Association of State and Territorial

ASTSWMO

Solid Waste Management Officials

CERCLA and Brownfields
Research Center

Sediment Focus Group

Sediment Remedy Effectiveness and Recontamination: Selected Case Studies

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Section I. Introduction

The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) Sediments Focus Group has produced two previous documents: 1) "Guide to the Assessment and Remediation of State-Managed Sediment Sites" (ASTSWMO, 2007); and 2) **"**Framework for Long-Term Monitoring of Hazardous Substances at Sediment Sites" (ASTSWMO, 2009). Both papers present issues and information related to State sediment sites. The current paper expands on those efforts and reviews and evaluates recontamination issues at sediment remediation sites around the country, with a focus on source control and long-term remedy effectiveness. The objective of this document is to assist State regulators in the planning and decision making processes necessary to minimize the potential for recontamination at contaminated sediment sites.

This document discusses causes and issues related to recontamination. Discussion topics include new contamination of sediment sites from both known sources and newly identified sources, including contamination from new chemicals or those not addressed in previous assessments, and identification of pollutants most commonly found in areas where recontamination has occurred. Also included are case studies at sediment remediation sites where inadequate source control and/or recontamination have been documented after remedy efforts have commenced.

Section I.1 What is ASTSWMO?

ASTSWMO is an organization supporting the environmental agencies of State and Trust Territories (States). ASTSWMO focuses on the needs of State hazardous waste programs; non-hazardous municipal solid waste and industrial waste programs; recycling, waste minimization, and reduction programs; Superfund and State cleanup programs; waste management and cleanup activities at federal facilities; and underground storage tank and leaking underground storage tank programs. The association's mission, briefly stated, is: "to enhance and promote effective State and Territorial programs for waste and materials management, to encourage environmentally sustainable practices and to affect relevant national waste and materials management policies".

The Sediments Focus Group is part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Brownfields Research Center Subcommittee. The Focus Group's mission is to create opportunities for State-to-State information exchange and the development of new approaches for contaminated sediment assessment and remediation, as well as to influence national sediment cleanup guidance and policy.

Section I.2 Overview of the Framework

Each section within this paper discusses a specific topic. Section II presents a review of the literature pertaining to sediment remediation sites that have become recontaminated. Section III describes source control and recontamination. Section IV highlights case studies in which long-term monitoring is used to demonstrate remedy effectiveness. In some cases, monitoring indicates that recontamination has occurred. Section IV provides a summary of recommendations and conclusions.

Section II. Literature Search

Available online and public information sources were reviewed to identify sites at which a remedy had been implemented to address contaminated sediment, and subsequent monitoring data indicated recontamination. Information from peer-reviewed journals and gray literature (e.g. government and environmental consultant authored documents) available on-line were also evaluated. Search terms generally included “sediment”, “recontamination”, “urban runoff”, “Superfund”, “cap/capping”, “dredge/dredging”, and “remedy/remediation”. Some of the papers evaluated in the peer-reviewed literature concerned some of the same sites discussed in the case studies presented in the attached Appendix. This was not necessarily considered a duplication of effort as the journal articles often presented specific information not readily available in the gray literature or information was presented in a much more condensed manner. The literature review is summarized in Table 1 with an associated summary discussion of the overall findings from the literature survey. This is accompanied by a more detailed table that provides specific information and reference details for those who may want to review the specific literature sources themselves.

The following information was captured by the review of the literature:

- Site Name/Site Location
- Contaminants
- Remedy
- Monitoring description
- Reasons for recontamination
- Hyperlink or other reference information
- Summary/notes

The sites listed in Appendix A represent a variety of site conditions and remedial response measures. Response actions at these sites included natural recovery, dredging, subaqueous capping, and combined remedies employing a combination of these remedial responses. Contaminants associated with these sites included polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), semi-volatile organic compounds (SVOCs), creosote, coal tar, dichlorodiphenyltrichloroethane (DDT), dieldrin, ordnance and nitroaromatic compounds, and metals.

The reasons for the various sites’ recontamination are site-specific and variable. In some cases, more than one type of source contributed to the recontamination of the site. Reasons for recontamination included surface runoff, seepage of site contaminants through the capping material (e.g., weathered creosote), bank storage of contaminants, resuspension or disturbance of contaminated sediment during capping or dredging, slumping/erosion of contaminated sediment in undredged areas beneath docks and pilings, dredge residuals, and contaminated storm sewers. At some sites, sediment remediation did not necessarily reduce biota tissue concentrations. At the Sangamo-Weston site in Pickens, South Carolina, although PCB concentrations in surficial sediment seemed to have met the target levels in the Record of Decision (ROD), fish tissue levels of PCBs have not declined in all species. Although reasons are unclear, researchers (Rashleigh, et al., 2009) suggested this could be due to irregular flushing of sediment collected behind dams and transfer of PCBs from detritus into the food web. At a former naval base in Norway, researchers (Voie, et al., 2002) suggested that PCB concentrations in mussels could be attributed to water column concentrations and resuspension of fine contaminated particles.

Section III. Recontamination and Source Control of Remediated Sediment Sites

Recontamination and source control are important issues for consideration when planning, remediating and monitoring contaminated sediment sites. Simply defined, recontamination occurs when a sediment site becomes impacted by contaminants following remedial measures. Existing site related contaminants are usually recognized as a potential recontamination concern, but other pollutants may also be identified through post-remediation monitoring. Sediment remediation sites could also become impacted by new and emerging sediment contaminants, such as pharmaceuticals, endocrine disrupting compounds, personal care products, and household chemicals. Examples of emerging chemicals include bisphenol-A, other phthalates (e.g., dibutyl phthalate), perchlorate, nonylphenols, brominated flame retardants, fluorinated organic compounds, and nanoparticles. Although many of these chemicals and classes of chemicals are not "new," they have been "emerging" as monitoring activities have been expanded to look for them, analytical methods for detection of these chemicals have improved, and/or research has demonstrated the toxicological and endocrine-disrupting effects of these chemicals. The detailed assessment of new and emerging chemicals is beyond the scope of this paper; evaluations and ongoing research are available elsewhere (e.g., USGS Toxics Substances Hydrogeology Program, U.S. EPA State of Great Lakes 2009). In any case, if new or emerging contaminants are found at remediated sediment sites, State and federal regulatory agencies should work within their existing program areas and public stakeholder groups to address appropriate response actions. A key question here is whether there is a monitoring program in place that would detect new and emerging chemicals in sediment in addition to the routine post-remedy monitoring of site contaminants. In some cases, States may undertake this identification and/or monitoring as part of the development of specific Water Quality Standards under the Clean Water Act.

Source control for contaminated sediment sites is generally defined as identifying and addressing direct and indirect sources of concentrated pollutants that cause continuing significant contamination to sediments. Source control is critical to understanding and implementing a successful remedy and is typically first evaluated while investigating contaminated sediment sites (e.g., U.S. EPA, 2005). The concept of evaluating source control is equally important after active remediation has been completed, as indicated by information gathered from implementing remediation and evaluating the results gathered from long-term monitoring. An evaluation of the effectiveness of source control should be incorporated into the conclusion section of monitoring reports required for post-remediation temporal changes in surface water, biota and/or sediment concentrations. Additional sources of sediment contamination may also become evident during actual remediation when new or unanticipated conditions are discovered.

A long-term monitoring program should be implemented during remediation to obtain pre-remediation baseline and post-remediation information. The results of continued monitoring should be examined to determine if the remedy is performing within an acceptable range of expectations or if recontamination of the sediment is occurring. If recontamination is occurring, the source(s) of contamination should be identified. Long-term monitoring following remediation may identify sources that were not anticipated during remedy selection and implementation. For this reason, every effort should be made early in the investigation process to identify all sources of sediment contamination, including sources not readily associated with the site in question. In some cases, a coordinated or regionalized remedial strategy may be a worthwhile consideration to better ensure overall success of the sediment remedy. Finally, long-term monitoring programs should be comprehensively designed to provide an early indication of recontamination potential from previously unrecognized on- and off-site sources.

The discussions that follow provide an overview of recontamination and source control at contaminated sediment sites which have been remediated. Broad categories (sources or causes) of recontamination are presented in general case summaries or are presented in general discussions. The cases summarized in this section are presented in more detail in Appendix B

III.1 Stormwater Releases to a Remediated Site

Point and non-point sources of stormwater are a source of recontamination at many sediment sites. Stormwater pipes, conveyance systems, and sheet flow stormwater runoff can impact remediated sites. An example of this is at the Thea Foss Bay Waterway, which is part of the larger Commencement Bay Superfund site in Tacoma, Washington. The waterway was contaminated by upland industrial facilities, residential/industrial stormwater, and combined sewer overflows (CSOs). Contaminants of Concern (COCs) included phthlates, PAHs, PCBs, phenols, metals, and pesticides. Monitoring results indicated phthalate recontamination from residential and industrial stormwater discharging from two 96-inch stormwater pipes.

Another example is found in Puget Sound, where a toxics loading study is being carried out by the State of Washington in collaboration with other partners. Phase I of the study has determined that surface runoff is generally the largest contributor of toxic chemicals into Puget Sound (Washington State Department of Ecology, 2011). Phase 2 results have shown that for all toxic chemicals considered (except for arsenic, mercury, DDT, and metabolites), residential land use areas were the largest source of loadings because they constitute a substantial portion of the basin, and the concentrations of toxic chemicals in the associated runoff were relatively large (EnviroVision Corporation et al., 2008).

III.2 Combined Sewer Overflow Releases to a Remediated Site

CSOs are an overflow of sewage and stormwater that occurs as a result of stormwater entering a combined sewer system. Combined sewer systems may collect stormwater runoff, domestic sewage, and industrial wastewater in the same pipe. When stormwater entering the sewer system exceeds the available system capacity during a rainfall event, a CSO can occur. Recontamination attributable to CSOs (in part) has been shown at the Duwamish/Diagonal Combined CSO in Washington State. This site was contaminated by previously uncontrolled CSO, two storm drains, and a former treatment plant outfall. This site is part of a larger Superfund site known as the Lower Duwamish Waterway. Sediments in the Lower Duwamish are contaminated with 41 different chemicals including PCBs, PAHs, dioxins/furans, metals and phthalates. Untreated sewage was the major source of the phthalate recontamination.

III.3 Contaminant Migration Through a Cap

The Denny Way CSO is a 3-acre site that included a 3 foot thick cap of clean sand placed over contaminated sediments. COCs included PAHs, PCBs, metals, and phthalates. Monitoring results indicated that contaminants may be migrating up through the bottom foot of the cap. The long-term monitoring plan was re-written to include more intensive coring to determine if the contaminants are actually migrating up or if the sampling techniques were resulting in 'smearing' of contaminants up the sampling core, resulting in errors in the cap-depth determination.

III.4 Post-remedial mobilization and/or Incomplete Source Control

Part of the remediation of the Puget Sound Naval Shipyard site included dredging contaminated sediments and placing them in a confined aquatic disposal (CAD) pit to be capped. The CAD was excavated and the clean material removed was stockpiled next to it. Approximately 225,000 cubic yards (yd^3) of contaminated sediments were dredged and deposited in the CAD pit. It was then capped with 17,000 yd^3 of sand to a thickness of about 1.4 feet. Then 69,000 yd^3 of clean native sediment were placed as a final cap to a combined thickness of 4.5 feet. Post-remedial monitoring around the perimeter of the

CAD pit revealed that PCB and mercury concentrations were elevated above pre-remediation levels. To remediate this, the CAD pit cap was redesigned to extend 100 feet from the existing pit boundary, clean native material was placed on three sides of the cap, and additional clean material was placed throughout the vicinity to enhance natural recovery.

The United Heckathorn Superfund site is located in Richmond Harbor, an inlet of San Francisco Bay, in Contra Costa County, California. It includes five acres of land and about 15 acres of marine sediments in two channels (Lauritzen and Parr) of Richmond Harbor. From 1947 through 1966, several companies used the site to formulate, package, and ship pesticides. No chemicals were manufactured on site. Heckathorn would receive technical grade pesticides from chemical manufacturers, grind them in air mills, mix them with other ingredients such as clays or solvents, and package them for final use in liquid or powder form. Although many pesticides were handled at United Heckathorn, DDT accounted for approximately 95 percent of Heckathorn's operations. United Heckathorn went bankrupt in 1966.

Dredging of Parr Canal and Lauritzen Channel occurred from August 1996 to March 1997. Approximately 2,620 yd^3 of sediment were removed from Parr Canal in August 1996. Dredging of Lauritzen Channel proved more difficult because of the extensive amount of debris found in the channel. Approximately 187 tons of salvaged metal were retrieved from the channel in addition to the 105,000 yd^3 of sediment.

The upland four-and-a-half acre area of the site was capped. The annual operation and maintenance report and the subsequent three Five-Year reviews indicate the upland cap is still protective and functioning as intended.

