Portland Harbor Superfund Site

Multnomah County, Oregon
Superfund Site ID#: ORSFN1002155

June 2016

SUPERFUND PROPOSED PLAN

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 10

EPA Announces Proposed Plan

The U.S. Environmental Protection Agency (EPA) invites the public to review and comment on this Proposed Plan for the cleanup of the in-river portion of the Portland Harbor Superfund Site. The Portland Harbor Site, as listed on the National Priorities List (NPL), includes an in-river and an upland portion; however, this Proposed Plan does not include actions to address the upland portion of the Portland Harbor Site. A description of the alternatives that were considered and EPA's preferred alternative for remediation of the in-river portion of the Site is provided in this Proposed Plan. The terms Site, harbor-wide, and Site-wide used in this document generally refer only to the in-river portion of the entire Portland Harbor Site.

EPA's preferred alternative, which includes a combination of dredging, capping, and enhanced natural recovery, will take approximately 7 years to construct with additional time for monitored natural recovery to occur and cost an estimated $745,660,000 (present value). The preferred alternative achieves substantial risk reduction and addresses the major sources of contamination within the Site.

This Proposed Plan was developed by EPA, the lead agency for the in-river portion of the Superfund Site, in consultation with the Oregon Department of Environmental Quality (DEQ), the support agency. EPA has entered into a Memorandum of Understanding (MOU) with the DEQ, six federally recognized tribes, two other federal agencies, and

MARK YOUR CALENDAR

Public Comment Period: June 9 to August 8, 2016

EPA will accept written comments on the Proposed Plan during the public comment period. Written comments should be addressed to:

Attn: Harbor Comments
U.S. EPA, 805 SW Broadway, Suite 500
Portland, OR 97205

Email: harborcomments@epa.gov
Electronic comment box:
https://www.epa.gov/or/forms/comment-epas-proposed-cleanup-plan-portland-harbor-superfund-site

Public Meetings
Attend one of the official EPA public meetings in Portland, OR to provide oral or written comments, and to hear an EPA presentation on the proposed plan (language interpretation is available - knudsen.laura@epa.gov).

- **June 24, 2016**, 11:30am-8pm, City of Portland Building, 1120 SW 5th Ave.
- **June 29, 2016,** 11:30am-8pm, EXPO Center, 2060 N Marine Dr.
- **July 11, 2016**, 11:30am-8pm, University Place Conference Center, 310 SW Lincoln St.
- **July 20, 2016**, 11:30am-8pm, Ambridge Center, 1333 NE Martin Luther King Jr. Blvd.

EPA will offer two presentations on the proposed plan during each public meeting (12noon to 12:30pm and 6pm to 6:30pm).

EPA will announce the details of the public meetings by posting them on our website (http://go.usa.gov/3Wf2B), issuing a public notice and placing ads in local newspapers. You can find links to the Proposed Plan and the supporting documents in the Administrative Record on our website.

one other state agency.[1] Under the MOU, DEQ is the lead agency for addressing contamination in the upland portion of the Superfund Site, and EPA is the support agency. The MOU partners have all provided input in the development of the Remedial Investigation and Feasibility Study (RI/FS).

EPA is issuing this Proposed Plan as part of its public participation responsibilities under Section 117(a) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA) and Section 300.430(f)(2) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under Section 300.430(f)(2), "*The purpose of the proposed plan is to supplement the RI/FS and provide the public with a reasonable opportunity to comment on the preferred alternative for remedial action, as well as alternative plans under consideration, and to participate in the selection of remedial action at a site.*"

The nature and extent of Site contamination and the remedial alternatives summarized in this Proposed Plan are described in greater detail in two documents: the *Portland Harbor Remedial Investigation Report* and the *Portland Harbor Feasibility Study Report*. These and other supporting documents are part of the publicly available Administrative Record. EPA encourages the public to review these documents to gain a more comprehensive understanding of the Site and the activities that have been conducted at the Site as part of the Superfund process (Figure 1).

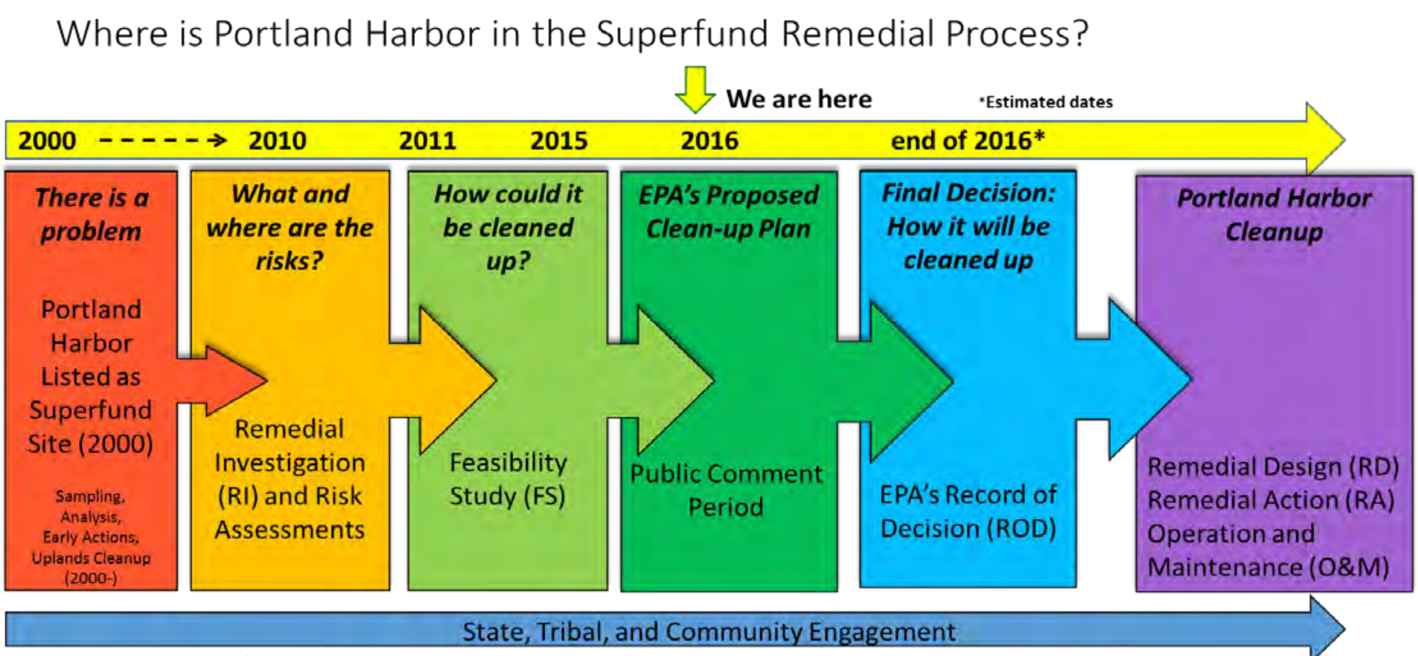

Figure 1. The Superfund Pipeline

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

Because the Site is a dynamic, interconnected system, EPA evaluated all contaminated media and exposure pathways on a Site-wide basis, and on smaller spatial scales, as appropriate. The environmental media evaluated include sediment, biota, surface water, groundwater, and river banks.

The human health and ecological risk assessments concluded that contamination within the Site poses unacceptable risk to human health and the environment due to the presence of a variety of contaminants. There are 64 contaminants of concern (COCs) at the Site, with most of the human health and ecological dietary risks attributed to polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzo-*p*-dioxins and furans (dioxins and furans), and pesticides such as dichlorodiphenyltrichloroethane (DDT) (see "*What are the Contaminants of Concern*"). Risks posed to benthic organisms is attributed to 16 COCs, including PAHs, pesticides such as DDT, cyanide, and volatile organic compounds (VOCs). EPA's preferred alternative addresses all identified risk pathways and COCs for the Site.

WHAT ARE THE "*CONTAMINANTS OF CONCERN*"?

EPA has identified many hazardous substances, pollutants and contaminants in the sediment at the Site. The following Contaminants of Concern (COCs) pose the greatest potential dietary risks to human health and the environment in the Site based on consumption of fish.

PCBs are human health and ecological COCs. They are man-made chemicals that were banned in the late 1970s. PCBs are mixtures of up to 209 compounds (or congeners). Some commercial PCB mixtures are known in the United States by an industrial trade name, Aroclor. Because they do not burn easily and are good insulating materials, PCBs were used widely as coolants and oils, and in the manufacture of paints, caulking and building material. PCBs stay in the environment for a long time and can build up in fish, shellfish, and mammals. PCBs are classified as probable human carcinogens. Children exposed to PCBs may develop learning and behavioral problems later in life. PCBs are known to impact the immune system and may cause cancer in people. In birds and mammals, PCBs can cause adverse effects such as anemia and injuries to the liver, stomach and thyroid gland. PCBs also can cause problems with the immune system, behavioral problems and impaired reproduction.

Dioxins and furans are human health and ecological COCs. They are by-products of chemical manufacturing, combustion (either in natural or industrial settings), metal processing and paper manufacturing. The dioxin compound (or congener) known as 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin is the most toxic form of dioxin) and others were byproducts in the manufacture of herbicides, such as "*Agent Orange*." Dioxins stay in the environment for a long time and can build up in fish and shellfish. Toxic effects in humans include reproductive problems, problems in fetal development or early childhood, immune system damage and cancer. In animals, effects include developmental and reproductive problems, hemorrhaging and immune system problems.

PAHs are human health and ecological COCs. These chemicals are a major component of petroleum products, or are formed during incomplete burning of coal, oil, gas, wood or other substances. There are more than 100 different PAHs, and they generally occur as complex mixtures. PAHs are toxic to invertebrates and cause inhibited reproduction, delayed emergence, sediment avoidance and mortality. In fish, PAHs cause liver abnormalities and impairment of the immune system. PAHs can cause cancer in humans, and adverse effects on reproduction, development and immunity in birds and mammals.

DDT and its primary breakdown products, dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl dichloroethene (DDE), are ecological COCs. DDT is a pesticide that was banned for use in the United States in 1972. It was used widely to control insects on crops and to control mosquitoes that spread malaria. These compounds can accumulate in fish and shellfish and can cause adverse reproductive effects such as eggshell thinning in birds.

There are 64 COCs that pose risk at this Site. They are listed in Tables 1-5 and 8.

EPA expects that implementing the preferred alternative for the Site, along with DEQ's actions to address upland contamination, will reduce contaminant concentrations in all media to acceptable levels. The proposed action for the in-river portion of the Portland Harbor Site presented in this Proposed Plan will be a final remedial action.

Community Role in the Remedy Selection Process

This Proposed Plan is being issued to inform the public of EPA's preferred alternative and to solicit public comments pertaining to the remedial alternatives evaluated, including the preferred alternative. EPA acknowledges that concerns have been raised regarding a confined disposal facility; however, EPA is proposing this disposal option in the preferred alternative and taking comment on all disposal options during the public comment period. EPA may modify the preferred alternative, or select a different alternative presented in this Proposed Plan based on new information and/or public comments. Therefore, the public is encouraged to review and comment on all the alternatives presented in this Proposed Plan. EPA will select a final remedy after reviewing and considering all information submitted during the public comment period. The public comment period for this Proposed Plan concludes on August 8, 2016.

EPA will hold public meetings during the comment period to present information regarding the investigations conducted, the remedial alternatives considered, and the preferred alternative. EPA will answer questions from the public, as well as receive public comments. Additional information on the public meetings and process for submitting written comments can be found on page 1 of this Proposed Plan. Comments received at the public meetings, as well as written comments received during the public comment period, will be documented in the Responsiveness Summary in the Record of Decision (ROD). The ROD is the document that selects the final remedy and provides EPA's basis for the selection of that remedy.

Site Background

The Site is located within the lower 12 miles of the Willamette River (Figure 2), which is an urban and industrial section of the river north of downtown Portland, Oregon. The Site is approximately 2,167 acres and extends from river mile (RM) 1.9 (upriver end of the Port of Portland's Terminal 5) to RM 11.8 (near the Broadway Bridge).

Portland Harbor has served as the City of Portland's major industrial corridor since the mid-1800s and has been vital in the growth and economic health of the City. As Oregon's major port and population center, the lower Willamette River sees a great variety of uses including shipping, industrial, fishing, recreational, natural resource, and other uses. In June 1878, Congress first authorized a federal navigation channel within the lower Willamette River through the Rivers and Harbors Act. The U.S. Army Corps of Engineers (USACE) maintains the channel, which has been deepened at various intervals since that time. The authorized depth of the channel was deepened to 40 ft in 1976. In 1999, Congress authorized the Willamette River to be deepened to 43 ft; however, this has not yet occurred.

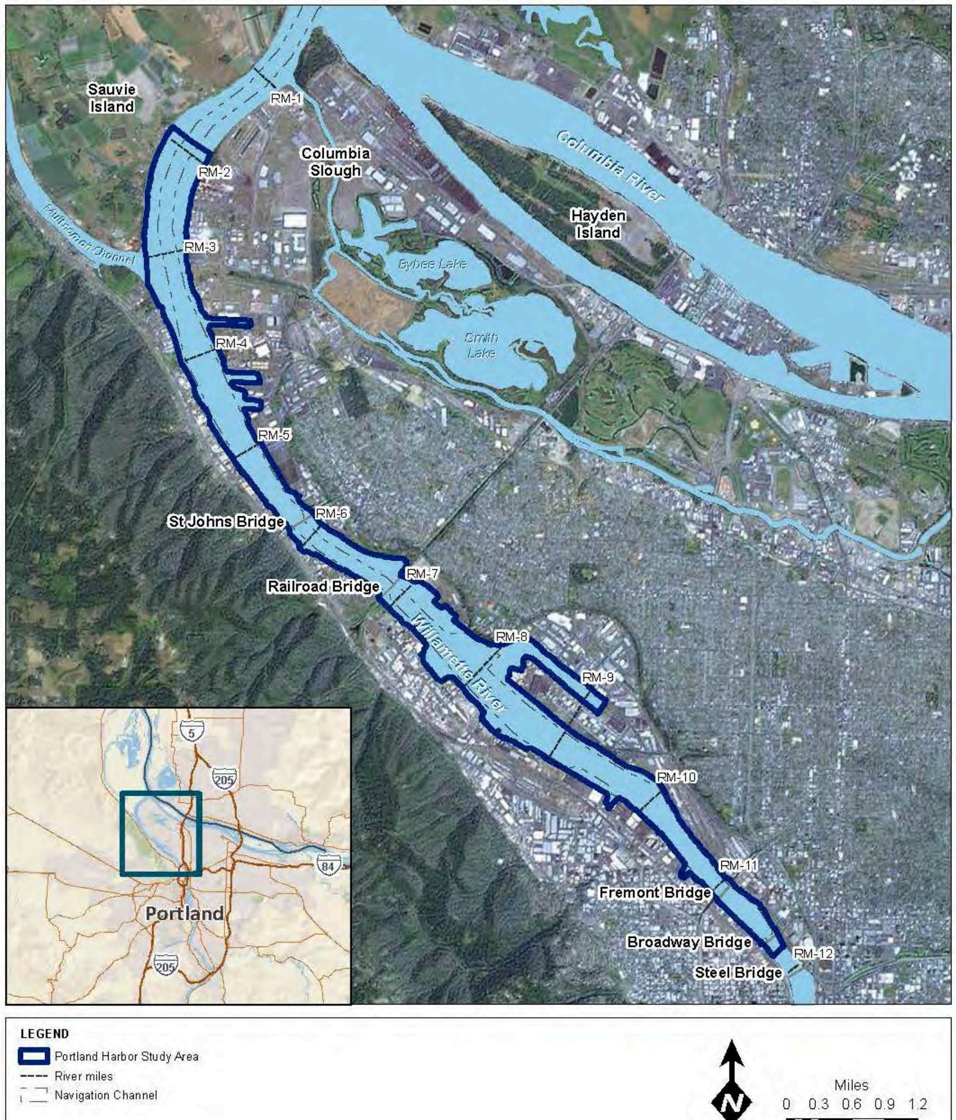

Figure 2. Site Map

Contamination in the Site reflects the historical industrial, marine, commercial, defense, and municipal practices for over 100 years in this active industrial, urban, and trade corridor. Contaminants from many facilities have entered the river system from different activities including, but not limited to: ship building, repair, and dismantling; wood treatment and lumber milling; storage of bulk fuels; manufactured gas production; chemical manufacturing and storage; metal recycling, production, and fabrication; steel mills, smelters, and foundries; and electrical production and distribution. These activities have resulted in direct discharges from upland areas through storm water and waste water outfalls, releases and spills from commercial operations occurring over the water; municipal combined sewer overflows, and indirect discharges through overland flow, bank erosion, groundwater, and other nonpoint sources. In addition, contaminants from off-site sources have reached the Site through surface water and sediment transport from upstream and through atmospheric deposition.

Operations that continue today along the river banks include bulk fuel storage, barge building, ship repair, automobile scrapping, recycling, steel manufacturing, cement manufacturing, transformer reconditioning, operation and repair of electrical transformers (including electrical substations), and many smaller industrial operations. Contaminants continue to reach the river through erosion of contaminated soils and river banks, and through groundwater and surface water discharges. Upstream sources within the broader Willamette River Basin contribute to contamination in sediment, surface water, and biota at the Site. EPA conducted an extensive search for potentially responsible parties (PRPs) and, to date, has identified about 150 parties as potentially responsible for releasing contaminants to the river (Figure 3).

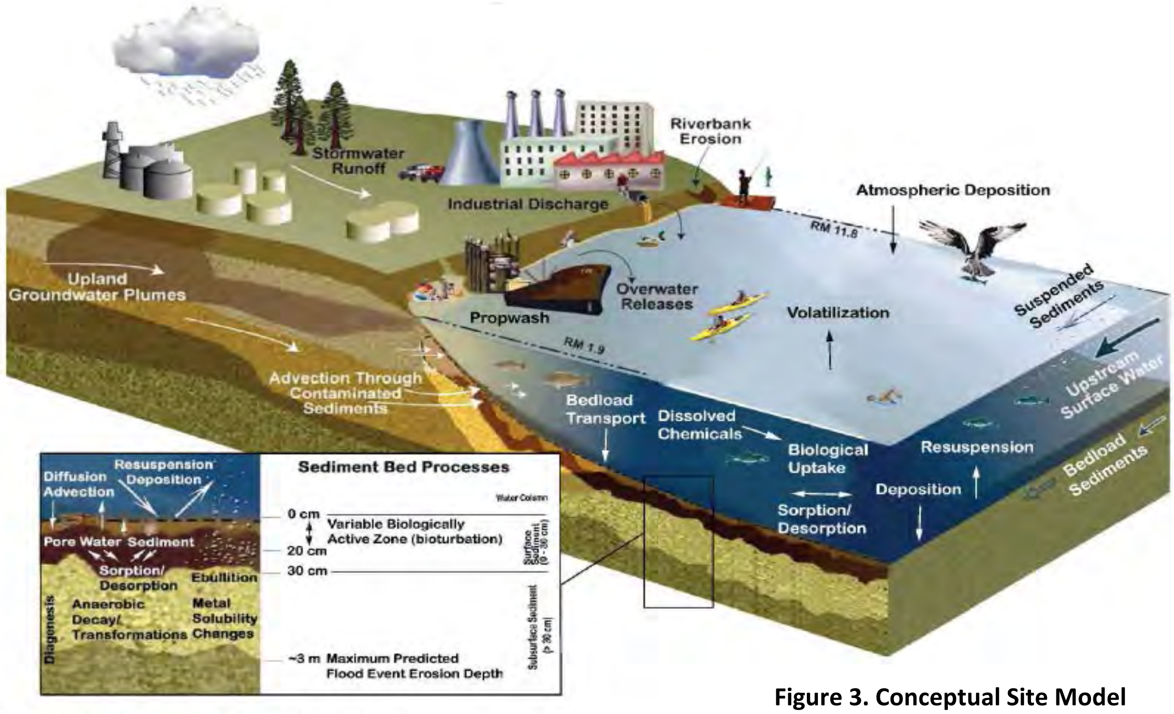

Figure 3. Conceptual Site Model

SOURCE: Figure created from PDF provided by Integral Consulting, Inc.

In addition to industrial activities, the Willamette River and surrounding watershed historically offered access to abundant natural resources in the river and on land. Many of these resources are still present, such as fish, marine mammals, waterfowl, land mammals, and native plants. Native Americans (Tribes) have been using these resources for thousands of years. Fish are among the resources most frequently utilized by Tribes in the Portland Basin and the Willamette Valley. Culturally significant species include salmonids, lamprey (eels), eulachon (smelt), and sturgeon. Native peoples also fished for a variety of other resident species, including mountain whitefish, chiselmouth, northern pikeminnow, peamouth, and suckers (Butler 2004; Saleeby 1983). The harvest of the Pacific lamprey was and continues to be important to many Tribes. Native plants were and continue to be gathered for food and medicinal purposes as well. Tribes have reserved hunting, fishing (particularly salmon and sturgeon species) and certain gathering rights through Treaties with the United States. These activities provide food for tribal families and cultural heritage knowledge and skills. Tribal uses of these resources continue today, but access to suitable patches of habitat continues to be both a challenge and an essential element of maintaining local Tribal cultural knowledge, practices and traditions.

Today, despite the degree to which the river is used for industrial and navigational purposes, the lower Willamette River still provides many natural areas and recreational opportunities, within the river and along the river banks. The State designated beneficial use of the lower Willamette River includes hunting, fishing, boating, and water contact recreation. Even though fishing is listed as a beneficial use for the lower Willamette River, the Oregon Health Authority (OHA) has posted fish advisories indicating that no species of resident fish within the Site (carp, bass, and catfish) should be eaten by vulnerable populations (which includes children under age 6, women of childbearing age and people with thyroid or immune system problems) and only one meal per month should be eaten by the rest of the population. Despite the fish advisories, the lower Willamette River is an important subsistence fishery for Tribes and many minority communities in the region. Under Oregon State Administrative Rules, the designated beneficial use of the lower Willamette River also includes private and public domestic water supply. However, there are no known current or anticipated future uses of the lower Willamette River within the Site as a private or public domestic water supply.

The lower Willamette River provides habitat for invertebrates, fish, birds, mammals, amphibians, reptiles, and aquatic plants. It has been designated by the National Marine Fisheries Service (NMFS) as critical habitat for several threatened or endangered salmon species that migrate through the Site.

Superfund History of the Site

Prior to the Site's listing on the NPL, many environmental investigations by private, State, and federal agencies had been conducted, both in the lower Willamette River and on adjacent upland properties that documented spills and discharges that may have occurred and general conditions of the river.

Investigations of the health of the river system in Portland Harbor date back to the 1920s, although most were conducted from the late 1970s through the 1990s. These have included studies by the USACE, the U.S. Geological Survey (USGS), the Oregon Department of State Lands (DSL), the Oregon Department of Fish and Wildlife (ODFW), the DEQ Water Program, and EPA. EPA issued a Preliminary Assessment and Site Investigation in May 1998. Sediment data collected during those investigations resulted in EPA proposing to add the Site to the NPL. Governor Kitzhaber concurred with EPA's determination and the Portland Harbor Site was listed on the NPL in December 2000. On September 28, 2001, ten PRPs that call themselves the Lower Willamette Group (LWG) entered into an Administrative Settlement and Order on Consent (AOC) with EPA to conduct the RI/FS. Two AOC Amendments were also signed by these parties and EPA in 2003 and 2006. In February 2001, EPA entered into the MOU with DEQ, the six federally recognized tribes, two other federal natural resource trustee agencies, and one other state natural resource trustee agency, who have all participated in providing support in the development of the RI/FS.

EPA is the lead agency for investigating and selecting a remedy for the in-river portion of the Portland Harbor Site, with support from DEQ. Under the MOU, DEQ is the lead agency for the upland source control efforts primarily using its voluntary cleanup authorities. When these State actions are complete, they must meet or be more stringent than CERCLA's remedial requirements. In November 2014, DEQ submitted the *Portland Harbor Upland Source Control Summary Report* to EPA and MOU partners. DEQ updated this report in April 2016 and it is posted on DEQ's website: www.deq.state.or.us/portlandharbor/.

Under the AOC, the LWG collected data for the RI during four major rounds of field investigations between 2001 and 2008. The field investigations began in 2001 and were conducted in the Initial Study Area (ISA) which was defined in the AOC, Statement of Work and Programmatic Work Plan as RM 3 to RM 9. As the field studies progressed, the Study Area was expanded to RM 1.9 to RM 11.8, as well as a portion of the Multnomah Channel. Studies conducted by the LWG also included off-site areas both downriver of the Site to the confluence with the Columbia River at RM 0 and upriver of the Site to RM 28.4. Surface and subsurface sediment, suspended sediment, surface water, stormwater, transition zone water (TZW), and biota/tissue samples were collected and analyzed. The investigations were often timed around varying river stages, river flows, and storm events. In addition, groundwater and river bank sediment and soil samples were collected and analyzed by upland facilities under DEQ oversight. Additional data collected between 2008 and 2010 by two members of the LWG at the Arkema and Gasco facilities were also included in the final data set.

The RI report, which was prepared by LWG and modified by EPA, describes the nature and extent of contamination at the Site (EPA 2016). Baseline ecological and human health risk assessments (Windward 2013; Kennedy Jenks 2013) have also been completed and are included as appendices to the RI Report. In 2012, the LWG prepared a draft FS for the Site pursuant to the AOC. EPA modified the LWG's 2012 FS and finalized the document in June 2016.

Some cleanup actions have already occurred or were initiated at several areas within the Portland Harbor Superfund Site:

- **Terminal 4.** Port of Portland and EPA signed an AOC for Removal Action in October 2003. The Port of Portland completed a Phase I Abatement Measure in 2008. Phase I consisted of dredging and offsite disposal of 12,819 cubic yards (cy) of contaminated sediment, capping contaminated sediment with an organoclay-sand mix cap in the back of Slip 3 and stabilizing the bank along Wheeler Bay. The Port also conducted a 60% design of a confined disposal facility (CDF) in Slip 1 under the AOC.
- **NW Natural**. NW Natural and EPA signed an AOC for a Removal Action in April 2004. The removal action was conducted at the Gasco facility between August and October 2005. Approximately 15,300 cy of a tar-like material and tar-like contaminated sediment were dredged from the river bank and nearshore area adjacent to the Gasco facility and disposed of off-site in a permitted disposal facility. An organoclay mat and sand cap was also installed over the dredged area.
- **Arkema**. Arkema Inc. and EPA signed an AOC for a Removal Action in June 2005. Arkema conducted some site characterization and preliminary design evaluations. However, the AOC was terminated in March 2016 and no cleanup actions have been taken to date.
- **U.S. Moorings**. EPA issued a RCRA 3013 order to the USACE for an upland source investigation in June 2007. The Corps completed a RI/FS for upland sources and addressed an area where potentially erodible, contaminated soils were found.
- **Triangle Park**. The University of Portland and EPA signed a Bona Fide Prospective Purchaser Agreement and an Order on Consent for and Upland Removal Action in December 2006 and an Amendment in April 2009. The four main components to the completed removal action included institutional controls, groundwater monitoring, excavation, and capping.
- **Gasco**. NW Natural, Siltronic Corporation and EPA signed an AOC for a Removal Action in September 2009. NW Natural and Siltronic are conducting site characterization and design evaluations for the area offshore of their two facilities. They have also agreed to perform further characterization, studies, analysis and preliminary design for the final remedy at the Gasco Sediment site. The studies and other work under the agreement were incorporated into the Portland Harbor RI/FS. No cleanup actions have been conducted to date.
- **River Mile 11E Project Area**. Cargill, Inc., CBS Corporation, City of Portland, DIL Trust, Glacier Northwest, Inc., PacifiCorp and EPA signed an AOC for a Supplemental RI/FS in April 2013. No cleanup actions have been conducted to date.
- **McCormick and Baxter Superfund Site**. The selected remedy for this wood treatment facility addressed both in-river and upland portions of the site and was completed in September 2005. As part of this cleanup, a cap was placed on 23 acres of nearshore and submerged land adjacent to the

facility. DEQ is the lead for Operations & Maintenance at the site and Five Year Reviews are conducted, since waste is left in place. The next five year review will be conducted in 2016.

- **Gould Superfund Site.** A remedy addressing upland soils at this secondary lead smelter and battery disposal site was completed in September 2000 and was deleted from the NPL in 2002. Five year reviews are conducted since waste is left in place. The next five year review will be conducted in 2017.

- **BP Arco Bulk Terminal**. A sediment removal action of the nearshore area adjacent to the BP Arco Bulk Terminal was conducted in 2007-2008 under DEQ oversight. Approximately 12,300 cy of petroleum-contaminated soil and sediment were removed and disposed off-site at a permitted facility. The excavated area was backfilled with clean fill and a steel sheet-pile seawall was installed along the entire river bank of the BP Arco Bulk Terminal property.

Community Engagement

EPA's outreach goal is to educate the community about the work being done at the Site and collaborate with stakeholders on how to successfully engage the public. EPA advertised the availability of a technical assistance grant in December 2000 and EPA awarded the grant to the Willamette Riverkeeper in August 2001. Willamette Riverkeeper is a member of the Portland Harbor Community Advisory Group (CAG), which formed in 2002 and is comprised of individuals from neighborhood associations, environmental, health, recreation, and business groups, and concerned citizens. The CAG provides a public forum for community members to learn about the Site and share community needs and concerns. The CAG provides input and feedback to EPA and DEQ so that community perspectives can be considered in the remedy selection process. The purpose of the technical assistance grant is to provide funds for a technical advisor to support the CAG. The advisor helps the CAG and other community members understand scientific and technical information related to the investigation and cleanup of the Site. Since 2002, EPA has shared information and met with the CAG and the public about Portland Harbor cleanup activities.

Over the past 2 years, EPA expanded its ongoing outreach efforts significantly and has held no less than two informational sessions a month. Over the last year EPA has also engaged with organizations representing people who are living along the river. EPA's objective for these meetings is to inform people of the risks associated with the contamination and to explain future proposed cleanup activities, and to seek assistance in engaging others living along the river. EPA is coordinating outreach with OHA, DEQ and Metro to inform particularly vulnerable communities of risks associated with contamination in the river and discuss City/State services that may be available to assist their needs. In addition to coordinating with the six federally recognized Tribes actively participating in the Superfund process, EPA also includes Tribal communities in the Portland area in its outreach efforts.

EPA has engaged with many communities, including those with Environmental Justice concerns. Some of the community groups that EPA has connected with include: Communities of Color, Native American Youth Association, Latino Network, Right 2 Dream Right 2 Survive, the Slavic Immigrant Association, Ecumenical Ministries Oregon, the Coalition of Black Men, the Oregon Environmental Justice Task Force, Oregon Tradeswomen, League of Women Voters, Verde, Portland Harbor Community Coalition, Sierra Club Portland, Occupy St. Johns, Audubon Society, Asian Pacific American Network of Oregon, Vietnamese Community of Oregon, Portland neighborhood associations and schools, People with Disabilities (access to river). EPA has also used public information sessions, fact sheets, websites, one-on-one discussions, and participation in community events as ways to share information with the broader community. EPA will continue to work hard to make sure these efforts reach historically underrepresented communities.

Tribal Engagement

Throughout the RI/FS process, EPA has meaningfully engaged with the MOU partner Tribes (the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Grand Ronde Community of Oregon, the Confederated Tribes of Siletz Indians, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe) and has encouraged and facilitated tribal involvement, including conducting formal tribal consultations. The most recent government-to-government consultations occurred in January and February of 2016.[2] Another round of consultations will occur during the public comment period. EPA considered numerous factors, such as tribal fish consumption rates and the effects of contamination at the Site on treaty-protected resources, to develop remedial alternatives for the Site. EPA recognizes that these Tribes have treaty-reserved or other fishing rights in areas impacted by the Site and that, once implemented, the cleanup will improve fish habitat and help further the Tribes' rights to fish.

EPA has received comments from Tribes and other stakeholders requesting that effects of Portland Harbor contamination to the Columbia River be considered when evaluating cleanup alternatives at the Site. The primary objective of the proposed action is to address the contaminated sediment in Portland Harbor, significantly reducing sediment concentrations and potential human health and ecological risks at the Site. Although reducing loading to the Columbia River is not a specific objective of the proposed action, it is an expected outcome of achieving the remedial action objectives presented below.

Site Characteristics

The Site is in a geological depression bordered to the west by the Tualatin Mountains (also known as the West Hills or Southwest Hills of Portland), and to the east by a 120-ft-high natural bluff that runs along the northeast border of the Site. Most of the lowlands on either side of the lower Willamette River within the Site are located on a terrace with elevations that range between 30 and 50 ft above sea level, mostly composed of fill material. The lowlands that make up the upland portion of the Site extend for approximately 0.5 to 1 mile from the river. Groundwater, creeks, and channels along the east face of the Tualatin Mountains and in the upland areas generally flow downward to the lower Willamette River.

Historically, portions of this stretch of the lower Willamette River were shallow and meandered, but it has been redirected and channelized via filling and dredging. The federally maintained navigation channel from RM 0 to 11.6 extends nearly bank-to-bank in some areas (currently varies in width from 600 to 1,900 ft), doubles the natural depth of the river, and allows transit of large ships into the active harbor. Therefore, today this section of the river is deeper and narrower with higher banks that reduce flooding during high-flow events. Further, a series of dams in the upper Willamette River and Columbia River watersheds moderate fluctuations of flow in the lower Willamette River. Flooding still occurs approximately every 20 years with the last flood occurring in 1996. Tidal influences also impact the flow of the river with tidal reversals occurring during low flow periods as far upstream as RM 15. Near the river, tidal action can

[2] EPA Policy on Consultation and Coordination with Indian Tribes, May 4, 2011. Incorporates the Executive Order 13175 "*Consultation and Coordination with Indian Tribal Governments*", November 2000 and Presidential Memorandum, November 5, 2009. See also EPA Policy on Consultation and Coordination with Indian Tribes: Guidance for Discussing Tribal Treaty Rights, February 22, 2016.

greatly alter groundwater flow directions, rates, and water quality and can increase the rate of river bank erosion.

Much of the river banks within the Site contain overwater piers and berths, port terminals and slips, and other engineered features. Armoring to stabilize the river banks covers approximately half of the harbor shoreline. Riprap is the most common bank-stabilization material. However, bulkheads and rubble piles are also used to stabilize the banks. Seawalls are used to control periodic flooding as most of the original wetlands bordering the lower Willamette River in the Site have been filled. Some river bank areas and adjacent parcels have been abandoned and allowed to revegetate, and beaches have formed along some modified shorelines. These extensive physical alterations have resulted in a river reach that bears little resemblance to its pre-industrialized character in terms of flow dynamics, capacity, sediment movement, ecological habitat, and human uses.

The primary factors controlling river flow, sediment deposition and erosion, and sediment characteristics appear to be the river cross-sectional area and navigation channel width. The upstream boundary of the Site to Willamette Falls (RM 11.8 to 28.4) is markedly narrower, more confined by bedrock outcrops, and faster flowing than the Site reach. The river widens as it enters the Site at RM 11.8 and becomes increasing depositional, most notably in the western portion of the river, until RM 7. From approximately RM 5 to RM 7, the river and navigation channel narrows, and this reach is dominated by higher energy environments with little sediment deposition. From RM 5 to approximately RM 2, the river widens again and becomes depositional, particularly in the eastern portion of the river. Immediately downstream of the Site, the river narrows as it turns and converges with the Columbia River.

Sediment is re-suspended and transported downstream during periods of high flow and from ship traffic (wake and prop wash). The degree of deposition and movement of sediment is controlled largely by river water flow dynamics and the sediment texture (grain size and organic matter content). Suspended fine-grained sediment (silts and clays) is typically transported farther than larger sandy sediment under all flow conditions.

Riverbed elevation changes between 2002 and 2009 show the greatest net sediment accumulation occurs where the channel is wide and where flow velocities are reduced. The measured riverbed elevation changes over this 7-year period illustrates a pattern of general deposition in the relatively wide reaches from RM 7 to 10 and RM 2 to 5, and scour or no change in the higher energy, narrow reaches upstream of RM 10 and between RM 5 and 7. Nearshore and off-channel areas, such as Swan Island Lagoon, Willamette Cove, and port terminals, exhibit both deposition and scour, based on the location within those areas. Sediment scour in some nearshore locations appears to be due to ship traffic and other human activities.

River Regions

For the evaluation in the FS, four river regions were identified and will be addressed[3] by the remedial alternatives (Figure 4):

- **Navigation Channel and Future Maintenance Dredge (FMD) Region (1,421 acres).** This region includes the federally-authorized navigation channel and areas near and around docks where maintenance dredging is likely to occur because of vessel activity, dock configuration, and future site

[3] The McCormick and Baxter cap, which is 23 acres of the site, is not addressed by this remedy.

uses. The navigation channel is authorized to 43 ft although it is currently only maintained to 40 ft. Future authorized channel depths could be increased to 48 ft to accommodate larger vessels.

- **Intermediate Region (572 acres).** This region is defined as outside the horizontal limits of the navigation channel and FMD areas to the riverbed elevation of 4 ft below the mean low low-water level (mllw).
- **Shallow Region (174 acres).** This region is defined as shoreward of the riverbed elevation of 4 ft below mllw.
- **River Bank Region (30,048 lineal ft).** This region is the area along the shoreline next to contaminated shallow areas that is also contaminated. Additional contaminated river banks may be addressed by EPA or DEQ under its uplands source control actions.

Nature and Extent of Contamination

This section summarizes the data collected during the RI and presents the contaminant concentrations in the different media at the Site.

Sediment

Sediment contaminant concentrations, for both surface (0-30 cm below mud line (bml)) and subsurface (below 30 cm bml) sediment are summarized in Table 1. Generally, concentrations of contaminants were greater in subsurface sediment samples than in surface samples, indicating that historical inputs of contamination were greater than current inputs. However, there are areas at the Site where surface concentrations are greater than subsurface concentrations likely reflecting more recent releases and/or disturbance of deeper, bedded sediment. Based on examination of contaminant distribution trends, some general patterns emerge for certain subsets of contaminants that reflect Site fate and transport processes, as well as the relative importance of off-site versus on-site sources. These patterns are:

- Most sediment contaminant concentrations are highest in nearshore areas.
- Organic contaminant concentrations (such as PCBs, PAHs, dioxins/furans, and DDx) are higher in subsurface sediment.
- Contamination from the watershed is widespread throughout the surface sediment at the Site.
- Areas of high concentrations are scattered throughout the Site and generally are located near likely upland sources.
- Areas with higher levels of some contaminants are more prevalent in the lower (downstream) half of the Site.
- Concentrations of certain metals are correlated with sediment grain size.
- Multiple contaminants are co-located throughout the Site.

Suspended Sediment

While much of the suspended sediment load passes through the Site, sediment traps were used to measure the suspended sediment load that would deposit within the Site. The areas where the highest concentrations of contaminants were detected in suspended sediment correspond with areas with high concentrations in surface sediment, indicating the effect of erosion and resuspension of bottom sediment, the presence of current sources, or both (Table 1).

Surface Water

Concentrations of contaminants in surface water samples varied spatially, with river flow, and within the Site (Table 2). These surface water concentrations are generally higher than those entering the upstream limit of the Site under all flow conditions. The highest contaminant concentrations in surface water within the Site were found near areas where concentrations in sediment are also highest, such as the areas adjacent to the Gasco and Arkema facilities (RM 6 through RM 7.5 west). Surface water samples collected at the downstream end of the Site indicate that contamination from the Site is being transported downstream to the Columbia River.

Groundwater

In some areas, groundwater is a source of contamination to the Site. Cleanup of contaminated groundwater is being managed by DEQ under an MOU with EPA. DEQ is responsible for controlling these sources because the groundwater contamination originates in the uplands. However, EPA has considered, where appropriate, in-river actions in the remedial alternatives to address residual impacts from contaminated groundwater to sediment and surface water. Currently, DEQ has identified multiple areas with groundwater contamination (Figure 5 and Table 3).

Biota

The biota data set includes fish and invertebrate samples collected during the RI. Eleven fish species, four benthic invertebrate species, benthic communities, and fish stomach contents were sampled. RI Table 5.6-1 provides a summary of analyses for each species and tissue type and RI Table 2.3-10 provides the number of fish and invertebrates in each sample composite. The COCs in fish tissue (fillet and whole body) are summarized in Table 4.

Contaminants were detected in a majority of fish and invertebrate species sampled throughout the Site. Contaminant concentrations varied within and between different species, and concentrations in fish tissue were generally greater than in invertebrates. Concentrations of bioaccumulative contaminants such as PCBs and pesticides (for example DDx) were often found at greater concentrations in organisms higher on the food chain and correlated with areas of elevated sediment concentrations. Biota samples from within the Site exhibited greater concentrations for most contaminants than those seen in background biota samples that were collected from the upriver reaches and above Willamette Falls. Localized areas of elevated concentrations of some contaminants were found in resident species, reflecting high concentrations in nearby surface sediment.

River Banks

Characterization of contaminated river banks is being managed by DEQ under an MOU with EPA. River bank remediation has already occurred at some locations in the Site. Remediation of contaminated river banks is included in the remedial alternatives if it is determined that it should be conducted in conjunction with the in-river actions (Figure 6 and Table 5). More information on these river banks is included in Appendix A of the FS. Other river banks may be included in the remedial action, if contamination contiguous with the river sediment is found during remedial design sampling.

Principal Threat Waste

Consistent with the NCP and EPA guidance, the identification of principal threats is made on a site-specific basis (see box at right). Principal threat waste (PTW) was identified at the Site based on one or more of the following considerations: a 10^{-3} (one in a thousand) cancer risk, existence of source material (non-aqueous phase liquid [NAPL]) within the sediment bed, or on an evaluation of mobility of contaminants in the sediment.

- **Source Material.** NAPL has been identified as globules or blebs of product in surface and subsurface sediment offshore of the Arkema and Gasco facilities (RM 6 through RM 7.5 west). NAPL observed offshore of the Arkema facility contains chlorobenzene with dissolved DDT. NAPL observed at the Gasco facility contains PAHs and other aromatic hydrocarbons. Figure 7 identifies locations where NAPL was observed in sediment offshore of the Arkema and Gasco facilities.

- **Highly Toxic**. Contaminated surface sediment in areas with concentrations that exceed a 1 x 10^{-3} risk based on consumption of fish is identified as PTW. This includes sediment contaminated with PCBs, cPAHs, DDx, and/or dioxins/furans (see *Summary of Site Risks* for more information). The highly toxic PTW concentrations for these COCs are presented in Table 6. Surface sediment areas with one or more COC that exceeds the PTW highly toxic concentration level thresholds are presented on Figure 7.

- **PTW That Cannot be Reliably Contained.** A capping model was utilized in the FS (Appendix D in the FS) to identify PTW that cannot be reliably contained by a cap. Representative site conditions and capping options were modeled to determine the maximum concentration of COCs in PTW material that would not exceed ambient water quality criteria (AWQC) in the sediment cap pore water after a period of 100 years. This assumption was used in developing the remedial alternative cost estimates in the FS (Appendix G). Chlorobenzene, dioxins/furans, DDx, naphthalene, PAHs, and PCBs were modeled. The results are summarized in Table 7. The areas where the model showed that PTW would not be reliably

WHAT IS A "*PRINCIPAL THREAT WASTE*"?

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP Section 300.430(a)(1)(iii)(A)). The "*principal threat*" concept is applied to the characterization of "*source materials*" at a Superfund site. A source material is material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be a source material; however, Non-aqueous phase liquids (NAPLs) in groundwater may be viewed as source material. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur. The decision to treat these wastes is made on a site-specific basis through a detailed analysis of the alternatives using the nine remedy selection criteria. This analysis provides a basis for making a statutory finding that the remedy employs treatment as a principal element.

Contaminant	Highly Toxic PTW Threshold (µg/kg) (10-3 risk)
PCBs	200
2,3,7,8-TCDD	0.01
2,3,7,8-TCDF	0.6
1,2,3,7,8-PeCDD	0.01
2,3,4,7,8-PeCDF	0.2
1,2,3,4,6,7,8-HxCDF	0.04
DDx	7,050
cPAHs (BaP eq)	106,000

Table 6. Concentrations of PTW Defined as "*Highly Toxic*"

contained are presented on Figure 7. More rigorous modeling for any material remaining in the river may be conducted, as needed, during remedial design to refine the cap design in these locations.

Scope and Role of the Action

Contaminant	PTW Contaminants Reliably Contained
Dioxins/furans	At all concentrations measured at the Site
PAHs	At all concentrations measured at the Site
Chlorobenzene	At concentrations <320 µg/kg
DDx	At all concentrations measured at the Site
Naphthalene	At concentrations <140,000 µg/kg
PCBs	At all concentrations measured at the Site

Table 7. Concentrations of PTW Defined as "*Reliably Contained*"

EPA's remedial strategy for the Site is to address all contaminated media and complete exposure pathways that pose unacceptable risk (see *Summary of Site Risks*) within the river, including sediment, biota, surface water, groundwater, and river banks. The primary objective of this action is to address the contaminated sediment within the Site, thereby reducing exposure to concentrations in other media and significantly reducing human health and ecological risks at the Site to acceptable levels. However, remediation of the sediment in the Site would also reduce this ongoing source of contaminants to Multnomah Channel and the Columbia River.

The cleanup of the upland contamination that also provides ongoing contaminant sources to the river is and will be conducted primarily under DEQ oversight using State authority through voluntary agreements, although some enforcement orders are in place. It is expected that controlling these sources will reduce or eliminate contamination in soil, groundwater, and surface water migrating to the Site. Significant sources of contamination to the river must be controlled prior to construction of the remedy. EPA may use its authority to require response action on upland sources that are not controlled before construction begins.

A final CERCLA remedial action was completed at the McCormick and Baxter Site (RM 7 east) in 2005 and, therefore, it is not included in this in-river remedial action. Three areas of the Site have had some early removal actions completed to address river banks and sediment under EPA or DEQ authority. These have occurred at Gasco (2005), Arco/BP (2007-2008), and Terminal 4 (2008) (see *Superfund History* above). Final actions for these areas will be addressed through the preferred alternative.

After taking into account the early actions and source control work already completed, EPA is proposing a remedy in this Proposed Plan that includes a combination of technologies including capping, dredging/excavation, ex-situ treatment, enhanced natural recovery, monitored natural recovery, and institutional controls to address the entire site. EPA anticipates that taking action on sediment and river banks, in conjunction with control of upland sources under DEQ authority, will reduce contaminant concentrations in all media, including fish tissue, pore water, and surface water, to acceptable levels. The in-river action in this Proposed Plan is a final remedial action.

In addition, the NCP states that EPA expects to use treatment to address principal threats posed by a site whenever practicable. As such, PTW was identified and alternatives that considered treatment of PTW were developed in the FS. Each alternative uses treatment (in-situ and ex-situ) to address PTW, however, not all of the alternatives address all of the PTW.

Summary of Site Risks

Baseline human health and ecological risk assessments were conducted for the Site to estimate the risks associated with exposure to contaminants based on current and likely future uses of the site. These baseline risk assessments are detailed in Appendix F and Appendix G of the RI report.

Baseline Human Health Risk Assessment

A Baseline Human Health Risk Assessment (BHHRA) was conducted to assess the cancer risks and non-cancer health hazards associated with exposure to COCs present at the Site. Exposure to COCs present on beaches, in sediment, surface water, groundwater seeps, or in fish and shellfish within the Site was considered (see box at right). Consistent with EPA guidance, risks were evaluated without taking into consideration the current OHA fish consumption advisory. Both a reasonable maximum exposure (RME) and a central tendency exposure (CTE) were evaluated to estimate cancer risks and non-cancer hazard. Remedial decisions are based on the RME, consistent with the NCP.

Populations were identified that could be exposed to contaminants through a variety of activities that are consistent with both current and potential future uses of the Site. These include people who work along and on the river, use the river for recreational purposes,

WHAT IS HUMAN HEALTH RISK AND HOW IS IT CALCULATED?

