LWG
LOWER WILLAMETTE GROUP

Portland Harbor Superfund Site
Draft Remedial Investigation Report

October 2009

EXECUTIVE SUMMARY

Prepared for:
The Lower Willamette Group

Portland Harbor Superfund Site Draft Remedial Investigation Report

In December 2000, the U.S. Environmental Protection Agency (EPA) identified the Portland Harbor area of the lower Willamette River (LWR, just north of downtown Portland, OR) as a priority for cleanup and placed it on the National Priorities List as a Superfund site.

The Draft Remedial Investigation (RI) report is a major milestone of the Superfund process to address environmental contamination by hazardous chemicals. It presents the results of the last eight years of work to characterize the Portland Harbor Superfund Site (the Site), to assess risks to human health and the environment from the Site, and to lay the groundwork for a Feasibility Study (FS) to evaluate cleanup options.

The Draft RI report is the result of cooperative working relationships between the group of businesses and public entities funding the study - the Lower Willamette Group (LWG) - and the EPA; the Oregon Department of Environmental Quality (DEQ); and federal, state, and Tribal trustees; as well as ongoing public involvement and outreach to the Portland community.

The Superfund work in the Portland Harbor area is one of many efforts focused on the greater Willamette River watershed. Other initiatives that address water quality, public health advisories, and land use are being conducted under several other federal and state programs, such as the Clean Water Act.

This Executive Summary contains:

- An overview of the Remedial Investigation and the Superfund process
- A summary of the Remedial Investigation results, including:
  - The physical, chemical and biological systems of the LWR
  - The baseline assessments of human health and ecological risks associated with chemicals present at the site
- A summary of the next steps in the Superfund process

BRIEFLY

- The Portland Harbor Superfund Site is within a major urban and industrial area. EPA has identified the Site as a priority for cleanup of chemical contamination.
- The Superfund work in the Portland Harbor area is one of many efforts focused on the greater Willamette River watershed. Other initiatives that address water quality, public health advisories and land use are being conducted under several other federal and state programs, such as the Clean Water Act.
- The Draft Remedial Investigation (RI) report describes the nature and extent of contamination, characterizes physical conditions and the potential movement of contaminants, and assesses the risks contamination poses to human health and the environment.
- The Draft RI report is the result of cooperative working relationships between the Lower Willamette Group (LWG) and EPA, the Oregon Department of Environmental Quality (DEQ), and federal, state, and Tribal trustees, as well as ongoing public involvement and outreach to the Portland community.
- Four chemical groups (PCBs, chlorinated dioxins and furans, the pesticide DDT and related breakdown products, and PAHs) account for most of the estimated human health and ecological risks in Portland Harbor. These four chemicals tend to be located with other chemicals that may also pose risk.
- PCBs are by far the most significant and widespread chemicals posing risks to humans and wildlife.
- Ingestion of fish represents the primary exposure pathway for risk to humans and wildlife, especially aquatic mammals. Risks to people from other exposure pathways, such as direct contact with sediment or water, are much lower.
- The next major milestone of the Portland Harbor Superfund Program will be a Feasibility Study (FS) that evaluates remedial alternatives and approaches to sediment cleanup.

Overview of the Remedial Investigation

The RI was conducted by the LWG, which is composed of the 10 parties who signed an Administrative Settlement Agreement and Order on Consent (AOC) with EPA to conduct the RI and FS at the Site and four other parties who have contributed financially to the project. The LWG is a small subset of potentially responsible parties identified by EPA.

PORTLAND HARBOR REMEDIAL INVESTIGATION/ FEASIBILITY STUDY TIMELINE

1997 | EPA Preliminary Assessment/Site Investigation
2000 | Portland Harbor Superfund Site Placed on National Priority List
2001 | Lower Willamette Group Members Sign Administrative Order on Consent
2002 | Remedial Investigation Round 1 Sampling Performed
2004 | Remedial Investigation Round 2 Sampling Begins
2006 | Remedial Investigation Round 3 Sampling Begins, Administrative Order on Consent Amended
2007 | Comprehensive Round 2 Site Characterization Summary and Data Gaps Analysis Report Submitted to EPA
2009 | Draft Remedial Investigation Report Submitted to EPA for Review
2010 | Draft Feasibility Study Report Expected to be Submitted to EPA
TBD | EPA Record of Decision and Post-Record of Decision Cleanup and Monitoring Activities

From 2001 to 2008, the LWG conducted the sampling and analysis described in the Draft RI report under the formal oversight of EPA and its partners including DEQ and the site's Natural Resource Trustees (U.S. Department of the Interior, National Oceanic and Atmospheric Administration, State of Oregon, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Grand Ronde Community of Oregon, Confederated Tribes of the Siletz Indians of Oregon, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe). EPA is the lead agency for the in-river site study and cleanup, and DEQ is the lead agency for investigating and controlling sources of contaminants entering the river.

STEPS IN THE SUPERFUND CLEANUP PROCESS

- Preliminary Assessment/Site Investigation
- Listing on the National Priority List
- Remedial Investigation/Feasibility Study
  - Scoping
  - Site Characterization (Remedial Investigation Report)
  - Development and Screening of Alternatives
  - Treatability Investigations
  - Detailed Analysis
- Record of Decision
- Remedial Design/Remedial Action
- Construction Completion
- Post Construction Completion
- Deletion of Site from National Priority List

The Draft RI report describes the nature and extent of contamination in the Study Area, characterizes sources of contaminants and the physical conditions that affect their movement, and assesses the risks contamination may pose to human health and the environment. A conceptual site model was developed to synthesize information gathered during the RI, including chemical sources and release mechanisms, pathways to the river, in-water transport and fate processes that affect the mobility of contaminants, and possible exposure and risks to ecological and human receptors.

The RI required a significant commitment of time and resources by the LWG, EPA and its partners. All of the parties involved have placed a high priority on a cooperative process to identify and resolve issues that are typically encountered in a Superfund investigation. Throughout the RI sample collection and analysis process, the LWG has worked with EPA and its partners to provide information to many sectors of the community, such as the Portland Harbor Community Advisory Group, business, educational institutions, and the media.

Study Area

The Study Area for the RI is a 10-mile stretch of the LWR. It is located north of downtown Portland between Sauvie Island (river mile [RM] 1.9) and the Broadway Bridge (RM 11.8).

The Study Area includes Portland Harbor, an urban and industrial reach of the LWR located immediately downstream of downtown Portland and extending almost to the confluence with the Columbia River. What was once, more than 100 years ago, a shallow, meandering portion of the LWR has been redirected, filled, and dredged. A federally maintained navigation channel, extending nearly bank-to-bank in some areas, doubles the natural depth of the river and allows transit of large ships into the active harbor. Much of the riverbank contains overwater piers and berths, port terminals and slips, and other engineered features (e.g., armoring such as rip rap makes up approximately half of the harbor shoreline). These extensive physical alterations have resulted in a river reach that bears little resemblance to its pre-industrialized character in terms of hydrodynamics, sediment processes, ecological habitat, and human uses.

The Willamette River is the 13th largest river in the contiguous United States, with substantial flows, averaging 33,000 cubic feet per second. Flows vary considerably by season, with the lowest flows occurring during the late-summer dry season, typically increasing by 10 times through the winter rainy season. River flows in the LWR are regulated to some degree by a series of upstream dams, although major floods of 200,000 cubic feet per second or more still occur every few years during large storms. Despite periodic scouring of some locations by floods, the Study Area is situated in a relatively low energy, depositional reach of the LWR. Although the LWR is over 100 miles from the Pacific Ocean, it is influenced by tides. Tides cause the river stage to rise and fall up to several feet through a tidal cycle. During the dry season, when river discharge is low, rising tides can cause intermittent flow reversals throughout the harbor.

