Draft Final

Design Basis Report
Installation Restoration Sites 7 and 18
Parcel B

Hunters Point Shipyard
San Francisco, California

May 29, 2009

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared by:
ChaduxTt, A Joint Venture of St. George Chadux Corp. and Tetra Tech EM Inc.
1230 Columbia Street, Suite 1000
San Diego, California 92101

Prepared under:
Naval Facilities Engineering Command
Contract Number N62473-04-D-3213
Contract Task Order 0019

CHAD-3213-0019-0022

Draft Final

Design Basis Report
Installation Restoration Sites 7 and 18
Parcel B
Hunters Point Shipyard
San Francisco, California

Contract Number N62473-04-D-3213
Contract Task Order 0019

Prepared for:

DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

Project Manager:	Timothy E. Mower Tim Mower, ChaduxTt	Date: May 29, 2009
Project Engineer:	(sign on Final) Stephen Fisher, ChaduxTt	Date: May 29, 2009

TABLE OF CONTENTS

Appendix

ATTACHMENTS

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BCDC	San Francisco Bay Conservation and Development Commission
bcy	Bank cubic yards
bgs	Below ground surface
BMP	Best management practice
Caltrans	California Department of Transportation
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic feet per second
COC	Chemical of concern
DBR	Design basis report
DTSC	Department of Toxic Substances Control
fps	Feet per second
FS	Feasibility study
HHRA	Human health risk assessment
HPS	Hunters Point Shipyard
IR	Installation Restoration
lcy	Loose cubic yards
LLRW	Low-level radioactive waste
LUC	Land use control
MHHW	Mean higher high water
MLLW	Mean lower low water
MPE	Maximum probabilistic earthquake
mph	Miles per hour
msl	Mean sea level
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operation and maintenance
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
psf	Pounds per square foot
PVC	Polyvinyl chloride

RD	Remedial design
ROD	Record of decision
SLERA	Screening-level ecological risk assessment
SVOC	Semivolatile organic compound
TCRA	Time-critical removal action
TMSRA	Technical Memorandum in Support of a ROD Amendment
TSP	Task specific plan
VOC	Volatile organic compound
W_{50}	Average weight
yd^3	Cubic yard

EXECUTIVE SUMMARY

This design basis report presents the selected remedy to protect human health and the environment from actual or threatened releases of pollutants, chemicals, or hazardous substances at Installation Restoration (IR) Sites 7 and 18 at Parcel B at Hunters Point Shipyard (HPS) in San Francisco, California. This report develops the design for the remedy selected in the amended record of decision for Parcel B to protect human health and the environment from chemicals of concern (COC) in soil, shoreline sediment, and groundwater. The selected remedy includes a soil cover and shoreline revetment to provide a physical barrier to prevent human and ecological contact with COCs.

IR Sites 7 and 18 are located on the northwestern corner of HPS. The sites cover about 14 acres; IR Site 7 includes a shoreline of approximately 950 feet along San Francisco Bay. HPS has been owned by the U.S. Navy since about 1939. Although most of the expansion of Parcel B had been completed before 1946, much of the land area of IR Sites 7 and 18 was created during the 1950s and 1960s.

The COCs in soil at IR Sites 7 and 18 include metals, volatile organic compounds, semivolatile organic compounds, pesticides, polychlorinated biphenyls (PCB), and radionuclides. COCs in sediment along the shoreline at IR Site 7 include metals, pesticides, PCBs, polycyclic aromatic hydrocarbons, and radionuclides. The primary risk to human health and the environment from these COCs is through direct contact with the soil or sediment, or through external radiation for radionuclides. The remedial design developed in this report includes a soil cover to prevent exposure and a revetment that will prevent contact with shoreline sediment and prevent wave action from eroding sediment and transporting it into the bay. The selected remedy does not include active treatment of groundwater; therefore, this report does not present any design components related to groundwater. However, groundwater monitoring is part of the selected remedy, and details of the proposed strategy for monitoring are included in the remedial action monitoring plan (also contained in this binder).

This design basis report is one component of the overall remedial design (RD) for IR Sites 7 and 18. The other components include a land use control RD, a remedial action monitoring plan for groundwater and methane, an operation and maintenance plan, and an engineer's opinion of probable cost. These other components of the RD are also included in this binder with this report.

1.0 INTRODUCTION

The Navy is implementing the remedy identified in the amended record of decision (ROD) for Parcel B (ChaduxTt 2009) at Installation Restoration (IR) Program Sites 7 and 18 at Parcel B at Hunters Point Shipyard (HPS). This design basis report (DBR) develops the design for the selected remedy, a soil cover and shoreline revetment, to protect human health and the environment from chemicals of concern (COC) in soil, shoreline sediment, and groundwater. The document was developed and the remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan.

The remedy selected in the amended ROD protects the public health and welfare and the environment from actual or threatened releases of pollutants, chemicals, or hazardous substances from soil, shoreline sediment, and groundwater at IR Sites 7 and 18. The selected remedy was based on the following:

- Site histories
- Field investigations
- Laboratory analytical results
- Evaluation of potential human health and ecological risks
- Current and reasonably anticipated future land use
- The 1997 Parcel B ROD

The Navy prepared the amended ROD for Parcel B because the Navy concluded that the remedy selected in the 1997 ROD needed to be amended to be protective of human health and the environment in the long term and that the proposed amendments to the remedy would fundamentally alter its basic features. The original remedy for soil involved excavation and off-site disposal; however, this strategy was unable to achieve cleanup goals across Parcel B, including IR Sites 7 and 18. The widespread distribution of metals, especially arsenic and manganese, in soil was the primary obstacle to this strategy. The amended remedy incorporates covers for the remaining soil containing hazardous substances to prevent exposure. Likewise, groundwater contamination was found to be more widespread (in areas outside of IR Sites 7 and 18) and at higher concentrations than was known when the original remedy for groundwater was selected. The original remedy relied on monitoring; the amended remedy includes active treatment of groundwater for selected areas outside of IR Sites 7 and 18. Only groundwater monitoring is proposed for IR Sites 7 and 18. Finally, the original remedy did not address radiological contaminants, and the amended remedy incorporates actions to address radioactive chemicals found in soil and structures at Parcel B.

This document describes the remedial design (RD) for the selected remedy the Navy will implement at IR Sites 7 and 18. Appendices and figures, referenced in this report follow Section 4.0. Attachments included with this report are Design Construction Drawings (Attachment 1), Construction Specifications (Attachment 2), and the Stability Evaluation Report (Attachment 3).

The DBR is one of several components that describe the selected remedy and its implementation. Other directly related documents are the land use control remedial design, the remedial action monitoring plan for groundwater and methane, the operation and maintenance (O&M) plan, and an engineer's opinion of probable cost. These documents are included in the same binder with this DBR. Other related documents include future transfer documents, such as a Covenant to Restrict Use of Property and a Quitclaim Deed.

2.0 BACKGROUND

The following sections describe the facility, location, and general history of IR Sites 7 and 18.

2.1 SITE DESCRIPTION

Hunters Point Shipyard is located in the City and County of San Francisco, California (Figure 1). HPS includes 866 acres (420 acres on land and 446 acres under water in San Francisco Bay). HPS is divided into 10 parcels: B, C, D-1, D-2, E, E-2, F, G, UC-1, and UC-2. Parcel B includes 59 acres on the northern side of HPS (Figure 2). IR Sites 7 and 18 consist of about 14 acres on the western side of Parcel B. IR Site 7 includes a shoreline of approximately 950 feet along San Francisco Bay.

2.2 HISTORY

The Navy used HPS starting around 1939 for shipbuilding, repair, and maintenance. However, the Navy continued to operate carrier overhaul and ship maintenance and repair facilities through the 1960s. Other significant activities after World War II included decontamination of ships used during atomic weapons testing in the South Pacific and operation of the Naval Radiological Defense Laboratory from the late 1940s until 1969. Navy ships that participated in atomic and nuclear weapons testing were brought back to HPS for decontamination from 1946 through the 1960s. HPS was deactivated in 1974 and remained largely unused until 1976. Between 1976 and 1986, the Navy leased most of HPS to Triple A Machine Shop, Inc., a private ship repair company. The Navy resumed occupancy of HPS in 1987.

Small portions of the area that are now identified as IR Sites 7 and 18 were in existence when the property was purchased by the Navy. The Navy significantly expanded the original area during development of the shipyard to its present configuration; the majority of the land area at IR Sites 7 and 18 was created by depositing fill into the bay. The expansion of the current location of IR Sites 7 and 18 was primarily through the use of engineered fill materials that were derived by quarrying the local bedrock. Some of the fill included construction debris. Although most of the expansion of Parcel B had been completed before 1946, much of the land area of IR Sites 7 and 18 was created during the 1950s and 1960s.

2.3 GEOLOGY AND SURFACE SOILS

The peninsula that forms HPS is within a northwest-trending belt of Franciscan Complex bedrock known as the Hunters Point Shear Zone. HPS is underlain by five geologic units: the youngest of Quaternary age; and the oldest, the Franciscan Complex bedrock, of Jurassic-Cretaceous age. In general, the stratigraphic sequence of these geologic units, from youngest (shallowest) to oldest (deepest), is as follows: Artificial Fill; Undifferentiated Upper Sand Deposits; Bay Mud Deposits; Undifferentiated Sedimentary Deposits; and Franciscan Complex Bedrock.

Artificial Fill covers the entire surface at IR Sites 7 and 18, except for colluvium and alluvium on the hillside at the southwestern edge. The Bay Mud separates the Undifferentiated Upper Sands and the Artificial Fill from the lower Undifferentiated Sedimentary Deposits over most of Parcel B; however, the Bay Mud is absent in some areas within IR Sites 7 and 18, and these two formations directly contact each other in those areas. These site soils and the proposed remedy were assessed for stability as described in Attachment 3 and summarized in Section 3.3 of this report.

The Franciscan Complex contains a variety of rock types, including basalt, chert, sandstone, shale, and serpentinite. Some of these rock types contain wide-ranging concentrations of naturally occurring metals; serpentinite also contains naturally occurring asbestos minerals.

2.4 HYDROGEOLOGY

The hydrostratigraphic units at IR Sites 7 and 18 include (1) the A-aquifer, (2) the aquitard, (3) the B-aquifer, and (4) the deep bedrock water-bearing zone. The A-aquifer consists mainly of unconsolidated Artificial Fill that overlies the aquitard and bedrock and forms a continuous zone of unconfined groundwater across the parcel. Alluvium and colluvium, Undifferentiated Upper Sand Deposits, and shallow bedrock also are part of the A-aquifer at various locations across IR Sites 7 and 18. The B-aquifer consists mainly of Undifferentiated Sedimentary Deposits that overlie bedrock or are contained within the Bay Mud Deposits at a few locations near the bay margin. The B-aquifer is not continuous across IR Sites 7 and 18, however. Bay Mud Deposits act as an aquitard that separates the A- and B-aquifers over most of IR Sites 7 and 18, except for a small area in the west-central portion of IR Site 18, where the Bay Mud is absent and the A- and B-aquifers are adjacent. The bedrock water-bearing zone is not considered an aquifer because of its low capacity for water production (primarily from fractures).

In general, groundwater flows from south to north, toward San Francisco Bay. Based on tidal influence studies conducted during the remedial investigation (PRC and others 1996) and the feasibility study (PRC 1996), the tidal influence zone extends inland up to about 300 feet from the shoreline. Tidal influence may also mix groundwater with bay water, but mixing usually does not occur as far inland as do the fluctuations in groundwater elevation. The proposed design summarized in this DBR does not include impermeable or low-permeability layers which would impede the natural mixing and infiltration of bay water and rain water with groundwater at the site.

2.5 NATURE AND EXTENT OF CONTAMINATION

Activities associated with known or potential chemical releases at IR Sites 7 and 18 were identified and environmental investigations were conducted to identify and assess the nature and extent of contaminants in soil, groundwater, and sediment. The following sections summarize the nature and extent of contamination; refer to the amended ROD (ChaduxTt 2009) and the Technical Memorandum in Support of a ROD Amendment (TMSRA) (ChaduxTt 2007) for more details.

2.5.1 Soil

The COCs in soil at Parcel B IR Sites 7 and 18 that pose a potential risk to human health based on current and reasonably anticipated future land uses include metals, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), pesticides, polychlorinated biphenyls (PCB), and radionuclides. The Navy removed about 87,000 cubic yards of soil from IR Sites 7 and 18 and removed most of the organic chemicals that exceeded the remediation goals in place at that time (see Section 2.6 for details). However, concentrations of a group of metals, especially arsenic and manganese, consistently exceeded cleanup goals at locations across Parcel B. The widespread distribution of this group of metals in soil at Parcel B (that is, their ubiquitous nature) is related to the occurrence of these metals in the local bedrock that was quarried for fill during the expansion of HPS in the 1940s. These metals occur naturally in the Franciscan Formation bedrock (especially in the serpentinite, chert, and basalt rock types) and were distributed throughout all parcels, including Parcel B, as HPS was built. Although it is possible that some releases of these metals could have occurred from Navy activities, the range of concentrations of these metals at Parcel B is consistent with the range of concentrations in local bedrock. The resulting distribution of metals concentrations in soil is nearly random across the parcel. The concentrations of metals in the bedrock fill sometimes exceed the ROD cleanup goals. The remedial design developed in this DBR addresses these concentrations of metals, regardless of their source, by eliminating the exposure pathway. Likewise, the remedial design also eliminates the exposure pathway to the other COCs that remain in soil.

