PUBLIC HEALTH ASSESSMENT
Initial Release

Portland Harbor
Portland, Multnomah County, Oregon
EPA Facility ID: OR0001297969
January 15, 2002

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Superfund Site Assessment Branch
Atlanta, Georgia 30333

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Purpose and Health Issues

Portland Harbor was proposed for the National Priorities List (NPL) on July 27, 2000 and listed on December 1, 2000. In this public health assessment, the Agency for Toxic Substances and Disease Registry (ATSDR) evaluates the public health significance of the site as mandated by Congress. ATSDR has reviewed available environmental data, exposure scenarios, and community health concerns to determine whether adverse health effects are possible. The focus of this document is the in-water portion of the Portland Harbor NPL site; no attempt is made to evaluate risk associated with upland source areas.

Based on this review, we identified the consumption of contaminated fish and other food items as the main way that people could be exposed to Portland Harbor site contaminants. However, we were unable to evaluate the possible health consequences due to a lack of data on this exposure pathway. Based on mercury levels in fish tissue that are not likely due to contamination from the Portland Harbor site, the State of Oregon has warned women and children to restrict their consumption of all resident fish (i.e., fish who remain in the river year-around) from this and other portions of the Willamette River [1]. We identified a need to inform and educate the community about the potential health risks from eating fish from the Willamette and from other sources and from direct contact with sediments and water from the Willamette River.

Because of the lack of data, ATSDR recommends that contaminant levels in fish and possibly other food items from the Portland Harbor area be identified through a carefully-designed investigation. As part of this investigation, the species and amount of fish consumed from the site area needs to be better understood. To educate and inform the community, ATSDR will work with the other involved federal, tribal, state, and local agencies to design and implement appropriate programs.

ATSDR's review of the limited amount of data on contaminants in fish from the lower Willamette River indicates that the concentrations of polychlorinated biphenyls (PCBs) exceed EPA's Monthly Fish Consumption Limits. This finding further illustrates the need for systematic sampling of fish from the lower Willamette.

Also in this document, ATSDR evaluates available sediment contaminant data for potential health impact on people who may be directly exposed to the sediments. The current information indicates that direct contact with sediment is not expected to result in adverse health effects. We recommend areas for further sediment characterization, namely those areas that are heavily used and would therefore lead to a greater chance for exposure.

Background

Site Description

The exact site boundaries of the Portland Harbor NPL site will be based on the results of the Portland Harbor remedial investigation/ feasibility study (RI/FS).[1] The initial study area for the site is a nearly six-mile stretch of the Willamette River, from the southern tip of Sauvie Island [river mile 3.5] to Swan Island [river mile 9.2] (see Figure 1). Sampling of sediments, and possibly other media such as ground water, surface water, and soil will be done both in and outside of this initial area and both in and out of the river. The final site boundaries could include a greater portion of the Willamette River and some of the source areas for the contamination.

The Willamette River begins in the Cascade Mountains and flows generally north to its confluence with the Columbia River [2]. The last 26.5 miles of the Willamette River before the confluence is wide, slow moving, and affected by tidal reversals. This last results in daily fluctuations in water levels and the amount of exposed sediment. This section of the river was generally shallow historically, but the last 12 miles of the Willamette River now has an average depth of 45 feet with a maximum of 140 feet. This greater depth is the result of regular dredging by the U.S. Army Corps of Engineers to allow large ocean-going ships to use Portland Harbor. The portion from river miles 3 to 10 is the principal sediment deposition area of the Willamette River.

This portion of the river is the most industrialized area of the river and lies entirely within the city limits of Portland, Oregon [2]. There is also heavy marine traffic. Possible sources of the harbor contamination include hazardous waste and petroleum product storage; marine construction; oil gasification plant operations; wood treating; agricultural chemical production; natural gas plant operations; chlorine production; ship loading, maintenance, and repair; and rail car manufacturing. Within or near the initial Portland Harbor study area, there are 45 active investigations or cleanups being performed under oversight by the Oregon Department of Environmental Quality (ODEQ) including the investigation of 26 City of Portland outfalls [3,4].

History

Development of the lower Willamette River area of Portland as a port, shipping, and industrial center began in the mid-1800s [5]. Currently, Portland is one of the busiest ports on the Pacific Coast. In 1996, 28 million tons of goods were exported from Portland, and 3 million tons were imported. However, this development, along with the discharge of untreated sewage into the river, polluted the lower Willamette River so much that it was declared “biologically dead” in 1944 [6]. While some actions to reduce discharge of untreated sewage were taken in the 1950s, cleanup of the Willamette River did not begin in earnest until the 1960s [5,6]. By 1972, the river was once again considered biologically viable [6]. Regulation of the discharge of industrial wastes to the river began in the 1970s [5]. Cleanup of the industrial sources of these discharges began in the late 1980s.

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[1] This description of the site boundary is based on discussions with Wally Reid, Chip Humphrey, and Dana Davoli of EPA; and Eric Blischke of ODEQ.

Two investigations in 1997 focused concern on contaminated sediments in the lower Willamette River [2,7]. In July 1997, the U.S. Army Corps of Engineers (COE) collected surface sediment between river miles 3.8 and 8.9 as part of a pre-dredging sediment quality study [2]. In the fall of 1997, consultants for the U.S. Environmental Protection Agency (EPA) and ODEQ conducted field work for a Site Inspection (SI) in the Lower Reach of the Willamette River within Portland Harbor [7]. Bottom sediment and porewater samples from near shore areas between river miles 3.5 and 9.2 were collected. These investigations documented that the sediments in this river segment had elevated levels of arsenic, mercury, several pesticides, polychlorinated biphenyls (PCBs), several semivolatile organic compounds (SVOCs), and tributyltin (TBT).

Because it was already involved in many cleanups on the banks of the lower Willamette River, ODEQ worked for over two years to develop a state-led cleanup approach to Portland Harbor [8]. However, several of the criteria for deferring the cleanup to the state could not be met, so EPA proposed on July 27, 2000 that Portland Harbor be added to the NPL. Oregon Governor John Kitzhaber concurred with that decision and agreed that ODEQ and EPA would work together on the cleanup. He also agreed that the cleanup would be integrated with other state initiatives to restore the health of the river.

EPA and ODEQ jointly manage the cleanup of the Portland Harbor NPL Site [8]. EPA has the primary responsibility for the sediment and ODEQ for the upland sources of contamination. These two agencies are also working closely with nine natural resource trustees. The trustees are designated by law to act on behalf of the public or tribes to protect and manage natural resources, such as land, air, water, fish, and wildlife. Among the trustees are six tribes - the Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Grand Ronde (CTGR), Confederated Tribes of Siletz Indians (CTSI), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe. The Oregon Department of Fish and Wildlife (ODFW), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (USFWS) are federal government natural resource trustees.

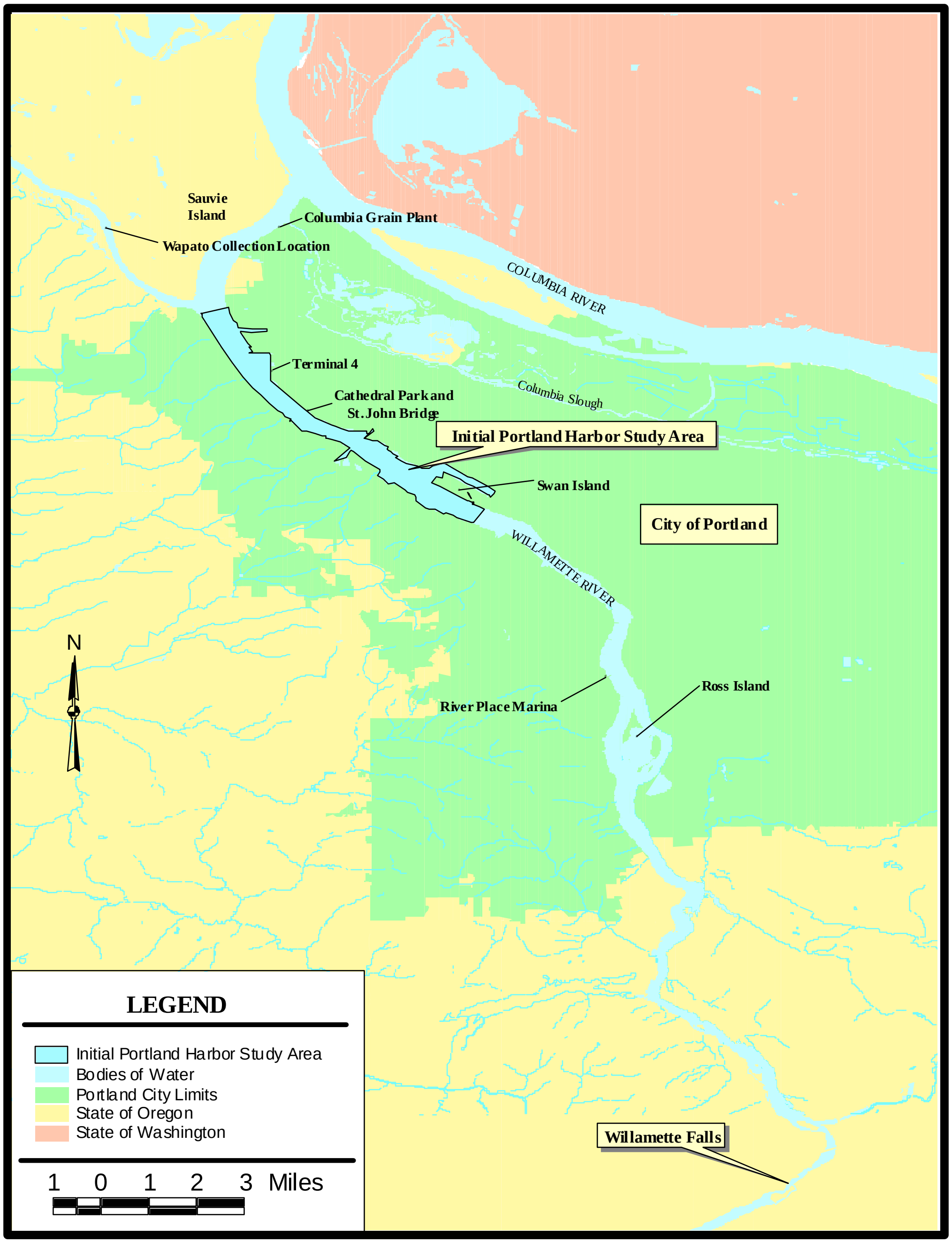

Figure 1 - Portland Harbor NPL Site Area Portland, Oregon

Portland Harbor Public Health Assessment - Initial Release 4 Prepared by John Crellin, Ph.D. - 010802

Demographics

ATSDR's public health assessments usually have a section where the demographic characteristics of the population within a mile of the site is described [9]. This is done because this population includes those individuals most at risk of being exposed to site contaminants. However, at the Portland Harbor site, the individuals most at risk are those who eat fish from the Willamette River or who have contact with the sediment or surface water. These "at risk individuals" appear to be anglers from specific ethnic and racial groups and recreational boaters and not simply those living near the river. Therefore, the usual demographic evaluation will not be done in this document. Instead there will be descriptions of these "at risk" groups in relevant sections of this public health assessment.

