Agency Review Draft
Feasibility Study
Tru-Grit Facility
Tacoma, Washington

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Prepared for

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LIST OF ABBREVIATIONS AND ACRONYMS

AO .... Agreed Order No. DE-8978
ARAR .... applicable or relevant and appropriate requirement
CanAm .... CanAm Minerals, Inc.
CAP .... cleanup action plan
CFR .... Code of Federal Regulations
cm .... centimeters
cm/yr .... centimeters per year
CSL .... cleanup screening level
CSM .... conceptual site model
COPC .... constituent of potential concern
CSM .... conceptual site model
CY .... cubic yards
DCA .... disproportionate cost analysis
Ecology .... Washington State Department of Ecology
EMNR .... enhanced monitored natural recovery
EPA .... US Environmental Protection Agency
FS .... feasibility study
ft .... feet, foot
IHS .... indicator hazardous substance
LAI .... Landau Associates, Inc.
MLLW .... mean lower low water
MNR .... monitored natural recovery
MTCA .... Washington State Model Toxics Control Act
PCL .... proposed cleanup level
PLP .... potentially liable party
PMI .... Port Maritime and Industrial
Port .... Port of Tacoma
PSL .... preliminary screening level
RAO .... remedial action objective
RCRA .... Resource Conservation and Recovery Act
RCW .... Revised Code of Washington
RI .... Remedial Investigation
SCO .... sediment cleanup objective
SCUM II .... Sediment Cleanup User's Manual II
SEPA .... State Environmental Policy Act
SMS .... Sediment Management Standards
Tru-Grit .... Tru-Grit Abrasives, Inc.
USACE .... US Army Corps of Engineers
WAC .... Washington Administrative Code

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1.0 INTRODUCTION

This feasibility study (FS) report has been prepared under the terms of Agreed Order No. DE-8978 (AO) for application to the Tru-Grit Abrasives, Inc. site (Tru-Grit; Site), located in Tacoma, Washington. The Washington State Department of Ecology (Ecology) identified CanAm Minerals, Inc. (CanAm; parent company of Tru-Grit) as a potentially liable party (PLP) under the Washington State Model Toxics Control Act (MTCA) and its implementing regulations (Chapter 173-340 of the Washington Administrative Code [WAC]) for releases of hazardous substances at the Site.

This FS report was prepared for submittal to Ecology in accordance with the provisions of the AO, and developed to meet the general requirements of an FS as defined by the MTCA Cleanup Regulation (WAC 173-340-350). This FS report summarizes the project background and conclusions of the remedial investigation (RI; Landau Associates, Inc. [LAI] 2019), Site cleanup requirements, screening of remedial technologies, comparison of cleanup alternatives, and the preferred cleanup alternative for the Site.

1.1 Site Description and Project Background

The Site, as described in AO No. DE-8978, is defined by the potential extent of contamination caused by the release of hazardous substances. The Site is not limited to lease area or property area boundaries and includes areas where hazardous substances have been deposited, or otherwise have come to be located. The Site, where sediment impacts were determined present during the RI, is located within the Blair Waterway on property owned by the Port of Tacoma (Port), and aquatic land controlled by the City of Tacoma and/or Port of Tacoma. Upland portions of the Tru-Grit facility[1] are excluded from the Site because the RI (LAI 2019) determined that concentrations of contaminants met MTCA cleanup standards.

The Tru-Grit facility occupies a portion of tax parcel 2275200292 located at 1110 East Alexander Avenue (Figure 1). The parcel is rectangular with the long axis oriented northwest to southeast, parallel to the Blair Waterway (the southwest side of the parcel extends approximately 130 feet [ft] into the waterway). The Tru-Grit facility occupies the northwestern one-third of the parcel; Orion Marine, a civil marine contractor, occupies the remaining two-thirds of the parcel (Figure 2). The parcel is zoned Port Maritime and Industrial (PMI) and Shoreline Port Industrial. For the purposes of this document, **Property** refers to the tax parcel occupied by both the Tru-Grit and the Orion Marine operational areas, **Facility** refers solely to the Tru-Grit operational area, and **Site** refers to the entire cleanup site that encompasses areas outside the Facility. A Site plan is presented on Figure 3.

[1] Note that MTCA defines the term “Facility” to mean the same as “Site;” however, in this document the term “Site” is used in accordance with the definition under MTCA and the term “Facility” is used to mean the Tru-Grit operational area.

1.2 Objective of the Feasibility Study

The purpose of the FS is to develop and evaluate a range of alternative cleanup actions that could meet the state's cleanup standards, then identify the preferred alternative based on which is considered permanent to the greatest extent practicable. MTCA has established requirements for selecting a cleanup action and the expectations for cleanup action alternatives in WAC 173-340-360 and 173-340-370 and Chapter 173-204 WAC. Based on results of the RI, this FS addresses cleanup in the marine portion of the Site only.

The AO indicates the RI/FS process for the Tru-Grit Site is only required to identify the nature and extent of contamination resulting from operations related to the Tru-Grit facility and to evaluate cleanup alternatives accordingly. This FS satisfies this requirement, but also acknowledges that the MTCA FS process does not differentiate between sources of contamination, and contamination unrelated to Tru-Grit operations is present at the Site. Though contamination from sources unrelated to Tru-Grit operations is present at the Site, the cleanup alternatives developed herein focus on addressing contamination related to Tru-Grit operations per the AO requirements. However, these cleanup alternatives also address the contamination present that is unrelated to Tru-Grit operations. Additionally, the preferred alternative selected in this FS was evaluated to be the most permanent cleanup to the maximum extent practicable for all contamination.

1.3 Report Organization

This FS report is organized as indicated below.

- Section 1.0—General background information, the history of environmental investigations completed at the Site, the regulatory framework, and the purpose of the FS
- Section 2.0—Conclusions of the RI and the affected media
- Section 3.0—Cleanup standards
- Section 4.0—Site cleanup requirements
- Section 5.0—Screening evaluation of remediation technologies and institutional controls
- Section 6.0—Cleanup action alternatives
- Section 7.0—Evaluation of the cleanup action alternatives
- Section 8.0—Disproportionate cost analysis for the cleanup alternatives
- Section 9.0—Preferred alternative
- Section 10.0—Use of this report
- Section 11.0—References used in preparing this report.

2.0 REMEDIAL INVESTIGATION CONCLUSIONS

An RI was conducted to evaluate potential environmental impacts from previous Tru-Grit operations (LAI 2019). The RI was conducted in accordance with MTCA and Sediment Management Standards (SMS) requirements, and determined the nature and extent of contamination sufficiently to develop a conceptual site model (CSM) of contaminant distribution and potential transport mechanisms, and to develop a range of remedial alternatives that could be used to clean up the Site. The RI included investigation of upland soil, surface and subsurface sediment in beach and subtidal areas, seeps, and marine surface water (Figure 3). Based on the results of the RI, both surface and sub-surface sediment are impacted. Contamination related to releases from historical Tru-Grit activities appears to be limited to copper and zinc in near-surface sediment. Copper and zinc are also present in soil, but groundwater (seep) sampling indicates that the concentrations of these metals in soil are not impacting groundwater and are not a hazard to human health through direct contact. The Site is excluded from a terrestrial ecological evaluation based on the heavily developed nature of the Upland Area, in accordance with WAC 173-340-7491(1)(c)(i).

Impacts to near-surface sediment were determined based on chemical and bioassay testing. The RI determined that concentrations of arsenic, copper, and zinc are above preliminary screening levels; although, the most recent testing in 2018 indicated copper and zinc concentrations are below the preliminary screening levels in all analyzed samples. Follow-up bioassay testing was also conducted on the samples collected in 2018. All samples passed the sediment cleanup screening level criteria for all bioassay tests. However, two sample locations failed the lower sediment cleanup objective (SCO) criteria for one out of three tests (larval development); the results for the other two tests passed the SCO criteria. While none of the samples exceeded the numeric screening levels for copper and zinc, it is notable that the two locations where samples passed all of the SCO bioassay criteria had higher copper and zinc concentrations than the locations that failed the larval development test.

2.1 Uplands Soil and Groundwater

Unpaved portions of the property with exposed soil are limited to a narrow strip along the shoreline and a gravel area on the Orion Marine portion of the property. Grit material released during the course of Tru-Grit operations is evidenced by low levels of copper and zinc being present in soil within the upland portion of the Site. However, the concentrations of copper and zinc found in soil are not considered hazardous to human health through direct contact, and as noted above, investigation of copper and zinc in groundwater indicated that the presence of these constituents in soil is not significant enough to impact groundwater quality.

Based on the results of the RI, copper and zinc were not determined to be indicator hazardous substances (IHS) in soil or groundwater, and therefore no cleanup activities are required in the upland portion of the Site to achieve cleanup standards.

2.2 Marine Sediment

Data collected during the RI indicate that grit material related to Tru-Grit operations is present in surface sediment. The metals copper, zinc, and arsenic are also present, at concentrations above preliminary screening levels (PSLs). Releases from Tru-Grit operations were limited to copper and zinc that were present in the grit material released near the ship-to-shore offloading conveyance system. Although arsenic contamination in surface and subsurface sediment is also present at the Site, the data indicate arsenic is not related to releases from Tru-Grit operations. Additionally, some subsurface copper and zinc concentrations are associated with elevated arsenic and appear to have contribution from sources other than Tru-Grit operations. The following sections present the findings of the RI related to surface and subsurface sediment quality conditions.

2.2.1 Surface Sediment

Grit material released during the course of Tru-Grit operations, which is indicated by elevated grit content percentages for 2008/2009 sediment samples on Figure 4, appears to have resulted in copper and zinc concentrations exceeding PSLs in surface sediment at the Site (Figure 5). These areas of surface sediment contamination are located in the vicinity of the ship-to-shore offloading conveyance system and west of the offloading area.

The copper contamination in surface sediment appears to be restricted to two small areas near the offloading system. The zinc contamination overlaps the area of copper contamination and is also limited to the close vicinity of the offloading system (Figure 5). The lateral extent of contamination from these two metals corresponds closely with the lateral distribution of grit material in surface sediment (Figure 4). A comparison of chemical results between 2008/2009 and 2018 sampling events showed overall lower concentrations of zinc and copper in surface sediment than in previous sampling events, and none of the 2018 surface sediment samples exceeded the PSL sediment criteria for copper and zinc.

Bioassay testing was conducted in 2018 using sediment from locations with elevated grit percentages and elevated concentrations of copper and zinc (based on 2008/2009 results) to determine the bioavailability of the copper and zinc. Bioassay results indicated compliance with the cleanup screening levels (CSLs) for all three tests at all four sample locations, and only exceeded the more conservative SCO criteria for one of three bioassay tests (larval development) at SG-16 and SG-17.

As discussed in the RI, surface sediment contamination was found in one other area near the Tru-Grit facility, indicated by chemical concentration and presence of grit material near sample location SG-23. However, the location was under a former dock adjacent to the Orion Marine facility and appears to be unrelated to Site releases; potential contamination in this area is not evaluated further herein.

2.2.2 Subsurface Sediment

Arsenic, copper, and zinc contamination is present in subsurface sediment (Figure 6). As confirmed through extensive and repeated testing, arsenic was not present in grit material processed at the Tru-Grit facility; explicitly, arsenic in subsurface sediment is not related to Tru-Grit operations.

The total depth of grit material in subsurface sediment was determined during core advancement at all sample locations where grit was present.

The vertical extent of subsurface sediment contamination contributed by Tru-Grit operations appears to be primarily limited to the upper 1–2 ft of sediment, based sediment deposition rates, sediment composition, and on deeper sediment samples that have exceedances of arsenic—uncharacteristic of the materials managed by Tru-Grit. This finding is consistent with the expected maximum amount of deposition (2.4 ft) over the time period that Tru-Grit operated at the Site. Additional evidence of other historical sources was present at SC-14A where a grit material with distinctive physical characteristics (paint chips and plastic/glass bead material) and chemical characteristics (elevated arsenic) was present at about 3 ft below the mudline. The material found at SC-14A is uncharacteristic of the Tru-Grit material, and provides additional evidence that other historical sources (e.g., sandblasting, painting, etc.) impacted sediment at the Site prior to Tru-Grit's operations.

3.0 DEVELOPMENT OF CLEANUP STANDARDS

This section identifies regulatory cleanup requirements through the development of a CSM and proposed cleanup levels (PCLs) based on the results of the RI and consideration of potentially applicable laws and regulations. The list of constituents of potential concern (COPCs) and media of potential concern are refined herein based on the RI data into a list of IHSs. Final Site cleanup levels will be established by Ecology in the cleanup action plan (CAP) following completion of the FS.

3.1 Conceptual Site Model

A CSM was developed during the RI to describe the potential sources of contamination, to summarize how the contamination might move through affected media, and to describe potential receptors that could be exposed to the contamination that must be protected through cleanup actions. This CSM considers historical Site activities, environmental data collected during the RI, and the physical processes that control the fate and transport of contaminants in the environment.

The CSM identified discharge sources and potential receptors associated with contamination identified in the RI associated with current and future site use. Grit material that was unintentionally discharged to sediment from barge offloading activities or from the ship-to-shore conveyor system is the primary discharge source to sediment contamination at the Site. Subsurface sediment contamination associated with arsenic exceedances or material otherwise distinct from the grit material historically managed at the Facility are not attributed to releases from Tru-Grit's operations, but are likely the result of historical releases over a longer period of time. The potential exposure pathway that may be present at the Site is uptake of contaminants in sediment by benthic organisms within the biologically active zone of sediment (the upper 10 centimeters [cm] below the mudline).

3.2 Indicator Hazardous Substances and Affected Media

Potentially affected media identified in the RI Work Plan (LAI 2013) include marine sediment, upland surface soil, and groundwater. However, findings from the RI investigation have eliminated upland soil and groundwater as affected media. Marine sediment is the only remaining potentially affected media. The COPCs for marine sediment are arsenic, copper, and zinc, and all three are retained as IHSs for the Site (Table 1). These IHSs were retained to include impacts related to releases of grit material attributed to Tru-Grit operations at the site (copper and zinc), and impacts because of other releases at the Site that are present, but unrelated to Tru-Grit operations (arsenic). Marine sediment is considered a potentially affected medium because of the potential for direct discharge of grit from barge offloading activities by Tru-Grit. Though arsenic is not present in grit material processed at the Tru-Grit facility and the source of arsenic contamination is currently unknown, arsenic was retained as an IHS because of elevated concentrations in surface and subsurface sediments.

3.3 Preliminary Sediment Cleanup Levels

PCLs were developed in the RI for protection of benthic organisms in accordance with the SMS regulations. The SMS provides numerical criteria for protection of benthic species for all Site IHSs, as presented in Table 1.