2.5.2 Radionuclides

The Historical Radiological Assessment identified the potential radionuclides of concern at IR Sites 7 and 18; these chemicals include strontium-90, cesium-137, radium-226, and plutonium-239 (NAVSEA 2004). The area at IR Sites 7 and 18 was used as a disposal site for excess large-scale shipyard debris as part of specific engineered fill operations conducted in that area to expand the shoreline. The Navy had limited controls for disposal of certain types of radioactive materials in place at the time of the shoreline expansion which may have allowed for land disposal of certain types of radioactive materials (such as sandblast grit used in decontamination of ships that participated in atomic weapons testing and radioluminescent dials and gauges). The remedial design also eliminates the exposure pathway to radionuclides. Vegetation established on the surface of the final cover as described in Section 3.2.2 of this report will not root to a depth that contains suspected radioactive contamination which will be at least 4 feet below the final cover elevation (4 feet includes the cover thickness of 3 feet and the 1 foot of screened existing soil over the site. Refer to Section 3.2 for further information regarding the radionuclide screening).

2.5.3 Groundwater

The human health risk assessment (HHRA) did not identify risks to human health from exposure to groundwater at IR Sites 7 and 18 based on current and future land uses (ChaduxTt 2007). A screening-level ecological risk assessment (SLERA) conducted as part of the TMSRA identified a potential risk to saltwater aquatic organisms from concentrations of copper and lead in groundwater at IR Sites 7 and 18 that could discharge into San Francisco Bay (ChaduxTt 2007). However, as described in the remedial action monitoring plan for groundwater, results from more recent samples do not indicate that copper or lead pose a risk to ecological receptors in the bay. Refer to the remedial action monitoring plan (located in this binder) for details on proposed groundwater monitoring.

2.5.4 Sediment

COCs in sediment along the shoreline at IR Site 7 that pose a potential risk to human health or ecological receptors include metals, pesticides, PCBs, polycyclic aromatic hydrocarbons (PAH), and radionuclides. The remedial design developed in this DBR includes a revetment that will cover shoreline sediment to prevent exposure and prevent wave action from eroding sediment and transporting it into the bay. Sediment in the area offshore from IR Site 7 was sampled during the feasibility study (FS) for Parcel F (Barajas and Associates 2008); the results for those samples did not exceed the benchmarks used to identify contamination that were established in the FS.

2.6 Previous Remedial and Removal Actions

After the remedial investigation and FS had been conducted and the original ROD completed, the Navy conducted remedial and removal actions at IR Sites 7 and 18 between 1998 and 2008.

Remedial Actions. The Navy selected excavation and off-site disposal as the remedy for contaminated soil at Parcel B, including IR Sites 7 and 18, in the ROD signed in October 1997 (Navy 1997). The Navy conducted remedial actions for soil in two phases: 1998 to 1999, and 2000 to 2001. The Navy excavated about 42,200 cubic yards of soil from 25 areas at IR Sites 7 and 18 between July 1998 and September 1999. However, the excavations failed to remove contaminants (mainly the ubiquitous metals) to below cleanup goals for soil in many excavations, and the soil remedial action paused in September 1999 while the Navy reevaluated the cleanup goals presented in the 1997 ROD. The Navy summarized revised cleanup goals in the May 2000 explanation of significant differences (Navy 2000). Between May 2000 and December 2001, the Navy excavated and disposed of off site an additional 27,700 cubic yards of soil from 10 areas, most of which had been originally excavated from 1998 to 1999. Similar to the first phase, the second phase of excavations did not remove all contaminants (again, mainly the ubiquitous metals) to below cleanup levels for soil, and the remedial action was halted for reevaluation. Details of the remedial action excavations are presented in the construction summary report (ChaduxTt 2008).

Removal Action for Methane. The Navy conducted a time-critical removal action (TCRA) to address methane detected in soil gas samples in the eastern portion of IR Site 7. The Navy excavated about 17,000 cubic yards of soil during August through October 2008. The excavated material included about 1,700 cubic yards of construction and demolition debris that could not be effectively screened for radioactivity and was, therefore, disposed of as low-level radioactive waste (LLRW). An additional 700 cubic yards of soil was identified as LLRW based on radiological sample results from screening of individual soil lifts.

The TCRA found that debris was confined to a layer that extended from about 2 to 8 feet below ground surface (bgs) and was above the water table, which was at about 18 feet bgs at the excavation site. Material below 8 feet bgs was predominantly clean, engineered fill without debris or staining. A layer of material at the top of the Bay Mud at about 23 to 25 feet bgs was observed to be highly organic and odiferous. Excavation continued into the native Bay Mud to a depth of about 27 feet bgs to remove the organic layer. The Navy concluded that the organic layer was the likely source of methane and that the debris used as fill located above the water table was not a likely source of methane. The Navy installed five soil gas monitoring probes in the excavation area. The Navy is monitoring the probes to evaluate whether methane remains at the site. Methane was not detected in any probe in samples collected in December 2008. Details of the TCRA for methane are presented in the removal action completion report (SES-TECH 2009).

2.7 LAND USE CONTROLS AND REUSE

The land use control objectives for IR Sites 7 and 18 include maintaining the physical barriers (such as fencing) and warning signs and maintaining the integrity of the soil cover and shoreline revetment, along with continued administrative restrictions that limit access to the site. The land use controls are described in the Land Use Control Remedial Design (LUC RD) report.

Parcel B is owned by the federal government under the jurisdiction of the Navy and is currently planned to be transferred to the City and County of San Francisco. Based on the City and County of San Francisco’s reuse plan, Parcel B is expected to be zoned to accommodate mixed uses, including open space for the majority of IR Sites 7 and 18. The open space areas will allow public access and use of the waterfront as well as provide a corridor for the Bay Trail (hiking and bicycle access) close to the shoreline (San Francisco Redevelopment Agency 1997). Plans for the open space area include recreational features such as sports fields, playgrounds, and gardens. Any modifications to the soil cover or revetment will be addressed the LUC RD report. Modifications to the soil cover or revetment are restricted throughout IR Sites 7 and 18 unless prior written approval for these activities is granted by the Federal Facility Agreement signatories (and the California Department of Health (CDPH) within the area requiring institutional controls for radionuclides). Land use controls are described in detail in the LUC RD report.

3.0 BASIS OF DESIGN

The following sections describe the basis of design for the two main containment components of the remedy for IR Sites 7 and 18: soil cover and revetment. Figure 3 is an overview of the design components and shows the extents of the soil cover and revetment. All of the potentially contaminated soil associated with IR Sites 7 and 18 will be contained by either the soil cover or the revetment. Future redevelopment of IR Sites 7 and 18 will likely change the surface grades and vegetation over the soil cover and may even change the nature of the cover. However, the basic features of the soil cover that provide protection from exposure to COCs will be maintained during development. This report describes one design approach proposed to meet the conditions present at IR Sites 7 and 18. Other types of soil covers may be appropriate for IR Sites 7 and 18 as well as other locations at Parcel B (see the amended ROD [ChaduxTt 2009]), so long as the covers prevent exposure to soil and are durable.

3.1 SITE PREPARATION

Site Security Fencing - The existing site security fence runs along the landward site boundary for IR Sites 7 and 18 and upslope from the shoreline as shown in Figure 4. This current fence location would obstruct construction of both the soil cover and the revetment and portions will need to be removed before construction. A temporary fence, also shown in Figure 4, will be constructed to provide site security and will be located sufficiently off of the site boundary to allow access along the boundary itself and allow for the sloping of the cover to meet the existing grade. An easement, or other agreement, between the Navy and the property owner northwest of the site will be needed to place the temporary fence on the neighboring property; however, neither the cover nor the off-cover slopes will run onto the neighboring property.

Open access between the landward portion of the site and the shoreline will be necessary for construction of the revetment. Therefore, no temporary fencing will be erected along the shoreline.

The existing site control fence and materials will be used wherever possible. The existing fence along Innes Avenue and along the southern corner of the site, in the vicinity of the entrance to the site, is located sufficiently outside of the work area and can be utilized during construction.

Clearing and Grubbing – The existing surface of IR Sites 7 and 18 will be cleared of vegetation and debris during the radionuclide surface screening of the site (TtEC 2009), which will be completed prior to the construction of the soil cover and revetment. Significant clearing and grubbing is not anticipated to be necessary, especially over the landward portion of the site; however, there may be some small areas around the perimeter of the site where some minimal clearing of vegetation or debris may be necessary to provide site access and allow for placement of the temporary fence.

Along the shoreline of the site, boulders and concrete have been placed in areas to provide slope stability. Radionuclide screening along the shoreline will likely be difficult due to the conditions along the shoreline and clearing and grubbing not conducted. Any rock and debris will need to be removed from the area before the excavation work and the revetment construction. Non-native materials (concrete, rebar and other metal debris, wood, and other refuse) that cannot be screened will be considered contaminated and disposed of off site at a low-level radioactive waste (LLRW) disposal facility. The rocks that have been used as shoreline armoring will be stockpiled and placed onto the exterior of revetment as supplemental armoring after the construction of revetment is completed. Extents of the clearing and grubbing for the site, including along the shoreline, are included in Figure 4 of this report.

Extension of Existing Monitoring Wells and Probes (groundwater and methane) – The existing groundwater monitoring wells and methane monitoring probes on site are within the potentially radiologically impacted area and will be extended by at least 3 feet to meet with the ground surface of the final soil cover. All existing bollards and stickup protective well casings will be removed. Concrete pads and flush-mounted protective casing materials will be left in place except when such materials are obstructive to the coupling between the extension and the existing well. New concrete pads and protective materials will be constructed flush to the completed cover ground surface following completion of the soil cover construction. The locations of the wells are provided in Figure 4 of this report. The following schedules summarize the groundwater monitoring well and methane monitoring probe information. Methods for extending and protecting the wells during soil cover construction will be at the discretion of the construction contractor.

TABLE 1
GROUNDWATER MONITORING WELL EXTENSION SCHEDULE

Well Identification	IR Site	Northing (NAD 27)	Easting (NAD 27)	Casing Stickup (ft)	Total Depth (ft)	Casing Diameter (in)	Stickup
IR07MW20A1	IR-07	453944.26	1460379.24	-0.99	24.00	4	no
IR07MW21A1	IR-07	453941.51	1459683.70	-0.12	16.50	4	no
IR07MW23A	IR-07	453693.82	1459476.14	-0.64	17.00	4	no
IR07MW24A	IR-07	453884.37	1459749.67	2.83	15.00	4	yes
IR07MW25A	IR-07	453990.88	1459624.70	2.92	18.00	4	yes
IR07MW26A	IR-07	453900.68	1460093.30	3.45	15.00	4	yes
IR07MW93A	IR-07	453533.20	1459686.30	-0.07	29.00	2	no
IR07MW94A	IR-07	453749.30	1459659.70	-0.05	25.00	2	no
IR07MWS-2	IR-07	453860.98	1460286.15	2.62	15.50	4	yes
IR07MWS-4	IR-07	453825.23	1459913.20	3.50	16.00	4	yes
IR07P20A	IR-07	453927.21	1460374.65	-0.68	25.00	2	no
IR18MW100B	IR-18	453579.54	1459329.10	-0.31	47.00	4	no
IR18MW101B	IR-18	453573.70	1459432.00	-0.07	45.00	4	no
IR18MW21A	IR-18	453595.74	1459304.90	-0.26	20.00	4	no
IR18MW92A	IR-18	453446.90	1459396.70	-0.20	27.00	2	no
PA18MW09A	IR-18	453628.25	1459405.47	-0.37	25.00	4	no

TABLE 2
METHANE MONITORING PROBE EXTENSION SCHEDULE

Well Identification	IR Site	Northing (NAD 27)	Easting (NAD 27)	Total Depth (ft)	Casing Stickup	Construction
SG-PT15	IR-07	453673.40	1459922.63	3.0	no	Poly tube
SG-PT16	IR-07	453632.67	1459939.27	3.0	no	Poly tube
SG-PT17	IR-07	453601.10	1459917.88	3.0	no	Poly tube
SG-PT18	IR-07	453623.16	1459880.20	3.0	no	Poly tube
SG-PT19	IR-07	453660.16	1459884.61	3.0	no	Poly tube

3.2 SOIL COVER

The existing surface of IR Sites 7 and 18 will be screened for radionuclides to a depth of 1 foot (the maximum effective depth of the surface scan) before the cover is installed. Any radiological contamination found to exceed the remediation goals for residential soil (see Table 8-4 of the amended ROD) will be removed, hauled off site, disposed of properly, and replaced with clean fill. Procedures for the screening surveys will be consistent with the basewide radiological work plan (TtEC 2008) and task-specific plans (TSP), which are separate from this remedial design.

A soil cover of clean imported soil is the selected remedy to prevent contact with COCs that may be present on the landward portion of the site. These chemicals may include metals, organic chemicals, and radionuclides. The cover components vary over the site as follows:

- The final cover for the potentially radiologically impacted area at IR Sites 7 and 18 will consist of a minimum 3-foot cover layer of clean imported soil and a demarcation layer over the area and within the cover layer, 1-foot above the existing ground surface.
- The final cover for the non-radiologically impacted area at IR Sites 7 and 18 will consist of a minimum 2-foot cover layer of clean imported soil.

A conceptual cross section of the soil cover components for both portions of the site is included as Figure 5 of this DBR and cross sections are provided as Figure 6. The following sections describe the components of the proposed soil cover.

