STAFF REPORT

RECOMMENDED REMEDIAL ACTION

For

WILLAMETTE COVE UPLAND SITE
PORTLAND, OREGON

Prepared By

OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
Northwest Region Office

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1. INTRODUCTION

1.1. INTRODUCTION

This document presents the Oregon Department of Environmental Quality (DEQ) recommended remedial action for the Willamette Cove Upland Site (Site) located along the northeast bank of the Willamette River in the St. Johns area of Portland, Oregon. The remedial action has been developed in accordance with Oregon Revised Statutes (ORS) 465.200 et. seq. and Oregon Administrative Rules (OAR) Chapter 340, Division 122, Sections 010 through 115, and is based on the administrative record for the Willamette Cove Site.

This report summarizes the more detailed information contained in site remedial investigation, risk assessment, removal action, feasibility study, and source control evaluation documents completed under a DEQ Voluntary Cleanup Agreement (ECVC-NWR-00-26) signed November 2000 by the Port of Portland (Port), Metro, and DEQ. Metro is the current property owner and the Port is participating as a past owner of a portion of the Site. A copy of the Administrative Record Index for the Site is attached as Appendix A.

1.2. SCOPE AND ROLE OF THE RECOMMENDED REMEDIAL ACTION

The recommended remedial action addresses the presence of polychlorinated dibenzo-p-dioxins and furans (dioxins and furans), metals, petroleum hydrocarbons (including polynuclear aromatics hydrocarbons or PAHs), polychlorinated biphenyls (PCBs), and volatile and semi-volatile organic compounds (VOCs, SVOCs) in the "Upland" portion of the Willamette Cove property. The Upland extends from top of riverbank landward, east and away from the Willamette River. Cleanup of the Willamette Cove riverbank, beach, and in-water contamination will be conducted under forthcoming Portland Harbor Superfund Site in-water actions, overseen by the United States Environmental Protection Agency (USEPA).

Soil contamination throughout the Upland exceed acceptable levels for both human health and ecology (plants and animals), and "hot spots" (elevated levels of contamination) are present. (Note that hot spot concentrations differ for humans versus ecology.) Groundwater contamination has also been identified in parts of the Site, notably in the West Parcel, which may require cleanup or other actions. Cleanup actions for groundwater are not presented in this staff report, but the need for additional investigation efforts is acknowledged. After the collection and analysis of additional groundwater data from the Upland, and forthcoming in-water (pre-design) investigation under USEPA, DEQ will determine whether a complete groundwater-to-surface water pathway is present which may require additional action.

The following remedial actions are recommended for the Willamette Cove Upland Site:

1. Excavation and offsite disposal of all soil exceeding hot spot levels for human health.

2. Consolidation and onsite capping of: a) soil posing an excess risk to humans but below hot spot levels; and b) soil with higher risk levels relative to animals and plants, including hot spots. Capping of consolidated soil will consist of a demarcation layer and a minimum of 3 feet of clean cover material.[1] The consolidation area will be engineered to meet long-term requirements for stability and tailored to accommodate Metro plans for a nature park (with a regional trial). Preliminary estimates indicate the Upland can accommodate approximately 23,000 cubic yards of contaminated soil in a consolidation feature compatible with plans for the property.

3. Excavation and offsite disposal of soil exceeding risk levels for humans or animals/plants may be required in cases where either in-place capping or onsite consolidation and capping are not feasible due to space limitations, flooding or seismic concerns, etc. To the extent this is necessary, a preference will be given to offsite disposal of soil posing a higher risk to humans or animals/plants.[2]

4. Following offsite disposal and onsite consolidation and capping, residual soil contamination posing a lower-level risk to animals and plants would be covered in-place. Cover thickness would be determined based on the level of residual risk; however, a minimum 1-foot of clean topsoil will be necessary.[3]

5. Completion of investigation efforts to determine whether groundwater contaminants have the potential to migrate to the Willamette River. The investigation is expected to include both additional Upland sampling and data analysis, and in-water investigation as part of (Portland Harbor Superfund Site) pre-design investigation under USEPA. If a complete groundwater-to-surface water migration pathway exists, source control options will be evaluated.[4] Following completion of this work, DEQ would prepare a Source Control Decision.

6. Long-term monitoring and maintenance of all engineering controls, including consolidation areas caps and soil covers, to confirm the ongoing effectiveness of these cleanup actions. A Cap Inspection and Maintenance Plan and Contaminated Media Management Plan will be developed, as well as a Community and Outreach Plan. The long-term monitoring and maintenance plan will include a discussion of contingency measures. In addition to regular monitoring, the cleanup action will be subject to five-year reviews, which provide an opportunity to evaluate the implementation and performance of a remedy to determine whether it remains protective of human health and the environment. The five-year review would include potential changes in land and water uses for the Site and nearby area.

7. Institutional controls, including recording of a deed restriction with the property identifying the nature of contamination, use restrictions, and necessary long-term controls.

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[1] Thickness of 3 feet is assumed for a soil-based cap. Alternative materials approved by DEQ could be incorporated, such as rock and hardscape. The final cap thickness and composition will be determined during remedial design.
[2] Non-dioxin/furan ecological hotspots will be disposed offsite, or contained within the consolidation area.
[3] Remaining ecological hot spots, if any, will be capped by 3 feet of clean soil or alternative DEQ-approved material.
[4] Potential source control options are presented in the *Revised Groundwater Source Evaluation and Alternatives Analysis* (Apex, 2020).

2. SITE HISTORY AND DESCRIPTION

2.1. SITE LOCATION AND LANDUSE

The Willamette Cove Site stretches approximately 3,000 feet on the northeast bank of the Willamette River in the St. Johns area of Portland, Oregon (see Figure 1: Site Location Map). The property is comprised of the following Multnomah County tax lots in Section 12, Township 1 North, Range 1 West of the Willamette Baseline and Meridian: TL 200 (8.33 acres); TL 300 (8.85 acres); TL 2200 (1.38 acres); TL 2300 (0.74 acres) and TL 5400 (5.02 acres). DEQ's environmental cleanup site information (ECSI) system designates the Willamette Cove as site 2066. While the property is approximate 24 acres, the total area of the Upland is approximately 19.1 acres (above top of bank).

The riverfront property is positioned between river mile 6 and 7 of the Willamette River, north (downriver) of downtown Portland and south (upriver) of the St. Johns Bridge. As shown in Figure 2: Site Map, the property varies in width from 100 to 700 feet between the Willamette River and Union Pacific Railroad (UPRR) tracks to the north. The tracks are situated alongside the toe of the vegetated bluff, which rises at a steep angle offsite to the east. Residential areas of the Cathedral Park neighborhood occupy the terrace above Willamette Cove, and the St. Johns and University Park neighborhoods to the north and south. Willamette Cove is bordered to the northwest by North Richmond Avenue and the adjoining "Crawford Street" properties (ECSI No. 2363 and 6167). The primary point of access to the site is North Edgewater Street, extending from the bluff margin (and North Willamette Boulevard) to the East Parcel area. The property can also be reached on foot by means of North Richmond Avenue, or from the river.

To the southeast, an embankment for the Burlington Northern Sante Fe (BNSF) railroad bridge separates the Willamette Cove and the McCormick & Baxter Creosoting Company property (ECSI No. 74). The "M&B" site is a USEPA Superfund Site, which has undergone remediation and subject to long-term monitoring. A portion of Willamette Cove has been impacted by releases from M&B and a sediment cap covers a southeast section of the "cove" (see Figure 2).

For the purposes of site investigation work, and roughly corresponding to tax lot boundaries, three upland areas have been designated for the Site: East Parcel, Central Parcel, and West Parcel. Willamette Cove has a notable crescent shaped indentation in the riverbank, or "cove" feature, located immediately downriver (north) of the embankment leading up to the BNSF bridge and approximately 800 feet from the main river channel. The cove was formed in the early 1900s during construction of the bridge and placement of the embankment, which extends into the river. A large sand beach is exposed in the inner portion of the cove during seasonal low water conditions.

The Site was largely created by historical filling of land adjacent to the Willamette River, and is generally flat-lying above the riverbank. Berms and hummocks are occasionally present, especially in the West and East Parcels. Historically the West Parcel contained an embayment utilized as a log pond (see Figure 2), which has since been backfilled. While terraced above the Willamette River, in general the property is low-lying and accessible from the river during lower river stages, particularly the inner cove area. In general, surface elevations range from 30 to 44 feet North American Vertical Datum 88 (NAVD88). The West Parcel is slightly higher (32 to 44 feet) and the southeast portion of the East Parcel dips as low as 28 feet. The 100-year floodplain and 500-year flood plain elevations (32 and 37 feet NAVD88, respectively) are depicted on Figure 3: Site Elevation and Floodplain Map. The top of bank (TOB) is generally located at 32 feet NAVD88 (see Figure 4: Bankline Cross-Sections), but ranges 28 to 40 feet. The riverbank is moderately

to steeply-sloped in the West and Central Parcels, and more variable in the East Parcel with gentle to moderate slopes behind the inner cove beach area and very steep below the BNSF abutment.

The property is currently zoned as Open Space (OS) and portions are covered by the City of Portland Greenway overlay zones (gq). According to the City, an OS zoning is intended to preserve and enhance public and private open, natural and improved park and recreational areas. The River General (g) overlay allows for uses and development, which are consistent with the base zoning, allow for public use and enjoyment of the waterfront, and enhance the river's natural and scenic qualities. The River Water Quality (q) overlay zone is designated to protect the functional values of water quality resources by limiting or mitigating the impact of development in the setback.

The Willamette Cove property has a history of development and use spanning over 100 years. Figure 5: Historical Photos, show examples of historical operations. Historically the site was utilized for industrial purposes. Former buildings and related infrastructure have generally been removed. However, remnant infrastructure is scattered across the parcels including a large concrete foundation and paved roadway in the East Parcel. Concrete footings or foundation elements are present in areas across the site, and structural pilings exist within the cove and along the riverbank. Riprap is also present along most of the riverbank on the West and Central Parcels, and variety of debris dispersed amongst the parcels as remnants of industrial uses.

The property is currently vacant, and native and non-native vegetation has reclaimed the parcels and provides habitat to wildlife. Approximately one-third of the Site is covered with hardwood forest that is targeted by the City and Metro for restoration. Native trees include madrone, big leaf maple, and Oregon white oak. The remainder of the site is primarily scrub/shrub or meadow plant communities.

Metro, a tri-county governmental agency, purchased the property in 1996 pursuant to Metro's Open Spaces, Parks, and Streams Bond Measure 26-26. Metro has held the property for the purpose of creating a green space area. Restoration plans include a natural area to support aquatic, bird, and native vegetation species. A multi-use trail alignment through the natural area is shown on the City's comprehensive plan and is part of the regional trail plan adopted by Metro. The proposed trail is part of the longer Willamette River Greenway, which was identified as Goal 15 in Oregon's Statewide Planning Goals & Guidelines in 1973.

The current understanding of proposed future development of the Site is summarized below from the Trail Alignment Refinement Report (Alta Planning & Design, 2010), modified based on discussions with Metro.

- The site "presents a significant open space opportunity along the riverfront."
- The zoning allows for "public use and enjoyment of the waterfront" that "enhance the river's natural and scenic qualities" but also requires uses that "protect the functional values of water quality resources by limiting or mitigating the impact of development."
- The City's draft North Reach River Plan indicates that the site is considered a potential mitigation site and allows "ecologically sensitive" trails to the river.
- Metro and the City are developing a restoration plan that focuses on restoration of the Oregon white oak and madrone plant communities on the site.
- The paved multi-use trail would be developed on existing open corridors through the site. It would be 12 feet wide with 2-foot shoulders.
- Viewing platforms and/or soft surface trails to the water's edge could be strategically placed to control use of the site and to view scenery or wildlife.

2.2. PHYSICAL SETTING

2.2.1. Climate

The Portland area has a temperate marine climate characterized by wet winters and dry summers. The majority of rainfall occurs from October to May. According to records from 1871 to 2017 provided by NOAA,[5] average rainfall in Portland is 42.9 inches. December is the wettest month, with rainfall averaging 6.9 inches. July is the driest month, averaging 0.6 inches of rainfall. The average annual temperature is approximately 54 degrees Fahrenheit (°F), with a normal maximum near 81°F in July-August, and normal minimum of 35°F in December-January.

2.2.2. Geology

The site is located in the Portland Basin, an approximately 770 square mile topographic basin in the Puget-Willamette Lowland, with its long axis oriented northwest. Studies indicate that as much as 1,800 feet of late Miocene and younger sediments have accumulated in the deepest part of the basin, with most sediments carried in from the east by the Columbia River. (Within the sequence of basin sediments, both local and regional volcanic influence are observed, along with reworking of basin sediments through river and erosional processes.) Naturally deposited near-surface geologic materials (primarily silts, sands, and gravels) in the site vicinity are generally non-lithified, the two most prominent sources being: a) deposits associated with Pleistocene catastrophic flooding, and b) Quaternary river and stream deposits. At depth lie course-grained materials with varying degrees of lithification deposited by the ancestral Columbia River (Troutdale Formation, Miocene). The basin is underlain at depth by thick basalt sequences of the Columbia River Basalt Group (middle Miocene).

Structurally, the Portland Basin is transected by a series of northwest-to-southeast trending shallow, crustal faults. Major faults in the vicinity of the Site include the East Bank Fault, roughly aligned with the east bank of the Willamette River in the site vicinity, and the West Hills Fault, located approximately one mile to the west across the river and paralleling the east bank of the river. Small magnitude seismicity in the vicinity of these faults over the past few decades suggests that these structures may be seismogenic (capable of generating earthquakes). The potential for seismic activity in the Site vicinity is discussed later in this staff report as it relates to the resiliency of remedial alternatives, including the proposed Site remedy.

The State of Oregon Portland Quadrangle geologic map[6] for the area shows surficial deposits along both sides of the Willamette River in the site area are dominated by flood deposits, alluvium, and human placed artificial fill.

Surface and near-surface geologic materials (hereafter "soil") in the Willamette Cove Upland consist of artificial fill and Pleistocene alluvial deposits. Early maps of the area indicate the current upland portion of the Site consisted of a strip of lowland adjacent to the current UPRR railroad tracks. Based on historical maps and photographs, fill was placed on this lowland and outward into the Willamette River prior to and concurrent with development. The thickness of the fill across the site likely varies from about 20 to 30 feet; however, in places, it could be up to 60 feet (such as in the log pond on the West Parcel filled in the 1970s).

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[5] https://www.wrh.noaa.gov/pqr/pdxclimate/index.php

[6] *Geologic Map of the Portland Quadrangle, Multnomah and Washington Counties, Oregon, and Clark County, Washington*. State of Oregon, Department of Geology and Mineral Industries (DOGAMI); USGS GMS-75, 1991.

Fill and alluvial deposits in the Upland consist of silts and sands. These units are often distinguished from natural deposits based only on historical topographic maps and the presence of anthropogenic debris in the fill. Debris encountered in explorations at the Site consisted mostly of bricks, metal, and wood, with lesser amounts of glass, asphalt and concrete. In the West Parcel, debris is only present along the southern half (riverside) of the parcel at depths of up to 35 feet below ground surface (bgs). In the Central Parcel, debris was present between 12 and 27 feet bgs in the western half of the parcel (only surficial debris was encountered in the east half). An area of concentrated debris (brick and metal) was encountered from 2 to 5 feet bgs near the former building foundation located on the Central Parcel. (This concentrated area of debris was removed during the 2015/2016 soil removal action). In the East Parcel, debris was present along the southeast perimeter, at depths of up to 15 feet bgs. Naturally deposited materials encountered in site borings, extending to a depths of 70 feet bgs, were a mix of alluvial and catastrophic flood deposits. The Troutdale Formation was not encountered.

2.2.3. Hydrogeology

Hydrogeologic units of the Portland Basin are well described in publications including USGS Water Resource Investigations Report 90-4196 (*A Description of Hydrogeologic Units in the Portland Basin*, Oregon and Washington, 1990). The geologic units discussed above in Section 2.2.2 are generally water-bearing, and eight or more major hydrogeologic units have been mapped for the Portland Basin. Groundwater within 100 feet of ground surface is generally unconfined. Aquifer units of local to regional importance in the area include the following: Unconsolidated Sediment Aquifer (USA); Troutdale Gravel Aquifer (TGA); Troutdale Sandstone Aquifer (TSA); Sand and Gravel Aquifer (SGA); and Columbia River Basalt Aquifer (CRBA). Important confining units are present at the base of the TGA and TSA within portions of the Portland Basin.

The TGA, TSA, and SGA are all considered important aquifer resources and utilized by the City of Portland and others for drinking purposes. The USA is less utilized because of limited productivity and proximity to ground surface (and potential sources of pollution). Regional groundwater gradients are generally in the direction of the Willamette and Columbia Rivers, with groundwater discharge to surface water a significant flow pathway.

At the Site, shallow groundwater is unconfined and largely present in alluvial or flood deposits. In the West Parcel where deep filling has taken place, shallow groundwater lies within both fill and underlying native material. As the Troutdale Formation was not encountered in site borings, all groundwater within at least 100 feet of ground surface is presumed to be part of the USA.

Nine groundwater wells (MW-1 through MW-9) have been installed in the uppermost saturated zone (water table aquifer) and water levels gauged over several years. As shown in Figure 6: Groundwater Sampling Locations, the wells are positioned immediately above and along the top of bank to assess contaminant impacts in the most downgradient portion of the Upland. Depth to groundwater generally ranges from 21 to 37 feet bgs, corresponding to 7 to 15 feet NAVD88. Higher groundwater elevations have been observed at MW- 2, which may be impacted by an (upgradient) City of Portland stormwater feature, or represent localized perched water conditions.

In general, the direction of flow in shallow aquifers is to the west, towards the adjacent Willamette River. Water level data from the U.S. Geological Survey Willamette River gauging station (located at the Morrison Bridge in downtown Portland, approximately 6 miles upriver from the site and adjusted for the distance

from the gauging station) were compared to the well elevation data collected during four 2016 monitoring events (February, June, September, and December) to confirm groundwater gradient. Westerly flow was confirmed, although DEQ notes that the linear arrangement of the wells is less-than-ideal for gradient "triangulation". In general, water levels at the Site indicate that the overall groundwater gradient is toward the river. Short-term, local reversals in gradient may occur near the riverbank, but these reversals would occur only during maximum water level events that are of short duration.

2.2.4. Surface Water and Stormwater Features

Surface Water
The Willamette River, adjacent to the site, is positioned approximately river mile (RM) 6.7 from the confluence of the Columbia River. Along this reach, the river flows to the northwest and is about 1,500 feet wide. In Portland, the river flows at an average rate ranging from 11,100 cubic feet per second (cfs) in summer to 34,000 cfs in winter (USACE, 2014). The elevation of the 100-year and 500-year floodplain along this reach is 32 and 37 feet NAVD88, respectively (FEMA, 2010). At the Morrison Bridge station (RM 12.8) flood stage is considered 23 feet NAVD88, and moderate to major flood stages 29 and 33 feet NAVD88, respectively. The 1996 flood crested at 33.6 feet NAVD88.

The majority of the Willamette Cove Upland was not flooded during the February 1996 flood and the mapped extent is shown on Figure 3. The top of bank was breached in some areas, however, the site has a slightly increasing grade above top of bank which prevented the flood from reaching most of the upland area.

Stormwater
The majority of the property is vegetated and precipitation either infiltrates or runs off via sheet flow. Surface and near-surface soils are comprised of fill, and generally contain a significant sand fraction. As such, rainwater infiltrates readily into the ground. Neither sheet flow or significant ponding of water have been observed by DEQ at the Site. The flat to gently-sloped site grade generally prevents stormwater flow over the top of bank; however, minor runoff may occur in areas.

To assess the potential for stormwater conveyances to be present, both riverbank inspections and a review of City of Portland utility records was completed. Six potential outfalls were identified at the Site through a combination of inspection and records review; five were determined to be no longer active. One active outfall is present (City of Portland storm sewer system OF-49). Stormwater from properties located upslope and east of the Site is conveyed through a stormwater line below the Central Parcel to OF-49, discharging to the Willamette River. At present, there are no storm drains or stormwater features that discharge surface water from the Site.

2.3. SITE HISTORY

The Willamette Cove Upland was extensively used for industrial activity from the early 1900s to 1970s, including a cooperage, lumber mill, and dry dock-related activities. Significant riverside and over-water activity also occurred, notably the operation of dry docks adjacent to the Central Parcel, with associated activities extending onto the riverbank and upland areas. While the focus of this staff report is on the Upland extending from top of bank landward, information on riverbank and in-water industrial activities, including

historical photos are provided for contextual purposes. Figure 5 present historical photos representing the early 1920s to peak industrial development at the site.

West Parcel. Prior to industrial development, the West Parcel was either undeveloped shoreline or used for residential purposes. A map from 1855 shows the William Caples homestead situated near the present day intersection of North Richmond Avenue and the UPRR tracks. The West Parcel was developed in 1901 as a plywood mill and operated as a wood products facility into the 1960s. The facility expanded in the 1930s and contained sixteen buildings including over-water structures. In 1963, the plant discontinued plywood production. Woodworking businesses occupied the parcel during the mid-1960s to 1970, including a cabinet shop and prefabricated home manufacturer. Around 1972, buildings on the West Parcel appear to have been demolished and the former log pond on the parcel was filled by 1976. The property was purchased by the Portland Development Commission (PDC) in 1979 and thereafter remained vacant. In 1996, Metro purchased the property.

Historical features on or adjacent to the West Parcel that may have contributed to contamination present include a glue mixing and gluing room, glue storage, presses, debarkers, an oil house, a blacksmith shop, a grinding room, fuel tanks, and an underground petroleum pipeline in the railroad right-of-way. Possible contaminants associated with these features are metals (from grinding); PAHs (from fuel and hydraulic oil use); PCBs (from hydraulic oil); phenol and formaldehyde (from glues); total petroleum hydrocarbons (TPH); and VOCs (from use of solvents to clean metal). No sources were initially identified suggesting dioxins and furans, also referred as "dioxins/furans", contamination in the West Parcel. A former log pond on the West Parcel (see Figure 2) was backfilled with import fill reportedly sourced within the Portland Harbor, including the Arkema Chemicals Company site (ECSI No. 398) located directly upstream and across the river from Willamette Cove (Integral, 2008). Imported fill had the potential to contain chemicals associated with Arkema, such as pesticides.

Central Parcel. Pre-1900 maps of the area show the bluff northeast of the Central Parcel extended to the river. As such, the Central Parcel upland did not exist or consisted of riverbank along the present day UPRR tracks. From about 1905 through 1953, the Central Parcel was owned by the Port of Portland and occupied by dry docks and shops. The Central Parcel development began in 1903, in conjunction with the construction of the St. Johns dry docks nearby and downriver.

Between 1903 and 1924, shops and ancillary structures were constructed on the parcel to provide support for dry dock activities. Initially, the dry dock complex consisted of one slip. In the 1920s, a second slip was added and dredge fill was placed between the dry docks and the UPRR tracks, creating the Central Parcel upland. The dry dock facility extended from the upland to several hundred feet into the river and westward (see Figure 7: Historical Site Features). The western portion of the Central Parcel was sold in 1950 and incorporated into the plywood and lumber mill operations on the adjacent West Parcel. The remainder of the Central Parcel was sold in 1953 and developed as a lumber mill. The majority of the former shops were demolished in the 1950s to early 1960s, and the pier structures that supported the dry docks were removed from 1966 through 1969. The lumber mill was no longer in use by 1970. Smaller businesses appeared to have occupied the parcel into the 1970s for a variety of purposes including log rafting, a marine salvage company, a demolition contractor facility, woodworking facilities, and boat building. By the 1982 timeframe, the property was under PDC ownership, under whom remaining site buildings were demolished. Metro purchased the property in 1996.

Historical features on or adjacent to the Central Parcel which may have contributed to contamination at the site include a machine shop, blacksmith shops, an air compressor room, an oil warehouse, a paint shed, a

fuel oil standpipe, a debarker, a saw filing room, dry docks, a power house, transformers, and an underground petroleum pipeline in the railroad right-of-way. Possible contaminants include metals, PAHs, PCBs (from transformers and hydraulic oil), TPH, and VOCs. No sources were initially identified suggesting dioxins/furans contamination in the Central Parcel. An area of concentrated debris was encountered and removed during a soil removal action in 2015/2016. During the excavation, a layer of multi-colored soil was found directly on top of areas of concentrated debris. This layer of soil ranged from approximately one to three inches thick and consisted of white, red, and black layers. Distinct from and below the multi-colored soil was debris from an unknown source. The debris consisted of brick and metal concentrated from approximately 2 to 5 feet bgs but present up to the ground surface. A matrix of white to gray colored soil was observed in the debris within areas of concentrated brick. The location of the debris area coincided with the highest concentrations of dioxins/furans found in soil at the site.

East Parcel. Prior to development, the East Parcel was a floodplain occupied by marshes, small ponds, or wet prairie. Historical maps show an island (a sand bar) inside the harbor line along the southwest perimeter of the parcel. The UPRR tracks immediately northeast of the Willamette Cove and below the bluff were laid in 1902. The railroad bridge and its embankment were constructed between 1906 and 1908, with the tracks laid in 1909. The embankment parallels the southeast perimeter of the parcel and formed the crescent "cove" shoreline.

The East Parcel was developed and occupied by a cooperage plant (i.e., wood barrel manufacturer) from 1915 until the 1950s. Prior to construction of the plant, the upland area was filled to its present grade (approximately 28 to 35 feet NAVD88 in elevation) and the sand bar was removed. The southern portion of the plant including a dock was constructed by 1915, and subsequently a large warehouse in the 1920s. The main portion of the riverward cove was used as a log pond. By 1950, a new building was used for veneer sizing. A loading dock and connected railroad were demolished by 1957, and the mill reportedly was closed by 1963. A variety of wood related businesses occupied the parcel into the 1970s and log rafts occupied the cove until at least 1972. PDC purchased the property in 1980 and demolished the buildings by 1982. A large concrete foundation of approximately 47,000 square feet, remnant of the former warehouse, remains present. In 1996, Metro purchased the property.

Historical features on or adjacent to the East Parcel which may have contributed to contamination include a machine shop, a grinding room, a saw filing room, an oil house, a transformer house, a battery charging room, a glue mixing and gluing room, presses, a timber debarker, and an underground petroleum pipeline in the railroad right-of-way. Possible contaminants include formaldehyde, metals, PAHs, PCBs, phenol, TPH, and VOCs. No sources were initially identified suggesting dioxins/furans contamination in the East Parcel.

Offsite Sources. Environmental investigation conducted and/or cleanup sites in the immediate vicinity of the site include McCormick & Baxter, BNSF line, UPRR line, and Crawford Street. Excepting the elevated BNSF rail line and M&B, both located southwest of the site, none of these properties are known or suspected sources of contamination to the Willamette Cove Upland. Contaminants including metals have been detected in the railroad embankment within the East Parcel, suggesting that fill used to create the embankment may contain contaminants or subsequent releases have occurred impacting the area.

2.4. REGULATORY HISTORY

A succession of site-specific investigations and removal actions have been implemented at the property since 1988, which are documented in the project administrative file (ECSI No. 2066). Information is also available on DEQ's ECSI electronic database.

In November 2000, the Port of Portland and Metro entered into a Voluntary Agreement (ECVC-NWR-00-26) with DEQ to perform a remedial investigation/feasibility study (RI/FS) and implement any needed source control measures to prevent releases to Portland Harbor.

In December 2000, the USEPA identified the Portland Harbor area of the lower Willamette River as a Superfund Site (ID No. ORSFN1002155) and placed it on the National Priorities List (NPL), mainly due to concerns of contamination in Willamette River sediments and the potential risks to human health and the environment from consuming the fish. The Portland Harbor Superfund Site (PHSS), or Portland Harbor, expanded to include approximately river mile 1.9 to 11.8. The USEPA selected a final action for the Portland Harbor documented in the January 2017 Record of Decision (ROD) and describes the remedial alternatives that were considered and selects a final remedy for the in-river portion of the harbor, including riverbanks.

USEPA entered into a 2001 Memorandum of Understanding (MOU) with the DEQ, six federally recognized Native American Tribes (tribes), two other federal agencies, and one other state agency.[7] Under the MOU, DEQ is the lead agency for addressing contamination in the upland portions of the Superfund Site, and USEPA is the support agency.

Willamette Cove is located within the Portland Harbor and subject to the USEPA ROD. DEQ is the lead agency for assessment and cleanup of upland facilities that could pose a source of sediment contamination to the harbor, and correspondingly the Willamette Cove was identified by DEQ for upland assessment. DEQ's recommended remedial alternative presented in this report is intended to address the "Upland" portion of Willamette Cove (top of riverbank and landward). This staff report also presents the current status of the Willamette Cove source control evaluation (for stormwater and groundwater).[8]

Prior to 2000, environmental assessments were conducted at Willamette Cove related to property transfers, including soil and groundwater sampling of areas of interest that could be attributed to former uses and locating/removal of buried objects, such as underground storage tanks. Sediments in and near the cove were also sampled during early studies, the neighboring M&B site, and the Portland Harbor. These investigations detected contaminants of interest, such as metals, PAHs, PCBs, TPH, and VOCs.

The McCormick and Baxter Superfund Site (ID No. ORD009020603; DEQ ECSI No. 74), located immediately upstream to the Willamette Cove, was added to the NPL in 1994. The M&B site has undergone

[7] Government parties that signed the MOU include: Oregon Department of Environmental Quality, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Grand Ronde Community of Oregon, the Confederated Tribes of Siletz Indians, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Nez Perce Tribe, the National Oceanic and Atmospheric Administration, the U.S. Department of the Interior (National Marine Fisheries Service and U.S. Fish and Wildlife Service), and the Oregon Department of Fish and Wildlife.

[8] Characterization and source control actions for the riverbank will be completed under USEPA oversight in accordance with Portland Harbor ROD.

investigation and cleanup to address contamination originating from the former creosote wood-treating facility. River sediment adjacent to Willamette Cove has been impacted by a non-aqueous phase liquid (NAPL) plume migrating from M&B under the BNSF railway right-of-way toward Willamette Cove. In addition to controlling upland NAPL sources, the M&B cleanup included construction of a multi-layer sediment cap that extends into the most southeastern portion of the Willamette Cove below the toe of the railroad embankment (see Figure 8: Sheen and NAPL Observations).

2.4.1. Upland Remedial Investigation

The purpose of remedial investigation (RI) activities was to identify and characterize contaminants released into the environment at or from the site. Remedial investigation activities were performed using a phased approach. Subsequent investigations were performed to address data gaps to complete human health and ecological risk assessments (HHRA and ERA, respectively) and a source control evaluation (SCE), and in preparation of removal actions (elevated metals in 2008 and dioxin/furan hot spots in 2015/2016). The first phase of the remedial investigation involved soil and groundwater sampling between April 2001 and September 2002. The results as well as historical investigations are presented in the RI Report (Hart Crowser, 2003).

2.4.1.2. *Soil*

Building on previous environmental assessments and review of historical uses at the property, areas of potential concern were identified for soil sampling (and groundwater discussed below). The first phase of the RI was a broad assessment for chemical contamination across the site and to assess each area of potential concern. A primary list of chemicals for analytical testing was developed (metals: arsenic, copper, lead, mercury, zinc; PAHs; TPH); however, additional chemicals were analyzed (e.g., pentachlorophenol, organochlorine pesticides, SVOCs, and priority pollutant metals). The phase I soil characterization included:

- Twenty-six test pits (TP-16 through TP-40, and TP-32B) were completed to assess soil characteristics and collect samples from surface and near-surface soils. (Test pits TP-1 through TP-15 had been completed during previous assessments.)
- Thirty push probes (B-1 through B-30) were advanced to depths generally ranging from 28 to 40 feet to assess subsurface soils (and to obtain groundwater samples discussed below).
- Seven hand-augured borings (HA-5 through HA-11) along the riverfront/ beach (HA-1 through HA-4 were previously performed by others) to assess historical concerns, fill material and possible petroleum seepage from the M&B site.

Based on the results the list of contaminants of potential concern (COPCs) were refined and areas requiring further assessment (i.e., data gaps) were identified to achieve RI objectives. Subsequent phase II sampling focused on delineation of contamination in surface soil at several specific locations and on a site-wide basis. The phase II soil characterization included the following:

- Thirty-eight surface soil samples (SS-1 through SS-37) from the upper 6 inches to delineate the extent and magnitude of contaminants in surface soil, including obtaining additional data to assess site-wide PAH concentrations.
- An erosion assessment was performed by means of a walking reconnaissance to observe the entire Upland and adjacent riverbank to observe surface water drainage and assess for erosional features.

- A debris assessment was performed to document the extent of slag and other debris (brick and pieces of metals, such as wire, cables, etc.) on the cove beach area. Debris included pieces of metal.

The primary chemical compounds detected were metals, PAHs, and TPH. PCBs and pesticides were each detected in two samples. Formaldehyde was detected in three samples from the West Parcel. Dioxins/furans analysis was not incorporated into the study based on site information at the time.

Subsequent investigations (summarized briefly below) were conducted to further delineate contamination and in preparation of removal actions. Figures 9 through 11 present an overview of soil sample locations by sampling method (discrete, composite, incremental) performed at the site (approximately 1998 to 2016). Soil data collected over the approximate 20-year timespan has also been assembled into tables and the most comprehensive presentations are provided in the feasibility study reports (Apex, 2017 and 2019).

Additional Soil Sampling of Riverbanks
Riverbank sampling was performed to assess the presence and magnitude of PCBs, PAHs, and metals in potentially erodible riverbank soil for evaluating this source control pathway, and for evaluating risk to human health and the environment. A series of phased riverbank sampling events followed from 2005 to 2012 to characterize contamination on the riverbank.[9,10] Riverbank sampling locations were generally limited to below top of bank (approximately 32 feet NAVD88) and above mean high water (MHW) at 13.3 feet. Ordinary high and low water lines (OHWL and OLWL) are approximately 20.1 and 6.9 feet NAVD88, respectively. Riverbank soil sampling methods included a combination of discrete and composite sampling in the West, Central, and East Parcels.

Based on the results of the first phase of riverbank sampling in 2005, additional sampling was conducted in 2007 to assess the lateral extent of PCBs in the riverbank at the boundary between the East and Central Parcels. Further delineation of the riverbank included analytical testing for dioxins/furans following detections of this compound class in sediments within the vicinity of the wharf historically serving the Central Parcel. The third round of riverbank sampling was performed in 2010. Dioxins/furans were detected and additional sampling of soil (by means of incremental sampling methods or ISM) was conducted in the vicinity of the former Wharf Road area in 2012.

Additional Soil Sampling for Dioxins/Furans
Surface soil sampling was conducted from 2014 through 2016 to support additional risk analysis, and design and completion of removal actions. The sample series, locations, methods, and analytes for the additional upland sampling events are summarized in the table below, as well as referenced reports with greater detail. While surface soil sampling focused on dioxins/furans and mercury, additional analysis included contaminants of concern (COCs) already detected at the site. Incremental sampling methods were used to assess surface soil concentrations over larger decision units (DU's) or exposure units: one DU for each East and West parcel and two DU's for the Central Parcel (see Figure 11: Baseline Exposure Units). Subsequent soil sampling used composite and discrete sampling to further delineate areas with elevated concentrations.

Surface soil sampling was also conducted to support design of a removal action (discussed in Section 2.4.3.3) focused on hot spot, or "highly concentrated" levels, of contamination in soil. This removal action

[9] The results of riverbanks sampling in greater detail is presented in a series of reports (BBL/Ash Creek/NF, 2006; Ash Creek/NF, 2008; Ash Creek/NF, 2008; Ash Creek, 2012).
[10] Further characterization of the riverbank and erodibility studies will be conducted under USEPA oversight in accordance with the Portland Harbor ROD.

was performed from October 2015 through January 2016 to remove hot spot levels (see Figure 12: Removal Action Areas). Soil sampling was conducted to confirm the removal of soil hot spots, including confirmation samples taken on the sidewalls and base of the five removal areas.

Additional Upland Soil Sampling Summary

Sample Series	Parcel	Sampling	Analysis
Incremental Surface soil Sampling Results (Apex, March 2014)			
DU-4 through DU-7	West, Central, East	ISM	Dioxins/Furans, PAHs, Metals,
Surface Soil Sampling – Remedial Design (Apex, May 2014)			
Area-1-1 through Area-6-16	West, Central, East	Discrete	PAHs, Metals
Surface Soil Sampling Results (Apex, June 2014)			
DU-6-COMP-1 through DU-6-COMP-8	Central	Composite	Dioxin/Furans
DU-5-COMP-5-1 through DU-5-COMP-5-6, DU-6-COMP-1-1 through DU-6-COMP-8-6	Central	Discrete	Dioxins/Furans, Mercury
Vertical Soil Characterization Results (Apex, April 2015)			
Area-2-10, Area-2-14, Area-3-3, Area-6-6, Area-6-9, Area-6-17, DU-6-COMP-5-3, DU-6-COMP-5-6	West, Central	Discrete	Dioxins/Furans, Metals, PAHs, SVOCs
Removal Action Completion Report (Apex, May 2016)			
RA-1 to RA-3, RA-5, RA-6	West, Central	Composite	Dioxins/Furans, Metals, PAHs, PCBs, SVOCs

2.4.1.3. *Groundwater*

Groundwater investigation has included both the collection of one-time "grab" samples, and multiple sampling events using shallow groundwater wells in the upland. Monitoring well sampling has been confined to the Upland, while grab sampling has occurred in both the site upland and near or adjacent to the river. The distinction between upland and non-upland sampling is important, particularly as it relates to the observation of sheen (both upland and near the river) and free-phase liquids (i.e., NAPL, adjacent to the river only). A summarization of well and grab sampling follows. Sampling locations are shown in Figure 6, while sampling results are discussed in Section 3.1.2.

Monitoring Well Installation and Sampling. During the initial phase of the site remedial investigation (2001-2002), seven groundwater monitoring wells (MW-1 through MW-7) were installed and sampled for contaminants of potential concern. Groundwater monitoring wells were installed with well screen intervals bisecting the shallow (water table) aquifer. Groundwater well locations and analytes to monitor were selected based on the results of previous grab groundwater sampling (1988 through 2001, discussed below) and knowledge of historical site uses/activities. Initial sampling occurred in February and May 2002 for COPCs including metals, PAHs, TPH, and VOCs. Monitoring wells were resampled in 2005 in two events to capture both dry (August) and rainy season (December) conditions. After a long period of no sampling, upland wells were redeveloped and sampled in 2016 at the request of DEQ. Four events were completed encompassing a full range of seasonal conditions, with the suite of chemical analytes broadened to incorporate contaminants (e.g., dioxins/furans) detected during more recent soil sampling events. The primary purpose of the 2016 sampling was to develop a robust, up-to-date groundwater data set to support upland remedy selection and source control decision-making. Two additional groundwater monitoring

wells were installed on the eastern portion of the Site at DEQ request. In the 2016 sampling events, samples from the nine monitoring wells were analyzed for dioxins/furans, metals, TPH, PAHs, PCBs, pesticides, SVOCs, VOCs, natural attenuation parameters, and total organic carbon.

Grab Sampling Events. Independent of well sampling, multiple grab groundwater sampling events occurred at Willamette Cove. As shown in Figure 6, most samples were collected in the upland. A few, notably in the vicinity of the former Wharf Road and Inner Cove, were collected at or near shoreline, largely to investigate sheen or free product thought to be associated with historical over-water activities. Grab sampling events are summarized in the table below. While Upland results are most relevant to DEQ decision-making, near-shore data are provided and relevant to whether contaminants detected in the upland and near the river, respectively, are "connected."

Groundwater Sampling Summary

Sample Series	Location	Sampling	Analysis
Remedial Investigation Report (Hart Crowser, 2003) - Includes Historical "Pre-RI" Data			
SE/E (1988/89)	West, Central, East	Grab	Metals, PAHs, PCBs, Pesticides, TPH, SVOCs/VOCs, Total Halides
TB (1995)	West, Central, East	Grab	Metals, PAHs, PCBs, TPH, SVOC/VOCs
B (2001), MW-1 to MW-7 (2002)	West, Central, East	Grab; Monitoring Well	Metals, Halides, PAHs, PCBs, Phenols, TPH, SVOCs/VOCs, Formaldehyde
2010 Source Control Sampling Results (Ash Creek, 2011)			
WC	Wharf Road	Grab	Metals, PAHs, PCBs, VOCs
Trench 2 and 4	Cove Beach	Grab	Metals, PAHs, PCBs, Pesticides VOCs
December 2016 Groundwater Data Report (Apex, 2017)			
DP, MW-1 to MW-9	West Parcel[1]	Grab; Monitoring Well	Arsenic III/V, Dioxins/Furans, Metals, Nitrate-Nitrite, PAHs, PCBs, Pesticides, Sulfate-Sulfide, SVOC/VOCs
Groundwater Monitoring Reports (Multiple Reports – See Administrative Index)			
MW-1 through MW-9	West, Central, East	Grab; Monitoring Well	Dioxins/Furans, Metals, PAHs, PCBs, Pesticides, TPH, SVOC/VOCs

Notes:
[1] Samples were collected in the West Parcel to assess groundwater contaminant conditions associated with former log pond fill.

Groundwater sampling results are presented in Section 3.2.3, including a discussion of so-called dissolved phase sampling results from both monitoring wells and borings, and observations of sheen or free product. The location of sheen and product observations are given particular attention given their significance from both a remedy selection and source control perspective.

In general, contaminants were detected at low concentrations or not detected above relevant screening values in the East and Central Parcel. Elevated contaminants were detected in the West Parcel and appear to be largely associated with the former log pond fill.

In addition to chemical sampling, hydraulic head/elevation data have been collected from site monitoring wells to determine groundwater flow direction. As discussed above in the hydrogeology section, the inferred groundwater flow direction is southwesterly, towards the Willamette River. Groundwater elevation data from the nine upland wells, along with river water level data were used to calculate groundwater

gradients, discussion of which is presented in Section 5 of the *Revised Groundwater Source Control Evaluation and Alternatives Analysis* ("Revised GW SCE"; Apex, 2020). The report presents the general gradient as perpendicular to the river (southwest) and downward toward the river at a magnitude in the range of 0.006 to 0.02. A groundwater mound is present in the vicinity of MW-2, the origin of which is unclear, but does not alter the conceptual groundwater flow model.

To support source control decision-making for a potential groundwater pathway to the river, additional groundwater sampling will occur in the upland (in groundwater wells located above the TOB) and porewater (where groundwater discharges to the river). A groundwater source control evaluation and analysis of potential response action alternatives, if needed, was completed in June 2019 (draft) and January 2020 (revised version referenced above) to address comments received by DEQ and Portland Harbor MOU partners. The evaluation serves to inform future "pre-design" data needs to determine whether groundwater is a source of contamination to the river, and if necessary, select a groundwater action.

