Cost and Performance Summary Report
Impermeable Isolation Cap at the Thea Foss Waterway Superfund Site, Tacoma, Washington
December 2008

Summary Information [1, 2, 3]

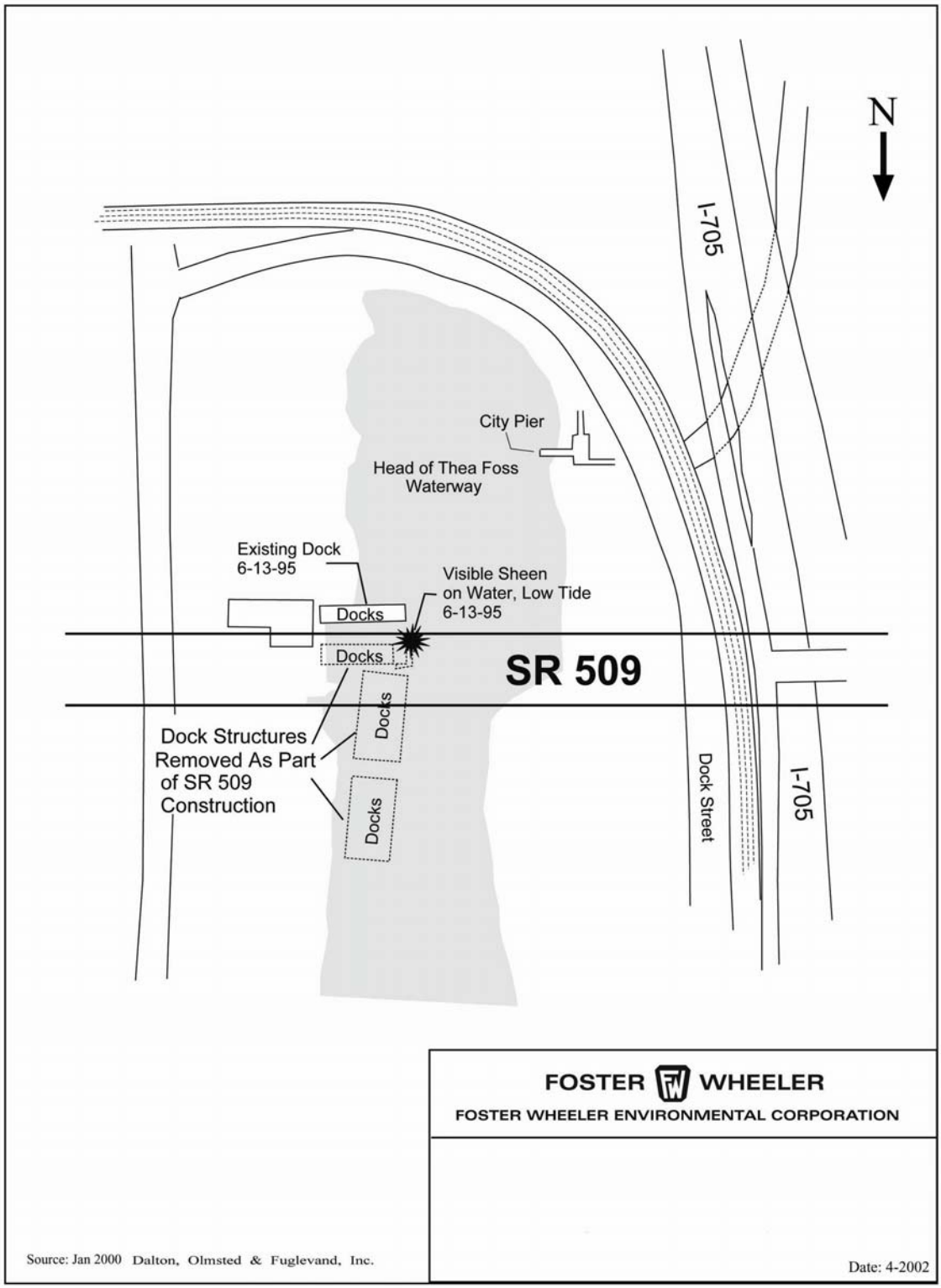
The Thea Foss Waterway (formerly known as the City Waterway) extends approximately one-and-a-half miles through the downtown area of the City of Tacoma, Washington. It is one of seven inlets located off of Commencement Bay at the southern end of the main basin of Puget Sound. The Waterway was created in 1905 by the U.S. Army Corps of Engineers. Figure 1 shows a map of the Thea Foss Waterway and its vicinity.

