RECORD OF DECISION

DECLARATION, DECISION SUMMARY, AND RESPONSIVENESS SUMMARY

FOR

HARBOR ISLAND SOIL AND GROUNDWATER
SEATTLE, WASHINGTON

SEPTEMBER 1993

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 SIXTH AVENUE
SEATTLE, WASHINGTON

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DECLARATION

SITE NAME AND LOCATION

Harbor Island

Seattle, King County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected final remedial action, for soil and groundwater, for the Harbor Island Site in Seattle, King County, Washington, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §§ 9601-96), as amended, and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record.

The Washington State Department of Ecology (Ecology) concurs with the selected remedy given the specifics found at this site.

This decision document excludes three separate operable units on Harbor Island: the Shell, Arco, and Texaco petroleum tank farms; Lockheed Shipyard; and marine sediments. EPA has designated Ecology as the lead agency for the three petroleum tank farm facilities on the island. The primary contamination at these facilities is petroleum, which is generally excluded from the definition of a hazardous substance in CERCLA but is a regulated hazardous substance under the State's Model Toxics Control Act (MTCA). Ecology intends to issue a decision document for the tank farm unit in early 1995.

The Lockheed Shipyard on Harbor Island has been designated as a separate operable unit and EPA anticipates that it will issue a separate decision document for this unit in early 1994. Marine sediments around Harbor Island have also been designated as a separate operable unit and EPA anticipates that it will issue a separate decision document for this unit in late 1994.

ASSESSMENT OF THE FACILITY AND ADJACENT AREAS OF CONTAMINATION

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The remedial action described in this Record of Decision represents a final remedy for treatment of Harbor Island soil and groundwater, except for those areas identified above as separate operable units. The remedial action presented in this ROD addresses the risks to human health and the environment by:

1) Excavation and treatment of the soil containing the highest levels of organic contamination ("hot spots"). These organic soil hot spots are defined as Total Petroleum Hydrocarbons (TPH) greater than 10,000 mg/kg, PCBs greater than 50 mg/kg, and soil with mixed carcinogens with a total risk greater than 10^{-4}. TPH hot spot soil will be treated on site in a thermal desorption unit. PCBs hot spot soil will either be sent off site for treatment (incineration) or be disposed in a hazardous waste disposal facility. Organic hot spot soil with risk greater than 10^{-4} will be disposed in a hazardous waste disposal facility.

2) Capping exposed contaminated soil exceeding inorganic or organic cleanup goals. The cap would consist of a low permeability material such as asphalt to prevent infiltration of rainwater and reduce contaminant migration into the environment. Existing asphalt and concrete surfaces would be repaired to also prevent infiltration of rainwater.

3) Invoking institutional controls which would require long term maintenance of new and existing caps, warn future property owners of remaining contamination contained under capped areas on their properties, and specify procedures for handling and disposal of excavated contaminated soil from beneath the capped areas if excavation is necessary in the future.

4) Removal of and treatment of floating petroleum product and associated contaminated groundwater at Todd Shipyards to prevent its migration into the marine environment. Implementing groundwater monitoring for 30 years, with review of groundwater quality trends every 5 years to assess the effectiveness of the selected remedy.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with state and federal requirements that are legally applicable or relevant and appropriate to the remedial actions, and is cost effective. This remedy uses permanent solutions and treatment technologies to the maximum extent

practicable for this site by treating the most highly contaminated areas and capping less contaminated areas. This remedy satisfies the statutory preference for remedial actions that employ treatment to reduce toxicity, mobility and volume.

Because this remedy will leave some hazardous substances on site above cleanup goals, a review of the site and its remedy will be conducted within five years after initiation of the remedial action to ensure the remedy continues to provide adequate protection of human health and the environment.

Gerald A. Emison
Acting Regional Administrator, Region 10
U.S. Environmental Protection Agency

9-30-93
Date

DECISION SUMMARY
HARBOR ISLAND, SEATTLE, WASHINGTON

INTRODUCTION

The Harbor Island site, Seattle, King County, Washington, was listed on the National Priorities List (NPL) as a Superfund site in 1983 due to elevated lead concentrations in the soil from a lead smelter on the island, as well as elevated concentrations of other hazardous substances. The site was ranked number 738 in the Hazardous Ranking System (HRS) based on a site assessment performed by the United States Environmental Protection Agency (EPA) in 1985, pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. § 9605, as amended, (CERCLA).

Pursuant to Executive Order 12580 (Superfund Implementation) and the National Oil and Hazardous Substances Pollution Contingency Plan (NPC), 40 C.F.R. Part 300, EPA performed a Remedial Investigation/Feasibility Study (RI/FS). The Remedial Investigation (RI) characterized contamination in soil, surface water and groundwater at the facility. The RI was completed in 1992. A (baseline) risk assessment was completed as part of the RI and evaluated potential effects of the contamination on human health and the environment. The Feasibility Study (FS), completed in February 1993, evaluated alternatives for remediating contamination.

SITE NAME, LOCATION, AND DESCRIPTION

Harbor Island is located about one mile southwest of downtown Seattle, in King County, Washington (Figure 1). It lies at the mouth of the Duwamish Waterway on the southern edge of Elliott Bay, in the inland marine waterway known as Puget Sound. The island occupies large portions of Sections 7 and 18 in Township 24, Range 4, and smaller portions of Sections 12 and 13, Township 24, Range 3. The flat-lying island covers an area of approximately 400 acres, and is bordered on either side by the East Duwamish and West Duwamish waterways. Elevation of the island varies from about 12 to 15 feet above sea level. There are no wetlands on the island and no endangered or threated species are known to inhabit the island.

Harbor Island is zoned exclusively as General Industrial, with the exception of a 200-foot shoreline zone that is designated as Urban Industrial. Major facilities and structures on the island are shown in Figure 2. Almost the entire eastern side of the island is occupied by the Port of Seattle Terminal 18 cargo container facility. The interior of the island is occupied by numerous small to medium sized businesses including Seattle Foundry Company, Aspen Points, Value Metal Plating, Pacific Rendering, Harbor Island

Figure 1
Harbor Island Location

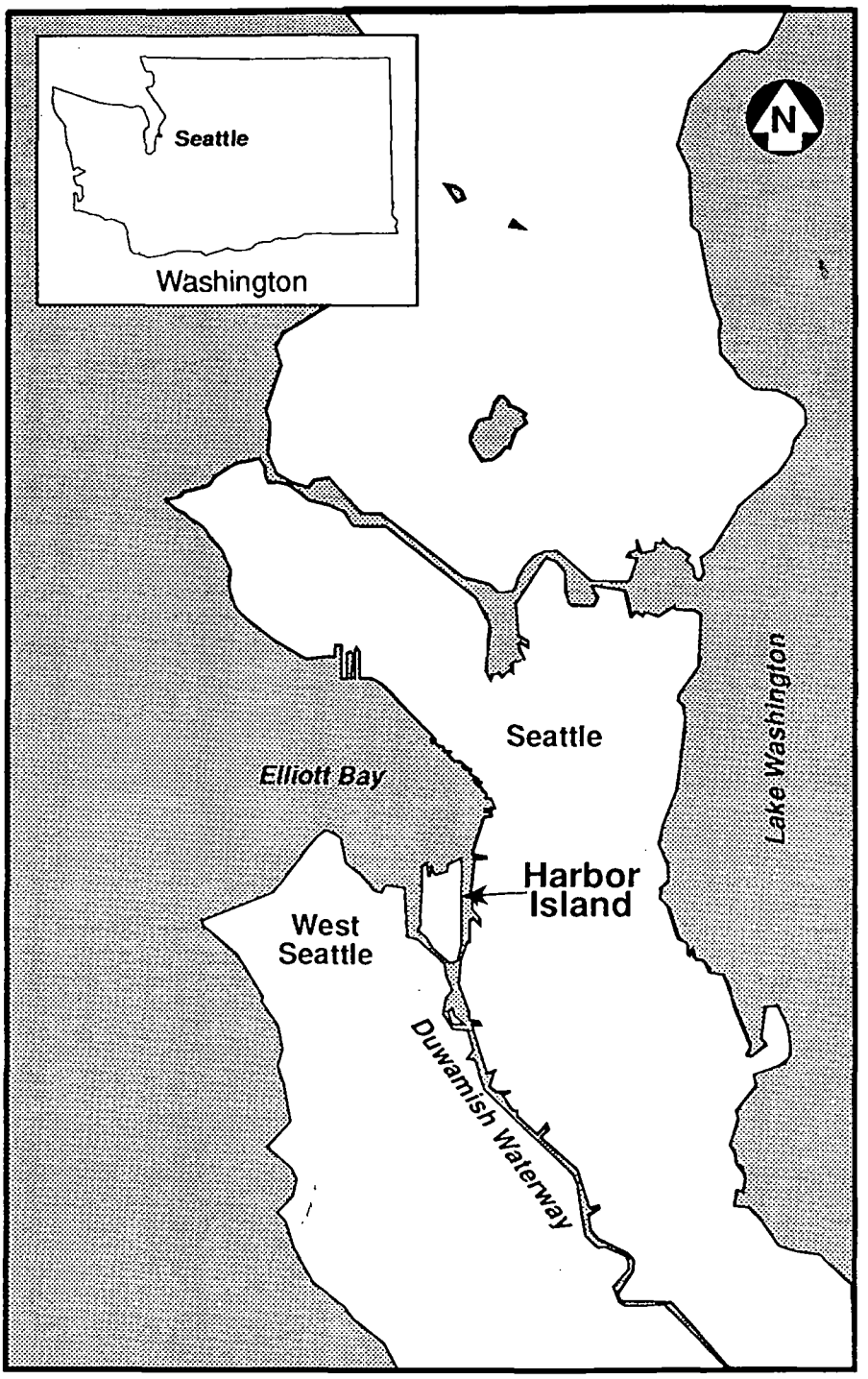
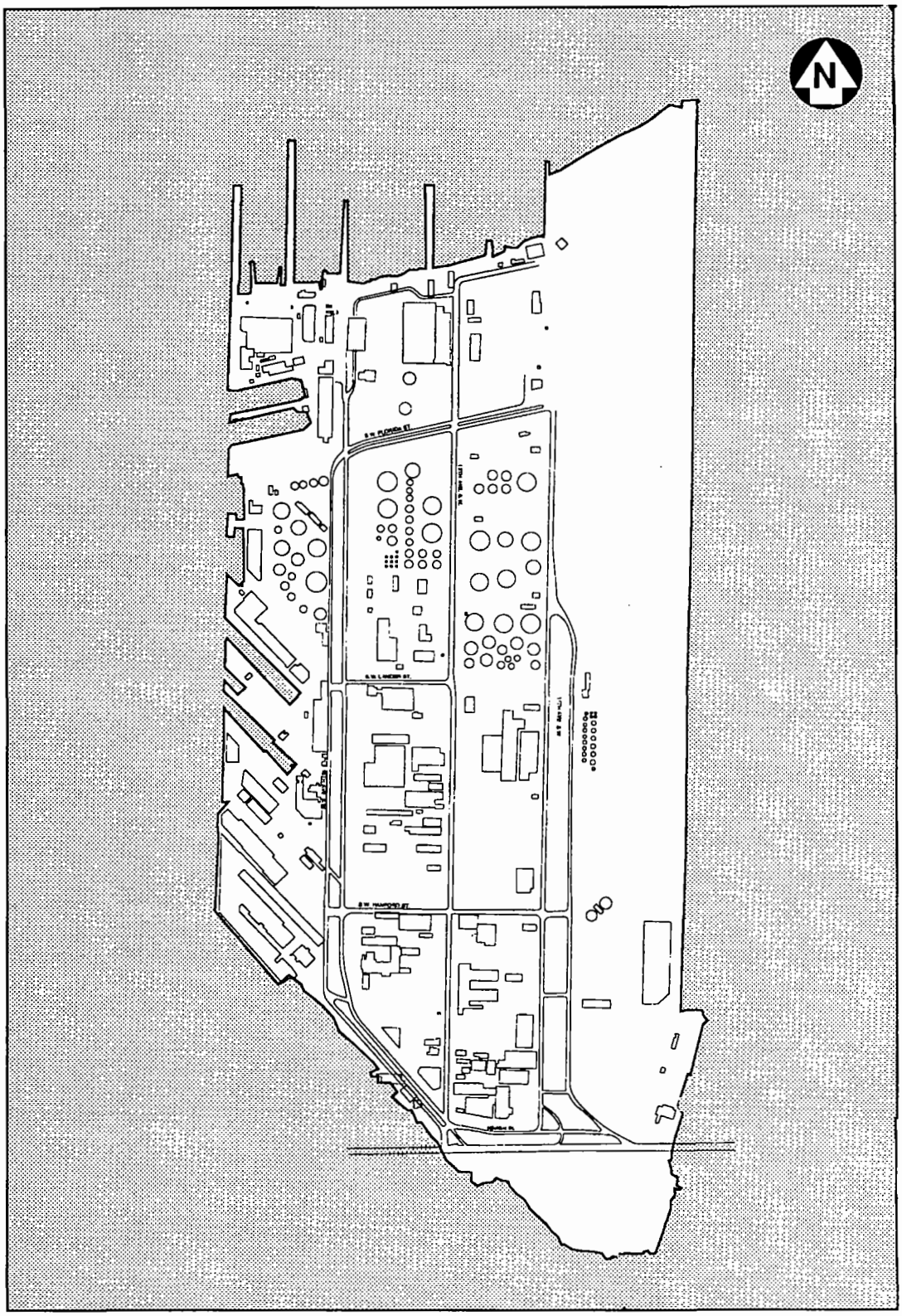


Figure 2
Harbor Island



Machine Works, and other metal fabricating companies. Arco, Texaco, and Shell maintain petroleum tank farms in the central portion of the island. Stevedoring Services of America operates a shipping and receiving dock with a container storage area along the north portion of the island. Todd Shipyard, a large shipbuilding facility, occupies the northwest corner of the island. A portion of the western side of the island is owned by Lockheed Corporation and was at one time used for shipbuilding. A concrete company, a marina, and a fishing pier are located on the southern part of the island. Commercial developments on the island include retail and wholesale establishments, offices, restaurants, and parking areas.

Approximately 70 percent of Harbor Island is covered with buildings, roads, or other impervious substances (e.g., concrete pads, parking lots). There are three main roads that run north and south: 11th Avenue SW, 13th Avenue SW, and 16th Avenue SE; and three streets that run east and west: Hanford, Klickitat, and Florida. Union Pacific railroad lines extend through the median of 11th Avenue SW and 16th Avenue SW. Union Pacific also operates a railroad switching facility on the northern end of the island, providing railroad spurs which lead to barge loading docks and industrial facilities.

Water and/or waste water generated on Harbor Island is transported via the Metro Sanitary Sewer Collection System to the West Point Metro sewage treatment plant. Storm water runoff is diverted into the Puget Sound through a storm sewers. Storm water is discharged into the East and West Waterways through municipal and privately owned outfalls around the perimeter of the island.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Harbor Island is a man-made industrial island covering about 400 acres located at the mouth of the Duwamish River in Seattle, Washington. Prior to 1885, the area consisted of tideflats and a river mouth delta with some piling-supported structures. Initial construction of the island began between 1903 and 1905 when dredging of the East and West waterways and the main navigational channel of the Duwamish River occurred. Dredged sediment was spread across the present island area to form a fill 5 to 15 feet thick. This dredged sediment was later covered with soil and demolition debris from Seattle regrade projects. Since its construction, the island has been used for commercial and industrial activities. Major activities have included ocean and rail transport operations, bulk fuel storage and transfer, secondary lead smelting, lead fabrication, shipbuilding, and metal plating. Warehouses, laboratories, and office buildings also have been located on the island. The secondary lead smelter was originally constructed on Harbor Island in 1937 and was located near the center of the island.

Concern over the levels of lead in the air, due to the operation of the lead smelter, prompted several air monitoring studies during the 1970s. A study conducted in 1979 by the Puget Sound Air Pollution Control Agency (PSAPCA) showed that the quarterly average ambient air concentration of lead exceeded the federal standard for lead of 1.5 $\mu g/m^3$ 95% of the time. Subsequently, a site inspection conducted by EPA in 1982 identified a significant volume of lead contaminated soil at the lead smelter facility. As a result of this site inspection, the island was listed on the NPL in 1983.

The lead smelter ceased operation in 1984, but the facility later was subject to a RCRA enforcement action in conjuction with the closure of a surface impoundment. As part of this action, groundwater monitoring wells were installed and soil borings were taken to determine soil quality. Elevated concentrations of lead, cadmium and sulfate were found at the facility. A groundwater monitoring program is now in effect which requires periodic sampling of the groundwater to ensure that the closed lagoon is not acting as a contaminant source to the groundwater.

In 1985, the Department of Ecology performed a preliminary investigation of the site to further define the nature and extent of contamination on the island. This investigation, and subsequent investigations, revealed numerous other types of contaminants in addition to lead, including: cadmium, chromium, arsenic, copper, zinc, mercury, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and petroleum products. Table 1 identifies some of the potential sources of these contaminants on the island.

Table 1 - Potential Sources of Contaminants

Contaminants	Sources (Present and Historical)
Metals	-Metal smelting and refining -Metal plating operations -Scrap metal recycling -Paint pigments -Battery recycling -Waste oil -Automotive emissions
Polychlorinated Biphenyls (PCBs)	-Transformer oils -Heat transfer fluids -Metal cutting oils
Polycyclic Aromatic Hydrocarbons (PAHs)	-Incomplete combustion of organic matter -Automotive and truck exhausts -Diesel and fuel oil, petroleum

In 1986, approximately 220 parties were sent 104(e) information request letters by EPA. Based on the responses received, a Potentially Responsible Party (PRP) search was completed for Harbor Island in 1987. Since many of the facilities on the island had multiple owners and operators, the search identified approximately 150 PRPs. These PRPs were subsequently sent "general notice" letters. As a result of further evaluation of PRP list, EPA removed about 50 parties from the PRP list in 1989, bringing the current total of PRPs to 98.

In 1987, EPA planned a Phase I RI which included only areas on the island where there had been a known release of hazardous substances from past operations. In an attempt to have this work performed by the PRPs, EPA sent "special notice" letters to 13 PRPs stating that EPA intended to conduct a remedial investigation unless the PRPs agreed to perform the work. EPA subsequently elected to perform the work with federal funds because EPA could not reach an agreement with these 13 PRPs. The Phase I investigation was initiated in 1988 and completed in 1990.

During implementation of the Phase I RI, EPA negotiated a Consent Order with the City of Seattle. Under the terms of this Order, the City of Seattle cleaned contaminated sediments from its storm drain system on Harbor Island. These storm drains were considered a major pathway for contaminants entering the surrounding waters and marine sediments. The work under this Order was completed in the Spring of 1990 and the City is now periodically monitoring the discharge from these stormdrains to ensure that they meet water quality standards. In a separate enforcement action, EPA negotiated a Consent Order for a removal with the owner of the Value Metal Plating facility in January, 1991. This Order required the removal and off-site disposal of about 80 drums of spent electroplating solution. The work under this Order was completed in December, 1992.

Before proceeding with the next phase of the RI/FS, EPA decided to break up the Harbor Island site into several operable units which could be managed more efficiently. Initially, six areas were defined as potential operable units: the petroleum tank farms, Todd Shipyard, Lockheed Shipyard, Terminal 18, the island-wide unit, and the marine sediment unit. The petroleum tank farm unit consists of three tank farms owned by Shell, ARCO, and Texaco. Since petroleum is generally excluded from the definition of hazardous substance under CERCLA but is a hazardous substance under the State's Model Toxics Control Act (MTCA), EPA and Ecology signed a memorandum of agreement that gives Ecology the lead in undertaking enforcement actions for these three tank farms. Agreements between Ecology and the tank farm owners to conduct RI/FSs were finalized in early 1993 and the selection of remedial actions is scheduled for early 1995.

Todd Shipyard and Lockheed Shipyard were sent special notice letters requesting that they conduct an RI/FS on their facilities in June, 1990. In September, 1990, a Consent Order was signed with

Lockheed and the Record of Decision for this unit is scheduled for the Spring of 1994. Negotiations were terminated with Todd due to submission of an inadequate good faith offer. An RI/FS special notice letter was sent to the Port of Seattle for Terminal 18 in January, 1991, but negotiations were terminated after the Port decided not to conduct the work. Both the Todd Shipyard and Terminal 18 facilities were then added to the island-wide operable unit.

The island-wide operable unit includes the entire island except for Lockheed Shipyard and the petroleum tank farms. The Phase II RI field work for this unit was initiated in May, 1991, and involved sampling soil at approximately 300 locations and installing 49 groundwater monitoring wells. The RI/FS reports for the island-wide operable unit were completed in February, 1993. The RI field work for the marine sediment unit was initiated in September, 1991, and involved sampling marine sediments at over 100 locations around the island. The marine sediment RI/FS reports are scheduled for completion in the Spring of 1994. The ROD for the marine sediment unit is scheduled for the fall 1994.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

CERCLA requirements for public participation include releasing the Remedial Investigation and Feasibility Study Reports and the Proposed Plan to the public and providing a public comment period on the Feasibility Study and Proposed Plan. EPA met these requirements in May, 1993, by placing both documents in the public information repositories for the site. EPA mailed copies of the Proposed Plan in June, 1993, to about 300 individuals on the mailing list. EPA published a notice of the release of the RI/FS and proposed plan in the Seattle Times in the morning and evening editions on June 23, 1993. Notice of the 30 day public comment period and the public meeting discussing the proposed plan were included in the newspaper notice. The public meeting was held on July 14, 1993, at the EPA Region 10 Headquarters on Sixth Avenue in Seattle. A request for a 30 day extension of the public comment period was received by EPA and was granted, extending the comment period to 23 August 1993. Public comments received and EPA's responses are located in the attached Responsiveness Summary section.

To date, the following community relations activities have been conducted by EPA at the Harbor Island site over the past 5 years:

March 1988- EPA updated the Community Relations Plan from 1985.

April 1988- EPA released a fact sheet explaining the environmental problems at the site.

December 1988- A fact sheet was released announcing the beginning

of the Remedial Investigation.

June 1989- EPA mailed an update on the work at the site.

November 1989- A fact sheet was released explaining the work being conducted by the City of Seattle to clean and sample the storm drain system on the island.

June 1990- EPA released an update of the activities at the site.

January 1991- EPA released a fact sheet announcing plans to remove approximately 80 drums and some miscellaneous containers at the Value Metal Plating facility.

April 1991- EPA released a fact sheet announcing the availability of the Phase I report and the beginning of the Phase II investigation.

September 1992- EPA released an update of site activities.site.

June 23, 1993- EPA ran an ad in the Seattle Times announcing the Public Comment Period and the date and time of the Public Meeting.

June 23, 1993- EPA released the Proposed Plan for site cleanup.

July 9, 1993- EPA releases a notice of the extension to the public comment period.

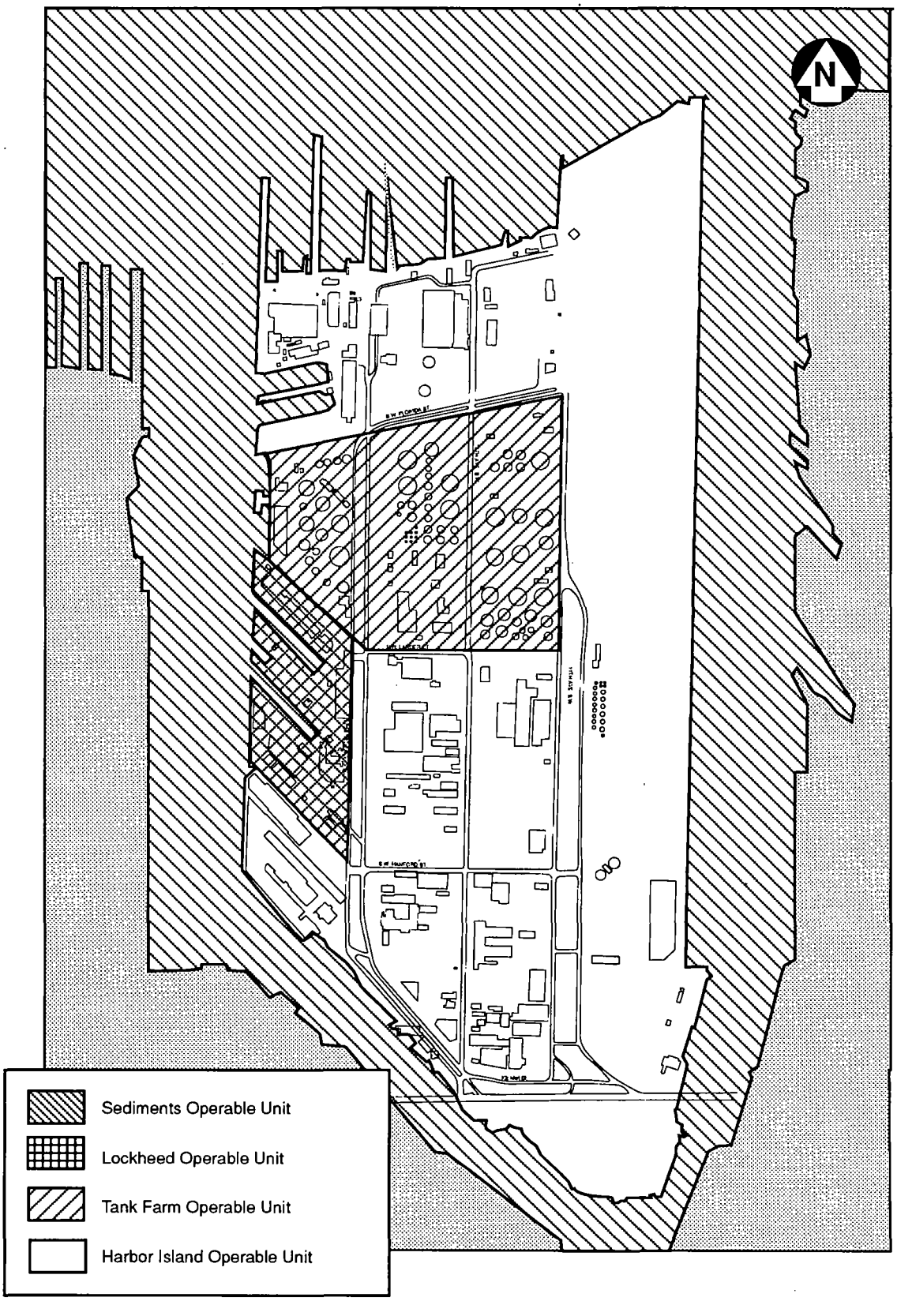
August 23, 1993- The Public Comment Period closed.

SCOPE AND ROLE OF RESPONSE ACTION WITHIN THE REMEDIAL STRATEGY

The operable unit addressed by this Record of Decision (ROD) is the island-wide unit. The remedial action selected in this ROD addresses all contaminated soil and groundwater exclusive of the petroleum tank farms and the Lockheed Shipyard, which are separate operable units as described previously. The marine sediments contaminated with hazardous substances released from Harbor Island is the fourth operable unit for this site. The areas covered by each of these four operable units are shown in Figure 3.

The remedial action selected for this operable unit is the first action to occur in any of the operable units. It is intended that the remedial actions to be selected for the Lockheed and tank farm operable units will be consistent with the remedial actions selected for the island-wide unit. Contaminated media at Harbor Island consists of soil, groundwater and sediments. The overall remedial strategy for Harbor Island is to initiate clean up of contaminated soil and groundwater first because they pose a risk to human health and act as sources of contamination to the marine

Figure 3
Harbor Island Operable Units



environment. The need for cleanup of sediments and the Lockheed Shipyard will be the subject of future RODs. Actions necessary to address the tank farms will be identified by Ecology in a state ROD. Cleanup of the sediments, if necessary, will occur after source control identified in this ROD has been initiated.

