Lockheed West Seattle

Seattle, Washington
EPA Facility ID: WAN001002655
Basin: Puget Sound
HUC: 177110019

Executive Summary

The Lockheed West Seattle site is a former shipyard in an industrial area of Seattle, King County, Washington. The site encompasses approximately 21 ha (52 acres); 11 ha (27 acres) are in the aquatic areas of Elliott Bay at the mouth of the West Duwamish Waterway. From 1946 to 1986, the facility was used for ship refurbishing and maintenance. The work was conducted at piers, in dry docks, and at a shipway. Wastes from these operations, including paint, metal scrapings, and sandblast grit, were discharged directly to Elliott Bay and the West Duwamish Waterway. Heavy metals, organotins (including tributyltin), PAHs, and PCBs have been detected in sediment samples collected from the West Duwamish Waterway and Elliott Bay during numerous investigations conducted at the site. Surface water runoff and direct discharge are the primary pathways for the migration of contaminants from the site to NOAA trust resources; groundwater transport is a secondary pathway. The habitats of primary concern to NOAA are Elliott Bay and the West Duwamish Waterway, which provide rearing and adult habitat and migratory routes for numerous NOAA trust resources, including anadromous, estuarine, and marine fish species, as well as invertebrates and marine mammals.

Site Background

The Lockheed West Seattle site is a former shipyard in an industrial area of Seattle, King County, Washington. The site encompasses approximately 21 ha (52 acres); 11 ha (27 acres) are in the aquatic areas of Elliott Bay at the mouth of the West Duwamish Waterway (Figure 1). Approximately 3 ha (7 acres) of the aquatic lands are currently owned by the Port of Seattle, and the remaining 8 ha (20 acres) of aquatic lands are owned by the Washington State Department of Natural Resources (USEPA 2006a). The West Duwamish Waterway is the western portion of the mouth of the Duwamish River.

The upland portion of the facility (Figure 2) was developed on fill material over mudflats in Elliott Bay. Two recently remediated Superfund sites are adjacent to the Lockheed West Seattle site: the Pacific Sound Resources Superfund site is to the west and the Harbor Island Superfund site is to the east (USEPA 2006b; Tetra Tech 2006).