A localized, intermittent, non aqueous phase liquid (NAPL) seep was discovered underneath the State Route (SR) 509 Bridge located at the Head of the Waterway shortly after its construction in the mid-1990s. NAPL droplets were observed on the water surface in this seep area during periods of low tide. Site investigations lead to the discovery of a buried coal tar-derived deposit or NAPL deposit. Based on past studies and reviews of historical information, it was determined that the most likely source of this NAPL contamination in the Waterway sediments was due to operations and practices associated with the Standard Chemical Company from 1915 to 1922. It is believed that the NAPL began to seep from the deposit during the construction of the SR 509 Bridge in the mid-1990s. Prior to the construction of the bridge, four docks for small boats were present along the eastern side of the Waterway. During construction, three of these docks were removed, and it is believed that the removal of the timber piles of these docks created a pathway through the sediment for NAPL deposits that were present at this location to escape to the surface and contribute to the seep. As part of the construction of the bridge, false work pilings were installed across the Waterway in the same areas that the wood pilings were removed. The false work piles were installed using a spud barge, and it is thought that penetration of the spuds into the soft sediment may have also contributed to the observed NAPL seepage. Other active NAPL seeps were also discovered at the bed surface; however, this case study focuses on the SR 509 seep in particular. Figure 2 shows the location of SR 509 and former dock structures.

NAPL in deeper sediments of the Waterway and in the SR 509 seep area has been described as containing primarily polycyclic aromatic hydrocarbons (PAHs). Investigations of the SR 509 seep were conducted in July of 2001 and 2002. These investigations consisted of video collection and diver observations and were conducted both at the surface and underwater. Divers were deployed in 2002 to investigate the outer boundary of the seep in relation to a grid consisting of 100 5-foot square cells that were placed over the area by the City of Tacoma in 2001. The grid was installed in this area to allow for the location and relocation of seep observations. The divers observed NAPL on the sediment surface of 16 of the 100 cells. Several of the 16 cells were observed to have

Figure 1. Thea Foss Waterway and Vicinity [3]

Figure 2. Location of SR 509 and Former Dock Structures [2]

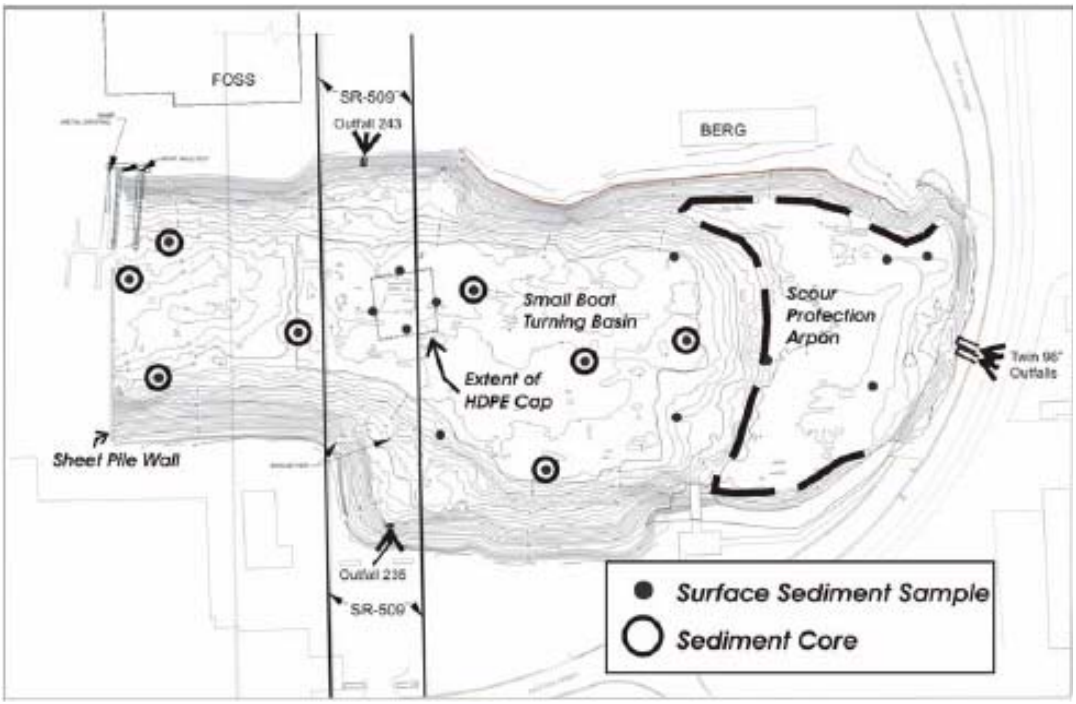


free-phase NAPL coming out of them. One of these cells was located adjacent to a false work piling at the southwest end of the grid. The divers also confirmed that the NAPL seeps did not extend beyond the underwater boundary of the grid.

The remedial action for this portion of the Waterway consisted of a combination of the following, performed in accordance with a Remedial Design/Remedial Action (RD/RA) Consent Decree:

- Installation of a sheet pile wall at Waterway station 70+10 (located north of SR 509 Bridge);
- Dredging beneath the current location of the scour protection apron at the Head of the Waterway and placement of capping and scour protection material in this area;
- Placement of a high-density polyethylene (HDPE) cap over the former location of the SR 509 seep (Figure 3);
- Placement of a sand cap over contaminated sediments and over the HDPE cap; and
- Placement of slope cap and armor material on Waterway slopes.