3.2.1 Initial Site Grading

The extents of potential radionuclide and non-radionuclide contaminated areas of the site will have been leveled during the radionuclide screening process and only minimal grading of the area will be necessary before construction of the soil cover over the site. Based on previous subsurface investigations, the existing soils at the site are suitable as an initial foundation for the soil cover, and settling of the existing material is not anticipated.

Special consideration needs to be given to both the property boundaries along the northwestern perimeter of the site and the access road along the southeastern perimeter. The neighboring property to the northwest (which is non-Navy property) and the access road abut the area that is addressed by the soil cover remedy. Neither the neighboring property nor the access road can be obstructed by the cover or the sloped portion of the cover where the cover will meet the exiting grade. Therefore, excavations along the site boundary are needed to allow for the final cover to slope and meet the existing grade within the site boundary while maintaining the minimum cover thicknesses of 2 or 3 feet. The soil cover will slope to meet the existing grade and retaining walls or other structures will not be used to transition from the cover to the existing grade. Figures 4, 5, 6, and 7 of this DBR show the extents and grading of the final cover over the site.

The excavated soil from the site boundary areas described above will be screened for radionuclide contamination. Non-radionuclide impacted soil will be returned to the site and ultimately placed under the minimum 3-foot soil cover. Radionuclide-impacted soil will disposed of off site at a LLRW disposal facility along with any debris that cannot be screened. An estimated 430 cubic yards (yd^3) will be excavated along the boundary of the site.

Excavation along the property boundary as described above and excavation of the shoreline for the revetment is estimated to yield 4,000 yd^3 of excavated soil and sediment (not including the estimated volumes of radionuclide-impacted soil or the debris for disposal). The excavations related to the construction of the revetment are more fully described in the revetment portion of this DBR – Section 3.3. This material will be placed on site between the approximate 15 foot and 10 foot elevations, as seen on Figure 4, and compacted and graded. There will then be at least 3 feet of clean imported fill cover material over this placed material. More specific grading plans and extents are contained in the Design Construction Drawings included as Attachment 1 to this DBR.

3.2.2 Soil Cover

The soil cover over the site will be comprised of clean imported fill material and will be not less than 3 feet thick over the potentially radionuclide-impacted portion of the site and not less than 2 feet thick over the non-radionuclide impacted portion of the site. The total volume of the soil cover layer is estimated at 64,000 bcy or 83,200 lcy considering a 1.3 bulking factor. Refer to Appendix A for the volumetric calculations of soil necessary for the cover remedy. The final cover components, cross sections, and final cover contours are included as Figures 5, 6, and 7.

Soil compaction for the soil cover depends on depth from the final surface. All imported soils at depths greater than 0.5 foot below the final cover surface will be compacted to 90 percent or greater of the maximum dry density at or near optimum moisture, in accordance with ASTM modified proctor density testing. Although the project is not a landfill, this compaction is based on standard practice for landfills according to Title 27 of the California Code of Regulations (CCR). Additionally, this compaction will provide sufficient stability considering the future use of the site as a park. The upper 0.5-foot portion of the soil cover will be compacted to not greater than 85 percent of the maximum dry density. This compaction scheme is based on U.S. Army Corps of Engineers technical guidance and optimizes slope stability with vegetative growth (U.S. Army Corps of Engineers 2001).

The majority of the final cover will have average slopes toward the north of between 1 vertical to 30 horizontal (1V:30H), or about 3 percent, and 1V:80H, or about 1 percent. Steeper slopes of approximately 1V:4H or 25 percent will exist in smaller portions of the southern and western corners of the site. Final cover slopes throughout the site will be approximately equal to the current existing slopes. The infiltration of water at the site is not a concern based on the nature of the COCs. However, the prescribed grading plan has been designed to maintain sheet flow of stormwater over the site to minimize ponding of water and infiltration.

The side portions of the cover will extend to meet the current existing grade at slopes not steeper than 1 vertical to 3 horizontal (1V:3H), or about 33 percent, along the perimeter of the site and retaining walls will not be used to transition from the cover to the existing off-site grade. This maximum slope of 1V:3H will also be maintained for the transition between the areas of 3 feet and 2 feet of cover.

The slope and vegetation of the cover will protect the final cover from erosion, as summarized in Section 3.2.5 of this DBR. The cover will be planted with the following seed mix, intended for survival without irrigation or significant maintenance after a 3-month establishment period.

SEED MIX

Scientific Name	Common Name	Pounds/Acre
Bromus carinatus	California Brome	25
Hordeum brachyantherum	Meadow Barley	10
Vulpia microstachys	Small Fescue	6
Trifolium wildenovii	Tomcat clover	4

Binders or degradable geonet will be used to minimize erosion during the 3-month establishment period for vegetation, which will be the responsibility of the construction contractor. The seed mix was selected considering the likely conditions of the fill to be used for the cover, and an amended topsoil layer will not be necessary. Irrigation during the vegetation establishment period may be necessary.

The grading, compaction, and vegetative cover of the upper 0.5-foot layer of the cover have been designed to convey water as sheet flow, prevent excessive ponding of surface water, and to be resistant to erosion.

3.2.3 Demarcation Layer

During the construction of the soil cover, a demarcation layer, consisting of both geotextile material and utility marking tape, will be installed within the cover over the potentially radiologically impacted area to provide a warning against digging into the potentially contaminated soil. The demarcation layer will be installed at least 1 foot above the existing grade, and any placed excavated soil, and the layer will ultimately be located at least 2 feet beneath the final cover ground surface. The geotextile material will be permeable to allow water to pass and will be colored orange. The utility marking tape will be printed with a warning message indicating the presence of the contaminated soil beneath.

The extent of the demarcation layer is included in Figure 3 of this DBR and cross sections included as Figures 5 and 6. The demarcation fabric will be unrolled and secured with a minimum of 1 foot overlap between the fabric sections to insure the continuity of the layer. A narrow trench or other small excavation will be opened along the boundary of the potentially radionuclide-impacted area to a depth of not less than 1 foot below the existing ground surface, and the demarcation fabric will be placed into the trench and anchored to hold the fabric in place. The anchoring of the fabric is intended to provide a warning for any angled excavations that would approach the potentially radionuclide-contaminated soil from the side. The anchored portion of the geotextile material along the boundary of the potentially radionuclide-contaminated area will be located at a depth of 3 to 4 feet below the final soil cover grade at the site. The geotextile material will also be secured within the crest of the revetment. The cross sections included in Figure 6 shows the anchoring of the demarcation fabric relative to the other cover layers.

The utility marking tape will be placed in a 10-foot grid on top of the fabric. Securing pins will hold both the tape and the fabric in place during placement of the subsequent soil cover layers. The utility tape will be of a material suitable to be detectable by electromagnetic geophysical equipment.

3.2.4 Surface Drainage

The final soil cover is designed to achieve sheet flow over the majority of the surface as a means to dissipate the energy and flow of runoff caused by storm events, as explained in the soil cover section (Section 3.2.2) of this DBR. Surface water runoff over the future cover is the same as the current drainage of the site, where water drains generally toward the north and flows either over the bank of the shoreline to the bay or joins the existing drainage along the northwestern property boundary and discharges to the bay. The portion of the soil cover in the vicinity of the shoreline will be constructed to slope gently toward the revetment and to minimize the ponding of water on this portion of the site. Final cover contours are provided in and in Figure 7 and as cross sections on Figure 6.

The natural topography of the area surrounding the site and the curbing and other drainage provisions along Innes Avenue prevent significant run-on to the IR 7 and 18 site. Given the future elevation and grade of the soil cover, only the area south of the site (between the boundary of IR Site 18 and Innes Avenue) will drain toward the soil cover. This drainage area is approximately 5 acres. The water flowing onto the site from this portion of the property will be controlled by a drainage swale incorporated into the soil cover along the boundary of the IR 18 site as shown on Figure 7. The drainage swale will be constructed through cover grading provisions on that portion of the site to direct flow toward the northeast along the southern boundary of the site and discharge to the existing off-site drainage channel along the southeastern portion of the site boundary. The minimum 2 feet and 3 feet cover requirements will be maintained under the drainage swale. The location of the drainage swale is included on Figures 6 and 7 of this DBR. The design of the drainage swale and the calculations are provided as Appendix C and D of this DBR.

The swale was designed to accommodate a storm event of a 100-year return interval. The methodology for the calculation of the peak flows is based on the methodology described in *Applied Hydrology* (Chow and others 1988) and methodology described in *Urban Hydrology for Small Watersheds – Technical Release 55* (Natural Resource Conservation Service [NRCS], 1986). The assumptions that were made when calculating the design peak flows from the watershed entering the swale channel were:

- Annual average precipitation of 21.5 inches
- Watershed drainage area of 5 acres divided by subcatchments
- A 100-year return interval storm was used in calculations
- The surface of the watershed is primarily grass and scrub growth in poor condition
- The average slope of the watershed is 14 percent
- The first 100 feet of runoff over the watershed is modeled as sheet flow and the remaining portion is shallow concentrated flow until inflow to the drainage.

The following criteria were used to design the drainage swale to convey the flows:

- The swale must drain the 100-year return interval storm without jeopardizing the in integrity of the final cover.
- Peak flow rate of 6.3 cubic feet per second (cfs) associated with the design storm must be controlled.
- Velocities of intermittent flow in grass-lined reinforced channels cannot exceed 8 feet per second (fps) without armoring or other considerations to dissipate energy.
- Maximum shear stress on the grass-lined swale during the establishment of the vegetation is 3.2 pounds per square foot (psf) and 8 psf following establishment, which includes reinforced matting.
- The side slopes along the drainage route will vary between approximately 1V:17H and 1V:4H for the area upgradient of the water course.
- The slope along the channel water course is between 0.2 and 1.8 percent.

The peak flow under the 100-year storm event calculated for the drainage channel is a conservative 6.3 cfs. Detailed calculations for the peak flow in the watershed and channel are provided in Appendix C and D.

Using these assumptions, a reinforced grass-lined drainage swale of 1 foot in height is sufficient to control the peak flow of a 100-year return interval storm, and water depth along the swale would not exceed 0.75 foot. This peak flow will not erode the soil along the drainage route or soil cover over the site. The calculation is provided as Appendix D. The location of the drainage swale is provided in the cross sections of Figure 6 and the final cover grade of Figure 7.

The drainage swale will discharge overland to the existing off-site drainage feature running along the southeastern property boundary and ultimately discharge to the bay. The swale will control all appreciable flow onto the soil cover from off site and thus control erosion from water. Overall the existing drainage patterns of the site and the surrounding area are not significantly affected by the proposed soil cover, and off-site drainage features will not receive significant increased flows as a result of the remedy. Overland sheet flow to the northwest property boundary will be reduced by 85 percent of current conditions as a result of the soil cover.

Although the drainage provisions for the project are being designed as a long-term remedy, it is anticipated that the City of San Francisco will begin construction of the park over the site within a relatively short period after the remedy is complete. Any future alterations to the soil cover or the areas draining toward the cover will affect the site drainage.

3.2.5 Erosion by Wind and Water

Erosion by wind and water of the soil cover was estimated, and the complete calculation is available as Appendix B of this report. The erosion calculations were completed for the two cover scenarios anticipated for the project: (1) the period just after the cover is seeded and before the grasses are established, which is considered the establishment period, and (2) the period after the grasses become established over the cover, which is considered the long-term cover scenario. These two scenarios were compared with the acceptable erosion rate of 2 tons/acre/year as suggested by the American Society of Civil Engineers for the design of landfill covers.

For the first scenario, it was assumed that the ground cover would be completely bare and fully exposed to wind and water erosion without protection for the period just after the grasses are planted over the soil cover. Under this scenario, total erosion losses over the cover would be anticipated to be approximately 5.3 tons/acre/year, or a loss of 0.034 inches of soil/year. This rate is considerably greater than the acceptable loss of 2 tons/acre/year; thus, vegetation is needed over the cover for erosion control and provisions are needed for erosion control during the establishment period. The establishment period is approximately 3 months; during this time, the construction contractor will use erosion control practices (binders or geonetting) to prevent erosion and ensure the success of the vegetative cover.

For the long-term vegetative cover scenario, it was assumed that the ground cover over the site would conservatively be 80 percent grass covered. Under this scenario, total erosion losses over the cover would be anticipated to be approximately 0.07 ton/acre/year, or a loss of less than 0.0005 inch of soil/year. This rate is considerably less than the acceptable loss of 2 tons/acre/year, and the recommended vegetative cover will be sufficient to control erosion over the site. Practices for controlling erosion and maintaining the vegetative cover are included in the O&M plan. It should be noted that the impact to the bay from sediment loading associated with the final cover will be negligible and provisions will be taken during the establishment period to control sediment migration.

The slope to the south of the site was not a part of the remedial design. No estimate of stability or erosion was performed for this area, and failure of this slope is not anticipated to threaten the integrity of the final cover.

3.2.6 Other Design Considerations – Soil Cover

Overall, the entire volume of soil estimated to be needed for the construction of the soil cover is 64,000 bcy or 83,200 lcy for acquisition, as calculated in Appendix A.

The elevation of the final cover over the site will be surveyed after the project is complete to document the final cover elevations. Two permanent survey monuments will be installed on the cover as required by Title 27 CCR 20950(d). It is anticipated that construction of the park will be initiated shortly after the property is transferred to the City of San Francisco, which will include significant filling and regrading on top of the soil cover. The final elevation of the future park will need to be considered in post-closure elevation monitoring of the cover.