Land and Natural Resource Use

Land Use

The habitat from river miles 3.5 to 9.2 (the initial Portland Harbor site study area) has been substantially altered to accommodate urban development and an extensive shipping industry [7]. Shoreline features include steeply sloped banks covered with riprap or constructed bulkheads, with manmade structures such as piers and wharves extending out over the water. This area of the river is largely devoid of trees and other vegetation along the river banks.

The habitat of the rest of the lower Willamette River is not as degraded [10]. This is indicated by the gently sloping, well-vegetated banks at Ross Island, the mouth of Stephens Creek, Powers Marine Park, the mouth and lower reaches of Johnson Creek, Multnomah Channel, Kelly Point Park, and the lower reaches of the Columbia Slough. The first four locations are upstream and the last three are downstream of the initial Portland Harbor site study area.

The site area is heavily industrialized [2]. Some of the historical or current industrial operations along Portland Harbor include: marine construction; bulk petroleum product storage and handling; construction material manufacturing; oil gasification plant operations; pesticide/herbicide manufacturing; agricultural chemical production; battery processing; liquid natural gas plant operations; ship maintenance, repair, and refueling; rail car manufacturing; and metal scrapping and recycling.

Residential areas are intermixed with these riverside industries or are close by [5]. In addition, the lower Willamette River is used for recreational fishing, boating, and water skiing. Cathedral Park is within the site boundaries and serves as a boat launch and bank fishing location [11,12]. Swan Island Lagoon is also used for bank fishing and to launch boats. During our site tours, we observed tents and make-shift dwellings, evidence that people were living along the river banks.

Fish and Shellfish

A 1993 survey indicated 39 species of fish residing in the lower Willamette River (river mile 0 to river mile 17) [13]. Four of these resident species are considered major sports fish. They are walleye *(Stizostedion vitreum vitreum*), black crappie *(Pomoxis nigromaculatus),* white crappie *(Pomoxis annularis*), and smallmouth bass *(Micropterus dolomieui*). The most common non-sports fish are northern pikeminnow *(Ptychicheilus oregonensis*, formerly known as squawfish), yellow bullhead *(Ictalurus natalis*), common carp *(Cyprinis carpio*), and largescale sucker

(Catostomus macrocheilus). These eight species of fish are abundant and easily caught, and subsistence use by the local population appears to occur. This conclusion is based on recent observations by a team of investigative reporters and conversations ATSDR staff had with area residents during site visits [11,12].

The lower Willamette River is both the migratory route and rearing habitat for several anadromous fish species [14]. Anadromous fish are those species which spend the juvenile stage of their life cycle in fresh water and the adult stage in salt water. Three runs of chinook salmon *(Oncorhynchus tshawytscha*), two runs of steelhead trout *(O. mykiss*), and individual runs of coho *(O. kisutch)* and sockeye salmon (*O. nerka*) use the lower Willamette River as their route to locations further up the Willamette River Basin where they will lay their eggs. “Runs” are genetically distinct populations that move up the river at different times of the year. In general, chinook and steelhead populations are the largest and most widespread of the salmonids (i.e., salmon and trout) found in the Willamette River basin. Cutthroat trout are also present, but their abundance is low. The lower Willamette River below Willamette Falls is where small populations of steelhead and cutthroat trout, and chinook and coho salmon lay their eggs and the juvenile fish spend the first part of their lives.

Other important species which use the lower Willamette River to migrate from salt to fresh water habitats are the American shad *(Alosa sapidissima*), white sturgeon (*Acipenser transmontanus*), and Pacific lamprey *(Entrosphenus tridentatus)* [14]. Lamprey are utilized by Native American populations in the area for subsistence, ceremonial and medicinal purposes.

In the lower Willamette River, lampreys are harvested primarily at Willamette Falls. Juvenile lampreys spend from 1 – 7 years in freshwater rivers and tributaries before transforming into adults [15]. The preferred habitat of juvenile lamprey is muddy bottoms, backwater, and low gradient areas. Its main food sources are microscopic plants and animals obtained by filtering mud and water. This makes juvenile lamprey particularly susceptible to contaminants present in sediments. After transforming to the adult form, lampreys move into the ocean where they live as predators/parasites on larger fish for a couple of years before returning to fresh water to spawn.

Shellfish known to reside in the lower Willamette River are the crayfish *(Pacifasticus lenisculus)* and bivalve *(Corbicula fluminea)*, though population numbers have not been determined [14]. Shellfish are known to bioaccumulate organic chemicals such as PCBs, DDT, chlordane, dioxins, and other related compounds.

Discussion

Data Used

Several sediment investigations have been conducted in the Willamette River in or near Portland [7,14]. The data from these studies have been incorporated into the Sediment Quality Information System (SEDQUAL), maintained by the Washington State Department of Ecology (WSDE) with support from EPA [16]. This database has information on sediment contamination in Alaska, California, Idaho, Oregon, and Washington. Using SEDQUAL, ATSDR identified all the sediment sampling locations in the lower Willamette River, and selected for further analysis the chemical data for those locations.

ATSDR visited the Portland area to better understand the physical and geographic setting of the site.[2] We also met with community members and local, state, federal, and tribal officials to learn more about the site and the health concerns of the community.

Evaluation Process

The process by which ATSDR usually evaluates the possible health impact of contaminants is described in detail in Appendix A beginning on page 28. At this time, there is only enough information to evaluate the direct contact with contaminants in sediment. These direct contact exposures represent only a fraction of the potential health impact of contaminated sediments in Portland Harbor, as described below.

Potentially, the most significant exposure pathway for Portland Harbor site contaminants is eating (ingestion of) fish and other food items (biota). Biota may become contaminated with chemicals that move up the food chain from the sediment in the Willamette River. The data available on contaminants in fish from the Portland Harbor site area will be discussed in this document, but there are not enough existing fish data to quantitatively determine the risk of health effects from this pathway. Although the risk cannot be quantified, we discuss potential risks based on the very limited data available, and describe common-sense measures the public can implement to reduce their risk for exposure to contaminants that may be present in fish.

The factors needed to predict contaminant levels in fish tissue from the concentrations identified in sediment have not been developed for the Portland Harbor site. Therefore, we were only able to evaluate the possible health impact of contaminated sediment on humans through the ingestion of fish tissue in a qualitative manner. We did this by relating the distribution and concentration levels of contaminants that can bioaccumulate in fish to locations known to be heavily used by people who fish, “anglers.” We use this evaluation to target our recommendations for sampling of fish from Portland Harbor. This sampling will allow us to perform a more quantitative analysis in the future.

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[2] ATSDR staff (John Crellin, Jill Dyken, and Dan Holcomb) visited the site on December 5 - 7, 2000, April 30 - May 4, 2001, June 25 - 26, 2001, and November 26 - 30, 2001. Karen Larson and Dean Seneca participated in portions of the second site visit, and Ms. Larson participated in a portion of the third visit. In addition, John Crellin met with Grand Ronde tribal representatives and members in Grand Ronde, Oregon on September 10, 2001. John Crellin also participated in meetings on December 18 - 19 about development of the Portland Harbor Human Health and Ecological Risk Assessments and toured the site area. Information obtained during these visits is described in the pertinent sections of this document.

Portland Harbor Exposure Pathways and Contaminants of Concern

The following sections discuss *exposure pathways*, the ways people might come into contact with contaminants from the Portland Harbor site. People could ingest *biota* (i.e., fish, wildlife, or plants) that have built up contaminants from the sediment, people could come in contact with the *sediments* directly or by accidentally swallowing sediment during recreational or fishing activities, or people could directly contact or accidentally swallow *surface water* contaminated by the sediment. These pathways are summarized in Table 1.

It should be noted that the exposure pathways evaluated in this document and the assumptions used in calculating exposures for evaluated pathways are based on the limited knowledge ATSDR has on uses of the Portland Harbor site. The draft Portland Harbor RI/FS Work Plan [14] contains a set of exposure scenarios which differ from the pathways evaluated in this document. However, because the scenarios and pathways are qualitatively similar, the overall conclusions should be the same.

Biota Exposure Pathway

Certain contaminants (including PCBs, PAHs, and mercury) existing in sediments may be taken up by benthic (bottom-dwelling) organisms. As fish feed on these organisms, the contaminants build up (bioaccumulate) in the fish tissue, resulting in greater concentrations than originally present in the sediment. Both subsistence and recreational fishing takes place within the Portland Harbor site, and anglers and their families who eat the fish may be exposed to high levels of contaminants. Resident fish, such as small-mouthed bass, crappie, carp, and bullhead catfish, are expected to bioaccumulate far greater amounts of contaminants than fish who only migrate through the site, such as salmon.

