of the Commencement Bay disposal site involving expansion of the dredged material cumulative volume ceiling, and location adjustments within the approved disposal zone. Based on the information and analyses contained in this NEPA SEIS, it is concluded that implementation of either of the action alternatives would not generate appreciable change in the nature and/or degree of effects on the quality of the human environment, as compared with those effects identified and evaluated in the 1988 PSDDA Phase I EIS, and would not constitute a major federal action that would result in significant impacts on valuable Commencement Bay environmental resources. Implementation of either alternative would meet the reauthorization objective while adhering strictly to all pertinent federal, state, and local laws and regulations.

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APPENDIX A: REVIEW OF ENVIRONMENTAL BACKGROUND AND MONITORING STUDIES AT THE DREDGED MATERIAL MANAGEMENT PROGRAM COMMENCEMENT BAY DISPOSAL SITE, 1988 TO 2007

(Due to their volume, Attachments A – E of Appendix A are excluded from the SEIS, and are provided on the attached CD)

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U.S. Army Corps of Engineers
Seattle District

WASHINGTON STATE DEPARTMENT OF
Natural Resources

Review of Environmental Background and Monitoring Studies at the Dredged Material Management Program Commencement Bay Disposal Site, 1988 to 2007

Final

March 21, 2008

Prepared for:

The Dredged Material Management Program Agencies

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BCOC	bioaccumulative contaminant of concern
BOD	biochemical oxygen demand
BRAT	Benthic Resources Assessment Technique
BT	bioaccumulation trigger
COC	chemical of concern
CTS	Chemical Tracking System
cy	cubic yard(s)
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DMMP	Dredged Material Management Program
DW	dry weight
DY	dredging year (16 June – June 15; overlaps 2 Calendar years)
EA	environmental assessment
EIS	environmental impact statement
FEIS	final environmental impact statement
ha	hectare(s)
HPAH	high molecular polycyclic aromatic hydrocarbon
LAET	lowest apparent effects thresholds
LPAH	low molecular polycyclic aromatic hydrocarbon
MDFATE	Multiple Dump Fate
MDL	method detection limit
ML	maximum level
MRL	method reporting limit
NEPA	National Environmental Policy Act
OC	organic carbon
OSI	Organism Sediment Index
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
ppb	parts per billion
ppm	parts per million
PSDDA	Puget Sound Dredged Disposal Analysis
PSEP	Puget Sound Estuary Program
RPD	Redox Potential Discontinuity
SAIC	Science Applications International Corporation

SEA	Striplin Environmental Associates
SL	screening level
SMARM	Sediment Management Annual Review Meetings
SQS	Sediment Quality Standards
STFATE	Short-term Fate (model)
SVOC	semi-volatile organic compound
SVPS	Sediment Vertical Profiling System
TBD	to be determined
TBT	tributyltin
TOC	total organic carbon
TTL	target tissue level
UEMP	Updated Environmental Monitoring Plan
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WW	wet weight

EXECUTIVE SUMMARY

Introduction

This document provides a review and data summary of environmental monitoring studies conducted at the Dredged Material Management Program (DMMP[1]) Commencement Bay non-dispersive open-water dredged material disposal site from 1988 through 2007. This review will provide essential information for the development of an environmental assessment (EA) pursuant to the National Environmental Policy Act (NEPA), involving future management of dredged material disposal at the Commencement Bay open-water site. Reauthorization of the disposal site is needed because the site is expected to reach the initial estimated soft-trigger volume threshold of 9.0 million cubic yards (cy) in dredging year (DY) 2009 or 2010.

DMMP Overview

The DMMP (formerly PSDDA) was formally implemented in December 1988 with the U.S. Army Corps of Engineers (USACE)/U.S. Environmental Protection Agency (U.S. EPA) Record of Decision finalizing the Phase I Central Puget Sound Final Environmental Impact Statement (FEIS). The DMMP process identified eight open-water disposal sites in Puget Sound, through a 4.5 year, $4.5 million, intense, public interest-stakeholder process. It developed vigorous Site Management Plans, and state-of-the art evaluation procedures for evaluating dredged material suitability for unconfined-open-water disposal, and for conducting environmental monitoring. Each dredging project contemplating open-water disposal undergoes a rigorous sediment testing process. The monitoring conducted at each non-dispersive site provides a direct feedback loop on the adequacy of program characterization of dredging projects documented in suitability determinations[2]. To date, monitoring conducted at the Commencement Bay site and at the other four non-dispersive sites has confirmed the adequacy of DMMP program evaluation procedures in characterizing dredging projects. The monitoring plan and evaluation procedures for DMMP testing are updated annually as necessary through the Sediment Management Annual Review Meeting (SMARM) to keep the program current based on the best-available-science.

Commencement Bay Disposal Site

The disposal site was formally established in 1988 (FEIS) and is located in a relatively flat, non-dispersive area in the central portion of Commencement Bay, with water depths varying from 540 to 560 feet. The site was selected to avoid significant adverse effects to the aquatic and human environment per NEPA guidelines, while meeting the in-water disposal needs for dredging in the vicinity of Tacoma, WA.

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[1]The DMMP implementation focus (1988-1995) was initially restricted to Puget Sound with the Puget Sound Dredged Disposal Analysis (PSDDA) Program. The geographic focus expanded to Coastal Washington in 1995 and to the Washington side of the Columbia River in 1998. For the sake of consistency, the PSDDA acronym is replaced with DMMP throughout this document. References to PSDDA indicate a Puget Sound restricted focus.

[2] Technical Memorandum summarizing the 4-agency (USACE, EPA, Ecology, WDNR) consensus determination on the sediment testing data collected for a given dredged material project for disposal at a DMMP open-water disposal site (http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=SDM`S_BY_YEAR).

Biological resource evaluations were conducted in 1986 to help guide the selection of the disposal site. A Benthic Resource Assessment Technique (BRAT) evaluation, which estimates the relative amount of trophic support of a given soft-bottom habitat, determined that the selected disposal site provided less trophic support than an alternative site to demersal, bottom-feeding fishes (Clark 1986). Bottom trawl surveys of the site also found low populations of shrimp and bottom fish, and Dungeness crabs were absent. The site was determined to be of little to no commercial value to fishermen (e.g., both tribal and non-tribal), making it an ideal location for open water disposal (Dinnel et al. 1986).

Environmental Monitoring

Environmental monitoring of the disposal site is conducted to ensure compliance with federal Clean Water Act Section 404(b)(1) guidelines, to verify that unacceptable adverse effects have not occurred within or beyond the disposal site, and to assure that dredged material disposed at the sites remains within the disposal site boundary. The overall monitoring program (SAIC 2007) addresses three primary questions related to potential impacts from dredged material disposal:

1. Does the deposited dredged material stay on site?
2. Is the biological effects condition for site management (i.e., DMMP-defined site condition II [PSDDA 1988b]) exceeded at the site because of dredged material disposal?
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?

Six testable null hypotheses were developed to clearly evaluate the three monitoring questions (Table ES–1). A null hypothesis identifies the specific effect to be monitored and defines the level that is considered to warrant additional site investigation and/or management (PSDDA 1988a). Five types of data are collected to address the hypotheses including physical measurements (sediment vertical profiling system [SVPS] photography and bathymetric surveys), sediment chemistry, sediment toxicity, tissue chemistry, and infaunal community structure.

A baseline survey was conducted in 1988 to document existing conditions at the disposal site, and surrounding area. Since that time, a cumulative total of 7,763,912 cy of dredged material has been disposed at the site. Eight environmental monitoring surveys have been conducted, including four full monitoring events (1995, 2001, 2003, and 2007), two partial events (1996 and 2004), and two physical monitoring events (1998 and 2005). A summary of findings for each monitoring event, within the context of the evaluation framework is provided in Table ES–2.

Conclusions

The DMMP monitoring program conducted at the disposal site between 1988 and 2007 has confirmed that dredged material disposal has had minimal impact on the physical and biological resources in Commencement Bay. Thin layers of dredged material have been measured in offsite areas, but the benthic habitat and resources have not been negatively affected. SVPS monitoring has found well developed benthic communities and undisturbed benthic habitat conditions during post-monitoring surveys in these areas. With the exception of elevated phenol concentrations measured during the 2003 survey, sediment chemistry has been below DMMP screening levels (SLs) and Sediment Quality Standards (SQS) criteria, and chemicals of concern have shown a general decreasing trend over time, which reflects in part the disposal of dredged material of relatively high sediment quality. The elevated phenol concentrations were short-lived and are likely related to natural sources. No sediment toxicity has been observed onsite during the site monitoring investigations, which is consistent with the DMMP testing conducted on all dredged material evaluated as suitable for open-water disposal at a DMMP non-dispersive site. Additionally, the site was shut down for disposal during DY 2002, to allow DMMP agencies to fully evaluate data collected from special studies conducted during 2001 in offsite areas within the observed thin layer of dredged material. They included toxicity testing, benthic infaunal analyses, and sediment chemistry stations, as well as analysis of archived samples at benchmark stations. The results of the special study found no elevated chemistry or toxicity, and benthic infaunal abundances were similar to other offsite areas (e.g., transect and benchmark stations). Offsite tissue chemistry and the benthic infauna community have not been altered due to dredged material disposal.

Table ES–1. The DMMP Monitoring Framework

Question	Hypothesis	Monitored Variable	Interpretative Guidelines	Action Item (When exceedances noted)1
1. Does the deposited dredged material stay on site?	1. Dredged material remains within the site boundary.	Sediment Vertical Profiling System (SVPS) Onsite and Offsite	Dredged material layer is greater than 3 cm at the perimeter stations.	Further assessment is required to determine full extent of dredged material deposit.
	2. Chemical concentrations do not measurably increase over time due to dredged material disposal at offsite stations.	Sediment Chemistry Offsite	Washington State Sediment Quality Standards and Temporal analysis	Post-disposal benchmark station chemistry is analyzed and compared with appropriate baseline benchmark station data.
2. Are the biological effects conditions for site management (DMMP-defined site condition II) exceeded at the site due to dredged material disposal? (PSDDA 1988b)	3. Sediment chemical concentrations at the onsite monitoring stations do not exceed the chemical concentrations associated with DMMP site condition II guidelines due to dredged material disposal.	Sediment Chemistry Onsite	Onsite chemical concentrations are compared to DMMP maximum levels.	DMMP agencies may seek adjustments of disposal guidelines and compare post-disposal benchmark chemistry with appropriate baseline benchmark station data.
	4. Sediment toxicity at the onsite stations does not exceed the DMMP site condition II biological response guidelines due to dredged material disposal.	Sediment Bioassays Onsite	DMMP Bioassay Guidelines (Section 401 Water Quality Certification)	Benchmark station bioassays are performed (if archived after monitoring) and compared with baseline benchmark bioassay data.
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?	5. No significant increase due to dredged material disposal has occurred in the chemical body burden of benthic infauna species collected down current of the disposal site.	Tissue Chemistry Transect	Guideline Values: Metals: 3x the baseline concentrations Organics: 5x the baseline concentrations	Compare post-disposal benchmark tissue chemistry with baseline benchmark tissue chemistry data.
	6. No significant decrease due to dredged material disposal has occurred in the abundance of dominant benthic infaunal species collected down current of the disposal site.	Infaunal Community Structure Transect	Guideline Values: Abundance of major taxa < ½ baseline macrobenthic infauna abundances.	Compare post-disposal benchmark benthic data with baseline benchmark data.

1. To determine if observed changes in chemical conditions or infaunal benthos are due to dredged material disposal, data from the benchmark stations are considered. All decisions are subject to DMMP agency review and best professional judgment.

Table ES–2. Summary of Commencement Bay Site Monitoring Findings 1988–2007

Survey	DY Specific Disposal Volume (cy)	Cumulative Volume (cy)	Hypothesis No. 1 (Dredged Material Within Site Boundaries?)	Hypothesis No. 2 (Offsite Chemistry Within SQS?)	Hypothesis No. 3 (Onsite Chemistry Below DMMP MLs?)	Hypothesis No. 4 (Onsite Toxicity passes DMMP Guidelines?)	Hypothesis No. 5 (Tissue Chemistry Passes DMMP Guidelines?)	Hypothesis No. 6 (Benthic Infauna Abundance Passes DMMP Guidelines?)
1988 Baseline Survey	0	0	--	Yes	Yes	No[1]	NA	NA
1995 Full Monitoring	290,857	308,405	Yes	Yes	Yes	Yes	Yes	Yes
1996 Partial Monitoring	460,684	769,089	Yes	Yes	Yes	Yes	--	--
1998 Physical Monitoring	693,540	1,462,629	No	Yes	--	--	--	--
2001 Full Monitoring	265,867	2,762,591	No	Yes	Yes	Yes	Yes	Yes
2003 Tiered-Full Monitoring	710,675	3,473,266	No	No[2]	Yes	Yes	Yes	Yes
2004 Partial Monitoring	1,205,993	4,679,259	No	Yes	Yes	Yes	--	--
2005 Physical Monitoring	949,399	5,628,658	No	Yes (SVOC Only)	--	--	--	--
2007 Full Monitoring	1,324,254	7,763,912	Yes	Yes	Yes	Yes	Yes	Yes

NA Not applicable. Baseline values used for guideline interpretation.
1. The 1988 baseline amphipod test did not pass the DMMP interpretive guideline for one of two reference sediment evaluations.
2. The SQS was exceeded for 1,2,4-trichlorobenzene, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and phenol.

1.0 Introduction

This document provides a review and data summary of environmental monitoring studies conducted at the Commencement Bay non-dispersive open-water dredged material disposal site from 1988 through 2007. This review is being conducted in support of an environmental assessment (EA) pursuant to the National Environmental Policy Act (NEPA), involving future management of dredged material disposal at the Commencement Bay open-water site.

The Commencement Bay dredged material disposal site was established in 1988 by the Puget Sound Dredged Disposal Analysis (PSDDA) program (1988 Phase I NEPA/SEPA FEIS) after conducting studies for central Puget Sound sites (PSDDA 1988a-d). The Commencement Bay site is one of five sites in Puget Sound approved for non-dispersive open-water dredged material disposal (Figure 1–1). The DMMP is conducting a NEPA/SEPA review of Commencement Bay site because the site is expected to reach the initial estimated soft-trigger volume threshold of 9.0 million cubic yards (cy) in dredging year (DY) 2009 or 2010 (ending on June 15, 2009 and June 15, 2010, respectively) (Table 1–1). Although beneficial use of dredged material is preferred when such uses are available and feasible, evaluating the existing site to accommodate additional dredged material is necessary to meet long-term disposal needs of regional dredging stakeholders from navigation dredging, recreation, public access, marinas, and Port of Tacoma construction activities in Commencement Bay.

With the geographic expansion of PSDDA oversight into Washington water bodies beyond Puget Sound, the program name has changed from PSDDA to the Dredged Material Management Program (DMMP). The DMMP is responsible for the environmental management of dredged material in Washington State and plans to examine all reasonable alternatives regarding future management of dredged material disposal at the Commencement Bay site. The DMMP is a federal and state interagency partnership consisting of the U.S. Army Corps of Engineers (USACE), Seattle District; the Washington State Department of Natural Resources (WDNR); the Washington State Department of Ecology; and the U.S. Environmental Protection Agency, Region 10 (USEPA).

1.1 DMMP Commencement Bay Disposal Site

The DMMP Commencement Bay disposal site is located in a relatively flat, non-dispersive area in the central portion of Commencement Bay, with water depths varying from 540 to 560 feet with northwest to southeast currents (PSDDA 1988d) (Figure 1–2). The site is an ellipsoid in shape and covers approximately 310 acres. The site was selected to avoid significant adverse effects to the aquatic and human environment per NEPA guidelines, while meeting the in-water disposal needs for dredging in the vicinity of Tacoma, WA.

The DMMP identified non-dispersive dredged material disposal sites in Puget Sound by conducting a depositional analysis and sediment characterization study of the proposed disposal sites. The DMMP designated a site as non-dispersive if the peak one percent current speed was less than 25 centimeters per second, surface sediments were fine-grained (e.g., silts and clays), and sediments were statistically elevated ($p=0.05$) in water content, volatile solids, and biochemical oxygen demand (BOD) compared to other areas of similar water depth (PSDDA 1988d). Elevated levels of volatile solids and BOD are associated with higher levels of organic matter, which indicate an area of deposition. The depositional analysis study found that the Commencement Bay site met these non-dispersive criteria. The median sediment grain size was coarse to fine silt, with the highest levels of clay (15 percent) at the center of the site. Volatile solids (>4 percent), BOD (ranging from 892 to 1338 mg/kg dry weight [DW]), and water content (50 percent) were found to be statistically elevated compared to areas of similar water depth in Puget Sound (PSDDA 1988d).

Effects-based environmental management and monitoring for the DMMP disposal sites were defined as part of the 1988 Final Environmental Impact Statement (FEIS) and are described in Section 1.2. Environmental monitoring of the Commencement Bay site may be triggered following the disposal of 500,000 cy of dredged material during any given DY (Brenner 2002). The DMMP agencies review the pertinent information relative to dredging projects that dispose material at the site during any given dredging year, especially the sediment quality data pertaining to each individual project, and that information helps to inform the DMMP decision on whether monitoring is required or not using best-professional-judgment.

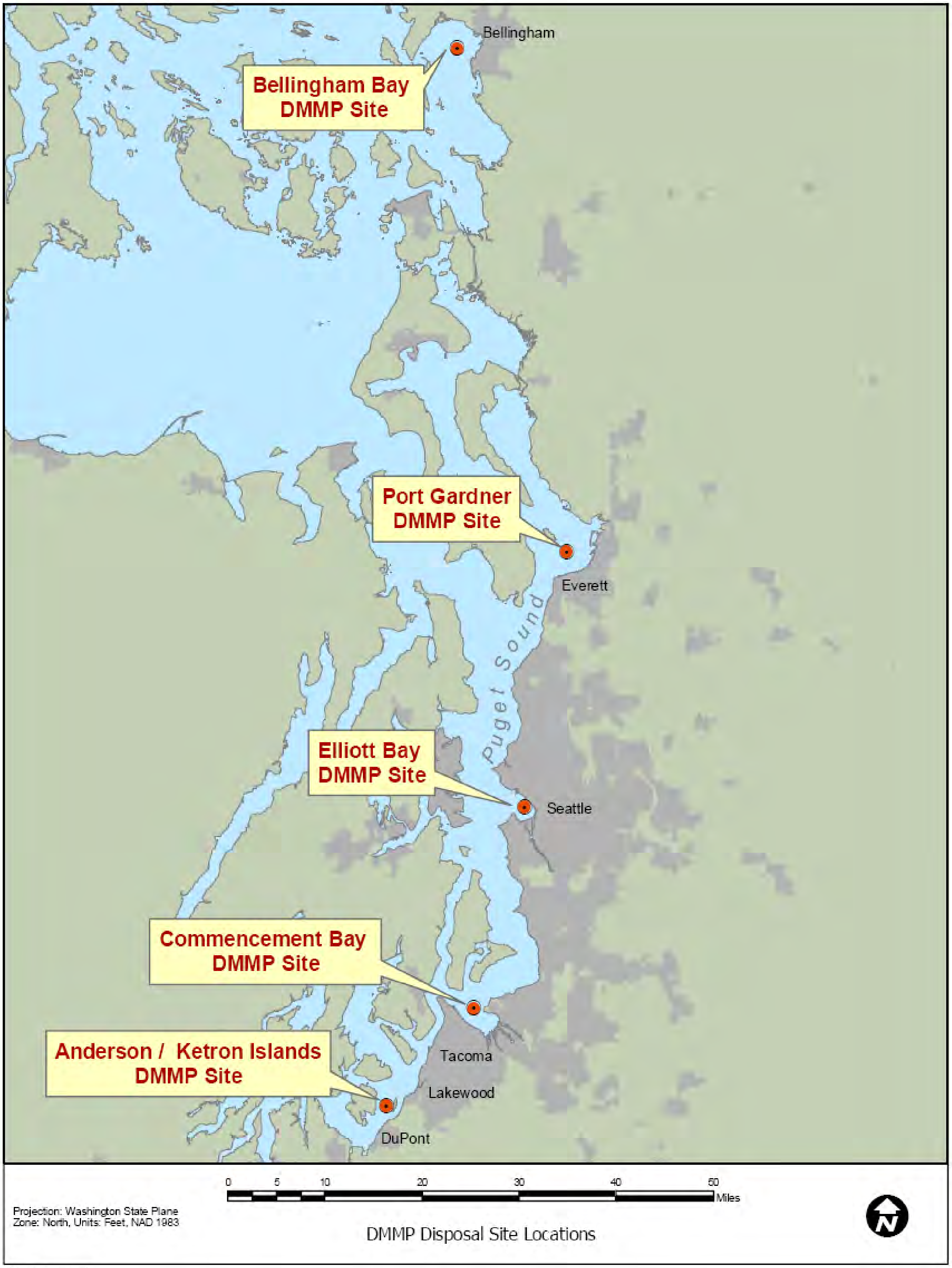

Figure 1-1. DMMP Non-Dispersive Disposal Sites in Puget Sound (Map from SAIC 2007)

Table 1-1. Commencement Bay Disposal Site Dredged Material Disposal and Monitoring History

Dredging Year	DY specific Disposal Volume (cy)	Cumulative Volume (cy)	Disposal Mound Height (feet)	Monitoring
1988	0	0	0	Pre-Disposal Site Baseline
1989	6,648	6,648	--	
1990	0	6,648	--	
1991	10,900	17,548	--	
1992	0	17,548	--	
1993	0	17,548	--	
1994	0	17,548	--	
1995	290,857	308,405	--	Full Monitoring
1996	460,684	769,089	--	Partial Monitoring
1997	0	769,089	--	
1998	693,540	1,462,629	--	SVPS
1999	140,319	1,602,948	--	
2000	893,776	2,496,724	--	
2001	265,867	2,762,591	48	Full Monitoring, Bathymetry
2002	0 (Site Closure)	2,762,591	--	
2003	710,675	3,473,266	--	Tiered-Full Monitoring
2004	1,205,993	4,679,259	80	Partial Monitoring, Bathymetry
2005	949,399	5,628,658	--	Sediment Vertical Profiling System (SVPS), Special Study (Phenol)
2006	811,000	6,439,658	112.6	MBS
2007	1,324,254	7,763,912	131.6	Full Monitoring, Resource Evaluation, MBS, Dioxin Baseline

– Not measured

MBS Multi-beam Bathymetry Survey

Dredging Year Period of June 16 from the previous year to June 15 of the current year in which dredged material was taken to the disposal site (e.g., 2007 = June 16, 2006 – June 15, 2007).

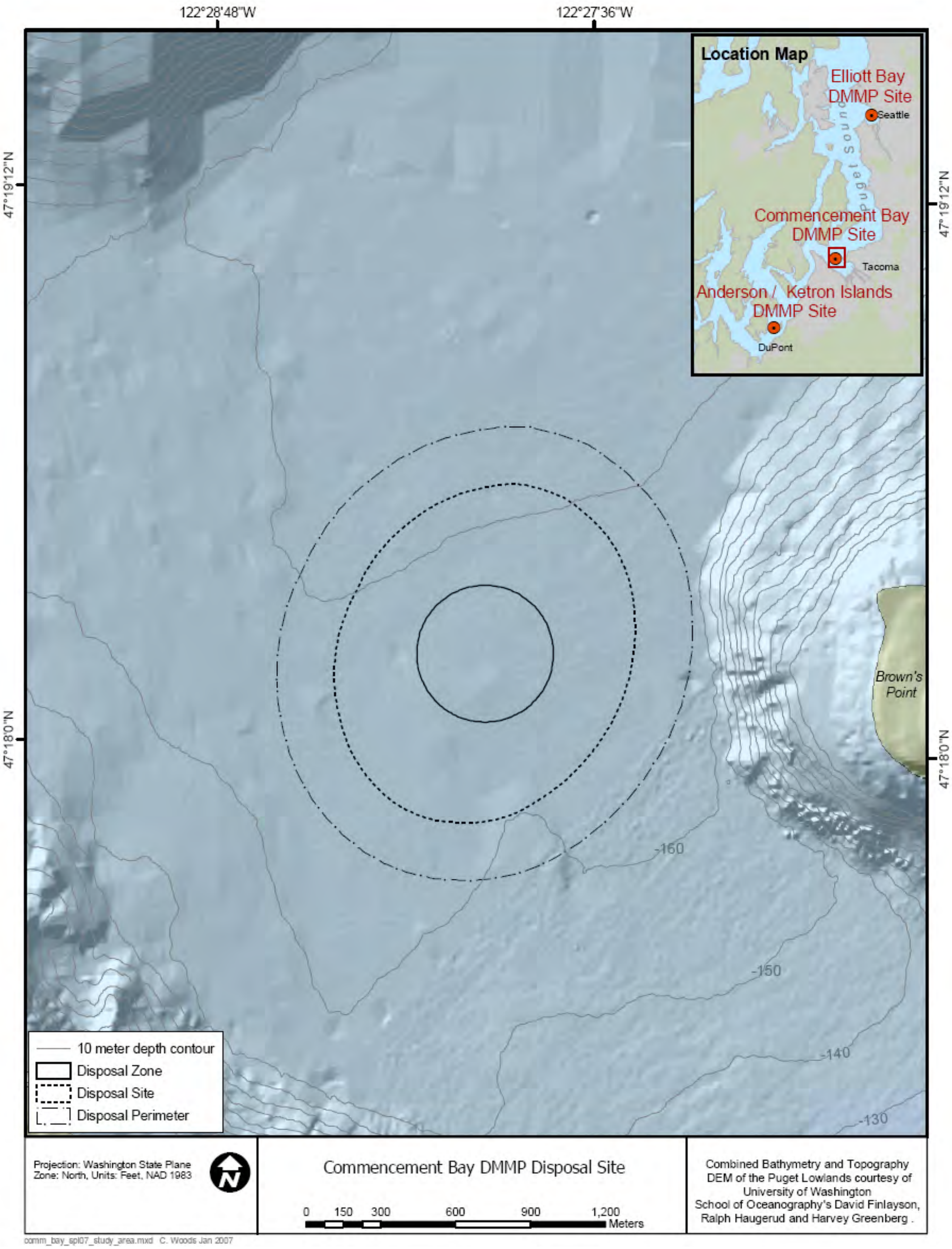

Figure 1-2. Commencement Bay DMMP Disposal Site

1.2 DMMP Monitoring Program[3]

An important objective of the DMMP program is to ensure that dredged material disposal in Puget Sound does not substantively harm the aquatic or human environment. The environmental monitoring plans for unconfined, open-water, dredged material disposal sites in Puget Sound were first published in 1988 for Central Puget Sound (Management Plans Technical Appendix, Exhibit 1; PSDDA 1988a), and in 1989 for North and South Puget Sound (Management Plan Report, Exhibit D; PSDDA 1989a). The DMMP is the only program nationwide that conducts routine disposal site monitoring on an annual basis. The latest environmental monitoring guidance is summarized in the Updated Environmental Monitoring Plan (UEMP) Unconfined, Open-Water, Dredged Material Disposal Sites, Non-Dispersive PSDDA Sites in Puget Sound (SAIC 2007), which incorporates all site management plan refinements from 1988–2007. The monitoring plans were designed to ensure compliance with federal Clean Water Act Section 404(b)(1) guidelines, to verify that unacceptable adverse effects have not occurred within or beyond the disposal site, and to assure that dredged material disposed at the sites remains within the disposal site boundary. The monitoring provides direct and objective feedback on the adequacy of technical evaluations of dredged material as documented in suitability determinations for individual dredging projects within the DMMP (http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=DMMO&pagename=SDM`S_BY_YEAR). The overall monitoring program design remains as initially conceived and addresses three primary questions related to potential impacts from dredged material disposal:

1. Does the deposited dredged material stay on site?
2. Is the biological effects condition for site management (i.e., DMMP-defined site condition II[4] [PSDDA 1988b]) exceeded at the site because of dredged material disposal?
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?

To clearly evaluate the monitoring questions, testable null hypotheses were developed for each concern. A null hypothesis identifies the specific effect to be monitored and defines the level that is considered to warrant additional site investigation and/or management (PSDDA 1988a). Use of null hypotheses allows the environmental questions to be framed in such a way that they can be tested using data gathered during monitoring and allows for clear interpretation of the monitoring results. Six hypotheses were developed to address the three questions and are presented in Table 1–2.

The DMMP monitoring framework includes a sampling design that monitors seven station types over time at and in the vicinity of the disposal site. In addition, an eighth station type (offsite reference station) is included to provide a non-anthropogenically affected sediment control (e.g., Carr Inlet, with similar sediment grain sizes, etc. to tested onsite sediment) for sediment toxicity testing. The eight station types and their purposes are described in Table 1–3. Station types for a typical monitoring event at Commencement Bay are displayed in Figure 1–3.

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3 The Puget Sound Dredged Disposal Analysis Program was renamed the Dredged Material Management Program (DMMP) following the expansion of the geographic focus beyond Puget Sound to Grays Harbor and Willapa Bay in 1995, and the Lower Columbia River in 1998. Therefore, references to DMMP or PSDDA used throughout the text are interchangeable.

4 Site condition II is defined as having minor adverse effects on biological resources due to sediment chemicals. Some species may be affected within the site from long-term exposure to sediment chemicals (only sublethal effects are anticipated) (PSDDA 1988c).

Five types of data are collected in order to address the hypotheses of the DMMP monitoring framework and each data type is briefly described below:

1. Physical data (via Sediment Vertical Profiling System (SVPS) photography)
2. Sediment chemistry
3. Sediment toxicity (bioassay testing)
4. Tissue chemistry
5. Infaunal community structure

Table 1-2. The DMMP Monitoring Framework

Question	Hypothesis	Monitored Variable	Interpretative Guidelines	Action Item (When exceedances noted)[1]
1. Does the deposited dredged material stay on site?	1. Dredged material remains within the site boundary.	Sediment Vertical Profiling System (SVPS) Onsite and Offsite	Dredged material layer is greater than 3 cm at the perimeter stations.	Further assessment is required to determine full extent of dredged material deposit.
	2. Chemical concentrations do not measurably increase over time due to dredged material disposal at offsite stations.	Sediment Chemistry Offsite	Washington State Sediment Quality Standards and Temporal analysis	Post-disposal benchmark station chemistry is analyzed and compared with appropriate baseline benchmark station data.
2. Are the biological effects conditions for site management (DMMP-defined site condition II) exceeded at the site due to dredged material disposal? (PSDDA 1988b)	3. Sediment chemical concentrations at the onsite monitoring stations do not exceed the chemical concentrations associated with DMMP site condition II guidelines due to dredged material disposal.	Sediment Chemistry Onsite	Onsite chemical concentrations are compared to DMMP maximum levels.	DMMP agencies may seek adjustments of disposal guidelines <u>and</u> compare post-disposal benchmark chemistry with appropriate baseline benchmark station data.
	4. Sediment toxicity at the onsite stations does not exceed the DMMP site condition II biological response guidelines due to dredged material disposal.	Sediment Bioassays Onsite	DMMP Bioassay Guidelines (Section 401 Water Quality Certification)	Benchmark station bioassays are performed (if archived after monitoring) and compared with baseline benchmark bioassay data.
3. Are unacceptable adverse effects due to dredged material disposal occurring to biological resources off site?	5. No significant increase due to dredged material disposal has occurred in the chemical body burden of benthic infauna species collected down current of the disposal site.	Tissue Chemistry Transect	Guideline Values: Metals: 3x the baseline concentrations Organics: 5x the baseline concentrations	Compare post-disposal benchmark tissue chemistry with baseline benchmark tissue chemistry data.
	6. No significant decrease due to dredged material disposal has occurred in the abundance of dominant benthic infaunal species collected down current of the disposal site.	Infaunal Community Structure Transect	Guideline Values: Abundance of major taxa < ½ baseline macrobenthic infauna abundances.	Compare post-disposal benchmark benthic data with baseline benchmark data.

1. To determine if observed changes in chemical conditions or infaunal benthos are due to dredged material disposal, data from the benchmark stations are considered. All decisions are subject to DMMP agency review and best professional judgment.

Table 1-3. Station Types and Purpose for the DMMP Sampling Design

Station	Designation Letter	Location	Purpose
Zone	Z	Within disposal target zone.	Assess sediment chemistry and toxicity of dredged material deposited in the target area (Question 2).
Site	S	Within the site boundary but outside of the target zone.	In conjunction with zone data, site station sediment chemistry and toxicity are used to evaluate Question 1.
Perimeter	P	Located 0.125 nautical mile from the site boundary.	Physical and chemical data are obtained to determine if dredged material is present beyond the site boundary and document the chemical character of sediments outside the site boundary (Question 1).
Transect	T	Situated along a radial transect that extends outward from the perimeter line. Located in the direction of dredged material transport.	Sampled for benthic infauna abundance and infauna tissue contaminant body burden to evaluate biological resource impacts off site (Question 3).
Benchmark	B	Located in the vicinity of the disposal site, but beyond the region affected by disposal activity.	Used to identify potential changes in sediment quality that may be unrelated to dredged material disposal. Data are evaluated only if site, perimeter, or transect data indicate that conditions at or adjacent to the site have changed relative to baseline conditions and to test hypotheses that observed changes are due to dredged material disposal.[1] Data may be used to evaluate hypotheses 2 through 6.
Central Transect	C	Situated along two perpendicular lines that bisect the disposal site and may extend beyond its boundaries.	Used for physical measurements to map the post-disposal distribution of dredged material (Question 1).
Floating	F	Located in various locations within and outside of the disposal site.	Used to help delineate the extent of the dredged material deposit. Stations are sampled for sediment and benthic infauna analysis, if necessary, to assess dredged material impacts outside of the disposal site.
Reference	R	Located in areas documented to be free of potential sources of contamination (e.g., Carr Inlet). Location is selected on the basis of grain size comparability with the bioassay test sediments.	Sediments used as a control for physical effects in toxicity testing.

1. All data types (physical, sediment chemistry, tissue chemistry, sediment toxicity, and benthic infauna) may be collected. Benchmark sediments are generally archived until disposal site analyses indicate benchmark data are needed for full evaluation. However, benchmark chemical analyses for volatile organics, mercury, sulfides, and ammonia are conducted in conjunction with disposal site sediments due to holding time constraints. In addition, because the freezing of bulk sediment samples may result in structural changes in the sediment, which will alter the availability of tributyltin (TBT), samples to be held for future TBT analysis should have interstitial water extracted prior to freezing (Hoffman 1998).

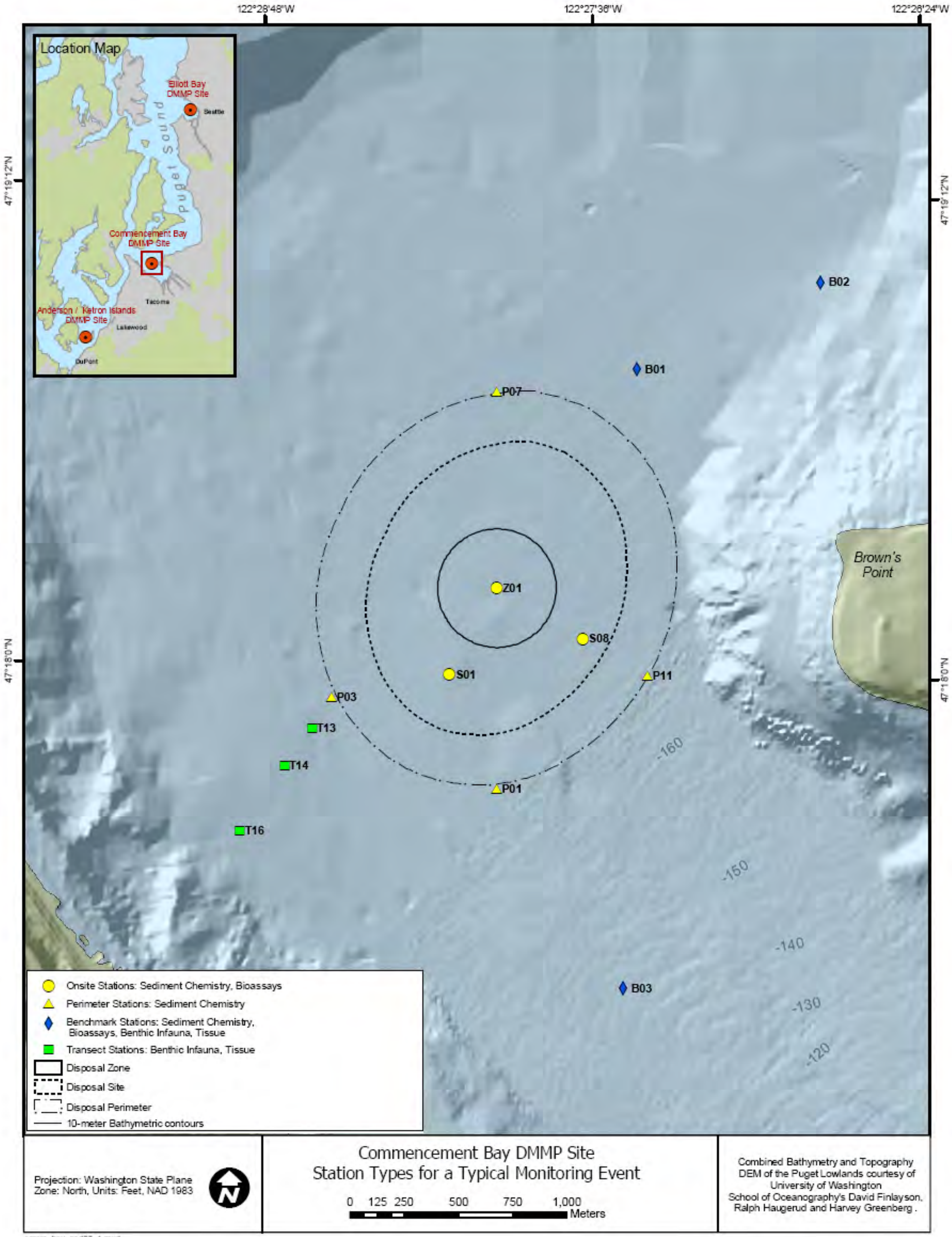


Figure 1-3. Station Types for a Typical Monitoring Event at the Commencement Bay DMMP Disposal Site

1.2.1 Sediment Vertical Profiling System

Physical monitoring data are collected using SVPS photography, also known as Sediment Profile Image photography. SVPS photographs the profile image of the sediment surface, to a depth of up to 20 cm (Figure 1–4). The SVPS 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, and roughness of the surface boundary layer. Biological parameters are also measured, including the depth of the apparent Redox Potential Discontinuity (RPD), and infaunal successional stage (Rhoads and Germano 1982, 1986). The apparent RPD depth estimates the depth of oxygenation in the upper sediment column and can be considered the biological mixing depth by infaunal organisms. Benthic infaunal communities generally follow a three-stage succession following a disturbance of the seafloor (Figure 1–5) (Pearson and Rosenberg 1978; Rhoads and Germano 1986). Stage I infauna typically colonize the sediment surface soon after disturbance (e.g., following dredged material disposal). These opportunistic organisms may consist of small, tubicolous, surface-dwelling polychaetes. Stage II organisms are typically shallow-dwelling bivalves or tube-dwelling amphipods. Stage II communities are considered a transitional community before reaching Stage III, the high-order successional stage consisting of long-lived, infaunal deposit-feeding organisms. Stage III invertebrates may feed at depth in a head-down orientation and create distinctive feeding voids visible in SVPS images (Figure 1–6). Figure 1–7 illustrates the benthic community stage distribution at the Commencement Bay site during the 2007 monitoring effort and demonstrates the presence of Stage III invertebrates at most onsite and offsite stations.

The Organism Sediment Index (OSI), a numerical index to characterize habitat quality, is also calculated (Table 1–4; Rhoads and Germano 1986). The lowest value (-10) is given to benthic habitats which have low or no dissolved oxygen in the overlying water, no apparent macrofaunal life, and methane gas present in the sediment. The highest value (+11) is given to an aerobic bottom with a deep apparent RPD, evidence of a mature macrofaunal assemblage, and no apparent sedimentary methane. Figure 1–8 illustrates the relative high OSI noted within and outside the Commencement Bay site during the most recent 2007 monitoring effort.

In the DMMP program, the primary function of SVPS imaging is to determine the post-disposal distribution of dredged material at the sites (i.e., dredged material stays within the disposal site boundary; hypothesis 1). In addition, the SVPS data help ensure that onsite sediment samples are collected from dredged material and that the offsite/transect samples are located in the direction, or most likely direction, of offsite dredged material movement. The chemical and biological inferences made from the SVPS images are used to supplement the sediment chemical and biological data. Figure 1–9 illustrates the dredged material footprint observed during the 2007 monitoring effort at the Commencement Bay site.

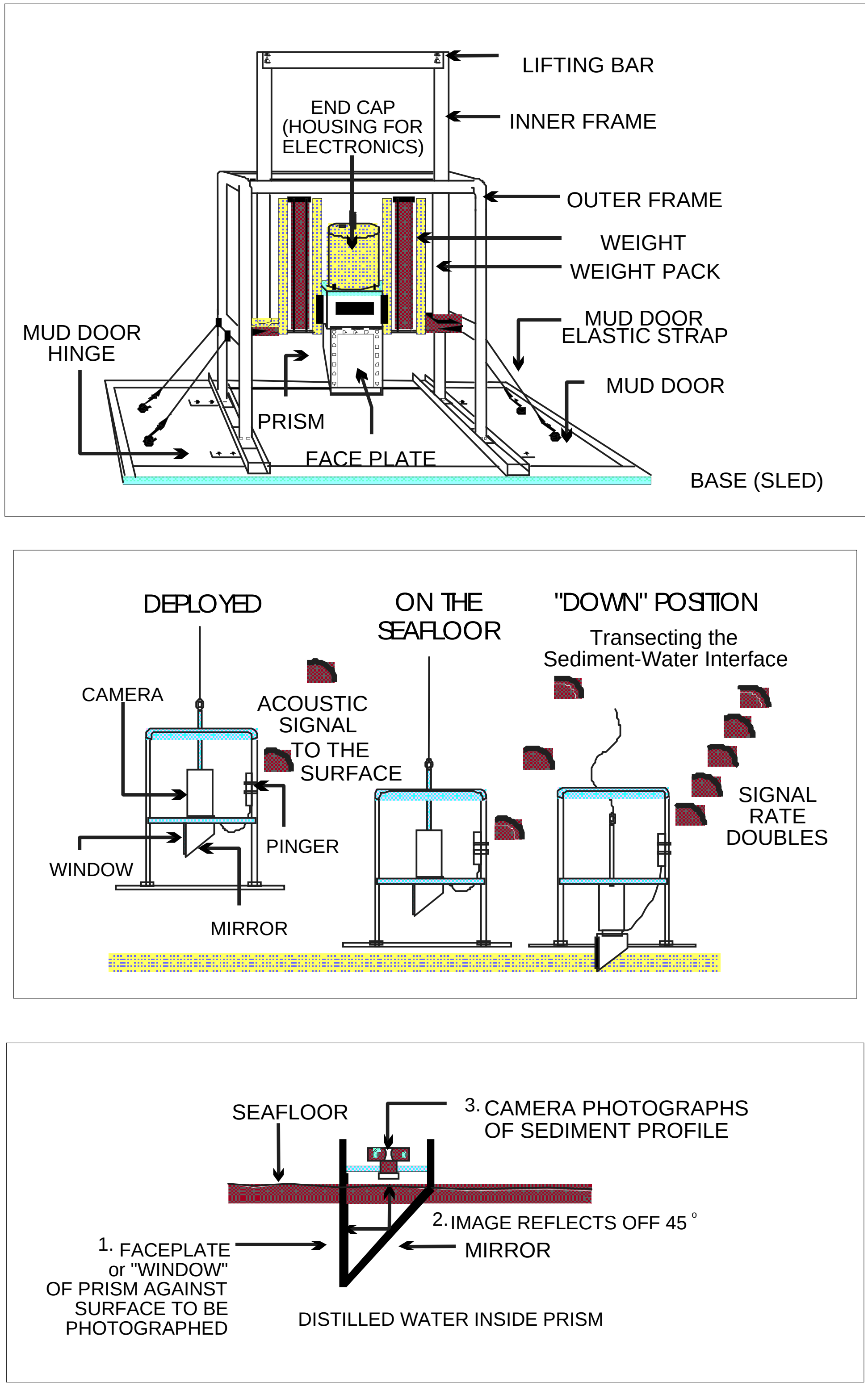
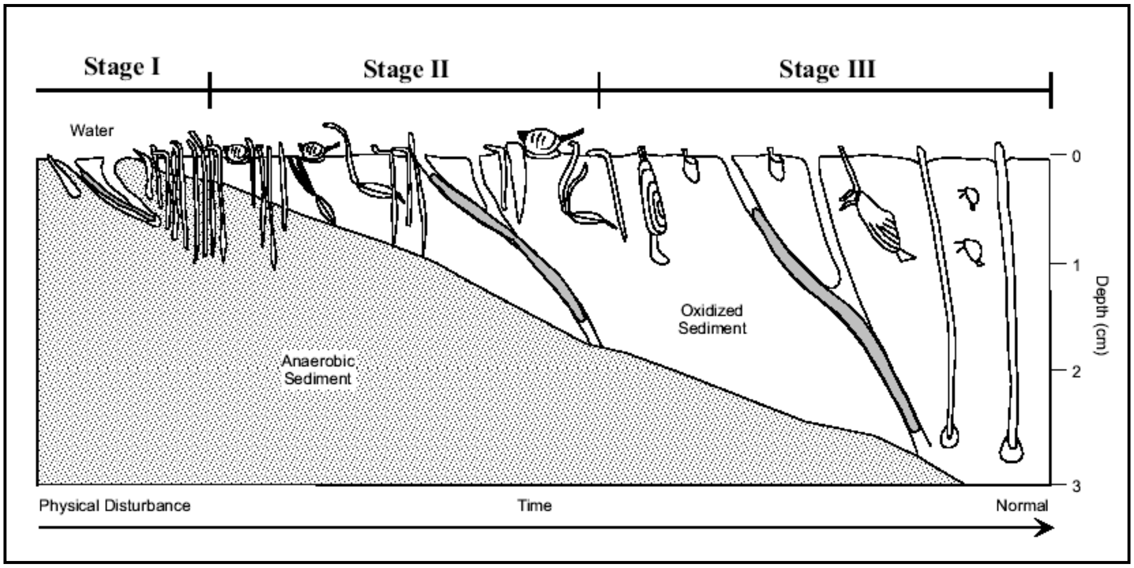


Figure 1-4. Schematic Diagram of Sediment-Profile Camera and Sequence of Operation on Deployment



Source: Rhodes and Germano (1986), modified from Pearson and Rosenberg (1978)

Figure 1-5. Idealized Development of Infaunal Succession Stages Over Time Following a Physical Disturbance

Table 1-4. Calculation of the Organism-Sediment Index

Choose One Value:		
	Mean RPD Depth Classes	**Index Value**
	0.00 cm	0
	> 0 - 0.75 cm	1
	0.76 - 1.50 cm	2
	1.51 - 2.25 cm	3
	2.26 - 3.00 cm	4
	3.01 - 3.75 cm	5
	> 3.75 cm	6
Choose One Value:		
	Successional Stage	**Index Value**
	Azoic	- 4
	Stage I	1
	Stage I - II	2
	Stage II	3
	Stage II - III	4
	Stage III	5
	Stage I on III	5
	Stage II on III	5
Choose One or Both if Appropriate:		
	Chemical Parameters	**Index Value**
	Methane Present	- 2
	No/Low Dissolved Oxygen	- 4
Organism-Sediment Index =		**Range: - 10 + 11**

CBP06 **CBF63**

Figure 1-6. SVPS Images from Commencement Bay Perimeter Stations CBP06 and CBP10 during the 2004 Monitoring Survey Both images show feeding voids indicative of Stage III infauna. A *Molpadia intermedia* sea cucumber, a common head-down deposit feeder in Commencement Bay, is visible at station CBP06 (arrow).

