LAKE RIVER 90% REMEDIAL DESIGN REPORT

LAKE RIVER REMEDIAL ACTION
111 W DIVISION STREET
RIDGEFIELD, WASHINGTON

Prepared for
PORT OF RIDGEFIELD
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The material and data in this report were prepared under the supervision and direction of the undersigned.

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CONTENTS

TABLES AND ILLUSTRATIONS

FOLLOWING REPORT:

TABLES

FIGURES

DRAWINGS

TABLES AND ILLUSTRATIONS (CONTINUED)

ACRONYMS AND ABBREVIATIONS

AINW	Archaeological Investigations Northwest
AU	approval unit
bml	below mudline
BMP	best management practice
CAP	cleanup action plan
the City	City of Ridgefield
COE	U.S. Army Corps of Engineers
CQA	construction quality assurance
CQC	construction quality control
CUL	cleanup level
DAHP	Washington State Department of Archaeology and Historic Preservation
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
ELS	Ecological Land Services, Inc.
ENR	enhanced natural recovery
ESA	Endangered Species Act
fps	feet per second
GeoDesign	GeoDesign, Inc.
H:V	horizontal to vertical
HAZWOPER	hazardous waste operations and emergency response
IDW	inverse distance weighting
JARPA	Joint Aquatic Resources Permit Application
LRIS	Lake River Industrial Site
MFA	Maul Foster & Alongi, Inc.
MTCA	Model Toxics Control Act
ng/kg	nanograms per kilogram
NGVD	National Geodetic Vertical Datum of 1929/1947
NOAA-Fisheries	National Oceanic and Atmospheric Administration Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OHW	ordinary high water
PFD	personal flotation device
the Port	Port of Ridgefield
PWT	Pacific Wood Treating Co.
RCRA	Resource Conservation and Recovery Act
REL	remediation level
RI/FS	remedial investigation and feasibility study
RNWR	Ridgefield National Wildlife Refuge
RTK-GPS	real-time kinematic global positioning system
TEQ	dioxin toxicity equivalency
TRM	turf reinforcement mat

USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife

1 INTRODUCTION

On behalf of the Port of Ridgefield (the Port), Maul Foster & Alongi, Inc. (MFA) has prepared this 90% Remedial Design Report for the remediation of sediment in Lake River adjacent to the former Pacific Wood Treating Co. (PWT) site in Ridgefield, Washington (see Figure 1-1). This document has been prepared under the authority of Consent Decree No. 13-2-03830-1 (Washington State Department of Ecology [Ecology], 2013b) between the Port and Ecology to satisfy the requirements of the Model Toxics Control Act (MTCA) and the state sediment management standards.

This report fulfills Ecology's requirement for an engineering design report summarizing the remedial design as specified in the remedial investigation and feasibility study (RI/FS) (MFA, 2013b) and as prescribed in the cleanup action plan (CAP) (Ecology, 2013a).

1.1 Site Description and Setting

PWT operated a wood-treating facility from 1964 to 1993 at the Port's approximately 40-acre Lake River Industrial Site (LRIS). PWT filed for bankruptcy in 1993 and abandoned the LRIS. PWT's operations involved pressure-treating wood products with oil-based treatment solutions containing creosote, pentachlorophenol, and water-based mixtures of copper, chromium, arsenic, and/or zinc. A remedial action has been completed on the uplands portion of the property, consistent with the remedy selected in the CAP (Ecology, 2013a). Pathways and sources of contamination to Lake River have been removed and an upland cap has been installed.

Lake River is a side channel of the Columbia River and lies within the lower Columbia River west of Ridgefield, Washington, near the confluence of the Columbia River and the Lewis River (see Figure 1-2). Lake River is a tidally influenced, 11-mile-long channel and is hydraulically connected at its mouth to the Columbia River, through Bachelor Island Slough approximately 1 mile upstream of the mouth, and through a tide gate/flushing structure along the western shoreline of Vancouver Lake. It originates at Vancouver Lake in Vancouver, Washington, to the south; runs parallel to the Columbia River; and merges with the Columbia at the northern tip of Bachelor Island. The National Wetlands Inventory has classified Lake River as a riverine, tidal, unconsolidated bottom, permanent tidal habitat. Lake River is slow moving because there are no significant inputs to Vancouver Lake; primary flow is associated with tidal fluctuation and with surges caused by cargo ship traffic on the Columbia. Its width varies from approximately 100 feet to over 300 feet, and its depth typically averages no more than 10 feet along the entire length.

In the remedial action area, Lake River is approximately 300 feet wide. Depth in the remedial action area varies with slopes from the riverbank to the channel; during the anticipated fall/winter work window (i.e., during typical high-water events), depths range from less than 10 feet near shore to more than 25 feet deep at the extent of the work area in the channel. Generally, steep banks occur on both sides of Lake River, and there is no emergent vegetation. Armoring and vegetation dominate Lake River's western shoreline.

The Port-owned property (the LRIS and a portion of the Port Marina) borders the remedial action area to the east. The Ridgefield National Wildlife Refuge (RNWR) borders the east side of Lake River. The RNWR also borders the west side of Lake River just north of the remedial action area. To the south, there is a public boat launch ramp and McCuddy's Marina, which offers moorage and spaces for houseboats (see Figure 1-3). Multiple in-water and overwater structures, such as the Port's pump house and piles are located along the shoreline of the LRIS.

Currently, Lake River is frequented by recreationists and is habitat to aquatic animals, including waterbirds such as the great blue heron, and aquatic mammals such as the river otter. Because Lake River is a tributary of the lower Columbia River, special-status anadromous fish (such as salmonids and eulachon) may be present at certain times of year; however, migration of listed species (i.e., listed as threatened or endangered) is generally expected to occur in the mainstem Columbia River.

1.2 Project Purpose

On September 24, 2001, the Port entered into an agreement with Ecology to conduct an RI/FS at the site. The RI/FS was finalized in July 2013 (MFA, 2013b). The remedial action was selected by Ecology (Ecology, 2013a; Ecology, 2013b) in accordance with MTCA, Washington Administrative Code (WAC) 173-340-380. The remedy selected by Ecology, and documented in the CAP (Ecology, 2013a), is based on the final RI/FS report.

The purpose of this remedial action is to address the presence of dioxins and other collocated chemicals (pentachlorophenol, m&p cresol, and polycyclic aromatic hydrocarbons) in sediment found in Lake River. The remedial action identified in the CAP for Lake River is intended to stabilize the bank and remove contaminated sediment to the extent feasible. The remedy components are described in detail in Section 3.

1.3 Selected Remedial Action

The selected cleanup includes bank and in-water actions. The approximate project location is shown in Figure 1-3. The in-water portion of the remedy entails removal of contaminated sediment, using precision mechanical dredging followed by placement of clean sand to control residuals and enhance the natural recovery of remaining low-level concentrations in the river. Additional in-water cleanup components include the following:

- Existing in-water structures identified in the plans will be demolished prior to dredging.
- Best management practices (BMPs) for water quality will be implemented during work; these will include operational controls; dredge methods; and turbidity monitoring before, during, and after construction. Decanted water from the dredged sediment will be treated for turbidity before it is discharged back to Lake River. Additional BMPs will be considered and implemented if required during the work.
- Dredged material will be disposed of as nonhazardous material waste at a Subtitle D landfill facility.

- Natural recovery will be monitored; monitoring will quantify the reduction and/or stabilization of concentrations relative to the cleanup level (CUL) (5 nanograms per kilogram [ng/kg] dioxin toxicity equivalency [TEQ]).

The bank portion of the remedy will stabilize the bank. The bank will be covered with a geotextile filter fabric and a rock stabilization layer consisting of rounded gravels and cobbles resistant to erosion (i.e., “fish mix”). The elevation where the fish mix will be applied varies; however, bank protection will extend from the toe of the slope to at least ordinary high water (OHW). Stabilization of the bank will reinforce the existing slopes; the fabric and fish mix will act as a physical barrier to movement of underlying soil and sediment. To protect against erosion during high-water events, turf reinforcement mat (TRM) will be placed on the existing upland clean soil cap above the fish mix layer to an elevation of approximately 25 feet National Geodetic Vertical Datum of 1929/1947 (NGVD) and will extend down into the fish mix layer for additional anchoring. TRM has already been applied in some areas.

Long-term institutional controls will not be required; however, an updated characterization of sediment conditions may be needed before any future activities that may result in significant sediment disturbance, such as in-water construction or dredging, are initiated.

1.4 Nearby Construction Projects

The Port is planning to construct roadway improvements between Division Street and Mill Street across a portion of the LRIS. The Port expects to begin construction activities in summer 2014. It is not anticipated that this construction will interface with construction of the sediment remedy in Lake River; however, if overland trucking of excavated sediments is required, the trucking route might interact with roadway construction at Division and/or Mill Street. The Port will coordinate with the contractor for the roadway improvements to ensure that continued access is provided for sediment-disposal trucks.

1.5 Permitting, Review, and Substantive Requirements for Sediment Remedial Action

Before the proposed work is initiated, the following notifications or authorizations must be acquired and the regulatory requirements met:

- Ecology’s approval of the final design
- Clean Water Act Section 404 permit and Section 10 Rivers and Harbors Act authorization—U.S. Army Corps of Engineers (COE). The Port submitted a Joint Aquatic Resources Permit Application (JARPA) to the COE for the Section 404 Permit on September 23, 2013.
- Demonstration of substantive compliance with the Clean Water Act Section 401 Water Quality Certification—Ecology Water Quality Division. The JARPA was provided to Ecology as a first step in the water quality certification process. The Port provided a draft water quality plan outline and draft monitoring plan for Ecology’s review. Ecology

provided comments on the draft water quality plan outline and draft monitoring plan; the Port has incorporated these comments into the water quality plan (See Appendix A).

- National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit—Ecology. The Port is preparing the application for the construction stormwater general permit to submit to Ecology. This application will include a site-specific stormwater pollution prevention plan.

- Right of Entry—Washington State Department of Natural Resources (DNR). The Port provided DNR with the JARPA on September 23, 2013.

- Demonstration of substantive compliance with the requirements of the Hydraulic Project Approval process—Washington State Department of Fish and Wildlife (WDFW). The Port provided WDFW with the JARPA on September 23, 2013. The Port, MFA, and Ecology met with WDFW to discuss the design on November 4, 2013. WDFW has yet to provide a list of substantive requirements.

- Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act consultation—National Oceanic and Atmospheric Administration Fisheries Service (NOAA-Fisheries). On November 20, 2013, the COE requested an informal consultation by NOAA-Fisheries under Section 7 of the ESA and the Magnuson-Stevens Fishery Conservation Act. The COE determined that the proposed project "may affect, not likely to adversely affect" ESA-listed species. As of this writing, NOAA-Fisheries has not issued a finding for this project.

- Demonstration of substantive compliance with applicable City of Ridgefield (City) code. The Port provided the City with the JARPA on September 23, 2013. The City issued a letter outlining which sections of the City's code would apply as substantive requirements for relevant City permits. The Port is preparing a narrative response outlining how the project meets these substantive requirements.

- Demonstration of compliance with the National Historic Preservation Act—COE and Washington State Department of Archaeology and Historic Preservation (DAHP). The COE has engaged DAHP and affected tribes. The remedial action likely will be conducted under a cultural resources monitoring plan. State compliance likely will be addressed through federal permitting requirements.

1.5.1 Contractor Work Plan Submittals

Prior to construction, the Contractor will be required to generate and submit a number of plans detailing their approach to the work and confirming their understanding and incorporation of the permit and project technical requirements. The work plans will be subject to review and approval by the Port and Ecology. A list of the work plans, and a reference to the specification section which details their requirements, is provided below:

- Submittal package identification (Section 01 33 00 – Submittal procedures).

- Environmental protection plan (Section 01 57 19 – Environmental protection).

- Corrective action plan for water quality action level exceedance (Section 01 57 19 – Environmental protection).
- Site plan layout (Section 02 00 00 – Mobilization and site preparation).
- Survey and bathymetry plan (Section 02 14 50 – Surveying and bathymetry).
- Structure and debris removal plan. (Section 02 41 00 – In-water structure and debris removal)
- Planting schedule (Section 32 93 00 – Planting).
- Watering plan (Section 32 93 00 – Planting).
- Dredge work plan (Section 35 23 16 – Dredging).
- Sediment transportation and transload work plan (Section 35 23 16 – Dredging).
- Dredge water handling and dewatering work plan (Section 35 23 16 – Dredging).
- Fill placement work plan (Section 35 42 00 – Fill).

2 EXISTING CONDITIONS

For the purposes of the remedial design, the bank and sediment areas of the site have been divided into two reaches, the downstream and upstream reaches. These are divided at station 11+25—the center of proposed work—on the project reference alignment (see Drawing C0.3). These reaches consist of five subreaches, which are identified based on the historical division of the property in different operational areas called cells. They consist of the Cell 2 north subreach, the Cell 2 archaeological subreach, the Cell 2 south subreach, the kayak launch subreach, and the Cell 3 subreach. The Cell 2 north and archaeological subreaches lie entirely within the downstream reach, and the kayak launch and Cell 3 subreaches lie entirely within the upstream reach. Each subreach requires a different approach to the remedial design, based on differences in bank geometry (see Section 3.6). The following descriptions of existing conditions reference the five subreaches that are shown on Figure 1-4.

2.1 Topography and Bathymetry

2.1.1 Topography

The upland portion of the site is generally flat, with elevations ranging from 11 feet to 37 feet NGVD. The 100-year floodplain elevation is approximately 23.5 feet along this reach of Lake River.

The elevation of the OHW line is 14 feet NGVD, as described further in Section 4.2 (COE, 2013). The elevation of the top of bank ranges from approximately 22 to 27 feet.

The topography of the site has been modified over the years by fill placement. As part of the RI/FS, aerial photographs taken between 1929 and 2004 were reviewed to determine the fill history of the site. The most recent fill was placed between 1966 and 1972. It is likely that fill initially was placed at the site in the early 1900s, when heavy industrial activity began in the area. The fill generally consists of sands with gravels, cobbles, wood, and metal debris.

In 2010, the bank on Cell 3 was cut back at a 2H:1V (horizontal to vertical) slope to form a shelf. Excavated soils were placed upland and the site was capped with clean soil. TRM was applied to the slope; this slope has been vegetated and has demonstrated stability since construction.

As part of an upland interim action in 2012, the steep bank in Cell 2 was cut back at a 6H:1V slope. This was done to stabilize the slope and provide pedestrian access to Lake River. Excavated soils were placed upland and the site was capped with clean soil.

2.1.2 Bathymetry

Lake River bathymetric surveys were conducted in 2004 and 2010 as part of the Port's planning activities. The bathymetric surveys included the entire length of Lake River adjacent to the upland portion of the LRIS. Surface sediment elevations were obtained during the 2010 RI sediment-sampling activities at specific locations and were consistent with elevations from the bathymetric surveys (Anchor and MFA, 2011). A bathymetric and topographic survey of Lake River was conducted by Minister-Glaeser in 2013 to inform the remedy design.

COE dredging records and existing bathymetry show relatively high deposition rates in Lake River in areas adjacent to the LRIS. Figure 2-1 shows the difference in Lake River mudline elevations from 1970 to the bathymetric survey completed in 2010. Based on files provided by the COE, the deepest dredging extent in Lake River adjacent to the LRIS appears to be from 1970. The 1970 survey is a post-dredge survey; based on available information, no maintenance dredging has taken place since then. The sediment thickness contours shown on Figure 2-1 are approximate because of the low survey measurement resolution in 1970 and the limited lateral extent shown by available data from the 1970 condition survey. Based on these evaluations, deposition rates in Lake River vary by location and can be up to 0.3 foot per year in the channel areas. Figure 2-2 shows the difference in Lake River mudline elevations from 2010 to the latest updated bathymetric survey completed in 2013. The depositional rates observed in this comparison are consistent with those observed between 1970 and 2010.

2.2 Stormwater

Stormwater from the LRIS either infiltrates into the ground, discharges to Lake River through five private outfalls, or discharges directly to Lake River by overland flow. The stormwater system is shown on Figure 2-3. The current stormwater system replaces the system removed as part of the upland remedial action undertaken to eliminate a source of contamination to Lake River. The outfalls are owned by the Port and serve primarily unpaved, soil-capped areas of the LRIS. The Port office building and paved parking area, as well as Division Street and the paved hard trails, are also served by the outfalls.

2.3 In-Water Structures, Debris and Obstructions

2.3.1 Structures and Debris

Known in-water structures in the project area include wooden piles, two wooden rails previously used to offload treated wood to barges, remnants of two treated-wood bulkheads, a wooden public access dock, the Port's pump house, a concrete boat launch ramp with a boarding float and transient tie-up, two "no-wake" buoys, and the City's wastewater treatment plant outfall pipe. These are identified on the existing conditions and targeted debris removal plans as structures to be protected or demolished (see Drawings C1.1, C1.2, C3.1 and C3.2).

2.3.2 Utility Crossings

There is one utility crossing in the vicinity of the dredging activities. An overhead power line at the end of Division Street crosses Lake River. The line is approximately 110 feet above the water surface. This utility crossing is shown on the existing conditions plans (Drawing C1.2).

2.4 Sediment Chemistry

As described in the CAP (Ecology, 2013a), the indicator hazardous substances in sediment at the site are dioxins. Dioxins are carcinogenic and are hydrophobic compounds that bioaccumulate in food chains; thus, these chemicals can cause adverse effects at low concentrations. The dioxin CUL established in the CAP is 5 ng/kg TEQ and the dioxin remediation level (REL) is 30 ng/kg TEQ. The dioxins are collocated with other contaminants in the sediment (i.e., pentachlorophenol, m&p cresol, and polycyclic aromatic hydrocarbons).

Concentrations of dioxins are generally highest in sediment located near former stormwater outfalls and decrease substantially with distance from the outfalls and the shore. Figure 2-4 shows the lateral and vertical distribution of dioxins above the CUL and the REL. Sediment chemistry and the identification of the remedial action areas are described in detail in the Lake River Remedy Predesign Sampling Report (MFA, 2013a).

2.5 Sediment Physical Parameters

Geologic and geotechnical investigations were conducted to evaluate the physical and mechanical properties of the sediments. These properties can greatly influence the dredging and handling processes and inform the ultimate project implementation procedures (PIANC, 2000). In addition, bench testing of sediment-handling methods was conducted.

The geology of Lake River sediment was described where borings were advanced (Anchor and MFA, 2011, and MFA, 2013a). Lake River surface sediment is characterized as fine sand and silt, ranging from silt with sand (ML) to silty sand (SM) to sand with silt (SP-SM), the relative quantities of which vary in different areas of Lake River. Generally, on the nearshore slope areas, the sediment is characterized as fine sandy silt to a depth of approximately 5 feet below mudline (bml); below this depth, sediment transitions to a fine to medium sand. Subsurface sediment in the channel area of Lake River is generally very fine sandy silt from the length of the core up to 11 feet bml. Fine to medium sand was encountered in two cores (LRIS-LR-02 and LRIS-LR-13) in the Lake River channel area at approximately 6 to 7 feet bml. Grain size data are summarized in Table 2-1 and the distribution of percent fines in surface sediment is shown on Figure 2-5.

Total organic carbon data were collected in the surface and subsurface and are summarized in Table 2-1. In surface samples, total organic carbon ranged from 0.34 to 3.2 percent, and, in subsurface samples, from 0.13 to 3 percent.

Additional physical parameters, i.e., moisture content, dry density, liquid limit, plastic limit, plasticity index, and permeability coefficient, were collected at locations representative of a variety of grain sizes and are summarized in Table 2-2. All sediment samples were found to be nonplastic, possessing no measurable cohesive properties. As a result, it can be expected that the sediment will behave as fine silty sand during handling.

In addition, bench testing of sediment-handling methods was conducted. Scaled handling processes were emulated using sediment from within the project area. "Apparent cohesion" (cohesion due to moisture surrounding the soil particles rather than the soil properties themselves) was noted during the bench testing. The results are provided in Appendix B and are used to guide sample-handling procedures discussed in Section 3.4.1.

2.6 Fluvial Setting

The low-flow velocity, bathymetric and historical analysis (see Section 2.1.2 and Figures 2-1 and 2-2), and percent fines distribution (see Figure 2-5) all indicate that Lake River is a predominantly depositional fluvial environment. Typically, fine-grained sediments (silts, clays) dominate in relatively low-energy environments where current velocities are low enough to allow fine particles to settle out of the water column and remain deposited. Coarse sediments (sands, gravels) are indicative of higher-energy environments where fines are kept in suspension in the water column and/or winnowed out of previously deposited material and transported away during high-energy events (e.g., floods, anthropogenic disturbances such as propeller wash and dredging). Figure 2-5 shows that fines content in most Lake River areas is generally high (> 40 percent) and can exceed 70 percent, indicating areas of deposition. Fines content is relatively low (< 20 percent) in several areas directly adjacent to former outfalls that discharged near the water/sediment interface, and likely caused some erosion in the past. For comparison, fines content in the relatively fast-moving midchannel portion of the Willamette River in the Portland Harbor Superfund Site is generally less than 20 percent, excluding areas known to be highly depositional (Integral et al., 2009). While local scouring may currently occur during large flood events and from propeller wash, the fluvial characteristics suggest that deposition occurs over most of Lake River's length.

2.7 Water-Dependent Site Activities and Expected Vessels

In the immediate work area as well as in the general area around Ridgefield, Lake River is heavily used for aquatic recreation. The Port operates two public launching facilities on the site: a public access ramp, typically used for kayak launch at the terminus of Division Street, and a recreational boat launch at the terminus of Mill Street. McCuddy's Marina operates at the upstream end of the site. Several floating homes are moored upstream of the site.

Various vessels (including canoes and kayaks, motorized personal water craft, and a variety of recreational power boats) use the river along this reach.

2.8 Biology and Habitat

Lake River is a tidally influenced, 11-mile-long channel on the Washington side of the Columbia River. The National Wetlands Inventory has classified Lake River as a riverine, tidal, unconsolidated bottom, permanent tidal habitat. Because of its proximity to the Columbia River, anadromous fish may use Lake River, and nearby areas may provide habitat for a diversity of species, including those in the following categories:

- Plants
- Shellfish
- Fish
- Reptiles and amphibians
- Birds
- Mammals

2.8.1 Plants

Lake River and adjacent areas support a variety of plant species. Three special-status plant species have been identified as potentially being present in the Carty Unit along which Lake River runs: water howellia (*Howellia aquatilus*), Bradshaw's desert parsley (*Lomatium bradshawii*), and Nelson's checker-mallow (*Sidalcea nelsoniana*) (MFA, 2003; U.S. Fish and Wildlife Service [USFWS], 2010). Oregon white oak woodlands are found along sections of Lake River both south and north of Ridgefield; this is a Washington State priority habitat potentially containing two plant species listed by the state as sensitive: the smallflower wakerobin (*Trillium parviflorum*) and the tall bugbane (*Cimicifuga elata*). Small patches (approximately 10 acres total) of unmanipulated upland grassland occur in oak woodland habitat in the Carty Unit adjacent to Lake River (USFWS, 2010). In addition, Washington State priority-designated palustrine aquatic habitats are present on stretches of Lake River (WDFW, 2011). Where Lake River passes high-impact areas such as the LRIS, vegetation such as reed canary grass, yellow marshcress, California false indigo, Himalayan blackberry, Pacific willow, Douglas fir, black cottonwood, and nonnative invasive shrub species are present (Ecological Land Services, Inc. [ELS], 2007; MFA, 2003). For a complete list of special-status plants that may occur in the vicinity of Lake River, see Table 2-3. This list is not specific to Lake River, but does encompass special-status plants that may potentially occur in the vicinity of Lake River.

2.8.2 Shellfish

Exotic mollusks carried in ship ballast (e.g., Asian clam [*Corbicula fluminea*]) are a potential threat to rivers and wetlands connected to the Columbia River. The Asian clam is abundant in some areas of the RNWR but was not found during sampling attempts by USFWS in 2000 (Buck, 2000). WDFW (as cited in Ecology, 2011) also reported no recreational take of shellfish from the Columbia River in 2006. Crayfish likely are present in Lake River. No native shellfish found in Lake River are currently listed as special-status species to be considered for conservation and management (USFWS, 2010; WDFW, 2011).