2.4.1.4. *Stormwater*

The stormwater source control pathway was also evaluated. Based on site observations, the majority of the site is vegetated and precipitation either infiltrates or runs off via sheet flow. The site grade generally prevents stormwater flow over the top of bank; however, minor runoff may occur in areas. At present, there are no storm drains or surface water features that discharge surface water from the site.

A 1998 reconnaissance conducted by the City of Portland identified six potential outfalls (shown on Figure 8). These potential outfalls were evaluated and the following concluded:

- OF-49: A City of Portland storm sewer outfall located on the Central Parcel near the boundary with the West Parcel drains property above the Willamette Cove site and no onsite stormwater enters this system.
- WR-189: This potential outfall is a 24-inch diameter corrugated metal pipe located on the West Parcel, near OF-49. It is no longer active, and its purpose is unknown.
- WR-190: A 6-inch diameter concrete pipe that is no longer active, and its purpose is unknown.
- WR-191 through WR-193: Steel pipes in the range of 2 to 5 inches in diameter were found near the boundary between the Central and East Parcels. It is unknown if these pipes were outfalls, but they are no longer active.

Stormwater mainly infiltrates onsite and there are no remnant stormwater conveyances draining the Site. Based on site reconnaissance information, a stormwater pathway from the Upland area (above top of bank and inland) to the river is not present.

2.4.2. Source Control Evaluation

The property is located within the Portland Harbor Superfund Site, and correspondingly upland source control investigations were guided by 2005 USEPA/DEQ *Portland Harbor Joint Source Control Strategy*, also known as the JSCS.

The objective of a source control evaluation (SCE) is to determine whether existing and potential sources of contamination at the site have been identified and if additional characterization or source control measures are needed. Each potential pathway to mobilize contamination from the site to the river is explored

and these determinations generally rest upon demonstrating that site-related information provides sufficient support to source control decision-making.

Screening of site data against regulatory values is the first line of evidence evaluated in the source control process. Site groundwater and stormwater data were compared to the Portland Harbor Cleanup Levels (CULs) presented in Table 17 of the January 2017 PHSS ROD, and for contaminants without CULs, screening level values (SLVs) presented in Table 3-1 of the 2005 JSCS were used.

Potential pathways for transport of contamination to the river identified at Willamette Cove include groundwater discharge and riverbank erodibility. As noted above, the riverbank pathway will be further evaluated under EPA oversight. A *Groundwater Source Evaluation and Alternatives Analysis* (Apex, 2020) has been completed, which further examines potential impacts from Central and East Parcels. Groundwater is considered a potentially complete pathway for the Site and additional remedial design sampling will be completed to further delineate the groundwater pathway and determine the final action for groundwater.

2.4.3. Interim Removal Actions

Three interim removal actions (identified on Figure 12) were completed at Willamette Cove.

2.4.3.1. *Removal Action – Inner Cove (2004)*

On July 1, 2004, a petroleum sheen was observed at the Site during implementation of the remedial action addressing impacts from McCormick & Baxter. The sheen was observed on the water, in the innermost portion of the cove (see Figure 8) adjacent to the East Parcel, during the removal of pilings near the shoreline. Test pits were excavated in the area of the sheen in July 2004. One of three test pit locations, directly inland from mean low water (MLW), indicated the presence of NAPL in soil. The soil with petroleum was bounded by a nearby test pit located farther inland and by a third test pit located to the southeast toward the M&B site.

On October 28, 2004, DEQ, Port, and Metro performed a removal action with the following objectives: (1) investigate the nature and extent of petroleum product along the innermost beach of the cove; and (2) remove mobile petroleum product inland of MLW to the extent practicable through soil excavation. The removal action delineated the extent and successfully removed the mobile petroleum product inland of MLW. Approximately 20 tons of soil were excavated and disposed of offsite at a permitted landfill. The removal action concluded that the sheen and NAPL a result of previous overwater activity, based on the complete delineation and removal of the NAPL (inland OLWL) and the co-location of the NAPL with the location of historic overwater activities associated with former cooperage operations. The test pits and removal action indicated there was not a continuing source to the river from the upland area.

2.4.3.2. *Removal Action – Metal Hot Spots (2008)*

The purpose of this removal action was to remove soils with lead and other metals to reduce risks posed to ecological receptors, for instance localized adverse effects to plant, bird, or mammals. An area on the eastern portion of the Central Parcel contained elevated concentrations, including hot spots, in surface soils. Concentrations of metals included lead up to 4,990 milligrams per kilogram (mg/kg), copper 1,650 mg/kg,

chromium 348 mg/kg, zinc 2080 mg/kg, and mercury 32.1 mg/kg. A mg/kg is equivalent to a part per million (ppm).

Approximately 987 tons of soil containing lead and other metals were removed from the site in June 2008 and disposed at the Hillsboro landfill. This included 356 tons of soil that was stabilized (i.e., treated with a reagent) prior to disposal to remove the hazardous characteristic and 631 tons of soil that did not require stabilization before disposal. Remnant structures and debris were encountered, some of which were also removed. The extent of the excavation was based on the RI data and the physical features around the area and up to 1.5 feet in depth. Post-removal soil sampling from the approximate final removal action grade coincided waste characterization sampling. Results are documented in the removal action report (Ash Creek, 2008c).

2.4.3.3. *Removal Action – Hot Spots (2015-2016)*

The discovery of dioxins/furans in the riverbank prompted additional delineation in the Upland. Surface soil sampling was conducted in 2014 and 2015 for dioxins/furans and other site contaminants using the ISM protocol to support additional risk analysis. Based on the detection of high concentrations of dioxins/furans and other contaminants in the upland and ongoing access by the public, it was determined that a time-sensitive removal action was necessary. The removal action goal, as outlined in the *Final Removal Action Engineering Design Report* (Apex, 2015) approved by DEQ, included the removal and offsite disposal of high concentration hot spots and soil with dioxin/furan concentrations above 1,000 nanograms per kilogram(ng/kg), equivalent to 1 part per billion (pbb).[11]

From October 2015 through January 2016, a removal action was conducted at Willamette Cove. The five removal areas are shown in Figure 12. The removal activities were conducted in accordance with the approved design and included the following:

- Approximately 5,014 tons of soil containing dioxins/furans, PAHs, and/or metals above hot spot levels (including brick/metal debris encountered in one of the excavation areas) were excavated and disposed of at the Wasco County landfill.
- Special excavation and backfill were used around madrone, big leaf maple, and Oregon white oak trees.
- Disturbed areas were seeded with native grasses.
- Temporary fencing was placed around the remaining upland PAH hot spot area.
- The haul road was restored by surfacing with gravel.

Confirmation sampling documented removal of soil as specified in the approved design report (see Apex May 2016 *Removal Action Completion Report*). Confirmation samples were taken on the sidewalls and base of the five removal areas. Excavation continued until soil concentrations were below the remediation goal (1 ppb dioxins/furans) as verified by confirmation sampling. Excepting the debris area excavated to 5 feet, soil concentrations below hot spot levels were achieved with 0.5 to 1-foot depth of excavation in the other four removal areas.

[11] The removal action remediation goal of 1ppb dioxins/furans in soil is below the human health hot spot value (1.5 ppb dioxins/furans) developed in the final risk assessment. That is, human health dioxin/furan hot spots were removed during the 2015/2016 removal action. While ecological hot spots were also removed during the removal action, hot spots remain onsite across the Upland, in part to the lower-risk threshold for ecology.

The 2015/2016 removal action removed the majority of human health hot spots in the Upland. Excluding dioxins/furans, remaining hot spots are primarily located along the riverbank that was not included in the removal action (copper, lead, and mercury) and in the central portion of the Central Parcel (primarily mercury but includes other metals). Remaining dioxins/furans in Upland soil are generally below 1 pbb. Confirmation sample results have been incorporated into the screening conducted as part of the feasibility study and source control evaluation for the Upland.

3. RESULTS OF INVESTIGATION(S)

3.1. NATURE AND EXTENT OF CONTAMINATION

Investigations of soil, groundwater, and surface water began in the 1990s, and continued when Metro and the Port of Portland entered into a Voluntary Agreement with DEQ in 2000. Characterization of the nature and extent of contaminants at the Site was performed during the remedial investigation and subsequent investigations to support completion of the risk assessments summarized below, and development and evaluation of remedial alternatives presented in Section 5. It has been determined that the Willamette Cove Upland is impacted with a wide range of contaminants including dioxins/furans, metals, PAHs, PCBs, and SVOC/VOCs. The nature and extent of contamination in each of these media are summarized below.

The Locality of the Facility (LOF) is defined as any point where a human or an ecological receptor contacts or is reasonably likely to come into contact with contaminants from the subject Site. The LOF takes into account the likelihood of the contaminants migrating over time.

For this project, the entire Upland is considered to be within the LOF. Groundwater beneath the site is towards and into the Willamette River. As such, the adjacent riverbank and river are also included. Properties to the north were not included as they lie upslope and upgradient of the Site. In summary, the LOF includes the entire Upland and the adjacent riverbank and river.

As noted above, the proposed remedy in this staff report does not address the riverbank and river sediments, which will be conducted under USEPA oversight. For the purpose of this staff report, the primary concern is coming into direct contact with contaminated soil, particularly highly concentrated hot spots in surface soils. Groundwater is impacted in the upland area above TOB but whether contaminants detected are migrating to the river at unacceptable levels will be further evaluated in coordination with forthcoming in-water activities. Stormwater which could potentially transport contaminants is no longer a pathway of concern for the Upland.

3.1.1. Soil

Contamination extends across the entire Upland, and discussed below, above risk levels for human health and ecology (i.e., plants and animals). Table 1 summarizes the COCs contributing to Upland soil risk to humans and ecology in each Parcel, while Table 2presents the COCs posing risk to site-related human health and ecological receptors. Tables 3 through 5 summarize COCs exceeding human health preliminary remediation goals (PRGs) and hot spots, and Tables 6 and 7 provide COCs exceeding ecological PRGs and hot spot values.

Figure 13: Human Health Risk Area and Figure 14: Ecological Risk Area summarize the locations of estimated cleanup areas above risk levels, including hot spot areas, based on upland soil exposure pathways. Note, various areas shown on the figures were determined by defining each locus of sampling points where soil data exceeded a PRG corresponding to an unacceptable baseline risk pathway or a hot spot level. Lateral and vertical extent of contamination will be further delineated in remedial design sampling and/or confirmation sampling following excavation.

3.1.1.1. *Lateral Extent*

West Parcel. Soil contamination is present across the West Parcel posing risk to humans and ecology. Ecological risk is primarily attributed to dioxin/furan contamination with additional contribution from metals. Dioxins/furans are also a primary risk driver for human health, and to a lesser extent from benzo(a)pyrene (BaP). Excess risk for dioxins/furans is based on an ISM sample DU-7, which is representative of the entire parcel (see Figure 11). Removal of the high concentrations above human health hot spots in 2015/2016 may have reduced concentrations of metals; however, there is no data to support reduction of dioxin/furan concentrations harmful to ecological habitat (with a lower risk threshold). Therefore, the lateral extent of the entire West Parcel is considered to have soils above PRGs and ecological hot spot concentrations. (Note, the Port anticipates the area exceeding risk will be substantially reduced based future remedial design sampling). The West Parcel no longer contains human health hot spots but soil concentrations exceed one or more PRGs.

Central Parcel. Soil contamination is present across the Central Parcel posing risk to humans and habitat. Ecological risk is attributed mainly to dioxins/furans and mercury with additional contribution from dibenzofuran, metals, and PAHs. Ecological hot spots resulting from dioxins/furans are present throughout the parcel. Scattered ecological hot spots for dibenzofuran, PAHs, and metals have also been detected. Human health risk present is primarily from dioxins/furans and benzo(a)pyrene, with additional contribution from arsenic and lead. Human health PRG exceedances have been observed throughout the west end of the Central Parcel and a small BaP hot spot area. The east end of the Central Parcel exceeds PRGs for dioxins/furans with metal PRG exceedances interspersed. Dioxin/furan hot spots were excavated during the 2015/2016 removal action and disposed offsite.

East Parcel. Soil contamination is present across the East Parcel posing risk to humans and habitat primarily from dioxins/furans, with additional contribution from zinc for ecological receptors. Based on the exceedance of both human health and ecological PRGs for dioxins/furans in the ISM sample, the entire parcel will be considered to have soil concentrations above PRGs, as well as ecological hot spots for dioxins/furans. The removal action included a limited area on the East Parcel and human health hot spots are no longer present.

3.1.1.2. *Vertical Extent*

Based on site investigations, soil contamination appear generally limited to the upper 3 feet. This assumption is supported by vertical profile sampling conducted in preparation of the 2015/2016 removal action (when five areas of high concentration of human health hot spots were excavated) and post-removal confirmation sampling. Soil up to 1.5 feet bgs was collected at multiple locations to support removal to remediation goal concentrations (which captures current human health hot spot values for dioxins/furans). This vertical soil sampling showed that concentrations of metals, PAHs, and dioxins/furans decreased below the top 6 inches to 1-foot of soil below ground surface.

During the removal action excavation continued until soil concentrations were below the remediation goal (i.e. 1,000 ng/kg dioxins/furans) as verified by confirmation sampling. In general soil concentrations below hot spot levels were achieved with 0.5 to 1-foot depth of excavation in the five areas. One exception was the debris area within the Central Parcel, which was removed to a depth of 5 feet bgs but the total area of greater depth was small compared to the total hot spot areas removed.

At the West Parcel, soil concentrations were achieved below PRGs and hot spot levels after excavating to 1-foot bgs. In the Central Parcel, soil concentrations were below hot spot levels, but not below PRGs after excavating from 0.5 to 1-foot bgs. Based on overall contaminants of concern in the East Parcel compared to the West and Central Parcels, it is expected soil with concentrations above PRGs on the East Parcel is limited to 1-foot bgs.

There is limited information to distinguish between the depths of soil with concentrations above ecological screening levels from that above human health screening levels. With the exception of arsenic, human health PRGs and hot spot levels exceed those for ecological receptors. As the screening levels are generally higher for human health it is reasonable to conclude that soil exceeding ecological screening levels is deeper than that exceeding human health. The Port has assumed that soil exceeding ecological risk extends 0.5 to 1-foot deeper than human health PRGs. Table 8 summarizes estimated depths of contamination above human and ecological risk levels at each parcel.

Note the uncertainty in depths was considered when evaluating the remedial alternatives. The depths of soil contamination will be further delineated by performing "remedial design" sampling.

West Parcel. Given there is limited data to support the depth of soil contamination above ecological PRGs, a 2-foot soil depth was assumed. Based on existing data and previous observations at the West Parcel, a 1.5-foot depth was estimated to remove soil above human health PRGs. With that said, backfill placed in the former log pond is a probable area containing deeper contamination.

Central Parcel. For the Central Parcel, the depth of soil contamination above human health PRGs differed between the east and west ends of the Parcel. Data from the removal action showed an excavation depth of 1-foot was sufficient to remove soil above PRGs, however, this depth was not sufficient at the west end. The west end of the Central Parcel corresponds to the location of ISM sample DU-6, the debris area, and the higher concentrations of dioxins/furans in soil. A depth of 3 feet was assumed representative of soil contamination above ecological PRGs in that area, and 2 feet for human health. For the east end, a 1-foot depth of soil contamination was assumed with ecological risk and 0.5 feet for human health.

East Parcel. Concentrations on the East Parcel are similar to those on the east end of the Central Parcel. Therefore, the Port assumed a depth of 1-foot as representative for soil with concentrations above ecological PRGs on the East Parcel and 0.5 feet for human health.

3.1.2. Groundwater

To refine the list of groundwater contaminants of potential concern, multiple lines of evidence were considered independently and collectively to identify the potential for adverse effects. Central to this analysis is current and reasonably likely future use of groundwater. Shallow groundwater at the site is not used for drinking or other purposes, nor is such use expected in the future. Construction/excavation workers are unlikely to come into direct contact with groundwater given the water table depth in the Upland is greater than 15 feet. The primary beneficial use of groundwater is recharge to the adjacent Willamette River.

3.1.2.1. *Chemical Analysis of Groundwater, Dissolved and Total*

To assess the potential for contaminants in groundwater to migrate to the Willamette River or sediments, groundwater sampling results were compared to the groundwater Cleanup Levels (i.e., CULs) from Table 17 of the PHSS ROD, and JSCS SLVs were used for contaminants without CULs. Contaminants that exceeded a relevant screening level at least once were retained as COPCs. These COPCs included the following: metals, PAHs, PCBs, dioxins/furans, pesticides, and select SVOCs/VOCs.

To assess contaminants of concern with the potential to adversely impact sediment and surface water, all data collected at the site were considered including data collected over more than a 20-year time span, grab samples, monitoring well samples, and dissolved and total analyses.

In evaluating the data, and as discussed in the *Revised Groundwater Source Control Evaluation and Alternatives Analysis* (Revised GW SCE) the following concepts were used: 1) monitoring well data are, in general, more representative of concentrations that have the potential to migrate to the river; 2) dissolved concentrations are considered more representative of concentrations with the potential to migrate towards the river; 3) more recent data are more representative of current conditions; and 4) comparison of grab and monitoring well results collected in close proximity both spatially and temporally provide a basis for interpreting historical grab groundwater results.

The following were determined to be relevant COCs in Upland groundwater: arsenic, dioxins/furans, 4,4- DDD, pentachlorophenol, PAHs, PCBs, and TPH-diesel. Contaminant plots, based on *average* concentrations for individual COCs, are presented the Revised GW SCE.

Groundwater at the West Parcel (corresponding to the location of the former log pond fill) has the potential for adverse effects on surface water and sediment (see Figure 15: Potential Groundwater Source Control Area). The remaining parcels have contaminants in groundwater that are commonly below, or modestly above, screening values for Willamette River human and ecological receptors as identified by USEPA. Based on evaluations presented by the Port/Metro, groundwater on the Central and East Parcels does not appear to adversely impact sediments or surface water adjacent to the Site. With that said, the assessment of the groundwater pathway is ongoing.

The Revised GW SCE, with support from further assessment of the groundwater pathway including additional sampling activities in the Upland and porewater (where groundwater discharges into the river), will be used to determine whether groundwater contaminants have the potential to migrate to the Willamette River. The supplemental groundwater investigation(s) will be included in pre-design sampling to be completed in the Willamette River adjoining the site, part of in-water work overseen by USEPA. If a complete pathway exists, contaminants could be addressed through in-water capping, although other remedial options, including those in the Upland (presented in the above-referenced report), will be considered.

3.1.2.2. *Sheen and NAPL Observations*

Observations of sheen and/or separate-phase petroleum hydrocarbons are depicted in Figure 8. NAPL has not been observed in the Upland; however, sheen observations include:

- A petroleum sheen in groundwater grab samples at SE/E-9, SE/E-10, SE/E-12, SE/E-13, and SE/E-19, collected in 1988-1989.

- A petroleum sheen in upland groundwater wells during two sampling events in 2002. Light sheens were observed on water from monitoring wells MW-1 (February and May) and MW-3 (May only) on the West Parcel, and from monitoring well MW-4 (May) at the west end of the Central Parcel. In six subsequent sampling events in 2005 and 2016, sheens were not observed from the monitoring wells.

Both sheen and NAPL have been observed in the East Parcel shoreline area including:

- The "McCormick & Baxter NAPL Seep" (petroleum, nearshore) observed between1983 and 1991 in the inner cove adjacent to the southern portion of the East Parcel. The seep originated from historical releases at the M&B site southeast of the BNSF railroad embankment and was capped as part of the M&B cleanup. The seep is no longer present.
- The "Inner Cove Sheen/NAPL" was observed on the water in the innermost portion of the cove adjacent to the East Parcel in 2004 during construction of the M&B cap. Test pits were completed and petroleum NAPL was observed in one test pit. The extent of NAPL was confined to the zone between MHW and the OLWL. The soil where the NAPL was observed was removed and disposed of offsite, as part of the 2004 Inner Cove removal action (see Section 2.4.3.1). Test pitting within the inner cover in low water conditions, completed under DEQ oversight, identified both sheen and some residual petroleum product. Contamination was associated with relic structures (concrete foundations, rebar, etc.) presumably from the former cooperage. Subsequent work suggest impacts associated with these samples were not connected to upland sources.
- The "Wharf Road Sheen" was observed at the shoreline, during low water levels in the river, in the former Wharf Road area. Conducting test pits overseen by DEQ, sheen was not observed to extend northeast into the adjoining steeply-faced riverbank. The former Wharf Road connected the site upland to in-water dry docks, and detections are likely associated with this feature.

Except for the McCormick & Baxter NAPL Seep that is connected to the adjacent M&B site, the shoreline sheen/NAPL observations are not connected to an upland source. These areas will be addressed by in-water remedial action. Forthcoming pre-design sampling under EPA is expected to include sampling to more fully characterize the extent of petroleum below top of bank within the Inner Cove and Wharf Road areas.

3.2. RISK ASSESSMENT

The standards for a protective cleanup are defined in the Oregon Revised Statute and Oregon Administrative Rules. ORS 465.315 sets standards for degree of cleanup required, risk protocol, hot spots of contamination, etc. OAR 340-122-0084 describes the requirements for risk assessments while OAR 340-122-0115 provides additional definitions of protectiveness.

The results of the risk assessment (RA) for human health and potential ecological receptors at the Willamette Cove site are summarized below. Human health risk is discussed in Section 3.2.1 and ecological risk is discussed in Section 3.2.2.

An analysis of the baseline risk for human health and ecological receptors at the site was submitted in draft form to DEQ in 2007 (Ash Creek/NF, 2007). The baseline risk assessment was revised based on comments from DEQ and additional data collected during the revision process. The revisions were presented in separate updated risk assessment documents for human health and ecological receptors, respectively (Formation, 2013 and 2014a). Note, these documents are termed residual risk assessments (RRAs), although they were subsequently revised, and do not constitute residual risk assessment discussed in Section

8.2. The conclusions of the RRAs were updated to include new information as additional remedial investigation and actions were completed, which were documented in technical memoranda (Formation, 2014b; Port, 2018), and included in the appendices of the *Revised Feasibility Study and Source Control Evaluation* ("Revised FS/SCE", Apex, 2019a).

3.2.1. Human Health Risk Assessment

3.2.1.1. *Human Health Conceptual Site Model*

Based on the RI data, a human health Conceptual Site Model (CSM) was developed, which describes sources, exposure routes, and human health receptors. Figure 16: Human Health Conceptual Site Model shows are diagram of identified exposure pathways. The elements of the CSM include upland soil and groundwater exposure, sources to the river, and in-water/sediment exposure. This staff report is limited to Upland soil.

For the purpose of evaluating baseline risk, the site was divided into six exposure units as shown on Figure 11. Two of these units, Central Beach Unit and Inner Cove Beach Unit, are not on the Upland but rather are located below MHW. Risks for these two units are not the subject of this remedial action and will be addressed as part of the PHSS in-water cleanup process. The former Wharf Road unit was originally separated from the remainder of the Central Parcel because it was believed that the dioxin/furan detections were unique to that area. Subsequent sampling showed that dioxins/furans were detected elsewhere on the Central Parcel, therefore, for contextual purposes potential baseline risks for the former Wharf Road unit are discussed with the Central Parcel. Soil samples were collected in 2014 to delineate areas of high concentration soil following completion of the RRAs for human and ecological health. The data was reviewed to assess any impact on the baseline risk assessments, and the results were submitted in a technical memorandum (Formation, 2014b). During design and implementation of the 2015/2016 soil removal action, additional soil samples were collected. These data were incorporated into the evaluation of COCs for the Site. A technical memorandum summarizing that evaluation was submitted in December 2018 (Port, 2018). The memorandum is included as Appendix G to the Revised FS/SCE.

There is no human beneficial use of groundwater, as such, there are no complete exposure pathways to groundwater within the Upland. (Risks associated with sources to the Willamette River are not discussed here.) This section addresses direct contact risk from Upland soil only. Upland soils are defined as those from top of bank landward to the property boundary. Note, the updated risk assessment presented in the Revised FS/SCE included all available data above TOB *and* the upper portion of the riverbank above MHW (which was the upland study area identified during development of the FS prior to USEPA undertaking oversight of the whole riverbank). Upland data were screened against PRGs, which are presented in Appendix E of the Revised FS/SCE.

<u>The following current and future receptors were evaluated:</u>

- **Recreational Trespasser/Park User - current/future (RT/PU):** This scenario represents current recreational use such as accessing the site for running, hiking, observing nature, or other similar passive recreational activities. Although access for these activities is currently not legal, such use is regularly observed. Active recreational use is not currently planned to be allowed. The baseline scenario conservatively assumes an individual may use the site, including active recreational uses, over 26 years.

Exposure and risk calculations assume child and adult exposures, and screening levels apply from 0 to 3 feet bgs.

- **Transient Trespasser - current/future (TT):** This scenario represents current exposures to trespassers that may camp (illegally) at the site for relatively short periods of time during a two-year period. The scenario applies only to adults, and screening levels apply from 0 to 3 feet bgs.
- **Onsite Construction Worker - future (CW):** This scenario represents individuals that may have contact with soils while building structures or conducting earthwork associated with the potential recreational development. The scenario assumes relatively high contact with soils, but for time periods that are associated with short-term construction projects. The scenario applies only to adults, and screening levels apply from 0 to 10 feet bgs.

3.2.1.2. *Human Health Risk Screening*

Contaminant concentrations for each environmental medium were compared with conservative risk-based concentrations (RBCs) to determine which media and contaminants posed potential risk to human health. If detected concentrations of chemicals in a particular medium did not exceed the screening levels, then that medium was eliminated as a medium of potential concern and was not evaluated further. Chemicals and pathways that exceeded the screening levels were carried through for detailed evaluation in the baseline risk assessment.

Screening of data occurred over many years, beginning with the initial risk assessment in 2007. Screening assessments were refined over time as more data were collected. For assessment of risk in surface soils (0 to 3 feet bgs), data were screened against RBCs for the three identified human receptors. Exposure to subsurface soils (3 to 10 feet bgs) is only applicable to the CW scenario, and correspondingly, subsurface soil data were screened against the CW risked-based concentrations. Table 3 shows the preliminary remediation goals that were developed from RBCs. For chemicals with both cancer and noncancer effects, the lowest RBC was selected. RBCs for inorganic chemicals were compared with background concentrations. Because the recreational RBC for cancer is below arsenic background levels, background arsenic levels were selected as the PRGs.

A detailed summary is presented in the 2019 Revised FS/SCE (see Appendix G, Table 1). Tables 4 and 5 show a summary of the chemicals of concern identified as contributing to unacceptable human health risk in the Upland.

3.2.1.3. *Human Health Risk Assessment Results*

The December 2013 risk assessment report as updated by the December 2018 memorandum describes in detail the procedures used to evaluate the potential risks associated with the chemicals and media retained for evaluation following the screening step. Results are summarized below by parcel. Table 2 summarizes the human health (and ecological) risk drivers for Upland soil.

West Parcel - Surface Soil

- Arsenic, dioxin/furan toxicity equivalent (TEQ), and benzo(a)pyrene toxicity equivalent (BaP Eq) were detected above human health PRGs in surface soil. Screening levels were exceeded only for the RT/PU receptor.

- COCs were not detected above hot spot concentrations.
- Arsenic was detected above the PRG in 2 of 10 samples with a maximum exceedance ratio (ER) of 1.0. The arsenic PRG is based on natural background levels.
- BaP Eq was detected above the PRG in 2 of 8 samples with a maximum ER of 2.3, resulting in a conclusion of unacceptable risk. Given the limited data, quantitative estimation of risk is uncertain.

West Parcel – Subsurface Soil

- Three subsurface soil samples were analyzed for PCBs. PCBs were not detected above PRGs.
- The primary human health risk driver on the West Parcel is dioxin/furan TEQ in surface soil. Secondary risk in surface soil may be contributed by BaP Eq. Unacceptable risk is present only for the RT/PU receptor.

Central Parcel – Surface Soil

- Antimony, arsenic, lead, dioxin/furan TEQ, and BaP Eq were detected above human health PRGs in surface soil. Dioxin/furan TEQ exceeds screening levels for all three human health scenarios. The remaining COCs exceed only for the RT/PU receptor.
- BaP Eq was detected above hot spot concentrations in one area.

Central Parcel – Subsurface Soil

- Two subsurface soil samples were analyzed for antimony, copper, and dioxin/furan TEQ. These COCs were not detected above PRGs.
- The primary human health risk drivers on the Central Parcel are dioxin/furan TEQ in surface soil (exceeds for RT/PU, TT, and CW receptors) and BaP Eq. Secondary risk is associated with lead and arsenic (for the RT/PU receptor).

East Parcel – Surface Soil

- Each human health COC was detected above PRGs in surface soil on the East Parcel. Each of these COCs exceeds screening levels for the RT/PU receptor. Antimony and copper also exceed for the CW receptor.
- COCs were not detected above hot spot concentrations.
- PCBs were not detected above PRGs in the upland, but sampling was limited. The presence of PCBs on the riverbank could be an indicator of PCBs in the upland, but the exceedance ratio is relatively low. PCBs are unlikely to pose a human health risk on the East Parcel.
- BaP Eq concentrations did not exceed PRGs in upland soil samples, although two samples in the riverbank did exceed PRGs.
- Sample RA6-S17 exceeds the PRG for antimony and lead. This sample was located on the sidewall of the Area 6 excavation from the 2015/2016 removal action. The excavation was limited at that location by the concrete building slab located on the East Parcel. Soil was removed up to the concrete slab, and this sample represents soil from under the concrete at the edge of the excavation. The other metals exceedances are discrete or composite samples associated with the riverbank and may not be representative of the Upland. Metals are not expected to pose unacceptable human health risk on the East Parcel.
- The human health risk driver on the East Parcel is dioxin/furan TEQ in surface soil for the RT/PU receptor.

East Parcel – Subsurface Soil

- Subsurface soil samples were not analyzed from the East Parcel.

3.2.2. Ecological Risk Assessment

Ecological risk was evaluated in an iterative fashion throughout several risk assessment and feasibility study documents, as several site characterization and removal actions occurred over several years. Screening for ecological risk initially occurred within the 2003 RI Report and was incorporated in the 2007 Baseline Risk Assessment. Risk assessment conclusions from the Baseline Risk Assessment identified "localized risk to current and future plant and invertebrate receptors, due to elevated concentrations of metals in surface soil in a limited area of the eastern portion of the Central Parcel." A removal action was recommended and implemented in 2008 to mitigate this risk, which was co-located with unacceptable risk to potential future recreational users. The removal action included the excavation and offsite disposal of elevated metal contamination, including lead, copper, chromium, zinc, and mercury. A residual risk assessment was subsequently prepared and finalized (Formation, 2014a), which incorporated additional characterization of dioxins/furans in soils near the Wharf Road, also located on the east side of the Central Parcel.

Updates to the 2014 RRA were made to incorporate sampling results from additional sampling conducted in January through April of 2014 for dioxins/furans, metals, and PAHs. These updates to risk assessment conclusions were documented in a technical memorandum (Formation, 2014b), and summarized in a 2014 Feasibility Study (see Section 3.0 and Appendix C - Updated Baseline Risk Evaluation, Apex, 2014). This residual risk assessment was used to inform the 2015/2016 removal action areas. The primary update was the identification of significant risk in the Central Parcel due exceedance of acceptable risk levels of dioxins/furans (up to 11,000 times the RBC), high molecular weight PAHs (up to 58), antimony, and elevated soil for mercury (250), lead (94), copper (78), and zinc (12).

The focus of the 2015/2016 removal action was primarily to remove upland soil with dioxins/furans above the human health remediation goal (mammalian TEQ of 1,000 ng/kg, or 1 ppb). The removal action also included select a hot spot concentrations of metals and PAHs within the removal areas (RA1 West Parcel, and areas RA2-RA6 on the Central Parcel). Concentration data, screening, and hot spot identification for soils removed can be found in the *Removal Action Completion Report* (Apex, 2016). Confirmation samples taken in the sidewalls and base of the excavation areas, along with any soil not removed during these actions, were used to update the exposure point concentrations and the identification of COCs. This assessment is included the 2019 Revised FS/SCE (see Appendix G - Re-Evaluation of Soil Data to Identify Chemicals of Concern – Technical Memo). The COC list and associated RBCs (from Appendix G) were used to develop PRGs for remedial actions in upland soil.

3.2.2.1. *Ecological Risk Conceptual Site Model*

An ecological-based CSM provides information about contaminant sources, release mechanisms, potential receptors, and exposure pathways for ecological risk. Figure 17: Ecological Conceptual Site Model shows are diagram of identified exposure pathways. The 2007 baseline risk assessment contains the fundamental ecological scoping, receptor-pathway interactions checklist and descriptions (see Appendix A-2), and a species of special interest list (see Appendix A-3) developed using information from the Oregon Natural Heritage Information Center. This list included special status species such as fish (e.g., sturgeon, Chinook, steelhead) the painted turtle, several listed bird and mammalian species including the bald eagle (de-listed in June 2007), American peregrine falcon, yellow-billed cuckoo, tricolored blackbird, and the Townsend's big eared bat.

The ecological risk assessment evaluated four representative ecological receptor groups protective of the sensitive and non-sensitive species: plants, invertebrates, birds and mammals. Plants and soil invertebrates were evaluated for direct contact and toxicity to site soils. Birds and mammal exposure included: a) incidental ingestion of site soil, and b) ingestion of dietary prey such as plants, invertebrates for ground feeding species in close contact with the soil. Carnivorous birds and mammals were assumed to feed primarily on small mammals from the site.

Assessment endpoints included (surrogates in parenthesis):

- Survival, growth and reproduction of resident songbirds (American robin).
- Survival, growth and reproduction of resident small mammals (short-tailed shrew)
- Survival, growth, and reproduction of resident raptors (red-tailed hawk) with home ranges that include the site; and
- Survival, growth, and reproduction of resident mammalian predators (long-tailed weasel) with home ranges that include the site.

3.2.2.2. *Exposure Assessment*

Contaminants of interest were evaluated at different spatial scales depending on the receptor. This included: 1) site maximum concentrations for immobile or nearly immobile receptors (i.e., plants, soil invertebrates, or 2) 90% upper confidence limit (90% UCL) of the mean concentrations for more mobile wildlife receptors (i.e., birds, mammals). In addition to 90% UCL on mean concentrations, samples using incremental sampling methods were used to characterize average exposure for mobile receptors. ISM samples were collected primarily in 2014 as a part of the additional characterization that occurred after the 2014 baseline residual risk assessment.

As a part of the RI, the site was divided into three parcels (West, Central, and East), corresponding with different historical use of the site. These parcel sizes were used to represent exposure areas of ecological receptors such as ground feeding bird and mammal species. The definition of soils in the risk assessment included the upland, riverbank, and beach soils of the parcels, but only upland soils (generally landward of top of bank), are considered as a part of the recommended remedial action. Therefore, two of the exposure units that occur below top of bank on the west side of the Central Parcel (Central Beach Unit), and the East Parcel (Inner Cove Beach Unit), are not described further as a part of the recommended remedial action for the Willamette Cove Upland Site.

The potential concentrations of COPCs in forage and prey items were estimated based on methods and bioaccumulation factors developed by USEPA in the Ecological Soil Screening Guidance (Eco SSL; USEPA, 2007). In order to cover root depths and burrowing mammals, the soil column down to 3 feet bgs was used to evaluate ecological exposure. The diet of resident hawks and larger mammals such as weasels were assumed to feed entirely on small mammals. Soil and food ingestion rates, uptake equations into prey items, and area use factors can be found in the 2014 RRA (see Tables 3-1 through 3-9). In some cases, updates to the 2014 exposure assessments were incorporated, including site-specific updates to bioavailability. For example, in the case of lead, RBCs were calculated assuming 75% bioavailability from ingested food (ATSDR, 2007).

3.2.2.3. *Ecological Effects Assessment*

Ecological benchmark values (EBV) were used to identify exposure levels that correspond to acceptable risk levels (ARLs) of toxicity. It was determined in the risk assessment that there are no threatened and endangered (T&E) species exposed to upland soils. Oregon rules identify ARLs for non-T&E species based on risk to populations. The population ARLs have two elements: 1) a probability no greater than 0.1 that more than 20% of the local population experiences exposures greater than the EBV for a given chemical, and 2) there are no other observed significant adverse effects on the health or viability (growth and reproduction) of the local population. Therefore, lowest observed effect level (LOAEL) values based on growth or reproduction were used as the EBVs and are levels where a small portion of individuals in a population may be affected. Ecological benchmark values used for each assessment endpoint (plants, invertebrates, birds and mammals) can be found in the 2014 RRA (see Tables 4-3 through 4-21).

For wildlife (birds and mammals), assumptions regarding exposure (soil and food ingestion rates), along with the ecological benchmark values, were used to back-calculate site-specific RBCs representative of acceptable risk. For plant and soil invertebrates with direct contact with soil, the RBCs represent concentration thresholds protective of toxicity. The comparison of site data to RBCs by receptor are shown in the Appendix G tables of the 2019 Revised FS/SCE: Table 3 (plants), Table 4 (soil invertebrates), Table 5 (ground feeding birds), Table 6 (ground feeding mammals), and the chemicals of concern by receptor are summarized in Table 8. Ground feeding species with small home ranges represent the potentially most exposed ecological receptors, as they feed on vegetation and invertebrates that are in close contact with the soils. Therefore, RBCs for ground feeding species applied over each exposure area (West, Central and East Parcels) were assumed to cover risk identified for hawks and weasels identified in the 2014 RRA.

3.2.2.4. *Ecological PRGs and Hot Spot Levels*

Upland soil RBCs and Oregon-based hot spot levels for ecological receptors are presented in Table 6. Preliminary remediation goals were identified as the receptor-specific RBC unless one or more of the four receptor specific RBCs was below background concentrations. In these cases, a background concentration was identified as the PRG, while also retaining PRGs for other receptors that are above background. Additionally, background levels were applied differently to account for the type of sample collected (discrete, average ISM). Average (ISM) samples are compared to average background levels, and discrete samples are compared to 95th upper prediction limits (UPLs). For example, the background PRG for chromium is 76 mg/kg as a UPL for comparison to discrete samples, and 39 mg/kg as an average (large composite or incremental samples). Comparisons to both RBCs and PRGs are provided in the 2019 FS/SCE (see Appendix E, Table E2a). Ten times the RBCs represent ecological hot spot levels.

It is important to note that the RBCs for dioxin/furan TEQ presented in Table 7 is for mammals, reported as an RBC of 6.1 ng/kg and a hot spot of 61 ng/kg. For birds, the RBC developed using avian toxicity equivalency factors (TEFs) is 89 ng/kg, with a hot spot of 890 ng/kg avian TEQ. For simplicity, a mammalian TEQ concentration protective of avian TEQ was estimated using a regression model shown in the 2019 FS/SCE - Appendix G, Attachment 4, which also provides location specific dioxin/furan congener concentrations and hazard quotients. The mammalian TEQ protective of birds is 35 ng/kg mammalian TEQ, with a hot spot of 350 ng/kg (see Appendix G, Table 5).

3.2.2.5. *Ecological PRGs Exceedances*

Comparisons between soil concentrations and PRGs allow for an estimate of location and magnitude of the exceedance for each COC. PRG exceedance ratios (ERs) are the ratio of the soil concentration to the PRG. ERs > 1 indicate unacceptable risk (above RBC or background), and ERs > 10 indicate hot spot concentrations. Tables and figures provided in the 2019 FS/SCE (see Appendix E - Upland Soil Chemical Data Screening and Figures) summarize ERs used for FS planning. Tables E2a through E2e show location specific exceedance ratios above PRGs by parcel, sample location, and receptor for all soil located landward of mean high water. Cumulative ERs (or "summed ERs") are also presented and describe the magnitude of exceedance for COCs found at given location. Figures E1 through E14e illustrate the distribution of maximum ERs by COC, and Figures E15 through E18e show the locations of cumulative summed ERs for each receptor (plants, invertebrates, birds, and mammals).

While the 2019 FS/SCE summarizes maximum PRG exceedance ratios and cumulative ERs for upland soil located landward of mean high water, the table below presents exceedances landward of top of bank, consistent with the focus of this remedial action.

Summary of Receptor-Specific Ecological PRG Exceedance Ratios (Adopted from FS Report)

COCs	West Parcel				Central Parcel				East Parcel			
	Plant	Invert	Bird	Mam-mal	Plant	In-vert	Bird	Mam-mal	Plant	In-vert	Bird	Mam-mal
Antimony	NC	NC	NC	NC	2.4	0.2	NA	4.5	1.5	0.1	NC	2.9
Arsenic	0.5	NA	NC	NC	2.2	NC	NC	NC	1.4	0.1	NC	NC
Chromium[b]	0.5	0.5	NC	NC	0.9	0.9	NC	NC	0.6	0.6	NC	NC
Copper	1.5	1.3	1.2	1.2	19.6	17.1	15.6	16.7	4.6	17.1	15.6	16.7
Lead	0.4	0.03	1.3	0.4	11.8	0.8	18.0	11.6	6.2	0.4	9.4	6.1
Mercury[a]	1.2	3.6	4.9	0.1	88.7	115.7	150.7	7.5	11.6	23.3	23.3	1.5
Nickel[b]	0.4	0.1	NC	0.7	2.6	0.4	NC	2.6	1.1	0.4	NC	2.2
Selenium[c]	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Zinc[b]	0.9	1.3	NC	NC	3.5	0.8	NC	3.1	3.8	3.8	NC	3.4
Total PCBs[c]	NA	NA	0.2	1.1	NC	NC	NC	NC	NC	NC	NC	NC
Total LPAHs	NC	0.03	NC	NC	NC	1.6	NA	NC	NC	0.01	NC	NC
Total HPAHs	NC	0.4	NC	1.1	NC	18.0	NA	57.9	NC	0.1	NC	0.3
Dibenzo-furan[c]	NC	NC	NC	NC	NC	NC	NA	58.3	NC	NC	NC	NC
Dioxin/ Furan TEQ	NA	NA	1.2	16.9	NC	NC	29.1	424.6	NC	NC	0.7	10.0
Max Cum PRG ER[d]	5.1	6.8	8.5	20.4	94.7	117.4	160.3	432.8	30.4	24.2	28.2	18.0

Notes:
NA= RBC not available
NC= RBC available but not calculated in the FS and will be calculated in the residual risk assessment using Table 6.
[a] Lowest PRG and hot spot level below background; background ER shown
[b] Lowest PRG below background; background ER shown
[c] Data limited or detection limits above PRGs
[d] Represents only cumulative risk for the receptors and pathways that were presented in the FS; complete cumulative risk calculations should be presented in the residual risk assessment.