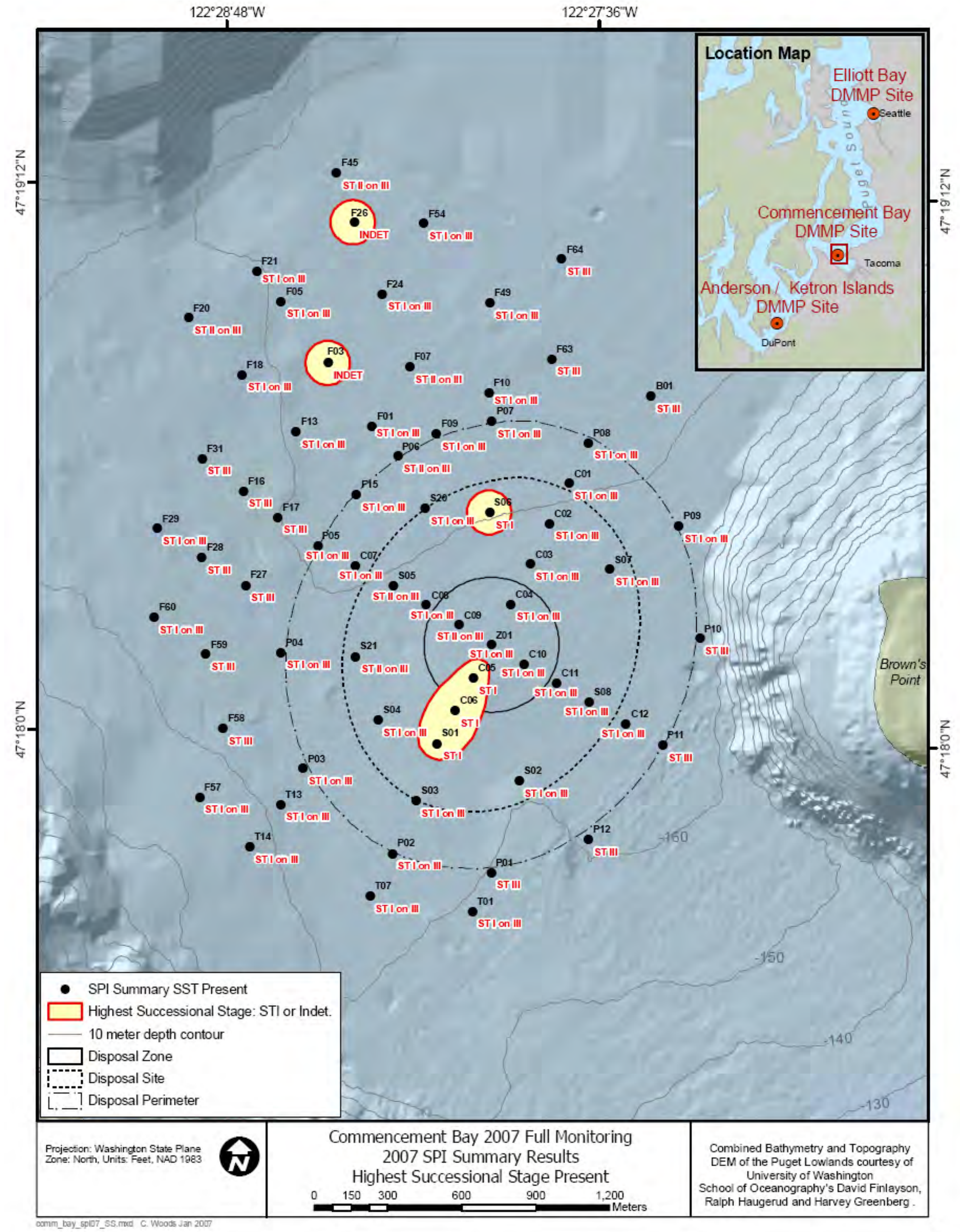


Figure 1-7. 2007 Infaunal Successional Stage Distribution (SAIC 2008)

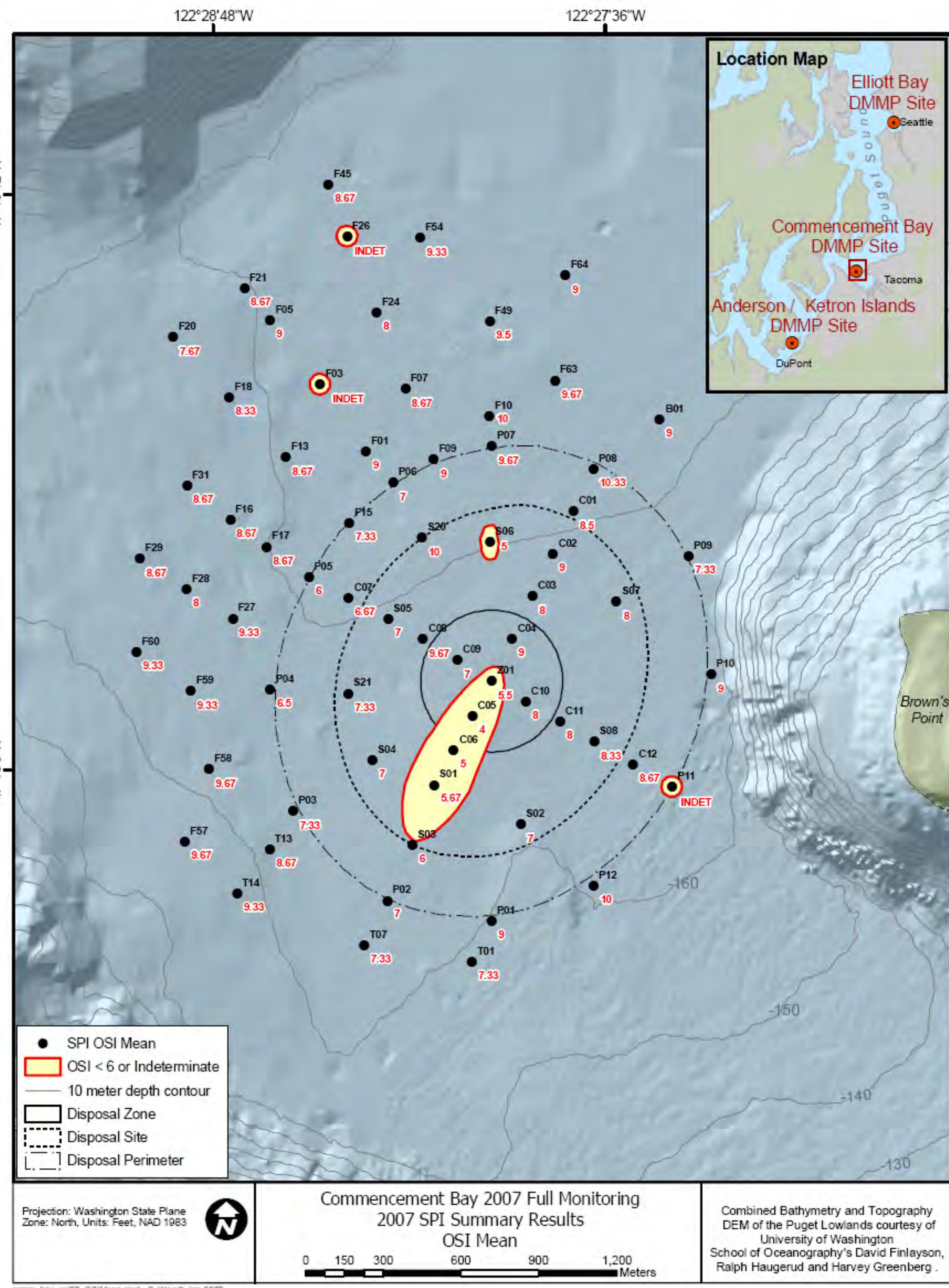


Figure 1-8. 2007 OSI Distribution (SAIC 2008)

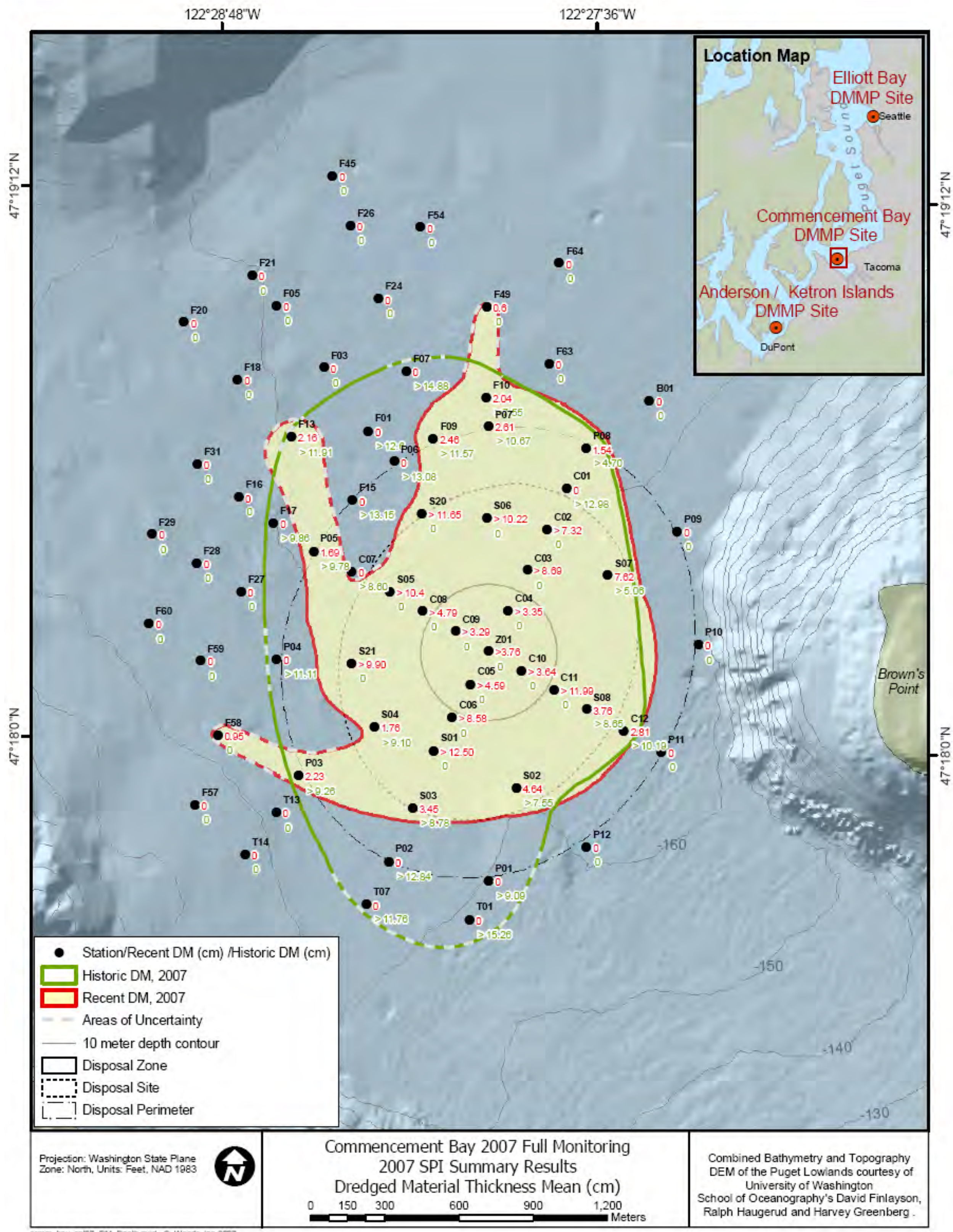


Figure 1-9. 2007 Commencement Bay Dredged Material Footprint (SAIC 2008)

1.2.2 Sediment Chemistry

Concentrations of the DMMP chemicals of concern (COC) and conventional parameters (total solids, total volatile solids, total organic carbon [TOC], total sulfides, ammonia, and grain size) are measured in sediments collected at the onsite (zone and site stations), perimeter, and benchmark stations. Selected conventional parameters (grain size and TOC) are analyzed at transect stations to help evaluate benthic infaunal abundance measurements (Table 1–3). The current COC and conventional parameters list and associated SLs, bioaccumulation triggers (BTs), and maximum levels (MLs) are presented in the UEMP (SAIC 2007) and summarized in Table 1–5. The full COC list was updated following the 2007 Sediment Management Annual Review Meeting (SMARM).

Perimeter chemistry data are used to address hypothesis 2 (i.e., chemical concentrations at perimeter stations do not increase over time due to dredged material disposal). Onsite chemistry is used to monitor hypothesis 3 (i.e., onsite sediment chemistry does not exceed DMMP site condition II guidelines due to dredged material disposal). If unacceptable changes in perimeter or onsite chemistry are observed, benchmark station chemistry is evaluated to assess whether the change is due to disposal activity or to some other factor (e.g., regional change in conditions).

1.2.3 Sediment Toxicity

Bioassays are conducted with sediments collected from onsite stations, benchmark stations, and the appropriate reference sediment site to assess sediment toxicity. Three bioassays are included in the DMMP program: a 10-day amphipod acute test (either *Eohaustorius estuarius, Rhepoxynius abronius*), a 48-hour sediment larval test (utilizing either bivalve larvae: *Mytilus galloprovincialis* or echinoderm larvae: *Dendraster excentricus*), and the 20-day *Neanthes* growth test. Onsite sediment bioassay results are used to test hypothesis 4 (i.e., sediment toxicity at onsite stations does not exceed the DMMP site condition II biological response guidelines due to dredged material disposal). The results for each test sediment are statistically compared to results obtained from a tested reference sediment of comparable grain size. If any two of the bioassays exhibit a statistically significant response (at $p=0.05$ for *Neanthe*s growth bioassay and amphipod bioassay; and $p=0.1$ for bivalve/echinoderm sediment larval bioassay) relative to reference conditions and are ≥ 20 percent over reference conditions, then the sediment is considered to exceed the site condition II biological response guidelines (Table 1–6).

The role of benchmark station bioassays is analogous to the benchmark chemistry analyses. If DMMP site condition II guidelines are exceeded, then benchmark bioassay data are evaluated to determine whether the change in site conditions is due to disposal activity or to some other factor (e.g., regional change in conditions).

Table 1-5. DMMP Conventional Parameters and Chemicals of Concern[5] (DMMP 2007a)

Parameter	Prep Method [1]	Analysis [1]	Sediment MDL [2]	DMMP [2]		
				SL	BT	ML
Conventionals						
Total Solids (%)	---	PSEP [3]	0.1	---	---	---
Total Volatile Solids (%)	---	PSEP [3]	0.1	---	---	---
Total Organic Carbon (%)	---	PSEP [4]	0.1	---	---	---
Total Sulfides (mg/kg)	---	PSEP [3]	1	---	---	---
Ammonia (mg/kg)	---	Plumb 1981 [5]	1	---	---	---
Grain Size	---	PSEP [3]	---	---	---	---
Metals parts per million (ppm)						
Antimony	3050B	6020	2.5	150	---	200
Arsenic	3050B	6020	2.5	57	507.1	700
Cadmium	3050B	6020	0.3	5.1	11.3	14
Chromium	3050B	6020	0.5	---	267	---
Copper	3050B	6020	15.0	390	1027	1300
Lead	3050B	6020	0.5	450	975	1200
Mercury	7471A	7471A	0.02	0.41	1.5	2.3
Nickel	3050B	6020	2.5	140	370	370
Selenium	7740	7740	0.2	---	3	---
Silver	3050B	6020	0.2	6.1	6.1	8.4
Zinc	3050B	6020	15.0	410	2783	3800
Butyltins						
Porewater Butytins (μg/L)	Michelsen et al. 1996; Hoffman 1998	Michelsen et al. 1996; Hoffman 1998	0.025–0.050	0.15	0.15	---
Organics parts per billion (ppb)						
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH)						
Naphthalene	3550B	8270C	20	2100	---	2400
Acenaphthylene	3550B	8270C	20	560	---	1300
Acenaphthene	3550B	8270C	20	500	---	2000
Fluorene	3550B	8270C	20	540	---	3600
Phenanthrene	3550B	8270C	20	1500	---	21000
Anthracene	3550B	8270C	20	960	---	13000
2-Methylnaphthalene	3550B	8270C	20	670	---	1900

5 The DMMP chemicals of concern were initially identified during the PSDDA environmental impact statement (EIS) (Evaluation Procedures Technical Appendix; PSDDA 1988c) and are continually updated through the SMARM process.

Parameter	Prep Method [1]	Analysis [1]	Sediment MDL [2]	DMMP [2]		
				SL	BT	ML
Total LPAH*				5200	---	29000
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH)						
Fluoranthene	3550B	8270C	20	1700	4600	30000
Pyrene	3550B	8270C	20	2600	11980	16000
Benzo(a)anthracene	3550B	8270C	20	1300	---	5100
Chrysene	3550B	8270C	20	1400	---	21000
Benzofluoranthenes (b + k)	3550B	8270C	20	3200	---	9900
Benzo(a)pyrene	3550B	8270C	20	1600	---	3600
Indeno(1,2,3-c,d)pyrene	3550B	8270C	20	600	---	4400
Dibenzo(a,h)anthracene	3550B	8270C	20	230	---	1900
Benzo(g,h,i)perylene	3550B	8270C	20	670	---	3200
Total HPAH				12000	---	69000
Chlorinated Hydrocarbons						
1,3-Dichlorobenzene	5030B	8260B	3.2	170	---	---
1,4-Dichlorobenzene	5030B	8260B	3.2	110	---	120
1,2-Dichlorobenzene	5030B	8260B	3.2	35	---	110
1,2,4-Trichlorobenzene	3550B	8270C	6	31	---	64
Hexachlorobenzene	3550B	8270C	12	22	168	230
Phthalates						
Dimethyl phthalate	3550B	8270C	20	71	---	1400
Diethyl phthalate	3550B	8270C	20	200	---	1200
Di-n-butyl phthalate	3550B	8270C	20	1400	---	5100
Butyl benzyl phthalate	3550B	8270C	20	63	---	970
Bis(2-ethylhexyl)phthalate	3550B	8270C	20	1300	---	8300
Di-n-octyl phthalate	3550B	8270C	20	6200	---	6200
Phenols						
Phenol	3550B	8270C	20	420	---	1200
2 Methylphenol	3550B	8270C	6	63	---	77
4 Methylphenol	3550B	8270C	20	670	---	3600
2,4-Dimethylphenol	3550B	8270C	6	29	---	210
Pentachlorophenol	3550B	8270C	61	400	504	690
Miscellaneous Extractables						
Benzyl alcohol	3550B	8270C	6	57	---	870
Benzoic acid	3550B	8270C	100	650	---	760
Dibenzofuran	3550B	8270C	20	540	---	1700
Hexachloroethane	3550B	8270C	20	1400	---	14000

Parameter	Prep Method [1]	Analysis [1]	Sediment MDL [2]	DMMP [2]		
				SL	BT	ML
Hexachlorobutadiene	3550B	8270C	20	29	---	270
N-Nitrosodiphenylamine	3550B	8270C	12	28	---	130
Volatile Organics						
Trichloroethene	5030B	8260B	3.2	160	---	1600
Tetrachloroethane	5030B	8260B	3.2	57	---	210
Ethylbenzene	5030B	8260B	3.2	10	---	50
Total Xylene (sum of o-, m-, p-)	5030B	8260B	3.2	40	---	160
Pesticides						
Total DDT	---	---	---	6.9	50	69
p,p'-DDE	3550B	8081A	2.3	---	---	---
p,p'-DDD	3550B	8081A	3.3	---	---	---
p,p'-DDT	3550B	8081A	6.7	---	---	---
Aldrin	3550B	8081A	1.7	10	---	---
Chlordane	3550B	8081A	1.7	10	37	---
Dieldrin	3550B	8081A	2.3	10	---	---
Heptachlor	3550B	8081A	1.7	10	---	---
Lindane	3550B	8081A	1.7	10	---	---
Total polychlorinated biphenyls (PCBs)	3550B	8082	67	130	38**	3100
Dioxins/Furans						
Total Polychlorinated Dibenzo-p-Dioxins/Furans	---	1613B [6]	---	---	---	---

* Total LPAH does not include 2-Methylnaphthalene.
** Total PCBs BT value in ppm carbon-normalized.

1. Sample preparation and analytical methods (3000, 5000, 6000, 7000, 8000, and 9000 series) are from SW-846, Test Methods for Evaluation Solid Waste Physical/Chemical Methods, USEPA 1986 and updates. http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm
2. Method detection limits (MDL), SLs (except TBT), MLs, and BTs (except PCBs and TBT) are on a dry weight (DW) basis.
3. Recommended Protocols for Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program (PSEP), March 1986 with minor corrections April 2003.
4. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment, and Tissue Samples – Appendix D, Puget Sound Estuary Program, 1997b.
5. Procedures for Handling and Chemical Analysis of Sediment and Water Samples, Russell H. Plumb, Jr., USEPA/USACE, May, 1981.
6. Analysis of dioxins/furans is necessary for establishing baseline conditions at each non-dispersive site and may be required as part of regular monitoring at the discretion of the DMMP.

Table 1-6. DMMP Bioassay Interpretation Guidelines

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

M = mortality, N = normals, I = initial count, MIG = mean individual growth rate (mg/individual/day)
SD = statistically different, NOCN = no other conditions necessary, N/A = not applicable
Subscripts: R = reference sediment, C = negative control, T = test sediment

1.2.4 Tissue Chemistry

To evaluate bioaccumulation of DMMP chemicals of concern, the concentrations of selected chemicals (Bioaccumulative Chemicals of Concern) in the tissue of infaunal organisms are measured at transect and benchmark stations (Table 1–7). The target species for measuring body burden at Commencement Bay is the sea cucumber *Molpadia intermedia*. The tissue chemistry data are used to test hypothesis 5 (i.e., no significant increase has occurred in the chemical body burden of benthic infauna species collected down current of the disposal site due to dredged material disposal). As in the case of sediment chemistry and bioassays, benchmark data are evaluated if transect station data reveal a significant increase in contaminant bioaccumulation.

1.2.5 Benthic Infauna Analysis

Benthic infauna samples are collected at transect and benchmark stations using a 0.06 m^2 Gray O'Hara box core or equivalent. To maintain data comparability between years, only the 1.0 mm fraction of the top 10 cm of each transect box core sample is analyzed[6] (identification and enumeration of organisms). The remaining sieve fractions are archived, pending review of analysis results. If the initial results are equivocal, the DMMP may require analysis of archived samples (e.g, < 10 cm samples, and/or benchmark station samples) to provide additional information to evaluate the benthic community.

The transect station data are used to test hypothesis 6 (i.e., no significant decrease in the abundance of dominant benthic infauna species has occurred down current of the disposal site due to dredged material disposal). Benchmark data are evaluated only if decreases in transect station infaunal abundance exceed trigger levels described by the interpretive guidelines (Table 1–2).

[6] During the baseline surveys of the Phase I disposal sites, whole box core samples were sieved and analyzed for benthic infauna analysis (PTI 1988). In part due to the change in methodology in subsequent years, the 1995 monitoring survey results were adopted as the new baseline for Commencement Bay.

Table 1-7. Bioaccumulative Chemicals of Concern

Chemical	Bioaccumulation Trigger (BT) mg/kg DW[1]	Target Tissue Level (TTL)[2] mg/kg wet weight (WW)	Analysis Method
List 1 (Required for Analysis)			
Arsenic	507.1	10.1	6020
Cadmium	11.3*	TBD	6020
Chlordane	0.037	0.3	8081A
Chromium	267*	TBD	6020
Copper	1027*	TBD	6020
Dioxins/furans[4]	TBD	n/a	1613B
Fluoranthene	4.6	8400	8270
Hexachlorobenzene	0.168	180	8081A
Lead	975*	TBD	6020
Mercury	1.5	1.0	7471A
Nickel	370	20000	6020
Pentachlorophenol	0.504	900	8270
Pyrene	11.98*	TBD	8270
Selenium	3*	TBD	7740
Silver	6.1	200	6020
Tributyltin (porewater)	0.15 µg/L	0.6[5]	Michelsen et al. 1996
Total Aroclor PCBs	38 mg/kg OC	0.75[5]	8082
Total DDT	0.05	5.0	8081A
Zinc	2783*	TBD	6020
List 2 (Strong Concern and Priority for Study)			
1,2,4,5-Tetrachorobenzene	TBD	TBD	8270C
4-Nonylphenol, branched	TBD	TBD	8270C
Benzo(e)pyrene	TBD	TBD	8270C
Biphenyl	TBD	TBD	8270C
Chlorpyrifos	TBD	TBD	8141
Chromium VI	TBD	TBD	7196A or 7199
Dacthal	TBD	TBD	8081A
Diazinon	TBD	TBD	8141
Endosulfan	TBD	TBD	8081A
Ethion	TBD	TBD	8141
Heptachloronaphthalene	TBD	TBD	8270C
Hexachloronaphthalene	TBD	TBD	8270C
Kelthane	TBD	TBD	8081A
Mirex	TBD	TBD	8081A
Octachloronaphthalene	TBD	TBD	8270C
Oxadiazon	TBD	TBD	8141
Parathion	TBD	TBD	8141

Chemical	Bioaccumulation Trigger (BT) mg/kg DW[1]	Target Tissue Level (TTL)[2] mg/kg wet weight (WW)	Analysis Method
Pentabromodiphenyl ether	TBD	TBD	8270C
Pentachloronaphthalene	TBD	TBD	8270C
Perylene	TBD	TBD	8270C
Tetrachloronaphthalene	TBD	TBD	8270C
Tetraethyltin	TBD	TBD	Michelsen et al. 1996
Trichloronaphthalene	TBD	TBD	8270C
Trifluralin	TBD	TBD	8081A

* Interim BT value
OC Organic carbon normalized
TBD To be determined
1. Except where noted otherwise.
2. The target tissue levels (TTL) are chemical concentrations in tissues used to interpret the results of bioaccumulation testing (Hoffman 2003).
3. Interim bioaccumulation trigger level.
4. DMMP dioxin/furan regulatory guidance will be forthcoming, developed through a series of DMMP-convened stakeholder workshops.
5. TTL is based on site-specific considerations for the Elliott Bay disposal site. Separate TTLs may need to be developed for other sites.

1.3 DMMP Site Monitoring Levels

Four general levels of environmental monitoring have been established for the DMMP program:

1. Full monitoring
2. Tiered-full monitoring
3. Partial monitoring
4. Special studies

The full monitoring program addresses all three questions (null hypotheses 1 through 6) of the DMMP monitoring framework. A tiered-full monitoring program collects all samples necessary under a full monitoring program, but it only analyzes data to initially answer the first two questions (null hypotheses 1 through 4) (SAIC 1995; Benson 1996). Analysis of archived samples to address the third monitoring question (hypotheses 5 and 6) is contingent on answers to the first two questions. A partial monitoring program only addresses questions 1 and 2 (null hypotheses 1 through 4).

Partial monitoring is conducted when appreciable volumes of dredged material are disposed at a site, but the volume is not enough to trigger a full monitoring effort (PSDDA 1988c). The DMMP agencies evaluate the conditions that warrant a partial monitoring effort and follow best professional judgment after reviewing sediment quality testing data for all dredging projects that were disposed at the site during the past dredging year.

The fourth level consists of special studies directed by the DMMP to address special topics related to the disposal site monitoring program. Recent examples include a contaminant investigation at the Elliott Bay site to evaluate potential impacts from the disposal of unsuitable dredged material (SAIC 2005a), and a phenol study at Commencement Bay to evaluate the temporal variability of concentrations and possible sources of phenol measured in offsite sediments (SAIC 2005b).

2.0 Resource Evaluation at Commencement Bay

Biological resources were evaluated at the Phase I DMMP sites in support of the 1988 environmental impact statement (EIS) for Central Puget Sound, which included Commencement Bay, Elliott Bay, and Port Gardner. The proposed sites were designated in areas that did not support commercial fisheries (this assessment included coordination with tribal and non-tribal fisheries) and where impacts to biological resources were expected to be low. The biological resource studies were conducted in 1986, prior to conducting baseline surveys of the Commencement Bay disposal site, and were used to help guide the selection of preferred and alternative sites and impact assessment for the PSDDA EIS.

The 1986 resource evaluation studies included a Benthic Resource Assessment Technique (BRAT) evaluation and bottom trawl surveys of the Preferred and Alternative sites. The BRAT is an analytical procedure that estimates the relative amount of trophic support that a given soft-bottom habitat provides demersal, bottom-feeding fishes (Clarke 1986). Bottom trawl surveys were conducted for Dungeness crab (*Cancer magister*), pandalid shrimp, and bottomfish (especially flatfish, Pacific hake, cod, and rockfish) (Dinnel et al. 1986). These three faunal groups were identified as important to Puget Sound commercial and sport fisheries. Detailed summaries of these studies are provided in Appendix A. A summary of findings is provided below.

2.1 1986 Benthic Resource Assessment Technique (BRAT) Evaluation

The BRAT is an analytical procedure developed to help resource managers evaluate and select alternative sites with lower trophic support for targeted demersal, bottom-feeding fishes. Figure 2–1 shows a schematic of the major steps in the BRAT and Figure 2–2 shows the final analysis steps to evaluate trophic support of a given soft-bottom habitat (PSDDA 1988d). The BRAT combines the benthic biomass in terms of size and vertical distribution in sediments and selected sites with the foraging depth and prey size exploitation pattern of demersal fishes at those sites.

Two alternative sites were evaluated in Commencement Bay. The alternative site was found to have the highest mean biomass per station (approximately 70 g/m^2); whereas, the Preferred site (e.g., evaluated in the 1988 FEIS) displayed lower mean biomass (approximately 57 g/m^2) in comparison. In general, estimates of trophic support potential for bottom-feeding fishes increased with increasing total benthic biomass in the area. Based on this evaluation, the preferred site was recommended for selection as the disposal site in the 1988 FEIS. The Alternative site had "slightly higher functional values for bottom-feeding fishes," particularly for the small size classes of Dover and English sole, which supported its exclusion as the preferred disposal site alternative for the EIS evaluation.

2.2 1986 Trawl Studies

Trawling was conducted at two alternative sites (e.g., Preferred and Alternative) using a 3-meter research beam trawl and a 7.6-meter (25-foot) Otter trawl to catch Dungeness crab (*Cancer magister*), pandalid shrimp, and bottomfish. **No Dungeness crab were caught by either trawl at either site**. **The absence of this species during trawling investigations in 1986 were a positive factor in the selection of the alternative sites carried forward in the DMMP EIS evaluation of impacts**. Additionally, the DMMP agencies conducted a limited 2007 trawling effort at six stations in both the preferred and alternative sites evaluated in 1986, to update the resource data for the existing disposal site and alternative site. The 2007 effort is discussed in Section 3.7, but these data confirmed and were entirely consistent with the 1986 findings.

The 1986 trawling studies estimated moderate densities of sidestripe shrimp (53.3 shrimp/hectare [ha]) and pink shrimp (306.4 shrimp/ha) at both sites. These densities were not sufficient to support a commercial or sport fishery. Additionally, Smooth pink shrimp (0.8 shrimp/ha) and spot shrimp (1.5 shrimp/ha) were also collected in low numbers.

The abundance, biomass, and species diversity of juvenile and adult flatfishes sampled at the Commencement Bay sites were uniformly low, especially when compared with areas outside the immediate site selection study area (e.g., nearshore shallower depth areas). Based on the data collected, the site was determined to be of little commercial value to fishermen, making it an ideal location for open water disposal (Dinnel et al. 1986).

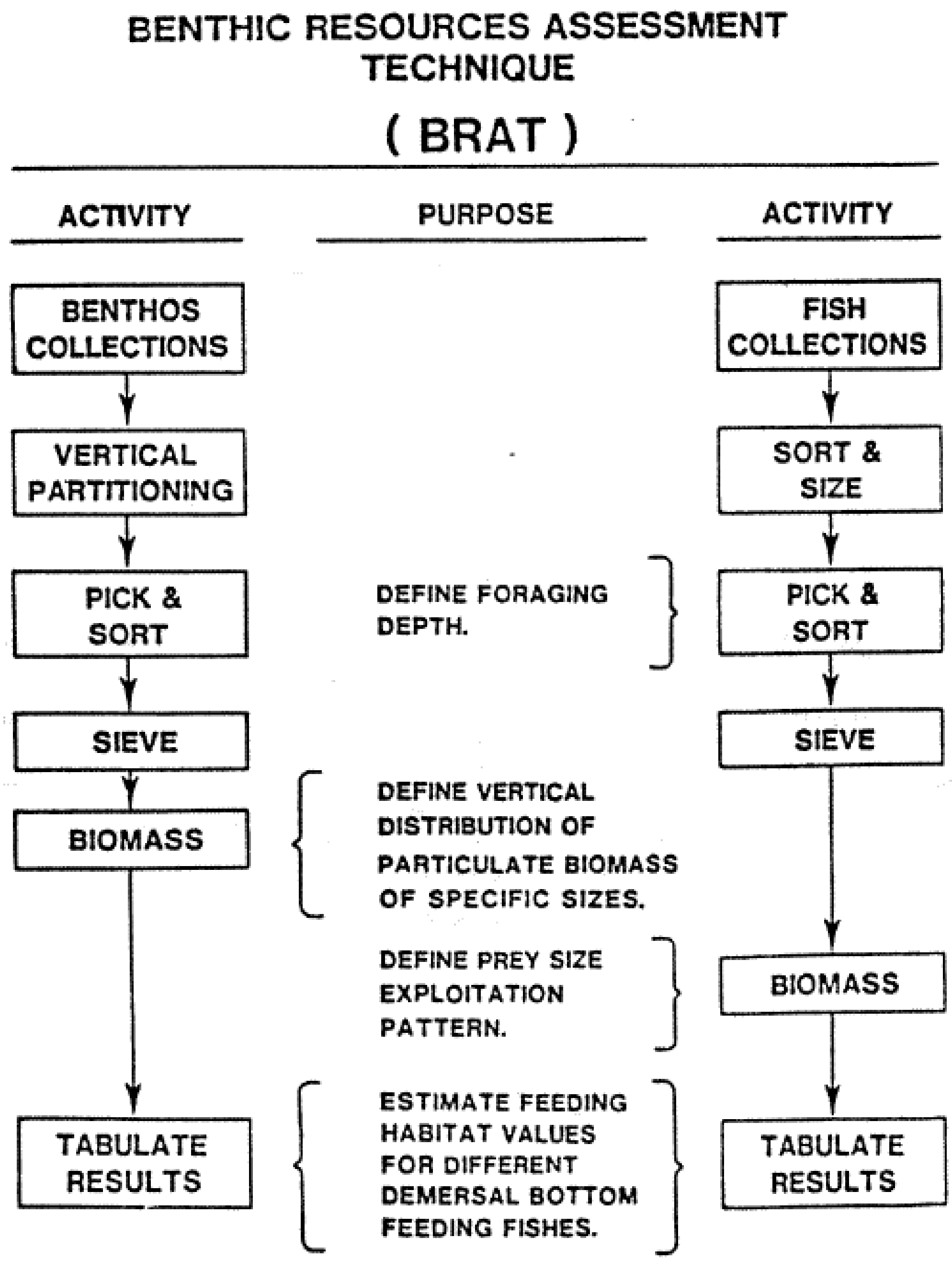


Figure 2-1. Major Steps of the BRAT (PSDDA 1988d)

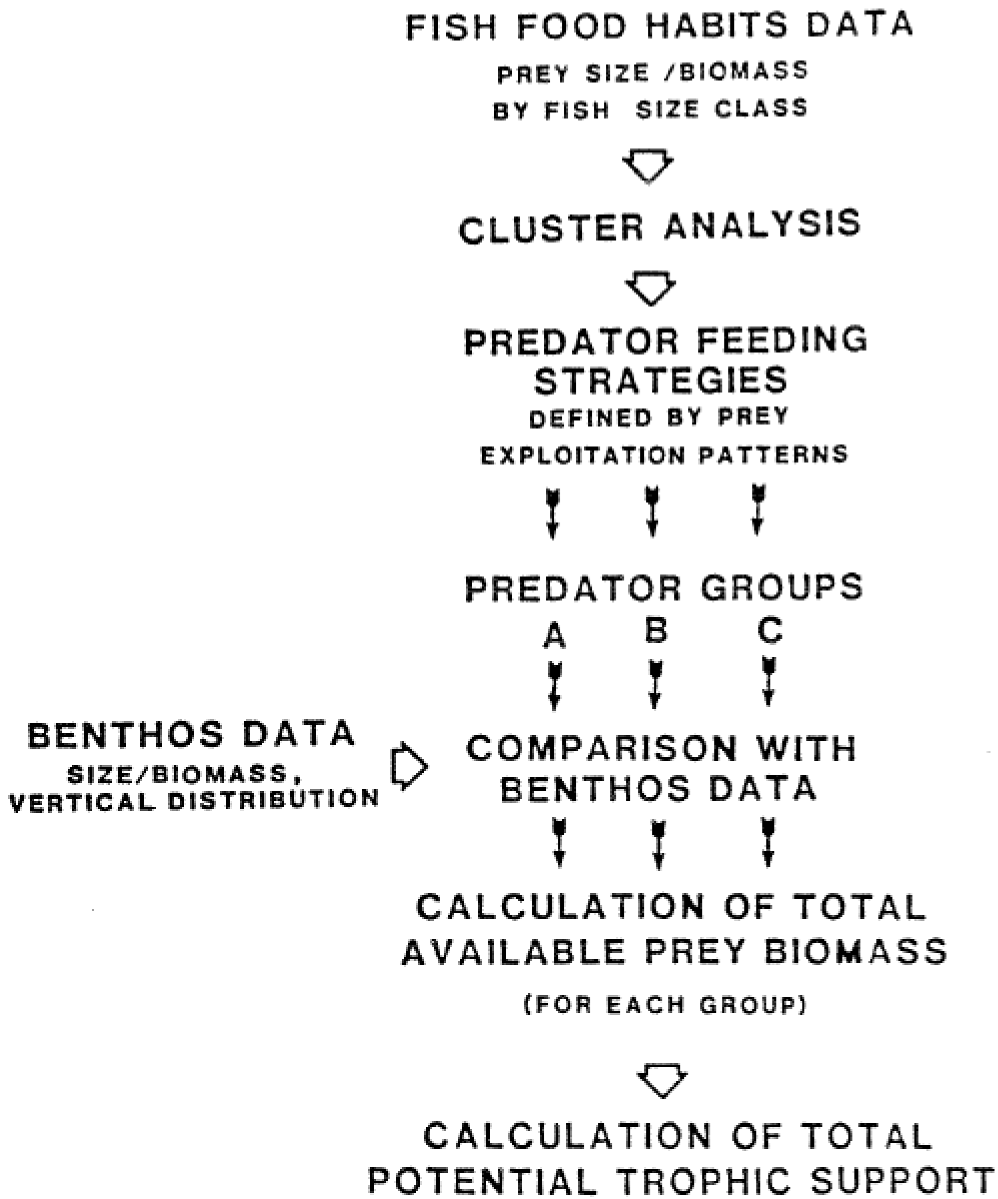


Figure 2-2. Final Steps to Evaluate Trophic Support of a Given Soft-Bottom Habitat (PSDDA 1988d)

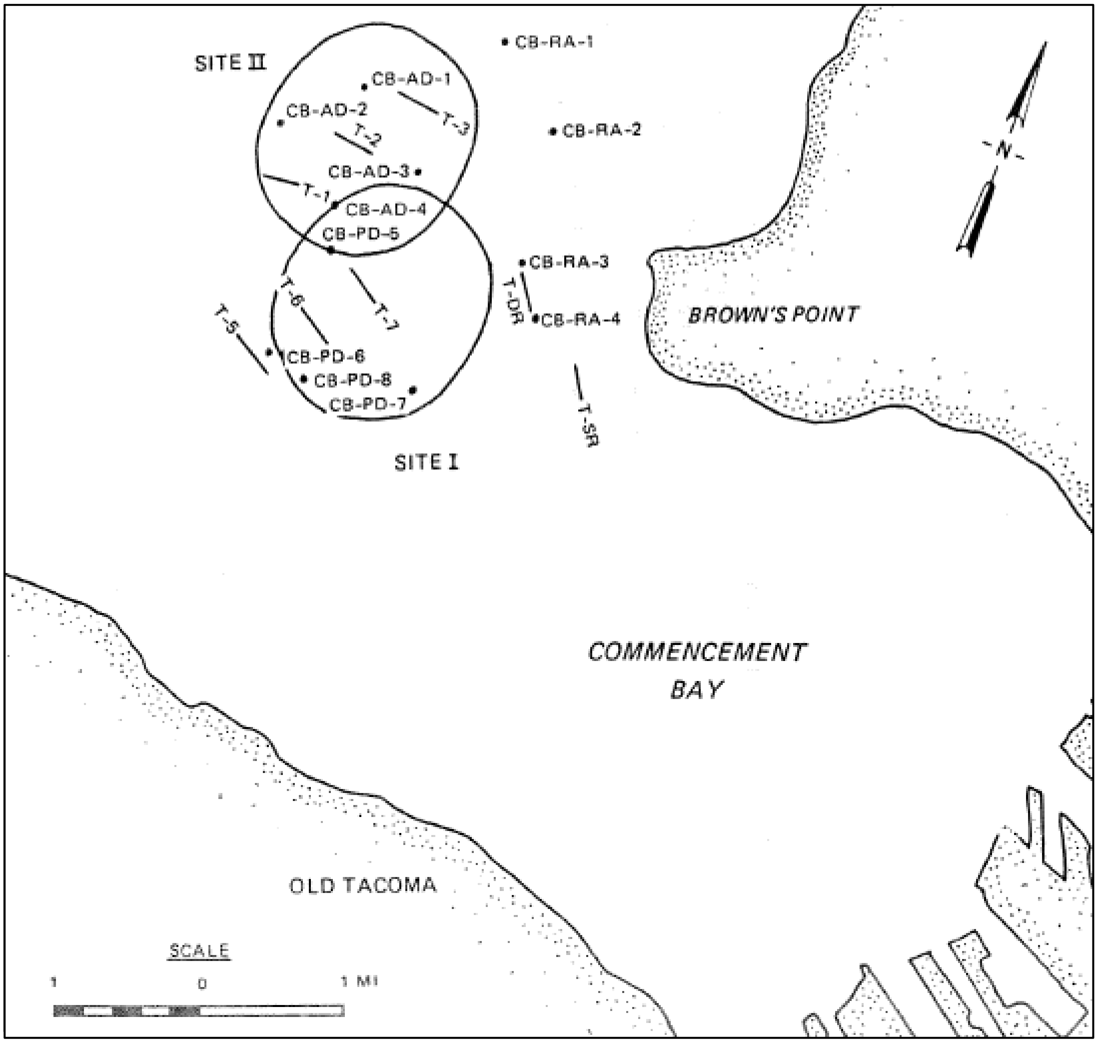


Figure 2-3. Preferred (Site I) and Alternative (Site II) Sites in Commencement Bay (Clarke 1986)

3.0 Summary of Monitoring Data

Following the predisposal baseline survey in 1988, a total of eight post-disposal monitoring surveys were conducted in Commencement Bay. They have included four full monitoring events (1995, 2001, 2003, and 2007), two partial events (1996 and 2004), and two physical monitoring events (1998 and 2005). A summary of findings for each monitoring event is provided in Table 3–1.

The following sections summarize the results by data type and provide conclusions regarding those results. The data types include physical monitoring, onsite sediment chemistry, onsite sediment toxicity, offsite tissue chemistry, offsite benthic infauna community, and bottom trawl studies, and special offsite chemistry, toxicity and benthic infaunal studies conducted to fully assess the thin layer of offsite dredged material noted in the 2001 monitoring event. Each data type fulfills a DMMP site monitoring element as described in Section 1.2. Detailed summaries of each monitoring event by year, including conclusions within the context of the site monitoring framework are provided in Appendix B.

3.1 Physical Monitoring

The DMMP monitoring program includes a physical component to address hypothesis 1 of the monitoring framework (dredged material remains within the site boundary). Sediment profile photography is the main physical sampling technique and is used to visually map the distribution of dredged material at the disposal site. Periodic bathymetric surveys are also conducted and compared to pre-disposal site bathymetry to determine the approximate height and diameter of the dredged material disposal mound.

3.1.1 Sediment Profile Photography

Physical monitoring of the Commencement Bay DMMP site includes the use of SVPS photography to map the thickness and distribution (footprint) of the dredged material deposit. SVPS photographs a profile of the sediment surface to a depth of up to 20 cm (Figure 1–3), depending upon the depth of prism penetration. Therefore, the strength of SVPS for physical monitoring is the mapping of the perimeter of the recent dredged material deposit and measuring the thickness of the thin flanks of the deposit if adequate penetration is achieved. Dredged material can often be identified by its contrasting optical appearance (e.g., grain size, chaotic sedimentary fabric, roughness, color) relative to ambient sediments. SVPS images from Commencement Bay showing ambient sediments, dredged material, and a thin dredged material layer over ambient sediments are provided in Figure 3–1. Including the baseline survey in 1988, a total of nine SVPS surveys have been conducted at the disposal site in support of DMMP site monitoring (Table 3–2). The dredged material footprint maps for each of the post-disposal surveys are presented in Figures 1–8 and 3–2 through 3–8.

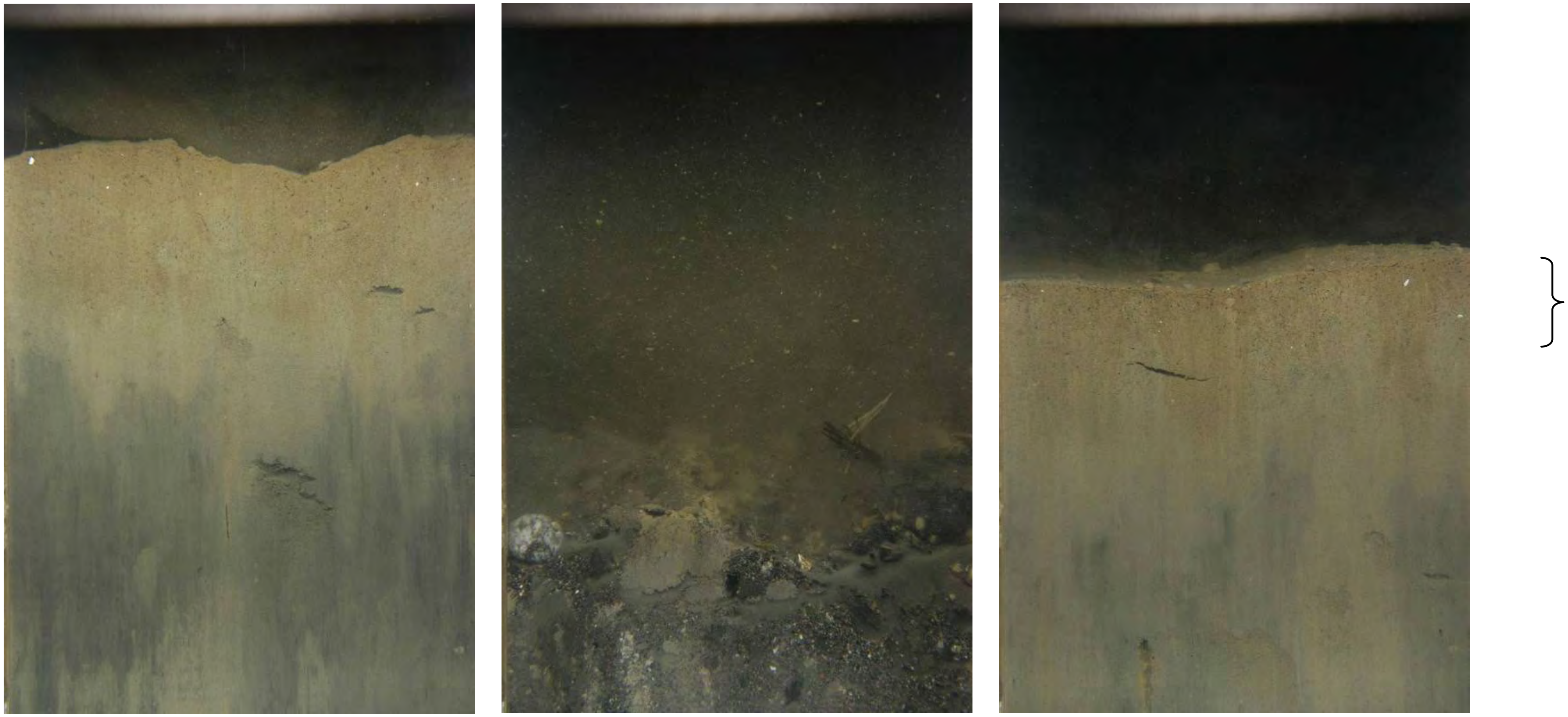
In addition, other important parameters measured from SVPS images include the depth of the apparent RPD, infaunal successional stage, and calculation of the OSI (Section 1.2.1). These parameters provide important inferences on the biological health of the benthic community and quality of sediment habitat and are discussed further in this section.

Table 3-1. Summary of Commencement Bay Site Monitoring Findings 1988–2007

Survey	DY specific Disposal Volume (cy)	Cumulative Volume (cy)	Hypothesis No. 1 (Dredged Material Within Site Boundaries?)	Hypothesis No. 2 (Offsite Chemistry Within SQS?)	Hypothesis No. 3 (Onsite Chemistry Below DMMP MLs?)	Hypothesis No. 4 (Onsite Toxicity passes DMMP Guidelines?)	Hypothesis No. 5 (Tissue Chemistry Passes DMMPGuidelines?)	Hypothesis No. 6 (Benthic Infauna Abundance Passes DMMP Guidelines?)
1988 Baseline Survey	0	0	--	Yes	Yes	No[1]	NA	NA
1995 Full Monitoring	290,857	308,405	Yes	Yes	Yes	Yes	Yes	Yes
1996 Partial Monitoring	460,684	769,089	Yes	Yes	Yes	Yes	--	--
1998 Physical Monitoring	693,540	1,462,629	No	Yes	--	--	--	--
2001 Full Monitoring	265,867	2,762,591	No	Yes	Yes	Yes	Yes	Yes
2003 Tiered-Full Monitoring	710,675	3,473,266	No	No[2]	Yes	Yes	Yes	Yes
2004 Partial Monitoring	1,205,993	4,679,259	No	Yes	Yes	Yes	--	--
2005 Physical Monitoring	949,399	5,628,658	No	Yes (SVOC Only)	--	--	--	--
2007 Full Monitoring	1,324,254	7,763,912	Yes	Yes	Yes	Yes	Yes	Yes

SQS Sediment Quality Standards
NA Not applicable. Baseline values used for guideline interpretation.
1. The 1988 baseline amphipod test did not pass the DMMP interpretive guideline for one of two reference sediment evaluations.
2. The SQS was exceeded for 1,2,4-trichlorobenzene, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and phenol.

CBB01-A CBZ01-B CBP11-C



Ambient sediments in Commencement Bay consisting of soft, tan to gray silt-clays with minor amounts of sand.

Dredged material at the site center consisting of gray and black sand with white clay, shell fragments, gravel, and woody material.

A thin layer of recent dredged material consisting of oxidized mud clasts and fine sand over ambient silts and clays.

Figure 3-1. Example SVPS Images from the 2005 SVPS Survey in Commencement Bay

Table 3-2. SVPS Surveys at Commencement Bay

Survey	DY specific Disposal Volume (cy)	Cumulative Volume (cy)	Dredged Material Within Site Boundaries? (PSDDA Hypothesis No. 1)	Dredged Material Footprint Description
1988 Baseline Survey	0	0	NA	NA
1995 Full Monitoring	290,857	308,405	Yes	Footprint within site perimeter.
1996 Partial Monitoring	460,684	769,089	Yes	Footprint within site perimeter.
1998 Physical Monitoring	693,540	1,462,629	No	Thin, small band (<5 cm) of dredged material to the northwest.
2001 Full Monitoring	265,867	2,762,591	No	Large accumulations (trace to 15.2 cm) to the northwest.
2003 Tiered-Full Monitoring	710,675	3,473,266	No	Thin, small band (2.7–4.5 cm) of dredged material to the northwest.
2004 Partial Monitoring	1,205,993	4,679,259	No	Thin, small band (0.4–3.8 cm) of dredged material to the northwest.
2005 Physical Monitoring	949,399	5,628,658	No	Thin (trace to 6.0 cm) but broad accumulation to the northwest.
2007 Full Monitoring	1,324,254	7,763,912	Yes	Thin band (0.6 to 2.6 cm) of dredged material did not exceed 3 cm guideline.

Dredged Material Confined to Site Boundary (1995, 1996, and 2007)

The dredged material deposit measured by SVPS was confined within the site boundaries during the 1995 full monitoring, 1996 partial monitoring, and 2007 full monitoring surveys (Figures 3–2, 3–3, and 1–8, respectively). Dredged material was not measured at any perimeter station in 1995 following the disposal of 290,857 cy of dredged material. Very thin accumulations (0.1–0.5 cm) were measured along the southeast perimeter during the 1996 survey following the disposal of 460,684 cy of dredged material. The 2007 full monitoring survey measured a thin band of recent dredged material extending to the north and west of the perimeter following disposal of 1,324,254 cy of dredged material, but the accumulations did not exceed the 3 cm DMMP guideline (Figures 1–8 and 3–3).

Dredged Material beyond the Site Boundary (1998, 2001, 2003, 2004, and 2005)

Four of the SVPS surveys (1998, 2003, 2004, and 2005) showed the presence of thin bands of recent dredged material beyond the northwest perimeter of the disposal site (Figures 3–4 and 3–6 through 3–8). Each new band was generally less than 5 cm in thickness, comprised of silt or silty fine sand, and extended approximately 450–700 meters beyond the northwest perimeter line. However, these deposits exceeded the 3 cm DMMP guideline for dredged material accumulation in offsite areas.

A review of the other SVPS parameters measured in these offsite areas (apparent RPD, infaunal successional stage, and OSI values) showed that the thin layer of dredged material accumulation did not adversely impact benthic habitat quality (Table 3–3). The apparent RPD depths measured in the offsite dredged material lobe were comparable to measurements in offsite areas where dredged material was not present. In fact, the mean apparent RPD depths in the dredged material lobe were slightly deeper than the mean for offsite areas during the most recent (2004, 2005, and 2007) surveys. The reason for this difference, in part, is the presence of coarse-grained ambient sediments to the north of the disposal site, which are included in the offsite summary statistics. The apparent RPD depths in these coarse-grained ambient sediments appear to be shallower than those measured in fine-grained ambient sediments (SAIC 2004).

The majority of stations showed the presence of Stage III infauna during these surveys, particularly the 2004, 2005, and 2007 surveys (Figures 3–9, 3–10, and 1–7, respectively). OSI values were relatively high (range of +8 to +9) and comparable between the offsite dredged material lobe and offsite areas where dredged material was not present. Similar to apparent RPD depths, the mean OSI values were slightly higher in the dredged material lobe compared to offsite areas.

The greatest accumulation of dredged material beyond the site perimeter was measured during the 2001 full monitoring survey. The SVPS survey in 2001 identified the presence of dredged material beyond the disposal site boundary to the south, west, and northwest (SEA 2001; Figure 3–5). The dredged material layer beyond the site boundary ranged from a trace to greater than 15.2 cm in depth. The largest amount of this material, which consisted of very fine-grained sand and silt, was found to the northwest of the site. Features measured from SVPS images tended to reflect the greater accumulation of dredged material (Table 4–3). Mean apparent RPD depths were shallower; infaunal successional stages showed a higher proportion of pioneering Stage I communities; and OSI values were also lower with a mean of 5.5 in the dredged material lobe and 5.9 in other offsite areas. The benthic infauna community data from the 2001 survey (Section 3.6) suggested an area-wide change in benthic community structure based on a review of benchmark and reference station evaluations. The lower OSI values measured in both the dredged material lobe and in other offsite areas compared to other monitoring surveys tend to support this conclusion.

However, the SVPS results from subsequent monitoring surveys (2003–2005, 2007) showed that any impacts were relatively short lived. Stage III infauna were observed in nearly all offsite areas, including areas of recent offsite dredged material deposition, apparent RPD depths had rebounded, and OSI values had increased to near baseline conditions (Table 3–3). Benthic infauna community data from the 2003 survey also showed a rebound in major taxa abundance relative to the 2001 survey (Section 3.6).

Conclusions

SVPS surveys through the years have indicated the presence of a thin layer of dredged material accumulation extending beyond the site perimeter, some of which exceeded the guideline parameter of 3 cm accumulation in offsite areas. Offsite dredged material accumulation was observed in 1998, 2001, 2003, 2004, and 2005. However, the amount of dredged material measured outside the boundaries of the site is relatively small, with over 95 percent located within the site boundary (Nelson 2006; Michelson 2008).

A review of the parameters measured from the SVPS images showed that long-term adverse impacts to benthic habitat quality have not occurred in offsite areas of Commencement Bay due to dredged material accumulation. The benthic community appears to be resilient and adaptable to the disposal of dredged material. This conclusion is supported by the wide distribution of Stage III infaunal communities and high OSI values observed within the disposal site during the post-disposal surveys. For example, following the disposal of 1.3 million cy of dredged material in 2007, the SVPS survey showed the presence of Stage III infaunal communities and OSI values greater than +6 at nearly all of the stations sampled with a mean of +9.5 (Figures 1–7 and 1–8, respectively).