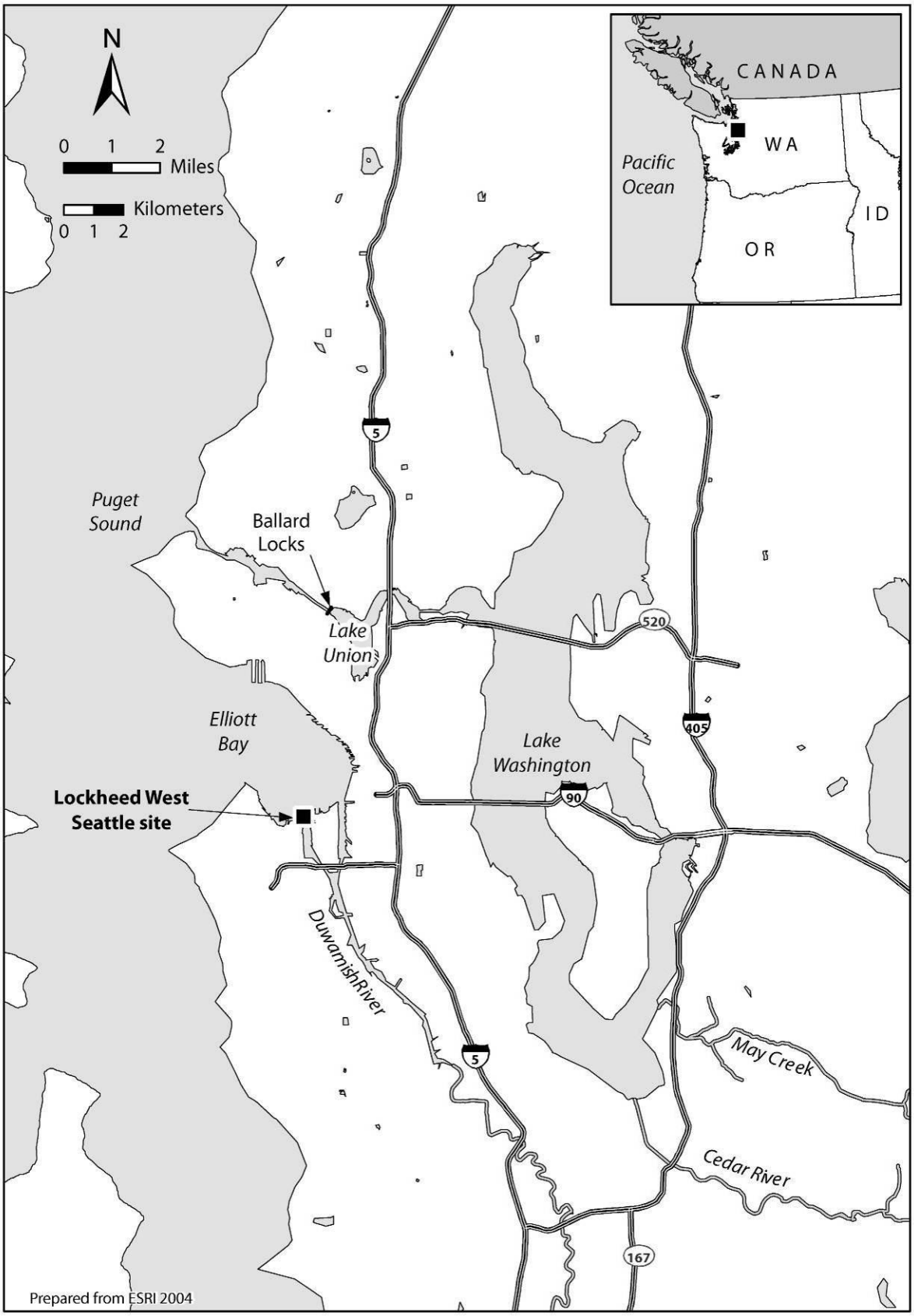

Figure 1. Location of the Lockheed West Seattle site in Seattle, Washington.