Sediments at Harbor Island have been contaminated by direct runoff from contaminated surface soil, indirect runoff through storm sewer systems, and groundwater contaminant loading. Contamination by direct and indirect runoff will be controlled by the selected remedy for this island-wide operable unit through: 1) excavating and treating organic contaminant "hot spots" in soil, and 2) capping all areas where contaminants exceed cleanup goals. Groundwater modeling conducted during the Feasibility Study indicates that the only significant contaminant loading to surface water is from floating petroleum product near the shoreline. The selected remedy will address this source by: 1) pumping and treating floating petroleum product and associated contaminated groundwater at Todd Shipyard, and 2) monitor the groundwater quality for 30 years with review of groundwater quality trends every 5 years. The selected remedial action on floating product, followed by Ecology's actions on floating petroleum product associated with the tank farm operable unit, is expected to meet the surface water cleanup goals over time and be protective of the marine sediments.

SUMMARY OF SITE CHARACTERISTICS

General Characteristics

Harbor Island is situated in a geographic area known as the Puget Lowlands, a trough characterized by low relief, with glacially shaped bluffs and low rising hills, and a vast area of intertidal and tidal flats. Puget Sound, in which Harbor Island is located, is an inland marine waterway formed through continental glaciation. Harbor Island is located on the former delta of the Duwamish River, which flows into Elliott Bay and Puget Sound from the Duwamish-Green River valley.

The island is recognized as one of the largest artificial islands in the world. The island is composed largely of native fluvial sand dredged from the surrounding areas. Prior to dredging, the surface of the delta was intertidal. When the lower Duwamish River channel and surrounding delta underwent major engineering modifications in the early 10900s, these former shallow tidal areas of the Duwamish River delta were filled with material largely derived from dredging of the Duwamish Channel and adjacent waterways. Dredged sediment was placed across the Duwamish tidelands to form a fairly homogeneous sandy fill which is now Harbor Island. This fine-grained fill consists primarily of poorly graded, very dark gray, fine to medium, damp to wet, loose sand.

The fine-grained fill thickness ranges from 3 to 15 feet. Alluvial deltaic deposits, consisting of unconsolidated, fine to coarse-grained sand, underlie the fill material. Overlying the fine-grained fill is a layer of coarse-grained fill which is from Seattle regrade projects conducted in the early 1900's. This coarse-grained fill consists of gravelly sand to coarse sand, dark grayish brown, poorly graded, loose, dry to moist. The thickness of the coarse-grained fill ranges from 0 to 7 feet.

Adjacent Land Use and Use of Natural Resources

Adjacent Land Use

Harbor Island is located in an area of mixed industrial and commercial use. Immediately adjacent to the island are similar industrial areas. Further to the west are residential and commercial properties. To the east lies the metropolitan Seattle area, which is primarily commercial with limited residential use. South of the island are industrial developments.

Use of Natural Resources

Surface water runoff is collected and drained from the site via a storm drain system consisting of catch basins, outfalls, and drainage manholes throughout the island. This system discharges at 11 outfalls around the perimeter of Harbor Island and into the East and West waterways. The East and West waterways are primarily commercial shipping lanes, but yacht clubs and marinas are permitted within the shoreline areas. There are no natural ponds on Harbor Island.

There are no drinking water wells in use on Harbor Island. Harbor Island groundwater is not currently used for drinking water and all water users on the island are serviced by the City of Seattle water system. Groundwater at a depth of approximately 40 feet is naturally brackish and not potable. Groundwater at Harbor Island is not considered to be a future drinking water source.

Groundwater Resources

Groundwater at Harbor Island occurs as shallow, unconfined groundwater within the fill and deltaic sediment. The depth to the groundwater is shallow and ranges from 2.5 feet to 11 feet below ground surface (bgs). This groundwater occurs as freshwater and becomes brackish at depths of 45 feet near the shoreline, and deeper at inland locations. The water bearing stratographic column behaves as a single hydrostatigraphic unit.

Groundwater recharge occurs through infiltration of precipitation. The groundwater level is highest in the northern half of the island, where recharge is greatest. Groundwater elevation

distribution indicates a radial flow condition with discharge to the adjacent waterways. Groundwater surface elevation decreases from the north central portion of the island to the southern portion because a greater percent of the southern portion is paved, preventing recharge through infiltration.

The groundwater responds to tidal forces within the adjacent marine estuary. Areas of the island where tidal forcing is sufficient to cause a reversal in the direction of groundwater flow are in the tidally influenced zone, which is 500 feet wide at the northern portion of the site and may extend to 1,000 feet at portions of the southern end of the island.

Water levels suggest that the south central portion of the island is internally drained. The aquifer may be infiltrating the METRO sewer system in that area.

Known or Suspected Sources of Contamination

Since construction, the island has been used for commercial and industrial activities. Major activities include shipping, railroad transportation, bulk fuel storage and transfer, secondary lead smelting, lead fabrication, shipbuilding, and metal plating. Warehouses, laboratories, and office buildings have also been located on the island.

Current sources of contamination were identified in the RI/FS and include current and past industrial practices associated with the activities mentioned above. Based on current information, the major sources of contamination appear to be:

- Atlantic Richfield Company (ARCO) – tank farm
- Lockheed Shipyard #1
- Nonferrous Metals, Incorporated
- The secondary lead smelter, currently Seafab Metal Corporation
- Seattle Iron & Metals, main yard
- The former Leckenby Company, (Port of Seattle property)
- Shell Oil Co., current tank farm and past tank farm located on Terminal 18 (Port of Seattle)
- Texaco USA – tank farm
- Todd Shipyards

Types of Contamination and Affected Media

The Harbor Island RI involved the collection of surface and subsurface soil samples from over 300 locations. Soil sample locations were based on a combination of a grid pattern over the entire island and additional (biased) sampling in areas of suspected or known contaminant releases. Surface soil samples were taken from the top 6 inches of soil and subsurface soil samples were taken at at intervals of 0.5-3.0, 3.0-6.0, and 6.0-10.0 feet.

Groundwater samples taken from approximately 69 monitoring wells (49 new wells and 20 existing wells). The intent of the sampling was to characterize the extent of contamination. The results of the sampling efforts for each medium are presented in the RI report and are summarized below.

Surface Soil (0-6 Inches)

Surface soil is contaminated with elevated levels of organic compounds and inorganic elements over a major portion of the island. By volume, the most significant organic contaminant in surface soil is petroleum products [total petroleum hydrocarbons (TPH)]. Approximately 95 percent of the samples with detectable TPH concentrations were between 20 mg/kg and 51,000 mg/kg, although most were between 50 and 2,000 mg/kg. Also present in smaller quantities in surface soil were polycyclic aromatic hydrocarbons (PAHs). The highest concentrations of heavy PAHs found in surface soil ranged between 10 and 50 mg/kg. Polychlorinated biphenyls (PCBs) in surface soil ranged from 2 to 420 mg/kg. TPH and PAHs were found mainly around the petroleum tank farms, and at Seattle Iron and Metals and Todd Shipyard facilities. PCBs were found predominantly in the central portion of the island.

The most significant inorganic contaminant on the island is lead, which is found over most of the island and originated primarily from the lead smelter. Approximately 55% of the surface soil samples and 12% of the subsurface soil samples exceeded a concentration of 1,000 mg/kg. The highest detected concentration was 401,000 mg/kg. Lead contamination was primarily confined to the upper three feet of soil. The majority of samples with elevated lead in the range from 5,000 to 200,000 mg/kg, occurred in the central portion of the site. The highest concentrations of other inorganics are found in surface soil include: arsenic at 1,830 mg/kg, cadmium at 131 mg/kg, and chromium at 791 mg/kg. The highest concentrations of most inorganic contaminants in surface soil are located in the central portion of the island and are associated with industrial operations in that area.

TCLP tests conducted on surface soil samples showed that leachate for lead exceeded the RCRA threshold for a characteristic waste at six locations.

Subsurface Soil (Below 6 inches)

Subsurface soil is also contaminated with the same organic compounds and inorganic elements found in surface soil, but contaminated subsurface area decreases rapidly with depth. The major organic subsurface contaminant is TPH, which ranges from nondetect to 90,517 mg/kg in subsurface soil. TPH contamination is associated with the petroleum tank farms, Seattle Iron and Metals, and Todd Shipyard facilities. High concentrations of TPH are located at depths from 0.5 to 10 feet below the surface in these

areas.

PAH concentrations in subsurface soil range from below the detection limit to 182 mg/kg. Approximately 90 percent of the subsurface soil contains less than 5 mg/kg heavy PAHs. PCBs in subsurface soil range from 0.02 to 5.48 mg/kg.

The most significant inorganic contaminants found in subsurface soil are lead and mercury. Lead contamination ranges from 2.3 to 32,200 mg/kg and mercury from 1.0 to 8.1 mg/kg. The highest concentrations of lead are found in the vicinity of the old lead smelter at depths of 0.5 to 10 feet, and the highest concentrations of mercury are located at depths of 0.5 to 3 feet at the Seattle Iron and Metal and Todd Shipyard facilities.

Groundwater

The results of the remedial investigation show that measurable or trace amounts of light nonaqueous phase liquid (floating product) is present in eight wells associated with the petroleum tank farms and three wells associated with Todd Shipyards. The only location where significant floating product is found near the shoreline is at Todd Shipyards. Components of this floating product include diesel fuel and gasoline. Thicknesses ranged from a sheen to 7 inches.

Groundwater at several locations along the shoreline on the northern portion of the island also contained benzene, ethylbenzene, and xylene, vinyl chloride, and other compounds associated with petroleum products. Benzene ranged from nondetect to 3,900 μg/L, ethylbenzene from nondetect to 1,800 μg/L, O-xylene from nondetect to 16,000 μg/L, and vinyl chloride from nondetect to 7.0 μg/L.

Elevated levels of inorganic contaminants including mercury, nickel, cadmium, lead, and zinc are also found in groundwater across the island. Mercury ranges from nondetect to 3.0 μg/L, nickel from nondetect to 230 μg/L, cadmium from nondetect to 21 μg/L, lead from nondetect to 64 μg/L, and zinc from nondetect to 1,700 μg/L. Ammonia is also present in elevated levels in the groundwater.

Based on the results of a groundwater model (FLOWPATH) which EPA used to predict the rate of migration of the above contaminants to the shoreline (where marine organisms could be exposed), it was determined that most of the contaminants currently in the groundwater would not reach the shoreline within 50 years. The only contaminants which are at the shoreline now or will be there in the next 50 years are the floating petroleum product at Todd Shipyards and low levels of VOCs dissolved in the groundwater at Todd Shipyards and two other locations along the shoreline.

Routes of Migration

The fate of contaminants originating from Harbor Island depends on location-specific migration pathways and on the chemical and physical properties of each contaminant. This section focuses on the contaminants of concern and identifies their probable routes of migration in surface soil, subsurface soil, and groundwater.

A transport of contaminants was established by review of storm drain analytical data and examination of RI maps depicting the concentration distributions for contaminants of concern in soil, groundwater, and offshore sediment. The presence of localized, elevated concentrations of contaminants in two or more media connected by a transport pathway (e.g., soil/groundwater or surface soil/storm drain/sediment) was considered evidence of contaminant release and transport.

Surface Soil

The principal transport mechanisms of the contaminants in surface soil are as suspended soil in surface water runoff. Surface water runoff is a significant current transport pathway for contaminants to reach the surrounding waterways and marine sediments. Surface water runoff can transport dissolved, suspended, and particulate-bound contaminants through storm drains into the surrounding estuary.

Subsurface Soil

The probable transport mechanism of the primary contaminants in subsurface soil is vertical transport of dissolved contaminants in rainwater which permeates through the soil. The primary factor which determines the rate which inorganic and organic contaminants leaches from the soil is the contaminant solubility. For inorganics, the pH of the water contacting the contaminated soil is also an important factor. Inorganics are relatively less mobile in the soil than organics because inorganics have relatively low solubility in water and they also strongly adsorb to soil particles, particularly silts and clay. Organics, on the other hand, are generally more soluble in water and primarily bind to naturally occurring soil organic matter, such as humic acid. Organic contaminants in high concentrations, such as petroleum, can also travel through pores in the soil as a Non-Aqueous Phase Liquid (NAPL). Organic contaminants in the NAPL state will not bind to soil organic matter and can flow through soil pores at a relatively fast rate. Residual NAPL can remain in the unsaturated (vadose) zone for long periods of time due to capillary attraction.

Groundwater

Contaminants in groundwater at Harbor Island are typically transported as either dissolved constituents or light nonaqueous

phase liquids (floating product). A two-dimensional groundwater transport model (FLOWPATH) along with a Digital Elevation Model was used to determine both loading rates and concentrations of contaminants at the shoreline. The contaminant transport calculations performed by the model predict the concentration of contaminants at the discharge point to the estuary and the time for the concentration of a contaminant to exceed a reference standard at the island-estuary interface.

On the basis of transport modeling, only floating petroleum product and benzene dissolved in the groundwater near the shoreline may exceed surface water quality standards at the shoreline within the next 50 years. All other contaminants currently in the groundwater across the island will take more than 50 years to reach the shoreline at levels exceeding these standards. The loading model estimates that groundwater transport to estuarine sediment and water is not likely to be significant for most contaminants, especially when compared to loading from surface water runoff and storm drains on Harbor Island.

SUMMARY OF SITE RISKS

An assessment of the human health risk at Harbor Island was completed according to EPA Region 10 risk assessment guidelines. The results of a habitat evaluation indicated that Harbor Island is unable to sustain a wildlife population or support a funcitoning wildlife habitat due to widespread industrial development. Therefore, an ecological risk assessment was not performed due to the absence of wildlife habitat areas on Harbor Island. An ecological risk assessment will be conducted for the marine sediment operable unit of this island. The human health risk assessment at Harbor Island involved analyte screening and evaluation, exposure assessment, toxicity assessment, lead biokinetics modeling and risk characterization.

People who may incidentally ingest soil through hand-to-mouth contact and absorb contaminants through dermal contact with contaminated soil were identified as the population most at risk of adverse health effects. Inhalation is not a significant pathway of exposure to contaminants on Harbor Island based on the results of air dispersion modeling conducted during the remedial investigation. The noncancer hazard from inhalation was not significant (hazard index of less than one), and the cancer risk was approximately two orders of magnitude less than that observed for the ingestion pathway for all scenarios evaluated.

Exposure to contaminants in groundwater was not evaluated because there is no current or foreseeable use of groundwater for drinking water purposes, and the entire island is serviced by the city of Seattle water system. Also, the majority of groundwater beneath Harbor Island is naturally brackish and unsuitable for drinking.

Contaminants of Concern

A multiple-step screening approach was used to identify the analytes of concern for the human health risk assessment. To be included in the risk assessment, contaminants had to occur in at least 5% of the samples and had to be at a concentration high enough to have a risk greater than 10^{-6} or hazard index of 0.1 As a result of this screening process, forty one contaminants were identified for evaluation at Harbor Island. These included tetrachloroethane, 2,4-dinitrotoluene, 3,3'-dichlorobenzidine, bis(2-ethylhexyl)phthalate, carbazole, pentachlorophenol, eight polynuclear aromatic hydrocarbons (2-methylnaphthalene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benz(a)pyrene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene), four PCB mixtures (aroclors 1242, 1248, 1254, and 1260), six pesticides or pesticide breakdown products (alpha-BHC, aldrin, dieldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT), and seventeen metals (antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, mercury, nickel, thallium, tin, vanadium, and zinc). Of these, antimony, arsenic, lead, carcinogenic PAHs and PCBs are considered the contaminants of concern because of their higher concentrations and toxicity compared to other contaminants. The maximum soil concentrations of these contaminants (the concentrations which resulted in the highest risk estimates) are shown in Table 2.

Table 2— Maximum Surface Soil Contaminant Concentrations

Contaminant	Maximum Concentration (mg/kg)
Antimony	3,640
Arsenic	1,830
Lead	401,000
Benz(a)anthracene	37
Chrysene	49
Benzo(b)fluoranthene	39
Benzo(k)fluoranthene	39
Benz(a)pyrene	18
Indeno(1,2,3-cd)pyrene	10.6
Dibenz(a,h)anthracene	2.9
Aroclor-1242	2.1
Aroclor-1248	4.3
Aroclor-1254	360
Aroclor-1260	420

Exposure Assessment

Harbor Island has been used for industrial purposes for approximately the last 80 years. Currently, there are no homes, residential areas, or commercial daycare facilities on Harbor Island. For these reasons, both current and future industrial exposure scenarios were evaluated. However, because Harbor Island is currently zoned as "industrial/commercial," a commercial scenario (daycare center) was also evaluated as a plausible future use of the island.

Risk was calculated for the resonable maximum exposure (RME) and for an average exposure. The risks cited in this document are for RME. The risks for the average exposure can be found in the Baseline Human Health Risk Assessment. RME is equal to the upper 95% confidence limit of the concentration distribution for each contaminant. For incidental soil ingestion and dermal contact exposures, measured soil concentrations were used to determine the RME values. RME values for inhalation exposures were estimated using the results of air dispersion modeling. The exposure assumptions used for all three pathways are based on EPA Region 10 risk assessment guidelines and are specified in the Baseline Human Health Risk Assessment.

Due to uncertainty on the appropriate toxicity criteria to use for evaluating lead, this metal was not included in cancer and noncancer risk calculations, but was evaluated using the uptake biokinetics model.

Industrial Exposures

RME values were determined at every surface soil sampling location on Harbor Island. In calculating risk from hypothetical industrial exposures it was assumed that risks from incidental soil ingestion, dermal absorption, and inhalation were additive and contributed to the total body burden. Combining all of the exposure assumptions, summary intake factors (rates of ingestion, absorption and inhalation) were derived for each exposure pathway. These factors are shown in Table 3.

Table 3— Summary of Intake Factors for Industrial Exposure Pathways

	Incidental Soil Ingestion	Dermal Absorption	Inhalation of Particulate and Vapors
Noncarcinogenic Summary Intake Factor	4.89E-07	1.86E-05	1.96E-01
Carcinogenic Summary Intake Factor	1.75E-07	6.64E-06	6.98E-02

Commercial Exposures

In the commercial scenario it was assumed that infants would be exposed to airborne contaminants for one year (age 0-1) and that children would be exposed to contaminants in air and soil for five years (age 1-6). Reasonable maximum exposure was determined at every surface soil sampling location on Harbor Island. As with industrial exposures, it was assumed that doses from incidental soil ingestion, dermal absorption, and inhalation (both infant and child) were additive for cancer risk and contributed to the total body burden. For noncancer health effects, child exposure pathways were summed to estimate the total dose to a child and the infant inhalation pathway was used to estimate total dose to an infant. Other key exposure assumptions used for the soil ingestion, dermal absorption, and inhalation pathways are based EPA Region X risk assessment guidelines. Combining all of the exposure assumptions, summary intake factors for each exposure pathway were derived for the child, and for the inhalation pathway for the infant. These factors are shown in Table 4.

Table 4— Summary Intake Factors for Commercial Exposure Pathways

	Incidental Soil Ingestion (Child)	Dermal Absorption (Child)	Inhalation of Particulate and Vapors	
			(Infant)	(Child)
Noncarcinogenic Summary Intake Factor	9.13E-06	9.57E-05	4.57E-02	4.57D-01
Carcinogenic Summary Intake Factor	6.52E-07	6.83E-06	6.52E-04	3.26E-02

Toxicity Assessment

In order of priority, the following EPA sources were consulted for toxicity criteria: Integrated Risk Information System (IRIS); Health Effects Assessment Summary Tables (HEAST); and EPA's Environmental Criteria and Assessment Office (ECAO). The basis for the noncarcinogenic and carcinogenic toxicity criteria used to calculate risk for the contaminants of concern is briefly discussed below.

The toxicity criteria used to evaluate noncancer risks are reference doses (RfDs). The term RfD refers to a daily intake of a contaminant to which an individual, including sensitive subpopulations, can be exposed without any expectation of noncarcinogenic adverse health effects (e.g., organ damage, biochemical alterations, birth defects).

The contaminants of concern for noncancer health effects were arsenic and antimony. These contaminants were only of concern through the oral route. The oral reference dose for arsenic (3.0E-04 for both chronic and subchronic exposures) is based on a study in which skin effects were noted in humans following arsenic ingestion. The oral reference dose for antimony (4.0E-04 for both chronic and subchronic exposures) is based on a study in which blood chemistry changes were noted in rats following antimony ingestion.

The toxicity criteria used to evaluate cancer risks are cancer slope factors. A cancer slope factor is a numerical estimate of the potency of a contaminant that, when multiplied by the average lifetime dose, gives the probability of an individual developing cancer over a lifetime. In developing cancer slope factors, it is assumed by the EPA that any dose of a carcinogen, no matter how small, is capable of causing cancer. Slope factors are derived by EPA using a linearized multistage model and reflect the upper-bound limit of a contaminant's cancer potency.

The contaminants of concern for cancer health effects were arsenic, PAHs, and PCBs. Because these contaminants were only of concern through oral and dermal routes, only slope factors for these exposure routes are discussed.

EPA uses a weight-of-evidence system to convey how likely a chemical is to be a human carcinogen, based on epidemiological studies, animal studies, and other supportive data. The classification scheme for characterization of weight-of-evidence for carcinogenicity includes: Group A-known human carcinogen, Group B-probable human carcinogen, Group C-possible human carcinogen, Group D-not classifiable as to human carcingenicity, and Group E-evidence of non-carcinogenicity in humans.

Arsenic is classified by EPA as a known human carcinogen (Group A). The oral slope factor for arsenic obtained from IRIS was 1.8 $(mg/kg\text{-}day)^{-1}$. Carcinogenic PAHs are classified by EPA as probable human carcinogens (Group B). The oral slope factor (also used as the dermal slope factor) obtained from the EPA ECAO was 5.8 $(mg/kg\text{-}day)^{-1}$. This is the slope factor for benzo(a)pyrene. In evaluating risk for other carcinogenic PAHs, this slope factor was used in conjunction with a toxic equivalency factor (TEF) approach. Using the TEF approach, the slope factor for benzo(a)pyrene was multiplied by a numeric factor to adjust for the differing toxicities of the carcinogenic PAHs. PCBs are also classified by EPA as probable human carcinogens (Group B). The oral slope factor (also used as the dermal slope factor) obtained from IRIS was 7.7 $(mg/kg\text{-}day)^{-1}$.

Risk Characterization

Noncarcinogenic risks were evaluated by comparing contaminant daily intakes to reference doses (RfDs). This was accomplished by calculating hazard quotients and hazard indices. A hazard quotient for a particular contaminant through a given exposure route is the ratio between the estimated daily intake and the applicable RfD. A hazard index is a sum of hazard quotients, which may be summed for all contaminants for a given exposure pathway, and across pathways. If a hazard quotient or hazard index exceeds 1.0, it indicates that potential noncarcinogenic health effects may occur under the defined exposure conditions.

For all three scenarios evaluated (industrial current, industrial future, and commercial future) hazard indices greater than one were determined for the incidental soil ingestion pathway only. In all three scenarios, the contaminants contributing the majority of noncancer risk at most sample locations were arsenic and antimony. Results show that for the current and future industrial scenarios, less than one percent of the sample location have a hazard index greater than one. For the commercial scenario, approximately 39 percent of the sample locations have a hazard index greater than one. Results for each pathway and scenario are shown in Table 5.

Carcinogenic risk was calculated for each carcinogen by multiplying the estimated daily intake of carcinogen by the appropriate cancer slope factor. Carcinogenic risk was calculated for each carcinogen through each exposure pathway for each individual. The total carcinogenic risk for each scenario was calculated by summing carcinogenic risk across exposure pathways for the industrial (current) and the industrial (future) scenarios, and across exposure pathways and age groups (i.e., infant + child) for the commercial scenario.

According to the National Contingency Plan, the acceptable risk range for carcinogens at a Superfund site is between 1 in 1,000,000 (10^{-6}) and 1 in 10,000 (10^{-4}). The excess lifetime cancer risk from reasonable maximum exposure to arsenic, PAHs, and PCBs ranges from less than 10^{-8} to 10^{-3} for both the current and future industrial scenarios. For both scenarios, the total carcinogenic risks were greater than 10^{-4} at only 2% of the sample locations.

The cancer risks range from less than 10^{-8} to 3×10^{-3} for children attending a daycare center (commercial scenario), if such a facility is established on Harbor Island in the future. For this scenario, the total carcinogenic risk was greater than 10^{-4} at 11% of the sample locations. For both the industrial and commercial scenarios, the majority of the carcinogenic risk was due to incidental ingestion of soil containing arsenic, PAHs, and PCBs. Results of cancer risk calculations are shown in Table 6.

Table 5 Summary of Noncancer Risk Calculations

Scenario	Range of Hazard Indices for the Following Pathways:				Percentage of Sample Locations with Hazard Index >1.0
	Inhalation	Ingestion	Dermal	Total	
Industrial (Current)	<0.00001 - 0.10	<0.00001 - 3.9	<0.00001 - 0.0084	<0.00001 - 3.9	<1
Industrial (Future)	<0.00001 - 0.10	<0.00001 - 3.9	<0.00001 - 0.0084	<0.00001 - 3.9	<1
Commercial (Child)	0.034 - 0.24	<0.00001 - 73	<0.00001 - 0.043	<0.00001 - 73	39

Table 6 Summary of Cancer Risk Calculations

Scenario	Range of Cancer Risk for the Following Pathways:				Percentage of Sample Locations with Risk greater than 1.0E-04	Percentage of Sample Locations with Risk greater than 1.0E-06
	Inhalation	Ingestion	Dermal	Total		
Industrial (Current)	<1.0E-08 - 5.4E-06	<1.0E-08 - 5.7E-04	<1.0E-08 - 6.4E-04	<1.0E-08 - 1.2E-03	1	98
Industrial (Future)	<1.0E-08 - 5.4E-06	<1.0E-08 - 5.7E-04	<1.0E-08 - 6.4E-04	<1.0E-08 - 1.2E-03	2	98
Commercial (Child)	7.4E-08 - 3.1E-06	<1.0E-08 - 2.1E-03	<1.0E-08 - 6.6E-04	<1.0E-08 - 2.8E-03	11	98

The biokinetic uptake model was use to determine appropriate cleanup levels for lead. This model estimates total blood lead levels in a child, resulting from exposure through routes which are both related to conditions at Harbor Island (such as incidental soil ingestion and inhalation-based on soil concentrations on Harbor Island), and routes which are general for a child living in the Seattle area (such as fruit/vegetable ingestion-based on regional lead levels in produce). Using this model, the range of acceptable soil lead concentrations was from 500-550 mg/kg for the commercial daycare scenario.

Uncertainty

The accuracy of the risk estimates depends in large part on the accuracy and representativeness of the sampling data, exposure assumptions, and toxicity criteria. Most assumptions are intentionally conservative so the risk estimates will be more likely to overestimate than underestimate.

Uncertainties in sampling data directly influence the final risk calculations. All analytical results have variability associated with them. A variability of minus 50 to plus 100% is typical for samples containing analytes at concentrations less than the contract-required quantitation limit. For samples containing higher levels of analytes, relative percent differences of 35% for soil are considered acceptable. Depending on the actual concentration of the analyte at these points, the reported value may either over- or underestimate the actual concentration. In addition to this uncertainty, the lack of PAH sampling in the tank farm areas on Harbor Island likely resulted in an underestimate of carcinogenic risk in these areas.

Another source of uncertainty in the risk assessment is the assumptions used to arrive at exposure doses. A number of assumptions were made in the risk assessment that overestimate exposure in areas where the limitations in the available data mademore specific quantitation difficult or impossible. It is inherent in these assumptions that the actual case would clearly result in reduced exposure and consequent risk.

A final source of uncertainty relates to the method by which carcinogenic and noncarcinogenic toxicity criteria are developed. Several conservative uncertainty factors are used in the development of toxicity criteria, which in turn cause these criteria to have an associated uncertainty spanning several orders of magnitude. Specific to this risk assessment, two of the three contaminants which made a significant contribution to carcinogenic risk, PAHs and PCBs, have cancer slope factors which were derived from animal studies, which contributes a high level of uncertainty. With respect to noncarcinogenic effects, the contaminants found to contribute most of the noncarcinogenic risk (arsenic and antimony)

had associated uncertainty factors of 3 and 1000, respectively. Based on these uncertainly factors, there is a high level of confidence in the RfD for arsenic, but a larger uncertainty for the RfD for antimony.