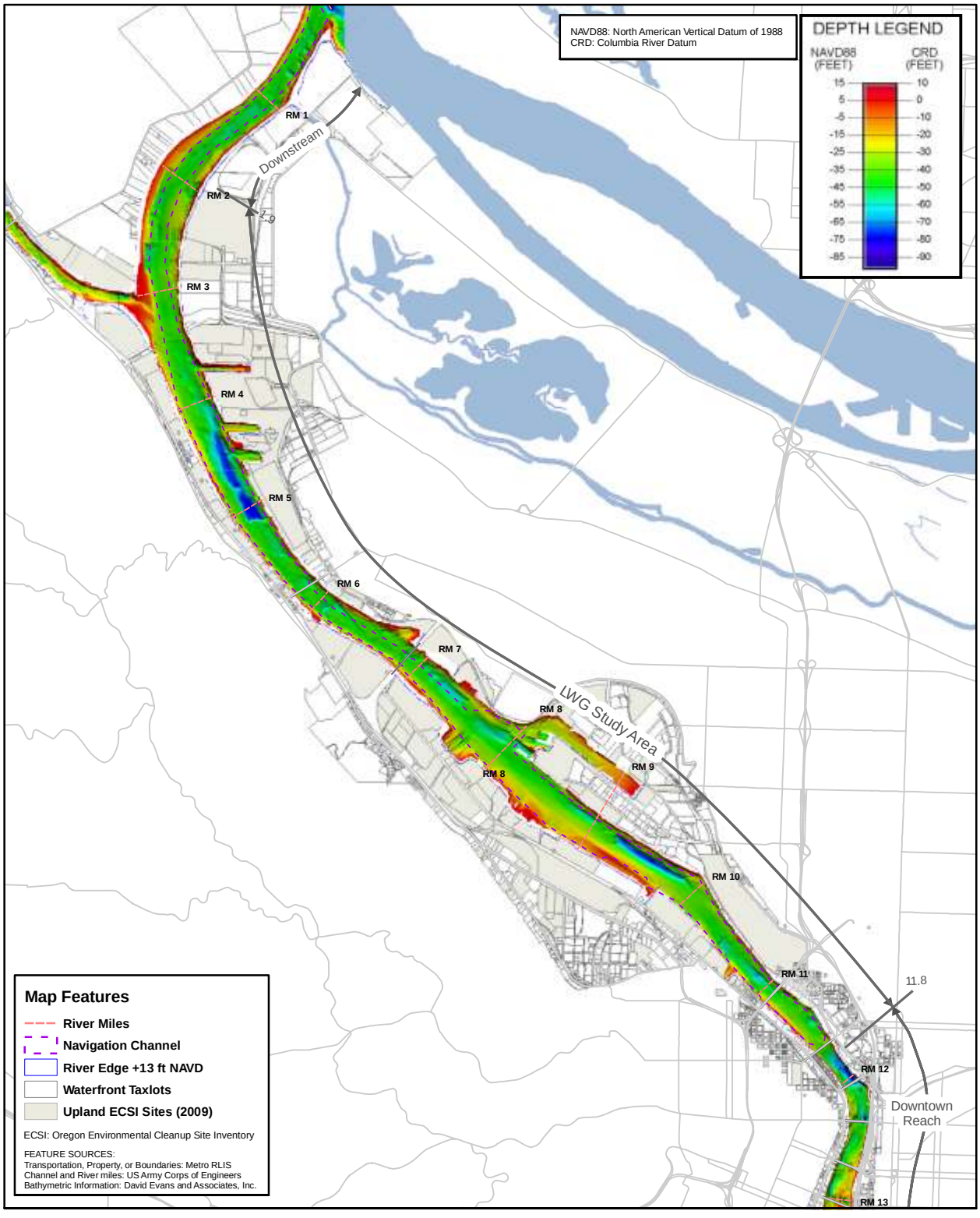
Current uses of the land and water in Portland Harbor include:

- Industrial and commercial operations
- Marine activities
- Surface transportation (railroads and roadways)
- Recreational use (including parks, boating and fishing)
- Cultural activities

Human activities contributed to chemical contamination of the Study Area via multiple pathways such as direct discharges, overwater releases and spills, stormwater and wastewater outfalls, overland flow, bank erosion and groundwater. Historical and current sources responsible for the existing contamination include, but are not limited to: 1) ship building, repair and dismantling; 2) wood treatment and lumber milling; 3) storage of bulk fuels and manufactured gas production; 4) chemical manufacturing and storage; 5) municipal combined sewer overflows (CSOs); and 6) stormwater from industrial, commercial, transportation, residential, and agricultural land uses. Various chemicals, including metals, polychlorinated biphenyls (PCBs), pesticides, polycyclic aromatic hydrocarbons (PAHs) from petroleum and other sources, and phthalates have been released to the river over many decades. More recently, cessation of operations, improved waste management practices, and source control activities have significantly reduced the amount of chemicals released to the Study Area.

Site Overview

2009 Bathymetric Hillshade



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Key Remedial Investigation Findings

The Draft RI report presents a detailed overview of the data gathering and analysis efforts performed at the Portland Harbor Superfund Site. Key findings of the RI include the following:

Extent of Contamination

- Higher concentrations of chemical contaminants in sediments occur in nearshore and off-channel areas.

- Chemical concentrations in sediment are generally higher in deeper sediments than in the surface layer, indicating that past chemical inputs were greater than current inputs, and that surface sediment quality has improved over time. The few exceptions include areas where higher surface sediment concentrations appear to be associated with ongoing local sources, low rates of sediment deposition, and physical disturbance of surface sediments, e.g., from boat scour.

- Chemical concentrations in surface sediments within the navigation channel and areas away from sources have relatively lower concentrations similar to levels measured in sediments upriver of the Study Area in areas unaffected by Portland Harbor sources.

Estimates of Risk

- Chemicals accounting for most of the estimated human health and ecological risks are primarily PCBs, and to a lesser extent dioxins/furans, PAHs, and the pesticide DDT and related breakdown products (collectively known as DDTs).

- PCBs are by far the most significant contributors to human health risk, with ingestion of fish representing the primary exposure pathway and the highest estimated risk.

- Consumption of fish and shellfish from the Study Area may pose human health risks that are greater than the EPA target risk range for human health (greater than one in a million [10^{-6}] to one in ten thousand [10^{-4}] excess risk of cancer).

- PCBs are also the most significant contributor to the estimated ecological risks, with the mink population being the receptor most at risk from PCB exposure. Along with total PCBs, total PAHs and total DDTs were associated with toxicity to benthic (i.e., bottom-dwelling) invertebrates in several localized areas constituting approximately five percent of the Study Area.

- Assessment of human health and ecological risks requires an understanding of chemical toxicity and estimates of exposures to these chemicals. The methods used to estimate risks within the Study Area are intended to be conservative and therefore may overestimate actual risks.

- Accumulation of PCBs in fish tissue is a regional (i.e., watershed-wide) and global problem that is not limited to fish within the Study Area. Consequently, fish in the Willamette and Columbia Rivers (outside of the Study Area) also contain PCBs that pose an increased cancer risk of greater than 10^{-4} based on a comparison with the EPA target fish tissue concentration. However, the concentrations of PCBs in fish tissue collected within the Study Area are generally higher than fish tissue concentrations at the regional level.

Sources of Contamination

- Much of the sediment contamination in the Study Area is associated with known or suspected historical sources and practices that have largely been discontinued or otherwise controlled. Industrial activities along the harbor included ship building, dismantling, and repair; gas and chemical manufacturing; steel production; wood treatment operations; metal recycling; fuel storage and transfer operations; electrical production and distribution; and rail yards. Other potential sources along the harbor included ship terminals, roads, numerous wastewater and stormwater outfalls and runoff, and overwater discharges. Agricultural activities, while present within the harbor in the early part of the last century, now occur primarily upriver.

- Chemicals still reach the Study Area through various pathways including stormwater, permitted industrial discharges, atmospheric deposition, bank erosion, groundwater, and incidental releases within the Study Area, and in surface water and sediment inflows from upstream.

- Upstream sources include or have included sewers, stormwater runoff, and direct discharge of industrial wastes; agricultural runoff; and aerial deposition of global or regional contaminants on the river water surface and drainage areas within the Willamette Valley.

- For most chemicals, the current mass of contaminants entering the Study Area from upstream river flows (in surface water and suspended sediments) per year exceeds the current mass from upland sources within the Study Area. This is due to the large volume of water and sediments that enters the Study Area from upstream.

- Stormwater input is likely the most important current source pathway within the Study Area (i.e., excluding upstream sources) for many chemicals. The issue of localized sources will be further evaluated in the recontamination analysis in the FS.

- Significant contributions of contaminants to the Study Area via groundwater are currently limited to only a few upland properties where there is known groundwater contamination.

- Although many specific sources of contamination have been identified, the RI report is not an exhaustive list of current or historical sources of contamination. Identification and evaluation of potential sources is ongoing.

Potential for Contaminant Transport Within and Downstream of the Study Area

- Most of the sediments with the highest chemical concentrations that pose potential risk are associated with relatively stable, nearshore areas.

- Most nearshore areas and much of the navigation channel are stable, depositional environments. Two well-defined portions of the channel (i.e., RM 5 to 7 and upstream of RM 10) are more dynamic and potentially subject to erosion during flood events. Deep sediments (greater than 1-ft sediment depth) in these two channel areas are generally not highly contaminated so the risks of re-exposure of buried contaminants during a flood event and downstream dispersal of contaminants are low.

- Sediments immediately downstream of the Study Area in either the Willamette River main stem or Multnomah Channel show little evidence of chemical migration from the Study Area.

The results of the RI and risk assessments provide the information necessary to evaluate remedial alternatives to reduce risk to human health and the environment. This evaluation will occur during the FS.

Summary of Data Collected for the Portland Harbor Remedial Investigation

The investigations to support the site characterization were performed by the LWG between 2001 and 2008. Three major rounds of environmental sampling addressed different investigation needs, often timed around varying river stages, seasonal river flows, and storm events. Extensive physical studies (e.g., time-series bathymetric surveys) and sampling and chemical testing of sediment, surface water, transition zone water (TZW), and biota were conducted to support the RI, the risk assessments, and the FS.

Round 1 sampling, which focused on the collection of biota (tissue) samples, was conducted in 2002. Round 2 sampling began with multiple field efforts in 2004 and focused on the characterization of surface and subsurface sediment quality. In 2006, specialized sampling to support the hydrodynamic sediment transport model (e.g., surface sediment erosion rates) was conducted. Round 3 sampling between 2006 and early 2008 included collecting samples of surface water, biota, sediment upstream and downstream of the Study Area, suspended sediments (in-river sediment traps), and stormwater from selected outfalls. Round 3 sampling also filled data gaps related to site characterization, ecological and human health risks, upriver background, and the FS.