Figure 3. Location of HDPE Cap [5]



Another source of contamination is the presence of two 96-inch stormwater outfalls (known as the Twin 96 outfalls) that discharge to the Head of the Waterway. In addition to the installation of the impermeable and thick caps, the Washington State Department of Ecology (Ecology) had the responsibility for controlling the discharge from these outfalls. Ecology is working with the City of Tacoma to address this ongoing source of contamination to the Waterway.

The 9-acre area at the Head of the Waterway where the remedial action took place was de-authorized as a navigation channel. However, the entire area currently remains navigable with a requirement to maintain a minimum bottom elevation of -9 feet mean lower low water (MLLW) within a turning basin.

Cleanup Authority	CERCLA
CERCLIS ID Number:	WAD980726368
Type of Action:	Remedial
Lead:	PRP (Utilities - PacifiCorp Environmental Remediation Company, Puget Sound Energy [PSE], and Advance Ross Sub Company)
Oversight:	U.S. EPA

Time Line [1, 3, 8]

1915 to 1922	Standard Chemical Company operations (likely resulted in sediment contamination)
1989	Commencement Bay Record of Decision (ROD)
1994	Remedial Design Study AOC signed between EPA and City of Tacoma
Mid 1990s	SR 509 Bridge constructed; multiple site investigations conducted.
2000	Explanation of Significant Differences (ESD) to the ROD issued by EPA
July 2001 and July 2002	Surface and underwater investigation of the SR 509 NAPL seeps
May 09, 2003	RD/RA Consent Decree issued
August 2003	EPA approved Remedial Design
August 2003 – February 2004	Remedial Action construction
November 13, 2003	Impermeable cap installed
April 2004	Baseline monitoring conducted
May 2005	Year 1 sampling conducted
May 2006	Year 2 sampling conducing
November 2006	Supplemental sampling proposal issued by City of Tacoma
May 2007	Year 3 sampling conducted
May 2008	Year 4 sampling conducted
June 24, 2008	Certificate of Completion of Remedial Action (for RA areas 23 and 24)

Factors That Affected Cost or Performance [1, 2]

The site-specific shallow geologic units defined in the middle of the Waterway are a recent and older fine-grained soft sediment that overlie a recessional outwash deposit unit. The geology of the SR 509 seep area is similar to other areas of the Waterway. The recent sediment is approximately 10 feet thick overlying a 3-foot thick older sediment unit.

Listed below are the key matrix characteristics for the cap employed at the site and the values measured for each during site characterization.

Matrix Characteristics [1, 2, 3]

Parameter	Value
Sediment Classification	Loose organic silt
Hydraulic Conductivity	Groundwater seepage velocity of underlying sediments: 1.7×10^{-4} cm/s; Pore velocity: 4.25×10^{-4} cm/s
Moisture Content	Ranging from 90% to 120% by weight
Median Grain Size	0.01 to 0.02 millimeters (fine grain silt or clay)
Shear Strength	75 to 120 pounds per square foot

Treatment Technology Description [1, 2, 3]

For the remediation of the active NAPL seep underneath the SR 509 Bridge, an impermeable isolation cap was placed over and beyond the limits of the seep. The cap was designed to meet the following goals:

- Halt dense non aqueous phase liquid (DNAPL) seepage and reduce groundwater flow through the preferred pathways. Geotechnical studies indicated that the soft sediment would consolidate on the order of 11 to 15 inches depending on cap thickness. Such consolidation was anticipated to reduce the permeability of underlying sediments and reduce flow through the preferred pathways.
- Lengthen the groundwater flow paths through fine grained sediment before discharge into the overlying sand capping material. Empirical evidence from sediment core data and groundwater modeling indicated that flow through the fine grained sediment coupled with a sand cap augmented with 0.5 percent organic carbon would meet the performance standards.