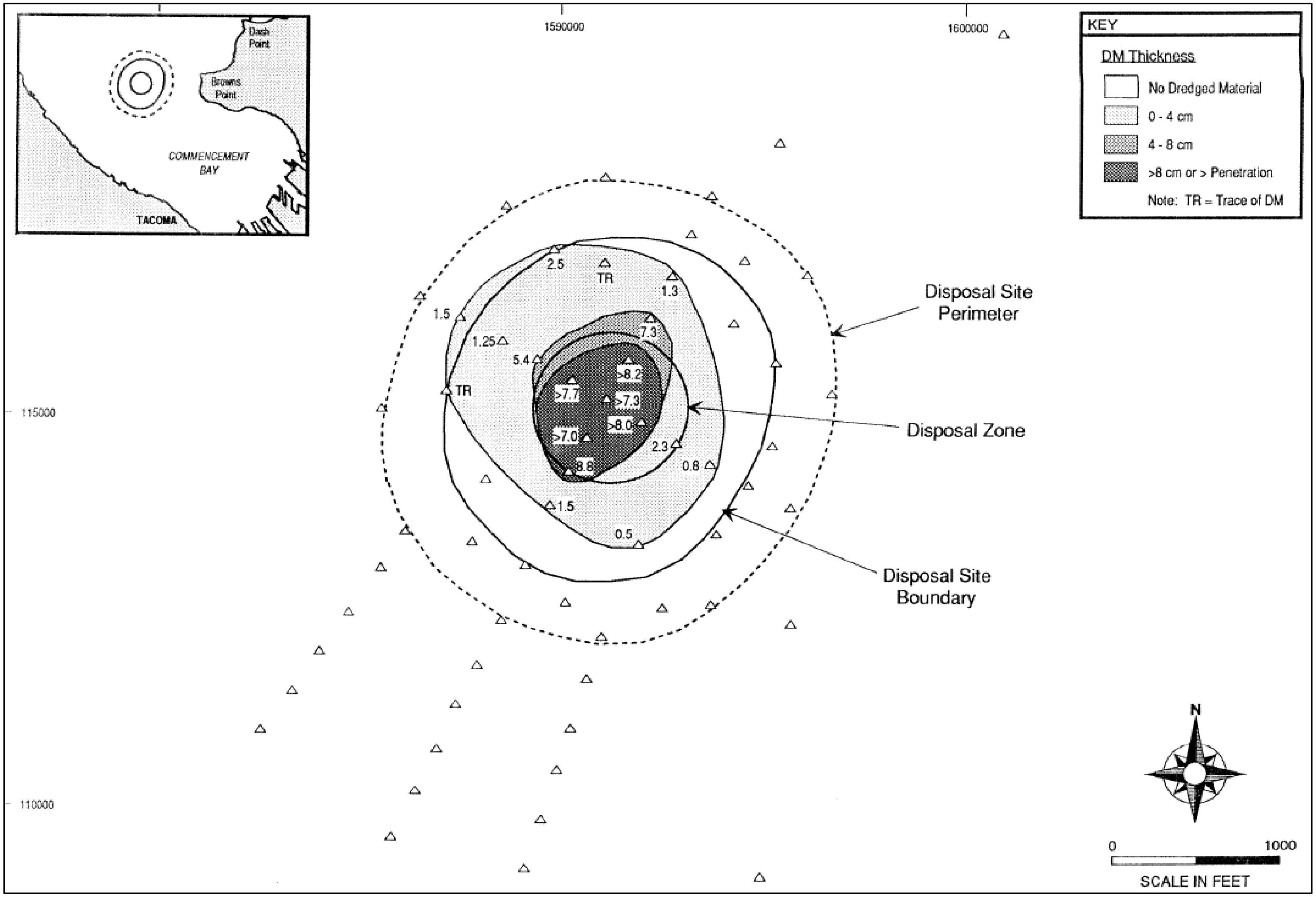


Figure 3-2. 1995 Commencement Bay Dredged Material Footprint (SAIC 1995)

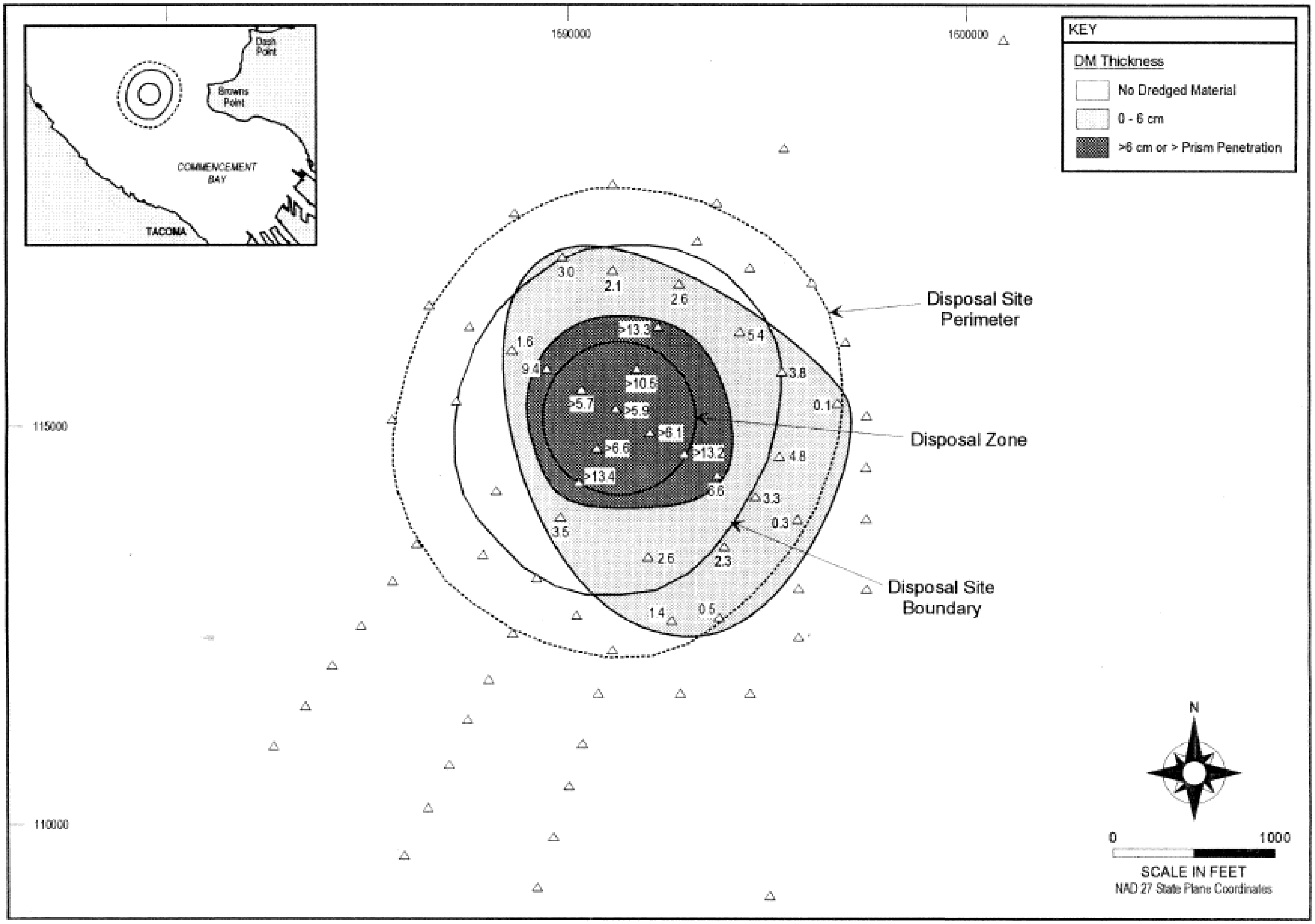


Figure 3-3. 1996 Commencement Bay Dredged Material Footprint (SAIC 1996)

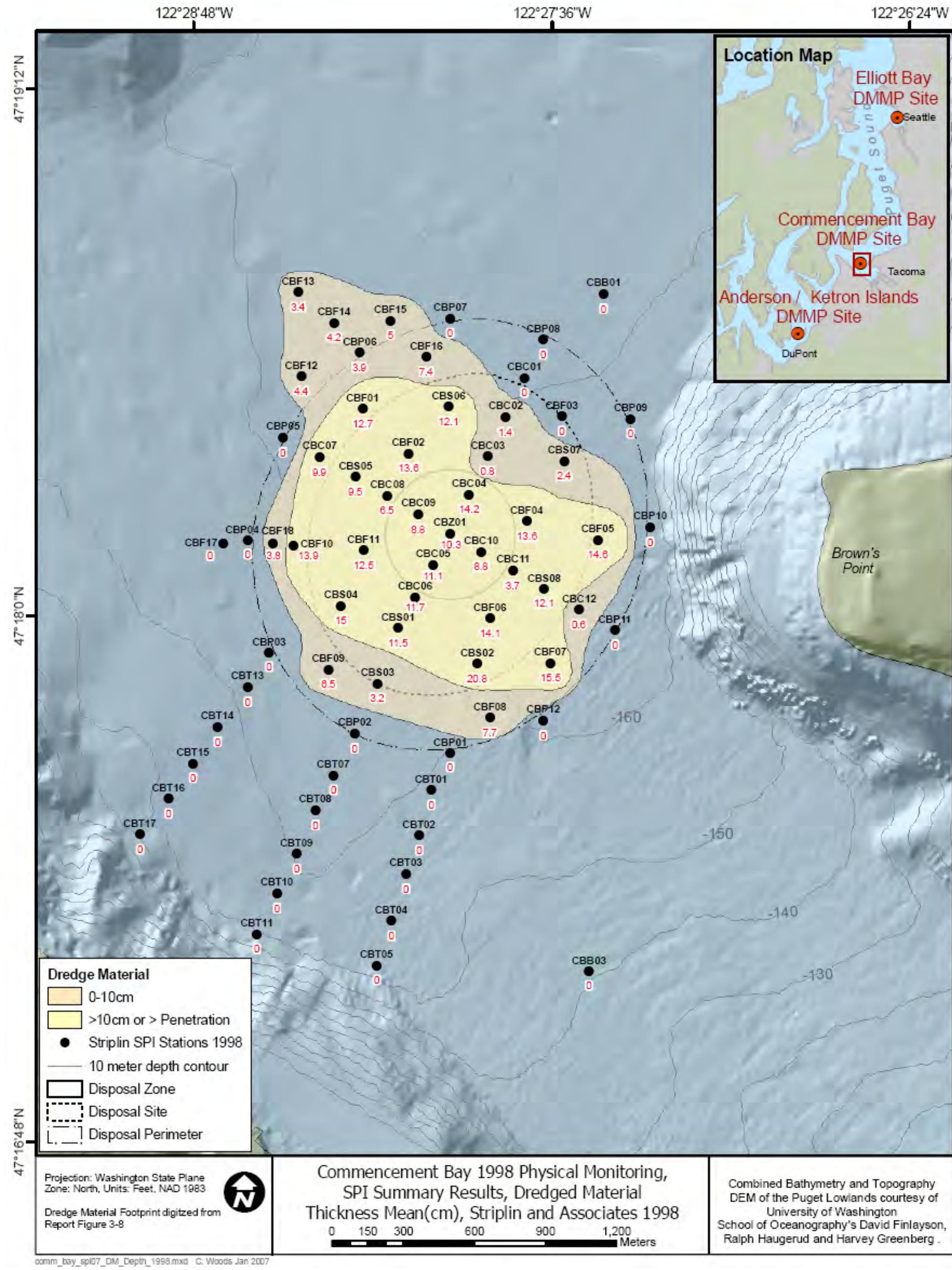


Figure 3-4. 1998 Commencement Bay Dredged Material Footprint (map recreated from SEA 1999)

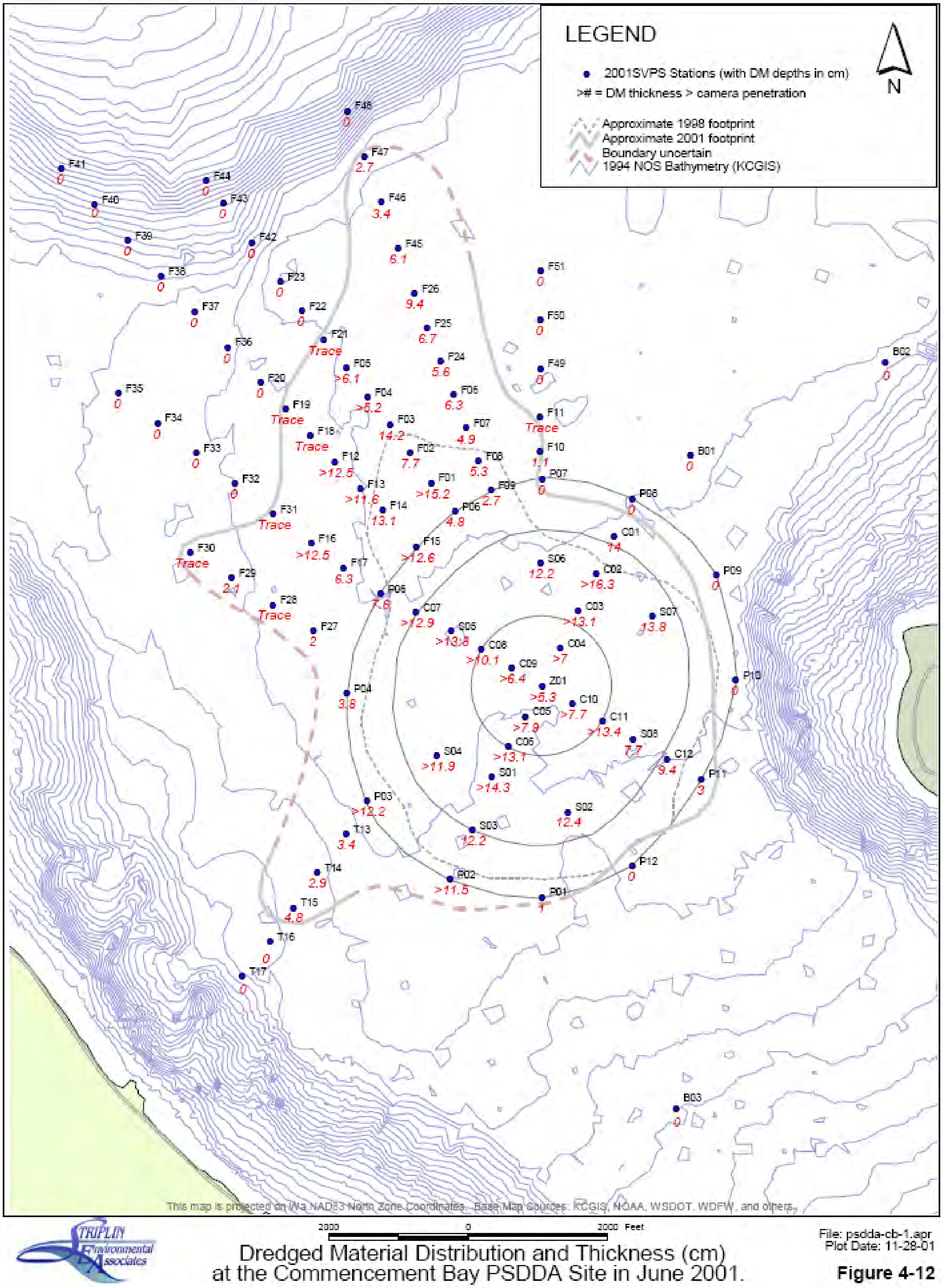


Figure 3-5. 2001 Commencement Bay Dredged Material Footprint (SEA 2001) (Dredged Material Thickness in cm)

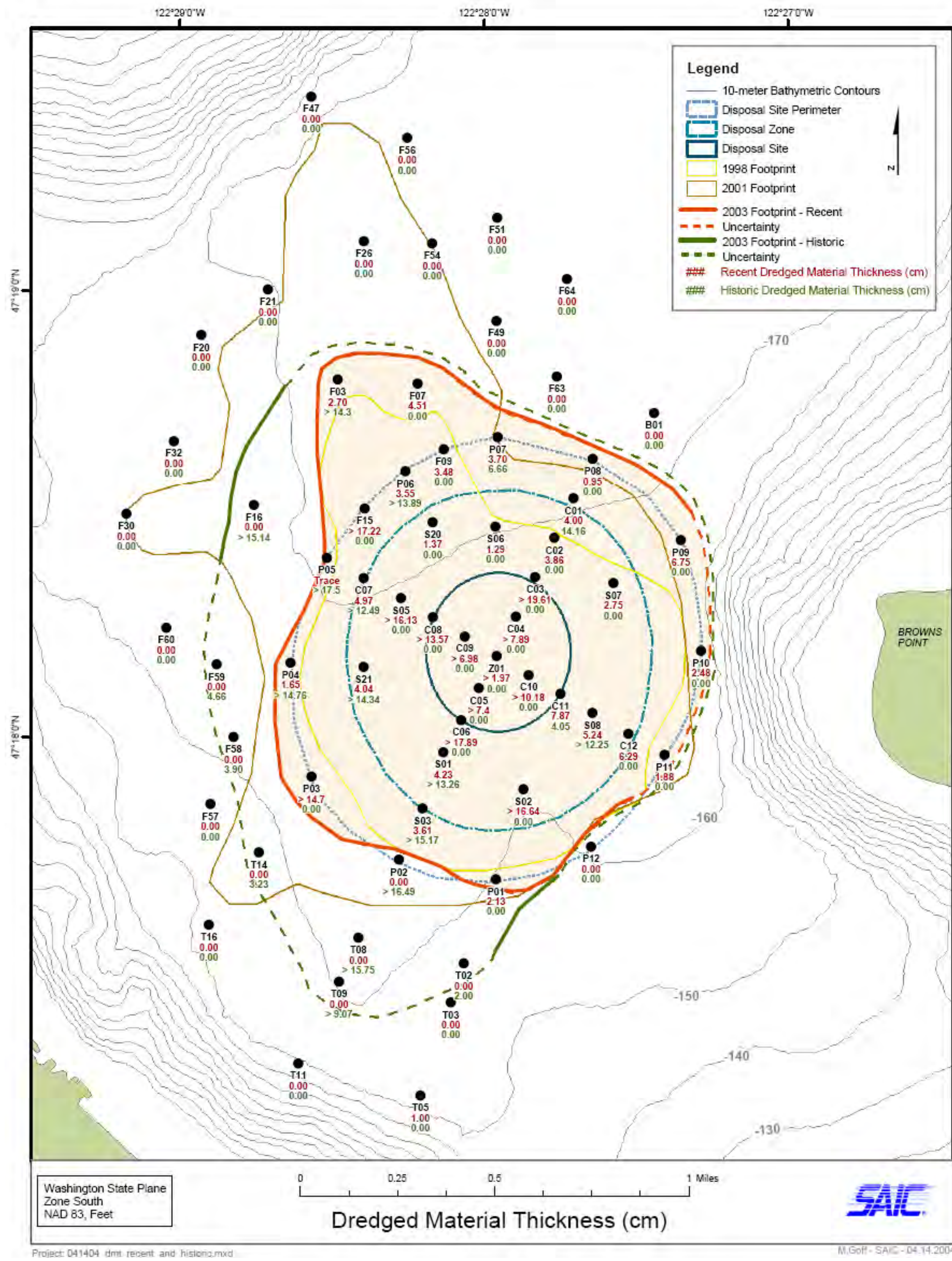


Figure 3-6. 2003 Dredged Material Footprint in Commencement Bay (SAIC 2003)

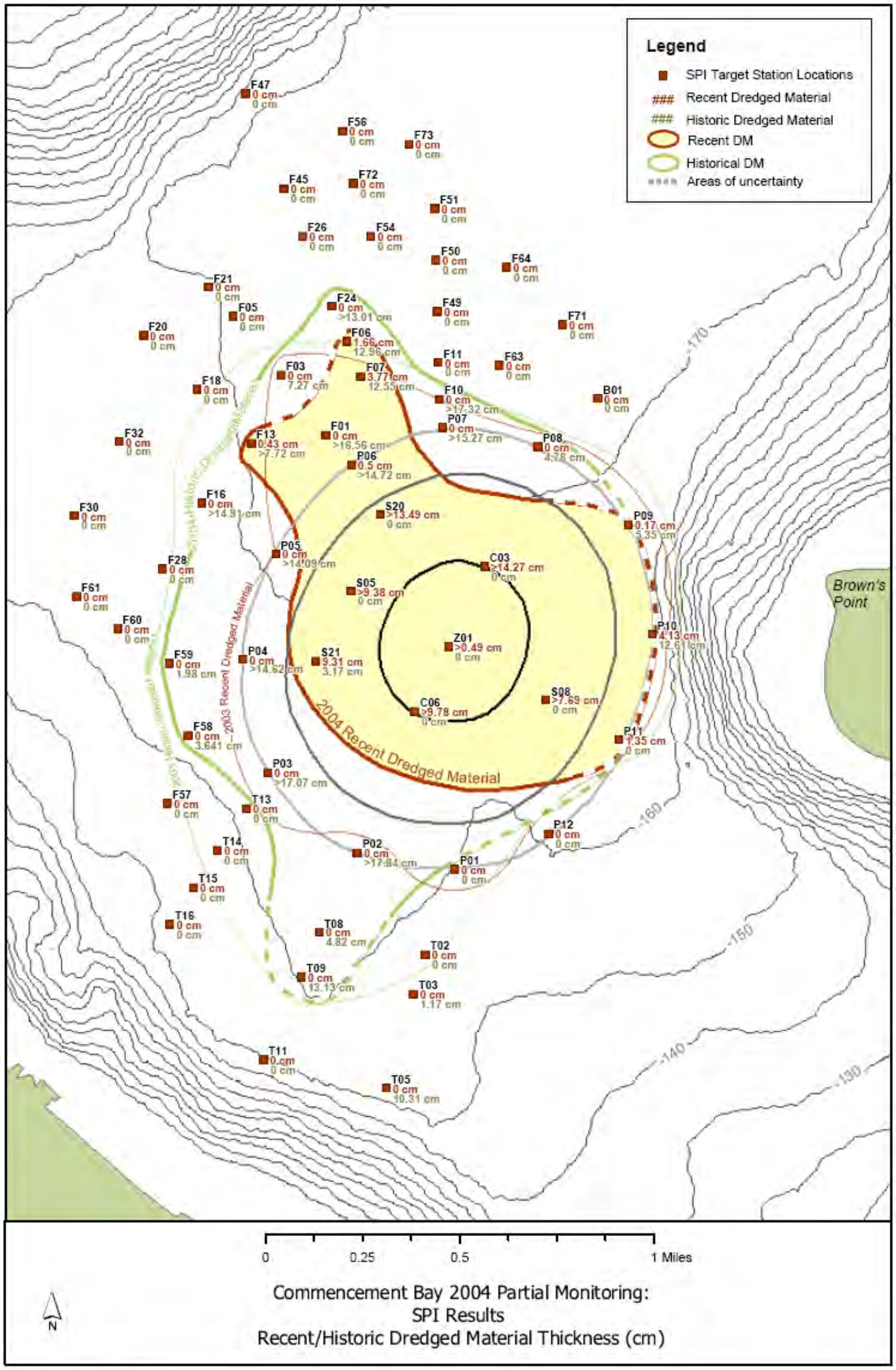


Figure 3-7. 2004 Commencement Bay Dredged Material Footprint (SAIC 2004)

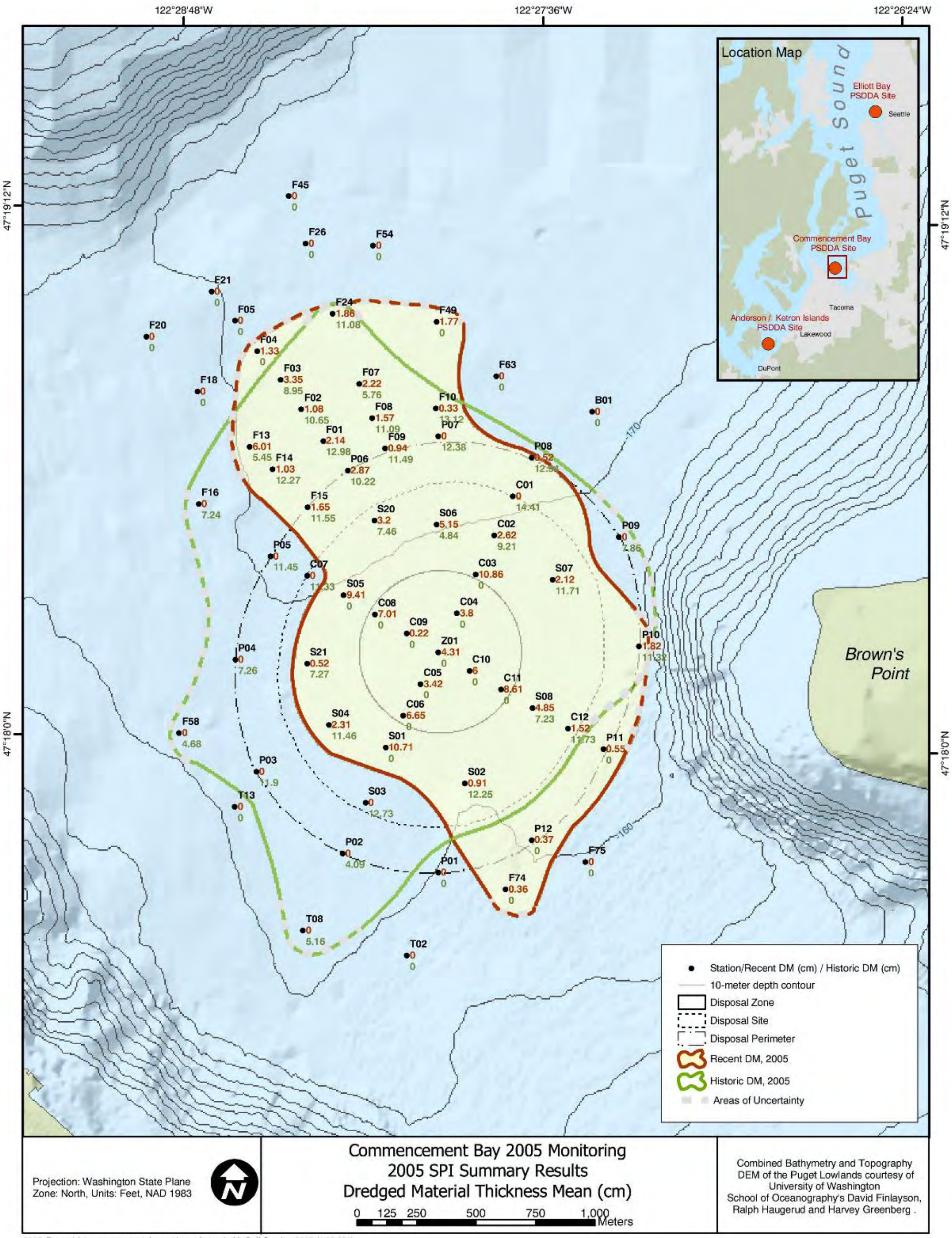


Figure 3-8. 2005 Commencement Bay Dredged Material Footprint (SAIC 2005b)

Table 3-3. Summary of SVPS Biological Parameters in Offsite Areas

Monitoring Year	Area[1]	Number of Stations	Highest Successional Stage Present (% of Stations)			RPD Depth (cm)			OSI[2]		
			Stage I	Stage II	Stage III	Min	Max	Mean	Min	Max	Mean
1988	Baseline Survey	30	7	0	93	2.0	6.3	4.3	6	11	10
1995	Offsite	19	6	47	53	2.6	5.4	4.1	7	11	9.5
	Dredged Material Lobe[3]	0									
1996	Offsite	24	22	0	78	2.0	9.7	3.6	5	11	8.9
	Dredged Material Lobe[3]	0									
1998	Offsite	38	16	0	84	0.9	3.4	2.1	4	10	7.7
	Dredged Material Lobe	4	0	0	100	1.2	2.8	1.8	7	9	8
2001	Offsite	27	30	0	70	0.6	1.7	0.9	3	8	5.9
	Dredged Material Lobe	42	33	0	67	0	2	0.8	2	7	5.5
2003	Offsite	30	30	10	60	1.8	4.6	3.2	4	11	8.4
	Dredged Material Lobe	3	0	0	100	1.8	4	2.7	8	11	9
2004	Offsite	41	0	5	95	1.9	4.3	3.3	4.7	11	9.4
	Dredged Material Lobe	4	0	0	100	3.1	4.1	3.6	7.3	10.3	9.6
2005	Offsite	15	0	0	100	1.7	4.3	3.1	4.5	10.7	8.7
	Dredged Material Lobe	14	0	0	100	2.7	3.8	3.3	7	10.3	9.3
2007	Offsite	27	0	0	100	2.1	5.8	2.7	7.3	9.7	8.7
	Dredged Material Lobe	4	0	0	100	2.5	3.6	3.0	8.7	10	9.5

1. Offsite – offsite areas (beyond the site perimeter) where dredged material was not observed. Dredged Material Lobe – offsite areas where dredged material was present.
2. OSI values greater than or equal to +6 are generally considered indicative of undisturbed benthic habitat quality.
3. Offsite dredged material not observed.

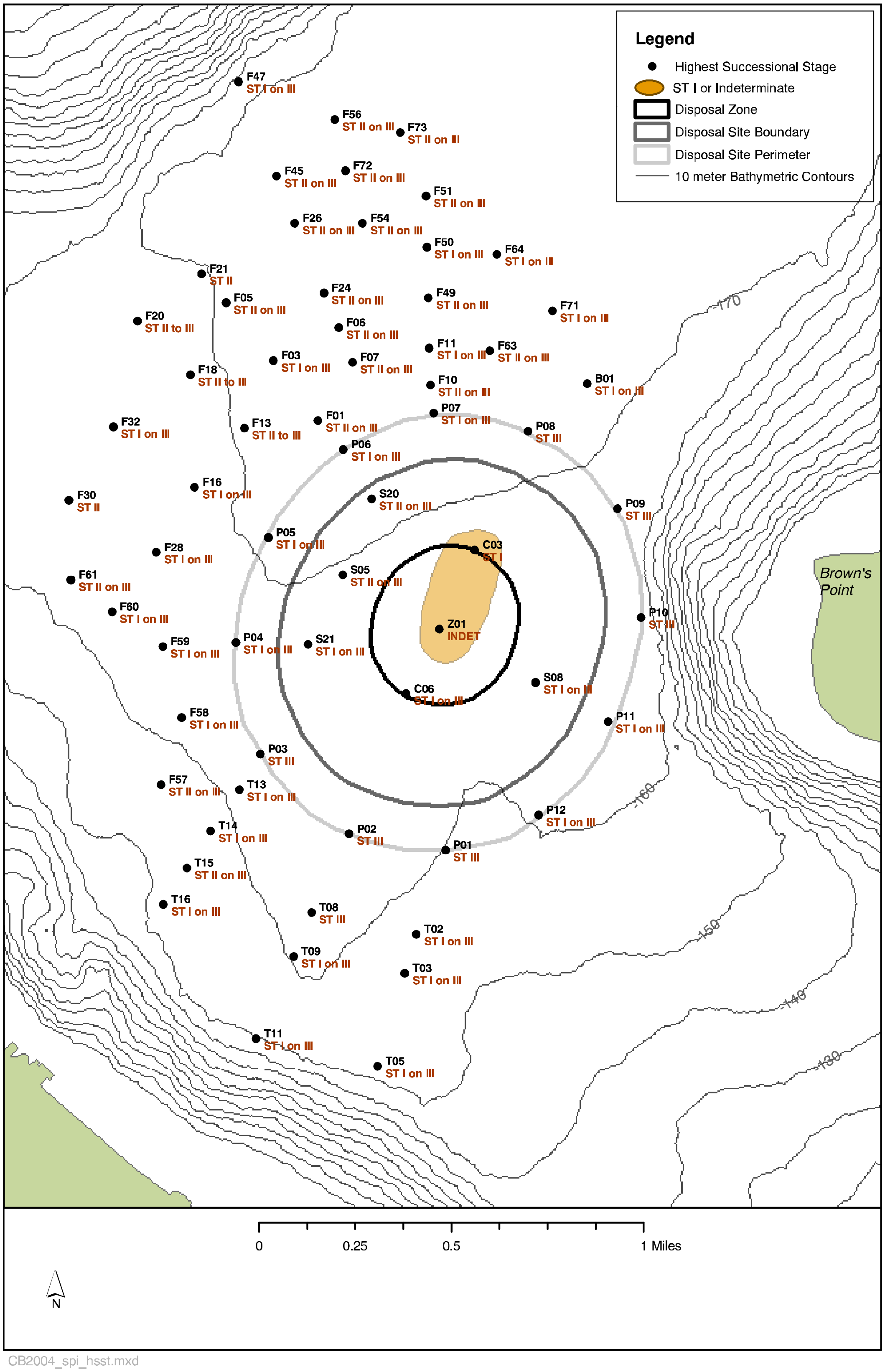


Figure 3-9. 2004 Infaunal Successional Stage Distribution (SAIC 2004)

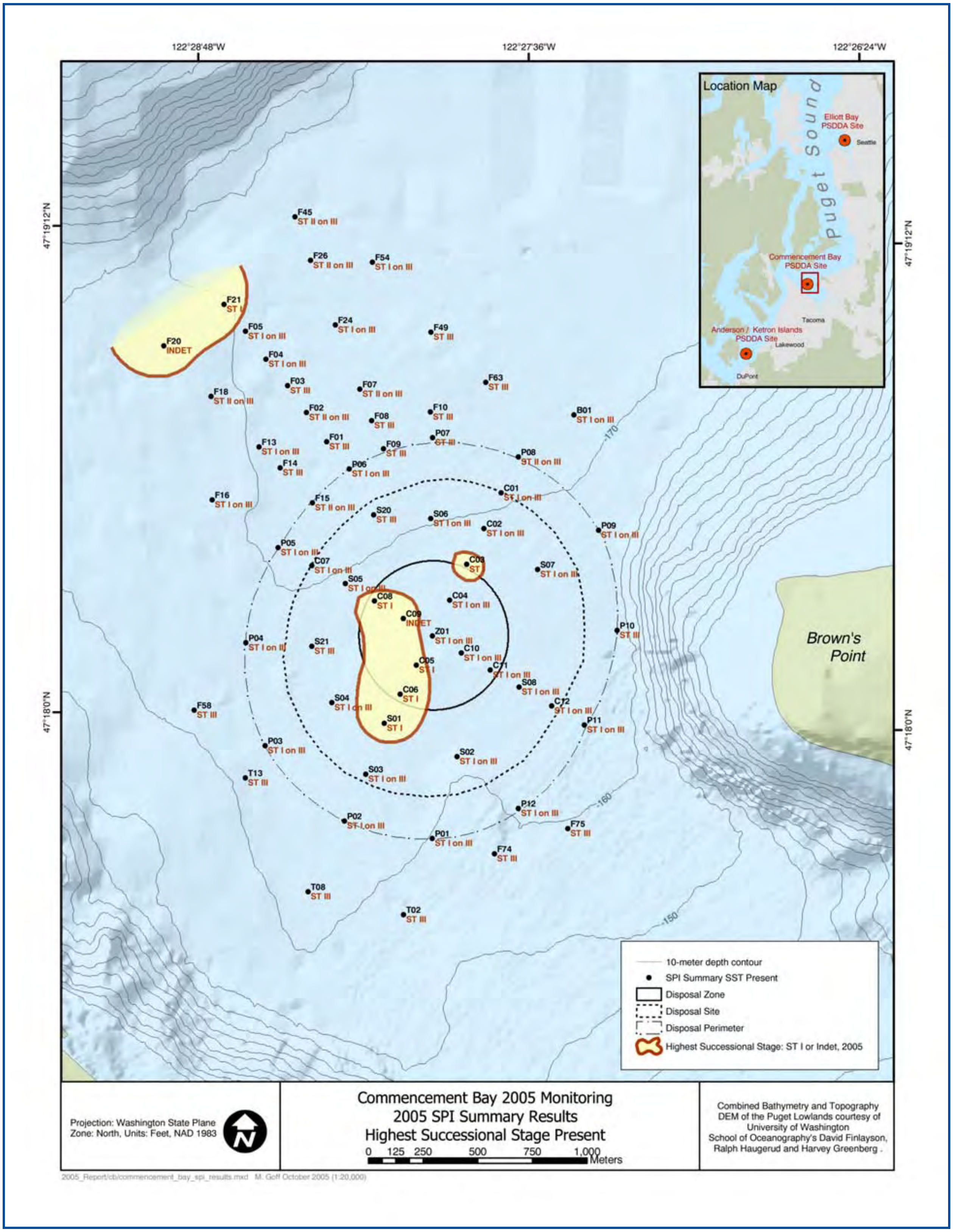


Figure 3-10. 2005 Infaunal Successional Stage Distribution (SAIC 2005b)

3.1.2 Bathymetric Surveys and Numerical Modeling

Physical monitoring of the Commencement Bay disposal site included periodic bathymetric surveys to assess the disposal mound height and distribution of dredged material at the site. Single beam bathymetry surveys were conducted at the site in 2001 and 2004. Multi-beam bathymetric surveys were conducted in 2006 and 2007. These periodic surveys were compared to historical bathymetry to measure the accumulation of dredged material at the disposal site. These survey results were also used to ground truth numerical modeling of dredged material disposal at the site using the Short-term Fate (STFATE) and Multiple Dump Fate (MDFATE) dredged material disposal models developed by USACE, ERDC, Vicksburg, MS, and to explain the dredged material footprint observed and help predict future mound height and extent characteristics (Moritz and Randall 1995).

During the 2001 full monitoring survey, SVPS photography results identified the presence of dredged material beyond the site boundary to the northwest and southeast (Figure 3–5). The USACE Seattle District conducted numerical modeling using the STFATE dredged material disposal model to help explain the observed distribution of dredged material. A bathymetric survey was conducted in 2001 to support this modeling. The survey measured a mound height of approximately 48 feet. The STFATE modeling suggested that the relatively small amount of material deposited offsite (approximately 5 percent) was likely carried beyond the site boundary during disposal operations, and that the material was composed of the clay, silt, and fine sand fractions of the disposed material (Nelson 2006).

By 2004, with a cumulative total of 4,679,259 cy of dredged material disposed at the site (Table 1–1) the mound height had increased to approximately 80 feet, with a total diameter of approximately 2,500 feet (Nelson 2006). The DMMP agencies agreed that additional evaluation was necessary, and the USACE Seattle District conducted STFATE modeling to evaluate the potential effects (footprint and mound height) of the incremental additional disposal of 5.0 million cy, 10.0 million cy, and 15.0 million cy of dredged material. If disposal continued at the existing target location, the modeling predicted mound heights of 167 feet after an additional 5.0 million cy, 255 feet after an additional 10 million cy, and 344 feet after an additional 15 million cy of dredged material disposal (Nelson 2006). The modeling also indicated that 95 percent of the dredged material would be deposited within the site perimeter. However, the STFATE analysis also predicted that if the disposal target area were relocated 565 feet to the southwest, the mound height was estimated to be 125 feet after 5.0 million cy, 182 feet after 10.0 million cy, and 238 feet after 15.0 million cy of dredged material disposal, a reduction in future mound height of between 25 and 31 percent (Nelson 2006). The modeling indicated that 92 percent of the dredged material would be deposited within the site perimeter under this scenario, which remains consistent with management predictions related to minimal dispersal of disposed materials.

In 2006 and 2007, multi-beam bathymetric surveys were conducted by the USACE Seattle District. In 2006, a mound height of 112.6 feet was measured, resulting from a cumulative disposal of 6,439,658 cy of dredged material (Figure 3–11). In 2007, a mound height of 131.6 feet was measured, with a cumulative total of 7,763,912 cy of dredged material (Figure 3–12). Based on the rapidly increasing height of the disposal mound, the deposition of dredged material to the northwest of the disposal site boundary, and the results of the STFATE modeling conducting by the USACE Seattle District, the DMMP agencies moved the disposal site target coordinates 565 feet to the southeast effective June 16, 2007 (Wasson et al. , 2007:

http://www.nws.usace.army.mil/PublicMenu/documents/DMMO/CB-Site-Management-07-Clarification.pdf), after presenting proposed change at the 2007 SMARM.

In 2007, the USACE Seattle District conducted MDFATE numerical modeling to forecast future mound height, footprint, and capacity at the Commencement Bay site based on the new disposal site target coordinates (Michelson 2008). An evaluation of the 2007 bathymetry showed that the disposal mound was confined within the disposal site perimeter (Figure 3–13). With the new target, avalanching of coarse sediments is expected on the southeastern side slope of the existing mound until the footprint becomes broad enough for vertical height accumulation. The model predicted that an additional 5 million cy of dredged material would increase the maximum mound height by approximately 10 feet from the present maximum height (Michelson 2008; Figure 3–14). The model predicted that the mound height would begin to increase rapidly when disposal volume exceeded 5 million cy, and it was recommended that the target area be similarly relocated at that time.

As part of the 2007 study, the USACE Seattle District also evaluated tidal circulation near the mound to determine the potential for sediment transport of disposed materials outside of the site boundary. A two-dimensional circulation model, CMS-M2D (Militello et al. 2004) was used to model tidal currents near the Commencement Bay site. Model results indicated that the depth averaged currents were less than 0.5 feet/second (0.15 meters/second), which is less than the critical velocity required to initiate bed load transport for the sediment characteristics at the site (Michelson 2008).

Conclusions

Periodic bathymetric surveys conducted at the site have confirmed that the dredged material mound is centered over the site target coordinates. The footprints and heights of the dredged material mound measured by the bathymetric surveys were consistent with SVPS survey results. Depth averaged tidal currents modeled in Commencement Bay are not at a sufficient velocity to initiate bed load transport. Recent disposal data also showed that 80 percent of disposal barges/scows were traveling in a northwest direction during disposal. This bias in vessel course could have been a contributing factor to the northwest deposition of dredged material, as observed during the 2001 survey (Michelson 2008). Moving the disposal target coordinates 565 feet to the southeast, effective June 16, 2007, is expected to reduce the rate of growth of the mound height and minimize the deposition of dredged material to the northwest (Wasson et al. 2007).

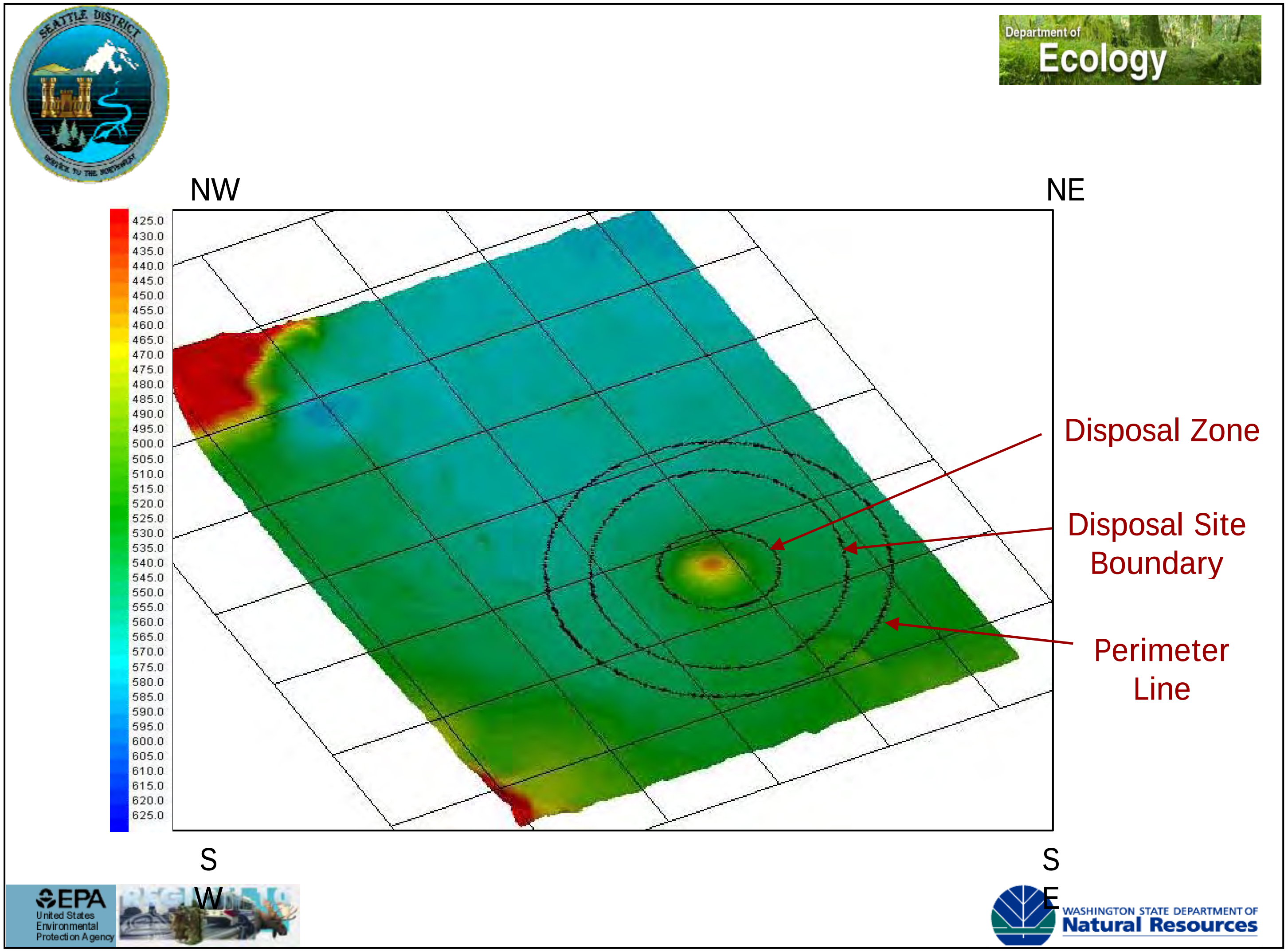


Figure 3-11. 2006 Multi-Beam Bathymetry Survey in Commencement Bay (DMMP 2006)

1 to 1 (vertical to horizontal aspect ratio). View of disposal mound within disposal zone (900-foot radius circle), disposal site boundary, and perimeter line (1/8 nautical mile boundary).

Note: The ellipsoid shape of the site is not apparent due to the aspect ratio.

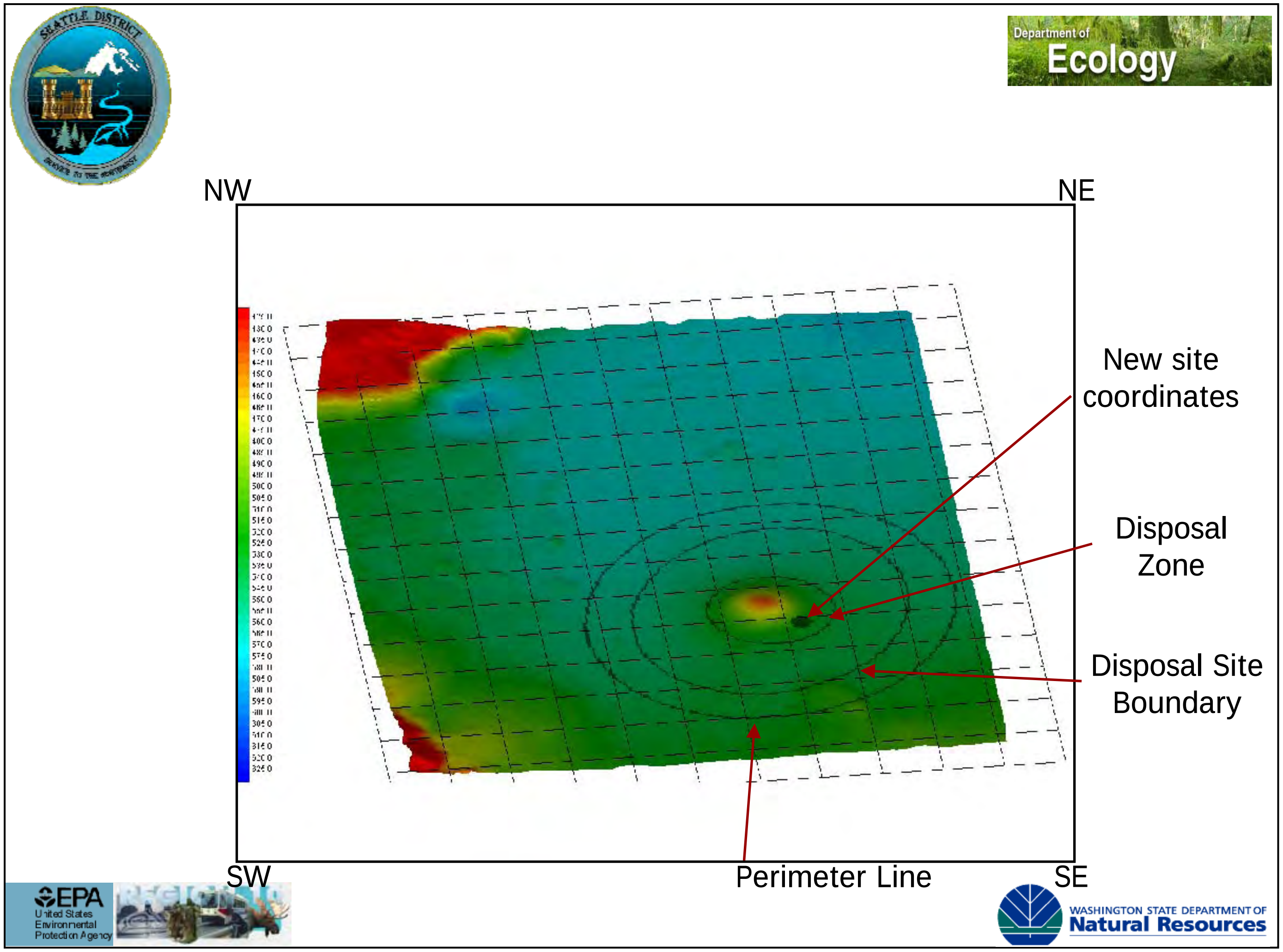


Figure 3-12. 2007 Multi-Beam Bathymetry Survey in Commencement Bay (DMMP 2007b)
1 to 1 (vertical to horizontal aspect ratio). View of disposal mound within disposal zone, disposal site boundary, and perimeter line (1/8 nautical mile boundary).
Note: The ellipsoid shape of the site is not apparent due to the aspect ratio.

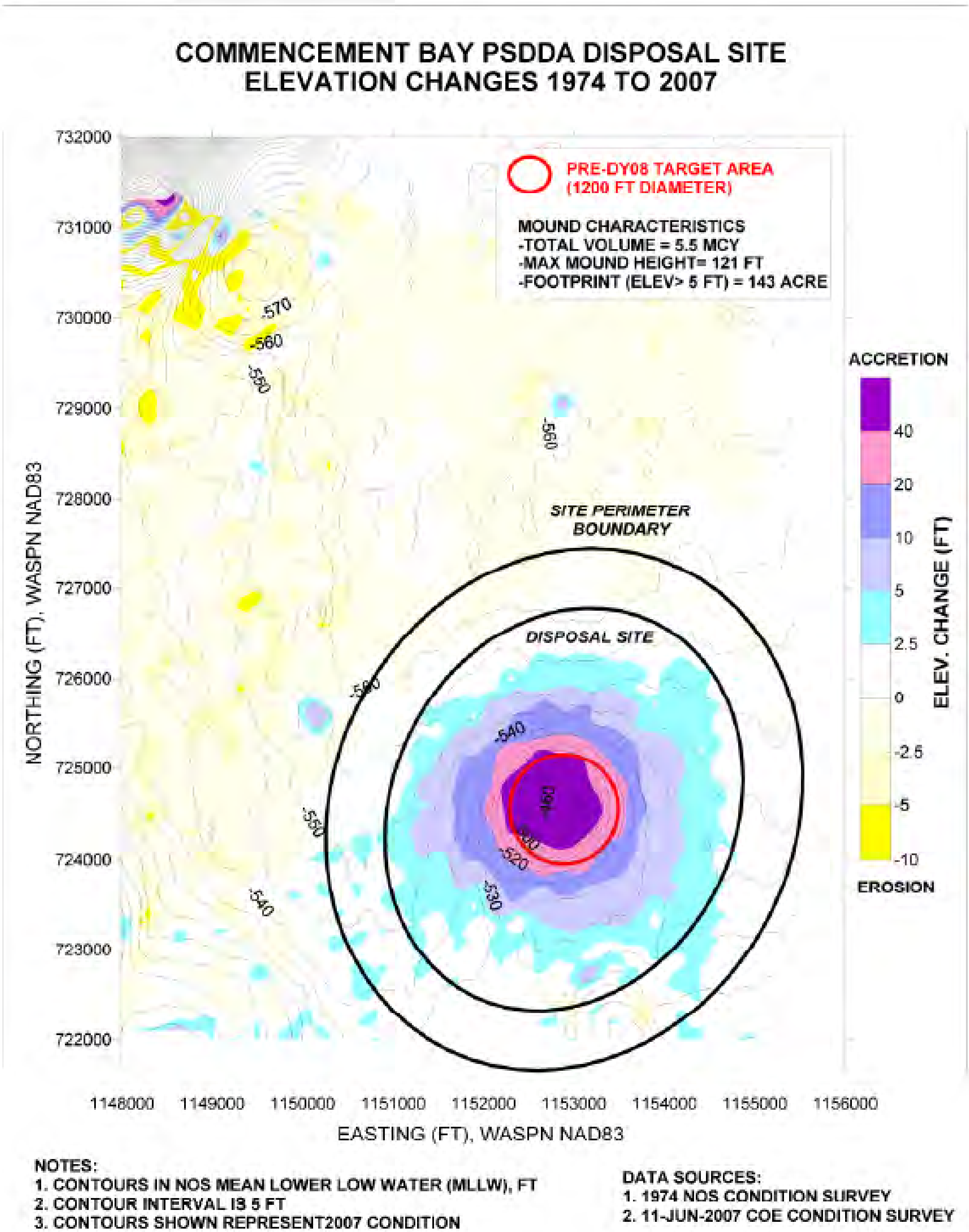


Figure 3-13. Commencement Bay DMMP Site Elevation Changes from Pre-Disposal to 2007 (Michelson 2008)

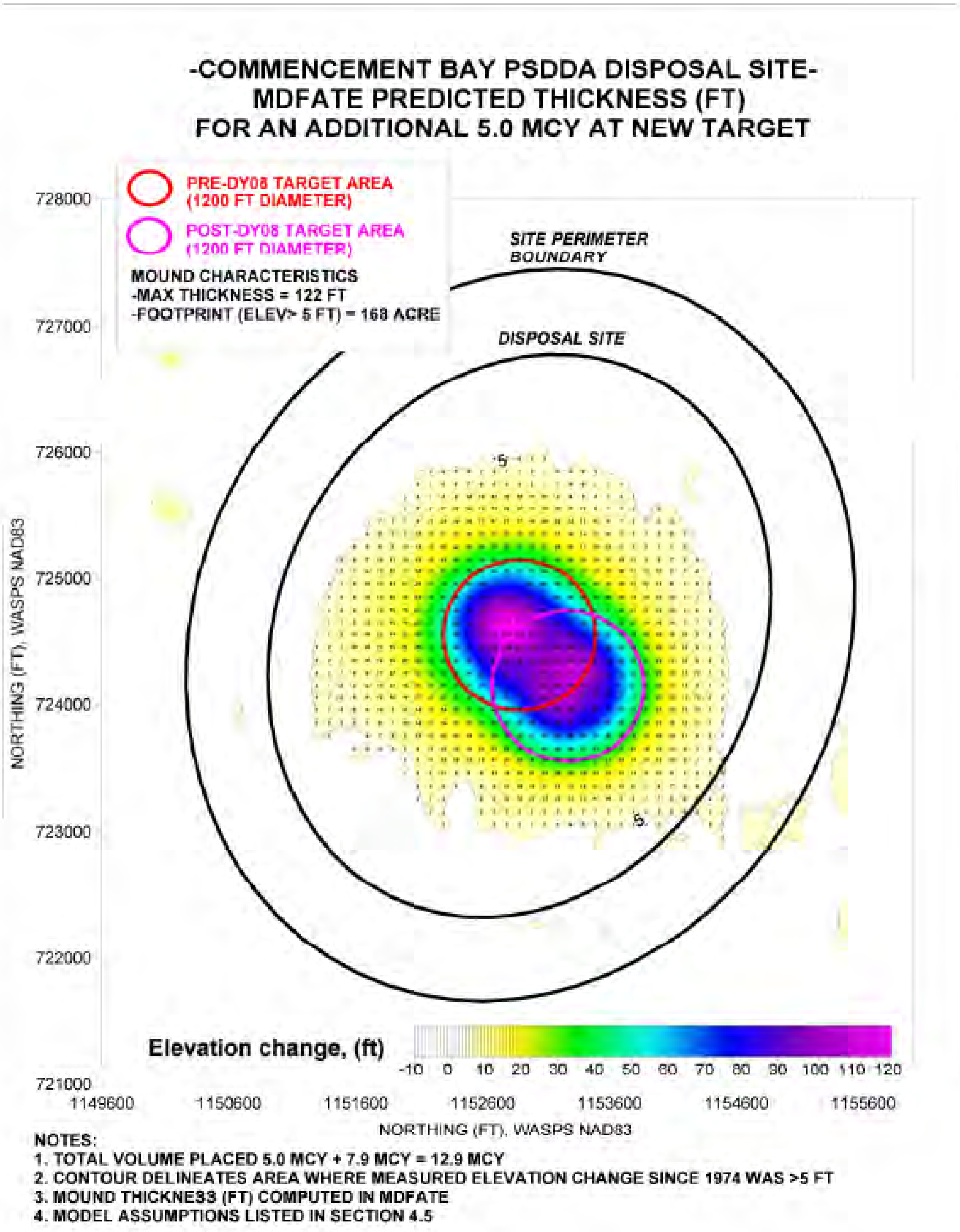


Figure 3-14. MDFATE Predicted Mound Height with New Target and 5 Million CY of Dredged Material (Michelson 2008)

3.2 Onsite Sediment Chemistry

Onsite sediment chemistry is used to evaluate hypothesis 3 (Table 1–2) of the DMMP monitoring framework (Sediment chemical concentrations at the onsite monitoring stations do not exceed the chemical concentrations associated with DMMP site condition II guidelines due to dredged material disposal). The DMMP site management objective involves comparing the onsite sediment chemical concentrations to the DMMP ML guidelines. The number of onsite stations sampled and analyzed for the DMMP chemicals of concern depends on the monitoring survey type. A full monitoring survey includes the sampling and chemical analysis of sediments from three onsite stations (CBZ01, CBS01, and CBS08); whereas, a partial monitoring survey only includes one onsite station for sediment chemical analysis (CBZ01).