A Superfund baseline human health risk assessment is an analysis of the potential adverse health effects caused by hazardous substance releases from a Site in the absence of any actions to control or mitigate these under current and future land uses. A four-step process is used for assessing site-related human health risks for reasonable maximum exposure scenarios.

Hazard Identification: In this step, the contaminants of potential concern (COPCs) at the Site in various media, such as soil, groundwater, surface water, and air are identified based on such factors as toxicity, frequency of occurrence, and fate and transport of the contaminants in the environment, concentrations of the contaminants in specific media, mobility, persistence, and bioaccumulation.

Exposure Assessment: In this step, the different exposure pathways through which people might be exposed to the contaminants identified in the previous step are evaluated. Examples of exposure pathways include consumption of contaminated fish or shellfish, incidental ingestion of and dermal contact with contaminated sediment and ingestion of and dermal contact with contaminated surface or groundwater (Figure 8). Factors relating to the exposure assessment include, but are not limited to, the concentrations in specific media that people might be exposed to and the frequency and duration of that exposure. Using these factors, a "*reasonable maximum exposure*" (RME) scenario, which portrays the highest level of human exposure that could reasonably be expected to occur, is calculated. A "*central tendency exposure*" (CTE) scenario is also calculated, which shows an average level of human exposure.

Toxicity Assessment: In this step, the types of adverse health effects associated with chemical exposures and the relationship between magnitude of exposure (dose) and severity of adverse effects (response) are determined. Potential health effects are chemical-specific and may include the risk of developing cancer over a lifetime or other non-cancer health hazards, such as changes in the normal functions of organs within the body (for example, changes in the effectiveness of the immune system). Some contaminants are capable of causing both cancer and non-cancer health hazards.

Risk Characterization: This step summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site risks for all COPCs. Exposures are evaluated based on the potential risk of developing cancer and the potential for non-cancer health hazards. The likelihood of an individual developing cancer is expressed as a probability. For example, a 10-4 cancer risk means a "*one in ten thousand excess cancer risk*"; or one additional cancer may be seen in a population of 10,000 people as a result of exposure to site contaminants under the conditions identified in the Exposure Assessment. Current Superfund regulations for exposures identify the range for determining whether remedial action is necessary as an individual excess lifetime cancer risk of 10-4 to 10-6, corresponding to a one-in-ten-thousand to a one-in-a-million excess cancer risk. For non-cancer health effects, a "*hazard index*" (HI) is calculated. The key concept for a non-cancer HI is exposures less than a specific "*reference dose*" (measured as an HI of less than or equal to 1) are not expected to result in adverse health effects. The goal of protection is 10-6 for cancer risk and an HI of 1 for a non-cancer health hazard. As a rule, the more the HI is greater than 1, the greater the level of concern. However, the HI is not a statistical probability. A ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring. Further, it is important to emphasize that the level of concern does not increase linearly as an HI of 1 is approached or exceeded, because RfDs do not have equal accuracy or precision and are not based on the same severity of toxic effects.

Contaminants that exceed a 10-4 cancer risk or an HI of 1 are typically those that will require remedial action at a site and are referred to as contaminants of concern (COCs) in the ROD.

professional divers engaged in routine inspections, maintenance or repair activities, and people who may live along the shoreline for a limited time (2 years was assumed). Use of the river as a drinking source was also considered as a future use because it is a designated beneficial use by the State. Many people catch fish in the lower Willamette River for recreation and as a supplemental or primary food source. Shellfish are also collected and consumed by people. The river provides a ceremonial and subsistence fishery for tribal members, who typically consume more fish than the general public. Fish are an important food source as well as an integral part of the tribes' cultural, economic, and spiritual heritage.

As a result of all these activities, exposure to contaminants at the Site can occur through direct contact with contaminated beaches, sediment, and surface water through incidental or intentional ingestion (for example, drinking water), or through skin contact with the contaminated sediment or water. Exposure to contaminants in groundwater can occur after it discharges into the river. Because of the persistent nature of many of the contaminants, they can bioaccumulate through the food chain, and the resulting concentrations in fish can be much higher relative to concentrations in water and sediment, and exposure can occur though consumption of fish and shellfish caught from the river. Finally, bioaccumulative contaminants can partition into breast milk; thus, infants can be exposed to these contaminants through breastfeeding.

Assumptions Regarding Fish Consumption Rates and Patterns

The fish consumption rates used in the risk assessment were developed by information gathered from published studies that evaluated the consumption habits of people in the Portland area, as well as consumption rates of the general public. Non-resident spring Chinook salmon, steelhead trout, Coho salmon, shad, crappie, smallmouth bass, and white sturgeon are the fish species generally preferred by local recreational fishers (DEQ 2000 and Steele 2002). Immigrants from Eastern Europe and Asia, African-Americans, and Hispanics are most likely to eat fish from the lower Willamette River either as a supplemental or primary dietary source (ATSDR 2002).

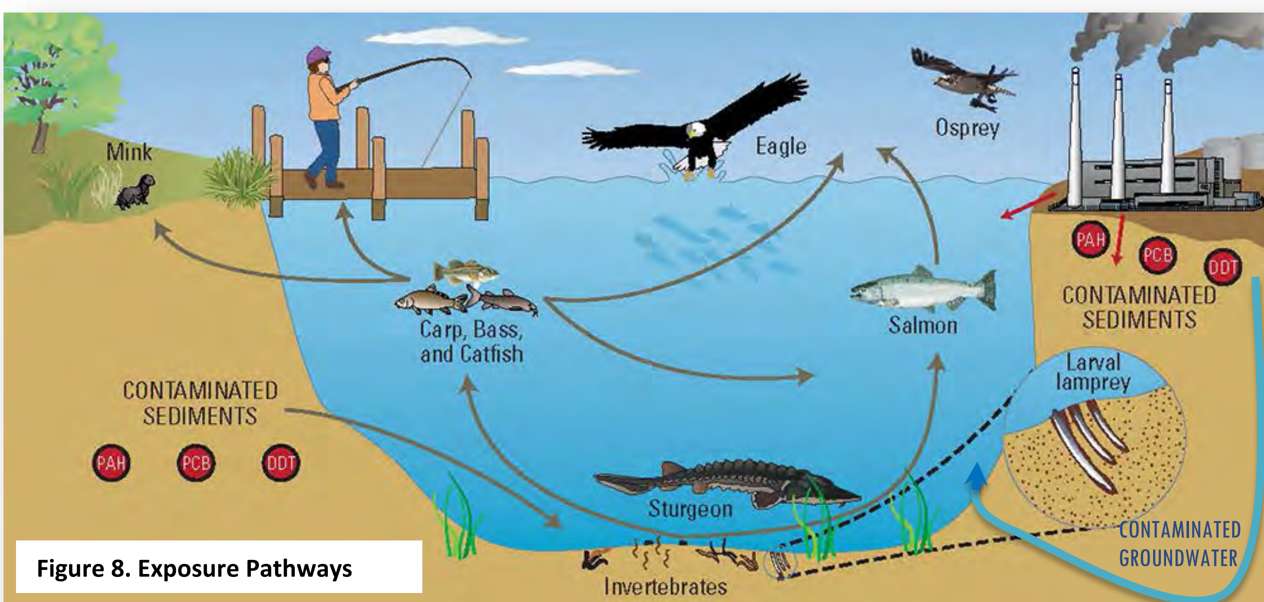

Figure 8. Exposure Pathways

The most commonly consumed species are carp, bullhead, catfish, and smallmouth bass. Three different consumption rates were evaluated to examine the range of exposures for non-tribal fish consumption patterns.

A rate of 17.5 grams per day (approximately 2 eight ounce meals per month) was used to represent a CTE value for recreational fishers, and 49 g/day (approximately 6 ½ eight ounce meals per month) was selected as representing the higher-end consumption rate for this group (Table 8). A rate of 142 g/day per day (19 eight ounce meals per month) was used for "*subsistence fishers*," a term used to represent those people for whom fish represent a substantial portion of their diet. This consumption rate was derived from data representing the general U.S. population as a whole (EPA 2002). This higher consumption rate was used on a Site-wide basis, and assumed consumption of all the types of resident fish evaluated in the BHHRA (representative species evaluated were carp, crappie, bullhead, and smallmouth bass). Consumption rates for children were estimated to be 42 percent of the corresponding rates for adults, and were used to estimate non-cancer hazards, as children are generally more sensitive to the non-cancer effect of exposure to contaminants. Risks to recreational fishers were evaluated on both a Site-wide and localized river mile spatial scale. The evaluation assumed a mixed diet of resident species. The river mile evaluation used only the data for smallmouth bass, as that is the only species for which contaminant data were available on that smaller scale. Because contaminant concentrations in migratory fish is not all related to the Site, only consumption of "*resident*" fish was considered.

	Subsistence Fisher - RME	Recreational Fisher - RME	Recreational Fisher - CTE
Adult	142 g/day	49 g/day	17.5 g/day
Child	60 g/day	20 g/day	7 g/day
Meals: **Adult (8oz)** **Child (3.4oz)**	19 meals/month	6.5 meals/month	2 meals/month

Table 8. Fish Consumption Rates – Subsistence and Recreational Fishers

Fish consumption by tribal members was evaluated assuming an overall rate of 175 g/day (approximately 23 eight oz meals per month), based on the CRITFC Survey.[4] However, this rate is based on a multi-species diet that includes both resident and migratory fish. Data from the CRITFC survey indicates that approximately 50 percent of the reported consumption consists of salmon, lamprey, and sturgeon. The BHHRA evaluated risks due to consumption of fish for tribal members assuming a mix of migratory and resident fish. In order to assess the risk associated with contamination within the Site, consumption of resident fish by tribal consumers was evaluated assuming a rate of 87 g/day, the remainder of the diet was assumed to be migratory fish (salmon, lamprey, and sturgeon). Consistent with the range of tribal practices, risks were evaluated assuming fillet-only consumption as well as using the entire fish in preparing meals.

Conclusions of the BHHRA

Risks resulting from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment or surface water. Estimated cancer risks associated with sediment exposures for people who would contact sediment while engaged in very frequent fishing activities (defined as more than 156 days per year) are up to 3×10^{-4} for Tribal fishers, and up to 2×10^{-5} for workers who may be exposed to sediment. Risks from recreational beach use are up to 5×10^{-5} at some locations. Exposure to contaminants on beaches by people engaged in frequent fishing activities are up to

[4] The Columbia River Inter-Tribal Fish Commission (CRITFC) fish consumption survey was conducted on the reservations of participating tribes and completed in 1994. Four tribes participated in the survey—the Yakama, Umatilla, Nez Perce and Warm Springs.

6×10^{-6} for non-tribal fishers, and up to 2×10^{-5} for tribal fishers. Non-cancer hazards slightly greater than 1 are associated with using the river as a drinking water source. Cancer risks and non-cancer hazards associated with fish consumption generally exceed the one-in-ten thousand upper end of EPA's acceptable risk range, and exceed a non-cancer hazard index (HI) of 1 (Table 9).

- Evaluated Site-wide, the estimated cancer risk for subsistence fishers is 1×10^{-2} (or one additional cancer per 100 people). The estimated risks for recreational fishers are up to 4×10^{-3} (or four additional cancers per 1,000 people) when evaluated Site-wide, and up to 1×10^{-3} within individual river miles.

Non-Cancer Hazard				Site-wide Cancer Risks	
Recreational Fishers		Subsistence Fishers		Recreational Fishers	Subsistence Fishers
Child	Nursing Infant	Child	Nursing Infant	All Ages	All Ages
300	4,000	1,000	10,000	4×10^{-3}	1×10^{-2}

Table 9. BHHRA Results – Recreational and Subsistence Fishers

- Evaluated Site-wide, the estimated non-cancer hazard for subsistence fishers is 1,000, and is 300 for recreational fishers. On a river mile scale, the HI for recreational fishers is up to 100. Evaluated on a Site-wide basis, the HIs for breastfed infants of subsistence and recreational fishers who eat resident fish are 10,000 and 4,000, respectively.

Averaged Site-wide, the estimated risk from consumption of shellfish (clams) is 4×10^{-4}, and is up to 7×10^{-4} when evaluated within individual river miles.

Tribal Fishers

The estimated cancer risks for Tribal fishers consuming a mixed diet of migratory and resident fish are 2×10^{-2} assuming whole body consumption, and 1×10^{-2} assuming fillet-only (Table 10). Non-cancer hazards are 800 assuming whole fish consumption, and 600 assuming fillet-only. The corresponding non-cancer hazards for nursing infants of Tribal mothers who eat resident and migratory fish are estimated at 9,000 (whole fish) and 8,000 (fillet). However, these risks cannot be wholly attributed to the Site contamination.

Non-Cancer Hazard				Cancer Risks	
Fillet Only		Whole Body		Fillet Only	Whole Body
Child	Nursing Infant	Child	Nursing Infant	All Ages	All Ages
600	8,000	800	9,000	2×10^{-2}	1×10^{-2}

Table 10. BHHRA Results – Tribal Fishers (Fillet and Whole Body)

PCBs are the primary contributor to risks from fish consumption, although dioxins/furans also contribute substantially to cancer risk and non-cancer hazards at some locations when evaluated on a river mile scale. PCBs are also the primary contributors to the non-cancer hazard to nursing infants, primarily because they bioaccumulate in fish, and infants are more susceptible to the developmental effects associated with exposure to PCBs.

Baseline Ecological Risk Assessment

The baseline ecological risk assessment (BERA) evaluated the potential for adverse effects to ecological receptors from exposure to contaminants at the Site. The following receptor groups and exposure pathways were evaluated in the BERA:

- **Benthic Invertebrates.** Direct contact with sediment and surface water, ingestion of biota and sediment, and direct contact with pore water. Risk to these receptors was evaluated primarily through the use of laboratory sediment toxicity tests.

- **Fish.** Direct contact with surface water, direct contact with sediment (for smallmouth bass), ingestion of biota, incidental ingestion of sediment, and direct contact with pore water (for smallmouth bass). Risk to fish was evaluated by modeling the potential exposure to these receptors to chemicals ingested in food items and prey.

- **Birds and Mammals.** Ingestion of biota and incidental ingestion of sediment. Risk to birds and mammals was evaluated by modeling the potential exposure to these receptors to chemicals ingested in food items and prey.

- **Amphibians and Aquatic Plants**. Direct contact with surface water and pore water. Risk to amphibians and aquatic plants was evaluated by comparing sediment chemical concentration levels to literature based screening levels.

The BERA evaluated risks to receptors under current and future use scenarios. A BERA quantifies risk to different potentially exposed ecological receptors as a Hazard Quotient (HQ). If an HQ is calculated to be equal to or less than 1, then no adverse effects are expected as a result of exposure. If the HQ is greater than 1, adverse effects are possible.

The following presents the primary conclusions of the BERA:

- Sixty-six contaminants indicated unacceptable risk to ecological receptors.

- Of the 66 contaminants posing unacceptable risks, only 20 contaminants were determined to pose ecological risks significant enough to consider in the development of remedial action alternatives.

- The 20 contaminants posing significant ecological risks are: bis(2-ethylhexyl)phthalate, cadmium, chlordanes, copper, cyanide, DDx, dieldrin, dioxins/furans, ethylbenzene, lead, Lindane (γ-HCH), manganese, mercury, PAHs, PCBs, perchlorate, tributyltin, TPH (C10 – C12) petroleum hydrocarbons, vanadium, and zinc.

- Unacceptable risks to benthic invertebrates are located in approximately 4-8 percent of the Site.

WHAT IS ECOLOGICAL RISK AND HOW IS IT CALCULATED?

A Superfund baseline ecological risk assessment (BERA) is an analysis of the potential adverse effects to biota caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these under current and future land and resource uses. The process used for assessing site-related ecological risks includes:

Problem Formulation: In this step, the contaminants of potential ecological concern (COPECs) at the site are identified.

Exposure Assessment: In this step, a quantitative evaluation is made of what plants and animals are exposed to and to what degree they are exposed.

Ecological Effects Assessment: In this step, literature reviews, field studies or toxicity tests are conducted to describe the relationship between chemical contaminant concentrations and their effects on ecological receptors, on a media-, receptor- and chemical-specific basis.

Risk Characterization: In this step, the results of the previous steps are used to estimate the risk posed to ecological receptors. Individual risk estimates for a given receptor for each chemical are calculated as a hazard quotient (HQ), which is the ratio of contaminant concentration to a given toxicological benchmark. In general, an HQ above 1 indicates unacceptable risk. The risk is described, including the overall degree of confidence in the risk estimates, summarizing uncertainties, citing evidence supporting the risk estimates and interpreting the adversity of ecological effects.

- Contaminants in sediment and pore water that pose the highest risks also tend to be located in areas that exhibited the greatest benthic invertebrate toxicity.
- PCBs, PAHs, and DDx are the COCs in sediment that are most commonly associated with locations of unacceptable risk to the benthic community or populations.
- The combined toxicity of dioxins/furans and dioxin-like PCBs pose the greatest potential risk of reduced reproductive success in mink, river otter, spotted sandpiper, bald eagle, and osprey.

Conclusion

Based on the results of the RI and the risk assessments, EPA has determined that the preferred alternative, or one of the other remedial alternatives presented in the Proposed Plan, is necessary to protect public health or welfare and the environment from hazardous substances released at the Site.

Remedial Action Objectives

Remedial action objectives (RAOs) consist of media-specific goals for protecting human health and the environment. RAOs have been developed for each COC in all environmental media of interest; all exposure pathways including exposure routes and receptors; and an acceptable contaminant concentration or range of concentrations for each exposure route. Below are the nine RAOs developed to address the human health and ecological risks posed by the contamination at the Site. A brief summary of how each RAO will be addressed by the alternatives is also provided.

Human Health

- **RAO 1 – Sediment. Reduce cancer and non-cancer risks to people from incidental ingestion of and dermal contact with COCs in sediment and beaches to exposure levels that are acceptable for fishing, occupational, recreational, and ceremonial uses**. Reducing concentrations, exposure to, and the bioavailability of the COCs in nearshore sediment and beaches will reduce risk at the Site. Ongoing source control efforts and the use of institutional controls (such as signs and fences) will provide additional risk reduction.
- **RAO 2 – Biota. Reduce cancer and non-cancer risks to acceptable exposure levels (direct and indirect) for human consumption of COCs in fish and shellfish.** Reducing concentrations, exposure to, and the bioavailability of the COCs in sediment will subsequently reduce surface water and fish and shellfish tissue concentrations and will reduce risk at the Site. Ongoing source control efforts and the use of fish consumption advisories and education and outreach programs will provide additional risk reduction.
- **RAO 3 – Surface Water. Reduce cancer and non-cancer risks to people from direct contact (ingestion, inhalation, and dermal contact) with COCs in surface water to exposure levels that are acceptable for fishing, occupational, recreational, and potential drinking water supply**. Reducing concentrations, exposure to, and the bioavailability of COCs in sediment will subsequently reduce surface water concentrations and will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.
- **RAO 4 – Groundwater. Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for human exposure.**

Reducing concentrations, exposure to, and the bioavailability of COCs in the pore water and groundwater flux to surface water and sediment will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.

Ecological

- **RAO 5 – Sediment. Reduce risk to benthic organisms from ingestion of and direct contact with COCs in sediment to acceptable exposure levels.** Reducing concentrations, exposure to, and the bioavailability of the COCs in sediment will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.

- **RAO 6 – Biota (Predators). Reduce risks to ecological receptors that consume COCs in prey to acceptable exposure levels.** Reducing concentrations, exposure to, and the bioavailability of the COCs in sediment will subsequently reduce surface water concentrations and in fish and shellfish and will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.

- **RAO 7 – Surface Water. Reduce risks to ecological receptors from ingestion of and direct contact with COCs in surface water to acceptable exposure levels.** Reducing concentrations, exposure to, and the bioavailability of COCs in sediment will subsequently reduce surface water concentrations and will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.

- **RAO 8 – Groundwater. Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for ecological exposure**. Reducing concentrations, exposure to, and the bioavailability of COCs in the pore water and in groundwater entering surface water will reduce risk at the Site. Ongoing source control efforts will provide additional risk reduction.

Human Health and Ecological

- **RAO 9 – River banks. Reduce migration of COCs in river banks to sediment and surface water such that levels are acceptable in sediment and surface water for human health and ecological exposures**. Reducing concentrations, exposure to, and the bioavailability of the COCs in river banks will reduce risk and recontamination at the Site. Ongoing source control efforts will provide additional risk and recontamination reduction.

It is EPA's expectation that DEQ's upland source control actions will adequately address groundwater contamination. EPA's RAOs above are focused on containing and reducing migration of COCs from groundwater to surface water and biologically active areas of sediment. Should groundwater not be addressed adequately under DEQ's actions, EPA may, at a future time, determine if action is warranted under CERCLA to further address groundwater contamination.

Preliminary Remediation Goals

In general, preliminary remediation goals (PRGs) are used to develop the long-term contaminant concentrations needed to be achieved to meet RAOs by the remedial alternatives. These goals must comply with Applicable or Relevant and Appropriate Requirements (ARARs) (or the basis for a waiver must be provided) and result in residual risk levels that fully satisfy the CERCLA requirements for the protection of human health and the environment. PRGs are based on ARARs, risk-based concentrations if standards are not available or not sufficiently protective, or background concentrations of contamination.

Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA requires remedial actions to comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility siting laws, unless such standards are waived. CERCLA provides that a remedy that does not attain an ARAR can be selected if the remedy assures protection of human health and the environment and meets one of six waiver criteria described in CERCLA Section 121(d)(4). At this time, EPA has no information to justify waiving any of the identified ARARs at this Site.

The substantive portions of the following key ARARs and To Be Considered (TBCs) were used in developing PRGs:

- Federal National Recommended Water Quality Criteria (NRWQC).
- Oregon Numeric Water Quality Standards (WQS),
- Maximum Contaminant Levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) established under authority of the Safe Drinking Water Act (SDWA) since the river is a drinking water source.
- Oregon Hazardous Substance Remedial Action (OHSRA) Rules that set standards for the degree of cleanup required and establish acceptable residual risk levels for humans (cancer risk of 10^{-6} and HI of 1).
- EPA regional screening levels (RSLs) for tap water (EPA 2014) established at a 10^{-6} risk level.

Site-specific PRGs were developed for each RAO for the following media: sediment (including beaches), river bank soil, surface water, groundwater (including pore water), and tissue (Table 11). The FS provides the basis for each PRG, including site-specific risk, chemical-specific ARARs, and consideration of background concentrations of COCs entering the Site from upstream. The risk-based PRGs are compared to the chemical-specific ARARs, and the lower of the two values was then compared to background. Where both the risk-based PRGs and chemical-specific ARAR are less than the background concentration, the background concentration is selected as the final PRG. PRGs for RAO 9 (river bank soil) were selected as the lowest sediment PRG for each COC to ensure that sediment would not be recontaminated. PRGs may be further modified through the evaluation of alternatives and the remedy selection process. Final cleanup levels will be documented in the ROD.

Human Health Risk-Based PRGs

Risk-based PRGs were calculated assuming an RME based on direct contact with beach and in-water sediment (RAO 1), as well as to be protective of indirect exposures through consumption of fish and shellfish (RAO 2). Risk-based PRGs for cancer effects were calculated based on an excess cancer risk of 1×10^{-6} (1 individual out of 1 million). Risk-based PRGs for non-cancer effects were calculated as concentrations that would result in a specified hazard quotient of 1.[5] Sediment concentrations needed to meet protective fish and shellfish tissue concentrations were estimated using a food-web model calibrated

[5] This is also a State ARAR- ORS 465.315.

to predict COC concentrations in fish based on the concentration in sediment. Risk-based sediment PRGs protective of fish/shellfish consumption were not developed for arsenic, hexachlorobenzene, mercury, BEHP, pentachlorophenol, and PBDEs because a relationship between fish and/or shellfish tissue and sediment concentrations could not be determined. Risk associated with these contaminants will be addressed by meeting PRGs for the other COCs and through institutional controls (ICs). The risk-based PRGs for RAOs 1 and 2 represent the lowest value in each media (beach or in-water sediment, and fish/shellfish tissue) to be protective of all potential receptors. MCLs and EPA RSLs were used to set PRGs for RAOs 3 and 4 to be protective of people who may drink or incidentally ingest water during recreational activities. EPA RSLs are only used when MCLs or other ARARs are not available for a specific contaminant.

Ecological Risk-Based PRGs

Ecological risk-based PRGs were developed for sediment, surface water, and pore water to meet the objectives associated with RAOs 5 through 8. Risk-based PRGs were developed from medium- and contaminant-specific toxicity reference values (TRVs) protective of ecological receptors used in the BERA. Risk-based PRGs in sediment were selected from protective TRVs presented in the BERA and address ingestion and direct contact of benthic organisms with sediment (RAO 5). PRGs based on consumption of prey (RAO 6) were calculated using the food-web model to predict acceptable COC concentrations in prey based on sediment concentrations. The lowest value for each COC was selected as the risk-based PRG for RAOs 5 and 6 to be protective of all species. COC-specific water concentrations from the BERA that are protective of ecological receptors were selected as risk-based PRGs for RAOs 7 and 8, with the exception of the manganese PRG for RAO 8, which is described in memorandum prepared by Windward Consulting in 2014. The risk-based PRGs selected for RAOs 5 through 8 are presented in FS Tables 2.2-8 through 2.2-11.

PRGs Based on Chemical-Specific ARARs

Chemical specific ARARs are discussed in the FS and presented in FS Table 2.1-4. The PRGs for RAOs 3 and 4 are based on the lower of the NRWQC (organism + water) and Oregon WQCs (organism + water), MCLs and non-zero MCLGs. EPA RSL values were only selected as PRGs when a value was not available based on NRWQCs, Oregon WQC or MCLs. The PRGs for RAO 7 are based on the lower of the NRWQC (chronic aquatic life) and Oregon WQC (chronic aquatic life) only when risk-based values are not available or are greater than ARARs.

Background Concentrations

EPA evaluated contaminant concentrations in locations that are not influenced by the releases from the Site and are either naturally occurring or not impacted by site-related activity. If background concentrations are higher than the PRG, EPA defaults to background concentration, as a matter of policy. Background concentrations in sediment for the Site are provided in Section 2 in the FS. There are insufficient data to compute defensible background concentrations for other media.

Summary of Proposed Preliminary Remediation Goals/Cleanup Levels

PRGs become final cleanup levels when EPA selects a remedy for the Site, after taking into consideration all public comments. According to the NCP and EPA guidance, the starting point for setting preliminary remediation goals is a risk level of 10^{-6} and a non-cancer HI equal to 1 for protection of human health and the lowest ecological PRG set to protect the various ecological receptors evaluated at an HQ equal to 1.

Summary of Remedial Alternatives

EPA developed nine remedial alternatives for the site that addressed the RAOs, considered the requirements of CERCLA and the NCP, and considered the large, complex nature of the Site. Detailed information about the remedial alternatives is provided in the FS Report. CERCLA § 121(b)(1), 42 U.S.C. § 9621(b)(1), mandates that remedial actions must be protective of human health and the environment, be cost-effective, and use permanent solutions and alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. Section 121(b)(1) also establishes a preference for remedial actions which employ, as a principal element, treatment to permanently and significantly reduce the volume, toxicity, or mobility of the hazardous substances, pollutants and contaminants at a site. CERCLA § 121(d), 42 U.S.C. § 9621(d), further specifies that a remedial action must require a level or standard of control of the hazardous substances, pollutants, and contaminants, which at least attains ARARs under federal and state laws, unless a waiver can be justified pursuant to CERCLA § 121(d)(4), 42 U.S.C. § 9621(d)(4).

There are limited technologies available for addressing contaminated sediment. The technologies available include institutional controls (ICs), monitored natural recovery (MNR), enhanced natural recovery (ENR), containment, sediment/soil treatment (in-situ and ex-situ), sediment/soil removal and disposal. Using these technologies, nine remedial alternatives were developed in the FS and are labeled A through I. Alternative A is a No-Action alternative, while Alternatives B through I all use a combination of these technologies to varying degrees. In addition, Alternatives E through I have been evaluated with two disposed material management (DMM) scenarios described on page 31.

In developing the different alternatives, sediment management areas (SMAs) were identified. These represent areas of localized contaminant concentrations in surface sediment where information collected during the RI indicates that natural recovery is not occurring or is not likely to be effective in reducing concentrations of COCs in a reasonable time frame.

Since it is difficult to design a range of alternatives using 64 COCs that have different distributions in various media throughout the Site, the alternatives were developed using COCs that were the most widespread and posed the greatest risk called "*focused COCs*."

The focused COCs are:

- PCBs
- Total PAHs
- DDx and dioxin/furans (1,2,3,7,8-PeCDD; 2,3,4,7,8-PeCDF; and 2,3,7,8-TCDD)

The specific focused COC concentrations to be addressed using containment and removal technologies in each alternative are referred to as remedial action levels (RALs). This range extends from current Site-wide average concentrations to the PRG level. RALs are a tool commonly used at sediment sites for evaluating the different alternatives and whether they achieve sediment RAOs within a reasonable time frame. More specifically, RALs are not cleanup levels, but are contaminant-specific sediment concentrations used to identify areas where capping and/or dredging will be conducted in order to reduce risks more effectively and faster than enhanced natural recovery or in- situ treatment in the SMA footprints. The evaluation and analysis used to develop the RALs is discussed in Appendix D of the FS. The RALs were developed by considering varying levels of expected reductions of contaminant concentrations throughout the Site. The

COC-specific RALs decrease from B through H, therefore the areas that are capped and/or dredged increase in acres from B through H. A summary of RALs for the focused COCs used to develop Alternatives B through H are presented in Table 12. Alternative I is a combination of different RALs and PTW values applied in specific areas of the Site. The RALs for Alternative I are presented in Table 13.

Focused COC	RAL (µg/kg)						
	Alt B	Alt C	Alt D	Alt E	Alt F	Alt G	Alt H
PCBs	1,000	750	500	200	75	50	9
Total PAHs	170,000	130,000	69,000	35,000	13,000	5,400	970
2,3,7,8-TCDD	0.002	0.002	0.002	6E-04	6E-04	6E-04	0.0001
1,2,3,7,8-PeCDD	0.003	0.002	8E-04	8E-04	8E-04	8E-04	0.0001
2,3,4,7,8-PeCDF	1	1	1	0.2	0.2	0.009	0.0002
DDx	650	550	450	300	160	40	6.1

Table 12. Summary of RALs for Focused COCs

The SMAs for Alternatives B through D include containment and removal inside the RAL footprints, in-situ treatment in depositional areas where PTW is present, and removal of PTW that is NAPL or not reliably contained. Where PTW that is NAPL or not reliably contained cannot be fully removed, a significantly augmented reactive cap will be placed over the remaining material. Since Alternatives E through I address all PTW through capping and dredging, it is not necessary to include in-situ treatment in areas beyond the RAL footprints, although in-situ treatment is used as a component of caps and post-dredge residual management layers in some parts of the Site. SMAs for Alternative I are the combination of PTW areas and the RALs presented in Tables 12 and 13 and are presented on Figure 9.

Focused COC	RAL (µg/kg)				
	PTW	Alt B +PTW	Alt D	Alt E	Alt F
PCBs	200	200	500	200	75
Total PAHs	870,000	170,000	69,000	35,000	13,000
2,3,7,8-TCDD	0.01	0.002	0.002	0.0006	0.0006
1,2,3,7,8-PeCDD	0.01	0.003	0.0008	0.0008	0.0008
2,3,4,7,8-PeCDF	0.2	0.2	1	0.2	0.2
DDx	7,050	650	450	300	160

Table 13. RALs for Focused COCs - Alternative I

Common Elements of the Alternatives

The following components are included in each alternative, except for Alternative A, No-Action. ***Note: The specific information associated with SMA footprints, dredging depths, estimated volumes of dredged material and cap material, and thickness of caps and/or types of cap layers are assumptions for purposes of developing cost estimates for the remedial alternatives. These assumptions were developed based on the existing data and will be finalized during the remedial design, after design level data to refine the baseline conditions are obtained.***

Containment

Containment or caps are designed to reduce unacceptable risk through: 1) physical isolation of the contaminated sediment or river bank soil to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface; 2) stabilization and erosion/scour protection to reduce re-suspension or erosion/scour of contaminated sediment and transport to other areas; and/or 3) chemical isolation of contaminated media to reduce exposure from contaminants transported into the water column.

Caps require monitoring and maintenance in perpetuity to ensure that the cap is performing successfully. They are generally constructed of granular material, such as fine-grained sediment, sand, or gravel, but can also include other materials with more complex designs. Four types of caps have been identified for use in areas that are suitable for capping:

- **Engineered Caps.** These involve placing layers of materials, including but not limited to sand, coarse gravel, or clay of different thickness to isolate and prevent movement of contamination. The type of material for the layers and their thickness is dependent on the type of contaminants, their concentrations, and flow dynamics of the river. For cost estimation purposes, the FS assumed a 3-ft thick engineered cap. Final cap thickness is dependent on area-specific considerations that will be addressed in remedial design.

- **Armored Caps.** Certain areas in the river may require armoring (for example, placement of large rocks) on caps to reduce erosion, particularly during large storm events. For cost estimation purposes, the FS assumed a 0.5-ft of armor stone in some areas. Re-deposition of fine-grained material in capped and armored areas is anticipated to occur over time, making the armored areas similar in surface grain size to non-armored areas. Over time, the re-colonized benthic community would likely be similar to the benthic community currently in the lower Willamette River.

  Armored caps are also necessary in the Shallow Region of the Site where wind and wake waves would erode the surface of an engineered cap. However, this area is also located within an area of the river that provides important habitat and placing large armor stone in this area would degrade the habitat and attract predators, which would require a large amount of mitigation. Adverse impacts on overall habitat existence and functions are important considerations during cap design and implementation. Under the Clean Water Act, avoiding or minimizing impacts to the aquatic environment from the cleanup action is a requirement. Therefore, it has been assumed that an engineered beach mix layer should be applied to the uppermost layer of all caps in areas where the minimum water depth above the cap will be < 20 feet. This beach mix layer will provide a material similar to the natural existing river bottom to minimize habitat impacts from the cleanup actions and help to stabilize the cap.

- **Reactive Caps.** Chemical isolation of contaminated sediment by capping may require an additional reactive layer of amendments such as activated carbon or organoclay when it is predicted that flow of groundwater or pore water will release contamination through the cap. In these instances, the ability of the cap material and amendments to contain contaminants will determine the ability to prevent contaminant movement through the cap. If sediment classified as containing highly toxic PTW is located in an area designated for capping, then a reactive cap was assumed for that area (see the PTW description above). All areas, including river banks, with known discharges of contaminated groundwater are assumed to require an in-river reactive cap to reduce the contaminant movement and limit potential exposures.

- **Armored Reactive Cap.** Within certain areas in the river where reactive caps are needed, armoring to reduce erosion, particularly during large storm events may also be necessary.

- **Significantly Augmented Reactive Cap.** In areas where PTW that is NAPL or cannot be reliably contained remains in the river either due to the depth of contamination or the presence of structures that preclude removal, organoclay reactive layers in conjunction with low permeable materials are assumed in the cap design. Organoclay has recently been used as an amendment in the capping of NAPL at the McCormick and Baxter site in the Willamette River within the Site. The use of low permeability materials is expected to further retard contaminant migration.

In-Situ Treatment

In-situ treatment of sediment refers to chemical, physical, or biological techniques for reducing contaminant concentrations, toxicity, bioavailability, or mobility while leaving the contaminated sediment in place. Given the NCP's expectation for treatment of PTW, in-situ treatment technologies are considered for the PTW areas. In-situ treatment is also considered in areas where groundwater plumes impact pore water.

Treatment options considered include in-situ solidification/stabilization and sequestration, which may be used to address PTW underneath and around pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities that remain intact. Amendments to caps or residual layers such as activated carbon or organoclay mats increases the ability to absorb certain types of organics and metals. The effectiveness of these amendments is dependent on the initial COC concentrations and the mixture of COCs present. Amendments can be engineered to facilitate placement in aquatic environments.

In the federally-authorized navigation channel and FMD areas, in-situ treatment alone is not compatible with current or future uses since future maintenance dredging would remove any material placed; thus, in-situ treatment is not considered to be effective over the long term or implementable in these areas. In-situ treatment is used in residual layers after dredging where PTW is left in place or where groundwater plumes may impact pore water. In intermediate, shallow and river bank regions of the site where PTW is left in place, either in-situ treatment or amendments to caps and post-dredging residual layers will be implemented.

Removal

Removal of contaminated sediment can be accomplished while submerged (dredging) or during low water levels or after water has been diverted or drained (dry excavation). For purposes of cost estimates, mechanical dredging and excavation from off-shore rigs was assumed for sediment and river bank soil removal. The most appropriate and effective method to remove sediment and river bank soils will be determined during remedial design. Dredged or excavated sediment/soil is placed on a barge and transported to a staging or handling area for dewatering and pretreatment, treatment, or final disposal. Several modes of transportation may be used to move dredged or excavated sediment depending on the dredge location(s), volume of sediment, whether it needs pretreatment, and the final disposal location.

If contamination at concentrations greater than the RALs extends below the maximum dredge depth, a cap will be placed over the remaining contamination. Otherwise, a residual sand layer will be placed over the dredged area to cover the exposed surface and isolate any dredge residuals and remaining contaminated sediment.

Several major considerations drive the design concept, cost estimates, and feasibility evaluation for the dredging included in the remedial alternatives, such as the following:

- **Mechanical Removal Equipment.** Environmental/closed buckets were assumed to be used to lessen releases to the water column. Articulated fixed-arm dredges are the preferred dredging option due to the greater bucket control that can be achieved versus cable-operated dredges. Articulated fixed-arm dredges are assumed to have a maximum arm reach of 50 ft and bucket sizes ranging from approximately 2 cy to 6 cy.

- **Productivity.** The duration of the dredging season is assumed to be 122 days based on an in-water fish work window established for the Willamette River of July 1 through October 31. This in-water work window accounts for fish migration patterns and may be refined following discussions with the relevant technical experts from the natural resource trustees. Dredging and excavation operations are assumed to occur 24 hours/6 days per week.

- **Volume Estimates.** Limited data exists on the depth of contamination at the Site. Actual dredge depths will be based on data collected during remedial design and the RALs selected in the ROD. A maximum dredge depth of 15-19 ft[6] is assumed in the Intermediate and Nav/FMD Regions and in the Shallow Region where PTW that is NAPL or not reliably contained is present since deeper dredge depths would require special design and side slope stabilization considerations. A maximum dredge depth of 5 ft in the rest of the Shallow Region is assumed because contaminant concentrations greater than RALs in this area of the Site is generally less than 5 feet.

- **Potential Contaminant Release during Construction.** Dredging best management practices (BMPs), such as silt curtains or sheet pile walls, will be used to minimize releases to the water column. Monitoring of water quality parameters will be conducted to measure the effectiveness of these controls and to determine whether additional control measures may be required. The monitoring program will include surface water and air.

- **Dredge Residuals.** Residuals are contaminated sediment remaining in or next to the dredged footprint. Managing dredge residuals through the placement of clean material soon after dredging is an important BMP for minimizing releases of contaminants, including resuspension. A 12-inch sand layer is assumed to be placed daily in all dredge areas to control residuals and releases. In areas where PTW is present post dredging, five percent activated carbon is assumed to be mixed with the sand layer. During excavation, river bank material will be susceptible to erosion from wind and surface water runoff. Erosion control measures will be used to divert surface water flows/runoff from excavations or limit transport of eroded river bank materials.

- **Buried Debris and Pilings.** Buried debris may impede removal of contaminated sediment and river bank materials at the Site, so they will be removed. A standard clamshell bucket, grapple, or equivalent will be used for debris removal.

- **Flood Rise Concerns.** A simple evaluation balancing the amount of sediment removed and the amount placed into the river was conducted in Appendix P of the FS. A HEC-RAS model will be run on the remedy selected in the ROD to ensure that flood rise management complies with regulatory requirements throughout the Site.

- **Material Handling.** Dredged material is assumed to be loaded directly into barges and transported for dewatering, treatment, or further transport. River bank materials excavated from above the water line are assumed to be loaded directly into containers or barges for transport and treatment as needed.

[6] Based on available information, nine acres of the site have contamination greater than PRGs at depths greater than 15 ft. These areas are located in the Navigation Channel, FMD, and Intermediate areas of the Site. Due to the very small volume that this creates and that an over-dredge of 3-5 feet would need to be made to place a cap in these areas due to current and future uses, these over-dredge depths were included in the dredge volume calculations.

Ex-Situ Treatment

Ex-situ treatment involves the application of chemical, physical or biological technologies to transform, destroy, or immobilize contaminants following removal of contaminated sediment. Depending on the contaminants, their concentrations, and the composition of the sediment, treatment of the sediment to reduce the toxicity, mobility, or volume of the contaminants before disposal may be warranted. Available disposal options and capacities may also affect the decision to treat some sediment. In general, treatment processes have the ability to reduce sediment contaminant concentrations, mobility, and/or toxicity by 1) contaminant destruction or detoxification, 2) extraction of contaminants from sediment, 3) reduction of sediment volume, or 4) sediment solidification/stabilization. Regulatory requirements determine the need to treat some sediments (such as RCRA Land Disposal Restrictions) and determine that some portion of the material constitutes PTW and as such, treatment has been considered. Prior to disposal, an evaluation of dredged sediment containing any RCRA wastes, pesticide residue, or PTW related to NAPL will be conducted to determine the need for and extent of treatment appropriate for the off-site disposal requirements.

Low temperature thermal desorption and solidification/stabilization are ex-situ treatment options considered in the FS for the Site, although other treatment options were retained and may be considered for the final remedy. Low temperature thermal desorption has been demonstrated at other sediment remediation sites, is effective for SVOCs and PAHs, but has limited effectiveness for PCBs. An acid scrubber was assumed to treat off-gas of material thermally treated. Solidification/stabilization has been effectively used for Gasco wastes and effective at reducing the mobility of contaminants. Fine-grained sediment and high moisture content will increase treatment times and volumes. There is widely-available commercial technology for both on-site and off-site applications of these treatment options.

Disposal

Disposal refers to the placement of dredged or excavated material and process wastes into a temporary or permanent structure, site, or facility. The goal of disposal is generally to manage sediment, soil, and/or residual wastes to prevent contaminants associated with them from impacting human health and the environment. Two disposal scenarios are discussed in the *Dredged Material Management* box on page 31.

Monitored Natural Recovery (MNR)

Natural recovery uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. These processes may include physical (sedimentation or dispersion), biological (biodegradation), and chemical (sorption and oxidation) mechanisms that act together to reduce the risks posed by contaminants. At this Site, it is expected that physical isolation through natural deposition of cleaner material coming in from upstream and dispersion and mixing are the primary mechanisms for natural recovery. Analysis of upstream suspended sediment data suggest incoming sediment COC concentrations are lower than sediment concentrations measured at the Site. Therefore, when the cleaner sediment is deposited on and mixed into the contaminated surface sediment within the Site, the overall contaminant concentration in the surface sediment is reduced; thus reducing the exposure to the contamination. The effectiveness of MNR will be dependent in large part on the surface sediment concentration and the concentration and rate of deposition and mixing of the cleaner sediment. Several lines of evidence were evaluated in Section 8 of Appendix D in the FS to determine the processes and areas where MNR would be effective.

DISPOSED MATERIAL MANAGEMENT (DMM): TWO SCENARIOS

The two options for disposal of dredged material include off-Site commercial landfills (RCRA Subtitle C and D) and a confined disposal facility (CDF). Sediment dredged from the Site will require characterization to determine whether it should be classified as material containing hazardous waste under RCRA or otherwise meets disposal criteria for the CDF.

Off-Site Commercial Landfills: A RCRA Subtitle C facility that accepts hazardous waste was used in the FS evaluation and for cost purposes, such as Chemical Waste Management of the Northwest (Chem Waste) Landfill. A RCRA Subtitle D facility that accepts non-hazardous waste was used in the FS evaluation and for cost purposes, such as Roosevelt Regional Landfill.

On-Site CDF. A CDF is an engineered structure, typically built on land adjacent to the water and extending into the waterbody (on the sediment bed) to store contaminated dredged material, isolating it from the surrounding environment. An in-water CDF may be constructed with sheet pile walls or other containment structures such as berms, either against the shore or as an island. Once an in-water CDF is filled, it would be capped, converting open water to dry land. CDFs have been proven to be a viable disposal option at other Superfund sediment sites. They can be a technically viable and cost effective means to dispose of contaminated sediment. In addition, a CDF is more efficiently integrated with dredging because transporting and offloading dredged material to a CDF causes fewer short-term impacts to the community and would be more cost-effective than transporting and offloading to an off-site landfill. The option to construct a CDF is dependent on the volume of dredged sediment. The CDF selected for FS evaluation and cost purposes is the Terminal 4 CDF, with a capacity of approximately 670,000 cubic yards of non-hazardous waste.

Using these two options, two disposal scenarios were developed that consider regulatory requirements governing disposal, sediment contaminant characteristics, and disposal capacity compared to volume of dredged sediment for each Alternative. Under RCRA, dredged material that is handled consistent with the Clean Water Act Section 404 is exempt from hazardous waste characterization and management requirements but if such dredged material is taken off-site for disposal, RCRA characterization would apply. The expected regulatory waste types that may be generated through dredging include waste that may contain RCRA characteristic hazardous wastes, RCRA- and State-listed hazardous wastes, and Toxic Substances Control Act (TSCA) waste. Additionally, dredged material that is not regulatory waste but has high concentrations or other characteristics requiring special disposal considerations will include "*Waste or Media containing Waste that May Warrant Additional Management*" and PTW. Information about each of these waste types and their special handling and disposal requirements are discussed in the FS.

DMM Scenario 1: Confined Disposal Facility and Off-Site Disposal. This scenario allows for the disposal of dredged material in a CDF and off site. This scenario is only applied to Alternatives E through I because the estimated dredged material volumes under these alternatives meet the minimum volume needed to justify construction of a CDF, which is approximately 670,000 cubic yards. Waste that meets the CDF disposal requirements will be placed in the CDF. Waste that does not meet the CDF requirements will be disposed of at an off-site RCRA Subtitle C or D facility. Acceptance criteria for the sediment that can be placed in the CDF include: no RCRA or State hazardous waste, no Waste or Media containing Waste that May Warrant Additional Management, no PTW that is highly mobile, no free oil, no debris or significant organic material, no contaminants that will leach out of the CDF, and other considerations such as the physical nature of the material, the nature of the chemical contaminants, and the quantity of material. More information on the CDF acceptance criteria are provided in the FS.

DMM Scenario 2: Off-Site Disposal. This scenario applies to all alternatives. All dredged material will be disposed of in an off-site landfill (RCRA Subtitle C or D facility). Non-hazardous dredged materials (as defined under RCRA) are eligible for direct landfill disposal at a RCRA Subtitle D facility if in compliance with the individual acceptance criteria of the receiving facility. Hazardous dredged material are eligible for direct landfill disposal at a RCRA Subtitle C or D (if treated) facility, if the material is in compliance with the individual acceptance criteria of the receiving facility. The capacity of the Roosevelt Regional RCRA Subtitle D facility and the Chem Waste RCRA Subtitle C Landfill is essentially unlimited relative to the volume of sediment expected to be dredged from the Site.

For both DMM scenarios, land-based disposal typically requires dewatering, waste water treatment, and transport to the disposal site via land based or water based transportation. Material that may need to be treated is assumed to be treated at a nearshore upland facility that will be sited and constructed in remedial design. To minimize the impact to surrounding communities, dredged material was assumed to be transported by barge to either the off-site facility or to the CDF. All material to be disposed of in a CDF would be barged directly to the CDF. There is no existing transfer facility within the Site to facilitate off-site disposal. Unless an on-site transfer facility is constructed, the most likely mode of transportation will be to barge the dredged material to an off-site transloading facility on the Columbia River and then truck or rail it to the off-site disposal facility. Should an on-site transloading facility be constructed, it is most likely that the material would be transloaded to an off-site disposal facility via rail. Little, if any, dredge material is expected to be trucked from an on-site transloading facility to the off-site disposal facility.