Although actions were taken to reduce the risk from the pesticides found on site, sediments and the water in the Lauritzen Channel are still contaminated with pesticides, primarily DDT and dieldrin. Levels are high enough to pose a threat to wildlife who feed in or around the water. Since these pesticides bioaccumulate in fish, people who subsistence fish in the area run the risk of exposure to unacceptably high levels of DDT and dieldrin. Because of this, the State of California issued an advisory against eating fish from the Richmond Harbor area. The advisory is still in effect:

http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dec8ba3252368428825742600743733/809066aa6131970088257007005e9450!OpenDocument

III.5 Recontamination from Off-Site Contaminated Sediments

Ten years of monitoring at three sediment caps (see text that follows) along the Seattle waterfront in Puget Sound, Washington showed that resuspension of contaminated sediment from the surrounding area is an important source of recontamination to the cap surfaces. Reasons for resuspension and recontamination at these sites included: 1) Repair of pilings that requires cutting below the mud line; 2) Use of a clamshell bucket to remove pilings and digging to remove broken pilings; 3) Propeller wash from large vessels and ferry boats along the waterfront; and 4) Untreated CSO discharge.

Pier 53-55 cap: Within one year of cap installation, removal of creosote pilings at an adjacent pier recontaminated the Pier 53-55 cap with PAHs. After three years, PAH concentrations dropped below criteria. However, monitoring results at 4 and 10 years post-remedy demonstrated that PCBs and phthalates had recontaminated the cap. The source was attributed to resuspension of off-site contaminated sediments.

Pier 64-65 cap: Monitoring results demonstrated that high molecular weight PAHs had recontaminated the Pier 64-65 cap. The recontamination was attributed to off-site contaminated sediment that was resuspended during piling repair work at an adjacent pier.

Denny Way cap: Monitoring results demonstrated that the cap was recontaminated with PAHs, mercury, PCBs and phthalates. This was resuspension of contaminated sediments by wave action and untreated/uncontrolled CSO discharges.

III.6 Groundwater Seepage and NAPL Migration

Groundwater and surface water bodies and associated sediments are interconnected on both a local and regional scale. A stream, or segment thereof, is referred to as a "losing stream" where the surface water elevation in that portion of the stream is greater than the water table elevation resulting in recharge to nearby groundwater. Conversely, if the surface water elevation in the stream is less than the water table elevation, the stream can be described as a "gaining stream" where groundwater is directly discharging to or feeding that portion of the surface water body. Depending on the local hydrogeology, contaminated groundwater can discharge to a water body causing degradation of surface water quality as well as additional contaminant loading to sediments. Sediment contamination (or recontamination) may be the result of discharge of dissolved phase contaminants, transport of contaminant-laden colloids or contaminants bound to small diameter particulates and/or migration of non-aqueous phase liquid (NAPL) into the surface water body. A demonstrable understanding of this relationship between groundwater and surface water is critical to the overall success of the remedial action, where impacted groundwater may release to surface water. Absent an accurate assessment of this relationship, remedy selection may be inappropriate or the remedy may not be fully effective due to continued recontamination from groundwater seepage into the water body.

The occurrence of NAPL at a sediment site is usually regarded as an extreme condition, since NAPL most likely represents an ongoing, persistent source of contamination to sediments or may cause recontamination of remediated sediment sites. The Pine Street Canal and the Fields Brook Superfund sites are examples where NAPL has been discovered during or after remedial action. The Pine Street Canal site cap will be redesigned and reconfigured to collect NAPL. This NAPL will be removed and shipped off-site for disposal. At the Fields Brook site; the discovery of a PCB dense non-aqueous phase liquid (DNAPL) in sediments has led to additional evaluation of source control and remediation.

III. Contaminated Soil Erosion

Erosion of riverbank, lakebank or shoreline soil into a water body may be a source of recontamination to sediments if the soil exhibits contamination at levels equal to or greater than the remedial action objective (RAO) for the sediments. In the absence of engineering controls or implementation of best management practices, this sediment recontamination would generally occur during or after the high stream flow rates associated with major storm events. This release pathway should be included in the development of the RAOs established for surficial soils, particularly those in close proximity to a surface water body or those more readily eroded. This may necessitate more than one RAO for surface soil depending on the distance from the water body or propensity for erosion. An example of this situation was found at the Torch Lake/Quincy Smelter NPL Superfund site, which identified ongoing sources of metals contamination to surficial sediments.

IV. Conclusion

Recontamination and source control are emerging as concerns at a number of contaminated sediment sites where remediation has been completed. This document focused on the potential concerns and issues associated with recontamination at contaminated sediment sites. Several factors including new contamination resulting from existing and new sources related to recontamination have been discussed. Through the case studies and the literature search, the paper explored the effects of inadequate source control and the remedial needs that result in after-remedy efforts.

The literature search yielded many useful insights into the effects of remedial planning and source control. The remedial sites evaluated presented a wide range of response actions including natural recovery, dredging, subaqueous capping, as well as combined remedies. For a number of the sites, recontamination can be linked to more than one type of source. Source control for contaminated sediment sites is generally defined as identifying and addressing direct and indirect sources of concentrated pollutants that cause continuing significant contamination to sediments, including stormwater point and non-point sources such as those outlined in Section III above. In the development of a remedial strategy, every effort should be made early in the remediation process to identify other superficially unrelated contaminant sources and other sites in close proximity to the contaminated sediment site(s) targeted for remediation. Notwithstanding the potential hurdles of such an approach, a coordinated or regionalized remedial strategy across government and private entities may be worthwhile to ensure the overall success of the sediment remedy.

In addition, long-term monitoring following remediation can identify sources that were not anticipated during remedy selection and implementation. New or previously unaddressed chemicals were evaluated at some of the sites and were summarized in the case studies. Monitoring programs that include the necessary water, sediment and biota sampling provide multiple results to evaluate the success of the remedy. Long-term monitoring programs should be comprehensively designed to provide an early indication of recontamination potential from previously unrecognized on- and off-site sources. At the same time, these long-term monitoring programs must include periodic decision points to determine whether the monitoring program results indicate sufficient information to modify the monitoring frequency, such as an observed sustained recovery to allow reduction or termination of the monitoring effort prior to the scheduled end date.

U.S. EPA. 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. Office of Solid Waste and Emergency Response. EPA-540-R-05-012. December 2005.

APPENDIX A
ASTSWMO Literature Review

Site: United Heckathorn Superfund Site in Richmond, California

Site Location: Richmond, California. East side of Lauritzen Channel which trends north off the Santa Fe Channel. The Santa Fe Channel, at its southeast end, connects to the Richmond Inner Harbor Channel. Google Earth 37o 55' 26.42" N, 122o 21' 58.96" W.

Type of Contaminant: Organo-chlorine pesticides.

Contaminants: The main contaminants of concern are DDT and dieldrin.

Remedy: The cleanup of the upland portion of the Site consisted of removal of pesticide-contaminated soils followed by capping the property. The cleanup of the marine portion consisted of dredging contaminated sediments from Lauritzen Channel and Parr Canal in Richmond Harbor, followed by more than five years of post-remediation monitoring.

Source: The United Heckathorn Superfund Site is located in Richmond Harbor in Contra Costa County, California. The Site is an industrial area dominated by petroleum and shipping terminals. From 1947 to 1956, several operators, who are collectively called United Heckathorn, used the Site to formulate and package pesticides. No chemicals were manufactured on the Site. United Heckathorn would receive technical grade pesticides from chemical manufacturers, grind them in air mills, mix them with other ingredients such as clays or solvents, and package them for final use in liquid or powder formulations. Although many pesticides were handled at the Site, DDT accounted for 95% of its operations.

Monitoring: The remedy implemented at the upland area of the Site is protective of human health and the environment. The remediation goals for the marine area have not been maintained since the remedy was implemented. The first Five-Year Review Report (2001) concluded that the concentrations of DDT and dieldrin in the water and sediment did not meet cleanup goals based on four years of post-remediation monitoring. It recommended studies to determine the sources of the residual contamination. These source studies, as well as additional investigations, have been completed and the results are being used to prepare a focused feasibility study (FFS).

Recontamination: The remedy implemented at the marine area of the Site is not yet protective of human health and the environment because cleanup goals for DDT and dieldrin for water and marine sediments have not been maintained. As a result, these contaminants may accumulate in the tissues of edible marine organisms (e.g., fish, mussels), posing a potential risk to fish-eating birds, mammals, and fishermen and their families. Contaminated biota (e.g., fish) cannot be prevented from migrating to areas outside of the Site where they might be harvested and consumed by fishermen, birds, or wildlife. EPA also conducted a fish collection and analysis to update the current baseline information for the human health and ecological risks at the site in summer 2008. Concentration ranged from 28 to 11,000 ppb DDT and 10 to 550 ppb dieldrin in the fish caught in the Laritzen Channel. EPA issued an updated draft human health and ecological risk assessments in January 2010.

Reason for Recontamination: The Phase I study (2002) identified a hotspot of DDT-contaminated sediment beneath a pier, DDT-contaminated embankment soils near the former United Heckathorn facility, and a previously unidentified outfall pipe discharging into the intertidal zone of Lauritzen Channel. Phase II (2003) delineated the hotspot, investigated the depth to which bank soils were contaminated, and plugged the outfall discharge. Additionally, during sampling a buried outfall only visible during low tide was found that contains high levels of DDT.

Reference: Five-Year Review Report for United Heckathorn Superfund Site, Town of Richmond, Contra Costa County, California. September, 2001. 3737-00068. Second Five -Year Review Report for United Heckathorn Superfund Site, Richmond, California. 2006. CAD981436363.

Hyperlinks:
http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dec8ba3252368428825742600743733/809066aa6131970088257007005e9450!OpenDocument

http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/a37f776aa35aecc08825727b006e91f6!OpenDocument

Text Summary/Other Notes: First five-year review completed 2001. Second 5 year review completed in December, 2006. EPA Region 9 Superfund Site Overview web page at http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/vWSOAlphabetic?openview. Although confirmation sampling after dredging recorded DDT levels below the cleanup goal of 590 ug/kg, post-remediation monitoring (water, sediment and mussels) showed elevated levels of DDTs that greatly exceeded the cleanup goals. The latest round of data gap sampling for the purpose of the focused feasibility study took place in Summer2007. The Summer 2007 results showed the following: the sediment concentrations (in dry weight) of total DDT in the Young Bay Mud and surface sediment samples ranged from 6.7 ug/Kg to 88,830 ug/Kg and from 2.4 ug/Kg to 2800 ug/Kg of dieldrin. The sediment concentrations of total DDT in the Old Bay Mud varied from 1.1 ug/Kg to 37,600 ug/Kg for total DDTs and from 1.5 ug/Kg to 130 ug/Kg dieldrin. The total DDT in the embankment samples varied from 26.7 ug/Kg to 4,525 ug/Kg and the dieldrin concentrations varied from 4.1 g/Kg to 97 ug/Kg. mussel tissue (in wet weight): Total DDT and dieldrin concentrations in the Lauritzen Channel varied from 323.3 ug/Kg total DDT and 24 ug/Kg dieldrin to 1,268 ug/Kg and 81 ug/Kg.

Site Name: Clark Fork River (CRF) Superfund Site in Montana

Site Location: The CFR Superfund Site is part of the largest Superfund complex in the United States. It stretches for 200 kilometers from the confluence of Warm Springs Creek and Silver Bow Creek, just outside of Butte, to where the Milltown Dam once was just outside of Missoula.

Type of Contaminant: Mine waste – metals.

Contaminants: The main contaminants of concern are arsenic, cadmium, copper, lead, and zinc. However, the monitoring project focus is on cadmium and copper.

Remedy: The cleanup is ongoing and consists of containment (large berms constructed in 1989 and 1990), in situ treatment of soils (small demonstration projects), removal, and bank stabilization. All efforts thus far have been spatially restricted to the upper 45 km and targeted only the most contaminated river segments.

Source: Mining and processing of metal ores in the headwaters of Silver Bow Creek (Butte) and the upper CFR have taken place for more than a century. Large quantities of waste rock, tailings and slag (all referred to as tailings) rich in heavy metals were produced. It is estimated that 100 million tons of tailings were disposed of in Silver Bow Creek and the upper CFR between 1880 and 1982. Erosion, runoff, and large floods transported and dispersed tailings over 400 km downstream and into the contiguous floodplain of the CFR.

Monitoring: Since only the most contaminated segments of the CFR were being addressed, concerns of recontamination were not as much of a concern as downstream influence contaminant reduction based on the removals. The influence of remediation was assessed by using contaminants as a spatial transport marker to quantify the strength of spatial connectivity throughout the study reach approximately 190 km from the Silver Bow/Warm Springs confluence to the Milltown Dam (removed in 2009). The monitoring had three specific objectives: 1. Describe spatial and temporal trends for cadmium and copper; 2. Use sediment metals concentrations as a spatial marker of downstream transport - test remedy/removal assumption; and 3. Quantify the strength of local (small-scale) and regional (large-scale) connectivity to identify reach-specific zones that influence downstream stations.

Recontamination: Per the objectives, monitoring for recontamination is not the over-arching goal as much as monitoring for downstream contaminant reduction due to upstream contaminant source control. The study was conducted by the USGS and does not include a Five-Year Review process.

Reason for Recontamination: Not assessed/evaluated.