Over the duration of the DMMP monitoring program (1988 – 2007), a total of six post-disposal monitoring surveys have been conducted to assess onsite sediment chemistry (Table 3–1). Full monitoring surveys were conducted in 1995, 2001, 2003, and 2007, and partial monitoring surveys were conducted in 1996 and 2004. In each monitoring year, the onsite chemistry not only did not exceed the ML guidelines, but were below the DMMP SL guidelines and SQS criteria.

A summary of metals data from onsite stations shows that all concentrations were well below the DMMP SLs (Table 3–4). Most metals showed similar levels between monitoring years, or a slightly decreasing trend over time (e.g., copper, lead, and zinc). Organic compounds at the onsite stations were also well below the DMMP SLs (Appendix C). Moreover, volatile organic chemicals, pesticides, and PCBs were undetected at all onsite stations with the exception of low concentrations of dichloro-diphenyldichloroethylene (DDE) at station CBS01 in 2001, Dichlorodiphenyltrichloroethane (DDT) at station CBZ01 in 2003, and Dichlorodiphenyldichloroethane (DDD) at all three onsite stations in 2007. Polycyclic aromatic hydrocarbons (PAHs) were detected at low concentrations during the 1988 baseline and the 1995, 2003, and 2007 monitoring years but concentrations were well below the DMMP SLs (Figure 3–15). All PAH compounds were undetected during the 1996, 2001, and 2004 monitoring years. Phenol was detected at slightly elevated concentrations at station CBZ01 during the 1988 baseline and at stations CBS01 and CBS08 during the 2003 monitoring survey. However, those concentrations were **all below** the 2007 DMMP SLs.

Conclusions

Onsite sediment chemical monitoring has confirmed that DMMP site condition II guidelines have not been exceeded, and actually demonstrated onsite chemistry below the SL and SQS. Site monitoring has also confirmed that dredged material taken to the site has passed DMMP suitability criteria (i.e., the chemical concentrations in dredged sediments are below DMMP SLs and SQS criteria), which provides a positive demonstration of the adequacy of the DMMP dredged material testing process over the past 19 years of implementation.

Table 3-4. Metals Concentrations at Onsite Stations in Commencement Bay

Monitoring Year	DMMP SL	DMMP ML	1988	1995	1996[1]	2001	2003	2004[1]	2007
Metals in mg/kg DW									
Station CBZ01									
Antimony	150	200	0.42	1.5	0.2	0.32	1.09	0.02	0.03
Arsenic	57	700	12	5.4	6	3.6	6.2	1.81	1.24
Cadmium	5.1	14	0.21	0.11	0.12	0.066	0.142	0.06	0.026
Chromium	--	--	--	--	--	--	24.9	23.2	5.57
Copper	390	1300	47	24	28	13	22.1	11.5	8.8
Lead	450	1200	32	50	46	2.9	7.51	1.75	1.43
Mercury	0.41	2.3	0.17	0.06	0.01	0.014	0.03	0.01	0.014
Nickel	140	370	31	28	25	7.5	21.8	33.6	5.15
Selenium	--	--	--	--	--	--	0.1	0.2	0.1 U
Silver	6.1	8.4	0.36	0.13	0.05	0.12	0.13	0.035	0.02
Zinc	410	3800	74	79.7	67	26	36.7	26.2	12
Station CBS01									
Antimony	150	200	0.82	1.5		0.46	0.56		0.05
Arsenic	57	700	13	10		3	6.3		2.51
Cadmium	5.1	14	0.16	0.18		0.14	0.194		0.103
Chromium	--	--	--	--		--	17.8		9.55
Copper	390	1300	48	37		18	26.5		15.7
Lead	450	1200	33	49		5.5	11.6		3.19
Mercury	0.41	2.3	0.18	0.1		0.038	0.04		0.03
Nickel	140	370	31	29		11	13.8		8.77
Selenium	--	--	--	--		--	0.1		0.2
Silver	6.1	8.4	0.34	0.24		0.66	0.16		0.05
Zinc	410	3800	77	84.6		34	42.4		20.1
Station CBS08									
Antimony	150	200	0.4	1.8		0.51	0.41		0.06
Arsenic	57	700	9.2	6.9		3	5.8		3.22
Cadmium	5.1	14	0.17	0.1		0.12	0.229		0.077
Chromium	--	--	--	--		--	17.6		10.7
Copper	390	1300	40	31.2		22	27.4		20.2
Lead	450	1200	24	53		7.1	13.4		4.38
Mercury	0.41	2.3	0.13	0.1		0.0636	0.04		0.05
Nickel	140	370	25	29		12	13.8		9.98
Selenium	--	--	--	--		--	0.1		0.3
Silver	6.1	8.4	0.39	0.2		0.63	0.2		0.06
Zinc	410	3800	66	78.1		40	47.1		23.6

1. Only station CBZ01 is sampled during partial monitoring surveys.

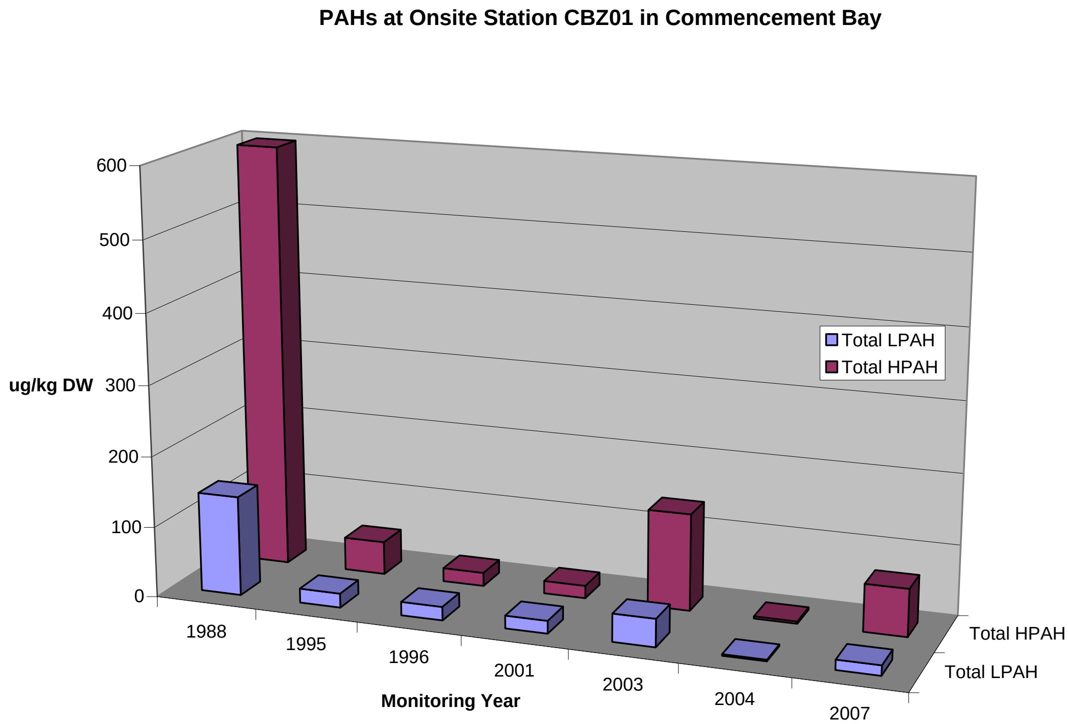


Figure 3-15. Total LPAH and HPAH Concentrations at Station CBZ01
SL for LPAH is 5,200 µg/kg DW. SL for HPAH is 12,000 µg/kg.

3.3 Onsite Sediment Toxicity

Onsite sediment bioassays are used to address hypothesis 4 of the DMMP monitoring framework (Sediment toxicity at the onsite monitoring stations do not exceed the DMMP site condition II biological response guidelines due to dredged material disposal). Onsite sediment toxicity responses are compared to the toxicity responses of reference sediments in accordance with DMMP bioassay guidelines (DMMP 2003). The standard DMMP bioassays include a 10-day amphipod acute test (*Eohaustorius estuarius, Rhepoxynius abronius*), a 48-hour sediment larval test, and the 20-day *Neanthes* growth test. The initial 1988 baseline toxicity testing results were based on two tests: the amphipod 10-day acute test (*Rhepoxynius abronius*) and the saline Microtox bioassay. The bivalve sediment larval testing results (*Mytilus galloprovincialis*) did not meet the Quallity Assurance/Quality Control testing requirements, and the data were not useable for baseline evaluations. The initial **pre-disposal** baseline toxicity results noted amphipod bioassay toxicity responses at the onsite center CBZ01 station and at benchmark station CBB01 exceeding the site condition II interpretation response (both registering a 1-hit response).

The number of onsite stations sampled and tested for the DMMP bioassays depends on the monitoring survey type. A full monitoring survey includes the sampling and testing of sediments from three onsite stations (CBZ01, CBS01, and CBS08). A partial monitoring survey only includes one onsite station for sediment toxicity (CBZ01). The DMMP toxicity testing requirements have evolved over the duration of the program (a chronology of modifications can be found at http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=dmmo&pagename=Bioassays).

Including the baseline survey in 1988, a total of seven monitoring surveys have included onsite sediment toxicity testing (Table 3–1). Full monitoring surveys were conducted in 1995, 2001, 2003, and 2007. Partial monitoring surveys were conducted in 1996 and 2004. In each post-disposal monitoring year, the onsite toxicity results passed the DMMP bioassay interpretive guidelines (i.e., toxic responses were not observed) (Appendix D).

The 1988 baseline toxicity results did not pass the DMMP interpretive guideline based on one of two reference sediment evaluations. Although the 1988 baseline survey included only two bioassay tests (amphipod and saline Microtox tests), the results of the bioassays were evaluated within the context of the DMMP monitoring plan guidelines. A comparison of the test results to the Carr Inlet indicated that station CBZ01 and benchmark Station CBB01 exceeded site condition II. The amphipod test results for CBZ01 and CBB01 showed significant differences to the Carr Inlet reference, and the difference in mortality was greater than 30 percent.

During the 2001 monitoring event, additional toxicity stations were evaluated in three floating stations, and one perimeter station outside the boundary of the disposal site, but within the thin layer of dredged material observed in the SVPS dredged material footprint (Figure 3–5). Additionally, toxicity was assessed at all 3 benchmark stations. No toxicity was observed in these toxicity tests, and these toxicity results were consistent with the DMMP non-dispersive site interpretation guidelines and site management objectives.

Conclusions

Although a toxic response was measured at CBZ01 during the 1988 predisposal baseline survey, there have been no toxic responses observed during postdisposal monitoring events at any onsite station since that time. Onsite sediment toxicity testing at the site has confirmed that DMMP site condition II biological response guidelines have not been exceeded since 1988, which also provides positive evidence of the adequacy of the DMMP evaluation procedures in properly characterizing dredging projects over the life of the DMMP.

3.4 Perimeter Sediment Chemistry

Perimeter sediment chemistry is used to address hypothesis 2 (Table 1–2) of the DMMP monitoring framework (Chemical concentrations do not measurably increase over time at offsite stations due to dredged material disposal). Four perimeter stations are monitored at Commencement Bay, including CBP01, CBP03, CBP07, and CBP11. Triplicate sediment samples are collected at each station and analyzed for conventional parameters and the DMMP chemicals of concern.[7] To address hypothesis 2, the chemical results from perimeter stations are compared to the Washington State SQS (WAC 173-204). Chemical concentrations are compared over time to the SQS levels and compared to pre-disposal baseline concentrations. A statistical time trend analysis is conducted using the Chemical Tracking System (CTS) developed in 1996 (SAIC and MWLS 1996). The CTS was developed as an "early warning" system and was first used as part of the 1996 partial monitoring survey evaluation of the Commencement Bay site.

Including the baseline survey in 1988, a total of eight monitoring surveys have included perimeter sediment chemistry monitoring (Table 3–5). Full monitoring surveys were conducted in 1995, 2001, 2003, and 2007. Partial monitoring surveys were conducted in 1996 and 2004. In addition, the physical monitoring survey conducted in 2005 included the analysis of semi-volatile organic chemicals (SVOCs) at perimeter stations to evaluate phenol concentrations. These results are included in this data evaluation of perimeter sediment chemistry.

3.4.1 Comparison to Washington State SQS

Perimeter sediment chemistry did not exceed Washington State Sediment SQS (Table 3–6) with the exception of monitoring years 2003 and 2004. In 2003, perimeter station chemistry exceeded the SQS for 1,2,4-trichlorobenzene, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and phenol (Table 3–7). However, 1,2,4-trichlorobenzene was **undetected** at all perimeter stations and the SQS was only exceeded based on the **detection limit**. For one replicate sample at station BP01, butylbenzylphthalate exceeded the SQS criteria and bis(2-ethylhexyl)phthalate exceeded the maximum level chemical guideline. The reported concentration for bis(2-ethylhexyl)phthalate was qualified due to laboratory blank contamination. Phthalates are a common contaminant in laboratory analyses. The other two replicate samples for station CBP01 had concentrations of butylbenzylphthalate and bis(2-ethylhexyl)phthalate well below the SQS criteria. Phenol slightly exceeded the SQS criteria in two replicate samples at station CBP01 and one replicate at station CBP03. Phenol results were also qualified due to low-level method blank contamination.

One year later, the partial monitoring survey in 2004 found all chemical concentrations at perimeter stations below the Washington State SQS with the exception of hexachlorobenzene, which was **undetected**. The reported detection limit, however, exceeded the SQS criterion at station CBP11 due to low TOC concentrations in Commencement Bay sediments, but was well

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[7] During the 1988 baseline survey, single replicate samples were collected at 12 perimeter stations. Collection of triplicate samples at a smaller number of stations was adopted in 1992 (SAIC 1992).

below the DMMP SL[8]. In 2007, 1,2,4-trichlorobenzene was undetected at onsite station CBZ01, but the carbon-normalized detection limit (1.0 U mg/kg TOC) slightly exceeded the SQS of 0.83 mg/kg TOC.

Table 3-5. Perimeter Sediment Chemistry Monitoring at Commencement Bay

Survey	Disposal Volume (cy)	Cumulative Volume (cy)	Perimeter Chemistry below SQS? (DMMP Hypothesis No. 2)	Chemical Groups with Statistically Significant Increases below SQS (CTS Analysis)
1988 Baseline Survey	0	0	Yes	CTS not implemented
1995 Full Monitoring	290,857	308,405	Yes	CTS not implemented
1996 Partial Monitoring	460,684	769,089	Yes	Metals at CBP01
2001 Full Monitoring	265,867	2,762,591	Yes	None
2003 Tiered-Full Monitoring	710,675	3,473,266	No[1]	None
2004 Partial Monitoring	1,205,993	4,679,259	Yes	None
2005 Physical Monitoring	949,399	5,628,658	Yes	None[2]
2007 Full Monitoring	1,324,254	7,763,912	Yes	None

1. The SQS was exceeded for 1,2,4-trichlorobenzene, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and phenol.
2. Only SVOCs were analyzed at perimeter stations in 2005.

[8] NOTE: In SMS, when TOC's are below 0.5%, carbon-normalizing of chemical data is not appropriate, and dry-weight concentrations equivalent to the LAET = SL would apply.

Table 3-6. Washington State Sediment Quality Standards and Cleanup Screening Levels

Analyte	SQS	CSL
Conventional Parameters		
Total Solids (%)	---	---
Total Volatile Solids (%)	---	---
Total Organic Carbon (%)	---	---
Total Sulfides (mg/kg)	---	---
Ammonia (mg/kg)	---	---
Grain Size	---	---
Metals (mg/kg)		
Arsenic	57	93
Cadmium	5.1	6.7
Chromium	260	270
Copper	390	390
Lead	450	530
Mercury	0.41	0.59
Silver	6.1	6.1
Zinc	410	960
Low Molecular Polycyclic Aromatic Hydrocarbons (LPAH) (mg/kg OC)		
Naphthalene	99	170
Acenaphthylene	66	66
Acenaphthene	16	57
Fluorene	23	79
Phenanthrene	100	480
Anthracene	220	1200
2-Methylnaphthalene	38	64
Total LPAH	370	780
High Molecular Polycyclic Aromatic Hydrocarbons (HPAH) (mg/kg OC)		
Fluoranthene	160	1200
Pyrene	1000	1400
Benzo(a)anthracene	110	270
Chrysene	110	460
Benzofluoranthenes	230	450
Benzo(a)pyrene	99	210
Indeno(1,2,3-c,d)pyrene	34	88
Dibenzo(a,h)anthracene	12	33
Benzo(g,h,i)perylene	31	78
Total HPAH	960	5300

Analyte	SQS	CSL
Chlorinated Benzenes (mg/kg OC)		
1,2-Dichlorobenzene	2.3	2.3
1,4-Dichlorobenzene	3.1	9
1,2,4-Trichlorobenzene	0.81	1.8
Hexachlorobenzene	0.38	2.3
Phthalate Esters (mg/kg OC)		
Dimethyl phthalate	53	53
Diethyl phthalate	61	110
Di-n-butyl phthalate	220	1700
Butyl benzyl phthalate	4.9	64
Bis(2-ethylhexyl)phthalate	47	78
Di-n-octyl phthalate	58	4500
Ionizable Organic Compounds (µg/kg)		
Phenol	420	1200
2-Methylphenol	63	63
4-Methylphenol	670	670
2,4-Dimethylphenol	29	29
Pentachlorophenol	360	690
Benzyl alcohol	57	73
Benzoic acid	650	650
Miscellaneous Compounds (mg/kg OC)		
Dibenzofuran	15	58
Hexachlorobutadiene	3.9	6.2
N-Nitrosodiphenylamine	11	11
Total PCBs	12	65

Table 3-7. 2003 Perimeter Station Chemistry that Exceeds Washington State SQS Criteria

Parameter	SQS Chem Criteria	CSL Chem Criteria	CBP01-A	CBP01-B	CBP01-C	CBP03-A	CBP03-B	CBP03-C
Chlorinated Aromatics (mg/kg TOC)								
1,2,4-Trichlorobenzene	0.81	1.8	1.52 U	1.48 U	1.5 U	1.62 U	1.72 U	1.63 U
Phthalates (mg/kg TOC)								
Butylbenzylphthalate	4.9	64	0.3 J	0.3 J	28.6	0.3 J	0.3 J	4.2
Bis(2-ethylhexyl)phthalate	47	78	1.3 JB	3.0 B	195 BE	1.9 B	2.0 B	1.3 JB
Phenols (µg/kg DW)								
Phenol	420	1200	420 BE	440 BE	480 BE	440 BE	420 BE	420 BE
Parameter	**SQS Chem Criteria**	**CSL Chem Criteria**	**CBP07-A**	**CBP07-B**	**CBP07-C**	**CBP11-A**	**CBP11-B**	**CBP11-C**
Chlorinated Aromatics (mg/kg TOC)								
1,2,4-Trichlorobenzene	0.81	1.8	1.24 U	1.21 U	1.38 U	1.53 U	1.60 U	1.63 U
Phthalates (mg/kg TOC)								
Butylbenzylphthalate	4.9	6.4	0.2 J	0.3 J	0.2 J	0.2 J	0.2 J	0.2 J
Bis(2-ethylhexyl)phthalate	47	78	0.8 JB	1.3 B	1.6 B	1.9 B	1.4 J	1.2 JB
Phenols (µg/kg DW)								
Phenol	420	1200	380 B	320 B	380 B	110 B	89 B	11 JB

Data Qualifiers:
J: The result is an estimated concentration that is less than the method reporting limit (MRL), but greater than or equal to the MDL.
U: The compound was analyzed for, but was not detected ("non-detect") at or above, the MRL/MDL.
B: The analyte was found in the associated method blank at a level that is significant to the sample result, indicating possible/probable blank contamination.
E: The result is an estimate amount because the value exceeded the instrument calibration range.
Shading indicates sample result exceeded SQS criteria.
Bolded text indicates sample result exceeds the maximum chemical criteria.

3.4.2 *CTS Analysis*

Statistical time trend analysis using CTS provides an "early warning" for perimeter sediment chemicals that may be increasing over time, but are below the Washington State SQS. CTS analysis found that the majority of chemical compounds at perimeter stations have exhibited a decreasing trend since the 1988 baseline.

In 1996, a statistically significant increase in metals was observed at CBP01 with an increasing trend of 6.2 percent per year since 1988. Further examination of the slopes and p-values indicated significant increases for arsenic, copper, lead, and zinc. However, **all** metals concentrations were **well below** the SQS and these increases represented small changes relative to low baseline concentrations (Table 3–8). In 2001, the maximum likelihood estimations for the major chemical groups (conventionals, metals, LPAHs, and HPAHs) all showed decreasing trends with the exception of LPAHs at CBP07, which had an increasing trend of 7.3 percent per year since 1988. However, the increase was not statistically significant.

In 2003, the maximum likelihood estimations for the major chemical groups also showed **decreasing** trends, with statistically significant decreases for some groups. Metals as a group showed small but statistically significant decreasing trends at stations CBP03 (-4.79 percent per year, p=0.012) and CBP07 (-4.13 percent per year, p=0.021). For individual metals, only silver at station CBP01 and cadmium at station CBP07 showed small increasing trends that were statistically significant. The LPAH and HPAH groups also showed decreasing trends at all perimeter stations. However, large and statistically significant increases in phenol were observed at stations CBP01, CBP03, and CBP07 (Table 3–9). Station CBP01 showed an increasing trend of +75.21 percent per year (p=0.017), station CBP03 showed an increasing trend of +23.76 percent per year (p=0.046), and station CBP07 showed an increasing trend of +25.4 percent per year (p=0.025). At stations CBP01 and CBP03, concentrations of phenol had increased from undetected in 1988 to concentrations just above the DMMP SL and SQS in 2003.

However, subsequent CTS analysis of perimeter chemistry found a **rapid decrease** in phenol concentrations. In 2004, phenol concentrations ranged from 11 to 54 µg/kg DW at the perimeter stations, concentrations well below the Washington State SQS. The CTS analysis still measured an increasing trend for phenol at all perimeter stations, but the trend was smaller in 2004 and not statistically significant. Station CBP01 showed the largest increasing trend of +48.49 percent per year. Increasing trends for the remaining perimeter stations ranged from +8.00 percent to +13.91 percent per year. Similarly, in 2005 and 2007, phenol concentrations were also very low with detected concentrations ranging from 9.8 to 39 µg/kg DW in 2005 and 13 to 62 µg/kg DW in 2007. The CTS analysis showed that the rate of increase continued to decrease over time, and the trends were not statistically significant ($p<0.05$).

Table 3-8. CTS Maximum Likelihood Results for Commencement Bay Perimeter Stations

Perimeter Station		CBP01		CBP03		CBP07		CBP11	
Year	Chemical Group	% Change/Year	P-Value	% Change/Year	P-Value	% Change/Year	P-Value	% Change/Year	P-Value
1996	Conventionals	117.57	0.0000	9.75	0.7972	18.95	0.1406	19.50	0.0000
	Metals	6.15	0.0024	-14.12	0.0883	-2.86	0.6847	-1.34	0.7449
	LPAH	-20.93	0.0006	-17.61	0.2720	7.59	0.6058	-3.72	0.3353
	HPAH	-17.37	0.0697	-12.87	0.8029	-4.50	0.6674	-14.07	0.2118
2001	Conventionals	-4.03	0.2853	-8.09	0.1898	-8.38	0.4759	-7.75	0.2298
	Metals	-2.05	0.2688	-4.30	0.0314	-5.00	0.0225	-5.40	0.0670
	LPAH	-19.54	0.1419	-2.46	0.6834	7.29	0.1126	-6.45	0.3425
	HPAH	-25.15	0.0893	-11.42	0.1109	-4.59	0.3136	-16.74	0.0478
2003	Conventionals	2.21	0.3945	-1.69	0.3710	2.05	0.4205	0.73	0.7446
	Metals	-1.68	0.3512	-4.79	0.0122	-4.13	0.0215	-2.75	0.1993
	LPAH	-21.22	0.0613	-6.86	0.2521	-0.83	0.8826	-7.71	0.3090
	HPAH	-21.09	0.0120	-10.41	0.0471	-4.03	0.3061	-11.84	0.0562
2004	Conventionals	0.25	0.8954	-12.82	0.0001	-4.68	0.3089	-2.09	0.2487
	Metals	-2.74	0.2569	-6.05	0.0313	-4.63	0.0808	-3.84	0.1746
	LPAH	-21.34	0.0417	-14.76	0.1055	-5.10	0.4379	-15.65	0.2258
	HPAH	-19.37	0.0063	-13.63	0.0175	-9.19	0.0853	-12.94	0.0293
2005	Conventionals	-2.05	0.3111	-12.92	0.0003	-7.64	0.0742	-2.89	0.1556
	Metals	--	--	--	--	--	--	--	--
	LPAH	-21.52	0.0305	-17.78	0.0677	-6.65	0.2992	-16.45	0.1867
	HPAH	-19.58	0.0030	-15.43	0.0075	-10.29	0.0413	-13.72	0.0142
2007	Conventionals	1.44	0.1790	0.23	0.8596	0.76	0.5960	0.43	0.6217
	Metals	-5.53	0.0074	-6.93	0.0006	-6.52	0.0013	-5.94	0.0076
	LPAH	-13.95	0.0035	-9.24	0.0333	-5.20	0.0841	-12.33	0.0210
	HPAH	-15.36	0.0012	-10.22	0.0103	-8.68	0.0092	-12.39	0.0013

-- Metals were not analyzed in 2005.

Table 3-9. CTS for Phenol at Commencement Bay Perimeter Stations

Perimeter Station	CBP01		CBP03		CBP07		CBP11	
Year	% Change/Year	P-Value	% Change/Year	P-Value	% Change/Year	P-Value	% Change/Year	P-Value
1996	--	--	--	--	-0.23	0.9971	23.28	0.0121
2001	--	--	--	--	1.01	0.9546	2.92	0.8170
2003	75.21	0.0175	23.76	0.0464	25.40	0.0249	11.92	0.1554
2004	48.49	0.0537	10.41	0.2990	13.91	0.1388	8.00	0.2042
2005	32.33	0.0598	3.81	0.6399	7.01	0.3647	3.51	0.4972
2007	22.05	0.0568	1.50	0.8131	1.91	0.7572	1.11	0.7435

3.4.3 *Conclusions*

Perimeter sediment chemistry monitoring has shown that detected chemical concentrations in offsite areas **have not** exceeded the Washington State SQS, with the exception of the 2003 monitoring survey, when elevated phenol concentrations (above the SLs and SQS) were observed. However, all other monitoring surveys between 1995 and 2007 found phenol concentrations below the SLs and SQS. The source of phenol measured during the 2003 survey is unknown. Several natural pathways (e.g., conifer needles, wood particles, natural degradation of various organic materials) may exist for phenol to accumulate in sediments (SAIC 2005). Elevated phenol concentrations above the SQS have been reported in many areas of Puget Sound (Long et al. 2003) and fluctuating levels of phenol have been observed in Hood Canal (M. Dutch, personal communication 2005).

Statistical time trend analysis using CTS has found that the majority of chemical compounds at perimeter stations have exhibited a **decreasing** trend since the 1988 baseline survey, suggesting an **improvement in sediment quality** due to dredged material disposal.

3.5 Offsite Tissue Chemistry

Tissue chemistry from offsite biological resources is used to address hypothesis 5 of the DMMP monitoring framework (The chemical body burden of benthic infauna species collected down current of the disposal site have not significantly increased due to dredged material disposal). Hypothesis 5 is addressed only during a full monitoring event (Table 3–1). The sea cucumber *Molpadia intermedia* is the target species in Commencement Bay. Triplicate tissue samples are collected from three transect stations and analyzed for the DMMP bioaccumulative contaminant of concern (BCOCs) (Appendix E). The results are then compared to tissue guideline values derived from baseline tissue concentrations. The tissue guidelines are three times the baseline concentrations for metals, and five times the baseline concentrations for organics.

During the 1988 baseline survey, single replicate *Molpadia intermedia* tissue samples were collected from 12 stations, including three benchmark stations and nine transect stations. The only organic compounds detected were HPAH and phenol at benchmark stations CBB03 and CBB01, respectively. All DMMP metals were detected in tissue samples at low concentrations. During the 1995 full monitoring survey, *Molpadia intermedia* tissue samples were collected from transect stations CBT01, CBT03, and CBT05. A comparison to the 1988 guideline values showed that all chemical compounds were below the guideline with the exception of bis(2-ethylhexyl)phthalate. This detection was thought to be a laboratory artifact as bis(2-ethylhexy)phthalate is a common analytical contaminant.

In 2001, triplicate tissue samples were collected at transect stations CBT13, CBT14, CBT15, and CBT16 due to the apparent offsite accumulation of dredged material to the northwest (SEA 2001). In addition, the 1995 monitoring results for tissue chemistry were adopted as the new baseline for Commencement Bay (Section 3.2). As a result, the 2001 tissue chemistry results could not be compared directly to the 1995 guideline values, as only stations CBT01, CBT03, and CBT05 were analyzed for tissue chemistry in 1995. Based on a review of water depths and sediment characteristics, it appeared that physical characteristics for stations CBT01 and CBT03 were similar to the 2001 sampling locations. Therefore, mean values calculated for CBT01 and CBT03 were used to derive the 1995 guideline values for comparison to 2001. Based on this comparison, guideline values were exceeded for one replicate sample for all transect stations (Table 3–10). Compounds exceeding guideline values included metals (mercury and copper) and phenol.

In accordance with the DMMP monitoring framework, the 2001 benchmark tissue samples were analyzed to determine whether the elevated chemical compounds at the transect stations were observed area wide. The benchmark tissue samples also exhibited elevated concentrations for metals (copper and nickel) and phenol (Table 3–11). These results indicated that hypothesis 5 was accepted (The chemical body burden of benthic infauna species collected down current of the disposal site has not significantly increased due to dredged material disposal).

Table 3-10. 2001 Transect Tissue Chemistry from Commencement Bay (SEA 2001)

	1995 Baseline	Guideline	Replicate CBT13-A	CBT13-B	CBT13-C	Mean	Maximum Percent Difference
Metals (mg/kg, wet weight)							
Antimony	0.175 J	0.525	0.28	0.34	0.15	0.26	-36
Arsenic	14.8	44.4	21.92	23.12	11.23	18.76	-48
Cadmium	0.1425	0.4275	0.022	0.030	0.011	0.021	-93
Chromium	--	--	0.43	0.44	0.34	0.40	--
Copper	0.57	1.71	0.85	1.11	1.02	0.99	-35
Lead	1.15	3.45	1.00	0.94	0.49	0.81	-71
Mercury	0.0175	0.0525	0.042 J	0.069 J	0.027 J	0.046 J	**31**
Nickel	0.4 U	1.2	0.37	0.39	0.25	0.34	-67
Selenium	--	--	1.10	1.25	0.84	1.06	--
Silver	0.006	0.018	0.005 N	0.004 N	0.003 N	0.004 N	-72
Zinc	10.6	31.8	10.43	11.41	8.61	10.15	-64
Organics (µg/kg, wet weight)							
Pyrene	50 U	250	1.8 J	1.7 J	5 U	5 U	-99
Benz(a)anthracene	50 U	250	1.3 J	5 U	5 U	5 U	-98
Benzo(b+k)fluoranthene	50 U	250	4 J	4.1 J	1.9 J	3.33 J	-98
Indeno(1,2,3-cd)pyrene	50 U	250	1.5 J	1.4 J	1.4 J	1.43 J	-99
Benzo(g,h,i)perylene	50 U	250	2.1 J	2.3 J	1.9 J	2.10 J	-99
Phenol	50 U	250	690	130	ND	410	**176**

	1995 Baseline	Guideline	Replicate CBT14-A	CBT14-B	CBT14-C	Mean	Maximum Percent Difference
Metals (mg/kg, wet weight)							
Antimony	0.175 J	0.525	0.45	0.19	0.28	0.31	-15
Arsenic	14.8	44.4	32.40	16.56	22.51	23.82	-27
Cadmium	0.1425	0.4275	0.032	0.017	0.020	0.023	-93
Chromium	--	--	0.64	0.30	0.47	0.47	--
Copper	0.57	1.71	1.85	1.15	1.78	1.59	**8**
Lead	1.15	3.45	1.02	0.58	0.70	0.76	-70
Mercury	0.0175	0.0525	0.044 J	0.045 J	0.020 J	0.036 J	-16
Nickel	0.4 U	1.2	0.50	0.26	0.35	0.37	-58
Selenium	--	--	1.24	1.02	1.13	1.13	--
Silver	0.006	0.018	0.004 N	0.004 N	0.004 N	0.004 N	-77
Zinc	10.6	31.8	14.94	10.32	13.20	12.82	-53
Organics (µg/kg, wet weight)							
Pyrene	50 U	250	1.8 J	5 U	1.6 J	5 U	-98
Benzo(b+k)fluoranthene	50 U	250	2 J	5 U	1.4 J	5 U	-98
Indeno(1,2,3-cd)pyrene	50 U	250	1.4 J	0.59 J	1.2 J	1.06 J	-99
Benzo(g,h,i)perylene	50 U	250	2.1 J	5 U	1.9 J	5 U	-98
Bis(2-ethylhexyl) Phthalate	91	455	80 U	91	80 U	91	-80
Phenol	50 U	250	100	110	80 U	105	-56
4,4'-DDT	5.0 U	25	0.54 J	1 U	1 U	1 U	-96
Total DDTs	5.0 U	25	0.54 J	1 U	1 U	1 U	-96

Table 3-11. 2001 Benchmark Tissue Chemistry from Commencement Bay (SEA 2002)

			Replicate			
Chemicals of Concern	1995 Baseline*	Guideline	CBB01-A	CBB01-B	CBB01-C	Mean
Metals (mg/kg, wet weight)						
Antimony	0.3	0.9	0.34	0.36	0.36	0.35
Arsenic	23.7	71.1	24.12	23.29	21.31	22.91
Cadmium	0.03	0.09	0.024	0.026	0.027	0.026
Chromium	--	--	0.41	0.19	0.08	0.22
Copper	1	3	4.38	1.10	2.11	2.53
Lead	1	3	1.04	1.03	1.05	1.04
Mercury	0.06	0.18	0.037	0.043	0.052	0.044
Nickel	0.4 U	1.2	4.34	0.78	1.40	2.174
Selenium	--	--	1.44	1.21	1.13	1.26
Silver	0.006	0.018	0.004	0.003	0.008	0.005
Zinc	14.3	42.9	11.69	10.68	13.77	12.05
Organics (µg/kg, wet weight)						
Anthracene	49 U	245	10 U	2.4 J	10 U	2.4 J
Benzo(b+k)fluoranthene	49 U	245	10 U	10 U	4.3 J	4.3 J
Indeno(1,2,3-cd)pyrene	49 U	245	4.6 J	4.3 J	7.8 J	5.6 J
Benzo(g,h,i)perylene	49 U	245	3.2 J	2.7 J	3.9 J	3.3 J
Phenol	49 U	245	420	420	160	333

			Replicate			
	1995 Baseline*	Guideline	CBB02-A	CBB02-B	CBB02-C	Mean
Metals (mg/kg, wet weight)						
Antimony	0.2	0.6	0.19	0.17	0.15	0.17
Arsenic	15.3	45.9	11.38	12.02	9.78	11.06
Cadmium	0.028	0.084	0.014	0.013	0.020	0.016
Chromium	--	--	0.29	0.06 U	0.09	0.19
Copper	0.76	2.28	4.18	1.01	0.81	2.00
Lead	1.1	3.3	0.63	0.62	0.54	0.60
Mercury	0.03	0.09	0.039	0.037	0.040	0.039
Nickel	0.4	1.2	0.61	0.40	0.30	0.44
Selenium	--	--	1.27	1.50	1.17	1.31
Silver	0.008	0.024	0.004	0.003 B	0.003	0.003
Zinc	12.5	37.5	10.83	8.84	9.15	9.61
Organics (µg/kg, wet weight)						
Indeno(1,2,3-cd)pyrene	49 U	245	4.4 J	4.9 J	5.1 J	4.8 J
Benzo(g,h,i)perylene	49 U	245	2.8 J	2.9 J	3.1 J	2.9 J
Phenol	49 U	245	560	310	280	383
Benzyl Alcohol	48.0 U	240	30 J	80 U	80 U	30 J

Table 3–11. 2001 Benchmark Tissue Chemistry from Commencement Bay (SEA 2001) (Continued)

	1995 Baseline*	Guideline	Replicate CBB03-A	Replicate CBB03-B	Replicate CBB03-C	Mean
Metals (mg/kg, wet weight)						
Antimony	0.2	0.6	0.23	0.24	0.22	0.23
Arsenic	28.7	86.1	32.26	35.13	34.31	33.90
Cadmium	0.03	0.09	0.017	0.017	0.016	0.017
Chromium	--	--	0.15 U	0.15 U	0.16 U	0.16 U
Copper	0.5	1.5	1.44	0.55	0.90	0.96
Lead	2 U	6	0.45	0.49	0.46	0.47
Mercury	0.02	0.06	0.015	0.048	0.018	0.027
Nickel	1 U	3	0.46	0.48	0.45	0.46
Selenium	--	--	1.38	1.24	1.22	1.28
Silver	0.005	0.015	0.002 B	0.002 B	0.002 B	0.002 B
Zinc	13	39	12.31	12.55	11.61	12.16
Organics (µg/kg, wet weight)						
Benzo(b+k)fluoranthene	49 U	245	2.4 J	10 U	10 U	2.4 J
Indeno(1,2,3-cd)pyrene	49 U	245	5.3 J	3.1 J	2.6 J	3.67 J
Benzo(g,h,i)perylene	49 U	245	3.5 J	2.5 J	2 J	2.67 J
Phenol	49 U	245	180	300	460	313

Notes:

Guideline assessments are applied only to detected compounds in the 2001 survey. Mean values represent either

1) arithmetic mean of 2 or more detected values,
2) single detected value for the three replicates, or
3) highest non-detected values.

The multiplier for metal guideline values is 3, and the multiplier for organics is 5.

Highlighted 2001 concentrations exceed guideline values.

U - Undetected at concentration shown

J - Estimated concentration

B - Estimated concentration

NA - Not Analyzed

* With the exception of using **1988** Mercury concentrations at Benchmark Stations for baseline evaluations.

In 2003, tissue samples were collected at transect stations CBT13, CBT14, and CBT16 and compared to the 1995 derived guideline values. Organic compounds were undetected and only the metal cadmium exceeded the guidelines. Silver was undetected, but the reported detection limit exceeded the extremely low guideline value. These results represent an improvement relative to body burden measurements during the 2001 survey. Therefore, the DMMP agencies determined that further evaluation of tissue chemistry (i.e., benchmark analysis) was not necessary and hypothesis 5 was accepted for the 2003 results.

In 2007, tissue samples were also collected at transect stations CBT13, CBT14, and CBT16 and compared to the 1995 guideline values. All organic compounds were undetected in transect tissues. All BCOC metals were detected, with the exception of cadmium and silver. Arsenic was detected at levels comparable to 2003 that exceeded the TTL. However, the levels were below guideline values. Cadmium, which was detected at low concentrations in 2003 that exceeded guideline values, was undetected in 2007. A review of the sediment chemistry data suggests that cadmium concentrations in tissues and sediments are correlated. Cadmium levels in 2003 sediments (mean concentration of 0.22 ± 0.03 mg/kg DW) showed a decrease in comparison to 2007 (mean of 0.09 ± 0.02 mg/kg DW). Cadmium levels in 2003 tissues were measured at 0.14 ± 0.08 mg/kg WW compared to undetected (0.08 U mg/kg WW) in 2007.

Conclusions

Chemical analysis of *Molpadia intermedia* tissue samples collected in offsite areas of Commencement Bay have shown that the chemical body burdens of offsite biological resources have not increased due to dredged material disposal.

3.6 Benthic Infauna Community

Offsite benthic infaunal community structure is used to address hypothesis 6 of the DMMP monitoring framework (The abundance of dominant benthic infauna species down current of the disposal site has not significantly decreased due to dredged material disposal). Hypothesis 6 is addressed only during a full monitoring event (Table 3–1). The abundance of dominant taxa groups (polychaetes, molluscs, crustaceans, and miscellaneous taxa) measured at offsite transect stations are compared to guideline values derived from baseline abundance values. If the taxa abundance from the transect stations during a full monitoring event is less than half of baseline and statistically significant, a potential impact is indicated and the benchmark benthic infauna samples are evaluated (Table 1–2). In Commencement Bay, benthic infauna samples were generally collected from three transect and three benchmark stations (Figure 1–3). Five replicate samples were collected at each station. The three transect stations selected for sampling and analyses during a full monitoring event were based on the direction of offsite dredged material deposition.

3.6.1 1988 Baseline Survey

During the 1988 baseline survey, benthic infauna samples were collected at nine transect stations and only the middle transect station samples (CBT07, CBT09, and CBT11) were analyzed. The entire box core sample was analyzed during the 1988 baseline survey and samples were identified and enumerated to major taxa groups only. Current methodology limits analysis to the top 10 centimeters of each box core sample to maintain data comparability between years, and benthic organisms are identified to species level, if possible (SAIC 2007).

Molluscs were the most abundant taxa group in 1988, followed by crustaceans and polychaetes (Table 3–12. A similar distribution of major taxa abundance was observed at the 1988 benchmark stations (PTI 1988).

Table 3-12. Comparison of 1988 and 1995 Benthic Infauna Abundance Data (from SAIC 1995)

Summary Characteristics	Abundance of Major Taxa		% Difference
	1988	1995	
	CBT07	CBT01	
Polychaeta	49.4 ± 8.9	33.4 ± 11.7	-32
Mollusca	180.2 ± 32.5	150.6 ± 33.1	-16
Crustacea	74.0 ± 17.2	89.2 ± 18.7	+21
Miscellaneous Taxa	2.8 ± 1.8	4.6 ± 2.3	+64
All Taxa	306.4 ± 41.7	278.2 ± 42.9	+9
	CBT09	CBT03	
Polychaeta	42.4 ± 7.9	30.4 ± 8.6	-28
Mollusca	126.4 ± 35.0	148.4 ± 36.8	+17
Crustacea	49.2 ± 5.5	90.6 ± 40.1	+84
Miscellaneous Taxa	2.0 ± 1.4	2.0 ± 1.6	0
All Taxa	220.0 ± 41.7	271.4 ± 74.6	+23
	CBT11	CBT05	
Polychaeta	28.6 ± 8.9	39.8 ± 6.2	+39
Mollusca	182.4 ± 23.6	73.4 ± 9.2	-60
Crustacea	72.8 ± 14.7	68.4 ± 19.2	-6
Miscellaneous Taxa	5.6 ± 3.8	8.2 ± 4.4	+46
All Taxa	289.4 ± 23.8	189.8 ± 26.9	-34

3.6.2 1995 Full Monitoring Survey

During the 1995 full monitoring survey, benthic infauna samples were collected from transect stations CBT01, CBT03, and CBT05, which was consistent with the indicated direction of the dredged material plume. Although the baseline guideline values are derived from a different set of stations (CBT07, CBT09, and CBT11), the DMMP agencies reached a consensus decision to compare the existing baseline and 1995 infaunal data. A review of the physical data (depth, proximity of stations, grain size) suggested that the stations were sufficiently similar to allow direct comparisons (SAIC 1995). The comparison of 1995 and 1988 data showed that all taxonomic groups were within guideline values, with the exception of molluscs at station CBT05 (Table 3-12). The two transect stations nearest the disposal site did not show any significant decreases in infaunal abundances. The SVPS survey indicated that all dredged material remained on site, all onsite and perimeter chemistry were below biological effects levels (i.e., less than the DMMP SLs and Washington State SQS), and no appreciable accumulation of chemicals of concern were measured in transect *Molpadia intermedia* tissues. Based on these data, the DMMP agencies determined that the decrease in mollusc abundance at station CBT05 was not likely due to dredged material accumulation. Therefore, hypothesis 6 was accepted during the 1995 full monitoring survey.

3.6.3 2001 Full Monitoring Survey

The 2001 full monitoring survey identified the presence of offsite dredged material to the northwest and southwest (Figure 3–5). Based on this discovery, the DMMP decided to sample the transect stations where offsite dredged material was identified (CBT13, CBT14, CBT15, and CBT16). In addition, three floating stations were sampled along a rough line to the northeast through the offsite dredged material to the north (CBF16, CBF13, and CBF03) (Figure 3–16). At the transect stations, abundance of major taxa groups increased away from the disposal site (Table 3–13). Station CBT13, the station closest to the disposal area, had the lowest total abundance of all transect stations with an average of 125.4 individuals per 0.06 m.^{2} Crustaceans were the dominant organism at stations CBT13 and CBT15, while molluscs and crustaceans shared dominance at stations CBT14 and CBT16. Abundance of infaunal organisms was higher at the floating stations, ranging from 211.4 individuals per 0.06 m^2 at station CBF03 to 274.8 individuals per 0.06 m^2 at station CBF13. Molluscs were the dominant taxa group at CBF13 and CBF16, while polychaetes were dominant at CBF03.

The 1995 monitoring results for benthic infauna community structure were adopted as the new baseline for Commencement Bay (SAIC 1996). Therefore, the 2001 results were compared to the 1995 derived guideline values. Transect stations CBT01, CBT03, and CBT05 were sampled during the 1995 survey. A review of physical characteristics at these stations found that stations CBT01 and CBT03 had grain size and water depths comparable to the transect stations sampled in 2001. Therefore, the mean 1995 baseline major taxa abundance values were calculated from CBT01 and CBT03. A comparison of 2001 taxa abundance to the mean 1995 baseline values showed a reduction in molluscs greater than 50 percent at stations CBT13, CBT14, and CBT15 (Table 4–12). The predominant trend at transect stations was one of a reduction in the abundance of infaunal organisms. To evaluate whether this decrease was due to offsite dredged material disposal or a region-wide change, the benchmark station samples were analyzed.

The 2001 benchmark samples were analyzed and compared to the 1988 baseline samples (Table 3–14). Molluscs had decreased at all benchmark stations and the reduction was greater than 50 percent at CBB03. A comparison of the arithmetic means of the benchmark station differences to the transect differences showed that the differences are greater than 50 percent for the majority of comparisons (Table 3–15), which suggests that the reductions may have reflected regional changes in conditions that are unrelated to dredged material disposal (SEA 2001). Overall, the changes in benchmark benthic community structure appeared to approach or exceed the magnitude and direction of the changes observed at the transect stations. Therefore, hypothesis 6 was accepted during the 2001 full monitoring survey.

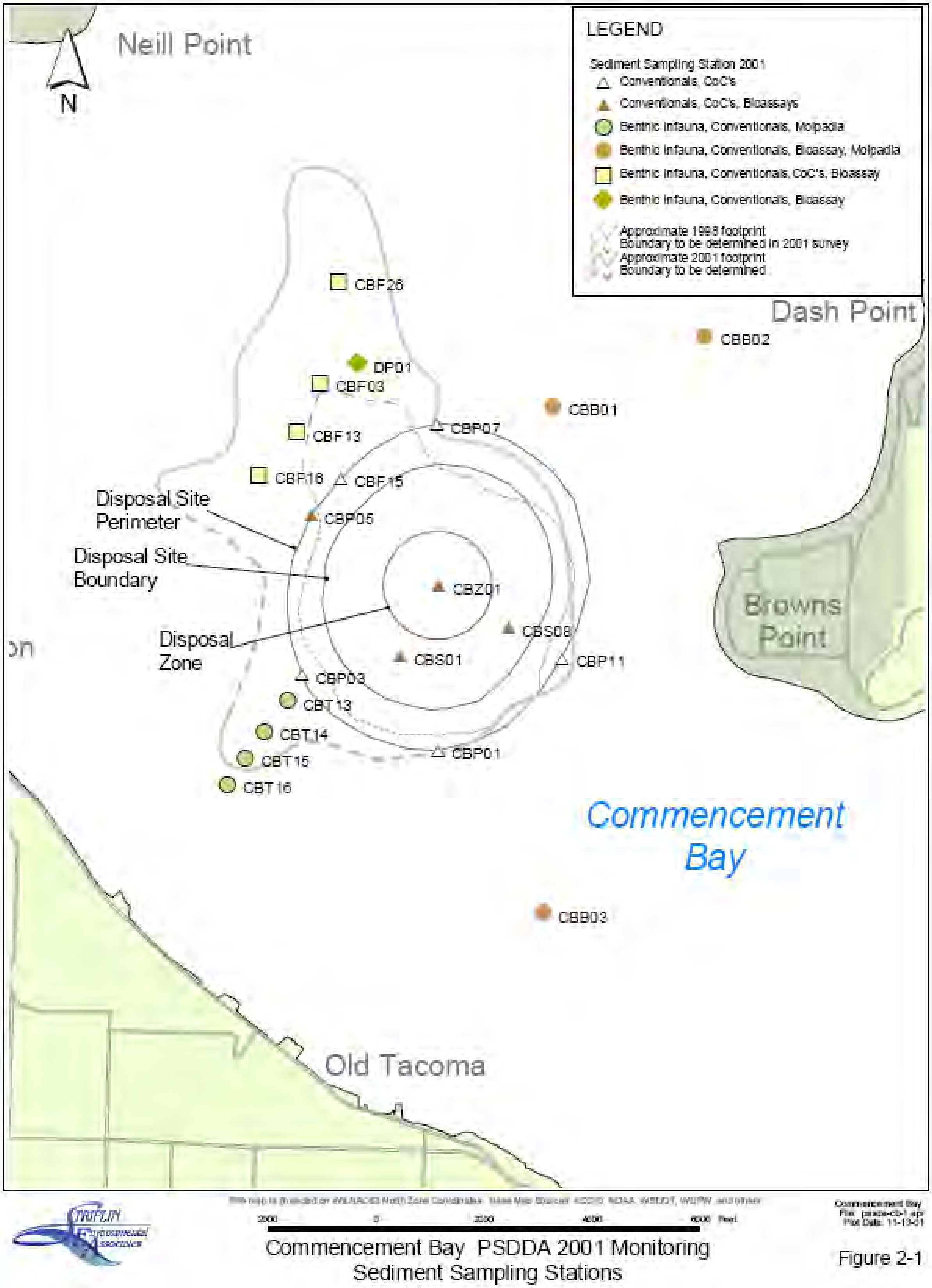

Figure 3-16. 2001 Commencement Bay Benthic Infauna Sampling Locations (SEA 2001)

Table 3-13. 2001 Major Taxa Abundance Compared to 1995 Baseline (SEA 2001)

Summary Characteristic	Abundance of Major Taxa 1995	Abundance of Major Taxa 2001	Percent Difference
	Mean	**CBT13**	
Percent Fines (%):	72	73	
Water Depth (m):	163	164	
Polychaeta	31.9	29.4 ± 7.8	-8
Mollusca	149.5	32.2 ± 21.2	-78
Crustacea	89.9	60.4 ± 24.7	-33
Miscellaneous Taxa	3.3	3.4 ± 2.3	3
All Taxa	274.8	125 ± 48.0	-55
	Mean	**CBT14**	
Percent Fines (%):	72	70	
Water Depth (m):	163	156	
Polychaeta	31.9	31.4 ± 5.7	-2
Mollusca	149.5	69.6 ± 17.4	-53
Crustacea	89.9	69.2 ± 16.1	-23
Miscellaneous Taxa	3.3	3.8 ± 1.8	15
All Taxa	274.8	174 ± 26.1	-37
	Mean	**CBT15**	
Percent Fines (%):	72	74	
Water Depth (m):	163	155	
Polychaeta	31.9	36.8 ± 18.2	15
Mollusca	149.5	46.2 ± 16.3	-69
Crustacea	89.9	94.4 ± 35.0	5
Miscellaneous Taxa	3.3	3.8 ± 1.9	15
All Taxa	274.8	181 ± 54.5	-34
	Mean	**CBT16**	
Percent Fines (%):	72	80	
Water Depth (m):	163	153	
Polychaeta	31.9	34.2 ± 13.3	7
Mollusca	149.5	87.6 ± 20.7	-41
Crustacea	89.9	89.2 ± 39.0	-1
Miscellaneous Taxa	3.3	2.4 ± 1.9	-27
All Taxa	274.8	213 ± 61.9	-22

Notes:

Mean 1995 baseline major taxa abundance values were calculated from CBT01 and CBT03. CBT01 and CBT03 were both fine-grained (66% and 78%, respectively) and were collected at water depths comparable to those stations sampled in 2001.