Data Collected for the Portland Harbor Remedial Investigation

NUMBER	COLLECTED SAMPLE TYPES AND INVESTIGATIONS
1,949	Surface sediment and beach composite samples
2,168	Subsurface samples from 860 core locations
460	Composite tissue samples
282	Surface sediment samples tested for toxicity to aquatic invertebrates
186	Surface water samples from 25 point and transect stations
420	Transition zone water samples from 9 sites
52	In-river sediment trap samples from 16 locations
501	Stormwater outfall composite water samples
44	Stormwater outfall sediment trap samples
281	Catch basin and in-line solids samples
6	Groundwater seep samples
500	Sediment profile images
800	Sediment trend analysis sample points
5	Major bathymetry surveys of 16 miles of the LWR
1	Time-series sediment stake nearshore bank elevation change measurements
3	Acoustic doppler current profiler surveys
1	Hydrodynamic and sediment transport model data collection effort
	In addition, the LWG conducted three wildlife habitat surveys and a cultural resource survey.

Note: Table includes data collected by LWG and other relevant studies.

Draft Remedial Investigation Findings
Physical, Chemical and Biological Systems

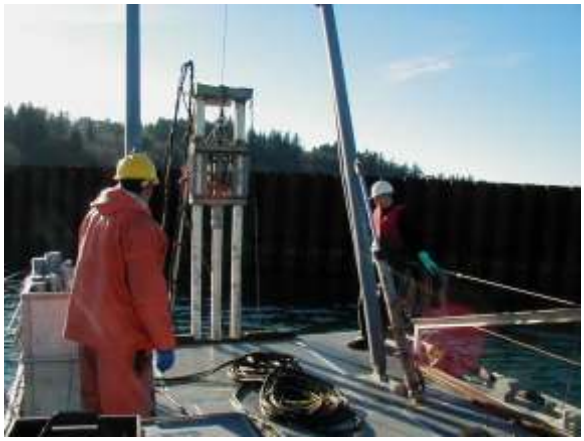
The results of RI studies performed to characterize the physical, chemical, and biological systems in the Study Area are described in the following sections.

Physical System

Portland Harbor occupies the last 12 miles of the Willamette River just above its confluence with the Columbia River. It is the widest portion of the LWR and overall acts as a depositional environment for sediments that enter the reach from upstream. Sediments need to be periodically dredged from portions of the navigation channel and berthing areas to allow marine operations. Sediments in some locations may also be resuspended and move downstream during periods of high flow such as flood events. Resuspension of sediments can also result from disturbances caused by ships operating within the harbor and other in-water activities.

The degree of deposition and movement of sediments is controlled largely by the texture (i.e., grain size and organic matter content) of the sediments, water velocity, and human activities. Once in suspension, finer-grained sediments including clay and silt are characteristically transported farther than larger sandy sediments under all flow conditions.

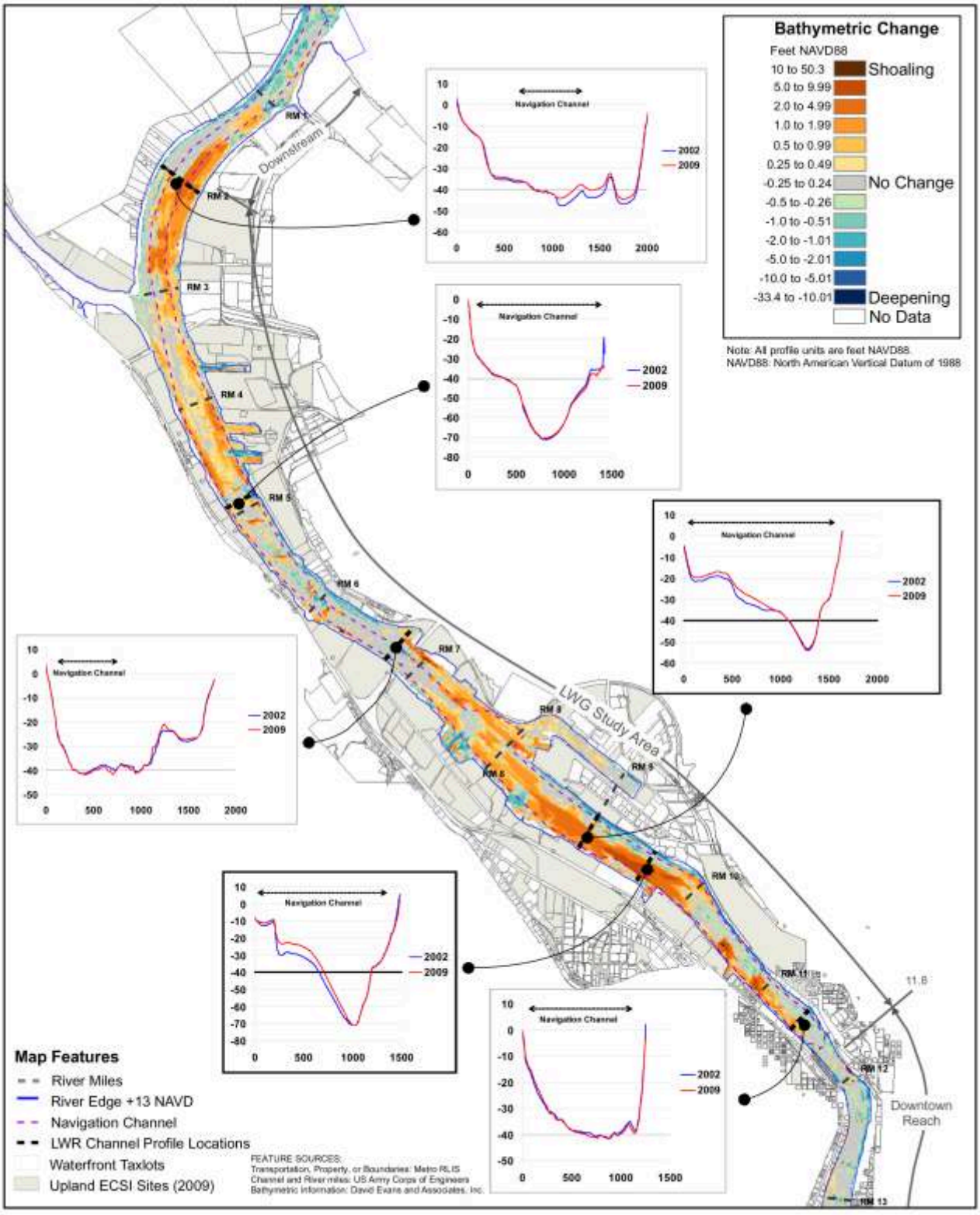
Bathymetric changes from 2002 to 2009 suggest the greatest net sediment accumulation from deposition on the river bottom occurs in the channel where the river is wide and where flow velocities are reduced. These shoaling areas show relatively high percentages of silt and clay sized particles. Long-term deposition rates are particularly high in some sections of the channel, exceeding 1 foot per year in the large shoal present from RM 7 to 10. Some natural scour areas and slip and berthing areas that have been dredged were also evident in the



bathymetric change data. The RI sediment transport model predicts that intermittent periods of erosion (i.e., greater than 1 ft) during flood events are limited to relatively narrow portions of the channel (e.g., RM 5 to 7). In these areas, sediments are relatively stable during low flow conditions but may be eroded when exposed to unusually high flow velocities.

Nearshore areas between the channel edge and riverbank, and off-channel areas, such as Swan Island Lagoon, Willamette Cove, and port terminals, do not show much net sediment accumulation. Evidence of sediment scour in some of these locations appears to be due to bottom disturbance by ship traffic (wakes and prop wash) and possibly other human activities. These factors also appear to mix surface sediments without resulting in net erosion or deposition.

Lower Willamette River Channel Profiles and Bathymetric Change 2002 - 2009



Chemical System

Various abiotic media (e.g., sediments, surface water) and biota from the Study Area have been analyzed for a wide range of chemicals of interest and physical parameters. Four chemical groups (total PCBs, total dioxins and furans, total DDTs, and total PAHs) are considered "bounding indicator chemicals" because their distribution is believed to encompass the spatial extent of chemicals posing potentially unacceptable risk identified in the baseline risk assessments. This is not intended to imply that other chemicals will not be evaluated in the FS.

The following focuses on important trends in distributions of these four bounding indicator chemicals. The Draft RI report contains a detailed evaluation of these four bounding indicator chemicals, as well as other indicator chemicals, in the Study Area.

SUMMARY STATISTICS FOR TOTAL PCBs, TOTAL DIOXINS/FURANS, TOTAL DDTs AND TOTAL PAHs IN SURFACE AND SUBSURFACE SEDIMENT, STUDY AREA (RM 1.9-11.8)

		CONCENTRATION			
Analyte	Number Analyzed	Mean	Median	95th Percentile	Maximum
Total PCBs (µg/kg) ppb					
Surface Sediment	1,191	176	19.5	553	35,400
Subsurface Sediment	1,326	265	27	486	150,000
Total Dioxins/Furans (pg/g) ppt					
Surface Sediment	216	2,480	391	5,620	264,000
Subsurface Sediment	241	2,550	279	4,150	218,000
Total DDTs (µg/kg) ppb					
Surface Sediment	1,210	249	6.5	376	84,900
Subsurface Sediment	1,291	7,360	9.01	743	3,640,000
Total PAHs (µg/kg) ppb					
Surface Sediment	1,603	28,100	1,120	65,600	7,260,000
Subsurface Sediment	1,545	219,000	1,130	266,000	53,300,000

ppb = parts per billion ppt = parts per trillion

Bottom Sediments

Elevated concentrations of chemicals in Study Area sediments are generally found in localized nearshore and off-channel areas (e.g., slips, embayments, and shallow areas) near some known or suspected sources. Concentrations of organic contaminants and metals tend to be higher in subsurface sediments than in surface sediments, particularly in depositional areas. The navigation channel, Multnomah Channel, and areas downstream and upstream of the Study Area generally have lower chemical concentrations in bottom sediment, especially for organic contaminants.