Reference: "Influence of Remediation in a Mine-impacted River: Metal Trends Over Large Spatial and Temporal Scales," Ecological Applications, 19(6), 2009, pp. 1522-1535, 2009 by the Ecological Society of America

Text Summary/Other Notes: Spatiotemporal analysis of a 19-year data set allowed for the measurement of the effects of remediation in a mine-impacted river. CFR remediation was found to positively influence downstream stations that are in close proximity to the remedial activities. Remediation of the most contaminated sites was proven to positively affect downstream stations. Long-term, large-scale monitoring is critical in systems heavily influenced by contaminants, especially in lotic systems where the redistribution of material is often dependent on hydrologic conditions.

Site Name: U.S. Army Corps of Engineers, Los Angeles County Regional Dredge Material Management Plan Pilot Studies, North Energy Island Borrow Pit (NEIBP)

Site Location: Los Angeles River Estuary sediment placed in the City of Long Beach and into an existing pit located in the inner harbor off the coast of Long Beach, CA. Google Earth 33o 45' 15" N, 118o, 09' 23.5"W.

Type of Contaminant: Elevated concentrations of metals and Polycyclic Aromatic Hydrocarbons (PAHs).

Contaminants: Inorganic elements and PAHs.

Remedy: 105,000 m3 of contaminated sediment were mechanically dredged from the Los Angeles Estuary in Long Beach, placed in an existing pit in the inner harbor off the coast of Long Beach, CA, and capped with 1 -1.5 meters of clean sand. It was barged to a large, pre-existing barrow pit located in Long Beach Harbor, where it was deposited.

Source: For the aquatic capping study (the subject of this report), 105,000 cubic meters (m3) of contaminated sediment were mechanically dredged from the mouth of the Los Angeles River Estuary (LARE) in the City of Long Beach. The dredge material was transported via split hull into a demonstration cell termed the North Energy Island Borrow Pit (NEIBP). After allowing the approximately 2.5 meter (m) layer of LARE material to consolidate in the disposal pit for three months, clean cap material was dredged from a second borrow pit –the NEIBP- and used to cover the LARE material with a 1.0m to 1.5m layer cap.

Monitoring: The capped site was monitored annually for three years to evaluate long-term stability of containment/isolation of the contaminated sediments, as well as biological re-colonization of the cap surface. Three years of intensive monitoring has shown that the cap has maintained its structural integrity. There has been no measurable erosion of cap material or fissures visible in the cap surface; rather, an accumulation of newly deposited material is now present, suggesting a rapid depositional process is at work. Chemical containment has also been maintained. In Year 2, core layer samples taken from 3 centimeters (cm) above the LARE material showed no evidence of either metals or PAH migration into the cap.

Recontamination: No. Elevated concentrations of contaminants have not been detected in overlying cap material or in the cap pore water at concentrations suggesting that contaminant migration is occurring. Biological re-colonization of the cap was rapid during the first two years of monitoring and maintained in Year 3.

Reason for Recontamination: Capping in this physical environment (behind outer harbor breakwater) appeared successful for these contaminants.

Reference: Los Angeles Regional dredged material management plan pilot studies, Los Angeles, California. Long-Term evaluation of aquatic capping disposal alternative. U.S. Army Corps of Engineers, Los Angeles District, 915 Wilshire Boulevard, Los Angeles, California 90017. September, 2005. The Los Angeles Contaminated Task Force Confined Aquatic Disposal Site
Long-Term Monitoring Program 2002 - 2003

Hyperlink: http://www.coastal.ca.gov/sediment/sdindex.html
http://www.coastal.ca.gov/sediment/NEIBP-CAD-9-2005.pdf
http://www.coastal.ca.gov/sediment/2002-2003CADSiteSummaryReport2.pdf

Site Name: St. Clair Shores

Site Location: St. Clair Shores, Macomb County, Michigan

Type of Contaminant: PCB oil

Contaminants: PCB

Remedy: Time Critical Removal Action is proposed in a February 2010 Memorandum.

Source: The St. Clair Shores Site is located northeast of Detroit in the City of St. Clair Shores, Macomb County, Michigan. The site is located in an urban area under investigation and a time critical removal action is underway by EPA Region 5. Michigan is in the process of nominating the site to the NPL. A removal action was performed in 2003 by EPA. Additional sampling performed by the City of St. Clair Shores and Michigan Department of Environmental Quality found high levels of PCBs in water and storm sewer sediment samples. The source of PCBs to the storm sewer has not been identified. PCB oil has been found in the storm sewer at concentrations up to 800,000 parts per million. Further investigation is underway.

Monitoring: The remedy has not been implemented at this site (2010). However, a removal action was performed on sediments from a canal that receives discharge from the storm sewer system. Monitoring in the storm sewer system indicates an ongoing source condition (800,000 ppm PCB oil).

Recontamination: The site has an ongoing source that is being investigated. Ongoing sources of PCBs have the potential to recontaminate sediments in the canal. Contaminants may eventually migrate to Lake St. Clair through the canal.

Reason for Recontamination: Newly discovered PCB oil in the storm sewer system is causing recontamination to the canal, which was dredged. Investigations are planned to identify the source, which has not been controlled.

Reference: USEPA Action Memorandum 2010, St. Clair Public Meeting Presentation Dec 2009, City of St. Clair Shores Ten Mile Drain Investigation (web site).

Site Name: Sangamo-Weston/Twelvemile Creek/Lake Hartwell Superfund Site

Site Location: Lake Hartwell, Pickens County, South Carolina

Type of Contaminant: PCBs

Contaminants: PCBs

Remedy: Natural recovery (aka natural capping).

Source: Releases from Sangamo-Weston plant, including land burial of capacitors and sludge, and effluent discharge.

Monitoring: Age-dated sediment cores analyzed for PCBs, largemouth bass, and hybrid bass filet monitoring. This was a modeling paper.

Recontamination: In the surface sediment, no, though possibly in fish tissue.

This was a modeling paper, but offers reasons as to why fish tissue levels have not declined.

Reason for Recontamination: For fish, other mechanisms other than surface sediment concentrations appear to be influencing tissue concentrations.

Model predicted that PCBs in bass come primarily from diet (*Chaoborus* invertebrate and shad). Contamination in shad and *Chaoborus* is mostly via their diets both which are dominated by Daphnia. Daphnia receives its contamination via die - detritus and algae. Thus a dominant pathway of PCB loading to the system was via transfer of PCBs from detritus into the food web. Model could not reproduce sharp increases; and these may be due to irregular flushing of sediment collected behind upstream dams. The paper also stated that the concentrations of PCB in input detritus to Lake Hartwell is largely unknown, and quantifying the amount, toxicity, and timing of input detritus is critical to the understanding of the current system dynamics.

Reference: Brenner, R.C., V.S. Magar, J.A. Ickes, E.A. Foote, J.E. Abbott, L.S. Bingler, and E.A. Crecelius. 2004. Long-Term Recovery of PCB-Contaminated Surface Sediments at the Sangamo-Weston/ Twelvemile Creek/Lake Hartwell Superfund Site. Environmental Science and Technology. 38(8):2328-2337.

Rashleigh, B., M.C. Barber, and D.M. Walters. 2009. Foodweb modeling for polychlorinated biphenyls (PCBs) in the Twelvemile Creek Arm of Lake Hartwell, South Carolina, USA. Ecological Modelling 220(2): 254-264.

Hyperlink:
http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235934%232009%23997799997%23742052%23FLA%23&_cdi=5934&_pubType=J&_auth=y&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=9a8ecece0b250c5c9102c6d03ebd0f86

Text Summary/Other Notes: PCB use stopped in 1977. Surface sediment layers generally meet the 1 mg/kg t-PCB requirement in the ROD. Ten years of fish filet monitoring between 1992 and 2002 indicate that fish tissues have not responded to the reduction in surface sediment concentrations and continue to exceed the 2.0 mg/kg FDA fish tolerance level.

Largemouth bass tissue concentrations have remained elevated. The USEPA AQUATOX model was used to better characterize foodweb dynamics that lead to biomagnification of PCBs. Model predicts bass tissue levels to be below the 2 ppm goal in 2011.

Site Name: Wyckoff/Eagle Harbor Superfund Site

Site Location: Bainbridge Island, Washington

Type of Contaminant: PAHs, creosote

Contaminant: PAHs

Remedy: 1993/1994 site partially capped; 2000/2001 sheet pile wall constructed adjacent to facility and area adjacent to facility capped with 3-10 feet of clean sand (after this study); natural recovery not indicated as a specific remedy.

Source: 1900s-1998 releases of creosote from Wyckoff wood treatment facility.

Monitoring: Age-dated sediment cores analyzed for PAHs and TPH. This study collected cores outside of the cap.

Recontamination: Some.

Reason for Recontamination: Some surface and near surface sediments dominated by a strong urban runoff signature at PAH concentrations far below (approximately 50 mg/kg for urban runoff and approximately 7,000 to 21,000 mg/kg for weathered creosote). Surface sediments with slightly weathered creosote concentrations attributed to creosote seeps and vertical contaminant migration.

Reference: Brenner, R.C., V.S. Magar, J.A. Ickes, J.E. Abbott, S.A. Stout, E.A. Crecelius, and L.S. Bingler. 2002. Characterization and FATE of PAH-Contaminated Sediments at the Wyckoff/Eagle Harbor Superfund Site. Environmental Science and Technology. 36(12):2605-2613.

Text Summary/Other Notes: There is a statement that the uniform vertical concentration profiles in some areas show no indication that PAH concentrations are dissipating and suggests that urban runoff PAHs are likely to continue to contaminate harbor sediments. There was no evidence that sediments near the site were being covered by clean uncontaminated sediments since the most recent deposits were impacted by contributions of weathered creosote and urban runoff.

Site Name: Portland Harbor Superfund Megasite and the McCormick and Baxter Superfund site

Site Location: Lower Willamette River, Oregon

Type of Contaminant: PAHs, creosote, and coal tar.

Contaminant: PAHs

Remedy: 23 acre sand and organoclay cap and articulated concrete block at MB Superfund site placed in 2004 over creosote contaminated sediment including NAPL hot spots; dredging of submerged coal tar (over 11,500 m3 of coal tar removed) at the Portland Harbor site in 2005.

Monitoring: From 2002–2006, semi-permeable membrane devices (SPMDs) deployed in river for 14 or 21 days and analyzed for PAHs.

Recontamination: Not for MB site; yes for Portland Harbor. SPMDs pre-and post-capping for MB revealed a decrease in sum dissolved PAH concentrations from an average of 440 (+/- 422) ng/L to 8 (+/- 0.5) ng/L. At PH, SPMDs showed significant higher mean concentrations during tar removal, and concentrations increased again in dry weather after removal.

Reason for Recontamination: Dredging readily desorbed PAHs and increased dissolved fraction of carcinogenic PAHs as measured by SPMD. Later dry season increase at one location speculated to be a result of bank storage. During high flows, the higher hydraulic pressure from the river "traps" contamination that is released during low flow. The report states that filling banks with PAH-laden asphalt was a common local practice.

Reference: Sower, G.J., and K.A. Anderson. 2008. Spatial and Temporal Variation of Freely Dissolved Polycyclic Aromatic Hydrocarbons in an Urban River Undergoing Superfund Remediation. Environmental Science and Technology. 42(24):9065-9071.

Text Summary/Other Notes: Sum PAH concentrations associated with PH site (all ng/L): Pretar removal (360 +/-100 wet and 1620+/-1370 dry); Tar removal (2610 +/-360 wet and 3200+/-380 dry); post-tar removal (160 +/-130 wet and 1870+/-90 dry).

Site Name: Marine Fjord

Site Location: Haakonsvern Naval Base, Norway

Type of Contaminant: PCBs

Contaminant: PCBs

Remedy: Sediments dredged by vacuum cleaning in 1998.

Monitoring: Semi-permeable membrane devices (SPMDs) and blue mussels analyzed for PCB congeners.

Recontamination: Dredging reduced sediment concentrations of PCB by 90%, but PCB levels in mussels increased during and after dredging and still no decrease after 6 months. Similar results for SPMDs. Mussel concentrations (dry wt) ranged from 40 ng/g in the low contaminated area to 400 ng/g in the highly contaminated area.

Reason for Recontamination: Primarily, that PCBs are accumulated in the water column.
1) Due to low solubility of PCBs in water, possible that a decrease in sediment concentration would leave the water concentrations unchanged; 2) Removal of fine organic sediments may play a role since seabed with coarse inorganic materials has lesser ability to bind PCBs;
3) Dredging may whirl up fine contaminated particles that settle to bottom, producing a thin contaminated sediment layer that determines the water concentration; 4) Bioaccumulation in blue mussels and SPMDs occurs mostly from PCBs in the water column and the water column concentrations were unchanged after dredging.

Reference: Voie, O.A, A. Johnsen, and H.K. Rossland. 2002. Why biota still accumulate high levels of PCB after removal of PCB contaminated sediments in a Norwegian fjord. Chemosphere. 46(9-10): 1367-1372.