Other plants and animals may also accumulate contaminants from the site. These may include vegetation growing along the river, root vegetables growing near the river, and animals feeding on this vegetation or the fish in the river. People who eat these plants or animals may also be exposed to elevated contaminant levels.

Table 1 - Completed Exposure Pathways for the Portland Harbor National Priorities List Site
Source: Contamination from Industrial Activities and Non-point Sources along Willamette River

Pathway Name	Environmental Media & Transport Mechanisms	Point of Exposure	Route of Exposure	Exposed Population	Time	Notes	Is this Pathway Complete?
Biota	Bioaccumulation of contaminants from surface water and sediments into fish, mammals, and/or vegetation along river	Meal prepared using biota from site	Ingestion	Recreational Users, Native American and other subsistence anglers	Past, Present, Future	Population may include young children	Y
Sediments	Deposition from surface water runoff and wastewater discharges into Willamette River	Swimming area in river	Incidental Ingestion, Dermal Exposure	Recreational Users	Past, Present, Future	Population may include young children	Y
Surface water	Wastewater discharge to river; contaminants dissolved from sediments	Swimming area in river	Incidental Ingestion, Inhalation, Dermal Exposure	Recreational Users	Past, Present, Future	Population may include young children	Y

There are very limited data on fish tissue for the Portland Harbor area and no data for other biota. A recent review of fish contaminant data files of the Oregon Health Division identified 56 fish obtained from the Portland Harbor area since 1980 [17]. Because some of these 56 fish were analyzed as composites, rather than individually, there were only 40 fish tissue samples. Sixteen of these samples were of carp; 7 of crappie; 4 each of northern pikeminnow, suckers, and small-mouth bass; 2 each of chiselmouth chub and peamouth; and 1 sturgeon. Twenty-one of the 40 fish tissue samples were obtained from 1980 - 1989 and 19 from 1990 - 2000. Twenty-nine of the 40 samples were taken near the railroad bridge at river mile 7. Twenty of these were analyzed only for mercury and other metals, while for 10 the analysis focused on PCBs. The last 10 were analyzed for mercury and several organic compounds including PCBs, chlordane, dieldrin, heptachlor, and DDT [17,18]. Mercury concentrations ranged from 0.02 - 0.9 ppm, while PCB levels were 0.025 - 1.4 ppm [17].

The PCB levels identified in fish from the lower Willamette River area (0.025 - 1.4 ppm) exceed EPA's Monthly Fish Consumption Limits [19]. These limits identify how many meals a month would be represent an acceptable health risk based on the PCB levels in fish tissue. A meal is defined an 8 oz (0.5 lb) portion of fish. In this guidance, it is recommended that no more than 1 meal a month be eaten if the PCB level is around 0.025 ppm to protect an individual from a lifetime additional risk of cancer of 1 in 100,000. Ten meals a month could be consumed if the concern level for cancer is 1 in 10,000. If the main health concern is non-cancer health effects, then the consumption limit for 0.025 ppm is 4 meals a month. The average PCB concentration in the 9 fish collected from Sauvie Island to St. Johns Bridge (river mile 3.5 to 6) in the Daily Oregonian's 2000 investigation was 0.051 ppm [18]. For this concentration, the guidance recommends no more than 3 meals a month be consumed to protect against non-cancer health effects.

It is not possible to conclude that PCBs in fish from the lower Willamette currently represent a health risk. There are not enough fish of any one species or of a similar size to accurately identify what the PCB concentrations are. However, these data are a matter of concern as exposure of mothers to PCBs through fish consumption is associated with health effects in children born to these women [21]. The health effects observed include abnormal reflexes, and deficits in memory, learning, and IQ.

PCB concentrations in fish from the lower Willamette were determined by analyzing for the individual Aroclor compounds [17]. Recent research, including a study done of Willamette River fish obtained upstream of Willamette Falls, indicates that this method does not accurately identify PCB levels in fish [20]. PCB concentrations in fish are best determined by analyzing for the individual PCB congeners.

ATSDR identified two health advisories on consumption of biota from the Willamette River [1,22]. In November 2001, the Oregon Department of Human Services (ODHS) used the data on mercury levels in fish to issue a health advisory which warned women and children to restrict their consumption of all resident species (i.e., fish who remain in the river year-around) from this and other portions of the Willamette River [1]. The second advisory cautioned against eating crayfish and shellfish obtained within 1,000 feet of the McCormick and Baxter wood treatment facility, located at about river mile 7.5 [22]. The contaminants of concern were arsenic, creosote, and pentachlorophenol.

ODHS has also issued two other health advisories on biota that relate to contaminant level in fish from the Portland area [23,24]. In 1996, Oregon and Washington issued an advisory for the Columbia River from Bonneville Dam to the Pacific Ocean on consumption of peamouth, carp and largescale sucker [23]. These species were identified because they had high levels of PCBs, dioxins/furans, DDT, arsenic and mercury. An advisory was issued in 1993 for carp and black crappie from the Columbia Slough due to elevated levels of PCBs [24]. These advisories are still in effect, and we observed that warning signs were posted along the Columbia Slough during a June 2001 site visit.

As indicated in an article in the *Daily Oregonian* newspaper, the only other evidence about contaminants in biota is a report that blue heron eggs in the Portland area had elevated levels of PCBs and DDT [25]. These chemicals would have come from the blue heron's diet of fish, frogs, and mice. This is an indication that some, if not all, of these food items may be contaminated.

During our site visits, we heard reports that members of some of the tribes in the Portland area collect wapato *(Sagittaria latifolia)* from at a couple of locations near the southern tip of Sauvie Island along the shore of the Multnomah Channel. One of those locations (Wapato Access Area) is maintained by the Oregon Department of Parks and is about 3.5 miles north of the start of Multnomah Channel. Wapato is a tuber which grows in shallow water and, because it is rooted in the sediment, potentially could be contaminated by the chemicals in the sediment. Wapato is used like a potato or made into flour.

In summary, only 40 total fish tissues from 7 species were identified for the Portland Harbor site area from over a 20 year span. Half of these fish tissue samples were analyzed for mercury and other metals. None were analyzed for dioxins or for the specific congeners of PCBs. Dioxins are a major contaminant in Columbia River fish and would be expected to be found in fish from the Willamette River [23]. All this illustrates the need for systematic sampling and analysis of the most frequently eaten fish and biota from the lower Willamette River.

However, the existing evidence, while not complete or of high quality, does indicate that biota in the Portland Harbor area are contaminated. These compounds might cause health effects in humans if there was greater consumption of fish than what was assumed for the existing advisories or if contaminant levels are higher. The PCB levels in the limited number of fish analyzed for these chemicals exceed EPA's Monthly Fish Consumption Limits, indicating that PCBs in fish from the lower Willamette may represent a health risk. Further, the advisories on the lower Columbia River and the Columbia Slough indicate that people should be aware that eating the same species from the lower Willamette River could result in similar health risks.

The following section is ATSDR's qualitative evaluation of where the known high levels of sediment contamination are versus the locations where people are known to fish and collect other biota. This evaluation gives further support for the idea that people need to be informed of the potential risks with biota consumption, even before we fully characterize and quantify the actual risk.

Qualitative Evaluation: Sediment Contamination vs. Biota Consumption

ATSDR evaluated the biota exposure pathway qualitatively by comparing the distribution of selected sediment contaminants to locations known to be frequented by anglers and wapato collectors. As indicated on page 32 in Appendix B, ATSDR identified 29 chemicals as contaminants of concern. We chose 7 of these chemicals to evaluate based on the relative concentrations, potential to bioaccumulate, and chemical group. The chemicals chosen were Aroclor 1260, arsenic, benzo(a)pyrene, DDT, dioxin[3], lead, and tributyltin. Aroclor 1260, benzo(a)pyrene, and DDT are intended as representatives for the other chemicals in their class which are PCBs, PAHs, and cyclodiene pesticides, respectively. The distribution of each chemical was plotted by concentration using Arcview 3.2[4]. Contaminant levels were grouped by quartile, and then the relative concentrations were evaluated for each known fishing or wapato collection location. The results for Aroclor 1260 and benzo(a)pyrene are displayed on Figures 2 and 3.

Fishing locations in or near the initial site study area (river miles 3.5 to 9.2) were identified from discussions with the authors of a series of articles on the topic in the *Daily Oregonian*, other knowledgeable people, and the tours of the area made by ATSDR staff [11,12]. As indicated on Figure 1, The major locations for bank fishing are the River Place Marina, the Swan Island area including the lagoon, St. John's Bridge and Cathedral Park, Terminal 4 (including the coves near this locations), and the Columbia Grain Plant and Kelly Point Park. Boat fishing appears to be focused near piers, docks, and other in-water structures from Swan Island to the Multnomah Channel. Bank fishing is done by a variety of ethnic groups including African-Americans, Vietnamese and other Southeast Asians, and Eastern European immigrants. Boat fishing is done mostly by whites and some tribal members. As indicated earlier, wapato is collected mostly by tribal members from locations near the southern tip of Sauvie Island along the shore of the Multnomah Channel.

River Place Marina (river mile 13.5) is utilized mostly by Eastern European immigrants who fish from marina docks during the day [11]. This location is upstream from the current boundaries of Portland Harbor site. Only one sediment sample was taken near this location, so it is not possible to predict whether the fish caught here could be contaminated.