Highlighted values are those showing a reduction in major taxa abundance from 1995 to 2001 exceeding 50 percent.

Table 3-14. 2001 Benchmark Station Major Taxa Abundance Compared to 1988 Baseline (SEA 2002)

Parameter	1988	2001	Percent Difference
CBB01	(Mean ± Std)	(Mean ± Std)	
Percent Fines (%):	87	71	
Water Depth (m):	175	171	
Polychaeta	44.6 ± 10.6	33.2 ± 11.9	-25.46
Mollusca	175.7 ± 23.3	128 ± 14.3	-27.11
Crustacea	67.8± 9.4	104 ± 26.4	53.39
Miscellaneous Taxa	4.2± 1.8	2 ± 1.6	-52.38
All Taxa	292.4 ± 34.3	267.2 ± 39.6	-8.47
CBB02	(Mean ± Std)	(Mean ± Std)	
Percent Fines (%):	91	78	
Water Depth (m):	174	167	
Polychaeta	29.4 ± 4.9	35 ± 3.3	19.05
Mollusca	201 ± 30.2	181.4 ± 16.9	-9.25
Crustacea	79.4 ± 28.1	22.4 ± 4.1	-71.19
Miscellaneous Taxa	2.2 ± 2.3	2.4 ± 2.1	9.09
All Taxa	312 ± 54.9	241.2 ± 22.3	-22.49
CBB03	(Mean ± Std)	(Mean ± Std)	
Percent Fines (%):	88	66	
Water Depth (m):	146	141	
Polychaeta	57.4 ± 9.9	49.2 ± 13.9	-14.29
Mollusca	163.6 ± 35.7	16.2 ± 11.3	-90.1
Crustacea	30.6 ± 9.9	101.4 ± 13.6	231.37
Miscellaneous Taxa	4.8 ± 0.8	2 ± 1.6	-58.33
All Taxa	256.8 ± 46.2	168.8 ± 23.2	-34.27

Notes:
Boxed in values are those showing a reduction in major taxa abundance from 1988 to 2001 exceeding 50 percent.
Gray shaded values are those showing an increase in major taxa abundance from 1988 to 2001 exceeding 50 percent.

Table 3-15. Comparison of Arithmetic Means of the Benchmark and Transect Station Differences for Major Taxa Abundance during the 2001 Survey (SEA 2002)

		Mollusca Abundance		
Percent Differences		-27	-9	-90
		* CBB-01	CBB-02	* CBB-03
-78	T13	35	12	**115**
-53	T14	**51**	17	**169**
-69	T15	39	13	**130**
-41	T16	**66**	22	**219**

		Total Abundance		
Percent Differences		-8	-22	-34
		CBB-01	* CBB-02	* CBB-03
-55	T13	15	40	**62**
-37	T14	22	**59**	**92**
-34	T15	24	**65**	**100**
-22	T16	36	**100**	**155**

		Tissue Phenol		
Percent Differences		584	694	539
		* CBB-01	* CBB-02	* CBB-03
720	T13	**81**	**96**	**75**
110	T14	**530**	**630**	**490**
566	T15	**103**	**122**	**95**
294	T16	**198**	**236**	**183**

* Statistically significant at alpha of 0.05 using Student's T-test (SYSTAT 1996) between '88-'01 and '95-'01 Benchmark Stations for Benthos and Tissue Chemistry Analyses, respectively. Highlighted results have a greater than 50 percent difference.

3.6.4 2003 Tiered-Full Monitoring Survey

During the 2003 tiered-full monitoring survey, benthic infauna samples were collected from three of the four transect stations where dredged material was present in 2001 (CBT13, CBT14, and CBT16). The abundance of major taxa at all of the transect stations had increased relative to the 2001 monitoring survey. Station CBT14 had the greatest total abundance with an average of 399.4 individuals per 0.06 m^2 and was dominated by molluscs followed by crustacea (Table 3–19). A similar dominance pattern was observed at stations CBT13 and CBT16. In general, the bivalve *Axinopsida serricata*, the cumaceans *Eudorellopsis integra*, and *Eudorella* nr. *pacifica* very strongly dominated the transect station benthic community (SAIC 2003).

A comparison of benthic infauna results to the 1995 baseline showed that nearly all major taxa groups in 2003 were greater than baseline at all stations (Table 3–16). In fact, all taxa groups at station CBT14 were significantly greater than the baseline values. Therefore, the abundance of major taxa collected in 2003 did not exceed the interpretive guideline value of 50 percent reduction relative to the 1995 baseline values for transect stations. Hypothesis 6 was accepted during the 2003 tiered-full monitoring survey.

3.6.5 2007 Full Monitoring Survey

During the 2007 full monitoring survey, benthic infauna samples were collected at the same stations as the 2003 survey (CBT13, CBT14, and CBT16). The abundance of major taxa had decreased since 2003. A comparison of the 2007 results to the 1995 baseline showed statistically significant decreases in the abundance of arthropods and molluscs at all transect stations that were greater than 50 percent. In addition, the miscellaneous taxa at CBT16 showed a statistically significant decrease greater than 50 percent (Table 3–17). To evaluate whether this decrease was due to offsite dredged material disposal or a region-wide change, the benchmark station samples were analyzed.

The 2007 benchmark samples were analyzed and compared to the 1988 baseline samples (Table 3–18). Similar to observations in 2001, the molluscs had decreased at all benchmark stations and the reduction was greater than 50 percent at all stations. Greater than 50 percent reduction was also seen for arthropods at all benchmark stations, and annelids at CBB01 and CBB02. A comparison of the arithmetic means of the benchmark station differences to the transect differences showed that the differences are greater than 50 percent for all of the mollusca comparisons, and the majority of the arthropod and miscellaneous abundance comparisons (Table 3–19). Based on the benchmark evaluation framework, these reductions reflected regional changes in conditions that are likely unrelated to dredged material disposal (SAIC 2008). Therefore, hypothesis 6 was accepted during the 2007 full monitoring survey.

3.6.6 Conclusions

Benthic infauna community structure at the offsite areas is not static, but can fluctuate greatly over time. A review of the benthic monitoring results within the context of the DMMP site monitoring framework (i.e., benchmark station monitoring) has shown that the variability observed in benthic community structure does not appear to be related to dredged material disposal.

It should be noted that benthic infauna studies during recent disposal site monitoring programs at the Port Gardner and Anderson/Ketron disposal sites have also identified significant reductions in major taxa abundance (molluscs and arthropods) relative to baseline conditions. Those changes appeared related to basin-wide changes, and not due to dredged material disposal (SEA 2002; SAIC and Caenum 2006). Other Puget Sound studies have also identified temporal variability in benthic community structure that appear related to natural cycles, and the population dynamics were complex and difficult to relate to physical and chemical sediment parameters (Nichols 2003; Partridge et al. 2005).

Table 3-16. Mean Major Taxa Abundance in 2003 and Comparison to 1995 Baseline Endpoints

1995 CBT01 & CBT03 to 2003	CBT13				CBT14				CBT16			
	1995 (mean)	2003 (mean)	t	P	1995 (mean)	2003 (mean)	t	P	1995 (mean)	2003 (mean)	t	P
Benthic Community Endpoints												
Total abundance	274.6	331.2	-1.82	0.022	274.6	399.4	-4.97	0.0001	274.6	283.8	-0.27	0.395
Total Taxa	34.4	38.0	-2.05	0.33	34.4	41.8	-2.55	0.020	34.4	34.8	-0.13	0.451
Crustacea Abundance	89.9	105.4	-0.22	0.219	89.9	123.6	-1.97	0.043	89.9	115.8	-1.42	0.099
Polychaete Abundance	31.9	56.0	-3.57	0.005	31.9	50.4	-2.76	0.016	31.9	33.8	-0.36	0.362
Mollusca Abundance	149.5	164.8	-0.72	0.249	149.5	219.8	-4.23	0.001	149.5	130	1.16	0.137
Shannon-Wiener Diversity (H')	2.09	2.16	-0.60	0.283	2.09	2.14	-0.55	0.295	2.09	2.29	-2.61	0.012
Pielou's Eveness Index (J')	0.591	0.594	-0.08	0.468	0.591	0.568	1.12	0.142	0.591	0.647	-2.75	0.008
Swartz's Dominance Index (SDI)	4.3	5.2	1.29	0.114	4.3	5.0	1.37	0.095	4.3	5.2	1.97	0.036

t = Calculated t-test value, P = Probability of significant difference. Shaded cells indicate a statistical difference between mean values.

Table 3-17. Mean Major Taxa Abundance in 2007 and Comparison to 1995 Baseline Endpoints

1995 CBT01 & CBT03 to 2007	CBT13				CBT14				CBT16			
	1995 (mean)	2007 (mean)	t	P	1995 (mean)	2007 (mean)	t	P	1995 (mean)	2007 (mean)	t	P
Benthic Community Endpoints												
Total abundance	274.6	69.2	1.81	0.000	274.6	65.6	1.80	0.000	274.6	84.2	1.18	0.000
Miscellaneous Abundance	3.4	2.8	1.77	0.267	3.4	1.8	1.78	0.038	3.4	1.4	1.78	0.034
Mollusca Abundance	149.5	10.8	1.83	0.000	149.5	12.6	1.83	0.000	149.5	41.6	1.77	0.000
Arthropoda Abundance	89.9	22.2	1.81	0.000	89.9	21	1.80	0.000	89.9	19.6	1.80	0.000
Annelida Abundance	31.9	33.4	1.80	0.369	31.9	30.2	1.77	0.325	31.9	21.6	1.78	0.006

t = Calculated t-test value, P = Probability of significant difference. Shaded cells indicate a statistical difference between mean values.

Table 3-18. 2007 Benchmark Station Major Taxa Abundance Compared to 1988 Baseline (SAIC 2008)

1988 to 2007	CBB01					CBB02					CBB03				
	1988 (Mean)	2007 (Mean)	Percent Change	t	P	1988 (Mean)	2007 (Mean)	Percent Change	t	P	1988 (Mean)	2007 (Mean)	Percent Change	t	P
Benthic Community Endpoints															
Total Abundance	292.4	58.8	-79.9	1.94	0.000	312.0	32.0	-89.7	2.02	0.000	256.8	142.6	-44.5	1.86	0.003
Miscellaneous Abundance	4.2	1.6	-61.9	1.86	0.026	2.2	1.4	-36.4	1.90	0.274	4.8	4.2	-12.5	2.02	0.309
Mollusca Abundance	175.6	23.8	-86.4	1.94	0.000	201.0	21.2	-89.5	2.02	0.000	163.6	73.2	-55.3	1.86	0.001
Arthropoda Abundance	67.8	12.2	-82.0	1.86	0.000	79.4	4.4	-94.5	2.13	0.002	30.6	5.4	-82.4	2.02	0.002
Annelida Abundance	44.6	21.2	-52.5	1.90	0.002	29.4	5.0	-83.0	1.94	0.000	57.4	59.8	4.2	1.94	0.408

t = Calculated t-test value, P = Probability of significant difference. Shaded cells indicate a statistical difference between mean values.

Table 3-19. Comparison of the Arithmetic Means of the Benchmark Station Differences to Transect Station Differences (2007 to baseline)

Mollusca Abundance Comparison	Arithmetic Mean Difference	1988 CBB01 to 2007 CBB01	1988 CBB02 to 2007 CBB02	1988 CBB03 to 2007 CBB03
		-151.8	-179.8	-90.4
1995 CBT01 & CBT03 to 2007 CBT13	-138.7	√	√	√
1995 CBT01 & CBT03 to 2007 CBT14	-136.9	√	√	√
1995 CBT01 & CBT03 to 2007 CBT16	-107.9	√	√	√

Arthropoda Abundance Comparison	Arithmetic Mean Difference	1988 CBB01 to 2007 CBB01	1988 CBB02 to 2007 CBB02	1988 CBB03 to 2007 CBB03
		-55.6	-75	-25.2
1995 CBT01 & CBT03 to 2007 CBT13	-67.7	√	√	
1995 CBT01 & CBT03 to 2007 CBT14	-68.9	√	√	
1995 CBT01 & CBT03 to 2007 CBT16	-70.3	√	√	

Miscellaneous Abundance Comparison	Arithmetic Mean Difference	1988 CBB01 to 2007 CBB01	1988 CBB02 to 2007 CBB02	1988 CBB03 to 2007 CBB03
		-2.6	-0.8	-0.6
1995 CBT01 & CBT03 to 2007 CBT13	-0.6	√	√	√
1995 CBT01 & CBT03 to 2007 CBT14	-1.6	√	√	
1995 CBT01 & CBT03 to 2007 CBT16	-2	√		

√ = Benchmark arithmetic mean difference is greater than 50 percent of transect arithmetic mean difference.

3.7 Trawl Studies

3.7.1 1986 and 2007 Trawl Studies

The DMMP Program was tasked with evaluating, selecting, monitoring, and managing sites within Puget Sound for long-term, unconfined disposal of uncontaminated dredged materials. Site selection was in part dependent upon detailed evaluations of biological resources in and around selected potential sites. The disposal sites were designated in areas that do not support commercial fisheries and where impacts to biological resources would be low. The crab, shrimp, and fish assemblage data collected in 1986 by the Disposal Site Work Group of the DMMP provide a baseline to monitor changes in the biological resources following dredged disposal activities.

In 2007, a full monitoring study was conducted which included trawl investigations of Dungeness crab, pandalid shrimp, and flatfish (July 10–11, 2007). Pandalid shrimp and flatfish were collected using a 7.6 meter (25-foot) Otter trawl at three stations along a transect through the existing Commencement Bay disposal site and at three stations along a transect through the former Alternative site (evaluated in the 1988 FEIS), covering a total of 1.4 ha of area (Figure 3–17). These stations were the same stations surveyed in 1986 and were re-sampled using the same Otter trawl. The Otter trawl was towed approximately 370 meters (1/5 nautical mile) at a target ground speed of 4.2 to 5.0 kilometers/hour (2.5 to 3.0 knots), which covered an area swept by the net (opening = 6 meters) of approximately 2,220 square meters, similar to the 1986 survey. Bottomfish were identified and counted following collection aboard the research vessel *Kittiwake*. Commercial shrimp species were identified, carapace length measured, and reproductive condition (females with or without eggs) noted. These data were compared with the baseline data collected in June and September of 1986 (Tables 3-20 and 3-21).

Three target shrimp species were collected during the sampling: pink shrimp (*Pandalus borealis*) at 3.5 shrimp/ha; smooth pink shrimp (*P. jordani*) at 2.8/ha; and sidestripe shrimp (*Pandalopsis dispar*) at 8.4/ha. Non-target shrimp species included Crangon shrimp (*Crangon sp.*), slender-blade shrimp (*Spirontocaris holmesi*), and glass shrimp (*Pasiphaea pacifica*). English sole (*Parophrys vetulus*) was encountered at 4.2 fish/ha and slender sole (*Lyopsetta exilis*) at 4.9/ha during the trawls. No Dungeness crabs were encountered during this survey, consistent with seasonal survey findings during 1986.

3.7.2 Conclusions

A preliminary criterion needed to support a commercial fishery was recommended at 6 flatfish/ha by the Washington State Department of Fish and Wildlife, but it is unknown how well the Otter trawl catches used in this survey estimate the actual flatfish species abundance or how comparable it is to a commercial trawl. Densities reported in 2007 are probably underestimates, due to the gear selectivity and sampling efficiency, but are comparable to the 1986 estimates that were used to evaluate potential impacts to these resources in the 1988 NEPA/SEPA FEIS.

Crabs

No Dungeness crabs were encountered during the 2007 full monitoring study or during the 1986 investigation, confirming that the site does not provide suitable habitat for this commercial species.

Shrimp

In 1986, the dominant species in the study were pink shrimp caught in moderate numbers at 306.4 shrimp/ha and sidestripe shrimp (53.3 shrimp/ha) over all seasons at Commencement Bay. In 2007, all shrimp species were encountered at a reduced rate, except for the smooth pink shrimp which was encountered at a greater rate of 2.8/ha versus, in 1986, 0.8/ha. The overall shrimp encounter was about 24 times less in 2007 (14.7 shrimp/ha) than in 1986 (362 shrimp/ha).

The Disposal Site Work Group concluded in their 1986 report that the Primary and Alternative sites contained relatively equal, moderate populations of sidestripe and pink shrimp and that both were **insignificant** as commercial or sport resources. The catches from the 2007 investigation resulted in fewer shrimp compared to 1986, so the conclusions remain unchanged.

Flatfish

In the 1986 baseline survey, flatfish were encountered at a rate of 17.6 flatfish/ha with Dover sole being the dominant species (10.4/ha) in June. Flatfish were encountered at more than four times the rate in September (77.9/ha) with Dover sole still the dominant species. In July 2007, flatfish were encountered at a rate of 9.1 flatfish/ha, a much lower rate than either month in 1986. Slender sole was the dominant catch and no Dover sole were caught. Compared to 1986, the English sole catch increased slightly in 2007, but the number of slender sole decreased.

In the 1986 report, the numbers of juvenile and adult flatfishes sampled were low, especially when compared with areas outside the DMMP sites. The flatfish catches in 2007 were lower than the numbers caught in either month in 1986. The difference in species occurrence could be an artifact of the different months over which the data were collected in 1986 and 2007. Over 20 years has passed between surveys, and interannual differences in ocean conditions or natural species population cycles could also affect fish populations. However, the results are consistent with the conclusion that the site is not serving as an attractive nuisance for demersal fishes.

Table 3-20. Average Shrimp Catches and Lengths for all Shrimp Caught by Otter Trawl in Commencement Bay

Species	1986	2007
Spot Prawn		
Average # /ha	1.5	0
Average carapace length (mm)	26.8	0
Sidestripe		
Average # /ha	53.3	8.4
Average carapace length (mm)	15.3	16.2
Smooth Pink		
Average # /ha	0.8	2.8
Average carapace length (mm)	16.5	9.7
Pink		
Average # /ha	306.4	3.5
Average carapace length (mm)	17.2	14.8
All species combined		
Average # /ha	362	14.7

Table 3-21. Abundance (Number) of Flatfish Caught by Otter Trawl in Commencement Bay

Species	June 1986	September 1986	July 2007
English sole			
# /ha	1.4	3.2	4.2
Slender sole			
# /ha	5.9	22.5	4.9
Dover sole			
# /ha	10.4	52.2	0
All species combined			
Average # /ha	17.6	77.9	9.1

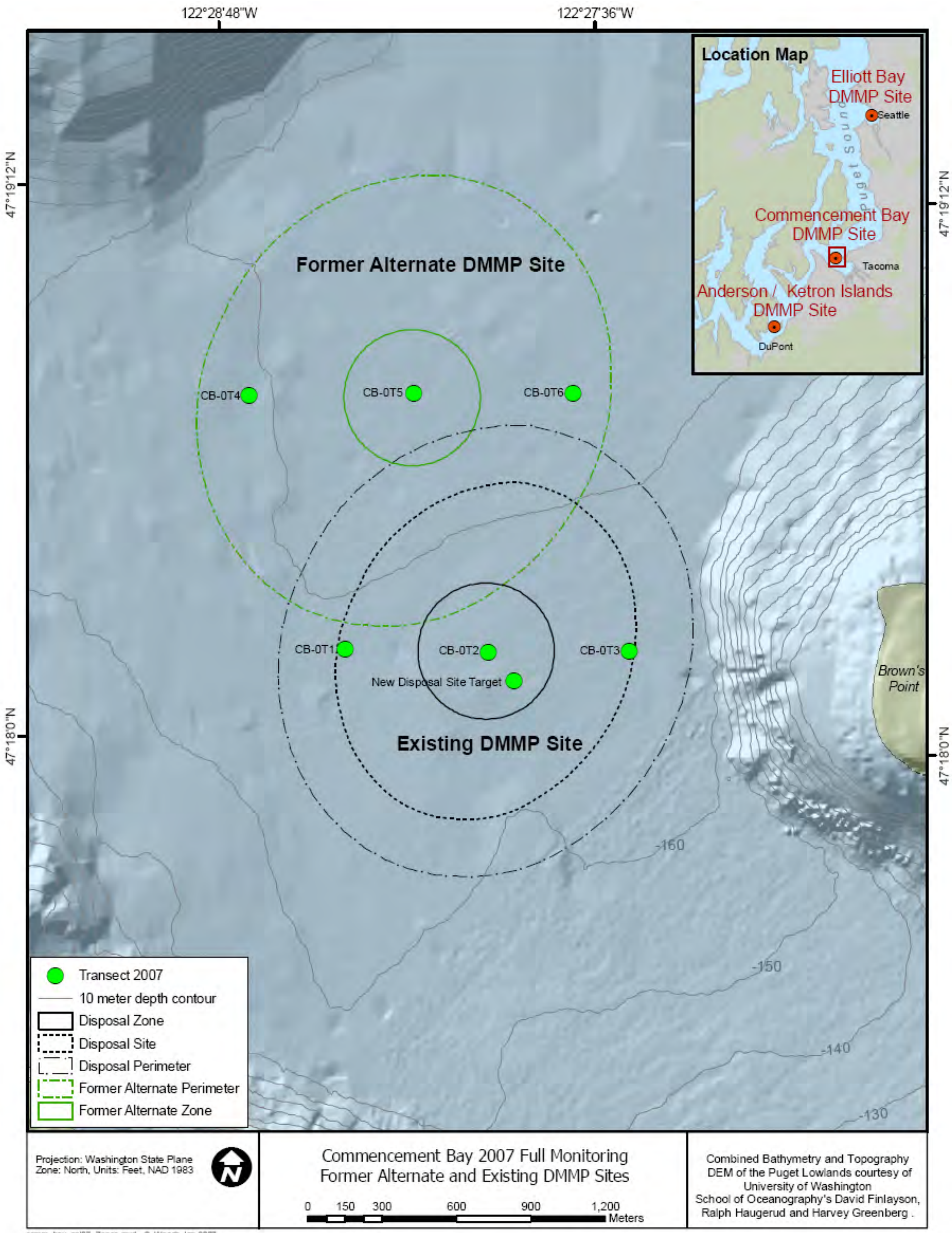

Figure 3-17. 2007 Commencement Bay DMMP Site Otter Trawl Stations

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APPENDIX B: DATA AND ASSUMPTIONS FOR AIR QUALITY IMPACT ANALYSIS

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Table B-1. Commencement Bay DMMP Disposal Site Project, No-Action Alternative

Location/Equipment Type	Power Rating (Hp)	Load Factor	# Active	Hourly Hp-Hrs	Hours Per Day	Daily Hp-Hrs	Work Days	Total Hp-Hrs
Dredging (1)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	175	1,575,000
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	175	1,181,250
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	175	75,600
Tugboat	800	0.25	1	200	8	1,600	175	280,000
Marine Disposal (2)								
Tugboat - Transport to AK Site	2,200	0.68	1	1,496	8.4	12,566	166	2,086,022
Tugboat - Transport to EB Site	2,200	0.68	1	1,496	11.2	16,755	166	2,781,363
Upland Disposal (3)								
Tug Boat - Transport to Tacoma Berth	2,200	0.68	2	2,992	0.4	1,197	37	44,282
Derrick Barge - Crane Hoist	564	0.50	1	282	12	3,384	37	125,208
Derrick Barge - Deck Winch	238	0.50	2	238	3	714	37	26,418
Derrick Barge - Generator	432	0.60	1	259	12	3,110	37	115,085
Derrick Barge - Generator	135	0.60	1	81	3	243	37	8,991
Haul Trucks - (4)	NA	NA	540	NA	114	61,560	37	2,277,720
Loader - 962G - Disposal Site	200	0.50	1	100	8	800	37	29,600

Notes:

1. Assumes 700,000 cubic yards (cy)/year @ 4,000 cy per day.
2. Assumes 700,000 cy/year * 0.9 @ 1,900 cy per barge = 331 barge trips/year and half of these to each site. Barge speed = 5 mph.
3. Assumes 700,000 cy/year * 0.1 @ 1,900 cy per barge = 37 barge trips/year.
4. Number Active = miles/roundtrip, Hours/Day = 3 of truck trips/barge, Daily Hp-Hrs = miles/barge, and Total Hp-Hrs = total miles. Assumes a truck capacity of 20 cy and a water factor of 20%.

Table B-2. Commencement Bay DMMP Disposal Site Project, Alternative 1

Location/Equipment Type	Power Rating (Hp)	Load Factor	# Active	Hourly Hp-Hrs	Hours Per Day	Daily Hp-Hrs	Work Days	Total Hp-Hrs
Dredging (1)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	175	1,575,000
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	175	1,181,250
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	175	75,600
Tugboat	800	0.25	1	200	8	1,600	175	280,000
Marine Disposal (1)								
Tugboat Transport	2,200	0.68	1	1,496	1.2	1,795	368	660,634

Notes:

1. Assumes 700,000 cy/year @ 4,000 cy per day.
2. Assumes 700,000 cy/year @ 1,900 cy per barge = 368 barge trips/year. Barge speed = 5 mph.

Table B-3. Commencement Bay DMMP Disposal Site Project, Alternative 2

Location/Equipment Type	Power Rating (Hp)	Load Factor	# Active	Hourly Hp-Hrs	Hours Per Day	Daily Hp-Hrs	Work Days	Total Hp-Hrs
Low Volume Option (1)								
Dredging (2)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	118	1,057,500
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	118	793,125
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	118	50,760
Tugboat	800	0.25	1	200	8	1,600	118	188,000
Marine Disposal (3)								
Tugboat Transport	2,200	0.68	1	1,496	1.2	1,795	247	443,414
High Volume Option (4)								
Dredging (2)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	293	2,632,500
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	293	1,974,375
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	293	126,360
Tugboat	800	0.25	1	200	8	1,600	293	468,000
Marine Disposal (5)								
Tugboat Transport	2,200	0.68	1	1,496	1.2	1,795	616	1,105,843

Notes:

1. Assumes 470,000 cy/year.
2. Assumes 4,000 cy per day.
3. Annual barge trips = 470,000 cy/1,900 cy per barge = 247 barge trips. Barge speed = 5 mph.
4. Assumes 1,170,000 cy/year.
5. Annual barge trips = 1,170,000 cy/1,900 cy per barge = 616 barge trips. Barge speed = 5 mph.

Table B-4. Air Emission Factors for the Commencement Bay DMMP Disposal Site Project Alternatives

Project Year/Source Type	Emission Factors (Grams/Horsepower-Hour)						References
	VOC	CO	NOx	SOx	PM10	PM2.5	
Year 2008							
Off-Road Equipment - 101-175 Hp	0.53	2.19	5.33	0.76	0.47	0.46	(1)
Off-Road Equipment - 176-300 Hp	0.40	1.65	4.86	0.75	0.36	0.35	(1)
Off-Road Equipment - 301-600 Hp	0.35	2.29	5.39	0.75	0.37	0.36	(1)
Off-Road Equipment - 751-1000 Hp	0.48	2.42	6.59	0.75	0.41	0.40	(1)
Off-Road Equipment - 1001-1200 Hp	0.47	2.35	6.52	0.75	0.40	0.39	(1)
On-road Truck - 5 mph (Gms/Mi)	1.42	10.72	16.80	0.04	0.34	0.29	(2)
On-road Truck - 25 mph (Gms/Mi)	0.62	3.18	10.70	0.04	0.34	0.29	(2)
On-road Truck - 55 mph (Gms/Mi)	0.34	2.02	13.31	0.04	0.34	0.29	(2)
Dredge Materials Haul Truck - Composite (Gms/Mi)	0.42	2.68	12.96	0.04	0.34	0.29	(3)
Tugboat (Gm/Hp-Hr)	0.37	0.82	9.85	0.75	0.67	0.62	(4)

Notes:

1. Composite emission factors developed from EPA NONROAD emissions model (2005) and based on average Kitsap. County equipment fleet age distributions for year 2008.
2. On-road non-idling emissions factors developed from the EPA MOBILE6 emissions model (2003).
3. Composite factors based on a round trip of 5% at 5 mph, 15% at 25 mph, and 85% at 25 mph. Units in grams/mile.
4. (Entec UK Limited 2002)

Table B-5. Total Emissions for the Commencement Bay DMMP Disposal Site Project, No-Action Alternative

Construction Activity/Equipment Type	Tons per Year					
	VOC	CO	NOx	SOx	PM10	PM2.5
Dredging						
Main Hoist - Clamshell Dredge	0.82	4.08	11.32	1.30	0.70	0.68
Main Generator - Clamshell Dredge	0.63	3.15	8.58	0.97	0.54	0.52
Deck Generator - Clamshell Dredge	0.03	0.14	0.41	0.06	0.03	0.03
Tugboat	0.12	0.25	3.04	0.23	0.21	0.19
Subtotal	1.60	7.62	23.35	2.56	1.47	1.42
Marine Disposal						
Tugboat - Transport to AK Site	0.86	1.89	22.65	1.72	1.54	1.43
Tugboat - Transport to EB Site	1.14	2.52	30.20	2.30	2.05	1.90
Subtotal	2.00	4.40	52.85	4.02	3.59	3.33
Upland Disposal						
Tug Boat - Transport to Tacoma Berth	0.02	0.04	0.48	0.04	0.03	0.03
Derrick Barge - Crane Hoist	0.05	0.32	0.74	0.10	0.05	0.05
Derrick Barge - Deck Winch	0.01	0.05	0.14	0.02	0.01	0.01
Derrick Barge - Generator	0.04	0.29	0.68	0.09	0.05	0.05
Derrick Barge - Generator	0.01	0.02	0.05	0.01	0.00	0.00
Haul Trucks	1.06	6.74	32.54	0.10	0.85	0.73
Loader - 962G - Disposal Site	0.01	0.05	0.16	0.02	0.01	0.01
Subtotal	1.20	7.51	34.80	0.39	1.01	0.88
Total - No Action Alternative	4.80	19.54	111.00	6.97	6.08	5.63

Table B-6. Total Emissions for the Commencement Bay DMMP Disposal Site Project, Alternative 1

Construction Activity/Equipment Type	Tons per Year					
	VOC	CO	NOx	SOx	PM10	PM2.5
Dredging						
Subtotal	1.60	7.62	23.35	2.56	1.47	1.42
Marine Disposal						
Tugboat Transport	0.27	0.60	7.17	0.55	0.49	0.45
Subtotal	0.27	0.60	7.17	0.55	0.49	0.45
Total (1)	1.87	8.22	30.52	3.11	1.96	1.87

Notes:

1) Equal to existing operations

Table B-7. Total Emissions for the Commencement Bay DMMP Disposal Site Project, Alternative 2

Construction Activity/Equipment Type	Tons per Year					
	VOC	CO	NOx	SOx	PM10	PM2.5
Low Volume Option						
Dredging						
Main Hoist - Clamshell Dredge	0.55	2.74	7.60	0.87	0.47	0.46
Main Generator - Clamshell Dredge	0.42	2.11	5.76	0.65	0.36	0.35
Deck Generator - Clamshell Dredge	0.02	0.09	0.27	0.04	0.02	0.02
Tugboat	0.08	0.17	2.04	0.16	0.14	0.13
Subtotal	1.07	5.12	15.68	1.72	0.99	0.95
Marine Disposal						
Tugboat Transport	0.18	0.40	4.81	0.37	0.33	0.30
Subtotal	0.18	0.40	4.81	0.37	0.33	0.30
Total	1.25	5.52	20.49	2.09	1.32	1.26
High Volume Option						
Dredging						
Main Hoist - Clamshell Dredge	1.37	6.83	18.92	2.17	1.17	1.13
Main Generator - Clamshell Dredge	1.05	5.26	14.34	1.63	0.90	0.87
Deck Generator - Clamshell Dredge	0.06	0.23	0.68	0.10	0.05	0.05
Tugboat	0.19	0.42	5.08	0.39	0.35	0.32
Subtotal	2.67	12.74	39.03	4.29	2.46	2.37
Marine Disposal						
Tugboat Transport	0.45	1.00	12.01	0.91	0.82	0.76
Subtotal	0.45	1.00	12.01	0.91	0.82	0.76
Total	3.12	13.74	51.03	5.20	3.28	3.13

Table B-8 - Commencement Bay DMMP Disposal Site Project—No Action Alternative—869,000 cy

Location/Equipment Type	Power Rating (Hp)	Load Factor	# Active	Hourly Hp-Hrs	Hours Per Day	Daily Hp-Hrs	Work Days	Total Hp-Hrs
Dredging (1)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	216	1,946,250
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	216	1,459,688
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	216	93,420
Tugboat	800	0.25	1	200	8	1,600	216	346,000
Marine Disposal (2)								
Tugboat - Transport to AK Site	2,200	0.68	1	1,496	8.4	12,566	205	2,574,459
Tugboat - Transport to EB Site	2,200	0.68	1	1,496	11.2	16,755	205	3,432,611
Upland Disposal (3)								
Tug Boat - Transport to Tacoma Berth	2,200	0.68	2	2,992	0.4	1,197	46	54,486
Derrick Barge - Crane Hoist	564	0.50	1	282	12	3,384	46	154,061
Derrick Barge - Deck Winch	238	0.50	2	238	3	714	46	32,506
Derrick Barge - Generator	432	0.60	1	259	12	3,110	46	141,605
Derrick Barge - Generator	135	0.60	1	81	3	243	46	11,063
Haul Trucks - (4)	NA	NA	540	NA	114	61,560	46	2,802,600
Loader - 962G - Disposal Site	200	0.50	1	100	8	800	46	36,421

Notes:

1. Assumes 869,000 cubic yards (cy)/year @ 4,000 cy per day.
2. Assumes 869,000 cy/year * 0.9 @ 1,900 cy per barge = 410 barge trips/year and half of these to each site. Barge speed = 5 mph.
3. Assumes 869,000 cy/year * 0.1 @ 1,900 cy per barge = 46 barge trips/year.
4. Number Active = miles/roundtrip, Hours/Day = 3 of truck trips/barge, Daily Hp-Hrs = miles/barge, and Total Hp-Hrs = total miles. Assumes a truck capacity of 20 cy and a water factor of 20%.

Table B-9 - Commencement Bay DMMP Disposal Site—Alternative 1 or 2—869,000 cy

Location/Equipment Type	Power Rating (Hp)	Load Factor	# Active	Hourly Hp-Hrs	Hours Per Day	Daily Hp-Hrs	Work Days	Total Hp-Hrs
Dredging (1)								
Main Hoist - Clamshell Dredge	1,200	0.50	1	600	15	9,000	216	1,946,250
Main Generator - Clamshell Dredge	900	0.50	1	450	15	6,750	216	1,459,688
Deck Generator - Clamshell Dredge	240	0.60	1	144	3	432	216	93,420
Tugboat	800	0.25	1	200	8	1,600	216	346,000
Marine Disposal (1)								
Tugboat Transport	2,200	0.68	1	1,496	1.2	1,795	455	817,288

Notes:

1. Assumes 869,000 cy/year @ 4,000 cy per day.
2. Assumes 869,000 cy/year @ 1,900 cy per barge = 368 barge trips/year. Barge speed = 5 mph.

Table B-10. Total Emissions for the Commencement Bay DMMP Disposal Site Project - No Action Alternative - 869,000 cy.

Construction Activity/Equipment Type	Tons per Year					
	VOC	CO	NOx	SOx	PM10	PM2.5
Dredging						
Main Hoist - Clamshell Dredge	1.01	5.05	13.99	1.60	0.86	0.84
Main Generator - Clamshell Dredge	0.78	3.89	10.60	1.20	0.66	0.64
Deck Generator - Clamshell Dredge	0.04	0.17	0.50	0.08	0.04	0.04
Tugboat	0.14	0.31	3.76	0.29	0.26	0.24
Subtotal	1.97	9.42	28.85	3.17	1.82	1.75
Marine Disposal						
Tugboat - Transport to AK Site	1.06	2.33	27.95	2.13	1.90	1.76
Tugboat - Transport to EB Site	1.41	3.11	37.27	2.84	2.54	2.35
Subtotal	2.47	5.44	65.23	4.96	4.44	4.11
Upland Disposal						
Tug Boat - Transport to Tacoma Berth	0.02	0.05	0.59	0.05	0.04	0.04
Derrick Barge - Crane Hoist	0.06	0.39	0.92	0.13	0.06	0.06
Derrick Barge - Deck Winch	0.01	0.06	0.17	0.03	0.01	0.01
Derrick Barge - Generator	0.05	0.36	0.84	0.12	0.06	0.06
Derrick Barge - Generator	0.01	0.03	0.07	0.01	0.01	0.01
Haul Trucks	1.30	8.29	40.03	0.12	1.05	0.90
Loader - 962G - Disposal Site	0.02	0.07	0.20	0.03	0.01	0.01
Subtotal	1.48	9.24	42.82	0.48	1.24	1.08
Total - No Action Alternative	5.92	24.09	136.90	8.61	7.50	6.94

Table B-11. Total Emissions for the Commencement Bay DMMP Disposal Site Project—Alternatives 1 or 2—869,000 cy

Construction Activity/ Equipment Type	Tons per Year					
	VOC	CO	NOx	SOx	PM10	PM2.5
Dredging						
Subtotal	1.97	9.42	28.85	3.17	1.82	1.75
Marine Disposal						
Tugboat Transport	0.34	0.74	8.87	0.68	0.60	0.56
Subtotal	0.34	0.74	8.87	0.68	0.60	0.56
Total	2.31	10.16	37.73	3.84	2.42	2.31

APPENDIX C: A COOPERATIVE SEDIMENT MANAGEMENT PROGRAM INTERAGENCY AGREEMENT (1995)

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Appendix C. ***Interagency/Intergovernmental Agreement***

between

U.S. Army Corps of Engineers, Seattle District (Corps)
U.S. Environmental Protection Agency, Region 10 (EPA)
Washington Department of Natural Resources (DNR)
Washington Department of Ecology (Ecology)
Puget Sound Water Quality Authority (PSWQA)

A COOPERATIVE SEDIMENT MANAGEMENT PROGRAM

OBJECTIVE.

To establish a coordinated and cooperative interagency/intergovernmental program to address sediment management issues emphasizing shared responsibilities and resources, consensus decision making in an open, cooperative forum, and active involvement and participation by others.

BACKGROUND.

The Puget Sound Dredged Disposal Analysis (PSDDA) program is a cooperative interagency/intergovernmental activity for managing sediments dredged to develop and maintain navigation and commerce activities. The PSDDA program identified acceptable open-water disposal sites, developed evaluation procedures to characterize the suitability of sediments for disposal at those sites, and provided objective standards for management of the sites.

Though resource limitations focused the PSDDA program to unconfined open-water disposal of clean dredged material, federal and state agencies are increasingly involved in contaminated sediment actions. Each agency is currently working (and expending resources) on these issues; however, no one agency has sufficient resources to fully address these challenges and to implement comprehensive solutions. In addition, no one agency has complete or unilateral authority to cover every contaminated sediment situation.

Though contaminated sediment challenges are broad and complex, all the issues are amenable to resolution, at least in part, through a cooperative, interagency/ intergovernmental model. Effective and efficient solutions will require development of policy and technical tools, and implementation strategies that are connected across agencies and agency programs. The active involvement of Ports, other resource agencies, local governments, tribes and the public need to be an integral and ongoing part of the solutions.

COMMON NEEDS.

- **Consensus on Problems and Needed Actions.** Each agency has significant responsibilities and/or expertise on various elements of dredged material, contaminated sediments, and habitat management. Mutual cooperation to identify and articulate problems, assess risks, develop priorities and solutions, and to support implementation will increase the opportunities for success and build credibility.

- **Greater Public Stewardship.** Cooperative stewardship among the agencies will increase public understanding and support for the hard decisions needed to manage navigation dredged material, remediate contaminated sediment situations, and to protect, enhance or restore important aquatic habitats.

- **Well Coordinated Use of Authorities/Policies.** Any solutions to contaminated sediments issues will require recognition of their cross-agency and -program nature and of the degree to which the issues are interconnected. The authorities and policies available to the various agencies must be closely coordinated to efficiently and effectively tackle specific problems and to avoid potential conflicts and inconsistencies.

IMPLEMENTATION.

This agreement formalizes interagency cooperation and coordination to establish regional priorities, jointly develop technical and policy responses, and mutually implement solutions for the management of clean and contaminated sediments and the protection and restoration of aquatic habitat within their mutual areas of jurisdiction. This agreement also reaffirms continued support for cooperative ventures that are already underway to manage dredged material (PSDDA), and to improve contaminated sediments management and aquatic habitats.

The following principles for interagency/intergovernmental cooperation are affirmed:

- Open communication regarding all sediment management and aquatic habitat development activities (excepting those situations that mandate confidentiality)

- Subject to the availability of agency resources, the agencies will seek opportunities to share resources and expertise to achieve the objectives of this agreement.

- To the extent allowed by law, the agencies will utilize their regulatory, enforcement, and proprietary authorities in concert with and in support of the actions of other signatory agencies that further the objectives of this agreement.

- **Periodic reviews of this agreement will occur to assess progress towards common objectives and to determine the need for continued work and additional initiatives.**

- **Where agreement on specific issues is not reached at the staff level, communications regarding resolution of any disputes will be elevated along parallel administrative levels. Resolution at the lowest staff level is encouraged.**

- **Nothing in this agreement alters any law or regulation or any agency's authority or responsibilities to accomplish their missions.**

Commitment to the goals, objectives, and agency responsibilities outlined in the PSDDA Management Plan are reaffirmed. These include:

- ***development and refinement of dredged material/sediment evaluation procedures;***

- ***monitoring and management of identified disposal sites; and***

- ***program accountability to the public through periodic review and update.***

Further, this agreement affirms these program goals, objectives, and responsibilities as the base framework for environmentally acceptable and cost-effective management of dredged material throughout those geographic areas of mutual jurisdiction.

INITIAL POINTS OF AGENCY CONTACT.

Routine contacts regarding actions identified in this agreement will be directed to the following offices which are responsible for assuring coordination with appropriate offices or programs within that agency:

Corps:	**Dredged Material Management Office**
EPA:	**Sediment Management Program, Water Division**
DNR:	**Aquatic Resources Division**
Ecology:	**Environmental Review and Sediment Section**
PSWQA:	**Contaminated Sediments and Dredging Program**

INITIAL JOINT ACTIONS.

Specific implementing actions to be pursued initially are identified below and are detailed in Appendix A.

- **Sediment Cleanup Strategy. The agencies will undertake a concerted and high priority effort to develop a strategy involving a range of approaches under different authorities on how to achieve the cleanup of contaminated sediments in the aquatic environment.**

- **Action Plan for Multiuser Confined Disposal Site(s). The agencies will** develop an action plan that outlines the requirements of a detailed study that will lead to development of one or more multiuser confined disposal sites for contaminated sediments.

- **Interagency/Intergovernmental Policies for Beneficial Use of Dredged Material.** The agencies will define policies to facilitate projects involving the beneficial uses of dredged material, and recommendations for their effective implementation in the context of existing agency authorities and programs.

FUTURE INITIATIVES.

This agreement will be amended as needed to cover new dredged material, contaminated sediment, or aquatic habitat management issues or actions, including development of assessment tools, pollution prevention, public outreach, technology transfer, etc. Such amendments shall become effective upon agreement of the signatory agencies and attachment of a description of the action to this agreement, within a time frame stipulated in the amendment. The attachments will specify the appropriate responsibilities, conditions and legal constraints. Approval of any amendments will occur by signature at the agency head level.

TRANSFER OF FUNDS. This agreement recognizes and affirms the transfer of funds among the signatory agencies as needed to accomplish joint objectives and as a critical and necessary component to successful implementation of this agreement. Fund transfers under this agreement will only occur in relation to specific actions to be described in the appendices to this agreement.

Appendix B to this agreement identifies the methods to accomplish transfer of funds between the signatory agencies, particularly with regard to Federal-to-State and State-to-Federal agencies transfers. It is recognized that there are constraints to transfer of funds. These constraints include, but are not limited to, for the federal agencies the prohibition against augmenting appropriations, and the requirements of the Competition in Contracting Act. With these limitations in mind, it is anticipated that transfer of funds will be accomplished through Cooperative Agreements under the Federal Grant and Cooperative Agreement Act of 1977, 31 U.S.C. 6301-08) (Federal to State); interagency transfers through the Economy Act, 31 U.S.C. 1535 (Federal to Federal); "work for others" through the Intergovernmental Cooperation Act, 31 U.S.C. 6501 (State to Federal); and Planning Assistance to States (Section 22, 1974 WRDA (P.L. 93-25) as amended) (State to Corps). The State's authority for transfer of funds is pursuant to Chapter 39.34 RCW.

DURATION OF AGREEMENT.

This agreement becomes effective upon final signature by all parties and remains in effect until modified by mutual consent or terminated with sixty day notice by any party.

Date: 2 May 1994

Lt.Colonel Rex N. Osborne
District Engineer
Seattle District, Corps of Engineers

Chuck Clarke

Date: May 2, 1994

Chuck Clarke
Regional Administrator
Environmental Protection Agency, Region 10

Jennifer M Belcher

Date: May 2, 1994

Jennifer Belcher
Commissioner of Public Lands
Washington Department of Natural Resources

Mary Riveland

Date: May 2, 1994

Mary Riveland
Director
Washington Department of Ecology

Nancy McKay

Date: May 2, 1994

Nancy McKay
Executive Director
Puget Sound Water Quality Authority

Interagency/Intergovernmental Agreement
A Cooperative Sediment Management Program

APPENDIX A
INITIAL JOINT ACTIONS

GENERAL.

The three initiatives described below were accepted by the agency heads of the signatory agencies to be implemented as initial joint actions under the interagency/ intergovernmental agreement titled "A Cooperative Sediment Management Program," dated May 2, 1994. These topic areas are already occupying significant staff time and some efficiencies are anticipated as the result of consolidation and formalization of efforts. The interagency/ intergovernmental agreement is the formal mechanism for implementing these initiatives and provides the platform for any future initiatives which the agencies agree to pursue.

The final products of each effort will be transmitted by the lead agency to the agency heads for their collective review and consideration. These products will include work conclusions and recommendations for any further work and implementation, as appropriate.

Work activity and product dates are established for each initial joint action. The signatory agencies recognize the significance of these actions and have directed their staff to undertake concerted and credible efforts. However, these dates are considered to be "target dates" subject to budgetary changes and progress in defining solutions with substantive agreement from external parties.

SEDIMENT CLEANUP STRATEGY

Objectives: The heads of the signatory agencies will convene an external work group to develop a sediment cleanup strategy. The results of the work group efforts will be presented to the agency heads for their collective consideration. The work group will consist of agency staff and external parties that are strongly vested in sediment cleanup policies. The work group will focus the bulk of their work on how to accomplish sediment cleanup with existing tools and systems. This will include review and consideration of existing, ongoing sediment cleanup programs. Possible methods for improving or changing the current regulatory and liability system would be discussed at the end of the study period.

Tasks: Ecology and DNR will co-chair the work group, which will be tasked to:

(1) determine how agencies can facilitate sediment cleanup under the existing regulatory and liability system by defining when to use regulatory enforcement discretion, determining how agencies could facilitate allocation of costs, using legal settlements, etc.;

(2) outline a strategy for achieving sediment cleanup along the urban waterfront, including consideration of the appropriate responsibilities and roles of aquatic landowners and proponents of waterfront developments, and guidance for the timing of sediment cleanup relative to the status of source controls;
(3) describe agency roles, responsibilities, and possible funding sources to participate in sediment cleanup under the existing regulatory and liability system and related source control efforts; and
(4) discuss whether sediment cleanup is best obtained by continued management under the existing regulatory and liability framework or whether to recommend legislative changes to the regulatory and liability scheme for sediment contamination.

For tasks 1 through 3 above, the work group would establish subgroups; different agency representatives may be needed for the different subgroups. The fourth task would be completed by the entire work group after the other subgroups had concluded their efforts.

The work group will not address the specific liability status of its individual members, or otherwise engage in discussions that would require parties to compromise their regulatory enforcement or liability defense strategies. These discussions will continue in separate forums.

Schedule: The work group will be convened in June 1994 and tasked to report back to the agency heads by December 1994 (7 months).

Resources: This work will be accomplished with existing staff and will require the active participation of staff from several programs within the regulatory agencies. No transfers of funds are anticipated to be necessary.

ACTION PLAN FOR MULTIUSER CONFINED DISPOSAL SITE(S)

Objective: The signatory agencies will develop an action plan for development of one or more multiuser confined disposal sites for contaminated sediments. The action plan will:

(1) detail the disposal siting process, including public participation;
(2) prepare a recommended site liability management scheme;
(3) evaluate institutional management agreements to specify alternative agency roles in siting, construction and operation of a site; and
(4) identify possible funding sources and mechanisms for future siting and construction steps.

The action plan will serve as a detailed plan of study for future steps towards a multiuser disposal site. The focus of the action plan will be step 1 (defining the siting process); the action plan will look at alternatives for steps 2-4, but these actions will not be completed until future studies are done.

Tasks: The Corps will work with the other signatory agencies to develop an action plan addressing most of the above topics and detailing the subsequent steps. The Corps' authority for this initial effort is the Planning Assistance to States (PAS) program, pursuant to Section 22 of the Water Resources Development Act. The Corps will initially rely on, and apply, prior studies and recommendations on multiuser sites as developed by Ecology pursuant to Element S-6 of the Comprehensive Conservation and Management Plan for Puget Sound. A review committee consisting of representatives of the other signatory agencies will be convened to assist the Corps in the study. Ports and others will be invited to participate.

The Corps will conduct the bulk of the study; development of the site liability management plan will be directed by Ecology. A subgroup will be convened by Ecology to address site liability management. The action plan will be provided to agency heads for decisions regarding subsequent implementation and funding.

Schedule: The action plan and liability management plan will be developed over a period of six (6) months (October 1994 through March 1995).

Resources: The Corps will request $30,000.00 in Federal funding for a portion of their staff and study costs. Assuming federal funding and the continuing availability of state funds, Ecology agrees to transfer to the Corps additional funding in the amount of $30,000.00 to cover the remaining Corps staff and study costs. Ecology will also make available additional funds not to exceed $10,000.00 for costs associated with developing a site liability management plan.

INTERAGENCY/INTERGOVERNMENTAL POLICIES FOR BENEFICIAL USE OF DREDGED MATERIAL

Objective: The signatory agencies will examine policies and procedures affecting beneficial uses and attempt to facilitate those uses in the context of existing agency authorities and programs, including PSDDA.

Tasks: Key tasks are:

(1) compile agency policies and procedures affecting beneficial uses;
(2) identify common and different policies and procedures;
(3) prepare a common set of policies (resolve differences, if possible);
(4) recommend an integrated procedure for agency review and approval of beneficial use projects; and
(5) identify implementation methods and any unresolved issues.

EPA will convene a work group from among the PSDDA program staff and will invite other offices and agencies to participate. EPA will: convene, facilitate and document meetings; assign research and writing to others, as appropriate; compile other agency input, then prepare and transmit draft and final reports.

Other agencies will: compile and summarize their laws, rules and policies that affect decisions regarding beneficial use of dredged material; assist in drafting recommended interagency policies and procedures regarding beneficial uses of dredged material; and conduct intraagency review of draft recommendations.

<u>Schedule</u>: The work group will be convened in December 1994 and will report back to the agency heads by the end of April 1995 (5 months).

<u>Resources</u>: This work is expected to be accomplished with existing staff resources by reducing current PSDDA activities during the five month period without impacting the public (regulated or federal projects). No transfers of funds are anticipated to be necessary. EPA has reserved $10,000.00 that could be used to contract studies for this effort, if needed.