Site Name: Lake Jamsanvesi

Site Location: Central Finland

Type of Contaminant: Creosote, PAHs

Contaminant: PAHs

Remedy: 0.5 ha area capped with a filter geotextile (polypropylene), and gravel and sand (1-1.5 m). This was spread out on ice and allowed to sink to the bottom when the ice melted.

Source: Use of creosote at impregnation plant.

Monitoring: Duck mussels sediment collectors (settled particulate matter) deployed upstream and downstream of cap (and plant) and analyzed for PAHs.

Recontamination: Maybe.

Reason for Recontamination: Concentrations of some PAHs were distinctly increased adjacent to the remediated area. When capping material was sunk to the bottom, it may have caused an agitation of the contaminated sediment or there may have been re-suspension of unremediated sediment.

Reference: Hyötyläinen, T., A. Karels, and A. Oikari. 2002. Assessment of bioavailability and effects of chemicals due to remediation actions with caging mussels (Anodonta anatina) at a creosote-contaminated lake sediment site. Water Research. 36(18): 4497-4504.

Hyperlink: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V73-4607Y74-J&_user=10&_coverDate=11%2F30%2F2002&_rdoc=8&_fmt=high&_orig=browse&_srch=docinfo(%23toc%235831%232002%23999639981%23339446%23FLA%23display%23Volume)&_cdi=5831&_sort=d&_docanchor=&_ct=27&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=d3214eb25461eab45364b0a62f95afa9

Text Summary/Other Notes: Whole body Total PAH concentrations of mussels (ug/g dw) upstream ranged between 9.1 - 12.9 depending on the lipid extractions treatment whereas concentrations immediately downstream of the capped area ranged between 114-146 ug/g dw. Further downstream concentrations ranged between 25.2-31.6 ug/g dw.

Site Name: Lauritzen Canal

Site Location: San Francisco Bay, California, inner Richmond Harbor area

Type of Contaminant: DDT and dieldrin

Contaminant: Sum DDT and dieldrin, also PAHs

Remedy: About 100,000 metric tons of sediment was removed from the channel. The area was capped with 15 to 46 cm of clean sand.

Source: United Heckathorn, a pesticide formulator.

Monitoring: One year after dredging, monitoring included 48-hr sediment toxicity tests using embryo-larval development of the mussel *Mytilus galloprovincialis* and 10-d amphipod (*Eohaustorius estuarius*) survival test, bioacummulation tests using mussels, benthic community analysis, and bulk sediment chemical analysis.

Recontamination: Maybe; mixed results.

Reason for Recontamination: Reasons were speculated. These include: incomplete removal where the clamshell dredge was not effective; new contamination from surface runoff, storm water pipes, dredge material dewatering, recontamination by the adjacent marine environment, recontamination from polluted groundwater. Source of PAHs unknown but there are industrial activities in the channel area. Post remediation grain size distributions of sediments indicate fine-grained sediments even though the channel was capped with sand. Finer grain sediments have settled in the channel and sources may include resuspended material from dredging of the adjacent Santa Fe Channel, slumping of sediments from the undredged margins of Lauritzen Channel, and material deposited from the dredging vessels that are stored in the channel.

Reference: Anderson, B.S., J.W. Hunt, B.M. Phillips, M. Stoelting, J. Becker, R. Fairey, H.M. Puckett, M. Stephenson, R.S. Tjeerdema, and M. Martin, M. 2000. Ecotoxicologic change at a remediated superfund site in San Francisco, California, USA. Environmental Toxicology and Chemistry 19(4):879-887.

Hyperlink: http://www3.interscience.wiley.com/journal/122672246/abstract

Text Summary/Other Notes: Survival of amphipods was considerably lower in post-remediation sediments; development of biovalve embryos declined. Post-remediation concentrations of OC-normalized sum DDT were still relatively high (2637 - 53.18 ug/g OC) and were 75-28% of pre-remediation concentrations. Post-remediation concentrations of chlorinated pesticides declined in mussels. PAH and PCB concentrations were higher in all post-remediation samples.

Site Name: Ostrich Bay

Site Location: An arm of Dyes Inlet on Puget Sound, Washington; an operable unit of the Jackson Park Housing Complex/Naval Hospital-Bremerton CERCLA site.

Type of Contaminant: Ordnance and nitroaromatic compounds, mercury, and some SVOCs.

Contaminants: Ordnance and nitroaromatic compounds, mercury, and some SVOCs.

Remedy: No remedy yet. Study concluded that none of the remedial alternatives (natural recovery, cover of dredged material, sediment cap) would meet federal/State criteria of permanence or long-term effectiveness under present depositional conditions.

Source: Naval ordnance formulation facility from World War I.

Monitoring: Echinoderm larvae total effective mortalities in fine-grained sediment of Ostrich Bay and Dyes Inlet were elevated over reference responses and exceeded the regulatory standard of 38.9% response. Ordnance compounds were not detected. Mercury was detected in excess of criterion of 0.42 mg/kg (range of 0.54-1.4 mg/kg in Ostrich Bay). Mercury concentrations only weakly correlated with toxicity tests.

Recontamination: Yes.

Reason for Recontamination: Fine-grained sedimentary material deposits throughout the Dyes Inlet/Ostrich Bay system from unknown sources and will prevent natural recovery and negate long-term effectiveness of active remedy.

Reference: Pascoe, G.A., P. McLarenb, and M. Soldatec. 2002. Impact of off-site sediment transport and toxicity on remediation of a contaminated estuarine bay. Marine Pollution Bulletin 44(11): 1184-1193.

Hyperlink: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V6N-475RF8W-3&_user=10&_coverDate=11%2F30%2F2002&_rdoc=5&_fmt=high&_orig=browse&_srch=doc-info(%23toc%235819%232002%23999559988%23365474%23FLA%23display%23Volume)&_cdi=5819&_sort=d&_docanchor=&_ct=20&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=52bf65ed902ac3bf54df3f40409c95a2

Text Summary/Other Notes: Net sedimentation and sediment transport in Ostrich Bay were evaluated. Fine-grained material is transported and deposited into Ostrich Bay and there is no erosion or removal from the bay.

APENDIX B
Case Studies

CASE STUDY NO. 1

Site Name: Thea Foss Waterway Cleanup, Tacoma, Washington

Location: Commencement Bay, Puget Sound

Site Description: In 1983, the U.S. Environmental Protection Agency (EPA) identified the Thea Foss Waterway as part of the larger 12-acre Commencement Bay Nearshore/Tideflats Superfund Site in the City of Tacoma, Washington. This waterway has been heavily industrialized for more than 100 years. Prior to regulations, industries dumped waste and raw sewage into the waterway. This practice led to the accumulation of more than one million cubic yards of contaminated sediment.

Contaminants: Phthalates, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phenols, metals and pesticides.

Summary of Remediation: In 1994, the City of Tacoma began developing a cleanup plan and investigated the sources and extent of contamination in the Thea Foss Waterway. This included hundreds of sediment samples from various depths and extensive chemical and biological tests. Based on the results of those tests, along with navigational uses of the waterway, cleanup options were developed. The City cleaned up 80 percent, an area extending from near the State Route (SR) 509 Bridge to the mouth of the waterway. Two utility companies (Utilities) cleaned up the other 20 percent, an area extending just north of the SR 509 Bridge to the head of the waterway. Beginning in 2002, about 425,000 cubic yards of contaminated sediments were dredged and placed behind a containment berm. Other areas of the waterway were capped with clean sediments (Figure 1).

Figure 1: Thea Foss Waterway cleanup design.

The cap in the head of the waterway was completed by the Utilities in 2004, and in that same year recontamination of the sediment surface on top of the cap was discovered north of the SR 509 Bridge. The cause of the recontamination was determined to be dredging of contaminated sediment by the City in an area directly north of the Utilities' completed cap. In December 2005, additional cap material was placed by the City in the northern section of the head of the Thea Foss Waterway to address recontamination of the cap.

Modeling was conducted during remedial design, which predicted that the average post-remediation PAHs and bis-2-ethylhexyl phthalate (BEHP) concentrations would exceed cleanup standards established by EPA. The modeling also predicted that the BEHP concentrations would level off over time. Operation, Monitoring and Maintenance Plan (OMMP) Year 2, 3, and 4 post-cleanup monitoring (2006, 2007, and 2008, respectively) results confirmed that BEHP had recontaminated the cap at the head of the waterway (Figure 2).

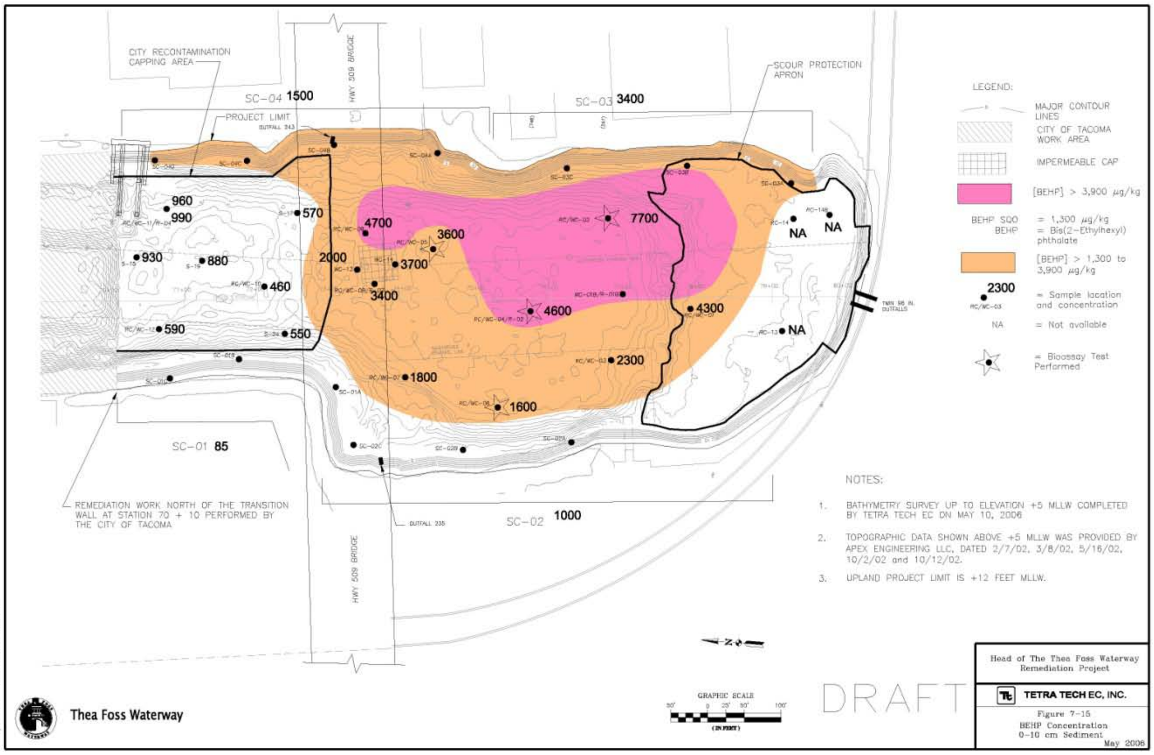


Figure 2: BEHP recontamination in the Thea Foss Waterway.

In response to the recontamination, the OMMP required specific next steps:

- Evaluate biological toxicity response to the BEHP chemical exceedances.
- Evaluate the probable cause of the BEHP exceedance.
- Consider the need for additional sampling to either define nature and extent or to determine the source.

The agreed upon approach included additional monitoring as part of Year 3 OMMP activities:

- Collect samples from compliance monitoring interval (0-10 cm) from sample stations in head of waterway (WC-01 thru WC-09 and WC-13 & WC-14).
- Analyze for phthalates and PAHs.
- Evaluate whether BEHP concentrations are continuing to rise or if concentrations are leveling off (or dropping).

The head of the Thea Foss Waterway has two 96-inch stormwater pipes (Twin 96ers) continuously discharging untreated residential stormwater and untreated and treated industrial stormwater. There are several other stormwater discharge pipes, but it was determined that the main source of BEHP at the head of the waterway is the ongoing, untreated stormwater from the Twin 96ers.

On a parallel track with the Thea Foss Superfund cleanup, the cities of Tacoma and Seattle, King County, Washington State Department of Ecology, and EPA put together a team in 2006 to better understand how phthalates reach Puget Sound sediments and the related impacts to humans and animals. The Sediment Phthalate Work Group goal was to summarize and evaluate existing information on phthalates sediment contamination issues, identify data gaps, and provide recommendations to address phthalate sediment contamination for regulatory agencies and the community to consider. An outcome of the group's work was the recognition that phthalates reach sediments via a complex pathway involving off-gassing to the air from plasticized polyvinyl chloride (PVC) products, followed by attachment to airborne particulates, deposition to the ground and transport to sediments through stormwater. The Work Group recommendation, presented to Washington's Department of Ecology in 2007, addressed the following general areas of potential action:

- Further study to identify other contaminants that follow pathways similar to phthalates.
- Interaction with other agencies to address the air to stormwater to sediment pathway.
- Evaluation and implementation (where appropriate) of stormwater source control and treatment options.
- Management of phthalate recontamination at cleanup sites through site-specific operation and monitoring plans.
- Consideration of a Sediment Management Standard rule amendment to address phthalates and other pervasive pollutants.