Environmental Evaluation

As the first step in the environmental evaluation, a habitat and ecological community evaluation was performed. The results of the habitat evaluation showed that Harbor Island consists of an industrial matrix with a number of small and disconnected undeveloped patches of land. Due to the industrial development on the island, these patches do not appear sufficient in size or quality to sustain a wildlife population or support a functioning ecological community. The evaluation of potential ecological receptors indicated that only those species (i.e., rats, dogs, crows, and gulls) associated with urban areas would be expected to temporarily reside on Harbor Island. A field investigation as well as interviews were unable to verify the presence of any mammals on Harbor Island. The lack of suitable habitat and ecological receptors precluded the necessity for further environmental evaluation.

REMEDIAL ACTION OBJECTIVES

The remedial action objectives (RAOs), and their associated numerical cleanup goals, are intended to protect human health and the environment by reducing risks to acceptable levels. RAOs are based on the state and federal applicable or relevant and appropriate requirements (ARARs). The numerical cleanup goals are based on criteria identified in these ARARs and on the results of the human health risk assessment. The RAOs and cleanup goals for Harbor Island are shown in Table 7.

For Harbor Island, the primary soil ARARs are the criteria contained in the State of Washington Model Toxics Control Act (MTCA). Three different MTCA methods were used to identify cleanup goals for contaminants in soil:
1) Method "A" for industrial soil, which specifies cleanup goals based on a risk of 10^{-5} from an individual carcinogen or hazard index of 1.0 from a non-carcinogen, was applied to subsurface soil because the potential for human exposure to the subsurface soil would be infrequent. Method "A" for industrial soil was used for lead in the surface and subsurface, because a risk-based calculation method has not yet been scientifically determined for lead.
2) The more stringent Method "C" for industrial soil, which specifies cleanup goals based on a total risk of 10^{-5} from all carcinogens or hazard index of 1.0 from all non-carcinogens, was applied to the surface soil where the potential for human exposure

Table 7— Remedial Action Objectives and Cleanup Goals

Medium	Primary Receptors	Remedial Action Objective	Cleanup Goals[a]
Soil—Surface	Humans	Protect human health from exposure to contaminants in surface soil which pose a combined risk of greater than 1 x 10^{-5}.	Lead: 1,000 mg/kg[b] Arsenic: 3.60 to 32.6 mg/kg[c] Antimony: 180 to 677[c] mg/kg Carcinogenic PAHs: 0.1 to 36.5[c] mg/kg PCBs: 0.18 to 2.99[c] mg/kg
Soil—Subsurface	Humans and Environment	Protect human health from infrequent exposure to contaminants in the subsurface which pose a risk greater than 10^{-5} for each contaminant. Prevent release of contaminants into the groundwater where they can be transported to the shoreline, where marine organisms could be exposed.	Lead: 1,000 mg/kg[b] TPH (diesel): 600 mg/kg[d] TPH (gas): 400 mg/kg[d] Cadmium: 10 mg/kg[b] Chromium 500 mg/kg[b] Mercury: 1.0 mg/kg[b] PAHs (carcinogenic): 20 mg/kg[b] Arsenic: 200 mg/kg[b] Benzene: 1.0 mg/kg[d] Ethylbenzene: 200 mg/kg[d] Toluene: 100 mg/kg[d] Xylenes: 150 mg/kg[d]
Groundwater	Environment	Prevent migration of contaminants to the shoreline where marine organisms could be exposed. Protect human health from consuming contaminated marine organisms which pose a risk greater than 1 x 10^{-6}	Carbon Tetrachloride: 4.4 µg/L[e] Benzene: 71 µg/L Trichloroethane: 42 µg/L Tetrachloroethylene: 8.8 µg/L PCBs: 0.03 µg/L Arsenic: 36 µg/L Cadmium: 8.0 µg/L Copper: 2.9 µg/L Lead: 5.8 µg/L Mercury: 0.025 µg/L Nickel: 7.9 µg/L Silver: 1.2 µg/L Thallium: 6.3 µg/L Zinc: 76.6 µg/L Cyanide: 1.0 µg/L

[a] Cleanup goals were determined at various locations over the island and vary based on the number and type of contaminants present.

[b] Goals are based on MTCA Method A for soil at industrial sites.

[c] Based upon achieving a 1 x 10^{-5} excess cancer risk or Hazard Index equal to 1.

[d] Based on the State of Washington Petroleum-Contaminated Soil Matrix Rating method.

[e] All groundwater levels are based on protection of marine organisms or human health from consumption of organisms.

would be more frequent.
3) The Petroleum-Contaminated Soils Rating Matrix method (which satisfies Method "B") was used to determine cleanup goals for surface and subsurface soil contaminated with petroleum products.

Approximately 200 acres of surface soil, shown in Figure 4, exceed the above listed cleanup goals. Of the total surface area which exceeds cleanup goals, only 40 acres are unpaved. The total volume of soil which exceeds these cleanup goals is approximately 900,000 cubic yards. Estimates for volumes of surface and subsurface soil exceeding the cleanup goals are shown in Table 8.

Table 8 - Volumes of Soil Exceeding Cleanup Goals

Contaminant Type	Volume of Soil (bank cubic yards)	
	Surface Soil (<0.5 Feet)	Subsurface Soil (>0.5 Feet)
Organics	58,000	416,000
Inorganics	33,000	267,000
Organics and Inorganics	21,000	71,000
Total	112,000	754,000

For groundwater, EPA and Ecology have determined that the federal and state drinking water standards do not apply because:
1) there is no current or foreseeable use of groundwater for drinking water purposes, 2) the entire island is serviced by the city of Seattle water system, and 3) surface water ARARs will apply at the shoreline. For Harbor Island, the surface water ARARs are the marine chronic criteria in the "Water Quality Standards for Surface Waters of the State of Washington" and the human health criteria for consumption of marine organisms in the federal "Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance Final Rule".

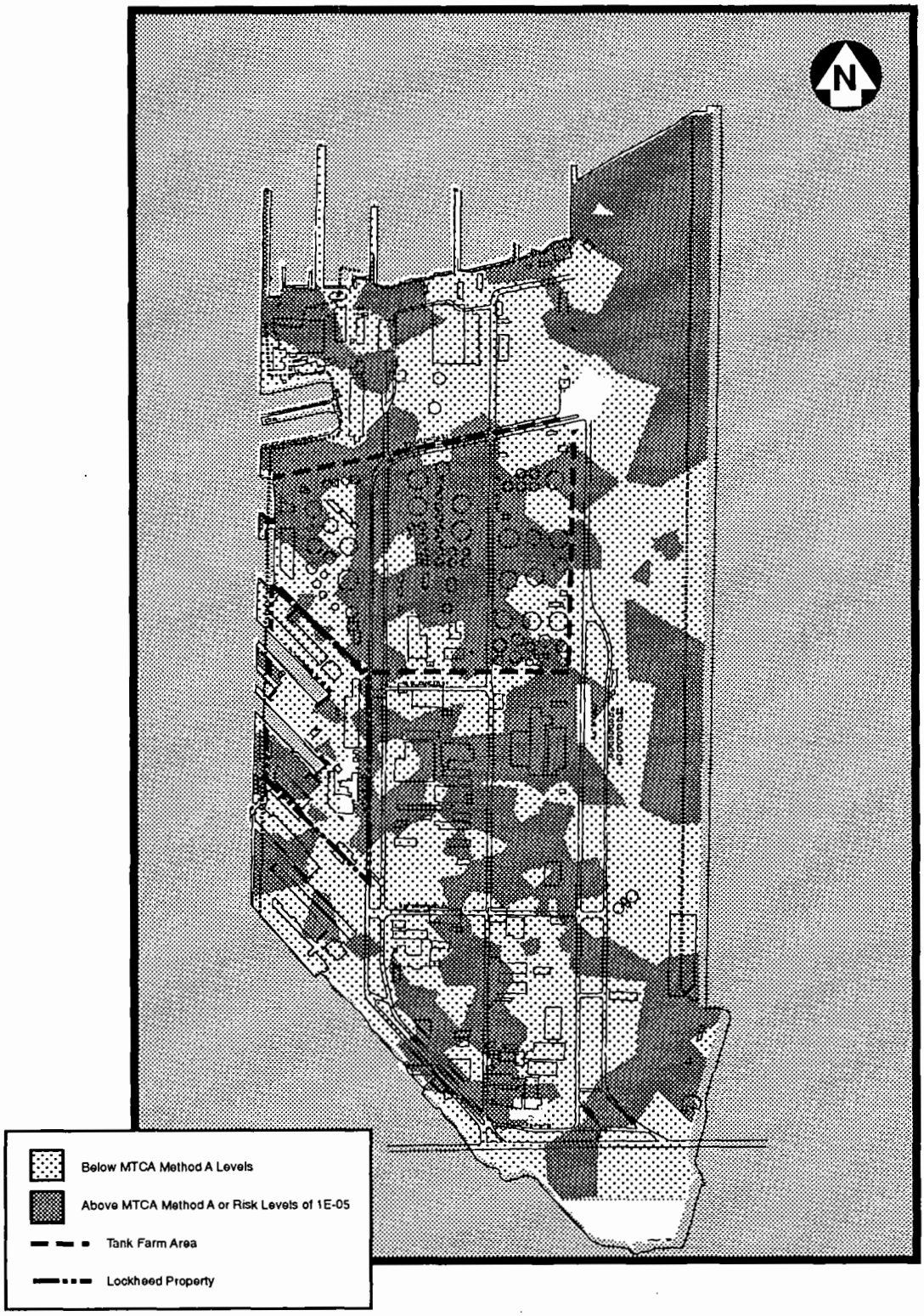
DESCRIPTION OF ALTERNATIVES

Eleven soil alternatives and four groundwater alternatives were evaluated. Groundwater alternatives are presented separately after the section on soil alternatives.

Soil Alternatives.

Alternative 1: No Action
Evaluation of a no action alternative is required in order to provide a basis for comparison of existing conditions and risks of potential conditions resulting from implementation of other remedial alternatives.

Figure 4
Surface Soil Exceeding 1.0E-5 Risk or MTCA Criteria



Major Components of the Remedial Alternative

Under the no action alternative, no additional remedial action will be taken to eliminate existing sources of contamination or to reduce the risks to humans or the effects on the environment. No engineering or institutional controls would be implemented. No additional requirements under Superfund would be imposed on local companies to inform workers of site conditions, nor would they be required to use precautions in their daily work activities, other than those required under existing regulations.

Treatment Component

There is no treatment component for this alternative. Reduction in toxicity or volume will occur only through natural processes such as photodegradation or biodegradation. Natural biodegrdation of some organics would occur over time due to the presence of indigenous bacteria in the soil. However, due to uncontrollable environmental factors and unknown biodegradation rates, the rate and degree in reduction of organic contaminants cannot be predicted with any level of certainty.

Containment Component

Containment is not a component of the no action alternative.

General Component

The no action alternative has no general component. There would be no source control, management of migration or long-term monitoring activities implemented in this alternative.

Cost and Remediation Time Frame

There are no costs associated with this alternative and the alternative can be implemented immediately.

Physical Effects on Environment Caused by Implementation

The no action alternative would not remove contaminated soil from Harbor Island. No remedial activities are performed. Therefore, the risk from implementation of this alternative is minimal.

Compliance with ARARs

This alternative will not meet any ARARs (see page 81, "Compliance with ARARs", for a complete list of ARARs which apply to all alternatives).

Alternative 2: Institutional Controls

Major Components of the Remedial Alternative

This alternative consists of implementing various engineering, safety and institutional controls to protect workers on Harbor Island from exposure to contaminated soil and groundwater. The contaminated soil and groundwater would not be treated and would remain a potential exposure route.

Treatment Component

This alternative does not have a treatment component. Some reduction in toxicity or volume of organic contaminants would occur over time through natural processes, such as biodegredation, as described in Alternative 1.

Containment Component

This alternative does not have a containment component.

General Components

This alternative would provide some degree of protection for workers through the use of various controls. Workers exposed to uncovered contaminated soil in industries that involve significant soil contact would be instructed to wear personal protective equipment. Facility operators would be instructed to provide air monitoring to determine if dust control measures were necessary to protect workers during daily work activities. Dust suppression could be implemented by spraying the site with water or covering the areas with tarps. If dust suppression is not effective or practical, the workers would be instructed to wear respirators.

Training and informational meetings would be held with employees and property owners to inform them of site hazards. Safety meetings would be held with employees instructing them on precautions to be taken when working on the site to avoid dermal contact or ingestion.

Controls would also be necessary for construction work on the island. If contaminated, soil piles would need to be provided with run-on/runoff controls such as tarps, curbing and liquid absorbing booms. Contaminated soil from construction excavations would be taken to a permitted off-site facility for treatment, storage or disposal. Signs would be located around the island to warn about underground contamination and hazards incurred by excavation in those areas. Notices would be posted within buildings to inform employees of hazards.

Institutional controls would also be imposed. One type of institutional control which could be used is deed notices. Deed

notices would warn future property owners of the contamination on their property and would specify that contaminated soil excavated in the future be properly handled and disposed of in accordance with state and federal regulations.

Alternative 2 would be easily implemented. Reduction in risk relies on the education of workers and property owners in addition to the enforcement of safety regulations. Since numerous businesses and heavy industrial activity exist across the island, enforcement of safety regulations may be difficult. Over long periods of time, the hazards, safety requirements, and need for protective clothing could be forgotten.

This alternative does not treat or contain the contaminated soil. The toxicity, mobility, and volume of the contaminated materials can be expected to remain in the current condition for an indefinite period of time.

Costs and Remediation Time Frame

The estimated capital costs for this alternative are $180,000. There are no operation and maintenance costs associated with this alternative.

The institutional controls alternative would take ten months to implement.

Physical Effects on the Environment Caused by Implementation

The physical effects on the environment are minimal, since the alternative incorporates no constuction.

Compliance With ARARs

This alternative would not meet any ARARs (see page 81) since no treatment or containment would be performed. Concentrations of organics in the groundwater may decrease through natural attenuation; the number of years for the concentration to decrease to cleanup goals cannot be predicted with any degree of certainty.

Alternative 3: Soil Containment

Major Components of the Remedial Action

This alternative consists of capping over areas where the contamination exceeds surface and subsurface cleanup goals identified in Table 7. The intent of this action would be to minimize the transport of the contaminants by rainwater infiltration and to prevent dermal contact or ingestion of the contaminated soil by personnel working on site. This alternative also includes engineering, safety, and institutional controls as

described in Alternative 2.

Treatment Component

This alternative has no treatment component.

Containment Component

Approximately 420,000 square yards (about 40 acres), which are currently uncovered and exceed cleanup goals, would be graded and capped. The design of the cap would be based on the subsequent use of each capped area. At a minimum, a 3-inch-thick asphalt cap with a mimimum permeability of 10^{-5} cm/sec would be required. In heavy industrial areas, a thicker asphalt cap or a reinforced, high-strength concrete cap may be required to support heavy loads. Any existing asphalt or concrete caps which are damaged would be resurfaced. A fence and/or warning signs would be placed around areas where capping is impractical or ineffective. Covered surfaces would be inspected quarterly and repaired if needed.

Capping reduces the mobility of contaminants by providing a barrier to infiltration which causes leaching of the organics and metals and by eliminating erosion. Because caps do not destroy contaminants, they provide no reduction in toxicity or volume. However, a reduction in toxicity and volume may be seen over time due to natural biodegradation of the organics. Long-term, periodic maintenance of the cap would be required to maintain its effectiveness.

General Component

In preparation for capping, some areas would be regraded to enhance surface drainage. Placement of the crushed rock sub-base would be done in a manner that does not disrupt surface drainage. Excavation of contaminated soil would be kept to a minimum.

Resurfacing paved areas on site with a surface treatment would be performed, although a thorough inspection of all pavement on site would be required to ensure that all damaged areas are located and repaired. This would require moving heavy equipment and stockpiled scrap materials to fully investigate pavement conditions. Quarterly noncompliance inspections for all covered areas, as well as periodic maintenance of damaged caps would be implemented.

Because contamination would remain on site, engineering, safety, and institutional controls would be implemented as described in Alternative 2.

Costs and Remediation Time Frame

The estimated present worth cost for this alternative is $15

million. Capital costs, which include regrading and capping, are $8.3 million. Operation and maintenance costs are $6.7 million and include cap inspection and repair. The cost estimate provided for this alternative, as well as the estimates for other alternatives which include a cap, are based on the minimum 3-inch asphalt cap. The identification of areas which will require a high-strength concrete cap, and the cost of this cap, will be determined in the remedial design phase.

Containment and associated engineering, safety, and institutional controls would take 2 years to complete.

Physical Effects on the Environment Caused by Implementation

Minimal impacts to the environment would be associated with capping exposed portions of the site. Areas would be graded, compacted and paved at one time, minimizing the risk to the environment. During wet weather, shallow ditches would be placed around work areas to minimize runoff. This would minimize the potential for the transport of contaminated soil into the storm drain system and into the environment.

Compliance With ARARs.

This alternative would meet all ARARs except for the Clean Water Act and the Washington Water Pollution Control Act which protect surface water quality at the shoreline. These ARARs would not be met because of remaining high levels of petroleum contamination left in the soil and floating on the goundwater which would act as continuing sources of contamination to the surface water. The cleanup goals for soil would be met through capping, invoking institutional controls, and compliance monitoring. Capping would provide protection by isolating contaminated soil to remove human exposure pathways. The cap would also mitigate further degradation of groundwater by reducing infiltration of rainwater and migration of contaminants to the groundwater. Institutional controls and long-term monitoring would also be implemented in compliance with MTCA.

Alternative 4: Soil Incineration/Solidification

Major Components of the Remedial Action

This alternative consists of excavating all soil contaminated above cleanup levels with organics and inorganics, transferring the material to an on-site treatment area, and treating it to levels at or below cleanup standards. Soil contaminated with organics would be incinerated, and soil contaminated with inorganics would be solidified. Soil with both organic and inorganic contaminated would be incinerated first and subsequently solidified. In areas where excavation could not be implemented, warning signs and

information and safety meetings would be implemented as described in Alternative 2.

Treatment Component

A transportable incinerator and stabilization and solidification processing equipment would be set up on the island. The treatment area required to locate the incinerator, solidification equipment, a stockpile area, mobile laboratory, and pollution control equipment is approximately 400 feet long by 300 feet wide. Contaminated soil would be transported to the treatment area. Soil would be stockpiled in the treatment area in accordance with Washington Dangerous Waste Regulations. The stockpile area would have an impermeable bottom. Asphalt curbing would be provided to prevent run-on/runoff.

Soil contaminated with organics would be screened prior to incineration. Approximately 474,000 cubic yards of soil contaminated with organics would be treated in the transportable incinerator. A destruction and removal efficiency (DRE) of 99.9999 percent would be achieved for PCBs and a DRE of 99.99 percent would be ahcieved for other organic contaminants. Incineration permanently destroys organics and achieves almost total reduction in contaminant toxicity and volume. Trial burns would be required prior to incineration of contaminated soil to determine the destruction efficiency and performance of air emission control equipment. A continuous emissions monitoring system would be used in conjunction with air pollution control equipment to regulate emissions from the incinerator. Treated soil would be sampled for total organic concentration to ensure that soil cleanup goals were achieved before it was placed back in the ground.

Approximately 300,000 cubic yards of soil contaminated with inorganics would be fed directly into the solidification process. The soil would be solidified to stabilize the inorganics, tested according to the TCLP leachate method, and placed in the ground if it passes the TCLP test. Solidification tests performed on Harbor Island soil indicates that this process may be implemented as an effective method to immobilize inorganic contaminants. Treatability studies were performed during the feasibility study to quantitatively evaluate the potential success of a process option to meet cleanup goals. Solidification testing was performed using materials common in the cement industry and/or in common use. Lead was used as the design controlling contaminant as an indicator of the overall performance of the technology. The solidified samples prepared under optimum conditions displayed a reduction in leachate concentrations of 2 to 3 times when compared to untreated soil.

Soil contaminated with both organics and inorganic contaminants, approximately 92,000 cubic yards, would be incinerated to destroy organic contamination and subsequently processed through a solidification treatment system to treat inorganic contamination.

This solidified soil would be tested according to the TCLP method before being placed in the ground.

Containment Component

This alternative has no containment component.

General Component

Excavation would require removal of asphalt or concrete surfaces to access the soil. The asphalt and concrete would be pressure-washed to remove adhering soil. After all contaminated soil had been removed, the concrete and asphalt would be taken to a construction landfill for disposal. Contaminated soil would be removed from under pavement and around utilities but not from under permanent buildings. Contaminated soil would be excavated in cells and transported via trucks to the treatment area. Soil would be preprocessed through a screening and crushing operation prior to incineration.

Following treatment, treated soil would be loaded onto trucks and taken to the cell it came from to be used as backfill. Clean fill would be brought in to return the site to the current grade, if necessary. Excavation would be performed around underground utilities and pipes and beneath pavement to minimize disruption of services. Areas under buildings and major permanent structures would not be excavated. In areas where excavation could not be implemented, warning signs would be posted to notify workers that training and personal protective equipment are recommended when conducting industrial and construction activities as described in Alternative 2. Information and safety meetings would be offered to employees to warn them of any remaining hazards.

Dust suppression methods would be used to minimize fugitive dust generated during remedial actions. Daily cleaning of paved roads would be performed using vacuum sweeping. Contamination controls (i.e., dust abatement and run-on, runoff controls) would be provided for excavation, stockpiling, and treatment areas. A debris washing station would be constructed near the soil screening operation. Debris screened from the soil, in addition to asphalt and concrete removed during excavation, would be washed.

Costs and Remediation Time Frame

The total present worth cost for this alternative is estimated at $245 million. Capital costs, $17 million, include site preparation, mobilization, and equipment costs and construction of the treatment area. Operation and maintenance costs, $228 million, include excavation of the soil, incineration, solidification, and implementation of warning signs and information and safety meetings.

The time required to implement this alternative would be approximately 130 months (10.8 years).

Physical Effects on the Environment Caused by Implementation

This alternative has activities that have the potential to impact the environment. These activities consist of excavation, incineration/solidification system installation and operation, soil transport, material handling and storage and treated soil handling. To mitigate the risks to the environment from these actions, certain precautions and procedures would be implemented.

Implementation of this alternative would require excavation of approximately 900,000 cubic yards of soil at numerous locations on the island. Ditches and/or berms and tarps would be used during excavation to eliminate contaminated runoff and protect the environment. Control of contamination would be implemented by setting up contamination control zones. Workers and equipment would require decontamination before leaving the zones. Hazards from dust and contaminated runoff from handling, storing and screening untreated soil would be minimized by using ventilation and dust collection systems on the soil screening and cement off-loading equipment, by covering loads of soil as it is being moved, by keeping the soil moist, and by storing all soil on double contained and covered pads.

Compliance With ARARs

This alternative would meet all ARARs. Soil cleanup goals would be met through incineration and stabilization of all soil above the cleanup goals. Emissions generated during the remedial actions (e.g., incineration, excavations, etc.) would be controlled to meet Puget Sound Air Pollution Control Authority (PSAPCA) requirements. The incinerator will also be operated in conformance with Dangerous Waste incinerator performance standards, and will achieve the 99.9999 percent destruction removal efficiency for PCBs to meet TSCA incinerator requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 5: Soil Bioremediation/Solidification

Major Components of the Remedial Action

This alternative consists of in situ bioremediation of areas contaminated with the organic contaminants of concern, excavation and solidification of areas contaminated with inorganics and landfarming and solidification of areas contaminated with both organics and inorganics. In areas where excavation could not be implemented, warning signs and information and safety meetings would be implemented as described in Alternative 2.

Treatment Component

In situ bioremediation of soil would be implemented by constructing a series of infiltration galleries in areas contaminated with organic contaminants only. Approximately 70 independent infiltration systems would be installed, each with its own set of tanks, pumps, instruments and pipes. Oxygenated water and nutrients would be pumped into the soil through the infiltration system to enhance bacterial growth and degrade organic contaminants. Extraction wells would be installed around the systems to remove the infiltration solution and recycle it back to the feed tank.

In areas which are only contaminated with organics and which are currently covered by pavement, the pavement would be removed and infiltration galleries would be installed. These areas would then be repaired. Areas under buildings would be left to slowly biodegrade under natural conditions.

Soil having both organic and inorganic contamination, and areas where the organic contamination is limited to surface soil, would be excavated, loaded into trucks and transferred to an area established for landfarming. The landfarming area would be approximately 650 feet long by 500 feet wide. Approximately 92,000 cubic yards of soil would be excavated for landfarm treatment. Landfarming would biologically degrade the organic contaminants. Following landfarming, the soil would be sent through a solidification process to treat inorganic contamination.

Areas contaminated with inorganics only would be excavated, transferred and directly treated through the solidification process. Approximately 300,000 cubic yards of soil contaminated with inorganics would be treated in this manner. After treatment by landfarming or solidification, soil would be tested according to the methods identified in alternative 4 before being returned to the ground.

The effectiveness of in situ bioremediation to meet cleanup goals is uncertain, as this technology has limited full scale demonstration. Site-specific treatability studies would be required to ensure that bioremediation would effectively degrade site contaminants in the soil. A pilot project demonstration would be required to confirm that soil cleanup goals could be met. In situ bioremediation and landfarming would continue until the soil cleanup goals were reached.

Reductions of TPH as high as 95 percent have been demonstrated using in situ bioremediation. Significant reductions in volitile organics and methylene chloride may also be expected, but implementing a reduction of PCBs through bioremediation may be difficult to achieve. Most organics may be degraded to levels below their treatment levels within one year using landfarming. The

effectiveness of landfarming PCB contaminants in soil is not proven. Installing a landfarming operation on site may be difficult due to the large area (approximately 3 acres) required.

Containment Component

This alternative has no containment component.

General Component

Excavation and backfill, as well as contamination control, would be implemented as described in Alternative 4. Dust suppression methods and contamination controls would be implemented as described in Alternative 4. Areas which could not be excavated would be covered by engineering, safety, and institutional controls as described in Alternative 2.

Costs and Remediation Time Frame

The ability to effectively degrade site contaminants to levels below cleanup goals through in situ bioremediation is unknown, because full-scale implementation of this process is not a demonstrated technology. The remediation time frame for in situ bioremediation, therefore, has some uncertainty.

The total present worth cost for this alternative is $117 million. Capital costs, $13 million, include landfarming and solidification processing of soil and installation of infiltration systems. Operation and maintenance costs, $104 million, include activities associated with maintaining and operating the infiltration system, excavation and implementation of the engineering, safety, and institutional controls.

This alternative would take approximately 87 months (7.25 years) to implement.

Physical Effects on the Environment Caused by Implementation

This alternative contains activities that have the potential to impact the environment. These activities consist of excavation, in situ bioremediation, landfarming, solidification, soil transport, material handling and storage, and treated soil handling. Hazards to the environment from these activities would be minimized by imposing the precautions and procedures described in Alternative 4. This alternative would cause minimal impacts to the environment.

Compliance With ARARs

Treatment of contaminated soil by landfarming and stabilization would meet all ARARs. However, the degree to which soil cleanup goals would be met using in situ bioremediation is uncertain, since this technology has had limited full-scale demonstration. Emissions

generated during the remedial actions would be controlled to meet PSAPCA requirements. Landfarming would be performed in conformance with Dangerous Waste landfarming requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 6: Solvent Extraction and Solidification

Major Components of the Remedial Alternative

In this alternative, organics in soil would be extracted by a solvent extraction process, and inorganics would be solidified. Mixtures (soil contaminated with organics and inorganics) would be treated by solvent extraction followed by solidification. In areas where excavation is impractical, engineering, safety, and institutional controls would be implemented as in Alternative 2.