Interagency/Intergovernmental Agreement
A Cooperative Sediment Management Program

APPENDIX B
MECHANISMS FOR
TRANSFER OF FUNDS BETWEEN SIGNATORY AGENCIES

This appendix outlines methods for transfer of funds under the interagency/ intergovernmental agreement titled "A Cooperative Sediment Management Program," dated May 2, 1994.

GENERAL

The appropriate agreement authority and form will be determined for each specific funding action under the interagency/intergovernmental agreement. The specific fund transfer agreements will be incorporated as additional appendices under the interagency/intergovernmental agreement.

It is recognized that there are constraints to transfer of funds. These constraints include, but are not limited to, for the federal agencies the prohibition against augmenting appropriations, and the requirements of the Competition in Contracting Act. With these limitations in mind, it is anticipated that transfer of funds will be accomplished through Cooperative Agreements under the Federal Grant and Cooperative Agreement Act of 1977, 31 U.S.C. 6301-08) (Federal to State); interagency transfers through the Economy Act, 31 U.S.C. 1535 (Federal to Federal); "Work for Others" under the Intergovernmental Cooperation Act, 31 U.S.C. 6501 (State to Federal); and Planning Assistance to States, Section 22, 1974 WRDA (P.L. 93-25), as amended (State to Corps). The State's authority for transfer of funds is pursuant to Chapter 39.34 RCW.

In general, fund transfer agreements under the interagency/intergovernmental agreement will contain the following:

- a purpose statement,
- a citation of authority for transfer of funds and specific statutory authority for proposed actions,
- a detailed scope of work that describes the services to performed, the responsibilities of each agency, any limitations that must be complied with in the work to be performed, and the amount and distribution of the funding,
- a specific date for expiration of the work, or for its review or renewal, and provisions for the work's termination,

- formatting and provisions as appropriate and required by the fund transfer authority, and

- signatures of the implementing agency heads.

The general purpose of fund transfers will be stated as the "furtherance of the Interagency/ Intergovernmental Agreement (dated May 2, 1994) to provide for cooperation and coordination to establish regional priorities, jointly develop technical and policy responses, and mutually implement solutions for the management of clean and contaminated sediments and the protection and restoration of aquatic habitat within their mutual area of jurisdiction. The agreement also reaffirms continued support for cooperative ventures that are already underway to manage dredged material (i.e., PSDDA Management Plan) and to improve contaminated sediments management (e.g., dredged material management standards) and aquatic habitats (e.g., fish habitat restoration)."

FEDERAL TO STATE FUND TRANSFERS

Transfer of federal funds to state implementing agencies will be accomplished by the use of "cooperative agreements" pursuant to the Federal Grant and Cooperative Agreement Act of 1977, 31 U.S.C. 6301-08. The purpose of the transfer must be to provide assistance to a non-federal entity in serving a public purpose authorized by federal statute. A cooperative agreement may not be used to acquire services for "the direct benefit or use of the United States," 31 U.S.C. 6303. Therefore, the purpose statement must explain how the Cooperative Agreement furthers a public purpose (see the general purpose statement above).

FEDERAL AGENCY TO FEDERAL AGENCY FUND TRANSFERS

Transfer of federal funds from one federal agency to another will be done by "interagency agreements" under the Economy Act, 31 U.S.C. 1535. In addition to requirements and limitations under the Economy Act, the Federal Acquisition Regulations (FAR 17.5) require a determination and findings that the services cannot be obtained through the competitive bidding process. The justification for the determination and findings would be the Interagency/Intergovernmental Agreement, etc. Therefore, transfers of money between federal agencies will require a determination and findings along with the Interagency Agreement.

STATE TO FEDERAL FUND TRANSFERS

Transfer of state funds to a federal agency will be done by one of two methods:

- through the Planning Assistance to States programs pursuant to Section 22 of the Water Resources Development Act of 1974, P.L. 93-25, as amended; or

- through the "Work for Others" program pursuant to the Intergovernmental

Cooperation Act of 1968, 31 U.S.C. 650.

The Planning Assistance to States program is used where a portion of the funding is provided from federal funds and the remaining (e.g., 50%) is provided by the State as a cost sharing requirement. The Work for Others program addresses activities funded entirely by State funds. The Work for Others program is based upon the State not having the specific technical expertise in a specific area. There are certain limitations to the authority such as manpower allocation, whether the work is within the specific expertise of the District, and concerns with taking work away from private sector, etc.

APPENDIX D: LETTER REPORT: COMMENCEMENT BAY PSDDA DISPOSAL SITE: HISTORIC USE, FORECASTED FUTURE MOUND CONFIGURATION, AND SEDIMENT TRANSPORT POTENTIAL NEAR THE SITE.

Prepared by David R. Michalsen, for Dr. David R. Kendall and the DMMP Agencies

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CENWS-EC-DB-CS 9 June 2008

MEMORANDUM FOR: David Kendall, OD-TS-DM

SUBJECT: Commencement Bay PSDDA Disposal Site: Historic use, forecasted future mound configuration, and sediment transport potential near the site

1.0 Introduction. The Commencement Bay PSDDA disposal site is located northwest of Tacoma Harbor near the mouth of the Puyallup River in Puget Sound as shown in Figure 1. Since its inception in 1989, the site has received 7.8 Mcy of material, totaling more than all other seven PSSDA sites combined. Table 1.1 lists the volume of material placed at the Commencement Bay PSDDA disposal site over its 19 year life. Since Dredging Year[1] DY00 (excluding DY02, when the site was closed) the average annual placement equaled 0.88 Mcy/year.

Since 2004 (DY05-DY07), approximately 3.3 Mcy of new dredge material has been placed at the disposal site. Several relatively large projects are expected in the next few years which would send a significant amount of material from the Blair Waterway to the Commencement Bay site. Nelson (2006) indicated that continued disposal at the existing target area could eventually create a mound with maximum height between 167 to 344 ft (with an additional 5 to 15 Mcy placed on site). The current mound height is 121 feet above the floor of Commencement Bay. It was recognized that a reduction in the mound height could be achieved by moving the target area to the southeast by 565 ft. This prompted the target area to be officially relocated beginning in DY08 (DNR et al. 2007).

The purpose of this study addresses two key objectives. The first is to forecast the disposal site footprint and mound height following additional disposal quantities of 5.0 Mcy (cumulative volume: 12.8 Mcy), 10.0 Mcy (17.8 Mcy), and 15.0 Mcy (22.8 Mcy) at the new target location within the next 15 to 20 years. The second is to evaluate tidal circulation near the mound and the potential for sediment transport of disposal materials outside the site boundaries.

The study employs two numerical models to help evaluate these two objectives.

Table 1.1. Commencement Bay PSDDA site

Dredging Year	Disposal vol. (cy)	Cumulative vol. (cy)
DY89	6,648	6,648
DY90	0	6,648
DY91	10,900	17,548
DY92	0	17,548
DY93	0	17,548
DY94	0	17,548
DY95	290,857	308,405
DY96	460,684	769,089
DY97	0	769,089
DY98	693,540	1,462,629
DY99	140,319	1,602,948
DY00	893,776	2,496,724
DY01	265,867	2,762,591
DY02	Site closed	2,762,591
DY03	710,675	3,473,266
DY04	1,205,993	4,679,259
DY05	949,399	5,628,658
DY06	811,000	6,439,658
DY07	1,324,254	7,763,912

The Multiple Dump FATE Model (MDFATE) (Moritz and Randall 1995) is utilized to describe short and long-term fates of the dredge material following multiple years of site use. The two-dimensional circulation model, CMS-M2D (Militello et al. 2004) is employed to investigate tidal currents near the disposal site.

2.0 Summary. The Commencement Bay disposal site is classified as a non-dispersive site meaning the material is required to remain within the site boundaries, with only minimal deposition of dredged material outside the perimeter boundary (e.g., <3 cm). Figure 1 shows, the site is elliptical in shape covering approximately 310 acres, with a long axis of 4,600 ft oriented parallel to the southwest-northeast direction and a short axis of 3,800 ft (PSDDA Reports 1988). Disposal of dredge material from the surface is constrained within a 1,800 ft diameter zone and a 1,200 ft diameter target area.

[1] Dredging Year: June 16 through June 15 of ensuing year. A dredging year overlaps 2 calendar years.

Figure 2, shows an isometric map of recent multibeam hydrosurvey data collected in June 2007 showing a distinct mound relative to the native seabed. Prior to disposal activity the seabed was at a depth of 546 ft mean lower low water (MLLW). Following DY07, the minimum depth at the site was 424.7 ft MLLW, amounting to a maximum height of 121 ft. The diameter with mound thickness larger than 5 ft was approximately 3,000 ft. The figure displays the old disposal target and the new disposal target relocated 565 ft southeast.

3.0 Background.

3.1 Site Use. Between November 1989 and February 2007, a total of 7,763,912 cy of dredged material was disposed at the PSDDA site. The material disposed between 1989 and 2001 was characterized as "maintenance material," the material disposed between 2001 and 2004 was slightly denser "native" or "new work" material. The material disposed from 2004 to 2007 was a combination of maintenance material and native new work material, see Tables A1-A3 for specific sediment characteristics. All dredging has been performed via clamshell dredge and disposal by split hull scow.

3.2 Bathymetric Surveys. Survey data obtained in 2001, 2004, 2006, and 2007 are used to monitor the growth of the mound. The 1974 NOS (H-9410) hydrographic survey is utilized as the baseline condition prior to disposal for estimating cumulative mound growth. Volume calculations from survey data are subject to a variety of errors including the type of equipment (single-beam or multibeam echo-sounder) and corrections for vessel motion, tides, and waves. Given the extreme depths at the site which range from 400-600 ft below MLLW, standard survey equipment can only be expected to have sounding accuracy within +/- 2 ft (USACE EM 110-2-1003).

Digital terrain model (DTM) surfaces were generated using Golden Software Surfer 8©. A 100 ft x100 ft gridded model is generated for each bathymetric survey using an inverse distance (power 2) routine with a point search radius of 500 ft. Isopatch surfaces computing elevation changes between two DTM surfaces represent an average mound thickness over each 100 ft x 100 ft cell. Figures 3 and 4 show the isopatch surface between 1974 and 2007. The volume of fill material computed from the difference between the two surfaces is approximately 5.5 Mcy. The maximum thickness is 112 feet above the pre-disposal 1974 bathymetry. The areal footprint with mound thickness greater than 5 ft above the pre-disposal bathymetry is 143 acres. The footprint with thicknesses greater than 2.5 feet is 233 acres.

In order to incorporate potential survey errors into the computed "in place" estimate, a confidence range is by adding/subtracting a uniform 2 ft thickness to the 1974 to 2007 isopatch surface. This results in a +/- 1.0 Mcy upper/lower bound, which translates to an "in place" volume between 4.5 to 6.5 Mcy. The actual disposed volume of 7.8 Mcy exceeds these bounds indicating processes such as sediment consolidation are an important factor in describing mound growth.

3.3 Sediment characteristics.

3.3.1 Dredged material. Dredge material disposed at the Commencement Bay PSDDA site has been primarily material from maintenance dredging and improvements to the Tacoma Harbor Blair Waterway performed by the Port of Tacoma. Tables A-1 to A-4 list sediment characterization results from DMMO related sampling from 2001 to 2007. In general sands and silts characterize the majority of the material by volume. However, a variable amount of gravels and clays are present. Historically, the material with highest clay content has been dredged from the eastern portion of the Blair Waterway.

3.3.2 Native seabed prior to site use. The median grain size of the native seabed at the Commencement Bay PSDDA site is comprised primarily of fine silt. Sampling data determined the sediment is composed of approximately 15% clay and 50% water by weight (PSDDA Reports 1987). The natural downslope bathymetric gradient is oriented toward the northwest.

3.3.3 Bulking potential and consolidation. Two important factors must be understood in order to accurately predict mound configuration over multiple disposals. Bulking occurs when the void space is altered from its in-situ state during the dredging process when air/water is entrapped. A clamshell bucket will increase the void ratio (e = Volume Voids/Volume Solids) resulting in larger volumes in the barge. Nelson (2006) estimates the bulking factor to be approximately 20%.

Over the 19 year life of the disposal site consolidation of sediments have likely occurred. Consolidation extrudes pore water from sediment and decreases void space. Two types of consolidation have likely occurred. The first is initial compression of the native seabed foundation in response to the surcharge loading of the mound. The second is self weight consolidation of the dredge material after each placement. The former likely occurred in the first couple of years of placement given that the foundation is composed of a fine silt-clay material with relatively high water content. Foundation compression terminates after the excess pore water in the native seabed drains (Poindexter-Rollings 1990). On the other hand, self weight consolidation occurs after each successive disposal cycle. The degree of consolidation is expected to vary based on the type of material disposed. Disposal years with larger quantities of silts and clays are expected to have a higher degree of consolidation than years where the majority of sediments were non-cohesive sands.

Early site capacity estimates assumed the degree of long-term consolidation would roughly equal the degree of bulking during the disposal process, thereby assuming a one-to-one ratio between dredge material volume and site capacity volume (§10.3, PSSDA Reports 1988). In-situ sediment profile imagery (SPI) data presented in Figure 5 confirm that limited material quantities outside the side boundary over the project life[2]. Given a relatively closed boundary implies that the computed volume estimates should be close to the volume of material disposed, if sediment bulking and consolidation are of the same degree. However, as discussed in section 3.2, the computed "in place" volumes are smaller than the disposed volumes suggesting the degree of consolidation is larger than that of bulking.

3.4 Hydrodynamic conditions. Commencement Bay is subject to deep tidal currents from the northeast-southwest through the main Puget Sound basin and currents from the northwest-southeast through Dalco passage (see Figure 1). The Puyallup River produces a shallow northwesterly surface layer flowing out of the bay. Oceanographic field data show an eddy-like circulation pattern prevailing within the bay (Ebbesmeyer et al. 1986). Additionally, lower salinities in the surface layer due to the freshwater discharge are observed (Newton et al 1997, Albertson et al. 2002).

3.5 Barge characteristics. Barge characteristics were evaluated using a sample of 895 out of 897 disposals occurring from 8/22/06 to 2/28/07 and presented in Table 3.1. Barge size a function of the contractor and barge availability. The effective barge dimensions are computed as a by number of disposals. The effective barge dimensions are used in the MDFATE analysis presented in the following section.

Table 3.1. Effective barge dimensions computed from DNR disposal log data

Barge name	# disposals	Length (ft)	Beam (ft)	Hull depth (ft)	Draft (ft) loaded	Draft (ft) empty
Northport	212	176.3	50	14	12	2
Southport	234	243.8	45.2	18	16	6
Manson 55	248[1]	136.3	9.5	39.2	37.2	27.2
Rockport	201	224.2	54.2	22	20	10
EFFECTIVE	**895**	**194**	**38**	**24**	**22**	**12**

[1] Manson 55 disposed a total of 250 times during this period, but data were missing for two of the disposal events.

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[2] The DMMP monitoring results have verified the relative amount of material outside the disposal site at the Perimeter Line (1/8 nautical mile perimeter surrounding the site, where management compliance requires recent dredged material to be less than 3 cm) documented in 1998, 2001, 2003, and 2004 through Sediment Profile Imagery (SPI). Based on DMMP monitoring, the amount of dredged material settling outside the disposal site has been relatively small (< 5 %), and remained within the site management objectives during 2007, after 1,324,254 cy was placed at the site.

4.0 Numerical modeling of mound configuration

4.1 Prior modeling work. Analysis by Nelson (2006) utilized the STFATE model to simulate the fate of dredge material from a bottom-dump split hull scow. STFATE simulates one disposal event, therefore in order to describe multiple disposal events a spreadsheet was constructed to simulate placement over the target area. A weighting algorithm was employed to effectively distribute the material in realistic manner. The 1200 ft diameter target was approximated using nine 400 x 400 ft grid cells where 35% more dumps in the center grid square were made than in each of the eight surrounding grid squares in order to accurately describe mound height and footprint. The model was calibrated by constraining the bottom aggregate voids ratio (AVR) which is equivalent to the in-situ bulk void ratio (*e*) of the four classes of sediment (gravel, sand, silt, and clay) in the mound after placement.

4.2 MDFATE modeling. The Multiple Dump FATE model (MDFATE) combines the existing models STFATE and LTFATE (Scheffner et al. 1995) to predict subaqueous mound configuration over a series of disposal cycles (Moritz and Randall 1995). STFATE simulates the short-term processes such as convective descent, dynamic collapse, and transport-diffusion while LTFATE describes long-term fate process such as slope avalanching, consolidation, and wave/current transport. Avalanching of noncohesive sediment (gravel and sand) occurs after numerous disposal events, producing a milder mound sideslope and broader footprint. Consolidation of cohesive sediments (silts and clays) occurs over longer time scales and results in reduced mound heights.

4.3 Calibration of MDFATE.

4.3.1 Model Setup. The MDFATE model uses a 100 x 100 foot grid size and a model domain of 10,000 ft north-south and 7,700 ft east-west. MDFATE reads in bathymetric data and computes the relative elevation change after the simulation is complete. The bathymetry from 1974 prior to disposal is used as a baseline survey to characterize mound growth.

4.3.2 Barge/Scow operation. MDFATE requires the speed and approach of the barge during disposal. Disposal data from 2007 indicate that 80% of disposals occur when the vessel is traveling from the southeast (or a northwesterly heading). The change in position of the barge from and open to closed position specifies the barge traveled a mean distance of 500 ft (standard deviation +/- 250 ft) during disposal. This distance includes the effects of currents moving the barge during disposal making it difficult to extract an absolute vessel speed. Thus a sensitivity analysis of the vessel speed is performed to determine its influence on footprint shape and area. In general, as vessel speed increases the shape of the disposal cloud becomes narrower and elongated. Additionally, the centroid of maximum thickness is biased toward the direction of travel. It is determined employing a vessel speed of 1 ft/s in MDFATE produces the best areal footprint coverage with respect to the field measurements. This speed is assumed to represent an average vessel speed over a large number of disposal events.

4.3.3 Target Centroid and Diameter. Coordinates of the pre-DY08 target centroid in Washington State Plane North (NAD83, ft) are: Easting = 1,152,892; Northing = 724,554. Disposal log data indicate that the actual disposal points fall within a smaller diameter than the 1,200 ft restricted target zone. A model sensitivity analysis determined that specifying a target diameter of 600 ft in MDFATE produces the best agreement in areal footprint and mound thickness for the actual volume of material disposed in the three calibration cases listed in Table 4.1.

4.3.4 Bottom AVR and Mound sideslope. The depositional void ratio of the cohesive sediments (e.g. silt and clay) is adjusted in MDFATE to produce similar "in place" volumes for the disposal volumes listed in Table 1.1. The depositional AVR is a weighted average of the void ratio of each sediment class by volume. In the calibration case (from 1989 to 2001), employing a depositional AVR = 1.2 agrees well with the "in place" mound thickness and volume. This is close to the computed in-situ AVR = 1.4 of the material prior to dredging as shown in Table A-1. In the second calibration case (from 2001 to 2004), employing an AVR = 0.9 matching the in-situ AVR listed in Table A-2 produces a good fit with field measurements. In the final calibration case (from 2004 to 2007), an AVR = 0.5 produces a good fit and is slightly lower than the in-situ AVR = 0.7 given in Table A-3, suggesting a higher degree of consolidation. These bottom AVR values are lower that those specified in Nelson (2006). One potential reason for this is believed to be the representation of avalanching and consolidation in the MDFATE model versus the weighting algorithm developed by Nelson (2006).

In order to represent mound sideslopes witnessed in the field (slope as large as 10°), the silt/clay material must be specified as cohesive in the MDFATE model. These sediments are able to hold a steeper post sheared angle than non-cohesive sediments meaning that avalanching is not initiated until steeper mound sideslopes are reached in the simulations.

4.3.6 Tidal Currents & Salinity. Currents of 0.5 ft/s are specified in the model to simulate typical ebb currents to the northeast (45°) and flood currents to the southwest (225°). MDFATE calculates the effective velocity on the seabed using the depth averaged velocity and an assumed vertical profile shape. Depth averaged currents computed in CMS-M2D are used to estimate the magnitude and direction input into MDFATE.

Stratification or vertical density gradients in the water column are also a contributing factor to settling rates of finer sediments. Density gradients cause these sediments to stay in the water column longer. Saline waters mixing with freshwater discharge from the Puyallup River produce surface waters with lower density than those near the seafloor. In MDFATE, salinities of 1.0292 g/cc and 1.03 g/cc are specified at the surface and seafloor respectively.

4.4 Model comparison to field measurements. Isopatch surfaces of the 2001-1974, 2004-1974, 2007-1974 bathymetry data are compared with the model results in Figures 6-8. Table 4.1 lists the model results versus field measurements for areal footprint and maximum mound thickness. The root mean square error is computed within the 1375 cells representing the site disposal area using the following relation

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(z_{pred} - z_{DTM}\right)^2}{n}} \qquad (1)$$

Table 4.1 Field measurements in bold versus MDFATE model calibration results in parentheses

Time period	Max mound thickness[1] (ft)	Footprint above 5 ft (acres)	RMSE (ft) within disposal site[2]
2001-1974	**47** (*51*)	**86 (***51***)**	**3.1**
2004-1974	**78** (*83*)	**116** (*108*)	**2.3**
2007-1974	**112** (*115*)	**130** (*130*)	**2.7**

[1] maximum mound thickness averaged within a 100ft x 100ft cell of gridded DTM
[2] the 310 acre disposal site is approximated by n = 1375 cells in the gridded model

4.5 Estimated future mound configuration with relocated target zone. The target location will be located 565 ft southeast of the existing location effective DY08. The new coordinates in Washington State Plane North (NAD83, ft) are: Easting = 1,153,275, Northing = 724,150. The simulations assume the disposal operation and environmental conditions are identical to those used in the calibration cases in section 4.3. A depositional AVR = 0.5 is specified in MDFATE since the material is most similar in characterization to the 2004-2007 material as indicated in Table A-4.

Table 4.2 lists the predicted maximum mound thickness and areal footprint of the mound after 5.0 Mcy (cumulative volume: 12.8 Mcy), 10.0 Mcy (17.8 Mcy), and 15.0 Mcy (22.8 Mcy) of material are disposed at the new target location. Figures 9-11 show the predicted thickness for each successive disposal quantity. Figure 14 displays an undistorted three-dimensional surface of the mound after 15 Mcy of additional material. The maximum mound heights displayed in Table 4.3 are calculated using a correlation factor between the maximum computed DTM thickness and the measured maximum height, as

$$MaxHeight_{predicted} = MaxThickness_{MDFATE(DTM)} \cdot \frac{MaxHeight_{Survey2007(Measured)}}{MaxThickness_{Survey2007(DTM)}} \qquad (2)$$

4.6 Estimated future mound configuration relocating target zone every 5 Mcy. The previous section indicates mound growth to begin accumulating at a similar rate prior to relocation after an additional 5 Mcy is disposed at the SE target relocation (i.e. No Action Alternative). In effort to limit mound growth, it is proposed to relocate the target following every 5 Mcy of material placed while avoiding the area northwest in the disposal zone where there is presently larger mound thickness. Two additional alternatives are proposed and analyzed.

Alternative 1 would entail shifting the target area 565 ft southwest from the original target centroid after 17.8 Mcy of material is disposed at the SE target area (total at SE target = 10 Mcy, total at SW target = 5 Mcy). The coordinates for SW relocation are: Easting = 1,152,492; Northing = 724,154. The simulated mound thickness computed by MDFATE is displayed in Figures 12 and 15.

Alternative 2 would entail shifting the target area 565 ft southwest from the original target centroid after 12.8 Mcy is disposed at the SE target then shifting the target area 565 ft northeast after 17.8 Mcy is disposed at the SW target area (total at SE target = 5 Mcy, total at SW target = 5 Mcy, total at NE target = 5 Mcy). The coordinates for SW relocation are: Easting = 1,152,492; Northing = 724,154. The coordinates for NE relocation are: Easting = 1,153,292; Northing = 724,954. The simulated mound thickness computed by MDFATE is displayed in Figures 13 and 16.

Tables 4.2 to 4.4 compare the predicted mound thickness, footprint, and maximum mound height relative to the No Action alternative. Figure 17 displays maximum mound height as a function of cumulative volume placed. Model results indicate substantial reduction in mound height can be achieved if the target area is repositioned at scheduled volume intervals. One additional relocation (i.e. Alt 1) would reduce the mound height by 75 ft following an additional 15 Mcy of disposal material. Two additional relocations (Alt. 2) would reduce the mound height by 152 ft. It should be noted that these simulations are performed assuming the bottom AVR closely matches the 2007 DMMO samples presented in Table A.4. The bottom AVR should be adjusted to account for changes in sediment type to better describe the actual mound growth as the data becomes available.

Table 4.2. Predicted maximum thickness[1] in **feet**, for additional disposal quantities

Additional quantity (Mcy)	No Action (SE)	Alt 1 (SE,SW)	Alt 2 (SE, SW,NE)
5	122	122	122
10	193	193	136
15	284	214	143

[1] **maximum mound thickness averaged within a 100ft x 100ft cell of gridded DTM**

Table 4.3. Predicted footprint with elevation above 5 feet in **acres**, for additional disposal quantities

Additional quantity (Mcy)	No Action (SE)	Alt 1 (SE,SW)	Alt 2 (SE, SW,NE)
5	168	168	168
10	197	197	191
15	231	215	215

Table 4.4. Predicted maximum mound height in **feet** for additional dredge quantities

Additional quantity (Mcy)	No Action (SE)	Alt 1 (SE,SW)	Alt 2 (SE, SW,NE)
5	132	132	132
10	209	209	147
15	307	232	155

5.0 Tidal circulation and sediment transport potential.

The final portion of the study investigates circulation within Commencement Bay and the influence of the disposal mound on tidal current patterns. Additionally, the potential for sediment transport at the site is investigated for current and future conditions. The CMS-M2D (Militello et al. 2004) circulation model is used to simulate tidal currents within Puget Sound and specifically Commencement Bay. CMS-M2D solves the two-dimensional, depth-integrated continuity and momentum equations by applying a finite-volume method. These equations are solved numerically using an implicit finite differencing method.

5.1 Numerical modeling of current patterns in Commencement Bay. The model domain covers the entire Puget Sound basin and is shown in Figure 18. Topographic and bathymetric data are obtained from the University of Washington PSDEM 2005 (Finlayson 2005) and the NDGC Coastal Relief Model (Divins and Metzger 2008). The offshore boundary is specified in the Strait of Juan de Fuca just east of Ediz Hook near Port Angeles, WA. Multiple methods are available for describing tidal forcing at the offshore boundary, including direct elevation time series input from a regional circulation model such as ADCIRC. However, due to time constraints the model is driven using NOAA published tidal constituents at Port Angeles, WA (Station ID: 9444090). CMS-M2D is capable of reading eight tidal constituents (M_2, S_2, N_2, K_2, K_1, O_1, M_4, M_6). To provide appropriate spatial resolution in the numerical grid, CMS-M2D has the capability of refining cells in areas such as inlets and steep transitions in bathymetry. The grid utilized in the study is 1074 cells in the north-south and 953 cells east-west directions. This is determined to provide the best resolution while still providing a reasonable simulation time (24 hr simulation = 6 hr CPU). A total of 423,924 computation cells are included in the model domain with cell sizes ranging from 100 ft to 1000 ft. The regions with the highest discretization are the various sills (i.e. Deception Pass, Admiralty Inlet, and Tacoma Narrows) in addition to the Commencement Bay PSDDA disposal site. The implicit computation scheme allows for a longer time step with higher computational efficiency. In this study a time step of t = 120 sec is utilized. Nine observation cells (see Figure 18) are specified in the model to record time series data of the water surface elevation, north-south velocity, and east-west velocity.

The model is run for a total of 96 hours. The model is initially run for 48 hours to spin up and reach equilibrium. The following 48 hour time period simulates a spring tide condition from June 1-2, 2008 when tidal currents are expected to be large. Figure 19 shows the predicted versus modeled water surface elevation at the NOAA Tacoma station. Adjusting the roughness (friction factor) of the cells representing the sills may improve model agreement; however this is determined unnecessary at this stage in the analysis; this may be refined at a later time. The default Manning's roughness friction factor of n = 0.025 is used in all M2D simulations.

Model results indicate that the largest currents around the disposal site occur near the end of the flood tide cycle. Figure 20 shows the tidal current magnitude for the nine observation cells representing the present bathymetric conditions. The model predicts a peak velocity of 1.1 ft/s (0.35 m/s) on 1 June 2008 13:00 PST at the northern most observation cell (Mound_N). Figures 21 and 23 show velocity vectors (magnitude and direction) along with the velocity magnitude designated by the color shade. The direction of the flood current is directed to the southwest, while the direction of the ebb tide is to the northeast which closely matches the Puget Sound basin geometry north of Commencement Bay. One interesting feature the simulations show is the formation of an eddy or gyre near the mouth of the Bay during the flood tide cycle. The location of the gyre is shown to move location from beginning to the end of the tide cycle. Flood currents are shown to enter the Bay along the western shore initially, while currents exit the Bay along the eastern shoreline along Browns Point (see Figure 23). The flood currents north of the Bay are naturally deflected to the west toward The Tacoma Narrows connecting the main Puget Sound basin to the South Sound basin. The presence of the PSDDA mound may have some influence on the gyre type feature within Commencement Bay; however it does not show a signature of any local changes in current magnitude around the disposal site.

5.2 Current patterns in Commencement Bay following 15 Mcy of additional disposal material. In conjunction with section 4.6, the affect of 15 Mcy of additional material placed at the disposal site on tidal currents is investigated. Figure 24 displays the current velocity time series of the disposal mound representing the 1. present conditions (2007 bathymetry), 2. No Action alternative, 3. Alternative 1, and 4. Alternative 2. The time series represents the depth averaged velocity at the location directly over the pre-2007 disposal target centroid (i.e. observation cell Mound C). Figures 25-26 display the time series for observation cells Mound N and Mound E respectively.

Due to the extreme depths at Commencement Bay, even for the largest mound height of 307 ft (i.e. No Action), the water depth would still be approximately 240 feet above the apex of the mound. As a result, its influence on tidal currents is not extreme. It is shown that a mound this large would increase the magnitudes of the ebb currents most significantly. Alternative 2, which limits the mound height by increasing the areal footprint shows the least impact on amplifying currents.

5.3 Sediment transport. Sediment is put into motion when the critical shear stress on the seabed is exceeded. Critical shear stress (τ_{cr}) is larger for coarser sediment grain sizes (d_{50}). Therefore smaller grain sizes such as clay and silts have greater potential for transport under lower velocities. Following Watanabe (1987), the critical shear stress is given as:

$$\tau_{cr} = (\rho_s - \rho_w) g d_{50} \theta_{cr} \tag{2}$$

where ρ_s is the sediment density (2.65 g/cc), ρ_w is the water density (1.03 g/cc), g is gravitational acceleration (9.81 m/s^2), and θ_{cr} is the critical Shields parameter. Utilizing sediment SVPS sample data from Striplin (2001) the d_{50} size of the material within the site boundary ranges from 0.052 mm in the southwest quadrant to 0.285 mm in the target location. Inserting these grain sizes and into Equation (2) results in critical shear stresses of $\tau_{cr} = 2.4 \times 10^{-3}$ for clays/silts and 1.08×10^{-2} lb/ft^2 for sands

The actual bottom stress on the seabed is a function of velocity, water depth, and bottom roughness. The bottom stress (τ_b) retarding fluid motion on the seabed can be expressed by the quadratic friction law:

$$\tau_b = \frac{\rho_s f_c U_c^2}{8} \tag{3}$$

Where U_c is the depth averaged current velocity and f_c is a current friction factor determined experimentally by Van Rijn (1988) as:

$$f_c = 0.24 \log\left(\frac{12d}{k_{sd}}\right)^{-2} \tag{4}$$

where d is the still water depth plus tidal amplitude, and $k_{sd} = 2.5d_{50}$. The maximum expected bottom stress on the seabed utilizing the velocity computed in the M2D simulation, U_c = 1.1 ft/s (0.35 m/s) results in $\tau_b = 4 \times 10^{-3}$ for clays/silts and 5×10^{-3} lb/ft^2 for sands. This indicates that material with grain size less than 0.052 (i.e. clays) may be mobilized for short time periods during extreme tide conditions. Coarser sediments such as silty sands and sands fall under the criteria where $\tau_b < \tau_{cr}$, or that sediment motion is not initiated under the expected maximum tidal current.

6.0 Conclusions. The first portion of the analysis investigates site use trends at the Commencement Bay PSDDA site using the available empirical data. Since the disposal site initiation in 1989, the mound height has grown to a maximum of 121 ft, or minimum depth of 424.7 ft MLLW. Heavy site use has continued since 2001 with an annual average disposal quantity of 0.88 Mcy/yr. Spanning this time period the areal footprint with an average thickness greater than 5 feet above the native seafloor has grown 10%. The maximum thickness was 112 ft following the 2007 dredging year which computes to an increase of in height of 51% since 2001 demonstrating the rapid rate of vertical accumulation relative to lateral expansion. This has prompted the DMMP agencies to relocate the target area 565 ft to the southeast beginning in DY08 which will in effect spread the footprint over a larger area within the site boundary while reducing the rate of vertical height accumulation.

One important conclusion found is that "in place" mound volumes were significantly lower than actual disposal volumes. This seems to suggest consolidation of both the native seabed and cohesive disposal material sediments have likely occurred over the project life. Thus, it may be useful to quantify the current rate of consolidation via field measurements, to accurately forecast future site capacity. Another interesting observation from recent disposal data is that 80% of vessel headings were directed to the northwest (or traveling from the southeast) during disposal. This bias in vessel course may have been a contributing factor to the skewed footprint to the northwest with respect to the pre-DY08 target centroid. Moving the target area to the southeast should effectively dampen this effect during future disposal events. However, if a similar pattern remerges a stricter disposal plan eliminating bias in vessel course could be beneficial.

The second portion of the analysis utilizes the MDFATE numerical model to forecast future mound height, footprint, and capacity of the Commencement Bay PSDDA disposal site. With the new target area assigned, avalanching of coarse sediments is expected on the southeastern sideslope of the mound until the footprint becomes broad enough for vertical height accumulation. The model predicts with an additional 5.0 Mcy disposed at the new target location, the maximum mound height will increase approximately 10 feet from the present maximum height (e.g., 122 ft). However with disposal quantities exceeding 5.0 Mcy, the model indicates mound height will begin to increase rapidly again, analogous to the rates from 2001 to 2007. Nearing this time it is recommended that the target area be similarly relocated. For an additional 15 Mcy, model simulations indicate relocating the target location every 5 Mcy provides a 98% reduction in maximum mound height in comparison to the No Action alternative.

The final portion of the analysis employs the CMS-M2D two-dimensional circulation model to investigate tidal currents near the Commencement Bay PSDDA site. The modeling does not attempt to describe vertical mixing induced by either the mound geometry or salinity gradients created by freshwater discharge. Vertical velocity is assumed to be small with respect to horizontal velocity which is the primary mechanism driving sediment transport near the seafloor. Model results indicate that maximum currents are less than 1.1 ft/s (0.35 m/s). This velocity is less than the critical velocity required to initiate bedload transport for the majority of sediments at the site, according to sediment transport theory. This agrees with empirical data showing little disposal material found outside the site perimeter boundary. It is believed more likely that transport of fine sediments outside the site boundary is a result of surface currents influencing the sediment descent cloud during the disposal process causing materials with lower settling velocities to drift slightly away from the target location.

Additional model simulations were performed to determine if current velocities may be deflected or amplified if the mound height were allowed to grow to the maximum height modeled in the MDFATE simulations. It was determined that, a mound with maximum heights over 300 feet resulted in little changes to the velocity field. However, relocating the target every 5 Mcy is shown to slightly reduce the impacts to tidal currents near the mound, providing further justification for initiating this management practice.

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DEFINITIONS

Aggregate Voids Ratio (AVR): Void ratio is defined as the volume of voids in a mixture divided by the volume of solids. The aggregate void ratio is the weighed average of each sediment class (i.e. clay, silt, sand, gravel) void ratio by volume.

Coastal Modeling System (CMS-M2D): Is a numerical computer model which employs a finite-volume representation of the two-dimensional (depth-integrated) continuity and momentum equations of water motion. The model is used to compute tidal velocities within Puget Sound and around the Commencement Bay PSDDA dredge material disposal site for present and future conditions.

Digital terrain model (DTM): A computer graphics software technique for converting point elevation data into a terrain model displaced as a contour map, sometimes as a three-dimensional "hill and valley" grid view of the ground surface. Digital terrain model or digital elevation model (DEM) is commonly used interchangeably.

Mound thickness: Is equivalent to the average mound elevation over a 100 ft x 100 ft cell in the digital terrain model.

Mound height: Is equivalent to the spot elevation difference (point to point). Equation (2) relates mound thickness to mound height for the future mound configuration alternatives based on the 2007 relationship between mound thickness and mound height.

NDGC Coastal Relief Model (Volume 8): The National Geophysical Data Center gridded database that merges the US Geological Survey 3-arc-second DEMs with a vast compilation of hydrographic soundings collected by the National Ocean Service and various academic institutions. This DEM is combined with the PSDEM in the areas located in the Strait of Juan de Fuca where additional coverage is required.

Puget Sound Digital Elevation model (PSDEM): Digital terrain model of bathymetry and topography of Puget Lowland, including Puget Sound, Hood Canal and Lake Washington. This data was current as of 2005. The data set was derived from high resolution LIDAR and multibeam SONAR wherever these data were available. It is suitable for detailed work at the 1:24000 level. This digital elevation model (DEM) is Copyright © 2005 David Finlayson.

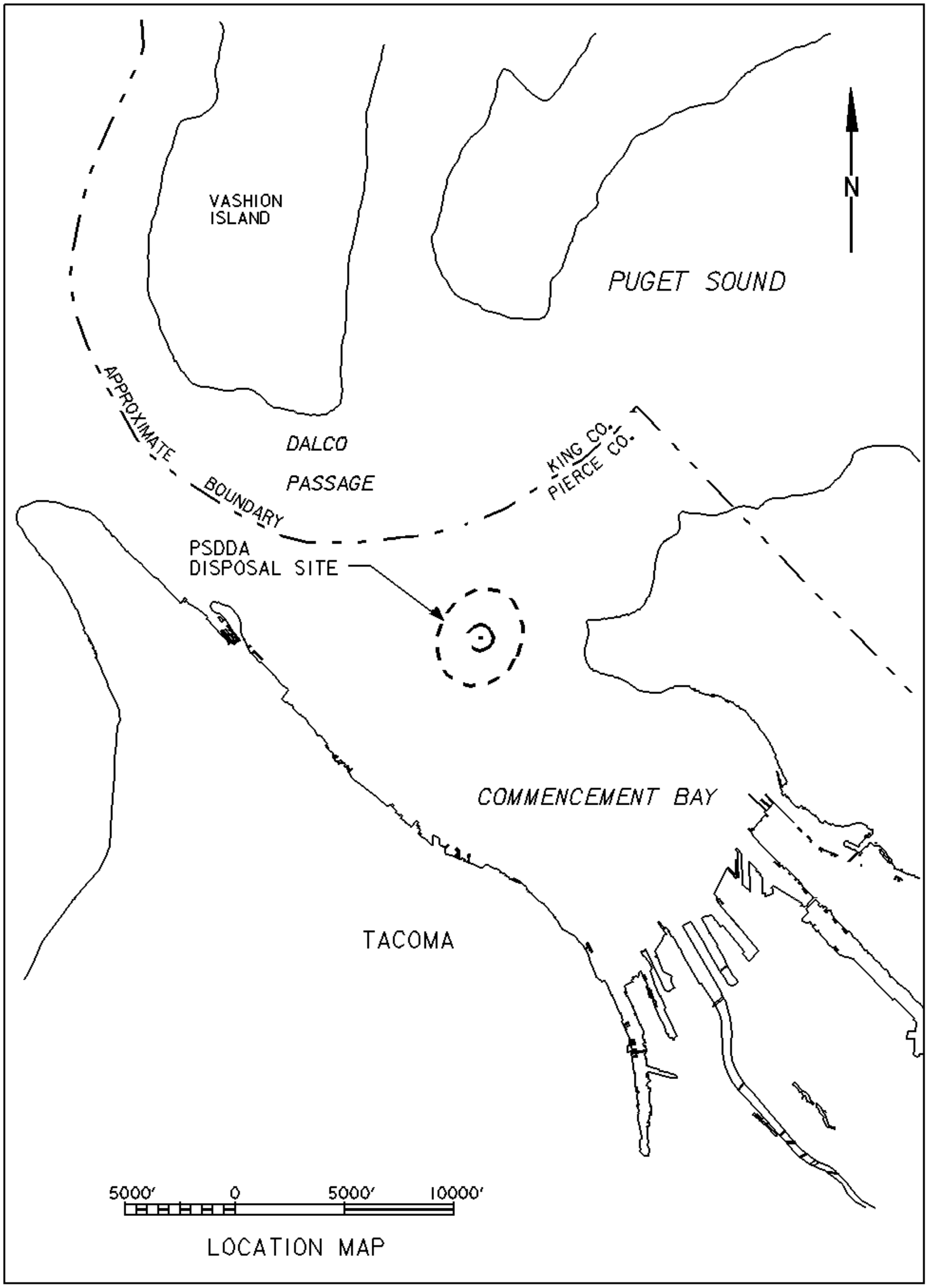

Figure 1. Commencement Bay PSSDA disposal site location map

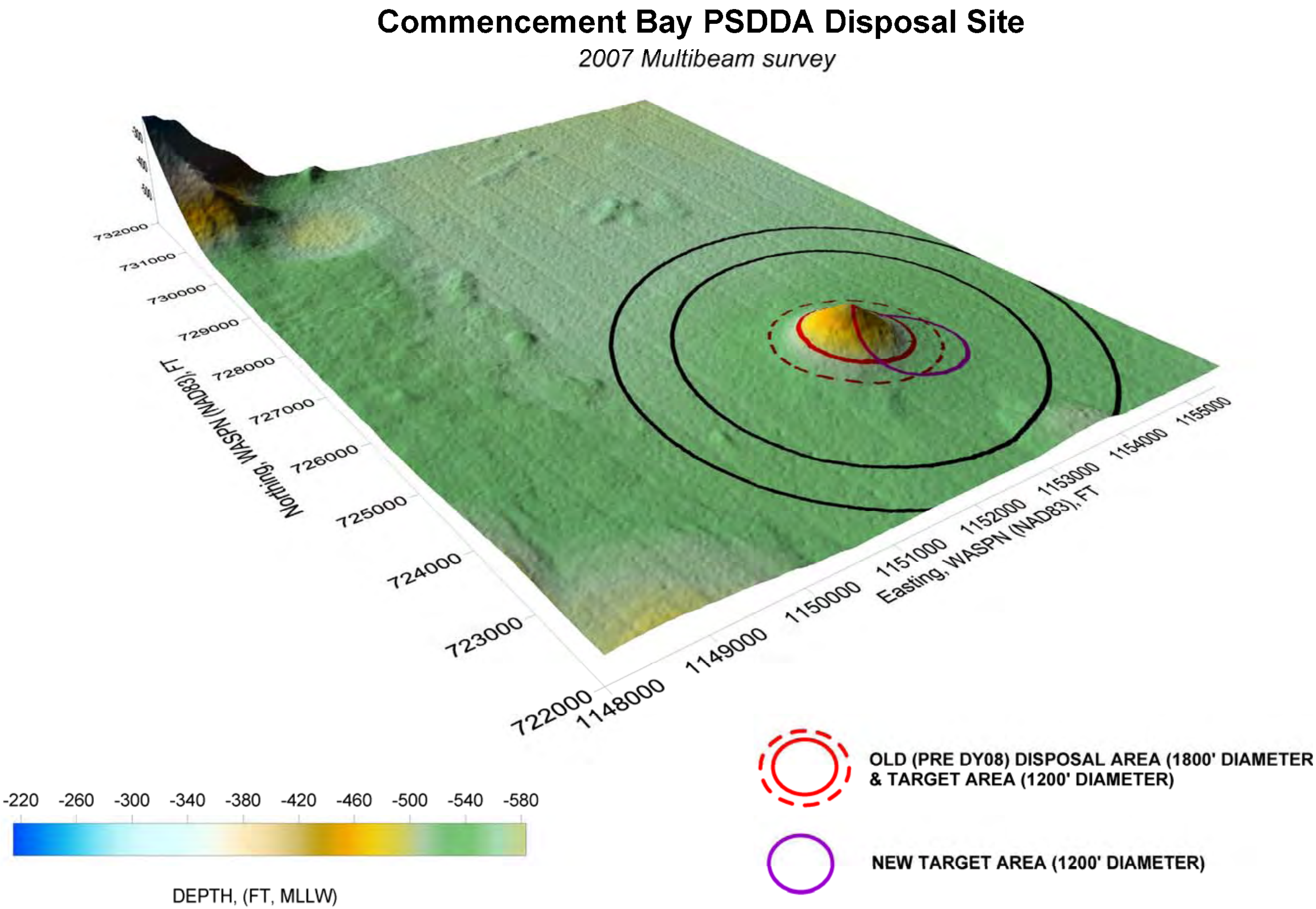

Figure 2. Commencement Bay PSSDA disposal site 2007 bathymetry (vertical scale is undistorted)

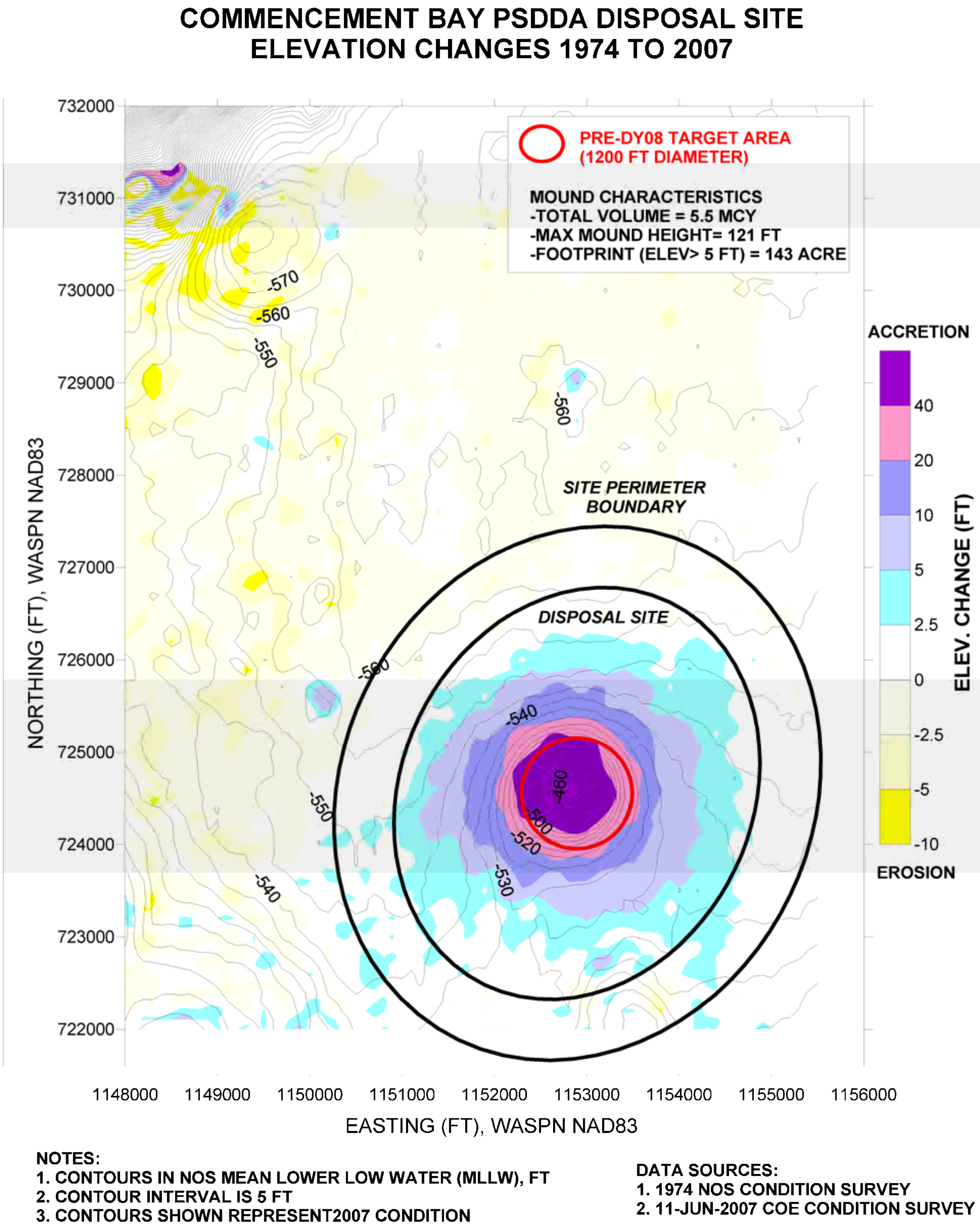

Figure 3. Commencement Bay PSDDA site elevation changes from pre-disposal to DY07

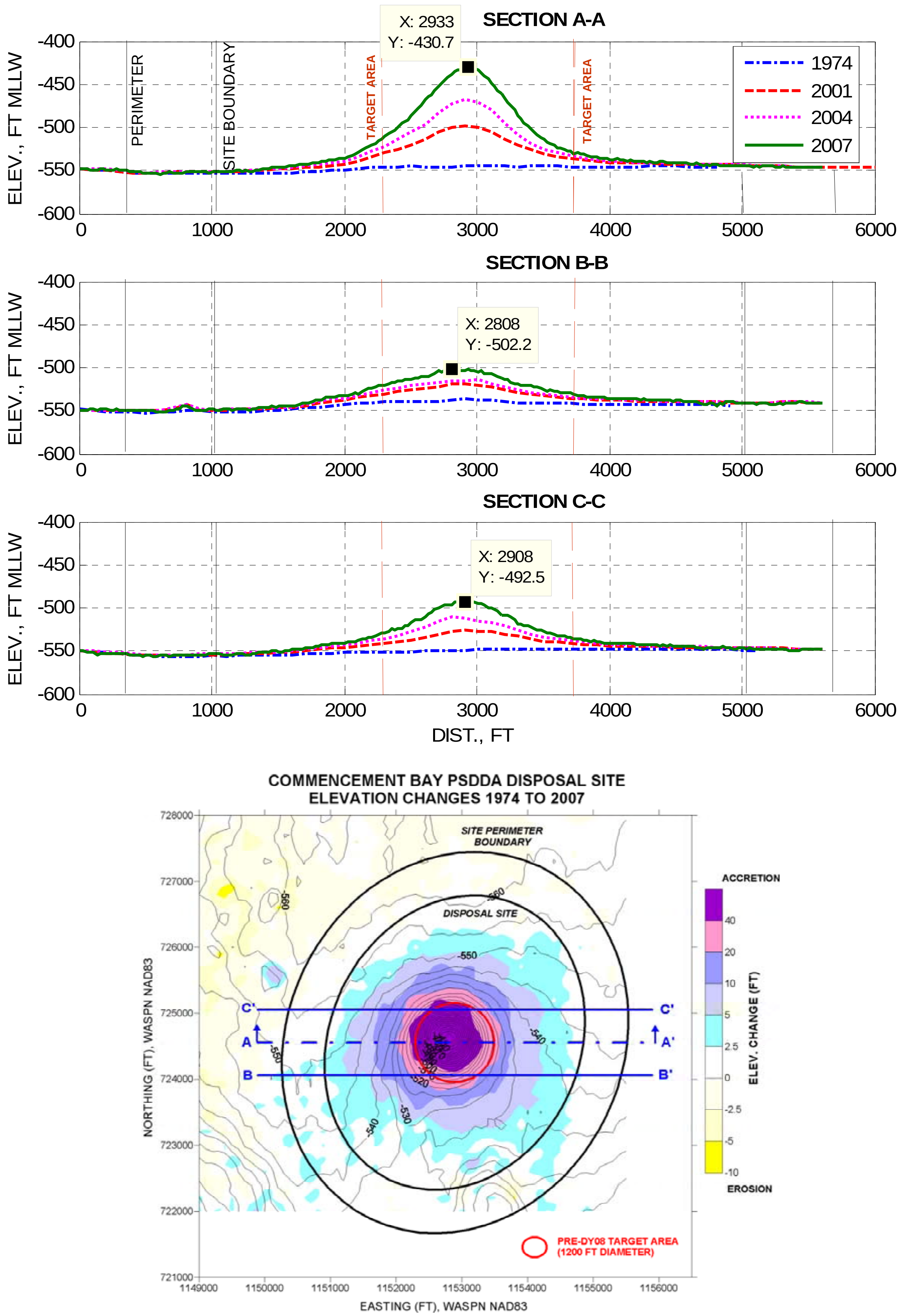

Figure 4. Commencement Bay PSDDA Site mound configuration 1974 to 2007 **(Note vertical scale is exaggerated 30x in cross-section plots).**

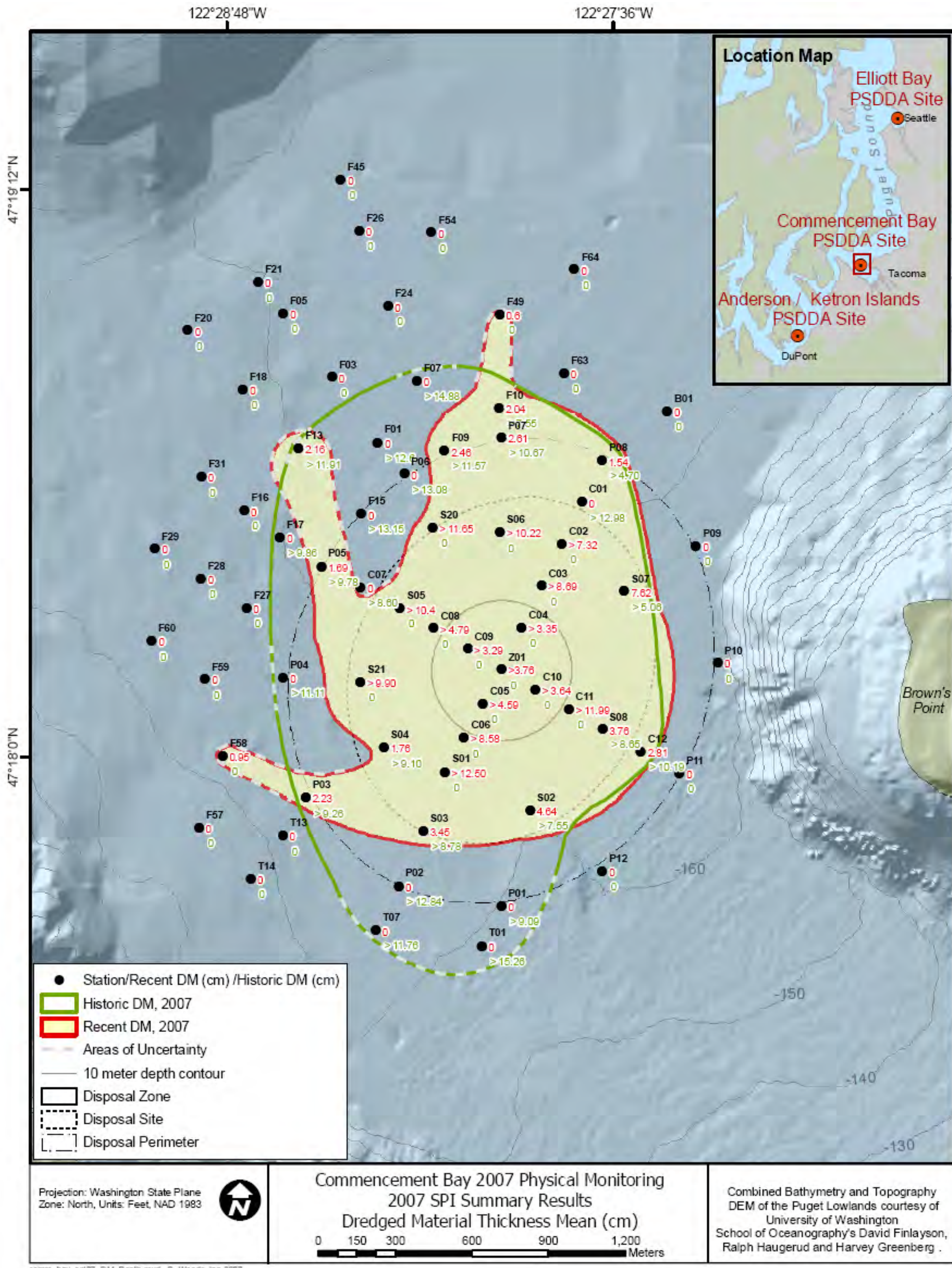

Figure 5. Commencement Bay PSDDA Site: 2007 sediment profile imagery (SPI) results.