The existing HPS radiological screening area is assumed to be available and sufficient for the screening of the soil excavated along the property boundary for the initial grading of the site. Grading this area is anticipated to generate less than 500 lcy of soil over a period of less than 1 week. The current screening area has a processing capacity at any given time of approximately 1,200 cubic yards of soil among six screening pads.

After the soil cover is installed, a permanent fence will be constructed around the perimeter of the site along the portions of the site abutting property that is not currently owed by the Navy. The current fence along Innes Avenue and extending around the southern corner of the site has been constructed as permanent fence, it will be used during construction along with the temporary fencing, and it will be used again as permanent site fence after construction. However, new fence will need to be constructed along the northwestern property boundary to separate current Navy property from non-Navy property.

All construction will meet the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and a San Francisco Bay Conservation and Development Commission (BCDC) major permit. Best management practices (BMP) will be implemented and maintained to minimize erosion and control sediment migration during construction.

3.3 REVETMENT

A revetment is a facing of armor material such as stone or concrete that is intended to protect a shoreline feature from erosion or slope failure. The primary physical components of the revetment are the armoring material, the toe, the crest, and the filter layer. The armoring material is selected and sized based on the forces to which the structure is exposed, such as water currents, wave action, and gravity. The extent of the revetment, or the elevations of the toe and crest, is based on the expected high and low water conditions, significant wave heights, and wave runup on the structure. The filter layer is set between the armoring material and the underlying soil or engineered fill and is intended to allow water to pass while supporting the structure and preventing erosion.

The design of the revetment for HPS IR Site 7 differs slightly from traditional revetment designs. These differences are related to the additional function in containment of the contaminated soil and sediment of the IR 7 site and protection of human and ecological health — similar to the provisions of the soil cover over the landward portion of the site. The following list summarizes the primary design considerations that were used in developing the revetment design.

- The impact of anticipated wave energy.
- Water levels from tidal fluctuations and potential sea level rise is considered.
- Encapsulation of all potentially contaminated sediment of IR Site 7; thus, the revetment needs to extend to the off-shore property boundary.
- Prevention of human contact with the potentially contaminated soil and sediment beneath and provision of a sufficient barrier similar to the function of the on-shore soil cover.
- Filling of the bay from riprap must be minimized.
- The future use of the area as a park, and the possibility for tampering with and foot traffic along the revetment.

The following sections summarize development of the design of the revetment for IR Site 7. The proposed revetment would be installed along the approximate 950 feet of shoreline where IR Site 7 meets the bay. A conservative approach for design of the revetment was taken to maximize its ability to prevent contaminated soil from migrating to the bay while remaining protective of human and ecological health, considering the future use of the area. The following sections and procedures for the revetment design are based on the U.S. Army Corps of Engineers "Design of Coastal Revetments, Seawalls, and Bulkheads" and "Coastal Engineering Manual" (1995 and 2006). A typical cross section of the revetment is provided as Figure 8 to this DBR, and the extent of the revetment is shown in Figure 9.

3.3.1 Water Level Ranges

The tidal ranges for HPS Parcel B IR Site 7 were estimated from data obtained through the National Oceanic and Atmospheric Administration (NOAA) Center for Operational Oceanographic Products and Resources and from NOAA tidal data for the area. Tidal data serve as the basis for design of a revetment as a primary component in calculating the crest elevation and the extent of the structure.

The tidal range between the mean higher high water (MHHW) and the mean lower low water (MLLW) was approximately 6.73 feet for the tidal epochs of 1960 through 1978 (NOAA Hunters Point Tidal Bench Mark and Datum). The MHHW and MLLW are defined as the mean of the higher high water height and the lower low water height of each tidal day observed over the tidal datum epoch. When adjusted for the location specific mean sea level (msl) at the site, the MHHW is +3.17 feet above msl and the MLLW is -3.56 feet below msl. Tidal ranges are generally referenced to MLLW; however, elevations are referenced to msl in this design to remain consistent with overall site elevations and the surveys completed. The surveyed elevations used in this DBR have been corrected to reflect the actual local sea levels at the site.

Also of significance for the revetment design is the determination of the highest water levels expected. Tidal data were obtained to assess the extreme high and low water events for the tidal epochs described above. An extreme high tide of +6.14 feet above msl can be expected for the project location and is associated with a 100-year return period (Moffatt and Nichol 2009). The tidal range calculations and adjustment factors are included as Appendix E to this DBR. The following table summarizes the primary tidal data elevations used for the revetment design and calculations.

TABLE 3
TIDAL RANGES AND ELEVATION DATUMS

Tidal Datum	Reference Datum		
	MLLW	NGVD 1929	MSL[b]
Extreme	+9.7[a]	+6.58	+6.14
MHHW	+6.73	+3.61	+3.17
MHW	+6.10	+2.98	+2.54
MSL	+3.56	+0.44	0
NGVD	+3.12	0	-0.44
MLW	+1.12	-2.06	-2.44
MLLW	0	-3.12	-3.56

Notes

NGVD National Geodetic Vertical Datum

[a] From Moffatt and Nichols, 2009. "Candlestick Point/Hunters Point development Project – Initial Shoreline Assessment".

[b] The MSL for the site is a locally established datum for the site. This datum is consistent with the survey data associated with the site as used in the design drawings and calculations.

The potential for an increase in the sea level elevation as a result of atmospheric warming has been considered in the design of the revetment. A contingency of up to a 3-foot increase in sea level has been considered (Church and others 2001, 2008; Moffatt and Nichol 2009), based on comments from the public and the regulatory agencies. This assumption incorporates additional conservatism into the design.

3.3.2 Wave Dynamics

Wave height depends largely on the velocity of wind over the water, the duration of the sustained wind, and the available wind fetch (the uninterrupted over-water distance where wind can affect the water surface). The greatest sustained wind speeds that might affect generation of waves for the site are anticipated to be from the northeast at a range between 36 and 41 miles per hour (mph) and have been estimated to have a 100-year return period. These wind velocities are associated with a 1-hour-long duration and are considered an extreme condition. Unsustained wind gusts of short duration do not effect formation of waves significantly. Determination of the wind dynamics for the design is summarized in Appendix F.

Fetch distances available for the IR 7 site are from the cardinal directions from north to east-northeast of the site. Fetch distances in the other cardinal directions are restricted by significant land masses. Additionally, the Bay Bridge north of the site is considered a limitation to the fetch distances because it interrupts the winds and waves that will affect the site. The range of available fetch distances associated with the site is between 4.1 miles and 6.2 miles. The summary of the available fetch distances for the site is provided as Appendix G to this report.

A series of deep-water wave heights can be calculated for given wind and fetch parameters available for a location. Appendix H summarizes the anticipated wave heights by appropriate cardinal direction for the site. The highest calculated wave height is considered the significant wave and is used in the design of a revetment or other coastal structures. The highest calculated significant wave height anticipated for the site would be from the north of the site with a height of 3.0 feet associated with the 100-year return period winds. This maximum anticipated significant wave of 3.0 feet serves as the design wave in calculations throughout the design.

This calculation of the design wave correlates with independent analysis of the wave conditions available for HPS when the site-specific conditions of the IR 7 site are considered (Woods Hole Group 2001, Moffatt and Nichol 2009).

The design wave, as summarized above, is an open water wave that would break before it reached the shoreline and the revetment. It is used in this design and provides a conservative estimate of the wave energy that can be expected to affect the revetment. Generally, a wave will break when it reaches a water depth equal to or less than approximately 127 percent of its height (U.S. Army Corps of Engineers 2006). Based on this ratio of wave height to depth, the design wave will crash in 3.8 feet of water or 20 to 100 feet from shore, depending on water elevation. This calculation and a figure that shows the wave breaking distance from shore is provided as Appendix I to this report. After it breaks, the design wave will move toward shore and its energy will dissipate. The open water wave has been used in this design because it is conservative; however, the actual wave energy along the revetment will be less.

3.3.3 Selection of Suitable Armor Material

Revetments can be constructed from a wide variety of materials, including stone, concrete, or prefabricated mats and blocks. Potential materials were screened and selected based on the strength, availability, cost, and constructability.

Special consideration was also given to the future use of the area as a park in selecting the material. Materials such as concrete and prefabricated alternatives were eliminated from consideration because of their unnatural appearance when compared with the stone options.

In addition to appearing more natural, stone-based options are flexible and are able to withstand minor damage without compromising strength and function. Revetments constructed from stone can also be repaired more easily than can structures made from prefabricated materials.

There are three primary natural stone based options: (1) multiple layers of angular uniform sized rock (quarrystone), (2) graded rock of sizes between upper and lower limits (riprap), and (3) layers of subrounded to rounded boulders (field stone). The primary disadvantage to revetments constructed of field stone is that they have considerably less strength than revetments constructed of more angular quarrystone or riprap material of the same weight. Obtaining larger field stone needed for a revetment could be difficult, and placement of this material is costly. For this reason, field stone was not considered.

When comparing the strengths of randomly placed quarrystone versus randomly placed riprap, a greater thickness of quarrystone is needed to achieve the strength of a less thick layer of riprap. The quarrystone option would likely have a greater cost than riprap for a comparable strength. For this reason, uniform quarrystone was not considered suitable. Additionally it has significant void space between rocks, which could pose a trip hazard to potential foot traffic given the anticipated future use of the site as a park.

Riprap is not recommended for revetments with sustained exposure to waves larger than 5 feet. The significant wave for this design was estimated at 3 feet, and a natural riprap material was deemed the most appropriate option. This design and calculations found in appendices related to the revetment were completed using a randomly placed natural riprap, which by definition is two layers of the median stone thick.

3.3.4 Revetment Slope Selection

The slope of a revetment is determined based on the existing conditions of the site and cost factors. A uniform slope along the revetment is desirable for ease in construction and to maintain uniform rock gradation throughout the structure. More steeply sloped riprap revetments are inherently less stable, and larger rock sizes are needed to achieve the same strength as less steeply sloped structures. If varying slopes are used along the revetment, varying riprap sizes are needed to maintain the stability, which can increase the risk of failure and can complicate O&M of the structure. Therefore, a uniform slope has been used in this design.

The other primary consideration in selection of the slope is the assessment of the existing shoreline slope and the amount of soil and sediment that would need to be excavated or filled to achieve the prescribed slope. The existing slope along the extent of the revetment varies considerably between about 1V:2H and 1V:10H. A uniform slope of 1V:4H approximates the existing slope along the shoreline, which reduces the total amount of excavation necessary along the upper portion of the revetment.

The revetment also needs to extend to at least the northern IR 7 site boundary with Parcel F to contain or encapsulate all the potentially contaminated shoreline soil and sediment. Revetments designed for nonhazardous waste sites ordinarily would not include this provision. As a result, an extended toe portion of the revetment will be necessary to achieve this lateral extent along portions of the structure. The extended toe portion of the structure will approximate the existing off-shore slopes in an effort to limit the amount of excavation while keeping the toe portion of the revetment submerged by sediment, which provides increased stability and reduces obstruction. Figure 8 of this report shows a typical cross section of the revetment and includes the extended toe portion. Figure 9 of this report shows a plan view of the revetment extents.

The construction of the revetment as designed will not result in a filling of the bay and the bay area will increase slightly as a result of this grading plan.

Approximately 5,100 bcy of material will excavated along the shoreline and 970 bcy (1,100 lcy) of fill material is necessary to achieve these prescribed slopes for the revetment. Refer to Appendix J for this calculation. This volumetric calculation includes debris and boulders that will be removed from the work area before excavation begins. The excavated materials will be screened for radionuclide contamination at the existing HPS radiological screening area. Radionuclide-contaminated material will be disposed of off site at a LLRW disposal facility; non-radionuclide contaminated material will be placed on the landward portion of the site and contained under the 3-foot soil cover as explained previously in Section 3.2.1 of this DBR and shown in Figure 4.

3.3.5 Armor Unit Sizing

Armor unit sizing for revetments depends on five primary physical factors: (1) wave height, (2) the slope of the structure, (3) the type of material used, (4) the configuration of the revetment, and (5) the degree of access by the public.

Considered in the determination of the armor unit size was the future use of the site as a park. Issues such as vandalism, theft, and inadvertent movement of the rocks caused by foot traffic needs to be considered in the design because of the public access to the area. Generally, rocks of weight between 400 to 500 pounds or rocks with an approximate diameter of 1.35 to 1.45 feet are of sufficient size to withstand vandalism, theft, and inadvertent movement. This sizing is based on guidance from the U.S. Army Corps of Engineers (1985).

The calculation of the median rock size (W_{50}) of the riprap was calculated using the Hudson formula. The calculation is included as Appendix K of this DBR. The calculation is based on a revetment slope of 1V:4H, revetment material consisting of randomly placed riprap, and a design wave height of 3.0 feet. Using this formula yields a W_{50} of approximately 130 pounds, which corresponds to a diameter of 0.93 foot.

The median weight calculated using the Hudson formula is considerably less than the recommended weight for projects with a high degree of public access of 500 pounds, as described above. The recommend weight of 500 pounds is the more conservative of the two sizing methodologies, so this weight was selected as the W_{50} for the revetment.

The layer thickness of graded riprap measured perpendicular to the slope is calculated based on both the W_{50} rock size and the largest rocks obtained (W_{100}). The California Department of Transportation (Caltrans) publishes rock gradation for riprap revetments. Based on the W_{50} of 500 pounds, the upper rock size of the gradation specified by Caltrans is 1,000 pounds with a minimum weight of 75 pounds. This gradation is commonly referred to as "¼-ton riprap" and is readily available in the vicinity of the site. Based on this gradation, the revetment will be 3.0 feet thick, or two times the diameter of the W_{50} rock. This calculation is provided as Appendix L of this DBR.