Treatment Component

Excavated soil would be transported to a treatment area (approximately 300 feet long by 250 feet wide) which would include a solvent extraction system and solidification process. Soil contaminated with organics would be treated using solvent extraction. Waste water generated from the solvent extraction process could be treated and discharged to the POTW or used in the solidification process. Soil contaminated with inorganics would be treated with the solidification process as described in Alternative 4. Soil contaminated with mixtures of organics and inorganics would be treated first in the solvent extraction process to remove organics and subsequently with the solidification process to stabilize the inorganics. After treatment by solvent extraction or solidification, soil would be tested according to the methods identified in alternative 4 before being returned to the ground.

Solvent extraction processes have been demonstrated to be effective in laboratory scale treatability studies, but few have been successfully demonstrated in full-scale field remedial projects. Approximately 90 to 95 percent of organic contaminants have been removed in treatability and prototype pilot studies. Solvents used in the process would be regenerated and recycled. Organic contaminants removed from the soil would be sent off-site for incineration or disposal in a hazardous waste facility.

Solvent extraction treatability studies using methanol and acetone were performed during the Harbor Island feasibility study to determine the effectiveness of removing organic contaminants from soil. Polychlorinated biphenyls (PCBs) and PAHs were the organics targeted for removal. These organics are the major health risks in Harbor Island soil. The results of the solvent extraction treatability studies indicated that acetone was a better solvent than methanol. Approximately 96 percent of the PCBs and 84 percent

of the PAHs were removed in the extraction tests. Additional prototype testing would be needed to fully demonstrate the removal efficiency of this process.

Construction of a treatment facility that would house the solvent extraction unit, stabilization process, screening apparatus, stockpiles, and mobile laboratory would require approximately two acres. Although areas of this size are available on Harbor Island, permission to use an areas of this size could be difficult to obtain.

Containment Component

This alternative has no containment component.

General Component

Alternative 6 consists of excavation and treatment of approximately 474,000 cubic yards of organic contaminated soil, 300,000 cubic yards of inorganic contaminated soil, and 92,000 cubic yards of organic and inorganic contaminated soil.

Excavation and backfill contamination control would be conducted as described in Alternative 4. Dust suppression and run-on/runoff controls would be implemented as described in Alternative 4. In areas where excavation is impractical, engineering, safety, and institutional controls would be implemented as described in Alternative 2.

Costs and Remediation Time Frame

The estimated present worth cost for this alternative is $184 million. Capital costs, which include the soil treatment equipment, are $9 million. Operation and maintenance costs are $175 million and include excavation, treatment, and implementation of engineering, safety, and institutional controls.

This alternative would take 175 months (14.6 years) to complete.

Physical Effects on the Environment Caused by Implementation

This alternative predominantly consists of the same activities as Alternative 4, which are soil excavation and transport, material handling and storage, and construction and operation of the treatment process. Potential environmental hazards exist due primarily to runoff containing contaminated material. Run-on/runoff controls (i.e., stockpile pads, ditches, and tarps) would be used to minimize the potential impact to the environment as described in Alternative 4. Other precautionary measures would be implemented as described in Alternative 4.

Compliance With ARARs

This alternative would be designed and implemented to meet all ARARs. Soil cleanup goals would be met by solvent extraction and stabilization of all soil above the cleanup goals. Emissions generated during the remedial actions would be controlled to meet PSAPCA requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 7: Soil Off-Site Treatment and Disposal

Major Components of the Remedial Action

This alternative consists of excavating areas that have soil exceeding cleanup goals and transporting the soil to an off-site treatment and/or disposal facility. Soil contaminated with organics (474,000 cubic yards), inorganics (300,000 cubic yards) and both organics and inorganics (92,000 cubic yards) would be excavated. Areas that could not be excavated would be subject to engineering, safety, and institutional controls as discussed in Alternative 2. The excavated areas would subsequently be backfilled with clean fill.

Treatment Component

Soil containing organics or mixtures of organics and inorganics that include PCBs in excess of 50 mg/kg (approximately 2,000 cubic yards) would be transported to an off-site incinerator for treatment. After incineration, the soil residue would be transported to a hazardous waste landfill for solidification, if necessary, and disposal. Soil containing organics or mixtures of organics and inorganics including less than 50 mg/kg PCBs (approximately 201,000 cubic yards) would be tested by the TCLP method to determine if it qualifies as a RCRA characteristic waste. Any portion of the soil which is a RCRA waste would be transported to an off-site hazardous waste disposal facility for stabilization and disposal. Soil which is not a RCRA waste would be taken to an approved sanitary landfill. Soil containing inorganics only (approximately 300,000 cubic yards) would be treated in the same manner. Soil containing only total petroleum hydrocarbons (TPH) exceeding the cleanup goal of 200 mg/kg (363,000 cubic yards) would be disposed in a local regulated landfill.

Containment Component

Soil exceeding cleanup goals is taken off-site for containment. There is no on-site containment component in this alternative.

General Component

Excavation and backfilling of the soil would be performed in cells as described in Alternative 4. Decontamination pads would be

constructed at critical locations to minimize the spread of contamination from excavation equipment and transport trucks. The transport trucks would be decontaminated prior to leaving the contaminated areas to minimize the spread of contamination to other areas of the site and to the roadways. Immediately after the soil was excavated for off-site disposal, clean fill would be brought in to backfill the hole. Roadways, parking lots and operational areas would be repaved with asphalt after backfilling. Dust and organic emission suppression would be implemented; contamination control addressed as discussed in Alternative 4. Areas that could not be excavated would be subject to engineering, safety, and institutional controls as discussed in Alternative 2.

This alternative would be difficult to implement because of the large volume of soil which must be excavated and transported off site for disposal. Limitations of institutional controls are the same as discussed in Alternative 2.

Costs and Remediation Time Frame

The total present worth cost for this alternative is estimated to be $220 million. Capital costs, which include equipment purchase for excavation and transport, are $12 million. Operation and maintenance costs are $208 million and include excavation, transport, and disposal expenses, fill and regrading expenses, as well as implementation of engineering, safety, and institutional controls. Alternative 7 would take 62 months (5.2 years) to implement.

Physical Effects on the Environment Caused by Implementation

Activities that would occur under this alternative consist of soil excavation, transport and backfill of excavated areas with imported soil. Off-site disposal would require hauling the contaminated soil to either an off-site hazardous waste landfill, an off-site incinerator, or a local landfill permitted to accept TPH-contaminated soil. This would require approximately 40,000 to 60,000 truck loads of material to be transported to the appropriate facilities. The two main hazards associated with this include vehicle accidents and spread of contamination off-site. Truck payloads would be covered with tarps to prevent loss of material.

Environmental risks would be associated with contaminated runoff from the excavation areas. This would be minimized by placing ditches or berms around the work location. In addition, vehicle accidents resulting in an overturned truck could cause a release of contaminated soil into the environment. The adverse impacts to the environment would depend upon the accident location and conditions.

Compliance With ARARs

This alternative will be designed and implemented to meet all ARARs. MTCA goals for soil would be met in this alternative through removal and off-site disposal. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternatives 8 Through 11
Definition of Hot Spot Treatment Levels

Soil contaminated with TPH, lead, mercury, PCBs, and mixed carcinogens at concentrations significantly above the cleanup goals (Table 7) were identified as "hot spots" in the Feasibility Study. The precise contaminant concentration which defines a hot spot was originally called the "cleanup action level" but is now called the "treatment level", to indicate that it is the level at which contaminated soil will be excavated and treated in alternatives 8 through 11. For each hot spot contaminant, the selected treatment level is based on a cost-benefit analysis or on existing regulatory limits. The treatment levels for lead, mercury, and TPH are based on a cost-benefit analysis which compared the cost of treating the entire volume of soil above each contaminant concentration to the benefit, which is the total mass of contaminant removed and treated. The treatment levels for lead, mercury, and TPH were selected at the point where the incremental mass of contaminant treated was found to be disproportionate to the incremental volume of contaminated soil. Appendix B describes in more detail the method used for selecting the treatment levels for lead, mercury, and TPH by this method.

The treatment level for PCBs is based on the federal Toxic Substances Control Act (TSCA) regulation which specifies that concentration of PCBs exceeding 50 mg/kg must either be incinerated or disposed in a hazardous waste disposal facility. The treatment level for mixed carcinogens is based on the exceedance of the highest acceptable risk (1×10^{-4}) for Superfund sites as specified by the National Contingency Plan (NCP).

The treatment levels selected for the hot spots, shown in Table 9, represent approximately 20 percent of the total contaminated soil volume, but contain approximately 70 percent of the total volume of contamination. Through this approach of identifying these hot spots, the volume of soil representing the greatest threat to human health and the environment could be treated to permanently reduce its toxicity in a cost-effective manner. Figure 5 shows the approximate locations of organic and inorganic hot spots on Harbor Island.

Table 9— Soil Hot Spot Treatment Levels

Item	Surface Soil	Subsurface Soil
Risk	$\geq 1 \times 10^{-4}$	Does not apply
PCBs	≥ 50 mg/kg	≥ 50 mg/kg
Lead	≥ 10,000 mg/kg	≥ 10,000 mg/kg
Mercury	≥ 5 mg/kg	≥ 5 mg/kg
TPH	≥ 10,000 mg/kg	≥ 10,000 mg/kg

Alternative 8A: Soil Hot Spot Solvent Extraction/Solidification and Containment

Major Components of this Remedial Alternative

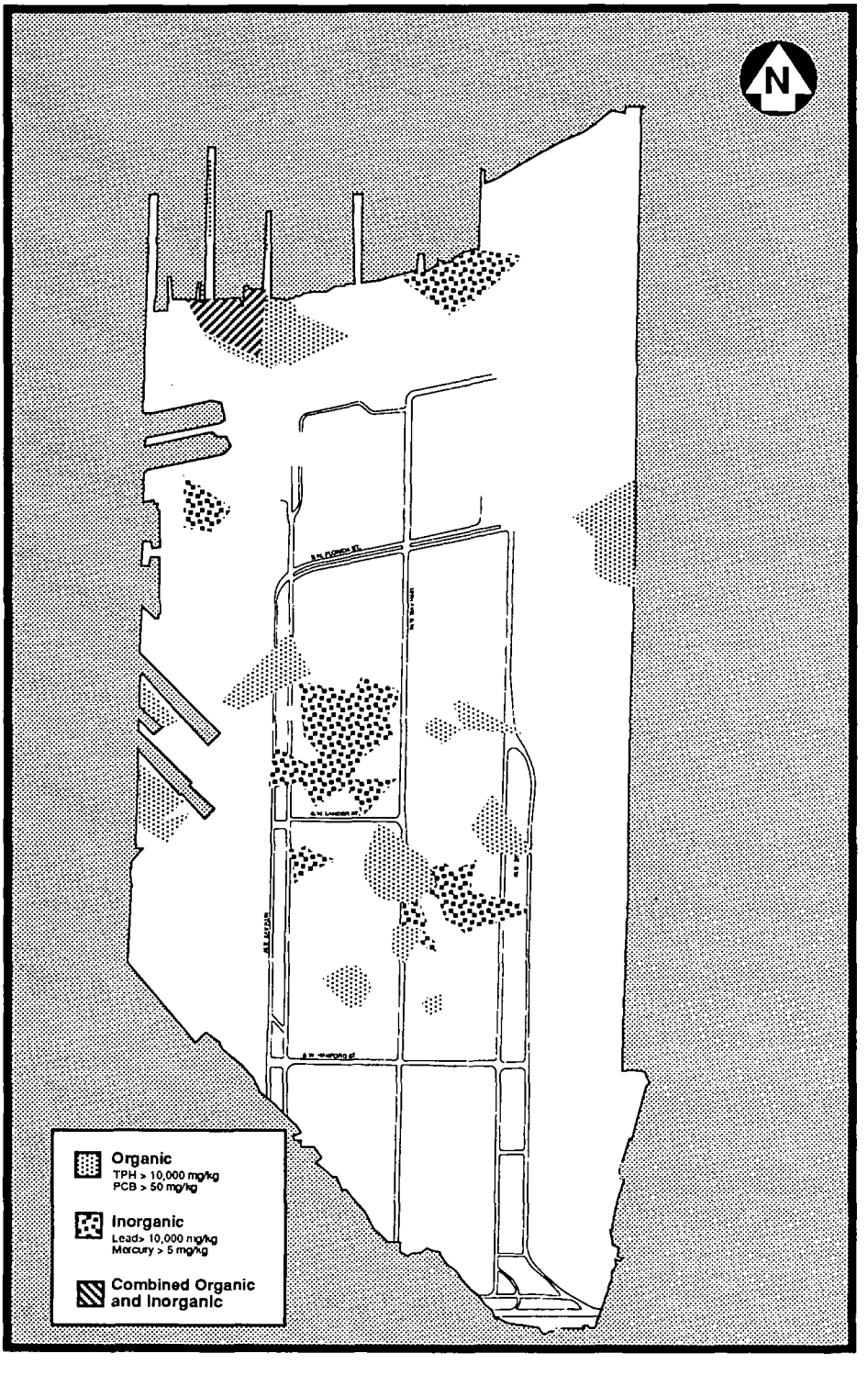
Alternative 8A consists of solvent extraction and/or solidification of areas containing contaminant concentrations above the treatment levels for organics and inorganics. Following hot spot removal and treatment, the remaining areas contaminated above cleanup goals would be capped. In areas where excavation is impractical, engineering, safety, and institutional controls would be implemented as discussed in Alternative 2.

Treatment Component

Approximately 94,200 cubic yards of surface and subsurface soil contaminated with organics above the treatment levels would be excavated and processed in an on-site solvent extraction system as in Alternative 6. Treated organic hot spot soil would be tested for total organic and inorganic concentrations and inorganic contaminant leachability, according to the TCLP method, before being returned to the soil. Soil which fails the TCLP test would be considered a RCRA characteristic waste. This soil would have to be solidified so that it no longer fails the TCLP test before being returned to the ground. If soil passes the TCLP test, but contains organics or inorganics above the cleanup goals, it would be placed in the ground and capped. Approximately 85,000 cubic yards of surface and subsurface soil contaminated with inorganics (lead and mercury) above the treatment levels would be excavated and solidified until it passes the TCLP test, as in Alternative 6.

An on-site treatment area would be constructed as described in Alternative 6. This alternative has the same destruction and removal efficiencies (DREs), treatability and prototype pilot study requirements, and limitations as Alternative 6.

Figure 5
Soil Hot Spot Locations



Containment Component

Areas where the soil exceeds the cleanup goals for TPH, lead, arsenic, mercury, PCBs, and PAHs would still exist after hot spot removal. Much of this area is presently covered with existing impermeable barriers of asphalt and concrete. The remaining areas not covered by asphalt/concrete would be capped with a 3 inches of asphalt for non-load-bearing surfaces. Load-bearing surfaces would require a thicker asphalt cap or reinforced concrete cap. The area to be capped is approximately 3.4 million square feet (40 acres). In addition, an inspection would be performed to identify areas where existing impermeable barriers were cracked or damaged. These areas would be patched or sealed. The capped surfaces would be maintained as described in Alternative 3.

General Component

Excavation and backfill would be conducted as described in Alterative 4. All treated soil would be transported back to its original location to be used as backfill. Dust suppression methods, run-on/runoff controls, and contamination controls would be implemented as described in Alternative 4. In areas where excavation is impractical, engineering, safety, and institutional controls would be implemented as described in Alternative 2. Limitations of the engineering, safety, and institutional controlsare the same as those described in Alternative 2.

Costs and Remediation Time Frame

Capital costs, which include the solidification and solvent extraction equipment, are estimated to be $6.2 million. Operation and maintenance costs are $76.5 million and include excavation, treatment, maintenance of the cap, and implementation of engineering, safety, and institutional controls.

Alternative 8A would take 57 months (4.75 years) to implement. The total present worth cost for this alternative is estimated to be $83.2 million.

Physical Effects on the Environment Caused by Implementation

This alternative has the same potential risks to the environment as described in Alternative 6. However, the risk would be reduced substantially due to confinement of the remedial activities to hot spots. Environmental risks would still consist of potential damage due to contaminated runoff. However, with fewer locations being remediated, the potential for environmental damage would be reduced below that anticipated in Alternative 6.

Compliance With ARARs

This alternative will be designed and implemented to meet all ARARs. ARARs would be met by selective treatment (extraction and stabilization) of soil contaminated above "hot spot" treatment levels, followed by capping the remaining soil above cleanup goals with long-term monitoring of the capped areas. Although concentrations above cleanup goals for lead, arsenic, mercury, PCBs, and TPH will remain in the unexcavated soil, capping would protect human health and mitigate further degradation of groundwater from infiltration. Some of the remaining organics exceeding cleanup goals would naturally attenuate over time. Emissions generated during the remedial actions would be controlled to meet PSAPCA requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 8B: Soil Organic Hot Spot Solvent Extraction/Solidification and Containment

Major Components of the Remedial Action

Alternative 8B is similar to 8A except that only the organic hot spots previously identified for PCBs, TPH, and risk greater than 10^{-4}, are included. The soil volumes, associated with each treatment level for the organic hot spots, are shown in Table 10.

Table 10— Organic "Hot Spot" Volumes

Soil Type	Volume (Bank Cubic Yards)
TPH greater than 10,000 mg/kg	91,000
PCBs greater than 50mg/kg	2,000
Mixed Carcinogens with risk greater than 10^{-4}	1,200
Total	94,200

The organic hot spots are selected for treatment here (as well as in alternatives 9B, 10B, and 11B) because TPH, which is associated with all the organic hot spots, is mobile in soil and groundwater. It could, therefore, be reasonably expected to migrate into the groundwater, and ultimately into surface water surrounding Harbor Island. In addition, these organic hot spots pose a significant potential risk to human health and marine organisms because the TPH contains carcinogens such as PAHs which bioaccumulate readily in marine organisms and pose a potential risk to humans who consume these organisms.

In this alternative, approximately 94,000 cubic yards of soil with organics above the treatment level would be excavated and processed in an on-site solvent extraction system as in Alternative 6. Areas contaminated above the cleanup goals but below hot spots concentrations, would be capped in place as described in Alternative 3, rather than treated.

In areas where extraction or containment is impractical, engineering, safety, and institutional controls would be implemented as described in Alternative 2.

Treatment Component

Approximately 91,000 cubic yards of soil contaminated with TPH would be excavated and treated in an on-site solvent extraction system as described in Alternative 6. Approximately 3,200 cubic yards of soil contaminated with mixed organics would also be excavated and treated in the on-site solvent extraction process. After treatment, organic hot spot soil would be tested for total inorganic concentrations and for leachability of inorganics, as in alternative 8A, to determine if solidification or capping is necessary prior to replacing the treated soil in the ground. This alternative has the same removal efficiencies, treatability and prototype study requirements, and limitations as Alternative 6.

Containment Component

Areas where the soil exceeds the cleanup goals for TPH, lead, arsenic, mercury, PCBs, and PAHs would still exist after hot spot removal. Much of this area is presently covered with existing impermeable barriers of asphalt and concrete. The remaining areas not covered by asphalt and concrete would be capped with asphalt. The area to be capped would be slightly less than 40 acres. Damaged existing surfaces would be resurfaced. All capped surfaces would be inspected quarterly and replaced as needed. This alternative has the same containment component limitations as Alternative 3.

Tests conducted during the remedial investigation to determine the adsorption of inorganics to soil showed that inorganics have a high affinity for the soil and have a low mobility in the groundwater. In addition, groundwater transport modeling conducted in the feasibility study indicates that the inorganics currently in the groundwater will take more than 50 years to reach the shoreline. Capping, with proper long-term maintenance, is expected to further decrease the mobility of inorganics in the hot spots by reducing the infiltration of rainwater through these areas.

General Component

Excavation and backfill would be conducted as described in Alternative 4. All treated soil would be transported back to its

original location to be used as backfill. Dust suppression, run-on/runoff controls, and contamination controls would be implemented as described in Alternative 4. In areas where excavation is impractical, engineering, safety, and institutional controls would be implemented as described in Alternative 2.

Costs and Remediation Time Frame

The total present worth cost for this alternative is $54.7 million. Capital costs are $6.7 million and include site preparation, mobilization, and the solvent extraction and solidification processing equipment. Operation and maintenance costs are $48 million and include excavation, treatment, maintenance of the cap, and implementation of engineering, safety, and institutional controls.

Alternative 8B would take 57 (4.75 years) months to implement.

Physical Effects on the Environment Caused by Implementation

This alternative would pose the same potential risks to the environment as described in Alternative 8A.

Compliance With ARARs

Solvent extraction/solidification of hot spots, followed by containment of the remaining soil, would achieve all ARARs as described in Alternative 8A.

Alternative 9A: Soil Hot Spot Off-Site Treatment/Disposal and Containment

Major Components of the Remedial Action

This alternative consists of selective off-site disposal of areas highly contaminated with organics and/or inorganics ("hot spots), as defined in Alternative 8A, followed by containment of the remaining portions of the site. Excavated soil hot spots would be classified into types based on disposal options, as discussed in Alternative 7. Soil contaminated with organics or mixtures of organics and inorganics, which contain PCBs in excess of 50 mg/kg (2,000 cubic yards), would be taken to an off-site incinerator for treatment and disposal. Soil contaminated with TPH and inorganics (71,000 cubic yards), and soil containing inorganics only (85,000 cubic yards) would be taken to an off-site hazardous waste disposal facility for disposal. Soil containing only TPH above 10,000 mg/kg (21,000 cubic yards) would be taken to a landfill that accepts TPH contaminated soil.

In areas where excavation or containment is impractical, engineering, safety, and institutional controls would be

implemented as described in Alternative 2.

Treatment Component

Alternative 9A includes only one treatment component, the off-site incineration of hot spots containing PCBs in excess of 50 mg/kg. This treatment component has the same DREs as discussed in Alternative 7.

Containment Component

As discussed in Alternative 8A, the remaining lower contaminated areas would be capped with asphalt or concrete, and cracked or damaged existing impermeable barriers would be patched or sealed. The containment component of this alternative has the same limitations as discussed in Alternative 3.

General Component

Excavation and contamination control would be performed as described in Alternative 4. Decontamination pads would be constructed near the areas of excavation and used to minimize the spread of contaminated soil as in Alternative 7. Immediately after soil was excavated, clean soil would be brought in for backfilling. Roadways, parking lots, and other operational areas would be repaved after backfilling was complete. The limitations to excavation and disposal are the same as described in Alternative 7.

Where excavation is impractical, signs would be posted to inform workers of the contamination and of appropriate safety precautions. Employee informational and safety meetings would be held and institutional controls implemented as described in Alternative 2, as necessary. Limitations of the engineering, safety, and institutional controls are the same as described in Alternative 2.

Costs and Remediation Time Frames

The total present worth cost for the alternative is $75.7 million. Capital costs are $6.7 million and include capping expenses. Operation and maintenance costs are $69 million and include excavation, transport, disposal expenses, and cap maintenance and implementation of engineering and institutional controls.

This alternative would take 54 months to implement.

Physical Effects on the Environment Caused by Implementation

In this alternative, soil hot spots are excavated and transported off site for treatment and/or disposal. The remaining contaminated soil is capped. This alternative presents the same short-term risks to the environment as Alternative 7. The frequency of occurrence of these risks is expected to be less than in

Alternative 7 due to the large reduction in the volume of contaminated soil that is excavated and disposed off site. Approximately 179,000 cubic yards of soil would be excavated and disposed under this alternative. The risks to the environment are due to contaminated runoff. These risks would be mitigated as discussed in Alternative 4.

Compliance With ARARs

The off-site treatment disposal of soil hot spots, followed by containment of the remaining soil above cleanup goals will be designed and implemented to meet all ARARs. Although concentrations above cleanup goals for lead, arsenic, mercury, PCBs, and TPH will remain in the unexcavated soil, capping with long-term monitoring would protect human health and mitigate further degradation of groundwater from infiltration. Organics exceeding cleanup goals would naturally attenuate over time. Emissions generated during the remedial actions would be controlled to meet PSAPCA requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 9B: Soil Organic Hot Spot Off-Site Treatment/Disposal and Containment

Major Components of the Remedial Action

This alternative is similar to Alternative 9A except that only the "hot spots" contaminated with organics as defined in Alternative 8B would be excavated for off-site disposal or treated. The remaining portions of the site would be capped. In areas where excavation or containment is impractical, engineering, safety, and institutional controls would be implemented.

Treatment Component

Soil organic hot spots, as defined in Alternative 8B, would be excavated and taken off-site for disposal. Excavated soil contaminated with organics or mixtures of organics and inorganics, which contain PCBs in excess of 50 mg/kg (2,000 cubic yards) would be taken to an off-site incinerator for treatment and disposal, as described in Alternative 7. This is the only treatment component of Alternative 9B. This treatment component has the same removal efficiencies as Alternative 7.

Containment Component

The hot spot areas contaminated with lead and mercury would be capped along with the areas which exceed the cleanup goals for other contaminants, as described in Alternative 8B. Damaged existing surfaces would be inspected quarterly and repaired as

needed. The containment component of this alternative has the same limitations as Alternative 3.

General Components

The general components of this alternative are the same as those described in Alternative 9A. Excavated soil which contains TPH and PCB levels less than 50 mg/kg and soil which contains inorganics only (71,000 cubic yards) would be taken to an off-site hazardous waste landfill for disposal. Soil which contains TPH exceeding 10,000 mg/kg, but for which all other constituents are below MTCA or other regulatory considerations, would be disposed in a regulated landfill. The limitations to excavation and disposal are the same as described in Alternative 7. Engineering, safety, and institutional controls have the same limitations as Alternative 2.

Costs and Remediation Time Frames

The total present worth cost for the alternative is $50.7 million. Capital costs are $6.7 million and include capping expenses. Operation and maintenance costs are $44 million and include excavation, transport and disposal expenses as well as cap maintenance and implementation of engineering, safety, and institutional controls.

This alternative would take 54 months (4.5 years) to implement.

Physical Effects on the Environment Caused by Implementation

This alternative presents the same risks to the environment as described in Alternative 9A.

Compliance With ARARs

Compliance with all ARARs is achieved as described in Alternative 9A.

Alternative 10A: Soil Hot Spot Incineration/Solidification and Containment

Major Components of the Remedial Alternative

This alternative consists of incineration and/or solidification of organic and inorganic hot spots, as defined in Alternative 8A, with containment of the remainding portions of the site contaminated above cleanup goals. In areas where excavation is impractical, engineering, safety and institutional controls would be implemented.

Treatment Component

Organic hot spots would be excavated and transported to an on-site mobile incinerator for treatment, as described in Alternative 4. The treatment component of this alternative has the same operational requirements, trial burn requirements, and limitations as Alternative 4. After treatment, organic hot spot soil would be tested for total inorganic concentrations and for leachability of inorganics, as in alternative 8A, to determine if solidification or capping is necessary prior to replacing the treated soil in the ground. Inorganic hot spots would be treated by an on-site solidification process as described in Alternative 4.

Containment Component

The remaining contaminated areas not covered by an impermeable barrier of asphalt or concrete would be capped as described in Alternative 8A. Cracked or damaged asphalt or concrete would be repaired or sealed. The containment component of this alternative has the same limitations as discussed in Alternative 3.

General Component

Excavation procedures, contamination control, dust control, and backfill would occur as discussed in Alternative 4. Areas where capping is impractical would be posted with signs, employees would be informed of potential hazards, and institutional controls would be implemented as described in Alternative 2, as appropriate. This alternative has the same limitations to engineering, safety, and institutional controls as discussed in Alternative 2.

Costs and Remediation Time Frame

The total present worth cost for the alternative is $103 million. Capital costs are $14 million and include site preparation, mobilization, equipment purchase and capping expenses. Operation and maintenance costs are $89 million and include excavation expenses, incineration and solidification costs, cap maintenance, and implementation of engineering, safety and institutional controls.

This alternative would take 57 months (4.75 years) to implement.

Physical Effects on the Environment Caused by Implementation

This alternative presents the same short-term risks to the environment as discussed in Alternative 4. Because the remedial action is limited to "hot spots," the volume of soil treated is reduced as compared to Alternative 4, and the frequency of occurrence of adverse effects would be reduced accordingly. Contaminated runoff from excavated areas and stockpiles would present a potential risk to the environment. Runoff control

measures would be implemented as discussed in Alternative 4 to reduce or eliminate this hazard.