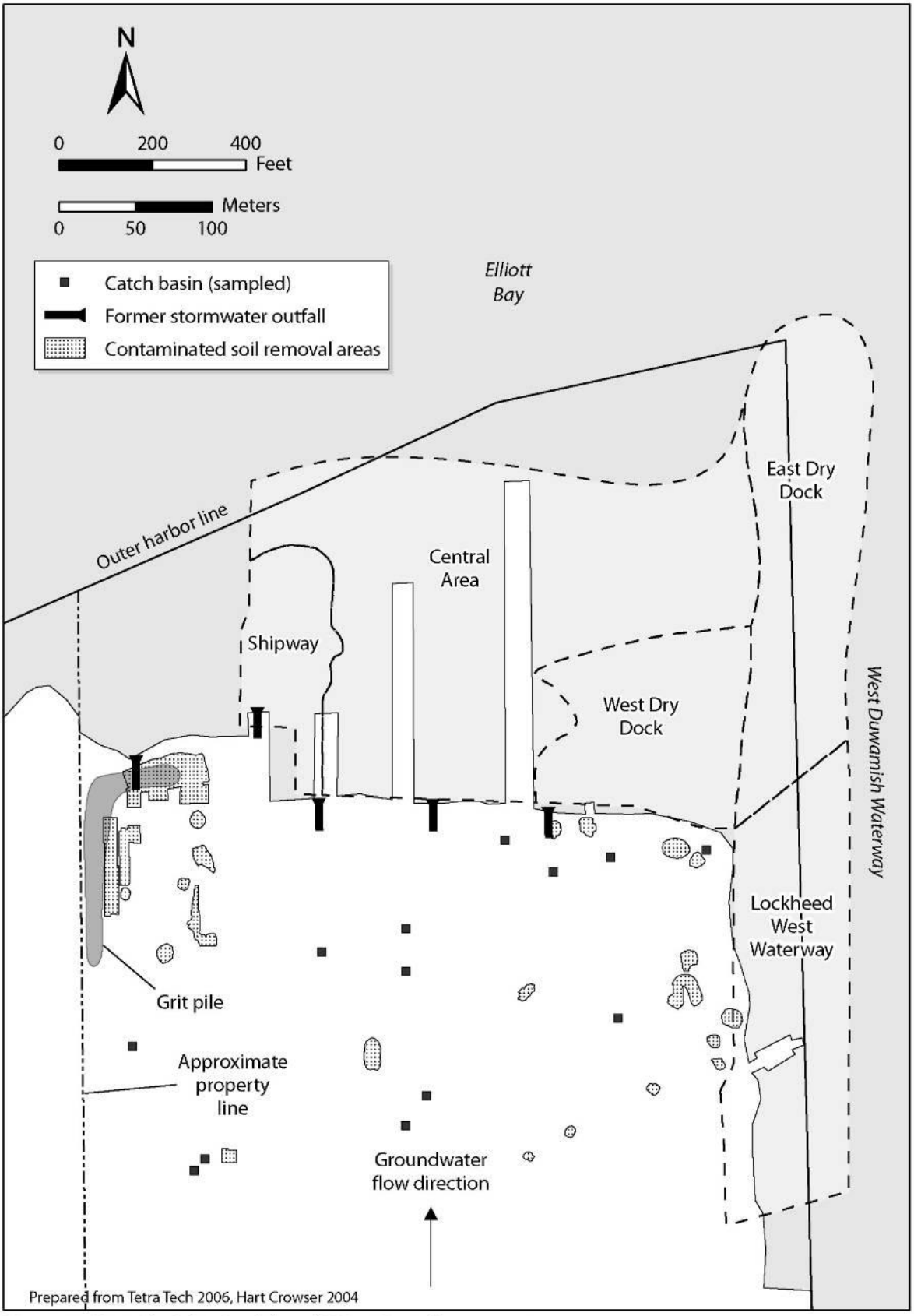

Figure 2. Detail of the Lockheed West Seattle property.

From 1946 to 1986, the facility was used for ship refurbishing and maintenance. The work was conducted at piers, in dry docks, and at a shipway. Operations included metal fabrication, pipe fitting, electrical wiring, sandblasting, painting, and yard vehicle maintenance. Paints used on ships contained metals to provide pigment and anti-fouling chemical agents to inhibit the growth of marine organisms on ship hulls. A sandblast grit pile was located in the northwestern portion of the site adjacent to the Elliott Bay shoreline (Figure 2). Runoff from the grit pile was not contained and was allowed to enter Elliott Bay. In addition, wastes, including paint, metal scrapings, and sandblast grit, were discharged directly to Elliott Bay and the West Duwamish Waterway. The stormwater system at the facility, which consisted of numerous catch basins draining to stormwater drainage pipes, also discharged directly to Elliott Bay and the West Duwamish Waterway (Tetra Tech 2006; USEPA 2006a).

Heavy metals (including arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc), organotins (including tributyltin), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) have been detected in sediment samples collected from the West Duwamish Waterway and Elliott Bay during numerous investigations conducted at the site (Hart Crowser 2004; Tetra Tech 2006). In addition, paint chips and bits of metal have been observed in sediments adjacent to the facility during investigations (USEPA 2006a). Since 1989, groundwater monitoring has been conducted at the site, and metals, PAHs, and organotins have been detected in groundwater samples collected from site monitoring wells (Tetra Tech 2006). The concentrations of detected groundwater contaminants were not provided in the documents reviewed for this report.

In 1995, under the direction of the Washington State Department of Ecology (Ecology), contaminated soils in the upland portions of the site were removed, catch basin and storm drain sediments were removed, the upland area was capped with asphalt, and the stormwater system was replaced. Contaminated sediment in the aquatic areas has not been removed. As shown on Figure 2, Ecology has defined five units in the aquatic areas for remediation: the Shipway, the Central Area, the West Dry Dock, the Lockheed West Waterway, and the East Dry Dock (Tetra Tech 2006).

In 2006, a risk assessment/feasibility study was conducted on the aquatic portion of the site by a consultant working under contract to the former owner of the property. To determine the site's eligibility for proposal to the U.S. Environmental Protection Agency's (USEPA) National Priorities List (NPL), a hazard ranking system documentation package was completed in September 2006 (USEPA 2006a). The Lockheed West Seattle site was proposed to the NPL on September 27, 2006 (USEPA 2006b).

Surface water runoff and direct discharge are the primary pathways for the migration of contaminants from the site to NOAA trust resources; groundwater transport is a secondary pathway. Surface water and stormwater runoff at the Lockheed West Seattle site discharge directly to Elliott Bay and the West Duwamish Waterway. The flow and depth of groundwater underlying the site are tidally influenced, but groundwater generally flows north to Elliott Bay (Tetra Tech 2006). Contaminated groundwater underlying the site is expected to discharge to Elliott Bay and the West Duwamish Waterway (USEPA 2006a).