A 3-foot uniform thickness of the revetment with a W_{50} rock weight of 500 pounds will prevent any human contact with the potentially contaminated soil and sediment beneath. This thickness is also consistent with the thickness of the soil cover over the potentially radionuclide-impacted portion of the landward portion of the site.

3.3.6 Crest Elevation

Ideally, the elevation of the top of the revetment or the crest should be at a sufficient height above the water level to prevent overtopping of water. Thus, maximum water levels, wave heights, contingencies, and potential wave runup are considered for selection of the crest elevation. Runup is defined as the vertical height above the still water level to which the uprush from a wave will rise on a structure.

The wave runup onto a revetment is based on the design wave, the design wave period, the depth of water on the revetment, and the slope of the revetment. The wave runup is calculated using the Ahrens and Heimbaugh Formula and the calculation is provided as Appendix M of this DBR. Using this formula and the site conditions anticipated yields a maximum wave runup of approximately 2.5 feet, which is associated with a 100-year return period.

The expected high water and wave conditions associated with a 100-year return interval are used in calculating the crest of the revetment. The following summarizes the data that were used.

- 100-year high water level of 6.1 feet msl
- Design wave of 3.0 feet
- Wave runup on the revetment of 2.5 feet

Using these 100-year return interval high water and wave conditions yields a crest height of the revetment of 11.6 feet above msl. This calculation assumes that the 100-year return interval wave would occur during the 100-year high water event and is an inherently conservative estimate for the crest elevation that would prevent wave overtopping.

A revetment crest elevation was selected of 15 feet msl, which is significantly greater than the extreme conditions summarized above. The 15 feet elevation will provide for 3.4 feet of allowance for freeboard and sea level rise. Sea level rise has been projected to be up to 3 feet (Church and others 2001, 2008; Moffatt and Nichol 2009).

Secondarily, the selected 15 feet crest elevation will also be protective of the soil cover over the landward portion of the site. The soil cover along the shoreline of the site will reach an elevation of approximately 15 feet above msl. Designing the revetment to rise to meet the elevation of the cover is more protective of the cover than sloping the cover more steeply downward to meet the revetment, which would be more susceptible to erosion from wind, water, and foot traffic.

Figures that show the typical cross section and extents of the revetment are provided as Figures 8 and 9 to this DBR.

3.3.7 Toe Protection

Toe protection is provisions in front of the revetment on the beach, bottom surface, or subsurface that prevents undercutting and scour of the structure. Scour potential at the location of the revetment is anticipated to be minimal based on the near-horizontal slope of the nearshore area. Additionally, sediment dynamics studies conducted for the HPS peninsula associated with Parcel F indicate that the nearshore area of the IR 7 site has a high potential for sediment deposition, regardless of tide (Woods Hole Group 2001). Based on the available data, the potential for scour along the toe of the revetment is low; however, the toe has been designed conservatively assuming that a low potential for scouring exists. Using this conservative scour potential criterion, the general toe design shown in Figure 8 was selected, which would be protective of the structure.

The toe will be of uniform 3-foot thickness, and the end of the toe will be excavated and placed a minimum of 4.5 feet below the existing off-shore grade. The top of the submerged toe will be at least 1 foot below the existing grade. Submerging the toe below the existing grade provides additional stability to the structure than would be the case of an exposed toe. Refer to the seismic stability analysis provided as Attachment 3 for information on the stability of the structure.

Some portions of the revetment will not reach the site boundary with Parcel F at the 1V:4H slope without excessive excavation. For these portions of the revetment, the toe will be extended at least 1 foot below and at the same slope as the existing nearshore grade until the site boundary is reached. This toe extension will contain the potentially contaminated shoreline sediments up to the site boundary without excessive excavation. Refer to Figures 7, 8, and 9 for the extent of the revetment and a typical cross section.

Using an equation similar as is used for armor unit sizing, the minimum weight of the riprap can be calculated specifically for the revetment toe. This calculation is provided as Appendix N of this report. Using this process and conservative assumptions about the final depths of the structure, a minimum stone weight of approximately 32 pounds is obtained for the revetment toe. Based on the Caltrans gradation for ¼-ton riprap provided in the calculation, all rock in the revetment will be at least twice the minimum weight requirement for the toe.

3.3.8 Filters and Underlayers

A filter layer is needed between the revetment rock and the underlying soil to ensure that the revetment is supported. The filter layer has a tramsmissivity of at least the surrounding sediment and soil allowing water to pass (both groundwater and surface water) while maintaining the stability of the soil. A geotechnical filter fabric intended for ocean shoreline and revetment applications is placed onto the base of the excavation in overlapping lateral sections and extends beyond the toe and crest sections to prevent sinking or moving of the entire structure as a result of soil erosion. A layer of gravel or crushed rock is spread over the filter fabric to protect it from the armoring and distribute the load of the rock. This gravel layer also contributes to the interlocking and securing of the armor material. Refer to Figure 8 for the typical cross section of the revetment and the filter layer and its location relative to the revetment stone.

The filter fabric will run under the entire length of the revetment and will be tied into the revetment rock at both the toe and the crest, as shown in Figure 8. Securing the filter fabric into the revetment as shown will secure the material in place even if the revetment material settles over time.

Given the site-specific conditions and the construction of the revetment, filter fabric sections should overlap by at least 2 feet to ensure continuity of the fabric material when the weight of the revetment armor is added and during any shift of the revetment that may occur over time. Additionally, a 6-inch layering of crushed rock of ¾-inch diameter would be sufficient as protection of the geofabric filter material from the weight of the revetment rock. These provisions are based on initial conversations with filter fabric manufacturers and given the conditions at the site.

3.3.9 Materials Quantities

Materials quantities for the revetment were calculated for the amounts of riprap, crushed rock, and filter fabric material that would be needed for the project. These calculations are provided as Appendix O and are summarized below.

- Riprap rock – 8,640 yd^3 or 13,470 tons
- Crushed rock – 1,440 yd^3 or 2,250 tons
- Filter fabric – 10,110 ft^2

The calculations include a 30 percent porosity for the crushed rock and riprap, 2 feet of overlap between filter fabric sections, and 15-foot fabric sections.

3.3.10 Other Design Considerations - Revetment

After construction of the revetment is complete, the structure will be surveyed to document the final elevations. These final elevations will be used for assessing the movement of the structure over time during O&M. Some movement and settlement of the structure are expected and will increase the strength and stability of the structure.

The majority of the revetment is to be located above the mean sea level elevation and can be constructed from shore without the use of barges or other provisions for construction from off shore.

Studies completed for the HPS peninsula (Woods Hole Group 2001) indicate that the bay area in the vicinity of the site is depositional and it is expected that over time the toe portions of the revetment will fill with sediment. The extent of filling is not known but could reach to the existing elevations. This filling will enhance the stability of the revetment to some degree through the further stabilization of the toe. This filling will have a negligible effect on the near shore wave dynamics.

It is anticipated that the construction contractor will excavate and construct the revetment in completed sections and progress along the shoreline as sections are completed. Constructing the revetment in this method will ensure that the bay water will not be in direct contact with the potentially contaminated soil and sediment that will be contained by the revetment. It also will ensure that erosion of the shoreline material will be minimal during construction, as excavations will be open only during the work day. Erosion control and soil stabilization practices such as silt fencing and hay bales will be used as necessary to ensure that erosion is prevented.

The existing HPS radiological screening area is assumed to be available and sufficient for screening the soil excavated during construction of the revetment. Grading the revetment area is anticipated to generate approximately 5,100 bcy of soil, sediment, and debris over a period of 2 months. Debris and boulders will be removed from this volume before screening. The current soil screening area has a processing capacity of approximately 1,200 cubic yards of soil among six screening pads The material excavated along the shoreline will be handled and screened in accordance with the requirements currently in place for the basewide radiological removal action (TtEC 2008). Excavated material that has been screened and meets residential radiological remediation goals (see Table 8-4 of the amended ROD [ChaduxTt 2009]) may be used as fill behind the revetment structure or spread on the land portion of the site under the proposed cover when possible to reduce or eliminate the need for off-site disposal.

3.4 STABILITY AND SEISMIC CONSIDERATIONS

The stability of the proposed soil cover and the riprap revetment was assessed and is included as Attachment 3 of this DBR. The analysis follows previously completed seismic studies at HPS, in particular an analysis completed for at Parcel E (Tetra Tech EM Inc. 2004).

The analysis completed for the proposed remedy was based on the maximum probabilistic earthquake (MPE), which for the site is magnitude 7.9 occurring 12 kilometers from the site associated with the San Andreas Fault Peninsula Segment. The conclusions of the assessment are as follows:

- The proposed slopes associated with the soil cover and the revetment are stable under static loading conditions.
- Estimated displacement from the MPE is less than 10 centimeters.
- Significant damage resulting from any potential deformation of the ground surface would not be anticipated during earthquake shaking given the estimated displacement.

- Any damage from earthquake shaking could be easily and inexpensively repaired and release of potential radiologically impacted soil is not anticipated. Provisions to secure the site in the event of damage or release of potentially impacted soil are included in the O&M plan.

- Site soils are predominantly sands and gravels and are not susceptible to liquefaction.

- More accurate evaluation of impacts during earthquakes would require significant additional subsurface investigation. Considering the limited risks associated with the site and the ease and low associated cost of repairs, further subsurface investigation is not recommended.

4.0 REFERENCES

Barajas and Associates. 2008. "Final Feasibility Study Report for Parcel F, Hunters Point Shipyard, San Francisco, California." April 30.

ChaduxTt. 2007. "Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California." December 12.

ChaduxTt. 2008. "Final Parcel B Construction Summary Report, Hunters Point Shipyard, San Francisco, California." July 25.

ChaduxTt. 2009. "Final Amended Parcel B Record of Decision, Hunters Point Shipyard, San Francisco, California." January 26.

Church, J.A., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth. 2001. "Changes in Sea Level." Chapter 11 in Climate Change 2001: The Scientific Basis: J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P. van der Linden, X. Dai, K. Maskell, and C.I. Johnson (eds). Contribution of working group 1 to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge. Available on-line at: http://www.grida.no/climate/ipcc_tar/wg1/index.htm

Church, John A., Neil J. White, Thorkild Aarup, W. Stanley Wilson, Philip L. Woodworth, Catia M. Domingues, John R. Hunter, Kurt Lambeck. 2008. "Understanding Global Sea Levels: Past, Present and Future." Sustainability Science, Vol. 3, No. 1, April 2008. Available online at: http://www.springerlink.com/content/v65402564j02170h/

Chow, V., Maidment, D., and Mays, L. 1988. "Applied Hydrology." McGraw-Hill Publishing

Department of the Navy (Navy). 1997. "Hunters Point Shipyard, Parcel B, Final Record of Decision." October 7.

Navy. 2000. "Final Explanation of Significant Differences, Parcel B, Hunters Point Shipyard, San Francisco, California." May 4.

Linsley, Ray K., and Franzini, Joseph B. 1979. "Water-Resources Engineering." McGraw-Hill Book Company.

Moffatt and Nichol. 2009. "Candlestick Point / Hunters Point Development Project, Initial Shoreline Assessment." February.

National Oceanic and Atmospheric Administration (NOAA) National Ocean Service. Tidal Benchmarks and Tidal Datums, Hunters Point. Station ID 9414358.

Naval Sea Systems Command (NAVSEA). 2004. "Historical Radiological Assessment, Volume II, Use of General Radioactive Materials, 1939 to 2003, Hunters Point Shipyard." August 31.

PRC Environmental Management, Inc. (PRC). 1996. "Parcel B Feasibility Study, Final Report, Hunters Point Shipyard, San Francisco, California." November 26.

PRC, Harding Lawson Associates, Levine-Fricke, and Uribe & Associates. 1996. "Parcel B Remedial Investigation, Draft Final Report, Hunters Point Shipyard, San Francisco, California." June 3.

San Francisco Redevelopment Agency. 1997. "Hunters Point Shipyard Redevelopment Plan." July 14.

SES-TECH. 2009. "Draft Removal Action Completion Report, Time-Critical Removal Action for the Methane Source Area at IR-07, Parcel B, Hunters Point Shipyard, San Francisco, California." February.

Tetra Tech EM Inc. 2004. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Liquefaction Potential, Hunters Point Shipyard." August 13.

Tetra Tech EC, Inc. (TtEC). 2008. "Final Base-wide Radiological Work Plan Revision 2, Hunters Point Shipyard, San Francisco, California." May.

TtEC. 2009. "Final Task-Specific Plan for the IR-18 Scoping Survey, Hunters Point Shipyard, San Francisco, California." March 20.

U.S. Army Corps of Engineers. 1985. "Coastal Engineering Technical Note – Riprap Revetment Design." CETN-III-1.

U.S. Army Corps of Engineers. 1995. "Design of Coastal Revetments, Seawalls, and Bulkheads."