Year 4 (2008) core sampling in the Thea Foss Waterway indicated that there was no evidence of bottom-up recontamination and that the cap was performing as designed. The Year 4 monitoring report concluded that recontamination is from top-down sources, primarily from stormwater outfalls in the head of the waterway.

The 12/23/09 Five Year Review for the Site concluded the following:

> *The remedy at Thea Foss Waterway currently protects human health and the environment because the sediment remedial action significantly reduced sediment concentrations and most of the required institutional controls are in place to protect the integrity of the sediment cap. However, in order for the remedy to be protective in the long-term, additional source control activities need to be identified and implemented to reduce the extent of recontamination in the waterway and the Unite States Coast Guard (USCG) institutional control needs to be completed to help protect the long-term integrity of the sediment cap. Recommendations were to continue to monitor and evaluate sources of phthalates and PAHs to sediments.*

Lessons Learned:

- Source control, ideally completed prior to sediment remediation, is very important in minimizing cap recontamination. At this site, on-going stormwater contaminants appear to be a recontamination issue.

- Source control for a stormwater drainage basin is actually a matter of developing an integrated watershed management plan based on the following:
    - rigorous cross-agency and cross-program coordination, which in this case yielded a much stronger understanding of the sources and pathways of contamination, and
    - monitoring which correlates to the cleanup in the receiving environment (water and sediment quality).

Sediment remediation construction should be coordinated and sequenced with planned or potential construction activities in the area that could cause contamination of the sediment cap by suspending contaminated sediment. In this case, it appears that a nearby in-water construction project occurred within one year after the cap was installed.

References:

TETRA TECH EC, INC. September 2009. *Results of Year 5 Operations, Maintenance, and Monitoring Plan Sampling, Head of the Thea Foss Waterway Remediation Project.*

http://yosemite.epa.gov/r10/CLEANUP.NSF/sites/Thea/$FILE/thea_util_y5_ommp.pdf

Related Links:

http://yosemite.epa.gov/R10/CLEANUP.NSF/sites/thea

CASE STUDY NO. 2

Site Name: Fields Brook Superfund Site, Ashtabula County, Ohio

Site Description: The Fields Brook Site is located in northeast Ohio, in Ashtabula County, approximately 55 miles east of Cleveland, Ohio (Figure 1). Fields Brook drains a six square-mile watershed. The eastern portion of the watershed drains Ashtabula Township and the western portion drains the eastern portion of the City of Ashtabula. The main channel is 3.9 miles in length and flows to its confluence with the Ashtabula River. Fields Brook first flows through an industrialized area and next flows through undeveloped and residential areas in the City of Ashtabula near the confluence. Fields Brook discharges to the Ashtabula River approximately 8,000 feet upstream from Lake Erie.

The Fields Brook Site is a complicated site with many operable units and has had two five-year reviews completed by the U.S. Environmental Protection Agency (EPA).

Contaminants: Polychlorinated biphenyls (PCBs), radionuclides, chlorinated benzene compounds, chlorinated solvents, hexachlorobutadiene, polycyclic aromatic hydrocarbons (PAHs), arsenic, other hazardous substances.

Size/Area of Site: The main channel of the Fields Brook is 3.9 miles.

- Operable Unit 1 - Sediment Fields Brook and tributaries; remedial action completed September 30, 2003.
- Operable Unit 2 - Known as the Source Control Operable Unit (OU), expanded OUs 5 – 10 for facility specific design and enforcement.
- Operable Unit 3 - Ashtabula River Area of Concern, contaminated sediments have been addressed outside of the Superfund process under the Great Lakes Legacy Act program.
- Operable Unit 4 - Floodplains and wetlands contaminated soils and floodplain sediments within the 100-year floodplain; remedial action completed September 30, 2003.
- Operable Unit 5 - Detrex Corporation, dense non-aqueous phase liquid (DNAPL) extraction system operating and expanded in 2004. EPA has drafted an Explanation of Significant Difference (ESD) for Detrex to add extraction wells and extend an existing slurry wall an additional 300’ to completely contain the source area from the brook.
- Operable Unit 6 - Millennium $TiCl_4$ Plant; remediation completed June 28, 2000. Additional PCB DNAPL was discovered in 2007 during a bridge reconstruction project. Contaminated soils were removed. Adjacent to Millennium, Field Brook was realigned and then lined with an engineered structure. Completed in July 2009.
- Operable Unit 7 - North Sewers; Remediation completed May 14, 2001.
- Operable Unit 8 - Acme Scrap Iron and Metal/South Sewers; remediation completed March 17, 2003.
- Operable Unit 9 - Conrail Bridge Yard; remediation completed April 17, 2000.
- Operable Unit 10 - RMI Metals Property; remediation completed September 10, 2002.

Volume of Contaminated Sediments: Estimated 52,000 cubic yards of sediment in the Record of Decision. Explanation of Significant Difference (ESD) was issued based on pre-design studies and reduced the estimated excavated sediment volume to 14,000 cubic yards. The discovery of the presence of radium led to the modification of the original remedy to include it in the cleanup goals. During sediment excavation a layer of liquid DNAPL was discovered and led to another ESD. At completion, 53,000 cubic yards of contaminated sediment and floodplain soil were removed from Fields Brook. Approximately 25,000 additional cubic yards of PCB-contaminated soil was removed by Millenium in a 2009 removal action.

Ecological System(s) Impacted: Fish uptake due to bioaccumulation of PCBs.

Human Health Risk(s): A State Fish Consumption Advisory has been in place for the section of the Ashtabula River that includes the mouth of Fields Brook since 1983. In 1998 and 2004, the fish advisory was revised to address updated information for PCBs and mercury for a variety of species. Fishing in the upstream portions of Fields Brook is not considered a significant risk pathway due to the small size and lack of access.

A few selected exceedances of health-based cleanup standards for PCBs and chlorinated solvents in industrial use areas of soils and sediment were detected. However, EPA believes that there are not complete pathways of human exposure likely to cause unacceptable risk because many of the exceedances are not located at the surface; all are located in industrial-use areas; and they are not an acute hazard. Therefore, EPA has made the determination in the Second Five-Year Review that human exposures currently remain under control. However, additional work is necessary to assure that human exposure remain under control for the long term.

Summary of Remediation: The remedies for the Fields Brooks Superfund Site in Ashtabula County, Ohio, included the removal of contaminated sediment and floodplain soil from Fields Brook. The contaminated sediment and soils were thermally treated; disposed of in an on-site landfill; or shipped off-site. In addition, remedial actions were implemented at six (6) separate source control operable units to prevent these industrial properties from contributing additional contamination to the brook. Recontamination was evaluated early in the remedial investigation and during the remedial action. The presence of PCB DNAPL in the sediments led to the issuance of an ESD, and the uncertainty over the geologic containment of the Detrex source area led to the issuance of another ESD in 2011.

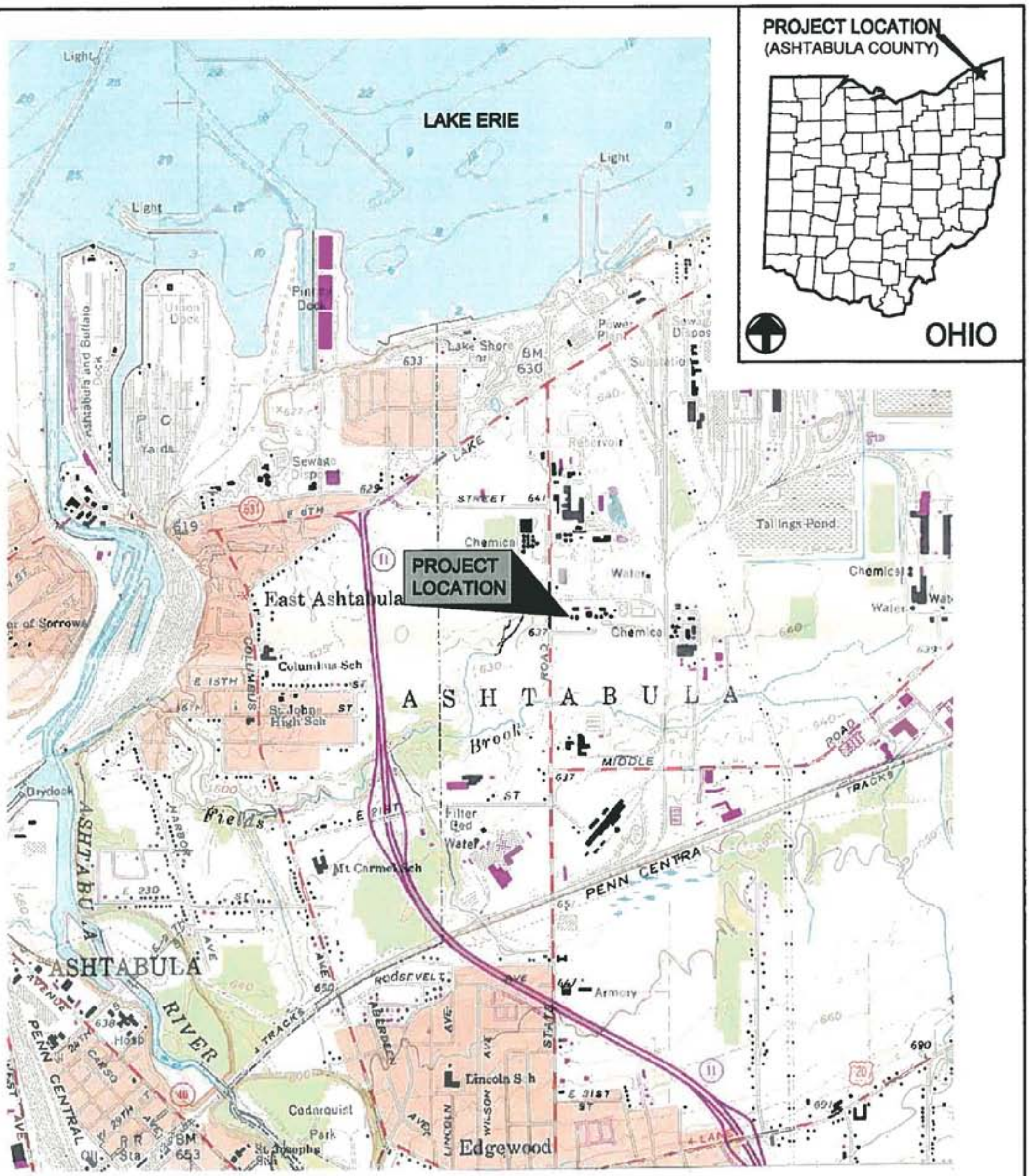
Lessons Learned:

- Sediment cleanup also included radionuclide cleanup goals.
- Source control was treated as its own operable unit and divided further to address facility specific cleanup and enforcement activities.
- When additional sources of contamination to Fields Brook were identified, the remedy was modified to address the newly discovered source.

References:

USEPA First Five-Year Review Report for the Fields Brook Superfund Site, Ashtabula, Ohio, June 2004.

USEPA Second Five-Year Review Report for the Fields Brook Superfund Site, Ashtabula, Ohio, June 2004.