MNR does not include active remedial measures. However, it does include monitoring to assess whether these natural processes continue to occur and the rate they may be reducing contaminant concentrations in surface sediment. Monitoring of the surface water, sediment, and fish tissue will all be used to determine the progress of MNR to achieve RAOs and cleanup levels. The planned frequency of monitoring is described below.

Enhanced Natural Recovery (ENR)

In areas where natural recovery is occurring, but not at a rate sufficient to reduce risks within an acceptable time frame, enhancement or acceleration of the recovery process by engineering means can be considered. ENR at this Site is accomplished by adding a thin-layer cover of clean sand over contaminated sediment to accelerate natural recovery. The acceleration can occur through several processes, including increased dilution of contaminant concentrations in sediment from mixing, therefore decreasing exposure of organisms to contaminants. Areas that are not erosional or are naturally recovering slowly are candidates for ENR. ENR with a thin-layer placement of sand is different than the caps used to isolate contaminants and it typically does not require long-term monitoring or ICs.

ENR will be accomplished through the placement of a sand layer, which is expected to be sufficient to allow for mixing with the underlying sediment bed, while also retaining a clean sand surface above the mixed layer. In areas where PTW is present, it is assumed that an activated carbon will be added to the sand layer and would be monitored in perpetuity. This may be further defined during the remedial design if areas with PTW are addressed through ENR.

An analysis of data collected during the RI indicate that MNR is not occurring in Swan Island Lagoon at a rate sufficient to reduce risks within an acceptable time frame. Water circulation is limited, which limits the rate of sediment deposition and clean upriver sediment from entering this area. Since MNR is not considered a viable technology in this area, ENR is being considered for the area in Swan Island Lagoon that is outside the areas to be dredged or capped in order to meet the PRGs within an acceptable time frame. This limits the need to apply dredging and capping to larger areas of Swan Island Lagoon to meet PRGs in an acceptable time frame. Appendix D of the FS provides an analysis of the trade-offs between ENR and dredging/capping a larger area within Swan Island Lagoon.

Institutional Controls

The objectives of institutional controls (ICs) are to prevent exposure to contaminants on both a short-term and long-term basis until protective levels are achieved for all populations and to maintain the integrity of the engineered components of the remedy. ICs will include fish consumption advisories, educating the community by conducting an enhanced community outreach program, and limiting other river use activities during and after implementation of the remedy. ICs will also be used to protect caps in perpetuity by limiting one or more waterway and land use activities that may disturb or reduce the cap's ability to contain the contaminated sediment or groundwater. More detail on the potential IC mechanisms is provided below.

- **Fish Advisories and Educational Outreach.** A fish advisory will be part of the CERCLA response and during construction of the selected remedy would advise people to eat no more than 6 fish meals every 10 years for most populations and 1 fish meal every 10 years for women who may breastfeed. Once construction is completed, the advisory would be updated to allow an increased consumption rate based on fish tissue concentrations. The advisory may be periodically updated until RAOs and cleanup levels are reached.

The outreach program may include: informational meetings, presentations, and workshops targeting affected community groups; development and distribution of informational materials such as brochures or maps; advisory notifications communicated through a variety of culturally appropriate outlets; design, installation, and maintenance of advisory signs at known fishing locations; and coordination with sport or recreational fishing clubs and licensing locations.

- **Waterway Use Restrictions or Regulated Navigation Areas (RNAs).** Where caps will be utilized to contain contamination in navigable areas of the river, waterway use restrictions or RNAs will be necessary to ensure the integrity of the cap is maintained in perpetuity. These restrictions would preclude boat anchoring and keel dragging, the use of spuds to stabilize vessels, structure and utility maintenance and repair, and future maintenance dredging in areas containing caps. Notifications such as signs and buoys placed by the Oregon Marine Board may be used to warn vessels away from the area. RNAs have been successfully used in the past to protect remedial actions at the McCormick and Baxter cap and the Gasco interim action cap from vessel activities. Periodic inspections of RNA notifications will be needed to ensure they are functional and effective and will be evaluated in 5 year reviews.

- **Land Use/Access Restrictions.** Land use or access restrictions may also need to be implemented in nearshore areas and river banks to maintain the integrity of caps and the CDF from existing or future activities, such as construction and maintenance of structures. Department of State Lands (DSL) has control of State-owned submerged or submersible land that may be subjected to remedial action. Adjacent landowners may control submerged land and river banks as well. Coordination with DSL and adjacent landowners would be needed to implement any land use or access restrictions. Monitoring, including inspections, will be needed to ensure that restrictions are functioning as intended and will be evaluated in statutory 5-year reviews.

Additional institutional control mechanisms may be developed during remedial design.

Monitoring

Monitoring is an integral component of all alternatives, and will be conducted to evaluate short- and long-term effectiveness. The monitoring program will include analysis of sediment, river banks, surface water, pore water, fish tissue, and air (before, during, and after construction):

- New baseline sampling and monitoring will be conducted prior to implementation of remedial activities to establish current baseline conditions (pre-construction) to delineate construction areas and evaluate construction activities and the performance of the remedy.

- Short-term monitoring will be conducted during construction and post construction until PRGs are met.

- Long-term monitoring will be conducted periodically after PRGs are met where waste is left in place. Statutory 5-year reviews of the remedy will be conducted until unlimited use/unlimited exposure for the whole Site is achieved.

ARARs

CERCLA requires remedial actions to comply with ARARs or waive them. The following are the key ARARs associated with the remedial alternatives presented below:

- Federal National Recommended Water Quality Criteria (NRWQC)
- Oregon Water Quality Standards (WQS)
- Maximum Contaminant Levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) established under authority of the Safe Drinking Water Act (SDWA) since the river is a drinking water source.
- Oregon Hazardous Substance Remedial Action Rules (OHSRA) that set standards for the degree of cleanup required and establish acceptable residual risk levels for humans
- Federal and state solid and hazardous waste regulations such as the Resource Conservation and Recovery Act (RCRA), including Land Disposal Restriction (LDRs), and Toxic Substance Control Act (TSCA) handling, characterizing, treating, and disposing of dredged sediment off-site
- The Endangered Species Act (ESA)
- Section 404 and 401 of the Clean Water Act (CWA)
- Section 10 of the Rivers and Harbors Act.
- FEMA flood rise regulations

Application of Technologies

The majority of the alternatives developed combine all the technologies described above. Determining the appropriate technology to assign to a specific area of the river is dependent on a number of area-specific characteristics and environmental conditions. These factors include contaminant concentrations, current and reasonably anticipated future land and waterway use, areas of erosion/deposition, sediment bed slope, infrastructure such as docks and piers, and physical sediment characteristics. The technology assignment is also based on the river regions, as explained in more detail below. Based on the conceptual site model (CSM), areas with levels of contamination greater than the RALs where MNR would not be effective in reducing contaminant levels and ultimately risks, were assigned dredging or capping. MNR will be applied to areas of low level contamination.

A flowchart of the technology assignment process that applies to all areas of the site is presented on Figure 10. The primary difference between the alternatives is the size of the SMA footprints shown on Figure 11. The lower the contaminant RAL concentration, the greater the sediment footprint to be dredged or capped. The summary of the areas of each assigned technology is presented in Table 14. The following sections describe the criteria used for each river region (Figure 4).

Navigation Channel and FMD Region

SMAs within the federally authorized navigation channel or designated as FMD are assigned dredging due to water depth requirements that must be maintained in this region due to ship traffic. Contaminated sediment will be dredged to the depth of the RAL concentrations (estimated as a maximum depth of 17 ft bml for the navigation channel and 19 ft bml for FMD areas based on current data). If NAPL or PTW that is not reliably contained has been identified in a dredge area, and it cannot be completely removed, a reactive residual layer (sand plus activated carbon) is assumed after dredging. Otherwise, a residual layer (sand only) is assumed after dredging. Navigation and maintenance dredge depth requirements will need to be considered during the design and implementation of dredging activities and the placement of any thin layer covers or caps for dredge residual management such that the final constructed elevation is below the authorized navigational channel or maintenance dredge level.

Altern-ative	Technology						
	Cap	Dredge	Dredge/ Cap	River Bank Excavation /Cap	In-Situ Treatment	ENR	MNR
	(acres)	(acres)	(acres)	(lineal ft)	(acres)	(acres)	(acres)
B	22.8	66.6	5.5	9,633	6.7	99.8	1,966
C	30.2	80.2	6.4	11,047	5.0	97.4	1,948
D	44.8	121.1	10.9	13.887	3.2	87.0	1,900
E	65.6	188.3	15.3	18,231	0	59.8	1,838
F	117.8	355.1	32.3	23,305	0	28.2	1,634
G	184.7	525.0	46.7	26,362	0	19.5	1,391
H	535.3	1525.5	106.4	30,048	0	0	0
I	64.1	150.2	16.9	19,472	0	59.8	1,876

Table 14. Summary of Acres Assigned to Each Technology

Intermediate Regions

A technology assignment process was developed in Appendix C of the FS to assign capping (engineered or armored) and dredging technologies to RAL footprints in the intermediate region. Each technology is scored based on multiple site characteristics such as river flow dynamics, sediment bed characteristics, and human activity related conditions. If dredging and capping score equally, capping is selected due to the lower initial capital cost. If an engineered cap and armored cap score equally, the engineered cap is selected due to lesser habitat impacts.

The maximum depth of contamination in the intermediate region is estimated to be 34 ft bml based on current data, but in most areas the contamination is much shallower (less than 10 ft). If dredging is assigned to an SMA in this region, contaminated sediment will be dredged to the lesser of the RAL concentrations or 15 ft (assumed maximum depth since dredging deeper than 15 ft requires special design and side slope stabilization considerations) with a residual layer after dredging.

If NAPL or PTW that is not reliably contained extends below 15 ft, then a significantly augmented reactive cap is assumed to be placed after dredging. If NAPL or PTW that is not reliably contained can be removed within 15 ft, then a reactive residual layer is assumed after dredging occurs.

Shallow Regions

In this region, avoiding or minimizing impacts to the aquatic environment and flood rise need to be considered and evaluated to meet Clean Water Act (Section 404) and federal floodway requirements and climate change impacts. Maintaining the existing elevation of the sediment bed in this region prevents the loss of shallow water habitat, an increase in the flood rise, converting submerged lands into uplands if caps are placed in the river and minimizes mitigation measures. Therefore, any area assigned dredge/cap will first be dredged to the depth of the assumed cap and any area assigned dredge only will be backfilled to existing grade with a beach mix cover.

In the shallow region, contaminated sediment will be dredged to the lesser of the RAL concentrations or a maximum depth of 5 ft bml. The dredged material will be replaced with clean backfill with a beach mix cover to the previous elevation. If RAL concentrations extend below 5 ft, the contaminated sediment will be dredged and replaced with an engineered cap with a beach mix cover to the previous elevation.

If NAPL or PTW that is not reliably contained is present within an SMA, the contaminated sediment will be dredged to the lesser of the RAL concentrations or 15 ft. The dredged area for highly toxic PTW is assumed to be replaced with a reactive residual layer on the bottom if PTW remains, backfilled with sand to the previous elevation, with beach mix for the top 6 inches. If NAPL or PTW that is not reliably contained extends below 15 ft, a significantly augmented reactive cap is assumed to be placed and the remainder of the dredged area will be backfilled with sand to the previous elevation, with a beach mix cover.

River Banks

The technology assignments for SMAs adjacent to identified contaminated river banks are extended to include those river banks. Where SMAs are projected onto the river bank, removal followed by capping is the assigned remedial technology.

Engineered caps with beach mix are assumed to be placed on river banks that are prone to erosive forces. Vegetation is assumed to be planted on caps that are not prone to erosion. If NAPL or PTW that is not reliably contained is present, a significantly augmented reactive cap is assumed.

Structures

Pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities will likely remain intact during remedial activities. Contaminated sediment and river bank materials underneath these structures are assumed to be capped to the extent practicable. Moveable floating dock structures found within the Site could be moved to allow for remediation.

Other structures (such as dilapidated, obsolete, or temporary structures) with their foundations in contaminated sediment or river bank materials and not servicing active wharfs or shore-based facilities are assumed to be removed prior to construction activities for FS evaluation and cost estimating. Removal of structures will incorporate controls to prevent adverse water quality impacts and the transport of contaminated sediment. Where structures are removed, the technology assignments default to those described for the shallow and intermediate regions. If dredging is assigned for areas located beneath and around structures, a fixed arm environmental bucket dredge or excavator is assumed to the extent practicable.

Remedial Alternatives

In the following pages EPA describes the nine alternatives that were evaluated in the FS, presents the comparison of the nine alternatives based on seven of the nine remedy selection criteria specified in the NCP, and then presents EPA's preferred alternative. Once the public comments are received on the Proposed Plan, EPA will reevaluate the preferred alternative and will consider comments and any new information from the State, Tribes, and community to complete the full evaluation of all nine criteria for the final Record of Decision.

Alternatives A through G were the first set of Alternatives developed in drafting the FS. However, following Tribal consultations and meetings with the CAG, EPA developed Alternative H, which reaches PRGs at the end of construction by capping/dredging the entire Site. Additionally, as EPA was evaluating the alternatives, EPA determined that none of the Alternatives achieved a consistent level of risk reduction throughout the Site after construction. In order to achieve consistent risk reduction throughout the Site, EPA developed Alternative I which uses a different combination of the technologies used in Alternatives B through F while ensuring that all PTW is addressed. Alternative C was screened out because it was so similar to Alternative B. When constructed, the difference between Alternatives B and C was negligible. Alternative H was also screened out due to implementability and cost considerations.

Note: The specific information associated with SMA footprints, dredging depths, estimated volumes of dredged material and cap material, and thickness of caps and/or types of cap layers are assumptions for purposes of developing cost estimates for the remedial alternatives. These assumptions were developed based on the existing data and will be finalized during the remedial design, after design level data to refine the baseline conditions are obtained.

The expected outcomes of all of the Alternatives are summarized in FS Tables 4.3-1 and Table 4.3-2.

Alternative A: No Action

Capital Costs:	$0
Periodic Costs:	$0
Present Value:	$0
Construction Duration:	0 years

The Superfund program requires that the No Action alternative be considered as a baseline for comparison with the other alternatives. The No Action alternative would not include any remedial measures beyond the early actions implemented at the Gasco and Terminal 4 sites in 2005 and 2008, respectively. OHA may continue to implement the fish consumption advisories already in place under State legal authorities, but it is not part of the CERCLA response. The No Action Alternative does not include implementation of any new ICs or monitoring as a part of a CERCLA action for the Site.

Alternative B

Capital Costs:	$352,097,000
Periodic Costs[7]:	$290,324,000
Present Value:	
With DMM Scenario 2:	$451,460,000
Construction Duration:	4 years

Alternative B uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative only supports DMM scenario 2 – off-site disposal, since this alternative does not generate enough dredged material to justify constructing a CDF.

Alternative B has a total constructed area of 201 acres of sediment and 9,633 lineal ft of river bank, will allow 2,000 acres of sediment to naturally recover, and will not address 20,416 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 95.0 acres of contaminated sediment, 99.8 acres of ENR and 6.7 acres of in-situ treatment. Additionally, 9,633 lineal ft of river bank are assumed to be appropriately

[7] Periodic costs include Operation and Maintenance (O&M) costs and 5-year review costs over 30 years.

sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (different depths): 72.2 acres - 494,000 to 659,000 cy
- Excavation: 51,000 cy
- Capping area: 22.8 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 6.7 acres
- ENR: 99.8 acres
- MNR: 1966 acres

The design concept for Alternative B is shown on Figure 12.

Construction Duration: This alternative will take an estimated 4 years of in-river construction, with no additional time required to complete dredged material processing (i.e., dewatering and sampling for disposal parameters). The estimated schedule is a follows:

- Year 0[8]: Establish initial conditions
- Year 0[9]: Construction of on-site material handling/treatment facility (if applicable)
- Year 0[10]: Start-up activities and mobilization, including pre-design investigations
- Years 1 and 2: Construct alternative
- Year 3: Demobilization and mitigation

Disposal: Under Alternative B, an estimated volume of 494,000 to 659,000 cy material dredged would be managed under DMM Scenario 2.

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are discussed in *Common Elements of the Alternatives*.

Alternative C

Capital Costs: $400,933,000
Periodic Costs: $317,464,000

[8] Monitoring (sampling) of sediment, water, biota, and pore water will need to be the first phase, and it will encompass the entire Site to establish a baseline and delineate the SMAs for construction. It is expected that this phase will take 3 to 5 years.
[9] If a location for an on-site material handling/treatment facility is determined, construction of the facility would occur prior to construction activities.
[10] Year 0 is the first year of construction.

Present Value:
With DMM Scenario 2: $496,760,000
Construction Duration: 5 years

This alternative was screened out since it was essentially the same constructed alternative as Alternative B.

Alternative C uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative only supports DMM scenario 2 – off-site disposal, since this alternative does not generate enough dredged material to justify constructing a CDF.

Alternative C has a total constructed area of 219 acres of sediment and 11,047 lineal ft of river bank, will allow 1,900 acres of sediment to naturally recover, and will not address 19,002 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 116.8 acres of contaminated sediment, 97.4 acres of ENR and 5.0 acres of in-situ treatment. Additionally, 11,047 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (different depths): 86.6 acres - 592,000 - 790,000 cy
- Excavation: 58,000 cy
- Capping area: 30.2 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil.
- In-situ treatment: 5.0 acres
- ENR: 97.4 acres
- MNR: 1948 acres

The design concept for Alternative C is shown on Figure 13.

Construction Duration: This alternative will take an estimated 5 years of in-river construction, with no additional time required to complete dredged material processing (i.e., dewatering and sampling for disposal parameters). The estimated schedule is a follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization including pre-design investigations
- Years 1 through 3: Construct alternative
- Year 4: Demobilization and mitigation

Disposal: Under Alternative C, an estimated volume of 592,000 to 790,000 cy material dredged would be managed under DMM Scenario 2.

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are also discussed in *Common Elements of the Alternatives*.

Alternative D

Capital Costs:	$556,004,000
Periodic Costs:	$397,028,000
Present Value:	
With DMM Scenario 2:	$653,700,000
Construction Duration:	6 years

Alternative D uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative only supports DMM scenario 2 – off-site disposal, since this alternative does not generate enough dredged material to justify constructing a CDF.

Alternative D has a total constructed area of 267 acres of sediment and 13,887 lineal ft of river bank, will allow 1,900 acres of sediment to naturally recover, and will not address 16,161 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 176.9 acres of contaminated sediment, 87.0 acres of ENR, and 3.2 acres of in-situ treatment. Additionally, 13,887 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (different depths): 132.1 acres - 950,000 - 1,266,000 cy
- Excavation: 73,000 cy
- Capping: area: 44.8 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 3.2 acres
- ENR: 87.0 acres
- MNR: 1,900 acres

The design concept for Alternative D is shown on Figure 14.

Construction Duration: Alternative D will take an estimated 6 years of in-river construction, with no additional time required to complete dredged material processing (i.e., dewatering and sampling for disposal parameters). The estimated schedule is a follows:

- Year 0: Establish initial conditions

- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization, including pre-design activities
- Years 1 through 4: Construct alternative
- Year 5: Demobilization and mitigation

Disposal: Under Alternative D, an estimated volume of 950,000 to 1,266,000 cy material dredged would be managed under DMM Scenario 2.

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are also discussed in *Common Elements of the Alternatives*.

Alternative E

DMM1 Scenario:	
Capital Costs:	$748,071,000
Periodic Costs:	$412,332,000
Present Value:	$804,120,000
DMM Scenario 2:	
Capital Costs:	$827,465,000
Periodic Costs:	$412,332,000
Present Value:	$869,530,000
Construction Duration:	7 years

Alternative E uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative supports DMM1 off-site disposal and CDF and DMM2 – off-site disposal. This alternative generates enough dredged material to justify constructing a CDF.

Alternative E has a total constructed area of 329 acres of sediment and 18,231 lineal ft of river bank, will allow 1,800 acres of sediment to naturally recover, and will not address 11,817 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 269.3 acres of contaminated sediment, 59.8 acres of ENR. Additionally, 18,231 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (varying depths): 203.7 acres -1,653,000 to 2, 204,000 cy
- Excavation: 96,000 cy
- Capping: area: 65.6 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 0 acres

- ENR: 59.8 acres
- MNR: 1,838 acres

The design concept for Alternative E is shown on Figure 15.

Construction Duration: Alternative E will take an estimated 7 years of in-river construction, with no additional time required to complete processing of dredged material (i.e., dewatering and sampling for disposal parameters). The estimated schedule is as follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization, including pre-design investigation
- Years 1 through 5: Construct alternative
- Year 6: Demobilization and mitigation

Disposal: The material removed from the Site under Alternative E would be managed in one of two disposal scenarios:

- DMM Scenario 1:
  - 670,000 cy to the onsite CDF
  - 983,000 to 1,534,000 cy to off-site disposal facilities in compliance with the off-site rule
- DMM Scenario 2:
  - 1,653,000 to 2,204,000 cy to off-site disposal facilities in compliance with the off-site rule

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are also discussed in *Common Elements of the Alternatives*.

Alternative F

DMM1 Scenario:

Capital Costs:	$1,550,014,000
Periodic Costs:	$549,512,000
Present Value:	$1,316,560,000

DMM Scenario 2:

Capital Costs:	$1,629,407,000
Periodic Costs:	$549,512,000
Present Value:	$1,371,170,000

Construction Duration: 13 years

Alternative F uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative supports DMM1 off-site disposal and CDF and DMM2 – off-site disposal. This alternative generates enough dredged material to justify constructing a CDF.

Alternative F has a total constructed area of 533 acres of sediment and 23,305 lineal ft of river bank, will allow 1,600 acres of sediment to naturally recover, and will not address 6,477 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 505.3 acres of contaminated sediment and 28.2 acres of ENR. Additionally, 23,305 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (varying depths): 387.4 acres - 3,825,000 to 5,100,000 cy
- Excavation: 123,000 cy
- Capping area: 117.8 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 0 acres
- ENR: 28.2 acres
- MNR: 1,634 acres

The design concept for Alternative F is shown on Figure 16.

Construction Duration: Alternative F will take an estimated 13 years of in-river construction, with no additional time required to complete processing of dredged material (i.e., dewatering and sampling for disposal parameters). The estimated schedule is as follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization, including pre-design investigations
- Years 1 through 11: Construct alternative
- Year 12: Demobilization and mitigation

Disposal: The material removed from the Site under Alternative F would be managed in one of two disposal scenarios:

- DMM Scenario 1:
  - 670,000 cy to the onsite CDF
  - 3,155,000 to 4,430,000 cy to off-site disposal facilities in compliance with the off-site rule

- DMM Scenario 2:
  - 3,825,000 to 5,100,000 cy to off-site disposal facilities in compliance with the off-site rule

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are provided in *Common Elements of the Alternatives*.

Alternative G

DMM1 Scenario:

Capital Costs:	$2,421,152,000
Periodic Costs:	$708,114,000
Present Value:	$1,731,110,000

DMM Scenario 2:

Capital Costs:	$2,500,545,000
Periodic Costs:	$708,114,000
Present Value:	$1,777,320,000

Construction Duration: 19 years

Alternative G uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. This alternative supports DMM1 off-site disposal and CDF and DMM2 – off-site disposal. This alternative generates enough dredged material to justify constructing a CDF.

Alternative G has a total constructed area of 776 acres of sediment and 26,363 lineal ft of river bank, will allow 1,400 acres of sediment to naturally recover, and will not address 3,686 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 756.4 acres of contaminated sediment and 19.5 acres of ENR. Additionally, 26,363 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (various depths): 571.7 acres (6,221,000 to 8,294,000 cy)
- Excavating: 139,000 cy
- Capping area: 184.7 acres
- Ex-situ treatment: 156,000-208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 0 acres
- ENR: 19.5 acres
- MNR: 1,391 acres

The design concept for Alternative G is shown on Figure 17.

<u>Construction Duration:</u> Alternative G will take an estimated 19 years of in-river construction, with no additional time required to complete processing of dredged material (i.e., dewatering and sampling for disposal parameters). The estimated schedule is as follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization, including pre-design investigation
- Years 1 through 17: Construct alternative
- Year 18: Demobilization and mitigation

<u>Disposal:</u> The material removed from the Site under Alternative F would be managed in one of two disposal scenarios:

- DMM Scenario 1:
  - 670,000 cy to the onsite CDF
  - 5,551,000 to 7,624,000 cy to off-site disposal facilities in compliance with the off-site rule
- DMM Scenario 2:
  - 6,221,000 to 8,294,000 cy to off-site disposal facilities in compliance with the off-site rule

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are also provided in *Common Elements of the Alternatives*.

Alternative H

DMM1 Scenario:		
	Capital Costs:	$8,869,180,000
	Periodic Costs:	$1,284,174,000
	Present Value:	$9,445,540,000
DMM Scenario 2:		
	Capital Costs:	$8,948,573,000
	Periodic Costs:	$1,284,174,000
	Present Value:	$9,524,940,000
Construction Duration:		62 years

Alternative H was screened out due to implementability and cost considerations. Given the extensive degree of capping and dredging associated with Alternative H, the volume of material to be handled, and the expected construction duration (62 years), which includes impacts to community and disruption and potential releases to the environment for that period of time, Alternative H is considered less implementable than the other alternatives. Alternative H also has a cost approximately 5 times higher than the next closest alternative (Alternative G).

Alternative H uses the RALs presented in Table 9 to develop the combination of remedial technologies applied at the Site. The RALs for this alternative are based on the PRGs for the focused COCs. It is the most aggressive of all the alternatives since it removes the most volume of contaminated material from the site and does not include/rely on MNR to achieve sediment PRGs. Sediment PRGs will be achieved at the end of construction. This alternative supports DMM1 off-site disposal and CDF and DMM2 – off-site disposal because it generates enough dredged material to justify constructing a CDF.

Alternative H has a total constructed area of 2,167 acres sediment and 30,048 lineal ft of river bank. All contaminated areas will be addressed through dredging and capping. MNR is not a component of this alternative.

This alternative includes capping and dredging 2,167.2 acres of contaminated sediment. Additionally, 30,048 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging (various depths): 1,631.9 acres (25,115,000 to 33,487,000 cy)
- Excavating: 158,000 cy
- Capping area: 535.3 acres
- Ex-situ treatment: 156,000 to 208,000 cy sediment and 9,500 cy soil
- In-situ treatment: 0 acres
- MNR: 0 acres
- ENR: 0 acres

The design concept for Alternative H is shown on Figure 18.

<u>Construction Duration:</u> Alternative H will take an estimated 62 years of in-river construction, with no additional time required to complete processing of dredged material (i.e., dewatering and sampling for disposal parameters). The estimated schedule is as follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization, including pre-design investigation
- Years 1 through 60: Construct alternative
- Year 61: Demobilization and mitigation

<u>Disposal:</u> The material removed from the Site under Alternative H would be managed in one of two disposal scenarios:

- DMM Scenario 1:

   - 670,000 cy to the onsite CDF
   - 24,445,000 to 32,817,000 cy to off-site disposal facilities in compliance with the off-site rule
- DMM Scenario 2:
   - 25,115,000 to 33,487,000 cy to off-site disposal facilities in compliance with the off-site rule

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. However, ICs for fish consumption and monitoring of fish tissue may only be needed in the short-term given that PRGs in sediment would be met at the time of construction. ICs and monitoring in the long-term would still be needed for any areas capped, since that material would remain in place in perpetuity. The key ARARs associated with this alternative are also provided in *Common Elements of the Alternatives*.

Alternative I

DMM1 Scenario:	
Capital Costs:	$671,966,000
Periodic Costs:	$421,940,000
Present Value:	$745,890,000
DMM Scenario 2:	
Capital Costs:	$751,359,000
Periodic Costs:	$421,940,000
Present Value:	$811,290,000
Construction Duration:	7 years

Alternative I was developed as a result of the FS evaluation process of Alternatives B-G in the drafting of the FS. Alternative I is a modification of Alternative E, which allows for a more consistent level of risk reduction in all areas of the site. Alternative I uses the RALs presented in Table 13 to develop the combination of remedial technologies applied at the Site. This alternative supports DMM1 off-site disposal and CDF and DMM2 – off-site disposal. This alternative generates enough dredged material to justify constructing a CDF.

Alternative I has a total constructed area of 291 acres of sediment and 19,472 lineal ft of river bank, will allow 1,900 acres of sediment to naturally recover, and will not address 10,577 lineal ft of known contaminated river bank.

This alternative includes capping and dredging 231.2 acres of contaminated sediment and 59.8 acres of ENR. Additionally, 19,472 lineal ft of river bank are assumed to be appropriately sloped and covered with either a significantly augmented reactive cap or an engineered cap using beach mix or vegetation.

Site Wide

- Dredging: (various depths): 167.1 acres (1,414,000 to 1,885,000 cy)
- Excavating: 103,000 cy
- Capping area: 64.1 acres
- Ex-situ treatment: 156,000 to 208,000 cy sediment and 9,500 cy soil

- In-situ treatment: 0 acres
- ENR: 59.8 acres
- MNR: 1,876 acres

The design concept for Alternative I is shown on Figure 19**.**

Construction Duration: Alternative I will take an estimated 7 years of in-river construction, with no additional time required to complete processing of dredged material (i.e., dewatering and sampling for disposal parameters). The estimated schedule is as follows:

- Year 0: Establish initial conditions
- Year 0: Construction of on-site material handling/treatment facility (if applicable)
- Year 0: Start-up activities and mobilization
- Years 1 through 5: Construct alternative
- Year 6: Demobilization and mitigation

Disposal: The material removed from the Site under Alternative G would be managed in one of two disposal scenarios:

- DMM Scenario 1:
    - 670,000 cy to the onsite CDF
    - 744,000 to 1,215,000 cy to off-site disposal facilities in compliance with the off-site rule
- DMM Scenario 2:
    - 1,414,000 to 1,885,000 cy to off-site disposal facilities in compliance with the off-site rule

ICs and monitoring as described above in *Common Elements of the Alternatives* will also be implemented under this alternative. The key ARARs associated with this alternative are also provided in *Common Elements of the Alternatives*.

Evaluation of Alternatives

In this section, the alternatives are evaluated in detail to determine which would be the most effective in achieving the goals of CERCLA and the RAOs for the Site. The alternatives are then compared to each other based on the nine criteria set forth in the NCP at 40 CFR 300.430(e)(9)(iii) (see box at right). A summary of the comparative analysis of alternatives is presented in FS Table 4.3-1. A qualitative depiction of the summary is presented in Table 15, where the threshold criteria are depicted as being achieved and the balancing criteria are ranked from lowest relative rank to the highest relative rank. The analysis includes an evaluation using relevant exposure scales for receptors covered by each RAO consistent with the assumptions used in the baseline risk assessments. Site-wide and smaller spatial scales were used to evaluate each alternative including attainment of the RAOs. Sediment decision units (SDUs) were developed as a tool to evaluate the expected effectiveness of the alternatives throughout the site. Fourteen individual regions of the river within the Site were designated as SDUs, generally identified as areas with the highest focused COC concentrations over one river mile segments where multiple contaminants and/or benthic risk were identified. One river mile is consistent with the assumed exposure area of a recreational fisher and corresponds with the home range of various ecological receptors. Locations of the SDUs and the predominant contaminants associated with each SDU are shown on Figure 20 and in Table 16. The effectiveness of each remedial alternative is evaluated in part by comparing each alternative's post-construction sediment surface-weighted average concentration (SWAC) to the PRGs for each RAO in the SDUs. This comparison provides an assessment of how the different alternatives reduce sediment contaminant concentrations, which can then be used to calculate reductions in contaminant concentrations in fish tissue. Risks to people and wildlife from eating contaminated fish can then be evaluated for each alternative at the end of construction. Consumption of contaminated fish

THE NINE SUPERFUND EVALUATION CRITERIA

The first two criteria are threshold criteria that must be met by each alternative.

1. **Overall Protection of Human Health and the Environment** evaluates whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)** evaluates whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified.

The next five criteria are the primary balancing criteria upon which the analysis is based.

3. **Long-term Effectiveness and Permanence** considers the ability of an alternative to maintain protection of human health and the environment over time.
4. **Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment** evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.
5. **Short-term Effectiveness** considers the length of time needed to implement an alternative and the risks the alternative poses to workers, the community, and the environment during implementation.
6. **Implementability** considers the technical and administrative feasibility of implementing the alternative, including factors such as the relative availability of goods and services.
7. **Cost** includes estimated capital and annual operations and maintenance costs, as well as present value cost. Present value cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.

The final two criteria are referred to as modifying criteria, which will be evaluated following comments received during the public comment period and will be addressed in making the final remedy decision and discussed in the ROD.

8. **State/Support Agency Acceptance** considers whether the State agrees with the EPA's analyses and recommendations, as described in the RI/FS and Proposed Plan.
9. **Community Acceptance** considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

and shellfish is a significant exposure pathway for people and wildlife, thus it is important to understand the relative improvements that each alternative achieves at the end of construction. SDUs are used in the comparative analysis and in the preferred alternative section of this plan.

SDU ID	Location	Description	Length (mile)	Acres	Focused COCs
RM2E	RM 1.6 - 2.8 East	Evraz Oregon Steel Mill	1.3	102.8	PCBs
RM3.5E	RM 3.1-4.1 East	Schnitzer	1	51.3	PCBs
RM4.5E	RM 4.2 - 5.0 East	Terminal 4	0.9	43.3	PAHs/PCBs
RM5.5E	RM 5.0 - 6.0 East	Mar Com	0.9	30	PAHs/PCBs
RM6.5E	RM 6.0 - 7.0 East	Willamette Cove	1.1	89.2	PCBs/PeCDD
SwanIs	RM 8.1 - 8.9	Swan Island Lagoon	1.1	117	PCBs
RM11E	RM 10.6 - 11.6 East	River Mile 11 East	1.1	28.8	PCBs/PeCDD
RM3.9W	Benthic Risk Area	Kinder Morgan	1.1	49.3	PAHs/DDx
RM5W	Benthic Risk Area	Nustar	1.1	24.6	PAHs/DDx
RM6W	RM 5.6 - 6.5 West	Gasco	1	38.1	PAHs
RM7W	RM 6.6 - 7.8 West	Arkema	1.4	68.3	DDx/PeCDF/TCDD
RM9W	RM 8.3 - 9.7 West	Shaver to Fireboat Cove	1.5	67.9	PCBs/PeCDD/TCDD
RM6Nav	RM 5.1 - 6.5 Nav	Navigation Channel	1.7	147	PAHs
NoSDU	RM 1.9-11.8	Any area not included in the other SDUs	9.9	1,309.4	Not defined by specific COCs

Table 16. Description of Sediment Decision Units (SDUs)

Overall Protection of Human Health and the Environment

A primary requirement of CERCLA is that the selected remedial action be protective of human health and the environment. An alternative is protective if it reduces current and potential future risks associated with each exposure pathway at a site to acceptable levels.

Alternative A would not be protective of human health and the environment and contaminated sediments in the site would continue to impact surface sediments, surface water, and biota and pose unacceptable risks to human health and the environment for the foreseeable future. Because no further action is taken, Alternative A would result in minimal reductions in COC concentration and related residual risks. Natural recovery process would result in reduction in the COC concentrations over time, but are unlikely to achieve all PRGs for COCs or meet all RAOs in a reasonable time frame. Because Alternative A is not protective, it is not carried forward in the comparative analysis of the alternatives.

All remaining alternatives, in conjunction with MNR and institutional controls, are expected to be protective of human health. Since institutional controls should be relied upon to the minimum extent practicable, the less reliant an alternative is on institutional controls the more protective the alternative. Reliance on fish advisories is greatest with Alternative B and decreases through Alternatives D, I, E, F, then G, while reliance on RNAs and land use restrictions is greatest with Alternative G and decreases through Alternatives F, E, I, D, then B. Additionally, Alternatives E, F, G and I, in conjunction with MNR, are expected be protective of the environment. Alternatives B and D may not be protective of the environment because of the time frame needed to achieve PRGs through MNR and ICs would not provide protection ecological receptors during this time period.

For purposes of comparing the alternatives and what level of risk reduction they provide at the end of construction, interim risk targets were developed. These interim targets are intended to specify the level of risk that is ideally achieved through active cleanup. Once these levels are achieved, natural recovery is then the mechanism for further reducing contaminant levels to PRGs. Based on the lines of evidence developed for supporting natural recovery, it is assumed that if the interim targets are achieved, natural recovery will be sufficient in cleaning the Site to protective levels. The interim targets are listed under each RAO below.

A summary of how the alternatives perform relative to interim targets to determine overall protectiveness is presented as follows:

- **RAO 1**. Alternatives B, D, and I do not achieve the carcinogenic risk interim target of 1 x 10^{-5}, all other alternatives achieve the interim target.

- **RAO 2.** Carcinogenic risks on a Site-wide scale do not achieve the interim target of 1 x 10^{-4} with Alternatives B, D, E and I; the interim target is achieved with Alternatives F and G. On a river mile scale, none of the alternatives achieve the carcinogenic risk interim target of 1 x 10^{-4}. On an SDU scale, Alternatives B, D, E, F, and I do not achieve the carcinogenic risk interim target of 1 x 10^{-4}; Alternative G achieves the interim target.

  Alternative G is the only alternative that achieves the interim target HI of 10 on a Site-wide scale; all other Alternatives do not achieve the interim HI target. On a river mile scale, Alternatives B, D, E, and I do not achieve the interim HI target of 10; the interim target is achieved in Alternatives F and G. On an SDU scale, Alternatives B, D, and E do not achieve the interim HI target of 10; the interim target is achieved in Alternatives F, G and I.

  All alternatives achieve the infant interim target HI of 1,250 on a Site-wide scale. Alternative G is the only alternative that achieves the infant HI interim target of 920 on a river mile scale; all other Alternatives do not achieve the interim target. Alternative B is the only alternative that does not achieve the infant HI interim target of 920 on an SDU scale; all other alternatives achieve the interim target.

- **RAO 3**. Alternative B is the only alternative that does not achieve the Site-wide interim target of 10 times the PRG for each COC; all other alternatives achieve the interim target. There is insufficient information to evaluate this RAO on an SDU scale.

- **RAO 4**. Post-construction, the estimated contaminated groundwater area addressed by each alternative increases as the footprint of the SMAs increases (Alternative B to G; Alternative I addresses 1 percent more than Alternative E).

- **RAO 5**. Alternative B is the only alternative that does not achieve the interim target of addressing 50 percent of the benthic risk area; all other alternatives achieve the interim target.

- **RAO 6.** Alternative B, D, E and I do not achieve the ecological HQ interim target of 10; Alternatives F and G achieve the interim target.

- **RAO 7**: There is insufficient information to evaluate this RAO on a Site-wide or SDU scale.
- **RAO 8**. Post-construction, the estimated contaminated groundwater area addressed by each alternative increases as the footprint of the SMAs increases (Alternative B to G; Alternative I addresses 1 percent more than Alternative E).
- **RAO 9**. Post-construction, the estimated contaminated river bank addressed by each alternative increases as the footprint of the SMAs increases (Alternative B to G; Alternative I addresses 4 percent more than Alternative E).

Compliance with Applicable or Relevant and Appropriate Requirements

Any alternative considered by EPA must comply with all federal and state environmental standards, requirements, criteria or limitations, unless they are waived under certain specific conditions. Alternatives B through G had common ARARs associated with the construction of the alternative since they are all essentially the same remedial technologies with varying degrees of area and scope. Alternative B does not achieve chemical-specific ARARs in a reasonable time frame, but will attain the action-specific and location-specific ARARs. All other alternatives will attain their respective Federal and State ARARs.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once PRGs are achieved. The magnitude of residual risk is defined as the estimated residual risk based on the PRGs and is RAO specific. The post-construction risk is greatest for Alternative B and decreases with implementation of alternatives with larger SMA footprints. A summary of the residual risk estimates for each RAO and the post-construction risks for each Alternative is as follows:

- **RAO 1**. The estimated Site-wide residual risk for sediment is 3×10^{-6}. Post-construction risk for Alternative B exceeds the residual risk estimate by an order of magnitude. Post-construction risk for the other alternatives is within an order of magnitude of the residual risk estimate. Post-construction risk decreases in the following order: Alternative B, D, I, E, F then G.

  The estimated residual risk for beaches is 9×10^{-6}. Post-construction risks cannot be quantified due to the lack of data.

- **RAO 2**. The estimated Site-wide residual risk is 8 x 10-5. Post-construction risks for each alternative are within an order of magnitude of the residual risk estimate. Post-construction risk decreases in the following order: Alternative B, D, E and I (Alternatives E and I are equal), then F and G. Alternatives F and G achieve the residual risk estimates.

  On both a river mile and SDU scale, the estimated residual risk is 3×10^{-5}. Post-construction risks are an order of magnitude greater than the residual risk estimate for both Alternatives B and D, within an order of magnitude for Alternatives E, F and I, and achieve the residual risk estimate for Alternative G. On a river mile scale, the post-construction risk decreases in the following order: Alternatives E and I are equal, Alternative F then Alternative G. On an SDU scale, the post-construction risks decreases in the following order: Alternative B, D, E, I, F then G.

The estimated Site-wide residual HI is 6. Post-construction HIs for each alternative are within an order of magnitude of the residual HI estimate. Post-construction HI decreases in the following order: Alternative B, D, Alternatives E and I are equal, and Alternatives F and G are equal.

On both a river mile and SDU scale, the estimated residual HI is 2. Post-construction HIs for both Alternatives B and D are an order of magnitude greater than the residual HI estimate. Post-construction HIs for the other alternatives are within an order of magnitude of the residual HI estimate. On a river mile scale, the post-construction HI decreases in the following order: Alternative B, D, I, E, F then G. On an SDU scale, the post-construction HI decreases in the following order: Alternative B, D, E, I, F then G.

The estimated Site-wide residual HI for the infant is 132. Post-construction HIs for each alternative are within an order of magnitude of the residual HI estimate. Post-construction HI decreases in the following order: Alternative B, D, Alternatives E and I are equal, and Alternatives F and G are equal.

On both a river mile and SDU scale, the estimated residual HI for the infant is 45. Post-construction HIs on a river mile scale are two orders of magnitude greater than the residual HI estimate for Alternatives B and D, an order of magnitude greater for Alternatives E, F and I, and within an order of magnitude for Alternative G. Post-construction HIs decrease in the following order: Alternative B, D, E, I, F then G. Post-construction HIs on an SDU scale are two orders of magnitude greater than the residual HI estimate for Alternative B, an order of magnitude greater for Alternative D, within and order of magnitude for Alternatives E, F and I, and achieves the residual risk estimate for Alternative G. Post-construction HI decreases in the following order: Alternative B, D, E, F and I are equal, then G.

- **RAO 3**. The PRG for PCBs is 0.000006 μg/L. Post-construction concentrations are an order of magnitude greater than the PRG for Alternatives B and D and within an order of magnitude for the other alternatives. Post-construction concentrations decrease in the following order: Alternative B, D, E and I are equal, F then G.

  The PRG for 2,3,7,8-TCDD eq is 0.0000000005 μg/L. Post-construction concentrations are within an order of magnitude for each alternative. Post-construction concentrations decrease in the following order: Alternative B, D and I are equal, E, then F and G are equal.

  The PRG for cPAHs is 0.0001 μg/L. Post-construction concentrations are within an order of magnitude for Alternative B and the PRG is achieved for all other alternatives.

- **RAO 4**. The magnitude of residual risk is uncertain because it is likely that not all contaminated pore water will be addressed by any alternative. Post-construction, the area of sediment impacted by contaminated groundwater decreases with the increasing SMA footprint for each alternative in the following order: Alternative B, D, E, I, F then G.

- **RAO 5**. The magnitude of residual risk is uncertain because it is likely that not all benthic risk will be addressed by any alternative. Post-construction, the area of sediment that poses unacceptable risk to the benthos decreases with increasing SMA footprint for each alternative in the following order: Alternative B, D and I are equal, E, F then G.

- **RAO 6**. The residual HQ once PRGs are achieved is 1 for each COC.

- Post-construction HQs for BEHP on a river mile scale are an order of magnitude greater than the residual HQ estimate for Alternatives B, D, E and I, within an order of magnitude for Alternative F, and achieves the PRG for Alternative G. On an SDU scale, post-construction HQs are an order of magnitude greater than the residual HQ estimate for Alternative B, within an order of magnitude for Alternatives D, E and I, and achieves the PRG for Alternatives F and G.

- Post-construction HQs for PCBs on a river mile scale are within an order of magnitude for Alternatives B, D, E and I, and achieves the PRG for Alternatives F and G. On an SDU scale, post-construction HQs are within an order of magnitude for Alternatives B and D, and achieves the PRG for all other alternatives.

- Post-construction HQs for HxCDF on a river mile scale are within an order of magnitude for Alternatives B and D, and achieves the PRG for all other alternatives. On an SDU scale, post-construction HQs are within an order of magnitude for Alternative B, and achieves the PRG for all other alternatives.

- Post-construction HQs for PeCDF on both a river mile and SDU scale are within an order of magnitude for Alternatives B and D, and achieves the PRG for all other alternatives.

- Post-construction HQs for TCDF on both a river mile and SDU scale are within an order of magnitude for Alternatives B and D, and achieves the PRG for all other alternatives.

- **RAO 7.** There is insufficient information to evaluation this RAO on a Site-wide or SDU scale.

- **RAO 8**. The magnitude of residual risk is uncertain because it is likely that not all contaminated pore water will be addressed by any alternative. Post-construction, the area of sediment impacted by contaminated groundwater decreases with the increasing SMA footprint for each alternative in the following order: Alternative B, D, E, I, F then G.

- **RAO 9**. The magnitude of residual risk is uncertain because it is likely that not all contaminated river bank will be addressed by any alternative. Post-construction, the area of contaminated river bank decreases with the increasing SMA footprint for each alternative in the following order: Alternative B, D, E, I, F then G.

The technologies used in Alternatives B through I are the same, but vary in degree of use. Off-site treatment and land-based disposal facilities are in operation and have proven to be reliable technologies. On-site water treatment and CDF are reliable and proven technologies as long as they are designed to deal with the specific contaminated media. Dredging, excavating, capping, in-situ treatment, and thin layer covers are reliable and proven technologies as long as they are designed for the appropriate environmental and anthropogenic conditions.

Since the majority of the contamination within the SMAs is either capped or removed, the overall concentrations of contaminated sediment and soil available for resuspension is greatest with Alternative B and decreases with increasing SMA footprint of each alternative. Thus, as the size of the SMA footprint increases, there is less reliance on MNR processes to achieve RAOs and less potential for recontamination of capped/dredged areas. The time needed for MNR to achieve the RAOs for each alternative is uncertain, but is likely to occur more quickly in areas of deposition and for alternatives with a larger remedial footprint.

Operation and maintenance activities, ICs and long-term monitoring need to be implemented for all alternatives to assure protectiveness and reliability of caps and would continue in perpetuity. Monitoring and maintenance of caps are directly related to the acreage of caps. The greater the acreage, the more monitoring and maintenance of caps and the related ICs such as RNAs would be required to ensure the contaminated sediment is adequately controlled. Since Alternative B has the smallest acreage of caps, it would require the least amount of monitoring and maintenance while Alternative G would require the greatest amount. Alternatives E, F, G and I also present the option of an on-site CDF. Should a CDF be constructed and used as a repository for contaminated sediment from the Site, additional monitoring and maintenance requirements would be needed in perpetuity to ensure the material is reliably contained.

The amount of area requiring land use restrictions is also directly proportional to the acreage capped, which is least for Alternative B and is greatest with Alternative G. Land use restrictions, including RNAs, have been used at many sediment sites and can be effective as long as they are administered by entities that possess the legal authority, and are capability and willing to implement the control.

Reduction in Toxicity, Mobility or Volume through Treatment

Reduction of toxicity, mobility or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. All retained alternatives include in-situ and ex-situ treatment technologies. PTW and groundwater contamination is addressed through treatment to varying degrees in all alternatives and as a result, the preference for treatment as a principle element of the remedial action is achieved for all alternatives.