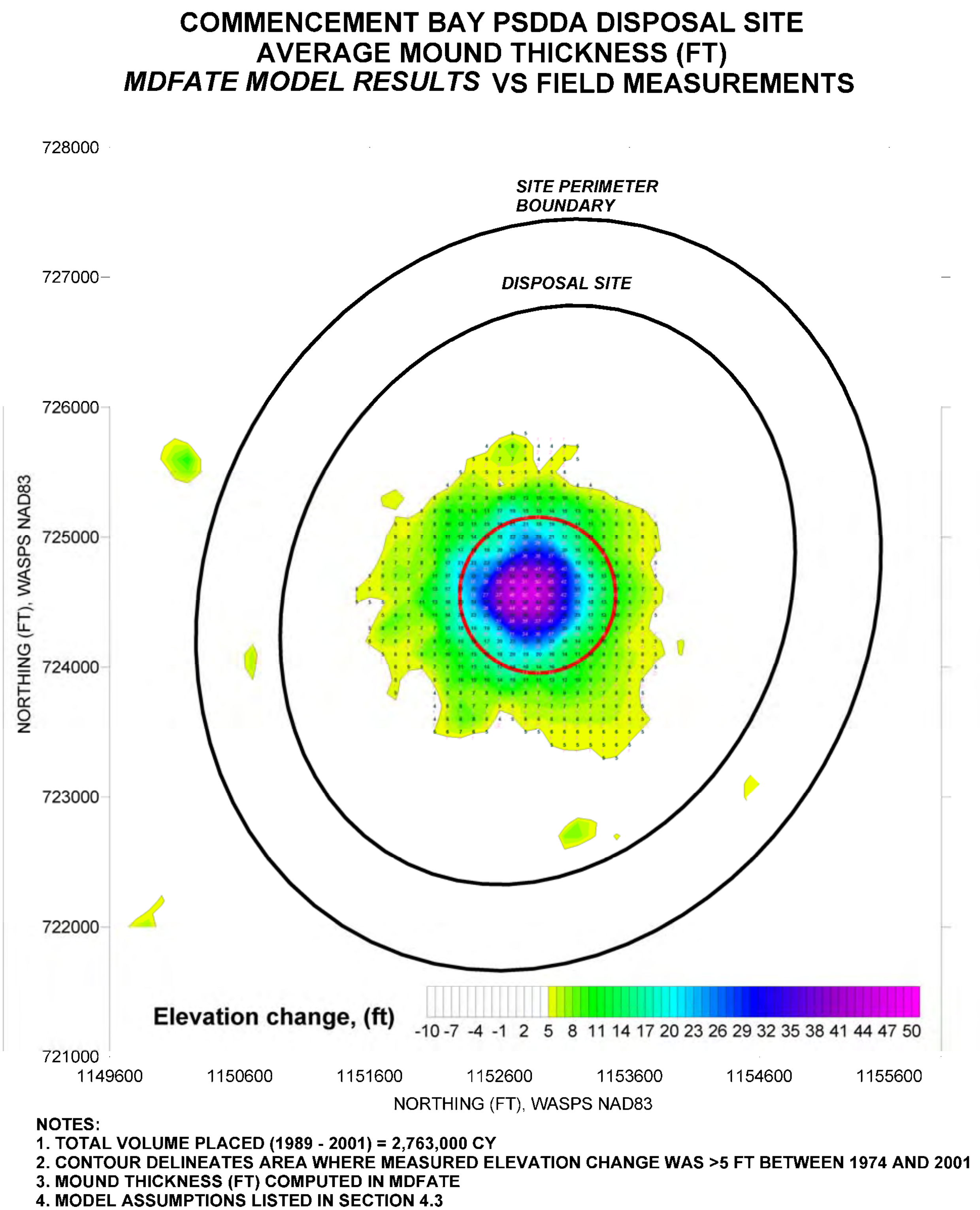

Figure 6. MDFATE model results vs. field measured 1989 to 2001 isoplot

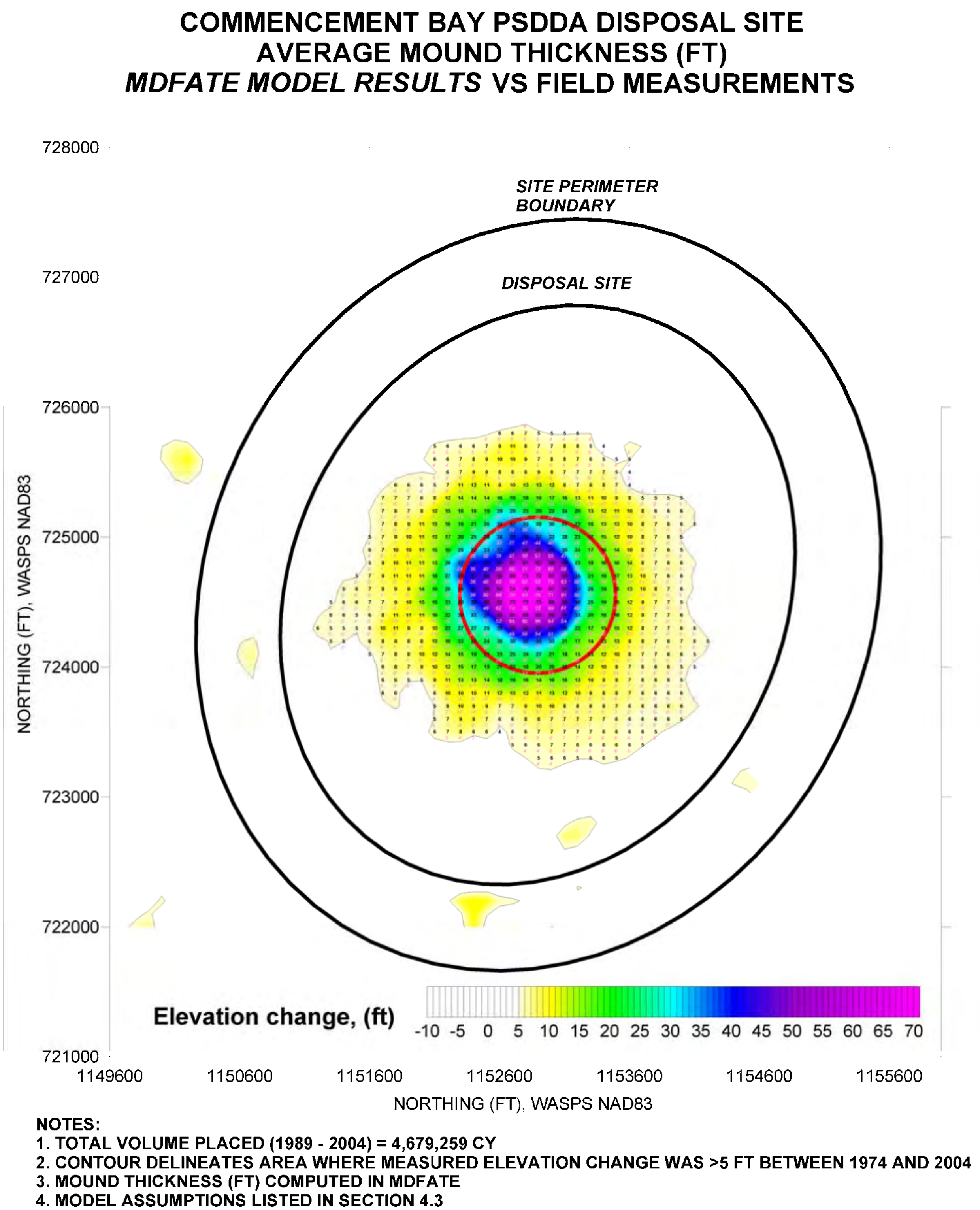

Figure 7. MDFATE model results vs. field measured 1989 to 2004 isoplot

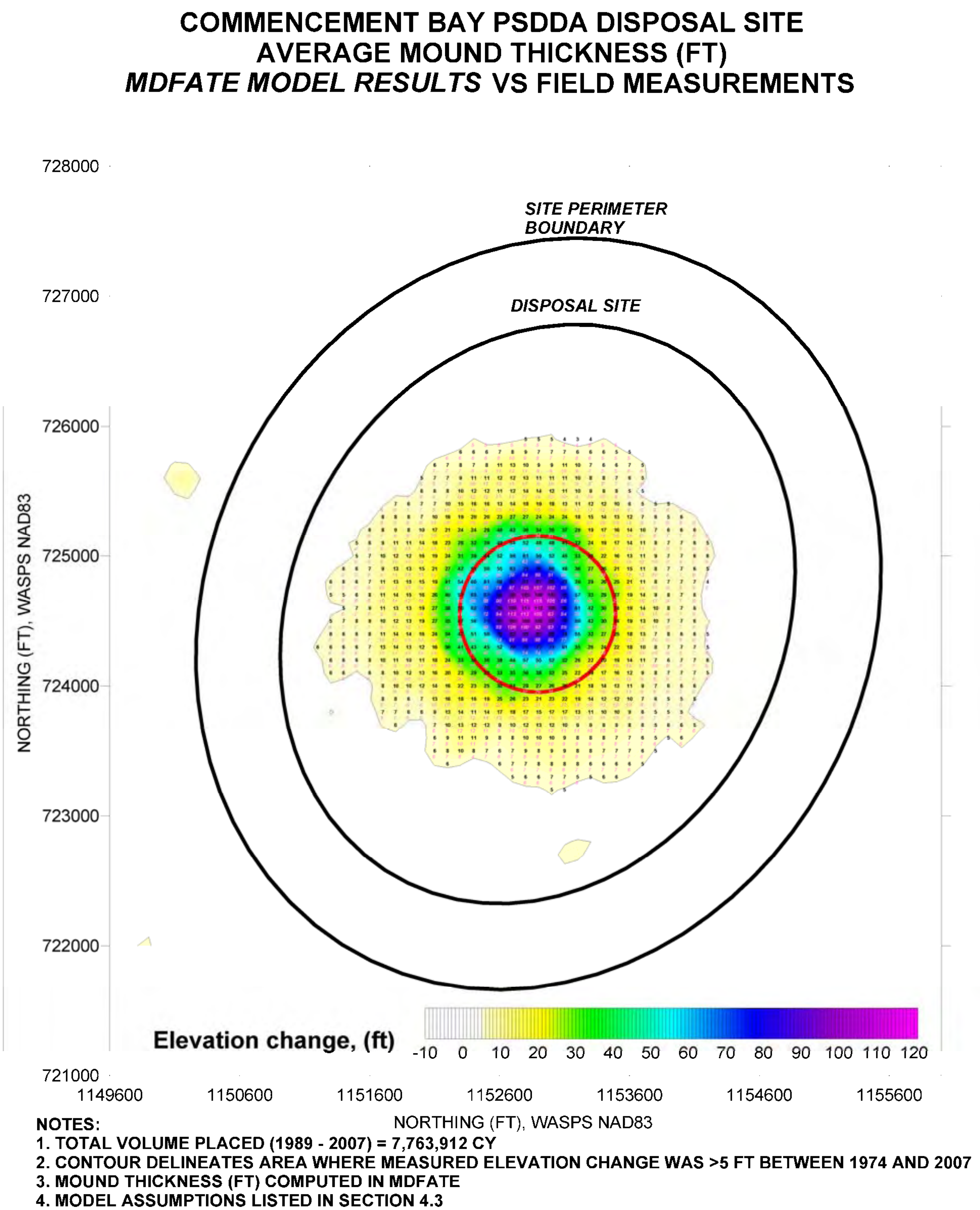

Figure 8. MDFATE model results vs. field measured 1989 to 2007 isoplot

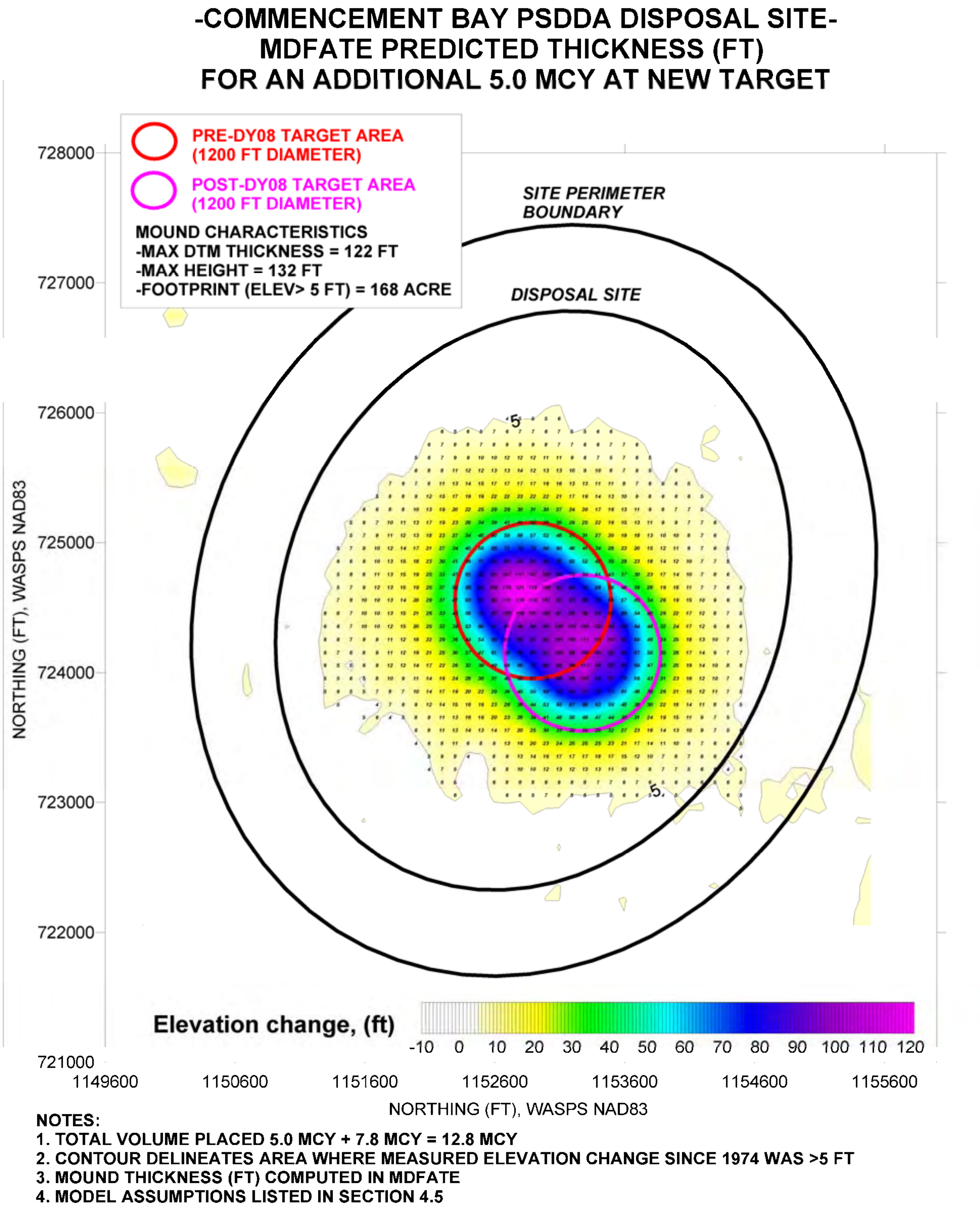

Figure 9. MDFATE predicted mound thickness with an additional 5.0 Mcy of material placed

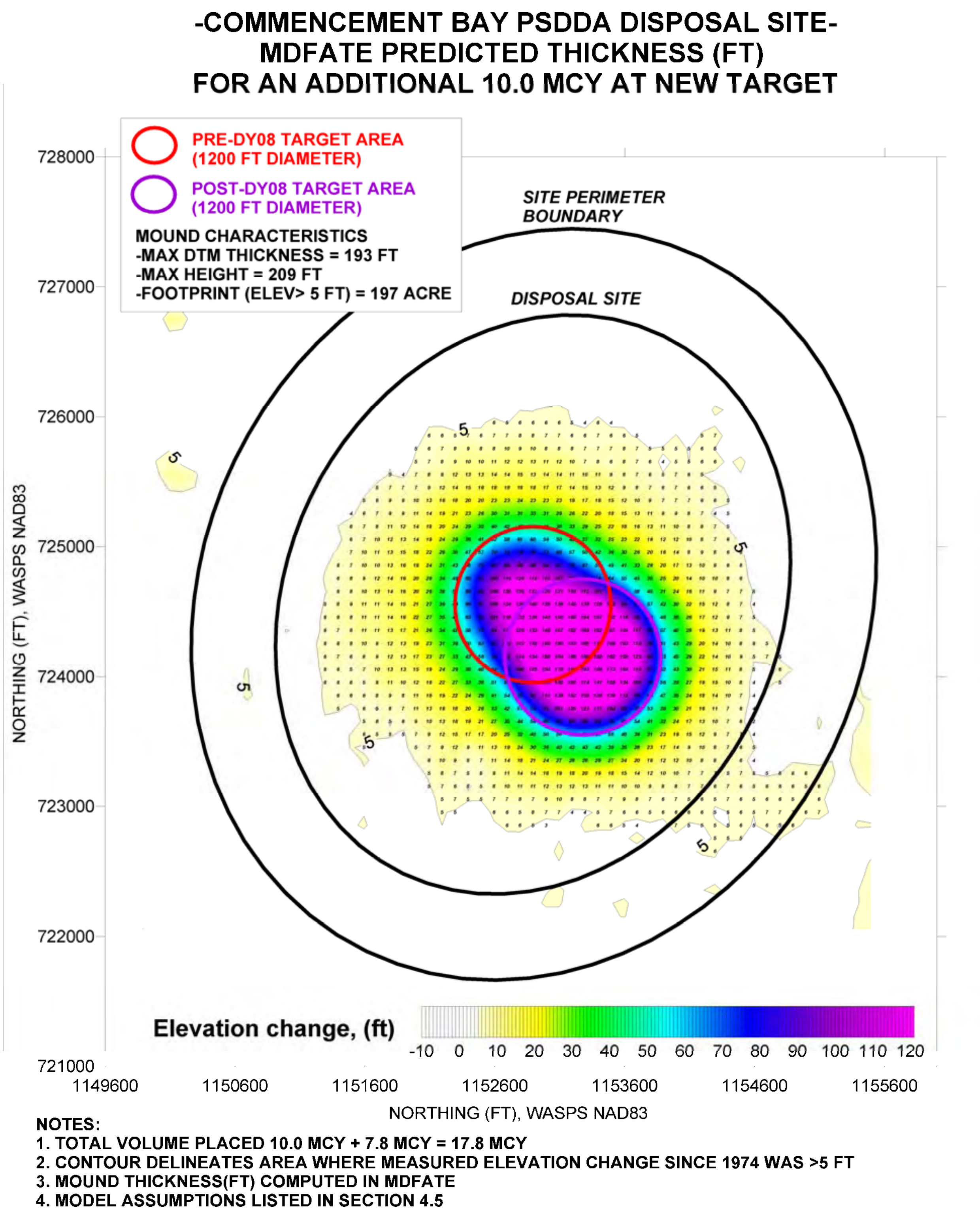

Figure 10. MDFATE predicted mound thickness with an additional 10.0 Mcy of material placed

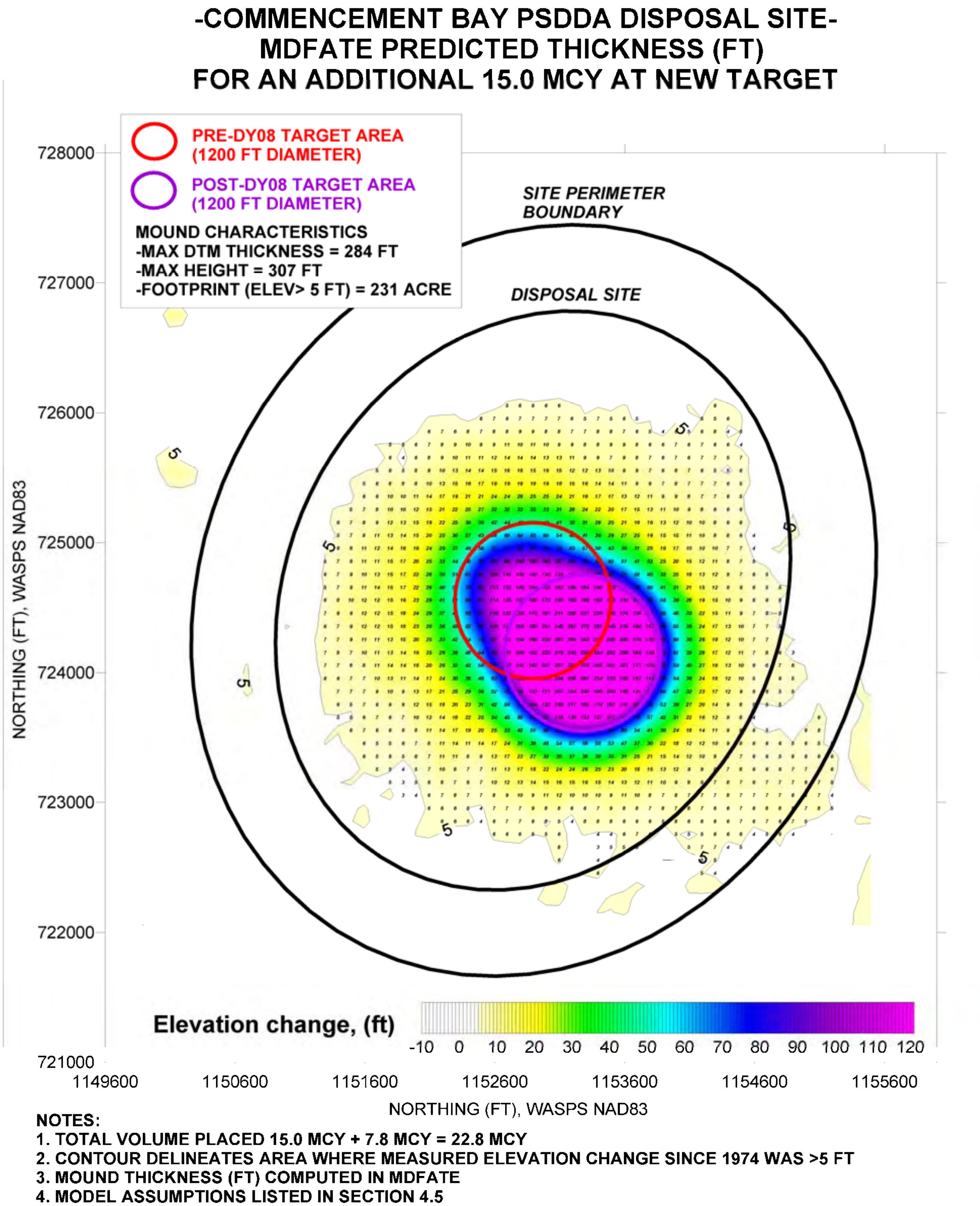

Figure 11. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed

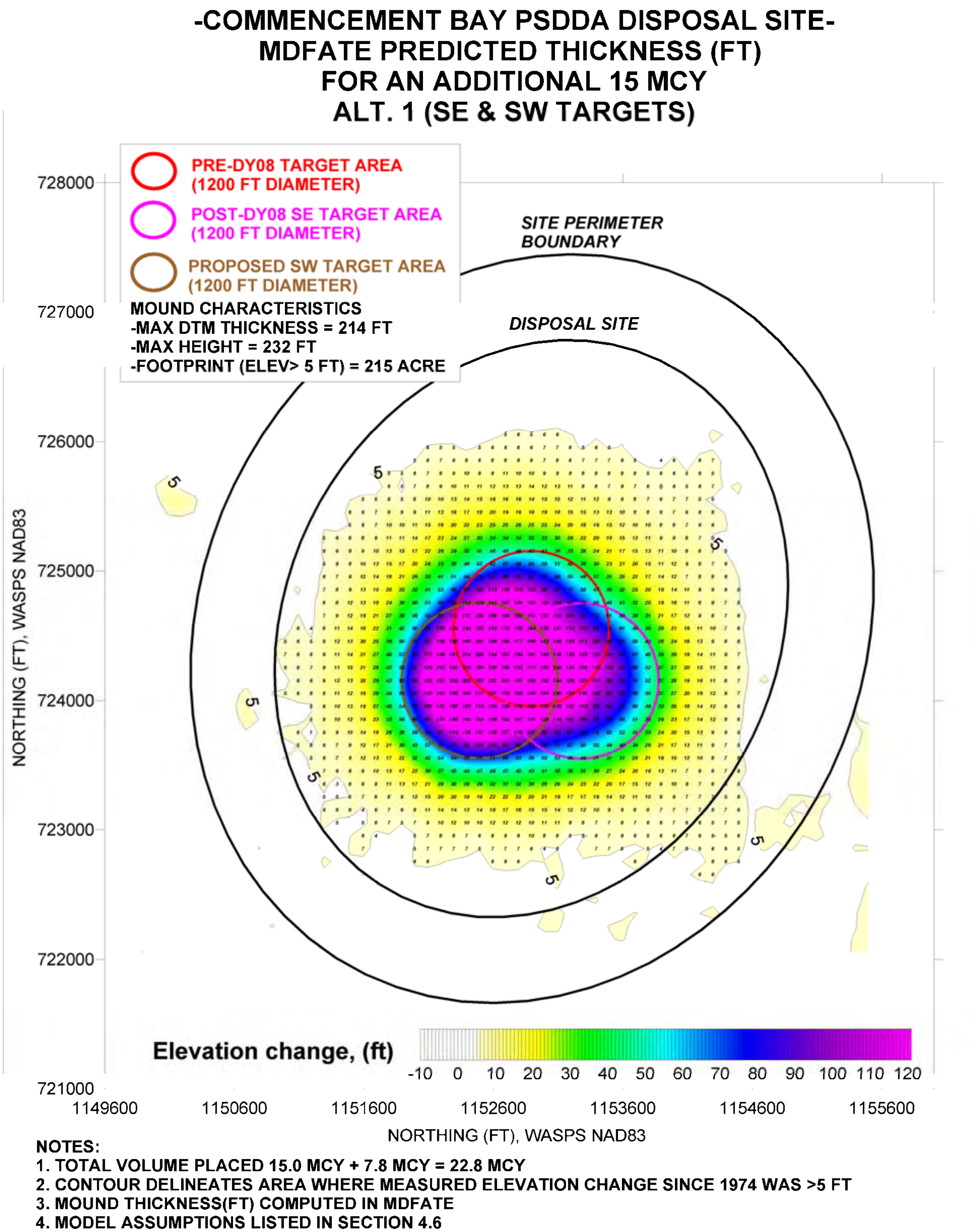

Figure 12. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed (Alt. 1)

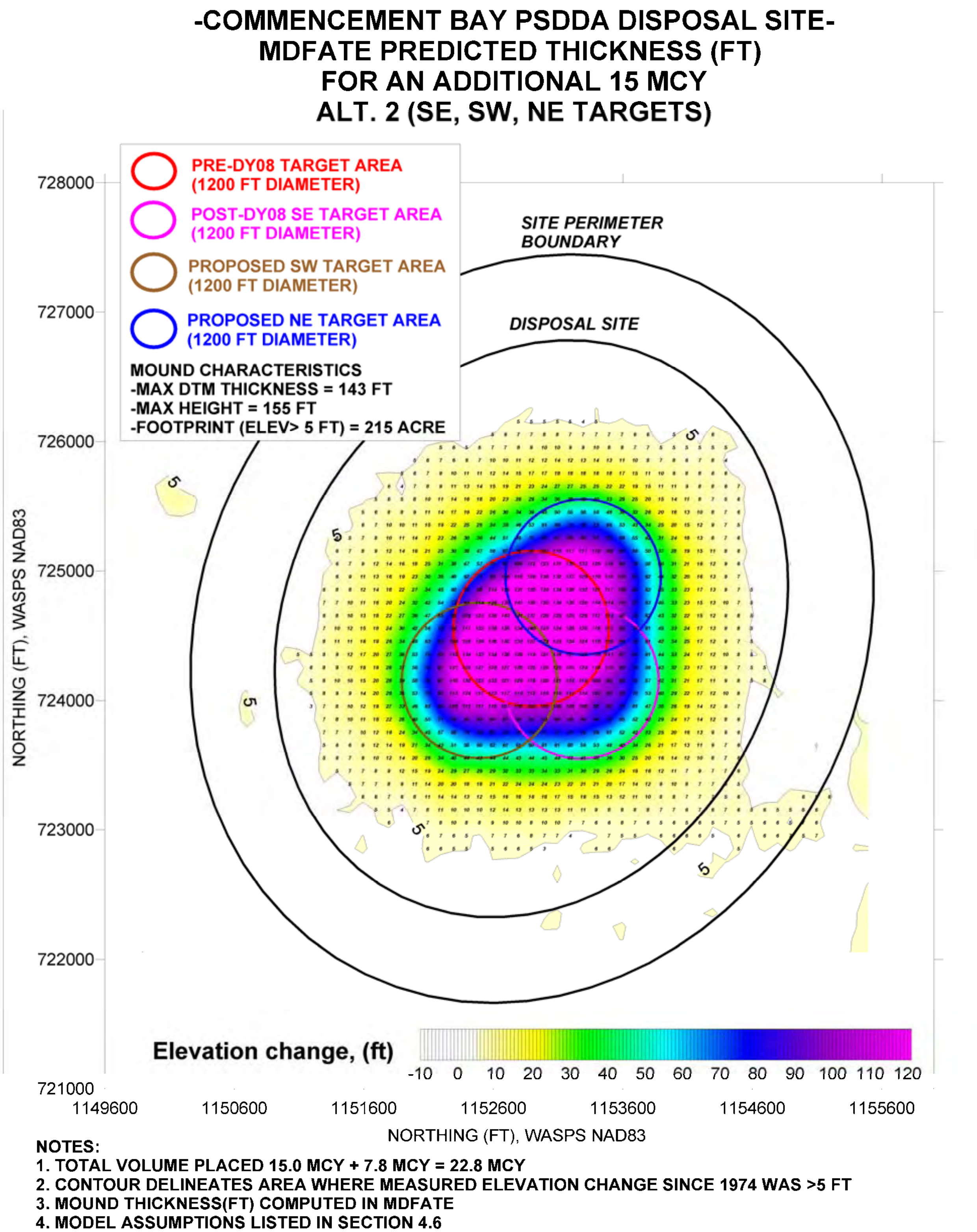

Figure 13. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed (Alt. 2)

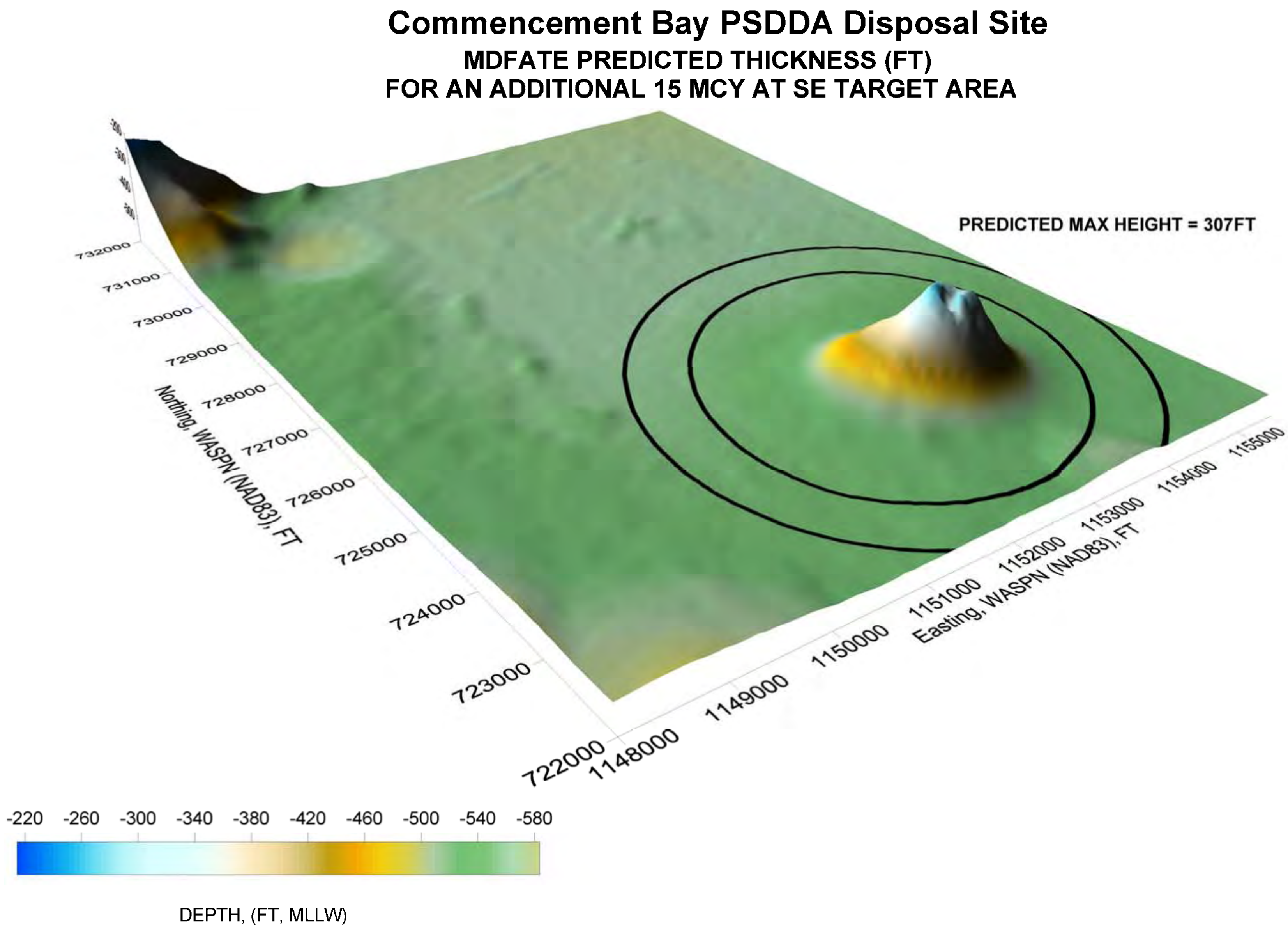

Figure 14. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed for No Action **(vertical scale is undistorted)**

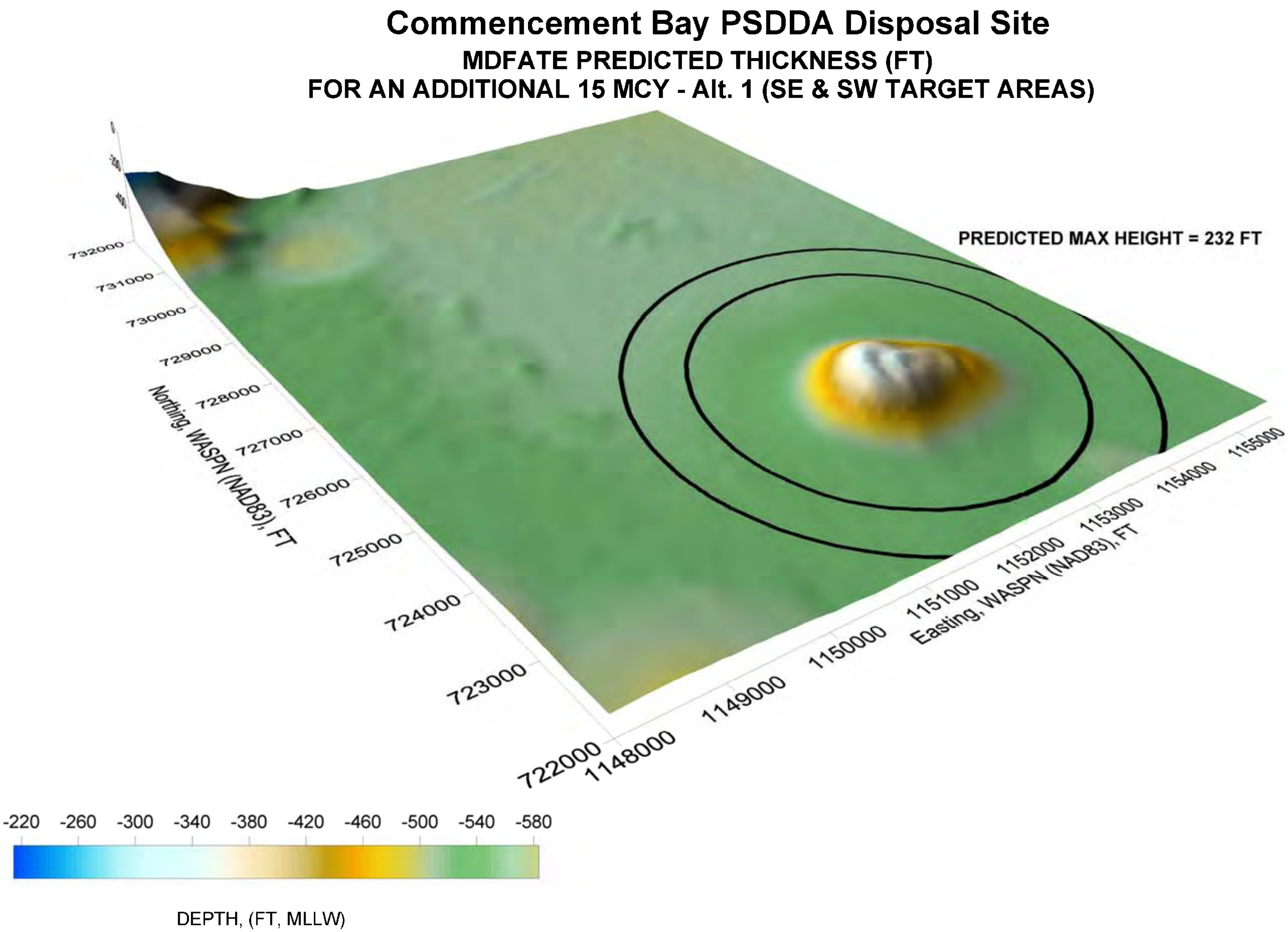

Figure 15. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed for Alternative 1 **(vertical scale is undistorted)**

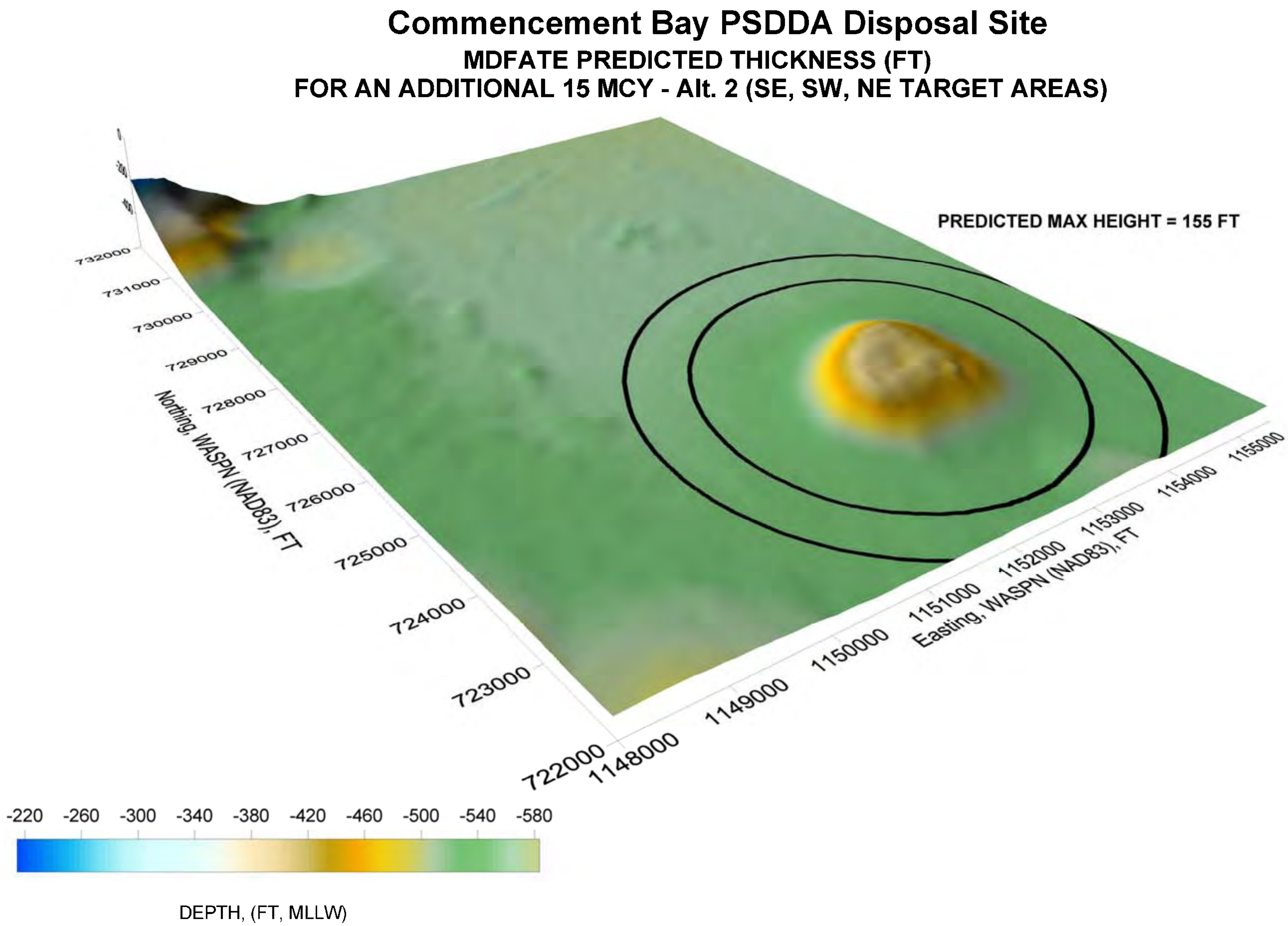

Figure 16. MDFATE predicted mound thickness with an additional 15.0 Mcy of material placed for Alternative 2 **(vertical scale is undistorted)**

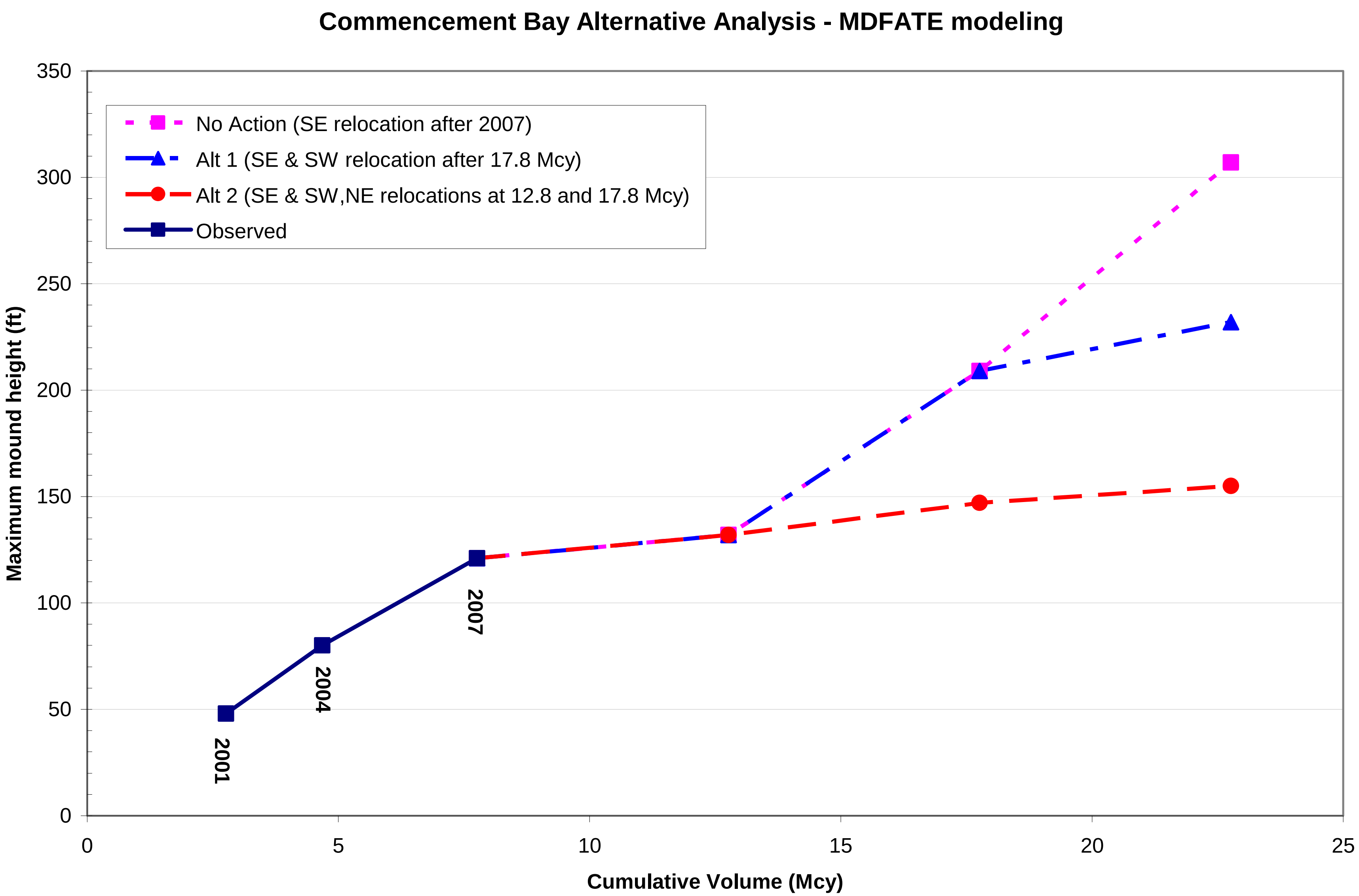

Figure 17. MDFATE predicted maximum mound height versus cumulative disposal volume for the three proposed alternatives

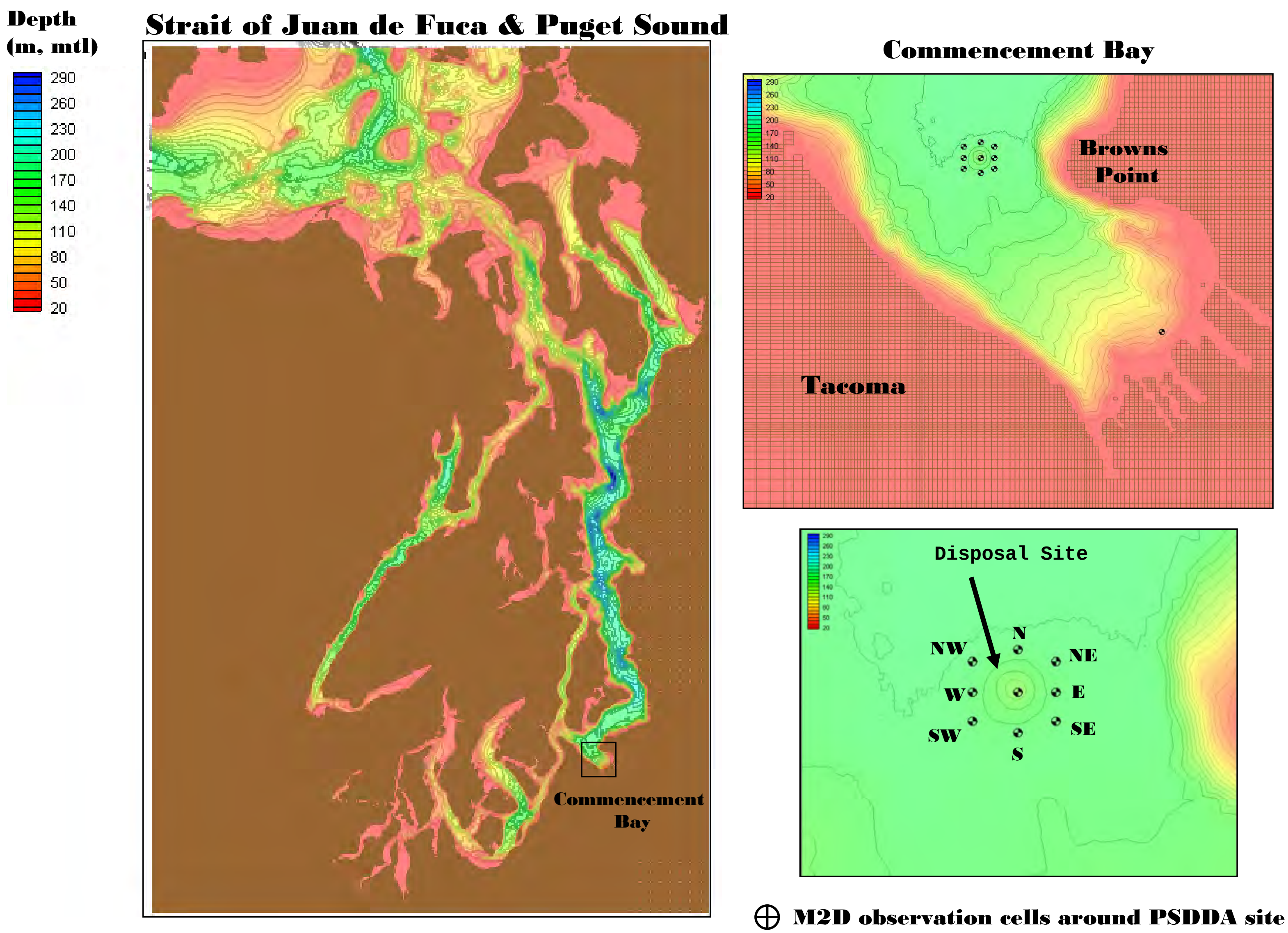

Figure 18. M2D Model domain and detail of Commencement Bay PSDDA site

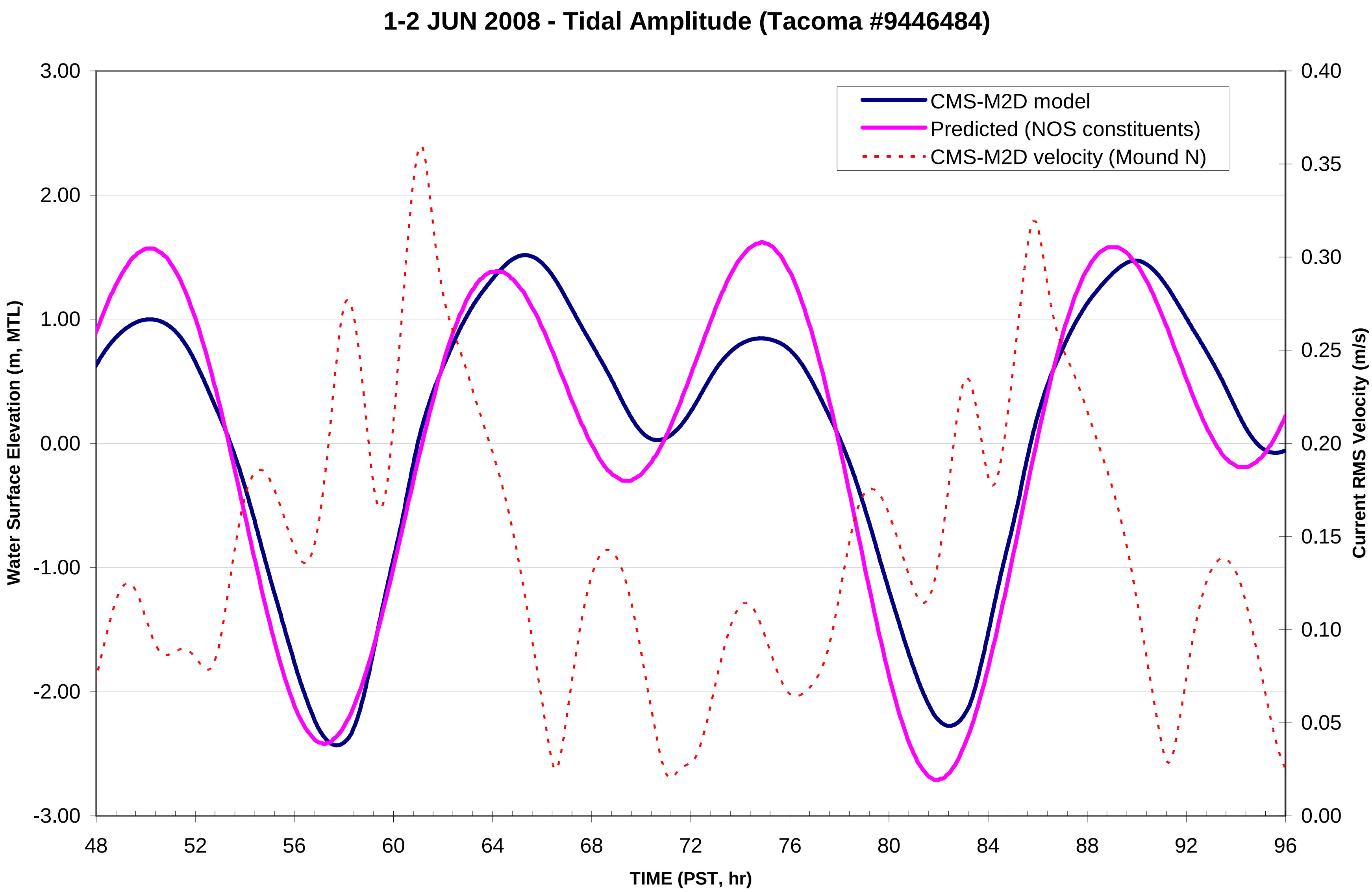

Figure 19. Predicted tidal amplitude versus CMS-M2D results at Tacoma (47° 16.0’ N 122° 24.8’ W) for present conditions (2007 bathymetry)