UNITED STATES GEOLOGICAL SURVEY
1:24,000 QUADRANGLE
ASHTABULA NORTH, OHIO
1960 PHOTO REVISED 1970
PHOTOINSPECTED 1978

0 1000 2000
SCALE: 1"=2000'

URS

DETREX CORPORATION

ASHTABULA, OHIO

PROJECT SITE LOCATION MAP

DRAWN BY:	CHECKED BY:	PROJECT No:	DATE:	FIGURE No:
YRC	MLS	13811443	1/18/10	1

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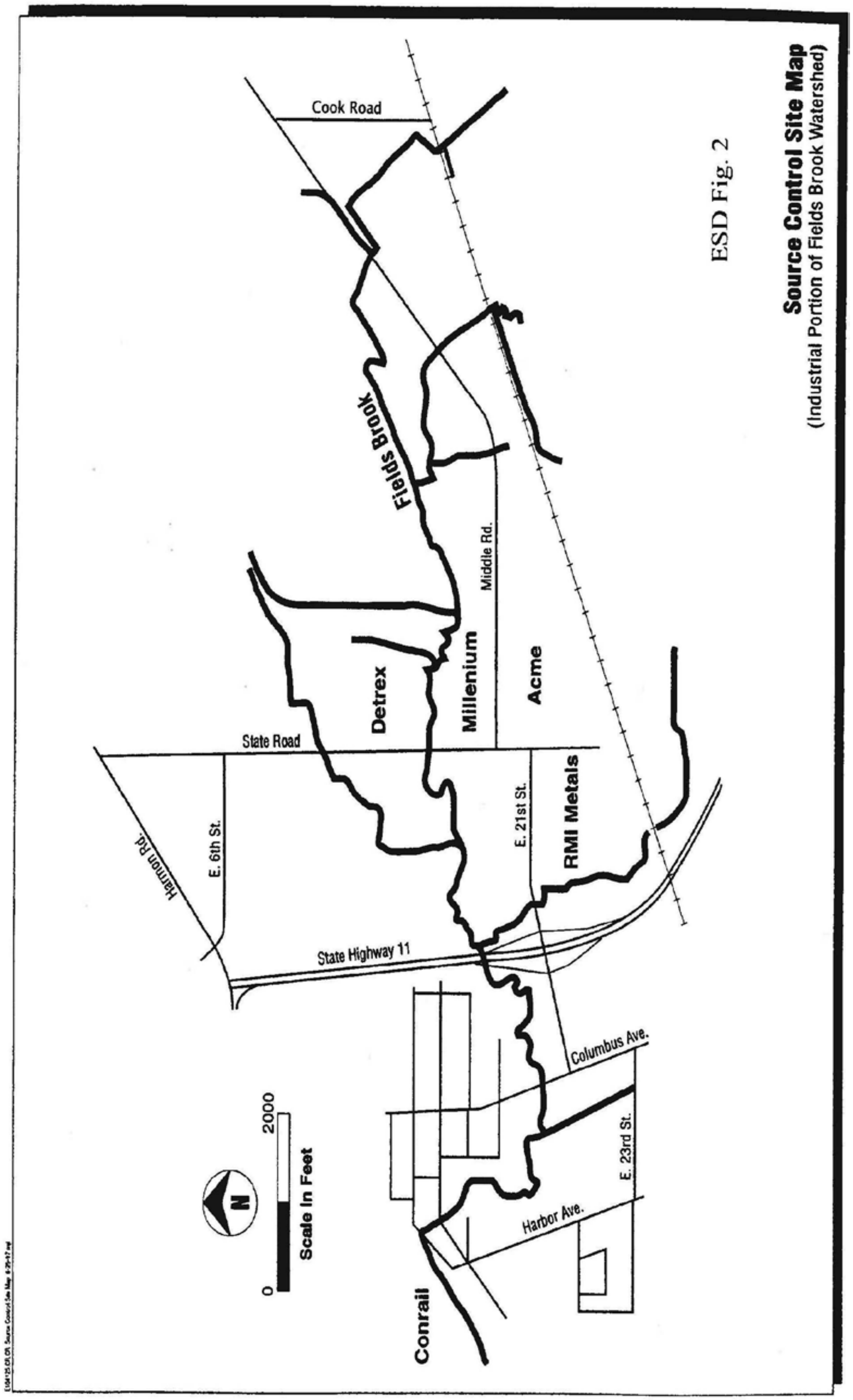


ESD Fig. 2

Source Control Site Map
(Industrial Portion of Fields Brook Watershed)

CASE STUDY NO. 3

Site Name: Cumberland Bay Sludge Bed, State Superfund Site, Plattsburgh, New York

Site Description: The Cumberland Bay Sludge Bed Site included underwater and shoreline wetland areas within and along the northwestern portion of Cumberland Bay in Lake Champlain that contained accumulations of contaminated sludge. The sludge bed was composed of wood pulp, wood chip debris, fine organic matter, and other processing wastes that were discharged from local wood product industries (sawmills, wood chip producing industries, and paper manufacturing and processing industries). Records show that the wastes either settled or were directly discharged in this area for several decades. The untreated waste disposal ended in 1973.

Environmental sampling determined that the sludge was impacted with polychlorinated biphenyls (PCBs) and other types of contamination. The PCB levels were the highest (up to 13,000 milligrams per kilogram (mg/kg)) in the layers or beds that contain cellulose wood pulp or fine wood debris. Contaminated wood chip debris was readily suspended by wave action or boats and typically washed up along the shoreline. Sampling and analysis detected PCB concentrations as high as 210 mg/kg in the wood chip debris washing up on shore and nearby bathing beaches. PCBs have generally been measured as total Aroclors.

The Record of Decision was signed in 1997 for the removal of the sludge bed. The Remedial Action began in April 1999 and dredging was completed in October 2000. A five-year review was completed in 2007.

Contaminants: PCBs with sediment concentrations up to 13,000 mg/kg (prior to remediation).
Other contaminants (within the sludge bed materials) included phthalates, polycyclic aromatic hydrocarbons (PAHs), polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These other contaminants were present at concentrations typical of paper sludge but below current action levels.

Size/Area of Site: Approximately 34 acres.

Volume of Contaminated Sediments: Removal included 195,000 cubic yards of sediments dredged, and 37,000 cubic yards of contaminated shoreline soils removed in the wetlands and near shore area. Remediation removed an estimated 20,000 pounds of PCBs. Sediment sampling performed post-remediation estimates the average sediment PCB concentrations to be 1.5 mg/kg.

Ecologic System(s) Impacted: Bioaccumulation of PCBs in fish.

Human Health Risk(s): The direct contact with PCB-contaminated wood chips that washed up onto public and private beaches was identified as an exposure concern before and after dredging was performed. This led to the removal of PCB-contaminated wood chips from the beaches up until 2006. No significant wood chip material was found in 2007 and cleanup was not necessary from 2008 through 2011.

The fish consumption advisory for Cumberland Bay is still in place and the commercial sale of yellow perch is banned. However, the PCB concentrations in fish have continued to show a decline following dredging.

Summary of Remediation: The remedial dredging project for the Cumberland Bay Sludge Bed began in April 1999 and continued until late October of 2000. Post-remediation sediment sampling was conducted in the summer and fall of 2000 to confirm the effectiveness of the dredging operation. Only a few samples exceeded 10 mg/kg, and the overall average concentration was about 1.5 mg/kg total PCBs.

Baseline monitoring was performed in April 1999 prior to commencement of remediation. The post-remediation monitoring plan assessed PCB concentrations in fish tissue, surface water and zebra mussels following remediation. More than five years of annual monitoring have been completed and the results have shown a consistent downward trend.

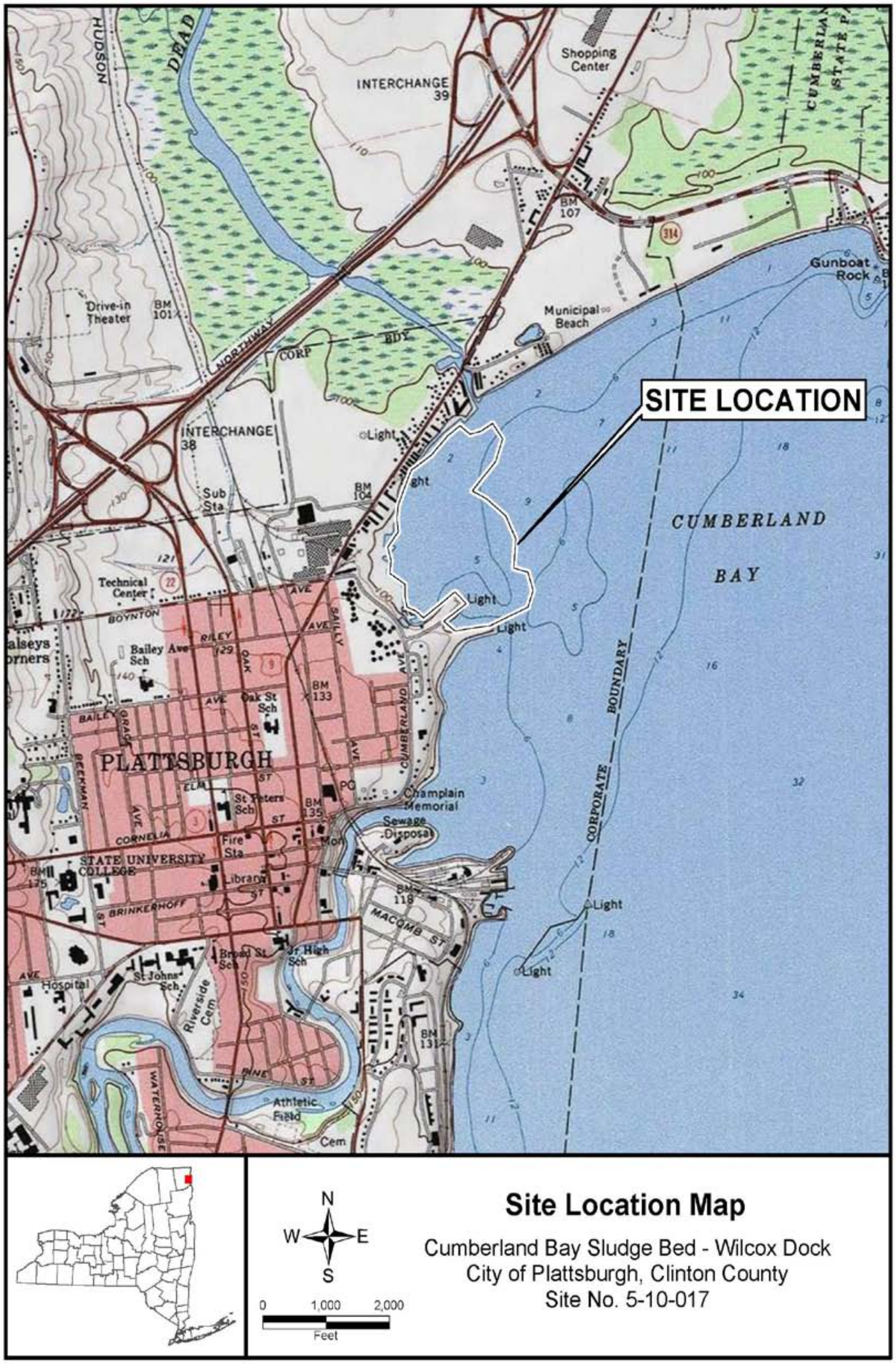
Lessons Learned:

- Confirmatory sediment samples were collected immediately after the dredging. Only sediment samples with wood sludge were analyzed for PCBs because samples that contained only sand were assumed to be clean. This represents a data gap. More complete confirmatory sampling for PCB concentrations in sediment should have been performed to determine post-remedy sediment concentrations and to facilitate comparison to pre-remedial sediment concentrations.

- PCB fish tissue sampling and analysis is important to assessing the effectiveness of dredging and issuing/revising fish consumption advisories. Tissue monitoring of multiple fish species is an important tool for evaluating long-term trends and variations.

References:

Earth Tech. 2007. Cumberland Bay Sludge Bed Removal and Disposal Project Pre- to Post-Dredging Monitoring. Five-Year Review. April 2007.



Site Location Map

Cumberland Bay Sludge Bed - Wilcox Dock
City of Plattsburgh, Clinton County
Site No. 5-10-017

CASE STUDY NO. 4

Site Name: Pier 53-55, Seattle, Washington
Pier 64-65, Seattle, Washington

Site Description: In March 1992, contractors for the U.S. Army Corps of Engineers (the Corps) completed a 3-foot sediment cap and 1-foot Enhanced Natural Recovery (ENR) area off-shore of Pier 53-55 in Elliott Bay on Seattle's downtown waterfront (Figure 1). The capping was performed on 4.5 acres of chemically contaminated bottom sediments. This action took place after four years of study and planning by the following agencies: the City of Seattle Department of Engineering, the King County Department of Natural Resources and Parks (KCDNRP) (formerly the Municipality of Metropolitan Seattle, or Metro), the Washington State Department of Ecology (Ecology), the Washington State Department of Natural Resources (DNR), the Washington State Department of Fisheries, the Corps, and the U.S. Environmental Protection Agency (EPA).

The second capping project along Seattle's waterfront project was installed in 1994 near Pier 64-65. This cap covered 4 acres with a thickness of one to two feet of sand.

The monitoring program for each of the sites occurred over ten years and it was designed to determine if the caps isolated the underlying contamination, resist erosion, become recolonized by organisms, and document recontamination of surface sediments.

Contaminants: Polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), bis(2-ethylhexyl) phthalate (BEHP), copper and lead for Pier 53-55. PAHs for Pier 64-65.

Size/Area of Site: 4.5 acres for Pier 53-55; 4 acres for Pier 64-65.

Volume of Contaminated Sediments: Unknown.

Ecological System(s) Impacted: Not described.

Human Health Risk(s): Not available.

Summary of Remediation:

Pier 53-55

The remedy involved placement of 22,000 cubic yards of clean sand to cap 4.5 acres of chemically contaminated bottom sediments. The thickness of the capping material varied in the capped areas, which included a 3-foot thick and a 1-foot thick ENR area.