The SMS bounds the acceptable range for sediment cleanup standards. The SCO is the contaminant concentration that represents the goal, and is the most conservative cleanup criterion developed under the SMS. The CSL is the maximum allowable concentration of any contaminant and level of biological effects permissible at a site after completion of the cleanup action. The sediment cleanup level will ultimately be determined by Ecology and established in a CAP. Although SMS allows for the cleanup level to be established between the SCO and CSL, this FS conservatively assumes the SCO will be selected as the cleanup level for the Site.

4.0 SITE CLEANUP REQUIREMENTS

As discussed in the preceding sections, sediment quality has been impacted by releases from historical operations and will undergo remediation to meet state cleanup requirements. Figure 7 shows the approximate boundary of the sediment cleanup unit, which is based approximately on the area where grit is present at concentrations of approximately 15 percent or greater. This unit encompasses an area inclusive of, and larger than, the area where chemical IHS exceedances were detected, and additionally encompasses a larger area than indicated through strict interpretation of the bioassay testing.

The boundary of this area is generally surrounding the area where inadvertent spillage occurred historically, near the loading areas. This encompasses sample locations SG-16, SG-17, SG-13, and G-5. As discussed above, the impacts at SG-23, SG-08, and G-B2SG-23 are unrelated to Site releases. Although there was a chemical exceedance of the PSL at SG-14 and SG-15, follow-up bioassay testing confirmed the existing concentrations are not affecting benthic organisms and, in accordance with SMS rules, meet cleanup standards. Based on the adjacency of location and the similar ratios of IHS concentrations, SG-14 and SG-15 are considered similar in character. Bioassay testing at SG-14 passed the SCO, and the sample collected in 2018 had no chemical exceedances of the SCO.

While some other contamination may be present nearby, it was determined during the RI not to be associated with releases from this Site. This area does not include areas with less than 15 percent grit content that still contain elevated concentrations of IHSs that are unrelated to Tru-Grit operations. These areas include the area around SG-23 (discussed above in Section 2.2.1) and locations with low grit content, low copper, and elevated zinc concentrations, which matches the results at background sample G-B2SG-23 (see Figures 4 and 5).

4.1 Remedial Action Objectives

Remedial action objectives (RAOs) were considered that must be achieved by a cleanup alternative in order to attain cleanup standards. The RAOs must address all affected media (only sediment contains IHS for this Site). Each cleanup alternative developed in this FS must achieve all RAOs to satisfy all applicable or relevant and appropriate requirements (ARARs) to be considered a viable cleanup action.

Based on the limited extent of contamination, only one RAO was identified for this Site: Prevent exposure of marine biota to sediment containing hazardous substances at concentrations that exceed cleanup standards protective of benthic organisms.

4.2 Potentially Applicable Laws

The primary ARARs are cleanup standards under the SMS and MTCA cleanup levels and procedures for implementation of a cleanup under MTCA. In accordance with MTCA, all cleanup actions conducted under MTCA must comply with applicable state and federal laws (WAC 173-340-710[1]). MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate (collectively referred to as the ARARs).

In addition to those primary ARARs (MTCA and SMS), if the cleanup action will include active in-water work such as dredging or constructing a physical cap, the following ARARs would require consideration during the construction phase.

- Washington Water Quality Act and Washington Water Pollution Control Act and the following implementing regulations: Water Quality for Surface Waters (Revised Code of Washington [RCW] 90.48; Chapter 173-201A WAC) and SMS (Chapter 173-204 WAC).
- State Environmental Policy Act (SEPA; Chapter 197-11 WAC).
- Clean Water Act, with respect to water quality criteria for surface water (Blair Waterway) and in-water work associated with dredging or sediment capping (40 Code of Federal Regulations [CFR] 230; 33 CFR 320, 323, 325, and 328).
- Construction in State Waters, Hydraulic Code Rules (RCW 75.20; Chapter 220-1101 WAC).
- EPA Water Quality Standards (National Toxics Rule)—40 CFR 131.
- Washington's Shoreline Management Act, with respect to construction activities conducted near the shoreline during the cleanup action (RCW 90.58; Chapters 173-18 and 173-20 WAC).
- Dredge and fill requirements under CFR 320-330 and Hydraulic Code Rules under Chapter 220-110 WAC.
- Endangered Species Act.
- Washington Clean Air Act (Chapter 70.94 WAC).
- Occupational Safety and Health Act, (29 CFR Subpart 1910.120; Chapter 296-62 WAC).
- Critical Areas Ordinance of the City of Tacoma (Tacoma Municipal Code Chapter 13.11 Critical Areas Preservation).

4.3 Current and Future Site Uses

Remedial alternatives must consider both current and foreseeable future land use to ensure that the cleanup alternatives are effective and will remain effective through their intended lifespan, even if future land use changes within reasonably predictable limits.

Tru-Grit does not intend to continue operations at the Facility. Prior to departure, paved areas will be swept, the storm drain system will be cleaned and emptied, and the vegetated strip between the Facility and the shoreline will be scraped clear of any remaining grit material. These actions will complete source control of material related to Tru-Grit activities.

This FS assumes the aquatic portion of the Site will remain in commercial and recreational maritime use, which could require maintaining, and possibly deepening channel depth to accommodate vessel drafts. Currently, the Port does not have plans for maintenance dredging in the Blair Waterway near the site (Hooton 2012). Also, future maintenance dredging by the US Army Corps of Engineers (USACE) is not expected to intersect with contaminated sediments (Kerns 2019), as the area requiring cleanup evaluation is outside of the navigation channel; the sediment cleanup unit is limited to the 40 ft mean lower low water (MLLW) bathymetric contour or shallower, while the current Blair Waterway project depth (NOAA 2019) of 51 ft MLLW is the current approximate channel depth adjacent to the Site (Figure 3).

This FS assumes that future maintenance and dredging activities in the Blair Waterway will not impact the Site. The existing channel depth would be maintained, or possibly deepened, but the dredging activities would be outside the sediment cleanup unit. Evaluation of cleanup alternatives described in Section 6.0, including those that leave existing sediment in-place, rank relative benefits of the cleanup alternatives under the assumption that deeper channel dredging within the remediation Site is not a future land use. However, a contingent cost that would apply to disposal of contaminated sediment associated with Tru-Grit operations and impact to the Site is presented with each cleanup alternative that leaves sediment in-place.

5.0 SCREENING OF REMEDIAL TECHNOLOGIES AND INSTITUTIONAL CONTROLS

The purpose of the FS is to develop and evaluate cleanup action alternatives to enable an appropriate cleanup action to be selected for the Site. This FS complies with the requirements under MTCA for performance of an FS (WAC 173-340-350) and selection of a cleanup action (WAC 173-340-360), with an emphasis on the SMS rules for selecting a preferred remedy (WAC 173-204-560).

The development of cleanup action alternatives involves the screening of remedial technologies to identify those capable of meeting cleanup requirements and then assembling the applicable technologies into a range of remedial alternatives that achieve the RAO. These remedial alternatives are then evaluated and compared to criteria established in the MTCA and SMS regulations; a preferred alternative is identified based on this evaluation.

All cleanup alternatives must consider both current and potential future Site uses to determine their long-term effectiveness. This requires that applicable cleanup elements be considered in the context of both current and potential future land uses to determine whether these uses could compromise the effectiveness of the cleanup action and, if so, modified so the cleanup element reasonably accommodates the anticipated land use.

Based on these considerations, remedial technologies were screened and those technologies anticipated to be effective and compatible with current and anticipated future Site uses were identified for development into Site remedial alternatives.

There are generally four categories of sediment cleanup technologies that can be used to cleanup sediment at this Site: monitored natural recovery (MNR), sediment capping (including enhanced MNR [EMNR]), sediment removal by dredging, and institutional controls.

Each of these technologies is discussed in the following subsections with relation to Site-specific considerations for application at the Site. Those technologies that are carried forward as potentially applicable for the Site are discussed in greater detail in Section 6.0.

5.1 Monitored Natural Recovery

Sediment natural recovery is a term used to describe the multiple natural processes by which sediment quality can improve without intervention. These natural processes can include physical processes such as sedimentation, advection, diffusion, dilution, dispersion, and bioturbation; biological processes such as biodegradation, biotransformation, phytoremediation; chemical processes such as oxidation/reduction, sorption; or other processes that may reduce bioavailability. These processes result in a reduction in concentration in the bioactive zone predominantly by intermixing newly deposited sediment with affected sediment, containing affected sediment beneath more recently deposited clean sediment, and/or destroying or otherwise reducing the bioavailability or toxicity of contaminants in sediment through chemical and biological processes. The predominant mechanism among these is sedimentation. Sediment accretion can provide a layer of uncontaminated habitat in surface sediment—the location of the predominantly biologically active zone (uppermost 10 cm of sediment). MNR remedies take advantage of naturally occurring processes such as sediment accretion, which have low-implementation costs and are non-invasive in nature. Additionally, they minimize the need to dispose of dredged contaminated material off site.

A disadvantage of MNR is that it can be slower to reduce risks in comparison to other remedies, such as capping or dredging. Therefore, its use should be limited to areas where natural recovery is already demonstrably occurring, and where sediment quality monitoring can be carefully implemented to track progress toward restoration within a reasonable time frame. In accordance with Sediment Cleanup User's Manual II (SCUM II) guidance (Ecology 2017), a reasonable restoration time frame for sediment recovery is approximately 10 years.

As discussed in the RI, sediment accretion appears to be occurring at the Site at an estimated rate of approximately 3.0 cm per year. In 1988, Ecology began monitoring deposition in sediment traps in the Thea Foss waterway (within Commencement Bay) and calculated yearly sediment accumulation rates. This monitoring was expanded to include the Hylebos and Sitcum waterways in 1990 (Ecology 1996). Ecology predicted average yearly sediment accumulation rates based on measured gross accumulation rates for the three waterways. Between 1991 and 1995, calculated sediment accumulation rates in the Hylebos and Thea Foss waterways had mean accumulation rates of 3.4 cm per year (cm/yr) and 2.5 cm/yr, respectively (Ecology 1996). The Sitcum waterway was excluded because of its proximity to the discharge point for the Puyallup River, which might result in an overestimate of accumulation rates. The mean accumulation rate for the two waterways taken together is 3.0 cm/yr.

In addition to the Site being an expected depositional environment, RI data collected between 2008/2009 and 2018 indicate lower concentrations of IHSs and lower grit content, supporting the conclusion that MNR is already occurring at the Site. The 10-year timespan between sampling events provided a compelling demonstration that natural recovery is occurring, and at a pace expected to meet the SMS and MTCA requirements for attainment of cleanup standards within a reasonable restoration time frame.

This evaluation strongly supports the conclusion that MNR is appropriate to be carried forward as an applicable remedial technology for further evaluation.

5.2 Sediment Capping

Sediment capping approaches range from a thin-layer cap to enhance the natural recovery process to an engineered cap that contains contaminated sediment by physically, and in some cases chemically, isolating contaminated sediment from the predominantly biologically active zone.

A thin-layer sediment cap enhances the natural recovery processes by providing suitable "clean" substrate (typically 1 ft, or less) to facilitate recolonization by benthic organisms and natural recovery. Thin layer caps can speed the recovery process by providing excess surface substrate, but do not provide the same function as a typical sediment cap. The use of this type of cap for a remedial action is generally described as "enhanced monitored natural recovery."

Engineered caps typically include a containment media layer (e.g., sand) at least 2 ft thick. In areas subject to erosional forces, such as wave action and/or vessel propeller-wash (such as a marina), an erosion protection layer to prevent disturbance or breaching of the containment layer (e.g., cobble-size or greater, depending on applicable erosional forces) at least 1 ft thick is typically placed over the containment layer. In some instances, a layer of finer-grained material is placed over the erosion protection layer to provide a stratum that can be recolonized by benthic organisms. Based on these design needs, an engineered cap in a working environment such as this Site may require a cap of at least 3 ft thick, and potentially 4 ft or greater in thickness in order to prevent loss of the cap through mechanisms such as disturbance from propeller-wash.

Although, the cap material would provide a clean stratum for recolonization, organisms residing in the biologically active zone prior to placement of the cap material, would be negatively affected. Use of EMNR must consider the impact of the existing sediment on benthic organism health and weigh the disadvantage of potentially destroying an existing healthy benthic community.

Both thin-layer and engineered capping are widely accepted technologies for addressing sediment contamination. However, the use of an engineered cap at the Site may interfere with maintaining required depth to accommodate vessel drafts for ongoing operations at the Site. As a result, the thin-layer cap technology to promote EMNR is carried forward for further evaluation but the engineered cap is screened out as being incompatible with long-term Site use.

5.3 Removal and Offsite Disposal

Physical removal (dredging) and offsite disposal of the contaminated sediment at a permitted disposal facility could be conducted to meet cleanup standards. Standard dredging techniques could be used to remove contaminated sediment, which would likely be disposed of offsite, at an upland licensed and permitted solid waste facility. Removal and offsite disposal of contaminated sediment is carried forward as a remedial technology for further evaluation.

5.4 Institutional Controls

Institutional controls can be used to limit exposure to or disturbance of contaminated sediment by limiting invasive activities, such as dredging, unless conducted in coordination with Ecology. Based on the Site setting, shellfish harvesting and beach-play activities do not occur within the boundary of where cleanup standards are exceeded and these activities do not require protection through institutional control. Institutional controls are often used for sediment cleanup projects that are designed for the protection of benthic organisms, which reside primarily in the biologically active zone near the sediment surface. Cleanup actions at these sites are often focused on enhancement of the surface sediment quality, and exposing deeper sediments can often cause more environmental harm than is necessary. As a result, institutional controls are typically paired with other cleanup technologies to ensure the long-term effectiveness of the remedy, and are carried forward for further consideration herein.

6.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section describes the remedial alternatives that were developed for the Site using the cleanup technologies carried forward from the screening process described in Section 5.0. For each alternative, this section provides the following information:

- A discussion of how each alternative would meet cleanup standards for the Site
- A description of the specific cleanup actions, including considerations for existing habitat, land use, and/or navigation considerations relevant to the cleanup action
- A description of the compliance monitoring for each alternative, including protection, performance, and confirmation monitoring
- A summary of costs and schedule.

Sufficient detail is included for each alternative to provide the reader with a conceptual understanding of the design's intent and to provide an adequate basis for developing the cost estimates for each alternative. Further conceptual-level design details will be developed for the remedial action selected by Ecology in the CAP. Then, after considerations of public comments, permit-level and construction-level design plans and specifications would be developed so the project can be fairly bid by contractors and constructed in accordance with ARARs.

The three remedial alternatives listed below were developed for further evaluation as options for cleanup, as discussed with Ecology:

- Alternative 1: Monitored Natural Recovery
- Alternative 2: Enhanced Monitored Natural Recovery
- Alternative 3: Sediment Dredging and Off-Site Disposal.