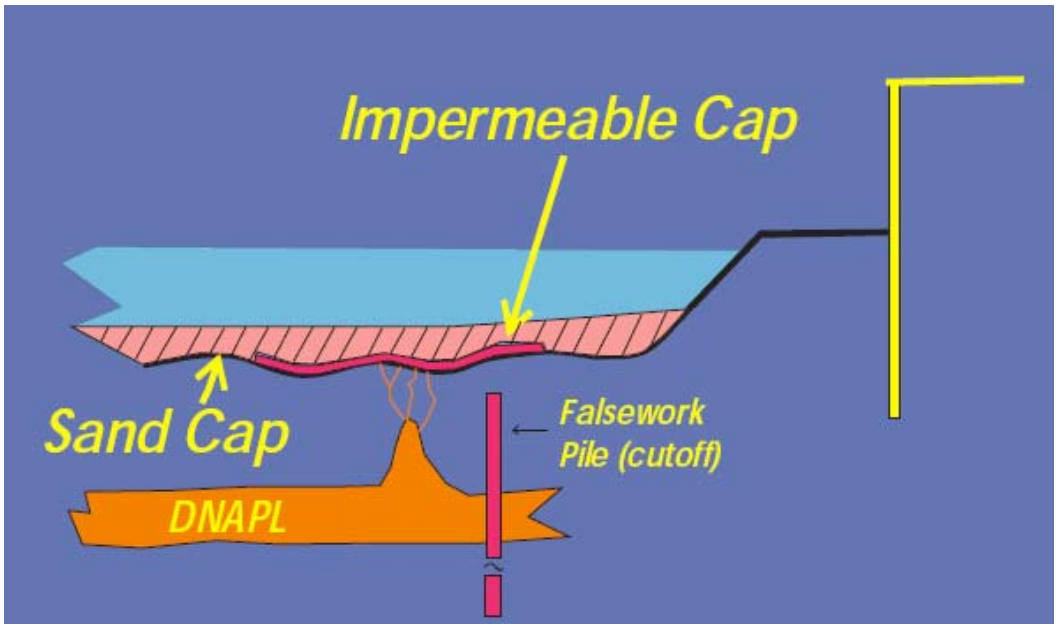
In order to design an impermeable cap to meet these goals, several site specific factors had to be considered. These factors were:

- Based on site observations, the seepage area was approximately 50 feet by 55 feet in size.

- The impermeable cap would need to be placed in the water at depths of 13 feet to 20 feet, depending on the tidal stage.
- The impermeable cap needed to have a profile low enough to allow for recreational boat traffic.
- The impermeable cap was to be placed in an area of soft surface sediment, which would require a material flexible enough to account for any differentials in the settlement of the sediment.
- The impermeable cap would need to be placed underwater in one piece, beneath a bridge with limited overhead clearance. The overhead limit of the bridge would limit the use of large marine equipment.

Based on these site conditions and an evaluation of potential impermeable materials, 3/8-inch HDPE plastic was selected for the cap. The existing 7 to 10 feet of fine-grained sediment was acting as a natural cap for the bulk of the NAPL contamination outside of the seep area. The impermeable cap was designed to enhance this cap by redirecting the NAPL and stripping it from gas bubbles. The overlying thick cap was designed to work in conjunction with the impermeable cap to address the potential movement of other contaminants. The cap was assembled upland before being transported to the site for final placement over the seep area and covered an area of 75 by 70 feet at bed elevations of -11 to -15 feet MLLW. After placement of the cap, a minimum of an additional 4 to 6 feet of sand was placed over it as part of the Waterway's continuous thick sand cap. Figure 4 shows a cross-section of the impermeable cap and overlying sand cap.

Figure 4. Cross-Sectional View of the Impermeable Cap and Waterway Cap [5]



Materials and Shop Fabrication

The impermeable cap was fabricated using thick sheets of stress-relieved, virgin-grade HDPE that were 10 feet long by 5 feet wide by 0.375 inch thick. The material was white in color and conformed to the requirements shown in Table 1 below. Prior to shop fabrication, the sheets were laid out in a staggered perpendicular weld pattern to increase structural integrity of the finished cap. The sheets were then aligned with 5-foot sides next to each other to create 75-foot-long by 5-foot-wide half panels. The half-panel sheets were welded into seven panels (10 feet wide by 75 feet long).

Table 1. Impermeable Cap Material Specifications [5]

Density	ASTM D-792	59.88 lb/cu ft
Yield Point	ASTM D-638	4,279 psi
Elongation at Yield	ASTM D-638	18%
Tensile Break	ASTM D-638	4,423 psi
Elongation at Break	ASTM D-638	1,350%

Site Preparation and Field Fabrication

An asphalt pad located under the east side span of the SR 509 Bridge was used as the field fabrication site and was initially cleaned using "dry" methods, followed by pressure washing of the area. The shop-fabricated 10-foot by 75-foot panels were unloaded directly onto the work pad and arranged into the final configuration. Lugs were welded to the upper surface of the cap to serve as attachment points for the required distributed ballast (¾-inch wire rope). A sufficient amount of wire rope ballast was attached to provide the cap with enough negative buoyancy to sink the cap in the Waterway but not cause the cap to bury itself in the soft bottom sediments. A guide consisting of strap steel beam and pieces of chain was attached to leading and trailing edges of the cap. The strap steel and a steel channel were bolted to the top and bottom sides of the cap. Short pieces of chain were attached to the steel edges, and a beam was used as a spreader bar to allow the cap to be pulled into position.

Testing

In addition to the visual and static testing described above during shop and field welding, cut-out sections of welded portions of the HDPE were subjected to tensile strength and bend testing. Results for the tested specimens were evaluated by structural engineers and were deemed to be more than adequate to meet the strength needs for the project. The HDPE thickness selection was based on parameters such as constructability, flexibility, and strength.