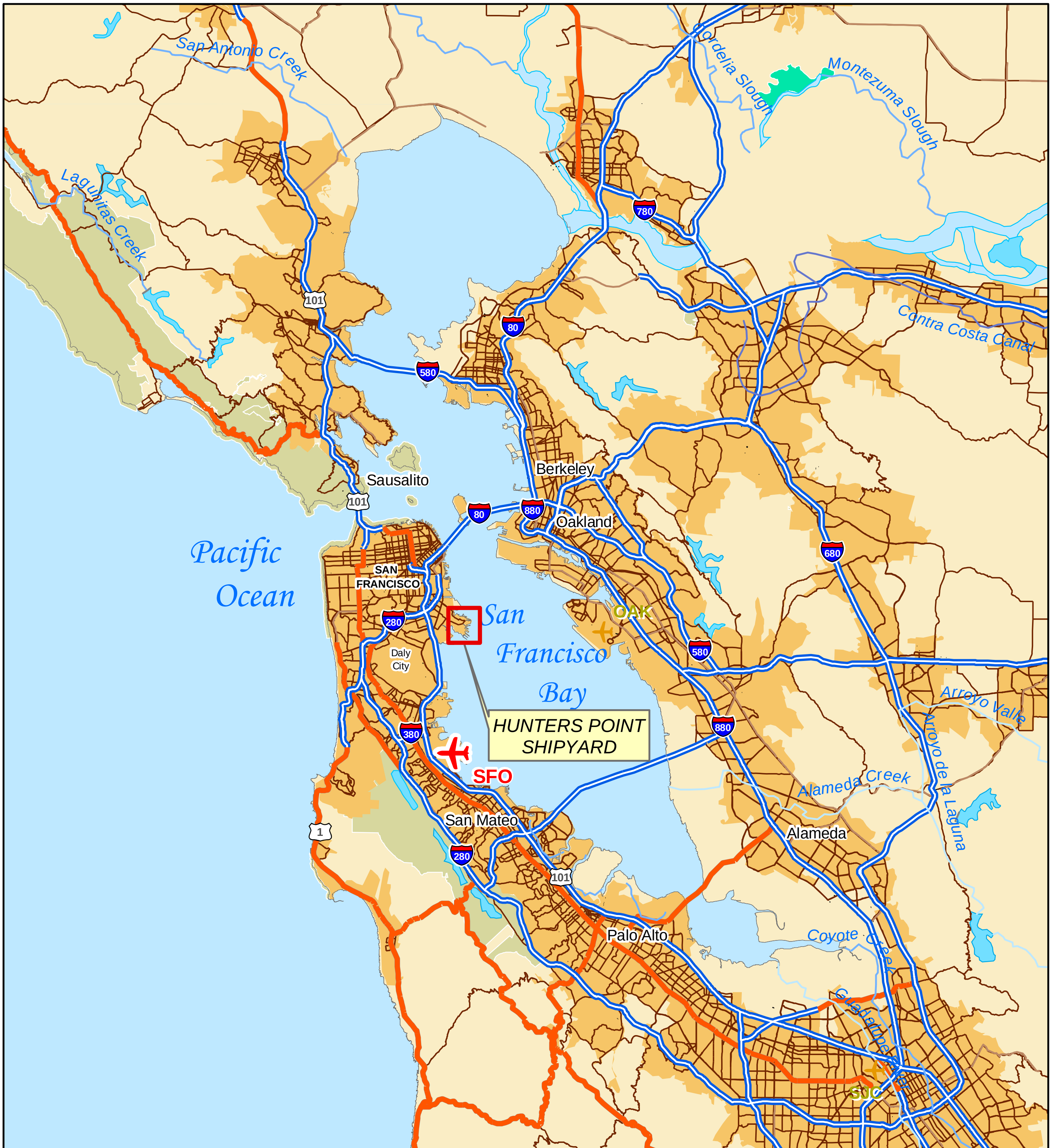
U.S. Army Corps of Engineers. 2001. "Determining Optimal degree of Soil Compaction for Balancing Mechanical Stability and Plant Growth Capacity." May.

U.S. Army Corps of Engineers. 2006. "Coastal Engineering Manual."

U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS), 1986. "Urban Hydrology for Small Watersheds – Technical Release 55." June

Woods Hole Group, 2001. "Hunters Point Shipyard Parcel F Winter 2001 Sediment Dynamics Study, Technical Memorandum" July 12.

FIGURES



Location Map

N

5 2.5 0 5

Miles

ChaduxTt JV
Consulting Engineers and Scientists

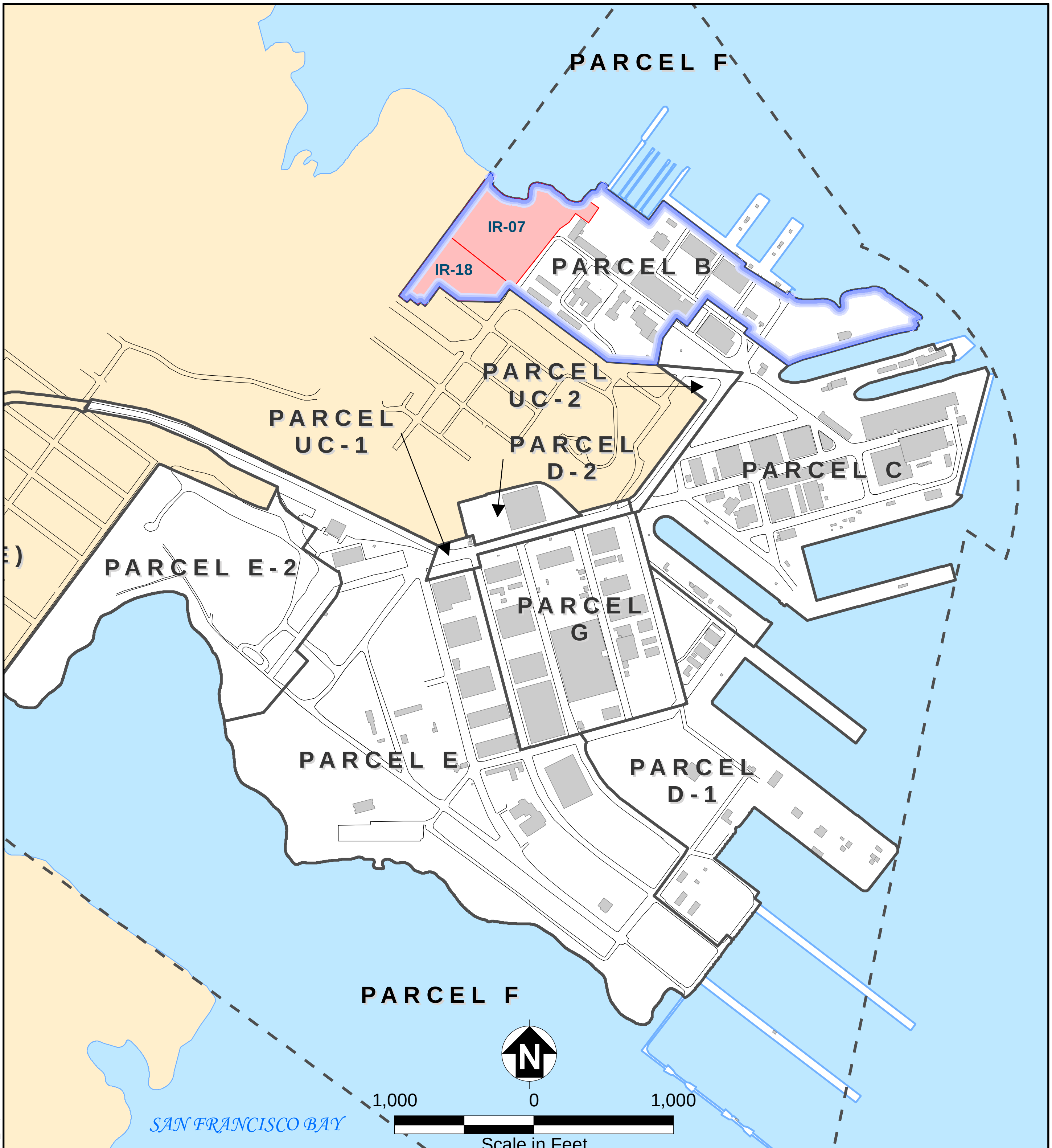
Hunters Point Shipyard, San Francisco, California

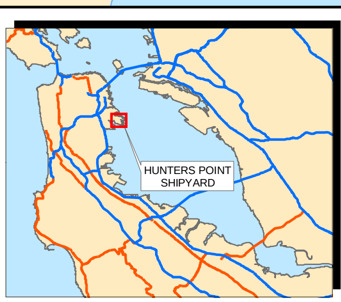
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1
HUNTERS POINT SHIPYARD
LOCATION MAP

Remedial Design for IR Sites 7 and 18

2008-12-02 O:\Hunters_Point\Projects\Parcel_B\RD\HPS_location_map.mxd TtEMI-DN kurt.cholak





Location Map

Installation Restoration Sites 7 and 18
Parcel B Boundary
Parcel Boundary
Parcel F Boundary
Building
Non-Navy Property
Road

ChaduxTt JV
Consulting Engineers and Scientists

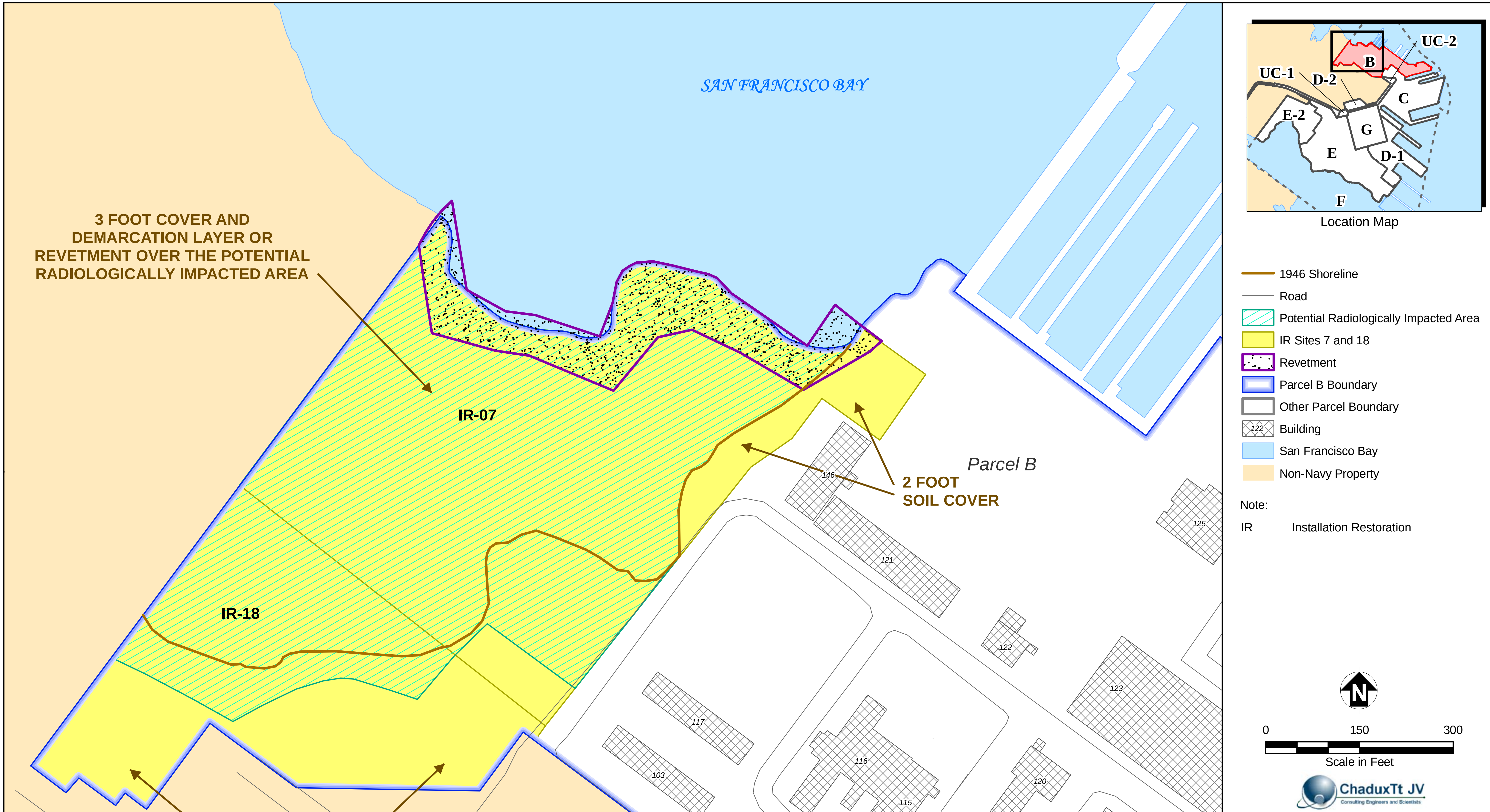
Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2

FACILITY LOCATION MAP

Remedial Design for IR Sites 7 and 18

05/18/2009 O:\Hunters_PointProjects\RD\Facility_Location_Map.mxd TtEMI-DN Kurt.Cholak