6.1 Alternative 1: Monitored Natural Recovery

This alternative uses the natural recovery processes of the marine environment to reduce risks to acceptable levels (Figure 8). Through natural processes, the concentrations of IHS throughout the sediment cleanup unit are anticipated to be reduced below the SCO. For copper and zinc, the two IHSs related to Site releases, cleanup standards are assessed and would be attained on a point-by-point basis except beneath the former Orion dock, where SG-23 and SG-04 are located. Because the over-water operations that were the apparent source of grit material releases to the sediment have been terminated, there is no longer an active source contributing contamination to the Site. This important consideration sets this cleanup apart from typical efforts, because it is usually necessary to address ongoing releases from upland sources, such as groundwater or stormwater discharges to the marine environment, prior to addressing sediment cleanup. In this case, source control (ceasing operations) is complete, and it has been shown empirically that the natural recovery processes discussed in Section 5.1 are already occurring. It appears that sedimentation is occurring and concentrations of contamination in the biologically active zone (upper 10–12 cm) are decreasing over time. Of the locations sampled in 2018, none exceeded PCLs for copper or zinc. The rate of sedimentation and other natural process at the Site can restore a "clean" sediment surface to support benthic organisms, thus MNR is considered an effective remedy that can achieve cleanup standards within a reasonable restoration time frame. This option represents the lowest-cost alternative that would meet the threshold requirements of MTCA and SMS. It also provides the sediment quality improvements without the risks that are inherent in applying more active cleanup technologies such as capping or dredging, which can cause significant short-term disruption and habitat destruction.

Compliance monitoring, and specifically, performance and confirmation monitoring is a fundamental component of this alternative. A significant data collection program is required to demonstrate through physical and chemical testing that sediment quality conditions are improving and to confirm that the recovery process is capable of achieving and maintaining cleanup standards. Based on the empirical evidence of natural processes already at work, discussed in Section 5.1, a preliminary estimate of the restoration time frame is 6–8 years for this alternative. This estimated time frame is based on a calculated sedimentation rate of 3 cm/yr. At this rate, a 12-cm-thick sediment surface could be deposited over a period of about 4 years. The additional 2–4 years included in the estimated time frame provide for uncertainties in the sedimentation rate, the additional time to develop and implement an approved monitoring program, and additional time for confirmation samples and reporting to confirm long-term effectiveness of the cleanup action.

Confirmation monitoring would include re-evaluation of sedimentation rates using bathymetric surveys and evaluation of sediment quality through chemical analyses at the completion of years 2, 5, and 10. Sediment samples would be collected and analyzed for comparison to cleanup standards and to evaluate for improving quality. Contingent costs for this alternative also include long-term compliance monitoring events at the completion of years 15 and 20.

Institutional controls would be required for this alternative, because some contamination would persist deeper in the subsurface. As long as that contamination remains covered with clean surface sediment, the benthic community and marine environment are protected. Institutional controls would be in-place to prevent dredging or other intrusive activities that could disrupt the cleanup action without proper notification and discussion with Ecology.

In order to provide for adaptive management, contingency measures can be enacted if the monitoring results indicate MNR is not proceeding effectively. In that situation, EMNR would be implemented, in coordination with Ecology, as a contingent measure to speed the restoration time frame. EMNR is discussed further in the following section.

6.2 Alternative 2: Enhanced Monitored Natural Recovery

Alternative 2 is similar to Alternative 1 in that it relies primarily on naturally occurring sediment recovery mechanisms to reduce Site risks and attain compliance with cleanup standards. As discussed in Section 5.1, the natural recovery processes can be enhanced through the application of a thin-layer sediment cap throughout the sediment cleanup unit. These thin caps are intended to provide suitable "clean" substrate to facilitate recolonization by benthic organisms and natural recovery. This would be accomplished by emplacing approximately 6 inches of sand throughout the sediment cleanup unit, generally where grit material is present in the sediment at concentrations greater than 15 percent.

Thin layer caps can speed the recovery process by providing excess surface substrate, but do not provide the same function as a typical sediment cap. Thin layer caps for EMNR typically do not have the thickness or rock gradation to withstand high-energy environments, and are subject to scouring forces such as vessel propeller wash. However, at this Site where natural recovery is already occurring, the application of a thin-layer of sand is anticipated to bring the Site into compliance with cleanup standards almost immediately, then long-term monitoring would be conducted to ensure cleanup standards are maintained. As noted in the previous section, one inherent concern with applying capping technologies—even thin layer caps—is the potential for short-term impacts to the existing marine ecosystem. This is particularly applicable to the Tru-Grit Site, where bioassay testing indicates the sediment can support a relatively healthy benthic community (biological compliance with the CSL on all 12 of 12 tests, and compliance with the SCO on 10 of 12 tests).

For the purposes of this FS, we assume a typical medium sand would be placed as clean substrate with a uniform thickness of 6 inches throughout the sediment cleanup unit shown in Figure 9. Based on these dimensions, the total volume of clean sand imported to the Site and emplaced by barge is approximately 300 cubic yards (CY). However, during the remedial design phase, the actual material sizing and thickness would be developed based on further evaluation of the actual bathymetry, wave action, and currents at the Site.

Bathymetric surveys would be conducted prior to and after construction to ensure that the thin-layer cap is constructed in accordance with plans and specifications, and that adequate depth is maintained within the capping area to accommodate vessel draft. The bathymetric surveys would be evaluated to determine how conditions change over time. As a contingency measure, thin layers of sand would be added to amend the thin-layer cap, if needed.

After installation of the thin-layer cap, compliance monitoring would be implemented in a similar manner described for Alternative 1. It would include repeated bathymetric survey events and chemical analysis of sediment samples following the completion of years 2 and 5 to demonstrate compliance is maintained and confirm sediment will be protective of benthic organisms over the long term. As a contingent action measure, costs for compliance monitoring are included for years 10 and 15 following the start of construction.

6.3 Alternative 3: Sediment Dredging and Offsite Disposal

This alternative would remove all sediment at the surface and subsurface exhibiting concentrations of grit material at greater than 15 percent—removing essentially all sediment impacted by Tru-Grit operations. Based on review of the RI data, the depth of dredging throughout the area shown on

Figure 10 varies from 3 to 5 ft beneath the mudline. Based on the preliminary conceptual design of this dredge prism, we assume approximately 1,800 CY of sediment would be removed, using traditional mechanical dredging techniques. This alternative was developed to represent the most permanent cleanup alternative that could be potentially implementable. The anticipated restoration time frame for this alternative is 1–2 years following construction.

Although this sediment removal would achieve cleanup standards relative to Tru-Grit impacts in surface sediment nearly immediately, there are some potentially negative impacts to consider. Intrusive dredging activities such as these often re-suspend and expose contamination that was otherwise buried and not affecting the benthic community or the marine environment. In this case, cleaning up the grit released during Tru-Grit operations could potentially expose other contamination that is not currently causing exposures. Additionally, this cleanup approach causes complete destruction of the existing benthic community, having even greater impacts than emplacing the 6-inch thin-layer cap discussed in Alternative 2. Large scale dredging to achieve sediment cleanup goals is best suited for sites where the existing surface sediment quality is far worse than observed at this Site. In addition to these potentially negative impacts on the environment, this cleanup alternative has significant administrative implementability issues because of the extensive permitting and environmental review process involved with the potentially negative impacts of dredging.

To mitigate potential impacts to the marine environment during construction, a silt curtain would be used to control turbidity and redistribution of contaminated sediment during construction, and thus limit impacts to surface water quality and sediment redistribution. Surface water quality monitoring would be conducted during the construction period to confirm compliance with applicable regulations.

It is assumed that dredged sediment would be dewatered on a small barge and the decanted water drained into the harbor. For cost-estimating purposes, it was assumed that sediment would then be offloaded to trucks and hauled off-Site for disposal at a permitted upland Resource Conservation and Recovery Act (RCRA) Subtitle D solid waste disposal facility; although, it may be determined during construction bidding that it is more cost-effective to transport dredged sediment via barge to an offloading facility in the Tacoma area.

It is common for sediment resuspension during the dredging process to result in a thin veneer of contaminated sediment residuals that settle on the clean dredge surface. This alternative assumes that a residuals layer could form on the dredge surface, and a thin layer of clean soil/sediment would be placed across the newly exposed sediment surface after dredging to address this veneer of dredging residuals (Figure 10). The thickness of this residuals cover layer is assumed to be 6 inches for cost-estimating purposes.

We assume for the purposes of this FS that the residuals layer would need to be approximately 20 percent larger in area than the sediment cleanup unit. This is because even with the application of all reasonable and appropriate measures to control turbidity and contaminated sediment suspended in the water column during dredging, some degree of contaminated sediment residuals redistribution could occur outside of the dredging footprint.

Compliance monitoring would be conducted 2 and 5 years after dredging to confirm post-construction sediment quality. This would include collecting surface sediment samples throughout the Site. Bathymetric surveys would also be conducted both pre- and post-construction to confirm dredging volumes, that dredging design depths and lateral limits were achieved, and to confirm that the dredging residuals layer was properly placed (if applicable).

Institutional controls may be necessary after dredging in the event that deeper contaminated sediments are exposed and compliance monitoring confirms cleanup standards are not achieved.

7.0 EVALUATION OF CLEANUP ALTERNATIVES

Both MTCA and SMS require that cleanup alternatives be compared to a number of criteria to evaluate the adequacy of each alternative in achieving the intent of the regulations, and as a basis for comparing the relative merits of the developed cleanup alternatives. Most of the evaluation criteria are identical between MTCA and SMS. Because this cleanup includes sediment only (no cleanup is needed in the upland site), WAC 173-204-570 will guide the evaluation and selection of a preferred remedy.

7.1 Minimum Requirements

As specified in WAC 173-240-570, sediment cleanup actions are required to meet the following threshold requirements:

- Provide protection of human health and the environment
- Comply with cleanup standards specified under SMS (WAC 173-204-560 through 173-204-564)
- Comply with applicable state and federal laws
- Provide for compliance monitoring
- Provide for public review
- Use permanent solutions to the maximum extent practicable as defined in WAC 173-340-360
- Provide for a reasonable restoration time frame per WAC 173-204-570(5).

In order for a cleanup alternative to meet these minimum threshold requirements, it must adequately protect human health and the environment, comply with cleanup standards, comply with state and federal laws, and provide for compliance monitoring. Compliance with the threshold requirements for cleanup actions under MTCA and SMS are presumed by definition to be protective of human health and the environment once the cleanup action meets the cleanup standards for all affected media. The following sections identify how the cleanup alternatives comply with the threshold requirements.

The potential exists for marine organisms in the biologically active zone to be impacted under current conditions based on sediment quality. The three remedial alternatives retained for evaluation would comply with the threshold requirements as follows:

- **Protection of human health and the environment**—Each cleanup alternative would provide protection of human health and the environment. Alternative 1 and Alternative 2 would rely on natural processes or enhanced natural processes that result in a clean layer of sediment to provide suitable and uncontaminated habitat for benthic organisms. Alternative 3 would provide protection through removal and offsite disposal of contaminated sediment, similarly resulting in a clean surface layer for protection of benthic organisms.
- **Compliance with cleanup standards**—Each of the cleanup alternatives would achieve MTCA and SMS cleanup standards by remediating sediment to protect the benthic community through improvement of surface sediment quality in the biologically active zone.

- **Compliance with state and federal laws**—Through compliance with ARARs including the MTCA and SMS regulations, each alternative would comply with relevant state and federal laws.
- **Provisions for compliance monitoring**—Compliance monitoring is proposed as part of each alternative. Each cleanup alternative would provide both performance and confirmation monitoring to demonstrate cleanup standards are achieved and maintained.

7.2 Requirement for Permanent Solution to the Maximum Extent Practicable

WAC 173-204-570 requires a cleanup action to be a permanent solution to the maximum extent practicable—one in which cleanup standards can be met without further action being required at the Site or at any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances. Ecology recognizes that permanent solutions may not be practicable for all sites and provides criteria for determining whether a cleanup action is permanent to the "maximum extent practicable." These criteria are explained in WAC 173-204-570 and WAC 173-240-360 and include:

- **Protectiveness** of human health and the environment, including the degree to which Site risks are reduced, the risks during implementation, and the improvement of overall environmental quality
- **Permanence** in the reduction in toxicity, mobility, and volume of hazardous substances, including the reduction or elimination of hazardous substance releases and sources of releases
- **Management of short-term risks**, including the protection of human health and the environment during construction and implementation
- **Long-term effectiveness**, including the degree of certainty that the alternative will be successful, the long-term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining waste
- **Implementability**, including consideration of whether the alternative is technically possible; the availability of necessary offsite facilities, services, and materials; administrative and regulatory requirements; scheduling, size, and complexity of construction; monitoring requirements; access for construction, operations, and monitoring; and integration with existing facility operations
- **Consideration of public concerns**, which will be addressed through public comment on the RI and this FS report and the CAP that will be subsequently developed by Ecology
- **Cleanup costs**, including capital costs and operation and maintenance costs.

Evaluation of the practicability of a given alternative is based on the disproportionate cost analysis (DCA), a comparative evaluation of whether the incremental increase in cost associated with increasingly protective cleanup actions is substantial and disproportionate to the incremental increase in environmental benefit. If the incremental cost is determined to be substantial and disproportionate to the incremental increase in environmental benefit, the cleanup alternative is considered impracticable and eliminated from further consideration.

The following subsections provides a summary of how the cleanup alternatives meet the permanence criteria and provides a comparative ranking score among the alternatives that is later used to assess practicability as part of the DCA process in Section 8.0.

7.2.1 Protectiveness

The overall protectiveness of each of the alternatives is sufficient to achieve cleanup standards through improvement of surface sediment quality. Alternatives 1 and 2 are expected to improve surface sediment quality through naturally occurring processes, or enhancement of naturally occurring processes. Alternative 3 would achieve cleanup standards and provide protectiveness through removal of sediment with concentrations of IHSs exceeding cleanup levels. Long-term reduction of risk at the Site is better for Alternative 3 through improvement of sediment quality at depths beneath the biologically active zone. However, both Alternatives 2 and 3 will temporarily disrupt and negatively impact the existing benthic community. The existing benthic community is relatively healthy (all bioassay tests passed the CSL criteria and 10 out of 12 bioassay tests passed the SCO criteria). Short-term destruction of the benthic community must be weighed against the potential for long term-improvement. Because the existing sediment quality is having only a minor impact on the benthic community and natural recovery processes are already in progress, the potential short-term harm may outweigh the long-term benefit. Based on these considerations, the alternatives received ranking scores for protectiveness as follows:

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	7
Alternative 2: Enhanced Monitored Natural Attenuation	7
Alternative 3: Sediment Dredging and Off-Site Disposal	8

7.2.2 Permanence

Each of the three alternatives provides a permanent reduction in the release of hazardous substances over the long term. Alternative 3 is considered the most permanent; it would permanently reduce contaminant volume by dredging and disposing of the marine sediment contamination associated with Site releases. Alternatives 1 and 2 achieve the marine sediment SCOs for IHSs, although they will provide somewhat less permanence, because some contamination will remain in the subsurface, which could be encountered if Site use changes and dredging were to occur. Alternatives 1 and 2 score lower than Alternative 3, and receive the same scores because they will each leave the same conditions in place—an acceptable sediment surface achieving cleanup standards through natural recovery that reduces contaminant concentrations in the surface sediment. Based on these considerations, the alternatives receive ranking scores for permanence as follows:

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	4
Alternative 2: Enhanced Monitored Natural Attenuation	4
Alternative 3: Sediment Dredging and Off-Site Disposal	10

7.2.3 Management of Short-Term Risks

Dredging activities, such as those that would be required for Alternative 3 cause significant short-term risks to human health and the environment. Health and safety risks can be mitigated through protocols to protect human health during construction. Environmental risk during dredging can be partially mitigated through engineering controls and best management practices to protect the environment; however, in-water engineering controls can be imperfect and there is still a potential to bring deeper contamination to the surface in localized areas and also to introduce the suspended sediment to the water column. Although these impacts would be temporary, they still have the potential to cause short-term environmental harm.