The Swan Island area (river miles 8 to 9) is fished mostly by African-Americans during the day, evenings and on the weekends, and at night by Southeast Asians [11,12]. The African-Americans are reported to catch crappie, small mouth bass, bullhead catfish, and carp. The Southeast Asians catch mostly crappie which they reportedly use as bait for sturgeon fishing at the Bonneville Dam on the Columbia River. This area is also extensively utilized by individuals catching mostly crappie and small-mouth bass from boats. Quantitatively, most of the highest 25% of Aroclor 1260, arsenic, lead, and tributyltin sediments levels were found in this one mile section of the

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[3] Dioxin levels were determined in toxic equivalents of 2,3,7,8 tetrachloro-p-dibenzodioxin. This is done by adjusting the concentration of each dioxin and furan compound identified at a location by its toxicity relative to 2,3,7,8 tetrachloro-p-dibenzodioxin []. Each of these adjusted concentrations is then added together.

[4] EPA and ODEQ provided ATSDR with geographic coordinates for each sediment sampling location in the lower Willamette River. We linked this coordinate information to the sediment sampling results from SEDQUAL.

Willamette River. Benzo(a)pyrene levels are also relatively high. Therefore, fish that spend a substantial portion of their lives in this area could bioaccumulate relatively high levels of these chemicals and related compounds. Based on our discussions with fisheries experts and local anglers, crappie, small-mouth bass, and bullhead catfish spend all of their lives in a 1- to 2- mile area. Therefore, individuals eating these species from this area would be exposed to these chemicals. Only a limited number of sediment samples were analyzed for DDT. No samples from Swan Island were analyzed for dioxin.

Fishing in the area around Cathedral Park and St. John's Bridge (river mile 6) is popular among Hispanics, Cambodians and other Asians, and other members of the nearby community [11]. The main species caught appear to be crappie, small-mouth bass, bullhead catfish, perch, bluegill, and carp. This area is also used by boat fishermen to catch crappie and small-mouth bass. Most of the highest 25% of benzo(a)pyrene, dioxin and DDT levels in sediment were found within a mile of this location. Concentrations of the other contaminants evaluated are also relatively high. The tissue from fish that live only in this area such as crappie and small-mouth bass could be contaminated with these chemicals and related compounds.

The area around and between Terminals 4 and 5 (river miles 4 to 5) is a popular fishing location in May and June. Southeast Asians and Eastern Europeans catch crappie, small-mouth bass, and carp from the docks and piers, and in coves they also catch bullhead catfish. This area is also a prime spot for boat fishermen to obtain crappie and small-mouth bass. The sediment contamination pattern in this area, and therefore the potential contaminants in fish, are similar to the Cathedral Park/St. John Bridge area with the exception of DDT and dioxin for which few or no samples were taken.

No sediment samples were taken within 4 miles, of the known wapato collection area, which is about 3.5 miles downstream of the start of Multnomah Channel. There are three sampling locations within 4.5 miles of this area which the benzo(a)pyrene concentrations are in the upper 25% of all the samples analyzed.

The Columbia Grain Plant area (river mile 1) is used mostly by Eastern Europeans to catch carp [11]. Only about 10 sediment samples were taken from the last two miles of the Willamette River. Contaminant concentrations from those locations were all in the lower 50% of all the samples analyzed. None of these were analyzed for DDT or dioxin.

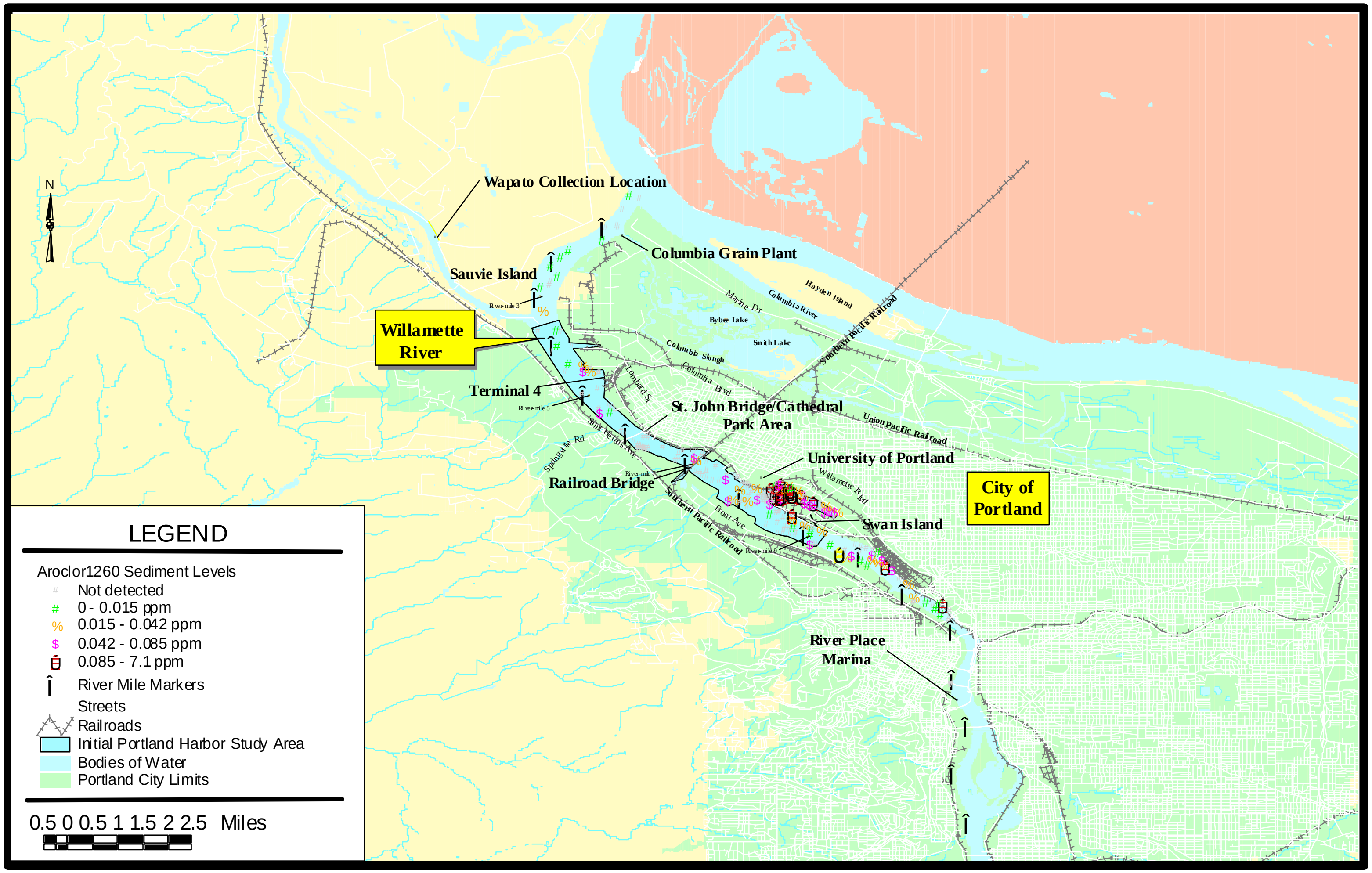

Figure 2 - Aroclor 1260 Sediment Levels in Portland, Oregon Area

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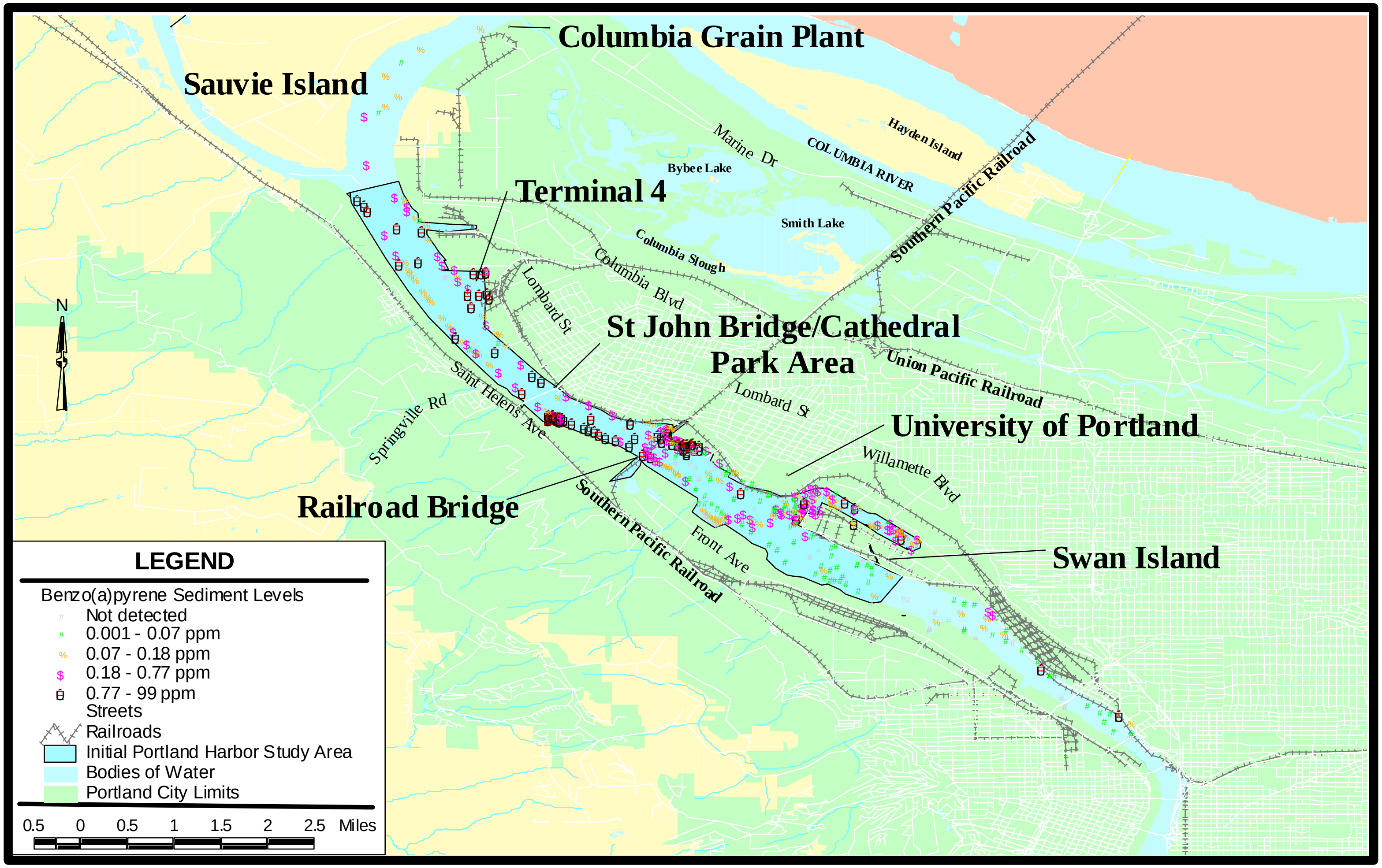