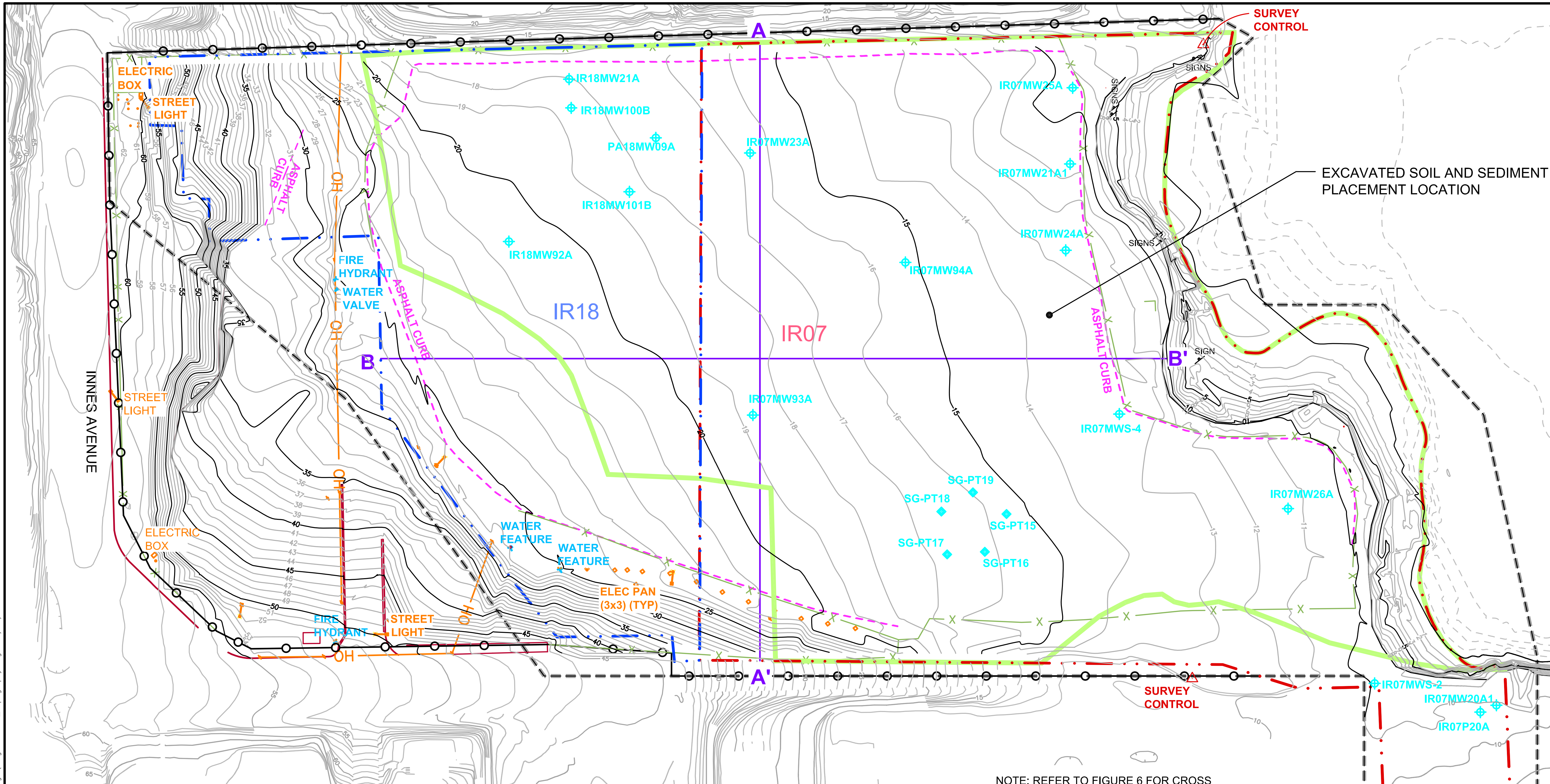
Hunters Point Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3
DESIGN OVERVIEW

Remedial Design for IR Sites 7 and 18

05/18/2009 O:\Hunters_Point\Projects\Parcel_B\RD\Fig3_InstitutionalControls.mxd TtEMI-DN Kurt.Cholak



NOTE: REFER TO FIGURE 6 FOR CROSS SECTIONS.

LEGEND

- IR SITE 7 BOUNDARY
- IR SITE 18 BOUNDARY
- RESTRICTIONS RELATED TO RADIONUCLIDES
- MAJOR CONTOUR
- MINOR CONTOUR
- A —— A' CROSS SECTION LINE
- SURVEY CONTROL
- CONCRETE CURB / PAD
- FENCE
- OVERHEAD POWER LINE
- TEMPORARY FENCE (DURING CONSTRUCTION)
- APPROXIMATE LIMITS OF CLEARING AND GRUBBING AND DEBRIS REMOVAL
- UTILITY FEATURE
- WATER FEATURE
- ASPHALT CURB
- MONITORING WELL
- METHANE MONITORING PROBE

SURVEY CONTROL DATUM

HORIZONTAL (BASIS OF BEARINGS): NAD27 ZONE-III (HUNTERS POINT WEST 1 PID HT0613) USFT.

VERTICAL (BENCH MARK): NGVD 29 LESS CORRECTION 7.76 FEET MSL

N

50' 0 50' 100'

SCALE: 1" = 100'

DRAFT
NOT FOR CONSTRUCTION

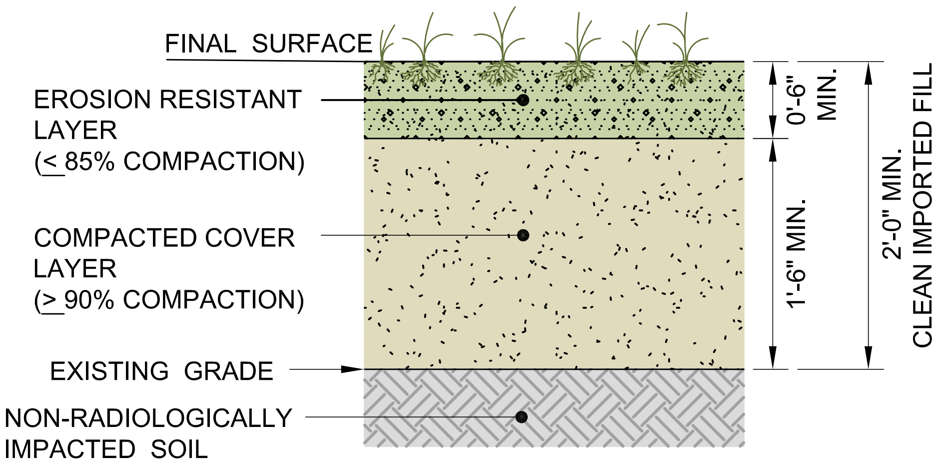
ChaduxTt JV

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

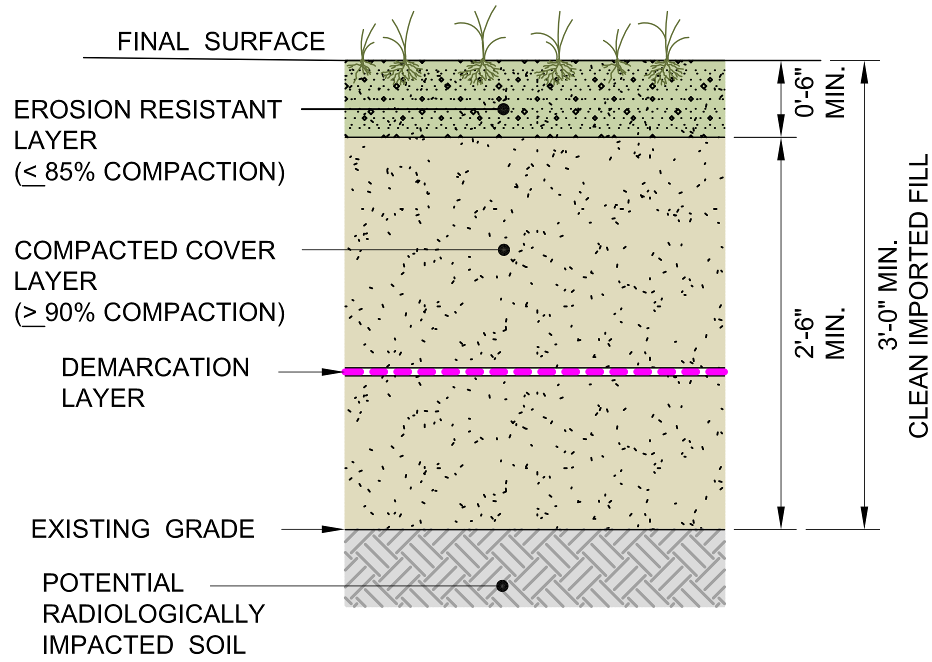
FIGURE 4
EXISTING TOPOGRAPHY AND CROSS-SECTION LOCATIONS

Remedial Design for IR Sites 7 and 18

R:\Navy\Hunters-Pt\Parcel B\Ir07_Ir08\Remedial Design\ Figure 4 Ex_Topography.dwg 05/19/2009 deborah.ford DN



COVER OVER NON-RADIOLOGICALLY IMPACTED AREA (2 FOOT COVER)



COVER OVER POTENTIAL RADIOLOGICALLY IMPACTED AREA (3 FOOT COVER)

NOTE:

EXCAVATED NON-RADIOLOGICALLY IMPACTED SOIL TO BE PLACED UNDER COMPACTED COVER LAYER.

NOT TO SCALE

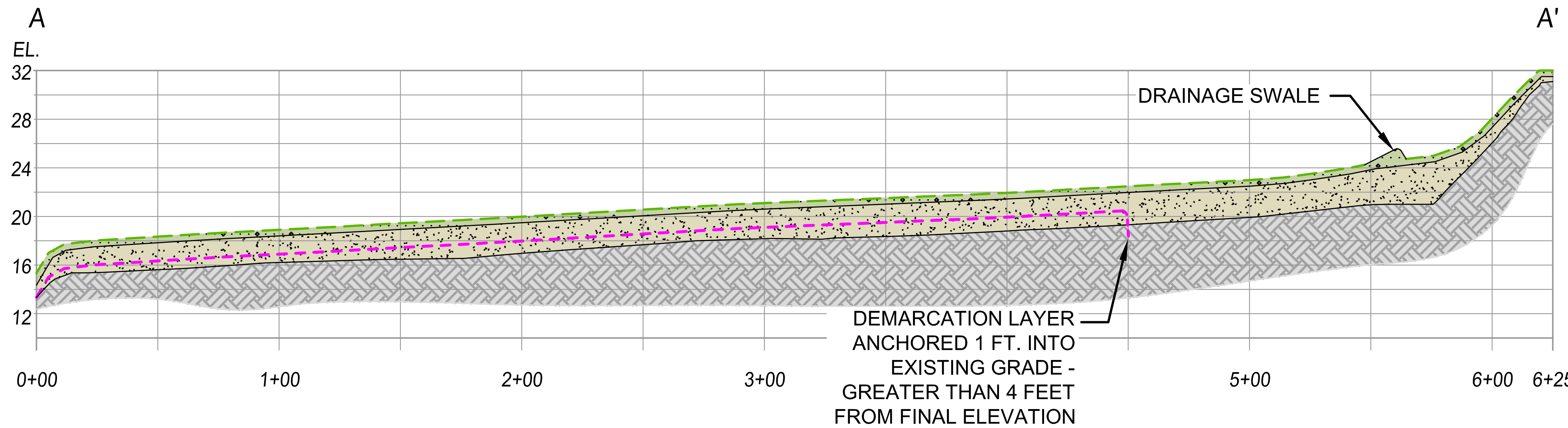
DRAFT
NOT FOR CONSTRUCTION

ChaduxTt JV
Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

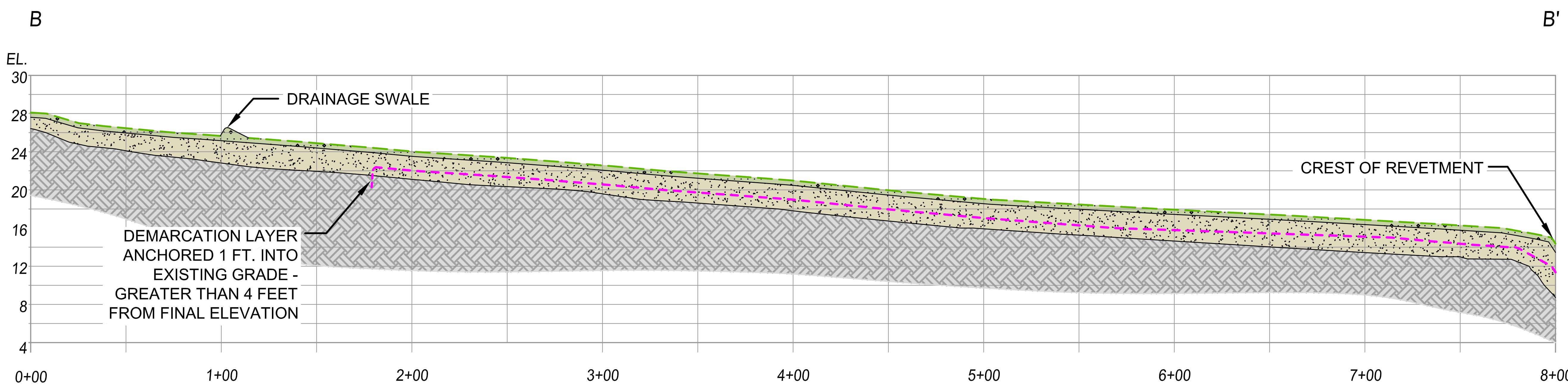
FIGURE 5
COVER COMPONENTS

Remedial Design for IR Sites 7 and 18



LEGEND

	EROSION RESISTANT LAYER
	COMPACTED COVER LAYER
	EXISTING SURFACE
	DEMARCATION LAYER
EL.	ELEVATION



NOTES:

1. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL.
2. SEE FIGURES 4 AND 7 FOR CROSS SECTION LOCATIONS.