Alternatives 1 and 2 have significantly fewer and lower short-term risks, with Alternative 1 providing the lowest concern of short-term risk because no active construction activities are required that could negatively affect aquatic habitat. Based on these considerations, the alternatives receive ranking scores for management of short-term risks as follows:

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	9
Alternative 2: Enhanced Monitored Natural Attenuation	8
Alternative 3: Sediment Dredging and Off-Site Disposal	5

7.2.4 Long-Term Effectiveness

Each of the three cleanup alternatives is anticipated to have a high degree of effectiveness in the long term. The long-term effectiveness of Alternatives 1 and 2 is slightly lower than Alternative 3, because of the risk that contamination beneath the biologically active zone could potentially be resurfaced at some point in the future through intrusive activities. However, this risk is considered small because it would be mitigated through institutional controls and ongoing monitoring and maintenance, as needed, to maintain cleanup standards. Consideration of long-term effectiveness should also capture the degree of certainty that cleanup levels would be achieved. Alternatives 1 and 2 provide slightly less certainty, because the naturally occurring processes, such as sedimentation rates, are less predictable. However, existing data demonstrate that natural recovery processes are already occurring, and the most recent surface sediment results showed no exceedances of PCLs with the exception of one location with an exceedance of arsenic. Based on these considerations, the alternatives receive ranking scores for long-term effectiveness as follows:

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	8
Alternative 2: Enhanced Monitored Natural Attenuation	8
Alternative 3: Sediment Dredging and Off-Site Disposal	9

7.2.5 Technical and Administrative Implementability

The technical implementability of Alternative 1 is high because MNR has few physical constraints. The technical implementability of Alternative 2 is considered moderate because the placement of a thin-layer cap to enhance MNR can be difficult in some areas, such as where wharfs, floats, or other marine structures are in place, and because placement of a thin-layer cap could interfere with, or be disturbed by, vessel drafts or other marina operations. The technical implementability of Alternative 3 is considered moderate to low because of the additional design, permitting, and construction requirements involved with dredging projects. Based on these considerations, the alternatives receive ranking scores for implementability as follows:

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	9
Alternative 2: Enhanced Monitored Natural Attenuation	7
Alternative 3: Sediment Dredging and Off-Site Disposal	4

7.2.6 Consideration of Public Concerns

Consideration of public concerns is an inherent part of the Site cleanup process under MTCA (refer to WAC 173-340-600). This FS report will be issued for public review and comment, and Ecology will determine whether changes to the report are needed in response to public comment. A similar process will occur for the CAP, prior to implementation of the final cleanup action, as specified in WAC 173-340-380. Consideration of public concerns will not be discussed further in this document (except as part of the DCA), in recognition of the public participation process that will be conducted for this report to comply with MTCA requirements. As a result, all three alternatives are given a ranking of 10 for consideration of public concerns.

Alternative	Ranking Score
Alternative 1: Monitored Natural Attenuation	10
Alternative 2: Enhanced Monitored Natural Attenuation	10
Alternative 3: Sediment Dredging and Off-Site Disposal	10

7.2.7 Consideration of Costs

Consideration of costs is required through MTCA and SMS in selecting which of the cleanup alternatives should be implemented. Cost considerations should include design, construction, present and future direct and indirect capital costs, long-term operations and maintenance costs, monitoring costs, and any other site-specific foreseeable costs associated with attaining and maintaining cleanup standards. Estimates of costs and underlying assumptions for the various cleanup options, as described in Section 6.0, are provided in Appendix A. The costs for each alternative are carried forward into the DCA, presented in Section 8.0.

Itemized cost estimates for each of the cleanup alternatives are provided in Appendix A and are summarized in Table 2. Estimated present-worth costs are as follows:

- Alternative 1: Monitored Natural Recovery $280,000
- Alternative 2: Enhanced Monitored Natural Recovery $360,000
- Alternative 3: Sediment Dredging and Off-Site Disposal $1,200,000

These estimated cleanup costs represent an order-of-magnitude cost estimate generally consistent with US Environmental Protection Agency (EPA) guidance for preparing FS cost estimates (USACE and EPA 2000). These costs are used as the cost basis for the DCA presented in Section 8.0.

7.3 Requirement for a Reasonable Restoration Time Frame

WAC 173-204-570 identifies the following factors that should be considered in establishing a reasonable time frame:

- Time required to achieve cleanup standards
- Potential risks to human health and the environment
- Practicability of achieving cleanup standards in less than a 10-year period
- Current use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site
- Potential future use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site
- Aquatic land use classification for state-owned aquatic lands
- Likely effectiveness and reliability of source control measures and institutional controls
- The degree of contamination present
- Ability to control and monitor migration of hazardous substances from the Site
- Toxicity of the hazardous substances at the Site
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions.

A cleanup action is considered to have achieved restoration once cleanup standards have been met. However, the practicability of achieving a shorter restoration time frame is addressed as part of the DCA evaluation presented in Section 8.0. In general, each of the cleanup alternatives presented herein achieves Site restoration in a reasonable time frame. The estimates of restoration time frame are based on the cleanup elements included in the alternatives and the estimated natural sedimentation rates presented in the RI. The estimated time frames are considered approximations that would be refined during compliance monitoring as part of any alternatives that rely to some degree on natural recovery processes. Typically, attainment of cleanup standards within 10 years is considered as a reasonable restoration time frame for sediment cleanup projects in Washington State.

Alternative 3 would achieve cleanup standards at the completion of construction, likely after emplacement of a residuals management layer. However, for the purposes of this evaluation the restoration time frame for Alternative 3 is considered 1–2 years after completion of the remedial construction, to allow time for post-construction sediment quality monitoring to confirm compliance with cleanup standards.

Alternative 2 has an estimated restoration time frame of 1–5 years from the completion of construction, after placement of the thin-layer sand cap to enhance natural recovery. This 5-year period provides for confirmation of protectiveness through post-construction monitoring.

Alternative 1 has an estimated restoration time frame of 6 to 8 years. This estimate provides time for establishing current sedimentation rates and conducting multiple monitoring events to confirm continual improvement of sediment quality until cleanup standards are achieved.

8.0 DISPROPORTIONATE COST ANALYSIS

In Washington State, remedy selection requires determining which cleanup alternative is considered permanent to the maximum extent practicable in accordance with MTCA. MTCA and SMS define permanent cleanup actions as those in which cleanup standards are met without further action being required. MTCA specifies that the evaluation of whether a cleanup action uses permanent solutions to the maximum extent practicable be based on a DCA consistent with the requirements of WAC 173-340-360(3)(e). The purpose of the DCA is to determine if the incremental increase in cost of a cleanup alternative over that of a lower-cost alternative is justified by the incremental increase in benefits to human health and the environment. If the incremental increase in costs is determined to be disproportionate to the benefits, the more expensive alternative is considered impracticable and the lower-cost alternative is determined to be permanent to the maximum extent practicable.

In the DCA analysis, cleanup alternatives are arranged from most to least permanent based on the criteria specified in WAC 173-340-360(3)(f). The DCA then compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental cost of the more permanent alternative exceeds the incremental benefits achieved by the lower-cost alternative (WAC 173-340-360[3][e][i]). Alternatives that exhibit disproportionate costs are considered "impracticable." Where the benefits of two alternatives are equivalent, MTCA specifies that Ecology select the least costly alternative (WAC 173-340-360[e][ii][c]). A summary of the ranking and comparative evaluation approach is provided in Table 2 and graphically on Figure 11.

8.1 Relative Rankings—Weighting Factors

Relative rankings for the alternatives were determined by assigning a value on a scale from 1 to 10 for each ranking category, where 10 is the highest benefit/value. Weighting factors are then applied and the summed weighted ranking values determine an overall alternative benefits ranking score. Weighting factors are based on Ecology input provided for other FSs conducted at similar cleanup sites. The six evaluation criteria and associated weighting factors are:

- Protectiveness: 30 percent
- Permanence: 20 percent
- Management of short-term risks: 10 percent
- Long-term effectiveness: 10 percent
- Implementability: 20 percent
- Considerations of public concerns: 10 percent

The DCA is based on a comparative analysis of the alternatives for each category above; ranking scores are summarized in Table 2 and described below.

8.2 Comparison of Relative Benefit Scores

In Section 7.0, each alternative was evaluated to determine a ranking score for each of the MTCA and SMS requirements of a DCA, related to the degree to which the alternative could be considered permanent to the extent practicable in a variety of categories. The ranking scores presented in Section 7.0 are also presented in Table 2, and were used to develop overall weighted benefit scores for each alternative using the weighting factors presented in Section 8.0. The overall weighted benefit scores for the alternatives, presented in descending order are listed below:

Alternative	Overall Weighted Benefit
Alternative 3: Sediment Dredging and Off-Site Disposal	7.6
Alternative 1: Monitored Natural Attenuation	7.4
Alternative 2: Enhanced Monitored Natural Attenuation	6.9

8.3 Relative Benefit-to-Cost Ratios

Consistent with MTCA and SMS requirements, the overall weighted benefit for each alternative is assessed in consideration of the incremental additional cost required to achieve improved benefit. Alternative 3 provides the greatest overall weighted benefit score, achieving the most permanent remedial alternative evaluated in this FS. As such, Alternative 3 provides the benchmark against which the incremental costs and benefits of the other alternatives are evaluated.

Alternative 3 receives an overall weighted benefit score of 7.6. Because this remedy uses the most permanent remedial technologies of those evaluated for this FS, it receives high benefit rankings for overall protectiveness, permanence, and long-term effectiveness. However, this alternative receives low benefit rankings for short-term risk management and implementability because of the difficulty and environmental risks associated with the removal of large volumes of sediment.

Although Alternative 3 is considered the most permanent, based on its cost ($1,200,000) it has a low benefit-cost ratio of 0.63. The weighted benefit score for Alternative 1 (7.4) is slightly lower than Alternative 3, but because its cost is so much lower ($280,000), its benefit-cost ratio (2.6) is more than four times that of Alternative 3. Based on achieving a relative benefit score that is 97 percent of the most permanent alternative at approximately 20 percent of the cost, the additional cost to implement Alternative 3 is considered substantial and disproportionate when compared to Alternative 1. As a result, Alternative 3 is determined to be impracticable and is eliminated from further consideration in the DCA process.

Alternative 2 receives an overall weighted benefit score of 6.9, which is lower than the score for Alternative 1 (7.4). The cost for Alternative 2 is also about 30 percent higher than Alternative 1. Based on Alternative 2 having a lower overall weighted benefit score and a higher cost than Alternative 1, the relative benefit-to-cost ratio is 2.6 for Alternative 1 and 1.9 for Alternative 2. Given the higher cost of Alternative 2 and the lower overall benefit score, the additional cost to implement Alternative 2 is considered substantial and disproportionate to the (lack of) incremental benefit and as a result, Alternative 2 is determined to be impracticable, and is eliminated from further consideration. Therefore, Alternative 1 is considered permanent to the maximum extent practicable in accordance with MTCA and SMS rules and is the preferred alternative.

9.0 PREFERRED ALTERNATIVE

This section describes the preferred cleanup alternative for the Site. The final cleanup action will be determined by Ecology, presented in the Site CAP, and could vary from the preferred cleanup action described herein.

As presented in the DCA, Alternative 1 is considered permanent to the maximum extent practicable in accordance with MTCA and SMS rules and is the preferred alternative. This alternative uses the natural recovery processes of the marine environment to reduce risks to acceptable levels. These processes have been shown empirically to already be occurring at the Site.

The preferred alternative includes the following activities:

- Monitoring of the sediment surface through repeated bathymetric surveys. The results of these surveys will be compared to evaluate sedimentation rates and confirm that natural processes are resulting in the enhancement of substrate conditions in the biologically active zone.
- After the initial baseline bathymetric survey and sediment quality testing, repeated monitoring events would be conducted 2, 5, and 10 years after initiating the cleanup. It is anticipated that the already-observed natural recovery processes will continue, and the Site will be demonstrated through testing to meet cleanup standards within 6–8 years. However, as a conservative measure, this FS assumes monitoring may need to be repeated in years 15 and 20 as a contingent measure.
- Institutional controls will be implemented in cooperation with Ecology and with input from other project stakeholders and landowners to effectively limit property usages to those that are consistent with attaining and maintaining cleanup standards. Primarily, this would include limitations on dredging or anchoring activities that would disturb the sediment surface. Anchoring is not anticipated, nor is maintenance dredging because the sediment cleanup unit requiring remediation is outside the existing navigational channel and the current depth to mudline in the channel is approximately equal to the permissible navigation channel elevation. If Site use were to change and channel deepening through dredging became necessary, it could be conducted but would require collaboration with Ecology to ensure it is conducted properly and does not interfere with the cleanup.

In addition to these planned activities, a contingent action has been identified if compliance monitoring indicates MNR is not attaining cleanup standards in a reasonable time frame. The primary contingent action would be emplacement of a recovery layer, similar to what is identified as Alternative 2 herein (i.e., EMNR).

In addition to being selected through the DCA process as the preferred remedy, MNR appears to be appropriately scaled for the relatively low level of contamination observed at the Site and minor impacts on the benthic community. In fact, under the traditional application of SCUM II guidance, an evaluation of sediment cleanup alternatives would not be warranted based on the RI bioassay analysis data, because those results passed the CSL (Ecology 2017). Also, as mentioned above, Alternative 1 builds on the natural recovery process already occurring, which when paired with source control (cessation of grit material releases), is anticipated to provide a comprehensive and timely Site restoration.

10.0 USE OF THIS REPORT

This document has been prepared for the use of Tru-Grit for specific application to the subject cleanup site. The reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the Pacific Northwest under similar conditions as this project. We make no other warranty, either express or implied.