Figure 3 - Benzo(a)pyrene Sediment Levels in Portland, Oregon Area

This qualitative evaluation of the biota pathway indicates the strong potential for exposure to contaminants from the Portland Harbor site for people eating resident fish caught from at least some locations on the lower Willamette River. The locations of most concern, based on relative sediment concentrations, is the area from Swan Island to Terminal 4 (river miles 5 to 9). Crappie, small-mouth bass, and bullhead catfish are the species whose tissues are most likely to reflect the contamination in the area because they move little during their lives. There were insufficient data to evaluate the potential for exposure at the River Park Marina, wapato collection, and the Columbia Grain Plant/Kelly Park locations. There also were insufficient data on DDT and dioxin at all locations.

Additional Data Needs

So far we have identified that there is a strong potential for exposure to site-related contaminants through ingestion of biota, but there are almost no data identifying contaminant levels in biota. Similarly, there is little information on who is consuming biota from the Portland Harbor area and, especially, how much is being eaten. While there have been four surveys with at least some information on fish consumption in the Willamette River, none had specific data for Portland Harbor [26-29]. This section will discuss what additional information is needed to evaluate the possible health consequences of ingesting contaminated biota.

The investigation by the *Daily Oregonian* and the surveys of other portions of the Willamette River suggest that the groups most likely to be catching and eating fish from the lower Willamette are immigrants from Eastern Europe and Asia, African-Americans, and Hispanics [11,12,26,27]. These same sources also suggest that the most consumed species are carp, bullhead catfish, crappie, and small-mouth bass. There is no indication on consumption rates overall or for any specific species.

The major data need is the systematic sampling of fish from the lower Willamette River. This systematic sampling should meet the criteria for a Tier 2 (phase I and II) study as described in the EPA *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* [30]. This would be an intensive study to determine the magnitude of contamination in edible portions of commonly consumed fish and shellfish species (Phase I), to determine size-specific levels of contamination, and to assess the geographic extent of the contamination (Phase II). For the lower Willamette River area, these two phases should be combined into one investigation.

As indicated in the History section, six tribes have treaty rights to utilize the natural resources in the Portland Harbor area. A survey of four of these tribes (Umatilla, Yakama, Nez Perce, and Warm Springs) indicated that tribal members consume large amounts of fish, primarily salmon, steelhead, and lamprey, but that the amount obtained from the lower Willamette River was relatively small [28]. In our discussions with them, Siletz and Grand Ronde leaders and members indicated that few tribal members consume fish from the lower Willamette. However, members of at least some of these six tribes collect and eat wapato from the lower Willamette.

This review of available data indicates that a qualitative survey of anglers from the ethnic groups identified earlier (Eastern European, Asian, African-American, and Hispanic) should be done. The objective of this survey would be to confirm that carp, bullhead, and small-mouth bass are the most consumed species and to identify consumption rates. In addition, there should be discussions with the six tribes involved with Portland Harbor as to how much tribal members consume fish and wapato from the lower Willamette River.

As discussed in the Fish and Shellfish section on page 6, small populations of steelhead and cutthroat trout, and chinook and coho salmon lay their eggs and the juvenile fish spend the first part of their lives in the lower Willamette River. Thus, they could be contaminated, but they would need to sampled only if information was developed indicating significant consumption. This is probably unlikely due to the small size of these populations.

Also as indicated in the Fish and Shellfish section, juvenile lampreys live from 1 to 7 years as filter feeders in the sediment of freshwater rivers and tributaries before transforming into adults [15]. This makes juvenile lamprey particularly susceptible to contaminants present in sediments. After transforming to the adult form, lampreys move into the ocean where they live as predators/parasites on larger fish for a couple of years before returning to fresh water to spawn. It is uncertain how much of the contaminants acquired as an juvenile would still remain in an adult. This issue needs further evaluation because members of several tribes catch and eat adult lampreys from the Willamette River.

This evaluation did not consider other populations of anadromous species (primarily salmon, steelhead, and sturgeon) as possible sources for exposure to site-related contaminants. They appear to spend only a small portion of their lives in the Portland Harbor area.

Sediment Exposure Pathway

People can be directly exposed to contaminants in sediments. This can happen when people wade and swim in the water and during fishing and shellfish collecting activities. People can take up contaminants through the skin (dermal exposure), or they may accidentally transfer sediments to their mouths where they are swallowed (incidental ingestion). The populations who may be exposed in this way include recreational users who swim, fish, and collect shellfish; Native Americans and other subsistence fishers who may also swim; and homeless people living next to the river.

We evaluated the potential for health effects from direct exposures to contaminated sediments through accidental swallowing, through contact with the skin, or a combination of both. The details of this evaluation are presented in Appendix B starting on page 32, and the results of this evaluation are briefly summarized here.

Our evaluation of the sediment exposure pathway considered exposures to sediment that might occur for adults and children during swimming, for children playing in sediment, and for adults while fishing with nets or digging for shellfish. The exposure doses for all the chemicals evaluated are all too low to result in health effects whether the exposure was through accidental swallowing, skin contact, or a combination. Excess cancer risks calculated for the cancer-causing contaminants were within or lower than EPA's target risk range of $1H10^{-4}$ to $1H10^{-6}$ (1 excess cancer in 10,000 or 1,000,000, respectively). The excess cancer risk for some contaminants (arsenic, dioxin/furan toxicity equivalents, hexachlorobenzene, and PAH toxicity equivalents) was higher than ODEQ's target risk of $1H10^{-6}$ (1 excess cancer in 1,000,000); however, because protective assumptions were used, the predicted increased risk of cancer from these contaminants is so low as to be negligible.

Surface Water Exposure Pathway

Contaminants in the sediments may dissolve into the river water. In addition, contaminants may be added to the water from combined sewer overflows (CSOs) from overland sources. People who swim in the river may be exposed to these contaminants in the water. People may take up the water contaminants through their skin (dermal exposure), or they may accidentally swallow some of the water (incidental ingestion). Although the city of Portland does not withdraw drinking water from this portion of the Willamette River, it is possible that some of the homeless people living next to the river use the river water for drinking water.

ATSDR was unable to evaluate the surface water exposure pathway due to a lack of data on contaminant levels in surface water. However, chemical concentrations in water due to sediment contamination should be low, based on the low solubility of most of the sediment contaminants. Chemical or bacteriological contamination from other sources may occur during storm events as sewage and storm waters are released from CSOs [18]. This is of potential concern for public health but is outside the scope of this public health assessment. Upland sources may contribute significant surface water contamination, but this is also outside the scope of this public health assessment. If requested by ODEQ or EPA, ATSDR will evaluate surface water contamination contributed by upland sources on a source-by-source basis.

Environmental Exposure Pathways not Evaluated

We do not evaluate the soil, air, and groundwater exposure pathways in this public health assessment. If requested by ODEQ or EPA, ATSDR will evaluate these pathways for specific upland sources.

Evaluation of Health Outcome Data

The Superfund law requires that health outcome (i.e., mortality and morbidity) data (HOD) be considered in a public health assessment (32). This consideration is done using specific guidance in ATSDR's *Public Health Assessment Guidance Manual* and a 1996 revision to that guidance (9,33). The main requirements for evaluating HOD are presence of a completed human exposure pathway, great enough contaminant levels to result in measurable health effects, sufficient persons in the completed pathway for health effects to be measured, and a health outcome database in which disease rates for population of concern can be identified (33).

This site does not meet the requirements for including an evaluation of HOD in this public health assessment. Although completed human exposure pathways exist at this site, neither the contaminant levels are great enough nor the exposed population well enough defined to permit meaningful measurements of possible site-related health effects as identified in existing HOD.

Health Hazard

For the biota pathway, ATSDR is unable to determine whether exposure to site contaminants from the Portland Harbor NPL site could result in health effects, due to insufficient data. Eating contaminated fish and perhaps aquatic plants appears to be primary way individuals could be exposed to site contaminants. The biggest data gaps are information on the species and amounts of fish obtained and eaten from the site area and on the contaminant levels in those fish. ATSDR classifies the Portland Harbor NPL site as *an indeterminate public health hazard*.

Based on the available sediment data, exposure to site contaminants through skin contact or accidental swallowing of sediments should not result in health effects.

Child Health Initiative

ATSDR recognizes that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the Portland Harbor site as part of the ATSDR Child Health Initiative.

The major exposure route for children at this site could be eating contaminated fish.

Community Health Concerns

ATSDR met with or contacted a variety of groups and individuals to identify health concerns that community members might have about exposure to contaminants from the Portland Harbor site. These groups included the Portland Urban League, Oregon State Public Interest Research Group (OSPIRG), Oregon Center for Environmental Health (OCEH), Willamette Riverkeepers, Immigrant and Refugee Community Group (IRCO), ODEQ, ODHS, and EPA. We also met with representatives of the Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Grand Ronde (CTGR), Confederated Tribes of Siletz Indians (CTSI), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe.
The only specific health concerns were a report of an angler getting a rash whenever he immersed his hands in the Willamette River. However, there were many questions and concerns about whether fish from the lower Willamette were safe to eat. Programs to educate and inform the community about this issue are currently in development by OSPIRG, OCEH, Willamette River Keepers, ODEQ, and EPA[5] [5].