DRAFT
NOT FOR CONSTRUCTION

30' 0 30' 60'
SCALE: 1" = 60'
HORIZONTAL

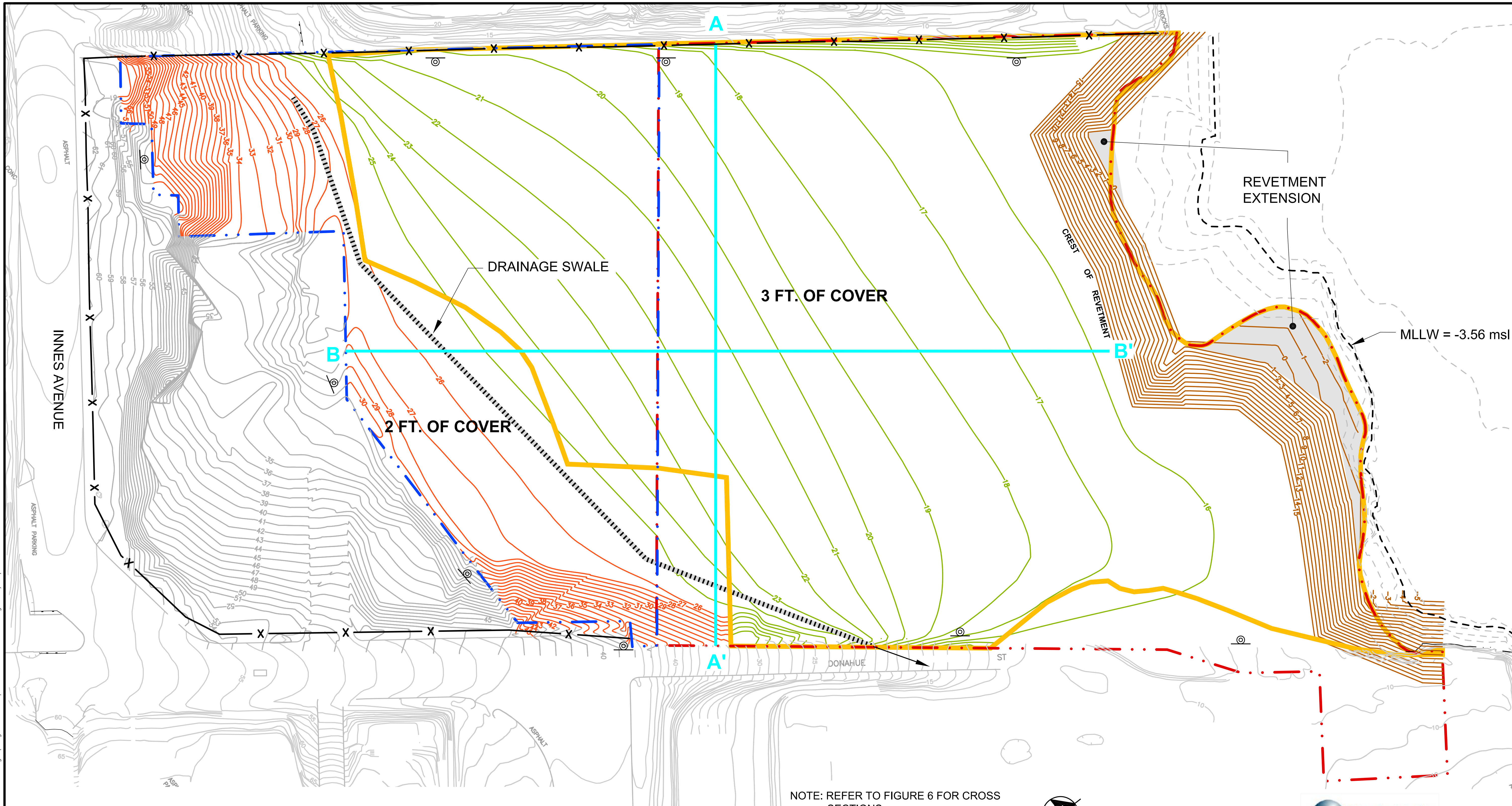
6' 0 6' 12'
SCALE: 1" = 12'
VERTICAL

ChaduxTt JV
Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 6
CROSS SECTIONS A-A' AND B-B'

Remedial Design for IR Sites 7 and 18



NOTE: REFER TO FIGURE 6 FOR CROSS SECTIONS.

Legend

- IR07 BOUNDARY
- IR18 BOUNDARY
- RESTRICTIONS RELATED TO RADIONUCLIDES
- EXISTING CONTOUR
- A—A' CROSS SECTION LINE
- SIGN
- PROPOSED CONTOUR 3 FT. COVER
- PROPOSED CONTOUR 2 FT. COVER
- PROPOSED OFFSHORE CONTOUR
- DRAINAGE SWALE
- PERMANENT FENCE

SURVEY CONTROL DATUM

HORIZONTAL (BASIS OF BEARINGS): NAD27 ZONE-III (HUNTERS POINT WEST 1 PID HT0613) USFT.

VERTICAL (BENCH MARK): NGVD 29 LESS CORRECTION 7.76 FEET MSL

50' 0 50' 100'

SCALE: 1" = 100'

DRAFT
NOT FOR CONSTRUCTION

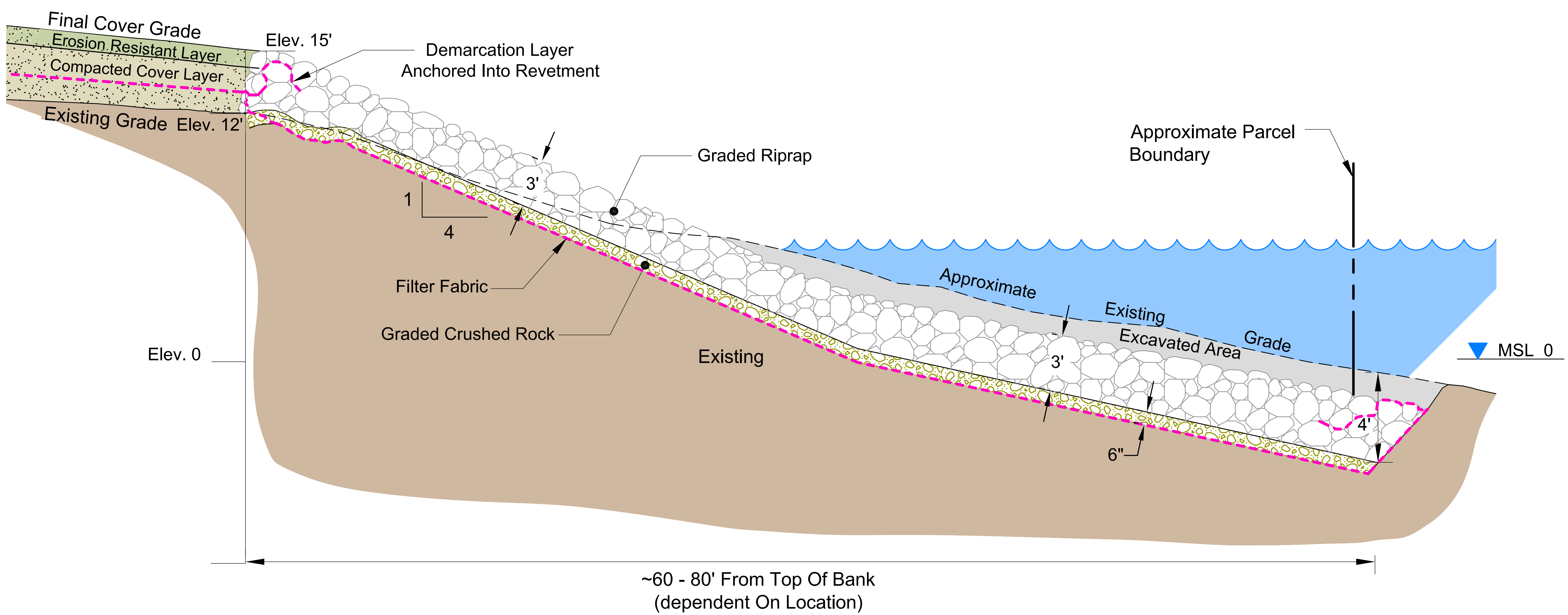
ChaduxTt JV

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 7
PROPOSED COVER CONTOURS

Remedial Design for IR Sites 7 and 18

R:\Navy\Hunters-Pt\Parcel B\ir07_ir08\Remedial Design\ Figure 7 Proposed Final Cover.dwg 05/19/2009 deborah.ford DN



DRAFT
NOT FOR CONSTRUCTION

LEGEND

- RIPRAP
- GRADED CRUSHED ROCK
- EXISTING MATERIAL
- SAN FRANCISCO BAY
- EXCAVATED GRADE
- FILTER FABRIC
- APPROXIMATE PARCEL BOUNDARY
- APPROXIMATE EXISTING GRADE

Elev.	ELEVATION
MSL	MEAN SEA LEVEL
MHHW	MEAN HIGHER HIGH WATER
MLLW	MEAN LOWER LOW WATER

NOTES:

1. ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL.
2. FOLLOWING THE COMPLETION OF THE REVETMENT IT IS ANTICIPATED THAT DEPOSITION OF SEDIMENT WILL FILL IN THE EXCAVATED AREA ABOVE THE REVETMENT. THE AMOUNT OF DEPOSITION IS UNKNOWN.

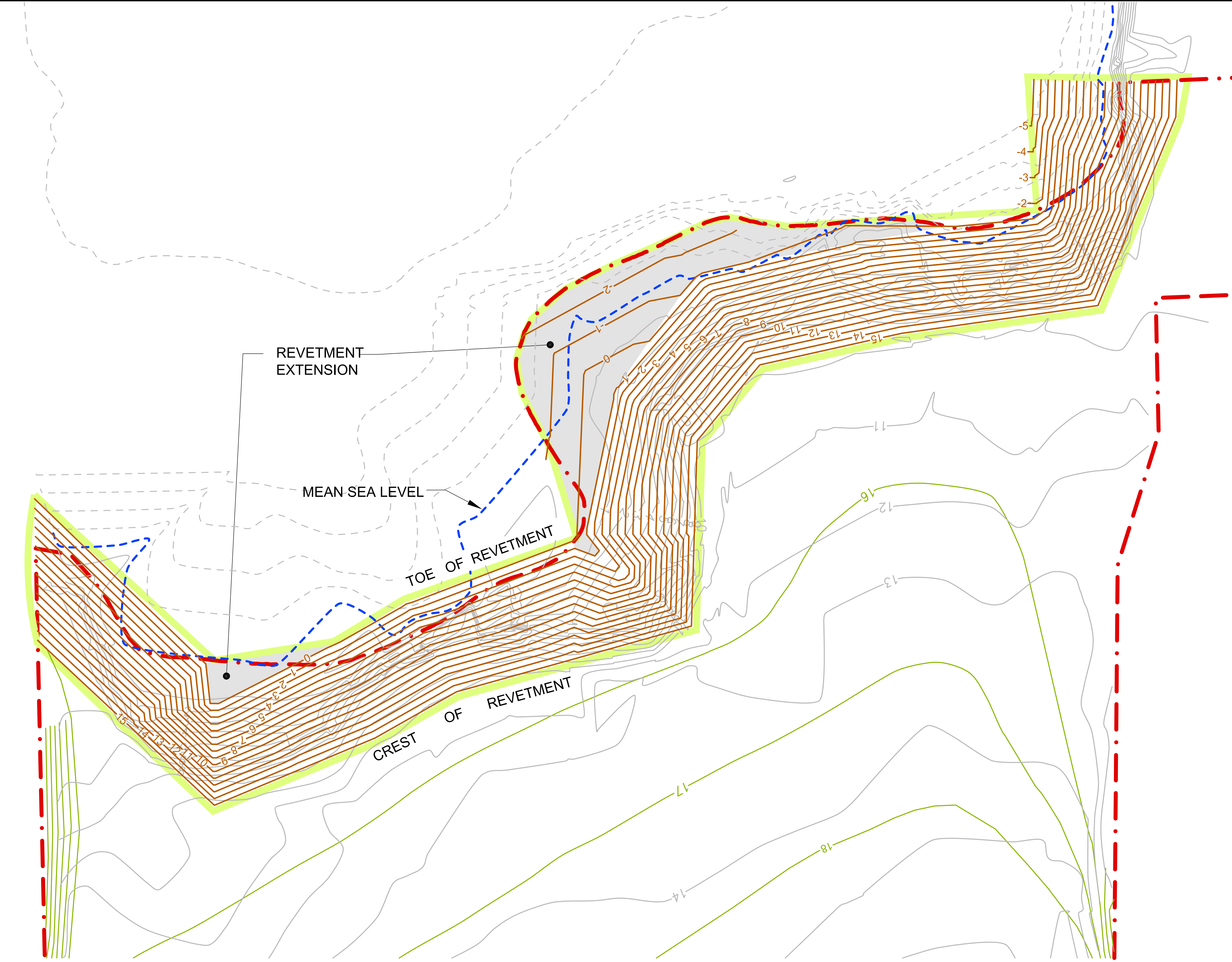
NOT TO SCALE

ChaduxTt JV
Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 8
TYPICAL REVETMENT
CROSS SECTION

Remedial Design for IR Sites 7 and 18



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING OFFSHORE CONTOUR
- IR SITE 7 BOUNDARY
- PROPOSED CONTOUR
- REVETMENT EXCAVATION AREA
- PROPOSED COVER CONTOURS

NOTE:
ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL.

30' 0 30' 60'
SCALE: 1" = 60'

ChaduxTt JV

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 9
PROPOSED REVETMENT GRADE

Remedial Design for IR Sites 7 and 18

DRAFT
NOT FOR CONSTRUCTION