Above PRG | Above Hot Spot

3.2.2.6. *Ecological Risk Assessment Results*

Risk in upland soils across all parcels is driven primarily by concentrations of dioxins and furans, copper, lead, mercury, zinc, and total high molecular weight PAHs (HPAHs). COCs above risk levels also include antimony, arsenic, nickel, selenium, total PCBs, total low molecular weight PAHs (LPAHs), total high molecular weight PAHs (HPAHs), and dibenzofuran. Plant and invertebrate chromium RBCs were exceeded site-wide, but below background based on the FS dataset. Site wide risk to Total PCBs is largely unknown due to a limited dataset for soils above top of bank. This data gap will be addressed during remedial design sampling. The most significant risk and high concentration hot spots are found within the Central Parcel, and West and East Parcel soils immediately adjacent to the Central Parcel.

Non-dioxin hot spots above background are found primarily on or adjacent to the Central Parcel, with significant maximum ERs for individual COCs of copper (20), lead (18), mercury (151), and HPAHs (58). Dioxin/furan concentrations are above PRGs and hot spot levels site-wide for mammals (maximum ER of 425), but risk and hot spot exceedances for birds are located primarily on the Central Parcel (maximum ER of 30). Maximum cumulative ERs found in the Central Parcel, range up to 160 for non-dioxin COCs and 433 when dioxins/furan TEQ is included. Ecological risk to these COCs are identified for all receptor groups, indicating the potential for effects at multiple trophic levels throughout the ecosystem.

West Parcel. The sample type available for the West Parcel are primarily parcel-wide average ISM exposure point concentrations, and exceedances over smaller spatial scales is uncertain. Maximum cumulative ERs are 5.1, 6.8, 8.5 and 20.4 for plants, invertebrates, birds, and mammals, respectively. Hot spots were identified for dioxin/furan TEQ for mammals and mercury for birds based on parcel-wide average ISM samples. No samples have been collected below top of the riverbank.

A summary of West Parcel maximum individual PRG ERs >1 landward of top of bank include:

- Copper: Plants (1.5), invertebrates (1.3), birds (1.2), and mammals (1.2)
- Mercury: Plants (1.2), invertebrates (3.6), birds (4.9)
- Total HPAHs: Mammals (1.1)
- Total PCBs: Mammals (1.1)
- Zinc: Invertebrates: (1.3)
- Dioxin/furan TEQ: Birds (1.2) and mammals (16.9)

Note, limited upland soil samples were tested for PCBs (2), selenium (3), and dibenzofuran (1).

Central Parcel. PRGs are exceeded in the Central Parcel for dioxins and furans, metals (antimony, arsenic, copper, copper, lead, mercury, nickel, and zinc), total high and low molecular weight PAHs, and dibenzofuran. Maximum cumulative risk ERs are 95, 120, 160, and 433 for plants, invertebrates, birds and mammals, respectively. Risk is identified across all receptor groups and trophic levels, indicating the potential for impacts within multiple trophic levels within the ecosystem. In addition, significant ERs are present across a larger spatial scale as compared to the East and West Parcels.

Similar to PRG exceedances, hot spot levels of mercury, copper, lead, dioxins and furan TEQ (birds and mammals), dibenzofuran, and HPAHs are found across multiple groups of ecological receptors. Unlike the West and East Parcels, risk is similar between the riverbank and upland soils.

A summary of maximum individual PRG ERs >1 landward of top of bank include:

- Antimony: Plants (2.4) and mammals (4.5)
- Arsenic: Plants (2.2)
- Copper: Plants (20), invertebrates (17), birds (16), and mammals (17)
- Lead: Plants (12), birds (18), and mammals (12)
- Mercury: Plants (89), invertebrates (116), birds (151), and mammals (7.5)
- Nickel: Plants (2.6) and mammals (2.6)
- Zinc: Plants (3.5), mammals (3.1)
- Total LPAHs: Invertebrates (1.6)
- Total HPAHs: Invertebrates (18) and mammals (58)
- Dibenzofuran: Mammals (58)
- Dioxin/furan TEQ: Birds (29) and mammals (425)

Limited (4) upland soil samples were tested for PCBs, but detection limits were greater than PRGs. Selenium was primarily non-detect in upland soils, but detection limits were greater than PRGs.

East Parcel. As compared to the West and Central Parcels, the East Parcel contains the most significant PRG and hot spot exceedances of copper (ERs of 679, 594, 542 and 579 for plants, invertebrates, birds and mammals, respectively), antimony (ERs of 38, 2, and 71 for plants, invertebrates and mammals), PCBs (ER of 19 for mammals), zinc (ER of 10 for plants, invertebrates and mammals), and nickel (ER of 6 for plants and mammals). However, these exceedances are found riverward of top of bank and will be addressed as a part of the in-water action. Exceedances of PRGs and hot spot levels in upland soil are found primarily in soils adjacent to the Central Parcel where significant concentrations of lead and mercury remain within 2015/2016 Removal Action Area 6 (RA6) and extend over the parcel line (see 2019 FS/SCE, Appendix E figures). The most significant exceedance ratios are for copper, lead, mercury, and dioxin/furan TEQ (mammals) as summarized below. Maximum cumulative risk ERs were 30, 24, 28 and 18 for plants, invertebrates, birds, and mammals, respectively. However, the upland average ISM concentrations of soil indicate high magnitude exceedances are likely contained within smaller areas as noted above.

A summary of individual PRG ERs >1 for samples in the East Parcel above top of bank are included below:

- Antimony: Plants (1.5) and mammals (2.9)
- Arsenic: Plants (1.4)
- Copper: Plants (4.6), invertebrates (17), birds (16), and mammals (17)
- Lead: Plants (6.2), birds (9.4), and mammals (6.1)
- Mercury: Plants (12), invertebrates (23), birds (23), and mammals (1.5)
- Nickel: Plants (1.1) and mammals (2.2)
- Zinc: Plants and invertebrates (3.8) and mammals (3.4)
- Dioxin/furan TEQ: Mammals (10)

Limited upland soil samples were tested for PCBs (3 samples), dibenzofuran (1) and selenium (5), but detection limits were greater than PRGs.

3.3. BENEFICIAL USE AND HOT SPOT DETERMINATION

OAR 340-122-155(9) defined beneficial uses of water as any current or reasonably likely future beneficial use of groundwater or surface water by humans or ecological receptors.

OAR 340-122-155(32) defines soil as a hot spot when the hazardous substances present pose a risk to human health or the environment exceeding the acceptable risk level, the extent to which the hazardous substances:

(A) Are present in concentrations exceeding risk-based concentrations corresponding to:
(i) 100 times the acceptable risk level for human exposure to each individual carcinogen;
(ii) 10 times the acceptable risk level for human exposure to each individual noncarcinogen; or
(iii) 10 times the acceptable risk level for exposure of individual ecological receptors or populations of ecological receptors to each individual hazardous substance.
(B) Are reasonably likely to migrate to such an extent that the conditions specified in subsection (a) or paragraphs (b)(A) or (b)(C) would be created; or
(C) Are not reliably containable, as determined in the feasibility study.

3.3.1. Groundwater Beneficial Use Determination

A beneficial use determination for groundwater and surface was completed in the RI Report. Beneficial uses were evaluated for each water-bearing zone considering current use and the following factors listed in OAR 340-122-080(3)(f)(F):

- Historical land and water uses
- Anticipated future land and water uses
- Concerns of community and nearby property owners
- Regional and local development patterns
- Regional and local population projections
- Availability of alternate water sources

Available records (e.g., water rights, points of diversion, water well records) were obtained from the Oregon Water Resources Department to assess current and historical water uses near the site. This information also was used to assess the reasonably likely future beneficial uses of groundwater and surface water. Review of historical files, such as Sanborn fire insurance maps, show piping supplying water (presumably City water) to the Site. No historical water supply wells were identified. At adjacent properties (Lampros Steel and M&B) water supply wells were identified, which are no longer in use or abandoned. In 1962, a 248-foot well was installed at 6850 North Lombard Street, about a half mile northeast of Willamette Cove. It was abandoned in 1998.

Shallow site groundwater has not been used historically and is not being used currently as drinking water or irrigation water, or for other purposes. Future onsite water sources, to the extent needed, will be supplied by the City of Portland drinking water system. Drinking water for adjacent properties and the surrounding general area is supplied by the City. Water used for commercial or industrial purposes in the area is likewise supplied by the City. The source of City water is the Bull Run Reservoir, located east of Portland in the Cascade Mountain foothills, with seasonal supplementation from the Columbia South Shore Wellfield. There is no known use of groundwater for irrigation in the Site vicinity.

The reasonably likely future beneficial use is recharge to surface water. Beneficial uses for surface water in the Willamette River Basin are identified in OAR 340-41-0340.[12] Beneficial uses for the Willamette River at Willamette Cove/Portland Harbor include aesthetic quality, water supply, recreation, transportation, wetland areas, fishing and hunting, anadromous fish passage, and fish and wildlife habitat (salmonid fish rearing, salmonid fish spawning, resident fish and aquatic life and fishing). Groundwater discharge will be further evaluated in coordination with in-water activities conducted under USEPA oversight.

3.3.2. Soil Hot Spots

As defined under OAR 340-120-0015(32), human health and ecological hotspots are present in the Willamette Cove Upland above the top of riverbank.[13] Following the 2015/2016 removal action, remaining human health hot spots include a limited area for carcinogenic PAHs, as shown in Figure 13. Ecological hot spots are present in the entire Upland, as shown in Figure 14. Upland hot spot values are presented in Tables 3 and 6. Hot spots identified within the riverbank and adjacent river sediments will be addressed under USEPA oversight.

3.4. ESTIMATE OF CONTAMINANT SOIL VOLUME

Based on the remedial investigation data and risk assessments described above, the extent of soil impacted by COCs at concentrations that exceed respective PRGs and hot spot levels were calculated. For development of remedial alternatives described below, dioxin/furan and non-dioxin/furan hot spots are distinguished, as well as human health and ecological risk. This allows evaluation of alternatives other than removal or capping of the entire site.

The interim removal action performed in 2015/2016 removed human health dioxin/furan hot spots from the site. It is estimated 800 square feet (sf) of soil containing human health non-dioxin/furan hot spots remain in the Upland. Soil contamination above human health PRGs is present in the entire upland property above the riverbank (i.e., approximately 19.3 acres or 843,000 sf).

Ecological hot spot levels for dioxins/furans are also present across the Upland. Non-dioxin/furan (i.e., metal) hot spots are present, primarily in the Central Parcel. Given the incremental sampling methods were used to characterize average parcel-sized exposure concentrations for dioxins/furans in the West and East Parcels, the Port anticipates that currently defined ecological hot spots on those parcels will decrease based on further delineation of hot spots during remedial design sampling.

Taking into account the concrete pad area (47,000 sf) in the East Parcel and the debris area removed in 2015/2016 (5,200 sf), approximately 790,000 square feet or 18.1 acres of exposed surface soil with unacceptable risk is present in the Upland. That is, approximately 18.1 acres require some form of remedial action to restore the Site to safe conditions.

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[12] Basin-Specific Criteria (Willamette) Beneficial Uses to Be Protected: (1) Water Quality in the Willamette Basin (Figure 1: Oregon Basin Index Map) must managed to protect the designated beneficial uses shown in Table 304A; (2) Designated fish uses to be protected are shown in Figures 340A and 340B.

[13] In terms of groundwater, NAPL is not present in Upland groundwater. However, COCs may be present above hot spot levels, which will be further evaluated as part of the ongoing groundwater specific SCE.

The table below summarizes areas exceeding PRGs, including the extent of hot spot levels. Contamination depth estimates (ranging from 0.5 to 3 feet) were used to develop approximate quantities of soil that require remedial action, estimate costs, and compare the feasibility of alternatives in the following sections. Table 8 provides calculated volumes of soil requiring remediation and Figure 18: Remedial Action Area Extent and Depth provides approximate depths by parcel. Remedial design sampling will be performed to provide better resolution in preparation of remedial implementation.

Willamette Cove Upland Contaminated Soil Areas Exceeding PRGs

Contaminated Soil Quantities[1,2]	Units	Parcel			Total
		West	Central[3]	East[4]	
Ecological Risk Areas					
Above PRGs	sf	187,800	346,800	256,000	790,000
Dioxin/Furan Hot Spots	sf	187,800	346,800	256,000	790,000
Non-Dioxin/Furan Hot Spots	sf	187,800	92,700	0	280,000
Assumed Non-Dioxin/Furan Hot Spots After Remedial Design Sampling[5]	sf	18,800	92,700	0	111,000
Human Health Risk Areas					
Above PRGs	sf	187,800	346,800	256,000	790,000
Dioxin/Furan Hot Spots	sf	0	0	0	0
Non-Dioxin/Furan Hot Spots	sf	0	800	0	800
Uplands Areas					
Total	sf	187,800	352,000	303,000	843,000
Total	acre	4.3	8.1	7.0	19.3

Notes:
[1] Estimated quantities based on site investigations and will be modified based on remedial design sampling.
[2] Depths of contamination are currently estimated to be present 0.5 to 3 feet bgs.
[3] Central Parcel total area minus concentrated debris area (5,200 sf excavated to 5 feet) during 2015/2016 soil removal action.
[4] East Parcel total area excludes the concrete pad (47,000 sf) covering the ground surface.
[5] Port anticipates remedial design sampling will further delineate and reduce this hot spot area (currently defined using ISM) to 10 percent of this parcel.

4.PEER REVIEW SUMMARY

Technical documents produced during the investigation of the Willamette Cove site have been reviewed by a technical team at DEQ. The team consists of the project manager and engineer, a hydrogeologist, and human health and ecological toxicologists. The team unanimously supports the recommended remedial action. Refer to the technical team evaluation file for more detailed information.

5. DESCRIPTION OF REMEDIAL ACTION OPTIONS

5.1. REMEDIAL ACTION OBJECTIVES

The process for selection of a remedial action by DEQ is outlined in OAR 340-122-0090, focusing on selection of an action that: a) is protective of present and future public health, safety, and welfare of human health and the environment as specified in OAR 340-122-0040; b) is based on balancing of remedy selection factors; and c) satisfies requirements for hot spots of contamination. DEQ's Guidance for Conducting Feasibility Studies (1998, updated 2006) provides more detailed guidance on the remedy selection process, including the development of remedial action objectives, identification of general response actions, identification and screening of remedial technologies, and assembly of remedial action objectives for evaluation. Each of these steps were considered by DEQ, and discussed below, in the identification of a recommended remedial action for the Upland.

Remedial action objectives (RAOs) and acceptable risk levels, as defined in OAR 340-122-115(1) through (6), were developed based on the identified beneficial uses, exposure pathways and the risk assessment. RAOs are media-specific goals for protecting human health, safety, and the environment. RAOs are developed to address the standards established in OAR 340-122-0040. Specifically, the remedial actions must achieve the numeric standards for protectiveness that correspond to acceptable risk levels; treat or remove hot spots to the extent feasible; prevent or minimize future releases and migration of hazardous substances in the environment; and provide long-term care or management as necessary and appropriate.

RAOs provide the framework for developing and evaluating remedial action alternatives, as any remedy DEQ selects or approves must achieve these site-specific goals.

5.1.1. Site-Specific Remedial Action Objectives

Site-specific RAOs were developed for soil for the purpose of achieving protection of human health, ecological receptors, and beneficial uses. Preliminary Remediation Goals, or acceptable risk levels, were calculated (see Tables 3 and 6) for soil to protect the identified beneficial uses and potential receptors.

The RAOs[14] for the Willamette Cove Upland Site consist of the following:

1. Prevent exposure of human receptors (recreational/park user, transient trespasser, construction worker) to soil containing COCs at concentrations exceeding individual and cumulative acceptable risk levels.
2. Prevent exposure of ecological receptors (mammals, birds, invertebrates, plants) to soil containing COCs at concentrations exceeding individual and cumulative acceptable risk levels.
3. Remove or treat soil hot spots of contamination to the extent feasible and practicable.
4. Prevent further migration of contaminated upland soil to the river, to the extent practicable.

[14] Groundwater RAOs will be developed and addressed under the groundwater source control evaluation and future source control decision-making.

5.2. REMEDIAL ACTION ALTERNATIVES FOR SOIL

General response actions and remedial technologies were screened in the Feasibility Study (FS). A draft Feasibility Study and Source Control Evaluation (FS/SCE) was completed in September 2017 and a revised FS/SCE was provided in March 2019 (Apex, 2017 and 2019) presenting cleanup options to address human health and ecological risk. In June 2019, the Port provided a response to comments received on the revised FS/SCE.

Given the upland contains hot spots of soil contamination, the FS included an evaluation of a treatment-based alternative and/or an excavation and offsite disposal alternative per OAR 340-122-0115(31)(b). The general response actions included containment, excavation and disposal, in-situ and ex-situ treatment, and engineering and institutional controls to address soil contamination. Several remedial technologies were evaluated for each general response action. The technologies were screened in accordance with OAR 340- 122-0085, having to meet the threshold criterion of protecting human health and the environment and considering their relative merits/drawbacks with respect to the balancing criteria including: level of effectiveness, ease of implementation, and relative cost. Tables 9 and 10 provides the rationale for eliminating or carrying forward general response actions and technologies for a detailed evaluation based on site characteristics, soil conditionals, and contaminate type.

Bioremediation Technologies Screened Out

The draft FS examined a broader range of remedial technologies, including various types of in-situ and ex- situ bioremediation methods: bioventing, bioaugmentation, biostimulation, land treatment, monitored natural attenuation, phytoremediation, biopiles, composting, landfarming, and slurry phase biological treatment. These technologies were determined to be ineffective in treating the *full range* of site contaminants, including those less amenable to treatment (metals, PCBs, and dioxins/furans) based on current remediation science, or would not be expected to be sufficiently effective to meet the very low (part per trillion) cleanup levels for some contaminants. Also, some of the bioremediation treatment options would take a long time (perhaps years) to be fully effective, and would be incompatible with the intended future use of the property and concerns about ongoing risk to site users (site use is discouraged but cannot be entirely eliminated given its size).

Only remedial alternatives considered capable of restoring site conditions to protective levels, in a reasonable time frame, were carried forward in the final FS. In light of recent interest in bioremediation treatment at Willamette Cove, including mycoremediation, DEQ conducted a literature search in 2019 and consulted with USEPA to determine if advancements have been made with this form of bioremediation. No case studies were found to treat dioxins/furans "in-situ" at the magnitude and scale of Willamette Cove. The current state of the science suggests that bioremediation is unlikely to be effective in reducing concentrations of recalcitrant contaminants *to below acceptable levels in a reasonable timeframe*. In summary, bioremediation technology at this time would not pass the primary requirement that the proposed remedial action be protective. In the event that additional information becomes available on the effectiveness of bioremediation for treatment of the contaminants of concern, DEQ will consider to what extent it might complement the Willamette Cove remedy.

General Response Actions and Applicable Technologies

Technologies that were carried forward after the initial screening and combined to develop comprehensive remedial action alternatives are summarized below and in Table 9.

Institutional Controls. These include legal or administrative actions such as deed restrictions, long-term site management plans (cap inspection/maintenance and contingency plans), or public access restrictions to reduce exposure to hazardous substances.

Engineering controls. These physical measures prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances.

Cap. This engineering control involves the placement of material over the contaminated area to prevent contact with the underlying media. The cap material can be tailored to site-specific needs. A soil-based cap and limited hardscape (such as a path) is compatible with plans for a park. Capped areas can be engineered in a manner to achieve long-term stability, which may require additional reinforcement to withstand future storm events, flooding, and/or seismic events. Demarcation material is typically installed below the cap to differentiate between contaminated soil and clean cap material.

Removal and Disposal. This technology involves the physical removal of contaminated soil using excavation methods. Disposal options include transport to permitted landfills offsite and/or consolidation onsite in a pre-determined location.

In-situ Treatment. Amendments can be added to the soil to immobilize and/or reduce the bioavailability of contaminants by sorption processes.

Ex-Situ Physical Treatment. Excavated soil can undergo a separation process to distinguish levels of contamination prior to transport offsite and/or consolidation onsite. Solidification (stabilization) technologies can be applied to contaminated soil after removal to immobilize contaminants as well as reduce their toxicity and/or leachability.

Assembly of Remedial Action Alternatives

Remedial Action Alternatives (RAAs) were developed using the general response actions/remedial technologies that were determined to be applicable to the Site through the technology screening process described above. RAAs were built by applying various combinations of remedial technologies. Applicable remedial technologies and the supporting rationale for these applications are summarized below and in Table 11. Technology applications were determined based on the nature, magnitude, and depth of surface and subsurface exceedances of PRGs and hot spots. Viable response actions and technologies that can meet the RAOs were assembled into remedial action options. These RAAs were organized into four main categories including no action (for comparison purposes only), capping, excavation, and a combination capping and excavation of contaminated soil.

Remedial Alternative 2 options center on the construction of a cap over contaminated soil, while Remedial Alternative 3 options concentrate on excavation (removal) scenarios. Remedial Alternative 4 options unite capping and excavation scenarios to capitalize on distinctive strengths of these technologies. Under these main technologies, the individual alternatives incorporate themes. For instance, “alternative” excavation represents an effort to preserve native trees to the extent possible (while achieving protectiveness), rather than “standard” excavation, which would require clearing all upland vegetation. Another theme incorporates onsite consolidation, which diverts a portion of contaminated soil slated for offsite disposal (under full removal) and isolates the contaminated soil in an engineered containment cell. This scenario also to serves to minimize “capped” areas across the Site to a focused area or areas. Onsite consolidation also has the potential to lessen construction-related impacts to the community (and energy consumption) through reduction of truck/barge trips, amongst other considerations.

Common elements to the remedial action alternatives include institutional controls, such as long-term site management plans (excepting complete removal). Remedial alternatives 2 through 4 options incorporate remedial design sampling. All the alternatives (except no action) entail substantial construction activities and correspondingly will require a comprehensive health and safety program for site workers, as well as measures to protect the community.

The following RAAs were developed for the Willamette Cove Upland Site.

5.2.1. Alternative 1: No Action

A "no action alternative" is included for comparative purposes only as stipulated in OAR 340- 122- 0085(2) and DEQ guidance. Under this alternative, no remedial would be performed. There would be no reduction in site risk, and thus this alternative is not considered protective by DEQ.

5.2.2. Remedial Alternative 2 Options: Capping

For this alternative, with two "options", unacceptable risk posed by contaminated soil would be managed by construction of an engineered cap (a barrier) to isolate contaminated soil. The cap would be comprised of clean soil or other DEQ-approved material(s). Contaminated soil, including hot spot material, would not be removed from the site under the alternative.

Where applicable, cap material would be placed in consultation with an arborist as to not endanger native trees deemed worthy of protection by Metro. Typical cap cross-section details are illustrated in Figure 19: Typical Cross-Section. After placement of the soil-based cap, the surface would be finished with native grasses, shrubs, and trees. A temporary irrigation system would be required for at least the first growing season.

Under these capping alternatives, contaminated soil including hot spots are not removed. Given their persistent nature, contaminants would not be expected to degrade and will be present *in perpetuity*. Institutional and engineering controls, such as site management plans, signage, and designated pathways will be required. Routine, long-term cap inspection and maintenance will be necessary for as long as contamination is present. Deed restrictions would be recorded on property deeds that limit site uses to passive recreation activities. A deed restriction will also identify the presence of the cap and contamination.

Operation and maintenance (O&M) would include irrigation, cap inspection/repair, plant inspection and replacement, herbivore control, and invasive species control. Active inspection and maintenance is expected, including after extreme weather events that may cause erosion or cap damage, such as an uprooted tree or damage to future site infrastructure. Protocols of how to address damage to the cap would be incorporated into site management plans.

5.2.2.1. *Alternative 2a: Standard Cap*

This alternative consists of:

- installing an engineered cap over the entire Upland to prevent human or animal/plant contact with underlying contaminated soil.

Figure 20: Alternative 2a illustrates the proposed cap area. In general, existing vegetation would be cleared to the ground surface. Demarcation fabric would be installed and covered with imported clean material (mainly soil, and rock if needed) with the upper 1-foot comprised of suitable topsoil to support vegetation. The final cap thickness would be at least 2 feet to account for mixing expected as a consequence of burrowing animals, plant growth, rainfall, runoff, and wind erosion. The concrete slab on the East Parcel could be incorporated into the final cap. The cap would cover a total area of approximately 790,000 square feet for a total quantity of 59,000 cubic yard (for a 2-foot soil cap).

Table 12 provides implementation tasks and expenses. The estimated alternative cost is 8.2 million dollars.

5.2.2.2. *Alternative 2b: Amended Cap*

This alternative consists of:

- placement of a 1-foot thick amended soil cap over contamination areas to prevent human or ecological exposure, and reduce contaminant bioavailability; and
- access restrictions (signage) or other controls to prevent human or animal/plant exposure to contamination.

Figure 21: Alternative 2b presents the proposed amended cap concept. Amendments are intended to reduce bioavailability of contaminants. During the design phase, immobilization additives (e.g., activated carbon or AC) would be evaluated for use in the thin-layer cap. Prior to capping, non-native trees and shrubs/grasses would be closely mowed and invasive species would be removed (disposed in an offsite landfill), but native trees would remain. No demarcation would be installed prior to cap installation. The concrete slab on the East Parcel could be incorporated into the final cap. The 1-foot thick cap would cover a total area of approximately 778,000 square feet for total quantity of 29,000 cubic yards (for 1-foot amended soil cap).

This alternative is a relatively lower cost alternative that could, under certain conditions, be protective and was included in the FS to provide a comparison to more costly and conservative approaches. Table 13 provides implementation tasks and expenses. The estimated alternative cost is 5.5 million dollars.

5.2.3. Remedial Alternative 3 Options: Excavation

This remedial action approach includes three options, each based on the general concept of removal of contaminated soil from the Upland, and either transport offsite for disposal or consolidation and capping in an onsite containment “cell”. Prior to implementation, extensive sampling would be required to determine the extent of necessary excavation.

Confirmation sampling would also be conducted to verify the final depth of excavation has removed soil above the PRGs (human health and ecological). Based on current site investigation data, the excavation depth is assumed to be 2 feet for the West Parcel, 3 feet for the west end of the Central Parcel, and 1-foot for the east end of the Central Parcel and East Parcel. Typical excavation cross-section details are illustrated in Figure 19. It is assumed that USEPA-designated hazardous wastes are not present. If necessary, stabilization could be used as a supplemental technology to treat hazardous wastes to non-hazardous conditions prior to disposal in a Subtitle D landfill; otherwise, hazardous wastes would require disposal at a Subtitle C landfill.

If contamination is encountered deeper than 3 feet, the remedial design/ remedial action would need to consider whether additional excavation is feasible. As a contingency measure, focused areas could be incorporate an engineered cap as a protective alternative.

Regardless of final placement of excavated soil (onsite or offsite), 1-foot of clean topsoil will be installed over removal areas and the surface finished with native grasses, shrubs, and trees. A temporary irrigation system would be required for at least the first growing season.

Depending on the specifics of the remedial alternative 3 option, operation and maintenance may include a combination of irrigation, cap inspection/repair, plant inspection and replacement, herbivore control, and invasive species control. Active inspection and maintenance is expected for capped areas, including after extreme weather events that may cause erosion or cap damage such as an uprooted tree or damage to future site infrastructure. Protocols of how to address damage to the cap would be incorporated into site management plans.

5.2.3.1. *Alternative 3a: Standard Excavation and Offsite Disposal*

This alternative consists of:

- complete removal of contaminated soil above human health and ecological risk levels; and
- offsite disposal of all excavated soil in a regulated landfill.

All vegetation would be cleared, including native trees, and soil would be excavated throughout the Upland using standard construction equipment. The Site would be backfilled with clean soil, regraded using remaining (clean) soil, or a combination of both. Continued monitoring would not be necessary given all contamination is removed under this option.

The total area of the excavation would be approximately 790,000 square feet with a total quantity of approximately 50,000 cubic yards. A foot of topsoil would cover a total area of approximately 790,000 square feet for a total quantity of 29,000 cubic yards. Finish grades would generally be consistent with the existing, leaving surface drainage substantively unchanged. Figure 22: Alternative 3a depicts the proposed excavation area. There would be no institutional or engineering controls. Site use would be unrestricted.

Table 14 provides implementation tasks and expenses. This has an estimated cost of 11.3 million dollars.

5.2.3.2. *Alternative 3b: Alternative Excavation and Offsite Disposal*

This alternative consists of:

- complete removal of contaminated soil from the Upland, excepting in areas where native trees are present and limit full excavation; and
- offsite disposal of all excavated soil.

Within the drip line (i.e., canopy) of designated trees, low impact excavation techniques would be used to remove soil to the maximum extent practicable without damaging the trees.[15] Outside of these areas, soil would be excavated using standard techniques. The remainder of this alternative would be the same as Alternative 3a. This alternative allows the conservation of native tree species under an excavation alternative. Note, it may be necessary to remove some native trees if highly contaminated soil cannot be removed using the revised excavation techniques.

The total area of the excavation would be approximately 730,000 square feet (all soil above PRGs including hot spots) with a total quantity of approximately 45,000 cubic yards. Figure 23: Alternative 3b shows the proposed excavation area and Table 15 presents the estimated cost.

There would be no institutional or engineering controls, and site use would be unrestricted. This is the most conservative cleanup approach (while preserving native trees to the extent possible) with an estimated cost of 10.7 million dollars.

5.2.3.3. *Alternative 3c: Standard Excavation and Onsite Consolidation*

This alternative consists of:

- excavation of all contaminated soil exceeding human health and ecological risk levels; and
- consolidation of all excavated soil onsite beneath a cap.

In general, existing vegetation would be cleared (including native trees) and soil would be excavated using standard construction equipment. Separation technologies could be used to separate rock and debris from contaminated soil, reducing the amount of material consolidated beneath the cap. This alternative is primarily intended to allow comparison with 3a and 3b.

As with the 'capping only' alternative, secondary technologies associated with capping would also need to be implemented and long-term cap inspections and maintenance would be necessary. The consolidation area would contain soil above acceptable risk levels, including hot spots. No offsite disposal is planned for this alternative; however, the action would remove contaminated soil from other portions of the site to a designated area or areas. The consolidation area would need to be engineered for long-term stability and withstand events, such as extreme storms, flooding, and earthquakes. The thickness of the consolidation area cap would be a minimum of 3 feet thick for a soil-based cap, with an underlying demarcation material. It is anticipated the cap would need to be reinforced (such as rock) for stability and to prevent burrowing of animals. The cap surface could be comprised of topsoil to allow for native plantings or other park infrastructure, such as asphalt paths.

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[15] In cases where contaminated soil above risk levels, specifically hot spots, cannot be removed using alternative/low-impact excavation methods, tree removal would be necessary.

Areas outside the consolidation area would no longer contain soil contamination posing risk and therefore institutional or engineering controls would not be necessary and site use would be unrestricted. The removal areas (not covered by the consolidation area) would be backfilled with clean soil, regraded using existing site soil, or a combination of both. The upper 1-foot would consist of topsoil and the surface replanted with native plants. Continued monitoring outside of the consolidation area would not be necessary given all contamination above risk levels would have been removed. Long-term cap inspections and maintenance in perpetuity would be required for the consolidation area.

Given no offsite disposal is planned for this alternative, the consolidation area covers a considerable portion of the Upland. An example is provided in Figure 24: Alternative 3c. The final dimensions and shape of the consolidation area would be designed to accommodate future park plans to the extent possible. The total area of the excavation would be approximately 631,000 square feet (total upland area minus the consolidation area footprint) for a total quantity of 42,000 cubic yards. For cost estimate purposes, it is assumed this volume would create a consolidation area covering 200,000 square feet. For reference, the West and East Parcels are approximately 188,000 and 303,000 square feet, respectively. If the consolidation area is located in the East Parcel and incorporates a vegetated cap, 1-foot of topsoil would cover a total area of approximately 842,000 square feet (i.e., entire Upland including the concrete pad) for a total quantity of 31,000 cubic yards.

Table 16 provides implementation tasks and expenses. The estimated cost for standard excavation and onsite consolidation is 10.4 million dollars.

5.2.3.4. *Alternative 3d: Standard Excavation, Offsite Disposal and Consolidation*

This alternative includes:

- excavation of contaminated soil with non-dioxin/furan hot spots for ecological and human health (estimated 4,100 cubic yards) for offsite disposal; and
- excavation and consolidating the remaining soil contamination onsite beneath a cap (approximately 38,000 cubic yards).

The remainder of this alternative is the same as Alternative 3c consisting of a considerable consolidation area (see Figure 25: Alternative 3d).

Accounting for additional offsite disposal (see Table 17), the estimated cost is 10.9 million dollars.

5.2.4. Remedial Alternative 4 Options: Focused Excavation and Capping Hybrids

This alternative presents three “options” (4a, 4b, and 4c), all focused on excavation and offsite disposal of highly concentrated contamination, followed with either construction of a standard cap, amended cap, or onsite consolidation area. Extensive remedial design sampling will be performed to further delineate contamination present and inform extent of excavation required prior to construction activities. Confirmation soil sampling would also be performed following excavation. Note, if sampling activities encounter additional dioxin/furan hot spots for human health, this soil will be excavated and disposed offsite.

A typical cross-section of a consolidation area is illustrated in Figure 19. Whether a cap or cover, 1-foot of topsoil will be necessary and the surface finished with native grasses, shrubs, and trees. A temporary irrigation system would be required for at least the first growing season.

As with the capping only alternative, secondary technologies associated with capping (engineering and institutional controls) would also need to be implemented and long-term cap inspections would be necessary. Controls will be recorded as restrictions on the property deeds and will identify areas of contamination remaining onsite (under engineered caps).

Operation and maintenance would include irrigation, cap inspection/repair, plant inspection and replacement, herbivore control, and invasive species control. Active inspection and maintenance is expected, including after extreme weather events that may cause erosion or cap damage, such as an uprooted tree or damage to future site infrastructure. Protocols of how to address damage to the cap would be incorporated into site management plans.

5.2.4.1. *Alternative 4a: Focused Standard Excavation, Offsite Disposal, Standard Cap*

This alternative is comprised of:

- excavation of contaminated soil with non-dioxin/furan hot spots for ecological and human health (estimated 4,100 cubic yards) for offsite disposal; and
- in-place capping of remaining soil contamination exceeding risk levels for humans or plants/animals (i.e., entire Upland).

The estimated volume to remove non-dioxin/furan hot spots is 4,100 cubic yards. The final depth of excavation would be determined by verification sampling, but based on the remedial investigation data the excavation depth is assumed to be 1-foot. Confirmation sampling would be completed to verify removal of the soil above hot spot levels. It is assumed hot spot removal areas would still require a cap given underlying soil are presumably above PRGs.

Consistent with the standard cap described in Alternative 2a, the site would be cleared of vegetation and covered with demarcation material and capped with 2 feet of clean soil (upper 1-foot topsoil). Focused areas may require additional reinforcement materials for stability. The concrete slab on the East Parcel could be incorporated into the final cap.

Figure 26: Alternative 4a presents representative excavation and cap areas. The cap area would cover approximately 790,000 square feet (upland area minus the concrete pad) for a total quantity of 59,000 cubic yards (for 2-foot soil cap).

Table 18 provides implementation tasks and expenses. The estimated cost is 9.5 million dollars.

5.2.4.2. *Alternative 4b: Focused Alternative Excavation, Offsite Disposal, Amended Cap*

This alternative involves:

- excavation of contaminated soil with non-dioxin/furan hot spots for ecological and human health (using alternative methods to preserve native trees) and disposal at a regulated landfill;

- in-place capping of remaining soil presenting an excess risk using a thin, amended cap; and
- restrictions to public access through the use of signage or other protective measures.

Amendment application (consistent with Alternative 2b) is intended to reduce bioavailability of contaminants. The excavation volume for offsite disposal is estimated to be approximately 4,000 cubic yards, slightly less than the Focused Standard Excavation (estimated 4,100 cubic yards) due to the special consideration of soil around native trees. The 1-foot-thick cap would cover a total area of approximately 778,000 square feet (upland area minus the concrete pad and designated tree areas) for total quantity of 29,000 cubic yards (for 1-foot amended soil cap). See Figure 27: Alternative 4b.

Table 19 provides implementation tasks and expenses. The estimated alternative cost is 5.9 million dollars.

5.2.4.3. *Alternative 4c: Focused Alternative Excavation, Offsite Disposal, Onsite Consolidation, and Cap*

This alternative involves:

- excavation of contaminated soil with non-dioxin/furan hot spots for ecological and human health (using alternative methods to preserve native trees) and disposal at a regulated landfill;
- onsite consolidation and capping of soil exceeding human health levels;
- onsite consolidation and capping of soil with higher risk (hot spots) to plants/animals, and
- cover residual (only) ecological risk with clean topsoil.

Soil excavation (while preserving native tress) and offsite disposal of non-dioxin/furan hot spots is estimated at 4,000 cubic yards. While exaction and consolidation activities would target remaining soil above human health PRGs, it is anticipated the extent of removal to achieve this outcome would also result in the removal of the majority of ecological risk (including ecological hot spots). If non-dioxin/furan ecological hot spots substantially exceed feasibility study estimates, during remedial design DEQ will consider the placement of this contamination within the consolidation area. Based on investigation data, the excavation depth was assumed to be 1.5 feet for the West Parcel, 2 feet for the west end of the Central Parcel, and 0.5 feet for the east end of the Central Parcel and East Parcel. The final depth of excavation would be determined by verification sampling.

Approximately 23,000 cubic yards of contaminated soil would be placed in the consolidation area but quantities would be further evaluated during remedial design. Unanticipated soil contamination may require offsite disposal due to size restraints for an onsite consolidation area. An example consolidation area (covering approximately 116,000 square feet) is presented in Figure 28: Alternative 4c for illustration purposes. The final location and dimensions (e.g., shape) of the consolidation area would be determined during remedial design, including stability considerations and accommodating future park plans to the extent possible.

The consolidation area would be engineered for long-term stability and containment of soil above human health risk levels (including ecological hot spots). The consolidation cap would be designed to withstand natural events, such as extreme storms, flooding, and earthquakes. The base of the consolidation area cap would consist of demarcation material as an indicator of underlying contaminated soil. The consolidation area cap presumably would need to be reinforced for long-term stability and prevent burrowing of

animals; however, the cap surface could be comprised of topsoil to allow for native plantings or other park infrastructure, such as asphalt paths.

Following excavation activities outside the boundaries of the proposed consolidation area, it is estimated the remaining contamination will consist of ecological risk or no risk covering approximately 727,000 square feet (e.g., the Upland minus the 116,000 square feet consolidation area). Areas containing soil above residual ecological risk levels would be covered with clean imported soil. The soil cap thickness (at least 1 to 3 feet) will be determined based on the magnitude of ecological risk remaining. For instance, a 1-foot clean soil cap may be sufficient above low-level contamination, while greater concentrations would need to be capped with additional clean soil. All ecological hot spots (if any remain due to deeper contamination) would be capped with 3 feet of clean soil. Areas no longer containing contamination would not be capped; however, a 1-foot topsoil "cover" for vegetation growth purposes would be necessary. Cap or cover surfaces would be finished with native grasses, shrubs, and trees, and properly irrigated. Long-term monitoring and maintenance in perpetuity would be required for the consolidation area.

For reference, the West and East Parcels are estimated to be 188,000 and 303,000 square feet, respectively. If the consolidation area incorporates a vegetated cap, 1-foot of topsoil would cover a total area of approximately 840,000 square feet (i.e., entire Upland).

Table 20 identifies implementation tasks and expenses. The hybrid alternative is estimated to cost 8.8 million dollars.

5.2.5. Periodic Monitoring, Review and Contingency Plan

There are a number of uncertainties at the site that make it difficult to predict the long-term reliability of any of the remedial action alternatives described above, including:

- Heterogeneity in the subsurface.
- Potential changes in future groundwater or surface water use patterns (i.e., beneficial uses).
- Potential changes in future land use and zoning.
- Changes in community concerns regarding remedial actions.
- Long-term performance of remedial cap areas.

Because of these uncertainties, a periodic monitoring, review and contingency plan will be developed that will evaluate the performance of the remedy, and any changes that may affect the ability of the remedy to meet the RAOs. The objective of the periodic monitoring, review and contingency plan will be to maintain the overall protectiveness of the selected remedy by establishing a series of decision criteria and related response actions for each potential area of uncertainty identified above, and the RAOs.

The first component of the contingency plan will be a review of both remedy performance and local land and water uses. If the supplemental monitoring is necessary and indicates that the RAOs are not being met, additional remedial actions will be evaluated to ensure that human health and the environment are protected.

6. EVALUATION OF REMEDIAL ACTION OPTIONS

6.1. EVALUATION CRITERIA

The criteria used to evaluate the remedial action alternatives described below are defined in OAR 340-122-090, and establish a two-step approach to evaluate and select a remedial action. The first step evaluates whether a remedial action is protective; if not, the alternative is unacceptable and the second step evaluation is not required. The remedial alternatives considered protective are evaluated and compared with each other using five balancing factors. The five balancing factors are 1) effectiveness in achieving protection, 2) long-term reliability, 3) implementability, 4) implementation risk, and 5) reasonableness of cost.

An evaluation of how each alternative achieves the specific requirements for treatment of hot spots is also included. The alternative that compares most favorably against these balancing factors and complies with the hot spot criteria is selected for implementation. A residual risk assessment is then conducted for the selected alternative to document that it is protective of human health and the environment.

6.2. PROTECTIVENESS

The protectiveness of a given remedial action is evaluated by comparing actual or estimated future COC concentrations to the PRGs (see Tables 3 and 6). The pathways or beneficial uses for which the anticipated maximum concentration of a COC exceeds the acceptable risk level are:

- Exposure to soil by humans (construction workers, recreational, and transient), and
- Exposure to soil by mammals, birds, invertebrates, and plants.

These are the pathways and beneficial uses that will be directly evaluated to establish if a given remedial alternative is protective.

OAR 340-122-090 states that protectiveness may be achieved by any of the following methods:

- Treatment
- Excavation and offsite disposal
- Engineering controls
- Institutional controls
- Any other method of protection
- A combination of the above

With the exception of hotspots, there is no preference for any one of the above methods for achieving protectiveness. Where a hot spot has been identified, OAR 340-122-090(4) establishes a preference for treatment to the extent feasible, including a higher threshold for evaluation of the reasonableness of costs for treatment.

Alternative 1 - No Action would not take any action to minimize potential human or environmental exposure, by reducing concentrations of COCs, or using engineering or institutional controls. The potential for future exposure of human or ecological receptors exposed to soil that exceed the acceptable risk levels would still exist. Therefore, Alternative 1 is not protective and will not be evaluated further. All other

alternatives are protective and were carried forward into the balancing factors evaluation.