Compliance With ARARs

The alternative, which features the incineration/solidification of soil hot spots followed by containment of remaining soil above cleanup goals, will be designed and implemented to meet all ARARs. Although concentrations above cleanup goals for lead, cadmium, chromium, PCBs, and TPH will remain in the unexcavated soil, capping would protect human health and mitigate further degradation of groundwater from infiltration. Organics exceeding cleanup goals would naturally attenuate over time. Emissions generated during the remedial actions (e.g., incineration, excavations, etc.) would be controlled to meet Puget Sound Air Pollution Control Authority (PSAPCA) requirements. The incinerator will be operated in conformance with Dangerous Waste incinerator performance standards, and will achieve the 99.9999 percent destruction removal efficiency for PCBs to meet TSCA incinerator requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 10B: Soil Organic Hot Spot Incineration/Solidification and Containment

Major Components of the Remedial Alternative

This alternative consists of excavation and incineration and/or solidification of organic hot spots as defined in Aternative 8B, followed by containment of the remaining portions of the site. In areas where excavation or containment is impractical, engineering, safety, and institutional controls would be implemented.

Treatment Component

Soil organic hot spots would be treated in an on-site incinerator. After treatment, organic hot spot soil would be tested for total inorganic concentration and for leachability of inorganics, as in alternative 8A, to determine if solidification or capping is necessary prior to replacing the treated soil in the ground. The treatment component of this alternative has the same operating requirements, trial burn requirements, and limitations as Alternative 4.

Containment Component

The hot spot areas contaminated with lead and mercury would be capped along with the areas which exceed the cleanup goals, as described in Alternative 8B. Damaged existing surfaces overlying contaminated soil would be repaired or replaced. Capped surfaces would be inspected quarterly and repaired as needed. The

containment component of this alternative has the same limitations as discussed in Alternative 3.

General Components

Excavation procedures, contamination control, dust control, and backfill would occur as discussed in Alternative 4. In areas where excavation or containment is impractical, engineering, safety, and institutional controls would be implemented as described in Alternative 2. The limitations to the controls are the same as described in Alternative 2.

Costs and Remediation Time Frame

The total present worth cost of the alternative is $67 million. Capital costs are estimated to be $14 million and include mobilization, site preparation, incineration and solidification equipment. Operation and maintenance costs are estimated to be $53 million and include excavation, treatment, cap maintenance, and implementation of engineering, safety, and institutional controls.

This alternative would take 57 months (4.75 years) to implement.

Physical Effects on the Environment Caused by Implementation

This alternative presents the same risks to the environment as Alternative 10A.

Compliance With ARARs

Incineration and solidification of soil hot spots defined by the modified criteria, followed by containment of the remaining soil above cleanup goals, would achieve all ARARs as described in Alternative 8A.

Alternative 11A: Soil Hot Spot Thermal Desorption/Solidification and Containment

Major Components of the Remedial Alternative

This alternative consists of thermal desorption and solidification of soil hot spots, as defined in Alternative 8A, with containment of the remaining contamination above cleanup goals. Since thermal desorption is not highly effective for removing PCBs from soil, hot spots containing PCB contaminants (3,200 cubic yards) would be excavated and treated in an off-site incinerator or disposed at a hazardous waste landfill. In areas where excavation or containment is impractical, engineering, safety, and industrial controls would be implemented.

Treatment Component

Thermal desorption is a process by which soil is heated to a moderate temperature (usually in the range of 200-1,000°F) to vaporize organic contaminants. The organics are not destroyed by this process, but are physically separated from the soil. Vaporized organics can then either be combusted in an afterburner or removed in liquid form after condensation. Thermal desorption would be a suitable technology for Harbor Island hot spots, since the technology requires lower capital and operating costs compared to incineration, organics are removed from solids and may be recycled, and low treatment temperatures minimize the potential to volatilize heavy metals. Based on literature performance data, it is probable that thermal desorption would effectively remove TPH, benzene, ethylbenzene, and xylene from soil to cleanup goals. Thermal desorption has not been proven as effective in removing PCBs and high molecular weight PAHs from soil and therefore it is uncertain if cleanup goals for these compounds could be achieved. Thermal desorption treatability studies would be required to verify removal efficiencies.

Soil TPH hot spots would be transported to an on-site thermal desorption unit for treatment. After treatment, organic hot spot soil would be tested for total inorganic concentration and for leachability of inorganics, as in alternative 8A, to determine if solidification or capping is necessary prior to replacing the treated soil in the ground. Limitations for the solidification process are the same as described in Alternative 4.

Soil contaminated with PCBs in excess of 50 mg/kg would be excavated and taken off-site either for incineration or directly to a hazardous waste disposal facility. The requirements for PCB incineration are the same as described in Alternative 7. Soil contaminated with PCBs less than 50 mg/kg or with heavy PAHs would be excavated and taken to an off-site hazardous waste disposal facility. Imported, clean soil would be used as backfill.

Soil contaminated with inorganics only would be treated in the on-site solidification process and returned to its original location as backfill.

Containment Component

This alternative has the same containment component as Alternative 8A. All areas where soil exceeds cleanup goals would be capped. Existing and impermeable barriers would be inspected and patched or sealed if necessary. All capped surfaces would be inspected quarterly and repaired as required. The limitations to the containment component are the same as Alternative 3.

General Components

Excavation procedures, contamination control, and dust control would occur as described in Alternative 4. Areas where capping is impractical would be posted with signs, employees would be informed of potential hazards, and institutional controls would be implemented as described in Alternative 2, as appropriate. The limitations to institutional controls are the same as described in Alternative 2.

Costs and Remediation Time Frame

The total present worth cost for the alternative is $57.1 million. Capital costs are $6.7 million and include thermal treatment and solidification equipment, mobilization, site preparation, and capping. Operation and maintenance costs are estimated to be $50.4 million and include excavation, treatment, transport, and disposal of soil, cap maintenance, and implementation of engineering, safety, and institutional controls.

Alternative 11A would take 57 months (4.75 years) to implement.

Physical Effects to the Environment Caused by Implementation

This alternative presents the same risks to the environment as the other excavation, treatment, and disposal alternatives for hot spots. Contaminated runoff from excavated areas and stockpiles presents a potential risk to the environment. Run-on/runoff control measures would be implemented as discussed in Alternative 4 to reduce or eliminate this hazard. Transport of contaminated soil off site presents a potential risk to the environment. Truck decontamination areas would be established on site to minimize or eliminate the spread of contamination off site. Truck payloads would be covered with tarps to prevent loss of material.

Compliance With ARARs

The alternative, which features the thermal desorption and solidification or off-site disposal of soil hot spots followed by containment of remaining soil above cleanup goals, will be designed and implemented to meet all ARARs. Although concentrations above cleanup goals for lead, arsenic, mercury, PCBs, and TPH will remain in the unexcavated soil, capping would protect human health and mitigate further degradation of groundwater from infiltration. Organics exceeding cleanup goals would naturally attenuate over time. Emissions generated during the remedial actions would be controlled to meet PSAPCA requirements. Any construction activities performed within 200 feet from the shoreline will be performed in conformance with the Shoreline Management Act.

Alternative 11B: Soil Organic Hot Spot Thermal Desorption and Containment

Major Components of the Remedial Alternative

This alternative consists of thermal desorption and solidification or off-site disposal of soil excavated from organic hot spots as defined in Alternative 8B. Treatment components of this alternative are the same as those of Alternative 11A, except that soil contaminated only with inorganics would not be solidified, but would be capped. The remaining contaminated areas not currently covered by an impermeable barrier of asphalt or concrete would be capped with asphalt. Institutional controls would be implemented.

Treatment Component

The organic hot spots would be treated the same as in Alternative 11A, although hot spot soil contaminated with inorganics only (lead and mercury) would not be treated on site but would be capped. In this alternative, 91,000 cubic yards of TPH contaminated soil would be treated with thermal desorption. After treatment, organic hot spot soil would be tested for total inorganic concentration and for leachability of inorganics, as in alternative 8A, to determine if solidification or capping is necessary prior to replacing the treated soil in the ground.

Soil contaminated with PCBs greater than 50 mg/kg would be excavated and taken off-site either for incineration or diposed of at a hazardous waste disposal facility. The requirements for PCB incineration are the same as described in Alternative 7. Soil contaminated with mixed organics with a risk greater thatn 10^{-4} would be excavated and taken to an off-site hazardous waste disposal facility. Imported, clean soil would be used as backfill. The operational requirements, treatability study requirements, and limitations of the treatment component of this alternative are the same as discussed in Alternative 11A.

Containment Component

This alternative has the same containment component as described in Alternative 11A. Contaminated soil not excavated, treated and/or disposed would be capped. The alternative has the same limitations to the containment component as discussed in Alternative 3.

General Components

General components of this alternative are the same as those described in Alternative 11A. Excavation procedures, contamination control, and dust control would occur as discussed in Alternative 4. Backfill would occur as discussed in Alternative 11B. This alternative has the same limitations to the engineering, safety and

institutional controls as Alternative 2.

Costs and Remediation Time Frame

The total present worth cost for this alternative is approximately $38.6 million. Capital costs are $6.7 million, and operation and maintenance costs are $36.9 million. The costs include the same items outlined in Alternative 11A.

Alternative 11B would take 57 months (4.75 years) to implement.

Physical Effects on the Environment Caused by Implementation

The physical effects on the environment caused by implementation of this alternative are the same as those discussed for Alternative 11A.

Compliance With ARARs

This alternative complies with all ARARs in the same manner as Alternative 11A.

Description of Groundwater Alternatives

Alternative 1: No Action

Evaluation of a no action alternative is required in order to provide a basis for comparison of existing conditions and risks of potential conditions resulting from implementation of other remedial alternatives.

Major Components of the Remedial Alternative

Under the no action alternative, no additional remedial action will be taken to eliminate existing sources of contamination or to reduce the risks to humans.

Treatment Component

There is no treatment component for this alternative. Reduction in toxicity or volume will occur only through natural processes such as biodegradation. Toxicity, mobility and volume of the contaminated materials will remain at their present value for an indefinite period of time.

Containment Component

There is no containment component for this alternative.

General Component

In this alternative, no action is required for its implementation.

Costs and Remediation Time Frame

Since no action is taken in this alternative, no costs or time are required for implementation.

Physical Effects on Environment Caused by Implementation

Since no action is taken in this alternative, the risk from implementation of this alternative is minimal.

Compliance with ARARs

The no action alternative will not meet any ARARs. This alternative is provided as a baseline to assess the effects of leaving the site in its current state.

Alternative 2: Removal of Floating Petroleum Product and Monitoring of Groundwater

Major Components of the Remedial Alternative

In this alternative, floating petroleum product located at Todd Shipyard facility will be removed and treated. Groundwater in the immediate vicinity of this floating product, which has been contaminated with benzene and other soluable constituents of petroluem, will be pumped and treated. Groundwater contaminant concentrations at selected wells across Harbor Island will also be monitored semi-annually for a period of 30 years.

Treatment Component

The floating petroleum product and the associated contaminated groundwater, will be treated on-site by oil/water separation, air stripping, and carbon adsorption.

Containment Component

Containment will be provided through the extraction of contaminated water associated with the floating product.

General Components

In this alternative, floating petroleum product will be removed by groundwater pumping. The water will then be treated by an oil/water separator, air stripping and carbon adsorption before discharge to the Metro POTW.

In all interior areas or the island where groundwater contaminants concentrations exceed the cleanup goals identified in Table 7, and

in all shoreline wells downgradient of these areas, groundwater will be sampled and analyzed semi-annually for 30 years. The shoreline wells will be considered the point of compliance for achieving the cleanup goals. Groundwater quality trends will be reviewed every 5 years to determine if reasonable progress is being made towards achieving the cleanup goals. If adequate progress towards the cleanup goals is not being achieved, the need for additional remedial actions will be evaluated.

Costs and Remediation Time Frame

The estimated capital cost for removal of floating product, monitoring and institutional controls is $500,000. The estimated operations and maintenance cost is $1,100,000.

It is anticipated that removal of the petroleum product will require 1 year for completion. Monitoring will continue for 30 years.

Physical Effects on Environment Caused by Implementation

The majority of effects on the environment caused by implementation of this alternative are associated with the installation of the groundwater extraction system. Human health risks could be incurred by contact with contaminated soil during excavation. Releases of toxic vapors could occur through excavation of soil containing volatile organic contaminants. Some contaminants may be emitted to the environment through the use of the air stripper and other treatment units. The system will be designed to meet PSAPCA regulations.

Compliance with ARARs

The primary ARARs are the Water Quality Standards for Surface Water of the State of Washington (WAC 173-201A), and the federal surface water quality standards (40 CFR Part 131). These surface water quality standards were adopted for the protection of marine organisms and protection of human health from consumption of marine organisms. With the removal of the floating product at Todd Shipyard, and treatment of associated contaminated groundwater, the surface water cleanup goals for organics in that area should be met in a relatively short timeframe. Subsequent actions to be taken by Ecology on floating product associated with the tank farms operable unit, should allow the goals for benzene in two other areas along the shoreline to be met over a longer timeframe through natural biodegrdation.

This groundwater alternative, if coupled with a soil alternative which controls sources of inorganic contamination over the entire island, should also meet the surface water cleanup goals for inorganics. This conclusion is supported by the results of groundwater transport modeling, conducted during the Feasibility

Study, which indicates that inorganics currently in the groundwater will take more than 50 years to reach the shoreline.

This alternative should also meet all other groundwater/surface water ARARs. These include the Washington Water Pollution Control Act (RCW 90.48, WAC 173-201A)/Water Resources Act (RCW 90.54), State Water Code (RCW 90.03) and Water Rights (RCW90.14), the substantive requirements of the NPDES Program as regulated by the State Discharge Permit Program (WAC 173-220), and the construction and maintenance of wells (WAC 173-160). Releases of contaminants to the air from the groundwater treatment system will also meet air quality standards established by the Puget Sound Air Pollution Control Authority (PSAPCA) (Regulations I,III).

Alternative 3: Precipitation/Filtration/Ion Exchange/Air Stripping/Nitrification/Denitrification with Storm Sewer Discharge

Major Components of the Remedial Alternative

In Alternative 3, contaminated groundwater will be extracted from three target areas along the shoreline to prevent migration of a contaminant (benzene) to the surrounding waterways. The water will be treated to meet surface water quality standards before discharge to the storm sewer. Floating petroleum product at Todd Shipyards would also be removed and treated. Groundwater contaminant concentration across the island would also be monitored for 30 years.

Treatment Component

Alternative 3 provides treatment of groundwater at three locations by precipitation and filtration of inorganics, air stripping of organics, and nitrification/denitrification of ammonia. Floating product at Todd Shipyards would also be removed and treated.

Containment Component

The goal of the groundwater extraction system is to provide containment of a contaminant (benzene) that is expected to migrate to the periphery of the island at concentrations which exceed cleanup goals within 50 years.

General Components

Alternative 3 includes the removal of groundwater from three target areas, which are located on Todd Shipyard, Shell, and Atlantic Richfield properties. These target areas were chosen to prevent the migration of contaminants to the periphery of the island at concentrations which exceed cleanup goals within 50 years.

The groundwater will be extracted through wells, then pumped to a

centrally located treatment facility. The treatment train will include a gravity separation unit to remove floating product. After gravity separation, a precipitation/sedimentation unit will be used to remove the bulk of the soluble and particulate inorganics. Microfiltration and ion exchange will be subsequently used to polish the remaining particulate and soluble inorganics, respectively. Organics will then be removed by air stripping. A nitrification/denitrification process will then be used to remove ammonia before subsequent discharge to the storm sewer. Off-gases will be treated by catalytic oxidation.

In all areas where groundwater contaminants concentrations exceed these cleanup goals and in associated downgradient areas, groundwater will be sampled and analyzed semi-annually for 30 years. Groundwater data trends will be reviewed every 5 years to determine if progress towards achieving cleanup goals is being made. If adequate progress towards cleanup goals is not being achieved, the need for additional remedial actions will be evaluated.

Costs and Remediation Time Frame

The estimated capital cost for the groundwater extraction and treatment facility and for installation of the monitoring network is $5,000,000. The estimated operation and maintenance cost for both the treatment facility and monitoring network is $15,000,000. Engineering, administrative, and contingency costs are include with operation and maintenance costs. The estimated time for groundwater treatment is 10 years. Monitoring will continue for 30 years. Monitoring may indicate that additional time or effort for remediation is required.

Physical Effects on the Environment Caused by Implementation

Many of the effects on the environment caused by implementation of this alternative are associated with the installation of the groundwater extraction system and the associated piping. Human health risks could be incurred by contact with contaminated soil during excavation. Release of toxic vapors could occur through excavation of soil containing volatile organic contaminants.

Some contaminants may be released to the environment through the use of the air stripper and other treatment equipment. The effect of this contamination will be minimized through the use of catalytic oxidation.

Compliance with ARARs

The primary ARARs are the Water Quality Standards for Surface Waters of the State of Washington and the federal surface water quality standards. These surface water quality standards were adopted for the protection of marine organisms and protection of human health from consumption of marine organisms. The groundwater treatment and extraction system will be designed and operated to meet the surface water cleanup goals for soluable petroleum constituents (primarily benzene) currently in the groundwater at three areas along the shoreline. With the removal of the floating product at Todd Shipyard, and subsequent actions to be taken by Ecology on floating product associated with the tank farms, the long term sources of soluable constituents of petroleum should also be eliminated.

This groundwater alternative, if coupled with a soil alternative which controls sources of inorganic contamination over the entire island, should also meet the surface water cleanup goals for inorganics. This conclusion is supported by the results of groundwater transport modeling, conducted during the Feasibility Study, which indicates that inorganics currently in the groundwater will take more than 50 years to reach the shoreline.

This alternative should also meet all other groundwater/surface water ARARs. These include the Washington Water Pollution Control Act (RCW 90.48, WAC 173-201A)/Water Resources Act (RCW 90.54), State Water Code (RCW 90.03) and Water Rights (RCW90.14), the substantive requirements of the NPDES Program as regulated by the State Discharge Permit Program (WAC 173-220), and the construction and maintenance of wells (WAC 173-160). Releases of contaminants to the air from the groundwater treatment system will also meet air quality standards established by the Puget Sound Air Pollution Control Authority (PSAPCA) (Regulations I,III).

Alternative 4: Precipitation/Filtration/Ion Exchange/UV Oxidation with Discharge by Reinjection

Major Components of the Remedial Alternative

In this alternative, contaminated groundwater will be extracted from the three target areas, as in alternative 3, but treated by a different treatment technology system. In this alternative, since the treated water will be reinjected into the ground and not released directly to the surface water, the performance goal of the treatment system may be slightly less stringent than that of alternative 3. The performance goal of this treatment system will be to reduce contaminant concentrations to levels which will not exceed the surface water standards at the shoreline. Floating petroleum product at Todd Shipyards would also be removed and treated. Groundwater contaminant concentration across the island

would also be monitored for 30 years.

Treatment Component

Alternative 4 provides treatment of groundwater at three locations by precipitation, filtration, and ion exchange of inorganics and UV oxidation of organics. Floating product at Todd Shipyards would also be removed and treated.

Containment Component

The goal of the groundwater extraction system is to provide containment of the contaminants that are expected to migrate to the periphery of the island at concentrations which exceed the cleanup goals within 50 years.

General Components

Alternative 4 includes the removal of groundwater from three target areas, which are located on Todd Shipyard, Shell, and Atlantic Richfield properties. These target areas were chosen to prevent the migration of contaminants to the periphery of the island at concentrations which exceed cleanup goals within 50 years.

The groundwater will be extracted through wells then pumped to a centrally located treatment facility. The treatment train will include a gravity separation unit to remove floating product. After gravity separation, a precipitation/sedimentation unit will be used to remove the bulk of the soluble and particulate inorganics. Microfiltration and ion exchange will be subsequently used to polish the remaining particulate and soluble inorganics, respectively. Organics will then be removed by UV oxidation before subsequent discharge by reinjection. Off-gases will be treated by catalytic oxidation.

In all areas where groundwater contaminants concentrations exceed these cleanup goals and in associated downgradient areas, groundwater will be sampled and analyzed semi-annually for 30 years. Groundwater data trends will be reviewed every 5 years to determine if cleanup goals are being achieved. At each 5 year review, the need for additional remedial actions will be evaluated.

Costs and Remediation Time Frame

The estimated capital cost for the groundwater extraction and treatment facility and for installation of the monitoring network is $3,000,000. The estimated operation and maintenance cost for both the treatment facility and monitoring network is $10,000,000. Engineering, administrative, and contingency costs are include with operation and maintenance costs. The estimated time for groundwater treatment is 10 years. Monitoring will continue for 30 years. Monitoring may indicate that additional time or effort for

remediation is required.

Physical Effects on the Environment Caused by Implementation

The majority of effects on the environment caused by implementation of this alternative are associated with the installation of the groundwater extraction system and the associated piping. Human health risks could be incurred by contact with contaminated soil during excavation. Release of toxic vapors could occur through excavation of soil containing volatile organic contaminants.

Some contaminants may be released to the environment through the use of the air stripper and other treatment equipment. The effect of this contamination will be minimized through the use of catalytic oxidation.

Compliance with ARARs

The primary ARARs are the Water Quality Standards for Surface Waters of the State of Washington and federal surface water quality standards. These surface water quality standards were adopted for the protection of marine organisms and protection of human health from consumption of marine organisms. The groundwater treatment and extraction system will be designed and operated to meet the surface water cleanup goals for soluable petroleum constituents (primarily benzene) currently in the groundwater at three areas along the shoreline. With the removal of the floating product at Todd Shipyard, and subsequent actions to be taken by Ecology on floating product associated with the tank farms, the long term sources of soluable constituents of petroleum should also be eliminated.

This groundwater alternative, if coupled with a soil alternative which controls sources of inorganic contamination over the entire island, should also meet the surface water cleanup goals for inorganics. This conclusion is supported by the results of groundwater transport modeling, conducted during the Feasibility Study, which indicates that inorganics currently in the groundwater will take more than 50 years to reach the shoreline.

This alternative should also meet all other groundwater/surface water ARARs. These include the Washington Water Pollution Control Act (RCW 90.48, WAC 173-201A)/Water Resources Act (RCW 90.54), State Water Code (RCW 90.03) and Water Rights (RCW90.14), the substantive requirements of the NPDES Program as regulated by the State Discharge Permit Program (WAC 173-220), and the construction and maintenance of wells (WAC 173-160). Releases of contaminants to the air from the groundwater treatment system will also meet air quality standards established by the Puget Sound Air Pollution Control Authority (PSAPCA) (Regulations I,III).

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The following section discusses the comparison of alternatives with respect to the nine statutory CERCLA requirements.

Protectiveness of Human Health and the Environment

Soil

Alternatives 4, 5, 6, and 7 rank highest of all alternatives, in terms of protection, because they either treat or remove from the site all contaminants above the cleanup goals. Alternatives 8A, 9A, 10A, and 11A are next because they treat or remove the organic and inorganic hot spots while leaving the remaining contaminants in place beneath an asphalt cap. Alternatives 8B, 9B, 10B, and 11B are next because they treat or remove the organic hot spots and leave the remaining contamination beneath a cap. Alternative 3 is next because it prevents direct human contact with contaminants but may not prevent the migration of organic contaminants to the surrounding surface water where marine organisms may be exposed. Alternative 2 provides only marginal protection because direct exposure to contaminants is still possible. Alternative 1 provides no protection to human health or the environment.

Groundwater

Alternative 3 and 4 rank the highest because they provide protection to the environment in the shortest timeframe through removal of one area of floating product and treatment of contaminated groundwater in three areas along the shoreline where marine organisms may currently be exposed to elevated levels of organic contaminants. Alternative 2 ranks next because it provides protection to the environment in a longer timeframe. Alternative 2 will achieve cleanup in a relatively short timeframe in the most critical area of organic contamination, the floating petroleum product at Todd Shipyard. For the two other areas of contaminated groundwater, cleanup goals for benzene will be achieved over a longer timeframe through a combination of source control and natural biodegrdation. If coupled with an adequate soil source control alternative, alternatives 2, 3, and 4, will also protect marine organisms from exposure to elevated concentrations of inorganics. Alternative 1 provides no protection to the environment.

Compliance with Federal and State Applicable or Relevant and Appropriate Regulations (ARARs)

Soil

Alternatives 4-11 comply with all chemical-specific and action-specific ARARs because they address all contaminated soil above the cleanup goals through containment, treatment, or both. Alternative 3 meets all ARARs except the state and federal surface water quality standards. Alternatives 1 and 2 do not meet any chemical-specific or action-specific ARARs because they do not include any action to address soil contamination above the cleanup goals.

Groundwater

Alternatives 3 and 4 ranked highest in terms of compliance with chemical-specific and action-specific ARARs because they achieve compliance with surface water quality standards for organic contaminants in the shortest timeframe. Alternative 2 ranks next because it achieves compliance with surface water quality standards for organic contaminants over a longer timeframe. If coupled with a soil source control alternative, alternatives 2, 3, and 4 will also protect marine organisms from exposure to elevated concentrations of inorganics. Alternative 1 ranks lowest because it does not provide any action to achieve surface water quality standards at the shoreline.

Long-Term Effectiveness and Permanence

Soil

Alternatives 4, 5, 6, and 7 ranked highest for long-term effectiveness and permanence because they permanently destroy or remove all contamination in the soil exceeding cleanup goals and require no long-term maintenance or controls. Alternatives 8A, 9A, 10A, and 11A are next best in terms of effectiveness and permanence because they permanently destroy or remove both organic and inorganic hot spots but would require maintenance of the capped areas. Alternatives 8B, 9B, 10B, and 11B are next because they permanently treat only the organic hot spots and would require long-term maintenance of the capped areas. Alternative 3 is next because it is effective over the long-term only if the cap is properly maintained. Alternatives 1 and 2 do not permanently remove health and environmental risk and, therefore, rank lowest in terms of long-term effectiveness and permanence.

Groundwater

If coupled with an adequate soil source control alternative, alternatives 3 and 4 are equally ranked because they provide the equivalent long-term effectiveness and permanence in protecting the environment from contaminants in the groundwater. Alternative 2 ranks next because it depends more heavily on adequate source control to achieve the cleanup goals than do alternatives 3 and 4.

Alternative 1 ranks lowest because it provides no long-term effectiveness.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Soil

Alternatives 4, 5, and 6 rank highest because they reduce toxicity or mobility for all contaminated soil on the site. Alternatives 8A, 10A, and 11A rank next because they remove, destroy, or immobilize organic and inorganic hot spot contaminants which amount to approximately 60% of the total organic contaminants and approximately 70% of the total inorganic contaminants. Alternatives 8B, 10B, and 11B rank next because they remove or destroy organic hot spot contaminants and reduce the mobility of the inorganics by capping in place. Alternatives 3, 7, 9a, and 9B all rank next because they primarily provide reduction in mobility either by capping contaminants in place or disposal in an off-site hazardous waste landfill. Alternatives 1 and 2 rank lowest because they provide no reduction in toxicity, mobility, or volume through treatment.

Groundwater

Alternatives 3 and 4 provide the best reduction in toxicity, mobility, and volume of contaminants in the groundwater through extraction and treatment. Alternative 2 ranks next because it extracts and treats floating product and associated contaminated groundwater in the most critical area which could effect surface water quality. Alternative 1 provides no reduction in toxicity, mobility, or volume of contaminants through treatment.

Short Term Effectiveness

Soil

Alternative 3 ranks highest in short-term effectiveness because it addresses site contaminants in the shortest period of time and causes minimal additional short term risk to workers and environment during remediation activities. Alternatives 8A, 8B, 9A, 9B, 10A, 10B, 11A and 11B all rank next in terms of short-term risk to workers, the community, and the environment because they require excavation and handling of comparatively moderate volumes of contaminated soil. Alternatives 4, 5, 6, and 7 rank next because they present a slightly higher degree of short-term risk due to the fact that they require excavation and handling of a much larger volume of contaminated soil and allow human exposure to this excavated soil over a longer period of time. Alternatives 1 and 2 rank the lowest because they do not provide any protection to human health or the environment in the short term.