Needs

The Oregon Department of Environmental Quality (ODEQ) has developed a public involvement plan for the Portland Harbor site [5]. This plan provides the frame work for a coordinated

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[5] This is based on discussions ATSDR had with these groups or organizations.

approach to educating the community about the Portland Harbor site and the risk of consuming fish from the lower Willamette River. The objectives of this plan are to:

- Build relationships and create opportunities for dialogue with the community and affected parties and provide reasonable opportunities for their involvement throughout the process.

- Provide consistent and regular information on status of the project, ecological and human health risk assessments, and issues related to the investigation and cleanup plans and their implementation.

- Provide a continuing mechanism for assessing the needs, values, and concerns of the community, including addressing the concerns and questions of the community to the best of ODEQ's ability.

- Identify the communication needs of the community based on community interviews and provide opportunities for changing the approach and tools used to communicate with the public as the needs change.

- Ensure mobile, non-traditional groups that use the Harbor for fishing and/or recreation have the opportunity to participate in the process.

The last objective of this plan should be the focus of outreach to the various ethnic groups who catch and consume fish from the lower Willamette River. As discussed in a recent National Risk Communication Conference, messages about fish consumption need to be tailored for each of these ethnic groups in their own language using terminology appropriate to their culture [31].

Conclusions

1) As discussed earlier, the most important exposure pathway at the Portland Harbor site is the biota pathway (consuming fish and aquatic plants). There are several major data gaps which make it impossible to evaluate the possible public health consequences of this pathway. These gaps are data on the:

   + contaminant concentrations in fish and wapato from the lower Willamette River. Based on the sediment data, the contaminants in fish on which data are most needed are congener-specific PCBs, PAHs, dioxins, DDT and related pesticides, and metals.

   + resident fish species caught and consumed and the consumption rates for these species.

   + anadromous fish species caught and consumed, the consumption rates for these species, and whether any of the distinct populations of these species have sufficient resident time in the lower Willamette to acquire significant amounts of site contaminants.[6]

[6] *This conclusion was added as a response to comments received when this document was first released*.

2) While there is a lack of quality fish tissue data from the Portland Harbor area, the available evidence suggests that there is an increased risk of health effects from eating fish due to contaminants from the site. Until the actual risk is quantified, it is prudent to educate the public how to minimize their potential exposure to contaminants in fish, perhaps by suggesting they follow fish advisories for similar industrialized areas of the Columbia River and Columbia Slough. Education of the public will need to be targeted to the various ethnic groups and sports anglers that catch and eat fish from the lower Willamette River.

3) Ingestion or direct contact with contaminated sediment from the Willamette River is the other exposure pathway where people might be exposed to site contaminants. ATSDR's evaluation of this pathway indicates exposure to contaminated sediments should not result in health effects.

4) The above conclusion is based on available sediment data which do not fully characterize contaminants in all sections of the river. There are data gaps from river mile 3.5 to the mouth of the Willamette River, and from river miles 15 to 9.2. There are also little or no data from sediment in the lower 15 miles of the Willamette on dioxin, congener-specific PCBs, and DDT and related pesticides. ATSDR notes that the areas with the highest potential risk may or may not lie inside the final boundaries of the Portland Harbor NPL site.

Recommendations and Public Health Action Plan

Recommendations

1) ATSDR recommends that systematic sampling of the fish populations, shellfish, and wapato in the lower Willamette River for chemical contaminants be conducted. We anticipate that the fish species sampled would include at least carp, bullhead catfish, crappie, and small-mouth bass. However, all species should be considered using criteria such as local consumption patterns, residence time in lower Willamette River, percentage body fat, and other relevant factors. The analytes should include congener-specific PCBs, PAHs, dioxins, DDT and related pesticides, and metals. This systematic sampling should meet the criteria for a Tier 2 (phase I and II) study as described in the EPA *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories*.[7]

2) ATSDR recommends that public health education and risk communication programs be developed and implemented to inform people of their risk and how they can minimize it. Further, it is recommended these programs be targeted at the various ethnic groups and sports anglers that catch and consume fish from the lower Willamette River. It is also recommended that these programs be developed with input and cooperation from the targeted groups to insure maximum effectiveness.

3) ATSDR recommends that there be systematic sampling of the sediment at the River Place Marina, wapato collection locations, and the Columbia Grain Plant/Kelly Point Park to better evaluate the potential for exposure. ATSDR also recommends that addition

[7] This recommendation was revised in response to comments received when this document was first released.

sediment samples be obtained from all fishing locations and analyzed for congener-specific PCBs, DDT and dioxin. The agencies should decide in advance how to handle those sites which lie outside the final boundaries of the NPL site, perhaps by including those specific sites as special exposure points.

Public Health Action Plan

The Public Health Action Plan for the Portland Harbor NPL Site contains a description of actions to be taken by ATSDR at the site. The purpose of the Public Health Action Plan is to ensure that this public health assessment not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR to ensure the plan’s implementation. The public health actions to be implemented, in cooperation with ODHS, EPA, and ODEQ, are as follows:

1) Participate in the development and implementation of public health education and risk communication programs to inform people of their risk and how they can minimize it.

2) Participate with EPA, ODHS, ODEQ, the Natural Resource Trustees (including the 6 tribes), and the Lower Willamette Group in the development of the Portland Harbor Baseline Human Health Risk Assessment.

ATSDR notes that these items may also be planned by other agencies and commits to cooperating with these other agencies to complete these public health actions in the most effective manner.

ATSDR will reevaluate and expand the Public Health Action Plan as needed. New environmental, toxicological, or health outcome data, or the results of implementing the above proposed actions may determine the need for additional actions at this site.

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Appendix A - Explanation of Evaluation Process

Explanation of Evaluation Process

Screening Process

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific media (soil or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of water and soil that someone may inhale or ingest each day.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and noncancer health effects. Noncancer levels are based on valid toxicologic studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the media concentrations at which there could be a one in a million excess cancer risk for an adult eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and noncancer numbers exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

CVs used in this document are listed below:

> *Environmental Media Evaluation Guides (EMEGs)* are estimated contaminant concentrations in a media where non-carcinogenic health effects are unlikely. The EMEG is derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL).
>
> *Remedial Media Evaluation Guides (RMEGs)* are estimated contaminant concentrations in a media where non-carcinogenic health effects are unlikely. The RMEG is derived from the Enviornmental Protection Agency's (EPA's) reference dose (RfD).
>
> *Cancer Risk Evaluation Guides (CREGs)* are estimated contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs).
>
> *Preliminary Remediation Goals (PRGs)* are the estimated contaminant concentrations in a media where carcinogenic or non-carcinogenic health effects are unlikely. The PRGs used in this public health assessment were derived using provisional reference doses or cancer slope factors calculated by EPA's Region IX toxicologists.
>
> *EPA Soil Screening Levels (SSLs)* are estimated contaminant concentrations in soil at which additional evaluation is needed to determine if action is required to eliminate or reduce exposure.

Evaluation of Public Health Implications

Estimation of Exposure Dose

The next step is to take those contaminants that are above the CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Child and adult exposure doses are calculated for the site-specific exposure scenario, using our assumptions of who goes on the site and how often they contact the site contaminants. The exposure dose is the amount of a contaminant that gets into a person's body.

Appendix B describes the assumptions used in calculating exposure dose for the sediment direct contact pathway. As described in the body of this document, there was not enough information to estimate exposure doses for the biota or surface water pathways.

Noncancer Health Effects

The calculated exposure doses are then compared to an appropriate health guideline for that chemical. Health guideline values are considered safe doses; that is, health effects are unlikely below this level. The health guideline value is based on valid toxicologic studies for a chemical, with appropriate safety factors built in to account for human variation, animal-to-human differences, and/or the use of the lowest adverse effect level. For noncancer health effects, the following health guideline values are used.

> *Minimal Risk Level (MRLs)* - developed by ATSDR
> An estimate of daily human exposure – by a specified route and length of time – to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects. A list of MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.
>
> *Reference Dose (RfD)* - developed by EPA
> An estimate, with safety factors built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause noncancerous health effects. The RfDs can be found at http://www.epa.gov/iris/.

If the estimated exposure dose for a chemical is less than the health guideline value, then the exposure is unlikely to cause a non-carcinogenic health affect in that specific situation. If the exposure dose for a chemical is greater than the health guideline, then the exposure dose is compared to known toxicological values for that chemical and is discussed in more detail in the public health assessment (see Discussion Section). These toxicological values are doses derived from human and animal studies which are summarized in the ATSDR Toxicological Profiles. A direct comparison of site-specific exposure and doses to study-derived exposures and doses found to cause adverse health effects is the basis for deciding whether health effects are likely or not.

Calculation of Risk of Carcinogenic Effects

The estimated risk of developing cancer from exposure to the contaminants was calculated by multiplying the site-specific adult exposure dose by EPA's corresponding Cancer Slope Factor (which can be found at http://www.epa.gov/iris/). The results estimate the maximum increase in risk of developing cancer after 70 years of exposure to the contaminant.

The actual risk of cancer is probably lower than the calculated number. The method used to calculate EPA's Cancer Slope Factor assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. The method also assumes that there is no safe level for exposure. Little experimental evidence exists to confirm or refute those two assumptions. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude [34].

Because of uncertainties involved in estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data [35]. Therefore, the carcinogenic risk is described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures must be given careful consideration in evaluating the assumptions and variables relating to both toxicity and exposure.