NOAA Trust Resources

The habitats of primary concern to NOAA are Elliott Bay and the West Duwamish Waterway. Elliott Bay is a large embayment of Puget Sound (Figure 1). The West Duwamish Waterway, which is the western portion of the mouth of the Duwamish River, forms the

Duwamish River estuary in the southern end of Elliott Bay adjacent to the site. This area is a transitional zone between estuarine and marine environments, with tides ranging from 4.6 m (15 ft) above mean lower low water (MLLW) to 1.4 m (4.5 ft) below MLLW. Tidal influence and river flow create consistent circulation in the vicinity of the site. Substrates in the area consist of sands, silts, and silty sands (Tetra Tech 2006). The shoreline in the vicinity is highly industrialized and developed.

Elliott Bay and the West Duwamish Waterway provide rearing and adult habitat and migratory routes for numerous NOAA trust resources, including anadromous, estuarine, and marine fish species, as well as invertebrates and marine mammals (Table 1). Anadromous species that use these habitats as migratory routes, nurseries, and osmoregulatory transition zones include Chinook, chum, coho, pink, and sockeye salmon, as well as steelhead trout (Foley 2007). Elliott Bay and the West Duwamish Waterway also provide adult habitat and a migratory route for the anadromous Pacific lamprey.

Chinook and coho salmon are the salmon species most frequently encountered in the Duwamish River, with the majority originating from two state and tribally managed hatcheries on the Green River, a tributary of the Duwamish River. NOAA Fisheries lists Chinook salmon as a threatened species and designates coho salmon as a species of concern. In addition, NOAA Fisheries has proposed steelhead trout for listing as a threatened species (NOAA Fisheries 2007). Bull trout and bald eagles, which are both listed by the U.S. Fish and Wildlife Service as threatened, have been observed in the vicinity of the site (USEPA 2006a).

Estuarine and marine species found in the vicinity include English sole, Pacific cod, Pacific herring, Pacific sand lance, Pacific staghorn sculpin, Pacific tomcod, prickly sculpin, shiner perch, starry flounder, surf smelt, threespine stickleback, and walleye pollock (Monaco et al. 1990). Estuarine and marine species primarily use Elliott Bay and the West Duwamish Waterway as juvenile rearing areas. Crab, shrimp, and squid are also found in the waters of Elliott Bay, which provides habitat for all life-history phases for many of these invertebrate species. The area also provides adult habitat for California sea lions, harbor porpoises, and harbor seals.

Commercial fisheries, as well as recreational and subsistence fishing, occur in the vicinity of the Lockheed West Seattle site. Table 1 identifies species targeted in these fisheries. The waters in the vicinity are the adjudicated usual and accustomed fishing grounds of the Muckleshoot and Suquamish Indian Tribes. Tribal fishers can be observed fishing in the area throughout the year (USEPA 2006a).

A fish consumption advisory is in effect for Puget Sound waters within King County (excluding Vashon Island) because of concentrations of mercury, PCBs, and historical industrial discharges.

Table 1. NOAA trust resources present in the West Duwamish Waterway and Elliott Bay near the Lockheed West Seattle site (Monaco et al. 1990; Bargman 1991; Tetra Tech 2006; Foley 2007; WDFW 2007).

Species		Habitat Use				Fisheries		
Common Name	Scientific Name	Spawning Area	Nursery Area	Migratory Route	Adult Habitat	Comm.	Rec.	Subsist.
ANADROMOUS FISH								
Chinook salmon	*Oncorhynchus tshawytscha*		♦	♦	♦	♦	♦	♦
Chum salmon	*Oncorhynchus keta*		♦	♦	♦	♦		
Coho salmon	*Oncorhynchus kisutch*		♦	♦	♦	♦	♦	♦
Pacific lamprey	*Lampetra tridentata*			♦	♦			
Pink salmon	*Oncorhynchus gorbuscha*		♦	♦	♦			
Sockeye salmon	*Oncorhynchus nerka*		♦	♦	♦			
Steelhead trout	*Oncorhynchus mykiss*		♦	♦	♦	♦	♦	♦
MARINE/ESTUARINE FISH								
English sole	*Parophrys vetulus*		♦					
Pacific cod	*Gadus macrocephalus*		♦			♦	♦	
Pacific herring	*Clupea pallasii*	♦	♦			♦		
Pacific sand lance	*Ammodytes hexapterus*		♦				♦	
Pacific staghorn sculpin	*Leptocottus armatus*		♦		♦			
Pacific tomcod	*Microgadus proximus*		♦					
Prickly sculpin	*Cottus asper*		♦					
Shiner perch	*Cymatogaster aggregata*	♦	♦		♦			
Starry flounder	*Platichthys stellatus*		♦			♦	♦	
Surf smelt	*Hypomesus pretiosus*		♦				♦	
Threespine stickleback	*Gasterosteus aculeatus*	♦	♦		♦			
Walleye pollock	*Theragra chalcogramma*		♦				♦	
INVERTEBRATES								
Blue mussel	*Mytilus edulis*	♦	♦		♦			
Dungeness crab	*Cancer magister*	♦	♦		♦		♦	♦
Opalescent inshore squid	*Loligo opalescens*							
Pandalid shrimp	*Pandalidae spp.*		♦		♦		♦	♦
Red rock crab	*Cancer productus*	♦	♦		♦		♦	♦
MARINE MAMMALS								
California sea lion	*Zalophus californianus*				♦			
Harbor porpoise	*Phocoena phocoena*				♦			
Harbor seal	*Phoca vitulina*				♦			