Well-defined areas of elevated PCB concentrations in bottom sediments were identified at locations throughout the Study Area. Elevated concentrations of total dioxins/furans are mostly concentrated in nearshore sediments at the center of the Study Area around RM 7. The area of highest total DDTs concentrations occurs along the western shoreline between RM 6 and 7.5. Total DDTs concentrations are generally higher in the subsurface than in the surface layer indicating predominantly historical point and nonpoint sources of DDTs. With few exceptions, total PAH concentrations are higher in subsurface than in surface sediments. Total PAH concentrations are highly variable across the Study Area, with peak concentrations around RM 6.

Upstream areas characterized during the RI for comparison with the Study Area included the downtown reach (RM 12 to 16), immediately above the Study Area, and upriver of Ross Island to Willamette Falls (RM 16 to 26). Excluding some known or suspected source areas and cleanup sites in the downtown reach, sediment chemical concentrations in these more physically dynamic reaches upstream of the Study Area are generally low and the sediments are sandier.

Most areas of highly elevated concentrations appear to be stable over time. However, migration of some chemicals within the Study Area is evident in limited areas consistent with source types and general sediment transport patterns. Sediments immediately downstream of the Study Area in either the Willamette River main stem or Multnomah Channel show little evidence of chemical migration from the Study Area.

Suspended Sediments

Elevated concentrations of chemicals in samples collected from sediment traps correspond with areas where chemical concentrations in surface sediments on the river bottom are very high, indicating the effect of resuspension of bottom sediment on water quality, the presence of current sources, or both. Sediment trap samples from the Study Area generally had higher concentrations of indicator chemicals than samples from upstream of the Study Area.

Surface Water

Concentrations of PCBs, pesticides, dioxins/furans, and PAHs in surface water were measured down to extremely low levels, parts per quadrillion in some cases, using specialized sampling techniques. Concentrations of these chemicals in surface water samples varied both spatially and with river flow.

Concentrations of total PCBs, total dioxins/furans, and total PAH in surface water within the Study Area were generally higher than those upstream of the Study Area under all flow conditions. Elevated concentrations were generally observed in both transect (i.e., cross-river composite samples) and single-point surface water samples at various locations throughout the Study Area. The highest concentrations of total DDTs and total PAHs in surface water during low-flow conditions were found adjacent to known sources of these chemicals. The highest total PCB concentrations are associated with single-point samples collected at RM 6.7 within Willamette Cove during low-flow conditions. At RM 2, at the downstream end of the Study Area, concentrations of total PCBs, total dioxins/furans, total DDTs, and total PAHs in surface water were generally lower than the rest of the Study Area.

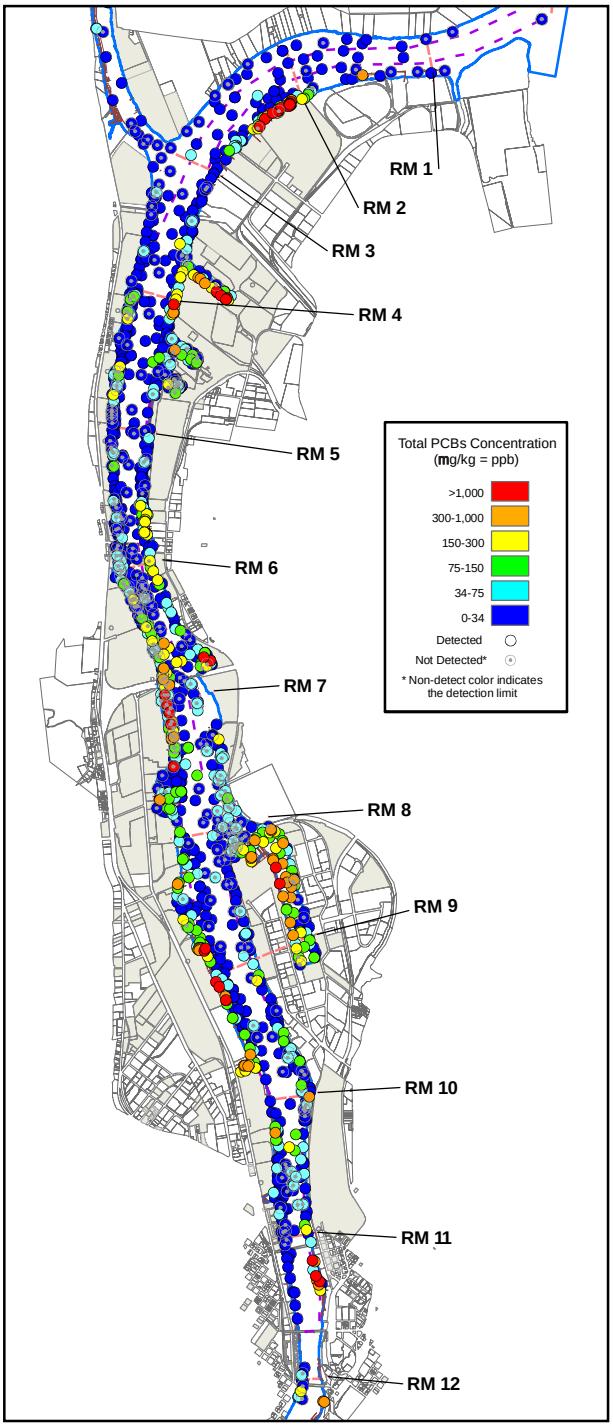
Concentrations of total PCBs and total PAHs in surface water tended to decrease with increasing flow rates due to the effect of dilution under higher flow conditions. No clear relationship was found between total dioxins/furans concentrations and river flow. Total DDT concentrations in surface water upstream of the Study Area were elevated in high-flow conditions, suggesting DDTs were mobilized from upstream sources during high-flow conditions.

Transition Zone Water

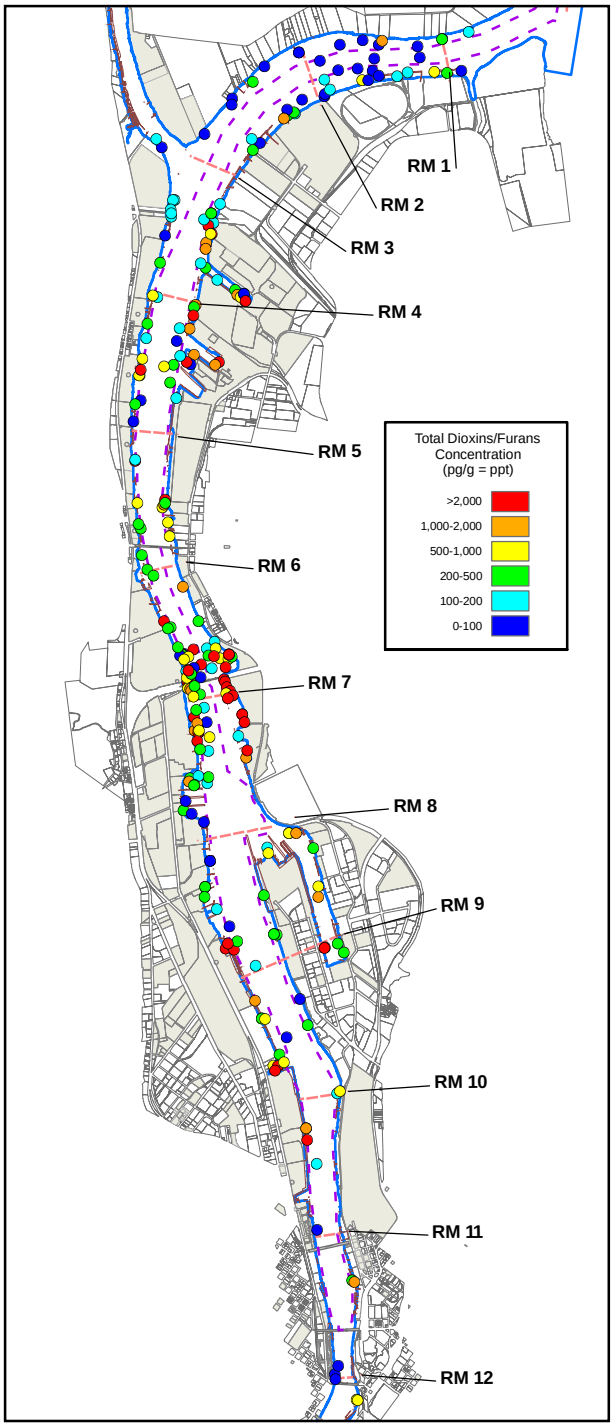
Samples of TZW (pore water) in surface and near surface sediments were collected offshore of nine upland sites where groundwater was suspected of potentially impacting sediment and/or pore water quality. The groundwater pathway was shown to potentially influence sediment/pore water quality at four of these sites.

Surface Sediment Samples (0 - 1ft)

Total PCBs Concentration



Total Dioxins/Furans Concentration



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0 0.25 0.5 1 Miles

N

FEATURE SOURCES:
Transportation, Property, or Boundaries: Metro RLIS.
Channel & River miles: US Army Corps of Engineers.
Bathymetric Information: David Evans and Associates, Inc.