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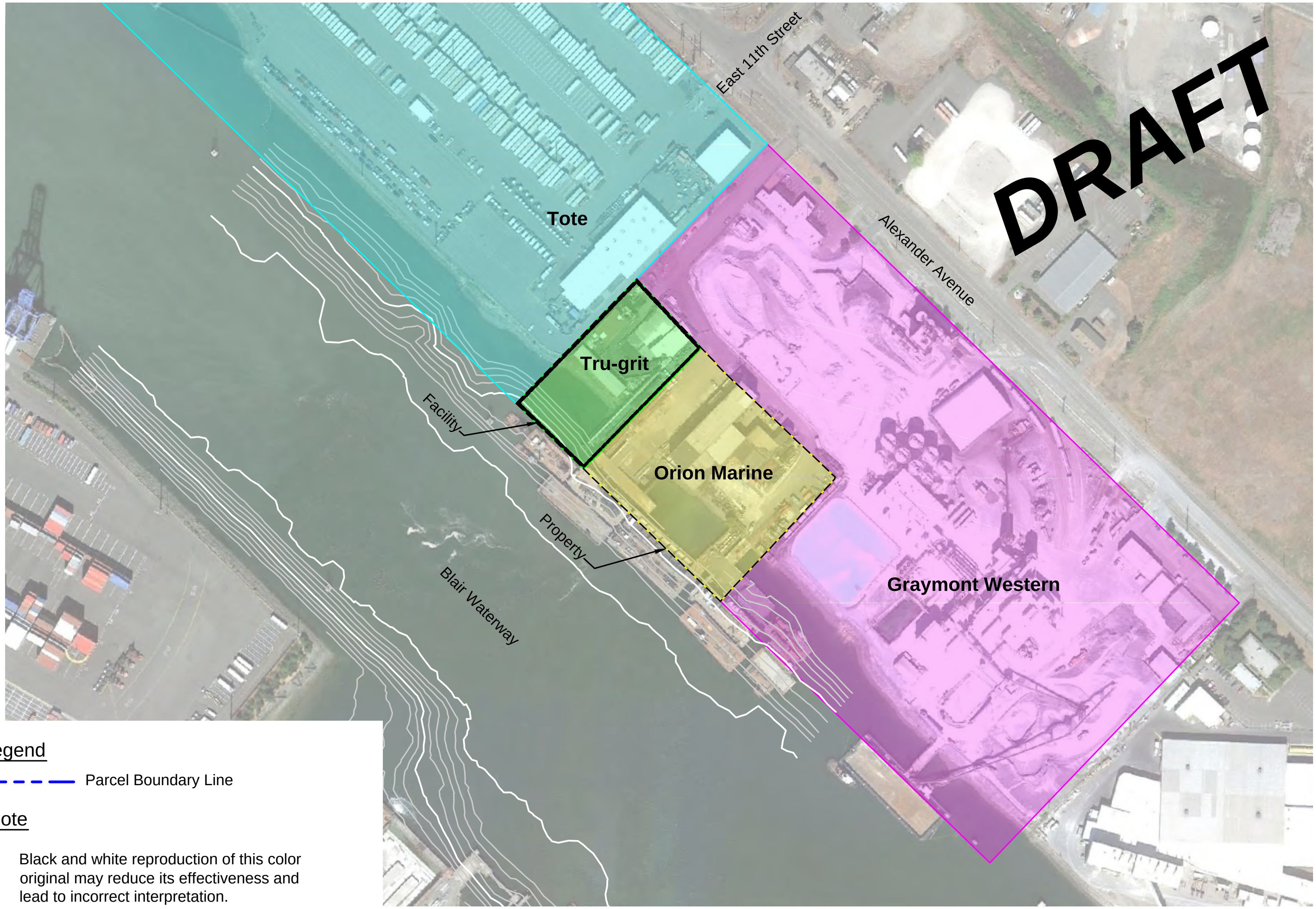
Data Source: Esri 2012

G:\Projects\241\008\010\014\RIFS 2014 R2\F01VicMap.mxd 9/26/2014 NAD 1983 StatePlane Washington North FIPS 4601 Feet

LANDAU ASSOCIATES	Tru-Grit Site Tacoma, Washington	**Vicinity Map**	Figure 1



Legend

Parcel Boundary Line

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Google Earth Pro 2010

0 300 600
Scale in Feet

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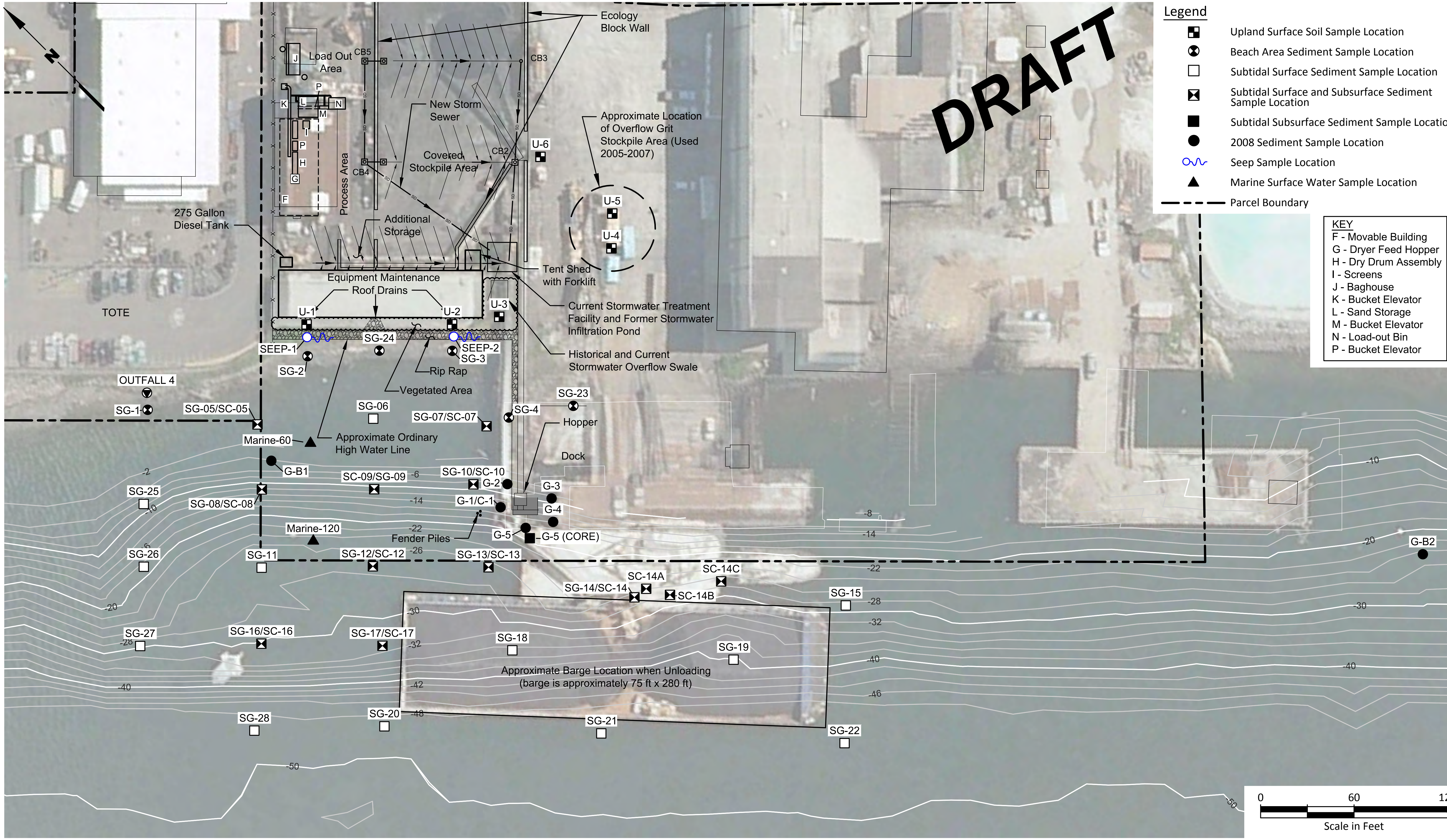
Tru-Grit Site
Tacoma, Washington

Facility and Adjacent Properties

Figure
2



Source: Google Earth Pro 2010; Aerial dated 04-30-2009

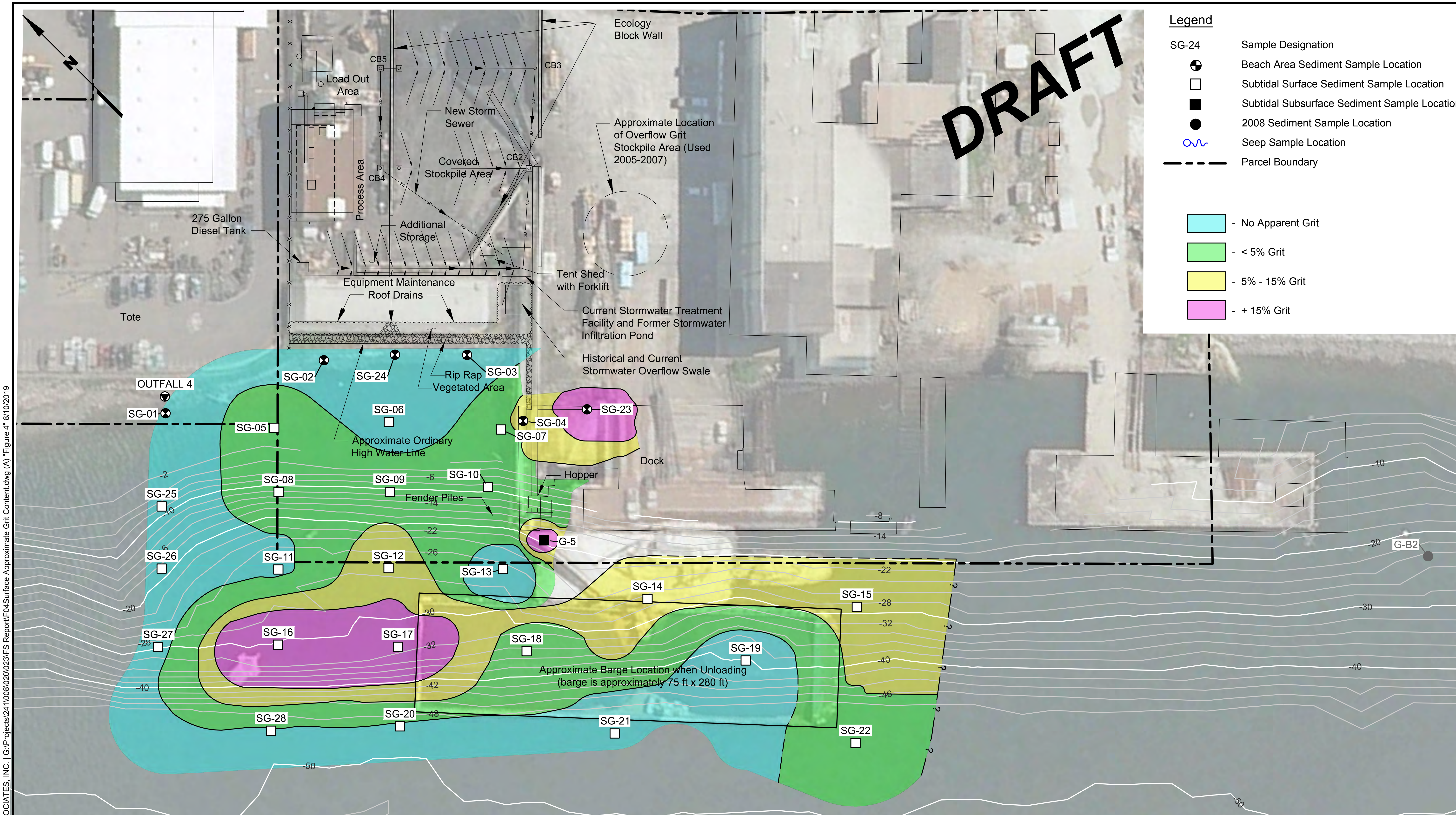
Landau Associates | G:\Projects\241\008\020\023\FS Report\F03SitePlanRISampleLocations.dwg | 8/10/2019 3:37 PM

Notes

1. Samples G-5, SG-14, SG-16, and SG-17 were collected in 2008/2009 and 2018. 2018 samples were collected within 10-ft of the 2008/2009 sample locations.
2. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

LANDAU ASSOCIATES

Tru-Grit Site Tacoma, Washington	**Site Plan and RI Sample Locations**	Figure 3



LANDAU ASSOCIATES, INC. | G:\Projects\241\008\020\023\FS Report\F04Surface Approximate Grit Content.dwg (A) "Figure 4" 8/10/2019

Notes
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Google Earth Pro 2010; Aerial dated 04-30-2009

Landau Associates

Tru-Grit Site
Tacoma, Washington

Surface Sediment Approximate Grit Content

Figure 4

G:\Projects\241\008\020\023\FS Report\F05SurfaceSedimentsAnalyticalResults.mxd 8/10/2019

Notes
1. Samples G-5, SG-14, SG-16, and SG-17 were collected in 2008/2009 and 2018. 2018 samples were collected within 10-ft of the 2008/2009 sample locations.
2. *Full SMS list analyzed at these locations.
3. Preliminary screening level, equivalent to SMS sediment cleanup objective (SCO) protective of the benthic community.
4. PG = Polychaete Growth
   AM = Amphipod Mortality
   LD = Larval Development
5. All results shown in mg/kg.
6. Red text indicates concentrations is greater than the preliminary screening level.
7. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Legend
- Beach Area Sediment Sample Location
- Subtidal Surface Sediment Sample Location with Bioassay Analysis
- Outfall
- Sediment Sampling Location
- Subtidal Subsurface Sediment Sample Location
- Subtidal Surface Sediment Sample Location
- Tax Parcels

G-5 (8.9,1390,3400) 2008/2009 Analytical Data (Arsenic,Copper,Zinc)
G-5 (11,120,390) 2018 Analytical Data (Arsenic,Copper,Zinc)

AM PG LD
- Pass SCO and CSL
- SCO Fail

Preliminary Screening Levels

Arsenic	Copper	Zinc
57	390	410

0 60 120
Scale in Feet

Data Sources: Pierce County GIS; Esri World Imagery.