Groundwater

Alternative 2 has good short-term effectiveness because it presents minimal exposure to humans during implementation and provides protection to the environment in the short term. Alternatives 3 and 4 rank next because, even though they provide good short-term protection to the environment, they expose workers to contamination during well installation or during treatment facility construction and operation. Alternative 1 ranks lowest because it provides no protection to the environment in the short term.

Implementability

Soil

Alternatives 1, 2, and 3 are easily implemented because they require little or no excavation, have the shortest implementation schedules, and provide the least interruption to island businesses. Among the alternatives which require soil treatment, the alternatives which treat the hot spots minimize disruption of island business because they require less excavation and have less logistical constraints compared to alternatives that treat all contaminated soil. Therefore, alternatives 8B, 9B, 10B, and 11B rank next in terms of implementability because they require excavation and treatment of only the organic hot spots. Alternatives 8A, 9A, 10A, and 11A rank next because they require excavation and treatment of the organic and inorganic hot spots. Alternatives 4, 6, and 7 rank next because they require excavation and treatment of large quantities of soil which will cause major disruptions to businesses on the island. Alternative 5 ranks last due to uncertainties regarding the ability of in-situ bioremediation to achieve cleanup goals in a reasonable timeframe, and the requirement for a large open area needed for bioremediation by land farming for the excavated soil.

Groundwater

Alternatives 3 and 4 may be difficult to implement due to difficulties in constructing the groundwater extraction and treatment systems. Also, the extraction system may pull in brackish water which may decrease the effectiveness of the treatment system. Alternative 2, because it only requires removal of floating product and a limited amount of contaminated groundwater, is more easily implemented. Alternative 1 does not require any action and is the easiest to implement.

Cost

Costs for all alternatives are summarized in Table 11. Alternatives 1 and 2 have the lowest costs of any soil alternatives. Alternative

3 has the next lowest cost because it only requires containment of the contaminated soil. The alternatives which require treatment of hot spots have the next lowest range of costs. Among the alternatives which require treatment of only the organic hot spots, alternative 11B is the lowest. For alternatives which require treatment of both organic and inorganic hot spots, alternative 11A is the lowest. Alternatives 4, 5, 6, and 7, which require treatment or disposal of all contaminated soil, have the highest costs.

For groundwater, treatment alternatives 3 and 4 are the most expensive. Alternatives 2 is relatively inexpensive and alternative 1 has no cost.

State Acceptance

The Department of Ecology concurs with EPA's preferred alternative, which is identified below.

Community Acceptance

The comments received during the public comment period were substantially in favor of the preferred alternative identified in the Proposed Plan. A complete summary of comments received and EPA's responses are provided in the Responsiveness Summary.

Table 11— Present Worth Costs for Harbor Island Remedial Alternatives

I. Soil Alternatives

1	No Action	None
2	Institutional Controls	$150,000
3	Asphalt Cap (All Areas Above Cleanup Goals)	$15,000,000

Alternatives Which Treat All Contaminants

4	Incineration/Solidification	$244,700,000
5	Bioremediation/Solidification	$117,400,000
6	Solvent Extraction/Solidification	$184,600,000
7	Off-Site Disposal	$220,000,000

Alternatives Which Treat Hot Spots and Cap Remaining Areas

8A	Solvent Extraction/Solidification	$83,200,000
8B	Solvent Extraction (Organics Only)	$54,800,000
9A	Off-Site Disposal	$75,400,000
9B	Off-Site Disposal (Organics Only)	$50,400,000
10A	Incineration/Solidification	$103,000,000
10B	Incineration (Organics Only)	$67,100,000
11A	Thermal Desorption/Solidification	$57,100,000
11B	Thermal Desorption (Organics Only)	$38,600,000

II. Groundwater Alternatives

1	No Action	None
2	Petroleum Product Removal/Monitoring	$1,600,000
3	Air Stripping/Monitoring	$19,900,000
4	UV Oxidation/Monitoring	$13,300,000

THE SELECTED REMEDY

Major Components of the Selected Remedy

EPA's selected remedy is soil Alternative 11B combined with groundwater Alternative 2. This remedy was selected over other alternatives because it best satisfies the nine evaluation criteria. In particular, it: is protective of human health and the environment, meets all ARARs, has good long-term and short-term effectiveness, reduces the toxicity and volume of the primary threat (TPH, PCBs, and mixed organics with risk exceeding 10^{-4}) and reduces the mobility of the low level threat (inorganics and organics below the treatment level), is technically and administratively feasible to implement, has the lowest cost of all other reasonable protective alternatives, and is acceptable to the state and the public.

The selected remedy includes the following specific components:

- Excavation and treatment of the soil containing the highest levels of organic contamination ("hot spots"). These organic soil hot spots are defined as Total Petroleum Hydrocarbons (TPH) greater than 10,000 mg/kg, PCBs greater than 50 mg/kg, and soil with mixed carcinogens with a total risk greater than 10^{-4}. TPH hot spot soil will be treated on site in a thermal desorption unit. PCBs hot spot soil will either be sent off site for treatment (incineration) or be disposed in a hazardous waste disposal facility. Organic hot spot soil with risk greater than 10^{-4} will be disposed in a hazardous waste disposal facility.

- Capping exposed contaminated soil exceeding inorganic or organic cleanup goals. The cap would consist of a low permeability material such as asphalt to prevent infiltration of rainwater and reduce contaminant migration into the environment. Existing asphalt and concrete surfaces would be repaired to also prevent infiltration of rainwater.

- Invoking institutional controls which would require long term maintenance of new and existing caps, warn future property owners of remaining contamination contained under capped areas on their properties, and specify procedures for handling and disposal of excavated contaminated soil from beneath the capped areas if future excavation is necessary.

- Removal of and treatment of floating petroleum product and associated contaminated groundwater at Todd Shipyards to prevent its migration into the marine environment. Implementing groundwater monitoring for 30 years, with review of groundwater quality trends every 5 years to assess the effectiveness of the selected remedy.

Soil organic hot spots containing concentrations of TPH exceeding the treatment level of 10,000 mg/kg (approximately 91,000 cubic yards) would be excavated and treated in an on-site thermal desorption unit. The performance goal for the thermal desorption unit will be to achieve soil cleanup goals for TPH, benzene, ethybenzene, toluene, and xylene (Table 7). TPH recovered from the thermal desorption treatment will be tested to determine if it is recyclable. If it is contaminated with other waste which prohibit recycling, it will be disposed off-site as required by regulations covering waste oil.

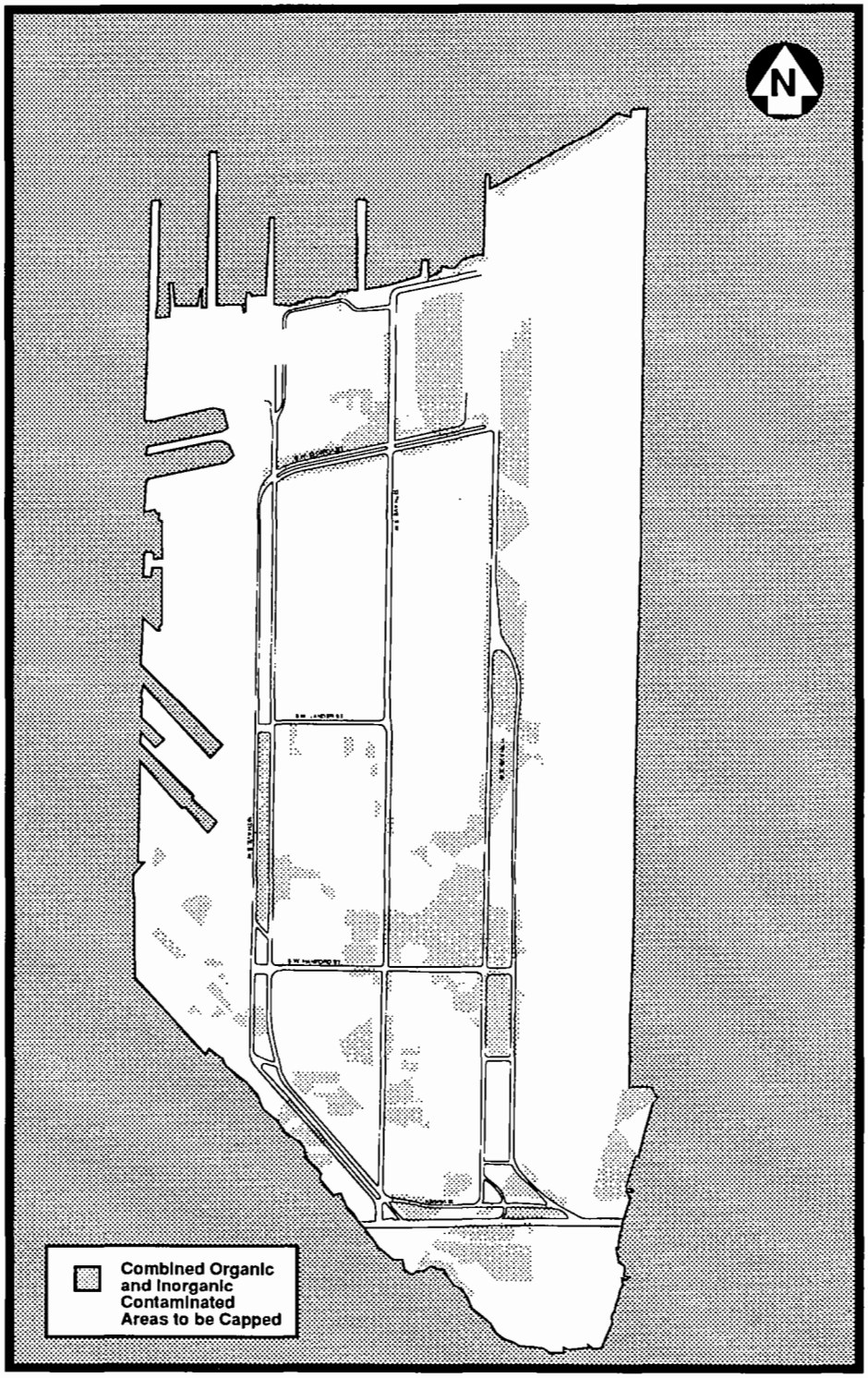
The treatment facility will consist of a soil stockpile area, thermal desorber unit, and a mobile laboratory. This facility will be provided with contamination control measures such as exclusion zones, decontamination equipment and facilities, and run-on/runoff controls. Treated organic hot spot soil would be tested for total organic and inorganic concentrations and inorganic contaminant leachability, according to the TCLP method, before being returned to the soil. Soil which fails the TCLP test, would be considered a RCRA characteristic waste. This soil would have to be solidified so that it no longer fails the TCLP test before being returned to the ground. If soil passes the TCLP test but contains organics or inorganics above the cleanup goals (Table 7), this soil would be placed in the ground and capped. TPH is not a RCRA hazardous waste or a state dangerous waste and the treatment and disposal of TPH contaminated soil will not have to comply with these regulations.

Organic hot spots containing concentrations of PCBs exceeding the treatment level of 50 mg/kg (2,000 cubic yards) would be excavated and either treated by off-site incineration or disposed at a hazardous waste disposal facility. Soil contaminated only with PCBs is not a RCRA hazardous waste nor a state dangerous waste but is a TSCA waste. The remedial action for this soil meets both the TSCA and state dangerous waste requirements. Organic hot spots contaminated above the treatment level of risk greater than 10^{-4} (1,200 cubic yards) would be taken to an off-site hazardous waste disposal facility.

The preferred alternative includes capping of lead and mercury hot spots and all remaining contaminated soil exceeding the cleanup goals (Table 7). Figure 6 shows areas of the island which will be capped. The cap will be composed of asphalt or concrete with a minimum thickness of 3 inches and with a minimum permeability (hydraulic conductivity) of 10^{-5} cm/sec. Capping will be effective in containing the lead and mercury in the hot spots because soil adsorption tests conducted during the remedial investigation showed that inorganic contaminants have a high affinity for the soil. Capping, with proper long-term maintenance, will decrease the migration of inorganic contaminants from the hot spots by reducing the infiltration of rain water and the potential for migration of

Figure 6

Contaminated Areas to be Capped



these contaminants into the groundwater. The results of the Remedial Investigation show that lead in soil fails the TCLP test at six locations and could be a RCRA characteristic waste. However, this soil will be managed within the area of contamination (AOC) and will receive a cap which complies with the RCRA hybrid closure requirements.

The floating petroleum product located at the Todd Shipyards facility would be recovered and recycled if possible. If not recyclable, it will be disposed off-site as required by regualations covering the disposal of waste oil. Removal of this petroleum is critical because it is currently at the shoreline, and is a direct source of contamination to the surface water of Elliott Bay. The contaminated groundwater associated with this floating product will be pumped and treated to surface water cleanup goals before being discharged to the storm drain system.

Surface water cleanup goals will be met in an acceptable period of time by taking source control actions which include: treatment and off-site disposal of the organic hot spot soil which could act as an ongoing source of contamination to surface water, removal of floating petroleum product at Todd Shipyards, and capping the remaining contaminated areas above the cleanup goals. These conclusions are supported by the results of groundwater transport modeling conducted in the feasibility study which indicate that the inorganics currently in the groundwater will take more than 50 years to reach the shoreline under current conditions. It is anticipated that subsequent action which may be taken by Ecology to remediate floating product at the tank farm operable unit will further ensure compliance with surface water cleanup goals.

In all areas where groundwater contaminant concentrations exceed the surface water cleanup goals (which apply at the shoreline), groundwater will be sampled semi-annually for 30 years. Groundwater quality data trends would be reviewed every 5 years to determine if additional remedial actions are required to meet the surface water cleanup goals.

Basis for Remediation Goals

Soil

For Harbor Island, the primary soil ARARs are the standards contained in the State of Washington Model Toxics Control Act (MTCA) and its implementing regulations. Compared to subsurface soil, surface soil presents a greater risk to human health because of the potential for more frequent exposure through direct contact or ingestion. Therefore, cleanup goals for the surface are more stringent and were based on a risk calculation specified by MTCA.

The cleanup goals for soil are shown in Table 7. The objective for

surface cleanup goals for carcinogens is to achieve a total cancer risk from all carcinogens of less than one in 100,000 (10^{-5}). Principle carcinogens of concern include PAHs, PCBs, and arsenic. Cleanup goals for noncarcinogens in the surface are also based upon the combined risk from all contaminants at each location. The cleanup goal for noncarcinogens was to achieve contaminant concentrations with a hazard index of less than 1.0 (one). A hazard index of less than 1.0 means contaminant concentrations will not pose an adverse health effect. The cleanup goal for lead, which is considered to be a probable carcinogen, is the MTCA numerical standard for an industrial exposure because a risk-based calculation method for lead has not yet been scientifically determined.

For subsurface soil, since human contact will be limited to infrequent excavations of limited duration, MTCA numerical standards for an industrial exposure were selected. The goal of these numerical standards is to achieve a risk from individual carcinogens of less than 1 in 100,000 (10^{-5}). The MTCA numerical standards selected for some of the contaminants in the subsurface are also designed to protect groundwater quality.

Groundwater

EPA and Ecology have determined that the federal and state drinking water standards do not apply to groundwater at Harbor Island. These drinking water standards are not relevant and appropriate to Harbor Island because: 1) there is no current or foreseeable use of groundwater for drinking water purposes, 2) the entire island is serviced by the city of Seattle water system, and 3) the surface water quality standards (Table 7) for the protection of marine organisms, and protection of human health from consumption of marine organisms, will apply at the shoreline.

Groundwater contaminant transport modeling conducted in the feasibility study demonstrated that substantially all of the contaminants would take more than 50 years to reach the shoreline. Only three areas along the shoreline were found to contain organic contaminants (above the surface water standards) which are currently at the shoreline or will be there in the next 50 years.

Protection of the Environment During Remedial Action

Engineering controls will be implemented to mitigate the impact on the environment. During excavation, run-on/runoff controls will be installed to keep soil from being transported into the island storm sewer system and ultimately to Elliott Bay. Contaminated soil in excavation areas will be covered in inclement weather to minimize contaminated runoff. The treatment area will also be provided with

run-on/runoff controls to minimize contaminant transport. Soil stockpiles in the treatment facility area will be covered with a rain shelter to prevent contaminated runoff.

Decontamination pads will be installed to clean equipment and minimize the spread of contamination to other areas of the site. Transport trucks will be covered as needed to prevent loss during transport.

Contaminated liquid storage tanks and storage facilities will be provided with double containment to prevent leaks from entering the environment. Routine inspections of facilities will be performed to assure safety measures are in place and functioning properly. Discharges to the environment will meet applicable state and federal regulations for protectiveness.

Cost and Remediation Time Frame

The preferred soil alternative is estimated to cost $38.6 million. Capital costs are $6.7 million and include site preparation, health and safety equipment, and cap placement. Operations costs are $31.9 million and include thermal desorption operating costs, disposal costs, soil stabilization costs, and long-term maintenance. Soil remediation is anticipated to take 57 months to complete.

The preferred groundwater alternative is estimated to cost $1.6 million. Capital costs of $500,000 include extraction well and pump costs, an equalization tank, oil water separator, signage, and monitoring well costs. Operational costs of $1.1 million include operations and maintenance costs, monitoring well sampling and analysis costs, and site inspections. Floating product removal is anticipated to require 1 year. Site monitoring and inspections will occur for 30 years.

Estimated costs for the soil and groundwater alternative are shown in Tables 12 and 13, respectively.

Table 12— Soil Remediation Alternative Costs

Description	Unit	Quantity	Unit Cost	Cost
Remedial Action Costs				
A. General				
1. Site Mobilization & Preparation				
Mobilization	LS	1	100,000.00	100,000
Temporary Construction & Security Fencing	LF	2,700	11.65	31,455
Site Survey/Layout	Week	4	2,675.00	10,700
Stockpile Area Preparation	Each	5	4,290.00	21,450
2. Site Health & Safety				
Decontamination Pad (30' x 60')	Pad	1	4,370.00	4,370
Decon Operations*	Day	974	100.00	81,962
Decontamination Rinsate Disposal	Gallon	243,500	0.77	157,776
Health & Safety Expendables (30 Personnel @ $66/day/person)*	Day	974	1,980.00	1,622,839
3. Field Sampling & Analyses*				
On-Site Laboratory	LS	1	200,000.00	200,000
Field Sampling & Analysis*	Day	778	1,920.00	1,256,991
Off-Site Analyses*	Sample	97	125.00	10,203
4. Impose Deed Restrictions	Property	50	1,000.00	50,000
5. Install Signage	Sign	30	85.00	2,550
B. Soil				
1. Install Asphalt Cap				
Shape & Compact Designated Areas*	SY	400,000	0.68	228,887
Place Base Course*	SY	400,000	3.63	1,221,850
Place Wearing Course*	SY	400,000	6.15	2,070,076
2. Removal of Existing Pavement				
Asphalt/Concrete Cutting & Removal*	SY	62,900	6.40	338,752
Decontamination Facility	LS	1	4,370.00	4,370
Material Decontamination*	SY	62,900	1.90	100,567
Concrete Debris Disposal (25%)*	SY	15,700	6.70	88,517
Asphalt Recycling and Repaving*	SY	62,900	10.19	539,357
3. Earthwork				
Soil Excavation*	CY	95,100	1.90	152,050
Excavation System (per 30' x 30' Cell)*	Cell	286	2,400.00	577,602
Hauling*	CY	95,100	2.91	232,876
Stockpiling*	CY	95,100	2.91	232,876
Backfill & Compact (Treated Soil)*	CY	91,000	1.49	119,239
Backfill & Compact (Imported Soil)*	CY	4,100	12	41,662
4. Thermal Desorption				
Mobilization/Demobilization	LS	1	500,000.00	500,000
Material Pretreatment Disposal*	CY	455	150.00	57,432
System Operation & Maintenance*	CY	91,000	100.00	7,657,600

Table 12 —Soil Remediation Alternative Costs *(Continued)*

Description		Unit	Quantity	Unit Cost	Cost
5.	Stabilization/Solidification				
	Mobilization/Demobilization	LS	1	100,000.00	100,000
	System Operation & Maintenance*	CY	1,200	100.00	100,979
6.	Off-Site Treatment				
	Hauling	CY	2,000	150.00	300,000
	Incineration	CY	2,000	2,550.00	5,100,000
7.	Off-Site Disposal (Hazardous Waste Landfill)				
	Hauling	CY	2,100	50.00	105,500
	Disposal	CY	2,100	150.00	315,000
SUBTOTAL					23,649,003
Engineering Expenses (15%)					3,547,485
Contingency Allowances (25%)					5,912,476
TOTAL REMEDIATION COSTS (SOIL)					33,109,864
POST REMEDIATION MONITORING COSTS					
1.	Site Inspections***	Year	30	6,000.00	56,561
2.	Cap Maintenance***	Year	30	413,000.00	3,893,318
SUBTOTAL					3,949,877
Administrative Costs (15%)					592,482
Contingency Allowances (25%)					987,469
TOTAL POST REMEDIATION COSTS (SOIL)					5,529,828
TOTAL PRESENT WORTH VALUE (SOIL)					38,639,692

* Computed using present worth value (P/A, 10%, 2.67 years).

** Computed using present worth value (P/A, 10%, 10 years).

*** Computed using present worth value (P/A, 10%, 30 years).

Table 13— Groundwater Remediation Cost

Item	Unit	Quantity	Unit Cost ($)	Cost ($)
Floating Product Removal System				
A. Equipment				
4-inch Extraction Wells	ea	6	6,000	36,000
Downhole Fluid Pumps	ea	6	4,000	24,000
Oil/Water Separator	ea	1	4,500	4,500
Equalization Tank	ea	1	3,750	3,750
Oil Storage Tank	ea	1	5,000	5,000
Air Stripper	ea	1	7,750	7,750
Fencing	ls	1	1,000	1,000
Installation	ls	1	15,000	15,000
Carbon Adsorption	ea	1	20,000	20,000
SUBTOTAL				117,000
Engineering (15%)				17,550
Contingency (40%)				53,820
B. Operations/Maintenance				
Operations/Maintenance	year	1	40,000	40,000
Metro Discharge	Kgal	31,536	2.56	80,732
TOTAL A AND B ABOVE				309,102
INSTITUTIONAL CONTROLS				
C. General				
1. Site Health & Safety				
Decon Operations	Day	60	100	6,000
Decontamination Rinsate Disposal	Gallon	300	0.77	231
Health & Safety Expendables (4 Personnel @ $66/day/person)	Day	60	264	15,840
2. Impose Deed Restrictions	Property	50	1,000	50,000
3. Install Signage	Sign	30	85	2,550
SUBTOTAL				74,621
Engineering (15%)				11,193
Contingency (25%)				18,655
TOTAL C ABOVE				104,469
D. Post Remediation Monitoring Costs				
1. Groundwater Monitoring				
Install Monitoring Wells	Well	23	2,000	46,000
Sampling*	Year	30	43,200	407,243
Laboratory Analyses*	Year	30	32,245	303,971
2. Site Inspections*	Year	30	6,000	56,561
SUBTOTAL				813,775
Administrative Costs (15%)				122,066
Contingency Allowances (25%)				203,444
TOTAL D ABOVE				1,137,285
TOTAL FOR ALTERNATIVE (ITEMS A, B, C, AND D)				1,552,856

* Computed using present worth value (P/A, 10%, 30 years)

STATUTORY DETERMINATIONS

The selected remedy will comply with CERCLA section 121 as follows:

Overall Protection of Human Health and the Environment

Long term protection of human health is obtained by removal and treatment of soil hot spots containing TPH and PCBs and by capping of all the remaining soil above cleanup goals. These actions give a reduction in contaminant toxicity, mobility, and volume. Following implementation of the remedy the overall risk to human health from contaminated soil will be less than 1×10^{-5}. Long term protection of the surface water quality will ultimately be achieved through the treatment of organic hot spots in the soil, capping of the remaining contaminated areas, removal of the floating petroleum product at Todd Shipyards, and natural attenuation.

Protection of human health during remediation will be obtained through compliance with OSHA requirements, the use of personnel protective equipment, and other safety measures and engineering controls. Protection of the environment will be obtained during remediation by covering stockpiles and using berms and ditches around excavations to control contaminated runoff. In addition, the environment will be protected from air pollution through compliance with the substantive requirement of the Puget Sound Air Pollution Control Authority.

Long term monitoring and maintenance will be required for the selected remedy. An asphalt cap has moderate permanence and requires periodic maintenance. Island-wide groundwater monitoring will be conducted semi-annually for 30 years after remediation. Periodic 5 year reviews of the island-wide groundwater quality trends will be conducted to determine if additional source control or groundwater treatment actions are required to achieve surface water cleanup goals at the shoreline. Removal and treatment of floating petroleum product and associated contaminated groundwater at Todd Shipyards will continue until surface water cleanup goals have been achieved. If groundwater treatment at Todd Shipyards is still ongoing at the time of the first five year review, the need for additional soil remediation will be evaluated in consultation with Ecology.

Compliance With ARARs

The selected alternative will meet all chemical-specific and action-specific applicable ARARs as described below. No location-specific ARARs have been identified for this alternative.

ARARs (Applicable)

Clean Air Act (42 U.S.C. §§ 7401 et seq.); Washington State Clean Air Act (RCW 70.94; WAC 173-400, -460)

Remedial actions which would result in major sources of emissions, such as soil treatment by thermal desorption, will be designed to meet federal and state ambient air quality standards.

Puget Sound Air Pollution Control Authority (Regulations I, III)

Remedial actions which could involve releases of contaminants to air will be performed in compliance with substantive requirements of a permit from PSAPCA.

Washington Water Pollution Control Act (RCW 90.48); Washington State Water Quality Standards for Surface Waters (WAC 173-201A)

The State surface water quality standards for protection of marine organisms will be achieved over time through the treatment of organic hot spots in soil, capping the remaining contaminated areas, removal of the floating petroleum product at Todd Shipyards, and natural biodegredation of remaining low level organics in the groundwater.

State Water Pollution Control Act (RCW 90.48; WAC 173-201A)/Water Resources Act (RCW 90.54)

The determination of the known, available and reasonable technologies (AKART) for achieving surface cleanup goals was performed during the feasibility study. State water quality standards will be achieved using the technology selected for treatment of floating petroleum product and associated contaminated groundwater.

State Water Code (RCW 90.03) and Water Rights (RCW 90.14)

These specifications for the extraction of groundwater will be met during remedial activities. Groundwater remediation (floating product removal and long-term monitoring) will be consistent with beneficial uses of the resources and will not be wasteful.

Model Toxics Control Act (RCW 70.105D; WAC 173-340)

MTCA soil cleanup standards for protection of human health in an industrial setting and for protection of groundwater from contaminants leaching from soil will be met through removal and treatment of organic hot spots, and capping the remaining contaminated areas.

Toxic Substance Control Act (15 U.S.C. §§ 2601-2671; 40 C.F.R. Part 761.60)

This regulation requires that PCBs at concentrations exceeding 50 mg/kg be destroyed by incineration or be disposed in a hazardous waste disposal facility.

Washington State Dangerous Waste Regulations (WAC 173-303)

This regulation may be applicable for soils contaminated with PCBs in the concentration range of 1-50 mg/kg and for inorganics which fail the TCLP test and are a RCRA characteristic waste.

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160)

Standards for construction, testing, and abandonment of water and resource protection wells will be met during the remediation and monitoring.

Solid Waste Disposal Act, also known as the Resource Conservation and Recovery Act, Subchapter III, (42 U.S.C. §§ 6921-6939; 40 C.F.R. Parts 261, 264, and 268)

There are no RCRA listed wastes at this site. The only RCRA characteristic waste is soil contaminated with high concentrations of lead which failed the TCLP leachate test conducted during the Remedial Investigation at six locations. In the selected remedy, this soil will be capped rather than excavated or treated because it poses a direct contact threat, but does not pose a groundwater threat. The three components of the cap are: 1) it prevents direct contact with residual contamination, 2) limited long-term maintenance of the cap and minimal groundwater monitoring is required, and 3) institutional controls restricting land use will be used as necessary.