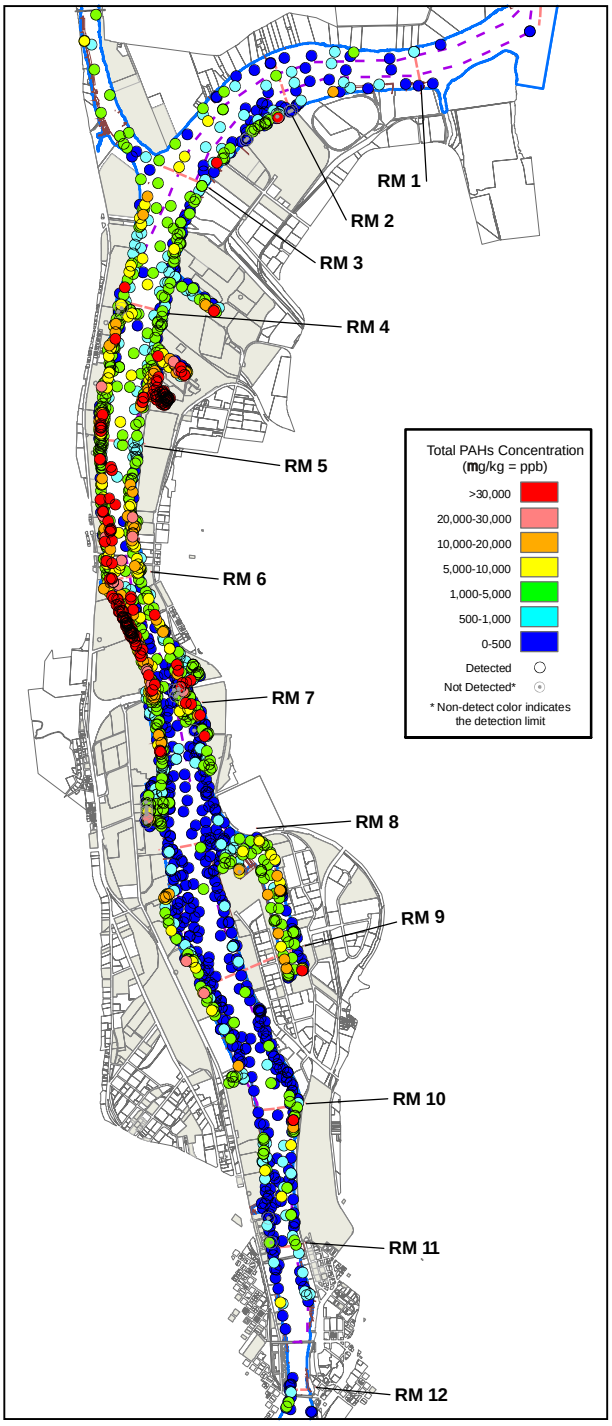
Map Features

- River Miles
- Navigation Channel
- River Edge +13 ft NAVD
- Bridges
- Waterfront Taxlots
- Upland ECSI Sites (2009)

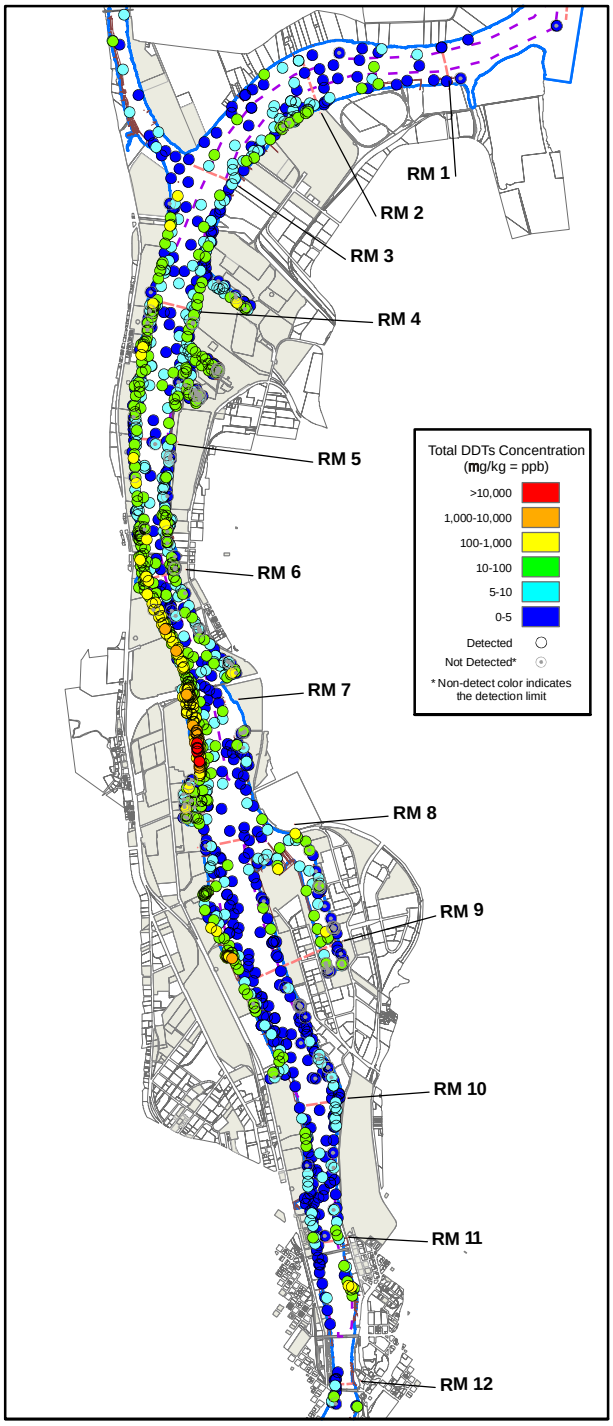
ECSI: Oregon Environmental Cleanup Site Inventory

Surface Sediment Samples (0 - 1ft)

Total PAHs Concentration



Total DDTs Concentration



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0 0.25 0.5 1 Miles

FEATURE SOURCES:
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Map Features
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ECSI: Oregon Environmental Cleanup Site Inventory

Fish and Invertebrate Tissue

PCBs, dioxins/furans, DDTs, and PAHs were detected in most samples of various fish and invertebrate species across the entire Study Area. Concentrations of these indicator chemicals varied greatly within and between species, with fish tissue concentrations generally greater than those in invertebrates. Concentrations of bioaccumulative compounds such as PCBs and DDTs were often found at greater concentrations in organisms higher on the food chain. On a site-wide scale, biological samples from within the Study Area exhibited greater concentrations of most indicator chemicals than those seen in samples from upriver reaches and above Willamette Falls. Localized areas of elevated concentrations of some indicator chemicals were found in resident species (e.g., sculpin), reflecting high concentrations in nearby surface sediment and biological uptake by species with small home ranges.

Sources of Chemical Contaminants

Chemicals from upland areas have entered the river system directly through outfalls, overwater releases and spills, and indirectly through overland flow, bank erosion, groundwater, and other nonpoint sources. In addition, contaminants from regional sources have reached the Study Area through inputs of surface water and sediment from upstream and through atmospheric deposition.

The main ongoing sources quantified in the Draft RI report are upstream surface water inputs (all upstream watershed sources), local stormwater in the Study Area, groundwater, and atmospheric deposition. Some unquantified sources such as bank erosion may also be important in localized areas.

Biological System

The Study Area is an active working harbor and supports invertebrate, fish, and wildlife communities as well as human recreation (e.g., boating, fishing, beach uses).

Ecosystem

Portland Harbor includes habitat for invertebrates, fishes, birds, mammals, amphibians, reptiles, and aquatic plants. Each group makes a contribution to the ecological function of the river, with its relative importance depending on its niche, its abundance, and its interaction with the physical environment.

The invertebrate community living in the sediments of Portland Harbor is dominated by worms, midge (fly) larvae, amphipods (small shrimp-like animals), mayfly larvae, caddisfly larvae, flatworms, crayfish, and the invasive Asiatic clam. Many of these benthic invertebrates provide important food for fish in the Study Area.

The diverse fish species that use Portland Harbor include migratory fish, such as salmon, lamprey, and sturgeon, and numerous resident fish, including recreational species such as smallmouth bass. Fish in the harbor provide an important food resource for birds, such as osprey and bald eagle, and some larger fish species like northern pikeminnow and smallmouth bass. Many aquatic mammals also feed on fish.

Birds that use the harbor include many migratory and resident species. Resident birds such as bald eagle, Canada goose, mallard, spotted sandpiper, great blue heron, and others are found in the Study Area. Spotted sandpiper, osprey, and bald eagle were selected for evaluating ecological risk to birds, the sandpiper because of its habit of probing mud for food, and osprey and bald eagle because they prey on fish and are high on the food chain.

Mink and river otter were used for assessing ecological risks to mammals because they feed on fish and shellfish. Mink are rare in the Study Area due to limited habitat. Evidence and sightings of river otter are more common. Other mammals with habitat in the Study Area include beaver, muskrat, raccoon, and California sea lion.

Portland Harbor provides limited habitat for amphibians and reptiles. Most of the native amphibians that might be found in Portland Harbor prefer undisturbed areas that offer seasonal wetlands with emergent plants and shallow waters. Most local reptile species prefer wet vegetated upland habitats.

Aquatic plant communities are used by wildlife for refuge and for nesting and breeding habitat. The plants also provide food for herbivores and play a role in the cycling of nutrients. Current habitat constraints in Portland Harbor, including muddy water and overwater obstructions (e.g., docks) that prevent the sun from reaching the bottom plus extensive bank armoring, limit the development of dense submerged and emergent plant communities in the Study Area.