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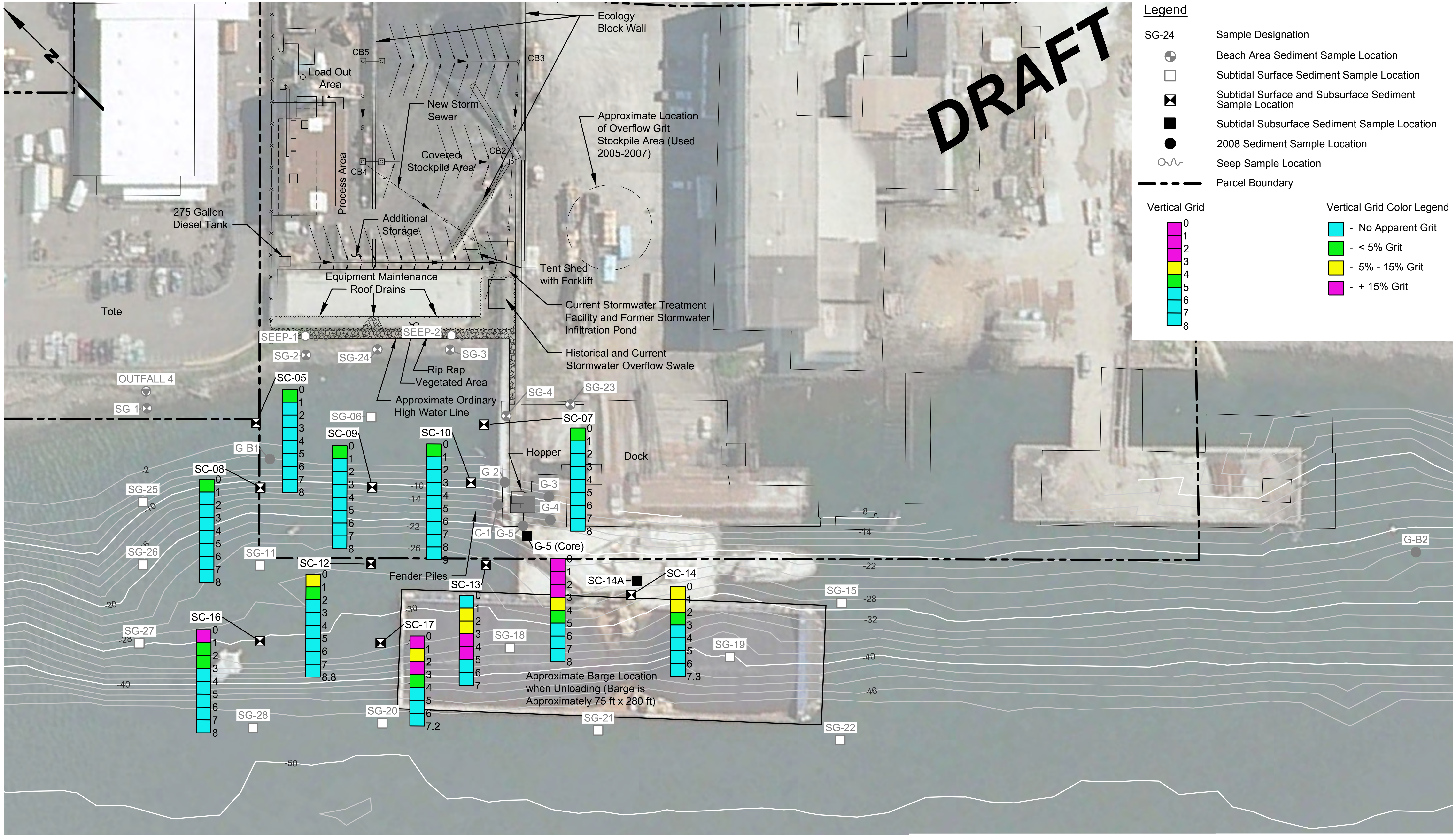
Tru-Grit Site
Tacoma, Washington

Surface Sediment Analytical and Bioassay Results

Figure 5



Source: Google Earth Pro 2010; Aerial dated 04-30-2009

Note
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Grit content in 0-1 ft interval taken from co-located surface sediment samples.

0 60 120
Scale in Feet

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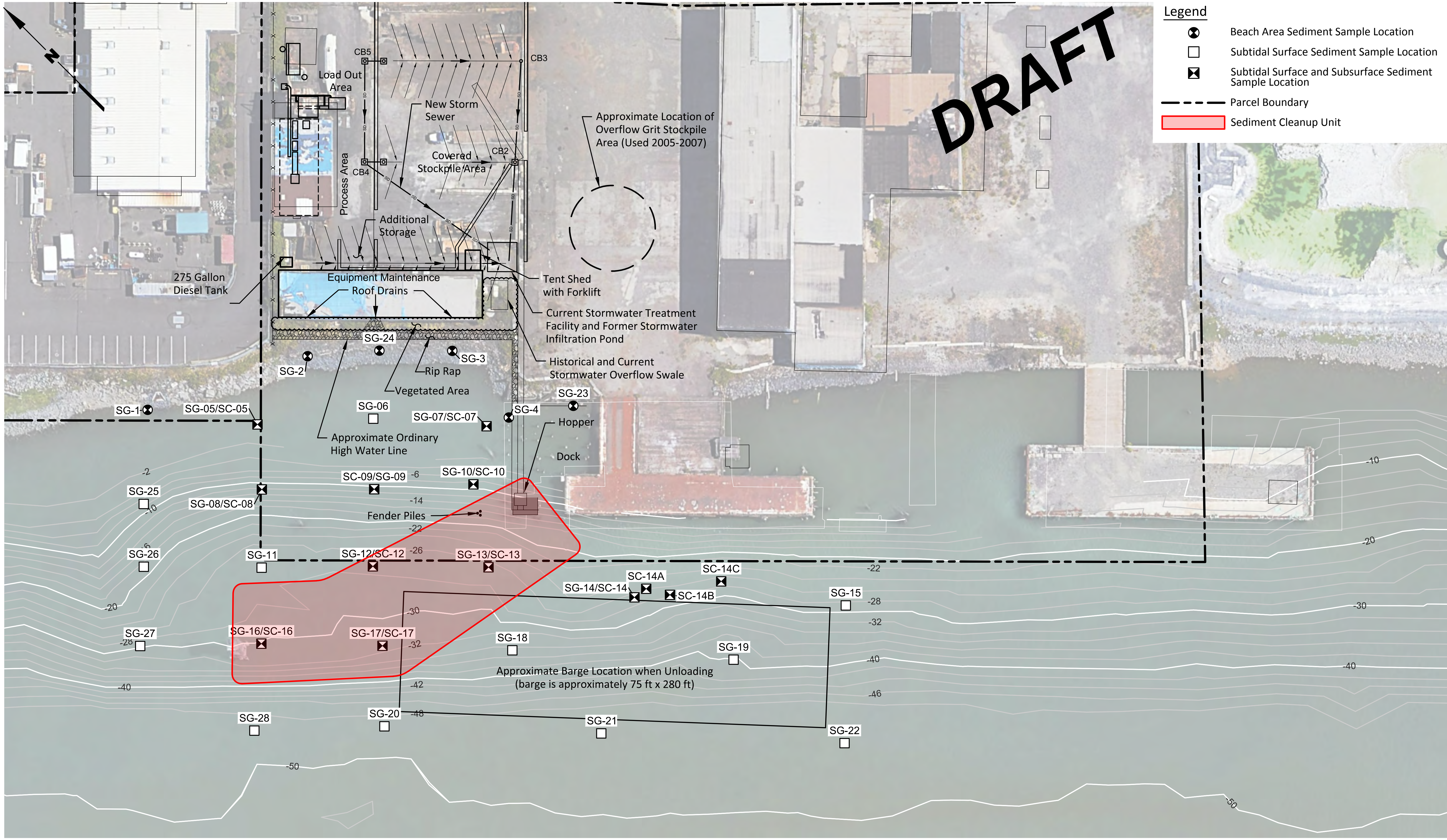
Tru-Grit Site
Tacoma, Washington

Subsurface Sediment Approximate Grit Content

Figure 6

LANDAU ASSOCIATES, INC. | G:\Projects\241\008\020\023\FS Report\F06Subsurface Approximate Grit Content.dwg (A) "Figure 6" 8/10/2019



Legend

- Beach Area Sediment Sample Location
- Subtidal Surface Sediment Sample Location
- Subtidal Surface and Subsurface Sediment Sample Location
- Parcel Boundary
- Sediment Cleanup Unit

Source: ©Google Earth Pro, 2019; Aerial dated 05-26-2018

0 60 120
Scale in Feet

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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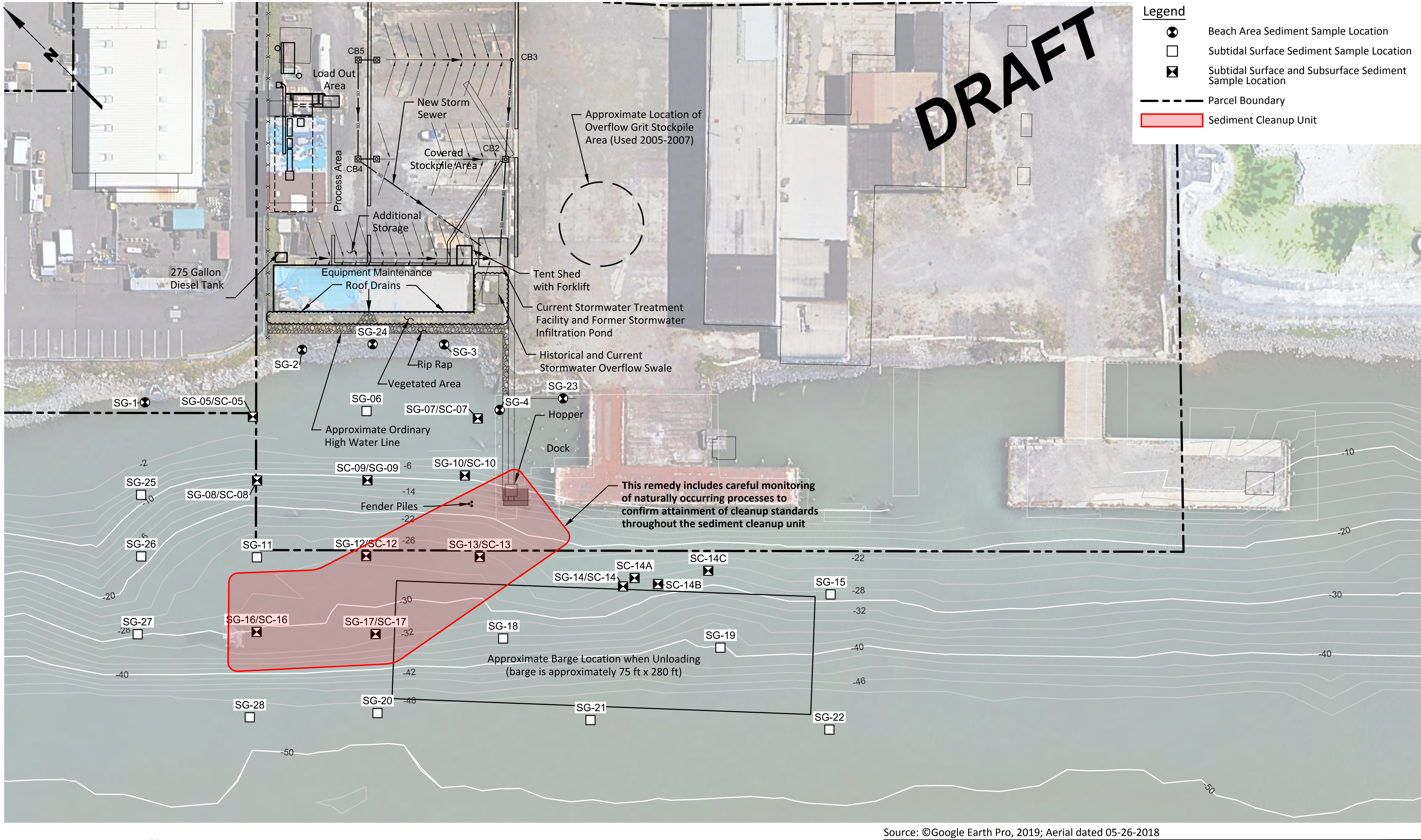
Tru-Grit Site
Tacoma, Washington

Sediment Cleanup Unit

Figure 7



Landau Associates | G:\Projects\241\008\020\023\FS Report\F07-F10AreaReqCleanup.dwg | 8/28/2019 9:39 AM

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

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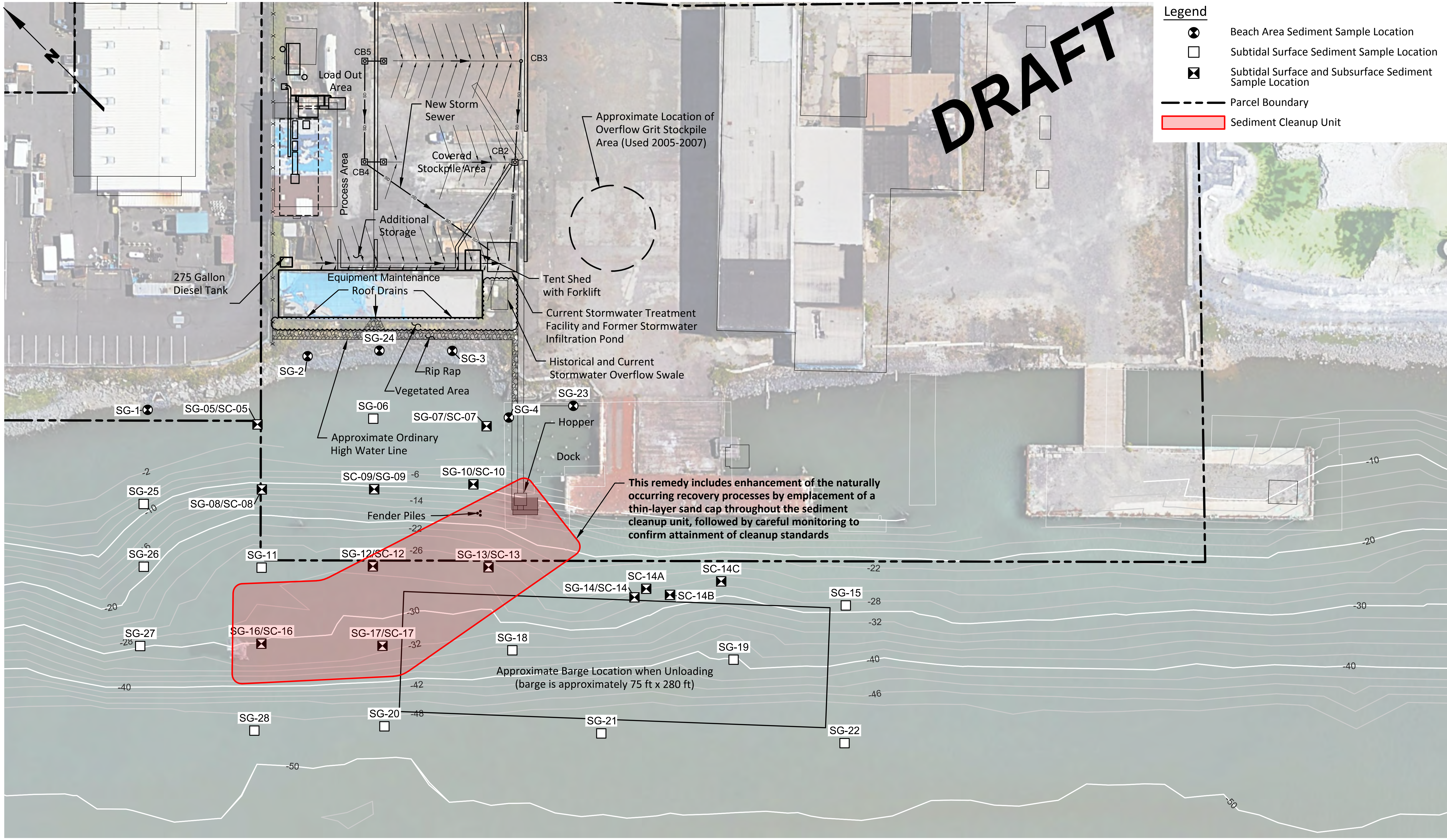
Tru-Grit Site
Tacoma, Washington