2.8.3 Fish

More than 40 species of fish have been documented in the RNWR, Lake River, and other waterways that flow in and around the RNWR (USFWS, 2010). Fish known to occur in Lake River include common carp, largescale sucker, channel catfish (introduced), Pacific lamprey, mountain whitefish, brown trout (introduced), chiselmouth, longnose sucker, and sandroller. Because the RNWR is located along the lower Columbia River, listed anadromous fish may occur in Lake River at certain times of year. Special-status species may also be present in Lake River; see Table 2-4 for a complete list of special-status fish that may occur in the vicinity of Lake River. This list is not specific to Lake River, but does encompass special-status fish that may potentially occur at Lake River.

2.8.4 Reptiles and Amphibians

Lake River and the RNWR provide riparian and wetland habitat for a variety of reptiles and amphibians. Reptiles and amphibians known to occur in the RNWR include the bullfrog (introduced), northern red-legged frog, western chorus frog, northwestern salamander, long-toed salamander, and western painted turtle. Special-status species may also be present in Lake River; see Table 2-5 for a complete list of special-status reptiles and amphibians that may occur in the vicinity of Lake River. This list is not specific to Lake River, but does encompass special-status reptiles and amphibians that may potentially occur at Lake River.

2.8.5 Birds

Various bird species are present and common along Lake River because of its proximity to high-quality habitat at the RNWR. Washington State-designated priority waterfowl habitat occurs along the entire length of Lake River. Waterfowl representing more than 30 species use the RNWR during winter or as a stopover site during spring and fall migrations. Twelve species of waterfowl are known to breed on the RNWR. Wintering species include Canada geese, cackling geese, tundra swan, mallard, American wigeon, gadwall, northern shoveler, northern pintail, and green-winged teal. Special-status sandhill cranes occur along portions of Lake River. The RNWR also attracts significant numbers of diving ducks such as ring-necked duck, lesser scaup, and bufflehead. Common waterbird species that use RNWR wetlands along Lake River include coot, pied-billed grebe, double-crested cormorant, great blue heron, great egret, ring-billed gull, California gull, Thayer's gull, and glaucous-winged gull. The riparian and floodplain forests adjacent to Lake River host breeding terrestrial species, including commonly seen resident and migrant species such as downy woodpecker, northern flicker, western wood-pewee, Pacific slope flycatcher, tree swallow, common bushtit, Bewick's wren, American robin, Swainson's thrush, cedar waxwing, common yellowthroat, Wilson's warbler, spotted towhee, song sparrow, and black-headed grosbeak. WDFW priority-designated purple martin foraging areas are present near Lake River. The RNWR's oak woodlands along Lake River provide habitat for oak-associated landbird species that are now rare in western Washington, including the slender-billed white-breasted nuthatch, western scrub jay, and house wren (USFWS, 2010). As many as 50 bald eagles have been sighted using riparian trees on or near the RNWR for roosts from December through March, and at least six pairs are known to nest and breed within approximately 1 mile of Lake River. Eagles regularly roost along the section of Lake River from the River "S" bridge north to the Ridgefield marina, and forage extensively on waterfowl within refuge boundaries (USFWS, 2010; WDFW, 2011). For a complete list of special-status birds that may occur in the vicinity of Lake River, see Table 2-6. This list is not specific to Lake River, but does encompass special-status birds that may potentially occur at Lake River.

2.8.6 Mammals

The RNWR is home to at least 23 verified species of mammals. American beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), common opossum (*Didelphis marsupialis*), and nutria (*Myocastor coypus*) commonly inhabit wetlands along Lake River in the RNWR. Omnivores, including coyote (*Canis latrans*), raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*), as well as carnivores such as mink (*Mustela vison*), are frequently seen along the Lake River shoreline. The most common large mammal occurring on the RNWR is the black-tailed deer (*Odocoileus hemionus columbianus*). Priority-designated white oak woodlands near Lake River may provide habitat for the special-status western gray squirrel (*Sciurus griseus*), although the presence of this species has not been confirmed (USFWS, 2010).

In December 2012, the USFWS proposed an emergency translocation of rare Columbian white-tailed deer (*Odocoileus virginianus leucurus*) to the RNWR from the Julia Butler Hansen Refuge near Cathlamet, Washington (USFWS, 2012). Columbian white-tailed deer are listed under the federal ESA as an endangered species. Emergency relocation of the deer to the RNWR began in January 2013.

For a complete list of special-status mammals that occur or that are likely to have occurred historically in the vicinity of Lake River, see Table 2-7. This list is not specific to Lake River, but does encompass special-status mammals that may potentially occur at Lake River.

2.8.7 Habitat

Existing habitat along the LRIS section of Lake River is generally of poor quality. In 2007, ELS performed a Critical Areas evaluation and a riparian habitat inventory for the Port (ELS, 2007). This inventory was conducted for the entire length of the proposed work area.

Lake River is classified by the National Wetlands Inventory as a riverine, tidal, unconsolidated bottom, permanent tidal habitat. ELS did not identify riverine wetlands associated with the Lake River habitat along the eastern shoreline of Lake River.

Riparian habitat was evaluated using the Clark County habitat conservation ordinance Riparian Habitat field rating form. This habitat received 11 out of a possible 48 points for fish habitat functions. ELS found that "the vegetation on-site provides little cover, there are no springs contributing to the main water channel, and there are no associated wetlands. The area had no observed influence over water flow, dissolved oxygen, or temperature. There are no pools or off channel habitats in which amphibians and fish may breed."

2.8.7.1 Riparian Enhancement and Mitigation Summary

The remedial action was designed to create a net benefit to the environment and will involve dredging and excavation of contaminated sediment in areas exceeding RELs, placement of clean sand to control sediment residuals and enhance the recovery of low-level contamination, and stabilization of the bank.

Mitigation sequencing has been incorporated throughout the project's design process, which has been overseen by Ecology. To effectively stabilize the bank, predominantly nonnative and some native vegetation will be removed or covered. Removal of native shrubs and trees will be offset through revegetation of the riverbank with natives following construction. The landscape plan is provided in Section 3.7.

3 REMEDIAL ACTION DESCRIPTION AND METHODS

As indicated above, the remedial action consists of in-water and bank activities, up to and beyond OHW. Preparation of the site for remedial activities includes constructing a staging area, clearing the bank of vegetation and debris, and removing structures and debris in water. Remediation of the contaminated material entails dredging, dewatering, and transporting sediment to a disposal facility; placing clean sand over low-level contamination and dredging-generated residuals; and stabilizing the bank. Upon completion of contaminant remediation, the bank will be planted with native vegetation and monitoring will be conducted to confirm compliance with performance criteria. The remedial action elements are further described below.

3.1 Site Preparation and Erosion and Sediment Control

Site preparation will begin prior to in-water sediment remediation activities. Generally, site preparation will include the construction of a staging and sediment-handling/dewatering area. The clean soil cap section and demarcation fabric, placed during the upland remedial action, will be removed (see Drawing C1.3). Two ramps will be constructed from clean, imported crushed rock to provide for contractor ingress and egress. A truck tire wash will be constructed to allow for the removal of mud before vehicles leave the site. Concrete barriers (jersey barriers) and silt fence will be placed around the perimeter of the area to prevent sloughing of the adjacent clean soil cap as well as to provide a relatively immobile and visible demarcation of the work area. Crushed rock will be placed to provide an operational surface. This sediment-handling area will be constructed during the summer of 2014 as part of a separate remedial action (i.e., the Carty Lake sediment remediation) to allow the area to be used for both sediment remediation projects. Following completion of the Lake River sediment remediation project, demarcation geotextile will be placed over the operational surface and contaminated soil, and the minimum 2-foot-thick clean soil cap will be restored (see Drawing C6.0.3). The area will be seeded with native grasses to provide long-term erosion control.

Installation of erosion and sediment controls will be consistent with the BMPs described in the Stormwater Management Manual for Western Washington and with the requirements of the Ecology 1200-C NPDES permit for construction activities, which will be obtained before the start of construction. Erosion- and sediment-control plans and details are shown on Drawings C2.0.0 through C2.1.1.

3.2 Clearing and Grubbing

Prior to dredging and bank stabilization, upland areas on the bank, within the limits of work, will be cleared and grubbed.

Invasive species are known to be present and will be removed. General brush and vegetation will be containerized and transported to a composting facility. Some invasives, such as Himalayan blackberry, may be treated with herbicides by a licensed applicator prior to clearing and grubbing.

In accordance with the Migratory Bird Act, the Port will not begin the removal of bank vegetation until areas are determined to be devoid of migratory-bird nests.

Debris encountered during site clearing activities will be removed as directed on the plans and in the field by the engineer and will be handled in accordance with Section 3.3, below.

3.3 Removal of Structures and Debris

Before dredge operations begin, existing in-water structures will be demolished. There are few remnants of infrastructure from former LRIS river operations; however, some dolphins and pilings are located in the sediment remediation area. Demolition and debris removal will be performed in a deliberate and controlled fashion before dredging operations, limiting the opportunities for the resuspension of easily erodible sediment through encounters with the dredge.

Known structures and debris slated for removal are shown on Drawings C3.1 and C3.2. A multibeam survey was performed in March and April 2013 and was reviewed in detail to identify surface anomalies indicating the presence of debris. In addition, during a low-water period in September 2013, MFA conducted a visual inspection for additional debris not mapped on the multibeam survey.

Debris will be removed with chokers or by similar means, using divers where necessary. Where debris is too cumbersome for removal by chokers or straps, a toothed bucket may be employed, upon approval from the engineer. Debris booms will be used during removal activities. A tender boat will be on hand during all debris-removal operations to retrieve any loose debris freed in the process. Debris under the mudline encountered during dredging will be removed by the precision dredge bucket (see Section 4.3 for description) or by a traditional open clamshell bucket, equipped with teeth on each jaw, deployed from a barge-mounted crane.

Pilings in the dredge and enhanced natural recovery (ENR) area identified for removal on the Drawings will be pulled using either vibratory extraction methods or a barge- or land-based crane using chokers or straps. Following completion of the remedial action, the pilings and former kayak dock may be replaced by the Port.

All pilings and debris generated from the removal and demolition effort will immediately be placed into a material barge or placed upland and properly contained. The material will subsequently be disposed of appropriately. Pilings in the work area appear to be treated wood, which is excluded from Dangerous Waste regulations under WAC 173-303-071; therefore, it is eligible for disposal at a Subtitle D municipal solid waste landfill in accordance with WAC 173-351.

Any other structures or debris found in the work area during dredging will be decommissioned as part of the proposed project. This will involve breaking, cutting, and dismantling of the structure(s) for removal and off-site disposal and/or decommissioning features in place. Inert materials may be left in place and backfilled or may be excavated and handled consistent with Section 3.3. It is believed that most structures were either previously removed or were located outside the work area and will not be encountered during dredging work. Ecology will be notified if any currently unknown structures are encountered and removed.

Dredging near the footprint of the existing pump house will be performed with care. The risk to the existing pump house from nearby dredging of approximately 1 foot of sediment was evaluated by geotechnical engineers at GeoDesign, Inc. (GeoDesign); the risk from this work was determined to be negligible (see Appendix C).

3.4 Dredge Removal of Sediment

The dredge area represents approximately 3.3 acres of surface area. The expected maximum dredge volume, accounting for overdredging (see Section 4.5.3) and constructability considerations, represents approximately 13,400 cubic yards. The predesign sampling report (MFA, 2013a) presents a rationale for the development of the dredge prism. The target dredging elevations are comprised by the neatline dredge prism and represent the vertical extent of contaminated sediment exceeding 30 ng/kg dioxin TEQ (MFA, 2013a). The analysis shows that, given the limited vertical distribution of dioxins, significant undisturbed residuals below the dredge target are unlikely. Sample depths that are measured from the mudline have been translated to NGVD elevations to establish the elevation of contamination and to develop the neatline dredge prism (see Section 4.5.3). The elevations reflect allowances for overdredging and for inaccuracies resulting from sediment compaction during sampling (see Section 4.5.2).

A removal grid was developed, based on the neatline dredge target, for use by the contractor to enhance the precision removal method. The grid is a digital representation of each bucket (6 feet by 7 feet) to be removed within the entire dredge prism. The dimensions of each grid cell are smaller than the actual bucket dimensions. This provides for overlap between adjacent buckets (on all sides) during sediment removal (see section 4-X). The grid will be used with dredging software and a real-time kinematic global positioning system (RTK-GPS) during dredging to verify that sediment removal is proceeding as intended. Each grid target identifies the desired dredge elevation that can be read by the operator and visualized on the dredging software in three dimensions.

Dredging will be performed using precision dredge methods, which include:

- Fixed-arm articulated dredge (barge-mounted excavator) on shallow draft spud barge
- Double-arc, fully enclosed 4-cubic-yard clamshell rehandling bucket with vents at the top and hydraulic articulation control
- RTK-GPS positioning control
- Dredge software that is capable of real-time tracking, monitoring, and reporting of the bucket position in all axes, as well as allowing for seamless integration of survey data

Dredging will be conducted in a controlled manner that minimizes contaminant release / resuspension and formation of residuals. The precision dredging method is considered to be a BMP for reducing turbidity in the water column and the potential for off-site migration of contaminants. As mentioned above, fixed-arm equipment (excavator) using double-arc closing environmental buckets will be used to complete the sediment removal. This specialized equipment provides multiple advantages (discussed in more detail in Section 4.3) over conventional clamshell environmental buckets mounted on derrick-type dredges.

Dredging will be conducted using a multiple-pass removal method requiring a minimum of two passes; the initial pass(es) will remove most sediment, and the final pass, considered a cleanup pass, will remove sediment to the neatline prism boundary or beyond (see Section 4.3). The cleanup pass will be made as many times as necessary to reach the design neatline elevations; the number of passes will depend on the results of the verification surveys.

Approval units (AUs), each consisting of 7 by 8 bucket grid cells (49 by 48 feet square), have been developed in order to track and communicate progress during the project. The contractor will dredge the area in each AU to the required elevation and then obtain a verification survey to demonstrate that the elevation has been met. Once the AU dredge surface has been approved by the engineer, the contractor will be allowed to place the ENR layer in the AU.

Dredging will generally proceed upstream to downstream and nearshore to farshore, as practicable. The operator will lower the dredge bucket to the dredge surface in a controlled fashion, guided by the dredge software with up-to-date bathymetry loaded into the program. The software will allow for the bucket location to be visualized in the x, y, and z dimensions and ensure that the bucket is closed, without overfilling, at the intended location and elevation. Once the bucket has fully closed, it will be brought to the surface and carefully opened over the material barges. Each material barge will be constructed such that dredge water is kept within the binwalls, and overtopping these walls will not be allowed. The material barges will be dewatered during the dredging process (as described in Section 3.4.1) and the water pumped upland to a treatment facility.

Once a material barge has been fully loaded, sediment will be transferred to either an upland, on-site facility or transported by barge to an off-site, transload facility (see Section 3.4.2). Sediment that has been transferred from the material barge will be disposed of at an approved Subtitle D landfill.

3.4.1 Sediment Dewatering

Because of the nature of the required enclosed bucket, a substantial amount of retained free water will be removed from the river and placed in the material barges during dredging operations. The quantity of this water can vary; the ratio of sediment to water in the bucket is proportional to the thickness of the sediment layer to be removed (Fuglevand and Webb, 2006). No dredge water will be allowed to overtop the binwalls; therefore, removal of excess water from the sediment will be required during dredging operations and before disposal. MFA has estimated the volume of water to be generated at the Lake River bank and sediment remediation site, using the method developed by Fuglevand and Webb, along with case studies (Fuglevand and Webb, 2006). This water will be pumped to a contractor-designed upland treatment system sized according to the volume estimation method cited above. The performance requirements for this contractor-designed treatment system are focused on the removal of turbidity. The treatment system will also include activated carbon effluent polishing to remove organic contaminants, as requested by Ecology (Ecology, 2014).

If dredged sediment is transported to a disposal facility overland by truck (as opposed to over water by barge; see Section 3.4.2.), sediment will be placed in an upland dewatering area on site. Upon placement upland, sediment will be evaluated to determine whether additional dewatering is required. The elimination of free water is desirable both because it is a regulatory requirement for landfilling solid waste and because the added water mass can represent a significant increase to the cost for disposing of sediment. Unless the landfill facility has a waiver, the dredged sediment will have to pass the Paint Filter Liquids Test (U.S. Environmental Protection Agency Method 9095B) before transport and disposal at the landfill. In this case, the contractor may mix approved admixtures (such as Portland cement, quicklime, perlite, Zapzorb) into the sediment to reduce free liquid. Initial pilot testing (see Appendix B) indicates that quicklime added at 10 percent by weight to severely remolded/loose sediment will result in a matrix dry enough for transport and disposal.

Any free liquid that drains from sediment in the dewatering area will be collected and treated through the contractor-designed system for turbidity before discharge back into Lake River in the dredge area. Consistent with Ecology requirements (Ecology, 2014), treated water will be sampled for turbidity, benzo(a)pyrene, and pentachlorophenol twice during the first week of treatment system operation and then once per month until the end of operation. The contractor-designed system will include activated carbon polishing to limit discharge of dissolved-phase organic chemicals.

3.4.2 Sediment Transport and Disposal

The transportation of dredged sediment from Lake River to the landfill will be by trucks and/or barges. The specific method of transport used will depend on multiple factors including, distance to the proposed landfill, available truck or river routes, and the river stage during the authorized in-water work window. The appropriate method of transport will be proposed by the contractor; however, certain operational controls will be required as BMPs for this project. The contractor will be required to submit a sediment transportation and transload work plan that provides appropriate detail with regard to method, route, BMPs, and other controls.

Dredged material will be disposed of as nonhazardous material at a Subtitle D landfill. The dredged material was reviewed for waste designation purposes, and the dredged material could not be designated as either a Resource Conservation and Recovery Act (RCRA)-listed hazardous waste or a RCRA characteristic waste. The dredged material is designated as a nonhazardous waste.

Under both transport scenarios, the contractor will use appropriate controls to prevent spillage or loss of sediment during transport, as discussed below. Any spills will be cleaned up promptly.

3.4.2.1 Barge Transport

Barge transportation of waste material could be a practical option for this project because all dredged sediment must first be loaded onto a material barge. The material barge can be moved to an unloading berth for upland handling on site (Section 3.4.2.2), or out to the Columbia River for off-site transload if water transport is planned. The ability to navigate the mouth of Lake River to the Columbia River is a significant concern associated with the selection of water transport. Higher water levels, typical of late winter months (January and February) and early summer months (May and June), would allow free passage of a loaded barge through the mouth of Lake River to the Columbia River. At lower water levels, navigation through this area may require the timing of transits to coincide with high tide or restricting the load on each barge to reduce the total draft (see the barge draft analysis in Appendix D). Low water levels, typical of early fall (September and October), likely would require on-site offloading of sediments for overland truck transport to the landfill. An additional factor affecting the selection of a transportation method is the number of barges available to the contractor versus the number of barges that would be required to optimize the loading, transport, and delivery of dredged sediment.

Should water levels allow for river transport, loaded scows containing approximately 800 to 1,200 cubic yards of moderately wet sediment will be transported downstream to the confluence of Lake River and the Columbia River. From there they will be transported to a transload facility associated with an appropriate landfill. This method could include an intermediate step to consolidate sediment into larger barges for transport to the transload facility.

BMPs would be in place to keep sediment from entering, or reentering, the waterway during the transfer of all sediments from barges. These BMPs would be closely monitored by oversight personnel. Barges would be situated to prevent the bucket transferring sediment from swinging over open water. Tarps, plastic sheeting, or rigid deflectors would be deployed between adjacent barges to catch any potential dropping sediment during the swing of the transfer bucket.

At the transload facility, sediment would be removed from the barge, conditioned, and then placed in trucks for short-haul disposal at the Subtitle D landfill facility. Conditioning of the sediment may be required in order to achieve the appropriate moisture content and consistency for disposal, and may require the use of absorption or drying additives.

The landfill transload facility would have BMPs in place consisting of, at a minimum, barriers to prevent contaminated sediment from entering the waterway. These could include a sealed holding cell, tarps or liners placed beneath the swing path of the bucket, and generally accepted upland erosion-control BMPs. The contractor would be required to submit the facility operating procedures describing BMPs in place to prevent the release of contamination during transload. Should any construction be necessary at the transload facility in order to accommodate the offloading of sediment, additional permits could be needed and would be obtained by the facility receiving the material. Any project-specific off-site construction and BMPs would also be subject to Ecology review.

3.4.2.2 Truck Transport

Truck transportation of waste materials is the most common form of transport for remedial projects. For this project, truck transport would require the construction of an on-site transload facility. Dredged sediment would be offloaded. Trucks would be required to be lined with a sealed plastic liner to prevent drippage and then covered with a tarp once full. Trucks would exit the loading area by way of a wheel wash to remove mud before they proceed on an existing truck route through downtown Ridgefield and out Highway 501 to Interstate 5.

If truck transportation is selected, the loaded scows will be moved to an offload berth predredged by the contractor and located adjacent to the on-site upland handling facility. The location of the offload berth will be selected in consultation with the engineer and the Port and will be designed to meet draft requirements for the loaded material barges. If constructed, this berth may require a deeper cut than the currently planned neatline dredge prism. Mooring piles would be driven in this area and could be placed such that they remain after the work is completed to provide structure for a future dock.

Sediment will be offloaded from the scow in an appropriately hygienic manner and placed in the sediment handling/dewatering area for any conditioning necessary for achieving the appropriate moisture content and consistency for disposal; such conditioning may require the use of drying additives. BMPs for upland transload will include, at a minimum, a spill management mechanism (e.g., tarps, liner, or other shield) below the swing path of the bucket to contain any dripping sediment. A transload, transport, and disposal work plan will be developed by the contractor, subject to review and approval by the engineer and Ecology, before the start of site activities. Additional BMPs consistent with upland construction erosion-control methods will be in place during the construction project at the upland sediment-handling/dewatering area (see the water quality plan, Appendix A). Conceptual sediment-handling cells are shown in plan view on Drawing C2.0.1; a typical section is shown on Drawing C2.1.0.

Once conditioned, sediment would be loaded into trucks for overland transport to a disposal facility. This operation would result in significant truck traffic through the town of Ridgefield to I-5.

3.5 Enhanced Natural Recovery Sediment Layer

To minimize the possibility of mobilizing any generated residuals and to reduce their contaminant concentration following dredging, an ENR layer, composed of approximately 1 or 2 feet of clean river sand, will be placed over the dredged surface and selected adjacent areas. Approximately 12,600 cubic yards of sand will be imported to the site for placement. The source of clean sand will be prescreened for chemical criteria consistent with Table VI in WAC 173-204-563 (sediment management standards) to determine acceptability.

The ENR layer will provide an enhancement to the natural process of deposition that will occur over time (long term). It is assumed that, in the long term, the ENR layer will mix with underlying sediment and further lower the residual contaminant concentrations (Palermo et al., 2008).

ENR will be placed in Lake River by mechanical means, likely using a barge-mounted crane (or similar) and a rehandling clamshell bucket. ENR will be placed in AUs of the same size and, where applicable, coincident with dredge AUs. The bucket will be held just above the water surface and will be slowly opened while translating laterally across the AU. The ENR sand layer will be placed over most of the site to a thickness of approximately 1 foot. A minimum of 2 feet of ENR sand will be placed over the deepest dredge area (see Drawing C4.1.0). Sand for ENR will be placed over dredged areas (and any resulting residuals) as well as over areas not dredged but with preremediation concentrations greater than 5 ng/kg dioxin TEQ.

It is expected that placement of ENR sand over the dredge area will effectively lower the final surface sediment contaminant concentration to meet the CUL on an areawide basis. The ENR sand layer will have near-zero initial contaminant concentrations and, as mentioned above, will be placed at a thickness of approximately 1 foot (2 feet in a selected area). An analysis contained in the RI/FS (MFA, 2013b) estimates that the final residuals layer will be substantially thinner (between 0.16 and 0.35 foot thick) than the 1-foot-thick ENR layer that will be placed over it. Mixing of the leave surface and the ENR layer is expected to drive the final surface concentrations (if any) toward that of the clean sand rather than those in the potential residual layer.