Appendix B - Evaluation of Portland Harbor Sediment Pathway

Evaluation of Portland Harbor Sediment Pathway

People can be directly exposed to contaminants in sediments. This can happen when people wade and swim in the water and during fishing and shellfish collecting activities. People can take up contaminants through the skin (dermal exposure), or they may accidentally transfer sediments to their mouths where they are swallowed (incidental ingestion). The populations who may be exposed in this way include recreational users who swim, fish, and collect shellfish; Native Americans and other subsistence fishers who may also swim and collect shellfish; and homeless people living next to the river.

Identification of Contaminants of Concern in Sediment

The data used were obtained from the SEDQUAL Database (release 4) developed by the Washington State Department of Ecology [16]. The database was queried to obtain all sediment sampling results from stations within the Portland Harbor site. The resulting data set contained information on more than 250 different contaminants. These data were screened by comparing the maximum value of each contaminant to human health-based comparison values (CVs). Because sediment CVs were not available, soil CVs were used. Soil CVs are appropriate to use in this scenario of direct human contact with the sediment; however, they may not be sufficiently protective in determining risk from biota pathways, as some contaminants build up (bioaccumulate) along the food chain. Contaminants whose maximum value was higher that the CV, and contaminants for which no CV was available, were retained for further evaluation. These contaminants are listed in Table B-1 on page 35. Among the 29 contaminants identified, there were 10 polyaromatic hydrocarbons (PAHs), 6 chlorinated pesticides, 5 metals, 2 polychlorinated biphenyls (PCBs), dioxin, tributyltin, and 4 other chemicals.

Exposure dose was estimated for incidental ingestion (accidental swallowing) and dermal (skin) contact using the average value of each retained contaminant of concern. Non-detects were addressed in calculating averages by using one half the detection limit as the contaminant concentration.

For dioxin and furan compounds, toxicity equivalence factors (TEFs) were used to obtain a composite value weighted for toxicity [36]. This value is know as the toxicity equivalence quotient (TEQ) and allows a single comparison with health guidelines for the most studied compounds to be made. The dioxin/furan TEQ was compared to health guidelines for 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD).

A similar weighting procedure was used to obtain a TEQ for the polycyclic aromatic hydrocarbons (PAHs) [37]. This TEQ was compared to the health guideline for fluoranthene for noncancer effects and to cancer guidelines for benzo(a)pyrene.

Sediment Incidental Ingestion

The equation used to calculate exposure resulting from incidental ingestion (accidental swallowing) of the above contaminants of concern follows.
Dose (mg/kg/day) = C * IR * (EF/365) * 10^{-6} / BW, where

C = chemical concentration in ppm
IR = ingestion rate in mg per day
EF = exposure frequency in events per year
BW = body weight in kg

For child swimmers, we assumed a 10-year-old child weighing 36 kilograms (kg), swimming 24 days per year, and accidentally swallowing 10 milligrams (mg) of sediment each day they swim. The exposure dose for adult swimmers, fishers, and clammers was calculated assuming a 70-kg adult exposed 52 days per year and accidentally swallowing 50 mg of sediment per day exposed. Table B-2 on page 36 tabulates the results of these calculations.

Using these assumptions, the exposure doses calculated are all too low to result in health effects. In addition, excess cancer risks calculated for cancer-causing contaminants were well within EPA guidelines. Therefore, no health effects are expected from incidental ingestion of the sediment through normal recreational and fishing activities.

Sediment Dermal Exposure

The equations used to calculate exposure resulting from dermal (skin) contact to the above contaminants of concern follows.

Dose (mg/kg/day) = C * 10^{-6} mg/kg * SA * AF * ABS * (EF/365) / BW, where

C = chemical concentration in ppm
SA = skin surface area in cm^2
AF = soil to skin adherence factor in mg/cm^2
ABS = Absorption factor
EF = exposure frequency in events per year
BW = body weight in kg

We evaluated four different exposure scenarios. We assumed adults weigh 70 kg, have 23000 cm^2 of skin surface area, have 52 exposure events per year, and have soil to skin adherence factor of 0.4 mg/cm^2 (average of "reed-gathering" activity in Exposure Factors Handbook [38]). Swimmers were assumed to have 85% of their skin surface exposed, and fishers and clammers were assumed to have 50% exposed. We assumed child swimmers weigh 36 kg, have 13500 cm^2 of skin surface area, with 85% exposed, swim 24 days per year, and have a soil to skin adherence factor of 0.6 mg/cm^2 [50% greater than adults]. Children playing in sediment are assumed to be the same size as child swimmers, with 4 exposure events per year and a soil to skin adherence factor of 21.4 mg/cm^2 (average of "kids-in-mud" activity from Table 6-12 of Exposure Factors Handbook [38]). The exposure dose for adult swimmers, fishers, and clammers was calculated assuming a 70-kg adult with a skin surface area of 23,000 cm^2 and exposed 52 days per year. The absorption factor for each contaminant was taken from EPA Region III guidance documents; contaminants with no guidance were assumed to be absorbed 100%.

As indicated in Table B-3 on page 37, the exposure doses calculated using these assumptions are below the health guidelines, except for the children playing in sediment scenario compared to 2,3,7,8-TCDD's chronic MRL. The possible health consequences of exposure of children to dioxin-contaminated sediment is evaluated in the following paragraph. Excess cancer risks calculated for the cancer-causing contaminants were not elevated above the recommended action level of 1E-4 (1 in 10,000) [34,35].

The dermal exposure dose for a 10 year-old child playing in sediment with an average dioxin/furan TEQ of 0.7 parts per billion (ppb) four days a year was about 2×10^{-9} mg/kg/day, which exceeds the ATSDR chronic MRL for 2,3,7,8-TCDD of 1×10^{-9} mg/kg/day [39]. This dose is several orders of magnitude lower than the LOAEL, therefore, health effects are not expected from this exposure.

Combination of Ingestion and Direct Contact with Sediment

We also calculated the additive cancer risk for ingestion and dermal exposure to sediment. As indicated in Table B-4 on page 38, the excess cancer risk for these combined exposures was not elevated.

Uncertainties in Calculating Cancer Risk

The actual risk of cancer is probably lower than the calculated number. The method used to calculate EPA's Cancer Slope Factor assumes that high dose animal data can be used to estimate the risk for low dose exposures in humans.[8] The method also assumes that there is no safe level for exposure. There is little experimental evidence to confirm or refute those two assumptions. Lastly, the method computes the 95 percent upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.

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[8] U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual. December 1989.

Table B-1. Contaminants of Concern for Sediment Dermal and Ingestion Pathways

Contaminant	Range in Sediment in ppm[1]	Samples > DL[2] / Total	Samples > CV[3]	CV in ppm	CV Source[4]
4,4'-DDD	ND - 29	155 / 275	10	3	CREG[5]
4,4'-DDE	ND - 4	139 / 274	1	2	CREG[5]
4,4'-DDT	ND - 81	144 / 275	1 / 18	30 / 2	RMEG[6] / CREG[5]
Aroclor-1254	ND - 1.8	74 / 246	3	1	EMEG[7]
Aroclor-1260	ND - 7	69 / 247	10	0.22	R9 PRG[8]
Arsenic	ND - 640	422 / 596	7 / 556	20 / 0.5	EMEG[7] / CREG[5]
Benzyl alcohol	ND - 23	11 / 304	-	none[9]	N / A
Beryllium	ND - 1	197 / 280	0 / 252	100 / 0.1	RMEG[6] / SSL[10]
Carbazole	ND - 44	123 / 294	3	32	SSL[10]
Dieldrin	ND - 4	17 / 327	1 / 20	3 / 0.04	EMEG[7] / CREG[5]
Dioxin/furan TEQ	0.000008 - 0.0108	20 / 20	-	none[9]	N / A
Heptachlor	ND - 2	1 / 275	0 / 1	30 / 0.2	RMEG[6] / CREG[5]
Hexachlorobenzene	ND - 14	8 / 375	3 / 38	1 / 0.4	EMEG[7] / CREG[5]
Hexachlorobutadiene	ND - 34	10 / 411	5 / 5	10 / 9	EMEG[7] / CREG[5]
Iron	0.5 - 64500	258 / 258	228	23000	R9 PRG[8]
Lead	ND - 1080	502 / 557	5	400	SSL[10]
Naphthalene	ND - 2500	363 / 623	2	1000	RMEG[6]
Thallium	ND - 27	147 / 273	126	5.2	R9 PRG[8]
Tributyltin	ND - 43	199 / 277	-	none[9]	N / A
Polycyclic Aromatic Hydrocarbons:					
Benzo(a)anthracene	ND - 170	428 / 602	125	0.9	SSL[10]
Benzo(a)pyrene	ND - 99	501 / 596	125 / 345	0.9 / 0.1	SSL / CREG[5]
Benzo(e)pyrene	ND - 50	49 / 61	-	none[9]	N / A
Benzo(g,h,i)perylene	ND - 76	475 / 593	-	none[9]	N / A
Benzo(k)fluoranthene	ND - 76	319 / 324	49	0.9	SSL[10]
Chrysene	ND - 170	524 / 597	4	88	SSL[10]
Dibenz(a,h)anthracene	ND - 25	276 / 594	183	0.09	SSL[10]
Fluoranthene	ND - 960	547 / 598	3	400	RMEG[6]
Fluorene	ND - 1100	362 / 598	4	400	RMEG[6]
Indeno(1,2,3-c,d)pyrene	ND - 74	455 / 598	98	0.9	SSL[10]

[1] ppm = parts per million of chemical in sediment.
[2] DL = Detection limit.
[3] CV = Comparison value.
[4] These comparison values are described in Appendix A starting on page 28.
[5] CREG = cancer risk evaluation guide.
Data Source: SEDQUAL [16]
[6] RMEG = remedial media evaluation guide.
[7] EMEG = environmental media evaluation guide.
[8] R9 PRG = EPA Region 9 preliminary remediation goal.
[9] No comparison value available.
[10] SSL = EPA soil screening level.