The RCRA Land Disposal Restrictions (LDRs) may be applicable for soil which is excavated and disposed off-site or treated on-site with thermal desorption, if it fails TCLP for lead. Remedial Investigation data indicates that none of the soil to be excavated or treated has high enough lead concentration to fail the TCLP test. To verify that excavated soil is not a RCRA waste, it will be tested by the TCLP method prior to off-site disposal or after treatment by thermal desorption. If any such soil fails TCLP, it will be solidified such that it passes TCLP and is in compliance with levels specified by the LDRs.

RCRA requirements for managing RCRA waste piles, storage or treatment in tanks, and monitoring, may be applicable if any excavated soil fails TCLP tests.

ARARs (Relevant or Appropriate)

Clean Water Act (33 U.S.C. §§ 1251 et seq.; 40 C.F.R. Part 131)

The Federal surface water standards for protection of marine organisms and human health from ingestion of marine organisms will be achieved over time through removal of hot spots from both soil and groundwater, capping, and natural biodegredation of remaining low level organics in the groundwater.

Cost Effectiveness

The selected remedy is cost effective because costs are allocated to remove and treat areas of the site that have the highest site contaminant concentrations and which pose the greatest risk to the environment and human health. The contaminants in these areas also have the greatest potential for migration in the environment. Areas of Harbor Island containing lower levels of contaminants would be capped, which is protective but less costly than treatment technologies, and appropriate given the lower site threats. The selected remedy would treat approximately 55 percent of the total contaminant mass, but treat only 10 percent of the contaminated soil volume, providing a balance between cost and reduction in toxicity and volume.

Utilization of Permanent Solutions and Resource Recovery Technologies to the Maximum Extent Practical

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost effective manner for remediation of soil and groundwater on Harbor Island. The selected remedy provides the best balance in terms of long-term effectiveness and permanence, reduction of toxicity, mobility and volume achieved through treatment, short-term effectiveness, implementability and cost, while also considering the statutory preference for treatment as a principle element and considering state and community acceptance.

Treatment of the organic soil hot spots and removal of the floating product provides long-term effectiveness and permanence and provides a significant reduction of toxicity, mobility and volume while minimizing short-term risks. Containment of less contaminated areas of the site also reduces the mobility and provides long-term effectiveness, while minimizing implementation difficulties and costs associated with removal of large and inaccessible quantities of soil.

Alternatives which treat all contaminated soil and groundwater provide greater reduction in toxicity, mobility and volume and better long-term effectiveness, but cause significant short-term

risks to workers, are very difficult to implement due to ongoing facility operations, and have high costs. Alternatives which consist of little or no treatment are more easily and quickly implementable and have lower costs, but provide little reduction in toxicity or volume.

This alternative meets requirements of the two mandatory threshold criteria—protection of human health and the environment and compliance with ARARs. The selected remedy uses a combination of treatment, containment, and institutional controls to achieve optimum compliance with the five balancing criteria: long-term effectiveness, short-term effectiveness, implementability, reduction in toxicity, mobility and volume, and cost. Reduction in toxicity and volume and cost effectiveness were the two balancing criteria which had the most influence on selection of the recommended remedy.

Preference for Treatment as a Principal Element

The selected remedy treats a significant fraction of the site's soil contamination through the use of thermal desorption. Removal of product floating on the groundwater is accomplished using physical extraction and separation technologies. The selected remedy meets the statutory preference for using treatment as a principal element by using these technologies in significant roles in cleanup of the site.

DOCUMENTATION OF SIGNIFICANT CHANGES

The remedy selected in this Record of Decision is the preferred alternative identified in the Proposed Plan. The only significant differences between the preferred alternative and the selected remedy are:

1) The preferred alternative did not specify the excavation and off-site disposal of hot spot soil containing mixed carcinogens with a cumlative risk exceeding 10^{-4}. However, the treatment level for this soil was identified in the Proposed Plan. The excavation and disposal of this organic hot spot soil is identified as a key element of the selected remedy in this Record of Decision.

2) The soil cleanup goals for petroleum products has been revised to be consistent with Ecology's cleanup goals for the petroleum tank farms at Harbor Island. These goals are: TPH (gas) = 400 mg/kg, TPH (diesel) = 600 mg/kg, Benzene = 1 mg/kg, Toluene = 100 mg/kg, Ethybenzene = 200 mg/kg, and Xylene = 150 mg/kg.

3) The preferred alternative specified incineration of soil contaminated with PCBs at concentrations exceeding 50 mg/kg. TSCA

allows either incineration or disposal in a hazardous waste disposal facility. In the selected remedy, EPA will therefore allow this type of soil to either be incinerated or disposed in a hazardous waste facility.

APPENDIX A

RESPONSIVENESS SUMMARY

Appendix A

RESPONSIVENESS SUMMARY FOR THE HARBOR ISLAND RECORD OF DECISION

Overview

From 1903 to 1905, Harbor Island was created from marine sediments dredged from the Duwamish River. Harbor Island has been used for commercial and industrial activities including shipping, railroad transportation, bulk fuel storage and transfer, secondary lead smelting, lead fabrication, shipbuilding and metal plating. Warehouses, laboratories and office buildings have been located on the island. Approximately 70% of Harbor Island is covered with buildings, roads or other impervious surfaces.

The site was placed on the National Priorities List in 1983, due to elevated lead concentrations in soil, as well as elevated levels of other hazardous substances. The lead concentrations were due to a lead smelter on the island, which ceased operations in 1984.

In 1985, Department of Ecology performed an initial investigation to define the general nature and extent of contamination. In 1990, EPA completed Phase I of the investigation, which focused on several suspected sources of contamination on the island. In 1991 and 1992, EPA conducted Phase II of the investigation.

The marine sediments and Lockheed shipyard on Harbor Island have been designated as separate operable units. The marine sediments proposed plan and the Lockheed shipyard proposed plan will be issued in 1994.

On June 23, 1993, EPA began the public comment period on the cleanup alternatives for the soil and groundwater at the Harbor Island site. The proposed plan as well as the reports of the investigation, were released for public comment.

The proposed plan recommended Alternative 11B for soil and which includes removal and treatment of organic hot spots, capping of areas exceeding defined cleanup goals for organics and metals. The proposed plan also recommended Alternative 2 for groundwater which includes removal and treatment of floating petroleum product and contaminated groundwater at one location and groundwater monitoring island-wide.

Background on Community Involvement

As described above, the proposed plan for the cleanup of the soil and groundwater at the Harbor Island Superfund site was

released on June 23, 1993. The public comment period ran from June 23 until July 23, 1993. A request from a citizen extended the comment period until August 23.

As part of the comment period, a public meeting was held on July 14, 1993. About 50 people attended the meeting, no one gave public comment. Copies of the transcript are available at the Region 10 Records office in the Park Place Building, 1200 West 6th Avenue.

Comments received in writing are included in the following summary. Where similar comments were received from several commentors, the comments were lumped together and a single response was prepared.

Responsiveness Summary

Preferred Alternative:

Comment: The Harbor Island Employers Association endorsed the preferred alternative. The association is anxious for the remediation to begin as quickly as possible so that normal activities can proceed.

Response: Commented noted.

Comment: Several commentors agreed with the general elements of the preferred alternative.

Response: Comment Noted.

Comment: The Proposed Plan calls for incineration of soil containing PCBs over 50 ppm. TSCA specifically allows for PCB contaminated soil at concentrations of 50 ppm or greater to be disposed of in a chemical waste landfill. Therefore the option of landfilling the soil should remain in order to reduce cleanup costs.

Response: EPA agrees. The selected remedial action will now include the option of disposal at a hazardous waste disposal facility for soil with PCB concentrations exceeding 50 ppm.

Comment: Digging up the lead contaminated soil and hauling it away could be more damaging than leaving it in the ground.

Response: The preferred alternative does not require excavation of lead contaminated soil. It will be capped in place to prevent direct contact and migration to the surface water.

Comment: Soils which are treated by thermal desorption to remove TPH should only be capped if concentration of other chemicals of concern exceed their cleanup criteria. It is unclear which soils need to be solidified after treatment by thermal desorption. During the thermal desorption process, substantial mixing and disturbance of the soils will also occur. Thus, prior to capping the presence of chemical concentration exceeding the cleanup goals should be determined. EPA should consider consolidation of materials that require capping to increase cost-effectiveness.

Response: Soil which contains inorganic contaminants above the cleanup goals, after removal of TPH by thermal desorption, would have to be solidified if the concentrations of inorganics were high enough to constitute a "characteristic" RCRA waste. To determine if treated soil is a RCRA characteristic waste, soil would have to be tested according to the TCLP (leachate) method before it is replaced in the ground. If soil contains inorganics which leach above concentrations established by RCRA regulations, this soil would have to solidified before placing it in the ground. If the treated soil does not leach at concentrations high enough to make it a RCRA waste, the soil would be placed in the ground and then capped. EPA will consider consolidation of treated materials if the results of the remedial design indicate that there may by an increase in cost-effectiveness.

Cleanup Goals:

Comment: Several commentors stated that EPA has improperly applied the State of Washington's Model Toxic Control Act, Method "A", to select cleanup goals for contaminants (particularly petroleum) at Harbor Island. Many commentors said that Method "C" would be more appropriate for determining cleanup goals at this site.

Response: In the Proposed Plan, EPA applied Method "A" to lead and Total Petroleum Hydrocarbons (TPH), for which no Method "C" calculations exist. Method "A" was also applied to all contaminants in the subsurface soil because of anticipated infrequent exposure of short duration. Method "C" was applied to all contaminants other than lead and TPH in the surface soil. As a result of comments received from Ecology (see below), EPA has decided to revise the cleanup goals for petroleum, based on Ecology's Petroleum-Contaminated Soils Rating Matrix method, to be consistent with Ecology's cleanup goals for the petroleum tank farm operable unit. In regard to EPA's use of Method "A", Ecology has confirmed that Method "A" is appropriate for lead in surface soil and for all contaminants, other than petroleum, in the subsurface.

Comment: Ecology informed EPA that the originally selected cleanup goal of 200 mg/kg for TPH, based on Method A, is not appropriate for Harbor Island. Ecology has recently established cleanup goals for petroleum contaminants for the petroleum tank farm operable unit based on the Petroleum-Contaminated Soils Rating Matrix method (which satisfies MTCA Method B). Ecology has determined that this method is appropriate for the rest of the island. The cleanup goals using this alternate method are: TPH (gas) = 400 mg/kg, TPH (diesel) = 600 mg/kg, Benzene = 1 mg/kg, Toluene = 100 mg/kg, Ethybenzene = 200 mg/kg, and Xylene = 150 mg/kg.

Response: EPA will accept these new cleanup goals for the above petroleum compounds and will eliminate the previously identified goal of 200 mg/kg for TPH identified in the Proposed Plan. The island-wide petroleum cleanup goals will now be consistent with the goals established by Ecology.

Comment: The Department of Ecology expressed concern that the method used by EPA to select cleanup action levels for hot spot contaminants was not justified.

Response: The objective of the cost-benefit method used to select the hot spot cleanup action levels was to identify areas containing high concentrations of contaminants in relatively small volumes of soil, which could be excavated and treated with an optimal cost-benefit. (The cleanup action levels are now referred to as "treatment levels" in the Record of Decision.) The cost-benefit method was used for the contaminants lead, mercury, and TPH. Treatment levels were derived through an iterative analysis which compared the contaminant volume to the contaminant mass within that volume, over a range of concentrations. The treatment level for each contaminant was then selected at the point where the incremental mass of contaminant was found to be disproportionate to the incremental volume of contaminated soil. Subsequent to performing this analysis, a more comprehensive cost-benefit analysis was performed to verify these treatment levels. A description of how this method was used to select treatment levels is provided in Appendix B.

The treatment levels for the PCBs and mixed carcinogens hot spots were set according to regulatory limits. The treatment level for PCBs of 50 mg/kg was set equal to the concentration regulated under the Toxic Substance Control Act (TSCA), and the treatment level for mixed carcinogens was set at the upper end of the acceptable risk level ($1x10^{-4}$) specified for Superfund sites according to the National Contigency Plan (NCP).

Comment: The cleanup goals for PCBs of 0.18 to 2.99 mg/kg is unreasonably stringent. This range is significantly below the 10 mg/kg standard for industrial areas under the state of Washington's MTCA Method A.

Response: When there is a mixture of contaminants, as occurs at many locations on Harbor Island, MTCA Method A is not appropriate. In such cases the appropriate method is Method C, which requires that cumulative risk from all carcinogens at each location not exceed 10^{-5}. At many locations, the PCBs are collocated with other carcinogens, such as arsenic or PAHs. To maintain an acceptable cumulative risk level, the PCB cleanup level must be a fraction of what it would be if it were the only contaminant present.

Petroleum:

Comment: Materials identified at Harbor Island as petroleum fuel products and residues are not hazardous substances as defined in CERCLA and therefore are not subject to EPA's jurisdiction under CERCLA.

Response: There has been some confusion about the CERCLA petroleum exclusion provision. Under CERCLA, pure petroleum products are not hazardous substances. However, when mixed with other hazardous substances, it is appropriate for EPA to take jurisdiction for cleaning up such mixtures. At Harbor Island, EPA specifically carved out a separate petroleum tank farm operable unit to be managed by Ecology because contamination in this unit is derived principally from petroleum. All areas of the island outside of the tank farm unit are not areas of purely petroleum contamination and are therefore subject to EPA's jurisdiction.

Comment: One commentor stated that EPA inappropriately excluded other viable remedial alternatives from consideration for petroleum contaminated soil. Two other alternatives specifically identified were in-situ bioremediation and use of petroleum contaminated soil for asphalt production.

Response: In the Feasibility Study, EPA evaluated a wide range of treatment technologies used to remediate hazardous waste sites and screened out many of these technologies based on the criteria of effectiveness, implementability and cost. Of the eleven alternatives which received full evaluation, EPA believes that thermal desorption best meets the nine evaluation criteria. In particular, it is a proven technology, it can meet the cleanup action goals, it is the most cost-effective treatment technology identified, and is easily implemented. In addition, the TPH

removed from the soil can be recycled and used in other applications, such as making asphalt. In-situ bioremediation was evaluated in alternative 5 and was not selected because: 1) it is not certain that cleanup action goals could be met without conducting an extensive treatability study, 2) it was not as cost effective as the selected technology, and 3) groundwater extraction, as required by this method, is not feasible at the shoreline because it would draw in and pump out saltwater from the surrounding surface water.

Comment: Where oil is in quantity and situated where it can be extracted from the soil it should be pumped and recovered.

Response: The selected remedial action is consistent with the concept of recovery because it requires that high concentrations of petroleum in the soil (hot spots) be recovered by thermal desorption and that floating petroleum product be pumped and recovered. Once recovered, this petroleum may have the potential to be used in such applications as asphalt production.

Cost:

Comment: There should be better substantiation of the estimated costs for the alternatives which are being compared.

Response: The level of cost detail and the assumptions used in developing the cost estimates for each alternative is adequate for a Feasibility Study. EPA included conservative contingencies into the cost calculations to cover additional unforeseen expenses. However, the costs at this point are only an engineering estimate and will be further refined during the remedial design.

Comment: It is unclear whether the cost estimate for the preferred alternative includes the cost to incinerate the 2,000 cubic yards of PCB-contaminated soil in an off-site commercial incineration facility.

Response: The cost estimate for the preferred alternative does include the cost of off-site incineration for PCB-contaminated soil.

Remedial Investigation/Feasibility Study:

Comment: The description of the selected alternative presented in the feasibility study addendum indicates that soil containing PCBs and PAHs at levels below the hot spot criteria will be excavated and disposed off-site in a hazardous waste landfill.

No such requirement is indicated in the description of the preferred alternative in the Proposed Plan.

Response: The Proposed Plan identified organic hot spots with a total carcinogen risk exceeding 10^{-4}. These organic hot spots constitute soil containing mixtures of PCBs (at concentrations below 50 ppm), PAHs, and arsenic. The total volume of soil associated with these organic hot spots is approximately 1,200 cubic yards. The description of the selected alternative in the feasibility study addendum identifies off-site disposal in a hazardous waste landfill for this soil. Because of an oversight, the preferred alternative in the Proposed Plan did not discuss disposal of this hot spot soil. The Record of Decision will identify this soil for off-site disposal.

Comment: Several commentors identified numerous technical errors, discrepancies and inaccuracies in the Remedial Investigation and Feasibility Study (RI/FS) Reports.

Response: None of the technical errors, discrepancies or inaccuracies identified were regarded as significant by EPA and did not change EPA's selection of the preferred alternative. However, EPA has responded to these comments collectively in the form of a Technical Errata Memorandum which will be attached to the RI/FS report.

Comment: The Port of Seattle (Port) believes that the groundwater monitoring plan should be revised to reduce the number and modify the locations of proposed compliance monitoring wells on Port of Seattle Terminal 18 property.

Response: The groundwater monitoring plan identified in the Feasibility Study is intended to be a preliminary design. Final location and number of monitoring wells will be determined during the Remedial Design and can be negotiated between EPA and the potentially responsible parties (PRPs) at that time, assuming that the PRPs are implementing the remedial action for the site.

Comment: Lockheed commented that the hot spot maps should be revised to incorporate the Phase II RI data collected at the Lockheed Shipyard 1. This new data has reduced the area defined as TPH hot spots on the Lockheed property by approximately 97%, relative to the TPH hot spot area estimated by EPA in the Feasibility Study.

Response: EPA intends to reevaluate the Phase II RI data and its impact on the size of the TPH hot spots on the Lockheed Shipyard facility before it issues a Proposed Plan for that facility next

year. Since these hot spots are substantially on the Lockheed facility, they were not addressed in the Harbor Island Proposed Plan and are not addressed in this Record of Decision.

Groundwater:

Comment: For the groundwater model, why were maximum concentrations of contaminants used. Also, using the current rate of rainfall infiltration is not reasonable since capping is recommended as part of the soil remedial action. The selection of groundwater treatment is based on data from only two rounds of groundwater sampling.

Response: Maximum contaminant concentrations and current rates of rainfall infiltration for the groundwater model were used because these conditions are considered conservative. Since there are uncertainties in the groundwater data collected during the Remedial Investigation, and uncertainties in the groundwater modeling used, EPA believes it is prudent to be conservative so that the environment is protected against the most sever groundwater contamination which could reach the shoreline. The only groundwater treatment in the selected remedy involves pumping and treating the floating petroleum product at Todd Shipyards. At this location approximately 6 inches of floating product was observed during installation of the monitoring well. Benzene concentrations at this location for both rounds of sampling exceeded the surface water cleanup goal by approximately an order of magnitude. This data indicates that this area of groundwater contamination presents a critical risk to the environment and should be addressed immediately. After remedial action is initiated, groundwater will be monitored island-wide semi-annually for up to 30 years. This groundwater data will be reviewed every five years to determine if progress towards cleanup goals is being achieved. If adequate progress is not being achieved at that time, additional groundwater treatment could be required.

Comment: In the Feasibility Study, groundwater cleanup goals (MCLs) based on drinking water standards were identified as alternate cleanup goals for several contaminants. MCLs are not appropriate for Harbor Island because the groundwater is not potable.

Response: EPA agrees. The MCLs were initially identified as alternate cleanup goals in the Feasibility Study before EPA and Ecology decided that the drinking water standards do not apply to the Harbor Island groundwater. In the Proposed Plan, only the surface water standards were cited as cleanup goals at the shoreline.

Comment: Lockheed commented that "the industrial nature of the area and the general consensus that groundwater will not be used as a potable water supply, a much higher cleanup level for TPH, such as 1,000 mg/kg for TPH as heavier petroleum fuel, would be appropriate and more than adequately health protective for the site."

Response: EPA has adopted Ecology's cleanup goals for petroleum products based on the Petroleum Contaminated Soils Rating Matrix method (see response above). The new cleanup goal for heavy petroleum fuel (diesel), is now 600 mg/kg.

Comment: The Port commented that it is unable to determine whether groundwater compliance will be based on monitoring data which includes only metals that exceed cleanup goals in each respective well or on all metals of concern at each well. The Port believes it would be more appropriate to monitor all compliance monitoring wells for all metals of potential concern, rather than selective metals, of potential concern in order to address trends in groundwater quality.

Response: EPA agrees. It is EPA's intent to monitor for all metals at all compliance monitoring wells. This will be necessary to determine trends in groundwater quality.

Comment: EPA has recommended a remedial action for soil based on limited soil data and overestimation of volumes due to use of Thiessen polygons.

Response: The RI/FS established preliminary estimates of contaminated soil volumes. Additional soil sampling will be required during the Remedial Design phase to more accurately identify volumes of soil which must be excavated and treated or disposed off-site.

Risk Assessment:

Comment: The risk assessment does not address background. The low end of the cleanup goal range for arsenic is potentially below background levels in surface soils for this area and it is unrealistic to clean up below background levels. EPA used an overconservative scenario (daycare facility) to estimate potential risk. Risk was also evaluated on a location-by-location basis which leads to an overestimation of risk.

Response: The low end of the cleanup goal range for arsenic occurs in locations where arsenic is collocated with other carcinogens and the combined risks of all carcinogens present

exceeds the cleanup goal of 10^{-5}. To maintain an acceptable cumulative risk level, the arsenic cleanup level must be a fraction of what it would be if it were the only contaminant present.. There are no daycare centers currently on Harbor Island, but the island is zoned for commercial uses, which includes daycare centers. The daycare center scenario was conducted as a hypothetical scenario, but was not used in establishing cleanup goals because EPA selected cleanup goals for an industrial scenario as appropriate for Harbor Island. EPA does not agree that a location-by-location risk assessment overestimates risk.

Potential Responsibility:

Comment: Several commentors raised the issue that they should not be considered Potentially Responsible Parties (PRPs), even though they were either owners of property or operators of facilities on the site.

Response: CERCLA 107(a)(1) which makes owners and operators of a Superfund site responsible parties is a strict liability statute. Fault is not a relevant consideration in assessing liability under any strict liability statute. Contribution or relative responsibility among PRPs is relevant with respect to allocation or cost sharing among PRPs at Harbor Island. EPA has not allocated relative cost share among PRPs. Allocation of liability among PRPs will be addressed in future Consent Decree negotiations with the PRPs for implementation of the remedial actions selected in this ROD.

Other:

Comment: Although the lead smelter may have been a source of lead on the island, data indicate that there are other sources of elevated lead concentrations in the soil.

Response: EPA recognizes that another potential source of lead found in the soil is combustion of leaded gasoline from cars and trucks on the island. However, the distribution of elevated lead in the soil (see Map 4-43 of the Remedial Investigation Report) strongly indicates the smelter as the primary source of lead contamination.

Comment: In addition to deed restrictions on affected property, EPA should also consider working with the City of Seattle to restrict zoning to insure the area remains industrial or to place deed restrictions on all parcels on Harbor Island to avoid incompatible uses adjacent to affected areas.

Response: EPA will consider these options. However, zoning restrictions are subject to political change and processess and cannot be viewed as comparably reliable or permanent as deed restrictions.

Comment: EPA should continue to work upstream on the Duwamish and evaluate contribution to marine sediment from the stream as well as from Harbor Island.

Response: As part of the marine sediment remedial investigation, EPA sampled sediments as far upstream in the Duwamish as Kellogg Island in an attempt to distinguish upstream sources from Harbor Island sources. The draft Sediment Remedial Investigation Report which discusses the results of this sampling is available for public review at EPA's Record Center, 7th Floor, 1200 Sixth Ave, Seattle. EPA intends to issue the Feasibility Study and Proposed Plan for the sediment operable unit next summer.

Comment: There are several Puget Sound Air Pollution Control Agency (PSAPCA) regulations that PSAPCA considers Applicable or Relevant and Appropriate Requirement (ARARs) for several of the options discussed in the soil cleanup plan including the preferred alternative.

Response: EPA will require that all substantive requirements of these PSAPCA regulations are met during implementation of the selected remedial action.

Comment: There is a misconception that (referring to page 17 of the Proposed Plan) "thermal desorption is not highly effective for removing PCBs from soil". Thermal desorbers are no less efficient than incinerators when operated under the same time and temperature conditions.

Response: EPA acknowledges that thermal desorbers can effectively remove PCBs from soil given the proper operating conditions. However, given that PCB concentrations were found as high as 420 ppm and that EPA's cleanup goal for PCBs is about 3 ppm, this will require a removal efficiency of greater than 99%. While this efficiency may be attainable, EPA believes the uncertainty of obtaining it poses a risk. As an alternative to incineration, EPA is now providing the option of disposal at a hazardous waste disposal facility for PCB contaminated soil, which should be more cost effective than incineration.

Comment: While the polygon map approach can provide a reasonable basis to screen remedial alternatives for the entire Harbor Island site, it should not provide the sole basis for determining

areas that require remediation. Field testing methods will be useful for distinguishing between soil containing PCBs and soil containing TPH alone.

Response: Additional soil sampling will be required during the Remedial Design phase to more accurately determine the areas and volumes which will require excavation and treatment. Certain field testing methods, with the appropriate detection limits and level of accuracy, could be used at that time as a screening technique to distinguish between PCB and TPH contaminated soil.

Comment: EPA's use of cumulative risk levels as a criterion for determining cleanup action levels for hot spots is not amenable to use of field screening methods to define areas requiring remediation during the Remedial Design phase.

Response: Field screening methods may not be as effective for defining these hot spot areas since they contain mixtures of carcinogens (PCBs, arsenic, PAHs). Since these areas contain mixtures, the corresponding detection limits required for individual carcinogens will be lower than if they occurred alone. If appropriate detection limits cannot be achieved with field screening methods, standard laboratory analytical methods, similar to those used by EPA during the Remedial Investigation, will be required.

Comment: On the Seattle Iron & Metals Corporation (SIMC) property, a PCB concentration exceeding the hot spot criterion was detected at one location, which was not tested for TPH. Because it is uncertain if TPH is present at this location, it cannot be determined if PCBs at that location are mobile. Because the cost of proposed treatment (offsite incineration) for PCBs is so high, additional field testing to assess TPH concnetrations at this location would be worthwhile. If TPH is not present at significant concnetrations, capping of the PCB contaminated soil would provide a more cost-effective approach to protecting human health and the environment.

Response: Enhanced mobility of PCBs in the presence of TPH was only one of the criteria used by EPA in selecting the cleanup action level for PCBs. The other criteria is that according to TSCA regulations, incineration or disposal at a hazardous waste disposal facility is required for all PCB contaminated soil with concentrations exceeding 50 mg/kg. EPA will allow disposal at a hazardous waste disposal facility as an alternative to incineration for levels of PCBs exceeding 50 mg/kg.

Comment: Based on information regarding SIMC's operations, it appears unlikely that gasoline or other lighter-weight, more

mobile petroleum hydrocarbons were a significant source of TPH detected at the SIMC property. Instead, heavier-weight, less mobile petroleum hydrocarbons are more likely to have been handled. Thus, EPA should consider capping the TPH hot spot on the SIMC property.

Response: EPA has made no distinction between the mobility of lighter-weight or heavier-weight petroleum hydrocarbons. EPA considers both types of hydrocarbons to be relatively mobile compared to other organic and inorganic contaminants found at Harbor Island. EPA will still require treatment of the TPH hot spot on the SIMC property.

Comment: The use of low-temperature thermal desorption is not appropriate in every instance because of its limitation in treatment of heavier petroleum hydrocarbons.

Response: EPA has determined that the concentrations of high molecular weight PAHs (HPAHs) in the TPH hot spots are not significantly elevated and can be effectively treated by thermal desorption and reduced to levels below the cleanup goals. Through its Research and Development Program, EPA has demonstrated that thermal desorption technology operated at higher temperatures and longer soil retention times can remove HPAHs from soil with a high efficiency.