As the construction acreage increases, the reduction in toxicity, mobility or volume increases. Reduction in the mobility or volume of contaminants in groundwater entering the river would be through the use of reactive caps where the reactive layer would isolate the contaminants as the groundwater fluxes through the cap. Likewise, reactive caps would be used to reduce the mobility of PTW contained in place. Ex-situ treatment of sediment and soil removed from the site will further result in reduction of toxicity, mobility and volume of contaminants in sediment and soil.

In general, the reduction of toxicity, mobility or volume increases in direct proportion to the construction acreage, where Alternative B would provide the least reduction and Alternative G would provide the most reduction. All PTW at the Site would be addressed by Alternatives E, F, G and I. Reduction in mobility of contamination not considered to be PTW would be through removal and sequestration in a permitted landfill or CDF, or sequestration under in-situ caps; however, there would be no reduction of toxicity or volume through permanent or irreversible treatment.

Ex-situ treatment of PTW in contaminated sediments and river bank soils is determined by the action-specific ARARs, such as LDRs as well as the NCP expectation of treatment for PTW. All PTW treated ex-situ is assumed to be disposed at a RCRA Subtitle C facility. The specific methods of treatment and associated treatment target concentrations of contaminants will be determined by the facility based on requirements of action-specific ARARs, such as identification of hazardous waste and compliance with LDRs under RCRA. The Subtitle C disposal facility selected as a representative process option (Chemical Waste Management in Arlington, Oregon) uses treatment processes such as cement stabilization or low temperature thermal desorption, as needed, to meet LDRs for hazardous waste. The actual amount of removed material subject to ex-situ treatment would depend on the results of waste characterization testing during the design phase.

In addition, the mobility of contaminants would be further reduced by placing the removed material in a permitted landfill (through sequestration in a landfill cell), although it is not due to permanent and irreversible treatment.

Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

During construction, impacts to the community, workers, and the environment would occur for 4 months per year for the duration of the construction project for every retained alternative. Since Alternative B has the shortest construction duration (4 years), implementation of Alternative B would have the least impact to the community, workers, and the environment during construction. As the construction duration increases with the increasing SMA footprint of each alternative, impacts would also increase. Alternative G would have the longest construction duration (19 years) and, thus, would have the most impact to the community, workers and the environment during construction. If an on-site CDF is constructed, an additional 24 months of construction would be required prior to beginning remediation to construct the berm face and 12 months after remediation in completed to construct the CDF cap. Further, construction of an on-site transloading facility or treatment plant would have added impacts.

Short-term impacts would be controlled through use of construction BMPs and health and safety plans. Measures such as air monitoring on-site and at the site boundary, and engineering controls would be implemented to control the potential for exposure. Workers would be required to wear appropriate levels of protection to avoid exposure during excavation and treatment activities. Appropriate precautions and controls will be used to prevent incidental and accidental discharges of toxic materials from entering the water column as a result of in-water work. The application of emissions reduction strategies during implementation of this alternative can reduce short-term impacts posed to the environment and promote technologies and practices that are sustainable according to the EPA Region 10 Clean and Green Policy. Elevated fish tissue concentrations from construction activities would also be dependent on the construction duration and would be shortest for Alternative B and longest for Alternative G. Fish consumption advisories would be required under each alternative until construction is complete.

Post-construction, environmental impacts would continue until RAOs are achieved. Alternative B relies more on MNR to achieve PRGs and would have the longest impact to the community and environment until RAOs are achieved. As the footprint of the SMAs increases in each alternative, MNR is relied on less to achieve RAOs and the short-term impacts to the community and environment would decrease. Alternative G achieves environmental RAOs, so there would be no impacts to the environment post-construction. Environmental impacts would include elevated contaminant concentrations in fish until RAOs are achieved. Fish consumption advisories would be implemented to control the exposure to humans during this timeframe.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered. The construction activities required for the implementation of all retained alternatives would be technically feasible and have been implemented at many Superfund sites around the country. Materials, services and equipment necessary for construction are readily commercially available. Disposal facilities are also readily available and have adequate capacity for the volumes of material being removed.

In general, the potential for technical problems and schedule delays increases in direct proportion to the duration, and amount of active remediation. As the construction acreage of the alternative increases, the construction period, required administrative coordination, and the potential for technical problems leading to schedule delays increases. The site logistics of implementation also increases in difficulty as more construction acreage is added in each alternative.

Conversely, alternatives with the smallest acreage of construction have a greater potential for triggering additional actions if monitoring data indicates inadequate performance in achieving all cleanup objectives. The risk of monitoring failing to detect a release of COCs to the environment in areas where waste has been left in place (caps, ENR or MNR areas) in a reasonable time frame is indirectly proportional to the acreage of contaminated sediment or soil capped.

Installation of the treatment, storage and transfer facility would require cooperation from the landowner and coordination with local authorities for the construction of utilities within existing right-of-ways.

The CDF component of DMM Scenario 1 in Alternatives E, F, G, and I would be logistically and administratively challenging. Construction of a CDF increases the duration of construction for Alternatives E, F, G, and I and will require sequencing remedial projects for effective CDF use and the potential disruption of navigation and other waterway uses throughout construction, filling, and closure. There also could be increased time associated with obtaining legal agreements among multiple parties for use of the CDF; as well as increased costs for maintenance and liability protections. Conversely, disposing of at least 670,000 cy of removed material in the onsite CDF reduces the number of barges needed and distance for the barges to transport the removed material to the appropriate transload facility increasing implementability.

Cost

The cost of each alternative increases as the degree of construction increases. The estimated present value costs for the alternatives range from $451 million for Alternative B to $1.77 billion for Alternative G. Cost summaries can be found in Table 15. A discount rate of 7 percent was used in the present value calculations, consistent with EPA guidance.

State and Tribal Acceptance

DEQ, as the support agency, has been actively involved in developing the Feasibility Study and the remedial alternatives. EPA believes that the Proposed Plan and Preferred Alternative address remedy selection issues raised by DEQ during its involvement. DEQ will provide its comments on the Feasibility Study and Proposed Plan during the public comment period. Based on DEQ's involvement throughout this process, EPA expects that it will support the Preferred Alternative.

EPA has extensively engaged with the six federally recognized tribes before the Site was listed on the NPL, and throughout the development of the RF/FS. EPA will carefully consider the comments received during the public comment period and tribal consultations when selecting a final remedy in the ROD.

Community Acceptance

EPA has actively engaged with the community for a number of years. Community acceptance of the preferred alternative will be addressed in the Responsiveness Summary of the ROD following review of the public comments received on the Proposed Plan. EPA acknowledges that concerns have already been raised by some community groups regarding constructing a CDF in the lower Willamette River. EPA encourages the public to comment on this disposal option, as well as the other disposal options presented, during the public comment period.

Summary

The following provides a summary of the comparative analysis of alternatives and describes the benefits and limitations of the alternatives relative to one another.

All alternatives equally rely on the adequacy of DEQ's source control to achieve PRGs and RAOs and to prevent recontamination of the Site. Addressing river banks will also help prevent recontamination of the Site.

Alternatives E, F, G and I all meet the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs. Alternative D may meet the threshold criteria, although there is more uncertainty with this alternative. Alternatives A and B do not meet the threshold criteria, therefore will not be further discussed.

Alternatives E, F, G, and I address all PTW at the Site and achieve the statutory preference for treatment, when applicable. Alternative D does not address all PTW at the Site.

Alternatives E and I both provide approximately an order of magnitude risk reduction from the no action alternative at completion of construction. Both of these alternatives control the major sources of sediment contamination by sequestering higher contaminant concentrations under engineered caps or removing the material and containing it in a disposal facility, which are maintained in perpetuity. Post-construction risks for Alternative D are nearly twice those for the risk of Alternatives E and I. Alternatives F and G achieve the risks associated with the PRGs at completion of construction. However, Alternatives F and G have greater impacts to the environment than Alternatives E and I due to the increased construction footprints and time to construct (2-3 times longer to implement), which would increase impacts to the community and workers implementing the remedy.

Estimating the number of acceptable fish meals at the end of construction is not a precise calculation, but rather is a prediction that has some degree of uncertainty. However, such calculations are useful to allow for a comparison of the outcomes of the different alternatives. During construction of the alternatives, people would be advised to eat no more than 6 fish meals every 10 years for most populations and 1 fish meal every 10 years for women who may breastfeed, assuming an HI of 1. Alternatives E and I would require this advisory for 7 years, while Alternatives F and G would require this advisory for 13 and 19 years, respectively. After 7 years of construction for both Alternatives E and I, the fish advisory would be relaxed to allow for approximately 8 times as much fish (approximately 50 fish meals every 10 years) to be safely consumed from the Site for most populations at completion of construction and 5 times as much fish for women who may breastfeed (5 fish meals every 10 years). While Alternative D has a shorter initial advisory during construction (4 years), only 5 times as much fish (about 30 fish meals every 10 years) can be safely consumed for most populations, and 4 times as much fish for women who may breastfeed (4 fish meals every 10 years). Since concentrations of contamination post-construction left to MNR are greater for

Alternative D, it is expected that a longer period of recovery would be necessary to meet PRGs and RAOs and thus fish advisories would occur for a longer period of time. Alternative F may allow for the consumption of approximately 75 fish meals every 10 years and Alternative G, approximately 100 fish meals every 10 years. However, construction of Alternatives E and I are less disruptive than F and G. Alternative F and G would take 13 and 19 years, respectively, to achieve those estimated fish consumption rates. That is almost 2 and 3 times longer than E and I. CERCLA-based fish advisories will be further informed by fish sampling conducted during and after construction. Removing these contaminants from the system will allow PRGs to be achieved and for all CERCLA-related fish advisories to eventually be removed. Although CERCLA-related fish advisories would remain in place until PRGs are achieved, OHA may still impose an advisory based on broader watershed risks. Because these contaminants can pose risks even when the concentrations in the environment appear to quite low, it is critically important to remove these persistent pollutants from the environment so that they are no longer available to receptors and are removed from the food chain.

Engineered caps would be effective in limiting the long-term exposure to COCs in the Site sediment and soil provided they are properly designed and the integrity of the caps are maintained. Therefore, monitoring and maintenance of the caps would be required in perpetuity. Caps also require river use restrictions and, where appropriate, armoring to prevent cap erosion, which may require mitigation. Alternatives E and I both have approximately the same capped area (81 acres). Alternative D has less capped area (56 acres), but does not reliably contain all PTW remaining in the river. Compared to Alternatives E and I, Alternative F has almost twice the capped area (150 acres) and Alternative G has more than two and half times the capped area (231 acres). As the area to be capped increases, impacts to the benthic community increase and more long-term monitoring, maintenance, and river use restrictions would be required.

All the alternatives achieve reduction of toxicity, mobility, or volume through treatment by using in-situ and ex-situ treatment technologies that have been demonstrated to be effective at Superfund sites around the country. In all alternatives, 182,000 cy of removed sediment and soil is treated ex-situ at the off-site disposal facility using low temperature thermal desorption or cement solidification/stabilization. In-situ treatment is applied to areas where PTW is left in place or where residual groundwater plumes may be discharging to the river. Under Alternative I, in-situ treatment is applied to 113 acres of the Site through the addition of reactive components to caps and residual layers. This area is more than Alternatives D (108 acres) and E (109 acres). Alternative I would ensure that the preference for treatment is achieved for all PTW and increases protection from impacts from contaminated groundwater plumes discharging into the Site. While Alternatives F (145 acres) and G (184 acres) address an increased footprint of the contaminated groundwater plume area, these alternatives would also have greater impacts to the benthic community due to the larger construction footprints. There is uncertainty regarding the overall area of the Site impacted by contaminated groundwater, therefore, the need for in situ treatment to address contaminated groundwater will be refined during remedial design.

Alternatives E and I, with a construction duration of 4 months per year for 7 years, would reduce impacts from construction to the community, workers implementing the remedy, and the environment compared to 4 Alternative F (13 years) and Alternative G (19 years). Since Alternative I also involves less construction than Alternative E, Alternative I would have less short-term impact on the community, workers, and the environment. Impacts to the environment and community would continue until MNR achieves PRGs and RAOs. Alternative I achieves more interim targets than Alternative D and is therefore more reliable in achieving PRGs and RAOs in a reasonable time frame because it relies less on natural processes.

Since ICs are not applicable to ecological receptors, it is ideal to address all ecological risks at construction completion. While none of the alternatives address all ecological risks, Alternative G addresses the most ecological risks at the completion of construction although it impacts their habitat for the longest period of time during construction (19 years) and would take the longest time for benthic populations to recover due to the large area of habitat impacted (776 acres). Alternatives D, E, F and I address greater than 50 percent of the benthic risk area, which is sufficient to ensure risks would not occur to the benthic population as a whole. While Alternative I does not achieve ecological PRGs for RAO 6 at construction completion for BEHP on an SDU scale and BEHP and PCBs on a river mile scale, most of this remaining risk is in Swan Island Lagoon and will be addressed through ENR. There would still be some remaining risk at RM 4W from BEHP (HQ less than 7), RM 8W from BEHP (HQ less than 3) and 9W from PCBs (HQ less than 2) that would be addressed through MNR. Implementing Alternative I will eliminate the need to disrupt 485 acres of habitat for 12 additional years that implementation of Alternative G would require, which would delay the re-establishment of ecological communities.

The sources of contaminated groundwater plumes are expected to be controlled though cleanup actions and monitoring under DEQ oversight. It is EPA's expectation that the majority of the current identified groundwater plumes will be addressed by DEQ's actions and the alternatives will only need to address the portion of the plumes that extend into the river. Since the extent of these plumes impacting pore water is not currently known, these areas will need to be refined during remedial design and at that point it will be determined which residual groundwater plumes will need to be addressed in the river. Alternatives E and I both address 33 percent of the contaminated groundwater area as currently delineated. Alternative D addresses 23 percent of this area, Alternative F addresses 46 percent, and Alternative G addresses 62 percent.

Removing contaminated sediment and river bank soil out of the river has long term benefits for the Site, but there are also impacts to the environment and community associated with transporting the removed material to a disposal facility. Alternatives E and I have similar removed material volumes (approximately 2,024,000 cy and 1,752,000 cy, respectively) and achieve similar risk reductions and long term benefits post-construction compared to the other alternatives. While Alternatives F and G achieve higher risk reduction post-construction compared with current risks; however, removed material volumes are more than 3-4 times greater (approximately 4,585,000 cy and 7,397,000 cy, respectively) than Alternatives D, E and I. This means that implementing Alternatives F and G would impose significantly greater impacts to the environment and community and have much greater costs (1.5-2 times more than Alternatives E and I) that are not commensurate with the additional risk reduction relative to Alternatives E and I. Depending on which form of transportation is used for the removed material, these impacts include increased barge traffic on the river, which would impact commercial and recreational use of the river, increased traffic on the roads in the community if trucking is used, and increased traffic on the rail lines if rail is used. There are also increased environmental impacts, such as potential spills and sediment disturbance from wake waves and propwash, associated with transporting such large volumes of material.

Treatment and disposal of approximately 206,400 cy contaminated sediment and soil are assumed to be sent to a Subtitle C landfill for all alternatives and DMM scenarios. This material would be barged to an off-site transload facility and trucked to the landfill because it would not meet the criteria for disposal in a Subtitle D landfill or a CDF. Alternatives E, F, G and I include DMM Scenario1, which includes disposal of approximately 670,000 cy of removed material in the Terminal 4 CDF. The construction of a CDF would destroy approximately 14 acres of habitat within the Site and mitigation will be required for this lost acreage. Disposing approximately 670,000 cy of removed material in the onsite CDF reduces the number of barges needed and distance for the barges to transport the removed material to the appropriate transload facility. Reducing the transport distance for disposal also reduces the chance that accidents could occur as well as reducing the number of impacted communities. Removed material not disposed of in a Subtitle C landfill or a CDF is assumed to be disposed of in an off-site Subtitle D landfill. This material would be barged to an off-site transload facility and trucked to the landfill. If an on-site transload facility were constructed, the number of barges would be reduced, but the volume of truck and rail traffic through communities would be increased.

On a Site-wide scale, none of the alternatives achieve surface water PRGs for PCBs and 2,3,7,8-TCDD eq; however, surface water concentrations from contaminated sediment are within an order of magnitude of the PRGs for Alternatives D, E, F, G, and I. Alternatives F and G contaminant concentrations are within a factor of 5 of the PRGs. It is expected that MNR in conjunction with ICs and source control, including control of upriver sources, is necessary to achieve surface water RAOs.

Delivery of construction material to the Site is assumed to be conducted via barge, although other modes of transportation (truck and rail) may be used. Impacts from transporting construction materials to the site, such as truck or barge traffic, are directly related to the size and thickness of the caps, the construction of an on-site CDF and the volume of materials required. Alternatives E and I would require twice the materials needed than Alternative D and would require additional year of construction. Alternative F would require three times and Alternative G would require almost five times the volume of material as Alternatives E and I and construction durations are significantly longer (2-3 times as long).

MNR is expected to occur as cleaner upriver sediments deposit on surface sediment in the Site during low-flow periods and mix and disperse downstream during higher flow periods. This transitional process is expected to occur until static equilibrium is reached in the river system. In order to achieve PRGs in a reasonable time frame, the surface sediment concentrations need to be low enough that these processes will be able to reduce the exposure to contaminants in a reasonable time frame. Since much of the Site has lower concentrations of contamination, the greatest footprint is assigned this technology in all alternatives. However, as the footprint for MNR decreases, the area of disturbance of the aquatic environment due to construction increases, the longer these disturbances occur, and the more the alternative costs. Alternatives D, E and I have about the same MNR footprint (88, 85, and 87 percent of the Site, respectively) while Alternatives F and G have a 10 and 20 percent smaller MNR footprint, respectively. The Site-wide post-construction sediment PCB concentrations (contaminant that poses the greatest risk) are the same for Alternatives E and I (81 percent), which is 7 percent more than Alternative D. Further, the Site-wide post-construction sediment PCB concentrations would decrease by an additional 7 and 11 percent for Alternatives F and G, respectively, but will have 35-50 percent greater impact on the aquatic environment due to the increased constructed footprint than Alternatives E and I.

MNR is not considered to be effective within Swan Island Lagoon because water circulation is limited, and thus it does not receive sufficient cleaner sediment from upstream to allow natural recovery to occur in areas with lower contaminant concentrations. For this reason, ENR, which involves placing a sand layer on the contaminated sediment, will be used to further reduce contaminant concentrations in these areas. This sand layer will mix with underlying contaminated sediment, resulting in overall lower contaminant concentrations at the surface. For this process to be effective, a sufficient amount of capping/dredging in areas with higher contaminant concentrations is needed in Swan Island Lagoon. As the areas of construction for each alternative increase, the certainty that ENR will achieve PRGs also increases. Although decreasing the ENR footprint and increasing the area of construction provides for a more permanent and reliable remedial alternative, the added cost of dredging, capping, and long-term maintenance is not commensurate with the added protections gained from these technologies at lower sediment concentrations. Alternative D has the largest ENR footprint (74 percent of the area within Swan Island Lagoon), E and I have the same ENR footprint (51 percent) while Alternatives F and G have the smallest ENR footprints (24 and 16 percent, respectively). Post-construction risks for Alternative D (5 x 10-4 cancer risk, HI is 22, and HI for infants is 476) are greater than interim targets. The ability of ENR in Swan Island Lagoon to achieve long-term effectiveness is uncertain since the volume of clean sand needed to dilute the remaining contaminated sediment is greater than Alternatives E, I, F and G, and several applications may be necessary. This would have greater disruption to the benthic population in Swan Island Lagoon for a longer period of time. Post-construction risks for Alternatives F and G are lower than the residual risk estimates, thus ENR would not be necessary. Post-construction risk estimates for Alternatives E and I are within a factor of 5 of the residual risk. Because the remaining concentrations in Swan Island Lagoon outside the SMA are sufficiently close to the PRGs, ENR would be sufficient to achieve and maintain protective levels in the long term and would reduce the costs from implementing Alternatives F and G.

Preferred Alternative

EPA's preferred alternative is Alternative I with DMM Scenario 1, which is a combination of Alternatives B through F and addresses all PTW. This alternative includes construction within 291 acres of contaminated sediments and 19,000 lineal feet of river bank using capping, dredging, and ENR. An additional 1,900 acres contaminated sediment will be remediated through MNR. Disposal under DMM Scenario 1 would include an on-site CDF and off-site disposal facilities (using an existing off-site transload facility). Alternative I will take approximately 7 years to construct with a present value of $745,890,000.

Alternative I was developed based on an evaluation of the information presented in the draft FS. None of the alternatives presented achieved a consistent level of risk reduction at the end of construction throughout the Site. A number of factors, or goals, were considered to facilitate evaluation and development of an alternative that provides risk reduction more consistently throughout the site. These goals are as follows:

- Address majority of PTW.
- Meet statutory preference for treatment of PTW, when applicable.
- Meet ecological PRGs for RAOs 5 and 6 through construction because ICs are not applicable to ecological receptors.
- Minimize length of time ICs are needed for human health related to meeting PRGs for RAOs 1 and 2.
- Meet RAOs 3 and 7 for surface water and RAOs 4 and 8 for pore water at construction completion.
- Minimize recontamination potential from river banks.
- Limit need for waterway use restrictions due to caps.

- Maximize permanence through removal of highly contaminated sediment.
- Reduce residual risks at construction completion for RAO 1 to less than 1 x 10^{-5} (State ARAR) and HI less than 10.
- Reduce residual risks at construction completion for RAO 2 to less than 10^{-4} and HI less than 10 (child).
- Reduce residual risks at construction completion for RAO 5 to HI less than 10.
- Reduce residual risks at construction completion for RAO 6 to HI less than 10.

Initially, Alternative E achieved the best proportion of the first three balancing criteria when compared to overall costs. However, a more detailed evaluation of the effectiveness of all alternatives on a SDU-scale indicated that some areas of the Site could use a less aggressive alternative than Alternative E while other areas needed a more aggressive alternative to meet the specific factors above. Each SDU was assigned the alternative that most closely achieved the interim goals with the least amount of construction, without exceeding the goal. Alternative I primarily uses the RALs for Alternative E presented in Table 9, but uses the RALs of other alternatives to define where the combination of remedial technologies will be applied at the Site. The following shows how Alternative I differs from Alternative E and applies the RALS from Alternatives B, D, E and F to specific areas of the river (SDUs) with some modifications to achieve more consistent risk reduction throughout the site. Specifically:

- Alternative B RALs + addressing all PTW will be used in SDUs 6.5E and 6NAV.
- Alternative D RALs will be used in SDU 6W, which include all PTW for this SDU.
- Alternative E RALs, which include all PTW will be used in SDUs 2E, 3.5E, 4.5E, 11E, 9W, and Swan Island Lagoon.
- Alternative F RALs, which include all PTW will be used in SDUs 5.5E and 7W.
- In areas outside of the SDUs (called NoSDU), all PTW will be addressed and MNR is assigned to the rest of the area.

Alternative I includes excavation, capping and re-vegetation, as appropriate, of approximately 19,000 lineal ft of contaminated river banks (Figure 19).

Alternative I includes the following components:

- Dredging approximately 167 acres of contaminated sediment within the SMAs to various depths. A residual management layer will be placed once dredging is complete within an area. A reactive residual layer is placed if pore water exceeds PRGs and a significantly augmented reactive cap is placed in areas where there is PTW that is NAPL or is not reliably contained. In the Shallow Region, either a cap or backfill with a beach mix cover will be placed to return the final surface to the existing grade or elevation. The dredge acres by river region of the Site are approximately:
    - Navigation Channel: 39 acres

- FMD: 74 acres
- Intermediate: 13 acres
- Shallow: 41 acres

- Capping approximately 64 acres of contaminated sediment using engineered and armored caps. AquaBlok™ is used under structures to reduce cap thickness. Reactive layers are added to caps in areas where pore water exceeds PRGs to address groundwater plumes and a significantly augmented reactive cap is placed in areas where there is PTW that is NAPL or is not reliably contained. The cap acres by river region of the Site are approximately:
  - Navigation Channel: 0 acres
  - FMD: 0 acres
  - Intermediate: 62 acres
  - Shallow: 2 acres
- Excavating approximately 19,000 lineal ft of river bank and covering with an engineered cap using beach mix or vegetation. Reactive layers are added to caps in areas where pore water exceeds PRGs and a significantly augmented reactive cap is placed in areas where there is PTW that is NAPL or is not reliably contained.
- ENR of approximately 60 acres in Swan Island Lagoon in areas outside SMAs.
- MNR of approximately 1,900 acres of the main channel in areas outside SMAs.
- Long-term maintenance and monitoring of engineered caps, areas of natural recovery, and environmental indicators to evaluate performance of the remedy.
- Institutional Controls to protect the remedy and inform the public about long-term contamination issues.
- Compensatory mitigation would be required for an estimated 34 acres and would cost $36,400,000.

Dredged and excavated material would be disposed of in the following way:

- Approximately 744,000 to 1,215,000 cy would be barged to an off-site transload facility, transferred to trucks, and disposed of in an off-site Subtitle D landfill in compliance with the off-site rule. If an on-site transload facility were constructed, the removed material would be barged to the on-site transload facility and trucked to the off-site disposal facility. Rail may also be used for transporting contaminated material to off-site disposal facilities, however, not all disposal facilities currently have connecting rail lines.
- Water generated by the dewatering of dredged materials would be processed through a water treatment plant to meet applicable water quality standards and discharged to the lower Willamette River.

- At least 670,000 cy would be barged to the on-site CDF and hydraulically slurried into the CDF. Current design estimates of the Terminal 4 CDF capacity can accommodate approximately one third of the volume of dredged material for Alternative I. Additional design work may result in increased capacity of an on-site CDF.

The estimated volumes of construction material needed for containment, dredge residuals management, and in-situ treatment are:

- Sand – 676,000 cy
- Very fine, low-permeability sand – 8,400 cy
- Beach mix – 50,000 cy
- Armor – 80,000 cy
- Organoclay mats – 490 cy
- AquaBlok™ – 5,700 tons
- AquaGate+10%PAC – 81,000 tons

During construction, water, air, sediment and fish monitoring would be conducted to evaluate whether the project is being managed effectively to mitigate releases of contaminants to the environment. In instances where water or air quality standards are exceeded, the construction activity that caused the exceedance would be evaluated and additional mitigation measures would be implemented. After construction, frequent monitoring of fish, surface water, and sediment would be conducted to determine when interim remediation milestones and remediation goals are reached. During and after construction, fish consumption advisories with enhanced community outreach to improve awareness and compliance would be implemented until PRGs and RAOs are achieved and monitoring information would be used to further inform ICs. Monitoring and maintenance of caps and the CDF would be required both on a regular basis and after significant environmental events (such as storms and earthquakes). Institutional controls prohibiting disturbance of the caps would be necessary to maintain cap integrity.

Since the preferred alternative will leave contamination in place above levels that allow for unlimited use and unrestricted exposure, five year reviews would be conducted as required by CERCLA.

Since the Site is large and the preferred alternative includes management of a significant volume of sediment and construction materials, the implementation will need to be conducted in a phased or sequenced approach. In implementing the preferred alternative, EPA expects to consider the following factors: prioritization of sediment contamination source areas, sequencing of design and construction activities and the potential effects of upstream work on downstream areas, logistics efficiencies, or other factors. Implementation of the preferred alternative will likely require the collection of additional sediment data and the possibility of prioritizing discrete actions for risk reduction or recontamination considerations. EPA will evaluate remedy implementation and modify activities, as appropriate, to attain remediation goals and remedial action objectives.

Rationale for Selecting the Preferred Alternative

The selection of the preferred alternative is accomplished through the evaluation of the nine NCP criteria. Alternative I with DMM Scenario 1 using an existing off-site transload facility is the preferred alternative. This Alternative meets the NCP's threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs. Alternative I uses dredging, capping and ENR for the areas of the river with the highest contaminant concentrations (291 acres). It relies on MNR (1,900 acres) to achieve PRGs in a reasonable time frame for the majority of the river where concentrations of contaminants are lower. Using this balanced combination of active and passive technologies, this alternative addresses the most significantly contaminated sediment to achieve a substantial and consistent risk reduction in all areas of the river at the time of construction completion. Reducing the exposure to sediment contamination within the Site by capping or removal will reduce the contaminant loading within the lower Willamette and to the Columbia River, thereby reducing risk to human and ecological receptors. The expected improvements in the overall river habitat from implementing the preferred alternative are also anticipated to have positive impacts on the species that have a role in tribal lifestyles. This is accomplished without the challenges of handling a significant volume of removed material over many years of construction or conducting maintenance and monitoring of many capped acres while facilitating MNR. Alternative I will also be consistent with the reasonably-anticipated future waterway uses in the river, including the federally-authorized navigation channel.

Alternative I reduces contamination in the river by removing approximately 1,753,000 cy of contaminated sediments/soils, capping/dredging of 231 acres, and ENR of 60 acres. It further reduces mobility of contamination in the river by covering all dredge residuals, and by capping and treating areas with carbon where required. Overall toxicity, mobility and volume are reduced by treatment and off-site disposal of approximately 192,000 cy of removed materials, some of which is characterized as hazardous under RCRA. Further mobility of the contaminants is effectively eliminated by disposing of the remaining volume of lower level contaminated material into a CDF and off-site landfill.

Alternatives E and I have the same level of risk reduction at construction completion (Table 17), while the other alternatives achieve different levels of risk reduction. Alternatives B and D may not be meet the first threshold criteria. Alternatives F and G achieve greater risk reduction at construction completion than Alternatives E and I, however, they involve a significantly greater amount of construction area, time, impact to the environment and the community and cost more. Alternatives E and I are similar in cost effectiveness.

Area	RALs for Alternative I	Alternative E	Alternative I
SDU 6Nav	Alternative B+PTW	1×10^{-4} HI=3	1×10^{-4} HI=5
SDU 6.5E	Alternative B+PTW	1×10^{-4} HI=4	1×10^{-4} HI=5
SDU 6W	Alternative D	7×10^{-5} HI=3	9×10^{-5} HI=3
SDU 5.5E	Alternative F	3×10^{-4} HI=12	2×10^{-4} HI=6
SDU 7W	Alternative F	3×10^{-4} HI=10	2×10^{-4} HI=5
Site-wide Scale		2×10^{-4}	2×10^{-4}
		HI=21	HI=21

Table 17. Risk at Construction Completion

The technologies of dredging, capping, ENR and MNR have been demonstrated to be technically and administratively feasible at various other Superfund sites. The distribution of technologies makes Alternative I technically and administratively feasible, because the volumes needed for capping and backfilling are manageable and disposal volumes are reasonable. The landfills included in DMM Scenario 1 are existing facilities that have the ability to handle the Site materials. The CDF in DMM Scenario 1 has been demonstrated to be technically and administratively feasible at other Superfund sites. An on-site CDF reduces the number of barges needed and distance for the barges to transport the removed material to the appropriate transload facility. Reducing the transport distance for disposal also reduces the chance that accidents could occur as well as reducing the number of impacted communities.

However, at a present value of approximately $746 million, Alternative I with DMM Scenario 1 is a more cost effective alternative because it involves approximately 40 fewer acres of dredging in the navigation channel (SDU 6Nav) and is approximately $58M less than Alternative E while achieving the same risk reduction. Cost effectiveness is based on the following three criteria: long-term effectiveness and permanence, reduction of toxicity mobility and volume through treatment and short effectiveness.

- Alternatives E and I achieve the same degree of long-term effectiveness, as the area capped (81 acres) is approximately the same. Therefore, maintenance and monitoring associated with the long-term management of these caps is the same. However, Alternative E achieves greater permanence because approximately 37 more acres are dredged compared to Alternative I, which equates to removing an additional 271,000 cy of contaminated material. Nevertheless, both alternatives are expected to achieve comparable levels of risk reduction, particularly in SDU 6.5E and 6Nav, where the majority of this extra dredging would occur under Alternative E. Despite the lower volume of dredging, Alternative I achieves greater risk reduction in SDU 5.5E and 7W. Overall, the site-wide risk reduction is the same for both alternatives. The table below highlights the SDUs where post construction risk differ between Alternatives E and I. Alternative achieves greater risk reduction in a greater number of SDUs than does Alternative E, while costing approximately an additional $58M.

- Short-term effectiveness for Alternatives E and I is equal, given that the implementation time frame for both is approximately 7 years.

- Alternatives E and I achieve similar reductions in toxicity, mobility and volume through treatment. Ex-situ treatment will be used for the same volume of material (192,000 cy) with each alternative; and an estimated 109 acres for Alternative E and 113 acres for Alternative I are treated with reactive caps or reactive residual layers.

After issuance of the ROD, fish advisories would be required under CERCLA, and outreach would be conducted to educate the public about the advisories to ensure protection of human health. EPA would likely revise the fish consumption advisories to allow an increase in the number of recommended fish meals per year as contaminant concentrations decline in fish tissue. Fish consumption advisories would not be required under CERCLA once PRGs for RAO 2 are achieved.

Alternative I does not meet all of the risk reduction goals at construction completion, but it does achieve a consistent amount of risk reduction throughout the Site when compared to the other alternatives. Further adjustments could be made to Alternative I to meet these goals, which would be finalized in the ROD.

Based on the information currently available and discussed above, the preferred alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The EPA expects the Preferred Alternative to satisfy the following statutory requirements of CERCLA Section 121(b): (1) be protective of human health and the environment:

(2) comply with ARARs (or justify waiver); (3) be cost-effective; (4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element, or explain why the preference for treatment will not be met. After receiving and reviewing comments during the public comment period, EPA will develop a Responsiveness Summary and finalize the remedy in the ROD. EPA's Administrator will approve and sign the ROD.

Community Participation

To ensure that the public was prepared to provide meaningful comments during the Proposed Plan public comment period, EPA extensively engaged with the community and held regularly scheduled meetings with key stakeholder groups. EPA reached out to the general community, as well, to a wide range of interest groups, including:

- Groups representing vulnerable populations
- Students ranging from elementary school to college classes and other youth organizations
- Local and national non-profit groups
- Neighborhood associations
- City, County and State elected officials
- Tribal government officials
- Business associations
- Media

EPA utilized some novel outreach techniques to engage communities, such as workshops, ethnic festivals, children's water festivals, presentations to Native American Youth and Adults (NAYA), Portland City and Earth Care summits, boat tours for stakeholders, Superfund 101 training, and radio broadcasts. In addition, EPA developed and distributed multilingual materials and provided translation services during information sessions.

FOR FURTHER INFORMATION

The Administrative Record file, which contains copies of the Proposed Plan and supporting documentation, is available at the following locations:

- Multnomah County Central Library, 801 SW 10th Avenue, Portland, OR 97205
- St. Johns Library, 7510 N Charleston Ave, Portland, OR 97203
- Kenton Library, 8226 N Denver Ave, Portland, OR 97217
- EPA Region 10, Superfund Records Center, 1200 Sixth Avenue, Suite 900, Seattle, WA 98101
- EPA Oregon Operations Office, 805 SW Broadway, Suite 500, Portland, OR 97205

In addition, documents from the administrative record and other information about Portland Harbor are available online at: http://go.usa.gov/3Wf2B

The Pre-Proposed Plan outreach goals were to:

- Remind people of EPA's role and basic principles of the Superfund program
- Educate a range of audiences about EPA's work to date to understand the health and environmental risks posed from contamination at the site, what options are being considered to reduce the risks and how people can weigh in when the Proposed Plan is released.
- Gain preliminary understanding of the public's concerns and questions

- Coordinate with stakeholders, where appropriate, to support successful public engagement

During the public comment period, EPA will:

- Provide additional information regarding the cleanup of the Portland Harbor Site through public meetings, availability sessions, the Administrative Record, and announcements published in the newspapers and on the EPA webpage

- Help the public to understand the Preferred Alternative and EPA's evaluation criteria so that the public can effectively provide input on the Proposed Plan

- Make the public aware of the full range of opportunities to learn about the Proposed Plan and how to provide input

- Provide interpretation services at the public meetings and materials translated in Spanish, Russian, Vietnamese, and Chinese

After release of the ROD, EPA will:

- Ensure the public is aware of EPA's final decision regarding the selected remedy and how the public's input was considered

- Begin to educate people about the next steps toward implementing the cleanup

EPA encourages the public to continue to engage on this Site throughout the Superfund cleanup process. It is important that the public understands the work that is being done and has an opportunity to provide meaningful input on cleanup decisions. EPA believes the best remedies are developed and implemented with the support of a well-informed community and Superfund law requires that the public has an opportunity to read and comment on EPA's proposed plan for cleanup.

EPA has been working closely with the public since the Portland Harbor Superfund Site was added to the National Priorities List in December 2000 and has worked with impacted communities, tribes, local government to provide information that is as easy to read and clear as possible. With the issuance of our proposed plan for cleanup, EPA has also prepared a stand-alone list of acronyms, glossary of terms, and contaminant summary to make it as easy as possible for the public to navigate the proposed plan and other technical documents. This document will be available to the public online and at information repositories and public meetings.

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References Cited

ATSDR 2002. *Public Health Assessment, Initial Release: Portland Harbor, Portland, Multnomah County, Oregon*. January 15, 2002.

Butler, Virginia L. 2004. *Where Have All the Native Fish Gone? The Fate of Fish That Lewis and Clark Encountered on the Lower Columbia River.* Oregon Historical Quarterly 105(3):438-463.

DEQ 2000. *Portland Harbor RI/FS Work Plan, DRAFT*. Oregon Department of Environmental Quality. 31 March 2000.

Kennedy/Jenks 2013. *Portland Harbor RI/FS, Final Remedial Investigation Report, Appendix F, Baseline Human Health Risk Assessment*. Portland, OR. March 2013.

EPA 2002. *Estimated Per Capita Fish Consumption in the United States*. EPA 821-C-02-003. August 2002

EPA 2016. *Portland Harbor Remedial Investigation Report, Final*. Prepared for the Lower Willamette Group, Portland, OR. Integral Consulting Inc., Mercer Island, WA; Windward LLC, Seattle, WA; Anchor QEA, LLC; Seattle, WA, Kennedy/Jenks Consultants, Portland, OR. As modified by U.S. EPA. April, 2016

Saleeby, Becky Margaret 1983. *Prehistoric Settlement Patterns in the Portland Basin of the Lower Columbia River: Ethnohistoric, Archaeological, and Biogeographic Perspectives*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

Windward 2013. *Portland Harbor RI/FS, Remedial Investigation Report Appendix G, Baseline Ecological Risk Assessment, Final.* Prepared for the Lower Willamette Group. Seattle, WA. D 2011

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Figures

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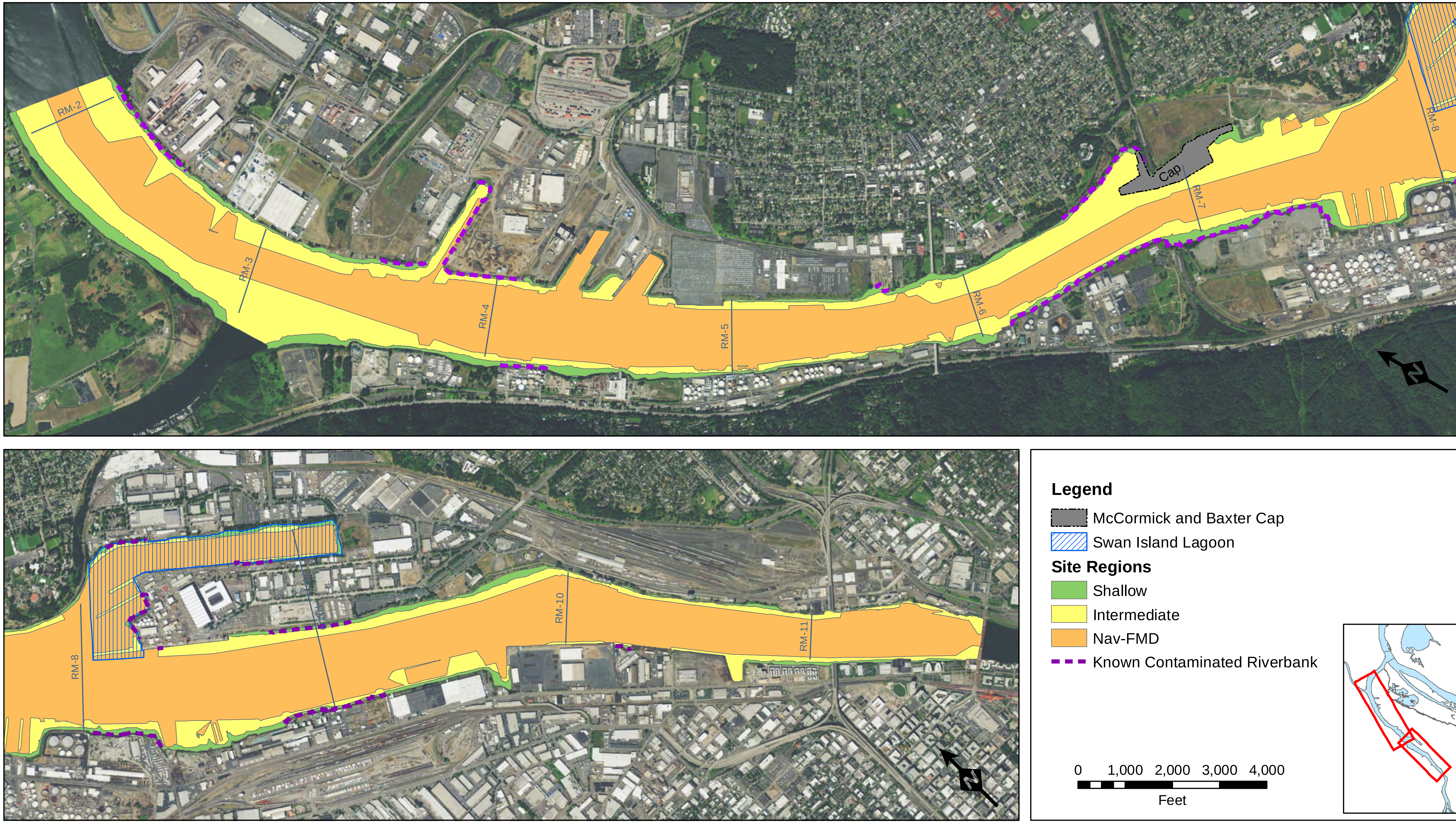

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Figure 4. Portland Harbor Site Regions

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Date: 4/8/2016

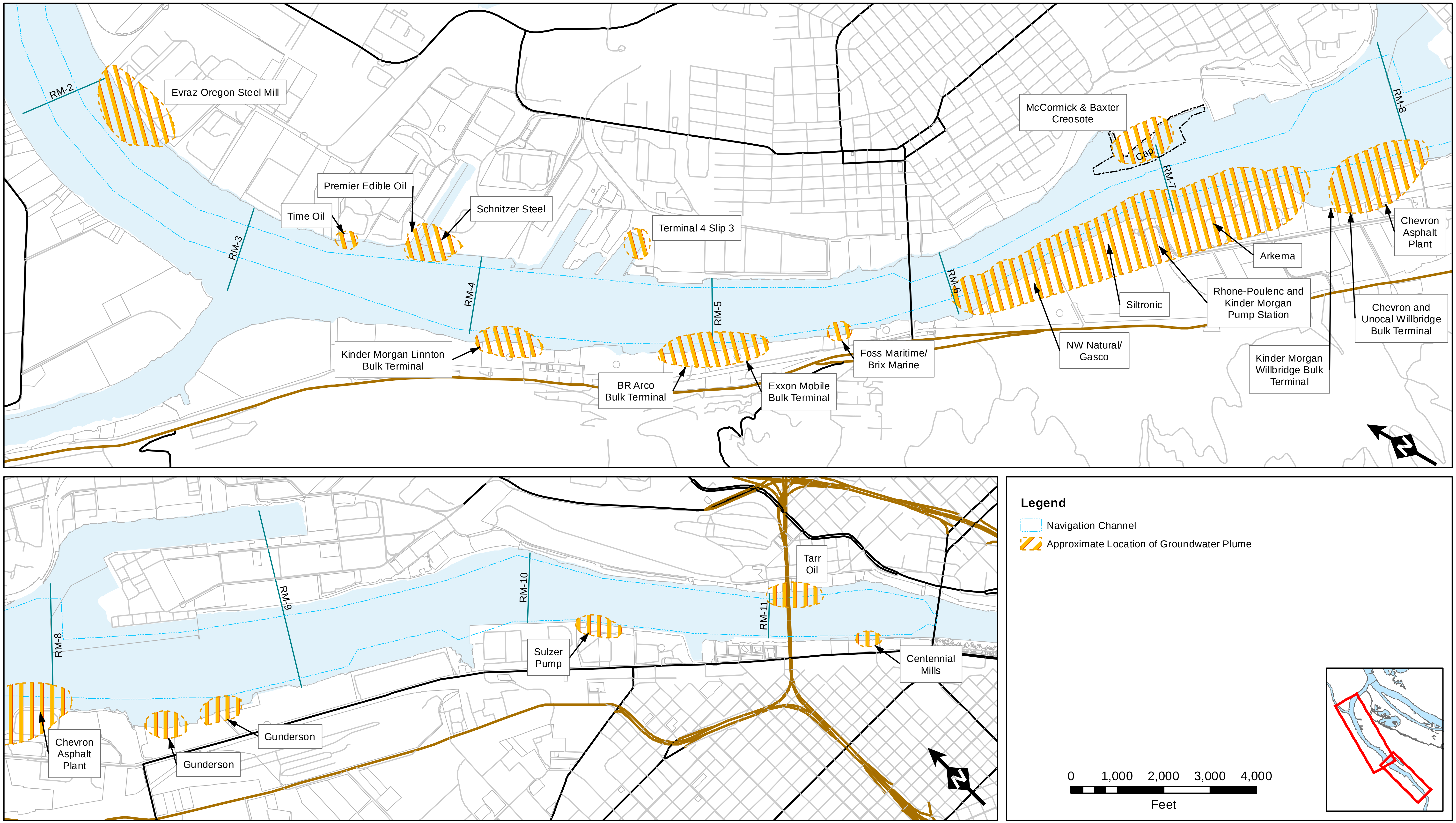

Figure 5. Portland Harbor Study Area Groundwater Plume Map

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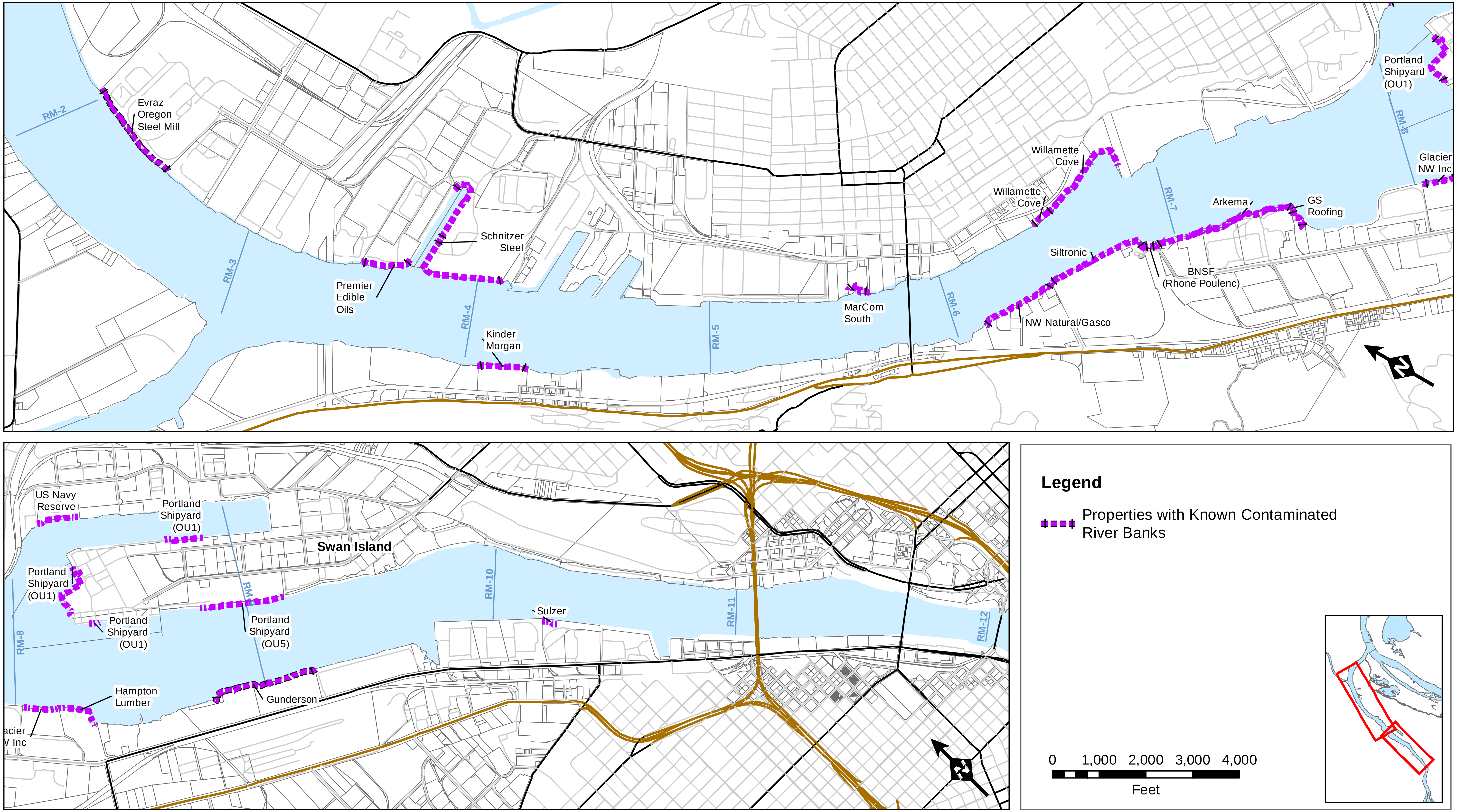