Remedial Alternative 1
Monitored Natural Recovery

Figure
8



Landau Associates | G:\Projects\241\008\020\023\FS Report\F07-F10AreaReqCleanup.dwg | 8/28/2019 9:39 AM

Source: ©Google Earth Pro, 2019; Aerial dated 05-26-2018

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 60 120

Scale in Feet

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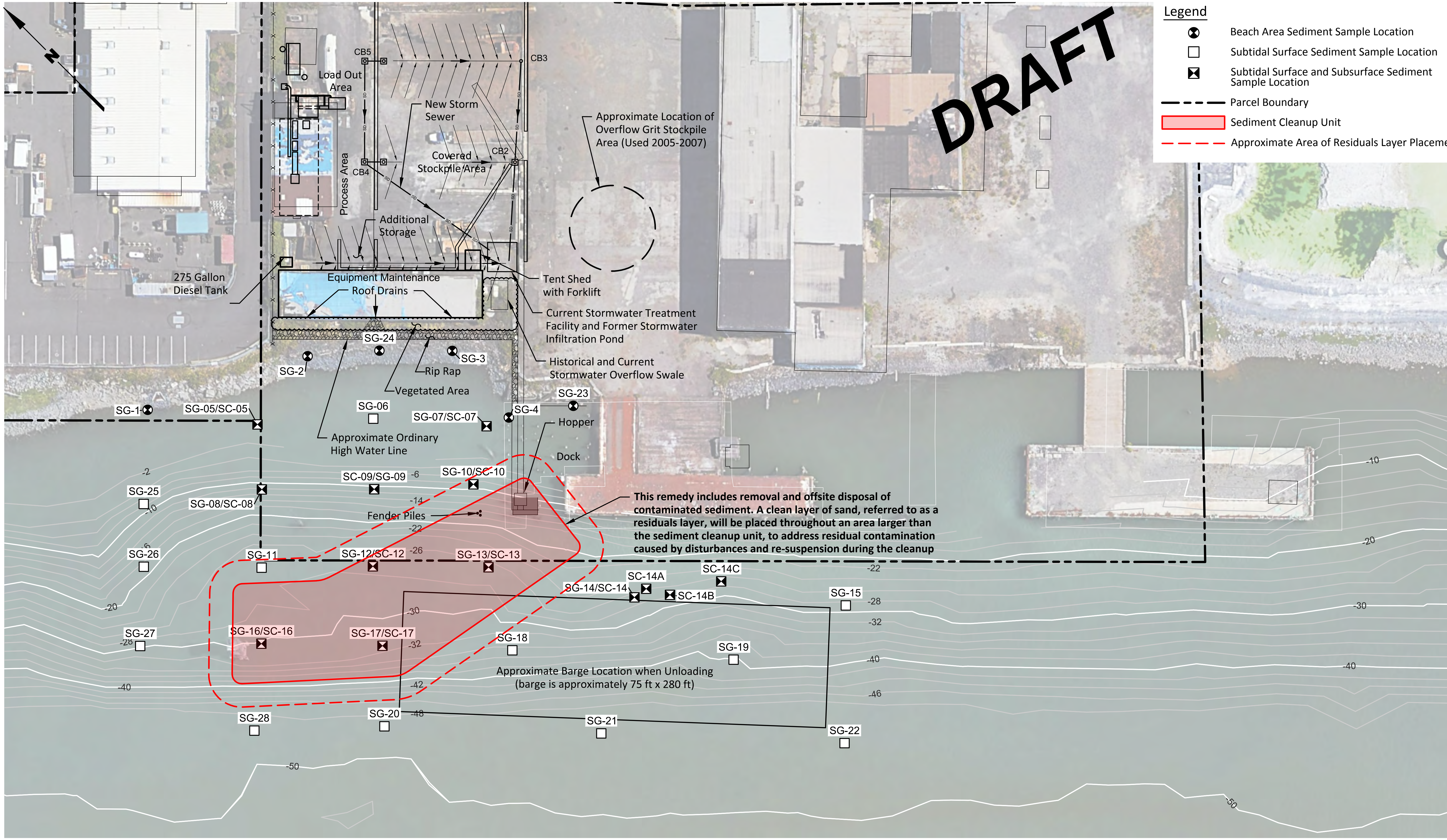
Tru-Grit Site
Tacoma, Washington

Remedial Alternative 2
Enhanced Monitored Natural Recovery

Figure
9



Source: ©Google Earth Pro, 2019; Aerial dated 05-26-2018

Notes

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

0 60 120

Scale in Feet

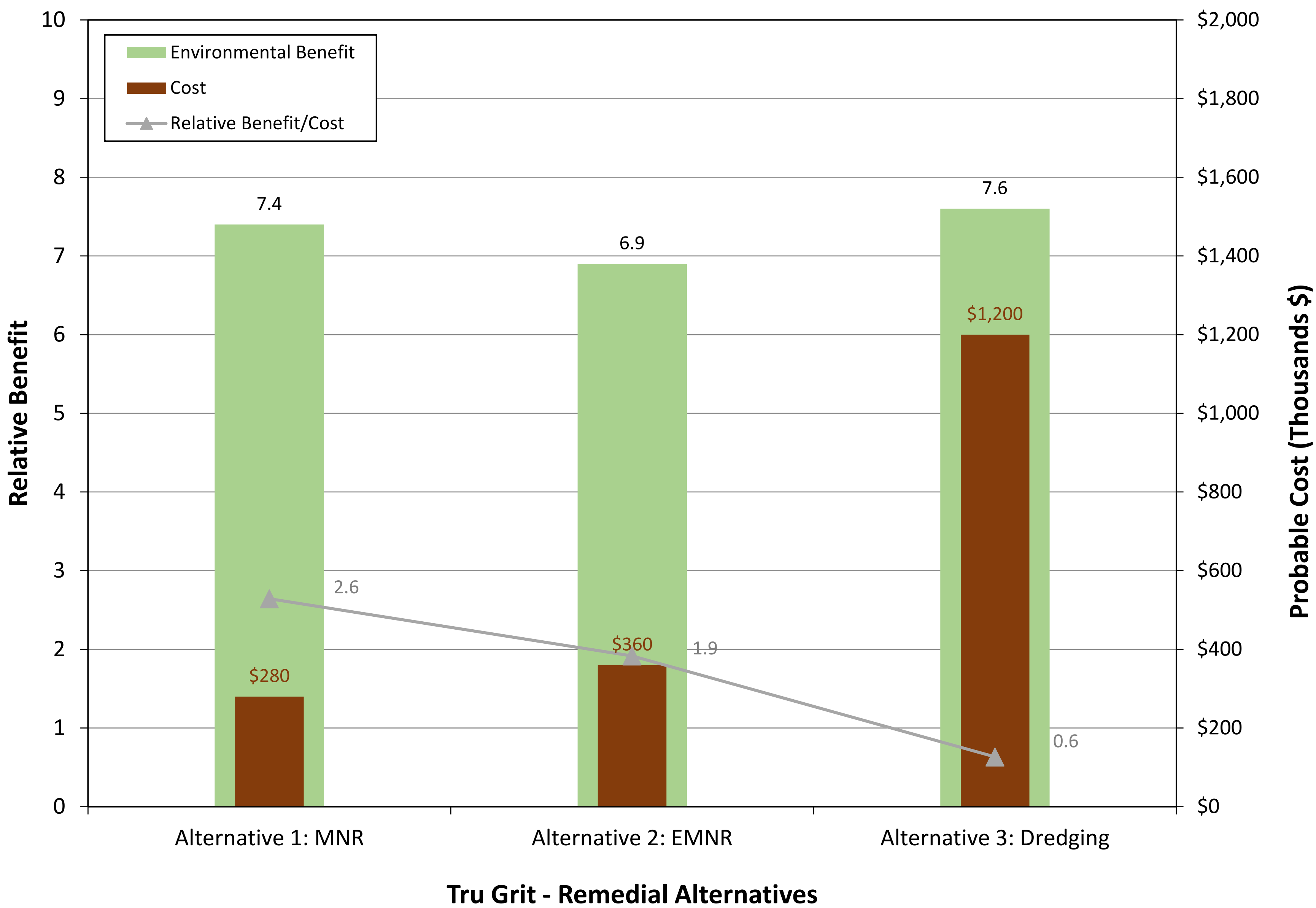
LANDAU ASSOCIATES

Tru-Grit Site
Tacoma, Washington

Remedial Alternative 3
Dredging and Offsite Disposal

Figure
10

Landau Associates | G:\Projects\241\008\020\023\FS Report\F07-F10AreaReqCleanup.dwg | 8/28/2019 9:40 AM



Landau Associates

Tru-Grit Site
Tacoma, Washington

Disproportionate Cost Analysis

Figure
11

Table 1
Indicator Hazardous Substances and Preliminary Cleanup Levels
Tru-Grit Site
Tacoma, Washington

Indicator Hazardous Substance	SCO WAC 173-204	CSL WAC 173-204
Metals	mg/kg - dry weight	mg/kg - dry weight
Arsenic	57	93
Copper	390	390
Zinc	410	960

Notes:
Grey shading indicates the preliminary cleanup level.
Marine sediment cleanup objectives set forth in WAC 173-204-562, unless otherwise indicated.
Dry weight equivalent criteria are based on the Puget Sound Apparent Effect Threshold Values (Barrick et al. 1988)

Acronyms/Abbreviations:
CSL = Cleanup Screening Levels
mg/kg = milligrams per kilogram
SCO = Sediment Cleanup Objectives
WAC = Washington Administrative Code

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Table 2
Summary of Cleanup Alternatives and Disproportionate Cost Analysis Ranking
Tru Grit
Tacoma, Washington

Alternative	Alternative 1. Monitored Natural Recovery (MNR)	Alternative 2. Enhanced Monitored Natural Recovery (EMNR)	Alternative 3. Sediment Dredging and Off-Site Disposal
Alternative Description	This alternative leverages natural sediment recovery processes of the marine environment to reduce risks to acceptable levels. Source control operations are complete and natural recovery processes are already occurring. Performance and compliance monitoring will demonstrate through physical, chemical, and biological testing that sediment quality conditions are improving. Monitoring will also confirm that the recovery process is capable of achieving and maintaining cleanup standards. Contingency measures will be implemented if monitoring results indicate that natural recovery processes are not sufficient to achieve and maintain cleanup standards.	This alternative enhances the naturally occurring sediment recovery mechanisms by applying a thin-layer sediment cap to the affected area in order to reduce site risks and attain compliance with cleanup standards. A thin-layer cap can speed the recovery process by providing excess surface substrate. Natural recovery processes are already occurring; the application of a thin-layer cap is anticipated to bring the site into compliance with cleanup standards almost immediately. Long-term monitoring will be conducted to ensure cleanup standards are maintained. Contingency measures will be implemented if monitoring results indicate that an additional cap is required to maintain cleanup standards.	This alternative removes all surface and subsurface sediment exhibiting concentrations of grit material greater than 15 percent. Traditional mechanical dredging techniques will be used to remove material below the mudline. This alternative represents the most permanent cleanup alternative potentially implementable at the site. Large-scale dredging will achieve cleanup standards almost immediately, but will potentially have adverse impacts on the existing aquatic environment. Engineering controls and surface water quality monitoring will mitigate impacts during construction. The dredged area will be covered with a thin sand layer to contain the contaminated sediment residuals that can settle after dredging. Long-term monitoring will be conducted to ensure cleanup standards are maintained.
Individual Ranking Criteria			
1 Meets Remedial Action Objectives	Yes	Yes	Yes
2 Meets Minimum Requirements for Sediment Cleanup Actions [WAC 173-240-570]			
-Provides protection of human health and the environment	Yes	Yes	Yes
-Complies with cleanup standards specified under SMS	Yes	Yes	Yes
-Complies with applicable state and federal laws	Yes	Yes	Yes
-Provides for compliance monitoring	Yes	Yes	Yes
-Provides for public review	Yes	Yes	Yes
-Uses permanent solutions to maximum extent practicable	Yes	Yes	Yes
-Provides for a reasonable restoration time frame	Yes	Yes	Yes
3 Restoration Time Frame [WAC 173-340-360(2)(b)(ii) and WAC 173-340-360(4)]	6-8 Years	1-5 Years (following start of construction)	1-2 Years (following start of construction)
-Potential risk to human health and environment	Low	Low	Moderate
-Practicability of achieving shorter restoration time	Moderate	Moderate	Low
-Current use of site, surrounding area, and resources	Marine Industrial	Marine Industrial	Marine Industrial
-Future use of site, surrounding area, and resources	Marine Industrial	Marine Industrial	Marine Industrial
-Likely effectiveness/reliability of institutional controls	Moderately High	Moderately High	Not Applicable
-Ability to monitor migration of hazardous substances	High	High	High
-Toxicity of hazardous substances at the site	Low	Low	Low
-Natural processes that reduce concentrations	Yes	Yes	Yes
-Overall reasonable restoration time frame	Yes	Yes	Yes

4 Relative Benefits Ranking for DCA
[WAC 173-340-360(2)(b)(i) and WAC 173-340-36093)(f)]

Comparative Overall Benefit	Alt. 1 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score	Alt. 2 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score	Alt. 3 Comparative Benefit Rating	Score	Weighting Factor	Weighted Score
-Overall Protectiveness	Moderately High	7	0.3	2.1	Moderately High	7	0.3	2.1	High	8	0.3	2.4
-Permanence	Moderate Low	4	0.2	0.8	Moderately Low	4	0.2	0.8	High	10	0.2	2.0
-Manageability of Short-Term Risk	High	9	0.1	0.9	Moderately High	8	0.1	0.8	Moderate	5	0.1	0.5
-Long-Term Effectiveness	Moderately High	8	0.1	0.8	Moderately High	8	0.1	0.8	High	9	0.1	0.9
-Implementability	Moderately High	9	0.2	1.8	Moderately High	7	0.2	1.4	Moderately Low	4	0.2	0.8
-Consideration of Public Concerns	High	10	0.1	1.0	High	10	0.1	1.0	High	10	0.1	1.0
Overall Weighted Benefit Score				7.4				6.9				7.6

5 Disproportionate Cost Analysis	Alternative 1	Alternative 2	Alternative 3
Estimated remedy cost	$280,000	$360,000	$1,200,000
Most permanent alternative	No	No	Yes
Lowest cost alternative	Yes	No	No
Relative benefit/cost ratio*	2.6	1.9	0.63
Magnitude of relative benefit compared to most permanent alternative	97%	91%	- -
Magnitude of cost compared to lowest cost alternative	-	129%	429%
Costs disproportionate to incremental benefits	No	Yes	Yes
Remedy Permanent to the Maximum Extent Practicable?	Yes	No	No
Preferred Alternative	**Yes**	**No**	**No**

* Benefit-Cost Ratio scaled by $100,000 in order to compare ranges similar in scale to comparative overall benefit, as presented on Figure 11.