ENR sand that is placed soon after dredging will physically cover potential residuals and prevent movement to other areas as construction continues. Placement of ENR sand should be delayed until the dredge operation has moved 3 AUs (approximately 150 feet) from the approved placement unit in order to reduce the potential for surface contamination of the clean ENR sand layer.

3.6 Bank Protection and Cap

A layer of erosion-resistant fish mix and geotextile fabric will be placed to support the bank along the length of the LRIS. Fish mix will be placed at a slope no steeper than 4H:1V with a minimum 2-foot thickness. The fish mix stabilization layer is a well-graded mixture of river cobble and gravel. The larger cobbles will provide more significant structure for supporting the bank and resisting bank erosion, while the small gravels will fill voids between the larger rocks to provide a consistent and stable surface. The geotextile fabric that is placed under the rock will act as a filter to prevent potentially impacted bank soil from being washed out into Lake River and recontaminating the river bottom. In total, a maximum volume of 12,300 cubic yards will be placed below OHW and 860 cubic yards will be placed above OHW.

3.6.1 Cell 2 North Subreach Bank Protection

In the north area along Cell 2, fish mix will be placed at a maximum 5H:1V slope and a minimum 2-foot thickness on the lower bank from the toe of the bank slope to an elevation of approximately 12 feet NGVD. Above 12 feet NGVD, fish mix will be transitioned at a less-than-2-foot thickness to the existing clean soil cap grades. It will be placed on a filter layer consisting of filter fabric to prevent erosion of underlying impacted bank soils. See Figure 3.1 and Section 1 on Drawing C4.1.0 for a typical section through the Cell 2 north subreach bank. TRM will be placed on the existing clean soil cap from the fish mix to the top of the bank (approximately elevation 24 feet NGVD).

3.6.2 Cell 2 Archaeological Subreach Cap and Bank Protection

During a 2012 interim action, archaeological items were found approximately midway along the bank in Cell 2. The protection plan developed by Archaeological Investigations Northwest (AINW) on behalf of the Port, and approved by the DAHP, prescribed protection in place (AINW, 2012). The upland bank excavation was stopped above the design subgrade elevations. As a result, the slope down to Lake River is steeper in this area and will require additional rock to stabilize the slope and prevent erosion and the release of both contaminants and artifacts.

In the archaeological area of Cell 2, fish mix will be placed at a slope of 4H:1V and a minimum depth of 2 feet on the bank from the toe of the bank slope to elevation 17 feet NGVD. Fish mix will be placed on a filter layer consisting of filter fabric to prevent erosion of underlying bank soils. See Figure 3.2 and Section 2 on Drawing C4.1.0 for a typical section through the Cell 2 archaeological subreach bank. Additional clean soil cap material may be placed on top of the archaeological area (above OHW) once the fish mix is in place to provide a better transition to adjacent clean cap grades. TRM will be placed over the additional clean soil material from the fish mix to the top of the bank (approximately elevation 24 feet NGVD).

3.6.3 Cell 2 South Subreach Bank Protection

In the southern portion of Cell 2, fish mix will be placed at a slope of 4H:1V and a minimum depth of 2 feet on the lower bank from the toe of the bank slope to an elevation of approximately 12 feet NGVD. Fish mix will be placed on a filter layer consisting of filter fabric to prevent erosion of underlying bank soils. Above 12 feet NGVD, fish mix will be transitioned at a less-than-2-foot thickness to the existing clean soil cap grades. See Figure 3.3 and Section 3 on Drawing C4.1.0 for a typical section through the Cell 2 south subreach bank. TRM will be placed between the fish mix and the top of bank (approximately elevation 26 feet NGVD).

3.6.4 Kayak Launch Subreach Cap and Bank Protection

In the area of the existing kayak launch, a minimum of 2 feet of fish mix will be placed from the toe of the bank slope to approximately 10 feet NGVD. Because of the existing grade, the final slope of this area is not expected to exceed 5H:1V in this subreach. Fish mix will be placed on a filter layer consisting of filter gravel and/or filter fabric to prevent erosion of underlying bank soils.

Between elevation 10 and 14 NGVD, fish mix will be topped with approximately 6 inches of crushed gravel to provide a functional extension of Division Street for recreationists. This area between Cells 2 and 3 was not capped during the interim actions above elevation 14, and therefore 1.5 feet of clean soil will be placed prior to the placement of the crushed gravel layer. The minimum thickness of the composite clean soil and crushed gravel cap will be 2 feet, in accordance with the CAP. The cap will extend up to the existing pavement at the western terminus of Division Street. Some minor soil excavation will be required near the western terminus to ensure that the minimum cap thickness is maintained to the limits of the existing asphalt cap. This excavated sediment will be placed and compacted in the upland staging, sediment handling, and water treatment area before restoration of the clean soil cap. See Figure 3.4 and Drawing C4.1.1 for a typical section through the kayak launch subreach bank.

3.6.5 Cell 3 Subreach Bank Protection

Along Cell 3, fish mix will be placed at a slope of 4H:1V and a minimum depth of 2 feet on the lower bank from the toe of the bank slope to the existing shelf (approximately 12 feet NGVD). Fish mix will be placed on a filter layer consisting of filter gravel and/or filter fabric to prevent erosion of underlying bank soils. Fish mix will be placed at a slope of no greater than 4H:1V. See Figure 3.5 and Drawing C4.1.1 for a typical section through the Cell 3 bank.

3.7 Landscaping Plan

The proposed landscaping along the former PWT property riverbank is intended to improve the physical characteristics of the riverbank and establish a native plant community. The new plantings will include native groundcover grasses and perennials, shrubs, and trees common to the area. The planting areas are located on the riverbank, generally between OHW and the gravel trail in the Cell 2 north, Cell 2 archaeological, and Cell 3 subreaches (see Drawings L1.0 and L1.1). The planting plan has been designed to cluster native trees and shrubs into three distinct groves to provide structural diversity while protecting scenic views. The planting groves span approximately 500 lineal feet. The open areas between the groves are planted or will be planted with native grasses. The total native plant area will extend the length of the LRIS bank (approximately 1,750 feet) and will be approximately 2.7 acres.

3.7.1 Planting Medium

The soil preparation specification for all areas planted with trees and shrubs includes a minimum percentage of organic carbon content for the upper 8 inches of the topsoil. A soil test will be completed prior to construction to provide an analysis of the existing soils in the proposed planting areas. The contractor will be required to demonstrate that the topsoil meets the ASTM D5268 Standard Specification for Topsoil Used for Landscaping Purposes, which identifies the correct nutrients and pH status for healthy plant growth.

3.7.2 Native Plant Hydroseeding

All proposed planting areas in the Cell 2, kayak launch, and Cell 3 subreaches will be hydroseeded. Hydroseeding will be sprayed directly into the TRM to increase erosion resistance, as well as directly onto the soil in the planted areas that extend above the gravel trail. Three native, drought-tolerant seed mixes will be used. One is an upland native mix of taller native grasses and herbaceous material that will cover much of the bank between the native tree and shrub groves. The second is an upland native mix of grasses and perennials that will be used in each of the proposed groves. The third is a blend of lower-growing native grasses that will provide opportunities for users to comfortably access the river.

3.7.3 Native Tree and Shrub Clusters

As described above, three distinct clusters above OHW will be planted with a combination of native trees, shrubs, grasses, and perennials. The proposed trees will include western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), Oregon ash (*Fraxinus latifolia*) and Pacific willow (*Salix lasiandra*). The proposed shrubs will include Pacific ninebark (*Physocarpus capitatus*), red twig dogwood (*Cornus sericea*), red flowering currant (*Ribes sanguineum*) and Nootka rose (*Rosa nutkana*). The entire plant list, spacing, size, and locations are identified on Sheet L1.1. Each of these species was specifically chosen for its shallow rooting characteristics to avoid the extension of roots beyond the newly restored, clean soil cap. The proposed planting will greatly increase the native plant diversity and complexity compared to the existing conditions. All of the native planting clusters will be hydroseeded immediately after the soil cap is completed in spring of 2014. Additional hand seeding may be required after planting of the trees and shrubs.

3.7.4 Irrigation

The proposed native plantings will be irrigated for the first two dry seasons or until the plants are established and able to survive without supplemental water. Irrigation will be provided by a drip-irrigation system with pre-installed emitter tubing in evenly spaced rows and/or hand-watering.

3.8 Compliance Monitoring

Long-term monitoring will be conducted in order to assess the effectiveness of the remedy. Confirmation sampling will not be conducted upon completion of dredging. The planned post-dredge surface was well-characterized before the project design was finalized, and the dredge prism was conservatively designed to remove contaminants. The estimated post-dredge and post-remedy (dredging and ENR placement) dioxin concentrations are shown in Figures 3-6 and 3-7, respectively. A baseline assessment of dioxins in surface sediment in the remedial action area will be conducted shortly after completion of the remedy, i.e., dredging and ENR placement. Monitoring for dioxins in the remediation area will be conducted at the end of years two, five, and ten, after baseline sampling. Specifics of the sampling and monitoring will be developed as part of the monitoring plan. The need for subsequent sampling events will be determined by Ecology if after review of year ten sampling there are indications that concentrations could increase above expected levels. Post-remedial monitoring sampling will be conducted in a way that ensures that results are reproducible, to the extent practicable, and that results and temporal trends can be established.

3.9 Construction Verification Methods

During construction, removal of sediment and placement of ENR will be tracked and verified using a number of methods. As previously mentioned, RTK-GPS will be employed to observe the dredging work in real time, as well as to track the progress and removal accuracy. Additionally, field verification methods, pilot tests, volume tracking, and topographic and bathymetric surveys will all be employed and used in combination to track quantities, thicknesses, placement, and general work progress.

3.9.1 Dredging

Multibeam bathymetric surveys will be obtained pre- and post-dredging to verify removal of sediment to at least the predetermined neatline dredge prism. The verification surveys will be compared to the target removal elevation and will be analyzed for completeness before the placement of sand for each AU is approved. To obtain approval for backfill, 95 percent of the line and grades provided on the neatline dredge prism must be met. An AU will not be accepted if any of the following conditions exist:

- More than 5 percent of the AU elevation is above the neatline dredge prism elevation.
- The AU contains high spots more than 6 inches above the neatline dredge prism.
- The AU contains high spots of more than 10 contiguous square feet.

Difference plots showing the pre- and post-dredge elevations will be created in Civil3D and used to verify that the specified elevations have been substantively met.

The contractor will be responsible for tracking the progress of work during the dredging operations, using soundings, lead line, bathymetric survey, or other appropriate methods taken "behind" the dredge as work progresses; those progress soundings will be shared and discussed with the oversight engineer. When the contractor believes that the suitable line and grades have been met, the approval survey will be initiated.

3.9.2 ENR Placement

Because of the potential low strength properties of the sediment that may be left behind the dredge (see Section 2.5 and Appendix B), multibeam bathymetry likely will be ineffective in detecting the addition of 1 foot of sand placed after dredging. The sand has a potential to consolidate the upper level of leave sediment, leading to a discrepancy between actual volume and thickness of sand and what is detected by the bathymetric survey. Placement of the ENR sand will be tracked during construction by observation of construction methods paired with monitoring of the total volume of sand placed from incoming barges into each specific AU (volume/area equivalent). Consistent distribution of sand will be tracked by using GPS positioning to record bucket location and spread.

3.9.2.1 Construction Observation and Pilot Test

Before construction begins, a pilot test will be performed on the deck of an empty material barge or in an accessible upland area, showing the approximate swing distance, speed of swing, and bucket opening operations that will result in the replicable placement of consistent lift thicknesses. Bucket tracking software marking the start and finish of each swing will be required; this information will be submitted to the engineer to demonstrate progress during placement operations. These methods will be employed and repeated by the crane operator responsible for ENR placement during construction and will be verified by the oversight engineer through continuous observation.

3.9.2.2 Volume/Area Placement

In addition to closely tracking placement methods, the draft of each material barge will be measured and recorded prior to placement of sand in each AU. The initial draft will be combined with the final draft to estimate the volume of sand placed, and the result will be compared to the area of the AU that has been completed. The volume/area determination will be used as a check to the visual observation of the sand placement.

3.9.3 Other Design Component Verification

All other design component verification will be performed using traditional construction means and methods. Oversight engineers will be present for the installation of all components and will verify completion of the work in compliance with the project plans and specifications.

4 REMEDIAL DESIGN CONSIDERATIONS

The following information is included to support the design described in Section 3.

4.1 Surveying and Base Map Development

In April 2013, Minister-Glaeser completed a combined nearshore topographic survey and bathymetric mapping to construct a master base map of the site. The master base map includes topography and bathymetry for the areas immediately surrounding the site. The master base map is referenced to NGVD 29/47.

The base map is being used in both Geographic Information Systems and AutoCAD Civil 3D software formats as a basis for all design work. Drawings C1.0 through C1.3 show the existing topography and bathymetry from the master base map.

4.1.1 High-Resolution Multibeam Sonar Bathymetric Survey

As part of the base map development, Minister-Glaeser generated a digital terrain model and image of the multibeam bathymetric data at 1-meter pixel resolution, which MFA has incorporated into

Figure 4-1. The image, color-coded by depth, was artificially illuminated, using a hillshade effect. The color-coded pixels in the imagery demonstrate the extent of coverage over the survey area and present a detailed image of the high-resolution multibeam bathymetric data. The resolution of the image is such that debris larger than 1 meter should be visible in the graphic. Based on the image, no subsurface features were identified at the site. The final bathymetric data set was also exported as an ASCII point file containing XYZ locations on a 3-by-3-foot grid, and as a surface in an AutoCAD Civil 3D format drawing.

It should be noted that the multibeam sonar survey was unable to cover much of the shallow bench located near shore because of shallow water. This area was instead surveyed by Minister-Glaeser, using single-beam sonar and standard upland topographic survey methods.

4.2 Ordinary High Water

As determined in coordination with the COE, the OHW level at the LRIS is 14 feet NGVD (COE, 2013). Most of the proposed work is therefore below the OHW level and under COE jurisdiction.

4.3 Dredge Method

A substantial consideration in dredging design for sediment remediation is the management of residuals—either undisturbed or generated. Undisturbed residuals are contaminated sediments that remain in place below the target dredge elevation. Generated residuals are defined by the technical guidelines for environmental dredging of contaminated sediments as "sediment dislodged, but not removed, by dredging which falls back, spills, sloughs, or settles in or near the dredging footprint and forms a new sediment layer" (Palermo et al., 2008).

Generated residuals typically result from:

1. Sediment that has lost shear strength (or has become loose) at the cut interface but was not removed. Typical conditions are:

    a. Imprecise removal leaving ridges of contaminated material that has been sheared by the bucket, or leaving a scalloped surface between bucket placements

    b. Plowing motion of the bucket, effectively remolding sediment and leaving windrows of low-shear-strength material behind

2. Settled sediment that was resuspended from the dredging activity. Typical conditions are:

    a. Sediment eroded from a bucket passing through the water column to the surface because of use of an open bucket or the overpenetration of a closed bucket

    b. Sediment-laden water that has spilled over the deck of a material barge because of overfilling

    c. Unanticipated debris encountered during dredging, effectively preventing the bucket from closing completely and allowing excavated sediment to wash out of the bucket during lifting

3. Sediment that has become loose as a result of a cut face that has failed in place because of steep slopes

Generated residual sediment layers can be very loose because of high water content, and therefore may be flowable. As the dioxin contaminants are strongly associated with the sediment particles, control of sediment resuspension will limit the generation of residuals and contaminant release.

In order to reduce the amount of residuals that are generated during the dredge project, precision sediment dredging was selected as a BMP. Traditional mechanical dredging methods have been shown to result in resuspension of sediment and the aforementioned generated fine residuals layer, both of which can lead to release of the contaminants into the water column that can settle in the clean dredge cut and clean areas downstream. Historical data show that sediment resuspension by the dredge can generally be limited to 1 percent of the total mass removed by traditional dredging methods. Additional avenues for resuspension and possible contaminant release result from other project aspects such as unknown debris encountered by the dredge; purposed debris removal; and erosion of the weak, low-shear-strength residuals layer by river traffic or high-flow events. Adding these losses can result in a contaminant release upwards of 2 percent of the total mass removed (Peer Review Panel, 2010). However, further data show that using precision equipment and controlled methodologies can limit resuspension to 0.5 percent (Palermo et al., 2008). Additional data gained from recent projects such as the Head of Hylebos show precision dredging resulting in still far less resuspension (Otten and Webb, 2008). Limiting the resuspension of sediment will have a profound impact on controlling the generation of residuals and possible contaminant release associated with the dredging process. The dredging method for the Lake River bank and sediment remedy has been developed such that short-term impacts to the environment, project personnel, and the general public are minimized.

The specifications require the use of fixed-arm equipment (hydraulic excavator) using a double-arc enclosed clamshell bucket (the rehandling clamshell bucket manufactured by Young Corporation, referred to as the "Young's bucket," or a functional equivalent). The two halves of the Young's bucket close under the hydraulic power of the excavator and are positioned at the end of an articulating excavator arm. The bucket and dredge method used is intended to result in minimal loss of sediment into the water column when the bucket is raised from the river bottom. This approach to sediment remediation has been employed successfully in the Puget Sound by Dalton, Olmsted, Fuglevand (Fuglevand and Webb, 2007).

The use of fixed-arm equipment allows for very precise placement of the bucket in three dimensions. Cable sway and current deflection reduce the precision of derrick-type buckets in the horizontal plane. Also, cable-mounted buckets rely on the momentum of a dropped bucket to penetrate the sediment; conversely, fixed-arm buckets can be lowered to the appropriate elevation before closure. The rigid connection of fixed-arm equipment is better able to handle dredging on slopes, rather than deflecting downslope as cable-suspended buckets can. In addition, the double-arc closing bucket provides a clean, level cut compared to the "cratered" surface left by traditional clamshell buckets (see Figure 4-2).

Design of the dredging methodology includes a minimum of two dredge passes. As noted in the 4 R's workshop developed by the COE, "generated residuals have been measured at 2–9% of the contaminant mass dredged during the last production pass" (Bridges et al., 2008). The mass balance is an effective measure for generated residuals; a multiple-pass method of dredging contaminated material, with the last pass being the smallest volume removed, has been shown to be an effective method for reducing the amount of generated residuals. The first pass will remove most of the sediment, and the second, considered a cleanup pass, will remove to the lower prism boundary, leaving a residual layer with a much lower contaminant concentration.

The following is a discussion of the three mechanisms that typically result in generated residuals as described above, contrasting the traditional clamshell and environmental bucket methods with the precision dredging method.

4.3.1 Low-Shear-Strength Surface Sediment

The way in which the bucket closes can significantly alter the strength of the sediment left at the cut surface. Loose material left at the cut surface is very easily eroded and can be transported to other areas of a dredge prism that may have already been verified clean, or to clean areas outside the dredge prism. Limiting the generation of loose sediment left by the dredge bucket lowers the potential for significant generated residuals.

Wire-Supported Environmental Bucket: Traditional clamshell buckets and level-cut enclosed environmental buckets are both referred to as "gravity-close" methods because both involve two halves of a bucket that rotate toward closure through a cable system employing gravity. The gravity-close dredge methods generally employ lattice boom cranes, and therefore are secured by a cable or wire rope system. The bucket is closed by raising (or shortening) one cable and slacking the other; the two halves of the bucket close under the weight of the bucket itself. Buckets that close in a level-cut fashion, such as the enclosed environmental bucket, do so with a plowing motion under the weight of the bucket itself. The cutting face of the environmental bucket is dragged along the sediment interface, plowing the sediment into the bucket, but also leaving behind a coarsely dragged sediment surface with significantly reduced shear strength (i.e., loose sediment). In addition, it is difficult to control the placement of these buckets, as they are effectively hanging on the end of a cable. This can result in unintentional dragging of the bucket over adjacent sediment on slopes, or imprecise placement on uneven surfaces.

Traditional Clamshell Bucket: As discussed above, the traditional clamshell bucket operates in a manner similar to the enclosed environmental bucket. However, buckets that close in a more circular fashion allow the faces of the two clamshells to slice through the sediment and minimize the disturbance of the sediment left in place. This results in a much less erodible cut surface and minimizes the potential for generated residuals to be transported away from the dredge face. As with enclosed environmental buckets, placement and control of traditional clamshell buckets are difficult and the buckets can disturb sediment adjacent to the intended cut, and/or leave a scalloped surface behind.

Fixed-Arm Excavator with Articulated Bucket: The Young's bucket (or equivalent designs) cuts through the sediment as it closes around the sediment and leaves a generally flat surface behind because of the geometry of the double-arc bucket and much more precise bucket placement and control. Fixed-arm excavators have a more precise vertical positioning, which is a significant advantage on a sloping river bottom. In addition, the fixed-arm equipment has the inherent capability of hydraulic closure of the bucket. The hydraulically controlled bucket can be rotated, allowing for more precise positioning and more efficient overlap of cuts.

4.3.2 Released Sediment

Another significant factor in the generation of residuals is the ability to contain excavated sediment throughout the entire removal process, from the riverbed to the sediment holding barge. Contaminated sediment that drains from the bucket or that is washed over the edge of the barge will eventually settle back onto the river bottom. This material settles out in an uncontrolled fashion over clean areas and dredge areas. The resulting residual has very low shear strength and is highly erodible. Limiting the spillage of sediment during dredge operation lowers the potential for generated residuals. In light of this, sediment removed from the river bottom will be placed directly onto material barges, which will be loaded in a manner that prevents overtopping of binwalls by sediment-laden water.

Traditional Clamshell Bucket: The traditional clamshell bucket is open at the top and cannot prevent sediment scouring when closed at the sediment surface or when raised through the water column.

Environmental Bucket and Precision Sediment Excavation: These two buckets fully enclose their contents while raising the sediment through the water column and onto the sediment barge. Because the contents are protected, there is little to no scour of sediment from the bucket during lifts. In addition, in the case of the Young's bucket, employing a hydraulically powered closing mechanism and incorporating an advanced RTK-GPS allow the operator to know the bucket location and the degree of bucket closure, which results in a much lower likelihood of overtopping (overpenetration) and insufficient closing of the bucket.

4.3.3 Slope Failure Releases

A third generated residuals mechanism is the failure, or sloughing, of overly steep slopes left at the cut face after removal of the dredge bucket. These steep cut faces are suddenly left unsupported and may cave in immediately after bucket removal, resulting in a layer of low-shear-strength material. Limiting the amount of unsupported steep cut faces also lowers the potential for generated residuals. A maximum 3H:1V slope will be excavated to ensure long-term slope stability and to limit undercutting and/or sediment cave-ins, which can result in sediment resuspension.

Traditional Clamshell and Environmental Buckets: The gravity-close buckets are the least maneuverable of the dredging tools—their positioning relies solely on raising and lowering the bucket vertically from the crane boom. The horizontal position of the tip of the boom is known, but the bucket cannot be precisely located because of the length of flexible cable above. The vertical position can be estimated by graduated marks on the cable or other means, but the bucket cannot be adjusted or rotated to match the slope of the riverbank or bed, nor can it be held precisely in place. Both of these buckets are driven into the sediment with a very steep angle of entry, resulting in a steep cut face (see Figure 4-2). Each clamshell that is removed creates the potential for a small slope failure on the leave surface as a result of these unsupported cut faces.

Precision Sediment Excavation: The Young's bucket is mounted at the end of an articulating excavator arm that can be controlled vertically and horizontally with a relatively high degree of accuracy. The bucket head can also be independently rotated on the horizontal plane and held securely in place so that it is relatively unaffected by slopes. Because if the offset double-hinged closure of the Young's bucket, which essentially allows the bucket to close in a wide arc, the resulting cut surface is relatively flat and does not leave the scalloped surface associated with gravity buckets (see Figure 4-3). A precision removal grid has been developed with built-in overlap for the bucket targets to address potential scalloped ridges left at the edges of the bucket closure profile. Successful overlapping of adjacent bucket grabs results in a smoother leave surface and will potentially leave behind less easily erodible, remolded sediment. To build in appropriate overlap, the removal grid cells were assigned smaller dimensions than the actual bucket dimensions (see Figure 4-3). This grid and the individual bucket target elevations are shown on Drawings C5.1.0 through C5.1.5. The precision associated with the bucket positioning and predesigned removal grid allows for more controlled removal of sediment in lifts that do not leave high vertical cuts.