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Figure 6. River Bank Areas

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Date: 6/2/2016

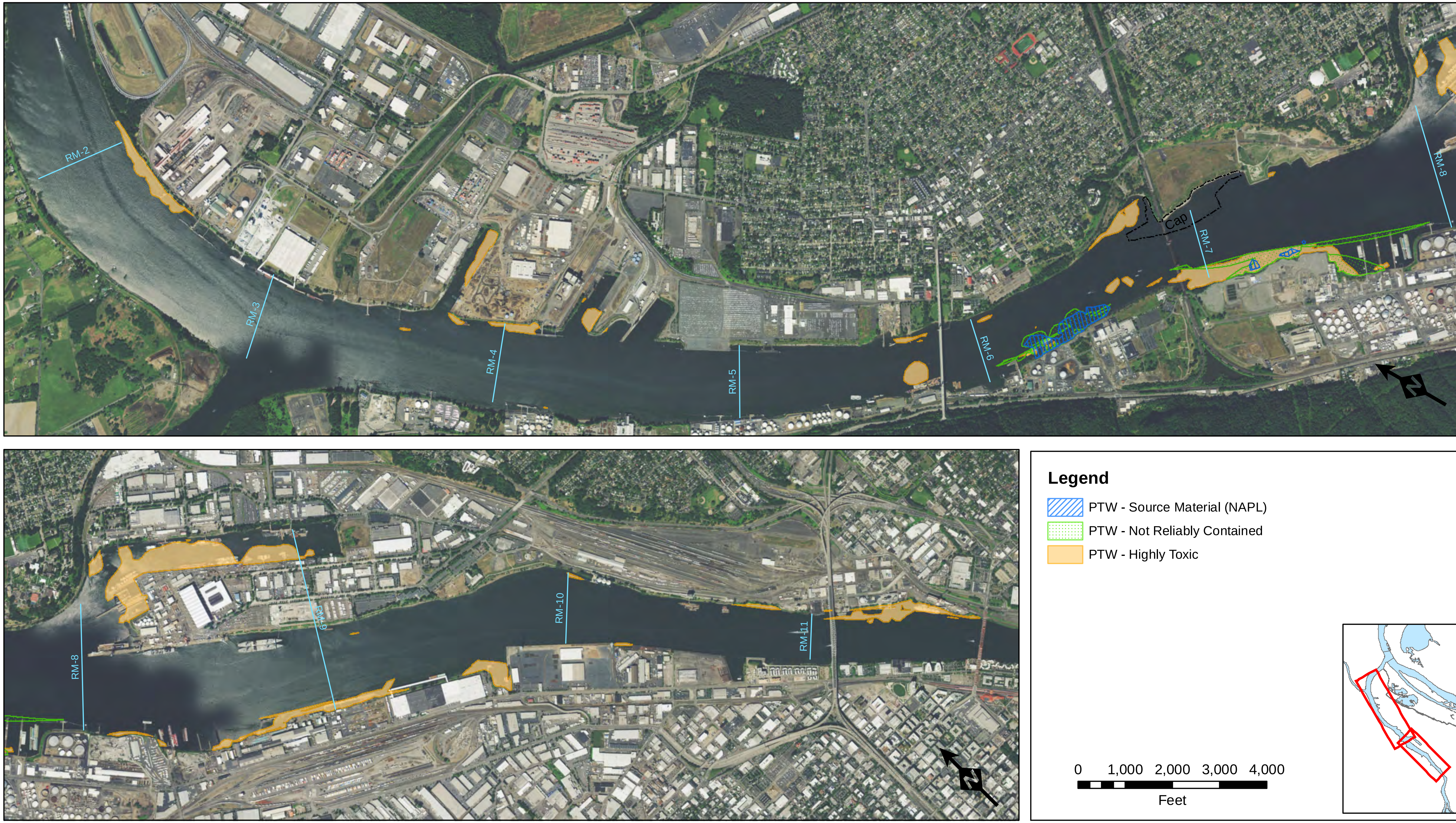

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Figure 7. Principal Threat Waste

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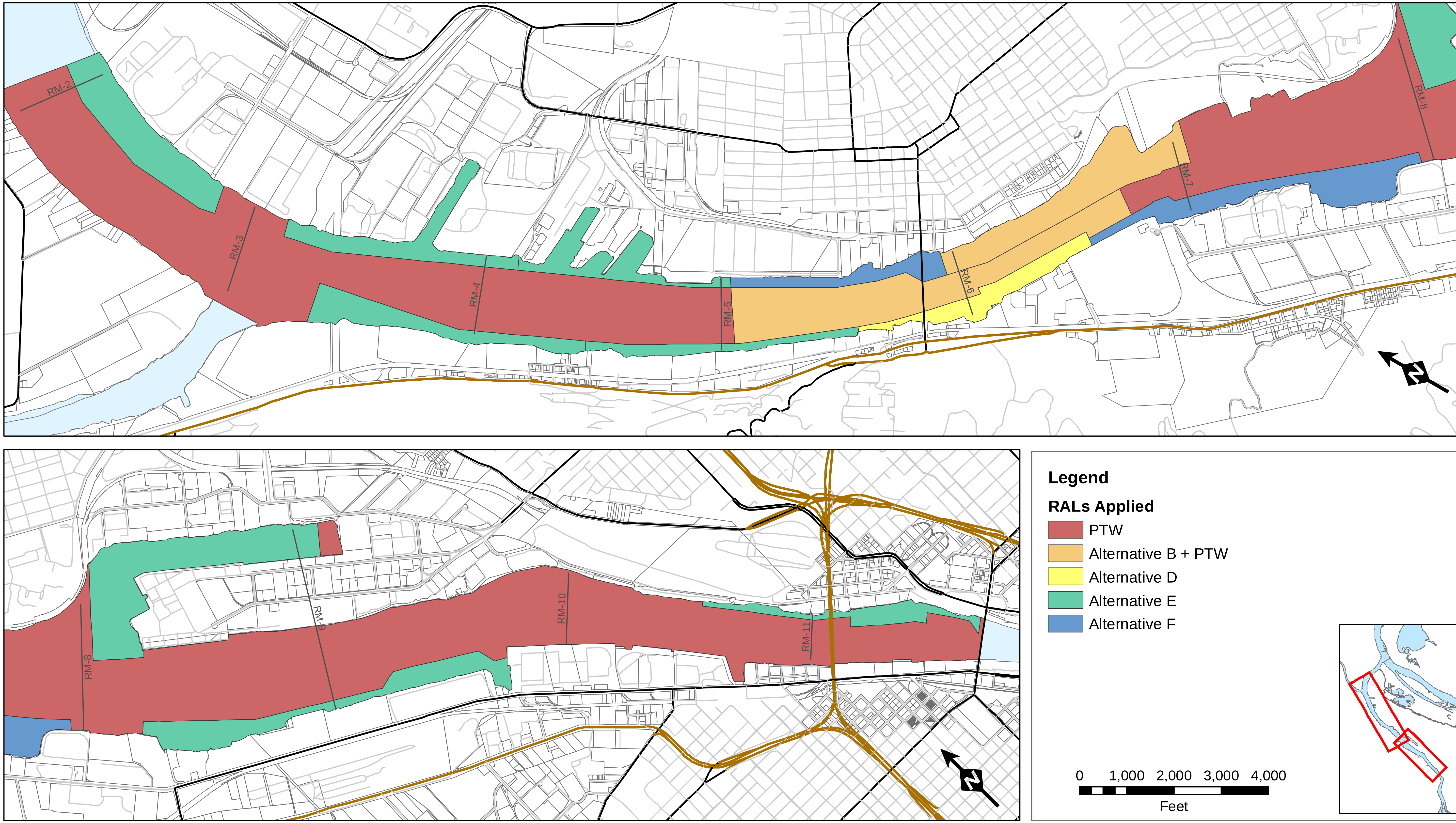

Figure 9. RALs Applied to Various Areas of the Site for Alternative I SMAs

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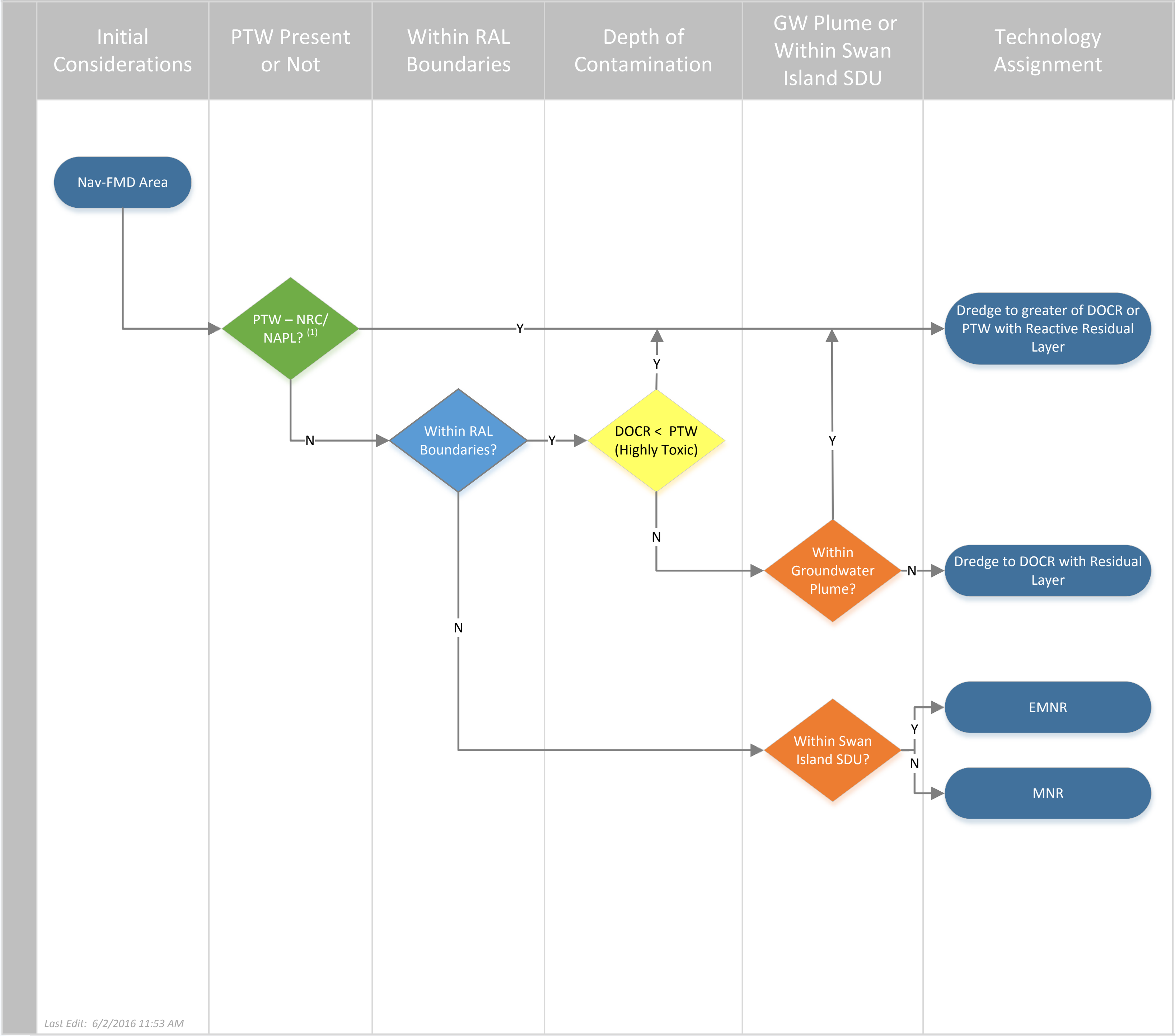
Date: 4/8/2016

Figure 10a: Technology Assignments for Navigation Channel and Future Maintenance Dredge Areas

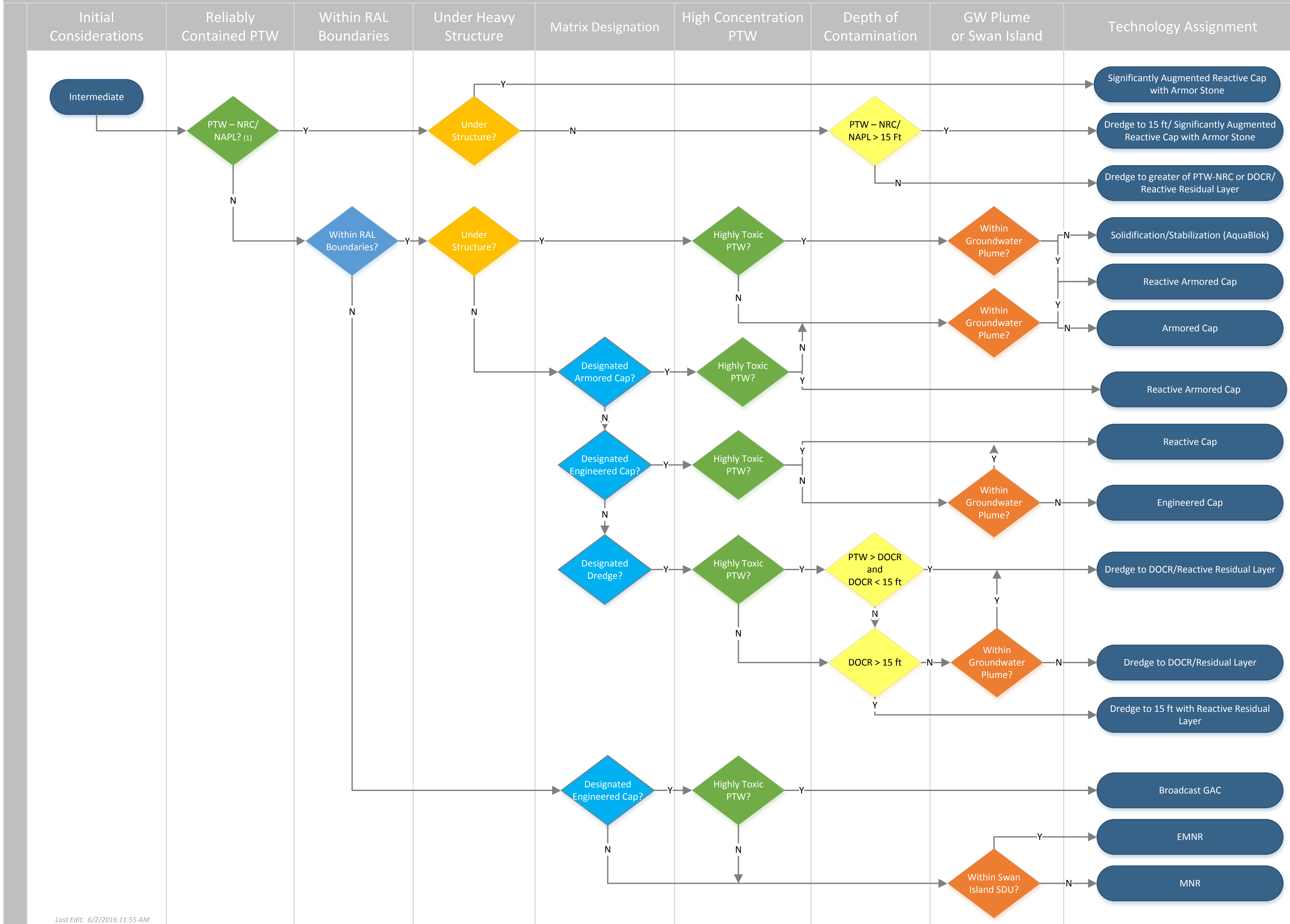


Notes:
All Concentrations greater than RAL alternative are less than 18 feet deep in the FMD and 15 feet in the Navigation Channel. The diagram is based on the assumption that no PTW or sediment concentrations are found below these depths.

(1) See Section 3.3.3.5 for explanation of not reliably contained PTW.

DOCR – Depth of contamination to be removed based on Remedial Action Levels (RALs)
EMNR – Enhanced monitored natural recovery
FMD – Future maintenance dredge
MNR – Monitored natural recovery
Nav – Navigation channel
PTW – Principal threat waste

Figure 10b: Technology Assignments for Intermediate Areas

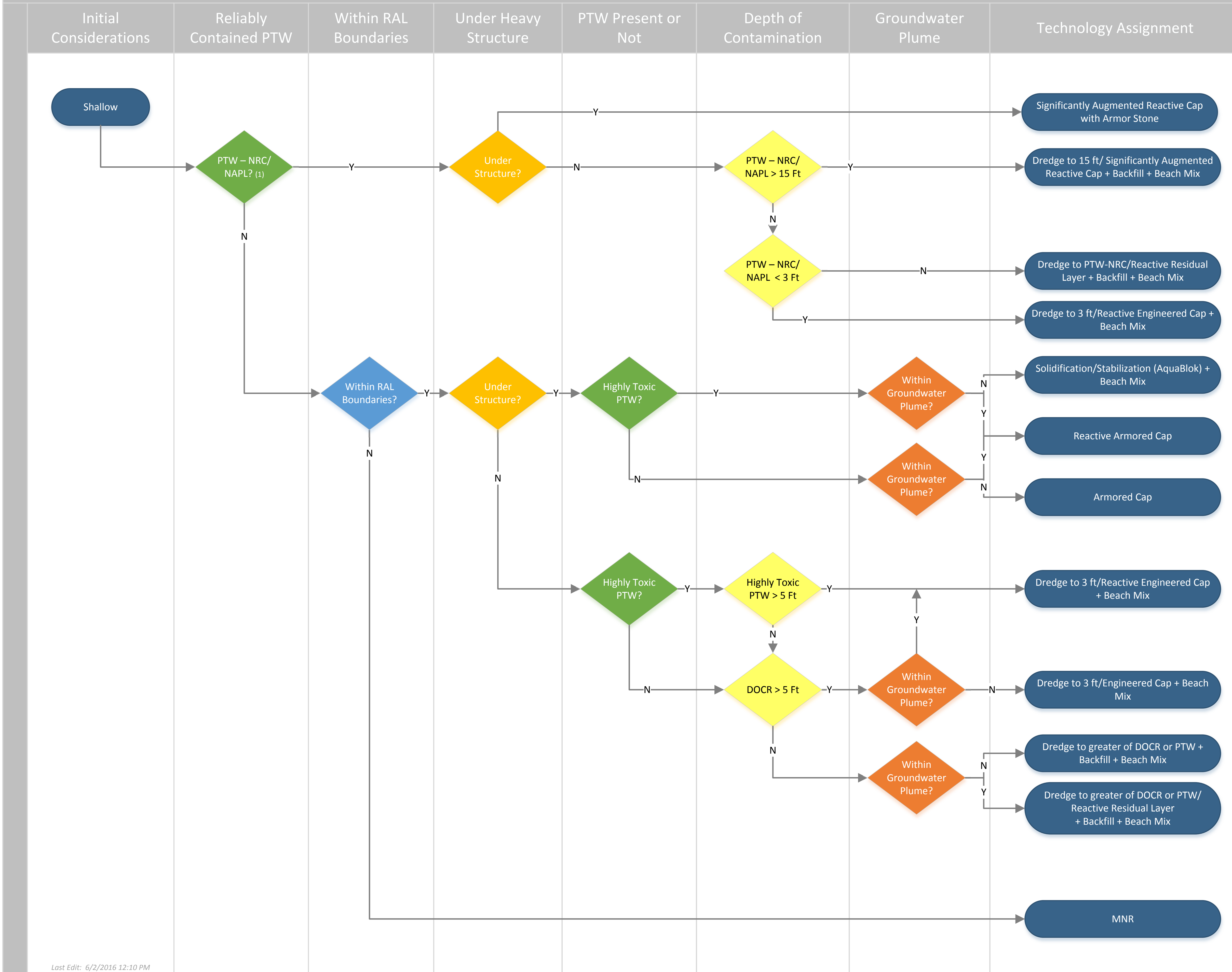


Notes

Notes:
(1) See Section 3.3.3.5 for explanation of not reliably contained PTW.

DOCR – Depth of contamination to be removed based on Remedial Action Levels (RALs)
EMNR – Enhanced monitored natural recovery
MNR – Monitored natural recovery
NRC – Not reliably contained. See Note 1.
NAPL – Non-aqueous phase liquids
PTW – Principal threat waste

Figure 10c: Technology Assignments for Shallow Areas

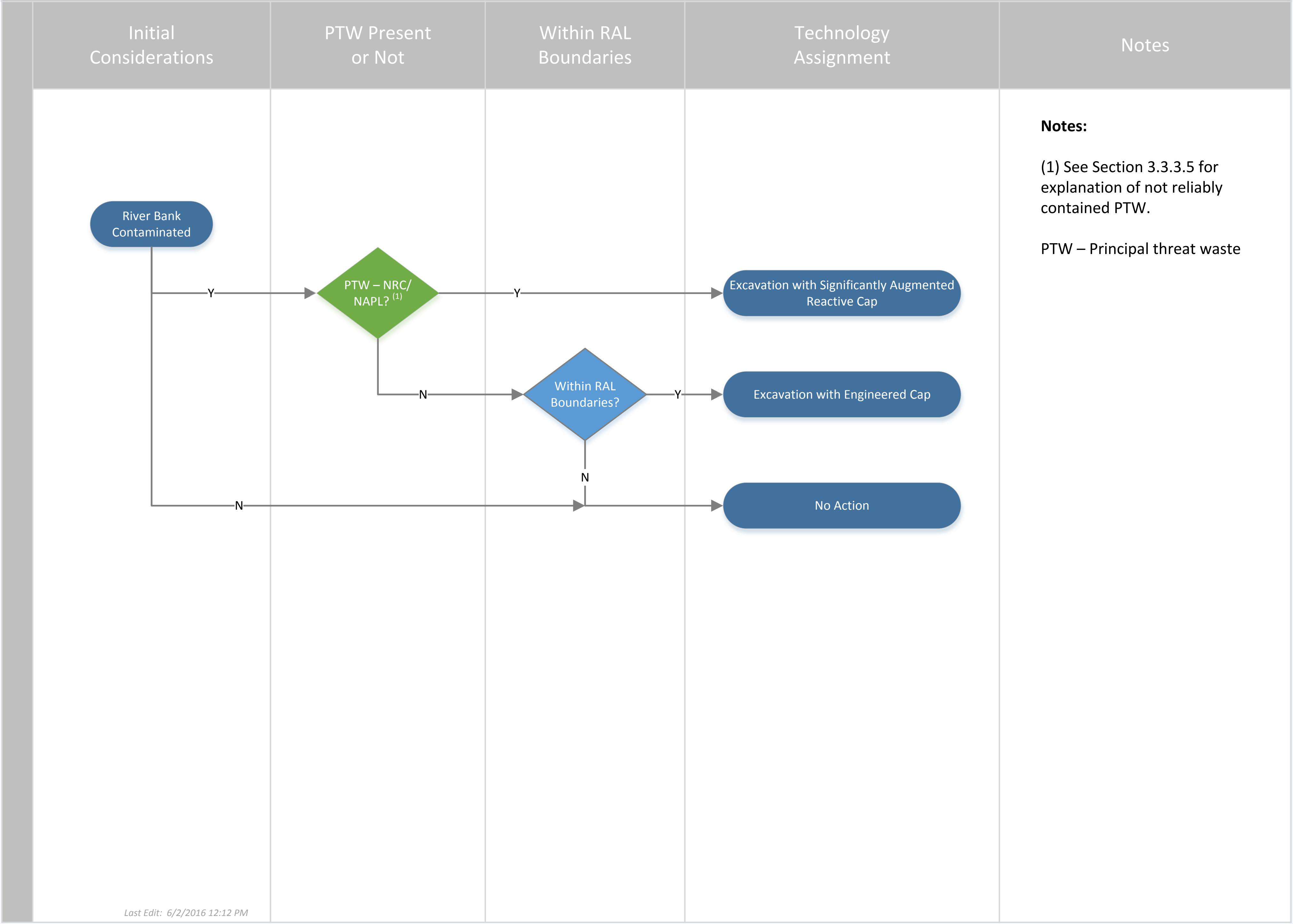


Notes:

(1) See Section 3.3.3.5 for explanation of not reliably contained PTW.

DOCR – Depth of contamination to be removed based on Remedial Action Levels (RALs)
MNR – Monitored natural recovery
NRC – Not reliably contained. See Note 1.
NAPL – Non-aqueous phase liquids
PTW – Principal threat waste

Figure 10d: Technology Assignments for Contaminated River Banks



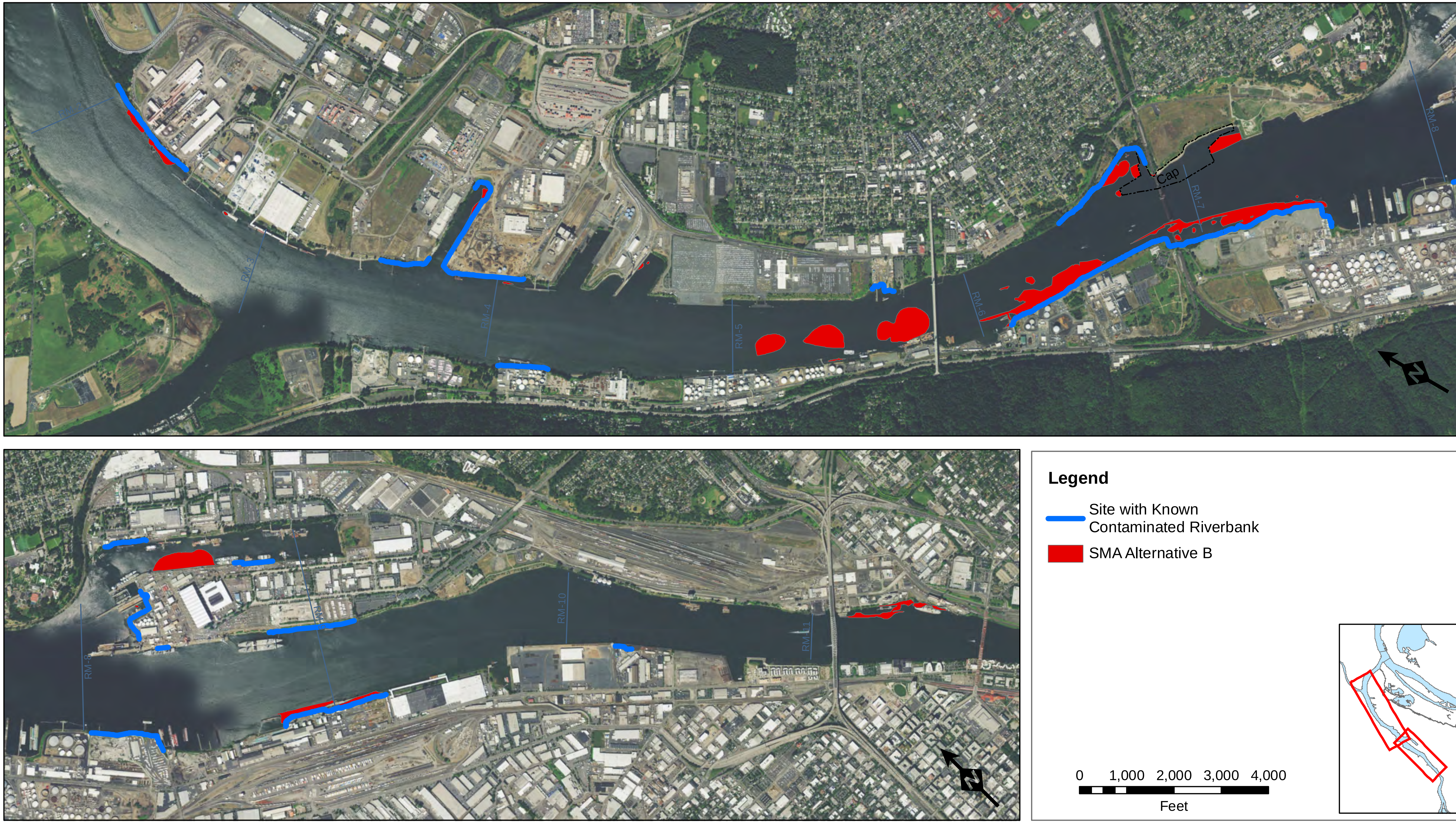


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Figure 11a. Sediment Management Areas, Alternatives B

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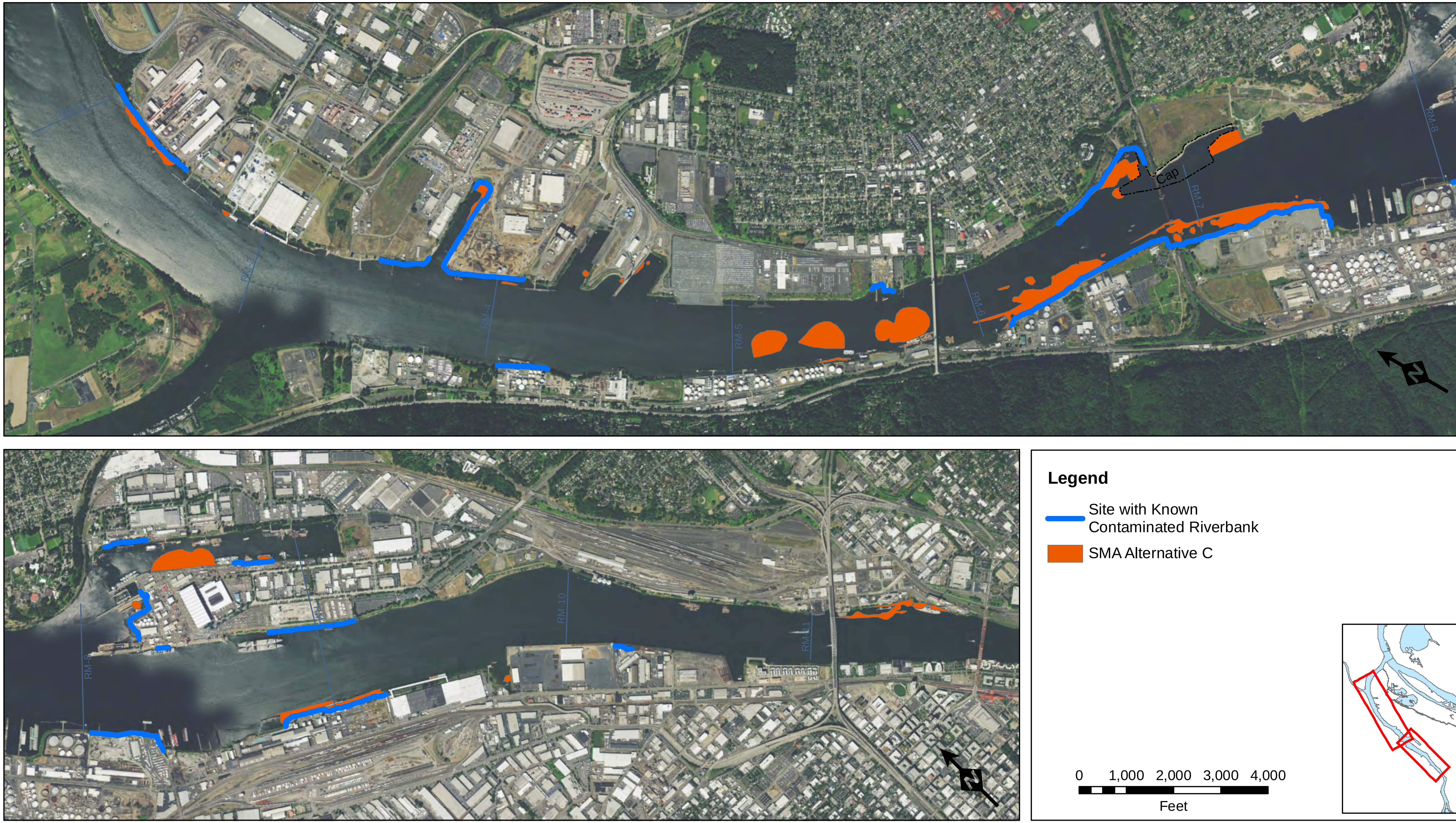
Date: 4/1/2016



Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 11b. Sediment Management Areas, Alternatives C

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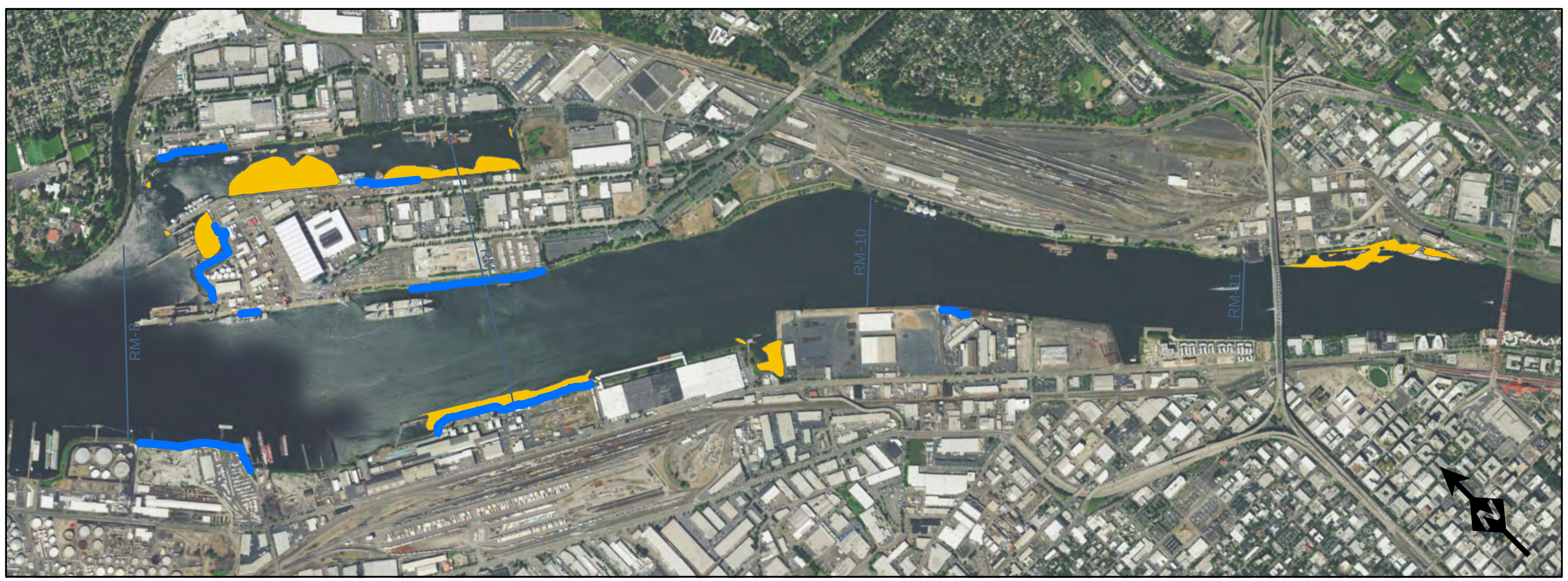
Date: 4/1/2016



Legend

Site with Known Contaminated Riverbank

SMA Alternative D

0 1,000 2,000 3,000 4,000

Feet

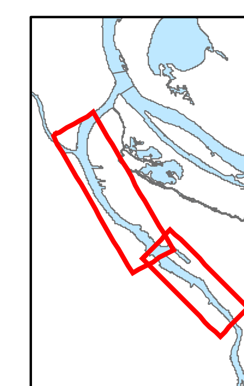


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Figure 11c. Sediment Management Areas, Alternatives D

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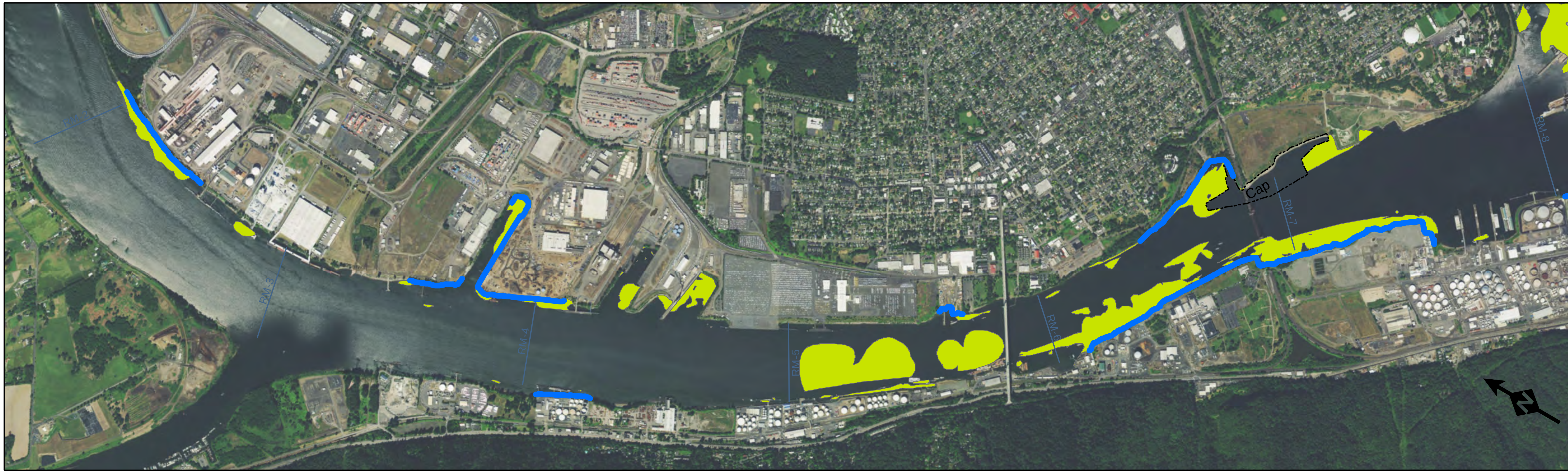
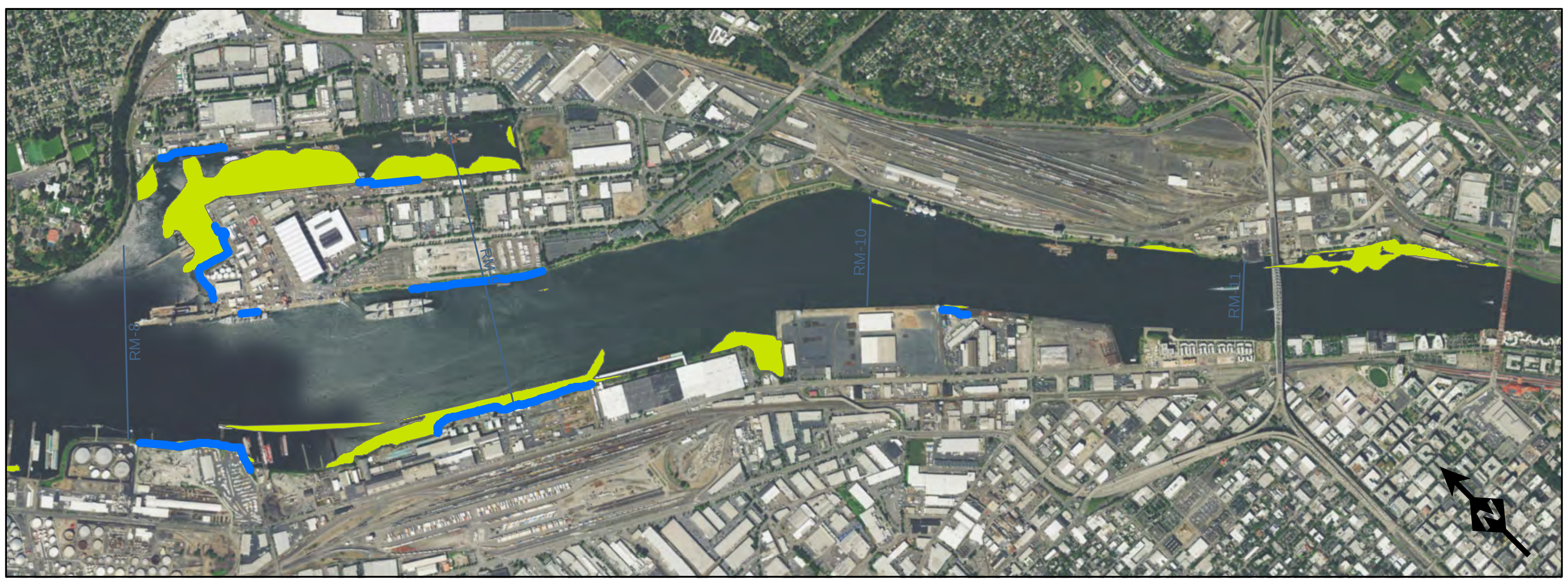
Date: 4/1/2016





Legend

- Site with Known Contaminated Riverbank
- SMA Alternative E

0 1,000 2,000 3,000 4,000
Feet

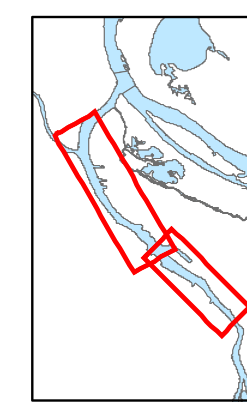


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Figure 11d. Sediment Management Areas, Alternatives E

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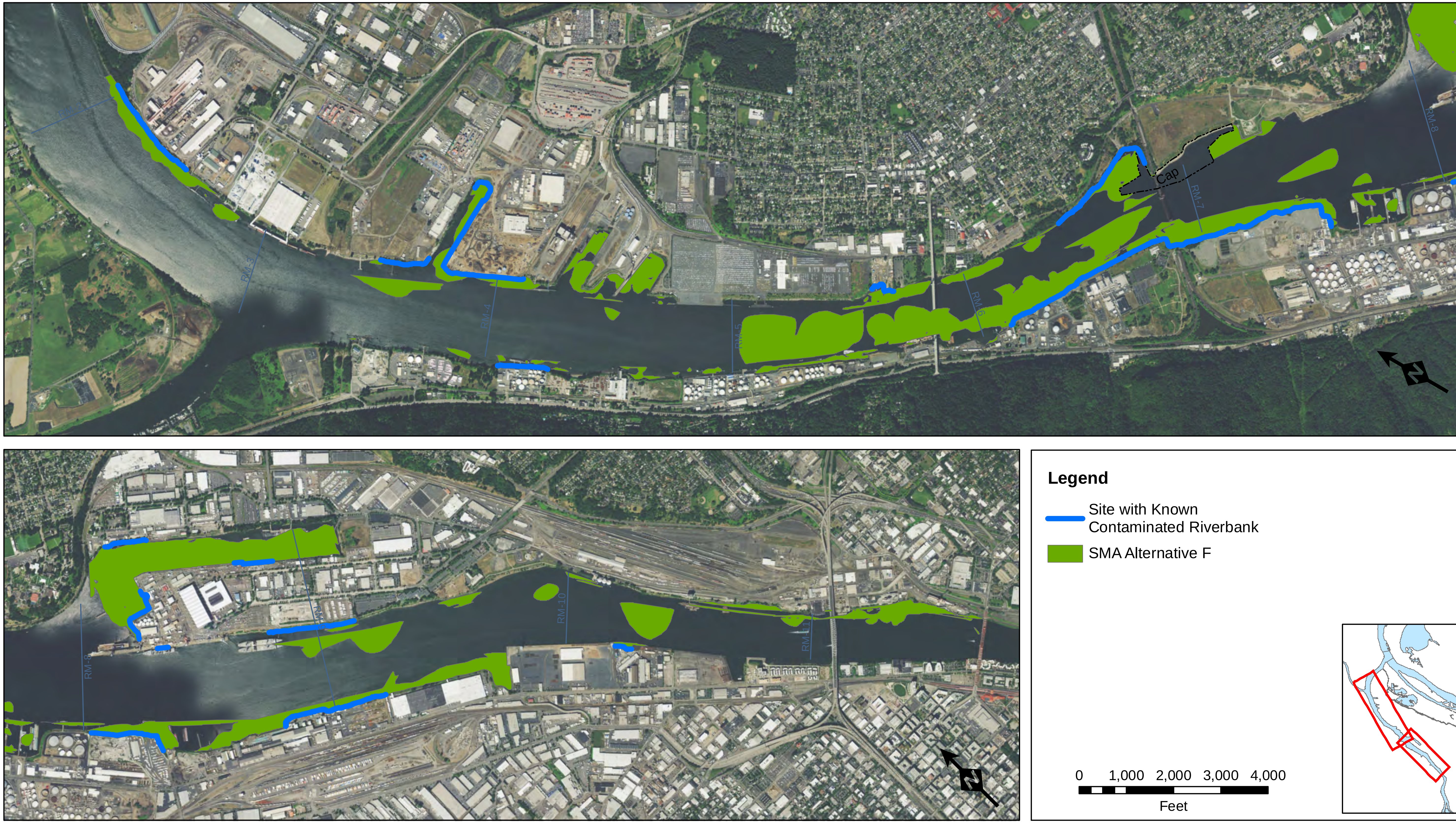

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Figure 11e. Sediment Management Areas, Alternatives F