APPENDIX A

Remedial Alternative Cost Summaries

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Table A-1
Remedial Alternative Cost Estimate – Cleanup Alternative 1
Tru-Grit
Tacoma, Washington

Alternative 1: **Monitored Natural Recovery (MNR)**

Scope of Work: Develop and implement compliance monitoring program to track and document attainment of cleanup through naturally occurring processes. Implement institutional controls to limit property usage to those consistent with attainment and maintenance of cleanup standards.

Capital Cost Item	Unit	Qty.	Unit Cost	Cost	Notes
Capital Direct Costs					
Evaluation of Baseline Conditions					
Baseline Bathymetric Survey	LS	1	$19,000	$19,000	1
Subtotal for Capital Direct Costs				***$19,000***	
Capital Indirect Costs					
Engineering Design Report	LS	1	$20,000	$20,000	2
Compliance Monitoring Plans	LS	1	$8,000	$8,000	3,4
Project Management	%	8		$7,000	3,5
Permitting and Regulatory Compliance	%	8		$7,000	6
Ecology Oversight	%	2		$2,000	2
Implement Institutional Controls	LS	1	$10,000	$10,000	3
Estimate of Taxes	%	10.2		$9,000	7
Subtotal for Capital Indirect Costs				***$63,000***	
Subtotal for Capital Direct and Indirect Costs				***$82,000***	
Contingency for Capital Direct and Indirect Costs	%	20		***$16,000***	3
Total for Direct and Indirect Capital Costs				***$98,000***	

Operation and Maintenance	Unit	Qty.	Unit Cost	Present Worth	Notes
Compliance Monitoring and Reporting (Years 0, 2, 5, 10)					
Sediment Sampling	EA	4	$12,000	$42,000	8
Reporting and Data Management	EA	4	$10,000	$35,000	2
Bathymetric Survey	EA	4	$19,000	$67,000	9
Subtotal for Operation and Maintenance Costs				***$144,000***	
Contingency on Operation and Maintenance Costs	%	20		***$29,000***	3
Total for Operation and Maintenance Costs				***$173,000***	
PRESENT WORTH OF ALTERNATIVE 1				**$280,000**	10

Contingency Actions	Unit	Qty.	Unit Cost	Cost	Notes
Capital Direct Costs					
Placement of Recovery Layer (Contingent Action)					
Contractor Mobilization / Work Plans	LS	1	$25,000	$25,000	2,11
Placement of Recovery Layer	CY	430	$42	$18,000	12
Post-Construction Bathymetric Survey	LS	1	$19,000	$19,000	1
Sediment Sampling (Year 15 and 20)	EA	2	$12,000	$24,000	8
Reporting and Data Management (Year 15 and 20)	EA	2	$10,000	$20,000	2
Subtotal for Contingency Measures				***$106,000***	

Notes

1 Based on a 2019 quote provided by David Evans and Associates.
2 Cost estimates based on costs incurred from similar projects, estimates from experienced contractors, and/or professional judgment.
3 Estimated cost based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
4 Compliance monitoring plan will include preparation of the plans necessary to establish data quality objectives for collecting and evaluating bathymetry and sediment quality data.
5 Project management includes bid/contract administration, cost and performance reporting, planning and coordination.
6 In-water permitting is estimated at a higher percentage of capital costs than on-land work based on required coordination with US Army Corps of Engineers and Federal Services.
7 Combined sales tax: 6.5 % (Washington State) + 3.7 % (Tacoma) = 10.2 %
8 Includes coordination, labor, boat and operator, and laboratory analytical for five sample locations. Assumes all samples collected in 1 day of on-site work.
9 Assumes bathymetry survey on same frequency as sediment monitoring.
10 Present worth value calculated assuming a 3% discount rate. Present worth value rounded to two significant digits.
11 Includes moving equipment and personnel on and off Site, establishing work zones, preparing contractor work plans, etc.
12 Area of recovery layer is approximately 16,000 SF; sand cap thickness is 6 inches.

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

Abbreviations

% = percent
CY = cubic yard
EA = each
EMNR = enhanced monitored natural recovery
EPA = US Environmental Protection Agency
FS = feasibility study
LS = lump sum
MNR = monitored natural recovery
SF = square feet

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Table A-2
Remedial Alternative Cost Estimate – Cleanup Alternative 2
Tru-Grit
Tacoma, Washington

Alternative 2: **Enhanced Monitored Natural Recovery (EMNR)**

Scope of Work:
Pre-design investigation to determine particle sizing and thickness of recovery layer.
Place recovery layer over sediment with grit percentage observed above 15% during the RI.
Perform baseline and follow-up bathymetric surveys to evaluate scour and transport of recovery layer.
Conduct compliance monitoring to document recovery processes and confirm attainment of cleanup standards.
Implement institutional controls.

Capital Cost Item	Unit	Qty.	Unit Cost	Cost	Notes
Capital Direct Costs					
Evaluation of Baseline Conditions					
Baseline Bathymetric Survey	LS	1	$19,000	$19,000	1
Construction of Recovery Layer					
Contractor Mobilization / Work Plans	LS	1	$25,000	$25,000	2,3
Placement of Recovery Layer	CY	300	$42	$13,000	4
Post-Construction Bathymetric Survey	LS	1	$19,000	$19,000	1
Subtotal for Capital Direct Costs				***$76,000***	
Capital Indirect Costs					
Engineering Design Report	LS	1	$25,000	$25,000	2
Remedial Design	LS	1	$20,000	$20,000	5,6
Project Management	%	8		$14,000	5,7
Permitting and Regulatory Compliance	%	8		$14,000	8
Ecology Oversight	%	2		$3,000	2
Implement Institutional Controls	LS	1	$10,000	$10,000	3
Estimate of Taxes	%	10.2		$17,000	9
Subtotal for Capital Indirect Costs				***$103,000***	
Subtotal for Capital Direct and Indirect Costs				***$179,000***	
Contingency for Capital Direct and Indirect Costs	%	25		***$45,000***	5
Total for Direct and Indirect Capital Costs				***$224,000***	

Operation and Maintenance	Unit	Qty.	Unit Cost	Present Worth	Notes
Compliance Monitoring and Reporting (Years 0, 2, 5)					
Sediment Sampling	EA	3	$12,000	$33,000	10
Reporting and Data Management	EA	3	$10,000	$27,000	2
Bathymetric Survey	EA	3	$19,000	$52,000	1
Subtotal for Operation and Maintenance Costs				***$112,000***	
Contingency on Operation and Maintenance Costs	%	20		***$22,000***	5
Total for Operation and Maintenance Costs				***$134,000***	
PRESENT WORTH OF ALTERNATIVE 2				**$360,000**	12

Contingency Actions	Unit	Qty.	Unit Cost	Cost	Notes
Capital Direct Costs					
Maintenance or Repair of Recovery Layers (Contingent Action)					
Contractor Mobilization / Work Plans	LS	1	$25,000	$25,000	2,3
Placement of Recovery Layer	CY	150	$42	$6,000	11
Post-Construction Bathymetric Survey	LS	1	$19,000	$19,000	1
Sediment Sampling (Years 10 and 15)	EA	2	$12,000	$24,000	10
Reporting and Data Management (Years 10 and 15)	EA	2	$10,000	$20,000	2
Subtotal for Contingency Measures				***$94,000***	

Notes

1 Based on a 2019 quote provided by David Evans and Associates.
2 Cost estimates based on costs incurred from similar projects, estimates from experienced contractors, and/or professional judgment.
3 Includes moving equipment and personnel on and off Site, establishing work zones, preparing contractor work plans, etc.
4 Area of recovery layer is approximately 16,000 SF; sand cap thickness is 6 inches.
5 Estimated cost based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000.
6 Remedial design includes preparation of construction plans and specifications for dredging, preparation of engineer's estimate of probable cost, and bidding support.
7 Project management includes bid/contract administration, cost and performance reporting, planning and coordination.
8 In-water permitting is estimated at a higher percentage of capital costs than on-land work based on required coordination with US Army Corps of Engineers and Federal Services.
9 Combined sales tax: 6.5 % (Washington State) + 3.7 % (Tacoma) = 10.2 %
10 Includes coordination, labor, boat and operator, and laboratory analytical for 5 sample locations. Assumes all samples collected in one day of on-site work.
11 Assumes approximately half of the sediment cleanup unit would need recovery layer maintenance or repair.
12 Present worth value calculated assuming a 3% discount rate. Present worth value rounded to two significant digits.

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

Abbreviations
% = percent
CY = cubic yard
EA = each
EMNR = enhanced monitored natural recovery
EPA = US Environmental Protection Agency
FS = feasibility study
LS = lump sum
MNR = monitored natural recovery
RI = remedial investigation
SF = square feet

Table A-3
Remedial Alternative Cost Estimate – Cleanup Alternative 3
Tru-Grit
Tacoma, Washington

Alternative 3: **Sediment Dredging and Off-Site Disposal**

Scope of Work:
Evaluate conditions of existing infrastructure (bulkheads, pilings, docs, etc.) to determine suitability for nearby dredging.
Remove contaminated material (identified by grit presence at greater than 15% during the RI).
Dispose of dredging spoils at an off-site location.
Place residuals layer (6-inch layer of sand) extending laterally beyond sediment cleanup unit by 20%.
Implement compliance monitoring to demonstrate attainment of cleanup standards.

Capital Cost Item	Unit	Qty.	Unit Cost	Cost	Notes
Capital Direct Costs -					
Contractor Mobilization					
Contractor Mobilization / Demobilization	LS	1	$75,000	$75,000	1,2
Dredging of Material with Grit Percentage Above 15%					
Pre-Construction Bathymetric Survey	LS	1	$19,000	$19,000	3
Sediment Dredging and Handling	CY	1,800	$37	$67,000	1,4
Dewatering, Water Treatment, and Disposal	LS	1	$40,000	$40,000	1
Sediment Transportation and Disposal	TON	2,700	$65	$176,000	1,5
Placement of Residuals Layer (6-inch layer of sand)	CY	400	$42	$17,000	6
Water Quality Monitoring During Construction	LS	1	$20,000	$20,000	1
Post-Construction Bathymetric Survey and Compliance Monitoring	LS	1	$31,000	$31,000	3,7
Subtotal for Capital Direct Costs				***$445,000***	
Capital Indirect Costs -					
Existing Marine Infrastructure Evaluation and Report	LS	1	$60,000	$60,000	8
Engineering Design Report	LS	1	$75,000	$75,000	1
Remedial Design	%	12		$53,000	9,10
Project Management	%	6		$54,000	9,11
Construction Management	%	8		$36,000	9,12
Construction Completion Report	LS	1	$60,000	$60,000	1
Permitting and Regulatory Compliance	%	8		$36,000	13
Ecology Oversight	%	2		$18,000	3
Estimate of Taxes	%	10.2		$45,000	14
Subtotal for Capital Indirect Costs				***$437,000***	
Subtotal for Capital Direct and Indirect Costs				***$882,000***	
Contingency for Capital Direct and Indirect Costs	%	30		***$265,000***	9
Total for Direct and Indirect Capital Costs				***$1,147,000***	

Operation and Maintenance - Tru Grit	Unit	Qty.	Unit Cost	Present Worth	Notes
Compliance Monitoring and Reporting (Years 2 and 5)					
Sediment Sampling	EA	4	$12,000	$22,000	7
Reporting and Data Management	EA	4	$10,000	$18,000	1
Bathymetric Survey	EA	4	$19,000	$34,000	15
Subtotal for Operation and Maintenance Costs				***$74,000***	
Contingency on Operation and Maintenance Costs	%	20		***$15,000***	9
Total for Operation and Maintenance Costs				***$89,000***	
PRESENT WORTH OF ALTERNATIVE M-3 - Tru Grit				**$1,200,000**	16

Notes

1 Cost estimates based on costs incurred from similar projects, estimates from experienced contractors, and/or professional judgment.
2 Includes moving equipment and personnel on and off Site, establishing work zones and transloading facilities, temporary fencing, and preparing contractor work plans.
3 Based on a 2019 quote provided by David Evans and Associates.
4 Assumes a total dredging depth of 3 ft over 16,000 SF of area. Includes use of silt curtains to limit migration of suspended solids.
5 Assumes material hauled by truck to Intermodal Transfer Station, and disposed of at Subtitle D facility.
6 Area of residuals cover is approximately 16,000 SF + 20% additional area laterally; thickness is 6 inches.
7 Includes coordination, labor, boat and operator, and laboratory analytical for 5 sample locations. Assumes all samples collected in one day of on-site work.
8 Assumes pre-design investigation activities include evaluating piling, dock, or bulkhead conditions to determine if nearby dredging is feasible. Report will be prepared to document conditions and recommend next steps.
9 Estimated cost based on: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002, OSWER 9355.0-75, July 2000. Capital indirect costs based on percentages of direct capital costs have been increased by 3% to account for applying the increased regulatory and engineering complexity for in-water design and construction.
10 Remedial design includes preparation of construction plans and specifications for dredging, preparation of engineer's estimate of probable cost, and bidding support.
11 Project management includes bid/contract administration, cost and performance reporting, planning and coordination.
12 Construction management includes submittal review, change order review, design modifications, and construction schedule tracking.
13 In-water permitting is estimated at a higher percentage of capital costs than on-land work based on required coordination with US Army Corps of Engineers and Federal Services.
14 Combined sales tax: 6.5 % (Washington State) + 3.7 % (Tacoma) = 10.2 %
15 Assume bathymetry survey on same frequency as sediment monitoring.
16 Present worth value calculated assuming a 3% discount rate. Present worth value rounded to two significant digits.

Costs presented in this FS are considered to have a relative accuracy within the range of -30 to +50 percent, as shown above, and should be used primarily as a basis for comparison of costs between alternatives. More exact costs will be developed during the design and implementation phases of the cleanup.

Abbreviations

% = percent
CY = cubic yard
EA = each
EPA = US Environmental Protection Agency
FS = feasibility study
GAL = gallon
IHS = indicator hazardous substance
LAI = Landau Associates, Inc.
LS = lump sum
O&M = operations and maintenance
SF = square foot / square feet