The advisory recommends consuming no more than one meal per week of Chinook salmon and no more than two meals per month of blackmouth, a resident Chinook salmon of Puget Sound. The advisory recommends no consumption of rockfish from Elliott Bay (WDOH 2006). In addition, the advisory recommends no consumption of English sole and other flatfish from the Duwamish Waterway and no more than two meals per month of flatfish from Elliott Bay. The advisory recommends no consumption of crab from the Duwamish Waterway and warns that the consumption of crab, shellfish, or seaweed from Elliott Bay may be unsafe due to pollution. The advisory recommends no consumption of crab hepatopancreas from Elliott Bay. Shellfish and seaweed harvesting in Elliott Bay and the Duwamish Waterway is closed due to pollution (WDOH 2006).

Site-Related Contamination

Large numbers of sediment samples have been collected over the years during numerous environmental investigations conducted at the Lockheed West Seattle site. These samples have been analyzed for a wide range of environmental contaminants, including metals, semivolatile organic compounds (including PAHs), organotins (including tributyltin), and PCBs (Hart Crowser 2004; Tetra Tech 2006). The primary contaminants of concern to NOAA are metals, tributyltin, PAHs, and PCBs.

Table 2 summarizes the maximum concentrations of contaminants of concern to NOAA detected during the site investigations and compares them to relevant screening guidelines. Site-specific or regionally specific screening guidelines are always used when available. In this case, the regional specific screening guidelines are the Washington State Department of Ecology's Sediment Management Standards (SMS) (Ecology 1995) and the sediment threshold for tributyltin, which is protective of most juvenile salmonid prey (Meador et al. 2002). Other screening guidelines that will be used for sediment in a saltwater environment are the effects range-low (ERL) concentrations (Long et al. 1998). Exceptions to these screening guidelines, if any, are noted on Table 2. Only maximum concentrations that exceeded relevant screening guidelines or for which there are no screening guidelines are discussed below. When known, the general sampling locations (refer to Figure 2) are also provided for maximum concentrations that exceeded screening guidelines or do not have screening guidelines.

Table 2. Maximum concentrations of contaminants of concern to NOAA at the Lockheed West Seattle site. Contaminant values in bold exceed or are equal to screening guidelines (Hart Crowser 2004; Tetra Tech 2006).

		Sediment (mg/kg)	
Contaminant	Sediment	SMS[a]	ERL[b]
METALS/INORGANICS			
Arsenic	**710**	57	8.2
Cadmium	**7.3**	5.1	1.2
Chromium	**660**	260	81
Copper	**1,900**	390	34
Lead	**2,200**	450	46.7
Mercury	**2.2**	0.41	0.15
Silver	**1.3**	6.1	1
Zinc	**2,600**	410	150
ORGANOTINS			
Tributyltin	**6**	NA	0.12[c]
PAHs			
Acenaphthene	**5.4**	0.32	0.016
Acenaphthylene	**1.9**	1.32	0.044
Anthracene	**8.7**	4.4	0.0853
Benz(a)anthracene	**19**	2.2	0.261
Benzo(a)pyrene	**15**	1.98	0.43
Benzo(b+k)fluoranthene	**22**	4.6	1.8[d]
Chrysene	**15**	2.2	0.384
Dibenz(a,h)anthracene	**4.2**	0.24	0.0634
Fluoranthene	**35**	3.2	0.6
Fluorene	**6**	0.46	0.019
Indeno(1,2,3-cd)pyrene	**8.9**	0.68	0.6[d]
2-Methylnaphthalene	**1.6**	0.76	0.07
Naphthalene	**6.9**	1.98	0.16
Phenanthrene	**35**	2	0.24
Pyrene	**36**	20	0.665
Total LPAH	**64**	7.4	0.552
Total HPAH	**160**	19.2	1.7
PCBs			
Total PCBs	**5.9**	0.24	0.0227