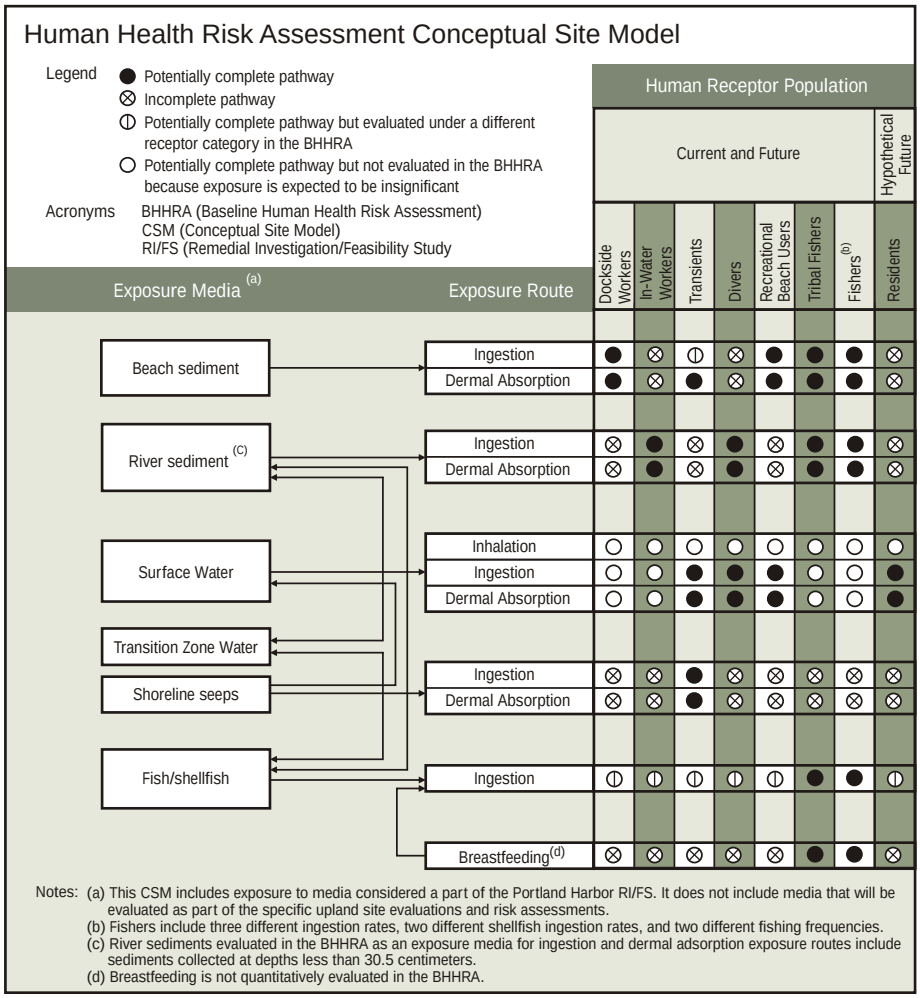
Human Use

Industrial and urban development of Portland Harbor and adjacent areas has been extensive. The majority of the shoreline in the Study Area is currently zoned for industrial land use and is designated by the City of Portland as an "Industrial Sanctuary". Worker activities occur at the industrial and commercial facilities in the Study Area.

Portland Harbor also provides recreational opportunities both within the river itself and along the riverbanks. Additionally, there are residential areas located near the river and downstream of the Study Area. Recreational activities are associated with the public access areas, such as beaches and boat ramps, and may include water skiing, occasional swimming, and waterfront recreation. Fishing for salmon, sturgeon, and other species is conducted throughout the Study Area, both by boaters and from locations along the banks. The LWR also provides Native American ceremonial and subsistence fisheries for Pacific lamprey (particularly at Willamette Falls) and spring Chinook salmon. In addition, transients have been observed along the LWR, including some locations within the Study Area.

Baseline Human Health Risk Assessment

The Baseline Human Health Risk Assessment (BHHRA) evaluated the potential for adverse human health effects from exposure to hazardous chemicals within the Study Area. The general objective of the BHHRA was to assess the potential risks to human health from exposure to chemicals present in sediment, surface water, and groundwater seeps, or accumulating in fish and shellfish. The results of the BHHRA will be used to refine remedial action objectives and to inform decisions about cleanup of the Site.

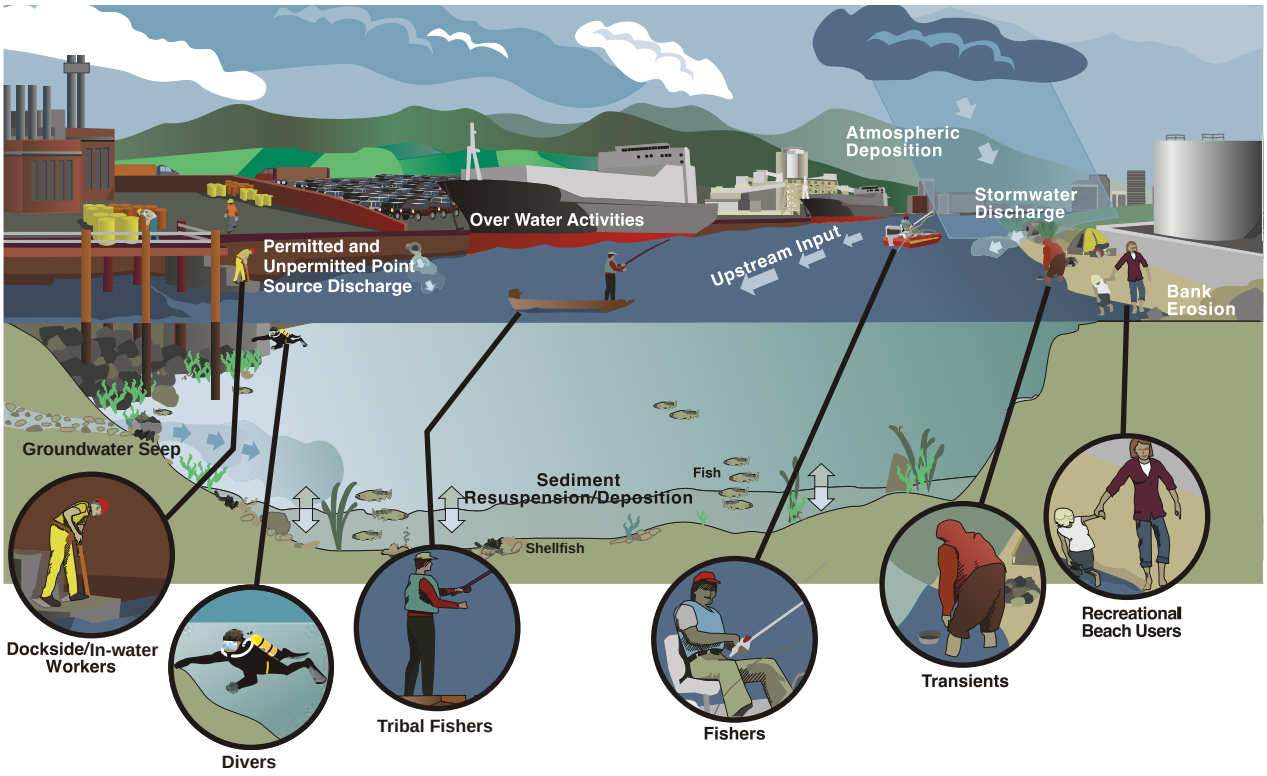


Approach to the Baseline Human Health Risk Assessment

The BHHRA evaluated the following exposure scenarios and receptors:

- Dockside worker — direct exposure to (i.e., ingestion of and dermal contact with) beach sediment
- In-water worker — direct exposure to in-water sediment
- Transient — direct exposure to beach sediment, surface water, and groundwater seeps
- Adult and child recreational beach user — direct exposure to beach sediment and surface water
- Tribal fisher — direct exposure to beach sediment or in-water sediment, and fish consumption
- Fisher — direct exposure to beach sediment or in-water sediment, fish consumption, and shellfish consumption
- Diver — direct exposure to in-water sediment and surface water.

Portland Harbor Superfund Site Illustration of Human Health Receptors and Exposure Pathways



A hypothetical future resident was also included as an exposure scenario to evaluate the domestic use of untreated surface water (ingestion and dermal contact). However, there are no known or anticipated future uses of the LWR within Portland Harbor as a domestic water source.

The BHHRA incorporated conservative, health protective assumptions in the development of exposure scenarios, the estimates of exposure, and the use of toxicity values, based on discussions with and direction from the EPA and its partners. The use of conservative exposure scenarios and toxicity values may overestimate risks, and this potential overestimation is considered when making decisions about Site cleanup.

Non-cancer and cancer effects were evaluated separately in the BHHRA. The potential for non-cancer effects was evaluated by comparing the estimated exposures to their toxicity values (i.e., threshold for adverse effects) using a ratio approach (i.e., Hazard Quotient HQ for single chemicals or Hazard Index HI for a chemical mixture where HI is the sum of HQs for chemicals in the mixture). When the HQ or HI is below 1, no hazard is expected. When the HQ or HI is above 1, a health hazard may be present. The potential for cancer was evaluated by comparing the estimated probability of cancer during an individual's lifetime to a target risk range of one in ten thousand (10^{-4}) to one in a million (10^{-6}), which is the "target range" within which the EPA strives to manage risk as a part of the Superfund program.