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Date: 4/1/2016

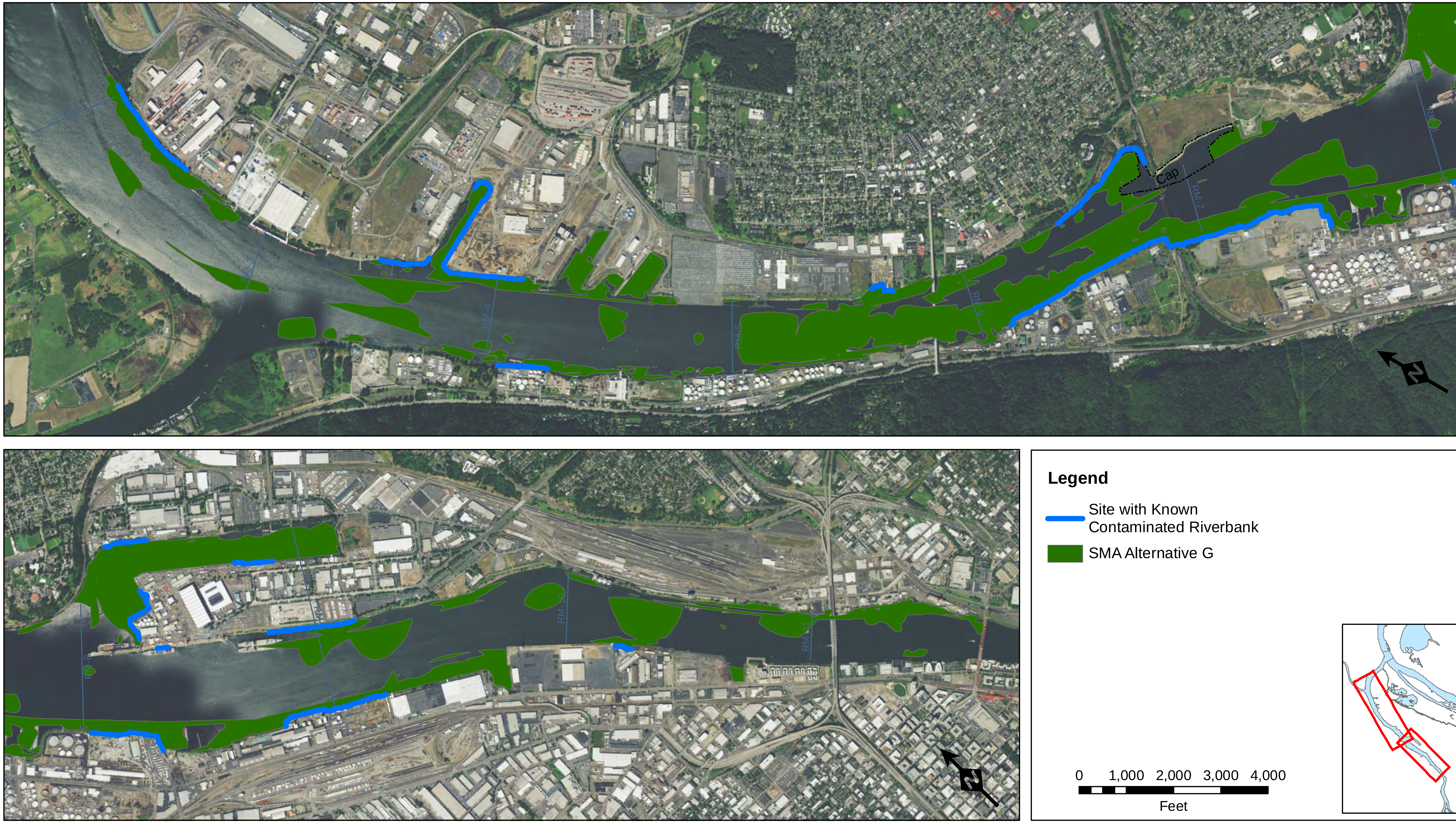

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Figure 11f. Sediment Management Areas, Alternatives G

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Date: 4/1/2016

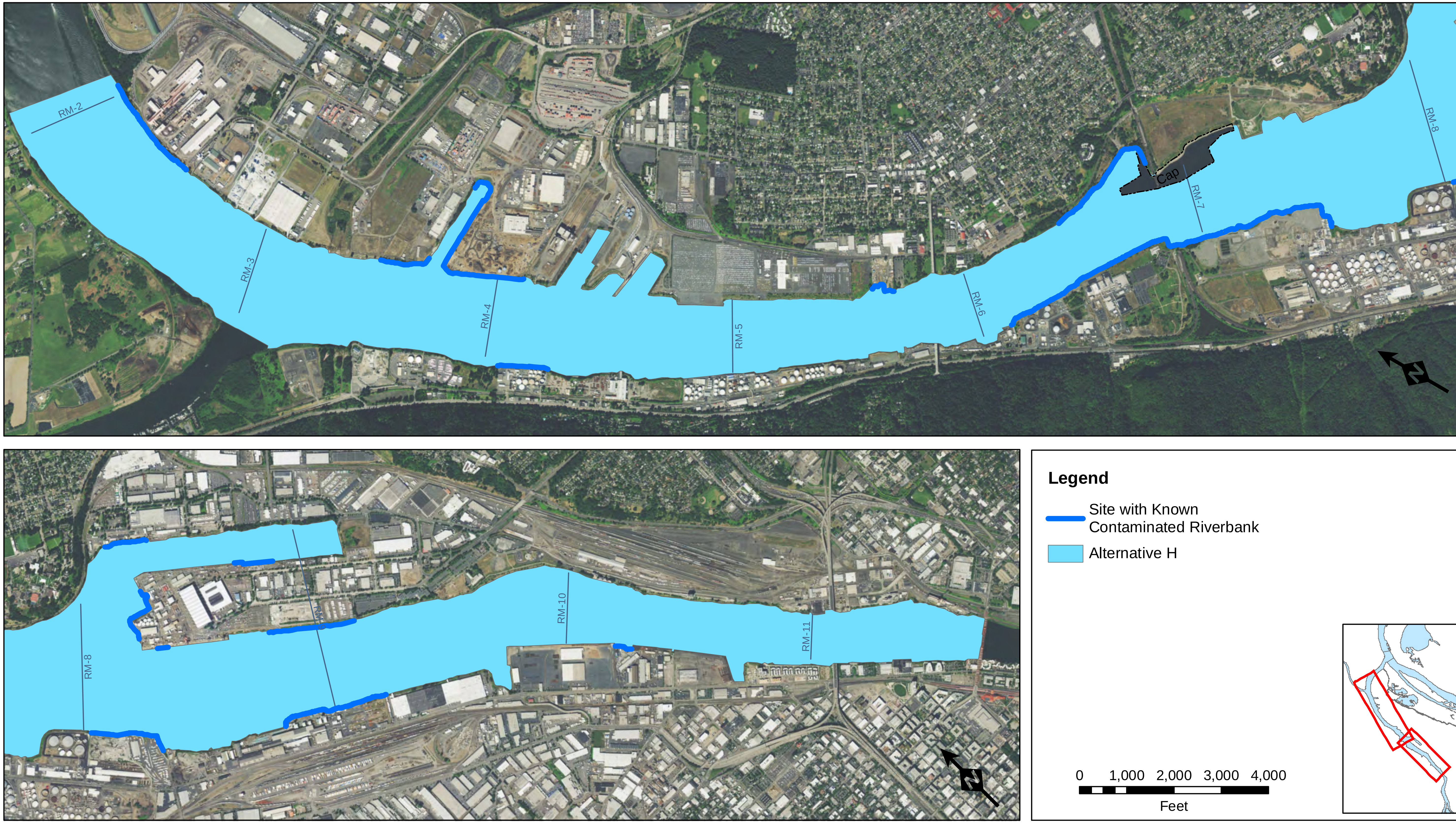

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Figure 11g. Sediment Management Areas, Alternative H

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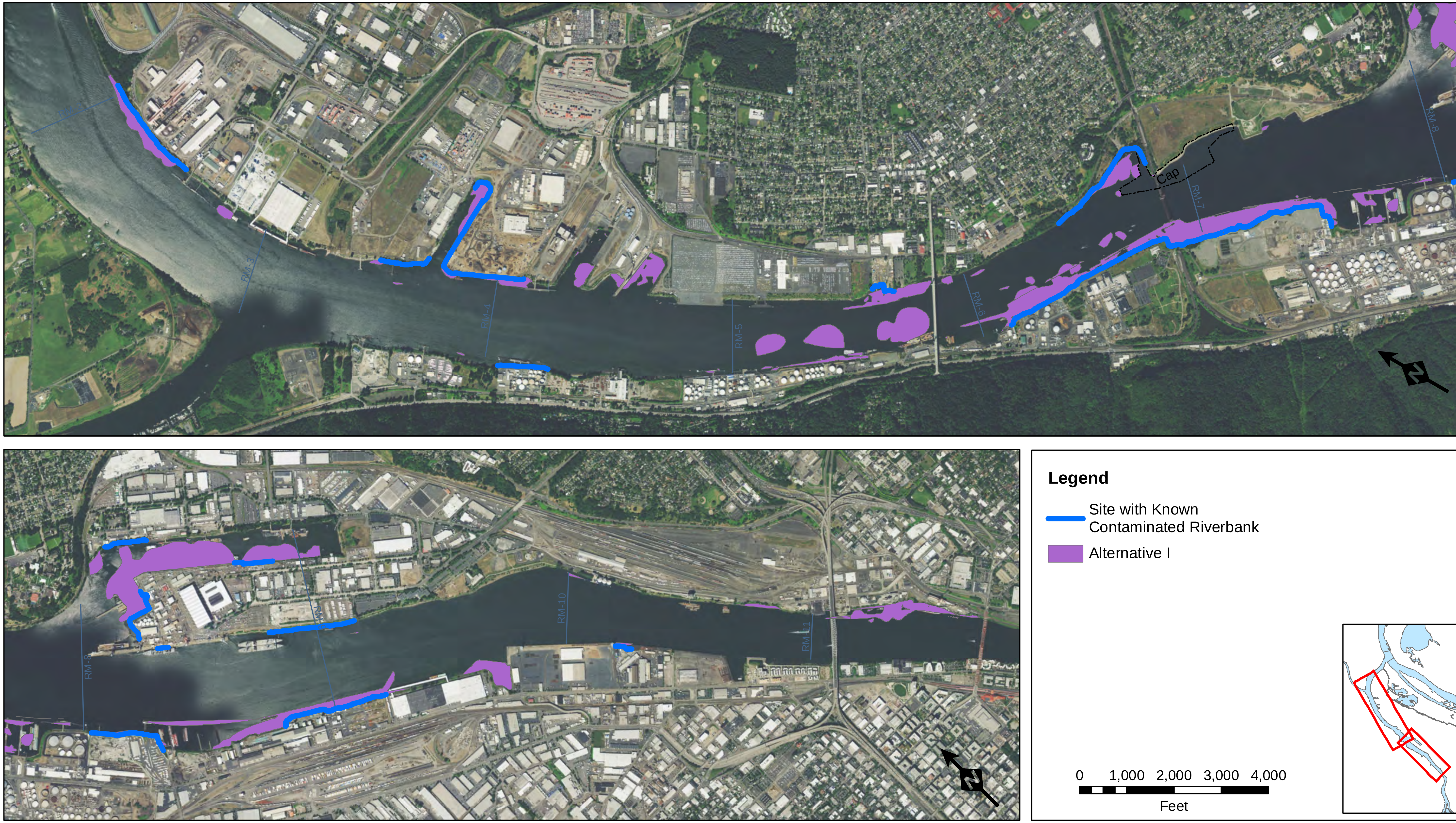

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Figure 11h. Sediment Management Areas, Alternative I

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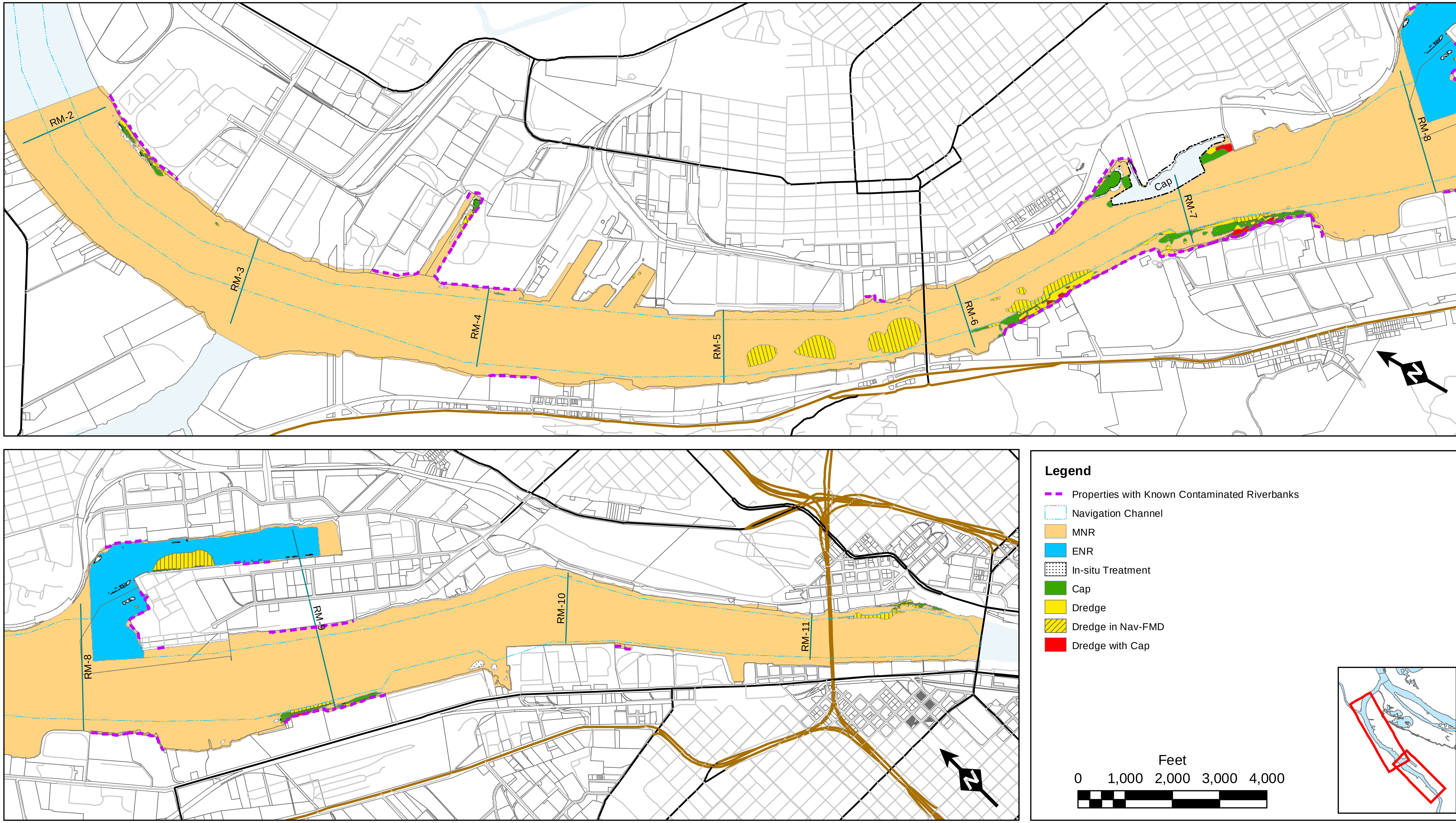

Figure 12a. Technology Assignments, Alternative B, Site-Wide

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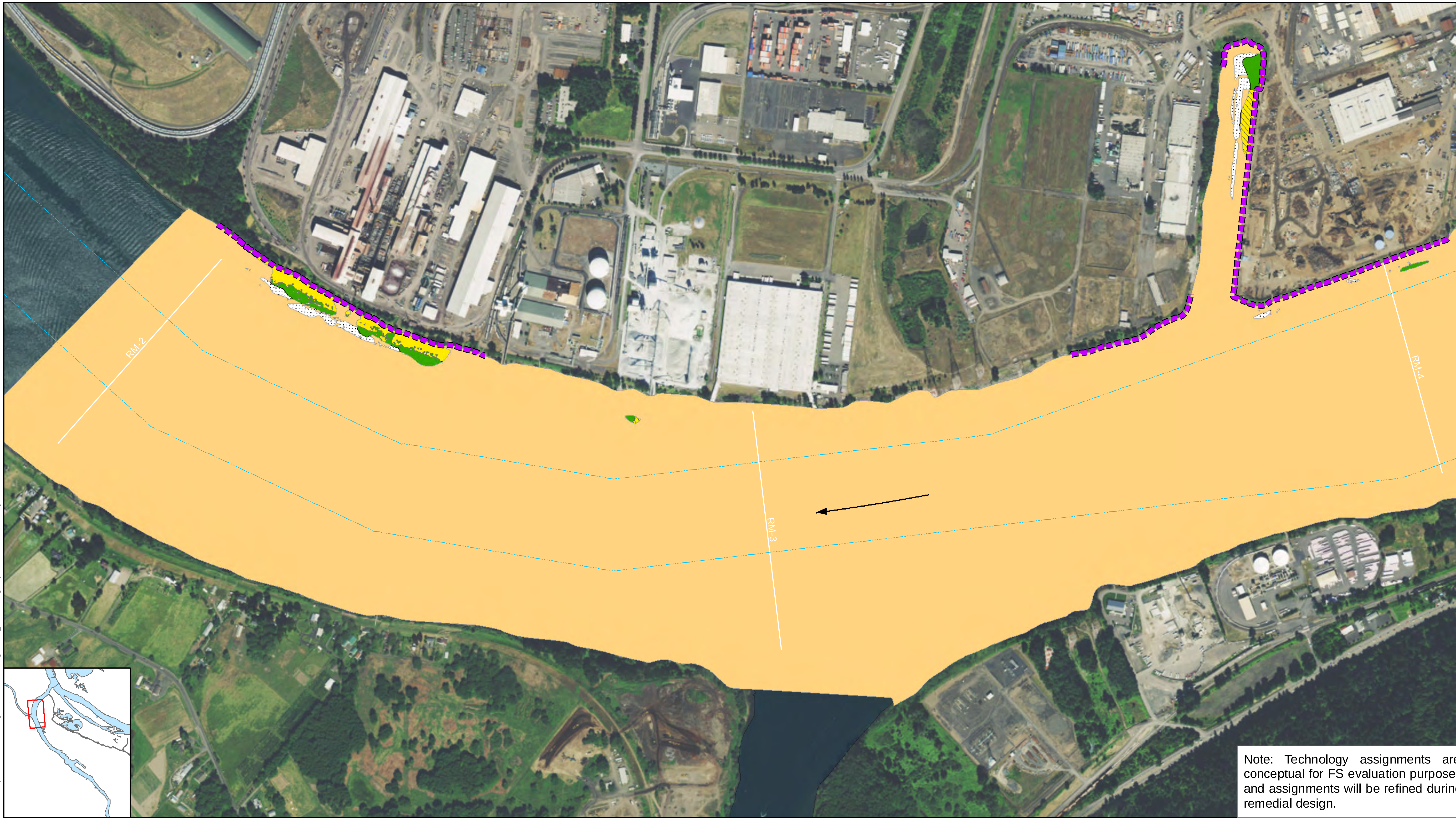

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 12b.
Technology Assignments
Alternative B
Rivermile 1.9 to 4

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 12c.
Technology Assignments
Alternative B
Rivermile 4 to 6

0 500 1,000
Feet

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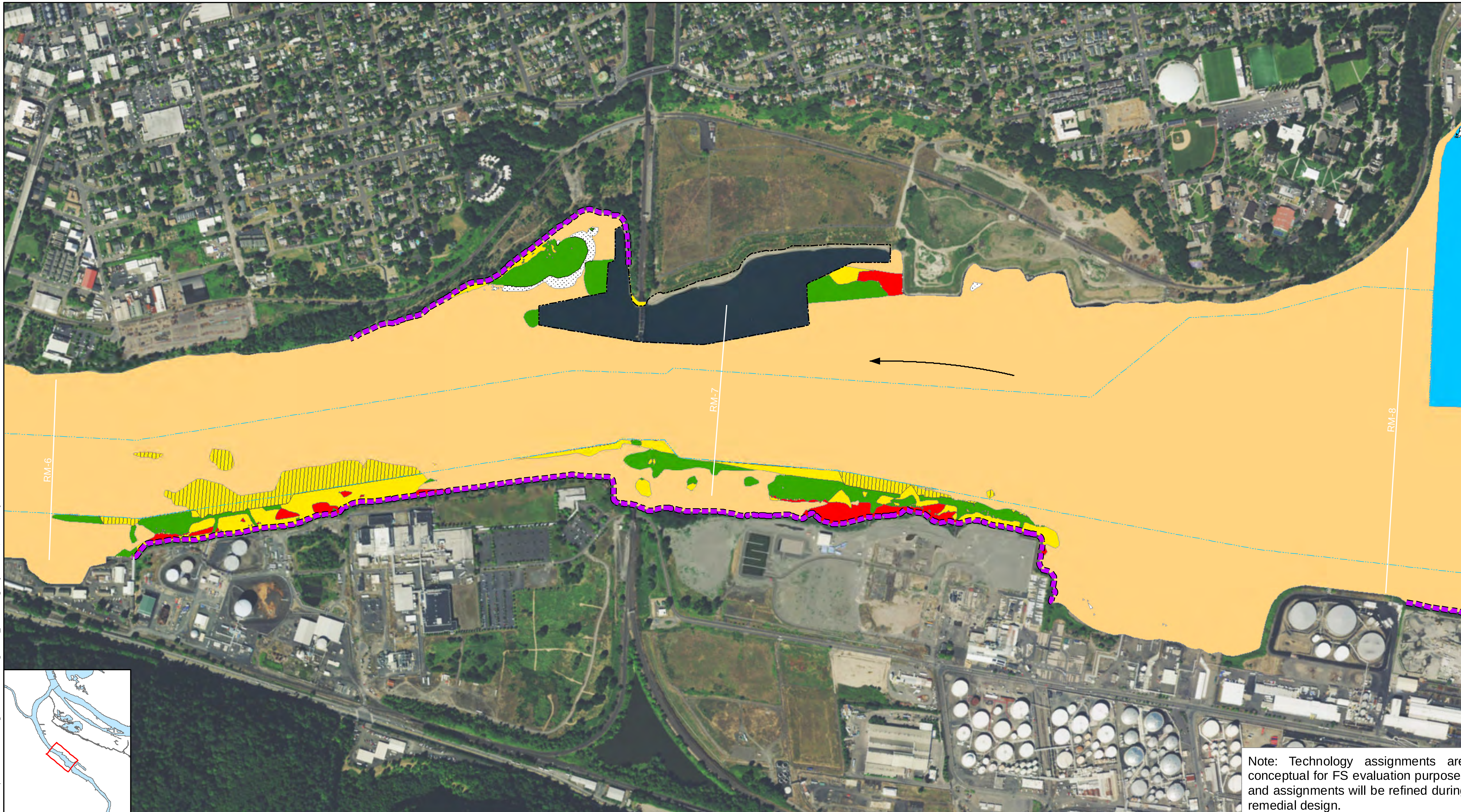

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 12d.
Technology Assignments
Alternative B
Rivermile 6 to 8

0 500 1,000
Feet

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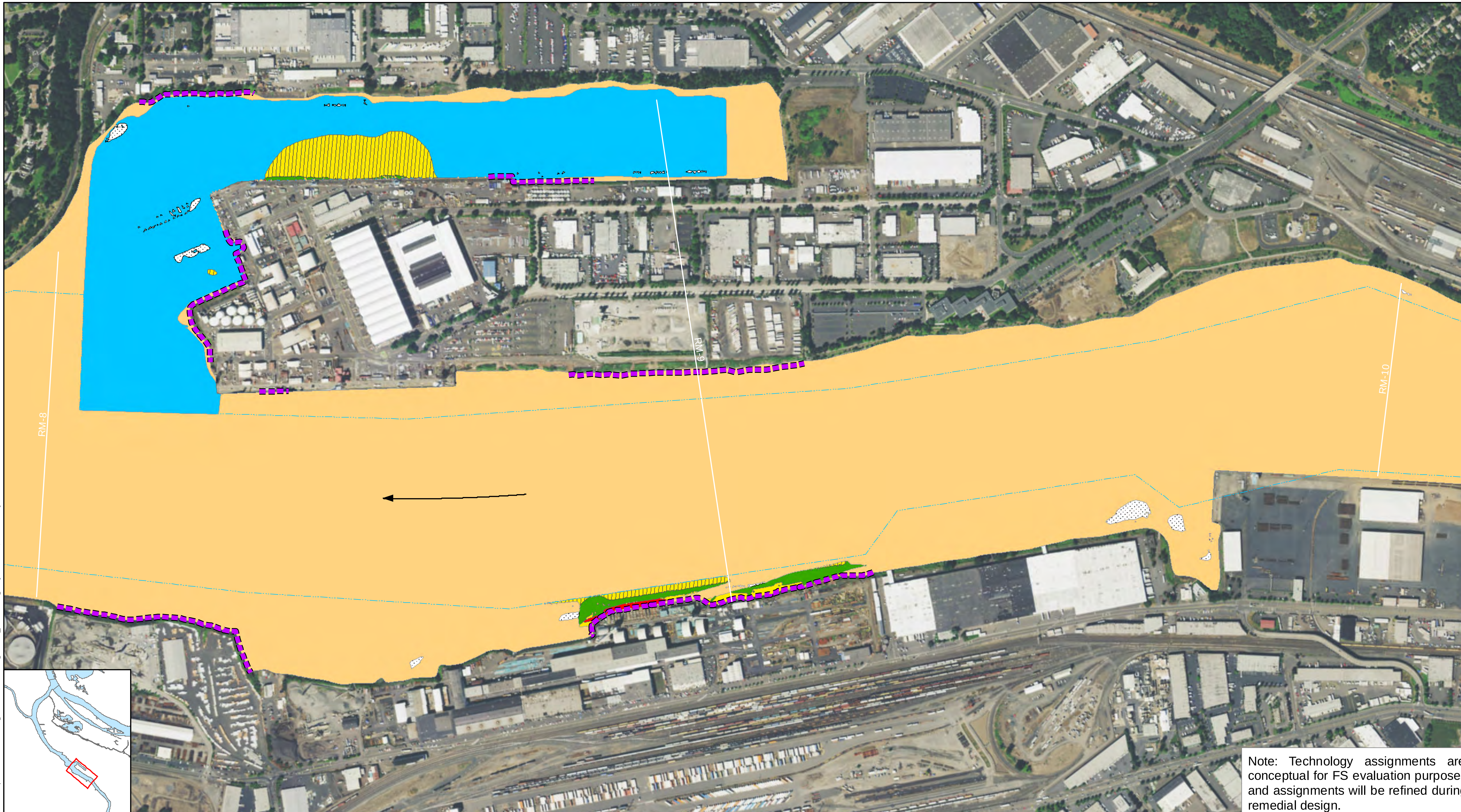

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 12e.
Technology Assignments
Alternative B
Rivermile 8 to 10

0 500 1,000
Feet

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 12f.
Technology Assignments
Alternative B
Rivermile 10 to 12

0 500 1,000
Feet

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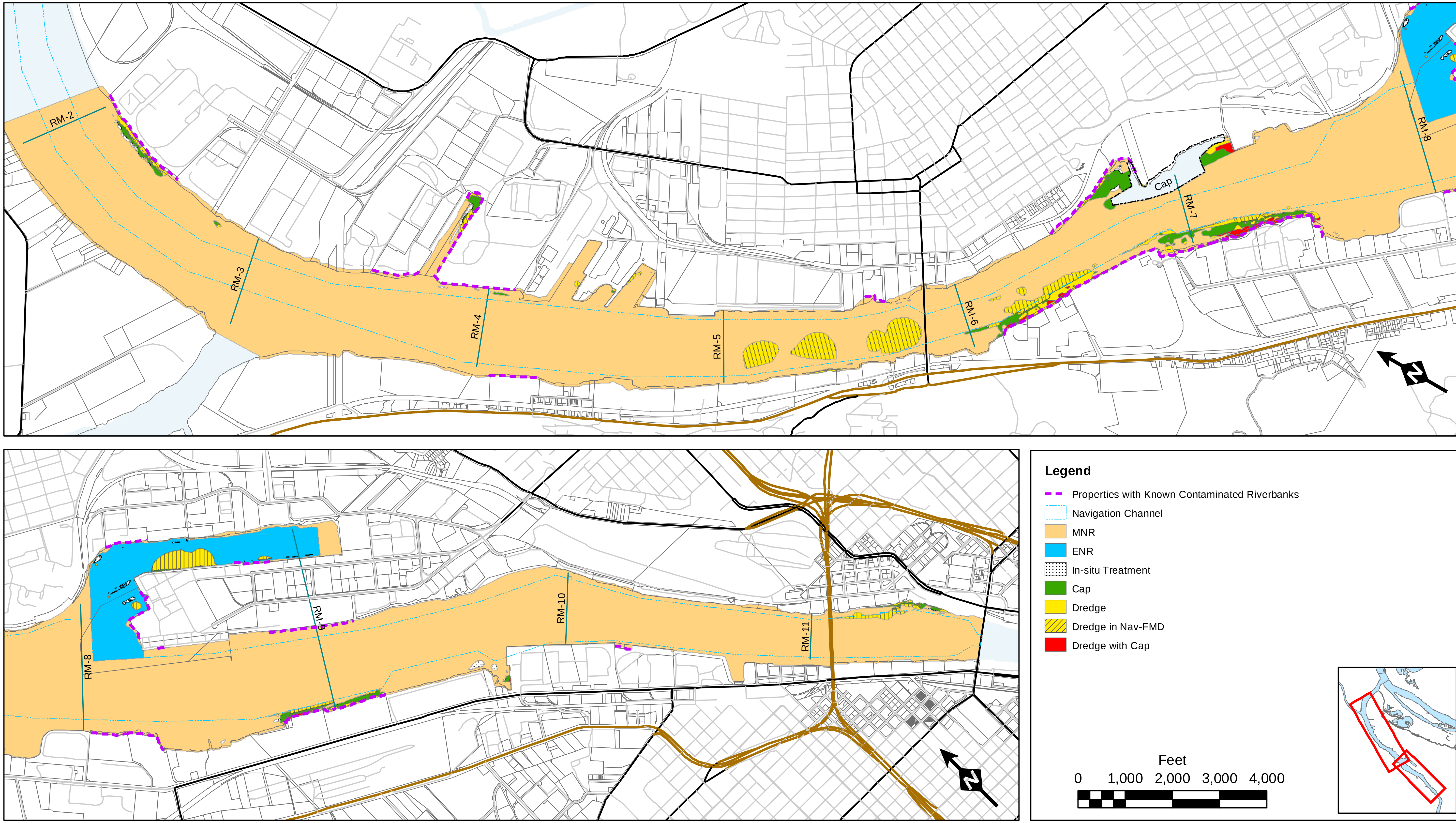

Figure 13a. Technology Assignments, Alternative C, Site-Wide

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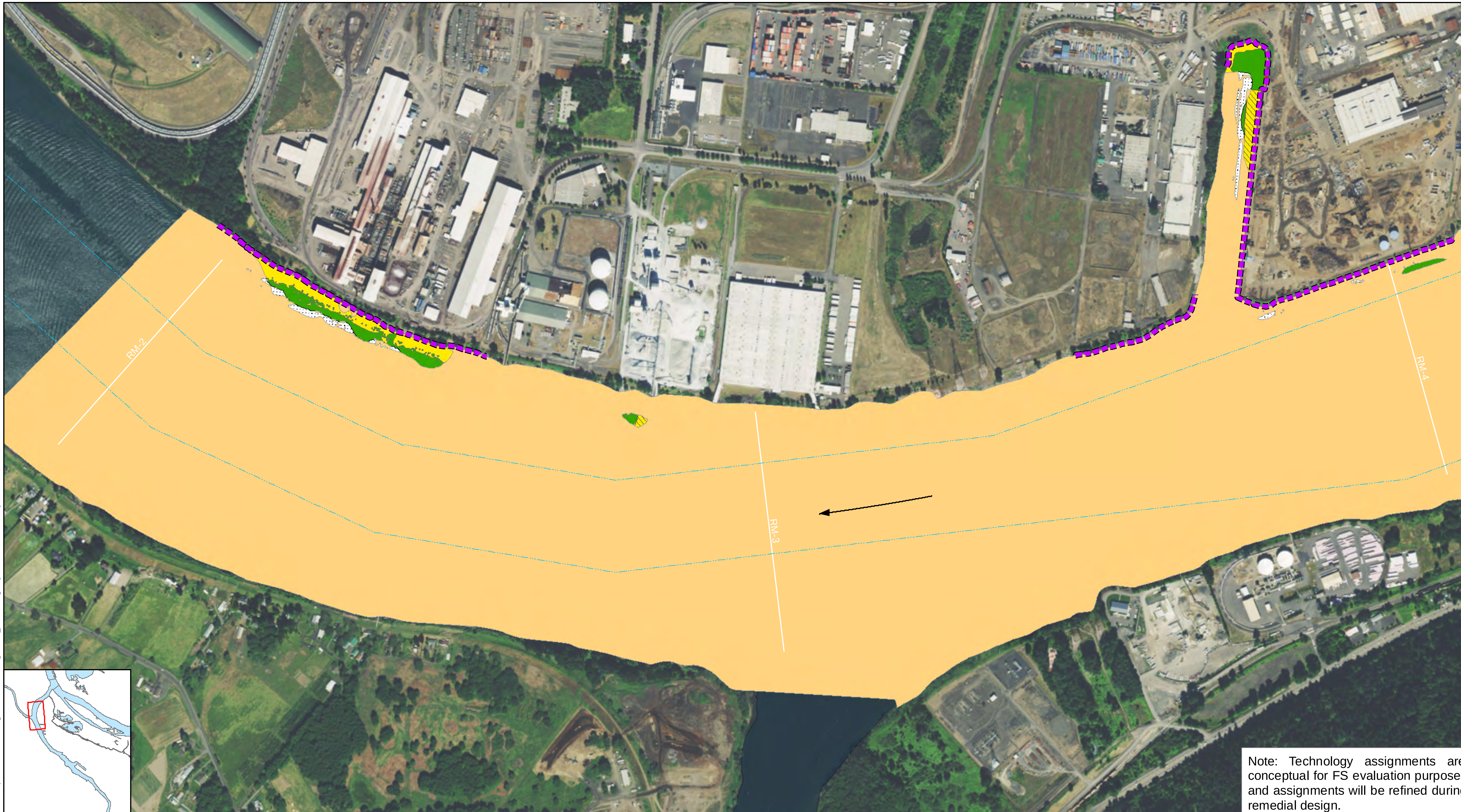

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 13b.
Technology Assignments
Alternative C
Rivermile 1.9 to 4

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 13c.
Technology Assignments
Alternative C
Rivermile 4 to 6

0 500 1,000
Feet

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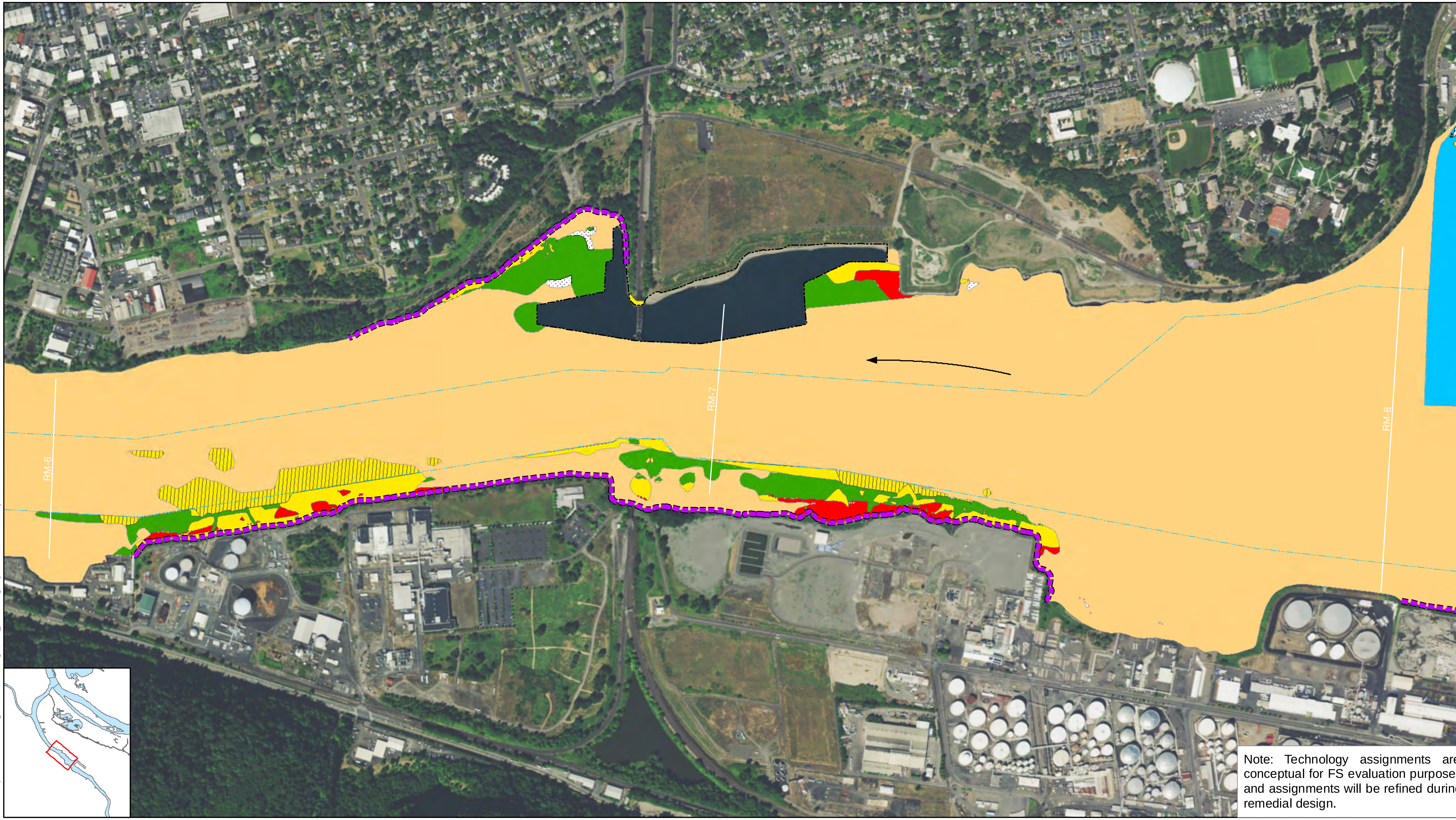

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 13d.
Technology Assignments
Alternative C
Rivermile 6 to 8

0 500 1,000
Feet

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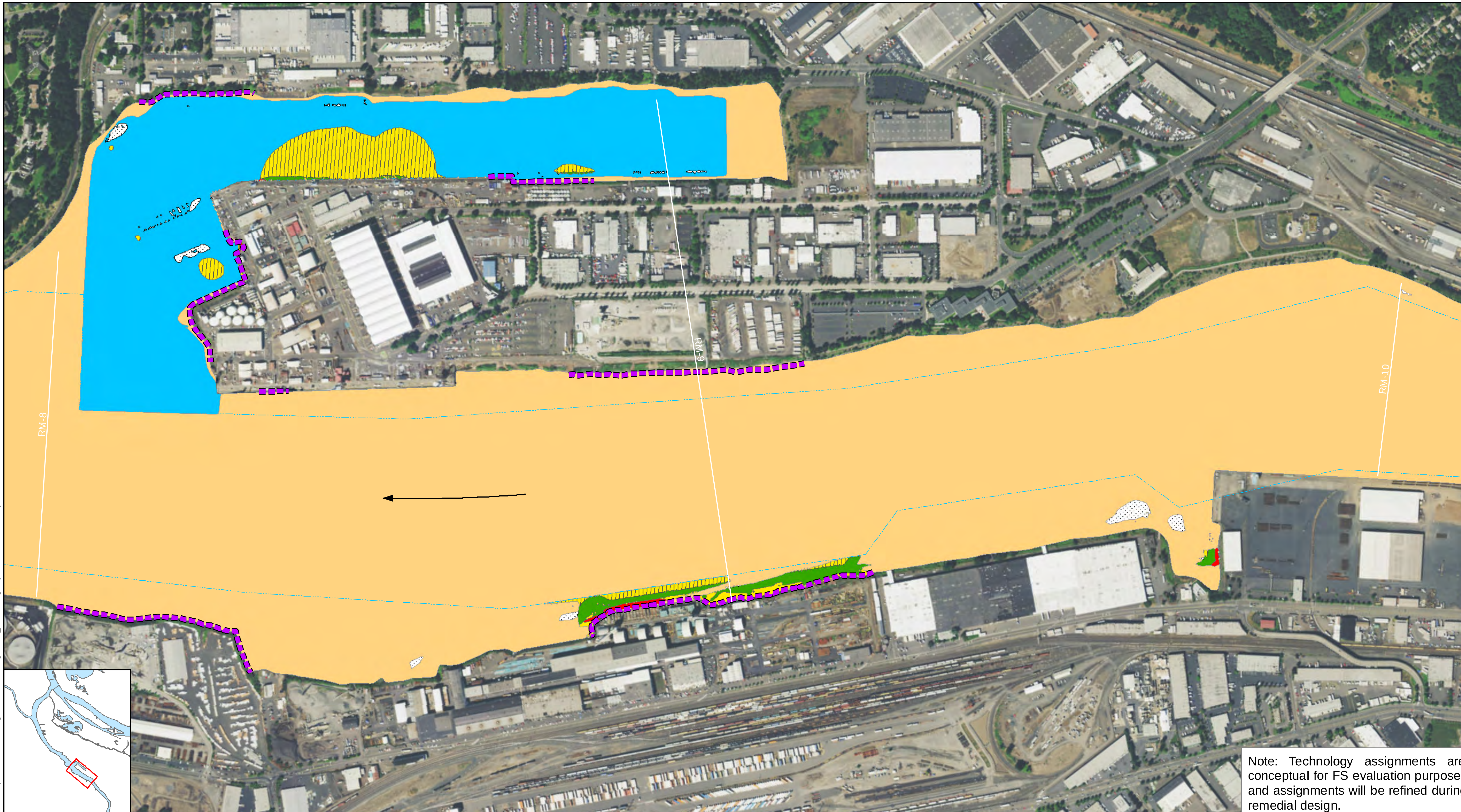

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 13e.
Technology Assignments
Alternative C
Rivermile 8 to 10

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 13f.
Technology Assignments
Alternative C
Rivermile 10 to 12

0 500 1,000
Feet

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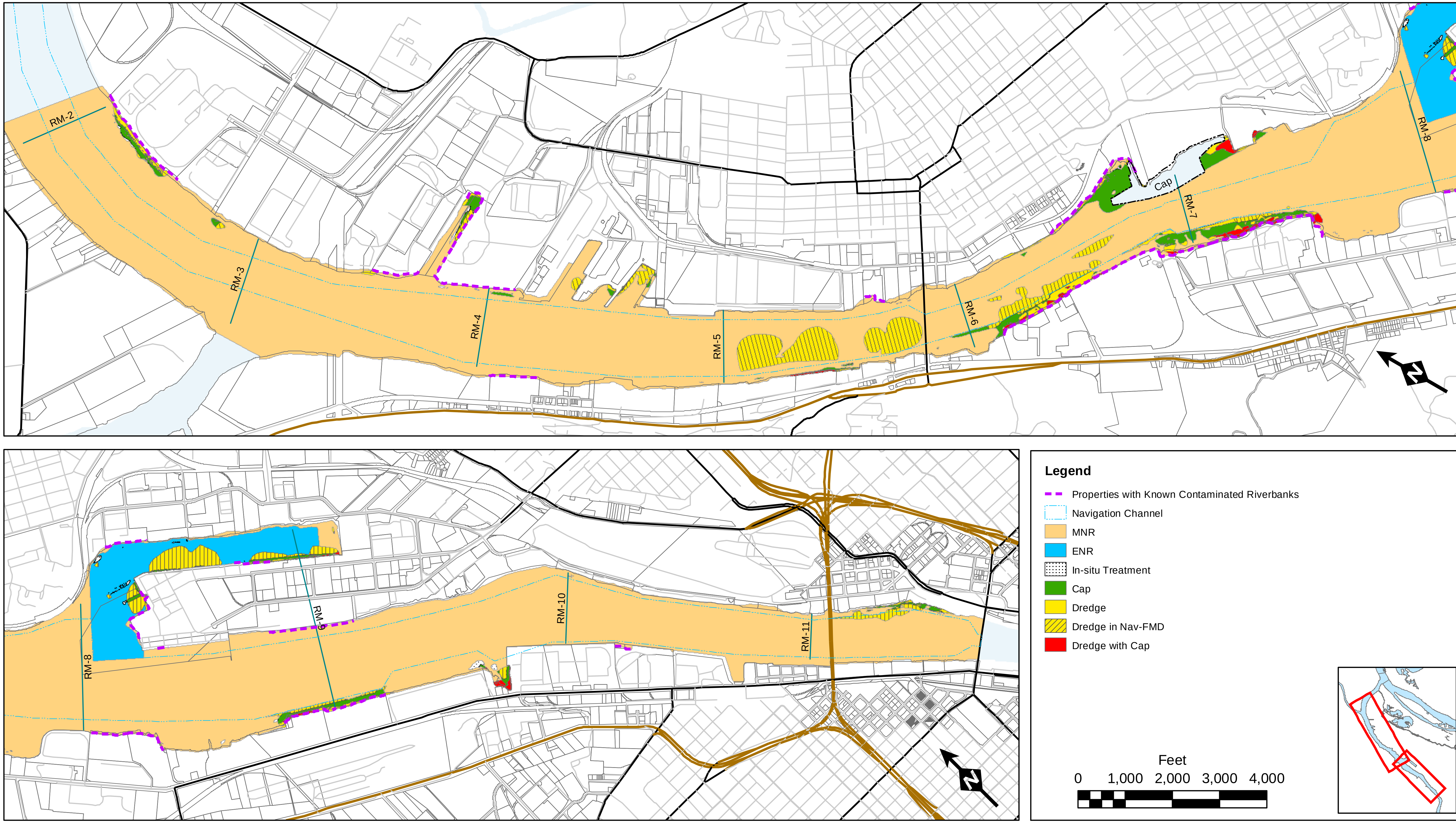

Figure 14a. Technology Assignments, Alternative D, Site-Wide

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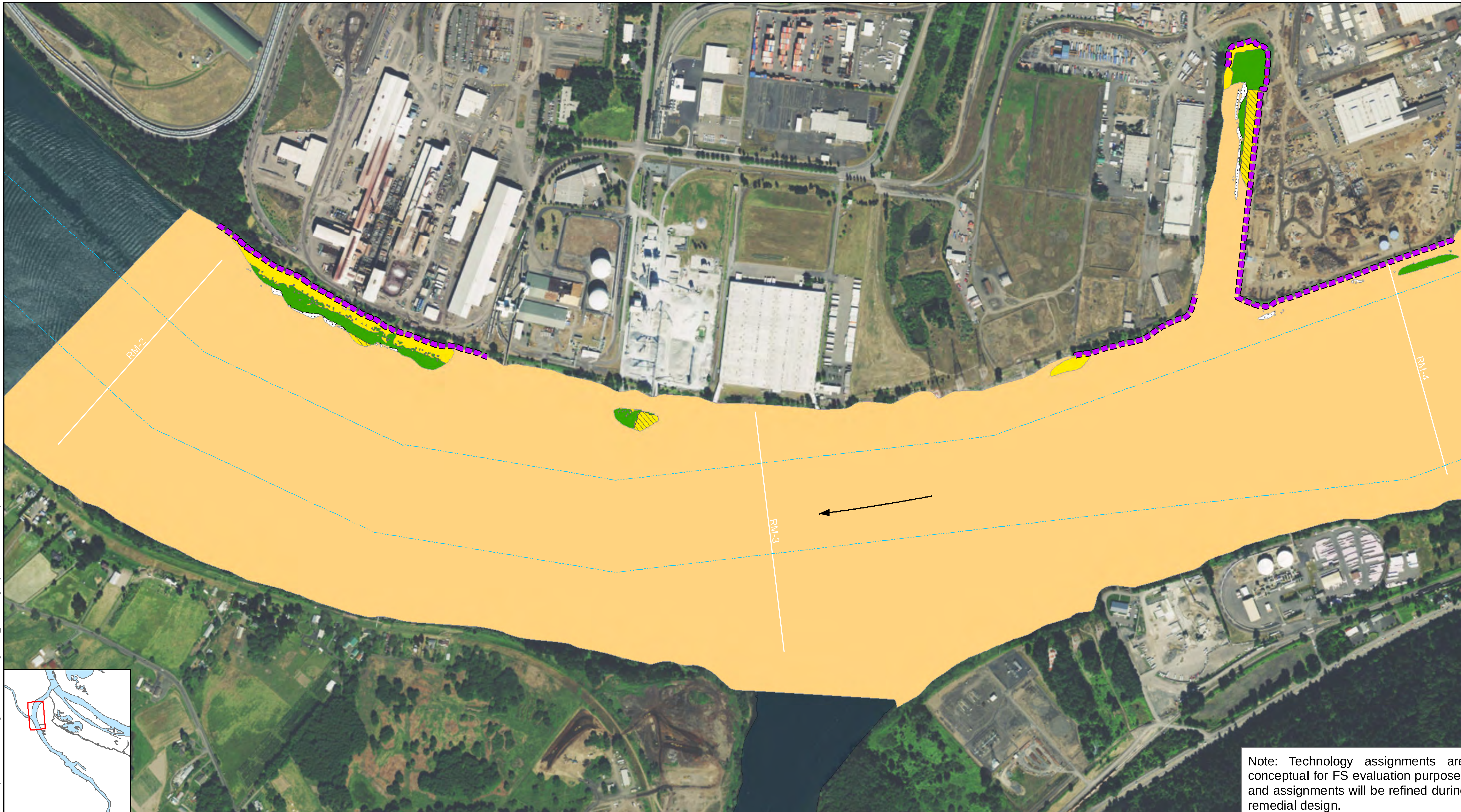

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 14b.
Technology Assignments
Alternative D
Rivermile 1.9 to 4

0 500 1,000
Feet

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Note: Technology assignments are conceptual for FS evaluation purposes and assignments will be refined during remedial design.