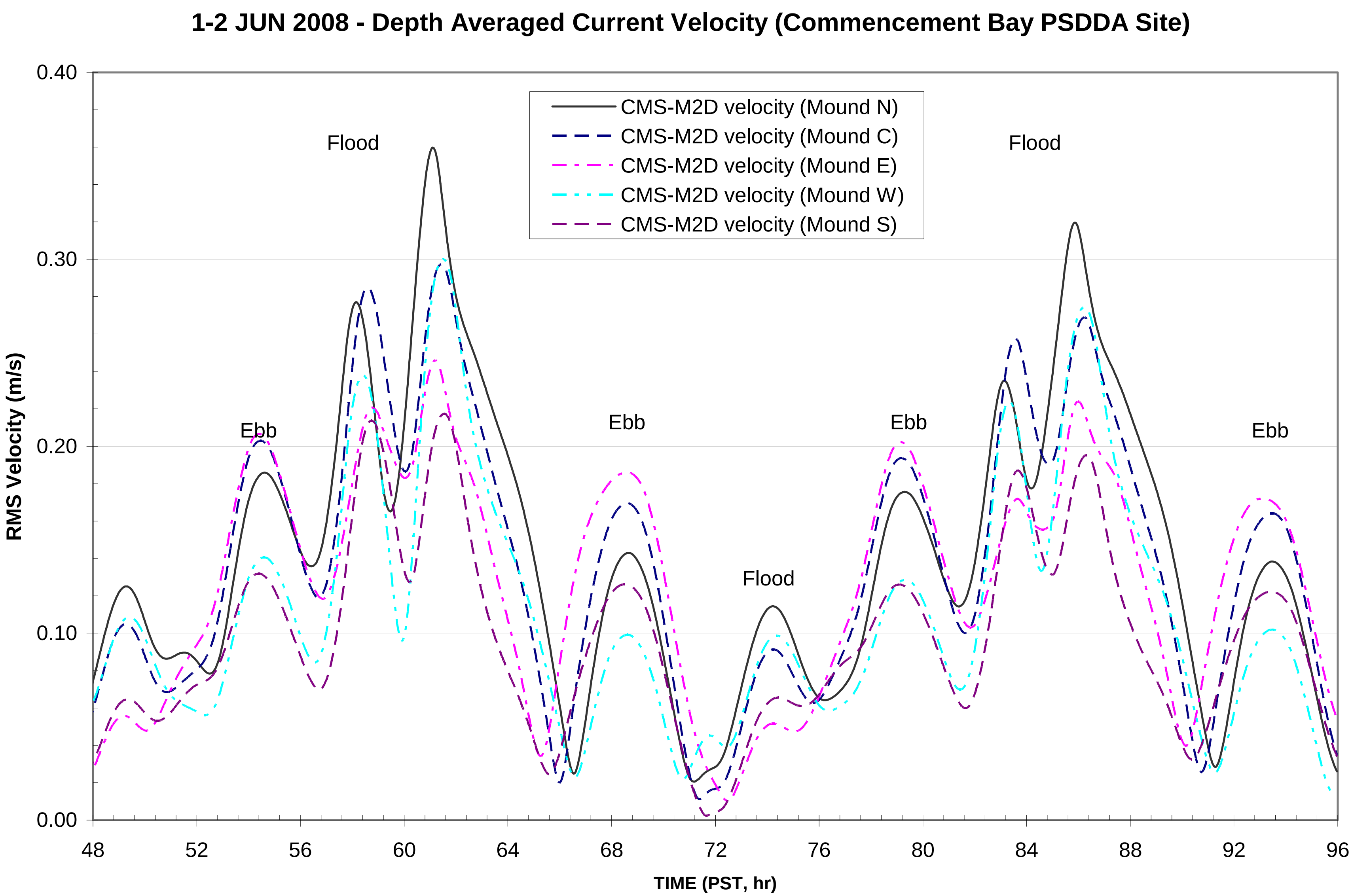

Figure 20. Depth averaged current magnitude computed in M2D at various observation cells for present conditions (2007 bathymetry)

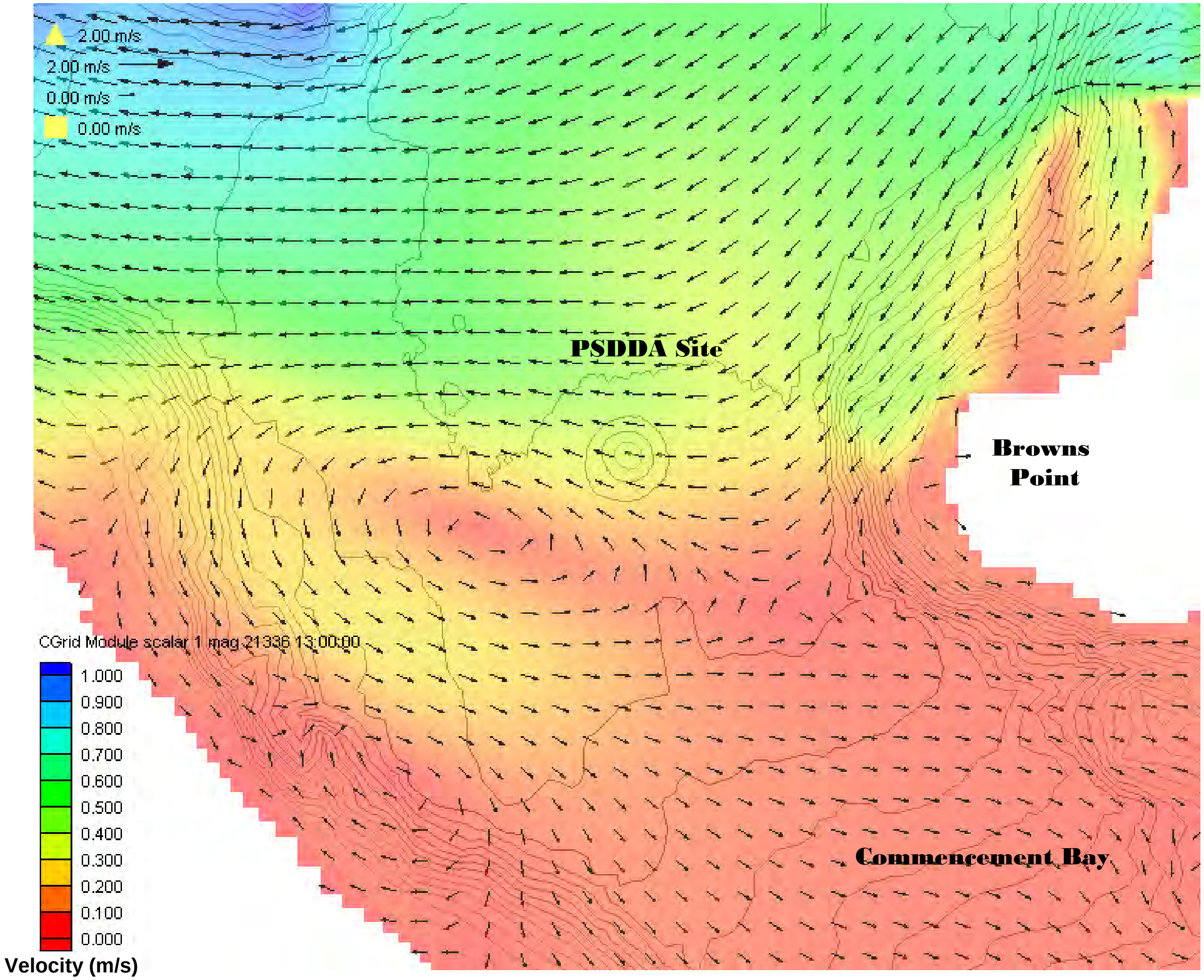

Figure 21. Simulated flood tide on 1 June 2008 1300 PST for present condition (2007 bathymetry), note gyre southwest of PSDDA site near end of flood

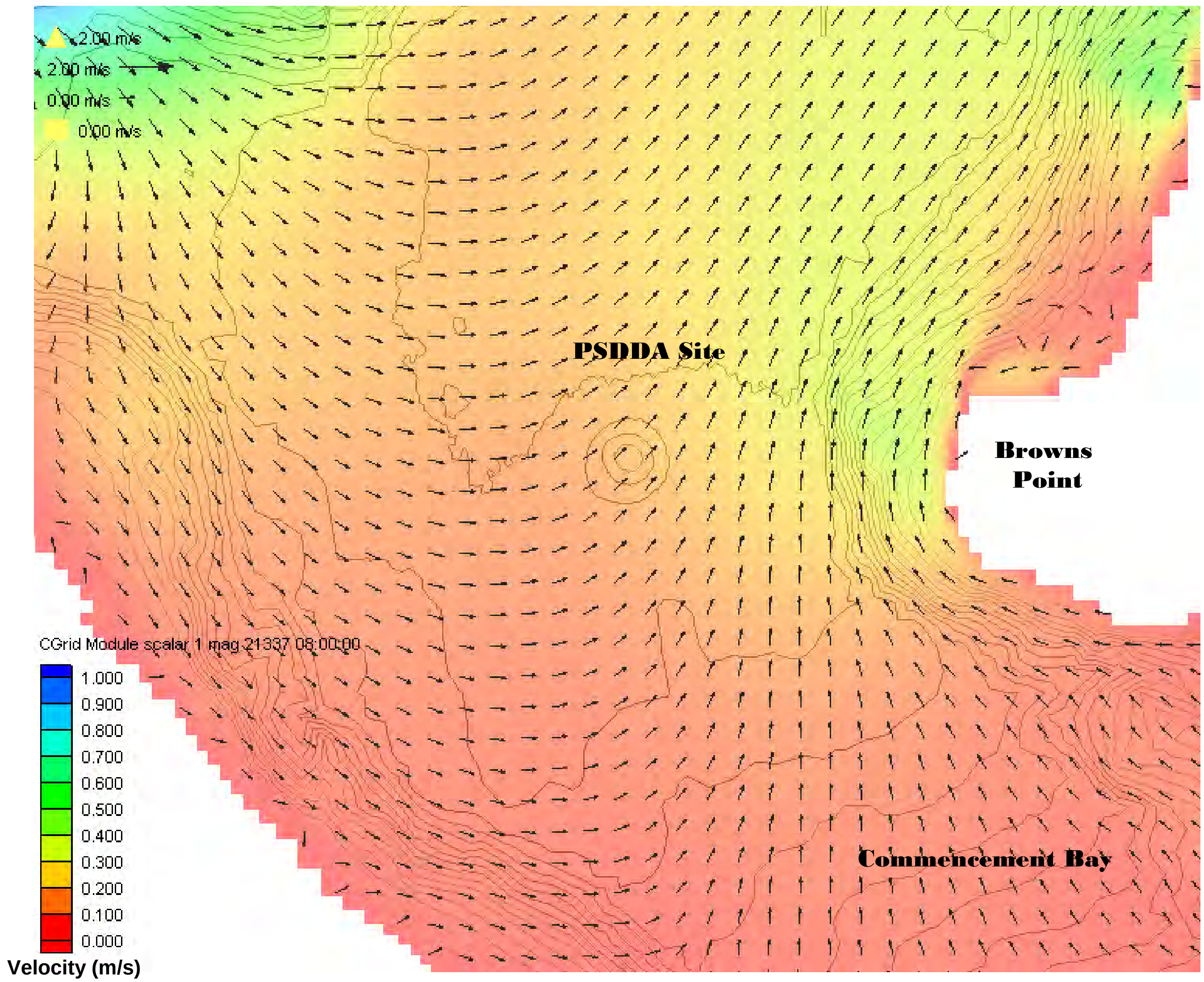

Figure 22. Simulated ebb tide on 2 June 2008 0800 PST for present condition (2007 bathymetry)

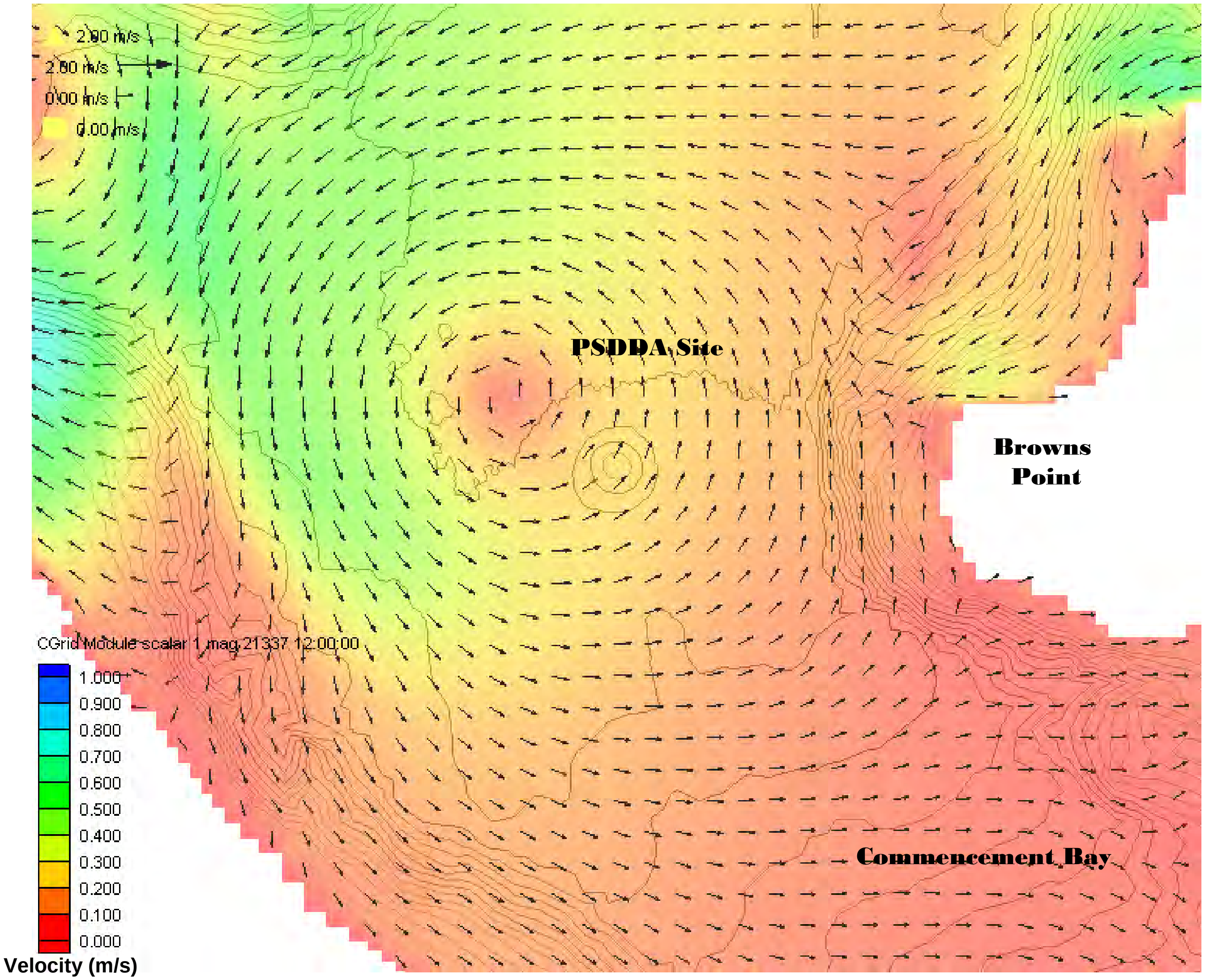

Figure 23. Simulated flood tide on 2 June 2008 1200 PST for present condition (2007), note gyre northwest of PSDDA site near start of flood

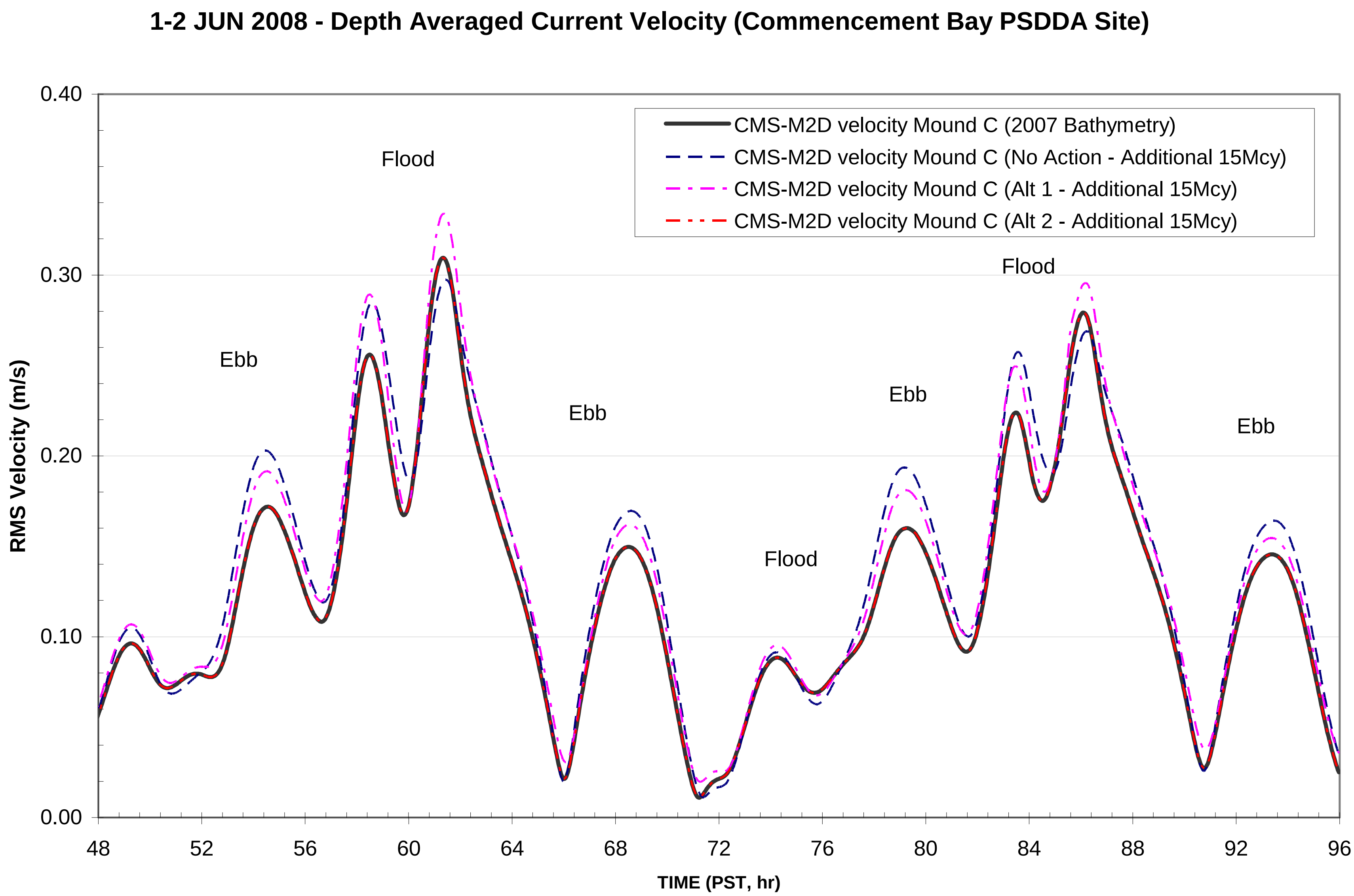

Figure 24. Depth averaged current magnitude computed in M2D at observation cell "Mound C", center of the Commencement Bay PSDDA site

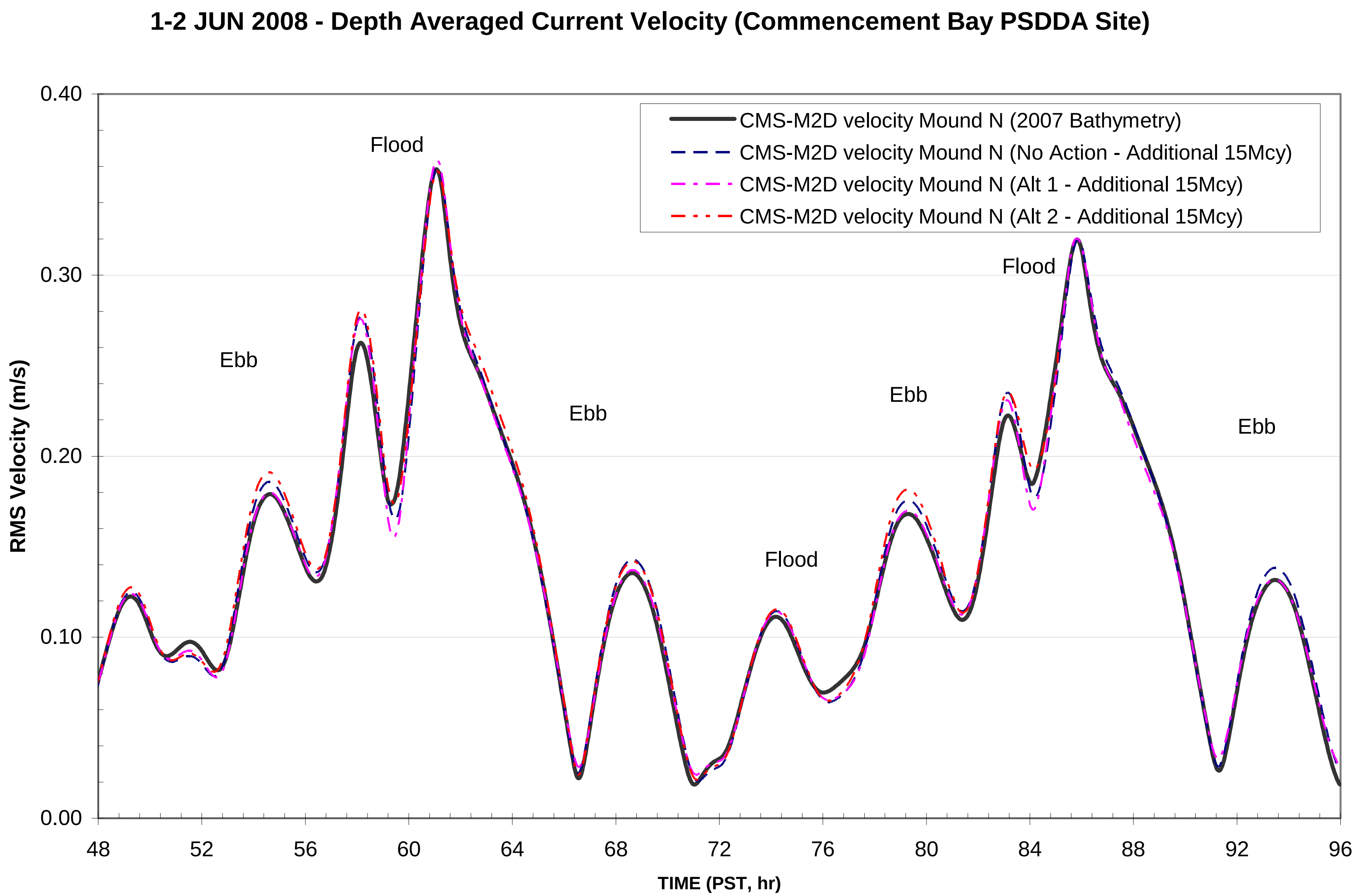

Figure 25. Depth averaged current magnitude computed in M2D at observation cell “Mound N”, just north of Commencement Bay PSDDA site

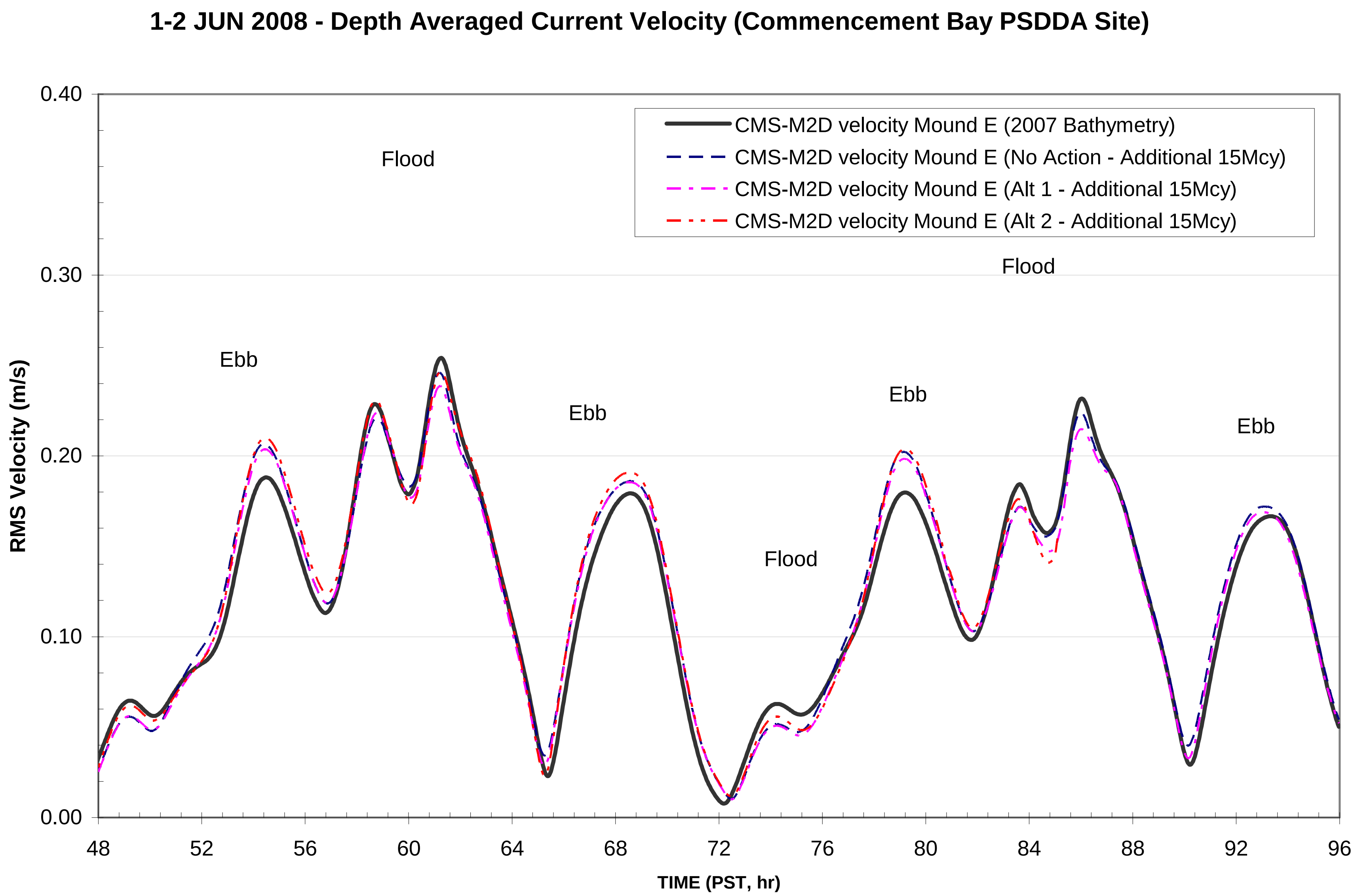

Figure 26. Depth averaged current magnitude computed in M2D at observation cell "Mound E", just east of Commencement Bay PSDDA site

Table A-1. BLAIR PCT EXPANSION DREDGED MATERIAL CHARACTERISTICS (2001-2003)

SAMPLE ID [1]	VOLUME CY	SOLIDS (% BY WEIGHT) OF SAMPLE	SOLIDS (% BY WEIGHT) OF TOTAL	GRAVEL % OF SOLIDS BY WEIGHT OF SAMPLE	GRAVEL % OF SOLIDS BY WEIGHT OF TOTAL	SAND % OF SOLIDS BY WEIGHT OF SAMPLE	SAND % OF SOLIDS BY WEIGHT OF TOTAL	SILT % OF SOLIDS BY WEIGHT OF SAMPLE	SILT % OF SOLIDS BY WEIGHT OF TOTAL	CLAY % OF SOLIDS BY WEIGHT OF SAMPLE	CLAY % OF SOLIDS BY WEIGHT OF TOTAL	
C1	125	65.10	6.51	0.80	0.08	43.40	4.34	42.30	4.23	13.40	1.34	99.9
C2	125	69.00	6.90	0.10	0.01	52.80	5.28	35.90	3.59	11.20	1.12	100.0
C3	125	65.80	6.58	0.80	0.08	30.30	3.03	54.90	5.49	13.90	1.39	99.9
C4	125	62.30	6.23	0.10	0.01	31.50	3.15	51.00	5.10	17.50	1.75	100.1
C5	125	63.90	6.39	0.20	0.02	31.00	3.10	50.80	5.08	18.10	1.81	100.1
C6	125	60.80	6.08	0.30	0.03	34.90	3.49	45.00	4.50	19.90	1.99	100.1
C7	125	67.10	6.71	0.10	0.01	45.20	4.52	40.90	4.09	13.90	1.39	100.1
C8	125	63.50	6.35	0.10	0.01	31.70	3.17	37.60	3.76	15.60	1.56	85.0
C9	125	63.30	6.33	0.20	0.02	30.10	3.01	55.20	5.52	14.70	1.47	100.2
C10	125	65.20	6.52	0.10	0.01	32.70	3.27	53.80	5.38	13.60	1.36	100.2
TOTALS	**1250**		**64.60**		**0.28**		**36.36**		**46.74**		**15.18**	**98.56**

64.6 % SOLIDS BY WEIGHT = 41.04 % SOLIDS BY VOLUME

[1] BLAIR CHARACTERIZATION (1989-2001)

ASSUME 20 % BULKING DURING DREDGING

VOLUME DISPOSED =	1250	X	1.20	=	1500	CY
VOLUME OF SOLIDS =	521	CY	=		14054	CF
% SOLIDS IN BARGE =	34.70					

COMPUTED COMPOSITION OF DREDGED MATERIAL

% GRAVEL BY VOLUME =	**0.12**	
% SAND BY VOLUME =	**15.14**	
% SILT BY VOLUME =	**19.46**	
% CLAY BY VOLUME =	**6.32**	
TOTAL	41.04	% SOLIDS BY VOLUME
	58.96	% WATER BY VOLUME

INSITU AGGREGATE VOIDS RATIO (AVR) = VOL OF VOIDS / VOL OF SOLIDS = 1.4

AVERAGE BARGE SIZE = **1500** **CY**

ESTIMATED COMPOSITION OF DISPOSED MATERIAL

% GRAVEL BY VOLUME =	**0.10**	
% SAND BY VOLUME =	**12.80**	
% SILT BY VOLUME =	**16.46**	
% CLAY BY VOLUME =	**5.34**	
TOTAL	34.70	% SOLIDS BY VOLUME
	65.30	% WATER BY VOLUME

IN-BARGE AGGREGATE VOIDS RATIO (AVR) = VOL. OF VOIDS / VOL. OF SOLIDS = 1.9

BARGE BULK DENSITY = 1.6 gm/cc

Table A-2. BLAIR PCT EXPANSION DREDGED MATERIAL CHARACTERISTICS (2001-2003)

SAMPLE ID [1]	VOLUME CY	SOLIDS (% BY WEIGHT)		GRAVEL % OF SOLIDS BY WEIGHT		SAND % OF SOLIDS BY WEIGHT		SILT % OF SOLIDS BY WEIGHT		CLAY % OF SOLIDS BY WEIGHT	
		OF SAMPLE	OF TOTAL	OF SAMPLE	OF TOTAL	OF SAMPLE	OF TOTAL	OF SAMPLE	OF TOTAL	OF SAMPLE	OF TOTAL
C1	36090	89.50	1.56	1.40	0.02	70.00	1.22	24.90	0.43	3.80	0.07
C2	32675	91.50	1.44	10.50	0.17	73.10	1.15	13.90	0.22	2.40	0.04
C3	42828	88.70	1.83	8.00	0.17	66.20	1.37	20.40	0.42	5.40	0.11
C4	49035	76.90	1.82	0.10	0.00	55.10	1.30	38.50	0.91	6.50	0.15
C5	37474	81.50	1.47	0.10	0.00	65.10	1.18	29.50	0.53	5.30	0.10
C6	624000	66.80	20.10	0.30	0.09	30.00	9.03	51.20	15.40	18.40	5.54
C7	624000	75.30	22.65	0.10	0.03	48.90	14.71	34.70	10.44	16.80	5.05
C8	624000	79.80	24.01	0.10	0.03	71.50	21.51	24.30	7.31	4.20	1.26
C9	4000	67.80	0.13	6.20	0.01	74.00	0.14	12.00	0.02	7.80	0.02
TOTALS	**2074102**		**75.01**		**0.52**		**51.61**		**35.69**		**12.33**

75.0 % SOLIDS BY WEIGHT = 53.38 % SOLIDS BY VOLUME

[1] BLAIR PCTEXPANSION

ASSUME 20 % BULKING DURING DREDGING

VOLUME DISPOSED = 2074102 X 1.20 = 2488922 CY
VOLUME OF SOLIDS = 1105489 CY = 29848201 CF
% SOLIDS IN BARGE = 44.42

COMPUTED COMPOSITION OF DREDGED

% GRAVEL BY VOLUME	**0.28**	
% SAND BY VOLUME =	**27.51**	
% SILT BY VOLUME =	**19.02**	
% CLAY BY VOLUME =	**6.57**	
TOTAL	53.38	% SOLIDS BY VOLUME
	46.62	% WATER BY VOLUME

INSITU AGGREGATE VOIDS RATIO (AVR) = VOL OF VOIDS / VOL OF SOLIDS = 0.87

AVERAGE BARGE SIZE **1500** **CY**

ESTIMATED COMPOSITION OF DISPOSED MATERIAL

% GRAVEL BY VOLUME =	**0.23**	
% SAND BY VOLUME =	**22.89**	
% SILT BY VOLUME =	**15.83**	
% CLAY BY VOLUME =	**5.47**	
TOTAL	44.42	% SOLIDS BY VOLUME
	55.58	% WATER BY VOLUME

IN-BARGE AGGREGATE VOIDS RATIO (AVR) = VOL. OF VOIDS / VOL. SOLIDS = 1.3

BARGE BULK DENSITY = 1.7 gm/cc

Table A-3. BLAIR CUTBACK & BRIDGE REACH WIDENING DREDGED MATERIAL CHARACTERISTICS (2004-2007)

SAMPLE ID [1]	VOLUME CY	SOLIDS (% BY WEIGHT) OF SAMPLE	SOLIDS (% BY WEIGHT) OF TOTAL	GRAVEL % OF SOLIDS BY WEIGHT OF SAMPLE	GRAVEL OF TOTAL	SAND % OF SOLIDS BY WEIGHT OF SAMPLE	SAND OF TOTAL	SILT % OF SOLIDS BY WEIGHT OF SAMPLE	SILT OF TOTAL	CLAY % OF SOLIDS BY WEIGHT OF SAMPLE	CLAY OF TOTAL	TOTAL
DMMU 1	16138	91.90	2.97	30.90	1.00	49.80	1.61	13.40	0.43	5.90	0.19	100.0
DMMU 2	15334	89.20	2.74	22.80	0.70	55.80	1.71	16.70	0.51	4.50	0.14	99.8
DMMU 3	15334	92.10	2.82	19.70	0.60	67.50	2.07	9.30	0.29	3.50	0.11	100.0
DMMU 4	40699	86.40	7.03	10.70	0.87	62.10	5.05	22.70	1.85	5.50	0.45	101.0
DMMU 5	38995	84.80	6.61	12.20	0.95	53.50	4.17	29.40	2.29	4.90	0.38	100.0
DMMU 6	24207	75.50	3.66	0.60	0.03	20.90	1.01	61.90	3.00	16.50	0.80	99.9
DMMU 7	11415	83.20	1.90	1.60	0.04	65.00	1.48	27.80	0.63	5.60	0.13	100.0
DMMU 8	24550	81.70	4.01	0.80	0.04	89.00	4.37	8.80	0.43	1.40	0.07	100.0
DMMU 9	24018	81.70	3.92	0.40	0.02	90.90	4.37	6.70	0.32	1.40	0.07	99.4
DMMU 10	23172	71.90	3.33	0.10	0.00	19.40	0.90	65.30	3.03	15.30	0.71	100.1
DMMU 11	23976	74.10	3.55	1.20	0.06	20.50	0.98	65.70	3.15	12.70	0.61	100.1
DMMU 12	22830	74.30	3.39	1.10	0.05	52.30	2.39	35.00	1.60	11.90	0.54	100.3
DMMU 13	24550	64.60	3.17	2.00	0.10	19.70	0.97	52.50	2.58	26.00	1.28	100.2
DMMU 14	21956	67.00	2.94	0.10	0.00	56.30	2.47	34.50	1.51	9.00	0.40	99.9
DMMU 15	24814	66.20	3.29	0.00	0.00	11.50	0.57	60.40	3.00	28.00	1.39	99.9
DMMU 16	23976	69.00	3.31	0.00	0.00	5.90	0.28	70.90	3.40	23.20	1.11	100.0
DMMU 17	22830	72.40	3.31	1.10	0.05	33.20	1.52	51.80	2.37	14.00	0.64	100.1
DMMU 1	11900	91.80	2.18	20.90	0.50	42.70	1.02	28.60	0.68	7.80	0.19	100.0
DMMU 2	13600	80.60	2.19	2.10	0.06	69.60	1.89	25.10	0.68	3.30	0.09	100.1
C1	5500	92.00	1.01	21.50	0.24	70.60	0.78	5.80	0.06	2.00	0.02	99.9
C2	4400	90.40	0.80	50.20	0.44	45.60	0.40	2.70	0.02	1.50	0.01	100.0
C3	5800	90.20	1.05	5.10	0.06	85.90	1.00	7.60	0.09	1.50	0.02	100.1
C4	4700	91.70	0.86	33.30	0.31	59.50	0.56	5.30	0.05	2.00	0.02	100.1
C5	10700	87.10	1.86	5.70	0.12	85.20	1.82	7.20	0.15	1.80	0.04	99.9
C6	10800	78.60	1.70	0.70	0.02	90.00	1.94	7.30	0.16	2.00	0.04	100.0
C7	11100	81.70	1.81	3.20	0.07	85.80	1.90	7.90	0.18	3.10	0.07	100.0
C8	11200	80.90	1.81	2.20	0.05	92.60	2.07	4.20	0.09	0.80	0.02	99.8
C9	11500	81.10	1.87	0.80	0.02	87.80	2.02	9.50	0.22	1.90	0.04	100.0
TOTALS	**499994**		**79.10**		**6.39**		**51.34**		**32.78**		**9.56**	**100.07**

79.1 % SOLIDS BY WEIGHT = 59.08 % SOLIDS BY VOLUME

[1] Blair Cutback 2004
Blair Turning Basin SW Cutback 2004
Blair Bride Widening Reach 2004

MATERIAL CHARACTERISTICS IN BARGE
20 % BULKING DURING

VOLUME DISPOSED = 499994 X 1.20 = 599993 CY
VOLUME OF SOLIDS = 295213 CY = 7970739 CF
% SOLIDS IN BARGE = 49.20

COMPUTED COMPOSITION OF DREDGED MATERIAL

% GRAVEL BY VOLUME **3.77**
% SAND BY VOLUME = **30.31**
% SILT BY VOLUME = **19.35**
% CLAY BY VOLUME = **5.65**
TOTAL 59.08 % SOLIDS BY VOLUME
40.92 % WATER BY VOLUME
INSITU AGGREGATE VOIDS RATIO (AVR) = VOL OF VOIDS / VOL OF SOLIDS = 0.7
AVERAGE BARGE SIZE = **1700 CY**

ESTIMATED COMPOSITION OF DISPOSED MATERIAL

% GRAVEL BY VOLUME = **3.14**
% SAND BY VOLUME = **25.24**
% SILT BY VOLUME = **16.12**
% CLAY BY VOLUME = **4.70**
TOTAL 49.20 % SOLIDS BY VOLUME
50.80 % WATER BY VOLUME
IN-BARGE AGGREGATE VOIDS RATIO (AVR) = VOL. OF VOIDS / VOL. 1.0
BARGE BULK DENSITY = 1.8 gm/cc

Table A-4. EAST BLAIR STUDY PHASE DREDGED MATERIAL CHARACTERISTICS (2007+)

SAMPLE ID [1]	VOLUME CY	SOLIDS (% BY WEIGHT) OF SAMPLE	SOLIDS OF TOTAL	GRAVEL % OF SOLIDS BY WEIGHT OF SAMPLE	GRAVEL OF TOTAL	SAND % OF SOLIDS BY WEIGHT OF SAMPLE	SAND OF TOTAL	SILT % OF SOLIDS BY WEIGHT OF SAMPLE	SILT OF TOTAL	CLAY % OF SOLIDS BY WEIGHT OF SAMPLE	CLAY OF TOTAL
DMMU 1	15216	92.30	4.43	25.20	1.21	65.40	3.14	7.50	0.36	1.60	0.08
DMMU 2	10116	93.80	2.99	11.00	0.35	78.10	2.49	9.20	0.29	1.60	0.05
DMMU 3	13496	92.20	3.93	20.20	0.86	64.20	2.73	13.10	0.56	2.50	0.11
DMMU 4	52260	83.00	13.68	17.10	2.82	64.80	10.68	15.80	2.60	2.30	0.38
DMMU 5	43198	84.70	11.54	4.50	0.61	77.10	10.51	15.50	2.11	2.60	0.35
DMMU 6	42279	79.60	10.62	0.10	0.01	59.70	7.96	33.70	4.49	6.50	0.87
DMMU 7	25056	74.90	5.92	0.20	0.02	63.20	5.00	31.10	2.46	5.50	0.43
DMMU 9	40440	78.30	9.99	0.60	0.08	55.40	7.07	33.10	4.22	11.20	1.43
DMMU 10	37584	78.30	9.28	1.60	0.19	83.60	9.91	11.10	1.32	3.70	0.44
DMMU 11	37372	77.80	9.17	0.60	0.07	79.10	9.32	16.60	1.96	3.80	0.45
TOTALS	**317017**		**81.55**		**6.22**		**68.81**		**20.38**		**4.58**

81.6 % SOLIDS BY WEIGHT = 62.77 % SOLIDS BY VOLUME

[1] 2007 EAST BLAIR STUDY PHASE

MATERIAL CHARACTERISTICS IN BARGE
ASSUME 20 % BULKING DURING DREDGING

VOLUME DISPOSED =	317017	X	1.20	=	380420	CY
VOLUME OF SOLIDS =	199020	CY	=		5373538	CF
% SOLIDS IN BARGE =	52.32					

COMPUTED COMPOSITION OF DREDGED MATERIAL

% GRAVEL BY VOLUME =	**3.90**	
% SAND BY VOLUME =	**43.20**	
% SILT BY VOLUME =	**12.79**	
% CLAY BY VOLUME =	**2.88**	
TOTAL	62.77	% SOLIDS BY VOLUME
	37.23	% WATER BY VOLUME

INSITU AGGREGATE VOIDS RATIO (AVR)
= VOL VOIDS / VOL SOLIDS = 0.6

AVERAGE BARGE SIZE = **1700** **CY**

ESTIMATED COMPOSITION OF DISPOSED MATERIAL

% GRAVEL BY VOL =	**3.25**	
% SAND BY VOL =	**36.00**	
% SILT BY VOL =	**10.66**	
% CLAY BY VOL =	**2.40**	
TOTAL	52.32	% SOLIDS BY VOLUME
	47.68	% WATER BY VOLUME

IN-BARGE AGGREGATE VOIDS RATIO (AVR) =
VOL. VOIDS / VOL. SOLIDS = 0.9
BARGE BULK DENSITY = 1.9 gm/cc

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APPENDIX E: PUBLIC REVIEW COMMENTS AND DMMP RESPONSES

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Appendix E. Public Review Comments and DMMP Responses

Port of Tacoma (edited copy of Draft SEIS sent on CD dated May 28, 2009).

1. **Comment (Abstract, and page 2 of Purpose and Need paragraph).** The date for reaching the site capacity ceiling of 9 mcy should be changed to acknowledge the recent drop in disposal at the site and the fact that the 9 mcy ceiling will not be reached in 2009. **Response.** The SEIS has been amended to read: "Currently, the Commencement Bay site volume is expected to reach 9 mcy in dredging year 2010 (ending on June 15, 2010)" in the Abstract and at bottom of page 2 of SEIS.

2. **Comment (Table 1, page 2). Provide inclusive dates in Table Header for clarity.** **Response**. The inclusive dates for the 15 year disposal forecasts in 1988 EIS (1989-2003) were added to Table 1 title for clarity.

3. **Comment. (Figure 3, page 7).** Fix the Figure to acknowledge that the site is ellipsoid in shape and the long axis is not uniform in width and length.
   Response. Figure 3 was edited to note that the ellipsoid site is 3800 ft by 4600 ft in dimension in the schematic.

4. **Comment (Top of page 8).** Date should be changed to acknowledge that the site volume from disposal is close to 8 mcy at the end of the 2009 dredging year, which ended on June 15, 2009.
   Response. The change in the text on page 8 was made to acknowledge the date change.

5. **Comment (Table 3, page 9).** Fix last 2 entries in Table under Monitoring header, as disposal at SE coordinates, while important to note is actually not monitoring.
   Response. The last 2 entries for 2008 and 2009 in Table 3 monitoring header were moved to a footnote.

6. **Comment (Page 97, Historical and Cultural Resources).** Please clarify that it is the permit applicant and not the DMMP that would be consulting with the Washington DAHP SHPO regarding the presence of cultural resources.
   Response. This sentence was changed on page 97 to correct the error and clarify that point.

Environmental Protection Agency Comment Letter dated June 8, 2009 (attached).

7. **Comment.** EPA recommends that the EIS analyze air quality impacts from dredging operations and how the project achieves general conformity.
   Response. The requested conformity analysis was added to Final SEIS using both the expected average volume of 700 kcy/year (Port of Tacoma, 2008) and the worst case high average of 869 kcy/year (e.g., observed from 2003-2008). This analysis demonstrates that both action Alternatives 1 and 2 are below the NEPA significance threshold (100 tons/year of Air Pollutant Emissions) for both average and worst case disposal forecasts (e.g., 700 and 869 kcy/year). However, the no-action Alternative 3

exceeds the NEPA significance threshold (100 tons/year of Air Pollutant Emissions) for both the 700 and 869 kcy/year disposal analyses. Additional language was added to the SEIS in Chapters 3 (pages 75-78) and 4 (Alternative 1: pages 95-97; Alternative 2: page 104, and Alternative 3 (No-Action): pages 111-113) to discuss the dredging operations impacts on air quality emissions, and the calculations for these analyses are provided in Appendix B of the SEIS.

8. **Comment** EPA recommends that the EIS include a discussion of potential climate change impacts on the proposed project.
Response. The requested analysis was added to SEIS as Chapter 9 (Pages 129-131).

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ECOSYSTEMS, TRIBAL AND
PUBLIC AFFAIRS

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Dr. Stephen Martin
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P.O. Box 3755
Seattle, Washington 98124-3755

Subject: Reauthorization Dredged Material Management Program Disposal Site Commencement Bay, Washington EPA Project Number 08-019-COE

Dear Dr. Martin:

The U.S. Environmental Protection Agency (EPA) reviewed the supplemental draft Environmental Impact Statement (SEIS) for the *Reauthorization Dredged Material Management Program Disposal Site Commencement Bay, Washington.* EPA is a Cooperating Agency because of our responsibility for site designation under the Marine Protection, Research and Sanctuaries Act. Our review of the SEIS is in accordance with our responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act.

The SEIS evaluates potential impacts associated with the continuation of disposal operations, and increasing the disposal site capacity to 23 million cubic yards (mcy) in Commencement Bay. This document supplements the 1988 EIS, which identified unconfined open water disposal sites in Puget Sound, including the Commencement Bay site. The alternatives analyzed in the SEIS are - Alternative 1, two coordinate shifts within the Target Area; Alternative 2, three coordinate shifts within the Target Area; and Alternative 3, No Action. Our comments focus on the Preferred Alternative (Alt 2).

We support the Preferred Alternative and we commend the Corps of Engineers' coordination with relevant agencies and stakeholders. We understand that this is one of the most monitored sites in the country and therefore, the data and analysis related to the in water disposal site is well documented. The main concern we have is related to the lack of information on air quality associated with dredging and potential impacts of climate change on the project. Due to concerns about potential impacts and lack of information on air quality and climate change we have given a rating of EC-2 (Environmental Concerns - Insufficient Information) to this project.

Air Quality

The SEIS analyzes the impacts to air quality from tug boat equipment. However, the EIS did not include an air quality analysis from dredging activities in the bay associated with the project. Because of this information gap, we have concerns about potential impacts to air quality.

The EIS discusses the baseline regional air quality and notes that a nonattainment rule for PM2.5 in Tacoma was signed by EPA in December 2008. The EIS should also note that Tacoma is a maintenance area for PM10. The impacts from tug operations are demonstrated to be well below the significance threshold of 100 tons per year for air emissions; however, it is unclear what the contribution would be from dredging equipment and operation and maintenance activities. The Port of Tacoma is one of the key agencies utilizing this disposal site for maintenance dredging and expansion. We believe that the Port of Tacoma likely has a general management plan for dredging and that it would be beneficial to include a comprehensive analysis of future foreseeable actions. This analysis should include disclosing all air pollutant emissions and air quality impacts associated with the continuation of disposal at the site. The EIS should also demonstrate how general conformity would be achieved for PM10 and PM2.5 as required under 40 CFR § 93.153.

Recommendation:

EPA recommends that the EIS analyze air quality impacts from dredging operations and how the project achieves general conformity.

Climate change

Currently, there are concerns that continued increases in greenhouse gas emissions resulting from human activities contribute to climate change. Effects of climate change may include changes in hydrology, sea level, weather patterns, precipitation rates, and chemical reaction rates. EPA believes that the cumulative effects analysis in the NEPA document should include changes to resources that can reasonably be anticipated due to climate change that may have bearing on aspects of the project (e.g. changes in hydrology that may increase sediment). Therefore, we recommend that the EIS consider how resources affected by climate change could potentially influence the proposed project.

Recommendation:

EPA recommends that the EIS include a discussion of potential climate change impacts on the proposed project.

Thank you for the opportunity to comment on this supplemental draft EIS. If you would like to discuss our comments, please contact Lynne McWhorter at (206) 553-0205 or by electronic mail at mcwhorter.lynne@epa.gov.

Sincerely,

Christine B. Reichgott

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