Installation

To provide a transition between the paved area and the Waterway where the impermeable cap was to be placed, steel beams were placed into the Waterway from the top of the bulkhead wall near the shoreline. These steel beams created a ramp structure to reduce the "break-over" angle at the top of the bulkhead wall during the cap transport and installation process. The cap was installed in the required location as confirmed by an independent licensed land surveyor on November 13, 2003. A diver was present in the water during installation, and several support boats including a large tug were on site.

The cap was installed and its position was confirmed by surveyors who were assisted by divers placing pipe poles on the corners and along the outside edge of the cap.

After six weeks of preliminary bed consolidation following the installation of the impermeable cap, the Waterway (sediment) cap was placed over the impermeable cap. The Waterway cap consisted of clean silty sand, with minor organic material. Because the impermeable cap was within the Center Waterway Deep Zone project area, the bed of the Waterway had to be at an elevation of -9 to -10 feet MLLW. The final sediment cap thickness, based on elevation differences between the bed before capping and the Waterway cap surface after capping, ranged from a minimum 4 feet to a maximum 6 feet. Figure 4 shows a cross-sectional view of the impermeable cap and the Waterway cap design.

Installation Control

Control during placement of the Waterway cap was accomplished by using a computer program developed to identify and control the bucket position based on input from a differential global positioning system (GPS) system. Bucket locations were recorded during placement of the cap by the excavator operator using the system. Daily bathymetric surveys were also used to verify location as-placed thicknesses.

Performance Information [1, 3, 6, 7, 8]

The goal of the impermeable cap was to prevent the release of NAPL and significantly reduce the migration of contaminated groundwater. In addition, the ROD specified Sediment Quality Objectives (SQO) that were required to be met. Monitoring for long-term impacts was conducted in April 2004 (Year 0 – baseline), May 2005 (Year 1), May 2006 (Year 2), May 2007 (Year 3), and May 2008 (Year 4).

Monitoring activities included inspections of the cap integrity, recolonization monitoring, and recontamination sampling. Physical observations of cap integrity included visual inspections of the cap and hydrographic surveys. Recolonization monitoring included assessment using Sediment Profile Imagery (SPI) as well as collecting benthic abundance samples. Sediment sampling included collecting sediment samples to test for chemical concentrations and toxicity. Sediment sampling consisted of three types:

- Compliance Samples, which are surface sediment samples collected from the surface to a depth of 10 centimeters (cm).
- Early-Warning Recontamination Samples, which are sediment samples collected from the cap surface to a depth of 2 cm. These were collected to provide warning from possible “top-down” recontamination of the cap from sources like stormwater.
- Core Samples, which are collected to provide data to evaluate possible future “bottom-up” recontamination of the Waterway cap.

Baseline Monitoring (April 2004)

Physical observations were made in May and July 2004 and surface and core sediment sampling were completed in April 2004. The samples taken in April 2004 provided baseline data on the conditions of the impermeable cap soon after installation was completed in February 2004. Analysis of the data indicated that stormwater constituents were accumulating on the overlying sand cap. In particular, the concentrations of high molecular weight PAHs (HPAHs) and bis(2-Ethylhexyl)phthalate (BEHP) were high and correlated to each other, indicating a common source.

Year 1 Monitoring (May 2005)

During Year 1 monitoring, physical observations of the cap were done more frequently at the request of the EPA. Observations were made in May, July, September and December 2004 and April 2005. The September 2004 observation event indicated that there was severe recontamination of the sediment above the sand cap. Sediment and cap sampling (including both surface and core sampling) were conducted in August, September, November, and December 2004. The results of the physical observations and sampling completed between August 2004 and April 2005 indicated that the cause of recontamination was due to dredging activities north of the cap (primarily north of the SR 509 Bridge). The dredging activities caused contaminated sediment to be suspended in the water column and to migrate and settle on a portion of the sand cap. Recontamination constituents included PAHs, phthalates, pesticides, and polychlorinated biphenyls (PCB). In December 2005, the City of Tacoma capped the dredged recontamination area.

Year 2 Monitoring (May 2006)

Physical observations, recolonization monitoring, and collection of sediment samples were completed again in May and June 2006. The results of both recontamination and compliance samples showed there were still exceedances in contamination of the surface sediment.

Bioassay testing was completed on selected samples because chemical concentrations of BEHP and HPAHs exceeded their respective SQO. The testing indicated that the sediment contamination had an impact on the mussel larvae in three of the four sampling locations, and on the sand fleas in one of the four sampling locations. The results also indicated that the test organisms were most adversely impacted where the chemical concentrations were highest.