APPENDIX B

METHOD FOR DETERMINING HOT SPOT TREATMENT LEVELS

Appendix B

Method for Selecting Hot Spot Treatment Levels

I. Method Used in the Feasibility Study

The objective of selecting hot spot treatment levels in the Feasibility Study was to identify areas containing high concentrations of contaminants in relatively small volumes which could be excavated and treated, providing an optimal cost-benefit. The benefit, in this context, is the total mass of contaminant treated. The first step in the process was to identify the contaminants presenting the greatest risk to human health and the environment. This was accomplished by comparing contaminant concentrations to the cleanup goals to determine which had the highest exceedances. This process identified lead, mercury, arsenic, TPH, and PCBs. Arsenic was eliminated at this point because the distribution of its concentration showed that it was widely distributed across the island at levels not significantly above background, and was not highly concentrated in any particular areas. PCBs were also elimianted from further evaluation because EPA decided to set its treatment level at an existing regulatory limit, which is 50 mg/kg as defined by the federal Toxic Substance Control Act (TSCA).

For TPH, lead, and mercury, the concentrations and soil volumes associated with these concentrations were reviewed to identify the approximate point at which the mass of contaminant started rapidly decreasing as a function of increased soil volumes. The treatment levels were selected at the contaminant concentrations where the incremental amount of contaminant was disproportionate to the incremental soil volume. The cost to treat these contaminants was also analyzed semi-quantitatively to verify that the cleanup level selected was also at the point where the cost per mass of contaminant treated started rapidly increasing.

For example, treating all lead contaminated soil would result in treating 5.9×10^6 cubic yards of soil to remove 4.4×10^6 pounds of lead for an average of 0.75 pounds/cubic yard treated. Treating soil exceeding 2,000 mg/kg lead would result in an average lead treatment rate of 40 pounds/cubic yard. Treating soil exceeding 5,000 mg/kg, 10,000 mg/kg and 20,000 mg/kg would result in average rates of 57, 60, and 100 pounds/cubic yard, respectively. A noticeable increase in the amount of lead treated percubic yard of soil occurs at a lead concentration of greater than 10,000 mg/kg. Therefore, 10,000 mg/kg was selected as the treatment level for lead. This treatment level contains approximately 85% of the total mass of lead within 40% of the total volume of lead contaminated

soil above the cleanup goal. The treatment level selected for TPH, 10,000 mg/kg, contains 66% of the total TPH mass within 14% of the TPH contaminated soil volume. The treatment level selected for mercury, 5 mg/kg, contains 27% of the mass of mercury within 8% of the contaminated soil volume. These results show that the objective of containing a majority of the contaminant mass in a minimum volume is achieved at the treatment levels for lead and TPH. The treatment level for mercury did not capture a majority of the mass of mercury, because mercury is more evenly distributed as a function of concentration than TPH or lead.

The corresponding cost analysis for lead, for example, also shows that as the pounds of contaminant per cubic yard decreases, the cost to treat each pound rapidly increases. Assuming it costs $100 to treat one cubic yard of soil, the average cost to treat a pound of lead at soil concentration exceeding 2,000 mg/kg, 5,000 mg/kg, 10,000 mg/kg, and 20,000 mg/kg is $2.50/lb, $1.75/lb, $1.66/lb, and $1.00/lb, respectively. The cost drops significantly at a lead concentration exceeding 10,000 mg/kg, indicating it is the cost effective breakpoint, and therefore, should be the treatment level. The cost effective breakpoint for TPH occurred at a concentration of about 10,000 mg/kg, and the breakpoint for mercury occurred at about 5 mg/kg.

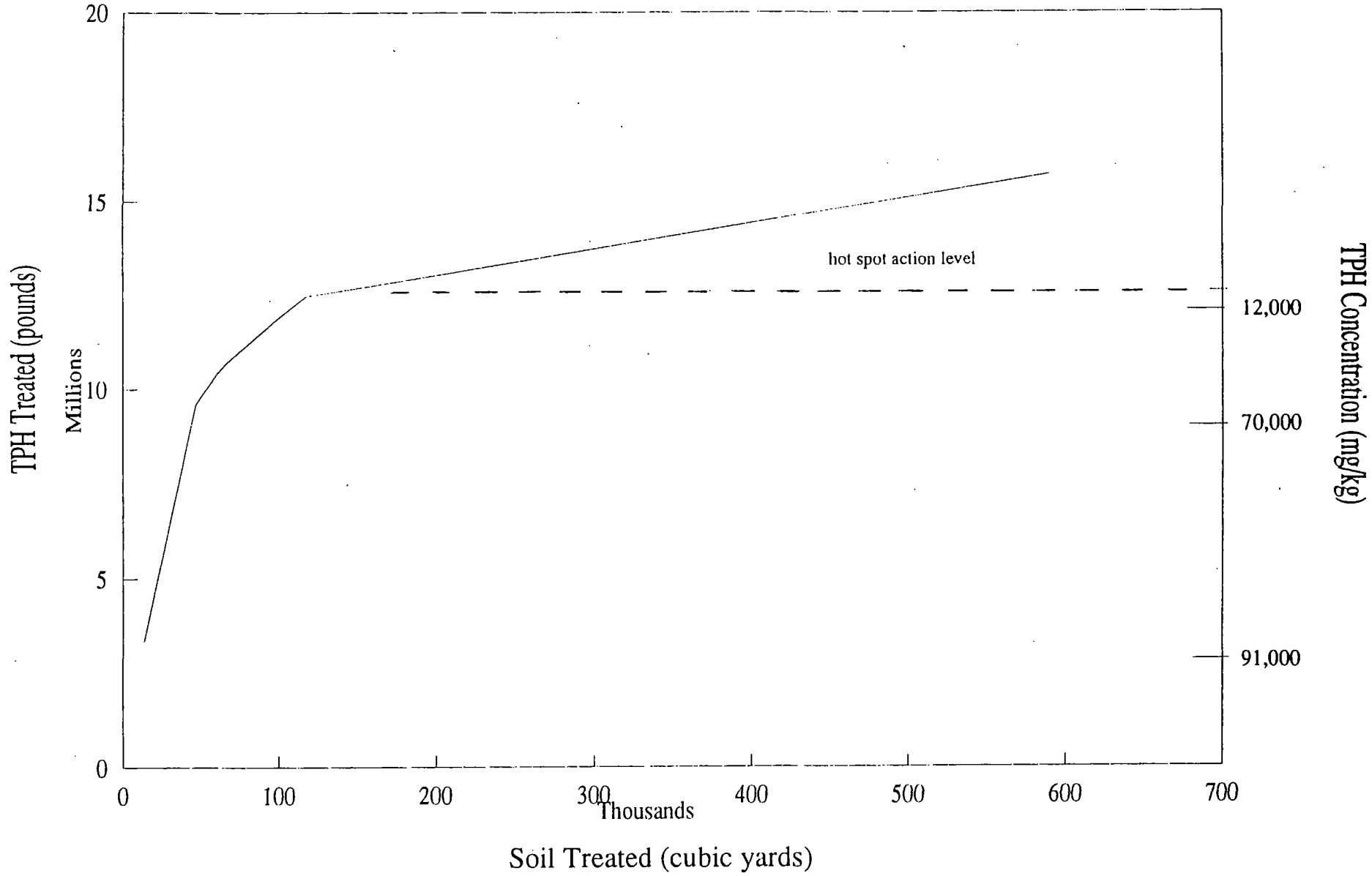
II. Cost-Benefit Analysis of Treatment Levels

After selecting treatment levels in the Feasibility Study, a cost-benefit analysis was completed for lead, mercury and TPH to confirm these treatment levels. The analysis involved generating two types of functions (curves). The first type of curve, soil volume versus contaminant mass, was generated by ranking areas with the particular contaminant in order of highest to lowest concentration. The curve is based on the cumulative total contaminant mass and soil volume for each contaminant concentration. One assumption used in generating this curve was that the average contaminant concentration is an area is represented by the single sample taken from that location.

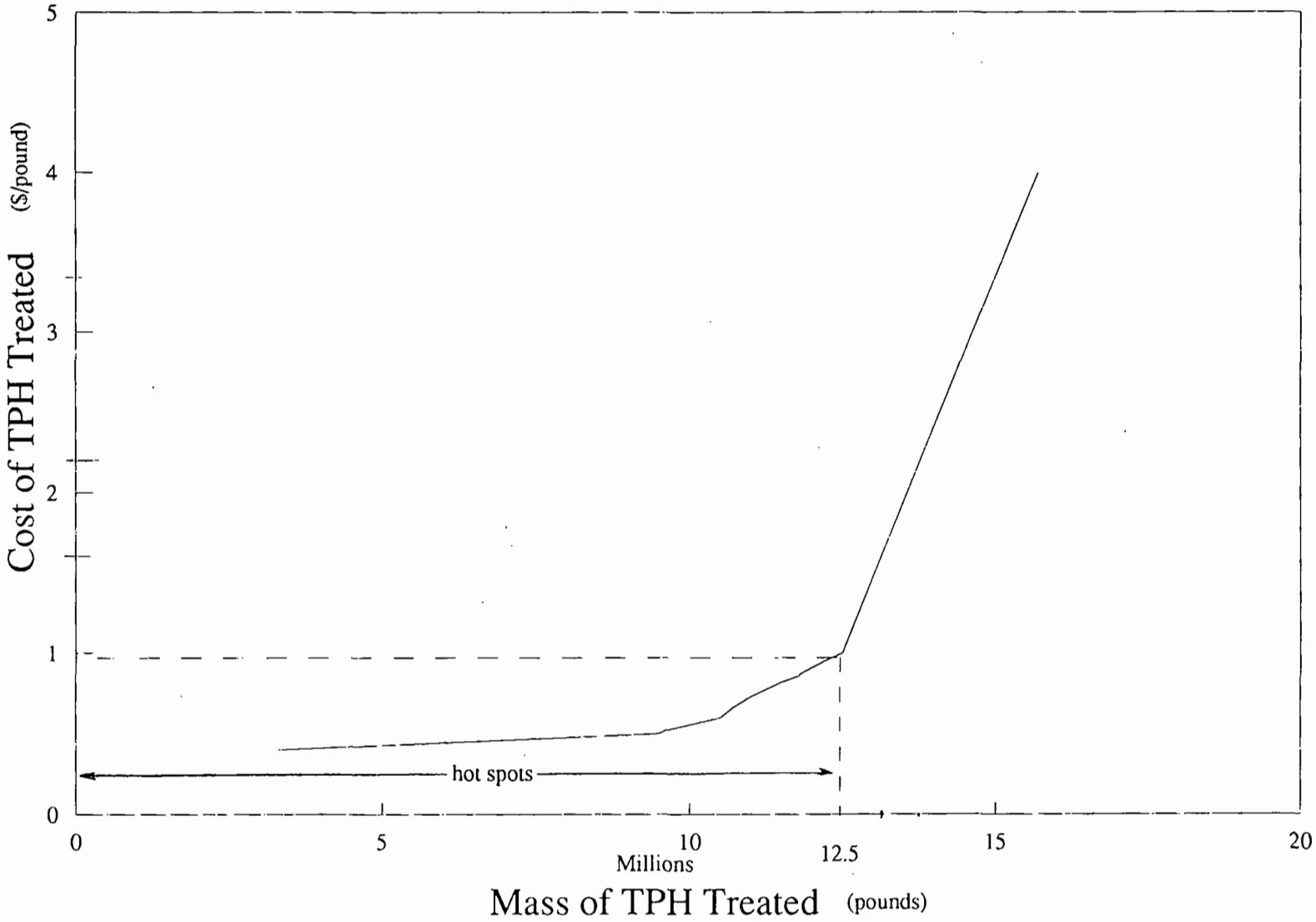
The second type of curve, mass of contaminant treated versus cost per pound of contaminant, was generated by calculating the excavation cost and treatment cost per cubic yard of soil, and dividing by the mass of contaminant treated. This process was also performed using cumulative totals as discussed above. It is important to note that this figure is semi-quantitative in nature since it used only excavation and treatment cost elements and did not include other costs required to implement the treatment alternative. Simplifying assumptions used to generate these curves include: 1) soil excavation costs are $2.00 per cubic yard, 2) excavation and handling costs are $6.00 per cubic yard, 3) lead and mercury are treated by solidification at a cost of $100 per cubic yard, 4) TPH is treated by thermal desorption at a cost of $100 per cubic yard, and 5) the contaminated soil associated with the Lockheed Shipyard operable unit was included in the calculation but

the contaminated soil associated with the petroleum tank farm operable unit was not included.

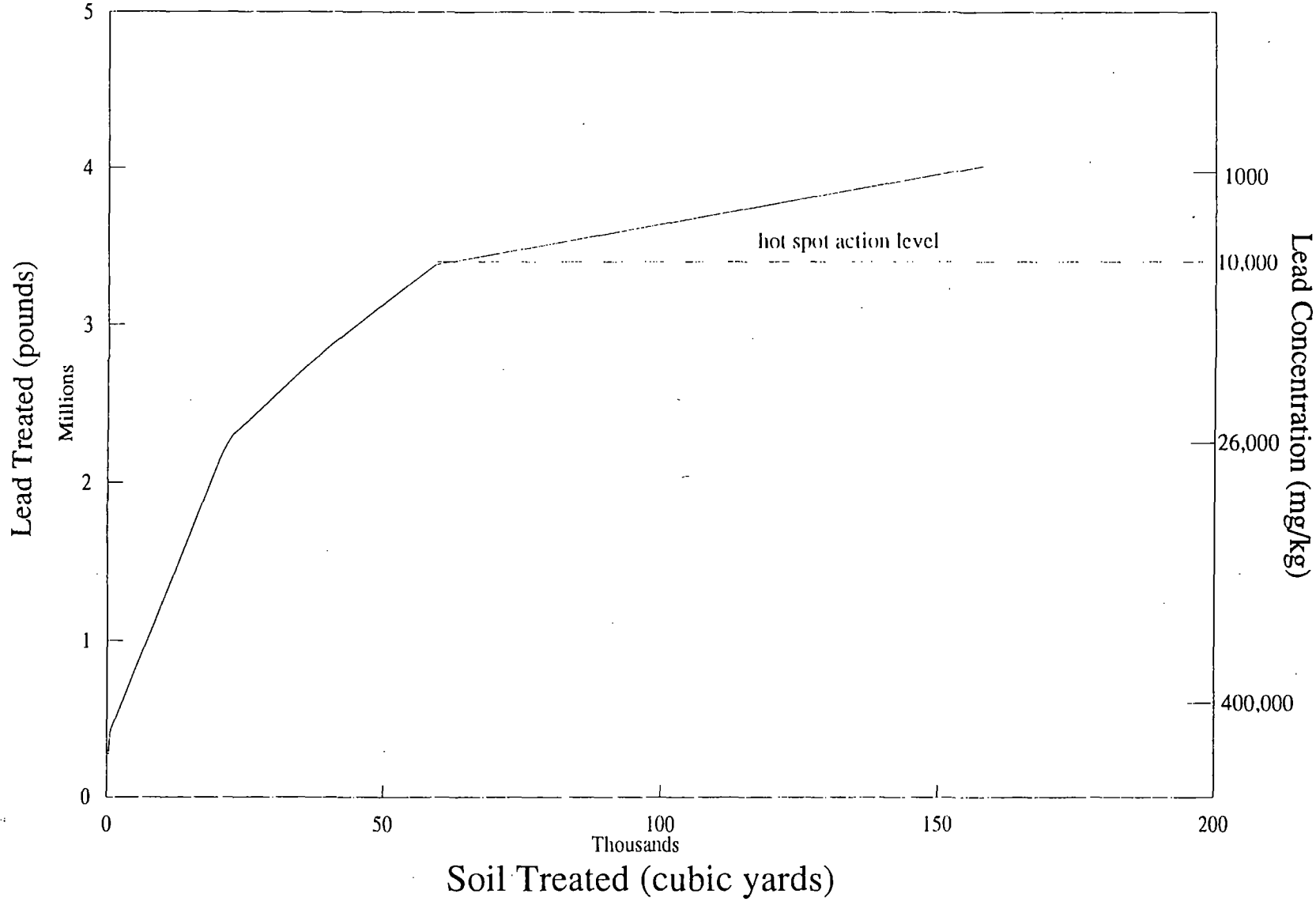
The volume versus mass curve was used to determine the point at which removing and treating additional soil volume does not provide a proportionate degree of benefit in term of mass treated. The mass versus cost per pound curve was used to determine the cost-benefit of treating an additional incremental volume of soil. As shown in each of the figures, the treatment levels generally mark the location at which signigicantly decreasing quantities of contaminant mass are treated with each incremental increase in soil volume removed. The treatment levels also generally locate the point at which the cost per pound of contaminant treated increases disproportionally with the soil mass removed.



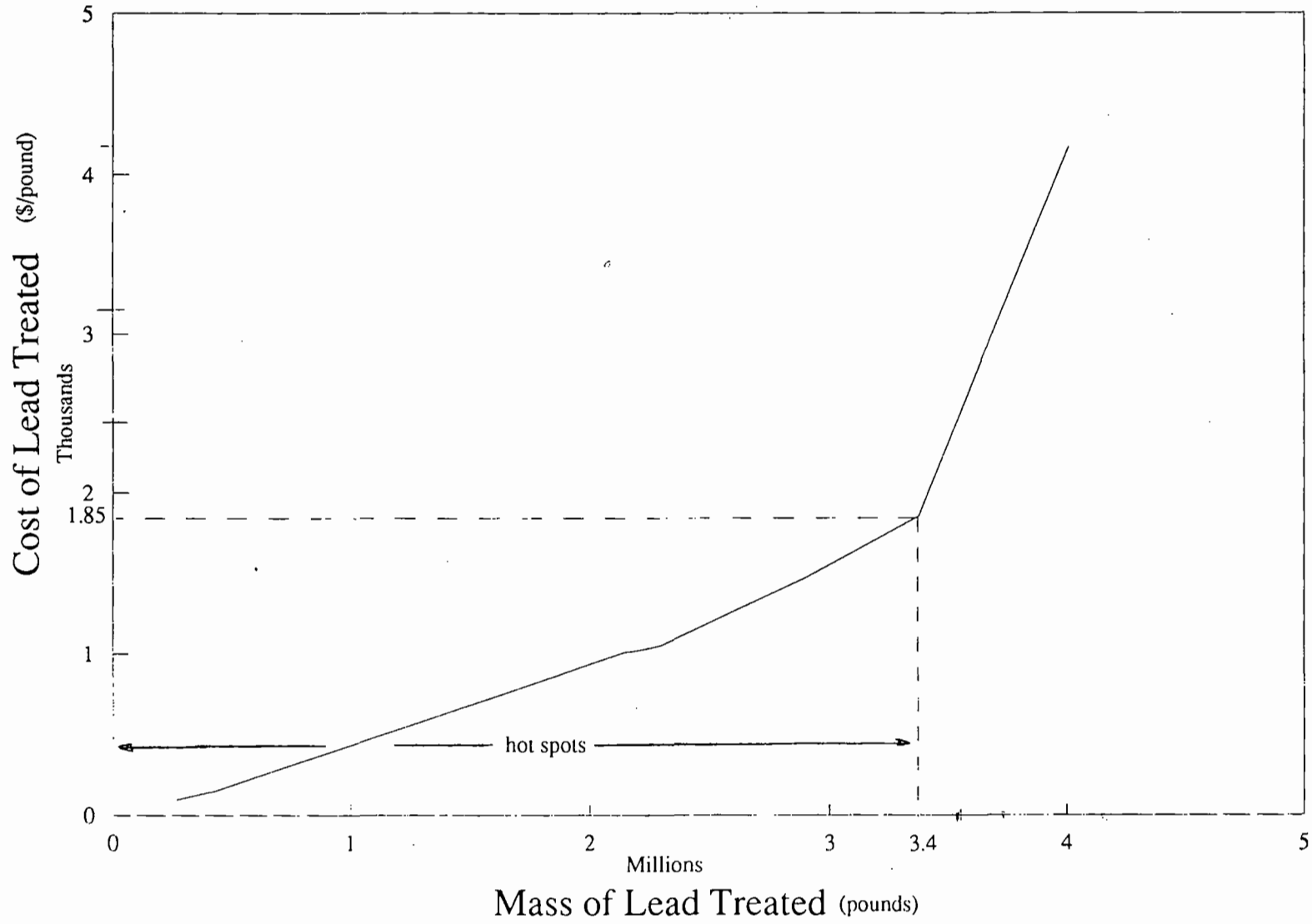
RFW564A - Graph 2A



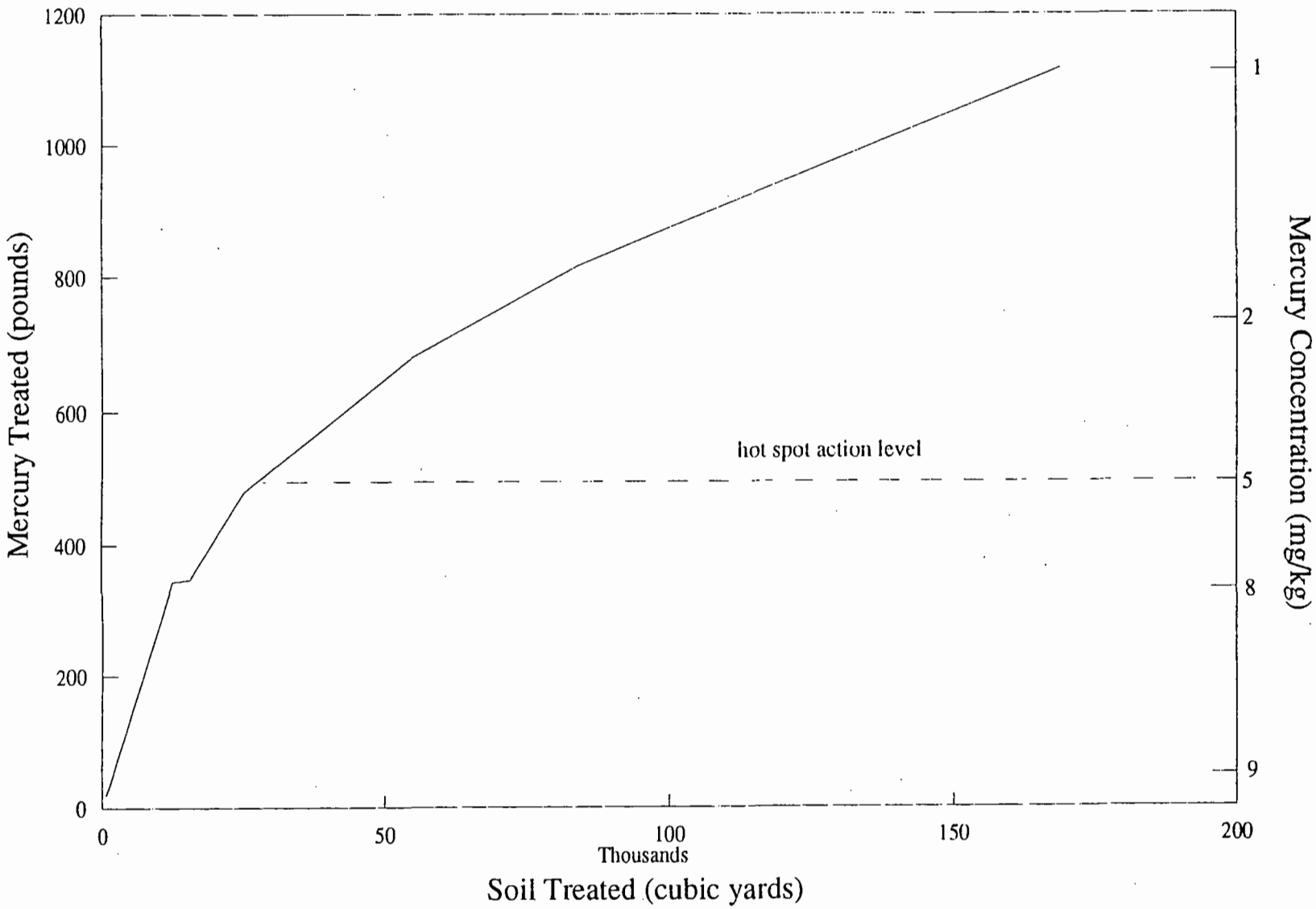
RFW564.WK3 - GRAPH 5



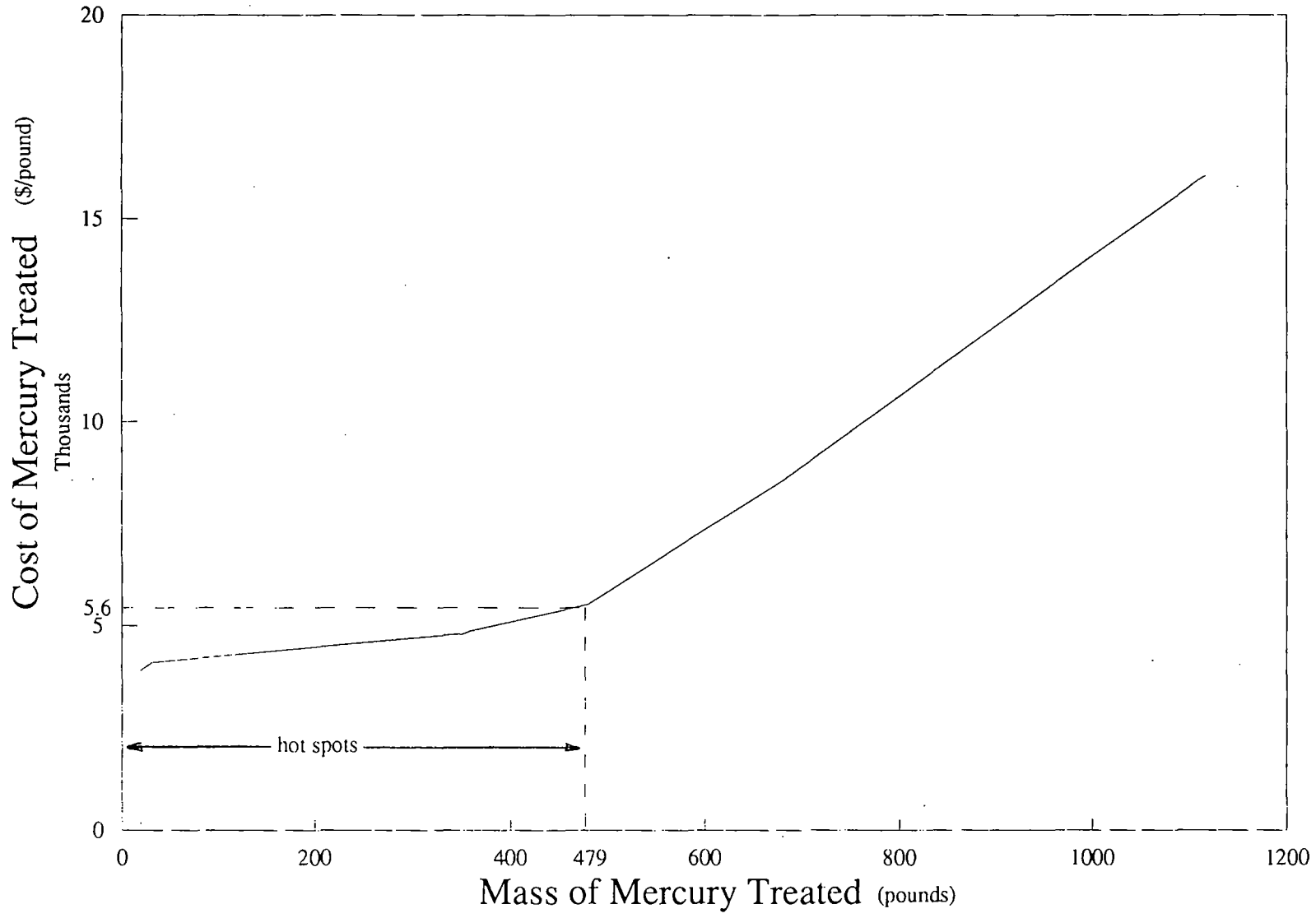
RFW564A.WK3 - GRAPH 3


Cost of Lead Treated ($/pound)
Thousands
5
4
3
2
1.85
1
0
hot spots
0
1
2
3
3.4
4
5
Millions
Mass of Lead Treated (pounds)

GRAPH 5



RFW564A.WK3 - GRAPH 4



RFWS64A.WK3 - GRAPH 7

APPENDIX C

ADMINISTRATIVE RECORD INDEX