6.3. BALANCING FACTORS

The nine remedial action alternatives determined to be protective are evaluated against the following balancing factors defined in OAR 340-122-090(3):

Effectiveness in achieving protection. The evaluation of this factor includes the following components:

- Magnitude of the residual risk from untreated waste or treatment residuals, without considering risk reduction achieved through onsite management of exposure pathways (e.g., engineering and institutional controls). The characteristics of the residuals are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, propensity to bioaccumulate, and propensity to degrade.
- Adequacy of any engineering and institutional controls necessary to manage residual risks.
- The extent to which the remedial action restores or protects existing or reasonably likely future beneficial uses of water.
- Adequacy of treatment technologies in meeting treatment objectives.
- The time until remedial action objectives are achieved.

Long-term reliability. The following components are considered when evaluating this factor, as appropriate:

- The reliability of treatment technologies in meeting treatment objectives.
- The reliability of engineering and institutional controls needed to manage residual risks, taking into consideration the characteristics of the hazardous substances being managed, the ability to prevent migration and manage risk, and the effectiveness and enforceability over time of the controls.
- The nature and degree of uncertainties associated with any necessary long-term management (e.g., operations, maintenance, monitoring).

Implementability. This factor includes the following components:

- Practical, technical, legal difficulties and unknowns associated with the construction and implementation of the technologies, engineering controls, and/or institutional controls, including the potential for scheduling delays.
- The ability to monitor the effectiveness of the remedy.
- Consistency with regulatory requirements, activities needed to coordinate with and obtain necessary approvals and permits from other governmental bodies.
- Availability of necessary services, materials, equipment, and specialists, including the availability of adequate treatment and disposal services.

Implementation Risk. This factor includes evaluation of the potential risks and the effectiveness and reliability of protective measures related to implementation of the remedial action, including the following receptors: the community, workers involved in implementing the remedial action, and the environment; and the time until the remedial action is complete.

Reasonableness of Cost. This factor assesses the reasonableness of the capital, operation and maintenance (O&M), and periodic review costs for each remedial alternative; the net present value of the preceding; and if a hot spot has been identified at this site, the degree to which the cost is proportionate to the benefits to human health and the environment created through treatment of the hot spot.

In general, the least expensive remedial action is preferred unless the additional cost of a more expensive corrective action is justified by proportionately greater benefits to one or more of the other balancing factors. For sites with hot spots, the costs of remedial actions must be evaluated to determine the degree to which they are proportionate to the benefits created through restoration or protection of beneficial uses of water. A higher threshold will be used for evaluating the reasonableness of costs for treatment of hot spots than for remediation of areas other than hot spots. The sensitivity and uncertainty of the costs are also considered.

6.4. EVALUATION OF BALANCING FACTORS

Table 21 summarizes the evaluation of each of the remedial action alternatives that met the protectiveness criteria against the balancing factors, while Table 22 scores the alternatives by comparing each alternative against the other, producing an overall ranking. Table 21 also describes how each alternative compares to all of the sub-criteria for each of the balancing factors. This comparative analysis summarize the major conclusions of this comparison and provide additional discussion for differentiating issues at this site discussed below.

7. COMPARATIVE ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

Nine remedial action alternatives (plus no action alternative) are compared with each other for each remedy selection criteria identified in Section 6.1. A brief discussion of the merits of the various alternatives of DEQ's "balancing factors" is summarized below. Table 22 includes one tool of comparison consisted of scoring, or ranking, the alternatives against each other by balancing factor categories, with the most favorable alternative (i.e., 4c) outranking the others.

7.1. PROTECTIVENESS

This criterion is pass/fail. An alternative must be protective as defined by OAR 340-122-040 to be acceptable. All options (except no action) were determined to be protective, at least on a short-term basis, as they are expected to prevent exposure to contaminated soil. As discussed below, some of the options may not be protective on a long-term basis where cap or cover elements are thin and disturbance may occur over time. Complete removal is highly protective given all contamination is removed and contained at a regulated landfill. The thin amended cap alternative would provide a limited level of protectiveness compared to the other options and is considered the least conservative alternative.

7.2. EFFECTIVENESS

Complete removal would be the most effective option given all contamination would be removed offsite, including all human health and ecological hot spots, to a regulated landfill. Consequently, site uses would be unrestricted after implementation. All options could be constructed in a similar timeframe. For capping options, smaller cap areas and thicker caps were deemed more effective. A minimum of 3 feet is considered appropriate to be protective of burrowing animals. As such the thin caps, as well as the standard cap alternative, would not be highly effective to prevent exposure to burrowing animals. A soil consolidation strategy would remove the majority of the contamination and all human health risk from a substantial portion of the Upland and would be capped with a thicker reinforced engineered cap. Alternative 4c improves on this concept by removing all human health hot spots from the Site and the consolidation area manages remaining human (and ecological) risk through capping. A thin amended cap would be the least effective in managing risk through engineering and institutional controls, particularly areas containing hot spots given the potential for disturbance over time.

7.3. LONG-TERM RELIABILITY

Complete removal provides the greatest long-term reliability given all contamination would be removed offsite and the only option that does not rely on institutional and/or engineering controls to ensure long-term protectiveness. Alternative excavation around native trees is comparable to standard excavation. Leaving contamination onsite (the remaining alternatives) would require long-term controls. For capping alternatives, alternatives that included removal were assumed more reliable, and alternatives that included thicker caps were considered more reliable. The consolidation area strategy would isolate contamination to a focused area and an engineered cap would be designed to withstand more extreme conditions (compared to a soil cap across the Site). The thin amended cap options provide limited reliability, particularly long-term. While amendments can reduce bioavailability, thin caps are more easily breached whether due to

storms/erosion or human and animal activity. A thin cap contains the highest level of uncertainty, would not protect borrowing-natured animals and human protectiveness relies on institutional controls (such as signage or fences), which are also less reliable than more robust engineering control (thicker cap) options. Alternatives that require less long-term maintenance were assumed more reliable.

For any of the alternatives that involve leaving contaminated soil onsite, either within or outside of a consolidation cap, the vulnerability of the Site to flooding and/or seismic events must be considered when evaluating long-term reliability. Portions of the Upland are vulnerable to flood. As illustrated in Figure 3, the 100-year flood zone encompasses the lower upland portion of the East Parcel and the 500-year flood would cover the majority of the Central/East Parcels. The potential for significant seismic activity exists, and DEQ notes that the prominent West Hills fault is located less than a mile west of the site. From the perspective of flooding and seismic concerns, the full excavation option is most reliable, while alternatives that entail leaving hot spot contamination in place and covered by thin capping elements are least reliable. Hybrid alternatives that involve offsite disposal of human hot spot soil, and a combination of offsite disposal and onsite containment of ecological hot spot material and more elevated non hot spot soil (e.g., 4c) are expected to have an acceptable level of long-term reliability if properly designed.

7.4. IMPLEMENTABILITY

The alternatives use similar equipment and techniques, are similarly compatible with other actions, have similar periods of construction, but have differing levels of transportation requirements and impacts. With that said, consolidation and capping strategy employs a combination of technologies, and consequently greater complexity would necessitate greater planning and construction logistics. A thin amended cap would be the easiest alternative to implement. Complete removal would be most difficult to implement.

Alternatives with fewer transportation impacts (using material quantities and truck/barge mileage as surrogates for impact; actual transportation methods will be evaluated during design with a preference for barge) were assumed to be more implementable.

7.5. IMPLEMENTATION RISK

Excavation activities involve the disturbance and movement of contaminated soil. With this activity, there are one or more of the following risks: worker exposure; and release of contaminated to soil during excavation, transport, and disposal. Alternatives with greater material quantities carry greater risk from dust, spills or incidents, noise/pollution, destruction of habitat, and generation of greenhouse gases and therefore rank lower. Alternatives were generally ranked based on barge/truck/train mileage as a surrogate for material transportation impacts (higher-ranked alternatives having fewer transportation trips or miles), quantities of earthwork (lower quantities rank higher), and impacts to site habitat (less destruction ranked higher).

Complete removal carries the greatest risk given extensive quantities of contaminated soil would need to be excavated, loaded, and transported offsite. Capping only scenarios contain less risk for worker exposure; however, site-wide capping would require substantial import of material. The thin cap alternative bears the least implementation risk.

7.6. REASONABLENESS OF COST

The thin amended cap alternative has the lowest cost (and the least conservative option). Complete removal or complete capping options are the most conservative and most expensive alternatives. Alternative 4c is hybrid conservative approach, not the least or most expensive.

8. RECOMMENDED SOIL REMEDIAL ACTION ALTERNATIVE

Based on the detailed evaluation of the soil remedial alternatives in Section 6 and 7, Alternative 4c is recommended to address soil contamination currently present and uncontrolled within the Willamette Cove Upland Site. This recommended remedial action is a hybrid of technologies, which provides a protective and cost-effective approach to remove and contain contaminated soil, including hot spots. Alternative 4c foremost will restore the site to protective conditions, and in comparison of the remedy selection balancing factors outranked the other potential alternatives.

8.1. DESCRIPTION OF THE RECOMMENDED SOIL REMEDIAL ALTERNATIVE

Soil containing human health hot spots would be removed for offsite disposal; remaining soil exceeding human health risk levels and ecological hotspots would be excavated (using alternative techniques to save native trees) and consolidated onsite and capped; and remaining soil with residual ecological risk would be managed using covers. All soil contamination exceeding human health and ecological acceptable risk levels (i.e., the majority of the upland property above top of riverbank) will be addressed under this remedial alternative. These actions will result in all human health hot spots removed from the site, and ecological hot spots either removed or consolidated beneath an engineered cap. Figure 28 illustrates the features of the soil remedy. The estimated cost for Alternative 4c is 8.8 million dollars.

This hybrid alternative intentionally limits offsite disposal to highly concentrated contamination and relocates remaining soil above human health risk levels to localized, robust containment feature. Consequently, soil in a large portion of the Upland will present *no human health risk* and only a modest risk to animals and plants, the latter primarily associated with dioxins/furans (in the part per trillion range) and addressed with a cover. Limiting offsite disposal to another location (i.e., landfill incumbent to institutional/ engineering controls) considerably reduces transportation miles, including truck trips through the adjacent community. It is preferable to limit transportation (miles and trips) and potential risk for related spills or incidents, as well as minimizing the carbon footprint of remedy implementation. This alternative aligns with DEQ's Green Remediation Policy and the EPA Region 10 Clean and Green Policy by reducing the demand placed on the environment during cleanup actions and to conserve natural resources.

Soil Removal for Offsite Disposal
Human health hot spot areas will be excavated and transported offsite to a regulated landfill. It is estimated approximately 4,000 cubic yards[16] of soil containing non-dioxin/furan hot spots would be subject to removal offsite; however, final volumes will be based on remedial design sampling. Similarly, if human health dioxin/furan hot spots are detected during additional sampling, supplementary soil removal will be performed for disposal offsite as deemed appropriate by DEQ. The final depth of excavation would be determined by verification sampling.

Additional excavation and offsite disposal of soil exceeding risk levels for humans or ecology (animals and plants) may also be required if in-place capping or onsite consolidation and capping are not feasible due to space limitations, flooding or seismic concerns, etc. To the extent this is necessary, a preference will be given to offsite disposal of soil posing a higher risk to humans or animals/plants, particularly non-dioxin/furan ecological hot spots.

[16] This estimate includes non-dioxin/furan ecological hot spots, which are currently proposed for offsite disposal.

Soil Removal for Onsite Consolidation
Remaining soil above human health risk levels and soil with higher ecological risk levels will be excavated (using methods to preserve selected native trees) and consolidated onsite in an engineered cap constructed to isolate the soil and prevent human or animal contact. Excavation and containment of soil above human health PRGs is expected to also remove the majority of ecological hot spots. While there is preference for ecological hot spots to be contained under the consolidation cap (or disposed offsite at a landfill), it would be a requirement for non-dioxin/furan ecological hot spots (e.g., metals including mercury). It is estimated that 23,000 cubic yards of contaminated soil would be excavated and placed in the consolidation area but quantities would be further evaluated following remedial design sampling. Correspondingly, excavation depths to remove contaminated soil above cleanup levels will be determined by verification sampling. Unanticipated soil contamination may require additional offsite disposal due to size restraints, amongst other considerations, for the onsite consolidation area.

Covers for Residual Ecological Risk
Outside the consolidation area, remaining soil contamination may consist of ecological risk or no risk covering an estimated 727,000 square feet (i.e., the upland area minus the 116,000 square feet consolidation area). Areas with remaining residual ecological risk would be covered with clean imported soil. The soil cover thickness (at least 1 to 3 feet) will be determined based on the magnitude of ecological risk remaining. (While not anticipated, 3-foot soil caps underlined with demarcation fabric would be required for ecological hot spots.) In general, cover material would be comprised of clean imported soil (upper 1-foot topsoil); however, additional materials approved by DEQ could be used, such as asphalt paths. Institutional or engineering controls would be unnecessary for "cover" areas where no contamination remains. Soil cover surfaces would be finished with native grasses, shrubs, and trees, and properly irrigated. In general, the site will be finished in a manner to manage stormwater onsite in an effective and controlled manner and minimize erosion of caps or covers.

Consolidation Area
The consolidation area would be engineered for long-term stability and containment of contaminated soil above human health risk levels (including ecological hot spots). The consolidation cap would be designed by professional engineers to withstand natural occurring events, including earthquakes, extreme storms, and flooding, in addition to human and animal impacts. The base of the consolidation area cap would consist of demarcation material as an indicator of underlying contaminated soil. The consolidation area cap would be comprised of a minimum 3 feet of clean material (unless otherwise approved by DEQ) and presumably would need to be reinforced for long-term stability and prevent burrowing of animals. The cap surface could be comprised of topsoil to allow for native plantings and/or the cap could also incorporate park infrastructure using materials approved by DEQ. This may include asphalt paths or viewing platforms. The final cap design would be tailored in coordination with Metro's plan for a nature park with a regional trail. Diverting stormwater around the consolidation area will be further examined during remedial design.

For illustration purposes an example consolidation area (covering approximately 116,000 square feet) is shown on Figure 28. Final location(s) and dimensions (e.g., shape) of the consolidation area would be determined during remedial design, including stability considerations and accommodating future park plans to the extent possible.

Remedial Design/ Remedial Action (RD/RA)
Under the recommended remedy, a robust remedial design sampling will further delineate soil contamination, extent and magnitude, to inform remedial design and minimize unexpected conditions during remedy construction. Comprehensive health and safety and contaminated media management plans

will be prepared and identify preventive measures necessary to protect site workers and the adjacent community. Communication/coordination plans will inform the community of planned construction activities, including traffic routes, timeframe and safety measures. It is DEQ's preference that materials transported on/offsite will utilize barge transport to the extent feasible. (Barge transport via the Willamette Cove occurred during the cleanup at the adjacent McCormick and Baxter site.)

In addition to remedial sampling and design, remedial preparation will include obtaining required permits or waivers for construction from appropriate agencies, such as a construction permits and working in the City's designated Greenway.

RD/RA will require close coordination with in-water and riverbank remedial action activities under USEPA oversight. It is anticipated the greater part of the Willamette Cove riverbank will require remedial action, including setback of steepened riverbank areas. Riverbank setbacks will reduce the "Upland" property at/near the top of riverbank. Upland and riverbank remedial action areas will need to be compatible and merge, as well as the in-water remedy, into a comprehensive Willamette Cove remedy. This will require considerable planning between agencies, multiple liable/responsible parties for cleanup, and other stakeholders.

In terms of schedule, if a hiatus is expected between remedy selection and full implementation, DEQ will evaluate interim removal options for remaining human hot spots and potentially the most highly concentrated ecological hot spots. Additionally, DEQ will require that the Port and Metro consider additional measures to prevent exposure to site contaminants prior to full remedy implementation.

Groundwater Source Control Evaluation

The ongoing groundwater source control evaluation will continue in consultation with USEPA and Portland Harbor partners. Investigation activities will be completed to determine whether groundwater contaminants have the potential to migrate to the Willamette River. Investigation will include both additional Upland sampling and data analysis, and in-water investigation as part of (Portland Harbor Superfund Site) pre-design investigation under USEPA. If a complete groundwater-to-surface water migration pathway exists, source control options will be evaluated.[17] Following completion of this work, DEQ would prepare a Source Control Decision.

Institutional Controls

Given contamination would be remain onsite (in a controlled manner) using engineering controls under the recommended remedy, institutional controls would be required to ensure long-term protectiveness through the following mechanisms:

- Site-management plans will be prepared and adhered to for the foreseeable future, including cap inspection and maintenance, contaminated media management plans, and contingency plans as needed.
- Site use restrictions and engineering and institutional controls will be memorialized on the property deed in the form of an easement and equitable servitudes.
- DEQ will perform periodic reviews (initially more frequent to 5-year reviews) after remedy construction to ensure the selected remedy remains protective.

[17] Potential source control options are presented in the *Revised Groundwater Source Evaluation and Alternatives Analysis*, dated January 20, 2020.

8.2. RESIDUAL RISK ASSESSMENT

OAR 340-122-0084(4)(c) requires a residual risk evaluation of the recommended alternative to demonstrate that acceptable risk levels, as defined in OAR 340-122-0015, will be attained in the locality of the facility:

- A quantitative assessment of the risk resulting from concentrations of untreated waste or treatment residuals remaining at the facility at the conclusion of any treatment or excavation and offsite disposal activities taking into consideration current and reasonably likely future land and water use scenarios and the exposure assumptions used in the baseline risk assessment; and
- A qualitative or quantitative assessment of the adequacy and reliability of any institutional or engineering controls to be used for management of treatment residuals and untreated hazardous substances remaining at the facility.

The recommended remedy achieves acceptable risk levels through a combination of contaminant elimination (excavation and offsite disposal) and isolation (consolidation and capping) technologies. Both are recognized by DEQ and USEPA as adequate and reliable if properly implemented and maintained. The most highly-contaminated soil would be removed from the site to a permitted landfill, eliminating the potential for future releases and migration. The majority of the contaminated soil remaining onsite, isolated in a containment cell, would be prevented from release/migration or direct contact with humans and ecology. This requires, however, that the cell be properly constructed, with monitoring and maintenance in perpetuity. Remedy design for the containment cell will include evaluation of risks associated with human disturbance, flooding, and seismic events.

Acceptable risk levels are discussed in Section 5.1 of this report (Remedial Action Objectives) and presented in Tables 3 and 6. Through the risk assessment process, these concentrations for individual upland COCs have been determined by DEQ to be protective for human and ecological (animal and plant) populations, respectively. RAOs are based on these risk-based criteria; cleanup to or below these levels would achieve these risk levels as follows:

- Contaminated soil removed from the site would no longer pose unacceptable risk to site users.
- Consolidation and isolation of contaminated soil remaining at the site would eliminate human and ecological exposure via normal routes of exposure (soil ingestion, dermal contact, and inhalation). Isolation would further prevent animal exposure via ingestion of contaminated prey or vegetation.

A final quantitative evaluation of residual risk will occur after collection of additional data (i.e., remedial design sampling) and completion of a remedial design.

9.APPENDIX A: ADMINISTRATIVE RECORD

ADMINISTRATIVE RECORD INDEX

Willamette Cove
Portland, Oregon

The Administrative Record consists of the documents on which the recommended remedial action for the site is based. The primary documents used in evaluating remedial action alternatives for the Willamette Cove site are listed below. Additional background and supporting information can be found in the Willamette Cove project file located at DEQ Northwest Region Office, 700 NE Multnomah Street, Suite 600, Portland, Oregon.

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Table 1
Upland Soil Risk Summary
Willamette Cove Upland Site
Portland, Oregon

	COCs Contributing to Upland Risk					
Receptors	**Ecological**			**Human Health**		
				Surface Soil		
Parcel	**West**	**Central**	**East**	**West**	**Central**	**East**
Antimony	--	X	--	--	--	--
Arsenic	--	--	--	--	X	--
Chromium	--	--	--	--	--	--
Copper	X	X	--	--	--	--
Lead	X	X	--	--	X	--
Mercury	X	**X**	--	--	--	--
Nickel	--	--	--	--	--	--
Selenium	--	--	--	--	--	--
Zinc	X	X	X	--	--	--
Total HPAH	--	X	--	--	--	--
Total LPAH	--	--	--	--	--	--
BaP Eq	--	--	--	X	**X**	--
Dibenzofuran	--	X	--	--	--	--
Total PCBs	--	--	--	--	--	--
Dioxin/Furan TEQ	**X**	**X**	**X**	**X**	**X**	**X**

Notes:

1. Upland Soil includes all samples located within the site boundary above mean high water
2. Ecological and Human Health - Surface Soil risk applies to soil from 0-3 feet below ground surface.
3. Human Health - Subsurface risk applies to soil from 3-10 feet below ground surface.
4. HPAH = High molecular weight polycyclic aromatic hydrocarbons
5. LPAH - Low molecular weight polycyclic aromatic hydrocarbons
6. PCBs = Polychlorinated biphenyls
7. TEQ = Toxicity equivalent
8. BaP Eq = Benzo(a)pyrene toxicity equivalent
9. COC =Contaminant of Concern
10. **X =** Bold denotes significant risk driver
11. X = Denotes secondary risk driver
12. = Shading denotes risk driver present above hot spot concentration

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 2
Ecological and Human Health Contaminants of Concern (COCs) in Upland Soil
Willamette Cove Upland Site

Chemical	Ecological				Human Health		
	Plant	Invertebrate	Bird	Mammal	Recreational Trespasser/ Future Park User	Transient Trespasser	Construction Worker
Antimony	X	X	NA	X	X		X
Arsenic	X				X		
Beryllium			NA				
Cadmium							
Chromium	X	X					
Copper	X	X	X	X	X		X
Lead	X	X	X	X	X		
Mercury	X	X	X	X			
Nickel	X	X		X			
Selenium	X						
Silver		NA					
Thallium		NA					
Zinc	X	X		X			
BaP Eq	--	--	--	--	X		
HPAH	NA	X	NA	X	--	--	--
LPAH	NA	X	NA		--	--	--
Dibenzofuran	NA	NA	NA	X			
Diesel[1]							
Total PCBs[2]		NA	X	X	X	X	X
Phthalates[1]							
Dioxins/Furans[3]	NA	NA	X	X	X	X	X

Notes:
Yellow Highlighted Cells indicate COCs new for this receptor, compared to Table 5-1 from Residual Risk Assessment.

PAHs = Polycyclic Aromatic Hydrocarbons
BaPEq = Benzo(a)pyrene Equivalent
HPAH = High molecular weight PAHs
LPAH = Low molecular weight PAHs
TPH = Total Petroleum Hydrocarbons
PCBs = Polychlorinated Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
NA = RBC not available due to lack of TRV.

[1]Diesel range hydrocarbons and phthalates are retained as a COC due to number of samples and detected concentrations, no RBCs are available for comparing to receptor scenarios.

[2]PCBs were not included in post-2014 analyses, but were identfied in the Residual Risk Assessments as a COC for locations that are technically in the Inner Cove Beach EU, but at the boundary with the East Parcel and Central Parcel EUs. PCBs are retained as COCs in this analysis based on this previous analysis.

[3] For birds and mamamals, congener-based RBCs were normalized to 2,3,4,7,8-TCDD Toxicity Equivalents.

Table 3
Human Health Soil Preliminary Remediation Goals and Hot Spot Values
Willamette Cove Upland Site
Portland, Oregon

Chemical of Concern	Receptor Specific RBCs												Human Health	
	Recreational Trespasser/Park User[2]				Transient Trespasser[2,3]				Construction Worker[4]				PRGs	
	Cancer		Non-Cancer		Cancer		Non-Cancer		Cancer		Non-Cancer			
	RBC	Hot Spot	RBC	Hot Spot	RBC	Hot Spot	RBC	Hot Spot	RBC	Hot Spot	RBC	Hot Spot	PRG	Hot Spot
Concentration in mg/kg														
Antimony	nc	nc	24.3	243	nc	nc	98	980	nc	nc	31	310	**24.3**	**243**
Arsenic	1.4	140	74	740	29	2,900	370	3,700	15	1,500	97	970	**8.8/4.4[5]**	**140**
Copper	nc	nc	11,000	110,000	nc	nc	56,000	560,000	nc	nc	14,000	140,000	**11,000**	**110,000**
Lead	nc	nc	400	4,000	nc	nc	800	8,000	nc	nc	800	8,000	**400**	**4,000**
BaP Eq	0.55	55	60	600	32	3,200	270	2,700	17	1,700	74	740	**0.55**	**55**
Total PCBs	0.74	74	4	40	14	1,400	18	180	8.4	840	4.9	49	**0.74**	**40**
Dioxin/Furan TEQ	1.50E-05	1.50E-03	1.70E-04	1.70E-03	3.20E-04	3.20E-02	1.10E-02	1.10E-01	1.70E-04	1.70E-02	2.30E-04	2.30E-03	**1.50E-05**	**1.50E-03**

Notes:

RBC = Risk Based Concentration

PRG = Preliminary Remediation Goal

nc = not carcinogenic, so no cancer values calculated

mg/kg = milligrams per kilogram

PCBs = polychlorinated biphenyls

Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent

BaP Eq = benzo(a)pyrene equivalents

1. Upland Soil includes all samples located within the site boundary above mean high water
2. Data screened against the Recreational Trespasser/Park User and Transient Trespasser PRGs include samples from the surface to 3 feet below the surface.
3. Due to an error in DEQ's RBDM spreadsheet for calculating site-specific RBCs for non-carcinogens, some of the transient trespasser RBCs were incorrect in the FS report. This table shows the corrected values.
4. Data screened against the Construction Worker PRG includes samples from the surface to ten feet below the surface.
5. The PRG for arsenic is based on the background soil 90 percent upper prediction limit (8.8 mg/kg) and the background soil arithmetic mean (4.4 mg/kg). The correct comparison of confirmation sample data to background will depend on the method used to collect the soil samples.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 4
Human Health Surface Soil Screening (0-3 feet bgs)
Willamette Cove Upland Site
Portland, Oregon

Chemical of Concern	Human Health Screening Levels (mg/kg)				Total Number of Samples				Highest Concentration Sample[6]			
	Discrete/ Composite		ISM		Analyzed	Above MDL	Above PRG	Above Hot Spot	Sample Name	Sample Type	Result (mg/kg)	ER
	PRG	Hot Spot	PRG	Hot Spot								
West Parcel												
Antimony	24.3	243	24.3	243	3	0	0	0	--	--	--	--
Arsenic	8.8	140	4.4	140	10	10	2	0	RA1 S4	Composite	8.92	1.01
Copper	11,000	110,000	11,000	110,000	10	10	0	0	DU-7	ISM	102	0.0
Lead	400	4,000	400	4,000	10	10	0	0	RA1 S4	Composite	48.9	0.1
BaP Eq	0.55	55	0.55	55	8	8	2	0	TP-21/S-2	Discrete	1.3	2.3
Total PCBs	0.74	40	0.74	40	2	1	0	0	WC-SSA	Discrete	0.111	0.2
Dixoin/Furan TEQ	0.000015	0.0015	0.000015	0.0015	1	1	1	0	DU-7	ISM	0.000103	6.9
Central Parcel												
Antimony	24.3	243	24.3	243	123	47	1	0	WC-SSV-1-1	Discrete	29.9	1.2
Arsenic	8.8	140	4.4	140	133	133	26	0	SS-19	Discrete	40.3	4.6
Copper	11000	110000	11000	110000	144	144	0	0	WC-SSP-1-1	Discrete	5440	0.5
Lead	400	4000	400	4000	146	146	21	1	WC-SSS-2b	Discrete	4040	10.1
BaP Eq	0.55	55	0.55	55	54	52	29	1	TP-22/S-1	Discrete	63.6	116
Total PCBs	0.74	40	0.74	40	21	2	0	0	WC-SSH-D	Discrete	0.21	0.3
Dixoin/Furan TEQ	0.000015	0.0015	0.000015	0.0015	54	54	41	2	WC-3 Surface	Discrete	0.0057	380
East Parcel												
Antimony	24.3	243	24.3	243	24	19	4	0	WC-SSL-1-2	Discrete	192	7.9
Arsenic	8.8	140	4.4	140	28	27	10	0	WC-SSL-1-2	Discrete	36.2	4.1
Copper	11000	110000	11000	110000	28	28	2	0	WC-SSL-1-2	Discrete	47500	4.3
Lead	400	4000	400	4000	26	26	6	0	WC-SSL-1-2	Discrete	3090	7.7
BaP Eq	0.55	55	0.55	55	20	20	2	0	WC-SSL-1-1	Discrete	0.89	1.6
Total PCBs	0.74	40	0.74	40	20	7	3	0	WC-SSH-3	Discrete	1.85	2.5
Dixoin/Furan TEQ	0.000015	0.0015	0.000015	0.0015	1	1	1	0	DU-4	ISM	0.0000612	4.1

Notes:

1. mg/kg = milligrams per kilogram
2. ISM = Incremental Sampling Methodology
3. PRG = Preliminary Remediation Goal
4. MDL = Method detection limit
5. ER = Exceedance Ratio
6. For analytes that have a lower PRG for ISM samples, this sample may not be the highest absolute concentration, but the highest concentraion of samples that exceed PRGs.
7. PCBs = polychlorinated biphenyls
8. Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent
9. BaP Eq = Benzo(a)pyrene Toxicity Equivalent
10. Upland Soil includes all samples located within the site boundary above mean high water
11. bgs = below ground surface

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 5
Human Health Subsurface Soil Screening (3-10 feet bgs)
Willamette Cove Upland Site
Portland, Oregon

Chemical of Concern	Construction Worker RBC[5] (mg/kg)		Total Number of Samples				Highest Concentration Sample			
	Discrete/ Composite		Analyzed	Above MDL	Above RBC	Above Hot Spot	Sample Name	Sample Type	Result (mg/kg)	ER
	RBC	Hot Spot								
West Parcel										
Antimony	31	310	0	0	0	0	--	--	--	--
Copper	14,000	140,000	0	0	0	0	--	--	--	--
Total PCBs	4.9	49	3	0	0	0	--	--	--	--
Dixoin/Furan TEQ	0.00017	0.0023	0	0	0	0	--	--	--	--
Central Parcel										
Antimony	31	310	2	0	0	0	--	--	--	--
Copper	14,000	140,000	2	2	0	0	RA3-D-B1	Composite	64.8	0.005
Total PCBs	4.9	49	0	0	0	0	--	--	--	--
Dixoin/Furan TEQ	0.00017	0.0023	2	2	0	0	RA3-D-B1	Composite	0.000144	0.6
East Parcel										
Antimony	31	310	0	0	0	0	--	--	--	--
Copper	14,000	140,000	0	0	0	0	--	--	--	--
Total PCBs	4.9	49	0	0	0	0	--	--	--	--
Dixoin/Furan TEQ	0.00017	0.0023	0	0	0	0	--	--	--	--

Notes:

1. RBC = Risk Based Concentration
2. mg/kg = milligrams per kilogram
3. MDL = Method detection limit
4. ER = Exceedance Ratio
5. Screening levels are the lowest of the cancer and non-cancer RBC
6. PCBs = polychlorinated biphenyls
7. Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent
8. Upland Soil includes all samples located within the site boundary above mean high water
9. bgs = below ground surface

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 6
Upland Soil Preliminary Remediation Goals and Oregon High Concentration Hot Spot Values – Ecological Receptors
Willamette Cove Upland
Portland, Oregon

Chemical of Concern	Receptor Specific Screening Levels and RBCs								Ecological PRGs			
	Plant		Invertebrate		Birds		Mammal		Sample Type			
									Discrete/Composite		ISM	
	Screening Level	Hot Spot	Screening Level	Hot Spot	RBC	Hot Spot	RBC	Hot Spot	PRG	Hot Spot	PRG	Hot Spot
Concentration in mg/kg												
Antimony	5	50	78	780	NA	NA	2.7	27	**2.7**	**27**	**2.7**	**27**
Arsenic	18	180	NA	NA	575	5750	83	830	**18**	**180**	**18**	**180**
Chromium	1	10	0.4	4	87	870	342	3420	**76**	**76**	**39**	**39**
Copper	70	700	80	800	87.7	877	82	820	**70**	**700**	**70**	**700**
Lead	120	1,200	1,700	17,000	33	330	122	1,220	**79**	**330**	**33**	**330**
Mercury	0.3	3	0.1	1	0.015	0.15	3.53	35.3	**0.23**	**0.23**	**0.073**	**0.15**
Nickel	38	380	280	2800	139	1390	20	200	**47**	**200**	**23**	**200**
Selenium	0.52	5.2	4.1	41	3.42	34.2	1.1	11	**0.71**	**5.2**	**0.52**	**5.2**
Zinc	160	1,600	120	1,200	673	6730	201	2010	**180**	**1,200**	**120**	**1,200**
Total HPAH	NA	NA	18	180	NA	NA	5.6	56	**5.6**	**56**	**5.6**	**56**
Total LPAH	NA	NA	29	290	NA	NA	100	1000	**29**	**290**	**29**	**290**
Dibenzofuran	NA	NA	NA	NA	NA	NA	0.01	0.10	**0.01**	**0.1**	**0.01**	**0.1**
Total PCBs	40	400	NA	NA	0.734	7.34	0.098	0.98	**0.098**	**0.98**	**0.098**	**0.98**
Dioxin/Furan TEQ	NA	NA	NA	NA	8.90E-05	8.90E-04	6.10E-06	6.10E-05	**6.10E-06**	**6.10E-05**	**6.10E-06**	**6.10E-05**

Notes:

NA = RBC Not Available

1. RBC = Risk Based Concentration
2. PRG = Preliminary Remediation Goal
3. ISM = Incremental Sampling Methodology
4. mg/kg = milligrams per kilogram
5. HPAH = high molecularl weight polycyclic aromatic hydrocarbons
6. LPAH = low molecular weight polycyclic aromatic hydrocarbons
7. PCBs = polychlorinated biphenyls
8. Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent
8. Upland Soil includes all samples located within the site boundary above mean high water
9. Data screened against ecological screening levels includes samples from the surface to three feet below the surface.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 7
Ecological Soil Screening Summary
Willamette Cove Upland Site
Portland, Oregon

Chemical of Concern	Ecological Screening Levels (mg/kg)				Total Number of Samples				Highest Concentration Sample[6]			
	Discrete/ Composite		ISM		Analyzed	Above MDL	Above PRG	Above Hot Spot	Sample Name	Sample Type	Result (mg/kg)	ER
	PRG	Hot Spot	PRG	Hot Spot								
West Parcel												
Antimony	2.7	27	2.7	27	3	0	0	0	--	--	--	--
Arsenic	18	180	18	180	10	10	0	0	RA1 S4	Composite	8.92	0.5
Chromium	76	76	39	39	4	4	0	0	B-1/S-2	Discrete	20.6	0.3
Copper	70	700	70	700	10	10	1	0	DU-7	ISM	102.0	1.5
Lead	79	330	33	330	10	10	1	0	DU-7	ISM	43.00	1.3
Mercury	0.23	0.23	0.073	0.15	18	3	2	2	DU-7	ISM	0.359	4.9
Nickel	47	200	23	200	4	4	0	0	B-2/S-1	Discrete	19.7	0.4
Selenium	0.71	5.2	0.52	5.2	3	0	0	0	--	--	--	--
Zinc	180	1200	120	1200	10	10	1	0	DU-7	ISM	151	1.3
Total HPAH	5.6	56	5.6	56	8	8	1	0	TP-21/S-2	Discrete	6.351	1.1
Total LPAH	29	290	29	290	8	7	0	0	TP-21/S-2	Discrete	0.754	0.03
Dibenzofuran	0.01	0.1	0.01	0.1	1	0	0	0	--	--	--	--
Total PCBs	0.098	0.98	0.098	0.98	2	1	1	0	WC-SSA	Discrete	0.111	1.1
Dixoin/Furan TEQ	0.0000061	0.000061	0.0000061	0.000061	1	1	1	1	DU-7	ISM	0.000103	17
Central Parcel												
Antimony	2.7	27	2.7	27	116	42	18	1	WC-SSV-1-1	Discrete	29.9	11
Arsenic	18	180	18	180	126	126	5	0	SS-19	Discrete	40.3	2.2
Chromium	76	76	39	39	125	125	0	0	SS-19	Discrete	68.6	0.9
Copper	70	700	70	700	137	137	55	7	WC-SSP-1-1	Discrete	5,440	78
Lead	79	330	33	330	139	139	87	30	WC-SSS-2b	Discrete	4,040	51
Mercury	0.23	0.23	0.073	0.15	171	153	127	127	Area-3-15	Discrete	26.6	116
Nickel	47	200	23	200	125	125	9	0	WC-SSV-1-2	Discrete	144	3.1
Selenium	0.71	5.2	0.52	5.2	116	16	12	0	WC-SSV-1-1	Discrete	1.8	2.5
Zinc	180	1200	120	1200	130	130	58	1	WC-SSS-2b	Discrete	1,460	8.1
Total HPAH	5.6	56	5.6	56	54	52	25	5	TP-22/S-1	Discrete	324.43	58
Total LPAH	29	290	29	290	54	50	2	0	TP-22/S-1	Discrete	45.78	1.6
Dibenzofuran	0.01	0.1	0.01	0.1	9	6	6	1	RA2-S9	Composite	0.583	58
Total PCBs	0.098	0.98	0.098	0.98	21	2	2	0	WC-SSH-D	Discrete	0.21	2.1
Dixoin/Furan TEQ	0.0000061	0.000061	0.0000061	0.000061	54	54	49	23	WC-3 Surface	Discrete	0.0057	934

Please see notes at end of table.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 7
Ecological Soil Screening Summary
Willamette Cove Upland Site
Portland, Oregon

Chemical of Concern	Ecological Screening Levels (mg/kg)				Total Number of Samples				Highest Concentration Sample[6]			
	Discrete/ Composite		ISM		Analyzed	Above MDL	Above PRG	Above Hot Spot	Sample Name	Sample Type	Result (mg/kg)	ER
	PRG	Hot Spot	PRG	Hot Spot								
East Parcel												
Antimony	2.7	27	2.7	27	24	19	12	3	WC-SSL-1-2	Discrete	192	71
Arsenic	18	180	18	180	28	27	2	0	WC-SSL-1-2	Discrete	36.2	2.0
Chromium	76	76	39	39	27	27	1	1	WC-SSL-1-2	Discrete	145	1.9
Copper	70	700	70	700	28	28	12	3	WC-SSL-1-2	Discrete	47,500	679
Lead	79	330	33	330	26	26	15	8	WC-SSL-1-2	Discrete	3,090	39
Mercury	0.23	0.23	0.073	0.15	26	20	3	3	RA6-S17	Composite	3.48	15
Nickel	47	200	23	200	25	25	7	1	WC-SSL-1-2	Discrete	306	6.5
Selenium	0.71	5.2	0.52	5.2	23	11	4	0	WC-SSO Composite	Composite	1.3	1.8
Zinc	180	1200	120	1200	28	28	19	2	WC-SSL-1-2	Discrete	1810	10
Total HPAH	5.6	56	5.6	56	20	20	0	0	WC-SSL-1-1	Discrete	5.58	1.0
Total LPAH	29	290	29	290	20	17	0	0	WC-SSL-1-1	Discrete	1.9976	0.1
Dibenzofuran	0.01	0.1	0.01	0.1	1	0	0	0	--	--	--	--
Total PCBs	0.098	0.98	0.098	0.98	20	7	5	2	WC-SSH-3	Discrete	1.85	19
Dixoin/Furan TEQ	0.0000061	0.000061	0.0000061	0.000061	1	1	1	1	DU-4	ISM	0.0000612	10

Notes:

1. mg/kg = milligrams per kilogram
2. ISM = Incremental Sampling Methodology
3. PRG = Preliminary Remediation Goal
4. MDL = Method detection limit
5. ER = Exceedance Ratio
6. For analytes that have a lower PRG for ISM samples, this sample may not be the highest absolute concentration, but the highest concentraion of samples that exceed PRGs.
7. HPAH = high molecularl weight polycyclic aromatic hydrocarbons
8. LPAH = low molecular weight polycyclic aromatic hydrocarbons
9. PCBs = polychlorinated biphenyls
10. Dioxin/Furan TEQ = 2,3,7,8-TCDD toxicity equivalent
11. Upland Soil includes all samples located within the site boundary above mean high water
12. Data screened against ecological screening levels includes samples from the surface to three feet below the surface.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 8
Summary of Impacted Areas and Volumes - Upland Soil
Willamette Cove Upland
Portland, Oregon

Remedial Action Extent		West Parcel	Central Parcel		East Parcel	Total
			West End	East End		
Exceeding PRGs						
Ecological and Human Health	Depth (ft)	2	3	1	1	--
	Area (sf)	187,720	162,040	184,760	255,950	790,470
	Volume (cy)	13,910	18,000	6,840	9,480	48,230
Human Health	Depth (ft)	1.5	2	0.5	0.5	--
	Area (sf)	187,720	162,040	184,760	255,950	790,470
	Volume (cy)	10,430	12,000	3,420	4,740	30,590
Exceeding Hot Spot Levels						
Ecological	Depth (ft)	1	1	1	1	--
	Area (sf)	187,720	162,040	184,760	255,950	790,470
	Volume (cy)	6,950	6,000	6,840	9,480	29,270
Human Health	Depth (ft)	0.5	0.5	0.5	0.5	--
	Area (sf)	0	0	0	0	0
	Volume (cy)	0	0	0	0	0
Exceeding Non-Dioxin/Furan Hot Spot Levels						
Ecological	Depth (ft)	1	1	1	1	--
	Area (sf)	18,770	55,750	36,950	0	111,470
	Volume (cy)	700	2,060	1,370	0	4,130
Human Health	Depth (ft)	0.5	0.5	0.5	0.5	--
	Area (sf)	0	800	0	0	800
	Volume (cy)	0	10	0	0	10

Notes:

1. PRGs = preliminary remediation goals
2. ft = feet below ground surface
3. sf = square feet
4. cy = cubic yards
5. Within the 2015 soil removal action areas, depth exceeding PRGs is assumed to be that listed in the table minus 2015 excavation dept
6. The areas listed include the site from top of bank
7. The volume listed is for alternatives using standard excavation techniques. Alternatives using low impact excavation around native trees will have smaller volumes due to the exceptions listed above.
8. All quantities are from the top of bank inland towards the property boundary.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 9
General Response Actions and Applicable Technologies
Willamette Cove Upland Site
Portland, Oregon