Table B-2. Exposure Doses for Sediment Ingestion Pathways

Contaminant	Average Concentration (ppm)	Child Swimmer Dose (mg/kg/day)	Adult Swimmer Dose (mg/kg/day)	Health Guideline (mg/kg/day)	Health Guideline Source
4,4'-DDD	0.5	9E-09	5E-08	none	
4,4'-DDE	0.1	1E-09	6E-09	none	
4,4'-DDT	0.9	2E-08	9E-08	5E-04	Oral RfD
Aroclor-1254	0.1	1E-09	8E-09	2E-05	Chronic Oral MRL
Aroclor-1260	0	3E-09	2E-08	none	
Arsenic	5	1E-07	5E-07	3E-04	Chronic Oral MRL
Benzyl alcohol	0.2	4E-09	2E-08	3E-01	Oral RfD
Beryllium	0.5	1E-08	5E-08	1E-03	Chronic Oral MRL
Carbazole	1	1E-08	8E-08	none	
Dieldrin	0.02	4E-10	2E-09	5E-05	Chronic Oral MRL
Dioxin/furan TEQ	0.0007	1E-11	7E-11	1E-09	Chronic Oral MRL
Heptachlor	0.0	3E-10	1E-09	5E-04	Oral RfD
Hexachlorobenzene	0.3	5E-09	3E-08	2E-05	Chronic Oral MRL
Hexachlorobutadiene	1	1E-08	6E-08	2E-04	Intermediate Oral MRL
Iron	36510	7E-04	4E-03	3E-01	Oral RfD
Lead	38	7E-07	4E-06	none	
Naphthalene	12	2E-07	1E-06	2E-02	Oral RfD
Thallium	6	1E-07	6E-07	7E-05	Oral RfD
Tributyltin	1	3E-08	1E-07	3E-04	Oral RfD
Polycyclic Aromatic Hydrocarbons:					
TEQ PAHs	5	9E-08	5E-07	none	
Benzo(a)anthracene	3	5E-08	3E-07	none	
Benzo(a)pyrene	2	3E-08	2E-07	none	
Benzo(e)pyrene	5	8E-08	5E-07	none	
Benzo(g,h,i)perylene	1	2E-08	1E-07	none	
Benzo(k)fluoranthene	1	2E-08	1E-07	none	
Chrysene	3	5E-08	3E-07	none	
Dibenz(a,h)anthracene	0.4	8E-09	4E-08	none	
Fluoranthene	11	2E-07	1E-06	4E-02	Oral RfD
Fluorene	9	2E-07	9E-07	4E-02	Oral RfD
Indeno(1,2,3-c,d)pyrene	1	2E-08	1E-07	none	

Table B-3. Exposure Doses for Sediment Dermal Pathways

Contaminant	Average Concentration (ppm)	Absorption Factor	Exposure Doses (mg/kg/day) child playing in sediment	child swimmer	adult swimmer	adult fisher/ clammer	Health Guideline (mg/kg/day)	Health Guideline Source
4,4'-DDD	0.5	10%	4E-06	6E-07	8E-07	5E-07	none	
4,4'-DDE	0.05	10%	4E-07	7E-08	9E-08	5E-08	none	
4,4'-DDT	0.9	10%	7E-06	1E-06	1E-06	9E-07	5E-04	Oral RfD
Aroclor-1254	0.08	6%	3E-07	6E-08	7E-08	4E-08	2E-05	Chronic Oral MRL
Aroclor-1260	0.2	6%	8E-07	1E-07	2E-07	1E-07	none	
Arsenic	5	3%	1E-05	2E-06	3E-06	2E-06	3E-04	Chronic Oral MRL
Benzyl alcohol	0.2	100%	2E-05	3E-06	4E-06	2E-06	3E-01	Oral RfD
Beryllium	0.5	1%	4E-07	7E-08	9E-08	5E-08	1E-03	Chronic Oral MRL
Carbazole	0.8	100%	6E-05	9E-06	1E-05	7E-06	none	
Dieldrin	0.02	10%	2E-07	3E-08	3E-08	2E-08	5E-05	Chronic Oral MRL
Dioxin/furan cmpds-TEQ	0.0007	3%	**2E-09**	3E-10	3E-10	2E-10	1E-09	Chronic Oral MRL
Heptachlor	0.01	10%	1E-07	2E-08	2E-08	1E-08	5E-04	Oral RfD
Hexachlorobenzene	0.3	100%	2E-05	3E-06	4E-06	2E-06	2E-05	Chronic Oral MRL
Hexachlorobutadiene	0.5	100%	4E-05	7E-06	9E-06	5E-06	2E-04	Intermediate Oral MRL
Iron	36510	1%	3E-02	5E-03	6E-03	3E-03	3E-01	Oral RfD
Lead	38	1%	3E-05	5E-06	6E-06	4E-06	none	
Naphthalene	12	10%	9E-05	1E-05	2E-05	1E-05	2E-02	Oral RfD
Thallium	6	1%	5E-06	8E-07	1E-06	6E-07	7E-05	Oral RfD
Tributyltin	1.3	100%	1E-04	2E-05	2E-05	1E-05	3E-04	Oral RfD
Polycyclic Aromatic Hydrocarbons:								
TEQ PAHs	5.0	10%	4E-05	6E-06	8E-06	5E-06	none	
Benzo(a)anthracene	2.7	10%	2E-05	3E-06	4E-06	3E-06	none	
Benzo(a)pyrene	1.8	10%	1E-05	2E-06	3E-06	2E-06	none	
Benzo(e)pyrene	4.6	10%	3E-05	6E-06	7E-06	4E-06	none	
Benzo(g,h,i)perylene	1.3	10%	9E-06	2E-06	2E-06	1E-06	none	
Benzo(k)fluoranthene	1.3	10%	9E-06	2E-06	2E-06	1E-06	none	
Chrysene	3.0	10%	2E-05	4E-06	5E-06	3E-06	none	
Dibenz(a,h)anthracene	0.4	10%	3E-06	5E-07	7E-07	4E-07	none	
Fluoranthene	11.2	10%	8E-05	1E-05	2E-05	1E-05	4E-02	Oral RfD
Fluorene	8.5	10%	6E-05	1E-05	1E-05	8E-06	4E-02	Oral RfD
Indeno(1,2,3-c,d)pyrene	1.1	10%	8E-06	1E-06	2E-06	1E-06	none	

Table B-4. Cancer Risk from Ingestion and Direct Contact of Sediment

Contaminant	Average Concentration (ppm)	Adult Swimmer Ingestion Dose (mg/kg/day)	Adult Swimmer Dermal Dose (mg/kg/day)	Combined Dose (mg/kg/day)	Excess Cancer Risk
4,4'-DDD	0.5	5E-08	8E-07	8E-07	2E-07
4,4'-DDE	0.05	6E-09	9E-08	9E-08	3E-08
4,4'-DDT	0.9	9E-08	1E-06	2E-06	5E-07
Arsenic	5	5E-07	3E-06	3E-06	5E-06
Carbazole	0.8	8E-08	1E-05	1E-05	2E-07
Dioxin/furan compounds- TEQ	0.0007	7E-11	3E-10	4E-10	6E-05
Heptachlor	0.01	1E-09	2E-08	2E-08	1E-07
Hexachlorobenzene	0.3	3E-08	4E-06	4E-06	7E-06
Hexachlorobutadiene	0.5	6E-08	9E-06	9E-06	7E-07
Polycyclic Aromatic Hydrocarbons:					
TEQ PAHs	5	5E-07	8E-06	8E-06	6E-05
Benzo(a)anthracene	3	3E-07	4E-06	5E-06	3E-06
Benzo(a)pyrene	2	2E-07	3E-06	3E-06	2E-05
Benzo(k)fluoranthene	1	1E-07	2E-06	2E-06	2E-07
Chrysene	3	3E-07	5E-06	5E-06	4E-08
Dibenz(a,h)anthracene	0.4	4E-08	7E-07	7E-07	5E-06
Indeno(1,2,3-c,d)pyrene	1	1E-07	2E-06	2E-06	1E-06

Appendix C - ATSDR Plain Language Glossary of Environmental Health Terms

ATSDR Plain Language Glossary of Environmental Health Terms

Absorption:	How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.
Acute Exposure:	Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.
Additive Effect:	A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
Adverse Health Effect:	A change in body function or the structures of cells that can lead to disease or health problems.
Antagonistic Effect:	A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
ATSDR:	The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
Background Level:	An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.
Bioavailability:	See **Relative Bioavailability**.
Biota:	Used in public health, things that humans would eat – including animals, fish and plants.
CAP:	See **C**ommunity **A**ssistance **P**anel.
Cancer:	A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control
Carcinogen:	Any substance shown to cause tumors or cancer in experimental studies.
CERCLA:	See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.
Chronic Exposure:	A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic.*

Completed Exposure Pathway:	See **Exposure Pathway**.
Community Assistance Panel (CAP):	A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.
Comparison Value: **(CVs)**	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
Concern:	A belief or worry that chemicals in the environment might cause harm to people.
Concentration:	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant:	See **Environmental Contaminant**.
Delayed Health Effect:	A disease or injury that happens as a result of exposures that may have occurred far in the past.
Dermal Contact:	A chemical getting onto your skin. (see **Route of Exposure**).
Dose:	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as “amount of substance(s) per body weight per day”.
Dose / Response:	The relationship between the amount of exposure (dose) and the change in body function or health that result.
Duration:	The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:
1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Malignancy: See **Cancer**.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume: A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

PRP: **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:
– Urgent Public Health Hazard
– Public Health Hazard
– Indeterminate Public Health Hazard
– No Apparent Public Health Hazard
– No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
– breathing (also called inhalation),
– eating or drinking (also called ingestion), and
– getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic effect: A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology:	The study of the harmful effects of chemicals on humans or animals.
Tumor:	Abnormal growth of tissue or cells that have formed a lump or mass.
Uncertainty Factor:	See **Safety Factor**.
Urgent Public Health Hazard:	This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.