Increases in sediment concentrations of PCBs and BEHP in 1996 and 2002 sampling signaled the potential for recontamination from sources off the cap. Sediment data in the vicinity of the capped area identified relatively high concentrations of PCBs. In 1992, two stations south of the cap and four stations under Piers 54-56, east of the cap, were composite-sampled for sediment chemistry (EB/DRP 1993). The 0-2 cm layer was sampled at all stations and the 0-10 cm layer was also sampled at two under-pier stations and one station south of the cap. Aroclor 1260 was detected at one station south of the cap at 270 micrograms per kilogram (µg/kg) dry weight (dw) in 0-10 cm, and the other results in this area were reported as nondetect. Under the piers, total PCB concentrations ranged from 280 to 3,850 µg/kg dw in 0-2 cm samples and 660 to 1,530 µg/kg dw in 0-10 cm samples. The highest total PCB concentrations at both depth intervals were found under Pier 54. These sediments may be resuspended periodically from a variety of physical forces, including propeller prop wash, and redeposited over the cap. BEHP results were all B-qualified and Method Detection Limits (MDLs) were 90-200 μg/kg dw, not as high as concentrations found in 2002 cap station samples (350-600 μg/kg dw). BEHP is a more recent contaminant than PCBs, which were phased out of production starting in 1977. Given the local presence of PCBs in the area at the time of capping, it seems likely that sediment resuspension and deposition onto the cap could be a mechanism to recontaminate the capped sediments. Over the ten year monitoring period, BEHP was widely used in a variety of plastic products. At the same time, hazards of phthalate exposure were being discovered and detection limits were being refined. These facts point to BEHP recontamination of the cap from active external sources (e.g., wastewater, stormwater, and atmospheric deposition).

Overall, the cap and the ENR layer are both functioning to isolate contaminants and both remain stable after ten years. There is no sign of upward migration of contaminants from underlying sediments into the cap or ENR layer. The ENR layer functioned similarly to the cap and benthic community recolonization occurred from external recruitment. There is no evidence that bioturbation in the ENR layer has mixed the underlying sediments into the surface layer above. The benthic community in both areas shows characteristics of a more robust, species rich community compared to the pre-capping state. By these criteria, remediation of the Pier 53-55 Site was concluded to be successful.

The various lines of evidence indicate that the 2002 benthic community at Pier 53-55 is healthier and more species are present than prior to cap placement. The community may still be changing with time as more sediment fines are deposited. However, the project goal appears to have been met.

Pier 64-65

The Port of Seattle was the lead agency that obtained permits for the Pier 64-65 cap and the cap thickness of one to two feet of sand was designed to isolate contaminated historic sediment and provide benthic habitat in this area.

Concerns were raised in 1996 about PAH recontamination on the cap when piling repair work was proposed immediately adjacent to the Pier 64-65 cap. Based on monitoring results from sediment traps, the state concluded there would not be any long-term recontamination of the cap due to the short duration of the work. Additional pile work was performed in 2002 shortly before the monitoring of the sediment caps. These sampling results contained high PAH concentrations. However, sampling results from 2004 demonstrated a rapid reduction of PAH values on the surface of the cap. The 2004 PAH values on the surface of the Pier 64-65 cap did not decrease to the same low levels observed in the original capping material.

Lessons Learned:

- Monitoring detected recontamination of surface sediments from sources that were not capped.
- The two capping projects identified instances where nearby construction activities involving pier replacement led to surface PAH recontamination of the cap.
- The surface contamination detected in monitoring data emphasizes the importance of monitoring and shows that surface recontamination can decrease over time. In fact, the contaminants that 'peak' early in monitoring may give an indication of which sediment contaminants are most mobile in the area of the remediation, and potentially focus future sediment remediation and/or monitoring.

References:

Kings County, Department of Natural Resources and Parks, Jenee Colton, Publication 43 June 2010 Pier 53-55 Sediment Cap and Enhanced Natural Recovery Area Remediation Project, 2002 Data and Final Report.

Recontamination Sources At Three Sediment Caps In Seattle, Proceedings of the 2005 Puget Sound Georgia Basin Research Conference, G. Patrick Romberg, King Country, Department of Natural Resources and Parks.

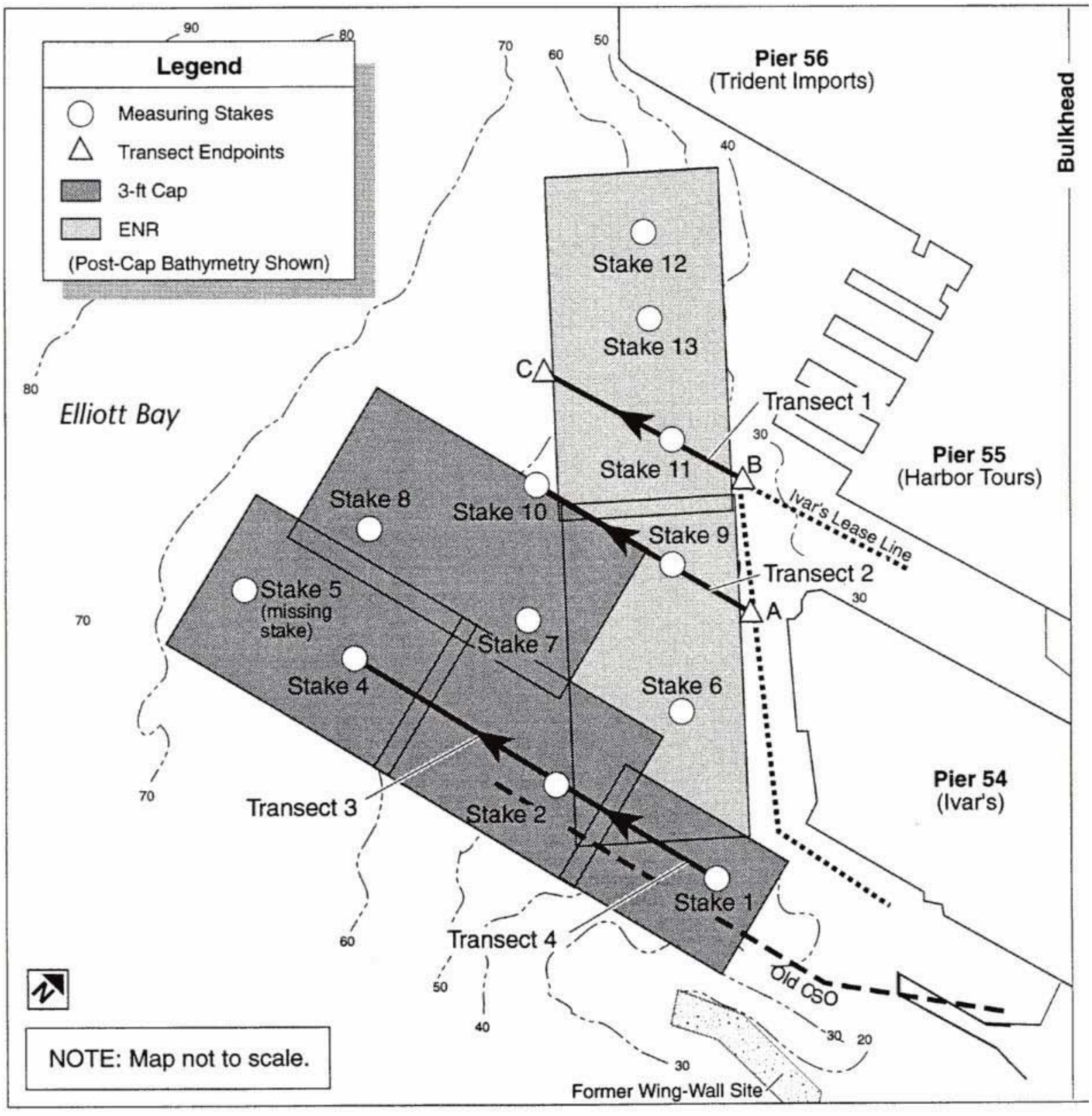


Figure 1: Pier 53-55 Capping Areas for 3 foot and 1 foot Cap (ENR)

CASE STUDY NO. 5

Site Name: Puget Sound Naval Shipyard Complex Site, Bremerton, Washington

Site Description: The Puget Sound Naval Shipyard Complex Site (site), is located in Bremerton, Washington, along the Sinclair Inlet on Puget Sound, about 15 miles west of Seattle, Washington. The Navy has owned and operated facilities at this location since 1891. The complex contains over 300 buildings and structures, six deep water piers, six dry docks, and numerous moorings. The Puget Sound Naval Shipyard (PSNS) is responsible for overhaul, maintenance, docking and decommissioning of ships. These activities generate large amounts of hazardous waste. The majority of the site is industrial and covered by pavement and buildings. Sinclair Inlet provides a habitat for a variety of marine life and is used for commercial fishing and recreational activities.

Contaminants: Petroleum hydrocarbons, heavy metals, semi-volatile organic compounds (SVOCs) and polychlorinated biphenyls (PCBs) have been identified in soil and sediments at a number of areas throughout the complex. Groundwater is contaminated with petroleum hydrocarbons, heavy metals and, in some locations, volatile organic compounds (VOCs). Groundwater flows into Sinclair Inlet and is not currently used for drinking water. The primary hazards posed by the site are to tribal fisherman, marine life and recreational users of Sinclair Inlet. People also may be exposed to the contaminated soils and groundwater during onsite construction activity.

Size/Area of Site: The complex covers about 350 acres of land and an additional 270 acres of sediments along 11,000 feet of shoreline.

Volume of Contaminated Sediments: Approximately 200,000 cubic yards were dredged from an area of approximately 32 acres.

Ecological System(s) Impacted: Fish tissue samples have been analyzed.

Human Health Risk(s): Recent monitoring and trend analysis indicates the PCB sediment clean up goal for Operable Unit (OU) B Marine will be achieved ahead of the 2014 target date specified by the Record of Decision (ROD). Mercury was added as a chemical of concern for the site because review of the human health risk evaluation associated with mercury concluded that Hazard Quotients exceed the target goal of 1 for seafood consumption in Sinclair Inlet at tribal consumption rates. Additional data collection is planned in the future, and if the data supports it, a focused feasibility study will be conducted that specifically addresses mercury contamination in Sinclair Inlet and potential approaches for reducing human health risks associated with mercury. Since there is insufficient data and a need for additional work, the protectiveness determination for OU B Marine was deferred until the next five-year Review.

Summary of Remediation: The Puget Sound Naval Shipyard Complex Site completed remedial actions at Operable Unit (OU), A, OU Naval Supply Center (NSC), OU B Terrestrial, OU B Marine, and OU D. The sediment remedy is in OU B Marine.

An Early Action ROD for the marine portion of OU B was signed on June 13, 2000. The selected remedy includes dredging of contaminated sediments with onsite disposal in a large underwater Confined Aquatic Disposal (CAD) pit, thick-and thin-layer capping, and natural recovery. The contaminated sediment cleanup was designed to coincide with the Navy's planned navigational dredging project which began in June 2000. All of the required construction, dredging and capping activities were completed in February, 2001. A final cap for the sediments disposal pit was completed in October 2001. Additional contamination associated with disposal of sediments in the CAD pit was discovered and additional thin-layer capping was necessary. This work was completed in March of 2004. The Navy conducted the first round of sampling for its long-term monitoring plan in the fall of 2003. Subsequent sampling took place in June 2005 and June 2007. The trend analysis indicates that PCB sediment and fish tissue contamination levels are decreasing.

All construction work required by each ROD has been completed. Therefore, Puget Sound Naval Shipyard, also known as the Bremerton Naval Complex, officially achieved the construction completion milestone in August, 2007. The cleanup goals for OU B Marine have not yet been achieved. The second Five Year Review was completed in October 2007.

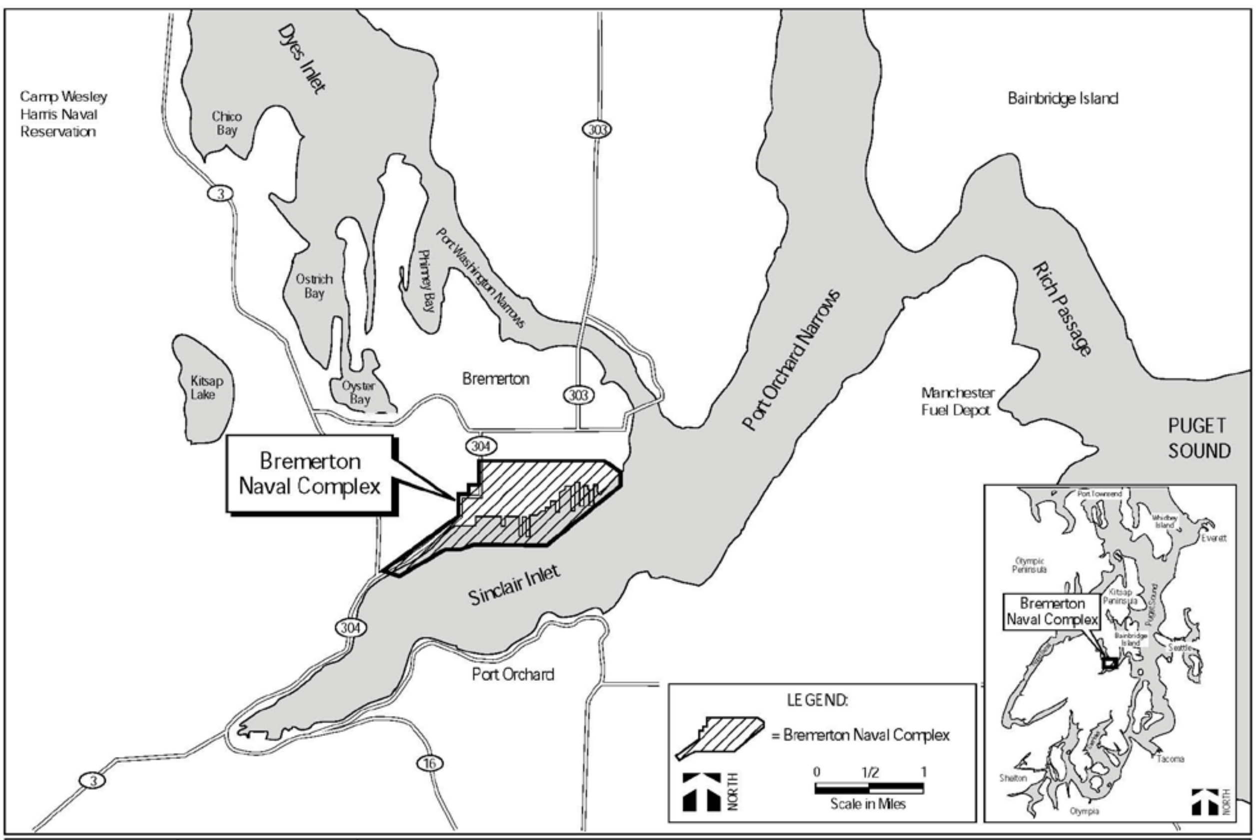
Lessons Learned:

- A thin layer cap was added to the confined aquatic disposal pit to address additional contamination.