General Response Actions	Applicable Technologies	Description	Is Technology Applicalbe Based on Site Characteristics, Soil Condition, and Contaminant Type?
No Action	No Action	• No Action	Yes
Institutional Controls	Deed Restrictions/Soil Management Plan	• Can prevent disturbance of any required soil cap or other engineering controls, address notification of Site hazards, and ensure proper controls are implemented during future Site activities. • Protocols must be established for handling and managing contaminated soils during future site work to protect workers, public health, and the environment.	Yes
	Monitoring	• Laboratory analysis of soil samples.	Yes
Engineering Controls	Access Restrictions	• Use of fencing, signage, or other controls to limit access to impacted soils.	Yes
	Control of Building HVAC System	• Use HVAC system to maintain positive pressure in buildings. • Effective for removal of volatile organic contaminants.	No - No buildings on site.
	Vapor Barriers	• Installation of low-permeability barriers beneath structures to prevent vapor intrusion of sealants on floor slabs or paved surfaces. • Effective for control of volatile organic contaminants.	No - No buildings on site.
	Sub-Slab Depressurization or Sub-Floor Venting	• Installation of sub-slab venting systems or suction pits to create negative pressures beneath structures to prevent vapor migration to ambient air. Vapors are collected in the suction pit or venting pipes below the building and vented to the outside of the building, either passively or with fans. • Effective for removal of volatile organic contaminants.	No - No buildings on site.
Containment	Capping	• Installation of an engineered cap (e.g., soil, asphalt, impermeable liner) over impacted soils. Soil caps may include various amendments (e.g., organic matter) to reduce bioavailability of contaminants. • Effective for all types of contaminants	Yes
Removal And Disposal	Excavation	• Excavation of some or all of the contaminated soil for subsequent treatment and/or disposal. • Effective for all types of contaminants	Yes
	Off-site Disposal	• Off-site disposal of excavated soil at permitted disposal facility. Soils would require waste profiling and approval by the disposal facility. • Effective for all types of contaminants	Yes
	On-Site Consolidation	• Consolidate excavated soil in an on-site, capped disposal area. • Effective for all types of contaminants	Yes
In Situ Biological Treatment	Bioventing	• Bioventing involves inducing air or oxygen flow in the unsaturated zone to promote biodegradation of hydrocarbons and VOCs. Applications include injection of air or oxygen into subsurface, or extraction of air at rates lower than for SVE. • Effective organics and volatile contaminants. Not effective with inorganic contaminants.	No - not effective for all site contaminant types.
	Enhanced Bioremediation (Bioaugmentation, Biostimulation)	• Adding nutrients, electron donor/acceptor, or other amendments to enhance bioremediation. • Most effective with organic contaminants, but can be used to change oxidative state of inorganics. • Can be difficult to achieve contact with all contaminant mass, particularly in unsaturated soils.	No - not effective for unsaturated soils.
	Land Treatment	• Combination of aeration (tilling) and amendments to enhance bioremediation in surface soils. • Effective for organic contaminants in shallow soil that can be degraded aerobically. Not effective for deeper contamination or inorganics.	No - not effective for all site contaminant types.
	Monitored Natural Attenuation	• Using natural processes to reduce contaminant concentrations to acceptable levels. Process is closely monitored to verify exposures are acceptable prior to concentrations reaching acceptable levels. • Most effective with organic contaminants, but natural processes can change oxidative state of inorganics.	Yes
	Phytoremediation	• Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil or sediment. • Can be effective at removing a variety of organic and inorganic compounds from soil through plant uptake in vicinity of roots (rhizosphere).	Yes

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 9
General Response Actions and Applicable Technologies
Willamette Cove Upland Site
Portland, Oregon

General Response Actions	Applicable Technologies	Description	Is Technology Applicalbe Based on Site Characteristics, Soil Condition, and Contaminant Type?
In Situ Physical/ Chemical/ Thermal Treatment	Soil Vapor Extraction (SVE)	• SVE involves extraction of vapors from the vadose zone using system of vertical wells or horizontal vents and vacuum pumps/blowers. Treatment of the discharge may be required. • Effective for organic volatile contanminants.	No - not effective for all site contaminant types.
	Electrokinetic Separation	• Application of a low-intensity direct current through the soil between electrodes that are divided into a cathode array and an anode array. This mobilizes charged species, causing ions and water to move toward the electrodes. • Effective for removing inorganic ions and polar organics from saturated soil. • Most effective in low-permeability soils (particularly clays). Not effective for vadose zone soil without supplemental saturation.	No - not effective for all site contaminant types or unsaturated soils.
	Fracturing	• Development of cracks in low-permeability or overconsolidated soils to create passageways that increase the effectiveness of other *in situ* processes and extraction technologies. • Effective in in deep, fine-grained or consolidated soils.	No - not effective in shallow unconsolidated soils.
	Chemical Oxidation	• Chemically converts hazardous contaminants to less toxic compounds. Effective in destroying organic contaminants and oxidizing inorganic contaminants to less toxic/less mobile forms. Can include oxidant chemicals such as peroxides, permanganates, or ozone • Can be highly effective at destruction of organic contaminants or oxidation of inorganics. • Can be difficult to achieve contact with all contaminant mass, particularly in unsaturated soils.	No - not effective in unsaturated soils.
	Soil Flushing	• Water (or water containing an additive to enhance contaminant solubility) is circulated through the soil to desorb contaminants, recovered, and treated. Implementation can involve injection followed by removal (such as via vacuum truck). • May be effective for soluble inorganics. • Most effective for deep or saturated soils. • Requires significant power and infrastructure for water extraction and treatment.	No - not effective for all contaminant types or unsaturated soils and site does not have ready access to necessary infrastructure.
	Solidification/Stabilization/ Vitrification/Immobilizatioin	• Contaminants are physically bound or enclosed within a stabilized mass (solidification and vitrification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization), or additives are uses to to reduce mobility or bioavailability of contaminants (immobilization). Could be directly applied/mixed with soil or applied as part of an active capping approach. • Effective in shallow unconsolidated soils. • Effective on many contaminant types.	Yes
	Thermally-Enhanced Removal	• High-energy injection (steam/hot air, electrical resistance, electromagnetic, fiber optic, radio frequency) is used to increase the recovery rate of semi-volatile or non-volatile compounds to facilitate extraction (enhanced volatilization or decreased viscosity). Coupled with a • Most suitable to semi-volatile organic contaminants or viscous compounds that are not otherwise extractable with vapor extraction or fluid extraction technologies. Not effective with inorganics. • Requires significant infrastructure for power and material application.	No - not effective for all contaminants and site does not have ready access to necessary infrastructure.
Ex Situ Biological Treatment	Biopiles	• Excavated soils are mixed with soil amendments and placed in aboveground enclosures and aerated with blowers or vacuum pumps. • Effective for removal of organic contaminants from excavated soil. Not be effective for inorganics.	No - not effective for all site contaminant types.
	Composting	• Excavated soil is mixed with bulking agents and organic amendments to promote microbial activity. • Effective for removal of organic contaminants from excavated soil. Would not be effective for inorganics	No - not effective for all site contaminant types.
	Landfarming	• Excavated soil is placed in lined beds and periodically tilled to aerate the soil. • Effective for removal of organic contaminants from excavated soil. Would not be effective for inorganics	No - not effective for all site contaminant types.
	Slurry Phase Biological Treatment	• An aqueous slurry of soil, sediment, or sludge with water and other additives is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. When complete, the slurry is dewatered and the soil is disposed of. • Effective for removal of organic contaminants from excavated soil. Would not be effective for inorganics	No - not effective for all site contaminant types.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 9
General Response Actions and Applicable Technologies
Willamette Cove Upland Site
Portland, Oregon

General Response Actions	Applicable Technologies	Description	Is Technology Applicalbe Based on Site Characteristics, Soil Condition, and Contaminant Type?
Ex Situ Physical/ Chemical/ Thermal Treatment	Chemical Extraction	• Excavated soil is mixed with an extractant, which dissolves the contaminants. The resultant solution is placed in a separator to remove the contaminant/extractant mixture for treatment. • Can be difficult to achieve contact with all contaminant mass, particularly in unsaturated soils. • Most suitable to removal of semi-volatile and inorganic contamination from excavated soil.	No - not effective for all site contaminant types or unsaturated soils.
	Solidification/ Stabilization	• Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Yes
	Dehalogenation	• Reagents are added to soils contaminated with halogenated organics to remove halogen molecules. • Effective at detoxifying halogenated organic compounds in excavated soil. Not applicable to inorganics or non-halogenated compounds.	No - not effective for all site contaminant types.
	Incineration	• High temperatures are used to combust (in the presence of oxygen) organic constituents in hazardous wastes. • Effective at removing organic contaminants from excavated soil. Not applicable to inorganics (though can change the oxidative state).	No - not effective for all site contaminant types.
	Soil Washing	• Contaminants are separated from the excavated soil with wash-water augmented with additives to help remove organics. • Most suitable to removal of semi-volatile and inorganic contamination from excavated soil.	No - not effective for all site contaminant types.
	Solar Detoxification	• Contaminants are destroyed by photochemical and thermal reactions using ultraviolet energy in sunlight or artificial UV light. Usually involves application of catalyst agent. • Can be effective at treating a variety of organic compounds. Not applicable to inorganics.	No - not effective for all site contaminant types.
	Thermal Desorption/ Pyrolysis/ Hot Gas Decontamination	• Waste soils are heated to either volatilize (desorption and hot gas) or to anaerobically decompose (pyrolysis) organic contaminants. Off-gas is collected and treated. Effective at removing organic materials from excavated soil (particularly volatile organics). • Pyrolysis generally used for semi-volatiles or pesticide wastes. Not effective for inorganics.	No - not effective for all site contaminant types.
	Separation	• Separation techniques concentrate contaminated solids through physical, magnetic, and/or chemical means. These processes remove solid-phase contaminants from the soil matrix. • Can be effective at treating a variety of compounds.	Yes

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 10
Screening and Evaluation of Technologies
Willamette Cove Upland Site
Portland, Oregon

General Response Action/Technology	Description	Screening Criteria			Screening Comments
		Effectiveness	Implementability	Cost	
No Action					
No Action	No Action	Not effective in achieving RAOs.	Easy to implement.	No capital or O&M costs incurred.	Does not meet threshold criteria. Required to be included for comparison purposes.
Institutional Controls					
Deed Restrictions/ Soil Management Plan	Can prevent disturbance of any required soil cap or other engineering controls, address notification of Site hazards, and ensure proper controls are implemented during future Site activities. Protocols will be established for handling and managing contaminated soils during future Site work to protect workers, public health, and the environment.	Effective at regulating human direct contact, but is not effective at preventing erosion or ecological exposures, and does not address contaminant reduction. Soil management plan useful for addressing future interaction with impacted soils.	Deed restriction reasonably easy to complete. Soil management plan would need to be prepared and maintained in perpetuity.	Low costs associated with implementing soil management plan and deed restrictions.	Institutional controls are useful technologies to address risks during cleanup and to address residuals remaining after primary cleanup. Would be necessary for alternatives that maintain impacted soil on-site (such as capping). Generally only applicable to human receptors.
Monitoring	Laboratory analysis of soil samples.	Effective for documenting Site conditions to evaluate migration and current Site risks. Does not address contaminant reduction.	Moderately easy to implement. Repeat sampling events may be necessary for tracking progress of active treatment technologies, which would require multiple mobilizations.	Low to moderate costs for monitoring.	Applicable to document Site conditions and effectiveness of any treatment. Must be used in conjunction with other technologies. Would include regular inspections of implemented technology (such as capping) and erosion control.
Engineering Controls					
Access Restrictions	Use of fencing, signage, or other controls to limit access to impacted soils.	Effective at preventing human direct contact exposure to shallow impacted soil. Not effective at preventing erosion or ecological exposures.	Reasonably easy to implement for shallow soils. Would restrict use of property, but probably consistent with future site use. Access restrictions to site have been difficult for site in past.	Possible high short-term costs for implementing site access restrictions, but not anticipated to have long term high costs.	Applicable especially in interim prior to park development. Addresses only human receptors, therefore must be used in conjunction with other technologies. Effectiveness of site access restrictions would need to be demonstrated prior to implementation.
Containment					
Capping	Installation of an engineered cap (e.g., soil, asphalt, impermeable liner) over impacted soils. Soil caps may include various amendments (e.g., organic matter) to reduce bioavailability of contaminants. Armoring and/or vegetation can be used as a method of preventing erosion.	Effective at preventing direct contact with contaminated soils. Amendments can reduce uptake for contaminants. Does not address contaminant reduction but engineered cap can prevent erosion. Cap design can also be compatible with expected future site use.	Site is unimproved and installation of a cap would be reasonably easy. However, cap installation could eliminate existing habitat. Cap would need to be maintained in perpetuity. Cap design could be incorporated into land use design for anticipated future use.	Moderate to high construction cost for installation of cap. Low to moderate costs for ongoing maintenance of cap to maintain effectiveness.	Potentially applicable to the site to prevent direct contact. Thin caps with soil amendments applicable to reducing bioavailability. Specific technology used would have to be compatible with future expected use (e.g., expansive asphalt concrete cap is not applicable, but a soil cap with strategically placed paved trails may be).
Removal And Disposal					
Excavation	Excavation of some or all of the contaminated soil for subsequent treatment and/or disposal. Focused excavation may include only higher concentrations or "hot spot" soil. Site restoration could include backfill with treated soil, imported soil, or re-grading surface soil.	Effective for removing source material from site or consolidating soil under an on-site cap. Addresses direct exposure pathways and migration by reducing or controlling on-site contaminant mass.	Implementation involves conventional construction equipment and methods. Integration into land use plan would be feasible. Depending on extent of excavation, may eliminate existing habitat.	Moderate to high costs due to required soil volumes.	Applicable to the site.
Off-site Disposal	Off-site disposal of excavated soil at permitted disposal facility. Soils would require waste profiling and approval by the disposal facility.	Effective for containing contaminated soils and reducing risks associated with direct exposure.	Implementation involves transportation of contaminated soils. Non-soil wastes (rock and debris) may be separable to reduce disposal volume.	Moderate to high costs depending upon soil volumes and characterization.	Applicable to the site.
On-Site Consolidation	Consolidate excavated soil in an on-site, capped disposal area such as a berm along the rail line to reduce noise.	Effective by consolidating on-site soil in a controlled area to prevent exposure. Because the primary concern is direct contact, a soil cap would be effective.	Implementation involves conventional construction equipment and methods. Integration into land use plan would be feasible. Depending on extent of excavation, may eliminate existing habitat.	Moderate to high costs depending upon soil volumes.	Applicable to the site.

Please Refer To Notes At End Of Table.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 10
Screening and Evaluation of Technologies
Willamette Cove Upland Site
Portland, Oregon

General Response Action/Technology	Description	Screening Criteria			Screening Comments
		Effectiveness	Implementability	Cost	
***In Situ* Biological Treatment**					
Monitored Natural Attenuation	Using natural processes to reduce contaminant concentrations to acceptable levels. Process is closely monitored to verify exposures are acceptable prior to concentrations reaching acceptable levels.	Most effective with organic contaminants, but natural processes can change oxidative state of inorganics. Likely unable to effect change in unsaturated soils.	Easy to implement. Monitoring of unsaturated soil would require repeated intrusive sampling events. Implementation would likely be ineffective.	Moderate costs for monitoring.	Not retained because ineffective with Site contaminants and conditions (i.e., shallow unsaturated soil).
Phytoremediation	Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil or sediment.	Can be effective at removing a variety of organic and inorganic compounds from soil through plant uptake in vicinity of roots (rhizosphere).	Requires significant land area suitable for large plants. Contamination must be accessible to plant root zones. Likely not compatible with anticipated future site use because required plant management not consistent with natural park.	Low to moderate implementation cost.	Although potentially suitable for some of the Site contaminants of concern, not suitable for long-term intended site use as a park.
***In Situ* Physical/ Chemical/ Thermal Treatment**					
Solidification/Stabilization/ Vitrification/Immobilizatioin	Contaminants are physically bound or enclosed within a stabilized mass (solidification and vitrification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization), or additives are uses to to reduce mobility or bioavailability of contaminants (immobilization). Could be directly applied/mixed with soil or applied as part of an active capping approach.	Potentially suitable to reducing mobility of and accessibility to site contaminants. Difficult to ensure complete enclosure of soil with in-situ process. Reduction of bioavailability of organic contaminants could be effective with use of (for example) carbon addition to soil.	Difficult to obtain full stabilization in-situ in heterogeneous subsurface by injection. Vitrification would require significant power supply. Finished product would not be compatible with anticipated future site use. Incorporation of additives into cap materials relatively simple.	High to very high implementation cost, except that incorporation of additives into cap material relatively inexpensive.	Immobilization to reduce bioavailability retained as potentially useful technology to combine with capping. Other process options not retained because less suitable to Site conditions and high cost.
***Ex Situ* Physical/ Chemical/ Thermal Treatment**					
Solidification/ Stabilization	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).	Potentially suitable to reduce leaching of contaminants prior to disposal.	Could be used to solidify wet soil or stabilize inorganics if needed for acceptance of excavated soil at the disposal facility. Successfully used on prior removal action at the site.	Low to Moderate implementation cost.	Retained as potentially applicable to soil fraction of excavated soil if stabilization has benefit for disposal.
Separation	Separation techniques concentrate contaminated solids through physical, magnetic, and/or chemical means. These processes remove solid-phase contaminants from the soil matrix.	Effective for removal of solids with distinct physical characteristics (size, composition, etc.).	Commercial equipment available for separation by size (sieving) or for removing iron (magnetic removal).	Low to moderate cost.	May be potentially applicable for removal of rock fraction and debris from excavated soil prior to offsite disposal (reducing disposal volume). Not expected to directly separate contaminants.

Note:
1. **Shading indicates technology has been eliminated from consideration.**

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 11
Summary of Remedial Alternatives
Willamette Cove Upland
Portland, Oregon

Alternative	Description	High Concentration Soil			Soil Above Human Health Risk Levels			Soil Above Ecological Risk Levels			Native Trees Retained	Institutional Controls
		Remove	Consolidate	Cap	Remove	Consolidate	Cap	Remove	Consolidate	Cap		
Alternative 1 - No Action												
1 No Action	▪ No action will be taken.											
Alternative 2 - Cap												
2a Standard Cap	▪ A two-foot soil cap will be placed across the Site. ▪ All trees will be removed.			✓			✓			✓		✓
2b Amended Cap	▪ A one-foot cap amended with organic matter will be placed across the Site. ▪ Native trees will be retained.			✓			✓			✓	✓	✓
Alternative 3 - Excavation												
3a Standard Excavation with Off-Site Disposal	▪ Standard excavation will be used to remove all soil with concentrations above human health and ecological risk levels. ▪ Soil will be disposed of in an off-Site landfill. ▪ All trees will be removed.	✓			✓			✓				
3b Alternative Excavation with Off-Site Disposal	▪ Alternative excavation will be used to remove soil with concentrations above human health and ecological risk levels. ▪ Soil will be disposed of in an off-Site landfill. ▪ Native trees will be retained.	✓			✓			✓			✓	
3c Standard Excavation with On-Site Consolidation	▪ Standard excavation will be used to remove all soil with concentrations above human health and ecological risk levels. ▪ Soil will be placed in an on-Site consolidation area. The soil consolidation area will be capped with two-feet of soil. ▪ All trees will be removed.		✓			✓			✓			✓
3d Standard Excavation with Off-Site Disposal/On-Site Consolidation	▪ Standard excavation will be used to remove all soil with concentration above human health and ecological risk levels. ▪ Soil with high concentrations will be disposed of in an off-Site landfill. ▪ Remaining soil with concentrations above human health and ecological risk levels will be placed in an on-Site consolidation area. The soil consolidation area will be capped with two-feet of soil. ▪ All trees will be removed.	✓				✓			✓			✓
Alternative 4 - Focused Excavation with Cap												
4a Focused Standard Excavation with Off-Site Disposal and Cap	▪ Standard excavation will be used to remove soil with high concentrations. ▪ Soil with high concentrations will be disposed of in an off-Site landfill. ▪ A two-foot soil cap will be placed across the Site. ▪ All trees will be removed.	✓					✓			✓		✓
4b Focused Alternative Excavation with Off-Site Disposal and Amended Cap	▪ Alternative excavation will be used to remove soil with high concentrations. ▪ Soil with high concentrations will be disposed of in an off-Site landfill. ▪ A one-foot cap amended with organic matter will be placed across the Site. ▪ Native trees will be retained.	✓					✓			✓	✓	✓
4c Focused Alternative Excavation with Off-Site Disposal/On-Site Consolidation and Cap	▪ Alternative excavation will be used to remove soil with high concentrations. ▪ Soil with high concentrations will be disposed of in an off-Site landfill. ▪ Remaining soil with concentrations above human health risk levels will be placed in an on-Site consolidation area. The soil consolidation area will be capped with two-feet of soil. ▪ A one- to two-foot soil cap will be placed across remaining areas with soil concentrations above ecological risk levels. ▪ Native trees will be retained.	✓				✓				✓	✓	✓

Notes:
1. High Concentrations Soil is defined as soil with a dioxin TEQ concentrations above the removal action level and/or soil with concentrations above hot spot levels for analytes other than dioxin/furans.
2. Native Trees are defined as Madrone, big leaf maple, and Oregon white oak with a diameter greater than six inches at breast height.
3. Organic matter will consist of a high concentration carbon material such as activated carbon or biochar with a large surface area for sorption and immobilization of large organic molecules.
4. Standard excavation is defined as excavation with large equipment without the consideration to the size or type of vegetation removed.
5. Alternative excavation is defined as excavation with varying types of equipment and in consultation with an arborist as necessary to protect native trees.
6. Focused excavation is defined as excavation targeting soil above a defined threshold concentration. This can be combined with either standard or alternative excavation techniques.

Table 12
Estimated Cost - Alternative 2a: Standard Cap
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$4,950,000	$742,500	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$743,000**	
Direct Construction				
Mobilization	10 %	$3,599,644	$359,964	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	5 months	$632 /month	$3,158	10% of Erosion Control and Construction Entrance
Dust Control	90 day	$280 /day	$25,200	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	10.7 ac	$9,700 /ac	$103,487	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	87,830 sy	$2.05 /sy	$180,052	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	93,685 ton	$23 /ton	$2,154,763	Means
Place and Compact	58,553 cy	$6.22 /cy	$364,202	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	0 cy	$6.22 /cy	$0	Means
Excavation				
Soil Excavation and Load (standard)	0 cy	$16 /cy	$0	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	0 each	$150 /each	$0	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	0 hr	$125 /hr	$0	Soil data compilation and prepare waste profile forms
Transport Off-Site	0 ton	$10 /ton	$0	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	0 ton	$30 /ton	$0	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	0 each	$440 /each	$0	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	0.0 ac	$43,500 /ac	$0	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	21.3 ac	$20,000 /ac	$426,750	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	25 %	$3,959,608	$989,902	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$4,950,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$4,950,000	$1,237,500	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,238,000**	
		Capital Cost Subtotal	**$6,931,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$5,800 /yr	$89,160	Inspection and report.
Cap Maintenance	30 yr	$26,990 /yr	$564,912	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$21,337 /yr	$99,130	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$10,826 /yr	$226,582	Assume 20% of Long-Term Costs annually
Contingency	25 %	$979,784	$244,946	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$1,225,000**	
Total		**Total**	**$8,156,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 13
Estimated Cost - Alternative 2b: Amended Cap
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$3,641,000	$546,150	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$546,000**	
Direct Construction				
Mobilization	10 %	$2,647,853	$264,785	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	2 months	$632 /month	$1,263	10% of Erosion Control and Construction Entrance
Dust Control	30 day	$280 /day	$8,400	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	9.2 ac	$9,700 /ac	$89,641	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	11.8 ac	$950 /ac	$11,222	Means (shrub/brush mowing)
Cap				
Demarcation Layer	0 sy	$2.05 /sy	$0	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Place and Compact	0 cy	$6.22 /cy	$0	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	46,110 ton	$23 /ton	$1,060,526	Means
Purchase/Deliver Activated Carbon	230,549 lb	$1.00 /lb	$230,549	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	230,549 lb	$0.25 /lb	$57,637	Professional judgment; could be direct application or blended
Place and Compact	28,819 cy	$6.22 /cy	$179,252	Means
Excavation				
Soil Excavation and Load (standard)	0 cy	$16 /cy	$0	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	0 each	$150 /each	$0	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	0 hr	$125 /hr	$0	Soil data compilation and prepare waste profile forms
Transport Off-Site	0 ton	$10 /ton	$0	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	0 ton	$30 /ton	$0	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	0 each	$440 /each	$0	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	10.7 ac	$43,500 /ac	$464,090	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	25 %	$2,912,638	$728,160	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$3,641,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$3,641,000	$910,250	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$910,000**	
		Capital Cost Subtotal	**$5,097,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$0 /yr	$0	Inspection and report.
Cap Maintenance	30 yr	$0 /yr	$0	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$33,873 /yr	$157,369	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$6,775 /yr	$141,795	Assume 20% of Long-Term Costs annually
Contingency	25 %	$299,165	$74,791	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$374,000**	
Total		**Total**	**$5,471,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 14
Estimated Cost - Alternative 3a: Standard Excavation with Offsite Disposal
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$7,866,000	$1,179,900	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$1,180,000**	
Direct Construction				
Mobilization	10 %	$5,296,980	$529,698	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	3 months	$632 /month	$1,895	10% of Erosion Control and Construction Entrance
Dust Control	50 day	$280 /day	$14,000	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	10.7 ac	$9,700 /ac	$103,487	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	0 sy	$2.05 /sy	$0	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Place and Compact	0 cy	$6.22 /cy	$0	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	0 cy	$6.22 /cy	$0	Means
Excavation				
Soil Excavation and Load (standard)	48,232 cy	$16 /cy	$759,660	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	82 each	$150 /each	$12,300	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	81,995 ton	$10 /ton	$819,950	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	81,995 ton	$30 /ton	$2,459,850	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	236 each	$440 /each	$103,840	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	10.7 ac	$43,500 /ac	$464,090	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	35 %	$5,826,678	$2,039,337	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$7,866,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$7,866,000	$1,966,500	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,967,000**	
		Capital Cost Subtotal	**$11,013,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$0 /yr	$0	Inspection and report.
Cap Maintenance	30 yr	$0 /yr	$0	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$33,873 /yr	$157,369	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	5 yr	$6,775 /yr	$31,474	Assume 20% of Long-Term Costs annually
Contingency	35 %	$188,843	$66,095	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$255,000**	
Total		**Total**	**$11,268,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 15
Estimated Cost - Alternative 3b: Alternative Excavation with Offsite Disposal
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$7,486,000	$1,122,900	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$1,123,000**	
Direct Construction				
Mobilization	10 %	$5,040,899	$504,090	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	3 months	$632 /month	$1,895	10% of Erosion Control and Construction Entrance
Dust Control	50 day	$280 /day	$14,000	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	9.2 ac	$9,700 /ac	$89,641	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	0 sy	$2.05 /sy	$0	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Place and Compact	0 cy	$6.22 /cy	$0	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	0 cy	$6.22 /cy	$0	Means
Excavation				
Soil Excavation and Load (standard)	44,535 cy	$16 /cy	$701,420	Means
Soil Excavation and Load (alternative)	922 cy	$88 /cy	$81,174	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	78 each	$150 /each	$11,700	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	77,277 ton	$10 /ton	$772,769	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	77,277 ton	$30 /ton	$2,318,308	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	233 each	$440 /each	$102,520	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	19.9 ac	$2,150 /ac	$42,807	Means
Re-Vegetation (forested)	9.2 ac	$43,500 /ac	$401,998	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	19.9 ac	$6,560 /ac	$130,610	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	35 %	$5,544,989	$1,940,746	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$7,486,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$7,486,000	$1,871,500	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,872,000**	
		Capital Cost Subtotal	**$10,481,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$0 /yr	$0	Inspection and report.
Cap Maintenance	30 yr	$0 /yr	$0	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$30,769 /yr	$142,946	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	5 yr	$6,154 /yr	$28,589	Assume 20% of Long-Term Costs annually
Contingency	35 %	$171,535	$60,037	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$232,000**	
Total		**Total**	**$10,713,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 16
Estimated Cost - Alternative 3c: Standard Excavation with Onsite Consolidation
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$6,748,000	$1,012,200	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$1,012,000**	
Direct Construction				
Mobilization	10 %	$4,543,778	$454,378	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	5 months	$632 /month	$3,158	10% of Erosion Control and Construction Entrance
Dust Control	90 day	$280 /day	$25,200	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	10.7 ac	$9,700 /ac	$103,487	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	22,242 sy	$2.05 /sy	$45,597	Means
Purchase/Deliver Gravel	7,043 ton	$22 /ton	$154,955	Means
Purchase/Deliver Cobbles	21,130 ton	$30 /ton	$633,906	Means
Purchase/Deliver Topsoil	11,863 ton	$23 /ton	$272,839	Means
Place and Compact	22,242 cy	$6.22 /cy	$138,347	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	37,441 ton	$23 /ton	$861,146	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	23,401 cy	$6.22 /cy	$145,552	Means
Excavation				
Soil Excavation and Load (standard)	42,356 cy	$16 /cy	$667,113	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	73 each	$150 /each	$10,950	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	0 ton	$10 /ton	$0	Means and professional judgement
Transport/Place On-Site	42,356 cy	$8.73 /cy	$369,771	Means
Disposal	0 ton	$30 /ton	$0	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	204 each	$440 /each	$89,760	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	10.7 ac	$43,500 /ac	$464,090	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	35 %	$4,998,156	$1,749,355	Percent of Direct Construction Cost (Incl. Mobe.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$6,748,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$6,748,000	$1,687,000	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,687,000**	
		Capital Cost Subtotal	**$9,447,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$4,800 /yr	$73,788	Inspection and report.
Cap Maintenance	30 yr	$12,456 /yr	$260,717	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$33,873 /yr	$157,369	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$10,226 /yr	$214,032	Assume 20% of Long-Term Costs annually
Contingency	35 %	$705,906	$247,067	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$953,000**	
Total		**Total**	**$10,400,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 17
Estimated Cost - Alternative 3d: Standard Excavation with Offsite Disposal and Onsite Consolidation
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting	15 %	$7,111,000	$1,066,650	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$1,067,000**	
Direct Construction				
Mobilization	10 %	$4,788,480	$478,848	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	5 months	$632 /month	$3,158	10% of Erosion Control and Construction Entrance
Dust Control	90 day	$280 /day	$25,200	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	10.7 ac	$9,700 /ac	$103,487	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	22,242 sy	$2.05 /sy	$45,597	Means
Purchase/Deliver Gravel	7,043 ton	$22 /ton	$154,955	Means
Purchase/Deliver Cobbles	21,130 ton	$30 /ton	$633,906	Means
Purchase/Deliver Topsoil	11,863 ton	$23 /ton	$272,839	Means
Place and Compact	22,242 cy	$6.22 /cy	$138,347	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	37,441 ton	$23 /ton	$861,146	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	23,401 cy	$6.22 /cy	$145,552	Means
Excavation				
Soil Excavation and Load (standard)	42,356 cy	$16 /cy	$667,113	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	73 each	$150 /each	$10,950	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	7,019 ton	$10 /ton	$70,186	Means and professional judgement
Transport/Place On-Site	38,228 cy	$8.73 /cy	$333,729	Means
Disposal	7,019 ton	$30 /ton	$210,558	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	204 each	$440 /each	$89,760	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	10.7 ac	$43,500 /ac	$464,090	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	35 %	$5,267,328	$1,843,565	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$7,111,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting	25 %	$7,111,000	$1,777,750	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,778,000**	
		Capital Cost Subtotal	**$9,956,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$4,800 /yr	$73,788	Inspection and report.
Cap Maintenance	30 yr	$12,456 /yr	$260,717	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$33,873 /yr	$157,369	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$10,226 /yr	$214,032	Assume 20% of Long-Term Costs annually
Contingency	35 %	$705,906	$247,067	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$953,000**	
Total		**Total**	**$10,909,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 18
Estimated Cost - Alternative 4a: Focused Standard Excavation with Offsite Disposal and Cap
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$5,813,000	$871,950	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$872,000**	
Direct Construction				
Mobilization	10 %	$4,227,988	$422,799	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	5 months	$632 /month	$3,158	10% of Erosion Control and Construction Entrance
Dust Control	90 day	$280 /day	$25,200	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	10.7 ac	$9,700 /ac	$103,487	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	87,830 sy	$2.05 /sy	$180,052	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	93,685 ton	$23 /ton	$2,154,763	Means
Place and Compact	58,553 cy	$6.22 /cy	$364,202	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	0 cy	$6.22 /cy	$0	Means
Excavation				
Soil Excavation and Load (standard)	4,129 cy	$16 /cy	$65,025	Means
Soil Excavation and Load (alternative)	0 cy	$88 /cy	$0	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	8 each	$150 /each	$1,200	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	7,019 ton	$10 /ton	$70,186	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	7,019 ton	$30 /ton	$210,558	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	64 each	$440 /each	$28,160	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	21.3 ac	$2,150 /ac	$45,876	Means
Re-Vegetation (forested)	10.7 ac	$43,500 /ac	$464,090	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	21.3 ac	$6,560 /ac	$139,974	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	25 %	$4,650,787	$1,162,697	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$5,813,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$5,813,000	$1,453,250	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,453,000**	
		Capital Cost Subtotal	**$8,138,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$5,800 /yr	$89,160	Inspection and report.
Cap Maintenance	30 yr	$26,990 /yr	$564,912	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$33,873 /yr	$157,369	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$13,333 /yr	$279,057	Assume 20% of Long-Term Costs annually
Contingency	25 %	$1,090,499	$272,625	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$1,363,000**	
Total		**Total**	**$9,501,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 19
Estimated Cost - Alternative 4b: Focused Alternative Excavation with Offsite Disposal and Amended Cap
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$4,050,000	$607,500	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$608,000**	
Direct Construction				
Mobilization	10 %	$2,945,116	$294,512	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	2 months	$632 /month	$1,263	10% of Erosion Control and Construction Entrance
Dust Control	30 day	$280 /day	$8,400	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	9.2 ac	$9,700 /ac	$89,641	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	0 sy	$2.05 /sy	$0	Means
Purchase/Deliver Gravel	0 ton	$22 /ton	$0	Means
Purchase/Deliver Cobbles	0 ton	$30 /ton	$0	Means
Purchase/Deliver Topsoil	0 ton	$23 /ton	$0	Means
Place and Compact	0 cy	$6.22 /cy	$0	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	45,996 ton	$23 /ton	$1,057,899	Means
Purchase/Deliver Activated Carbon	229,978 lb	$1.00 /lb	$229,978	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	229,978 lb	$0.25 /lb	$57,495	Professional judgment; could be direct application or blended
Place and Compact	28,747 cy	$6.22 /cy	$178,808	Means
Excavation				
Soil Excavation and Load (standard)	3,986 cy	$16 /cy	$62,777	Means
Soil Excavation and Load (alternative)	71 cy	$88 /cy	$6,281	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	7 each	$150 /each	$1,050	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	6,897 ton	$10 /ton	$68,973	Means and professional judgement
Transport/Place On-Site	0 cy	$8.73 /cy	$0	Means
Disposal	6,897 ton	$30 /ton	$206,918	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	64 each	$440 /each	$28,160	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	19.9 ac	$2,150 /ac	$42,807	Means
Re-Vegetation (forested)	9.2 ac	$43,500 /ac	$401,998	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	19.9 ac	$6,560 /ac	$130,610	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	25 %	$3,239,627	$809,907	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$4,050,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$4,050,000	$1,012,500	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,013,000**	
		Capital Cost Subtotal	**$5,671,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$0 /yr	$0	Inspection and report.
Cap Maintenance	30 yr	$0 /yr	$0	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$30,769 /yr	$142,946	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	5 yr	$6,154 /yr	$28,589	Assume 20% of Long-Term Costs annually
Contingency	25 %	$171,535	$42,884	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$214,000**	
Total		**Total**	**$5,885,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 20
Estimated Cost - Alternative 4c: Focused Alternative Excavation with Offsite Disposal, Onsite Consolidation, and Cap
Willamette Cove Upland
Portland, Oregon

Alternative Component	Units	Unit Cost	Extension	Notes
Capital				
Pre-Construction				
Pre-Design Sampling, Surveying, Work Plan, Design, Permitting, Procurement/Contracting				
	15 %	$5,822,000	$873,300	Assume 15% of Direct Construction Cost
		Pre-Construction Subtotal	**$873,000**	
Direct Construction				
Mobilization	10 %	$4,070,995	$407,100	Assume 10% of Direct Construction Cost; includes contractor work plans
Site Prep				
Utility Locating	8 hr	$70 /hr	$560	Unit rate from recent subcontract
Access Road Improvements	1,420 sy	$23.66 /sy	$33,597	4-inch overlay (Means) along N Edgewater Ave
Erosion Control	4,500 lf	$1.07 /foot	$4,815	Means
Construction Entrance	1 LS	$1,500 /each	$1,500	25 x 60 rock construction entrance (per City req's)
Erosion Control Maintenance	4 months	$632 /month	$2,526	10% of Erosion Control and Construction Entrance
Dust Control	70 day	$280 /day	$19,600	Water truck/driver (Means); purchase water from City (0.5 gal/sy/hr)
Survey Control	22.4 ac	$2,200 /ac	$49,326	Means
Site Clearing (forested)	9.2 ac	$9,700 /ac	$89,641	Means (cut and chip trees, close-cut stumps)
Site Clearing (unforested)	10.7 ac	$950 /ac	$10,135	Means (shrub/brush mowing)
Cap				
Demarcation Layer	12,858 sy	$2.05 /sy	$26,360	Means
Purchase/Deliver Gravel	4,072 ton	$22 /ton	$89,580	Means
Purchase/Deliver Cobbles	12,215 ton	$30 /ton	$366,464	Means
Purchase/Deliver Topsoil	6,858 ton	$23 /ton	$157,730	Means
Place and Compact	12,858 cy	$6.22 /cy	$79,979	Means
Cover/Topsoil				
Purchase/Deliver Topsoil	45,777 ton	$23 /ton	$1,052,879	Means
Purchase/Deliver Activated Carbon	0 lb	$1.00 /lb	$0	EPA, OSWER 9200.2-128FS, 2013; assume 1% by dry weight to supplement topsoil organics for 25% of area
Apply Amendment	0 lb	$0.25 /lb	$0	Professional judgment; could be direct application or blended
Place and Compact	28,611 cy	$6.22 /cy	$177,960	Means
Excavation				
Soil Excavation and Load (standard)	25,791 cy	$16 /cy	$406,209	Means
Soil Excavation and Load (alternative)	922 cy	$88 /cy	$81,174	Means - hand excavation around minor structures, normal soil
Chemical Analyses (TCLP metals)	46 each	$150 /each	$6,900	1 sample per 1000 tons; Unit rate from lab price list
Waste Profiling Data Package	20 hr	$125 /hr	$2,500	Soil data compilation and prepare waste profile forms
Transport Off-Site	6,897 ton	$10 /ton	$68,973	Means and professional judgement
Transport/Place On-Site	22,656 cy	$8.73 /cy	$197,789	Means
Disposal	6,897 ton	$30 /ton	$206,918	Quote from Waste Management for Hillsboro Landfill
Confirmation Soil Sampling and Chemical Analyses	211 each	$440 /each	$92,840	Assume one sample per 100 lineal feet of perimeter and one sample per 5000 sf bottom; analyze for total metals (20% of samples for PAHs and 10% of samples for dioxins and PCBs); Unit rate from lab price list
Site Restoration				
Site Grading	19.9 ac	$2,150 /ac	$42,807	Means
Re-Vegetation (forested)	9.2 ac	$43,500 /ac	$401,998	Means; hydroseeding, trees @ 20' spacing, shrubs @ 6' spacing
Re-Vegetation (unforested)	10.7 ac	$20,000 /ac	$213,375	Means; hydroseeding, shrubs @ 6' spacing
Temporary Irrigation System	19.9 ac	$6,560 /ac	$130,610	Temporary Drip System for trees and shrubs; cost from similar project
First Year of Irrigation	9 months	$6,250 /month	$56,250	Water truck/driver (Means); purchase water from City
Construction Contingency	30 %	$4,478,095	$1,343,428	Percent of Direct Construction Cost (Incl. Mob.); From EPA guidance use 25% for cap focused alternatives; 30% for mixed alternatives; and 35% for excavation focused alternatives; includes both scope and bid contingency
		Direct Construction Subtotal	**$5,822,000**	
Indirect Construction Costs				
Contractor OH/Bonding/Insurance, Soil Management Plan/Institutional Controls, Construction Management, Engineering, Agency Oversight, Completion Reporting				
	25 %	$5,822,000	$1,455,500	Assume 25 percent of Direct Construction Cost
		Indirect Construction Subtotal	**$1,456,000**	
		Capital Cost Subtotal	**$8,151,000**	
Long-Term Costs (Net Present Value)				Assume net discount rate of 5% for present-worth calculations.
Cap Annual Inspections	30 yr	$3,800 /yr	$58,415	Inspection and report.
Cap Maintenance	30 yr	$7,201 /yr	$150,722	Assume 1% of cap installation cost annually
Plant Inspection and Replacement/Control	5 yr	$30,769 /yr	$142,946	Assume 5% of plant installation cost annually
Indirect Long-Term Costs (Project Management, Agency Oversight, Reporting)	30 yr	$8,354 /yr	$174,851	Assume 20% of Long-Term Costs annually
Contingency	30 %	$526,934	$158,080	Percent of Long-Term Costs; percentage same as construction
		Long-Term Subtotal (Net Present Value)	**$685,000**	
Total		**Total**	**$8,836,000**	

Notes:

1. Means - 2017 RS Means Online Cost Estimating

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 21
Soil Alternative Evaluation Summary
Willamette Cove Upland Site
Portland, Oregon