4.4 Positioning Control

Accuracy in dredging is greatly impacted by the type of equipment used to perform the work, the positioning controls used to secure that equipment in place, and the type of global positioning system employed to inform location and track progress. The technical guidelines provided by the COE for environmental dredging of contaminated sediments (Palermo et al., 2008) state that:

> it would be reasonable to plan on overall dredging accuracy of no better than +/- 6 in. vertical and horizontal, and only if:
>
> - RTK-GPS-based positioning systems are employed.
> - A fixed arm or ladder dredge is used.
> - Experienced and skilled operators are employed.
> - There is limited debris and obstruction to dredging.
> - A proper quality control system is employed to verify the positioning system at least once per day throughout the full range of motion.

Fixed-arm equipment (e.g., excavator) using RTK-GPS positioning employs multiple sensors located at various positions on the equipment; environmental factors such as current or wind do not result in changes to the equipment geometry.

RTK-GPS positioning will be employed on fixed-arm equipment (excavator) for this remedial action in order to track overall progress and material removal during the project. The dredge derrick will be secured in place with spuds and the excavator will be fixed to the deck of the derrick. In addition, bucket placement data will be paired with frequent progress surveys to verify approvals and the initiation of ENR placement. Daily verification of the positioning system will be required.

4.5 Dredge Prism Design

The remedy described in this design report generally targets sediment exceeding 30 ng/kg dioxin TEQ for dredging. The dredge areas are shown in plan view on Drawings C5.0.0 through C5.1.5 and were developed using high-density sampling and inverse distance weighting (IDW) contours between sample points, based on a 10-foot-by-10-foot grid, the Lake River bathymetry, and construction feasibility. See the Lake River Remedy Predesign Sampling Report (MFA, 2013a) for more information on the development of the dredge prism.

4.5.1 Depth of Dredge

The depth of the dredge prism was developed using high-density sampling and IDW interpolation between sample points. Sediment concentrations between sample locations were interpolated within a 10-foot-by-10-foot grid at depths of 1, 2, 3, and 4 feet below the current sediment elevations. The method identified areas at depths of 1, 2, or 3 feet where contaminated sediment concentrations exceed the 30 ng/kg target concentration. See the Lake River Remedy Predesign Sampling Report (MFA, 2013a) for more information on the development of the dredge depth.

4.5.2 Depth Correction Factor

Compaction of the sand and organic material can occur during sampling because of the intense vibrating action of the vibracore equipment. Compaction of the sampled material results in a reduced length of recovered core compared to the depth of sediment actually penetrated by the coring device, i.e., recovery less than penetration. A compaction correction factor typically is developed by dividing the penetration depth by the recovery length and then multiplying the result by the direct reported depth of the sample measured from the top of the core.

It is important to note that the compaction correction method does not account for other factors contributing to a situation where recovery less than penetration might occur, such as: the loss of sediment from the bottom of the core barrel as it is raised through the water column, resulting from loose debris encountered or larger grain sediment (i.e., cobbles, gravel, or loose sand); or the inability to see the core barrel encounter the sediment bottom, leading to an imprecise record of the starting depth. The correction method also does not account for nonlinear compaction that might be observed in interbedded soft and hard sediment layers. Given the uncertainty caused by these considerations, the correction factor method was applied in order to achieve a conservative estimate of the maximum dredge depth required to remove the contamination.

Sample depth was measured directly from the top of the recovered core; approximate penetration depth was reported in the predesign sampling report (MFA, 2013a). In order to calculate a reasonable and illustrative correction factor, cores in areas with multiple deployments due to low recovery resulting from loss (i.e., sediment falling out because of large granular cobbles or debris) were removed from the analysis. A measure of penetration depth to sediment recovery was averaged across all of the cores, and a correction factor of 1.17 was developed. Based on the maximum 3-foot dredge depth estimated in the IDW method, this correction factor results in an additional depth of approximately 0.5 foot.

Average Recovery	85%
Correction Factor (inverse of Avg. Recovery)	1.17
3 foot equivalent	3.51
2 foot equivalent	2.34
1 foot equivalent	1.17

In order for the design to be both conservative and constructible, each target depth was multiplied by the depth correction factor for all dredge areas in the design prism to account for compaction correction of the original sampling event. These dredge depths are used to create the neatline elevations for the dredge prism.

4.5.3 Neatline and Overdredge

Dredging underwater is imprecise; the excavated surface cannot be seen by those performing the work, and floating equipment is not completely stationary and can move laterally and vertically on the surface of the water as a result of equipment movements, tides, boat wake, and generally rough water. Because the design requires achievement of a minimum dredge elevation, called the "neatline" dredge target, the contractor will inevitably dredge deeper than the target surface; this is called overdredging. Some amount of overdredging by the contractor is inherent in the work to ensure that the neatline target is achieved throughout the dredge footprint. However, it is important that the design specify allowable overdredge amounts so that the contractor does not significantly overshoot the design quantity. Therefore, for contracting and permitting purposes, overdredge is accommodated in the design.

An overdredge of 0.5 foot is considered a reliable expectation of performance, given the precision of the dredge method proposed for this project. The Port can manage the cost impact of this assumption by paying the contractor for material removed within this tolerance limit (paid-overdredge). However, in order to account for contingencies in the excavation/fill permit process and to ensure that the project does not remove more volume than the permit allows, an additional overdredge allowance (unpaid-overdredge) is recommended. This would account for occasional errors in the dredge depth made by the contractor due to an inability to see the bottom surface or to changing water levels throughout the day. The contractor will not be paid for sediment volumes between the paid-overdredge line and the unpaid-overdredge line, but these events will not trigger a penalty from the oversight/permitting agencies. A 1-foot total overdredge (0.5-foot paid overdredge and 0.5-foot unpaid overdredge) will be included in the permit request to ensure that the maximum permitted removal is not exceeded. See Figure 4-4 for an illustration of neatline, allowable contract overdredge, and allowable permitted overdredge.

4.6 ENR Layer Design

Surface sediment exceeding 5 ng/kg but below 30 ng/kg will not be dredged but will receive ENR treatment. All areas within the dredge prism will also receive the ENR layer. Development of the ENR area is described in the Lake River Remedy Predesign Sampling Report (MFA, 2013a).

The method specified for ENR placement has been used for several previous projects and has proven to be an effective means of controlling not only the water quality, but the placement consistency as well. Spreading the sand at the water surface results in consistent and even sand placement, and allows the ENR layer to settle gently on the river bottom, mitigating potential sediment resuspension. Placing the material below the waterline with the bucket fully submerged runs the risk of "stirring up" the river sediment. The bucket's movement through the water below the water line and above the sediment surface greatly increases turbulence, essentially creating vortices between the bucket and the sediment layer that scour and erode the river bottom. An additional risk associated with spreading below the waterline is inadvertently contacting the river bottom with the bucket while attempting to spread. This risk is notably increased in shallow water such as that found in the Lake River remedy area. Sand cannot be spread effectively with the bucket fully submerged. Often, this results in piling up large humps in some spots while leaving others uncovered, and runs the risk of "bombing" the underlying sediment with large clumps of sand falling at higher velocities than the evenly spread sand.

4.7 Riverbank Protection Design

The following section presents MFA's design criteria for protection of the riverbank. The Lake River bank will be subject to erosive forces from waves (wind-driven and vessel-generated), river flow velocities, and propeller wash.

4.7.1.1 Vessel-Generated Waves

While Lake River along the LRIS frontage is currently designated as a no-wake zone, this regulation is frequently ignored, exposing the bank to wake impacts. MFA conducted a literature review of available methods to estimate vessel-generated waves, specifically from the smaller vessels typical on Lake River. These vessels generally include recreational fishing boats, recreational power boats (runabouts and small cruisers), and small gillnet boats.

MFA used three methods to estimate the maximum vessel-generated wave height expected at the LRIS frontage: the Bhowmik model (Bhowmik et al., 1991), the Blaauw model (Blaauw et al., 1984), and the Sorensen and Weggel model (1984). MFA used a 2013 Sea Ray cabin cruiser (length 35 feet 6 inches, beam 11 feet 6 inches) as the design vessel for the worst-case scenario. The vessel dry weight is reported as 15,840 pounds; MFA estimated a loaded weight of 20,000 pounds. The vessel draft at rest value, required by the Bhowmik model, was taken as 2.0 feet, the value reported for a similar 37-foot Sea Ray (Bhowmik et al., 1991).

As Froude numbers approach unity, the wake height from planning vessels diminishes as the vessels plane. A design vessel velocity of 19 feet per second (fps) was used, which, in the Lake River main channel (depth of approximately 18 feet with river stage at OHW), corresponds to a Froude number of 0.79. The distance between the sailing line and the bank was 100 feet for all model runs.

With these inputs, the Bhowmik model predicts a maximum wave height of 0.94 foot, the Blaauw model predicts a maximum wave height of 1.39 feet, and the Sorensen and Weggel model (1984) predicts a maximum wave height of 1.46 feet. MFA has selected the most conservative result, 1.46 feet, as the design-vessel-generated wave height.

4.7.1.2 Wind-Driven Waves

Lake River is a relatively narrow body of water with several gentle meanders along its length. This geometry limits the fetch available for generation of wind-driven waves. By inspection, the longest fetch in a direction that would result in waves impacting the LRIS bank is approximately 900 feet.

MFA used the methodology presented in the Coastal Engineering Manual (COE, 2002) to estimate the significant wind-driven wave height for fetch-limited waves expected at the LRIS. Using the fastest mile wind speed for the region, 88 miles per hour (NOAA, 2011), MFA estimated a theoretical fetch-limited significant wave height of 1.40 feet. However, according to the Coastal Engineering Manual, the time required for these waves to develop is much longer than the duration of the fastest mile wind speed (482 seconds vs. 41 seconds). Waves generated by the fastest mile wind speed are duration-limited rather than fetch-limited; the fetch-limited wave height reported above is an overestimate of the wind-driven waves to be expected at the LRIS.

As the overly conservative fetch-limited significant wind-driven wave height is still less than the 1.46-foot significant vessel-generated wave height selected above, wind-driven waves do not control the design of bank protection.

4.7.1.3 Bank Protection Rounded Rock Sizing

As the vessel-generated waves were found to control the bank protection design, MFA used the Hudson equation for rock, two-layer armored non-overtopped slopes (COE, 2002) to determine the size of fish mix required to withstand the design wave of 1.46 feet. At the proposed 4H:1V maximum slope, and assuming a K_D of 1.2 (for smooth, rounded rocks), the required median rock mass is 30 lb—equivalent particle size (D_{50}) of approximately 7 inches. The proposed minimum fish mix protection layer thickness is 2 feet, which will ensure ample protection of the bank and allow for placement of occasional larger rock in the protection layer. The fish mix will have a D_{100} of 10 inches and a D_{10} of 1 inch, and will be free of fines.

4.7.1.4 River Velocity

Lake River is a low-energy, tidally influenced backwater of the Columbia River. A U.S. Geological Survey (USGS) stream gauge that recorded both river stage and velocity was in operation roughly 1 mile upstream of the LRIS between September 2010 and November 2012 (USGS, 2013). The highest velocity recorded during the period of record was 2.64 fps. As there are no major tributaries or significant changes in channel geometry between the stream gauge and the LRIS, there is no reason to anticipate significantly higher velocities at the LRIS frontage under similar conditions. MFA used Maynord's method (Palermo et al., 1998) to evaluate the velocity protection afforded by the proposed fish mix (D_{50}=0.57-foot). MFA found that the proposed fish mix provides erosion protection for velocities in excess of 9 fps. As noted below, Lake River is part of the Columbia River floodplain, but is outside the regulatory floodway during the 100-year flood; velocities above 9 fps are not expected under any conditions. When compared to the river velocities on record, the proposed fish mix represents a factor of safety of 3.4.

4.7.1.5 Propeller Wash

As the proposed slope of the bank protection is roughly 4H:1V, it is unlikely that vessels will be traveling close enough to the bank protection to cause significant impacts to it from propeller wash. Nevertheless, MFA used Maynord's methodology (Palermo et al., 1998) to evaluate what size of rounded rock would be required to protect the bank from propeller wash from the 35-foot Sea Ray design vessel operating above the bank protection. MFA assumed that the design vessel was equipped with twin 375-horsepower stern drives, each with 16-inch-diameter propellers (the maximum horsepower factory available on the 2013 model). MFA further assumed that the vessel was operating roughly 8 feet above the bank protection (near the toe of the bank slope at OHW) and using half engine power. The required rounded rock size predicted by Maynord's method under these conditions is D_{50}=0.49 foot. The proposed D_{50}=0.57-foot rounded rock provides protection from propeller wash for more than 235 horsepower per propeller. MFA concludes that the proposed rounded rock provides more than adequate protection from propeller wash for a vessel traveling <u>above</u> the permitted speed on Lake River.

4.7.2 Slope Stability Design

A geotechnical evaluation was prepared by GeoDesign geotechnical engineers and included an analysis of proposed bank slopes. Specifically, GeoDesign evaluated the stability of the proposed temporary construction and permanent slope configurations under seismic and static loading. The seismic analysis used a seismic coefficient of 0.15—one half of the site peak ground acceleration of 0.30 g. The maximum accelerations considered are typical for a near-source magnitude crustal earthquake. The COE-required minimum factors of safety for long-term slope stability are 1.4 for static conditions and 1.1 for seismic conditions. The long-term slope stability factors of safety at the critical sections for the proposed design are 1.76 and 1.59; the slope stability analysis has shown that the proposed slopes satisfy the minimum recommended factors of safety (see Appendix C).

4.7.3 Slope Settlement Evaluation

The addition of bank fill at a 4H:1V slope (consisting of fish mix rock) at thicknesses of up to 5 feet significantly increases mass over the nearshore sediments, potentially inducing consolidation and settlement of the newly constructed shoreline. GeoDesign also evaluated the settlement potential for the bank fill to ensure that unacceptable conditions would not develop after the placement of the fill. The settlement analysis was based on limited information available in upland soil cores and sediment cores obtained during site investigation and is therefore considered preliminary. The analysis estimated the maximum settlement potential to be on the order of 18 to 24 inches at the thickest fill areas (5 feet). This condition will not result in unacceptable differential settlement and will not contribute to an unstable condition in the bank cap. It is also anticipated that most of the settlement will occur shortly after the fill is placed; the bid quantity for fish mix will include a contingency for placement of additional material to meet the design line and grades after this primary settlement. This additional volume was anticipated in the JARPA permit volumes.

5 CONSTRUCTION SITE OPERATIONS

5.1 Health and Safety

All contractors will be required to prepare a health and safety plan that is consistent with the Port's site-specific plan, which is to be prepared by MFA. All employees working at the site will be required to read and sign their employer's health and safety plans before beginning work at the site. The Port's health and safety plan identifies the site hazards; however, the contractor's plans will provide additional information regarding the hazards associated with specific work activities to be conducted by the contractor.

5.1.1 Site Entry Restrictions

All sediment-handling and in-water work areas will be restricted to construction and oversight workers who have received hazardous waste operations and emergency response (HAZWOPER) training. The minimum personal protective equipment for all site activities will be Level D (steel-toed boots, hard hat, safety glasses, hearing protection), although the contractor may require additional protection for specific activities. The contractor will be required to install temporary construction fencing around the sediment-handling area; the area will be secured at the end of each workday to prevent unauthorized access. Signage, notifying the public that Millers Landing is temporarily closed to public access, will be placed on Division Street just west of the Port's driveway by the Port prior to construction work.

Additional temporary buoys will be placed to reinforce the existing no-wake zone on Lake River; the Port will notify the U.S. Coast Guard as to the placement of these buoys. Additional measures to keep the public out of the work area may include placement of strings of marker buoys around active parts of the work area. Members of the public who encroach upon the work area will receive verbal policing by site workers when within 100 feet of construction vessels.

After the dredging is completed and the ENR and fish mix layers have been placed, soil cap placement and plantings may be completed by contractor employees with or without HAZWOPER training, as long as they are not disturbing soil below the demarcation layer.

The contractor office and parking area will not be restricted except to the general public.

5.1.2 Over-Water Work

All boats must carry at least one U.S. Coast Guard-approved personal flotation device (PFD), which properly fits the intended user, for every person aboard. Such devices must be in serviceable condition. They must not have any rips, tears, or broken straps. All devices must also be kept readily accessible for use in an emergency situation. PFDs in a plastic bag or in a storage compartment are not deemed readily accessible.

PFDs are required for all operations near, in, or over water, except in cases where an approved site-specific HASP defines the conditions for an exemption (e.g., diving).

5.2 Hours of Operation

Consistent with City noise regulations (Ridgefield Municipal Code 9.14.010), operation of large equipment carrying out remedial activities will be generally be limited to the hours of:

- 7 a.m. to 10 p.m. Monday through Friday
- 9 a.m. through 6 p.m. on weekends and holidays

The Port will may apply for an exemption to these regulations to provide the contractor greater flexibility should 24-hour operations be required to complete the remedy during the in-water work window.

5.3 Fencing

The site is currently not fenced because the upland remedy has been implemented. A paved shoreline trail and an unpaved trail are currently open to the public. Fencing of the contractor's work area will be required because of the impacts associated with dredged sediment and/or untreated decanted water, which will be stored in the contractor's laydown area. As noted above, the contractor will be required to install temporary construction fencing around the upland staging, sediment-handling, and water treatment area. This area will be secured at the end of each work day to prevent unauthorized access.

5.3.1 Access Restrictions before Final Remedy Completion

The Port will place signage in the following locations to warn of ongoing construction and to further discourage public access to the work area:

- The Port's boat launch and parking area
- The south terminus of the Miller's Landing waterfront trail
- The Port's pump house—located in water near the downstream extents of the work area
- In water around the active work area

5.4 Security

The site will be secured nightly at the end of construction activities. Security patrols may be conducted by the contractor to ensure that site entrances are locked and to prevent trespassing, reducing the potential exposure of the public to hazardous situations.

5.5 Transportation Plan

5.5.1 Overland Transport Alternative

Haul-Route Selection: Site to Freeway: Division Street or Mill Street to 3rd Avenue to Pioneer Street. Pioneer Street to I-5.

Freeway to Landfill:

Wasco County Landfill: I-5S to I-205S. I-205S to I-84E. I-84E to US-197S (Exit 87). US-197S to 5 Mile Road. Right (west) on 5 Mile Road to Steele Road—Wasco County Landfill in The Dalles, Oregon. 2250 Steele Road, The Dalles, Oregon.

Hillsboro Landfill: I-5S to I-405S. I-405S to US-26W. US-26W to Waste Management Hillsboro Landfill.

Headquarters Landfill: I-5N to Headquarters Road (Exit 46). Right (east) on Headquarters Road to S Silver Lake Road and Headquarters Landfill.

Other Landfill: As appropriate from I-5.

Truck Haul Schedule: Heavy-truck transportation to and from the site will take place between the hours of 7 a.m. and 6 p.m.

Restricted Routes: Standard truck routes are incorporated in the routes described above. No other route restrictions are anticipated.

Traffic-Control Needs: The need for traffic control will be assessed based on the number of trucks accessing the site. If truck traffic is expected to exceed 20 trucks per day for more than five days, construction signage will be placed to indicate that trucks are entering the roadway. Trucks waiting to be loaded will be managed on site so that they do not block traffic entering or exiting the Port office parking lot or the City wastewater treatment plant. Traffic management will also be provided by site personnel on an as-needed basis.

Accident Prevention and Response: All drivers will be informed of the nature of the materials contained in the loads being hauled. In addition, all loads will require tarping before they leave the site to prevent loss of material during transit. All loads leaving the site will be provided with a nonhazardous-shipping manifest. In the event of an accident or spill, the driver will be instructed to report the incident to an emergency response number listed on the shipping manifest, at which point the appropriate landfill agency will dispatch emergency spill response crews and notify MFA, Ecology, and either the Washington or Oregon Department of Transportation (depending on the spill location).

Decontamination: All trucks will pass through a construction entrance/exit and wheel wash to remove residual contamination from tires before the trucks leave the site and to minimize tracking of mud or sediment onto public roads.

5.5.2 Barge Transport Alternative

Sediment will be barged down Lake River to the Columbia River. Transload of sediment onto larger barges may take place in the Columbia River near the mouth of Lake River. Sediment will be barged on the Columbia River to the transload facility. Sediment will be offloaded at the transload facility and the barge will return to the project site.

Sediment may be amended to remove excess free water at the transload facility and will be loaded into trucks for transport to the landfill. BMPs will be in place at the transload facility to remove residual contamination from tires before the trucks leave the site and to minimize tracking of mud or sediment onto public roads.

5.6 Agency Notifications and Communications

5.6.1 U.S. Army Corps of Engineers

The COE requires that the COE Regulatory Branch be notified of the date on which the activities authorized in waters of the U.S. are scheduled to begin. The notification will be sent consistent with the permit requirements.

5.7 Public Outreach

Public outreach will be addressed through informal communications with neighboring property owners and display of project informational signage. An informational flier will be developed and sent to neighboring property owners. Signs will be posted at the Port, at nearby launch locations, and at local establishments such as the hardware store and kayak rental at McCuddy's Marina. The informational material will be developed in consultation with Ecology and will include contact information for Ecology and for the Port.

5.8 Construction Quality Assurance/Quality Control

A construction quality assurance/quality control plan will be prepared before the final design report is issued.

The contractor will be responsible for construction quality control (CQC). CQC is a planned system of inspections performed by the construction contractor that are used to directly monitor and control the quality of a construction project. CQC refers to measures taken by the contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project. CQC activities will include bathymetric and topographic surveying, weight tracking for materials delivered and disposed of, water treatment system operation monitoring and optimization, and other standard CQC techniques to ensure that the project is constructed as designed.

MFA will provide construction quality assurance (CQA) on behalf of the Port. CQA is a planned system of activities that provides the Port and Ecology assurance that a project is constructed as specified in the design. CQA may include inspections, verifications, audits, and evaluations of materials and workmanship as necessary to determine and document construction quality. CQA refers to measures taken by the Port, or its representatives, to assess whether the contractor is complying with the plans and specifications for a project. CQA checks are performed independently of CQC actions; however, CQC and CQA frequently complement each other. CQA activities will include review of the contractor's bathymetry and survey submittals, turbidity monitoring to ensure that the project work is in compliance with the water quality plan, water quality discharge monitoring/treatment system performance monitoring, compaction testing of soil fill, review of disposal documentation, and construction observation and recordkeeping.

5.9 Construction Completion Reporting

Within 90 days following the demobilization of construction equipment from the Lake River sediment remediation, MFA will submit a remedial action construction summary report to Ecology. The report will include:

- Photographic documentation and mapping (including surveyed dredge limits) to show the location of the disturbed area(s) and adequate restoration
- Volumes and locations of sediment disposed of off site and bills of lading or other shipping records
- Bathymetric and topographic survey information recording the final arrangement of the dredge, ENR, and bank protection areas
- Construction verification procedures and results
- Water quality monitoring results for both the in-water compliance points and the water treatment system discharge sampling

6 ENGINEERING AND INSTITUTIONAL CONTROLS

The remedy will achieve compliance with the CUL through removal of sediments with the highest concentrations and placement of a clean sand layer to enhance the natural recovery of residuals and remaining low-level contamination. Therefore, long-term institutional controls will not be required.

The project will place temporary buoys to notify boaters of the existing no-wake zone and the work area. The Port will provide the U.S. Coast Guard with notification.

7 PRELIMINARY CONSTRUCTION SCHEDULE

Table 7-1 presents a conceptual schedule for construction activities associated with the Lake River sediment remediation. The schedule assumes that in-water construction permits will be available before the winter 2014-2015 in-water work window.

LIMITATIONS

The services undertaken in completing this report were performed consistent with generally accepted professional consulting principles and practices. No other warranty, express or implied, is made. These services were performed consistent with our agreement with our client. This report is solely for the use and information of our client unless otherwise noted. Any reliance on this report by a third party is at such party's sole risk.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this report.