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 14c.
Technology Assignments
Alternative D
Rivermile 4 to 6

0 500 1,000
Feet

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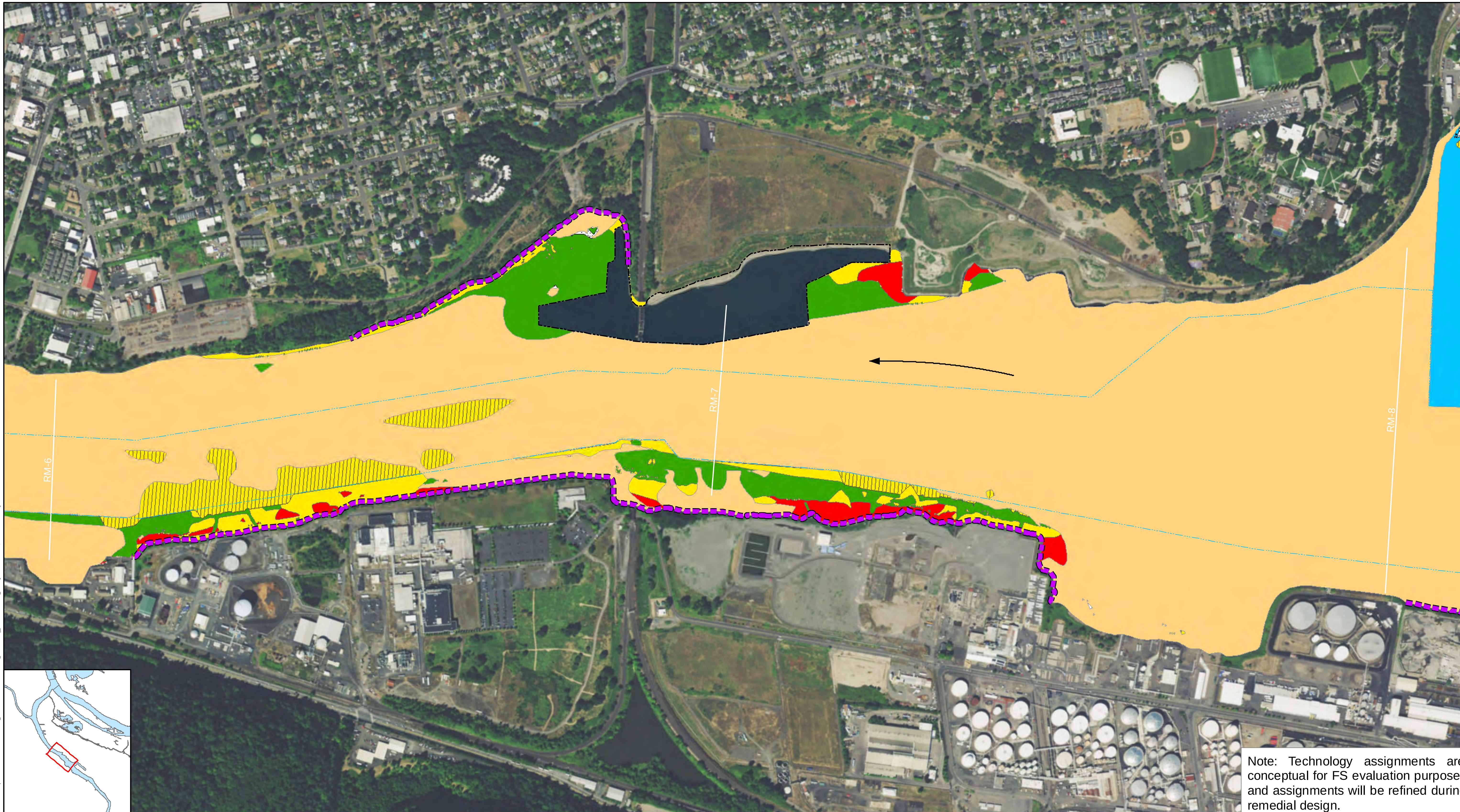

Note: Technology assignments are conceptual for FS evaluation purposes and assignments will be refined during remedial design.

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 14d.
Technology Assignments
Alternative D
Rivermile 6 to 8

0 500 1,000
Feet

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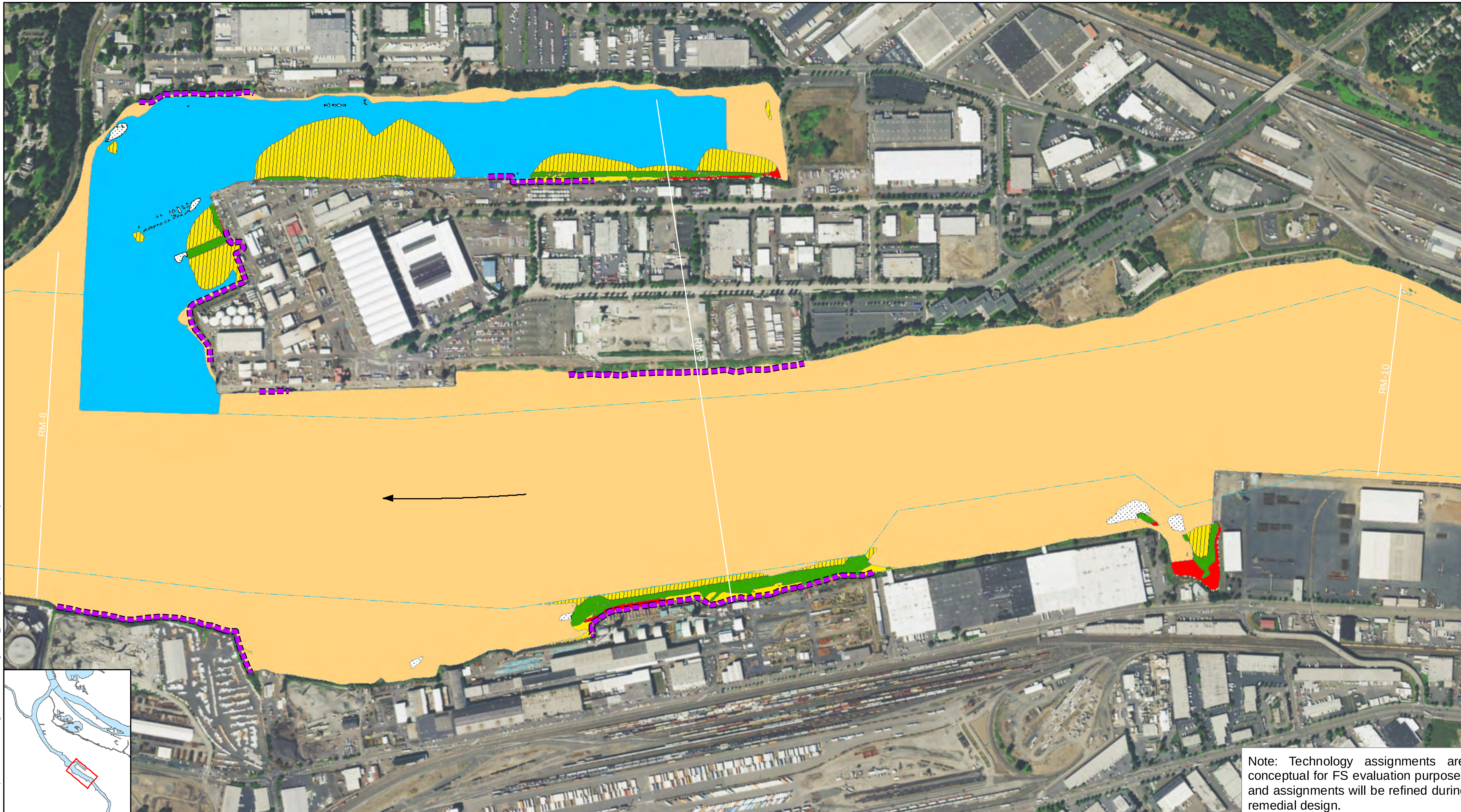

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Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 14e. Technology Assignments Alternative D Rivermile 8 to 10

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 14f.
Technology Assignments
Alternative D
Rivermile 10 to 12

0 500 1,000
Feet

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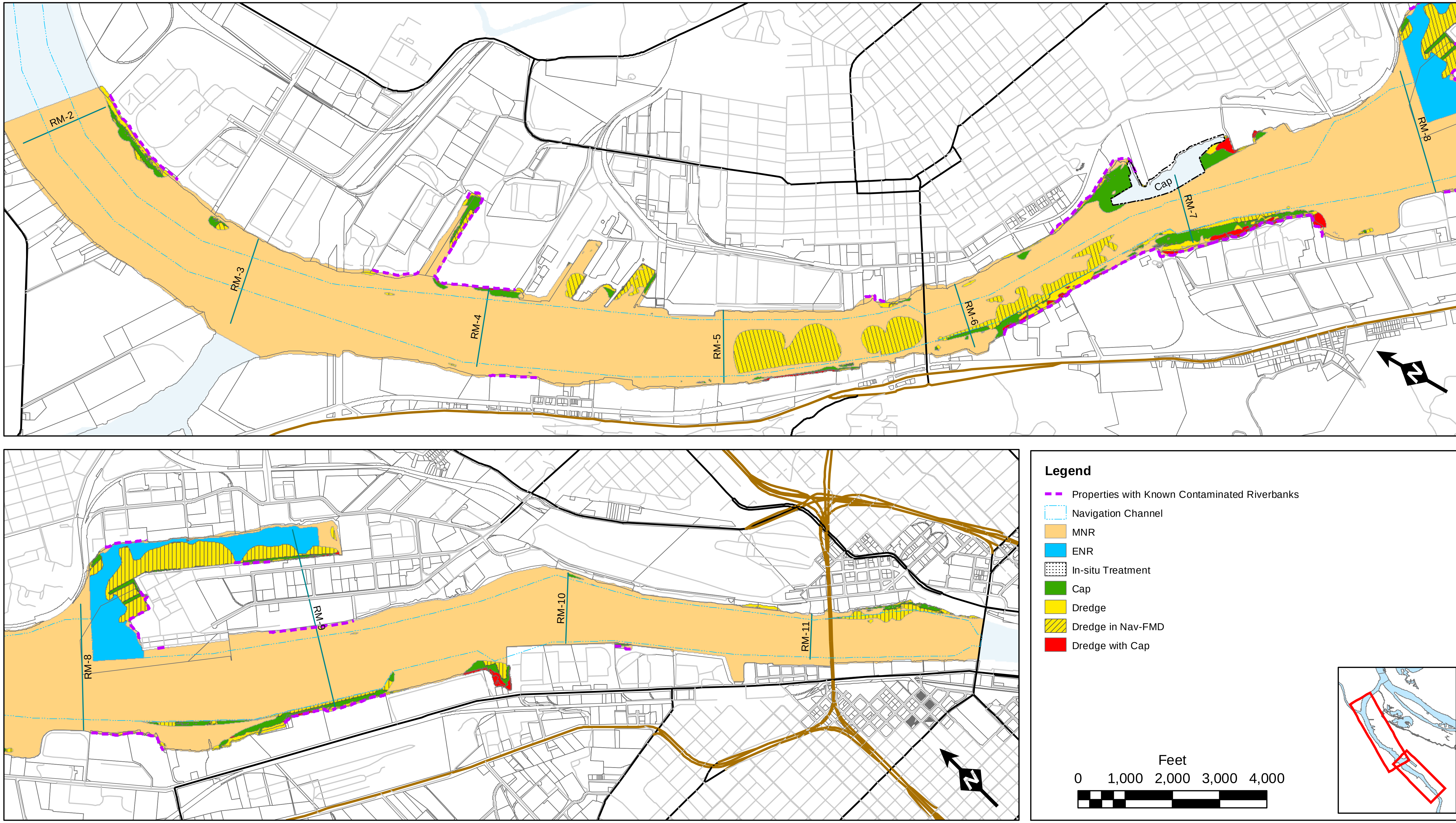

Figure 15a. Technology Assignments, Alternative E, Site-Wide

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 15b.
Technology Assignments
Alternative E
Rivermile 1.9 to 4

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 15c.
Technology Assignments
Alternative E
Rivermile 4 to 6

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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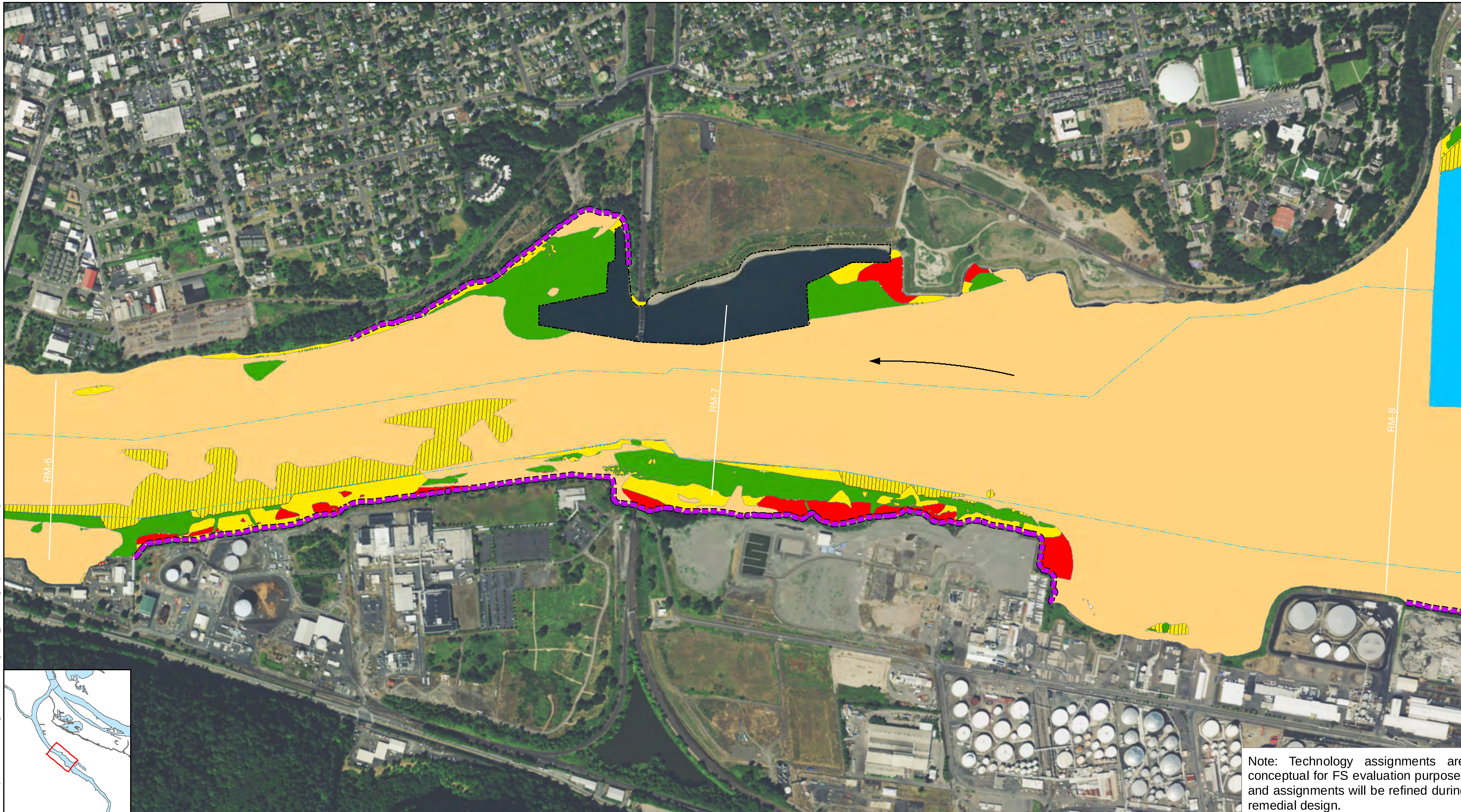

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 15d.
Technology Assignments
Alternative E
Rivermile 6 to 8

0 500 1,000
Feet

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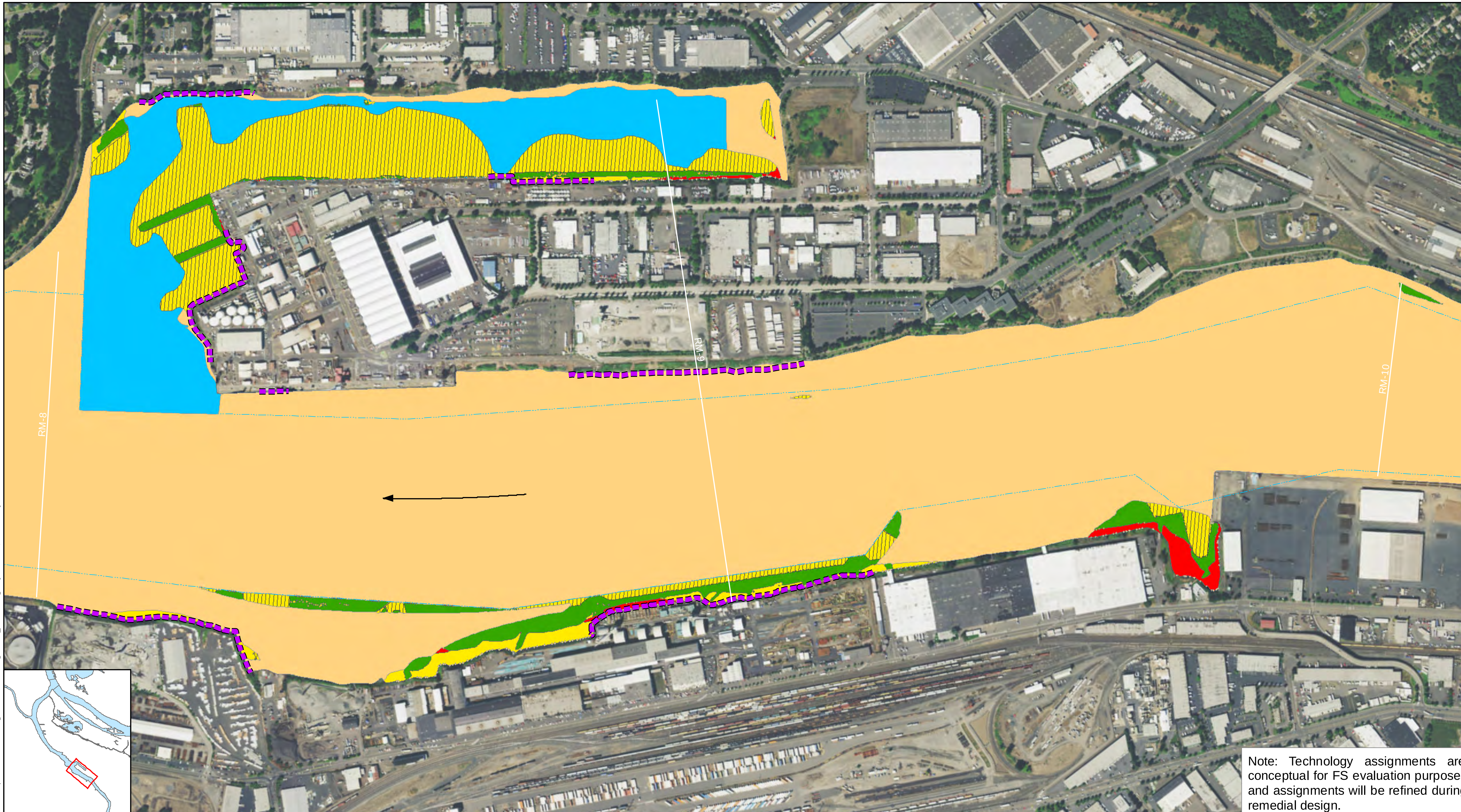

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Figure 15e.
Technology Assignments
Alternative E
Rivermile 8 to 10

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 15f.
Technology Assignments
Alternative E
Rivermile 10 to 12

0 500 1,000
Feet

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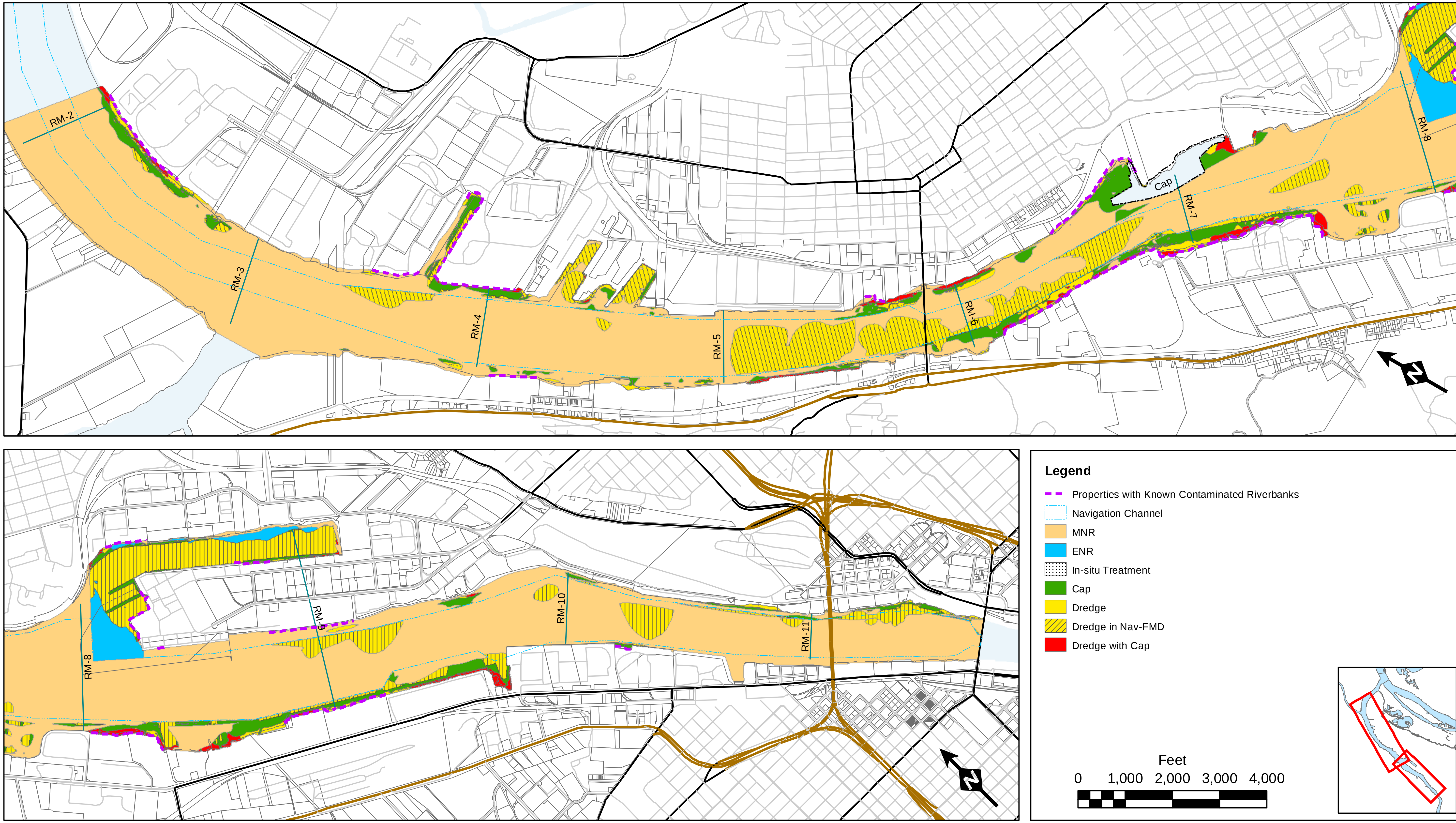

Figure 16a. Technology Assignments, Alternative F, Site-Wide

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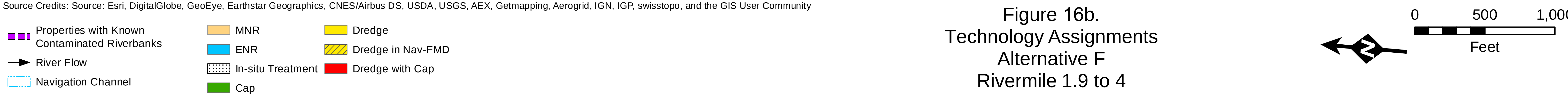

Figure 16b.
Technology Assignments
Alternative F
Rivermile 1.9 to 4

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 16c.
Technology Assignments
Alternative F
Rivermile 4 to 6

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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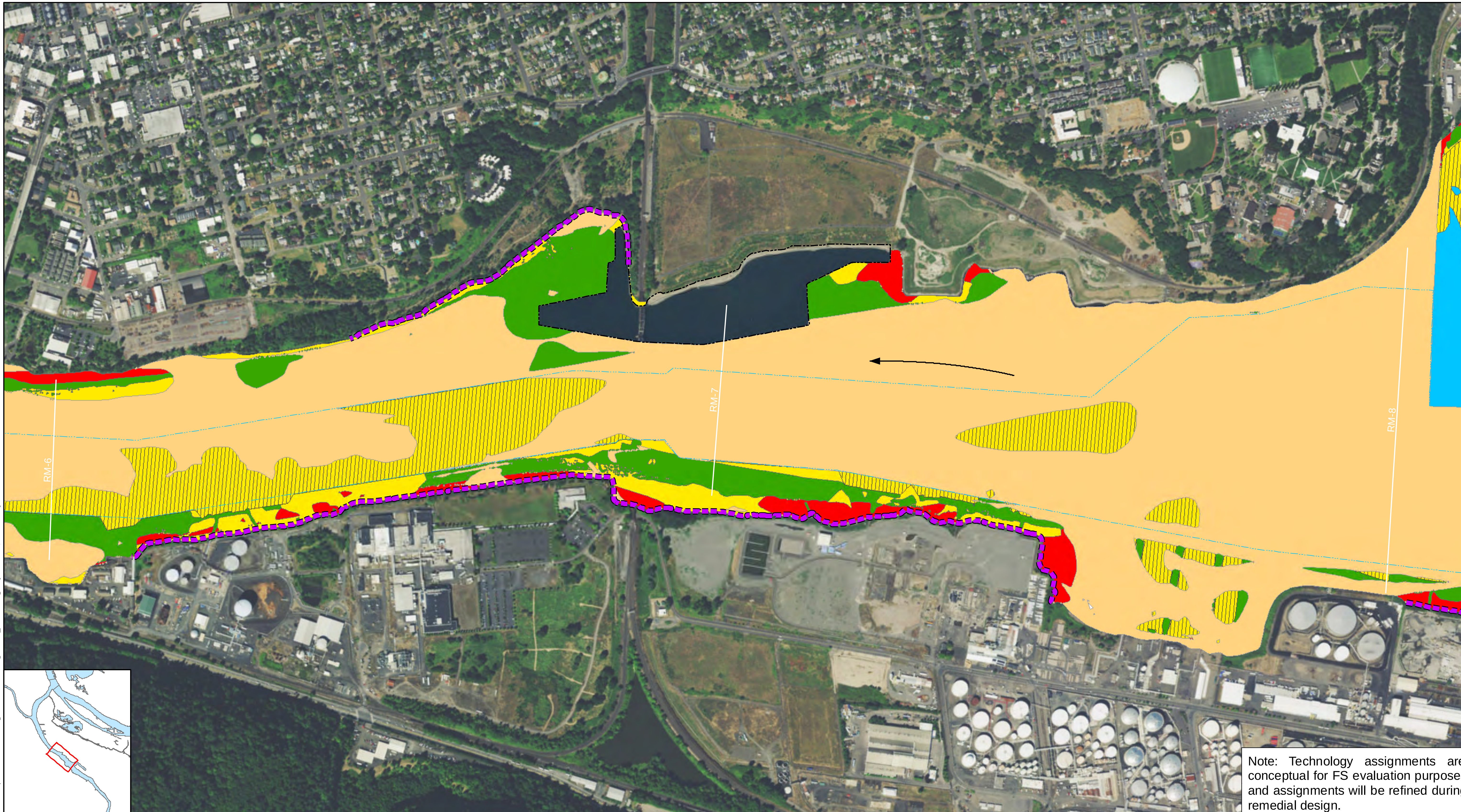

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 16d.
Technology Assignments
Alternative F
Rivermile 6 to 8

N

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 16e.
Technology Assignments
Alternative F
Rivermile 8 to 10

0 500 1,000
Feet

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 16f.
Technology Assignments
Alternative F
Rivermile 10 to 12

0 500 1,000
Feet

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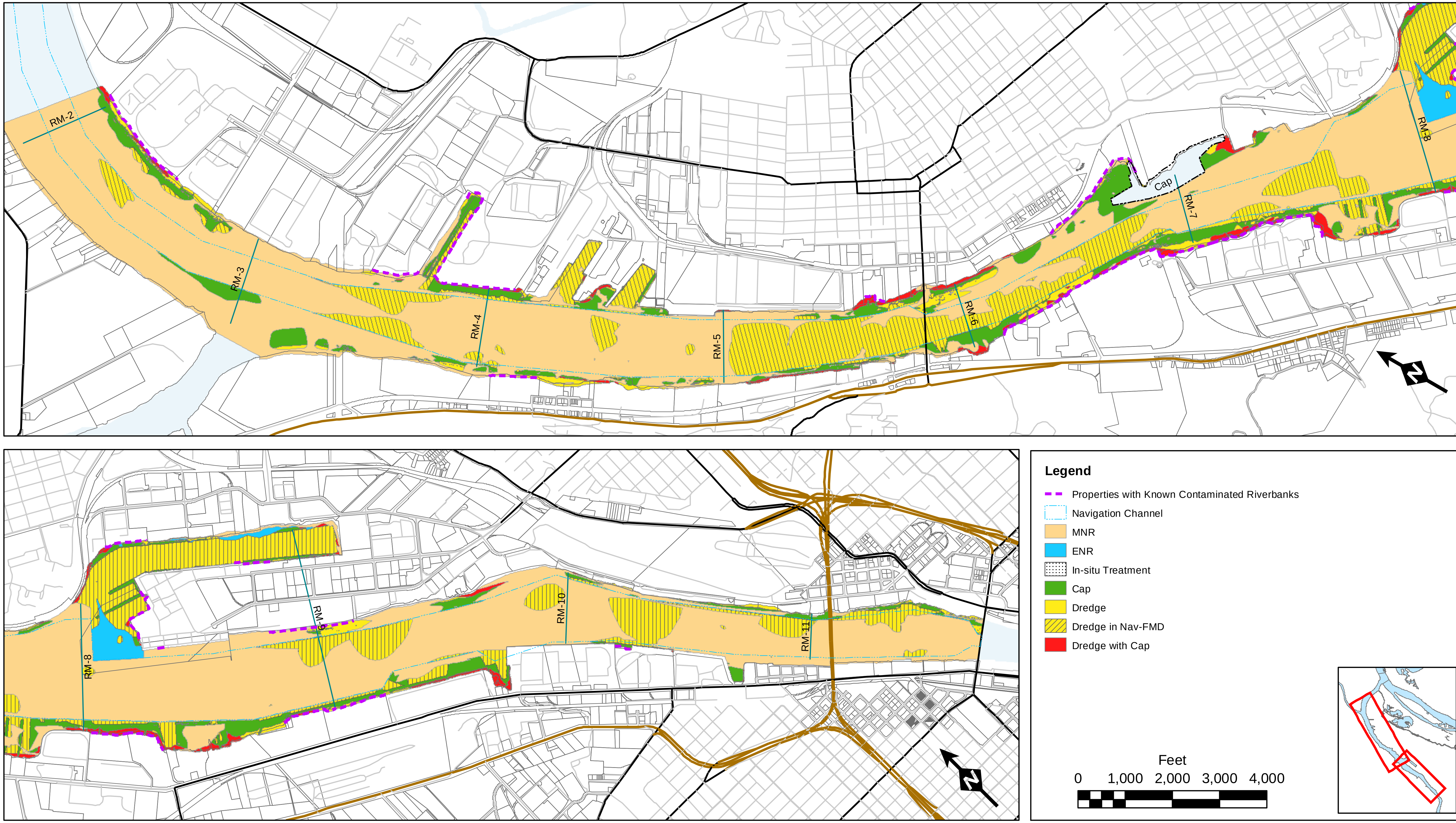

Figure 17a. Technology Assignments, Alternative G, Site-Wide

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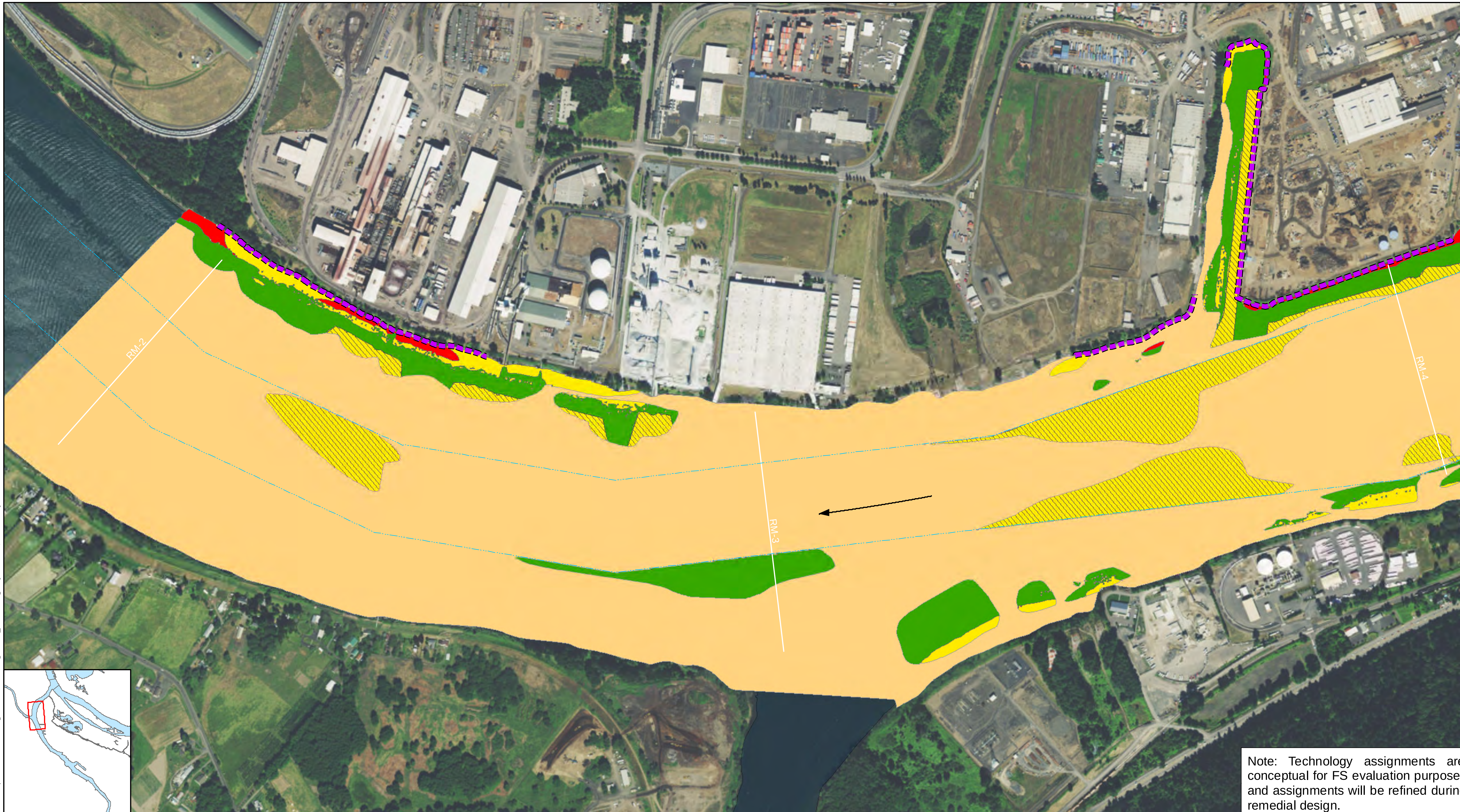

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Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

**Figure 17b.
Technology Assignments
Alternative G
Rivermile 1.9 to 4**

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 17c.
Technology Assignments
Alternative G
Rivermile 4 to 6

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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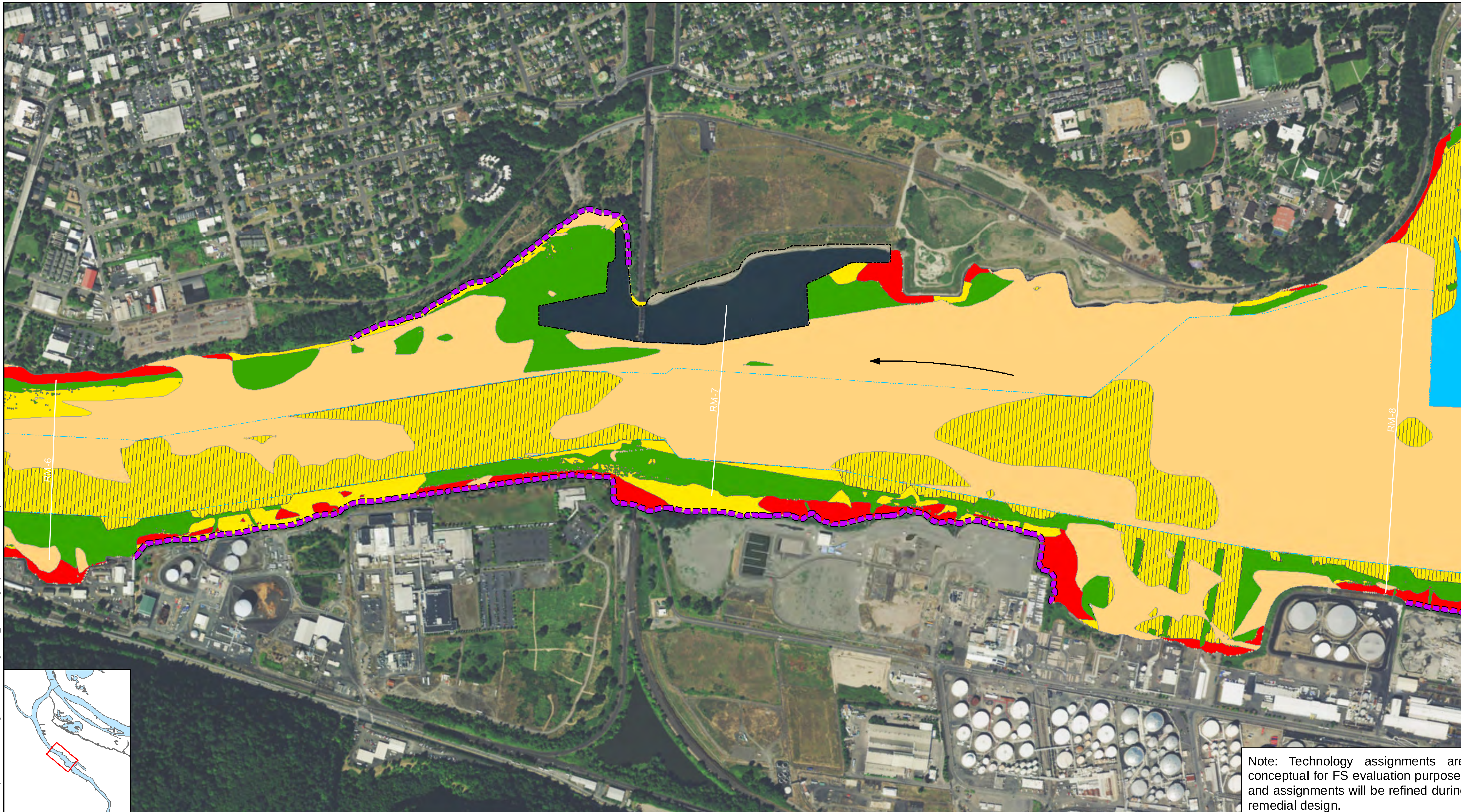

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 17d.
Technology Assignments
Alternative G
Rivermile 6 to 8

0 500 1,000
Feet

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 17e.
Technology Assignments
Alternative G
Rivermile 8 to 10

0 500 1,000
Feet

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

0 500 1,000
Feet

Figure 17f.
Technology Assignments
Alternative G
Rivermile 10 to 12

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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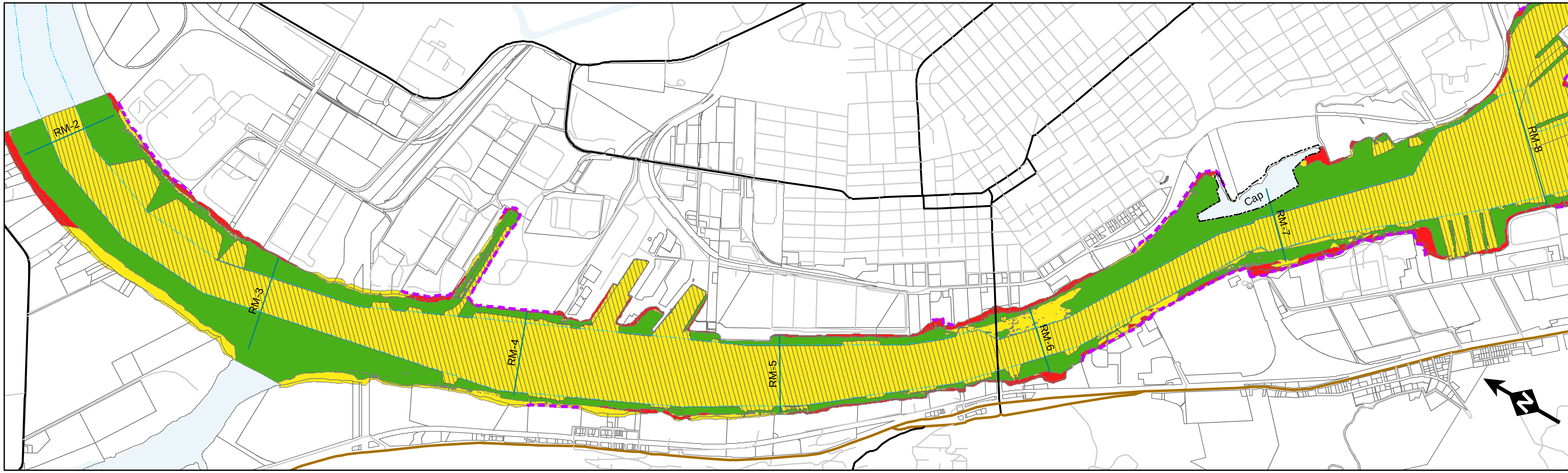

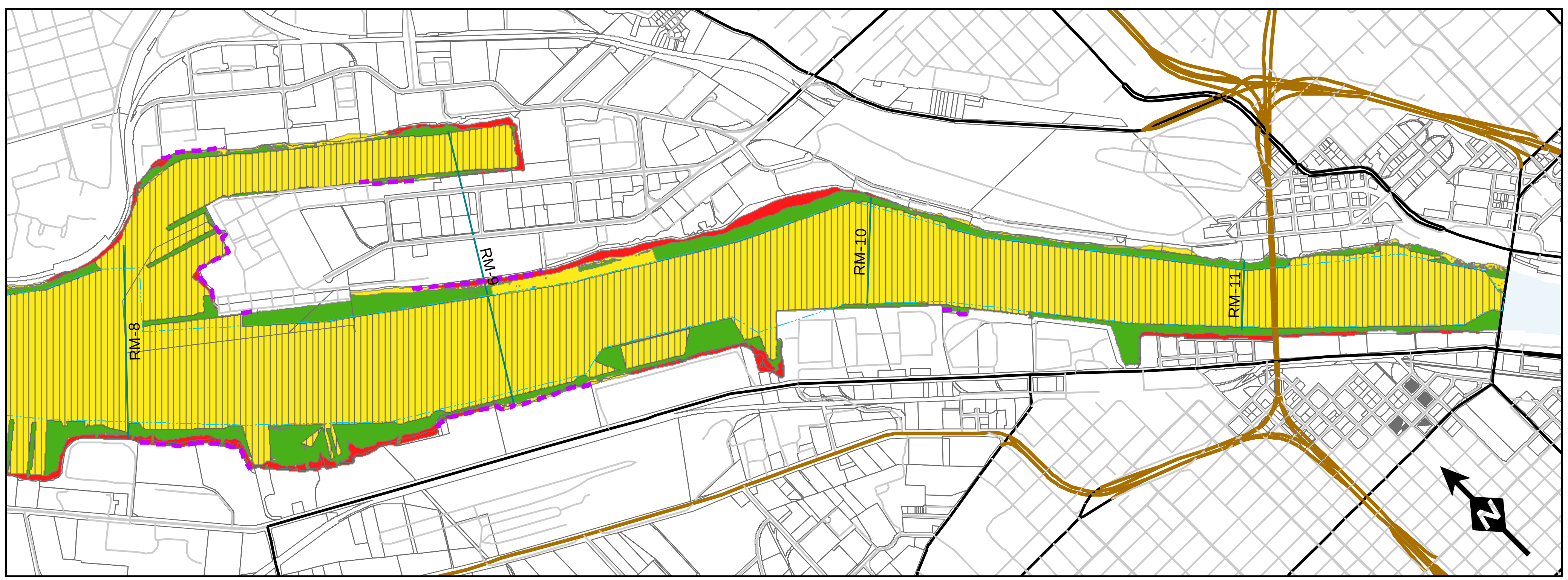

Legend

- Properties with Known Contaminated Riverbanks
- Navigation Channel
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Feet

0 1,000 2,000 3,000 4,000

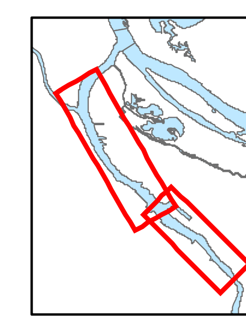

Figure 18a. Technology Assignments, Alternative H, Site-Wide

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 18b.
Technology Assignments
Alternative H
Rivermile 1.9 to 4

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 18c.
Technology Assignments
Alternative H
Rivermile 4 to 6