a: Washington State Sediment Management Standard (SMS) Marine Sediment Quality Standards. The SMS is based on organic carbon content of the sediment so a 2% total organic carbon content is assumed (Ecology 1995).

b: Effects range-low (ERL) represents the 10th percentile for the dataset in which effects were observed or predicted in studies compiled by Long et al. (1998).

c: This number is based on the tissue residue approach and available data. The number protects most salmonid prey species against severe adverse sublethal effects. This number is based on sediment with a 2% total organic carbon content (Meador et al. 2002).

d: Marine apparent effects threshold (AET) for bioassays. The AET represents the concentration above which adverse biological impacts would be expected.

NA: Screening guideline not available.

Sediment

Eight metals were detected in sediment samples collected from the Lockheed West Seattle site at maximum concentrations that exceeded the screening guidelines. The maximum concentrations of arsenic and silver were detected in samples collected from Elliott Bay in the site's Central Area. The maximum concentration of arsenic exceeded the ERL and the SMS by one order of magnitude. The maximum concentration of silver slightly exceeded the ERL.

The maximum concentrations of cadmium, chromium, copper, lead, mercury, and zinc were detected in samples collected from Elliot Bay along the eastern border of the site in the East Dry Dock area. The maximum concentrations of copper, lead, mercury, and zinc exceeded the ERLs by one order of magnitude. The maximum concentrations of chromium and cadmium exceeded the ERLs by a factor of eight and six, respectively. The maximum concentration of zinc exceeded the SMS by a factor of six. The maximum concentrations of copper, lead, and mercury exceeded the SMSs by a factor of approximately five. The maximum concentration of chromium exceeded the SMS by a factor of 2.5 and the maximum concentration of cadmium slightly exceeded the SMS.

The maximum concentration of tributyltin, which was detected in a sample collected from Elliott Bay in the eastern portion of the site in the Central Area, exceeded Meador's sediment threshold by one order of magnitude. No SMS is available for comparison to the maximum concentration of tributyltin.

Sixteen PAHs were detected in sediment samples collected from the Lockheed West Seattle site at maximum concentrations that exceeded screening guidelines; maximum concentrations of total low-molecular-weight PAHs (LPAHs) and high-molecular-weight PAHs (HPAHs) also exceeded screening guidelines. The maximum concentrations of all detected PAHs (Table 2) occurred in samples collected from Elliott Bay along the eastern border of the site in the East Dry Dock area. The maximum concentrations of acenaphthene, anthracene, fluorene, phenanthrene, and total LPAHs exceeded the ERLs by two orders of magnitude. The maximum concentrations of acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, 2-methylnaphthalene, naphthalene, pyrene, and total HPAHs exceeded the ERLs by one order of magnitude. The maximum concentrations of total benzofluoranthenes and indeno(1,2,3-cd)pyrene exceeded the apparent effects threshold (AET) by one order of magnitude.

The maximum concentrations of acenaphthene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, and phenanthrene exceeded the SMSs by one order of magnitude. The maximum concentrations of benzo(a)anthracene and total LPAHs exceeded the SMSs by a factor of approximately nine. The maximum concentrations of total HPAHs, benzo(a)pyrene, and chrysene exceeded the SMSs by a factor of eight, 7.5, and seven, respectively. The maximum concentrations of total benzofluoranthenes, naphthalene, and 2-methylnaphthalene exceeded the SMSs by a factor of four, three, and two, respectively. The maximum concentrations of acenaphthylene, anthracene, and pyrene slightly exceeded the SMSs.

PCBs were detected in sediment samples collected from the Lockheed West Seattle site at concentrations that exceeded the screening guidelines. The maximum concentration of total PCBs, which was detected in a sample collected from Elliott Bay along the eastern border of the site in the East Dry Dock area, exceeded the ERL by two orders of magnitude and the SMS by one order of magnitude.

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