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TABLES

Table 2-1
Lake River Surface and Subsurface Sediment Characteristics
Lake River 90% Remedial Design Report
Ridgefield, Washington

Location ID	LRIS-LR-01			LRIS-LR-02	LRIS-LR-03			LRIS-LR-04	LRIS-LR-05			
Sample Date	04/19/2010	04/26/2010	04/26/2010	04/19/2010	04/19/2010	04/27/2010	04/27/2010	04/19/2010	04/19/2010	04/27/2010	04/27/2010	04/27/2010
Sample Depth	0-0.3 ft	1-2 ft	4-5 ft	0-0.3 ft	0-0.3 ft	1-2 ft	3-4 ft	0-0.3 ft	0-0.3 ft	1-2 ft	9-10.5 ft	9-10.5 ft
Conventional Parameters												
Total organic carbon (%)	1.3	1.4	0.84	1.9	1.1	1.4	1.4	2.1	1.8	1.3	0.3	0.13 J
Grain Size (%)												
Clay	6.4	17 J	6.7	11	7.6	20	15	11	11	21	1.9	1.1
Gravel	0	0	0	0	0	0	0	0	0	0	0	0
Sand, Coarse	0	0	0	0	0	0	0	0	0	0	0	0
Sand, Fine	32	18	58	18	31	9.3	22	29	18	24	85	85
Sand, Medium	0.8	0.5	0.1	0.5	0.6	0.4	0.4	0.5	0.7	1.1	7.9	8.6
Sand, Very Fine	9.7	5.1	9.2	9.8	13	6.3	4.6	11	9.5	6.3	0.41	0.5
Silt	51	60	26	61	48	64	58	49	61	48	4.6	4.6
Total Clay	6.4	17 J	6.7	11	7.6	20	15	11	11	21	1.9	1.1
Total Fines (silt + clay)	57.4	77	32.7	72	55.6	84	73	60	72	69	6.5	5.7
Total Gravel	0	0	0	0	0	0	0	0	0	0	0	0
Total Sand	42.5	23.6	67.3	28.3	44.6	16	27	40.5	28.2	31.4	93.31	94.1
Total Silt	51	60	26	61	48	64	58	49	61	48	4.6	4.6
Total Grain Size	99.9	100.6	100	100.3	100.2	100	100	100.5	100.2	100.4	99.81	99.8

Location ID	LRIS-LR-06			LRIS-LR-07	LRIS-LR-08			LRIS-LR-09		
Sample Date	04/19/2010	04/28/2010	04/28/2010	04/19/2010	04/19/2010	04/28/2010	04/28/2010	04/19/2010	04/29/2010	04/29/2010
Sample Depth	0-0.3 ft	1-2 ft	3-4 ft	0-0.3 ft	0-0.3 ft	1-2 ft	3-4 ft	0-0.3 ft	1-2 ft	4-5 ft
Conventional Parameters										
Total organic carbon (%)	1.6	0.93	1.5	0.87	0.84	1.2	3	1	0.87	1.3
Grain Size (%)										
Clay	9.2	17	22	8	5.9	2.6	15	6.6	7.1 J	18.3
Gravel	0	0	0	0	0	47	0	0	0	0
Sand, Coarse	0	0	0	0	0	8.2	0	0	0	0
Sand, Fine	28	34	17	54	76	33	31	40	46.7	11.3
Sand, Medium	0.8	0.7	0.5	0.5	1.3	7.2	2.4	0.7	0.2	0.1
Sand, Very Fine	11	7.6	3.5	14	5	1.5	5.2	14	9.1	6.1
Silt	52	41	57	23	12	0.44	46	39	36.9	64.2
Total Clay	9.2	17	22	8	5.9	2.6	15	6.6	7.1 J	18.3
Total Fines (silt + clay)	61.2	58	79	31	17.9	3.04	61	45.6	44	82.5
Total Gravel	0	0	0	0	0	47	0	0	0	0
Total Sand	39.8	42.3	21	68.5	82.3	49.9	38.6	54.7	56	17.5
Total Silt	52	41	57	23	12	0.44	46	39	36.9	64.2
Total Grain Size	101	100.3	100	99.5	100.2	99.94	99.6	100.3	100	100

Location ID	LRIS-LR-10			LRIS-LR-11	LRIS-LR-12			LRIS-LR-13	LRIS-LR-14		
Sample Date	04/19/2010	04/28/2010	04/28/2010	04/20/2010	04/20/2010	04/28/2010	04/28/2010	04/20/2010	04/20/2010	04/28/2010	04/28/2010
Sample Depth	0-0.3 ft	1-2 ft	5-6 ft	0-0.3 ft	0-0.3 ft	1-2 ft	4-5 ft	0-0.3 ft	0-0.3 ft	1-2 ft	4-5 ft
Conventional Parameters											
Total organic carbon (%)	1	1.2	2.3	1.4	0.36	2.4	1.9	1.2	1.1	0.79	2
Grain Size (%)											
Clay	0.96	9.1	9.5	8.9	1.6	2.6	10	7.4	5.7	12	24
Gravel	0	0	0	0	0	0	0	0	0	0	0
Sand, Coarse	0	0	0	0	0.7	0	0	0	0	0	0
Sand, Fine	50	36	37	38	84	60	39	42	58	53	20
Sand, Medium	0.7	0.9	5	0.6	9.4	5.3	1.8	0.8	1.7	1.7	0.6
Sand, Very Fine	7.5	9.3	5.8	12	2.1	6	8.1	12	5.7	4.7	4.5
Silt	41	45	43	41	2.7	26	41	38	29	28	51
Total Clay	0.96	9.1	9.5	8.9	1.6	2.6	10	7.4	5.7	12	24
Total Fines (silt + clay)	42.0	54.1	52.5	49.9	4.3	28.6	51	45.4	34.7	40	75
Total Gravel	0	0	0	0	0	0	0	0	0	0	0
Total Sand	58.2	46.2	47.8	50.6	96.2	71.3	48.9	54.8	65.4	59.4	25.1
Total Silt	41	45	43	41	2.7	26	41	38	29	28	51
Total Grain Size	100.2	100.3	100.3	100.5	100.5	99.9	99.9	100.2	100.1	99.4	100.1

Table 2-1
Lake River Surface and Subsurface Sediment Characteristics
Lake River 90% Remedial Design Report
Ridgefield, Washington

Location ID	LRIS-LR-15		LRIS-LR-16	LRIS-LR-17	LRIS-LR-18	LRIS-LR-19	LRIS-LR-20	LRIS-LR-21	LRIS-LR-22	LRIS-LR-23	
Sample Date	04/20/2010	04/20/2010	04/20/2010	04/20/2010	04/20/2010	04/21/2010	04/21/2010	04/21/2010	04/21/2010	04/21/2010	04/21/2010
Sample Depth	0-0.3 ft	0-0.3 ft (dup)	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft (dup)
Conventional Parameters											
Total organic carbon (%)	1.1	1.3	3.2	0.77	1.2	2.1 J	2.4 J	0.63 J	1.6 J	0.49 J	0.57
Grain Size (%)											
Clay	9	9.6	14	6.7	11	6.4	7.8	4.6	3.2	5.2	4.2
Gravel	0	0	0	0	0.9	0	0	0	0	0	0
Sand, Coarse	0	0	0	0	3.3	0	0	0	0	0	0
Sand, Fine	49	46	43	70	44	47	37	67	70	66	67
Sand, Medium	0.6	0.8	2.7	0.8	5.1	1.5	2	0.2	2.3	0.3	0.3
Sand, Very Fine	13	12	6.5	7.9	5.7	7.4	7.5	7.5	3.8	8.7	8.7
Silt	28	31	34	15	30	38	46	21	20	20	20
Total Clay	9	9.6	14	6.7	11	6.4	7.8	4.6	3.2	5.2	4.2
Total Fines (silt + clay)	37	40.6	48	21.7	41	44.4	53.8	25.6	23.2	25.2	24.2
Total Gravel	0	0	0	0	0.9	0	0	0	0	0	0
Total Sand	62.6	58.8	52.2	78.7	58.1	55.9	46.5	74.7	76.1	75	76
Total Silt	28	31	34	15	30	38	46	21	20	20	20
Total Grain Size	99.6	99.4	100.2	100.4	100	100.3	100.3	100.3	99.3	100.2	100.2

Table 2-1
Lake River Surface and Subsurface Sediment Characteristics
Lake River 90% Remedial Design Report
Ridgefield, Washington

Location ID	LRIS-LR-24	LRIS-LR-25	LRIS-LR-26	LRIS-LR-27	LRIS-LR-28	LRIS-LR-103[a]	LRIS-LR-105[a]	LRIS-LR-109[a]	LRIS-LR-119[a]	LRIS-LR-120[a]	LRIS-LR-126[a]
Sample Date	04/21/2010	04/21/2010	04/21/2010	04/21/2010	04/21/2010	12/04/2012	12/04/2012	12/04/2012	12/04/2012	12/04/2012	12/04/2012
Sample Depth	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	0-0.3 ft	1 ft	1 ft	0.5 ft	0.5 ft	0.5 ft	1.5 ft
Conventional Parameters											
Total organic carbon (%)	1.9	1.3	0.97	0.99	0.34	nv	nv	nv	nv	nv	nv
Grain Size (%)											
Clay	4.3	1.2	1.7	5.4	3.1	11	10	16	10	15	8
Gravel	0	0	0	0	0	0	0	0	0	0	0
Sand, Coarse	0	0	0	0	0	0	0	0	0	0	4
Sand, Fine	43	61	75	42	86	18	40	6	34	14	17
Sand, Medium	1.5	7.2	1.7	0.3	0.9	0	1	0	2	1	6
Sand, Very Fine	10	3.8	4.9	12	2.7	nv	nv	nv	nv	nv	nv
Silt	41	27	17	40	6.8	70	48	78	54	70	64
Total Clay	4.3	1.2	1.7	5.4	3.1	11	10	16	10	15	8
Total Fines (silt + clay)	45.3	28.2	18.7	45.4	9.9	81	58	94	64	85	72
Total Gravel	0	0	0	0	0	0	0	0	0	0	1
Total Sand	54.5	72	81.6	54.3	89.6	18	41	6	36	15	27
Total Silt	41	27	17	40	6.8	70	48	78	54	70	64
Total Grain Size	99.8	100.2	100.3	99.7	99.5	99	99	100	100	100	100

NOTES:

% = percent.

dup = field duplicate.

ft = feet.

J = estimated value.

nv = no value.

[a] Values for coarse sand, fine sand, and medium sand approximated from grain size charts.

Table 2-2
Physical Parameter Results
Lake River 90% Remedial Design Report
Ridgefield, Washington

Location ID	LRIS-LR-103			LRIS-LR-105			LRIS-LR-109			LRIS-LR-119			LRIS-LR-120			LRIS-LR-126	
Sample Date	12/04/2012			12/04/2012			12/04/2012			12/04/2012			12/04/2012			12/04/2012	
Sample Analysis Depth	1 ft	1.5 ft	2 ft	1 ft	1.5 ft	2 ft	0.5 ft	1 ft	1.5 ft	0.5 ft	1 ft	1.5 ft	0.5 ft	1 ft	1.5 ft	1.5 ft	2 ft
Physical Parameters																	
Moisture Content (%)	nv	54	nv	nv	64	nv	nv	53	nv	nv	84	nv	nv	62	nv	nv	61
Dry Density (pcf)	nv	65	nv	nv	61	nv	nv	65	nv	nv	49	nv	nv	60	nv	nv	69
Liquid Limit	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv
Plastic Limit	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv
Plasticity Index	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv	nv	NP	nv
Permeability Coefficient (cm/s)	nv	nv	1.5E-06	nv	nv	5.4E-07	nv	nv	1.9E-05	nv	nv	1.9E-06	nv	nv	1.3E-06	nv	nv

NOTES:
% = percent.
cm/s = centimeters per second.
ft = feet.
NP = nonplastic.
nv = no value.
pcf = pounds per cubic foot.

Table 2-3
Special-Status Plants That May Occur in Vicinity of Lake River
Lake River 90% Remedial Design Report
Ridgefield, Washington

Species	Federal	Washington State	Current Occurrence on Ridgefield National Wildlife Refuge
Bradshaw's desert parsley (*Lomatium bradshawii*)	E	E	Two known locations in Washington, both in Clark County; not documented on RNWR. Experimental plantings on RNWR in 2007.
Nelson's checker-mallow (*Sidalcea nelsoniana*)	T	E	Occurs in Cowlitz and Lewis counties; not documented on RNWR. Experimental plantings on RNWR in 2007.
Smallflower wakerobin (*Trillium parviflorum)* Syn: *T. chloropetalum*		S	Occurs on RNWR.
Water howellia (*Howellia aquatilis*)	T	T	Occurs in small vernal ponds in the Carty Unit (only Clark County record).
Key to Codes: C = Candidate, E = Endangered, T = Threatened, SC = Species of Concern. Source: Adapted from USFWS (2010); WDFW (www.wdfw.wa.gov).			

Table 2-4
Special-Status Fish That May Occur in Vicinity of Lake River
Lake River 90% Remedial Design Report
Ridgefield, Washington

Species	Federal	Washington State	Current Occurrence on Ridgefield National Wildlife Refuge
Bull trout (*Salvelinus confluentus)*	T	SC	Records from Clark County, use of refuge unlikely.
Chinook salmon (*Oncorhynchus tshawytscha)* (Lower Columbia evolutionarily significant unit [ESU])	T	C	Columbia River migration takes fish past RNWR. RNWR waterways may be used for rearing habitat. Juveniles trapped in Gee Creek in 1990s but not in 2002-2005 surveys. Juveniles trapped in Campbell Slough June 2007.
Chum salmon (*Oncorhynchus keta*) *(Columbia River ESU)*	T	C (Lower Columbia River)	RNWR not used. Columbia River migration takes fish past RNWR. Reported in Gee Creek in 1940s; extirpated.
Coastal cutthroat trout (*Oncorhynchus clarkii clarkii*)	SC		Spawning documented in Gee Creek. Gee Creek utilized for rearing habitat.
Coho salmon (Oncorhynchus kisutch) (Lower Columbia ESU)	T		RNWR waterways may be used for rearing habitat. Juveniles trapped in Gee Creek in 1990s and 2002-2005 surveys. Spawning not known in watersheds adjoining the RNWR.
Sockeye salmon (Snake River ESU)	E	C	RNWR not used. Columbia River migration takes fish past RNWR.
Steelhead trout (*Oncorhynchus mykiss*) (Lower Columbia ESU)	T	C	RNWR not used. Columbia River migration takes fish past RNWR. Spawning not known in watersheds adjoining the RNWR. Juveniles trapped in Gee Creek in 1990s, not in 2002-2005 surveys.
Pacific smelt (Southern distinct population segment [DPS])	T	C	Present in Gee Creek in low numbers; Columbia River migration takes fish past RNWR.
Western Brook Lamprey (*Lampetra richardsonii*)	SC		Large numbers of adults and ammocetes trapped in Gee Creek, 1995-1997; no adults and only two larvae in 2005.

Key to Codes: C = Candidate, E = Endangered, SC = Species of Concern, T = Threatened. Source: Adapted from USFWS (2010); WDFW (www.wdfw.wa.gov).

Table 2-5
Special-Status Amphibians and Reptiles That May Occur in Vicinity of Lake River
Lake River 90% Remedial Design Report
Ridgefield, Washington

Species	Federal	Washington State	Current Occurrence on Ridgefield National Wildlife Refuge
Western pond turtle (*Clemmys marmorata*)	SC	E	RNWR in historical range, contains suitable habitat. Single adult found in 2005.
Western toad (*Anaxyrus boreas*)	SC	C	RNWR in historical range. No documented occurrences in Clark Co. after 1984.
Northern red-legged frog (*Rana aurora*)	SC		Occurs on RNWR, uses suitable wetland and riparian habitat.
Oregon spotted frog (*Rana pretiosa*)	C	E	RNWR in historical range. No documented occurrences in Clark Co. after 1984.
Key to Codes: C = Candidate, E = Endangered, SC = Species of Concern. Source: Adapted from USFWS (2010); WDFW (www.wdfw.wa.gov).			

Table 2-6
Special-Status Birds That May Occur or That May Have Occurred in Vicinity of Lake River
Lake River 90% Remedial Design Report
Ridgefield, Washington

Species	Federal	Washington State	Current Occurrence on Ridgefield National Wildlife Refuge
American white pelican		E	Infrequently seen Jan.-July; wintering and migrant birds; nonbreeding subadults.
Bald eagle	SC	S	Thirty to 50 eagles winter on or near the RNWR; six pairs nest on or near the RNWR.
Caspian tern		M	Infrequent observations.
Common loon		S	Rare, fall/winter/spring.
Golden eagle		C	Rare.
Lewis's woodpecker		C	Rare, fall/winter/spring.
Loggerhead shrike	SC	C	Rare, spring.
Long-billed curlew		M	Rare.
Northern goshawk	SC	C	Rare.
Olive-sided flycatcher	SC		Occasional seasonal migrant, spring/summer/fall.
Oregon vesper sparrow	SC	C	Rare, spring/fall.
Peregrine falcon, American	SC	S	Occasional observations, all seasons; displaced birds reared on RNWR.
Pileated woodpecker		C	Resident and nests on RNWR.
Purple martin		C	Uncommon, spring/summer/fall. Breeding; 15 pairs nest on RNWR.
Rufous hummingbird	SC		Nests on RNWR.
Sandhill crane, Canadian (*G. c. rowani*)		E	The RNWR and Sauvie Island, Oregon, are significant migration and wintering areas. Fall roost averages 1,700 birds; winter population 700-800. Occasionally seen in summer. Unconfirmed breeding record from Bachelor Island, late 1970s.
Short-billed dowitcher	SC		Rare.
Slender-billed white-breasted nuthatch	SC	C	Resident, nests on RNWR. Mainly confined to Vancouver vicinity, especially the RNWR.
Streaked horned lark	C	E	Rare, fall.
Vaux's swift		C	Seasonal migrant; uncommon summer/fall; occasional winter.
Western bluebird		M	Rare, spring.
Western grebe		C	Occasional, fall/winter/spring.
Willow flycatcher (*ssp. brewsteri*)	SC		Uncommon spring/summer/fall. Breeds on RNWR.

Key to Codes: C = Candidate, E = Endangered, M = Monitored, S = Sensitive, SC = Species of Concern. Source: Adapted from USFWS (2010); USFW (2008). (http://www.fws.gov/migratorybirds); WDFW (www.wdfw.wa.gov),

Table 2-7
Special-Status Mammals That Occur or That May Have Occurred in Vicinity of Lake River
Lake River 90% Remedial Design Report
Ridgefield, Washington

Species	Federal	Washington State	Current Occurrence on Ridgefield National Wildlife Refuge
Columbian white-tailed deer	E	E	Historically occurred on RNWR; last confirmed sighting on RNWR 1974-75 (Tabor, 1976). Have been relocated from Julia Butler Hanson Refuge to RNWR (2013).
Gray-tailed vole *(Microtus canicaudus)*		C	A species known to Clark County, not confirmed on RNWR.
Mazama (Western) pocket gopher *(Thomomys mazama)*	C	T	A species historically present in Clark County; probably extinct in southwest Washington.
Townsend's big-eared bat (*Pacific ssp.*)	SC	C	Within range of species; not confirmed on RNWR.
Western gray squirrel *(Sciurus griseus)*	SC	T	The RNWR is in historical range and contains suitable oak habitat; not confirmed on RNWR. Two or more reliable reports in Clark County in the last five years (Linders and Stinson, 2007).

Key to Codes: C = Candidate, E = Endangered, SC = Species of Concern, T = Threatened. Source: Adapted from USFWS (2010); WDFW (www.wdfw.wa.gov).

Linders and Stinson. 2007. Washington State recovery plan for the western gray squirrel. WDFW, Olympia, WA.

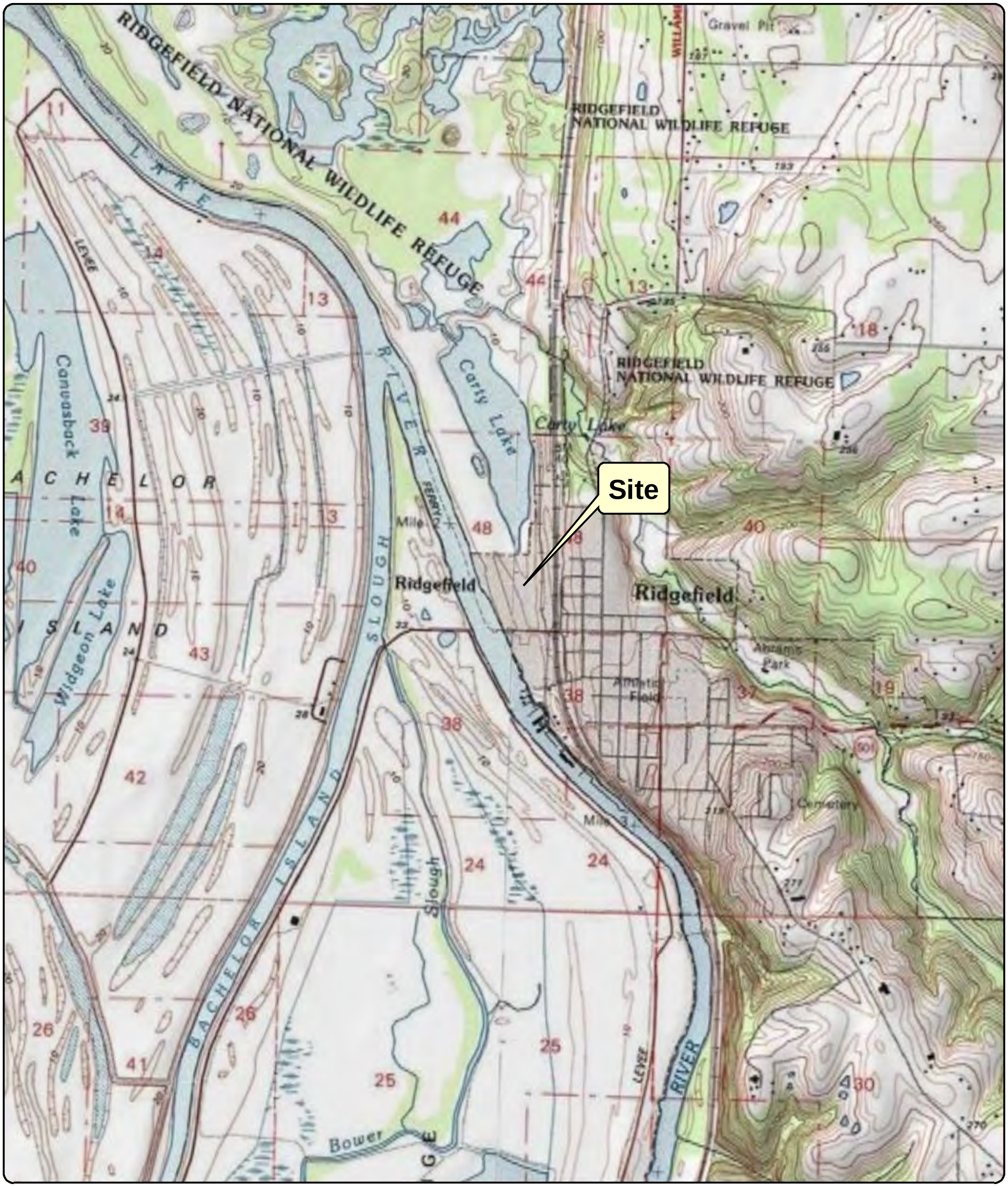
Tabor. 1976. Inventory of riparian habitats and associated wildlife along the Columbia River. U.S. Army Corps of Engineers, North Pacific Region, Walla Walla, WA.

Table 7-1
Preliminary Construction Schedule
Lake River 90% Remedial Design Report
Ridgefield, Washington

Item	Schedule
Final Design, Permitting, and Preconstruction	March 2013 through August 2014
Site Preparation and Erosion Control	August through September 2014
Construction below OHW	October 1, 2014 through January 15, 2015
Planting	Spring 2015
NOTE: OHW = ordinary high water.	