Natural recolonization of the capped areas was monitored using SPI and benthic community sampling. The results of the SPI analysis were consistent with the bioassay testing. The SPI results indicated that in the portion of the Thea Foss Waterway Head where the fine-grained material is accumulating, the post-cap sediment is organically enriched relative to surrounding sediments and also shows evidence of high sediment oxygen demand. As a result, the biological community has been compromised at several sampling stations. It is expected that recovery of the benthic community will continue to

be disturbed if the stormwater outfalls continue to discharge the volume and quality of material that they have since the completion of the capping operations. Core samples taken near the bottom of the impermeable cap showed that the cap still contains the underlying contaminated sediments. The core samples also showed that there is no "bottom-up" recontamination of the sediments and that the cap is functioning as intended. Evaluation of the available data determined that the recontamination of surface sediment may be from the stormwater outfalls that discharge into the Head of the Waterway.

To further assess the stormwater recontamination issue, the City submitted a supplemental sampling proposal to EPA in November 2006 to monitor concentrations of phthalates and PAHs in the Head of the Waterway. The scope of the Year 3 Operation , Maintenance, and Monitoring Plan (OMMP) sampling program was expanded to include additional compliance monitoring sampling to evaluate the concentration trends for BEHP and PAHs. The City was responsible for these sampling requirements as well and coordinating their efforts with the Utilities.

Year 3 Monitoring (May 2007)

Results of the Year 3 OMMP early-warning and compliance sampling indicated that recontamination of the sand cap continued to occur and is from "top-down" sources. This determination was based on the following:

- All 14 of the Year 3 early-warning samples (0 to 2 cm) contained BEHP concentrations above the SQO of 1,300 micrograms per kilogram (µg/kg). PAHs exceed SQOs at locations at the southern end of the head of the waterway. Fine grained sediment continues to accumulate on the top of the cap from the stormwater outfalls.

- Comparison of the analytical results of the compliance samples to the SQOs indicates that in Year 3, BEHP exceeded its SQO (1,300 µg/kg) at all stations located below and south of the SR 509 Bridge. BEHP concentrations ranged between approximately 2,000 and 4,900 µg/kg. PAH concentrations (phenanthrene, most individual HPAHs, and sum of HPAHs) also exceeded the SQOs at station WC-02, located in the turning basin near the scour protection apron. The highest BEHP concentration (4,900 µg/kg) and highest HPAH concentration (20,000 µg/kg) were co-located at station WC-02. Compliance sample concentrations of BEHP and HPAH south of the SR 509 Bridge appear to have generally declined between 2006 and 2007. The average concentration of BEHP declined from approximately 3,600 to 2,700 µg/kg, whereas the average concentration of HPAH declined from approximately 9,700 to 7,800 µg/kg.

Sufficient data are not available to reliably assess long-term trends in sediment contaminant concentrations. Variations in stormwater sediment volumes and concentrations discharged to the waterway coupled with sediment mixing and stabilization of the impacts of the 2004 dredging recontamination obscure the potential trends in the data provided by the two sample sets (2006 and 2007) collected after the

dredging recontamination and capping occurred. Additional OMMP sampling rounds will be necessary to assess the longer term sediment quality trends in the Utilities' Work Area.

Overall, the May 2007 physical and visual observations indicated that the scour protection apron is functioning as intended. No obvious signs of significant erosion were observed. Side slopes showed no visible evidence of slope erosion, sloughing, etc. Visual observations during low tides of the former SR 509 seep area indicated the impermeable cap is preventing the upward migration of tar that would cause visual sheens.

Year 4 Monitoring (May 2008)

As with previous OMMP activities, surface sediment samples, slope cap samples, and core sediment samples were collected. An additional location (Y4-SS-01) was sampled based on discoloration observed during sampling activities. Table 2 shows the concentrations that equaled or exceeded each SQO for the Year 4 sampling. Also shown in Table 2 are the exceedance factor (EF) values (sample concentration divided by the SQO) for each contaminant in each sample location. The highest EFs were seen for BEHP.

- All early-warning samples (0 to 2 cm) had BEHP concentrations above the SQO, with a maximum of 14,000 µg/kg at SC-03.
- Compliance samples (0 to 10 cm) concentrations of BEHP and HPAH south of the SR 509 Bridge appear to have generally increased between 2007 and 2008, even though they had generally decreased between 2006 and 2007. The average concentration of BEHP increased from approximately 3,100 to 4,500 µg/kg, whereas the average concentration of HPAH increased from approximately 8,700 to 10,800 µg/kg.
- Concentrations in core samples did not exceed SQOs indicating no evidence of bottom-up recontamination and that the cap is performing as designed.

Year 4 monitoring activities also included visual inspection, bathymetric survey, and SPI survey. Observations during the visual inspection conducted in May 2008 noted the scour protection apron was functioning as intended, no obvious signs of erosion were found, and side slops showed no visible evidence of erosion. Gas bubbles were observed throughout the Waterway and in the area of the former SR 509 seep, but no rising NAPL sheen was observed. During sample collection, however, oily sheen spots were noted at six locations. The bathymetric survey was conducted in August 2008 and results indicated the sediment cap to be relatively stable. Slight variations were noted (possibly due to erosion); however, the minimum thickness of 3 feet continued to be achieved. At most locations, an increase in cap thickness between 2007 and 2008 was approximately 1 to 4 cm; however, one location (RC/WC-07) showed an increase of 6 cm.