Alternative	Protectiveness	Effectiveness	Long-Term Reliability	Implementability	Implementation Risk	Reasonableness of Cost	Ability to Treat Hot Spots
Alternative 1: No Action	**Unacceptable** Protectiveness requirements are not met because contaminants are left in place at concentrations that exceed risk levels.	**Rank: 10** - No action taken - Risks are not reduced or managed - Residual risk unacceptable	**Rank: 10** - No long-term reliability	**Rank: 1** - Easiest to implement	**Rank: 1** - No implementation risks	**Rank: 1** This alternative has no cost. Total Cost: $0	**Unacceptable** This alternative does not treat or remove soil above hot spot or risk levels.
Alternative 2a: Standard Cap - *REVISED*	**Acceptable** Overall excellent protectiveness. Relies on long-term effectiveness and reliability through inspection, maintenance, and institutional controls.	**Rank: 8** - No removal - 2-Foot Cap in-place is effective - 6 months to construct	**Rank: 8** - All soil remains on-site - 2-foot cap - Cap maintenance - Engineering/institutional controls - Soil management plan	**Rank: 7** - Excavate and Place On-Site: 0 cy - Excavate and Dispose Off-Site: 0 cy - Import: 59,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 8** - Standard construction hazards - Removes native trees	**Rank: 4** Capital: $5,941,000 Long-Term (Present Worth): $980,000 Contingency: $1,235,000 Total: $8,156,000	**Poor** Does not remove or treat hot spots.
Alternative 2b: Amended Cap	**Acceptable** Protective. Relies on long-term effectiveness and reliability through inspection, maintenance, and institutional controls. Uncertainty in long-term reliability of cap.	**Rank: 9** - No soil removed - Soil capped in place - 1-Foot Cap with amendments has some uncertainty in effectiveness - Relies partially on access restrictions for human health; generally effective - 6 months to construct	**Rank: 9** - All soil remains on-site - 1-foot amended cap - Cap maintenance - Engineering/institutional controls - Soil management plan - Long-term effectiveness of cap uncertain	**Rank: 2** - Excavate and Place On-Site: 0 cy - Excavate and Dispose Off-Site: 0 cy - Import: 29,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 2** - Standard construction hazards - Saves native trees	**Rank: 2** Capital: $5,097,000 Long-Term (Present Worth): $374,000 Contingency: $803,000 Total: $5,471,000	**Poor** Does not remove or treat hot spots.
Alternative 3a: Standard Excavation and Off-Site Disposal	**Acceptable** The excavation and off-site disposal of impacted soils is highly protective to human health and the environment. Overall protectiveness is better than capping alternatives because the performance of an off-site landfill is presumed to be more protective than on-site capping of materials.	**Rank: 1** - All soil removed off-site to landfill - 6 months to construct	**Rank: 1** - Off-site in controlled landfill	**Rank: 10** - Excavate and Place On-Site: 0 cy - Excavate and Dispose Off-Site: 49,000 cy - Import: 0 cy - Compatiable with riverbank/in-water cleanup	**Rank: 10** - Standard construction hazards - Removes native trees	**Rank: 10** Capital: $11,013,000 Long-Term (Present Worth): $255,000 Contingency: $2,105,000 Total: $11,268,000	**Excellent** This alternative removes hot spots within a reasonable time frame.
Alternative 3b: Alternative Excavation and Off-Site Disposal	**Acceptable** Same as Alternative 3a except that soil above risk levels may be left below the drip line of trees (up to 6% of total area)	**Rank: 2** - Most soil removed off-site to landfill - Some soil remains in tree drip line area (approx. 6% of total area) - 1-Foot cap of remaining soil is effective, but less so than thicker cap - 6 months to construct	**Rank: 3** - Most soil off-site in controlled landfill - Remaining soil has 1-foot cap - Cap maintenance - Engineering/institutional controls - Soil management plan	**Rank: 9** - Excavate and Place On-Site: 0 cy - - Excavate and Dispose Off-Site: 45,000 cy - Import: 0 cy - Compatiable with riverbank/in-water cleanup	**Rank: 5** - Standard construction hazards - Saves native trees	**Rank: 8** Capital: $10,481,000 Long-Term (Present Worth): $232,000 Contingency: $2,001,000 Total: $10,713,000	**Good** Removes a large portion of hot spots.
Alternative 3c: Standard Excavation and On-Site Consolidation	**Acceptable** Same as Alternative 3a except for the operation of the on-Site landfill is less reliable than that of a commercial landfill.	**Rank: 4** - No removal - Soil consolidated prior to capping - 2-Foot Cap is effective - 6 months to construct	**Rank: 4** - All soil on-site in smaller footprint than Alt. 2 - 2-foot cap - Cap maintenance - Engineering/institutional controls - Soil management plan	**Rank: 5** - Excavate and Place On-Site: 43,000 cy - Excavate and Dispose Off-Site: 0 cy - Import: 46,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 6** - Standard construction hazards - Removes native trees	**Rank: 7** Capital: $9,447,000 Long-Term (Present Worth): $953,000 Contingency: $1,996,000 Total: $10,400,000	**Fair** Does not remove or treat hot spots. Hot spots consolidated on-site beneath cap.
Alternative 3d: Standard Excavation with Off-Site Disposal and On-Site Consolidation	**Acceptable** Same as Alternative 3c except the removal of non-dioxin/furan hot spots makes this more protective.	**Rank: 3** - Higher concentration soil removed - Remaining soil consolidated prior to capping - 2-Foot Cap is effective - 6 months to construct	**Rank: 2** - Same as Alternative 3c except higher concentration soil removed to off-site landfill	**Rank: 6** - Excavate and Place On-Site: 38,000 cy - Excavate and Dispose Off-Site: 4,000 cy - Import: 46,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 7** - Standard construction hazards - Removes native trees	**Rank: 9** Capital: $9,956,000 Long-Term (Present Worth): $953,000 Contingency: $2,091,000 Total: $10,909,000	**Moderate** This alternative removes non-dioxin/furan hot spots within a reasonable time frame. Dioxin/furan hot spots consolidated on-site beneath cap.
Alternative 4a: Focused Standard Excavation and Offsite Disposal with Cap - *REVISED*	**Acceptable** Same as Alternative 2a except removal of non-dioxin/furan hot spots makes this more protective.	**Rank: 6** - Higher concentration soil removed - Remaining soil capped in place - 2-Foot Cap is effective - 6 months to construct	**Rank: 6** - Same as Alternative 2a except higher concentration soil removed to off-site landfill	**Rank: 8** - Excavate and Place On-Site: 0 cy - Excavate and Dispose Off-Site: 4,000 cy - Import: 59,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 9** - Standard construction hazards - Removes native trees	**Rank: 6** Capital: $6,975,000 Long-Term (Present Worth): $1,090,000 Contingency: $1,436,000 Total: $9,501,000	**Fair** This alternative removes non-dioxin/furan hot spots within a reasonable time frame. Dioxin/furan hot spots remain.
Alternative 4b: Focused Alternative Excavation with Offsite Disposal and Amended Cap	**Acceptable** Same as Alternative 2b except the cap thickness is less, but the lesser thickness is off-set with the addition of the soil amendment.	**Rank: 7** - Most higher concentration soil removed - Remaining soil capped in place - 1-Foot Cap with amendments has some uncertainty in effectiveness - Relies partially on access restrictions for human health; generally effective - 6 months to construct	**Rank: 7** - Most higher concentration soil removed to off-site landfill - 1-foot amended cap - Cap maintenance - Engineering/institutional controls - Soil management plan	**Rank: 3** - Excavate and Place On-Site: 0 cy - Excavate and Dispose Off-Site: 4,000 cy - Import: 29,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 3** - Standard construction hazards - Saves native trees	**Rank: 3** Capital: $5,671,000 Long-Term (Present Worth): $214,000 Contingency: $853,000 Total: $5,885,000	**Fair** This alternative removes non-dioxin/furan hot spots within a reasonable time frame. Dioxin/furan hot spots remain.
Alternative 4c: Focused Alternative Excavation with Off-Site Disposal/On-Site Consolidation and Cap	**Acceptable** Overall very good protectiveness. Most higher concentration soil removed. Human health soil and remaining hot spot soil consolidated and capped. Remaining area capped. Relies on long-term effectiveness and reliability through inspection, maintenance, and institutional controls.	**Rank: 4** - Most higher concentration soil removed - Remaining hot spot soil and soil above human health risk levels consolidated prior to 2-foot cap - Remaining soil with 1-Foot Cap is effective - Access restrictions for human health generally effective - 6 months to construct	**Rank: 4** - Higher concentration soil in controlled landfill - Soil above hot spot and human health risk levels consolidated and capped providing greater reliability than just capping - 1-foot cap on remaining lower risk soil - Cap maintenance - Engineering/institutional controls - Soil management plan	**Rank: 4** - Excavate and Place On-Site: 23,000 cy - Excavate and Dispose Off-Site: 4,000 cy - Import: 41,000 cy - Compatiable with riverbank/in-water cleanup	**Rank: 4** - Standard construction hazards - Saves native trees	**Rank: 5** Capital: $8,151,000 Long-Term (Present Worth): $685,000 Contingency: $1,502,000 Total: $8,836,000	**Moderate** This alternative removes non-dioxin/furan hot spots within a reasonable time frame. Dioxin/furan hot spots consolidated on-site beneath a cap.

Table adapted from Revised Feasibility Study and Source Control Evaluation

Table 22
Comparative Evaluation of Alternatives
Willamette Cove Upland Site
Portland, Oregon

Release Area Alternative	Protective	Balancing Factors																																																		Score	Rank
		Effectiveness										Long-Term										Implementability										Implementation Risk										Reasonableness of Cost											
		1	2a	2b	3a	3b	3c	3d	4a	4b	4c	1	2a	2b	3a	3b	3c	3d	4a	4b	4c	1	2a	2b	3a	3b	3c	3d	4a	4b	4c	1	2a	2b	3a	3b	3c	3d	4a	4b	4c	1	2a	2b	3a	3b	3c	3d	4a	4b	4c		
1 No Action	No		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-		+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	--	NA
2a Standard Cap	Yes	+		+	-	-	-	-	-	-	-	+		+	-	-	-	-	-	-	-	-		-	+	+	-	-	+	-	-	-		+	+	-	-	-	-	-	-	-		-	+	+	+	+	+	+	+	-	+	-15	8
2b Amended Cap	Yes	+	-		-	-	-	-	-	-	-	+	-		-	-	-	-	-	-	-	-	+		+	+	+	+	+	+	+	-	+		+	+	+	+	+	+	+	-	+		+	+	+	+	+	+	+	+	+	7	3
3a Standard Excavation with Off-Site Disposal	Yes	+	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	-	-	-		-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-9	7
3b Alternative Excavation with Off-Site Disposal	Yes	+	+	+	-		+	+	+	+	+	+	+	+	-		+	-	+	+	+	-	-	-	+		-	-	-	-	-	-	+	-	+		+	+	+	-	-	-	-	-	+		-	+	-	-	-	1	4
3c Standard Excavation with On-Site Consolidation	Yes	+	+	+	-	-		-	+	+	0	+	+	+	-	-		-	+	+	0	-	+	-	+	+		+	+	-	-	-	+	-	+	-		+	+	-	-	-	-	-	+	+		+	-	-	-	1	4
3d Standard Excavation with Off-Site Disposal and On-Site Consolidation	Yes	+	+	+	-	-	+		+	+	+	+	+	+	-	+	+		+	+	+	-	+	-	+	+	-		+	-	-	-	+	-	+	-	-		+	-	-	-	-	-	+	-	-		-	-	-	1	4
4a Focused Standard Excavation with Off-Site Disposal and Standard Cap	Yes	+	+	+	-	-	-	-		+	-	+	+	+	-	-	-	-		+	-	-	-	-	+	+	-	-		-	-	-	-	-	+	-	-	-		-	-	-	-	-	+	+	+	+		-	-	-15	8
4b Focused Alternative Excavation with Off-Site Disposal and Amended Cap	Yes	+	+	+	-	-	-	-	-		-	+	+	+	-	-	-	-	-		-	-	+	-	+	+	+	+	+		+	-	+	-	+	+	+	+	+		+	-	+	-	+	+	+	+	+		+	9	2
4c Focused Alternative Excavation with Off-Site Disposal/On-Site Consolidation and Cap	Yes	+	+	+	-	-	0	-	+	+		+	+	+	-	-	0	-	+	+		-	+	-	+	+	+	+	+	-		-	+	-	+	+	+	+	+	-		-	-	-	+	+	+	+	+	-		11	1

Notes:

+ = The alternative is favored over the compared alternative (score=1)

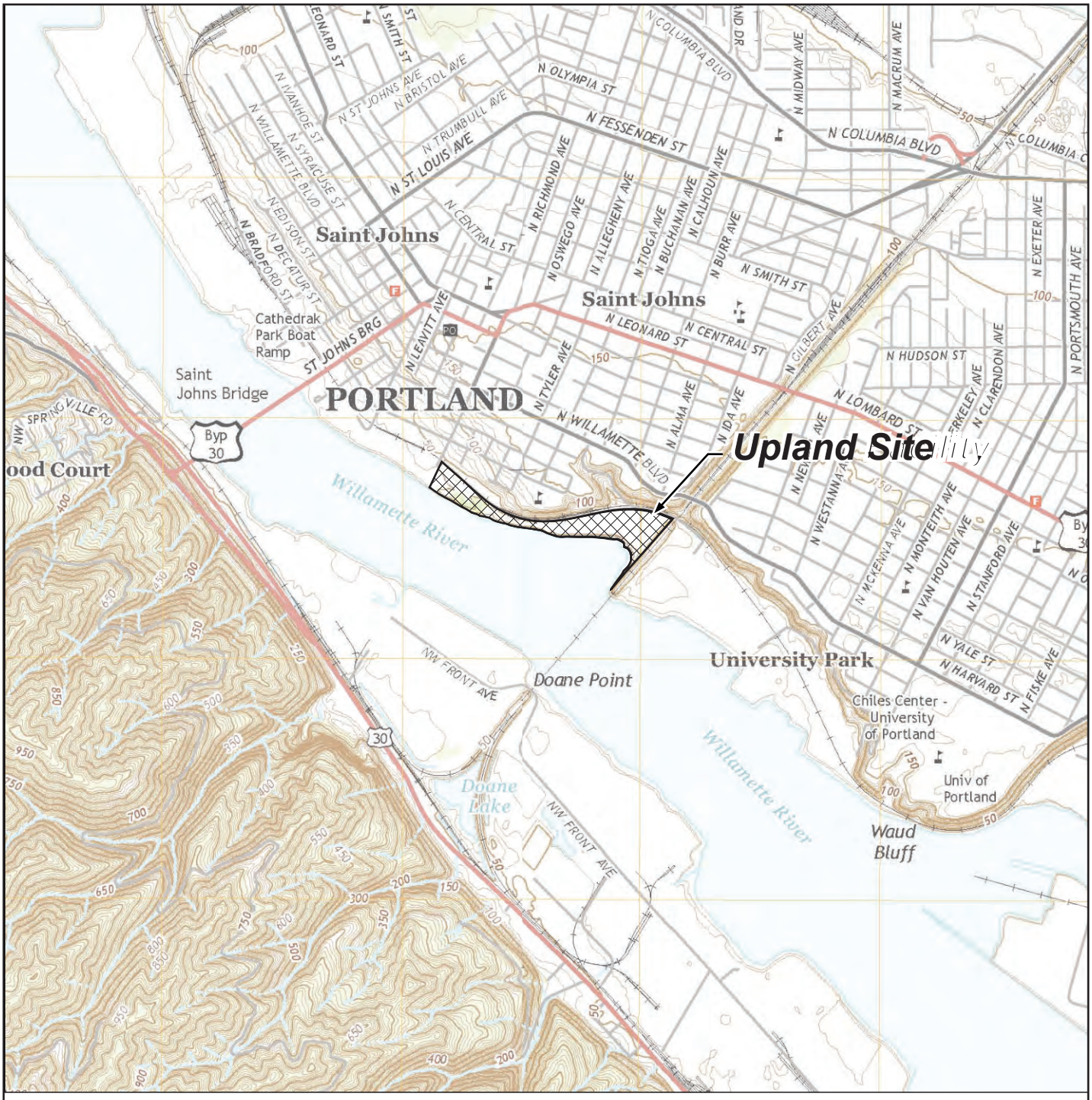
0 = The alternative is equal with the compared alternative (score=0)

- = The alternative is less favorable than the compared alternative (score=-1)

na = Not protective, therefore not ranked

Alternative	Compared Against:									
Alternative 1		2a	2b	3a	3b	3c	3d	4a	4b	4c
Alternative 2a	1		2b	3a	3b	3c	3d	4a	4b	4c
Alternative 2b	1	2a		3a	3b	3c	3d	4a	4b	4c
Alternative 3a	1	2a	2b		3b	3c	3d	4a	4b	4c
Alternative 3b	1	2a	2b	3a		3c	3d	4a	4b	4c
Alternative 3c	1	2a	2b	3a	3b		3d	4a	4b	4c
Alternative 3d	1	2a	2b	3a	3b	3c		4a	4b	4c
Alternative 4a	1	2a	2b	3a	3b	3c	3d		4b	4c
Alternative 4b	1	2a	2b	3a	3b	3c	3d	4a		4c
Alternative 4c	1	2a	2b	3a	3b	3c	3d	4a	4b	

Table adapted from Revised Feasibility Study and Source Control Evaluation



Note: Base map prepared from USGS 7.5-minute quadrangles of Linnton and Portland, OR, dated 2014 as provided by USGS.gov.

0 2,000 4,000

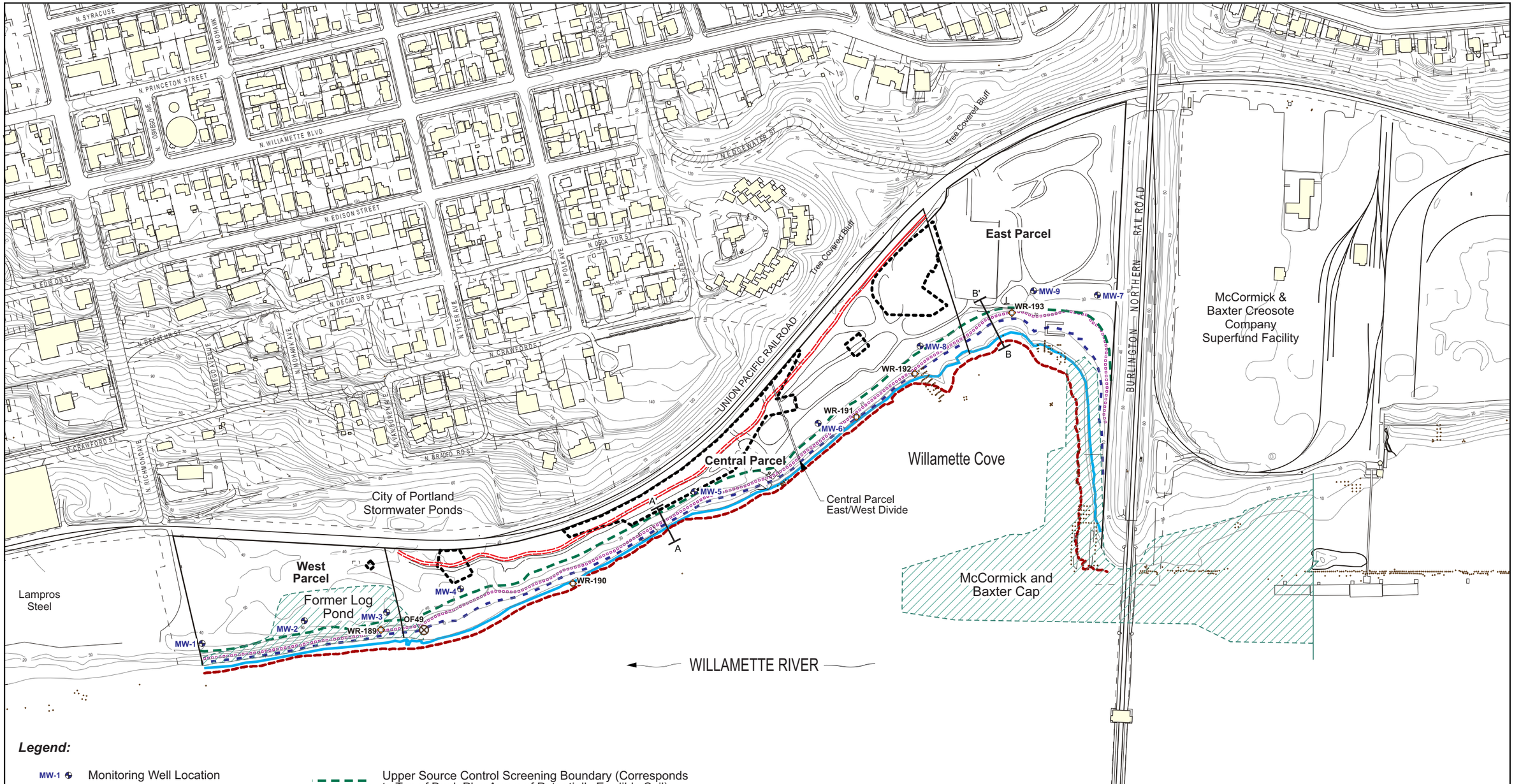
Approximate Scale in Feet

N

Site Location Map

Willamette Cove Upland
Portland, Oregon

APEX Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1056-10	Figure
		March 2020	1



Legend:

- MW-1 — Monitoring Well Location
- OF49 — City of Portland Outfall
- WR-189 — Potential Historical Outfall (Inactive)
- 2008 and 2015 Removal Action Area
- Proposed Bike Path
- A' — A Cross-Section Location (See Figure 3)
- Upper Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- Lower Source Control Screening Boundary (Corresponds to -2 Columbia River Datum; 3.2NAVD88)

0 300 600

Approximate Scale in Feet

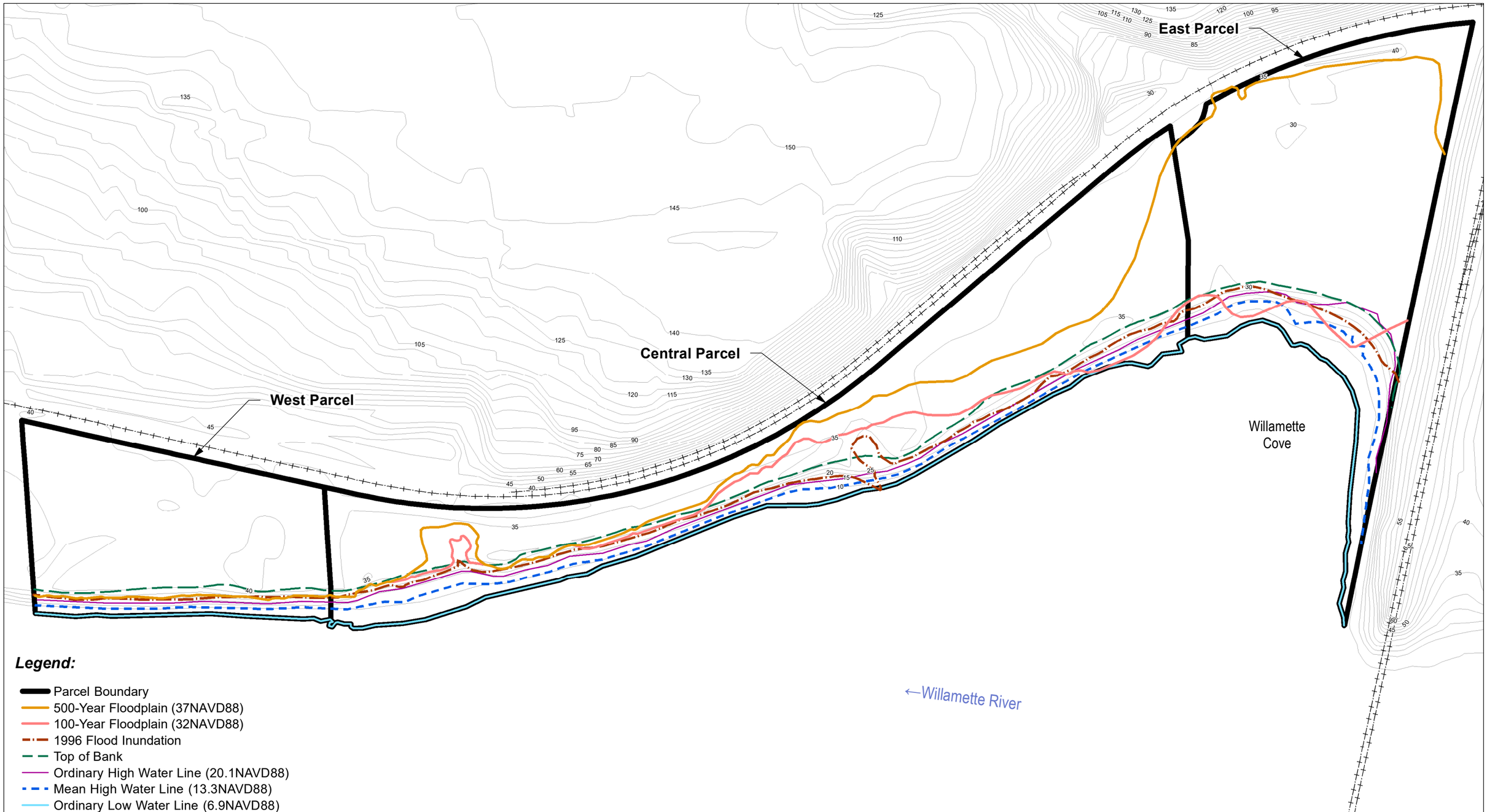
Source: Base map prepared from an electronic file provided by Hart Crowser.

Site Map

Willamette Cove Upland
Portland, Oregon

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	2



Legend:

- Parcel Boundary
- 500-Year Floodplain (37NAVD88)
- 100-Year Floodplain (32NAVD88)
- 1996 Flood Inundation
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)

0 200 400

Approximate Scale in Feet

N

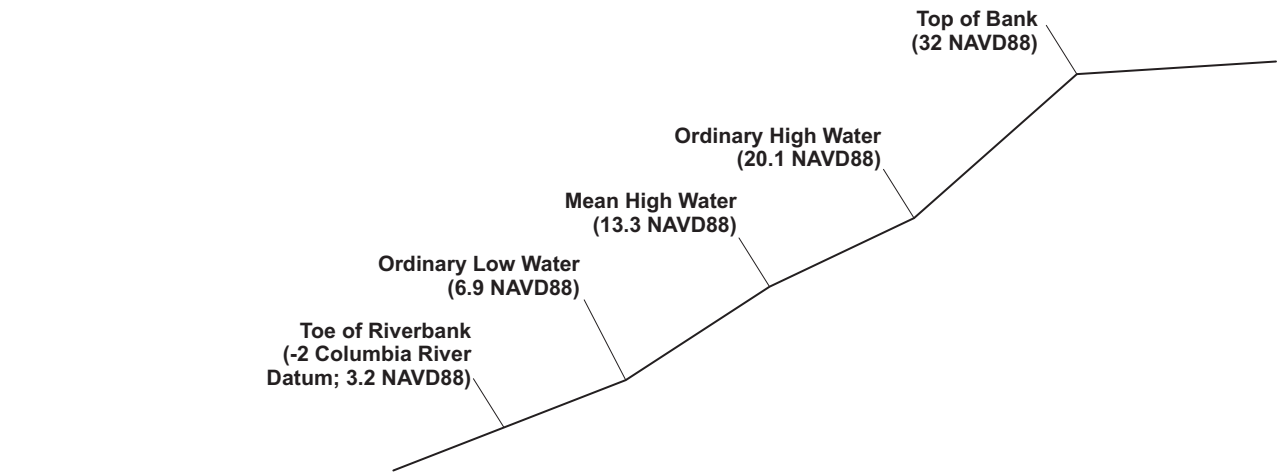
Basemap prepared using spatial data from Metro (2010-2017), Apex, Formation Environmental, and Hart Crowser.
Coordinate System: NAD83 HARN StatePlane Oregon North FIPS 3601 (Intl Feet).

Site Elevation and Floodplain Map

Willamette Cove Upland
Portland, Oregon

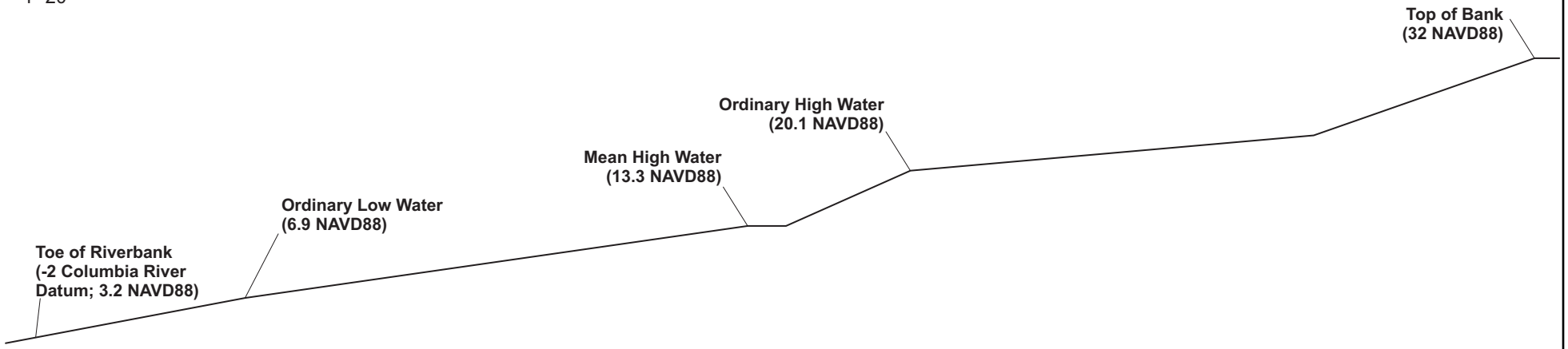
APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2020		3



A-A' Central Parcel

1" 20'



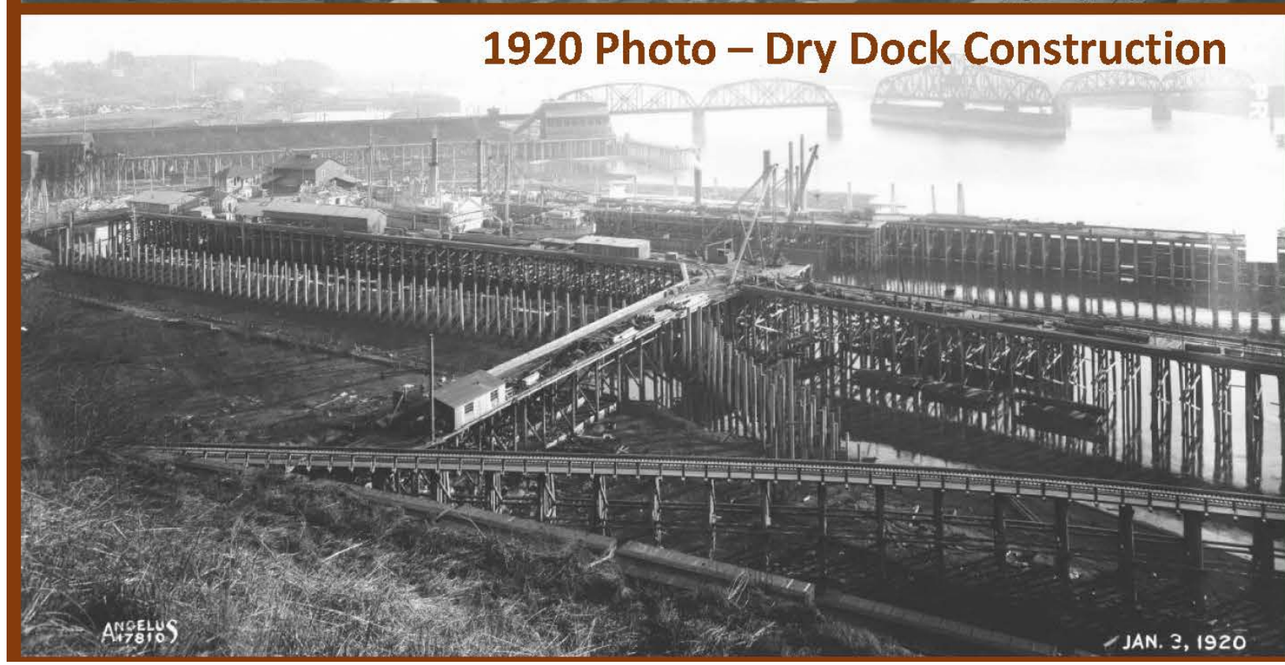
B-B' East Parcel/Inner Cove

1" 20'

Bankline Cross-Sections

Willamette Cove Upland
Portland, Oregon

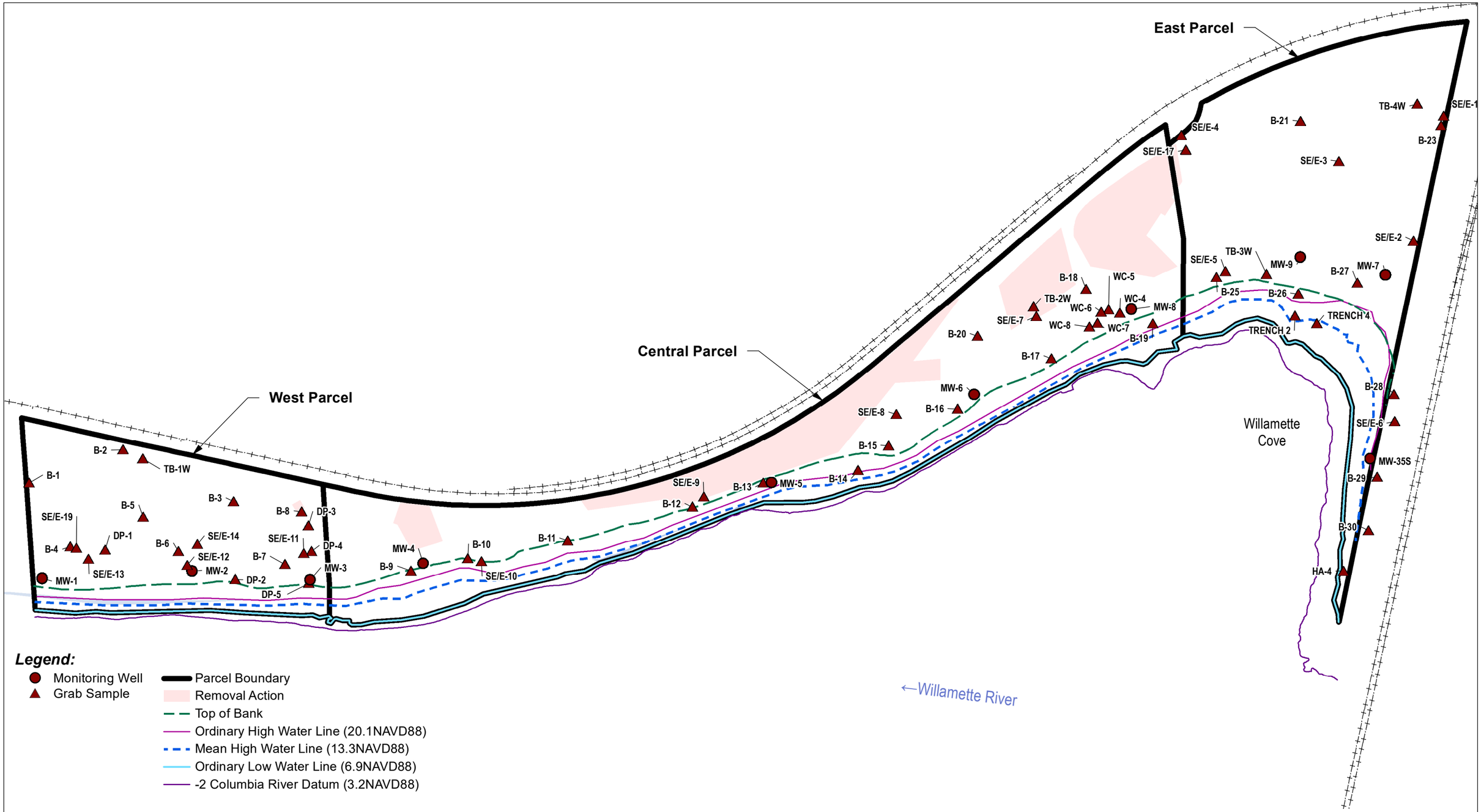
APEX	Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number 1056-10 March 2020	Figure 4



Historical Site Photos

Willamette Cove Upland Site

APEX — Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1056-10	Figure
	March 2019		5



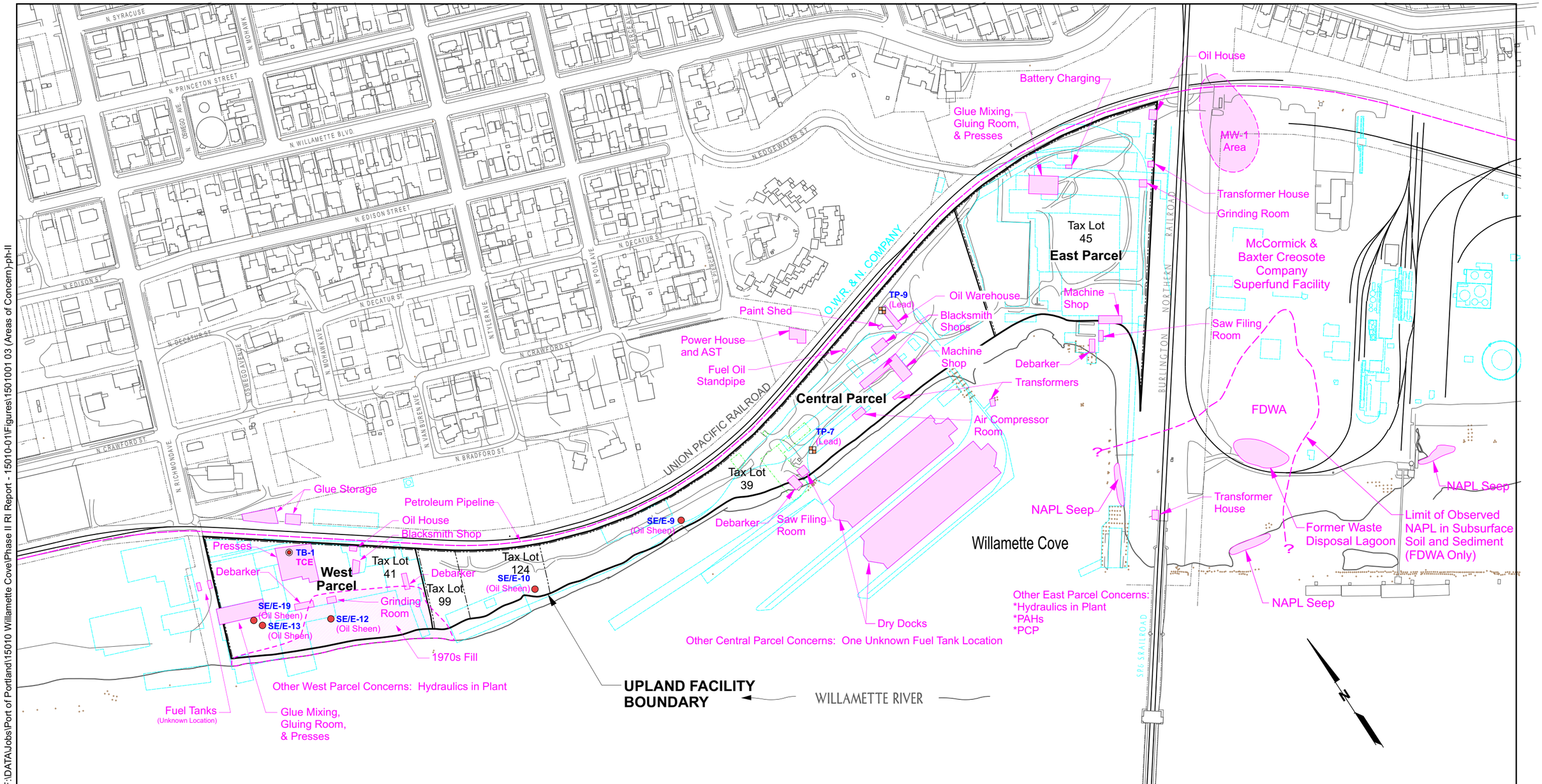
Basemap prepared using spatial data from Metro (2010-2017), Apex, Formation Environmental, and Hart Crowser.
Coordinate System: NAD83 HARN StatePlane Oregon North FIPS 3601 (Intl Feet).

Groundwater Sample Locations

Willamette Cove Upland
Portland, Oregon

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2020		6



F:\DATA\Jobs\Port of Portland\15010 Willamette Cove\Phase II RI Report - 15010-01\Figures\1501001 03 (Areas of Concern)-ph-II

Note: Base map prepared from an electronic file provided by the City of Portland.