FIGURES

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig1-1_Site Location.mxd



Source: Topographic Quadrangle obtained from ArcGIS Online Services/NGS-USGS TOPO! US Geological Survey (1999)
7.5-minute topographic quadrangle: Ridgefield
Address: Lake River Industrial Site
111 W. Division Street, Ridgefield, WA 98642
Section: 24 Township: 4N Range: 1W Of Willamette Meridian

Figure 1-1
Site Location

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 1,000 2,000
Feet

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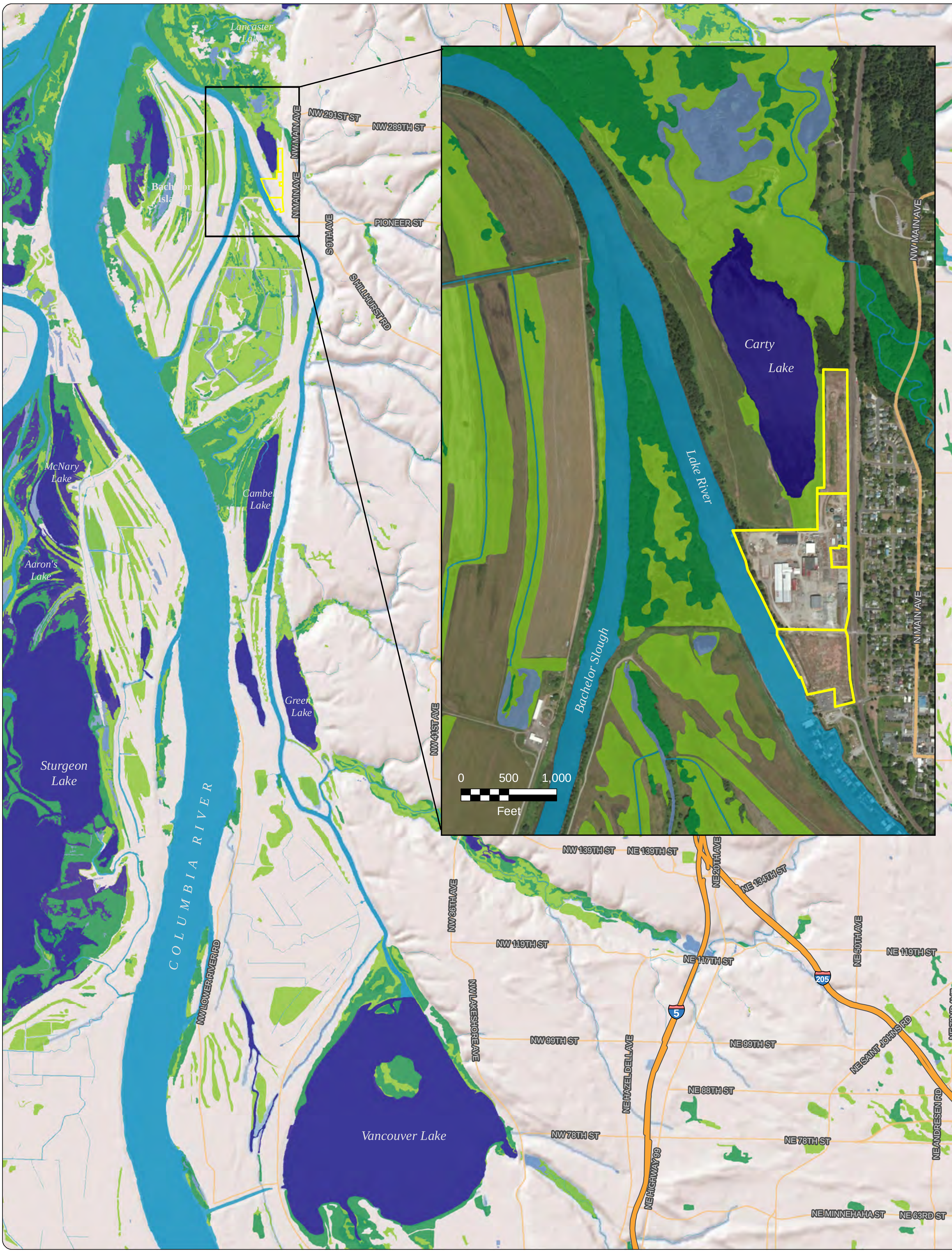
Project: 9003.01.20 Produced By: D. Coe/ W. Coffey Approved By: J. King Print Date: 2/20/2014



Source: Aerial photograph and shaded relief obtained from ESRI, Inc. ArcGIS Online.

Notes:
1. Wetlands Delineation obtained from the U.S. Fish and Wildlife Service, National Wetlands Inventory.
2. COE = Army Corps of Engineers
3. Dredge project boundary is approximate and was digitized from COE project map number LK-1-26, January 20, 1970.

Legend

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- River
- POR Cell Boundaries

Figure 1-2
Lake River Setting

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 0.5 1
Miles

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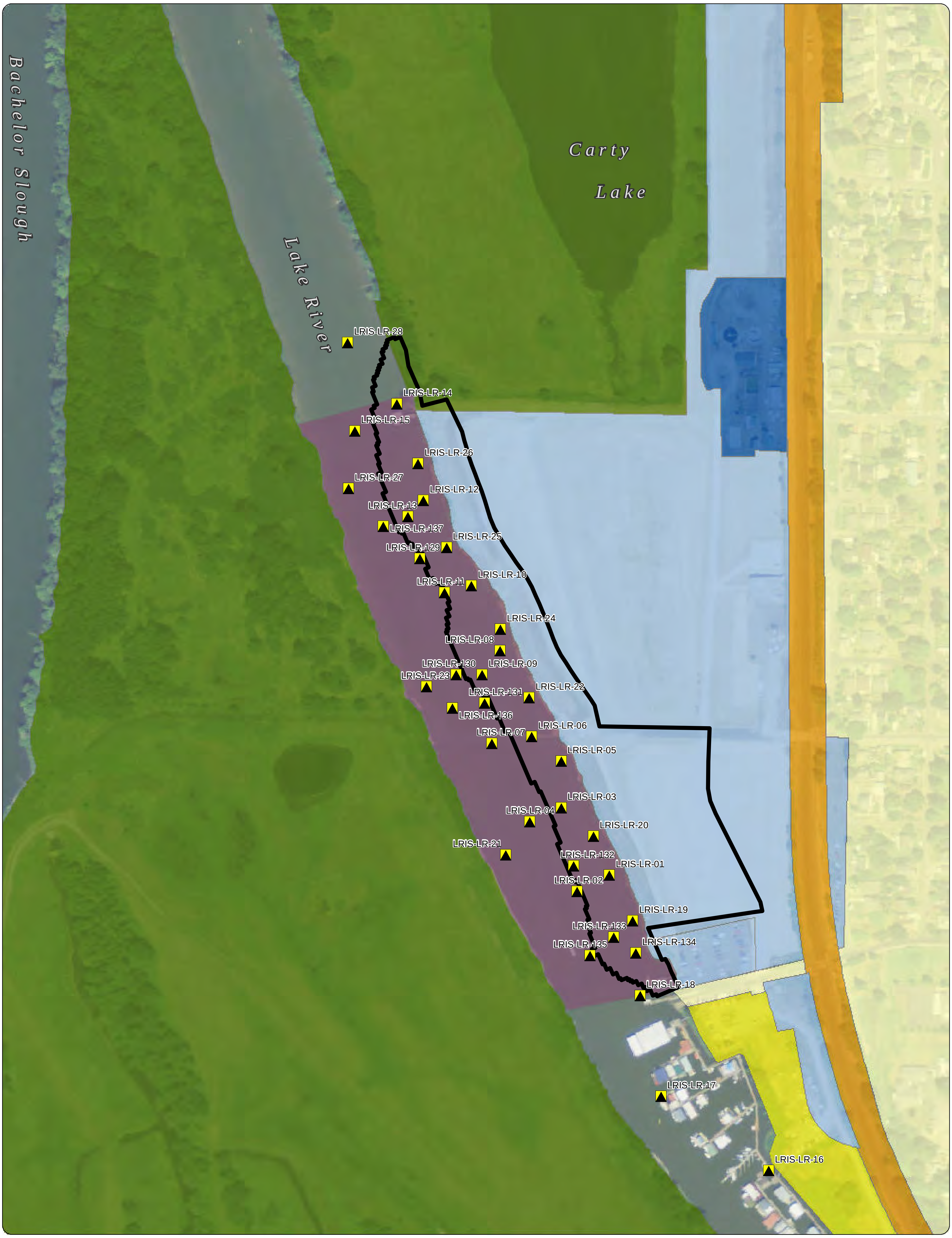
File: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig1-2_Lake River Setting.mxd
Print Date: 2/20/2014
Approved By: M. Novak
Produced By: J. Schane
Project: 9003.01.40



Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Notes:
1. BNSF = Burlington Northern Sante Fe
2. Port = Port of Ridgefield
3. RNWR = Ridgefield National Wildlife Refuge
4. WWTP = Wastewater treatment plant

Legend

Sediment Sample Location
Clark County Tax Lots (2010)
Limits of Work

Area Designations

Port-Owned
Port-Owned
City of Ridgefield WWTP

Private
Residential; Low-Density
McCuddy's Marina Property

Other
RNWR
BNSF Railroad Property
Lake River

0 150 300
Feet

Figure 1-3
Site and Property Diagram

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

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Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP); taxlot and road data obtained from Clark County (August 2013).

Note: ENR = enhanced natural recovery

Legend

- Dredge Prism
- Fish Mix
- Clean Soil
- Gravel
- ENR Sand

Figure 1-4
Lake River Remedy Areas

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 100 200
Feet

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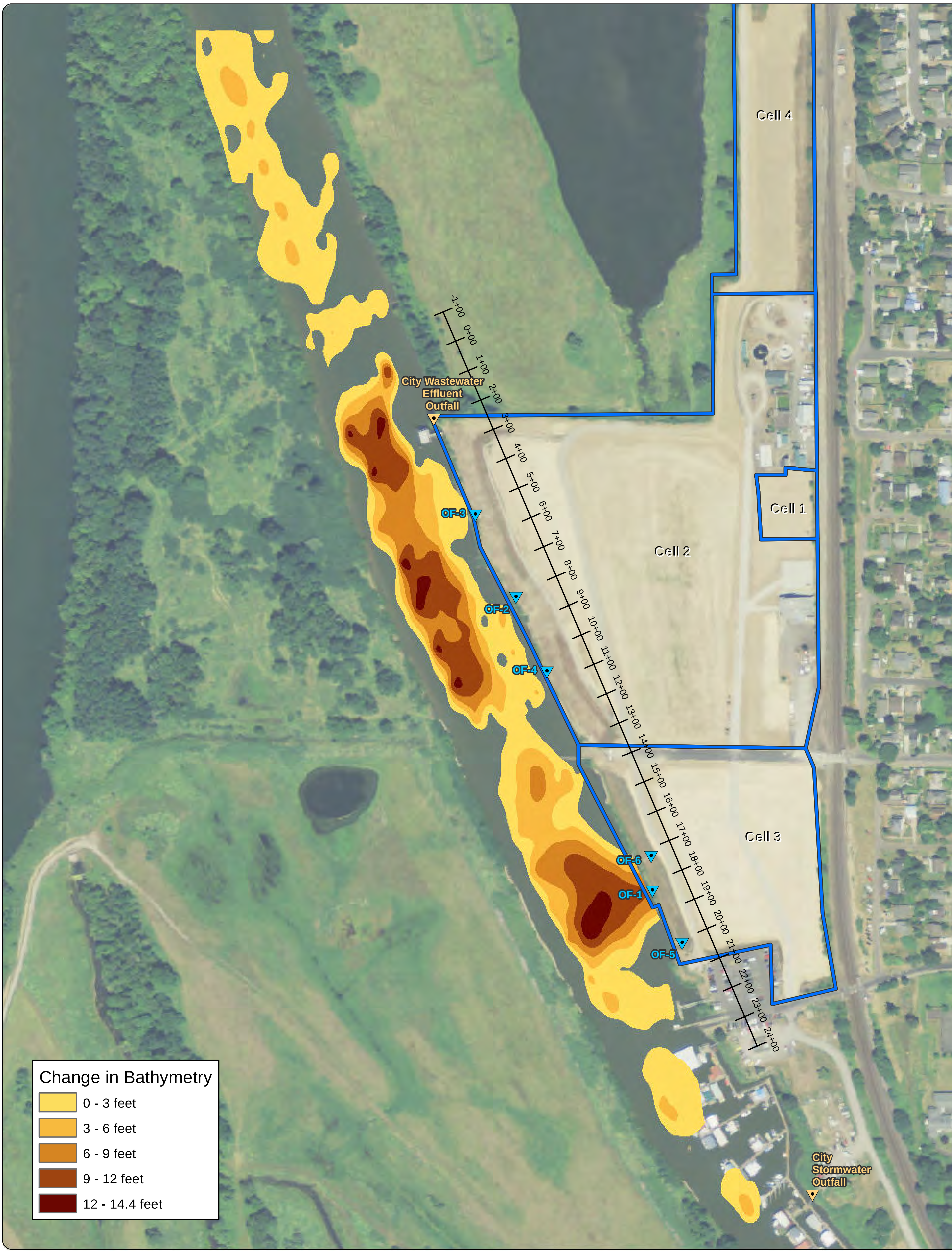

Notes:
1. Sediment deposition estimated by comparing 1970 soundings with 2010 soundings; the representation shown can only be considered as indicating the general conditions existing at the time.
2. Bathymetric surveys from 1970 and 2010 obtained from the COE (Army Corps of Engineers).
3. Bathymetric surfaces created using the ArcGIS 10 Spatial Analyst extension spline method.

Legend

- Historical Outfall
- City of Ridgefield Outfall
- Cell Boundary

Figure 2-1
Estimated Sediment Deposition
1970 - 2010 - Lake River

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 150 300
Feet

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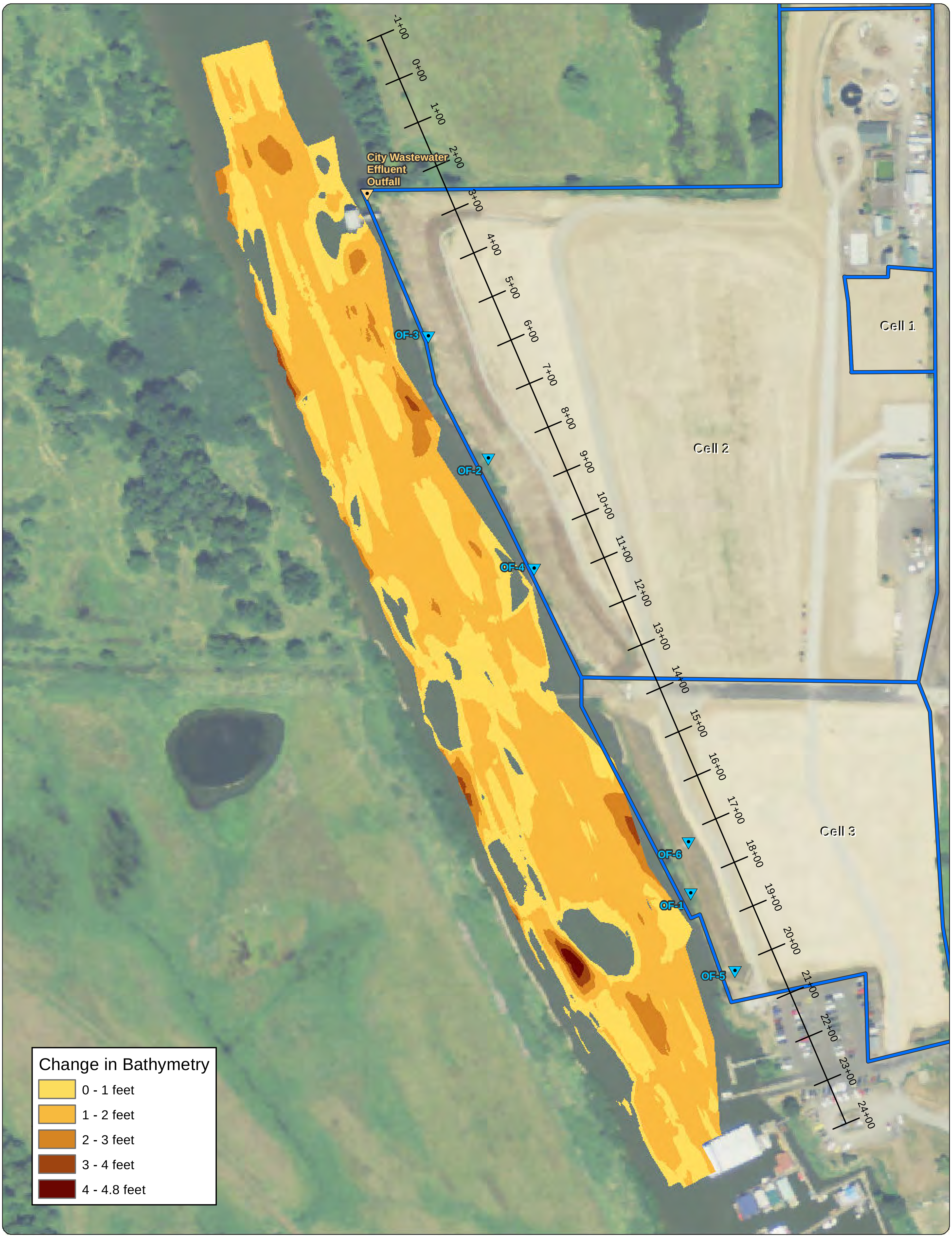
Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig2-1_Estimated Sediment Deposition 1970-2010 - Lake River.mxd
Print Date: 2/26/2014
Approved By: M. Novak
Produced By: J. Schane
Project: 9003.01.40



Notes:
1. Sediment deposition estimated by comparing 2010 soundings with 2013 soundings; the representation shown can only be considered as indicating the general conditions existing at the time.
2. Bathymetric survey from 2010 obtained from the COE (Army Corps of Engineers). 2013 survey obtained from Minister-Glaeser.
3. Multibeam bathymetric survey was provided as a GeoTIFF from MG; 2010 was created in ArcMap 10.1 using the TIN to Raster geoprocessing tool.

Legend

- Historical Outfall
- City of Ridgefield Outfall
- Cell Boundary

Figure 2-2
Estimated Sediment Deposition
Lake River 2010 - 2013

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 100 200
Feet

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Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig2-2_Estimate Sediment Deposition Lake River 2010 - 2013.mxd

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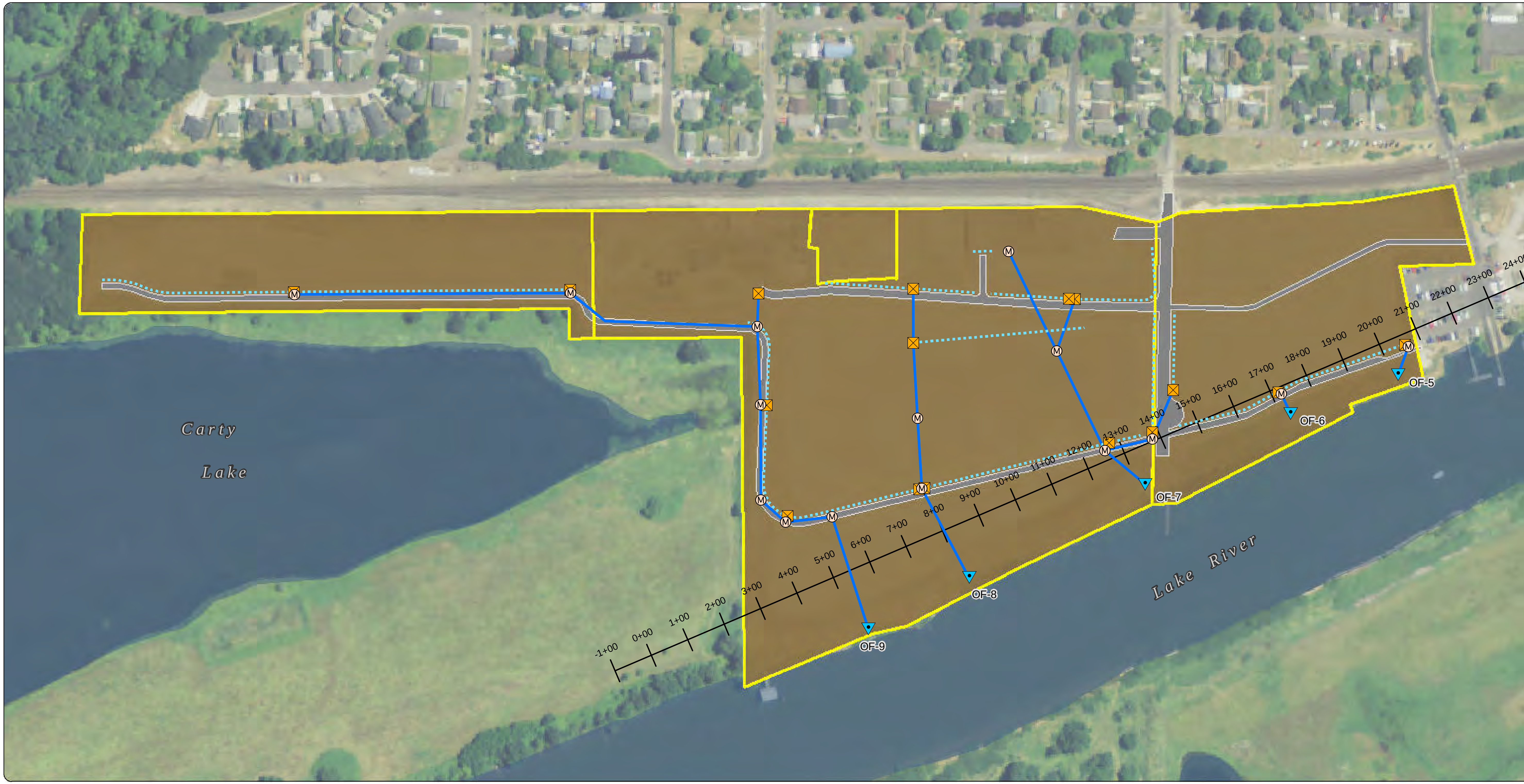

Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Legend

- Manhole
- Catch Basin
- Outfall
- Ditch
- Stormline
- Roads
- Lake & River
- Cell Boundaries

Figure 2-3
Current Stormwater System

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 125 250
Feet

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Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig2-3_Current Stormwater System.mxd
Print Date: 2/20/2014
Approved By: A. Hughes
Produced By: jschane
Project: 9003.01.40

Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Notes:
1. bml = below mudline.
2. IDW = Inverse Distance Weighted.
3. ng/kg = nanograms per kilogram.
4. TEQ = Toxicity Equivalent.
5. Surface Dioxin TEQ west of sample points was extrapolated to an assumed constant of 2.0 ng/kg.
6. Analysis extent has been clipped to the upshore extent of dredge feasibility plus 20 feet bankward. Dredge boundaries near the shore were generally determined by projection of a 3:1 horizontal to vertical slope down from the shoreline inflection point to the required dredge depth. ENR boundaries near the shore were determined by the point where the shore slope transitions to less than a 5:1 horizontal to vertical slope.
7. Sample concentrations were log-normalized prior to conducting interpolation because of a positively skewed histogram indicating the presence of a few very large concentrations.
8. IDW parameters: Power=1, 200-ft x 100-ft elliptical search neighborhood at 155°, minimum samples=1, smoothing factor=0.5.