Results of the Baseline Human Health Risk Assessment

The major findings of the BHHRA include:

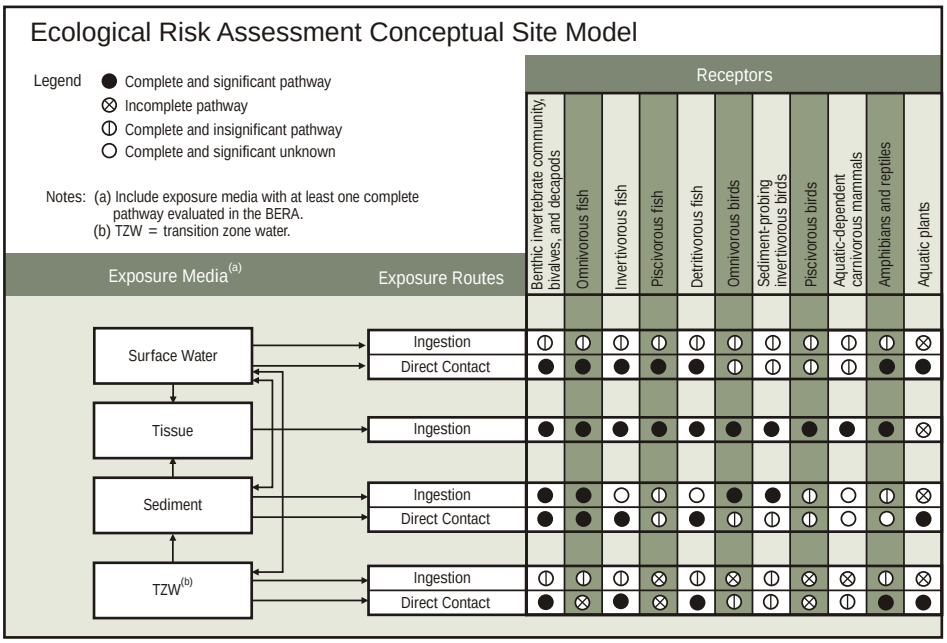
- Fish consumption is the exposure scenario accounting for the majority of risks to human health in the Study Area. Risks from fish and shellfish consumption exceed the target HI of 1 and the target cancer risk range of 10^{-6} to 10^{-4}.
- PCBs account for most of the risk from fish consumption, followed by dioxins/furans. Together, PCBs and dioxins/furans contribute approximately 98 percent of the cumulative excess cancer risk for fish ingestion.
- Risks resulting from the consumption of fish or shellfish are generally orders of magnitude higher than risk resulting from direct contact with sediment, surface water, or seeps. With the exception of two ½-river mile segments for the tribal fisher scenario, all of the direct contact scenarios result in risks within or below the EPA target cancer risk range of 10^{-6} to 10^{-4} and below the target HI of 1.
- The impact of uncertainties associated with risk estimates for the fish and shellfish consumption scenarios will be considered during the FS and taken into account for decisions about cleanup of the Site. Risk estimates in the BHHRA are based on multiple assumptions that may underestimate, or more likely over-estimate the actual risks.
- The contribution of background sources of chemicals of concern (COCs) is an important consideration in decisions about site cleanup.

Two Examples of Human Health Risk Assessment Receptor Exposure Assumptions

	Fisher		Beach User	
	Fish	Sediment	Sediment	Water
Intake Rate	19 meals per month 10 meals per month 2 meals per month	Face, hands, forearms and lower legs (beach) Hands and forearms (in-water) Soil ingestion rates	Face, hands, forearms and lower legs (beach) Soil ingestion rates	Entire body Approx. 2 ounces per hour ingested
Exposure Duration and Frequency	365 days per year 30 years	2 or 3 days per week 30 years	5 days per week in summer, 1 day per week in spring/fall, 1 day per month in winter 30 years (adult) 6 years (child	2 days per week in summer (adult) 5 days per week in summer (child) 30 years (adult) 6 years (child)
Uncertainties	Preparation methods Maximum concentration Species consumed Site use Toxicity values	Beach use Site use Amount of contact Sediment adherence Toxicity values	Beach use Site use Amount of contact Sediment adherence Toxicity values	Swimming frequency Dermal absorption Toxicity values

Ecological Risk Assessment

The Baseline Ecological Risk Assessment (BERA) evaluated the potential for adverse effects on plants, invertebrates, amphibians, fish, and wildlife from hazardous chemicals within the Study Area. The primary objective of the BERA was to characterize the risks of chemical effects on these aquatic and aquatic-dependent ecological receptors in the Study Area.

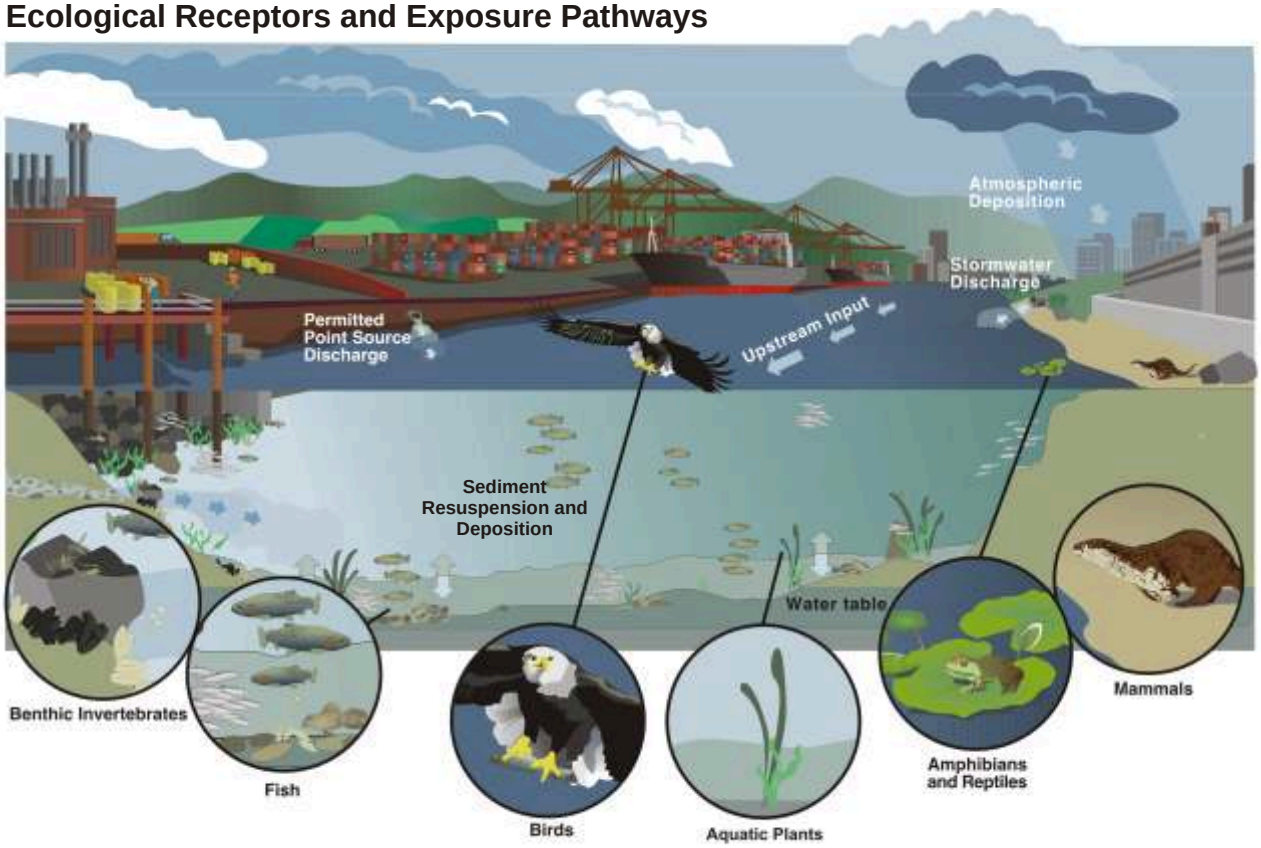


Approach to the Baseline Ecological Risk Assessment

The BERA was performed in accordance with EPA guidance and as otherwise directed by EPA. Ecological receptors were chosen for the assessment based on criteria consistent with EPA Superfund guidance. The receptors selected for assessment were:

- Benthic invertebrate community — benthic macroinvertebrate community, which includes clams, amphipods, crayfish, midge larvae and oligochaetes worms
- Omnivorous fish populations — largescale sucker, carp, and pre-breeding white sturgeon
- Invertivorous fish populations — sculpin, peamouth, and juvenile Chinook salmon
- Piscivorous fish populations — smallmouth bass and northern pikeminnow
- Detritivorous fish individuals — Pacific lamprey ammocoetes
- Omnivorous bird populations — hooded merganser
- Sediment-probing invertivorous bird populations — spotted sandpiper
- Piscivorous bird populations/individuals — osprey population and individual bald eagles
- Aquatic-dependent carnivorous mammal populations — river otter and mink
- Amphibian and reptile populations — amphibians (e.g., frog, salamander) and reptiles (turtle species)
- Aquatic plant community — phytoplankton, periphyton, macrophyte species

Portland Harbor Superfund Site Illustration of Ecological Receptors and Exposure Pathways



The assessment endpoints for all ecological receptors are based on the protection and maintenance of their populations and the communities in which they live, with the exception that survival, growth, and reproduction of organisms was designated by EPA as the assessment endpoint for juvenile Chinook salmon, Pacific lamprey ammocoetes, and bald eagle. For practical reasons and to be conservative, the organism-level measurement endpoints (survival, growth, and reproduction) were used for all receptors, requiring extrapolation to assess risks to populations and communities.