Legend:

- SE/E-12 Soil Boring (EMCON, 1989)
- TP-7 Test Pit (EMCON, 1989)
- TB-1 Soil Boring (EMCON, 1996)
- Area of Potential Concern
- Building
- Railroad Tracks
- Former Site Features (~ 1950)
- Scritsmier Company Sawmill (~ 1960)

0 300 600

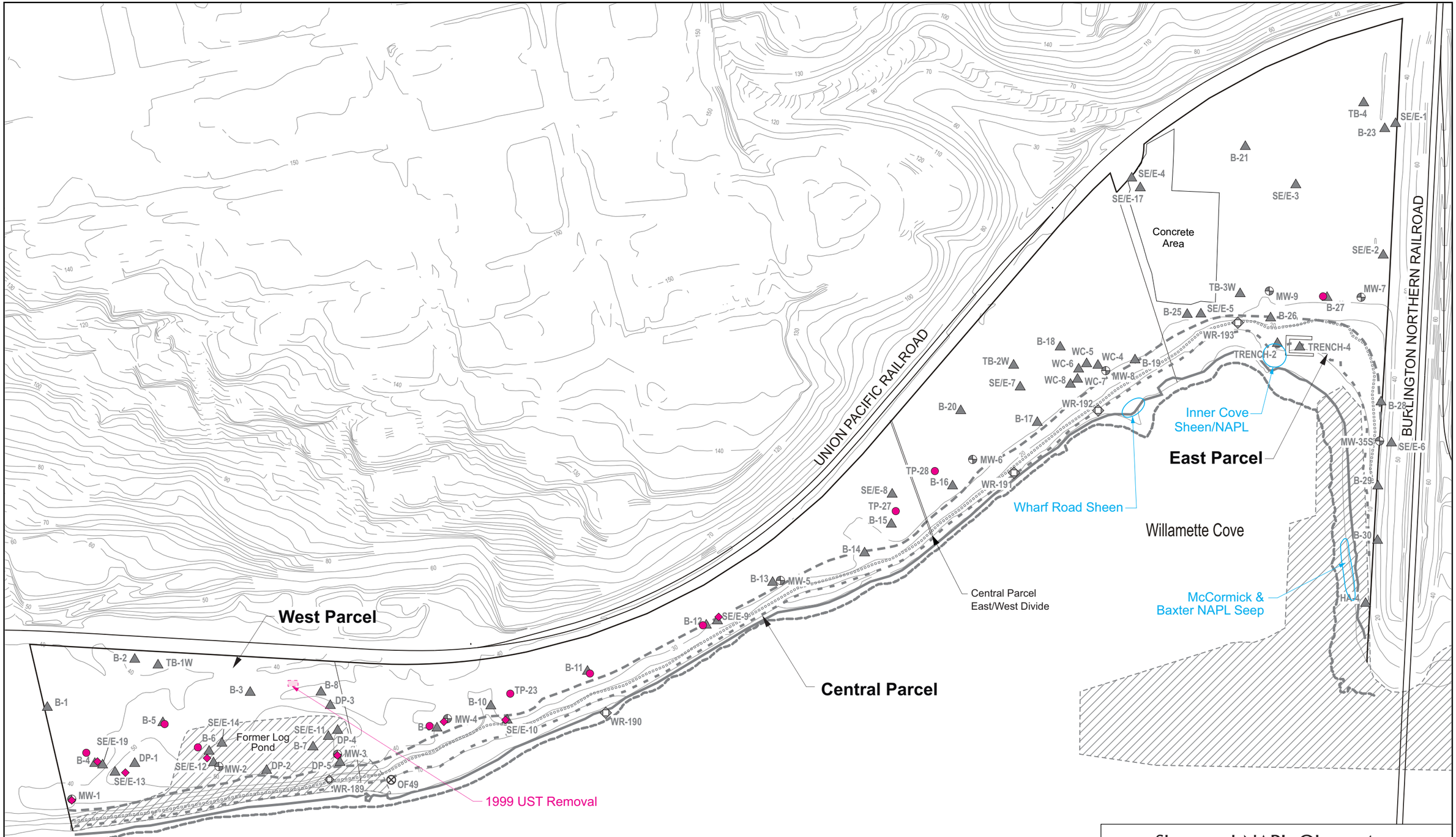
Approximate Scale in Feet

Historical Site Features

Willamette Cove Upland Site

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
February 2020		7



Legend:

- Monitoring Well Location
- Grab Groundwater Sample Location
- City of Portland Outfall
- Potential Historical Outfall (Inactive)
- Sheen Observed in Upland Groundwater
- Sheen Observed in Upland Soil
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum (3.2NAVD88)

0 200 400

Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

N

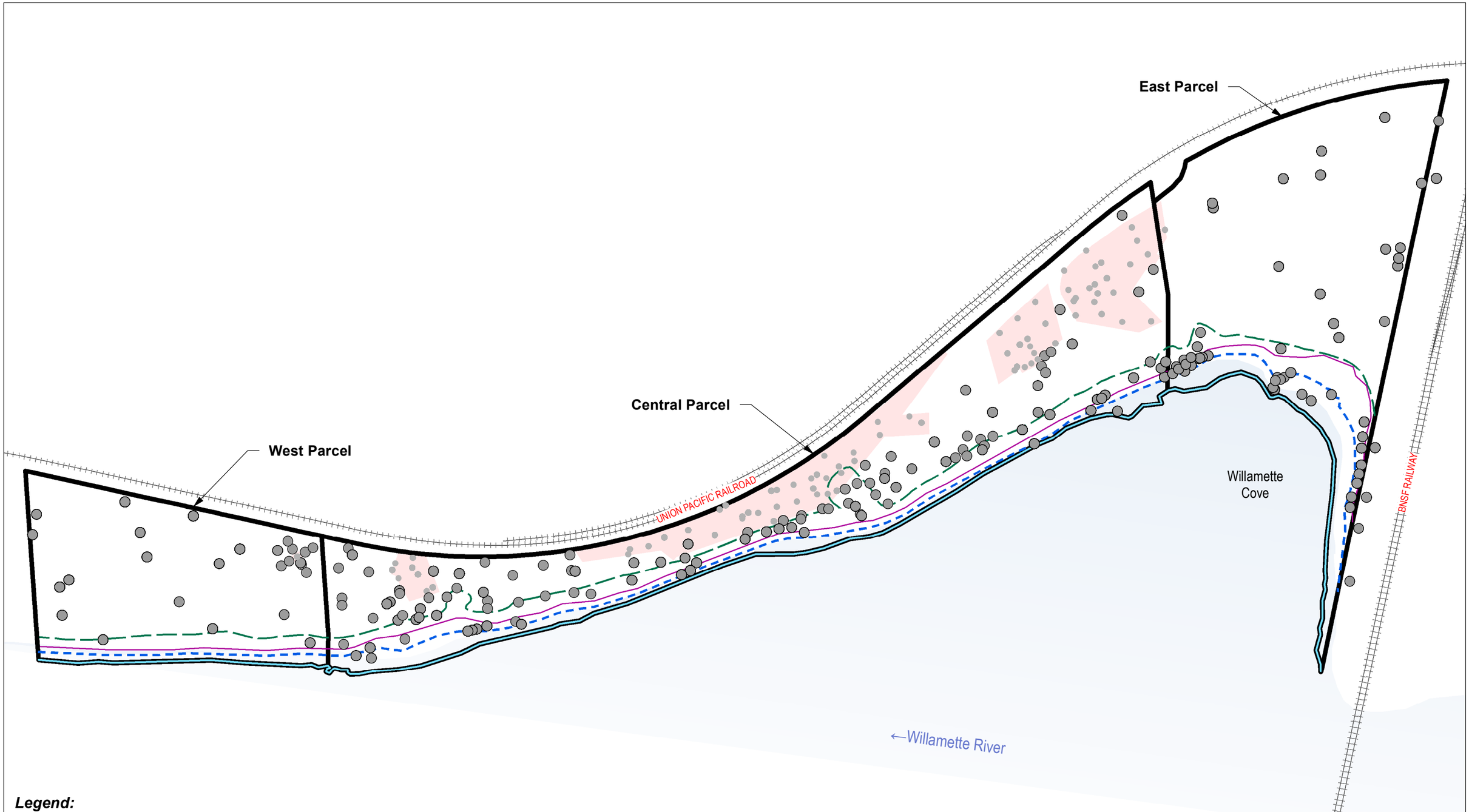
Sheen and NAPL Observations

Willamette Cove Upland
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2020		8



Legend:

- Discrete Sample Location
- Sample Locations Removed During 2008/2015 Soil Removal Actions
- Parcel Boundary
- Removal Action Area
- Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)

0 200 400
Approximate Scale in Feet

N

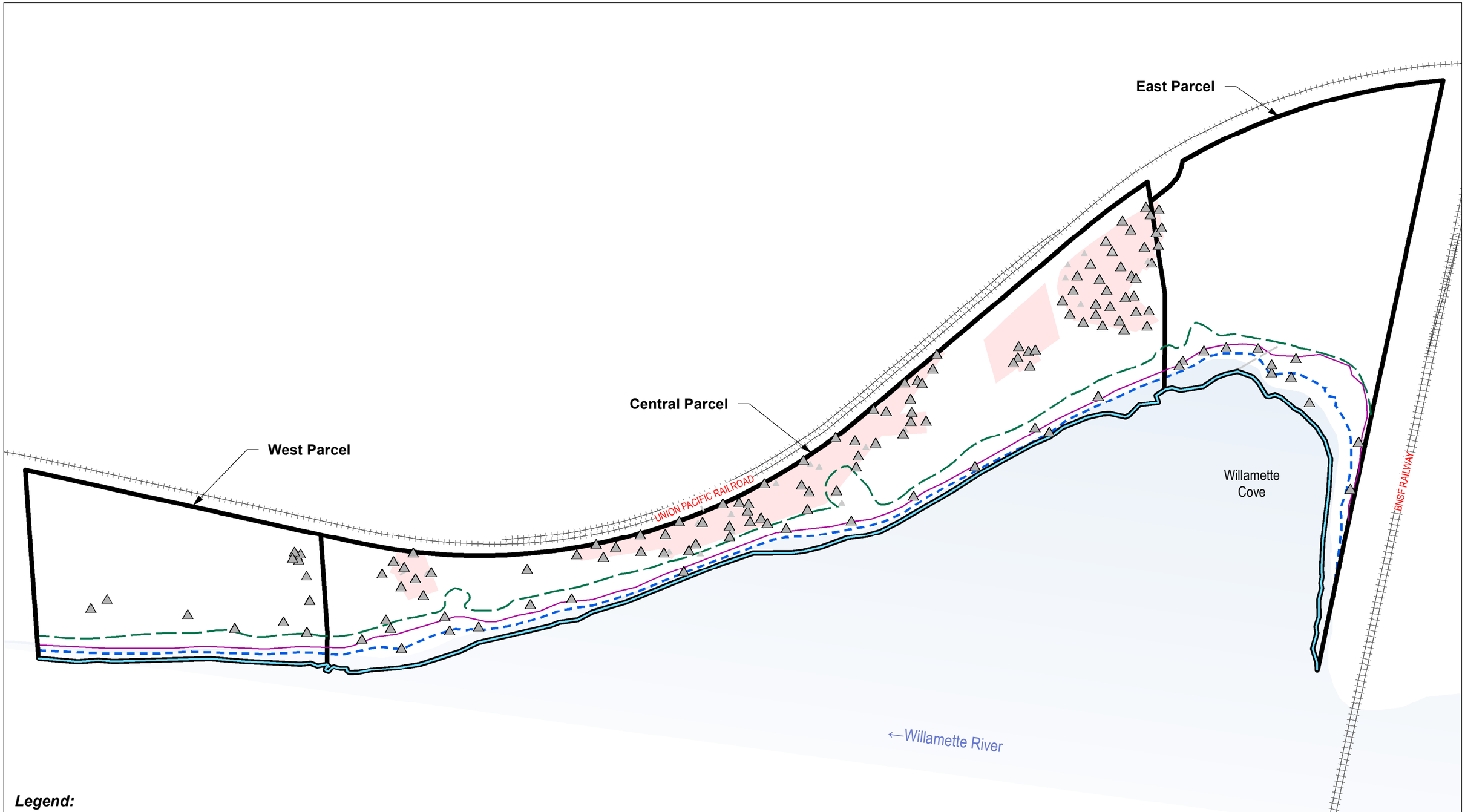
Soil Investigations - Discrete

Willamette Cove Upland Site

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2019		9

Basemap prepared using spatial data from Metro (2010-2017), Apex, Formation Environmental, and Hart Crowser. Coordinate System: NAD83 HARN StatePlane Oregon North FIPS 3601 (Intl Feet).



Legend:

- Composite Sample Location
- Center of Entire or Significant Portion of Sample Location Removed During 2008/2015 Soil Removal Actions
- Parcel Boundary
- Removal Action Area
- Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)

0 200 400
Approximate Scale in Feet

N

Basemap prepared using spatial data from Metro (2010-2017), Apex, Formation Environmental, and Hart Crowser. Coordinate System: NAD83 HARN StatePlane Oregon North FIPS 3601 (Intl Feet).

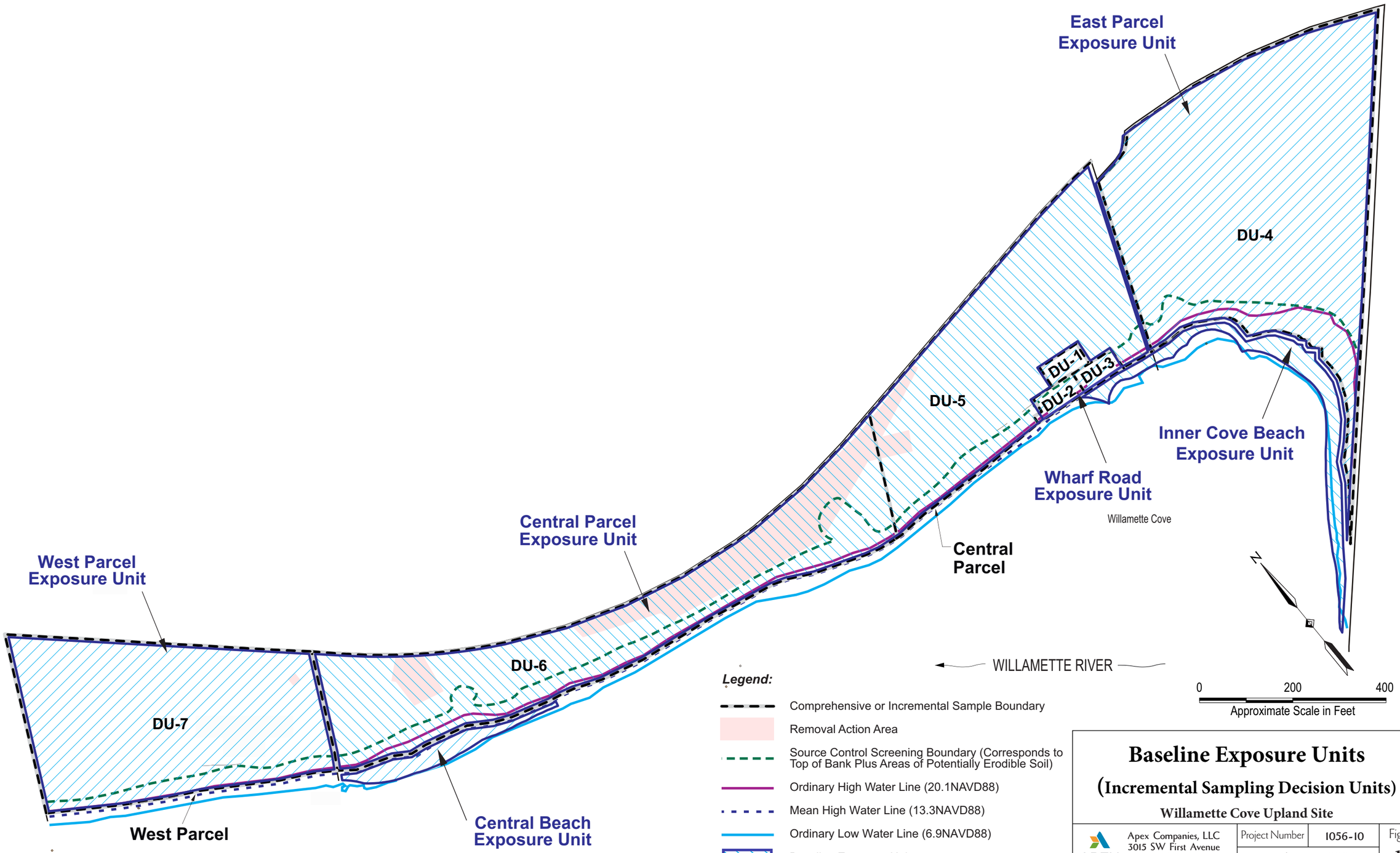
Soil Investigations - Composite

Willamette Cove Upland Site

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2019		10



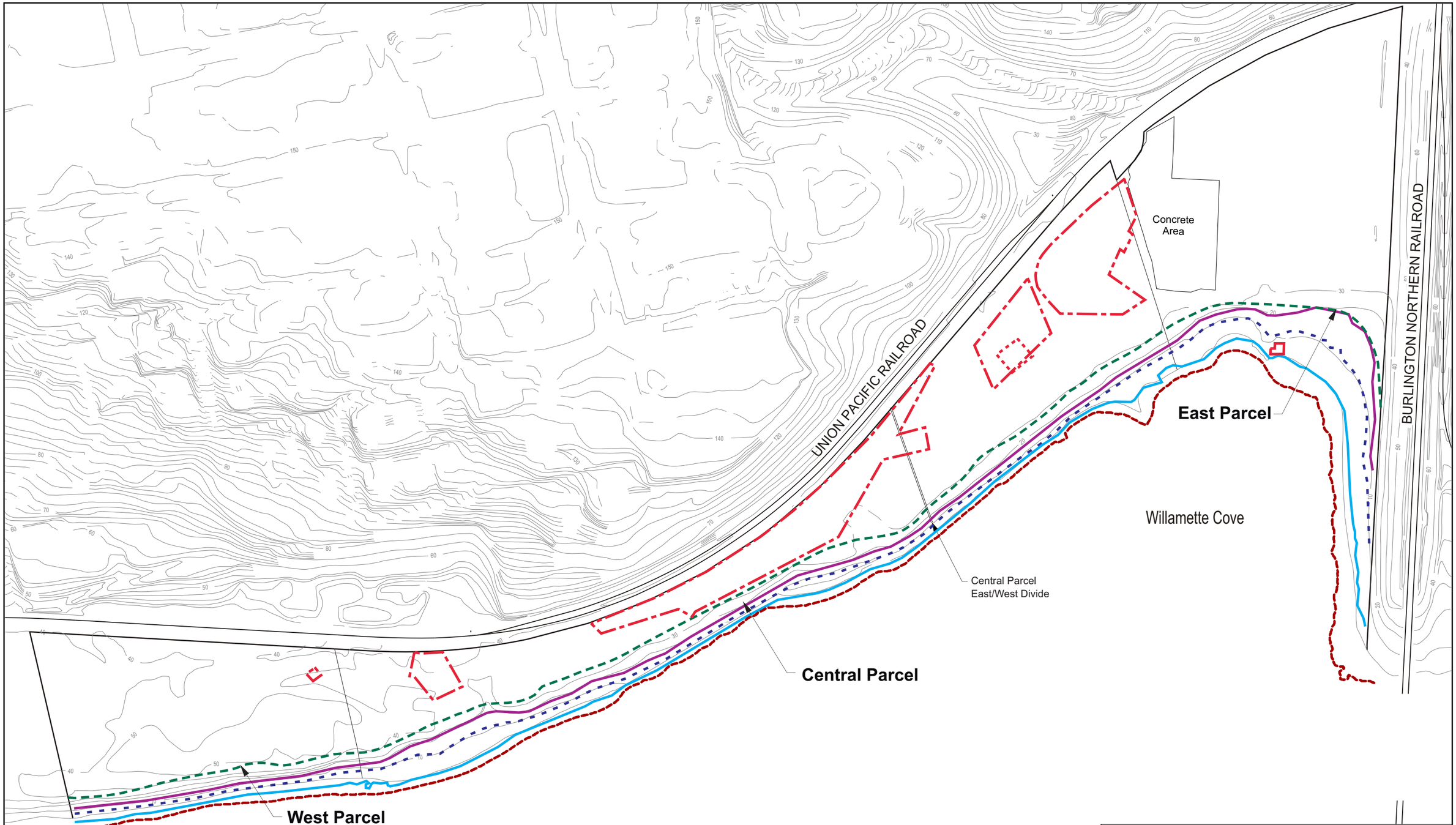
Note: Base map prepared from an electronic file provided by Hart Crowser.

Baseline Exposure Units

(Incremental Sampling Decision Units)

Willamette Cove Upland Site

APEX	Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number 1056-10 February 2020	Figure 11



Legend:

- 2004 Removal Area
- 2008 Removal Area
- 2015 Removal Area
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- Lower Source Control Screening Boundary

0 200 400
Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Removal Actions Map

Willamette Cove Upland Site

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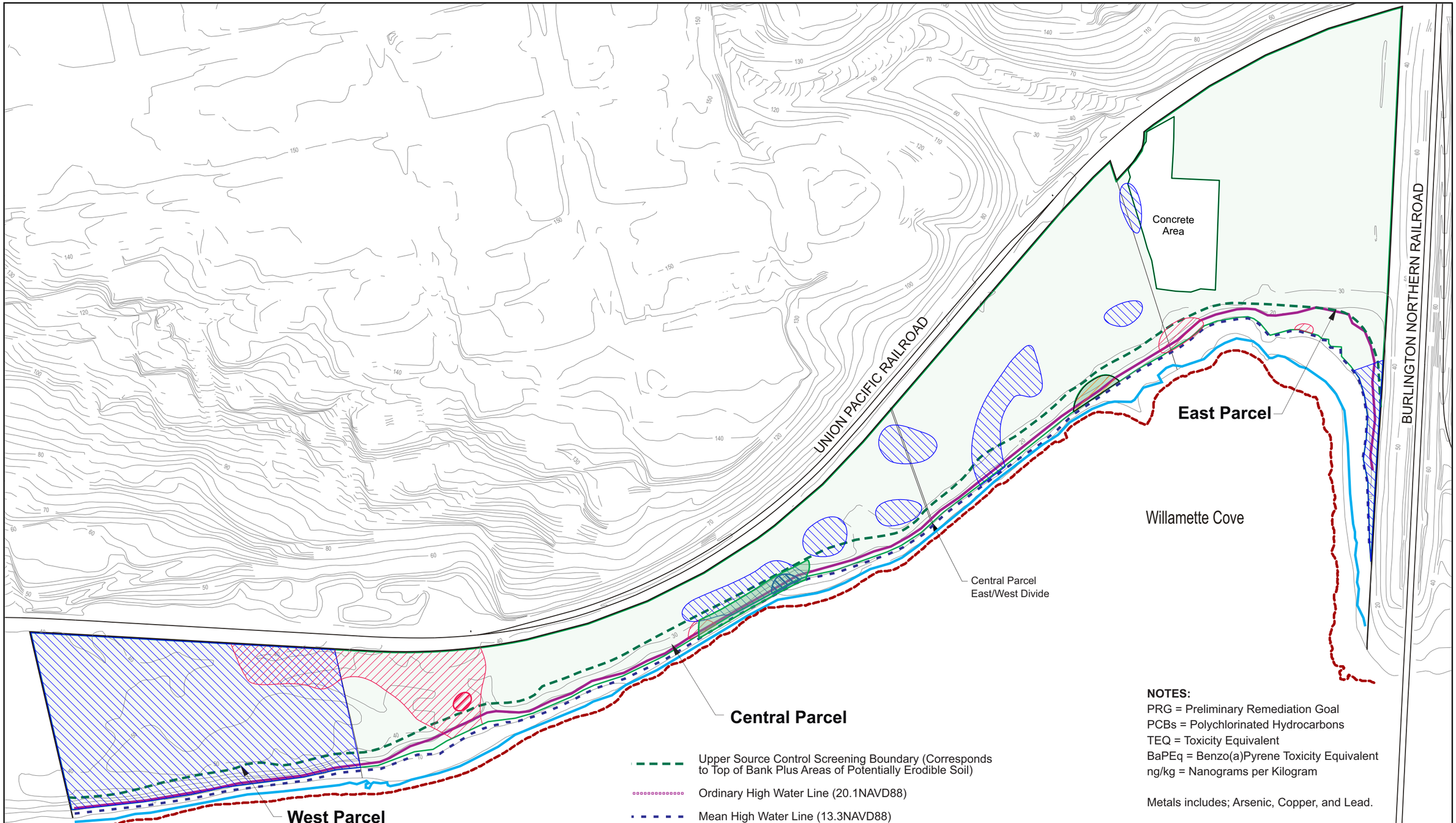
Portland, Oregon 97201

Project Number	1056-10	Figure
	February 2020	12



NOTES:
PRG = Preliminary Remediation Goal
PCBs = Polychlorinated Hydrocarbons
TEQ = Toxicity Equivalent
BaPEq = Benzo(a)Pyrene Toxicity Equivalent
ng/kg = Nanograms per Kilogram

Metals includes; Arsenic, Copper, and Lead.

Legend:

- Exceeds Dioxin TEQ PRG and Hot Spot Concentration
- Exceeds Dioxin TEQ PRG
- Exceeds One or More Metal PRG
- Exceeds One or More Metal Hot Spot Concentrations
- Exceeds Total PCBs PRG
- Exceeds BaPEq PRG
- Exceeds BaPEq Hot Spot Concentration
- Upper Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- Lower Source Control Screening Boundary (Corresponds to -2 Columbia River Datum; 3.2NAVD88)

0 200 400
Approximate Scale in Feet

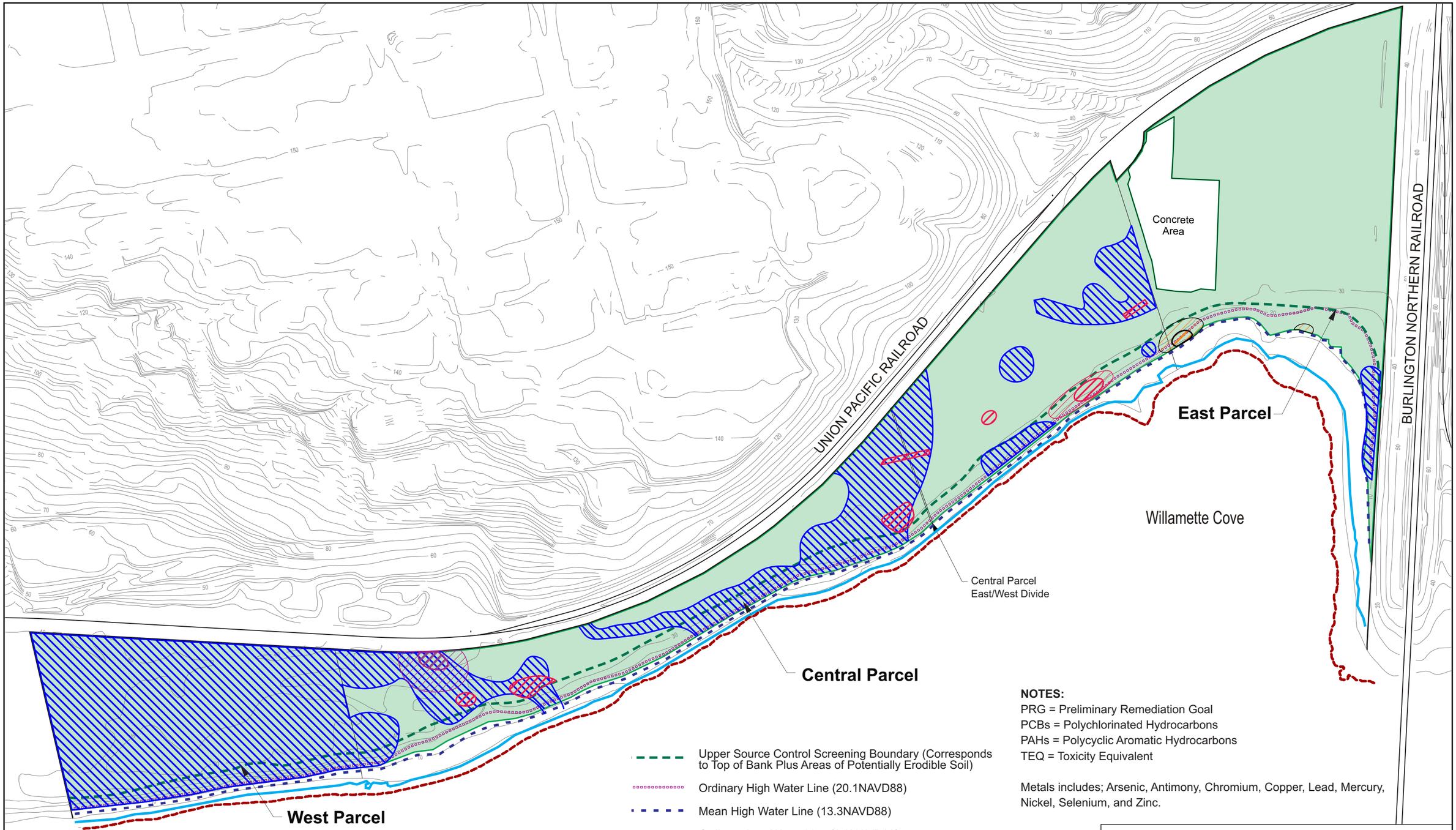
Source: Base map prepared from an electronic file provided by Hart Crowser.

Human Health Risk Screening Summary - Surface Soil

Willamette Cove Upland
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	13



NOTES:
PRG = Preliminary Remediation Goal
PCBs = Polychlorinated Hydrocarbons
PAHs = Polycyclic Aromatic Hydrocarbons
TEQ = Toxicity Equivalent

Metals includes; Arsenic, Antimony, Chromium, Copper, Lead, Mercury, Nickel, Selenium, and Zinc.

Legend:

- Exceeds Dioxin TEQ PRG and Hot Spot Concentration
- Exceeds One or More Metal PRG
- Exceeds One or More Metal Hot Spot Concentrations
- Exceeds Total PCBs PRG
- Exceeds Total PCBs Hot Spot Concentrations
- Exceeds PAHs PRG
- Exceeds PAHs Hot Spot Concentrations
- Exceeds Dibenzofuran PRG
- Exceeds Dibenzofuran Hot Spot Concentrations
- Upper Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- Lower Source Control Screening Boundary (Corresponds to -2 Columbia River Datum; 3.2NAVD88)

0 200 400
Approximate Scale in Feet

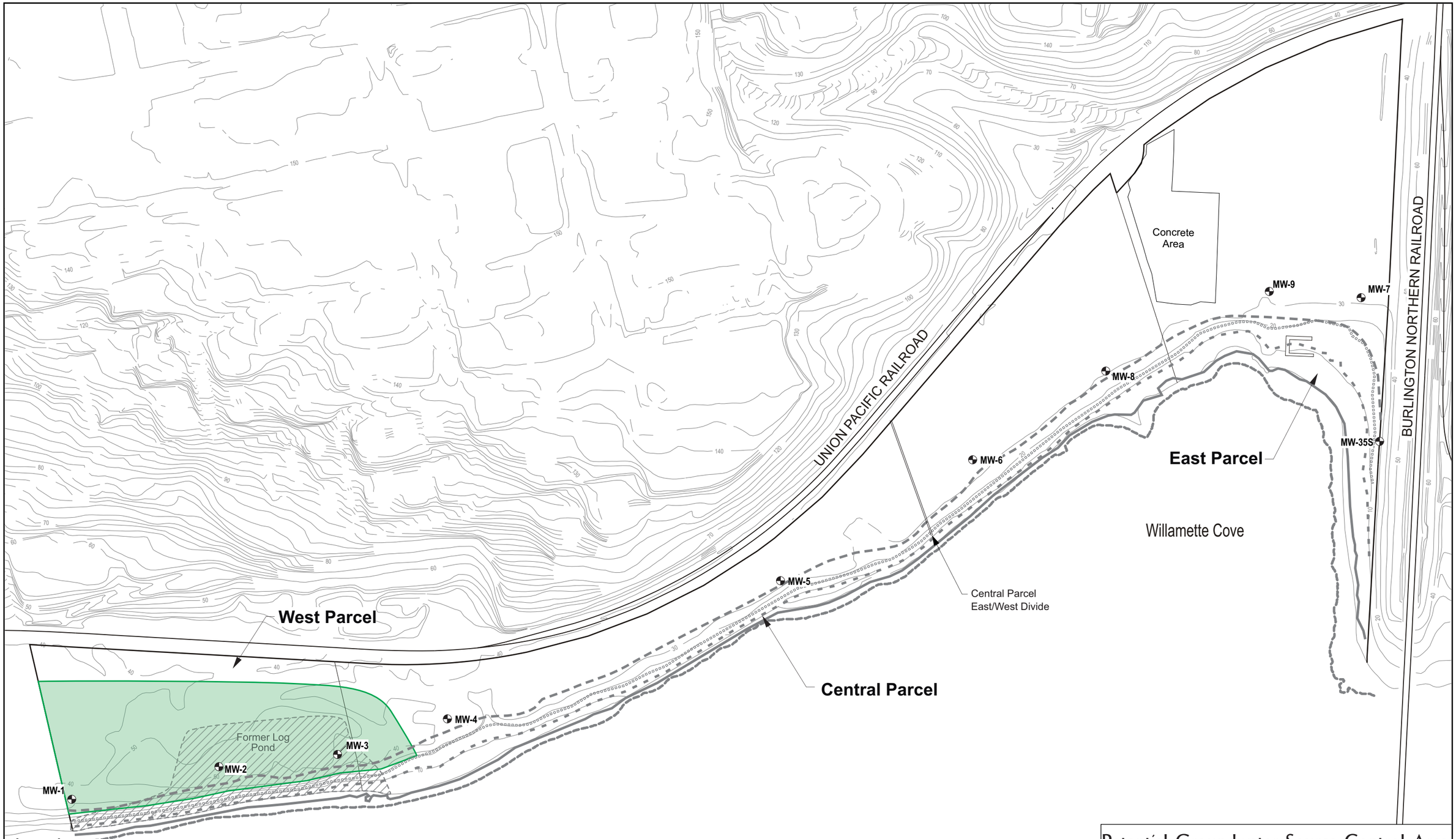
Source: Base map prepared from an electronic file provided by Hart Crowser.

Ecological Risk Screening Summary

Willamette Cove Upland
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	14



Legend:

- Monitoring Well Location
- Potential Groundwater Source Control Area

Contaminants of Concern: Arsenic, TPH - Diesel (C10 - C12 Aliphatic), Pentachlorophenol, PAHs (cPAHs, 2-Methylnaphthalene), 4,4'-Dichlorodiphenyldichloroethane, Total Polychlorinated Biphenyls, and Dioxins/Furans.

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum (3.2NAVD88)

0 200 400
Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

N

Potential Groundwater Source Control Area

Willamette Cove Upland Facility
Portland, Oregon

APEX
Apex Companies, LLC
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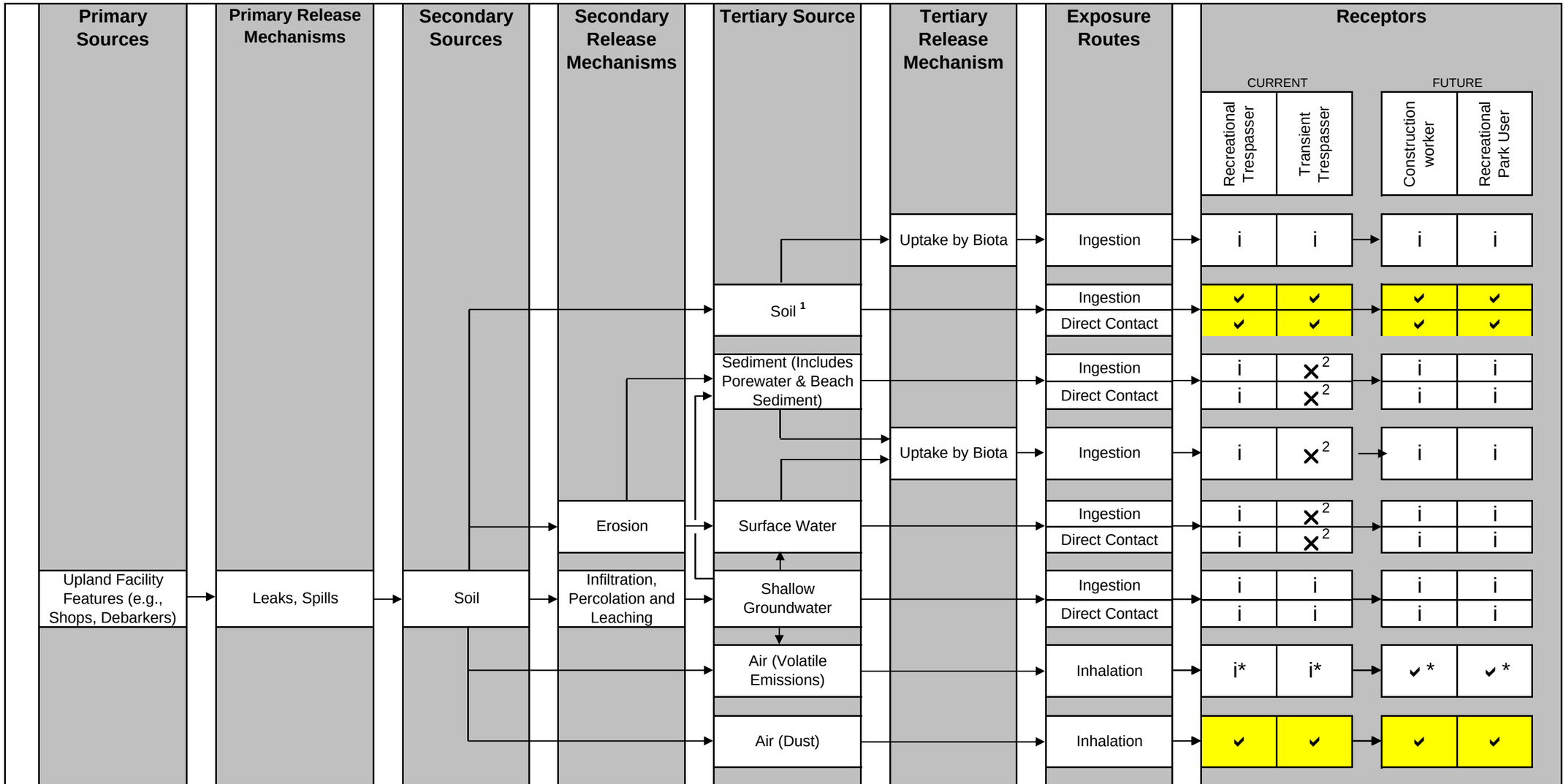
Portland, Oregon 97201

Project Number	1056-10	Figure
March 2020		15



Legend:

i Incomplete Pathway for Willamette Cove Upland Facility Residual Risk Assessment

✔ Potentially Complete Exposure Pathway Evaluated in Willamette Cove Upland Facility Residual Risk Assessment

✔ * Potentially Complete Exposure Pathway Evaluated in Willamette Cove Upland Facility Baseline Risk Assessment; will not be further evaluated in Residual Risk Assessment

✕ Potentially Complete Exposure Pathway Evaluated in Portland Harbor RI/FS

[1] A source control evaluation will be submitted under separate cover and will include evaluation of pathways related specifically to potentially erodable riverbank soil.

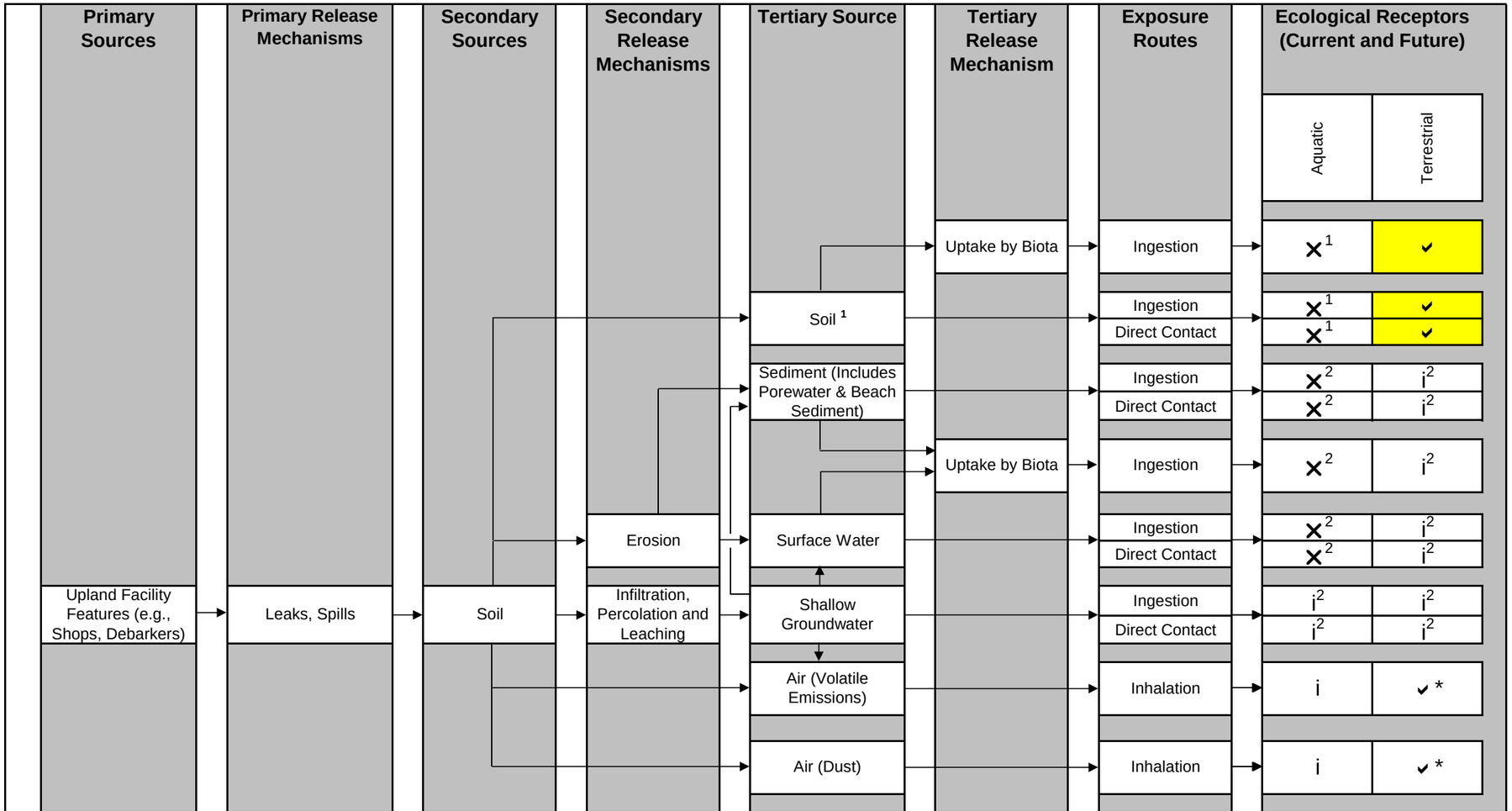
[2] There is no exposure to surface water, groundwater, or sediment on the Upland Facility; direct and indirect exposure of human receptors to media associated with the Willamette River (including biota) will be evaluated in the Portland Harbor RI/FS and via the source control evaluation (submitted under separate cover).

* Potentially complete exposure to volatiles in outdoor air (from soil or shallow groundwater) was evaluated in the Willamette Cove Baseline Human Health Risk Assessment. There was no indication of unacceptable risk from inhalation of volatiles from soil or groundwater in either indoor or outdoor settings.

Yellow highlights indicate pathways that are assessed in the Willamette Cove Upland Facility Residual Risk Assessment.

WILLAMETTE COVE UPLAND SITE
PORT OF PORTLAND, OREGON
Figure 16
Conceptual Site Model of Human Health Exposure Pathways

FORMATION ENVIRONMENTAL



Legend:

i Incomplete Pathway for Willamette Cove Upland Facility Residual Risk Assessment

✔ Potentially Complete Exposure Pathway Evaluated in Willamette Cove Upland Facility Residual Risk Assessment

✔ * Potentially Complete Exposure Pathway, but not evaluated quantitatively in the Willamette Cove Upland Facility Residual Risk Assessment.

✕ Potentially Complete Exposure Pathway Evaluated in Portland Harbor RI/FS and/or source control evaluation

Willamette Cove Upland Facility Boundary is defined by the Mean High Water Mark (MHWM). The West Parcel, Central Parcel, and East Parcel Upland Exposure Units (EUs) are bounded by the MHWM on the riverward side of the parcels. The Inner Cove Beach EU and the Central Beach EU are below the MHWM, and are not within the Facility Boundary, but are included in this residual risk assessment as requested by DEQ.

[1] Soils include upland, riverbank, and beach soils as defined for each Exposure Unit. Evaluation of pathways related to potentially erodable riverbank soil are evaluated in the Portland Harbor RI/FS and via the source control evaluation (submitted under separate cover).

[2] There is no exposure to surface water, groundwater, or sediment on the Upland Facility; direct and indirect exposure of ecological receptors to media associated with the Willamette River (including biota) are evaluated in the Portland Harbor RI/FS and via the source control evaluation (submitted under separate cover).