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Legend

- Surface Sediment Sample
- Historical Outfall

Dioxin TEQ (ng/kg)
5.1 - 30
> 30

Figure 2-4
Distribution of Surface and Subsurface Dioxin using IDW Interpolation
Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 150 300
Feet

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig2-4_Distribution of Surface and Sub-Surface Dioxin using IDW Interpolation.mxd
Print Date: 2/26/2014
Approved By: mnovak
Produced By: jschane
Project: 9003.01.40/06

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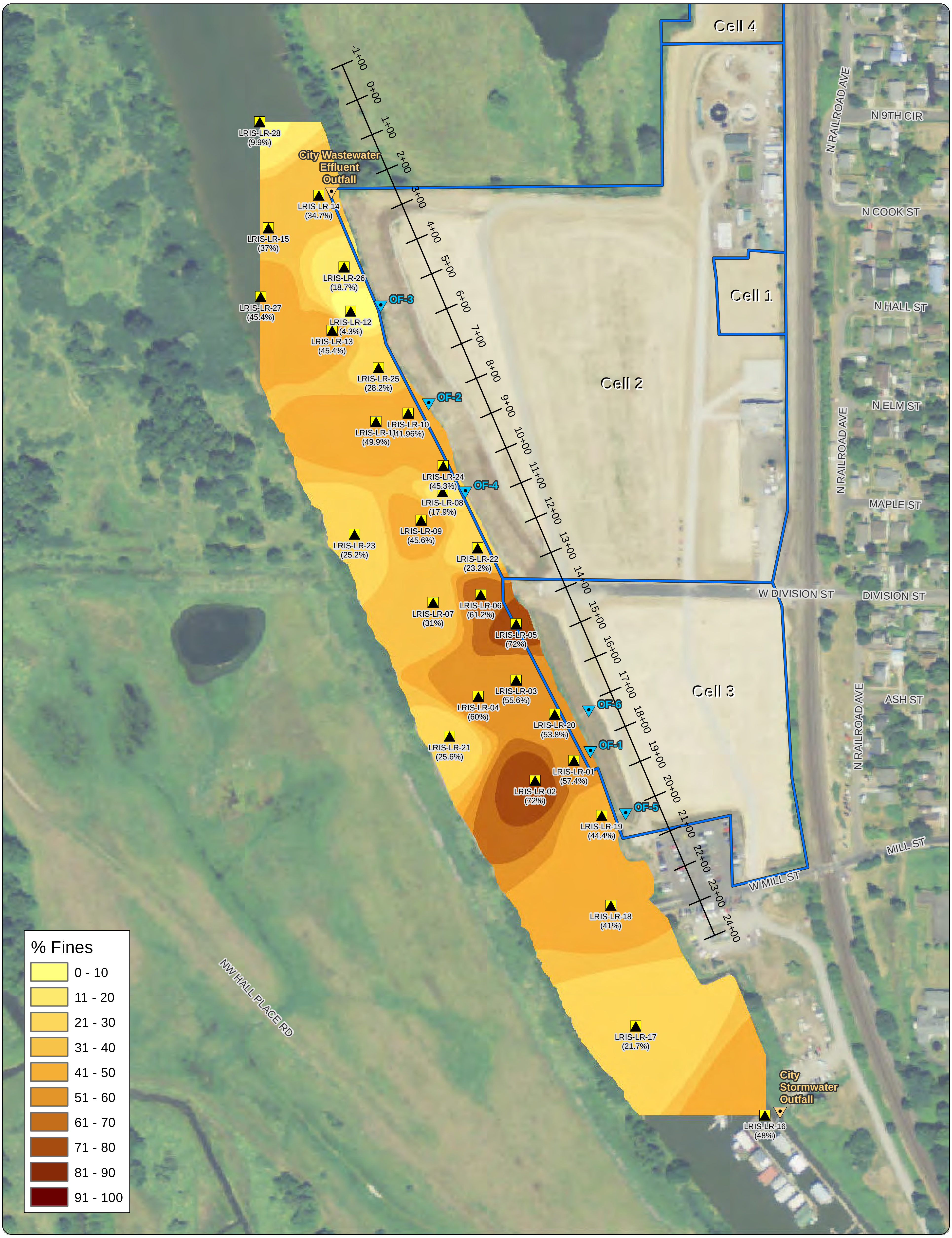

Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Notes:
1. Percent fines is percent of clay and silt.
2. Percent fines sampling depth is 0-10 cm.
3. Contours created using ArcGIS 10 Spatial Analyst inverse distance weighted (IDW) interpolation method.
4. IDW parameters: Power of 6, 12 Points

Legend

- Sediment Sample Location
- Historical Outfall
- City of Ridgefield Outfall
- Cell Boundary

Figure 2-5
Lake River Percent Fines

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 125 250
Feet

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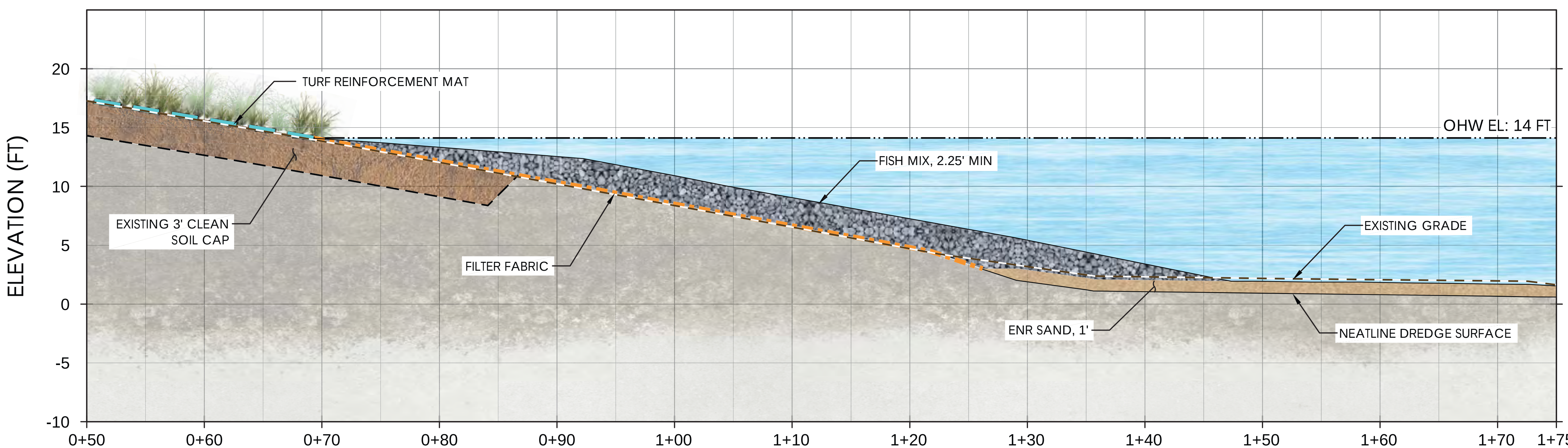
Project: 9003.01.40



LEGEND

- Existing Grade
- Ordinary High Water Level
- Filter Fabric
- Turf Reinforcement Mat
- Demarcation Fabric
- Lake River
- Native/Historical Fill Material
- Erosion Resistant Fish Mix
- ENR Sand Layer
- Existing Clean Soil Cap
- Native Grasses

0 10' 20'

NOTE: BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALE ACCORDINGLY.

CELL 2 NORTH SUBREACH TYPICAL SECTION

LAKE RIVER SEDIMENT REMEDY

PORT OF RIDGEFIELD
RIDGEFIELD, WA

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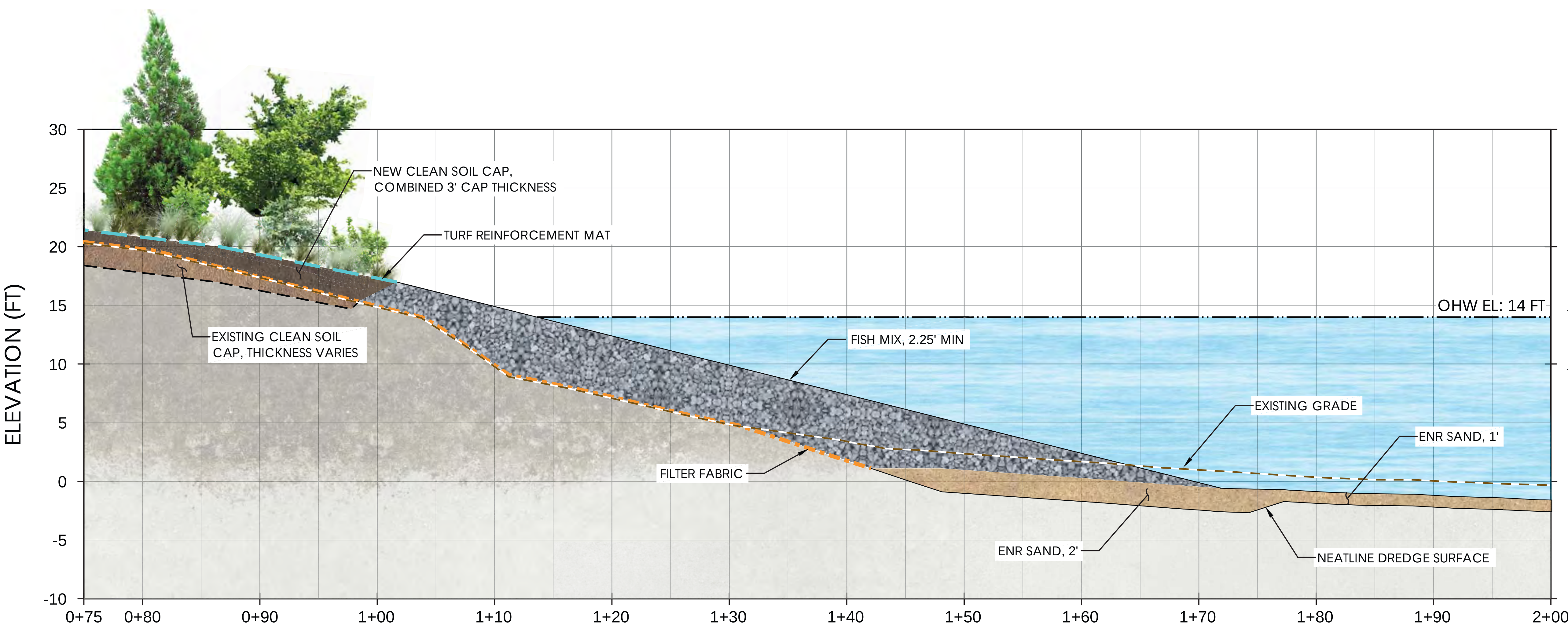
FIGURE 3-1



LEGEND

- Existing Grade
- Ordinary High Water Level
- Filter Fabric
- Turf Reinforcement Mat
- Demarcation Fabric
- Lake River
- Native/Historical Fill Material
- Erosion Resistant Fish Mix
- ENR Sand Layer
- Existing Clean Soil Cap
- New Clean Soil Cap
- Native Trees, Shrubs & Grasses

0 10' 20'

NOTE: BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALE ACCORDINGLY.

CELL 2 ARCH. SUBREACH TYPICAL SECTION

LAKE RIVER SEDIMENT REMEDY

PORT OF RIDGEFIELD

RIDGEFIELD, WA

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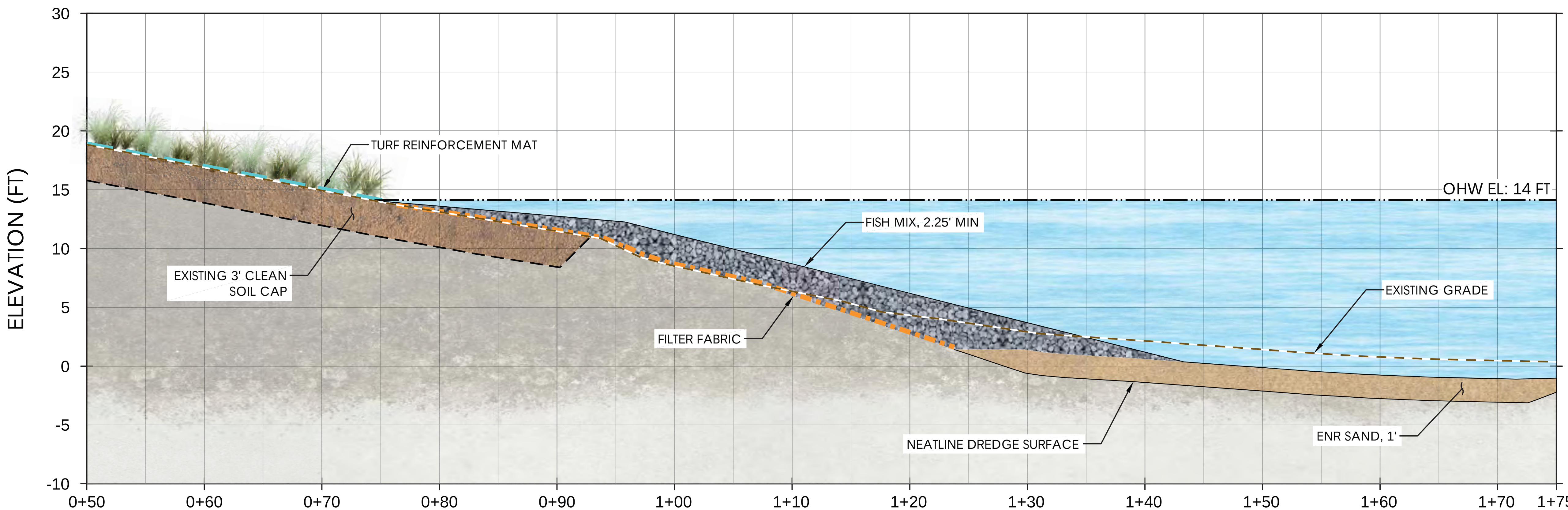
FIGURE 3-2



LEGEND

- Existing Grade
- Ordinary High Water Level
- Filter Fabric
- Turf Reinforcement Mat
- Demarcation Fabric
- Lake River
- Native/Historical Fill Material
- Erosion Resistant Fish Mix
- ENR Sand Layer
- Existing Clean Soil Cap
- Native Grasses

0 10' 20'

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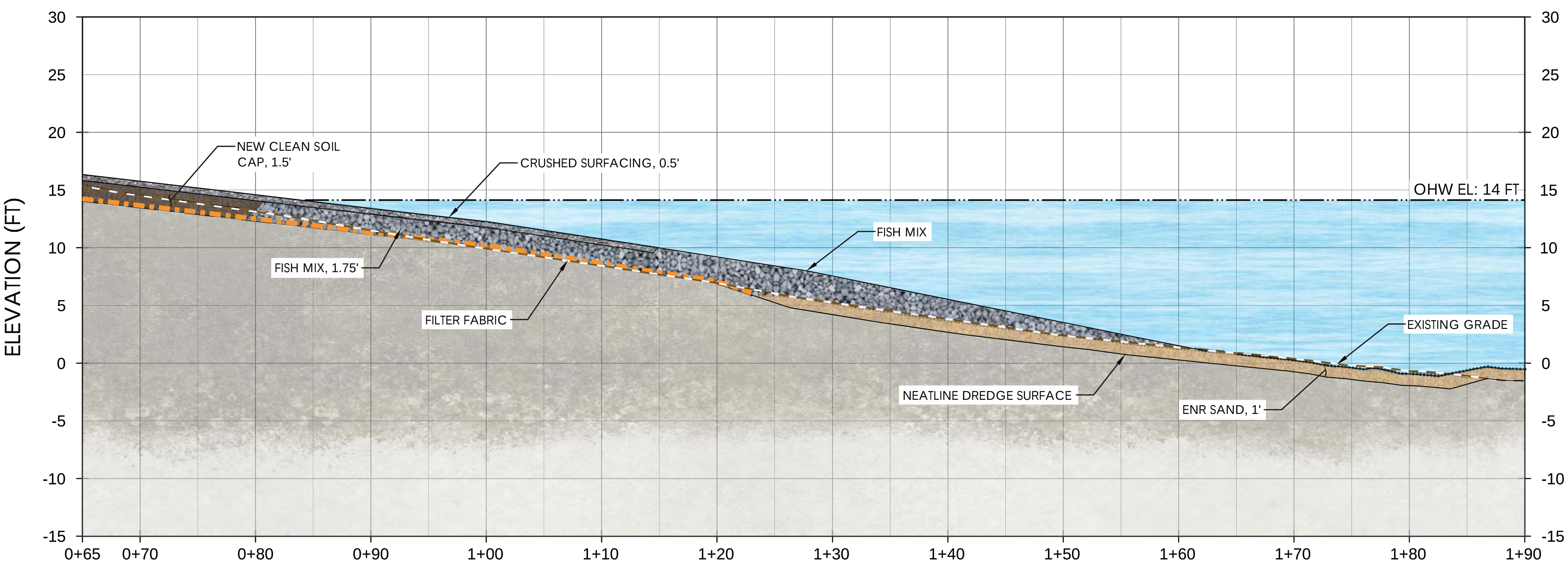
CELL 2 SOUTH SUBREACH TYPICAL SECTION
LAKE RIVER SEDIMENT REMEDY

PORT OF RIDGEFIELD
RIDGEFIELD, WA

FIGURE 3-3



LEGEND

Existing Grade		Lake River		ENR Sand Layer	
Ordinary High Water Level		Native/Historical Fill Material		New Clean Soil Cap	
Filter Fabric		Erosion Resistant Fish Mix		Crushed Gravel Surfacing	

0 10' 20'

NOTE: BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALE ACCORDINGLY.

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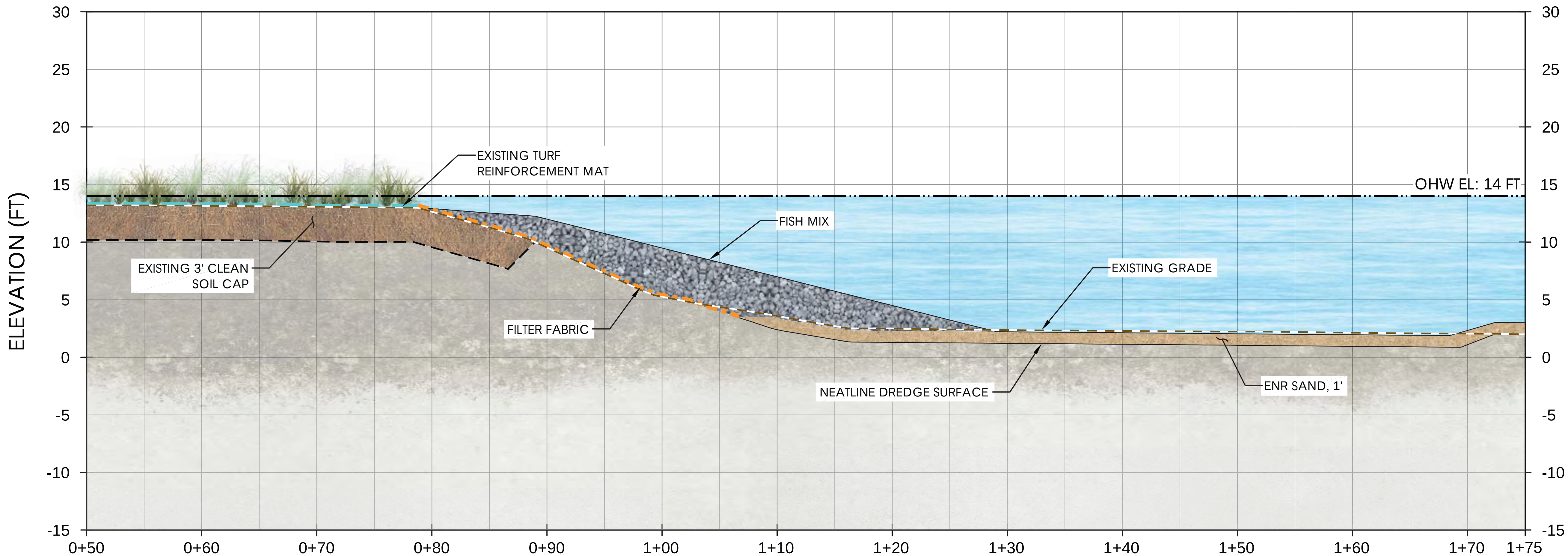
KAYAK LAUNCH SUBREACH TYPICAL SECTION
LAKE RIVER SEDIMENT REMEDY

PORT OF RIDGEFIELD
RIDGEFIELD, WA

FIGURE 3-4

CELL 3 SUBREACH TYPICAL SECTION
LAKE RIVER SEDIMENT REMEDY
PORT OF RIDGEFIELD
RIDGEFIELD, WA



LEGEND

- Existing Grade
- Ordinary High Water Level
- Filter Fabric
- Turf Reinforcement Mat
- Demarcation Fabric
- Lake River
- Native/Historical Fill Material
- Erosion Resistant Fish Mix
- ENR Sand Layer
- Existing Clean Soil Cap
- Native Grasses

0 10' 20'

NOTE: BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALE ACCORDINGLY.

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FIGURE 3-5

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig3-6_Post-Dredge Dioxin Concentration Estimates.mxd

Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Notes:
1. ENR = Enhanced Natural Recovery.
2. IDW = Inverse Distance Weighted.
3. TEQ = Toxicity Equivalent.
4. ng/kg = nanograms per kilogram.
5. Analysis extent has been clipped to the upshore extent of dredge feasibility plus 20 feet bankward. Dredge boundaries near the shore were generally determined by projection of a 3:1 horizontal to vertical slope down from the shoreline inflection point to the required dredge depth. ENR boundaries near the shore were determined by the point where the shore slope transitions to less than a 5:1 horizontal to vertical slope.
6. Post-remedy concentrations were log-normalized prior to conducting interpolation to maintain consistent methodology with the interpolation of the pre-remedy surface.
7. IDW parameters: Power=1, 200-ft x 100-ft elliptical search neighborhood at 155°, minimum samples=1, smoothing factor=0.5.

Legend

Surface Sediment Sample

Outfall

Surface Dioxin TEQ (ng/kg)

5.1 - 30

> 30

Figure 3-6
Post-Dredge Dioxin Concentration Estimates

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 100 200
Feet

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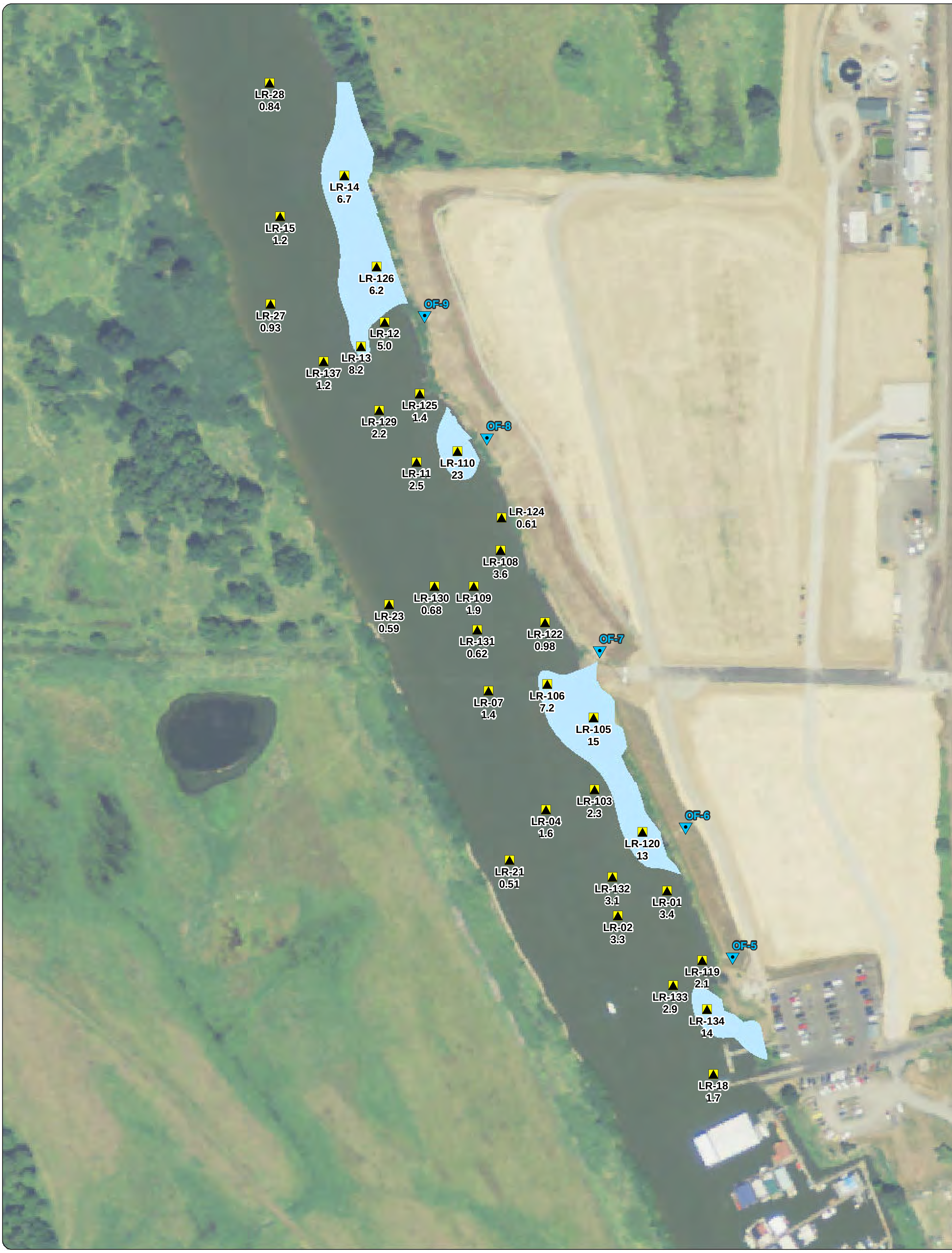
Print Date: 2/20/2014
Approved By: mnovak
Produced By: jschane
Project: 9003.01.40/06



Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Notes:
1. ENR = Enhanced Natural Recovery.
2. IDW = Inverse Distance Weighted.
3. TEQ = Toxicity Equivalent.
4. ng/kg = nanograms per kilogram.
5. Post-remedy concentrations were log-normalized prior to conducting interpolation to maintain consistent methodology with the interpolation of the pre-remedy surface, which presented a positively skewed histogram.
6. Analysis extent has been clipped to the upshore extent of dredge feasibility plus 20 feet bankward. Dredge boundaries near the shore were generally determined by projection of a 3:1 horizontal to vertical slope down from the shoreline inflection point to the required dredge depth. ENR boundaries near the shore were determined by the point where the shore slope transitions to less than a 5:1 horizontal to vertical slope.
7. IDW parameters: Power=1, 200-ft x 100-ft elliptical search neighborhood at 155°, minimum samples=1, smoothing factor=0.5.