Results of the SPI survey indicate conditions are similar to the previous study conducted in Year 2 (2006), and mostly positive changes have been observed. One concern is the continued deposition of organically enriched, fine-grained material from stormwater

outfalls that serve as a source of stress to the benthic community by maintaining high oxygen demand.

Performance Data Quality [1]

No exceptions or issues with data quality were noted in the available references.

Cost Information [4, 5]

The final cost for the installation of the impermeable cap was $11.5 million. The final cost included a capital cost of $10.5 million and $1 million for monitoring. The capital cost included:

- $726,000 for site investigation
- $2.2 million for design of the impermeable cap
- $7.2 million for the construction of the impermeable cap
- $11,500 for community relations, and
- $333,000 for insurance premiums.

Monitoring costs are projected costs for monitoring the performance of the impermeable cap from April 2004 to October 2014.

Several factors were identified that affected the cost to implement the remedy. Refinement of the conceptual site model (CSM) for NAPL seepage during the design phase of the project greatly reduced the cost of the remedy in the construction phase. The CSM allowed for the elimination of extensive and expensive capping in all of the NAPL-contaminated areas by showing the specific location of the NAPL seeps.

The use of an impermeable cap instead of a sorbent material reduced costs associated with maintenance. The overall cost of the impermeable cap was approximately 10 to 15 percent of the estimated cost for a cap using sorbent material. This comparison is based on the assumption that the sorbent material cap would need to be replaced only once after installation.

Table 2. SQO Exceedances (Year 4 Monitoring - May 2008) [8]

Location	Zinc (EF)	Phenanthrene (EF)	Fluoranthene (EF)	Pyrene (EF)	Benzo(b+k) fluoranthenes (EF)	Benzo(a) pyrene (EF)	Indeno(1,2,3-cd)pyrene (EF)	Dibenz(a,h) anthracene (EF)	Benzo (g,h,i) perylene (EF)	Total HPAH (EF)	bis(2-Ethylhexyl) phthalate (EF)
SQO (µg/kg)	**410,000**	**1,500**	**2,500**	**3,300**	**3,600**	**1,600**	**690**	**230**	**720**	**17,000**	**1,300**
Early Warning (0-2 cm)											
RC/WC-01		1600 (1.1)	3900 (1.6)				890 (1.3)	350 (1.5)	910 (1.3)	17000 (1.0)	6000 (4.6)
RC/WC-02	452,000 (1.1)	1500 (1.0)	3800 (1.5)		3,900 (1.1)	1600 (1.0)	760 (1.1)	310 (1.3)	760 (1.1)	18000 (1.1)	8200 (6.3)
RC/WC-03											2100 (1.6)
RC/WC-04/R-02											2800 (2.8)
RC/WC-05			2500 (1.0)								6900 (5.3)
RC/WC-06			2600 (1.0)				950 (1.4)	270 (1.2)	1100 (1.5)		6000 (4.6)
RC/WC-07											5200 (4.0)
RC/WC-08/R-03											4500 (3.5)
RC/WC-09											5100 (3.9)
RC/WC-10								230 (1.0)			2500 (1.9), 1600 (1.2)
RC/WC-11/R-04			3400 (1.4)	3300 (1.0)	3,600 (1.0)	1700 (1.1)	1200 (1.7)	400 (1.7)	1600 (2.2)	19000 (1.1)	10000 (7.7)
RC/WC-12							780 (1.1)	260 (1.1)	870 (1.2)		3600 (2.8)
RC-13		1800 (1.2)	4400 (1.8)	3400 (1.0)	3,700 (1.0)	1600 (1.0)	960 (1.4)	390 (1.7)	950 (1.3)	19000 (1.1)	6600 (5.1)
RC-14		1700 (1.1)	4100 (1.6)		3800 (1.1)	1600 (1.0)	860 (1.2)	340 (1.5)	920 (1.3)	19000 (1.1)	8000 (6.2)

Table 2. SQO Exceedances (Year 4 Monitoring - May 2008) (continued)