* Potentially complete exposure to volatiles in outdoor air (from soil or shallow groundwater) was evaluated in the Willamette Cove Baseline Human Health Risk Assessment. There was no indication of unacceptable risk from inhalation of volatiles from soil or groundwater in either indoor or outdoor settings.

Yellow highlights indicate pathways that are assessed in the Willamette Cove Upland Facility Residual Risk Assessment.

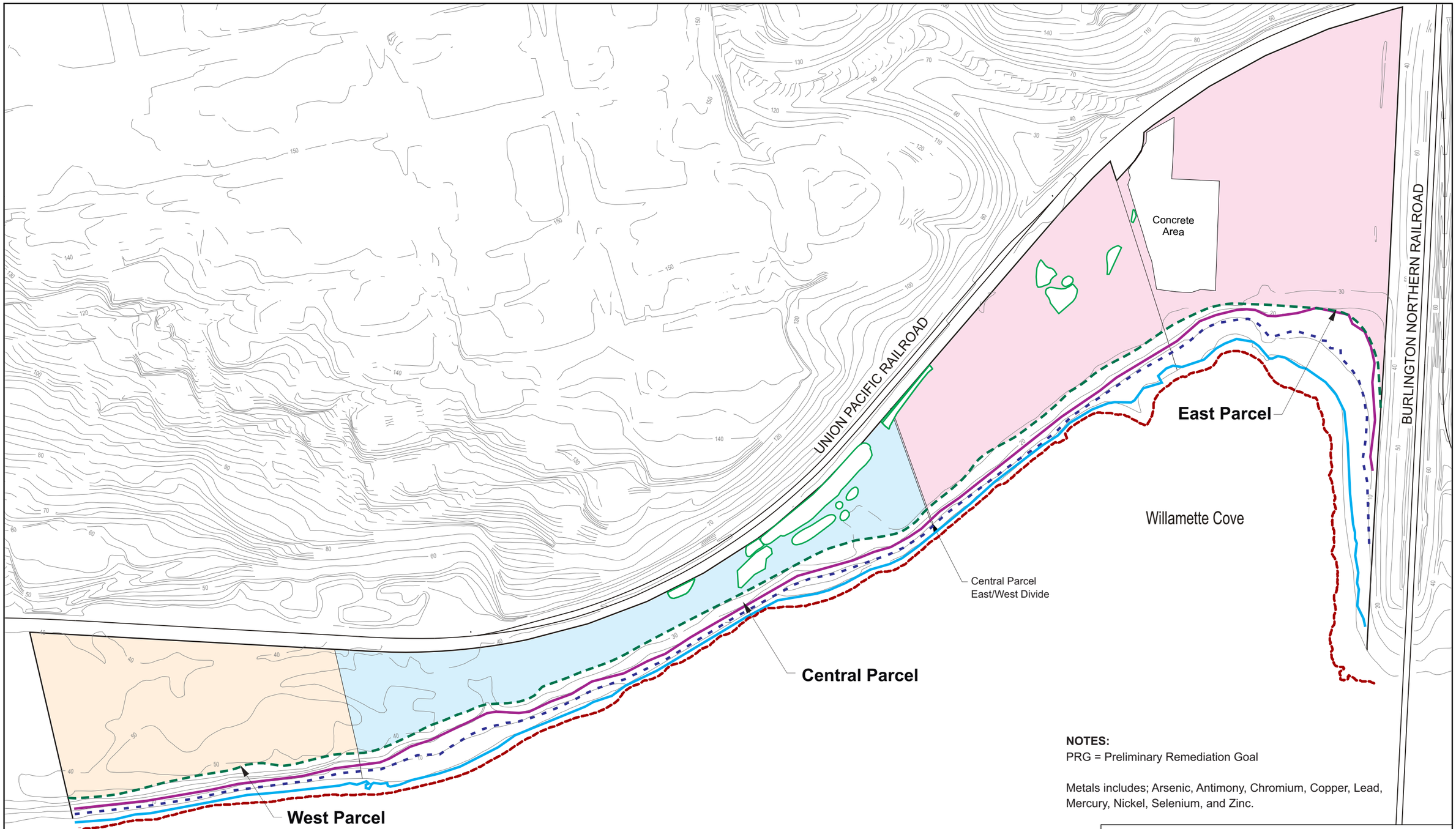
WILLAMETTE COVE UPLAND SITE

PORT OF PORTLAND, OREGON

Figure 17

Conceptual Site Model of Ecological Exposure Pathways

FORMATION ENVIRONMENTAL



NOTES:
PRG = Preliminary Remediation Goal

Metals includes; Arsenic, Antimony, Chromium, Copper, Lead, Mercury, Nickel, Selenium, and Zinc.

Legend:

2015 Soil Removal Action Low Impact Excavation Areas Surrounding Designated Native Tree Species

Depth of Soil Exceeding PRGs (In Feet Below Ground Surface):

- Ecological-1; Human Health - 0.5 Feet
- Ecological-2; Human Health - 1.5 Feet
- Ecological-3; Human Health - 2.0 Feet

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- 2 Columbia River Datum; 3.2NAVD88

0 200 400
Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Remedial Action Area Exceeding PRGs

Willamette Cove Upland
Portland, Oregon

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Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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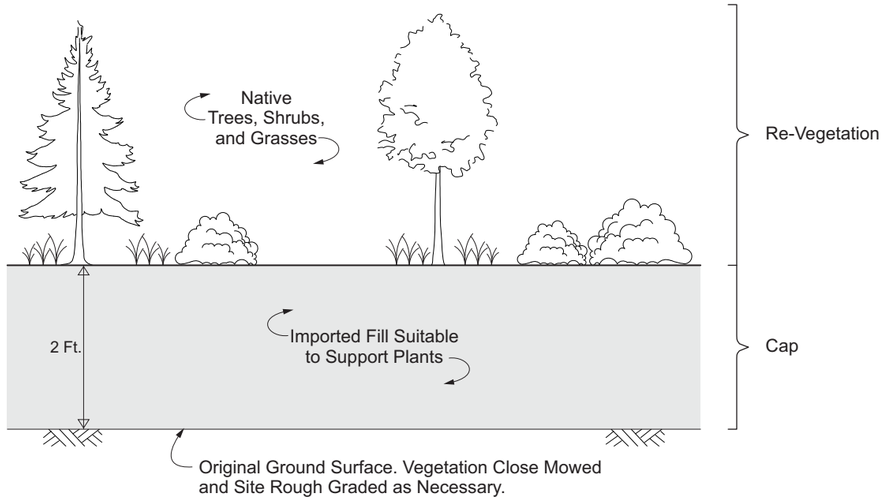
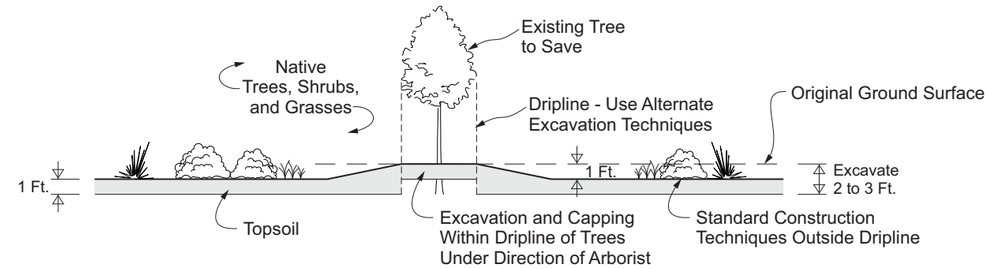
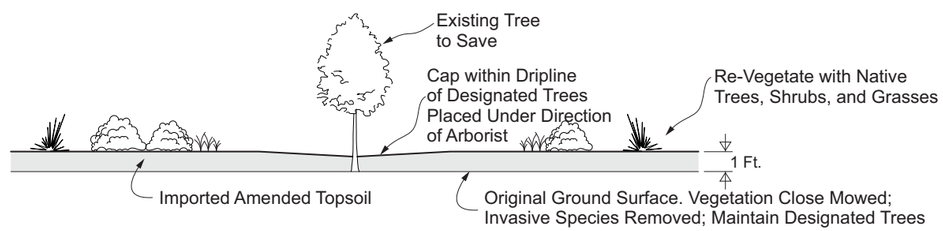


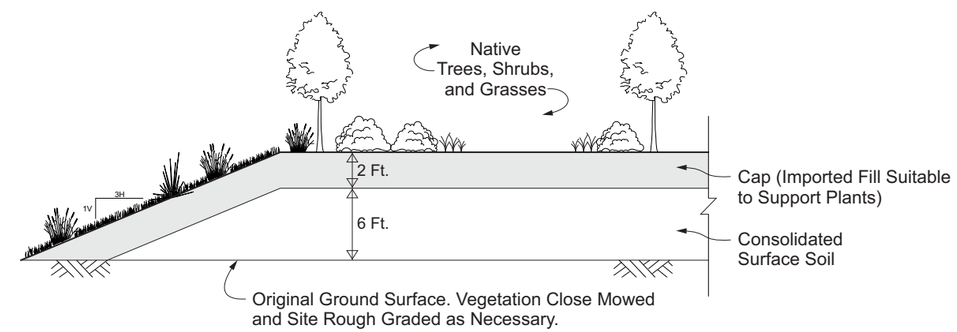
A Standard Cap Detail
Not To Scale



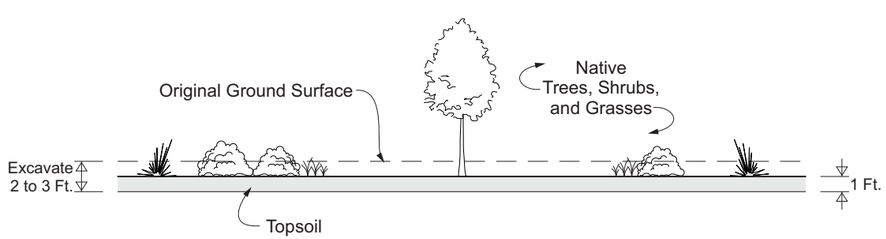
D Alternative Excavation Detail
Not To Scale



B Amended Cap Detail
Not To Scale



E Soil Consolidation Area Detail
Not To Scale

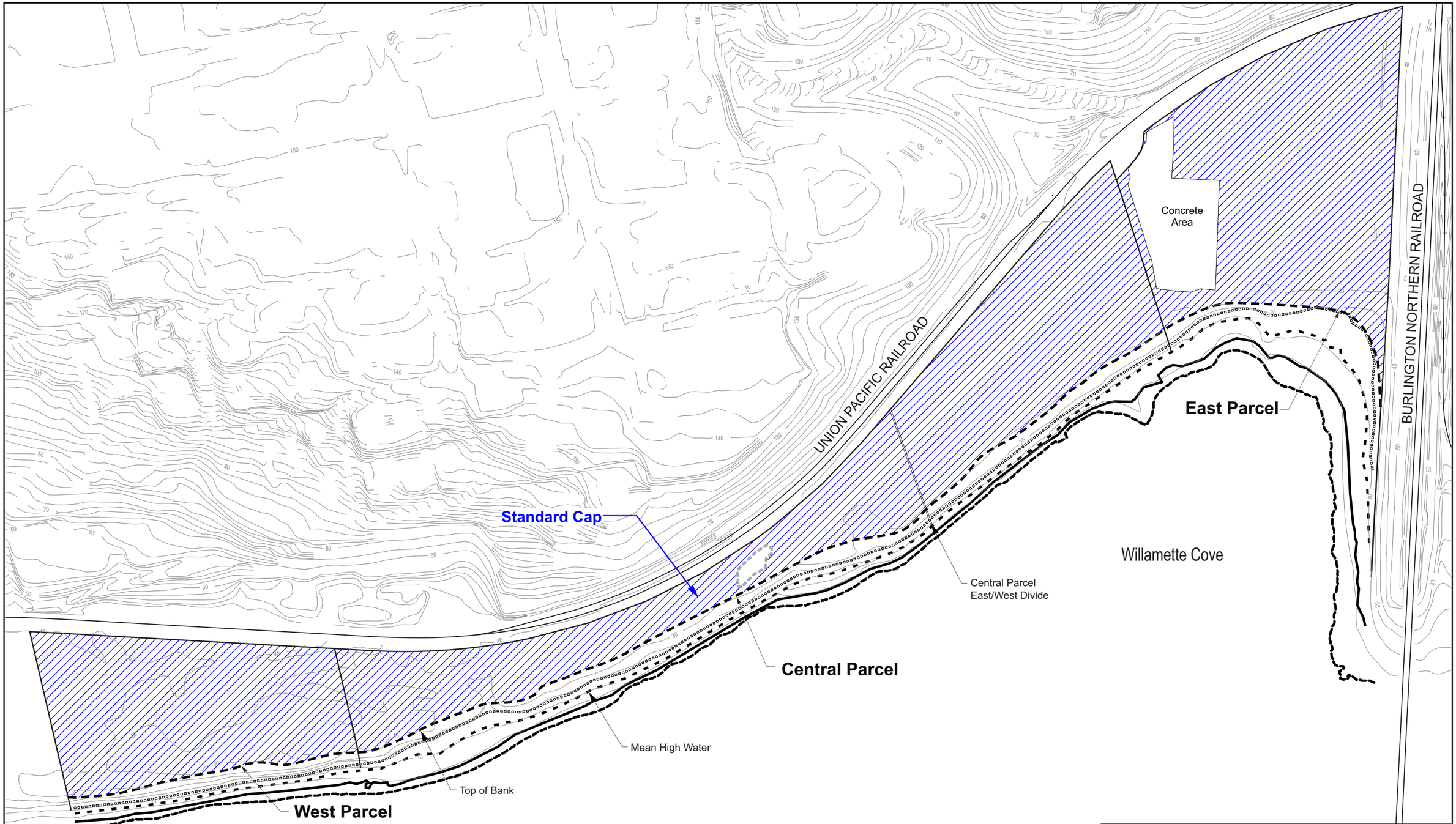


C Standard Excavation Detail
Not To Scale

Typical Cross-Sections

Willamette Cove Upland
Portland, Oregon

APEX Apex Companies, LLC 3015 SW First Avenue Portland, Oregon 97201	Project Number	1056-10	Figure
		March 2020	19



Legend:

- 2015 Soil Removal Deep Excavation Area
- Standard Cap Area - 2-Foot thick soil cap.
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

0 200 400
Approximate Scale in Feet

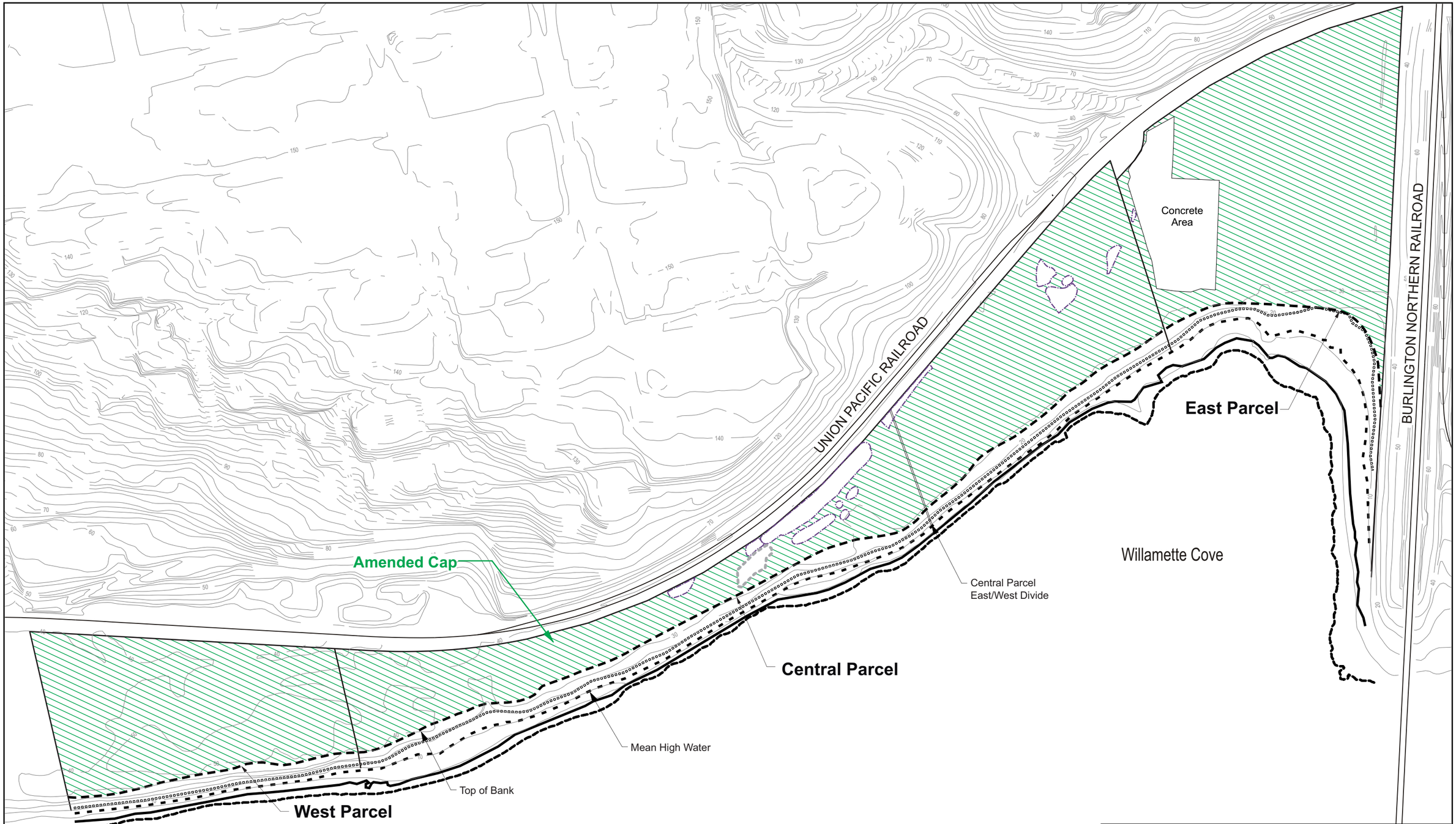
Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 2a: Standard Cap

Willamette Cove Upland
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	20



Legend:

- 2015 Soil Removal Deep Excavation Area
- 2015 Soil Removal Action Low Impact Excavation Areas Surrounding Designated Native Tree Species
- Amended Cap Area - 1-Foot thick soil cap amended with organic matter.
- Top of Bank Plus
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

0 200 400
Approximate Scale in Feet

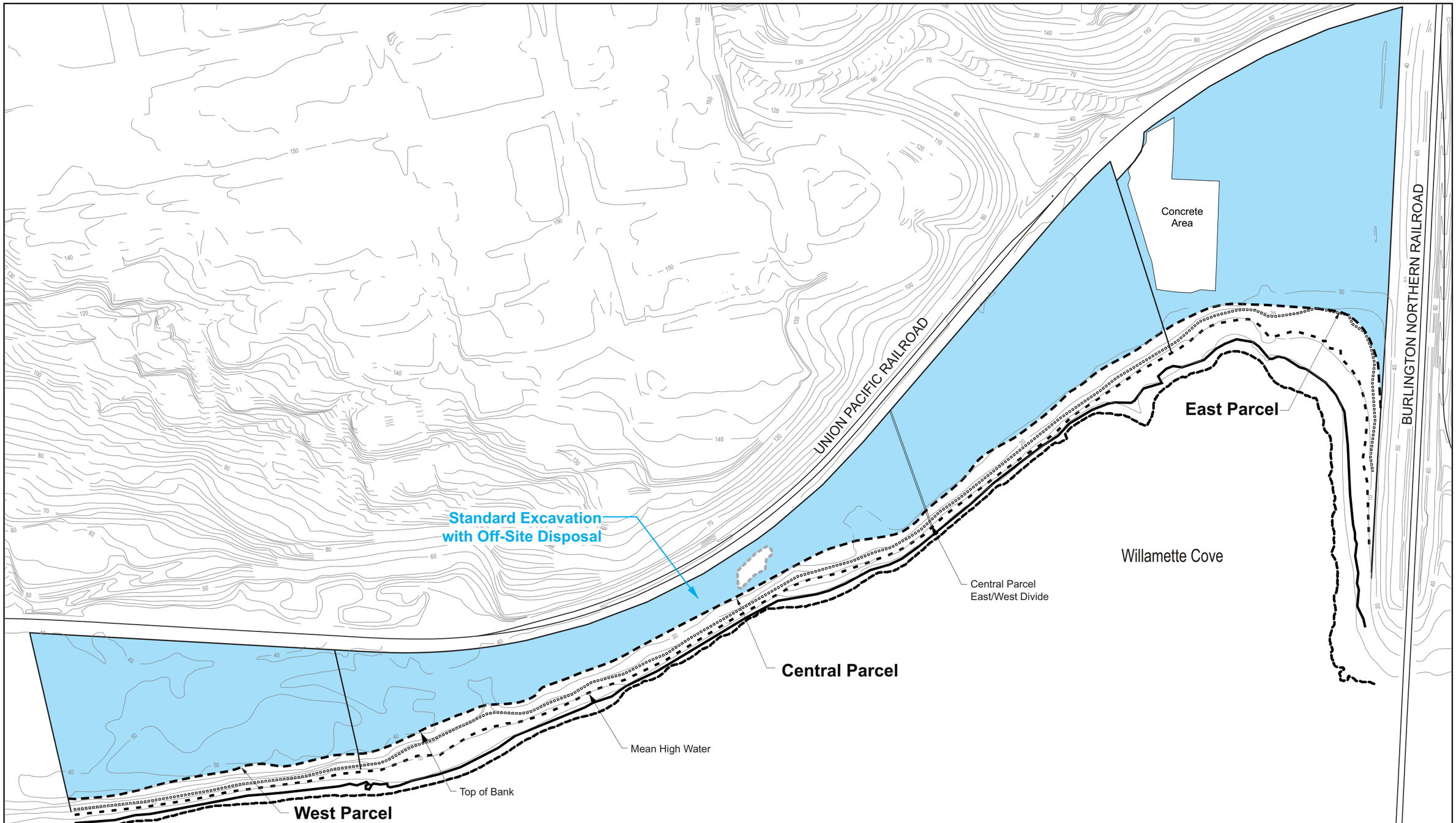
Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 2b: Amended Cap

Willamette Cove Upland
Portland, Oregon

APEX
Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	21



Legend:

- 2015 Soil Removal Deep Excavation Area
- Standard Excavation Area - All soil above human health and ecological risk levels excavated and taken off-site.
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

Note: Standard excavation area is approximate. Actual area will be determined by confirmation sampling conducted during remedial action.

0 200 400
Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 3a: Standard Excavation with Off-Site Disposal

Willamette Cove Upland
Portland, Oregon

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Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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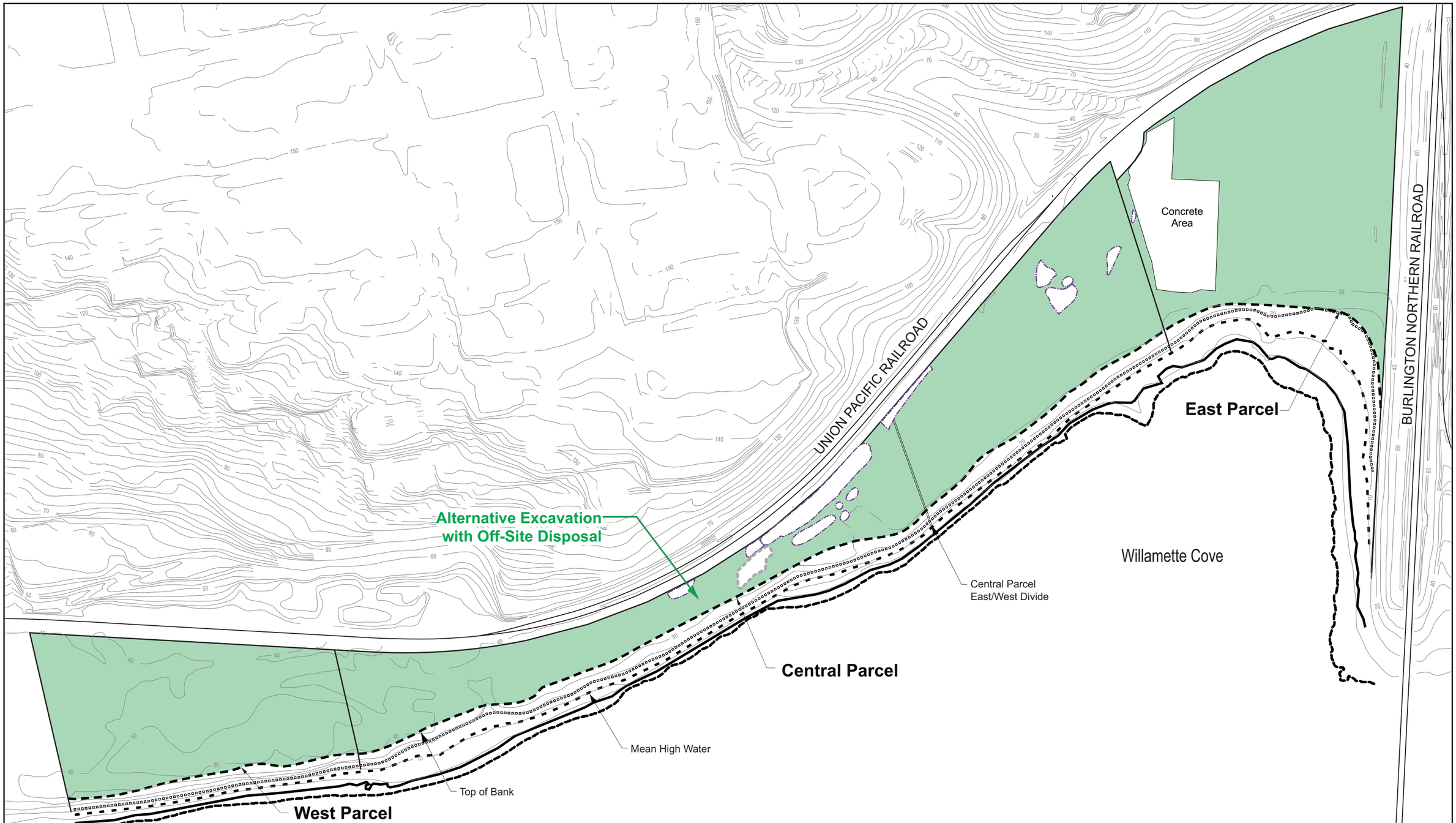

Legend:

- 2015 Soil Removal Deep Excavation Area
- 2015 Soil Removal Action Low Impact Excavation Areas Surrounding Designated Native Tree Species
- Alternative Excavation Area - All soil above human health and ecological risk levels will be excavated and taken off-site, except near native trees where only soil that can be removed without damaging trees will be excavated.

Note: Alternative excavation area is approximate. Actual area will be determined by confirmation sampling conducted during remedial action.

- Upper Source Control Screening Boundary (Corresponds to Top of Bank Plus Areas of Potentially Erodible Soil)
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- Lower Source Control Screening Boundary

0 200 400
Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

N

Alternative 3b: Alternative Excavation with Off-Site Disposal

Willamette Cove Upland
Portland, Oregon

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Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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Soil Consolidation Area

Concrete Area

UNION PACIFIC RAILROAD

BURLINGTON NORTHERN RAILROAD

East Parcel

Standard Excavation with On-Site Consolidation

Willamette Cove

Central Parcel East/West Divide

Central Parcel

Mean High Water

Top of Bank

West Parcel

Legend:

- 2015 Soil Removal Deep Excavation Area
- Standard Cap Area - 2-Foot thick soil cap.
- Standard Excavation Area - All soil above human health and ecological risk levels excavated and placed in soil consolidation area.

Note: Standard excavation and soil consolidation areas are approximate. Actual areas will be determined by confirmation sampling conducted during remedial action.

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88) -2
- Columbia River Datum; 3.2NAVD88

0 200 400

Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

N

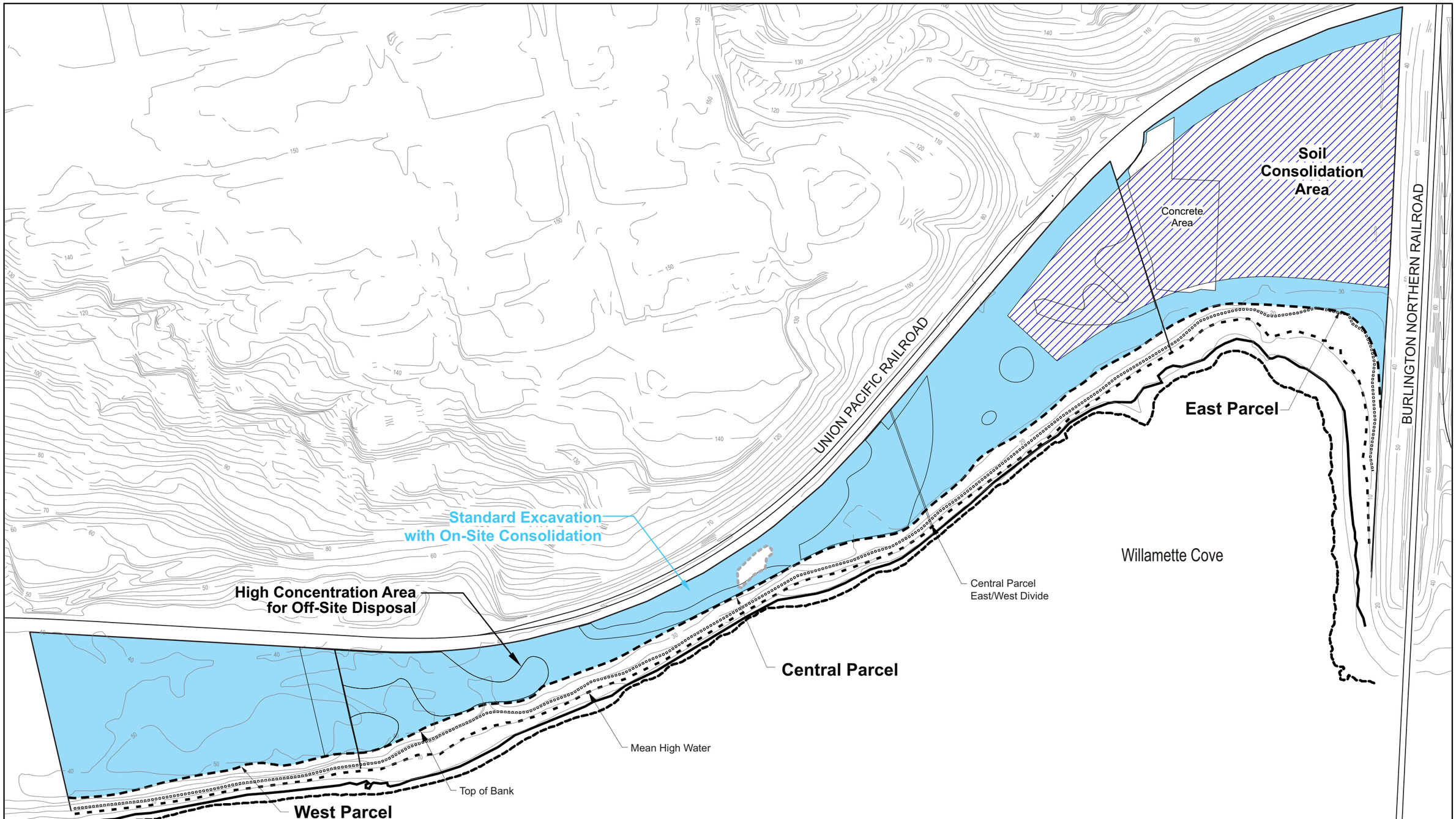
Alternative 3c: Standard Excavation with On-Site Consolidation

Willamette Cove Upland
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	24



Legend:

- 2015 Soil Removal Deep Excavation Area
- Standard Cap Area - 2-Foot thick soil cap.
- Standard Excavation Area - High concentration soil excavated and taken off-site. Remaining soil above human health and ecological risk levels excavated and placed in soil consolidation area.

Note: High concentration, standard excavation, and soil consolidation areas are approximate. Actual areas will be determined by confirmation sampling conducted during remedial action.

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

0 200 400
Approximate Scale in Feet

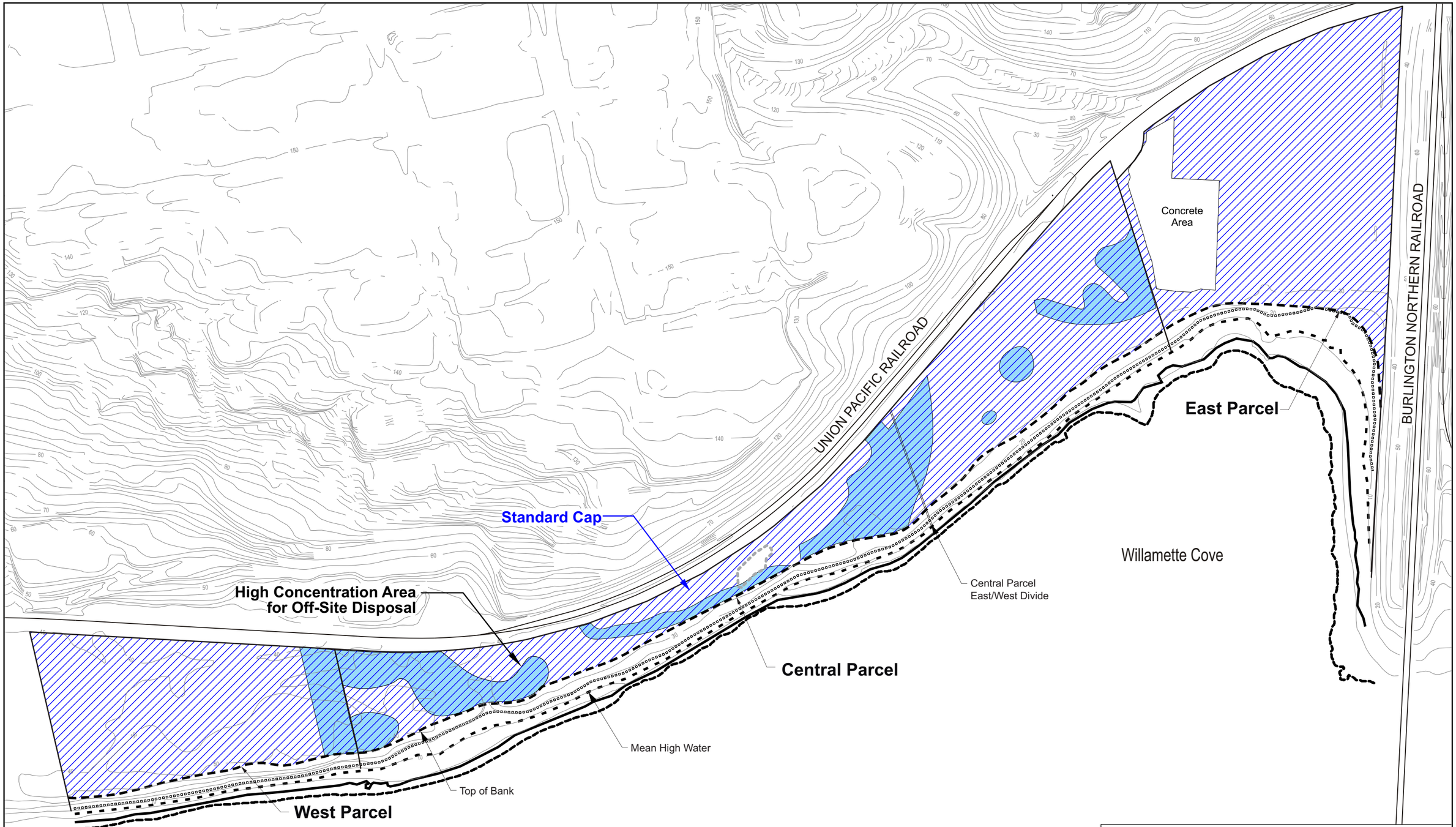
Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 3d: Standard Excavation with Off-Site Disposal/On-Site Consolidation

Willamette Cove Upland
Portland, Oregon

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

Project Number	1056-10	Figure
	March 2020	25



Legend:

- 2015 Soil Removal Deep Excavation Area
- Standard Cap Area - 2-Foot thick soil cap.
- Standard Excavation Area - High concentration soil excavated and taken off-site.

Note: High concentration, standard excavation, and standard cap areas are approximate. Actual area will be determined by confirmation sampling conducted during remedial action.

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

0 200 400

Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 4a: Focused Standard Excavation with Off-Site Disposal and Standard Cap

Willamette Cove Upland
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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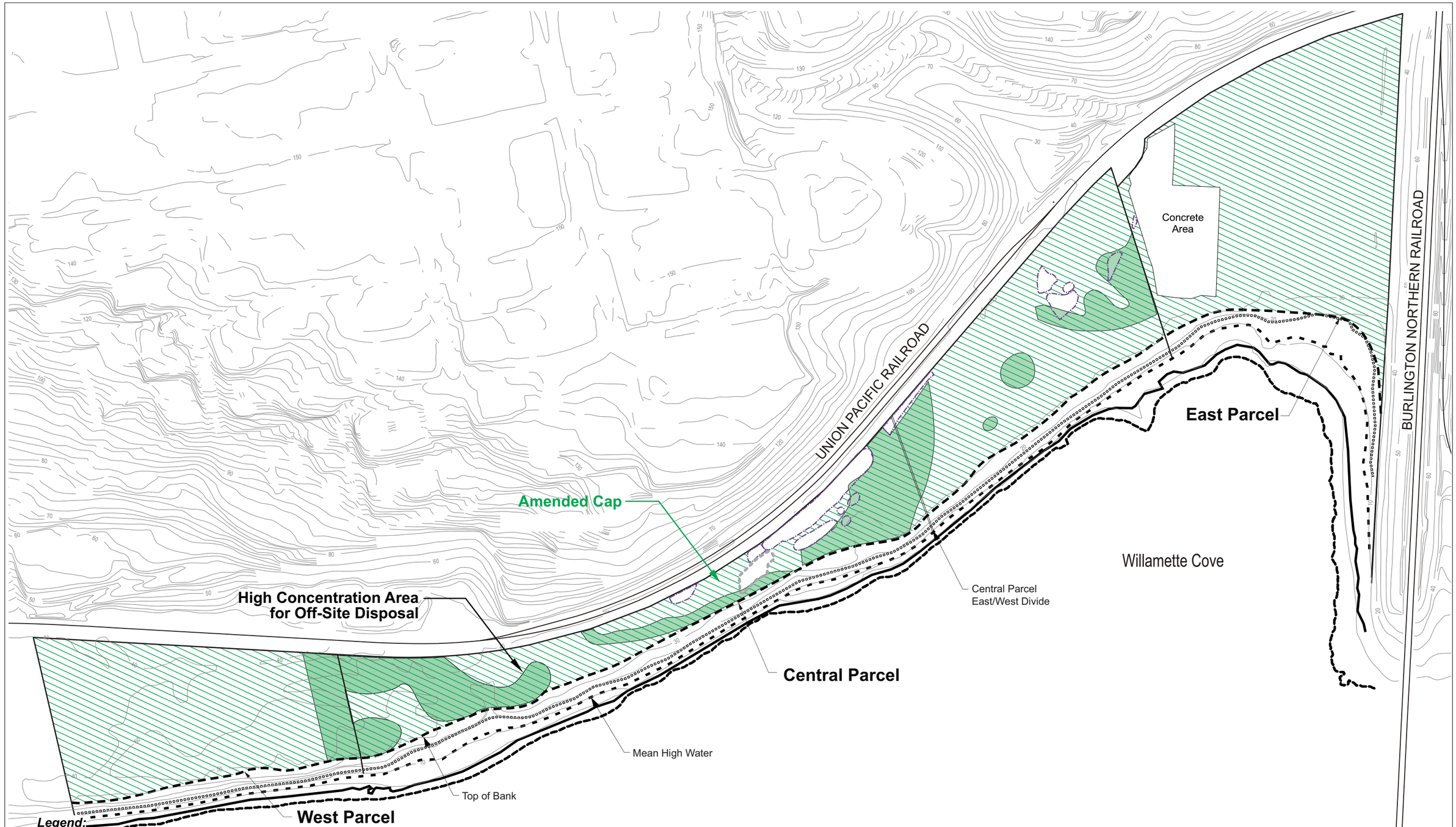

Legend:

- 2015 Soil Removal Deep Excavation Area
- 2015 Soil Removal Action Low Impact Excavation Areas Surrounding Designated Native Tree Species
- Amended Cap Area - 1-Foot thick soil cap amended with organic matter.
- Alternative Excavation Area - All high concentration soil excavated and taken off-site, except near native trees where only soil that can be removed without damaging trees will be excavated.

Note: High concentration and alternative excavation areas are approximate. Actual areas will be determined by confirmation sampling conducted during remedial action.

- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

0 200 400

Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Alternative 4b: Focused Alternative Excavation with Off-Site Disposal and Amended Cap

Willamette Cove Upland
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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Soil Consolidation Area

Concrete Area

Alternative Excavation Area for On-Site Consolidation

UNION PACIFIC RAILROAD

BURLINGTON NORTHERN RAILROAD

East Parcel

Cap/Covers

Willamette Cove

High Concentration Area for Off-Site Disposal

Central Parcel East/West Divide

Central Parcel

Mean High Water

Top of Bank

West Parcel

0 200 400

Approximate Scale in Feet

Source: Base map prepared from an electronic file provided by Hart Crowser.

Legend:

- 2015 Soil Removal Deep Excavation Area
- 2015 Soil Removal Action Low Impact Excavation Areas Surrounding Designated Native Tree Species
- Standard Cap Area - 2-Foot thick soil cap.
- Cover/Cap Area - One- to 3-foot thick soil cap over areas where soil concentrations exceed ecological risk levels.
- Alternative Excavation Area - All high concentration soil excavated and taken off-site, all soil above human health risk levels placed in soil consolidation area, except near native trees where only soil that can be removed without damaging trees will be excavated.
- Top of Bank
- Ordinary High Water Line (20.1NAVD88)
- Mean High Water Line (13.3NAVD88)
- Ordinary Low Water Line (6.9NAVD88)
- -2 Columbia River Datum; 3.2NAVD88

Note: High concentration, alternative excavation, standard cap, and soil consolidation areas are approximate. Actual areas will be determined by confirmation sampling conducted during remedial action.

Alternative 4c: Focused Alternative Excavation with Off-Site Disposal/On-Site Consolidation and Cap

Willamette Cove Upland Facility
Portland, Oregon

APEX

Apex Companies, LLC
3015 SW First Avenue
Portland, Oregon 97201

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