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Legend

- Surface Sediment Sample
- Outfall

Surface Dioxin TEQ (ng/kg)

- 5.1 - 30
- > 30

Figure 3-7
Post-Dredge and ENR Dioxin Concentration Estimates

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 100 200
Feet

Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig3-7_Post-Dredge and ENR Dioxin Concentration Estimates.mxd
Print Date: 2/21/2014
Approved By: mnovak
Produced By: jschane
Project: 9003.01.40/06

Source: Aerial photograph (2013) obtained from the National Agriculture Imagery Program (NAIP).

Note: Multibeam bathymetric survey was provided as a GeoTIFF from Minister-Glaeser; hillshade effect was created in ArcMap 10.1 with the Esri 9.3 Swiss Hillshade tool.

Legend

Outfall

City of Ridgefield Outfall

Cell Boundaries

Multibeam Bathymetry

High : 1.9

Low : -16.8

Figure 4-1
Lake River Multibeam Digital Terrain Model

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

0 100 200
Feet

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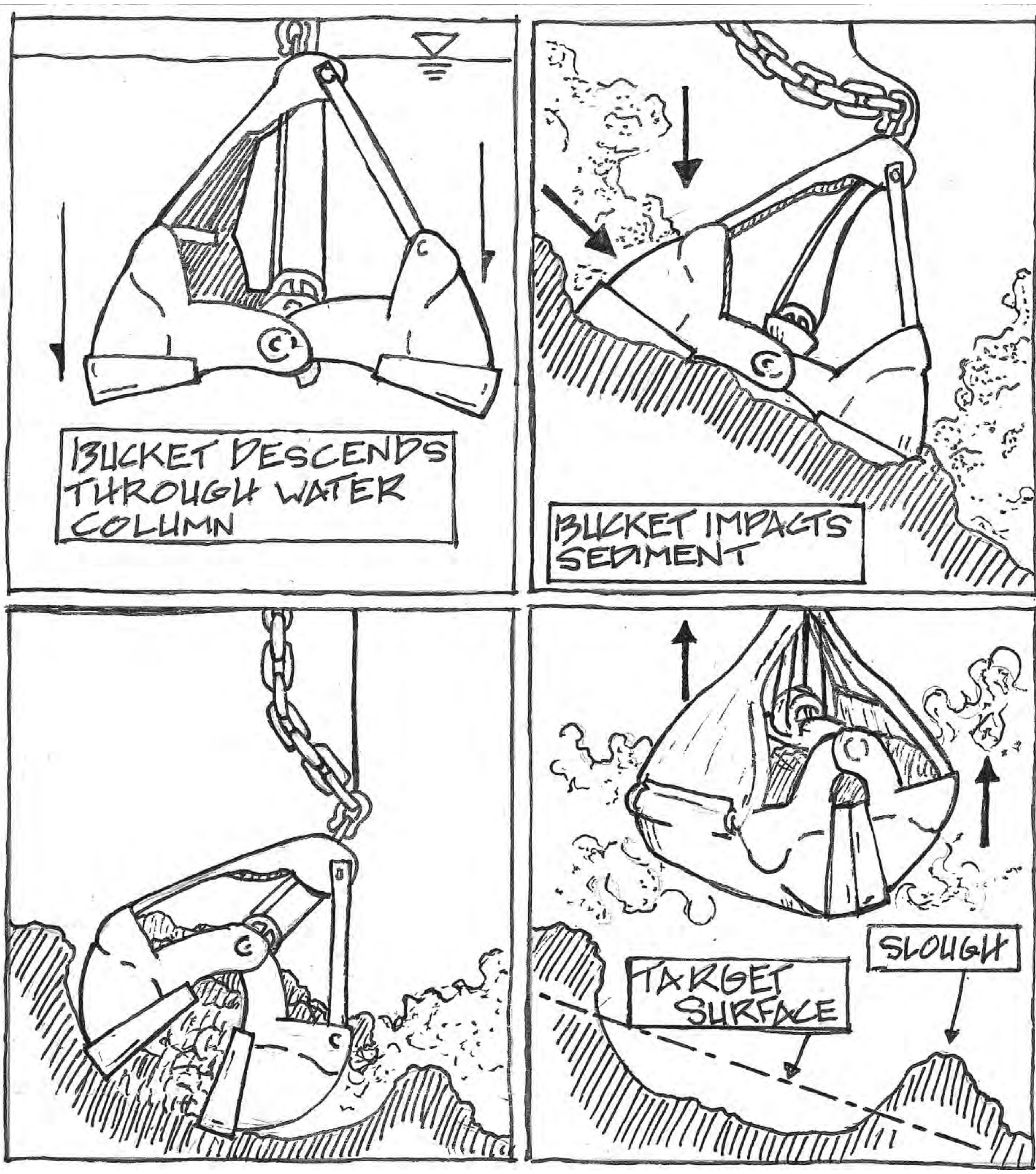
Path: X:\9003.01 Port of Ridgefield\40\Projects\06\Lake River Remedial Design\Fig4-1_ Lake River Multibeam Digital Terrain Model.mxd

Print Date: 2/21/2014 Approved By: M. Novak Produced By: J. Schane Project: 9003.01.40



Path: L:\Projects\9003.01 Port of Ridgefield\040 Sediment RI\Lake River Design\Report\Figures

Produced By: c.riley   Print Date: 2/14/2014

Project: 9003.01.40-06

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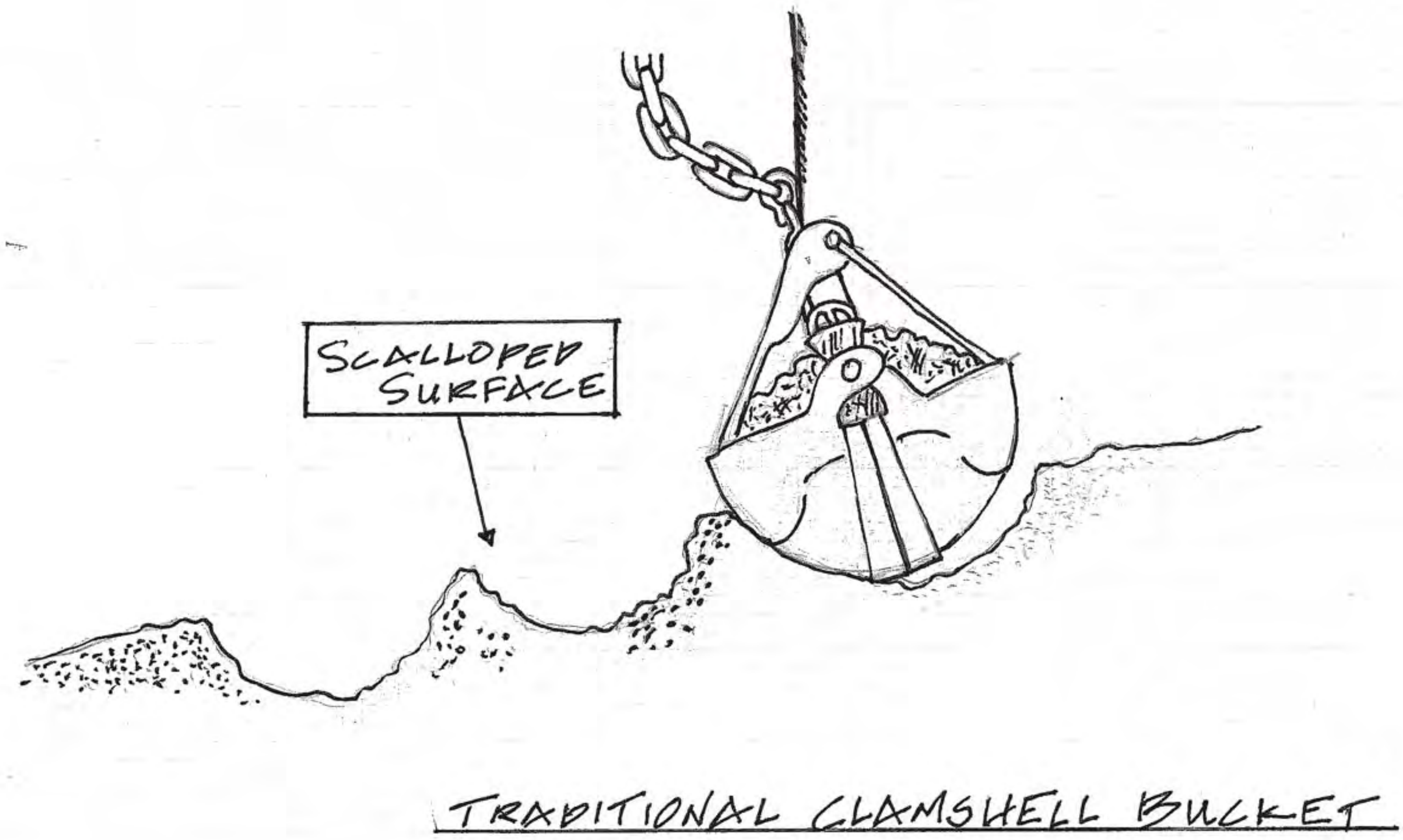
Figure 4-2
Traditional Clamshell Bucket

Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington



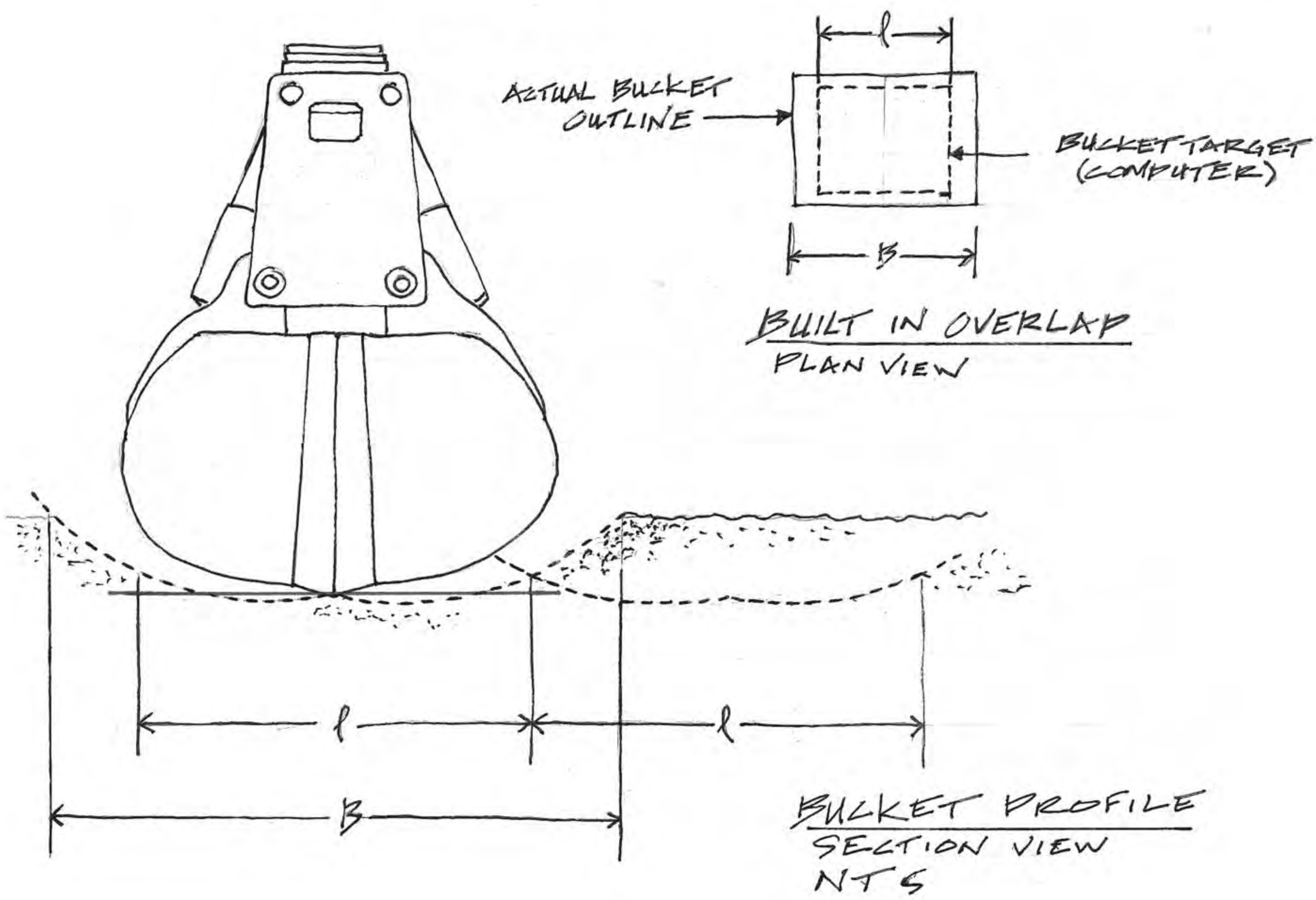


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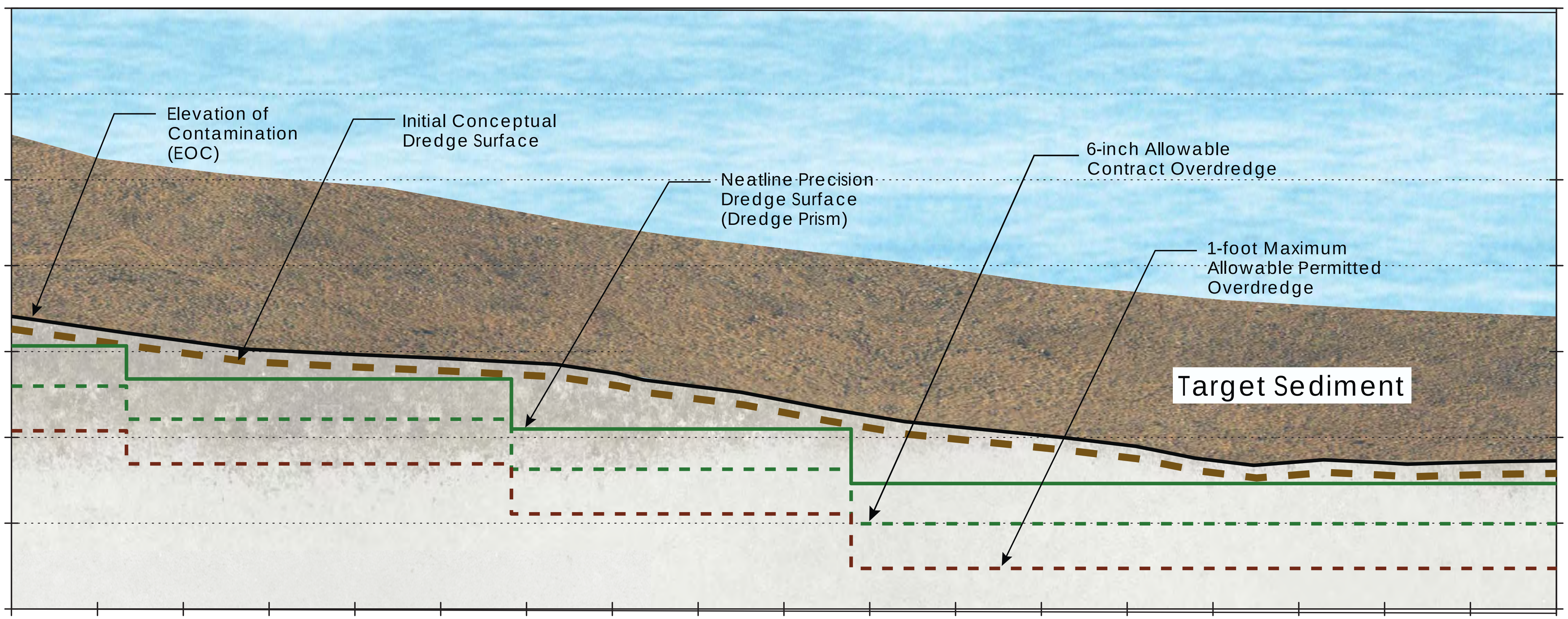
Figure 4-3
Bucket Cut Profile
Lake River Remedial Action
Port of Ridgefield
Ridgefield, Washington

Project: 9003.01.40-06 Produced By: c.riley Print Date: 2/14/2014 Path: L:\Projects\9003.01 Port of Ridgefield\040_Sediment RI\Lake River Design\Report\Figures



LEGEND

- EOC
- Initial Conceptual Dredge Surface
- Neatline Precision Dredge Surface
- Allowable Contract Overdredge
- Maximum Permitted Overdredge
- Lake River
- Sediment to Remain
- Sediment to be Removed (Dredged)

NOT TO SCALE

Precision Dredge Design Surfaces
LAKE RIVER SEDIMENT REMEDY
PORT OF RIDGEFIELD
RIDGEFIELD, WA

MFA JOB #:	9003.01.40-06
ISSUE DATE:	06/20/2013
CHECKED:	E. BAKKOM
DRAWN:	C. LAMB

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FIGURE 4-4

APPENDIX B

MEMORANDUM RE: SEDIMENT HANDLING PHYSICAL CHARACTERIZATION BENCH TESTING

MEMORANDUM

To:	File	Date:	March 3, 2014
From:	Connor Lamb, P.E.	Project:	9003.01.40
	Joshua Elliott, P.E.		
RE:	Sediment handling physical characterization bench testing		

This memorandum serves to document work undertaken by Maul Foster & Alongi, Inc. (MFA) to understand the physical handling characteristics of sediment taken from Lake River along the Port of Ridgefield (the Port) frontage. Sediment was obtained during the December 2012 environmental sampling carried out by MFA. The bench testing and observations are intended to inform the design of environmental dredging within Lake River. The bench testing included physical manipulation of the sediment in order to simulate dredging and handling methods. The general behavior of the sediment during each test was observed and recorded. The tests are intended to show how the sediment will react to handling, stacking, drying, and amending, among other characteristics that can be observed and recorded. The testing was carried out by MFA on January 18, 2013 (E. Bakkom and J. Elliott) and January 24, 2013 (C. Lamb and J. Elliott) at the Port facilities.

PROCEDURE:

- Sediment collected during the December 2012 sampling event was placed in labeled 5 gallon buckets with sealed lids for use in the bench test.
- Observations and measurements were recorded on a table (see attached).
- MFA generally described and recorded the range of grain sizes within each sample (sand with silt, mostly silt, etc.).
- Subsamples were taken from each sample. Each subsample was placed into a bowl of known mass and was weighed.
- Subsamples were evaluated by placing the subsample on the wooden platform and observing and recording slump and stackability. Material was placed onto the platform by inverting the container.
- Water was then added to each subsample in 10 percent increments (by mass); each subsample was worked with a paint stick to incorporate all added water into the sediment slurry. After adding each increment of water, the subsample was again placed on the wooden platform to evaluate apparent slump, stackability and flowability.

- Portions of each subsample were placed in coffee filters to simulate the paint filter test and observations were noted.
- Admixtures were then added to all subsamples. Both Portland cement and quicklime (CaO) were used as dewatering admixtures. Each was added in 5 percent increments (by mass). The admixtures were mixed into the sediment on the platform to simulate mixing by an excavator.

RESULTS

See the attached tables, photos, and videos for a complete record of the results. The following generalities can be made regarding the results of this testing:

- In its undisturbed condition, the material was generally moist to wet with some free water on the material or in the bucket. When initially placed on the platform, no visible slump was noted.

- Apparent cohesion was noted. Significant effort was required to remold the sediment during the first two (10% and 20%) moisture addition steps.

- Once water was added to 20% by weight, the material became a flowable slurry with no cohesive properties.

- All sub samples dripped through the filter immediately after the 10% water addition.

- Admixtures were generally successful at amending the material at the varying moisture contents over various timeframes.

CONCLUSION

Initial attempts to remold the sediment required significant effort; however, when more than 20 percent added water was worked into the sediment, the material became a flowable slurry that did not give up free water easily. If overworked, the sediment will become difficult to handle without admixtures. A dredge method resulting in as little remolding of the sediment is preferable, thereby keeping the sediment in as unsaturated a state as possible. Additionally, rehandling of the sediment should be limited to the extent possible.

Both admixtures were effective dewatering agents; not surprisingly, the quicklime exhibited more dramatic results. . As more water was added to the sediment, ever increasing amounts of either admixture were required to restore workability. The range of admixture evaluated was between 5% and 15% by mass.

Table 1
General Observations
Sediment Physical Handling Characteristics

Sample ID	General Description	Observations at % Added Water			
		0	10%	20%	30%
120	Silty, possibly even finer material "mud". wet, some standing water	Stands up when placed on surface. No slump. Some freewater in material	Added water at 10% by weight, remolded by mixing with paint stick to get consistent mixture. Takes a bit of effort to remold: Showed some cohesion, no freewater escaped/well mixed. Slumped down but did not flow.	Added 10% more and remolded with paint stick to get consistent mixture: Immediate flow, slurry like consistency, no freewater upon placement	Flow. Thin slurry. No freewater resulted from placement on surface
109	Sandy, some "mud", some wood fiber	Stands up when placed on surface. No slump. Some freewater in material. Material at bottom of bucket relatively dry	Added water at 10% by weight, remolded by mixing with paint stick to get consistent mixture: Takes a bit of effort to remold. Some cohesion, no freewater immediately		
119	Sandy silt, less "mud", large wood chunk in material, rotten decaying	Stands up, no slump, some freewater on surface	Added water at 10% by weight, remolded by mixing with paint stick, does not remold easy, have to stir significantly: flowed fairly freely, very wet	Added 20% total by weight (new mud). Have to stir significantly to remold: flowed freely, very slurry like	

Table 2
Paint Filter Test
Sediment Physical Handling Characteristics

Sample ID	Paint Filter			
	0%	10%	20%	30%
120	one drip in 3 minutes resulting from freewater on sample	Dripped free water within 1 minute	Dripped freewater immediately (within 20 seconds)	NA
109	one drip in 3 minutes resulting from freewater on sample	Dripped immediately		
119	No drip - passes	Dripped immediately		

Table 3
Addmixture Notes
Sediment Physical Handling Characteristics

Sample ID	Portland cement			Quick Lime		
	5%	10%	15%	5%	10%	15%
109 (at 10% Addwater)	2 drops after about 3 minutes: After 1.5 hours no drops through coffee filter				Immediately sorbed water and material was visibly dry and stacked up within minutes of mixing it. Passed paint filter	
109 (at 20% Addwater)			Still wet: after 1.25 hours, some freewater at base of pile, dripped through filter within 30 seconds			
119 (at 20% Addwater)				turned slurry-like 20% mixture into material that would stand up, still wet, no pass on the paint filter	made material stackable, not noticeable free water, still quite wet, no pass on the paint filter after approx 20 minutes of hydrating	made material noticeably dryer, no remaining surface moisture, material giving off a lot of heat,