0 500 1,000
Feet

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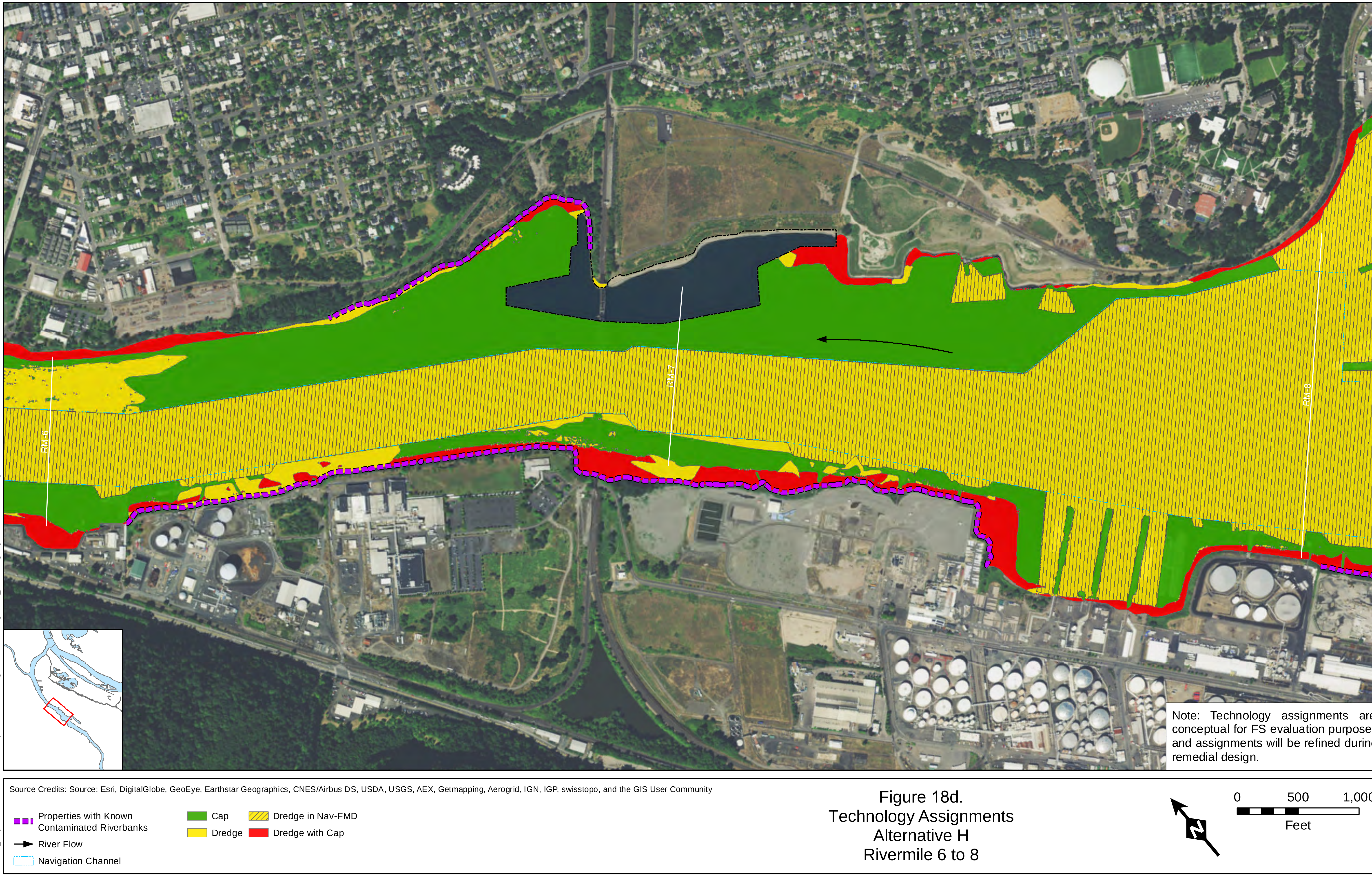

Figure 18d.
Technology Assignments
Alternative H
Rivermile 6 to 8

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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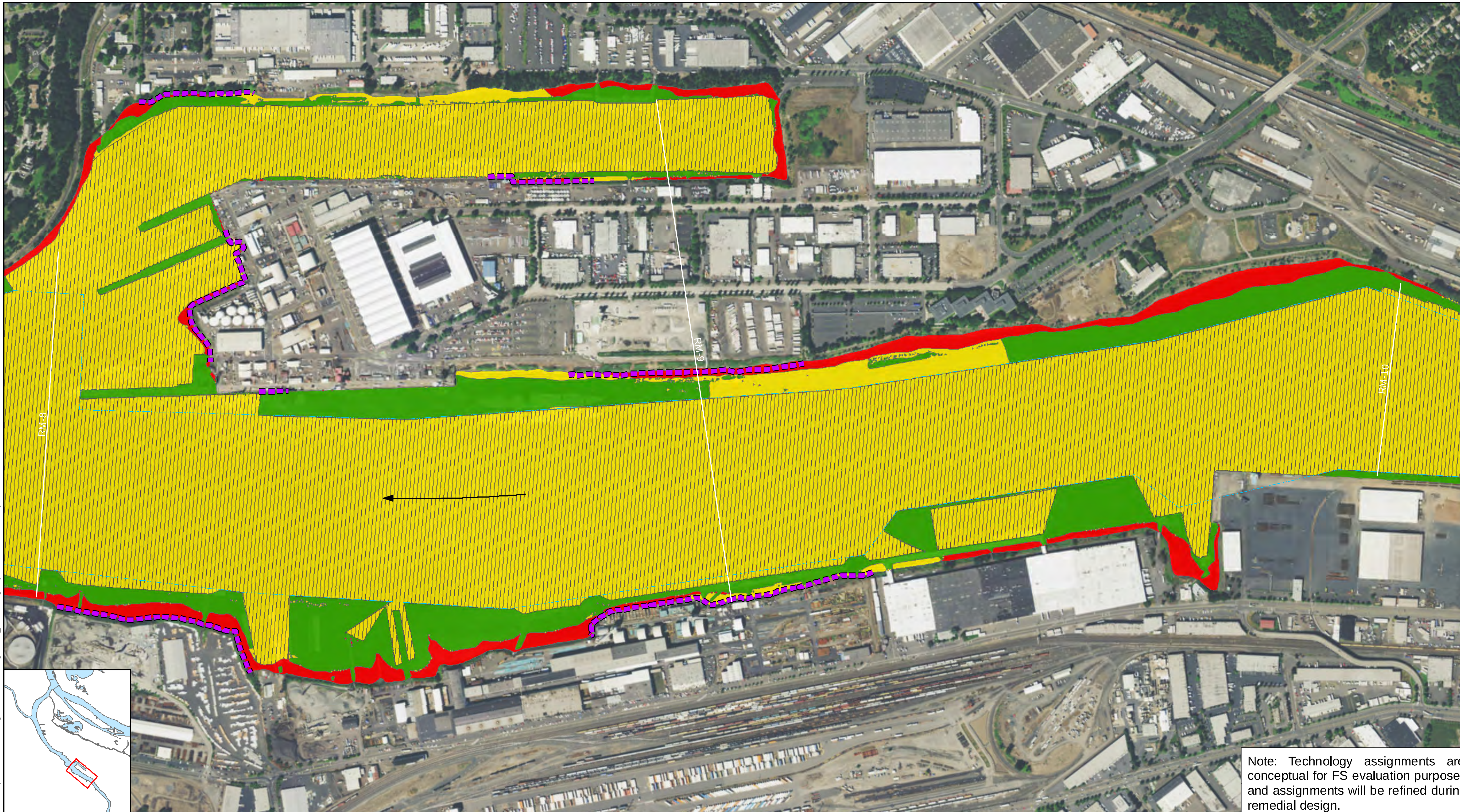

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 18e.
Technology Assignments
Alternative H
Rivermile 8 to 10

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 18f.
Technology Assignments
Alternative H
Rivermile 10 to 12

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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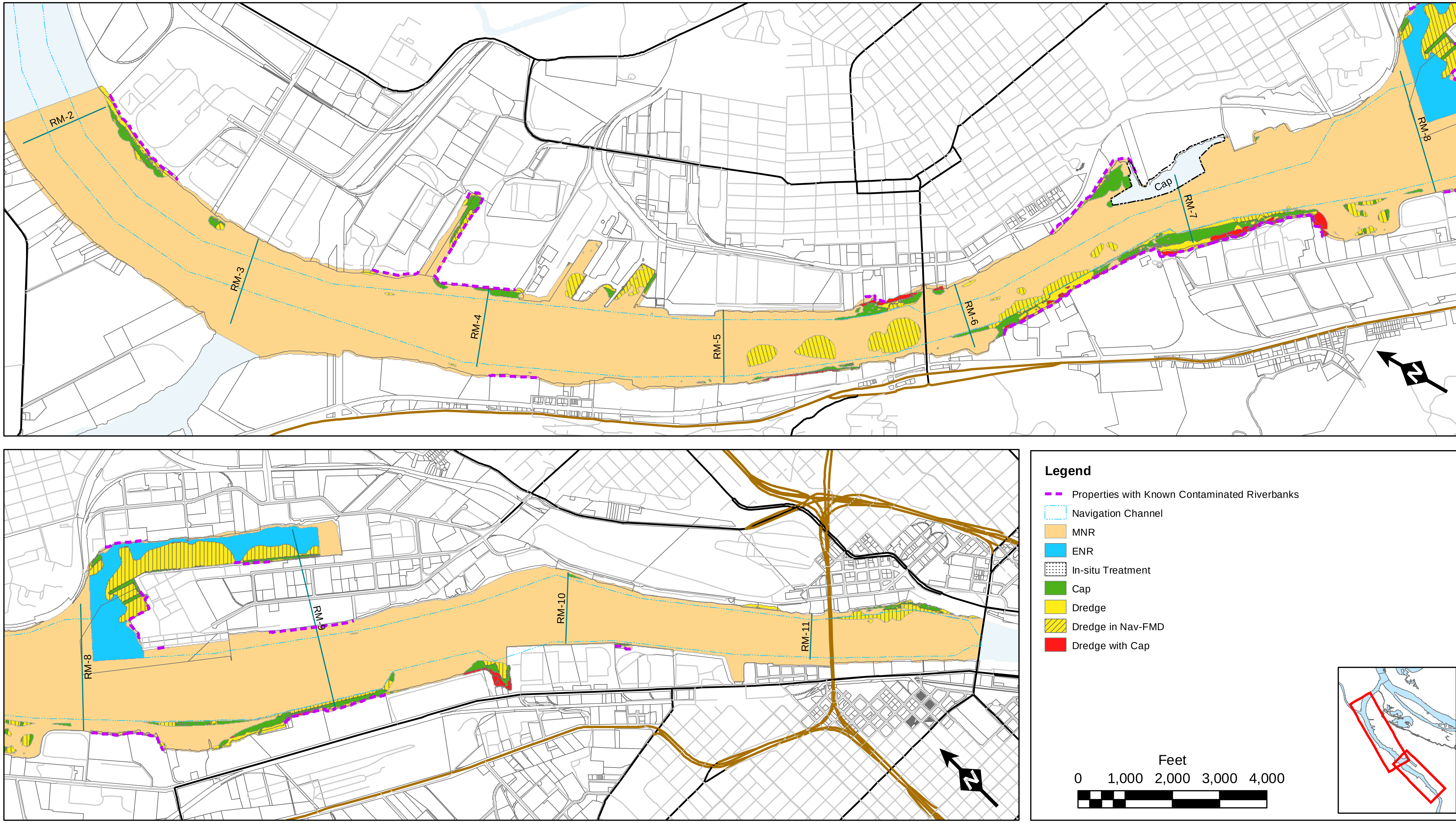

Figure 19a. Technology Assignments, Alternative I, Site-Wide

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 19b.
Technology Assignments
Alternative I
Rivermile 1.9 to 4

0 500 1,000
Feet

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\FS Figures\Section 3\Fig3-07-X_Tech-Assign-by-RM.mxd, Created by: MLF

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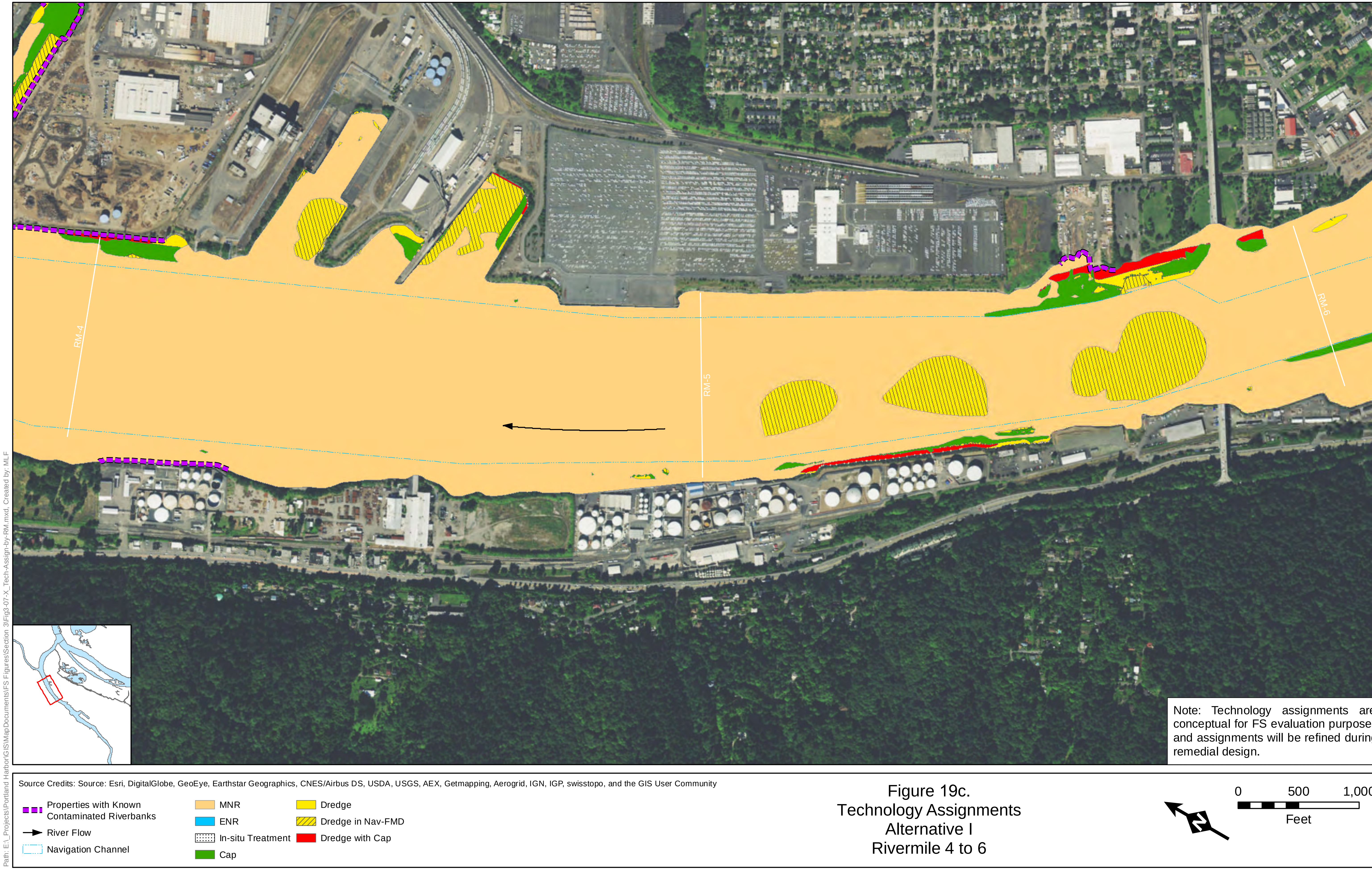
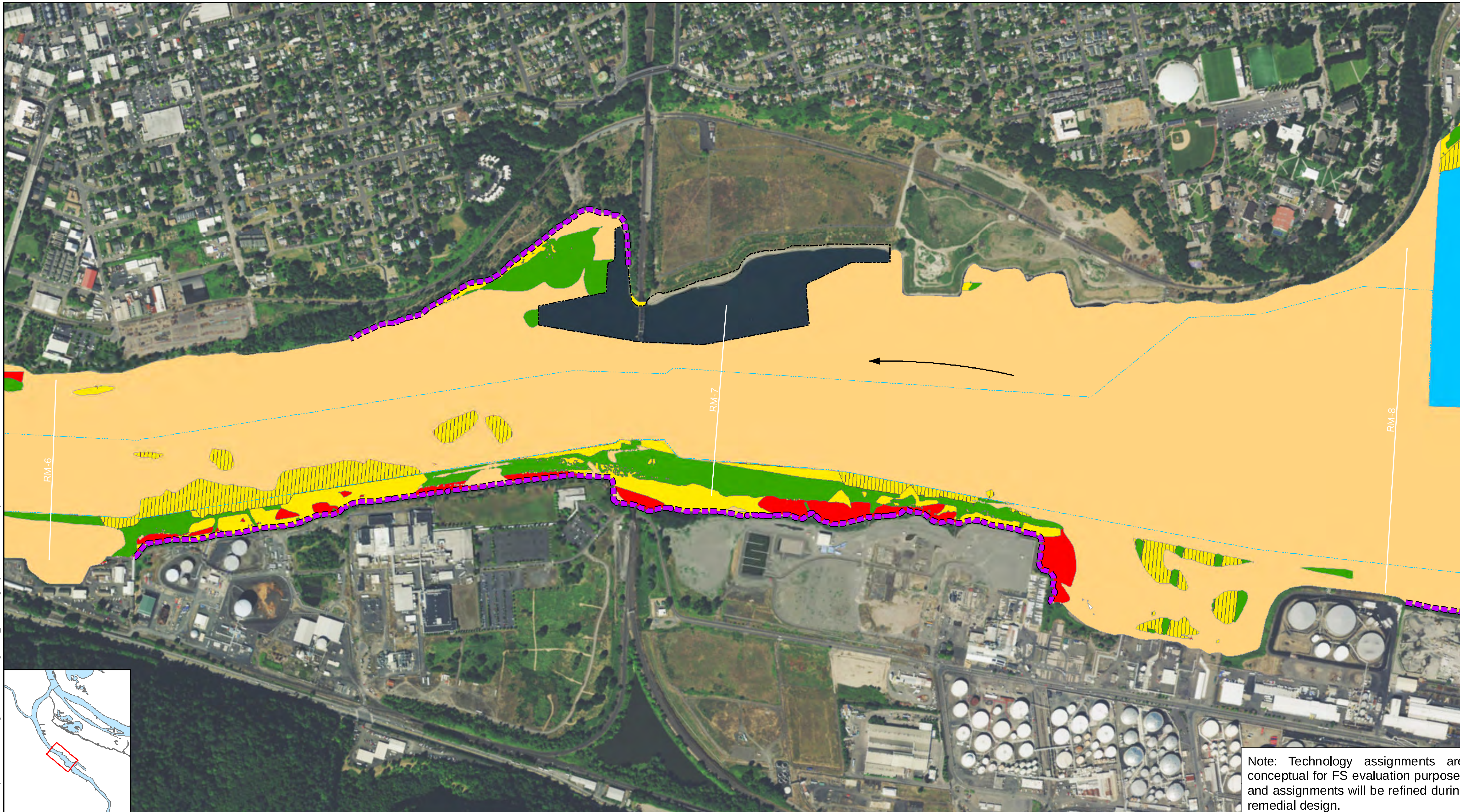


Figure 19c.
Technology Assignments
Alternative I
Rivermile 4 to 6



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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
MNR
ENR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 19d.
Technology Assignments
Alternative I
Rivermile 6 to 8

0 500 1,000
Feet

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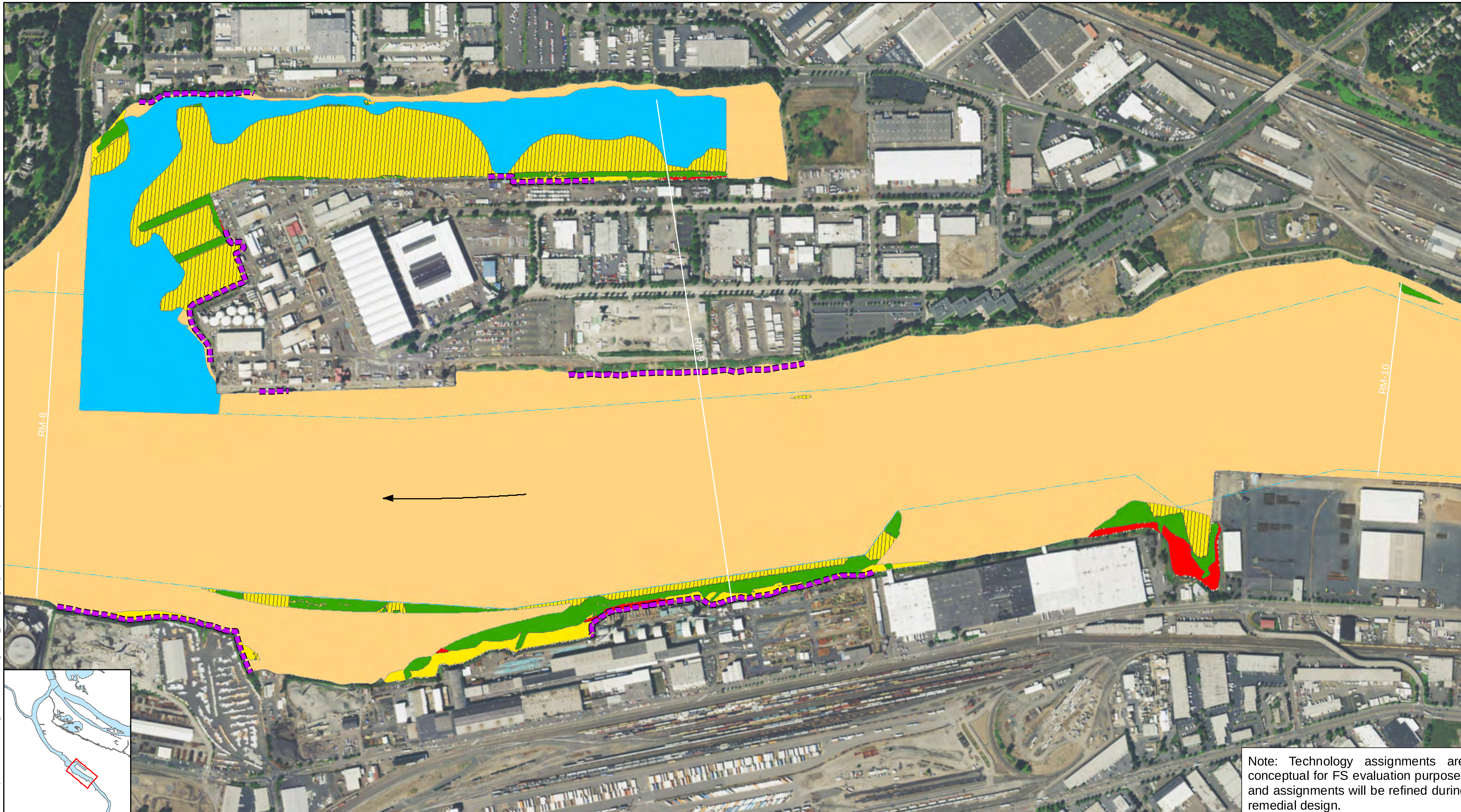

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- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- MNR
- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 19e.
Technology Assignments
Alternative I
Rivermile 8 to 10

0 500 1,000
Feet

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- Properties with Known Contaminated Riverbanks
- River Flow
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- ENR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 19f.
Technology Assignments
Alternative I
Rivermile 10 to 12

0 500 1,000
Feet

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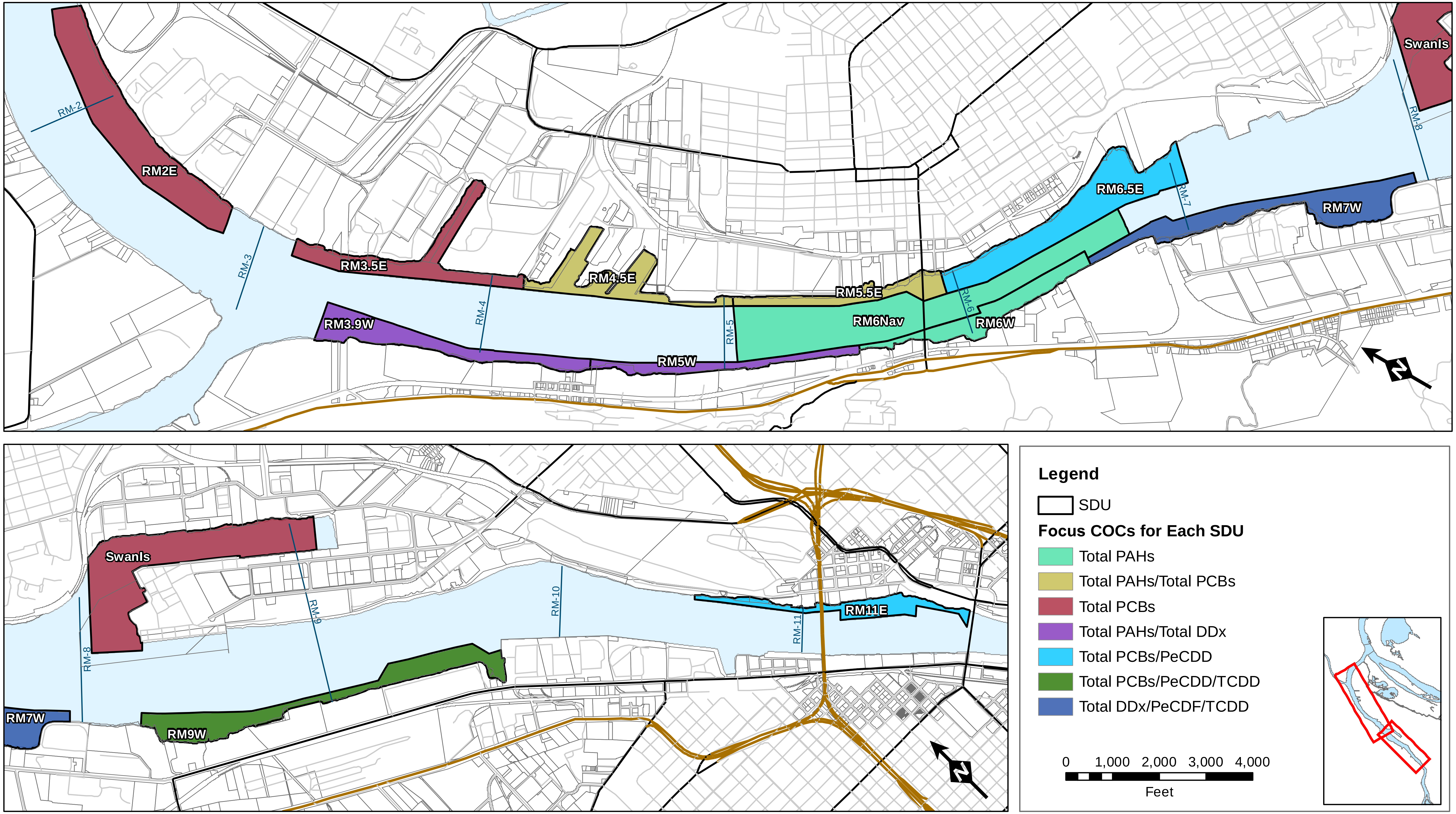

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Figure 20. Sediment Decision Units and Focus COCs

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Date: 8/17/2015

Tables

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Table 1 - Summary of Contaminants of Concern in Sediment

		Surface				Subsurface			
Contaminant	**Units**	**Frequency of Detection**	**Min-Max**	**Mean**	**Median**	**Frequency of Detection**	**Min-Max**	**Mean**	**Median**
Aldrin	µg/kg	254/1081	0.00333 - 691	5	0.5	127/1102	0.11 - 1,340	24	0.85
Arsenic	mg/kg	1348/1473	0.7 - 132	5	3.7	1429/1492	0.5 - 51	4	3.6
BEHP	µg/kg	884/1438	7 - 440,000	1,061	150	595/1496	2.4 - 18,000	355	95
Cadmium	mg/kg	1332/1460	0.0156 - 10	0.41	0.25	1377/1469	0.011 - 44	0.42	0.27
Chlordanes	µg/kg	723/1103	0.063 - 669	6	1.2	607/1103	0.11 - 2300	21	2.1
Copper	mg/kg	1457/1461	6.19 - 2,830	58	38.7	1481/1481	9.42 - 3,290	56	36
DDD	µg/kg	982/1179	0.051 - 11,000	43	2.3	969/1298	0.087 - 690,000	2483	4.5
DDE	µg/kg	964/1176	0.052 - 2,240	16	15.97	846/1298	0.054 - 24,000	81	3.9
DDT	µg/kg	801/1165	0.0613 - 81,000	259	2.19	755/1275	0.069 - 3,500,000	5,201	3.5
DDx	µg/kg	1072/1179	0.13 - 85,000	267	8.3	1065/1294	0.18 - 3,600,000	4,756	14
Dieldrin	µg/kg	238/1121	0.00834 - 356	3	0.28	72/1134	0.038 - 100	4	0.43
gamma-BHC	µg/kg	198/1126	0.0031 - 430	4	1.2	114/1145	0.052 - 172	5	1.29
Hexachlorobenzene	µg/kg	7/50	0.28 - 3	1	0.66	210/1270	0.066 - 14,000	78	0.94
HxCDF	µg/kg	201/222	0.000043 - 66	0.347	0.00127	183/250	0.000014 - 41	0.374	0.0023
Lead	mg/kg	1469/1484	1.1 - 13,400	49	15.8	1528/1536	1.54 - 3330	47	20
Mercury	mg/kg	1331/1452	0.005 - 65	0.144	0.068	1316/1395	0.004 - 17	0.192	0.089
PAHs, total	µg/kg	1559/1580	6.3 - 7,300,000	26,006	1,200	1553/1620	3.3 - 53,000,000	234,036	1,400
cPAHs (BaP eq)	µg/kg	1533/1580	0.42 - 450,000	2,477	130	1485/1620	0.26 - 1,300,000	9,163	140
PeCDD	µg/kg	131/222	0.00002 - 0.021	0.001	0.000219	128/251	0.000018 - 0.058	0.002	0.00035
PeCDF	µg/kg	175/222	0.000026 - 9	0.058	0.000551	168/251	0.000024 - 11	0.125	0.00069
TCDD	µg/kg	46/222	0.00004 - 0.111	0.003	0.00035	74/251	0.000045 - 0.084	0.003	0.00048
TCDF	µg/kg	139/222	0.000058 - 14	0.11	0.00088	125/250	0.000095 - 15	0.207	0.00164
PCBs (Aroclors)	µg/kg	725/984	6.2 - 6,000	162	40	744/1294	3.8 - 26,000	311	83
PCBs (congeners)	µg/kg	244/244	1.7 - 35,000	467	36	149/153	0.4 - 37,000	705	100
Tributyltin	µg/kg	321/342	0.45 - 47,000	480	22	213/397	0.32 - 90,000	1,469	29
Zinc	mg/kg	1490/1490	3.68 - 4,220	153	106	1521/1521	24 - 9,000	148	105

Table 2 - Summary of Contaminants of Concern in Surface Water

Contaminant	Units	Frequency of Detection	Minimum	Maximum	Mean	Median
Aldrin	µg/L	124/268	0.0000001	0.005	0.00004	0.000001
Arsenic	µg/L	295/346	0.18	0.75	0.39	0.39
BEHP	µg/L	37/226	0.004	64	4.09	1.00
Benzo(a)anthracene	µg/L	132/335	0.00003	0.27	0.006	0.0005
Benzo(a)pyrene	µg/L	107/335	0.00002	0.19	0.005	0.0005
Benzo(b)fluoranthene	µg/L	128/335	0.00002	0.13	0.004	0.0004
Benzo(k)fluoranthene	µg/L	13/179	0.0017	0.13	0.032	0.007
Chlordanes	µg/L	166/268	0.0000001	0.002	0.0001	0.00002
Chromium	µg/L	164/346	0.1	1.92	0.53	0.38
Copper	µg/L	344/346	0.37	3.68	1.02	0.87
DDD	µg/L	177/268	0.000001	0.003	0.0002	0.00004
DDE	µg/L	180/268	0.000003	0.001	0.00007	0.00004
DDT	µg/L	183/268	0.000001	0.02	0.0004	0.00003
DDx	µg/L	200/268	0.000008	0.02	0.0006	0.0001
Dioxin/Furan (TCDD eq)	µg/L	147/149	0.0000000003	0.0000009	0.00000006	0.00000002
Ethylbenzene	µg/L	8/23	0.55	11.4	3.09	1.65
Hexachlorobenzene	µg/L	165/353	0.000001	0.007	0.0001	0.00002
MCPP	µg/L	7/164	7.3	34	15	13
Naphthalene	µg/L	55/358	0.001	605	44	0.02
PAHs	µg/L	262/335	0.0001	7.4	0.07	0.01
PAHs (BaP eq)	µg/L	193/335	0.0000001	0.27	0.005	0.0002
PCBs	µg/L	735/876	0.000007	0.02	0.001	0.0002
Pentachlorophenol	µg/L	0/178	ND	ND	ND	ND
PeCDD	µg/L	65/149	0.000000002	0.0000005	0.00000002	0.00000001
PeCDF	µg/L	51/149	0.000000002	0.0000003	0.00000003	0.00000001
TCDD	µg/L	7/149	0.000000005	0.0000003	0.00000004	0.00000001
TCDD TEQ	µg/L	237/240	0.00000000004	0.0000009	0.00000004	0.000000006
Tributyltin	µg/L	11/167	0.001	0.004	0.002	0.001
Zinc	µg/L	208/346	0.9	58	3.68	2.74

Table 3 - Summary of Contaminants of Concern in Pore Water and Transition Zone Water

Contaminant	Units	Frequency of Detection	Minimum	Maximum	Mean	Median
Acenaphthene	µg/L	160/170	0.0031	680	41	3.1
Anthracene	µg/L	129/170	0.0027	257	7.2	0.14
Arsenic	µg/L	202/237	0.30	77	12	8
Benzene	µg/L	166/316	0.14	8,200	537	4.6
Benzo(a)anthracene	µg/L	80/170	0.0035	147	5.6	0.14
Benzo(a)pyrene	µg/L	70/170	0.0025	144	7.1	0.14
Benzo(b)fluoranthene	µg/L	59/170	0.0042	126	7.3	0.21
Benzo(g,h,i)perylene	µg/L	69/170	0.0041	54	4.5	0.13
Benzo(k)fluoranthene	µg/L	50/170	0.004	30	2.6	0.25
Cadmium	µg/L	119/188	0.004	36	0.48	0.099
Chlorobenzene	µg/L	66/312	0.15	30,000	856	2.1
Chromium	µg/L	147/228	0.2	147	13	4.1
Chrysene	µg/L	82/170	0.0033	174	6.3	0.11
Copper	µg/L	88/210	0.03	182	19	8.3
Cyanide	mg/L	52/61	0.004	23	1.03	0.18
1,1-DCE	µg/L	38/312	0.18	283	29	3.2
cis-1,2-DCE	µg/L	109/275	0.12	574,000	7,185	8.5
2,4-D	µg/L	10/18	0.12	0.97	0.32	0.18
DDD	µg/L	18/31	0.029	2.5	0.64	0.18
DDE	µg/L	10/31	0.0039	0.24	0.09	0.07
DDT	µg/L	14/31	0.0075	3.2	0.79	0.75
DDx	µg/L	22/31	0.0075	5.7	1.1	0.17
Dibenzo(a,h)anthracene	µg/L	50/170	0.0024	11.7	0.89	0.07
Ethylbenzene	µg/L	116/316	0.09	905	104	5.3
Fluoranthene	µg/L	116/170	0.0055	407	16.1	0.87
Fluorene	µg/L	135/170	0.0075	304	15.3	1.90
Indeno(1,2,3-cd)pyrene	µg/L	68/170	0.0037	53	4.0	0.11
Lead	µg/L	116/237	0.01	166	13.8	4.7
Manganese	µg/L	279/279	23	66,200	4,503	2,710
2-Methylnaphthalene	µg/L	49/157	0.0078	1,260	138	0.94
Naphthalene	µg/L	183/369	0.048	19,700	2,342	15
PAHs	µg/L	165/170	0.0025	21,000	1,470	8.1
cPAHs (BaP eq)	µg/L	104/170	0.0000033	188	6.3	0.06
PCE	µg/L	23/312	0.14	12,000	596	1.7
Pentachlorophenol	µg/L	0/11	ND	ND	ND	ND
PeCDD	µg/L	0/6	ND	ND	ND	ND
PeCDF	µg/L	1/6	0.0000013	0.0000013	0.0000013	0.0000013
Perchlorate	µg/L	21/42	105	210,000	61,002	49,900
Phenanthrene	µg/L	125/170	0.012	1,510	50	3.1
Pyrene	µg/L	121/170	0.012	409	17	0.87
Silvex	µg/L	4/18	0.76	22	7.0	2.6
2,3,7,8-TCDD	µg/L	0/6	ND	ND	ND	ND
TCE	µg/L	73/312	0.14	585,000	9,788	1.9
Toluene	µg/L	168/316	0.2	821	26	1.7
TPH-Diesel	µg/L	93/135	26	28,800	1,522	600
Vanadium	µg/L	9/24	11.6	379	91	40
Vinyl chloride	µg/L	130/312	0.06	28,900	421	2.5
Xylene	µg/L	144/316	0.11	1,430	86	2.6
Zinc	µg/L	144/237	0.95	983	64	17

Table 4 - Summary of Contaminants of Concern in Fish Tissue

		Fillet						Whole Body			
Contaminant	**Units**	**Frequency of Detection**	**Minimum**	**Maximum**	**Min - Max**	**Mean**	**Median**	**Frequency of Detection**	**Min - Max**	**Mean**	**Median**
Aldrin	µg/kg	15/53	0.005	0.119	0.005 - 0.119	0.05335	0.0541	47/141	0.00532 - 0.163	2.19	0.5
Arsenic	mg/kg	53/53	0.02	0.538	0.02 - 0.538	0.156962264	0.16	141/141	0.034 - 1.06	0.254618897	0.22
BEHP	µg/kg	4/33	69	130	69 - 130	96.5	98	20/124	44 - 87,000	8487	220
Cadmium	mg/kg	21/53	0.001	0.009	0.001 - 0.009	0.002952381	0.002	116/141	0.002 - 0.108	0.015750889	0.0093
Chlordanes	µg/kg	40/53	0.915	11.8	0.915 - 11.8	3.787125	1.765	97/141	0.59 - 67	9.42	9.13
Copper	mg/kg	53/53	0.127	1.12	0.127 - 1.12	0.360792453	0.335	141/141	0.365 - 7.16	1.09	0.9525
DDE	µg/kg	53/53	4.98	253	4.98 - 253	38.89641509	15	134/141	7 - 657	93	75
DDx	µg/kg	53/53	6.41	494	6.4 - 494	64.51132075	26	141/141	12.7 - 3,060	166.1120567	99.6
Dieldrin	µg/kg	33/53	0.183	3.3	0.183 - 3.3	0.936909091	0.436	78/141	0.23 - 24	3.106544304	2.11
Hexachlorobenzene	µg/kg	32/53	0.24	140	0.240 - 140	5.5	0.49	68/141	0.62 - 8.1	2.15	1.8
1,2,3,4,7,8-HxCDF	µg/kg	30/32	0.000013	0.00588	0.000013 - 0.00588	0.00062	0.00008	98/102	0.000051 - 0.0771	0.00187	0.00029
Mercury	mg/kg	53/53	0.035	0.349	0.035 - 0.349	0.13	0.096	141/141	0.01014 - 0.494	0.065	0.047
cPAHs (BaP eq)	µg/kg	10/38	0.00799	3.38	0.00799 - 3.38	0.79	0.04	24/127	0.0020 - 1.64	0.36	0.11895
PBDEs	µg/kg	26/32	8.28	82.3	8.28 - 82.3	27.5	11.2	No whole body results			
PCBs	µg/kg	53/53	19.6	19700	19.6 - 19700	650.9283019	96.2	141/141	30 - 25,100	842	301

Table 5 Summary of Contaminants of Concern in River Bank Soil

		Surface				Subsurface			
Contaminant	**Units**	**Frequency of Detection**	**Min - Max**	**Mean**	**Median**	**Frequency of Detection**	**Min - Max**	**Mean**	**Median**
Arsenic	mg/kg	66/66	1.5 - 70	14	5.7	133/159	1.04 - 143	7.9	4.7
BEHP	µg/kg	22/26	25.5 - 27,100	2,976	389	10/18	72 - 4,610	1,017	724
Cadmium	mg/kg	25/42	0.06 - 1.4	0.24	0.15	81/125	0.051 - 26	1.3	0.3
Copper	mg/kg	52/52	10 - 13,300	589	33	155/155	9.9 - 3,340	142	28
DDD	µg/kg	0/7	ND - ND	ND	ND	2/26	100 - 150	125	125
DDT	µg/kg	2/7	0.23 - 0.52	0.37	0.37	3/26	5.6 - 16	9.8	7.8
Hexachlorobenzene	µg/kg	1/4	22 - 22	22	22	0/26	ND - ND	ND	ND
Lead	mg/kg	72/72	3.6 - 4,160	469	40	157/159	2 - 2,950	164	16
Mercury	mg/kg	32/43	0.013 - 19	1.64	0.19	69/113	0.006 - 10.6	0.54	0.10
PAHs	µg/kg	25/25	25 - 6,150	889	420	20/26	110 - 600,000	92,061	5,500
PCBs	µg/kg	7/13	9.8 - 154	46	25	27/35	6 - 1,020	336	156
2,3,7,8-TCDD	µg/kg	4/4	0.0006 - 0.0022	0.00148	0.00156	No results			
Tributyltin	µg/kg	13/38	3 - 240	40.00	10.5	8/20	0.97 - 16	6.0	2.9
Zinc	mg/kg	72/72	42 - 9,470	1,057	111	162/162	15 - 9,000	329	83

Table 11 - Summary of PRGs by Media

	Surface Water			Groundwater			River Bank Soil/Sediment			Fish Tissue		
Contaminant	**Units**	**Conc.**	**Basis**	**Units**	**Conc.**	**Basis**	**Units**	**Conc.**	**Basis**	**Units**	**Conc.**	**Basis**
Aldrin	µg/L	0.00000077	A				µg/kg	2	R	µg/kg	0.06	R
Arsenic	µg/L	0.018	A	µg/L	0.018	A	mg/kg	3	B	mg/kg	0.001	R
Benzene				µg/L	0.44	A						
BEHP	µg/L	0.2	A				µg/kg	135	R	µg/kg	72	R
Cadmium				µg/L	0.091	A	mg/kg	0.51	R			
Chlordanes	µg/L	0.000081	A				µg/kg	1.4	R	µg/kg	3	R
Chlorobenzene				µg/L	64	A						
Chromium	µg/L	100	A	µg/L	11	A						
Copper	µg/L	2.74	A	µg/L	2.74	A	mg/kg	359	R			
Cyanide				µg/L	4	A						
DDx	µg/L	0.01	R	µg/L	0.001	A	µg/kg	6.1	R	µg/kg	3	R
DDD	µg/L	0.000031	A	µg/L	0.000031	A	µg/kg	114	R			
DDE	µg/L	0.000018	A	µg/L	0.000018	A	µg/kg	226	R			
DDT	µg/L	0.000022	A	µg/L	0.000022	A	µg/kg	246	R			
1,1-DCE				µg/L	7	A						
cis-1,2-DCE				µg/L	9.9	A						
Dieldrin							µg/kg	0.07	R	µg/kg	0.06	R
2,4-D				µg/L	70	A						
Ethylbenzene	µg/L	7.3	R	µg/L	7.3	R						
Hexachlorobenzene	µg/L	0.000029	A				µg/kg			µg/kg	0.6	R
Lindane							µg/kg	5	R			
Lead				µg/L	0.54	A	mg/kg	196	R			
Manganese				µg/L	430	R						
MCPP	µg/L	16	R									
Mercury							mg/kg	0.085	R	mg/kg	0.031	A
Pentachlorophenol	µg/L	0.03	A	µg/L	0.03	A				µg/kg	130	R
Perchlorate				µg/L	15	A						
PBDEs										µg/kg	26	R
PCBs	µg/L	0.0000064	A	µg/L	0.014	R	µg/kg	9	B	µg/kg	0.25	R
PAHs							µg/kg	23000				
cPAHs (BaP eq)	µg/L	0.00012	A	µg/L	0.00012	A	µg/kg	12	B	µg/kg	7.1	R
Acenaphthene				µg/L	23	R						
Acenaphthylene												
Anthracene				µg/L	0.73							
Benzo(a)anthracene	µg/L	0.0012	A	µg/L	0.0012	A						
Benzo(a)pyrene	µg/L	0.00012	A	µg/L	0.00012	A						
Benzo(b)fluoranthene	µg/L	0.0012	A	µg/L	0.0012	A						
Benzo(g,h,i)perylene												
Benzo(k)fluoranthene	µg/L	0.0013	A	µg/L	0.0013	A						
Chrysene	µg/L	0.0013	A	µg/L	0.0013	A						
Dibenz(a,h)anthracene	µg/L	0.00012	A	µg/L	0.00012	A						
Fluoranthene												
Fluorene												
Indeno(1,2,3-c,d)pyrene	µg/L	0.0012	A	µg/L	0.0012	A						
2-Methylnaphthalene												
Naphthalene	µg/L	12	R									
Phenanthrene												
Pyrene												
Dioxins/Furans (2,3,7,8-TCDD eq)	µg/L	0.0000000005	A									
1,2,3,4,7,8-HxCDF							µg/kg	0.0004	B	µg/kg	0.00006	R
1,2,3,7,8-PeCDD							µg/kg	0.0002	B	µg/kg	0.000006	R
2,3,4,7,8-PeCDF							µg/kg	0.0003	B	µg/kg	0.00002	R
2,3,7,8-TCDF							µg/kg	0.00040658	R	µg/kg	0.00006	R
2,3,7,8-TCDD							µg/kg	0.0002	B	µg/kg	0.000006	R
PCE				µg/L	0.24	A						
Toluene				µg/L	9.8	R						
TPH-Diesel				µg/L	2.6	R						
TBT	µg/L	0.063	A				µg/kg	3080	R			
TCE				µg/L	0.6	A						
2,4,5-TP				µg/L	50	A						
Vanadium				µg/L	20	R						
Vinyl Chloride				µg/L	0.022	A						
Xylenes				µg/L	13	R						
Zinc	µg/L	36.5	R	µg/L	36.5	R	mg/kg	459	R			

Notes:

A- ARAR

R - Risk

B - Background

Table 15 - Summary of Comparative Analysis for Remedial Alternatives

Remedial Alternative	Description	Threshold Criteria		Balancing Criteria				
		Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Present Value Cost (Dollars)
Contaminated Sediment Alternatives								
A	No Action/No Further Action	–	–	NA	NA	NA	NA	NA
B	Dredge/Cap 95 acres; ENR 100 acres MNR 1,966 acres; In-situ 7 acres Ex-situ 234,455 cy; Disposal 668,455 cy	–	–	○	○	◑	●	$
D	Dredge/Cap 177 acres; ENR 87 acres MNR 1,900 acres; In-situ 3 acres Ex-situ 234,455 cy; Disposal 1,339,192 cy	–	+	◔	◔	◕	◕	$
E	Dredge/Cap 269 acres; ENR 60 acres MNR 1,838 acres; Ex-situ 234,455 cy; Disposal 2,300,086 cy	+	+	◑	◑	◕	◑	$$
F	Dredge/Cap 505 acres; ENR 28 acres MNR 1,634 acres; Ex-situ 234,455 cy; Disposal 5,222,800 cy	+	+	◕	◕	◔	◔	$$$
G	Dredge/Cap 756 acres; ENR 19 acres MNR 1,391 acres; Ex-situ 234,455 cy; Disposal 8,432,900 cy	+	+	●	●	○	○	$$$$
I	Dredge/Cap 231 acres; ENR 60 acres MNR 1,876 acres; Ex-situ 234,455 cy; Disposal 1,987,600 cy	+	+	◑	◑	◕	◑	$$

Legend for Qualitative Ratings System:

Threshold Criteria		Balancing Criteria (Relative Performance of Criterion)		Balancing Criteria - Cost (Present Value Cost in Dollars)	
–	**Unacceptable**				
+	**Acceptable**	○	**Least**	$	**$500M through $750M**
		◔	**Low**	$$	**$750M through $1,000M**
		◑	**Moderate**	$$$	**$1,00M through $1,500M**
		◕	Better	$$$$	**Greater than $1,500M**
		●	**Best**		