Location	Mercury (EF)	Phenanthrene (EF)	Fluoranthene (EF)	Pyrene (EF)	Benzo(a) anthracene (EF)	Benzo(b+k) fluoranthenes (EF)	Benzo(a) pyrene (EF)	Indeno(1,2,3-cd)pyrene (EF)	Dibenz(a,h) anthracene (EF)	Benzo(g,h,i) perylene (EF)	Total HPAH (EF)	bis(2-Ethylhexyl) phthalate (EF)
SQO (µg/kg)	**590**	**1,500**	**2,500**	**3,300**	**1,600**	**3,600**	**1,600**	**690**	**230**	**720**	**17,000**	**1,300**
Waterway Cap (0-10 cm)												
RC/WC-01			2700 (1.1)									6400 (4.9)
RC/WC-02		1800 (1.2)	4800 (1.9)	3700 (1.1)	1600 (1.0)	4900 (1.4)	2000 (1.3)	860 (1.2)	370 (1.6)	860 (1.2)	22000 (1.3)	8000 (6.2)
RC/WC-04/R-02												2400 (1.8)
RC/WC-05												5400 (4.2)
RC/WC-06												3200 (2.5)
RC/WC-07			2500 (1.0)					720 (1.0)	230 (1.0)	840 (1.2)		4700 (3.6)
RC/WC-08/R-03												2500 (1.9)
RC/WC-09												3100 (2.4)
RC/WC-11/R-04	1650 (2.8)											3500 (2.7)
RC/WC-12												1600 (1.2)
WC-13												2100 (1.6)
WC-14												3500 (2.7)
Slope Cap (0-10 cm)												
SC-03												14000 (10.8)
SC-04												2400 (1.8)
Y4-SS-01												7900 (6.1)
Notes:												
(EF)- Exceedance Factor Value												

Observations and Lessons Learned [3, 4, 8]

Some observations and lessons learned from the implementation of the remedy include:

- Due to the tide activity associated with the location of the project, scheduling of work was difficult. The shoreline work had to be accomplished during low tides, which meant that the work could only be done at night and only on certain days of the week. Additionally, the in-water placement of the capping material by the barge had to be scheduled during times when there was sufficient water for the barge to draft and to allow for sufficient overhead clearance when working beneath and south of the SR 509 Bridge.
- Placement of the Waterway cap material through the water column to get a smooth capping surface while minimizing turbidity and loss of organic materials contained in the sand matrix was difficult.
- The Waterway and slope cap initially placed over the dredged area near the Twin 96 outfalls had eroded from stormwater during periods of extremely low tide. This required a redesign and corrective measure in this area.

Recommendations for Revising the OMMP

To address the issue of "top-down" recontamination caused by the City's dredging activities, the scope of the work for the Year 4 OMMP was expanded to include the collection of four supplemental compliance samples from the area where the City placed additional capping material on the north end of the Utilities' Work Area. The need for further assessment or modifications to the OMMP to address elevated levels of phthalates and PAHs on top of the cap will be discussed and determined between the City and EPA. In addition, the Utilities proposes modifications to the OMMP because, due to the continued deposition of material from stormwater outfalls, the objective of ensuring the clean cap material has not been recontaminated is no longer applicable. Also, the SPI survey can no longer evaluate the original cap surface due to the accumulated material.

The evaluation of bottom-up recontamination with the analysis of core samples at the bottom of the cap was required in the Year 4 monitoring. Core penetration through the cap had been problematic due to the coarse sand cap material. A vibrocore had been used to collect the cores in the past. Therefore, a modification to the coring method was recommended for the Year 4 sampling. A MSS vibratory hammer coring device was used to collect core samples.

The recording of the thickness of the fine-grained material deposited on top of the cap has become routine during OMMP monitoring. Consistently, measurement of the thickness has been recorded in the van Veen grab sampler. During Years 2 and 3 measurements at RC/WC-02 indicated that the fine-grained sediment thickness was greater than 17 cm and 13 cm, respectively (the sample collected in the grab sample did not reach the sand cap material). Because the maximum penetration of the grab sampler is 17 cm, it was recommended that a true measurement of the fine-grained sediment

thickness at locations with deep deposits be documented using a hand-corer device such as a piston core. In Year 4 monitoring, samples were collected using a Power grab sampler, which penetrated 24 cm.

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References

1. Braun, G., G.L. Hartman, B. Wallace, L. Hass, and B. Brickey. Battelle Press, 2005. Design, Construction, and Installation of Impermeable Isolation Cap for a NAPL Seep at the Head of the Thea Foss Waterway. Proceedings of the Third International Conference on Remediation of Contaminated Sediments, New Orleans, Louisiana, January 24-27, 2005.

2. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2003. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington: Interim Design – Impermeable Cap Remediation. March.

3. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2006. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington: Results of Year 2 Operations, Maintenance, and Monitoring Plan Sampling. November.

4. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2004. Remedial Action Construction Report. August.

5. Dalton, M., G.L. Hartman, and B. Wallace. Battelle Press, 2007. Impermeable "Hard" Cap Evaluation – Thea Foss Waterway, Tacoma, Washington. Proceedings of the Fourth International Conference on Remediation of Contaminated Sediments, Savannah, Georgia, January 2007.

6. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2005. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington: Results of Year 1 Operations, Maintenance, and Monitoring Plan Sampling. October.

7. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2007. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington: Results of Year 3 Operations, Maintenance, and Monitoring Plan Sampling. August.

8. PacifiCorp Environmental Remediation Company & Puget Sound Energy, 2008. Head of the Thea Foss Waterway Remediation Project, Tacoma, Washington: Results of Year 4 Operations, Maintenance, and Monitoring Plan Sampling. September.