The BERA identified chemicals that might pose ecological risk (COCs). Throughout the process of assessing ecological risks and identifying COCs, a number of conservative assumptions were made. The most important conservative assumption in the process for initially identifying COCs was that effects on organism-level (i.e., individual-animal) endpoints translate into effects on ecological populations and communities. In reality, populations compensate for individual losses through a variety of ecological processes, so individual level risks do not necessarily imply population level risks. Therefore, the final list of COCs that have a plausible chance of causing adverse ecological effects was developed by considering the magnitude and spatial extent of risk estimates for organism-level endpoints.

Results of the Baseline Ecological Risk Assessment

The major findings of the BERA include:

- The majority of COCs identified in the Draft BERA were determined to pose no unacceptable risks to ecological populations or communities.

- Potentially unacceptable ecological risks are primarily from four chemical groups: PCBs, and to a lesser extent, dioxins/furans, DDTs, and PAHs. The BERA evaluates ecological risk to receptors from direct uptake and through the food chain (bioaccumulation). Bioaccumulation of PCBs by receptors and their prey poses the most significant ecological risks. PCBs were found to pose potentially unacceptable risk to populations of mink, river otter, osprey, hooded merganser, and spotted sandpiper throughout the Study Area; and to individual bald eagles and the benthic invertebrate community (in localized areas only).

- Mink and otter were identified as the ecological receptors at greatest risk. Most unacceptable ecological risks from other chemicals are spatially collocated with mink PCB risks. The potentially unacceptable ecological risks for other chemicals likely would be reduced or eliminated as a result of remedies in areas of elevated PCBs.

- Other areas of potentially unacceptable risk were identified for the benthic invertebrate community based on exceedances of sediment quality guidelines (SQGs) for PAHs and DDTs, primarily in portions of the middle reach of the Study Area (RM 5 to 8). Approximately five percent of the Study Area poses potentially unacceptable risk to the benthic community.

- Surface water and TZW results do not identify any additional ecological risk areas.

- Exposure to mercury concentrations in fish was found to potentially pose unacceptable risk to individual bald eagles; however, mercury contamination is a greater Willamette River issue requiring watershed-scale management action.

- Background levels of chemicals are an important factor, in addition to site-specific releases, contributing to potentially unacceptable ecological risks in the Study Area.

Next Steps

The Draft RI report provides extensive information, including Study Area physical, chemical, and biological characteristics; source identification; contaminant loading; a conceptual site model for the Study Area; and risk assessment results. Data collection for the RI is complete.

To support the FS, some tasks begun under the RI will be continued as part of the FS analysis, including:

Fate and transport modeling

Fate and transport models will support the evaluation of the effectiveness of remedial alternatives in the FS. They will also be used to assess the potential for recontamination of the Site from upland or upstream sources after implementation of potential remedies. The hydrodynamic and sediment transport model developed for the RI will be refined and coupled to chemical fate and transport models to achieve these objectives. In addition, the relative percentages of chemicals in fish and wildlife resulting from sediment versus surface water contamination will be evaluated using the fate and transport and bioaccumulation models developed for the RI/FS.

Ongoing source inventory update

Additional source information, including appropriate data collected by others, will be compiled in the FS to develop an updated inventory of ongoing sources for each potential in-water cleanup area. This information will be used to address the potential for unacceptable levels of recontamination or the need for DEQ to undertake upland source controls.

Refinement of the Conceptual Site Model

The Conceptual Site Model provided in the Draft RI will be refined as necessary and focused on individual sediment management areas identified in the FS.

To expedite development of the FS, EPA and the LWG have started to discuss Preliminary Remedial Goals and areas of potential concern. Early Preliminary Remedial Goals and areas of potential concern will be refined following EPA's review of the Draft BHHRA and Draft BERA. The refined Preliminary Remedial Goals and areas of potential concern will be incorporated into the FS. The LWG is currently proceeding with initial development and screening of remedial alternatives. Following EPA's review of the alternatives screening effort, the LWG will proceed with a detailed evaluation and comparative analysis of the remedial alternatives in accordance with EPA's evaluation criteria, culminating in development and submittal of the Draft FS report expected in late 2010.

List of Acronyms

AOC	Administrative Settlement Agreement and Order on Consent
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
COCs	chemicals of concern
DDD	dichlorodiphenyldichloroethane, a breakdown product of DDT
DDE	dichlorodiphenyltrichloroethylene, a breakdown product of DDT
DDT	the pesticide dichlorodiphenyltrichloroethane
DDTs	the pesticide DDT and its metabolites, DDD and DDE
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HI	hazard index
HQ	hazard quotient
LWG	Lower Willamette Group
LWR	lower Willamette River
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RI	remedial investigation
ROD	record of decision
RM	river mile
TZW	transition zone water

Glossary

10^{-6} to 10^{-4} risk: A range of cancer risk corresponding to a chance (probability) of excess cancer from one in a million to one in ten thousand. EPA considers this range when evaluating whether a risk estimate indicates an unacceptable risk to human health. Cancer probability is expressed in terms of risks in excess of those encountered over a life time in the general population.

Abiotic: Non-living. Typically refers to sediment, surface water, groundwater and other non-living environmental media.

Area of Potential Concern: An area of contaminated sediments that potentially contributes to unacceptable risks within the Site.

Background: Concentrations of chemicals, either naturally occurring or related to human activities that are not influenced by the releases from a site.

Benthic: Relating to or characteristic of the bottom of a water body or the organisms and plants that live there.

Bioaccumulative: Tending to accumulate in biota.

Biota: The animal and plant life of a given site or region.

Bounding Indicator Chemicals: In the RI, four chemical groups (total PCBs, total dioxins/furans, total DDTs, and total PAHs) are referred to as “bounding” indicator chemicals because their distribution is believed to encompass the spatial extent of potentially unacceptable risks associated with all COCs identified in the baseline risk assessments.

Chemicals of Concern: Chemicals identified through the baseline risk assessment that are associated with potentially unacceptable risk to human and/or ecological receptors.

Cleanup: Actions taken to remove contaminants from the environment and/or prevent excessive exposure of humans and ecological receptors. The term "cleanup" is sometimes used interchangeably with the terms remedial action, removal action, response action, natural attenuation, or corrective action.

Combined Sewer Overflow: Discharge of a mixture of stormwater and domestic wastewater when the flow capacity of a combined sewer system is exceeded during rainstorms.

Contaminant Loading: A rate of chemical input to a specified location within the river.

Dermal Contact: Contact between a chemical and the skin.

Ecological Risk Assessment: The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors, including chemicals.

Exposure Pathway: The path from sources of chemicals through environmental media to human or ecological receptors.

Groundwater: Water found beneath the ground surface in pore spaces between soil particles and in fractured rock. Groundwater provides drinking water from wells, and discharges to springs, rivers and wetlands.

Hazard Index: An indicator of the potential for cumulative noncancer effects that is derived by summing individual hazard quotients for two or more chemicals. HI values below 1 indicate a negligible hazard. HI values above 1 indicate a potentially unacceptable hazard.

Hazard Quotient: An indicator of the potential for adverse effects other than cancer from a given chemical calculated by dividing an estimated exposure (dose or concentration) by a toxicity reference value or reference dose. HQ values below 1 indicate a negligible hazard. HQ values above 1 indicate a potentially unacceptable hazard.

Human Health Risk Assessment: The process that evaluates the likelihood that adverse human health effects may occur or are occurring as a result of exposure to one or more stressors, including chemicals.

Lower Willamette River: The stretch of the Willamette River from the confluence with the Columbia River (river mile 0) to Willamette Falls (approximately river mile 26).

Media: Specific environmental materials such as air, water, soil and biological tissue.

Pathway: The physical course a chemical takes from its source to the exposed organism.

Preliminary Remediation Goal: A chemical concentration in a specific medium (e.g., sediments and water) that should meet acceptable risk levels.

Receptor: Human, fish, wildlife, or other species to be evaluated in a risk assessment.

Remedial Action: The actual construction or implementation phase of a Superfund site cleanup that follows remedial design.

Risk Assessment: Qualitative and quantitative evaluation of the risk posed to human health or the environment by the actual or threatened release of specific chemical(s).

Risk Estimate: A quantitative value indicating the likelihood of an adverse effect (e.g., a cancer risk for humans). Although hazard quotients (e.g., for assessing non-cancer effects in either humans or ecological receptors) are typically referred to as risk estimates, they are not quantitative indicators of likelihood and should be interpreted mainly as indicating thresholds for hazard.

Study Area: The 10-mile stretch of the lower Willamette River (LWR) from river mile 1.9 to river mile 11.8, roughly between Sauvie Island and the Broadway Bridge north of downtown Portland.

Superfund: The EPA program that addresses both emergency removal and long-term remedial activities for contamination by hazardous chemicals. The Superfund program includes investigating sites for inclusion and ranking on the National Priorities List, and conducting and/or supervising cleanup and other remedial actions.

Transition Zone Water: The groundwater/surface water transition zone (also known as the hyporheic zone) is the interval where a mixture of groundwater and surface water compose some percentage of the water occupying interstitial space in the sediments.

Toxicity: The capacity for a substance or mixture of substances to cause adverse effects in humans or other organisms.

LWG
LOWER WILLAMETTE GROUP

For More Information on the Draft Remedial Investigation Report go to:

www.epa.gov/region10/portlandharbor