References:

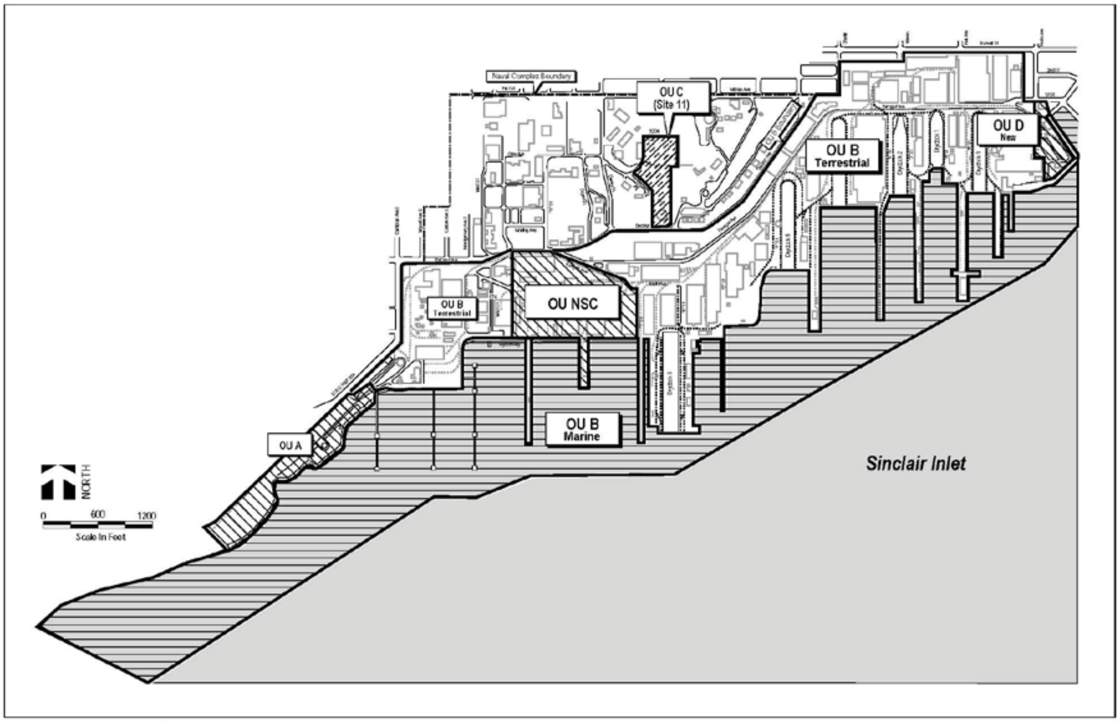
Department of the Navy, Naval Facilities Engineering Command Northwest. October 2007. Second Five-Year Review Bremerton Naval Complex

Department of the Navy, Naval Facilities Engineering Command Northwest. September 2011. 2011 Addendum to Second Five-Year Review Bremerton Naval Complex



U.S.NAVY | Delivery Order 0004 Bremerton Naval Complex ROD FOR OU B TERRESTRIAL

Figure 1-1
Bremerton Naval Complex Vicinity Map



U.S.NAVY	Delivery Order 0004 Bremerton Naval Complex ROD FOR OU B TERRESTRIAL	**Figure 1-2** **Bremerton Naval Complex Operable Units**

CASE STUDY NO. 6

Site Name: Black River Area of Concern, Ohio

Site Description: The Black River is located in north-central Ohio and drains over 467 square miles (1,210 km2) of land. Fifty-one percent of the land within the area of concern (AOC) is used for agriculture, while only one percent is truly industrial. Between these two extremes are rural (thirty-eight percent) urban residential (seven percent) and commercial land (three percent). Water and sediment quality have shown improvement in the Black River in part due to dredging performed. Contaminated sediments were remedially dredged and impacts from point sources (factories, wastewater treatment plants, etc.) have been significantly reduced. However, the Black River, like many major rivers across the country, is being threatened by major nonpoint source impacts coming from the entire watershed.

The Black River was designated as an AOC within the Great Lakes in 1991. Originally, the Black River AOC only included the lower mainstem. This stretch was designated an AOC because discharges from the many industrial operations on the lower river had contaminated the river sediments with heavy metals and polycyclic aromatic hydrocarbons (PAHs). The PAHs came from a steel mill coking operation that had closed a decade earlier and had severely impacted the health of the resident fish communities. Around the Great Lakes, the Black River was known as the “River of Fish Tumors.”

Contaminants: PAHs, heavy metals.

Size/Area of Site: Over 50,000 cubic yards of contaminated sediment were dredged at the USS/Kobe Steel Company between 1989 and 1990 along 0.8 river mile stretch.

Volume of Contaminated Sediments: 50,000 cubic yards dredged.

Ecological System(s) Impacted: Extensive studies over the years have established a link between high sediment PAH concentrations and liver cancers in bullhead and external deformities in other fish populations. The river sediments had been contaminated by discharges from a coking plant that closed in the early 1980s and remedial dredging of those sites occurred in 1989-1990. Since that time, studies have shown a dramatic decrease in both external tumors and liver cancers. The health of Black River fish are now approaching what would be expected at other urban rivers. In the 2004, the Black River Remedial Action Plan Coordinating Committee determined sufficient progress had been made in the health of the fish communities of the Black River and applied to the USEPA for a change in designation for this beneficial use impairment from ‘Impaired’ to ‘In Recovery Stage.’

Human Health Risk(s): The following were identified:

- A 21-year Ohio Department of Health contact advisory on the lower six miles of the Black River mainstem was lifted in April 2004. The contact advisory warned against swimming or wading and was associated with the elevated levels of PAH in river sediments and the high incidence of fish tumors. A 1989-1990 dredging of the contaminated stretch of the river removed the contaminated sediments.

- Around 1983, a fish consumption advisory was issued for the lower five miles of the Black River mainstem. The advisory warned against eating any fish species from that part of the river. At the time, it was issued because of a concern over the high incidence of liver and lip cancers found in the river’s resident fish communities. In the early 1990s, fish consumption advisories were based more on a health protection basis and the mainstem advisories were amended to only include smallmouth and largemouth bass, brown bullhead catfish, buffalo, freshwater drum and common carp, due to polychlorinated biphenyl (PCB) tissue contamination. Then, in 1997, the Black River fish consumption advisories were further revised to only include brown bullhead catfish, freshwater drum and common carp. The Black River AOC remains impaired for the fish and wildlife consumption beneficial use. Over the past decade, more species, including snapping turtles, have been added to the advisory list due to mercury contamination. Currently, there are consumption advisories for the mainstem, both the East and West Branches and Findley Lake.

Summary of Remediation: Dredging was performed to remove 50,000 cubic yards in 1989 and 1990.

A number of post-remediation studies have been conducted on the Black River. Sediment sampling was conducted in the fall of 1997, and fish samples were collected in the spring of 1998. The results of this study indicate that PAH levels in both sediment and fish have declined since the early 1980s. The results of a fish study conducted two and three years after the dredging of the Black River showed a high prevalence of tumors in fish, which indicated that these fish were adversely affected by PAH-contaminated sediments, to which they were exposed during the 1989-1990 dredging, that had previously been buried. However, the results of the 1998 fish study in the Black River, eight years after the dredging took place, show that liver cancers are at their lowest documented levels, and that the percentage of fish with normal healthy livers is almost seventy percent, as opposed to twenty percent in the early 1980s. The results of this study indicate that both the closure of the coke plant and the remedial dredging of the contaminated river, although initially exposing fish to previously buried contaminated sediments, had beneficial results on the Black River.

Lessons Learned:

- Dredging for PAHs likely caused increased exposure to buried contaminants in the near term, but the long term results were beneficial.

References:

USEPA, Great Lakes Area of Concern website: http://epa.gov/glnpo/aoc/blackriver.html

Figures:

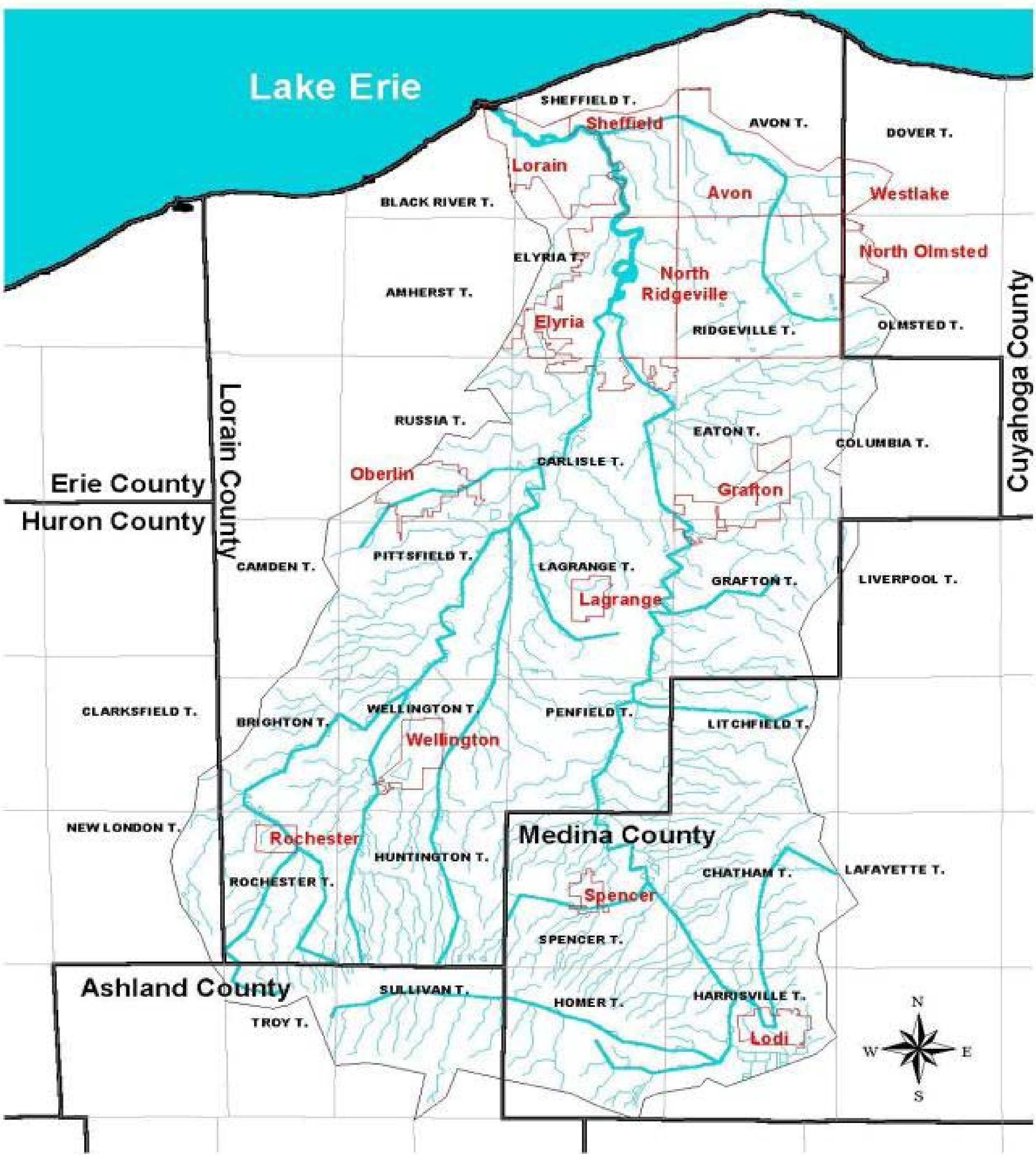


Figure 1. The Black River AOC, including political jurisdictions
http://www.blackriverrap.com/cms/files/File/Black%20River%20RAP%20Stage%202.pdf

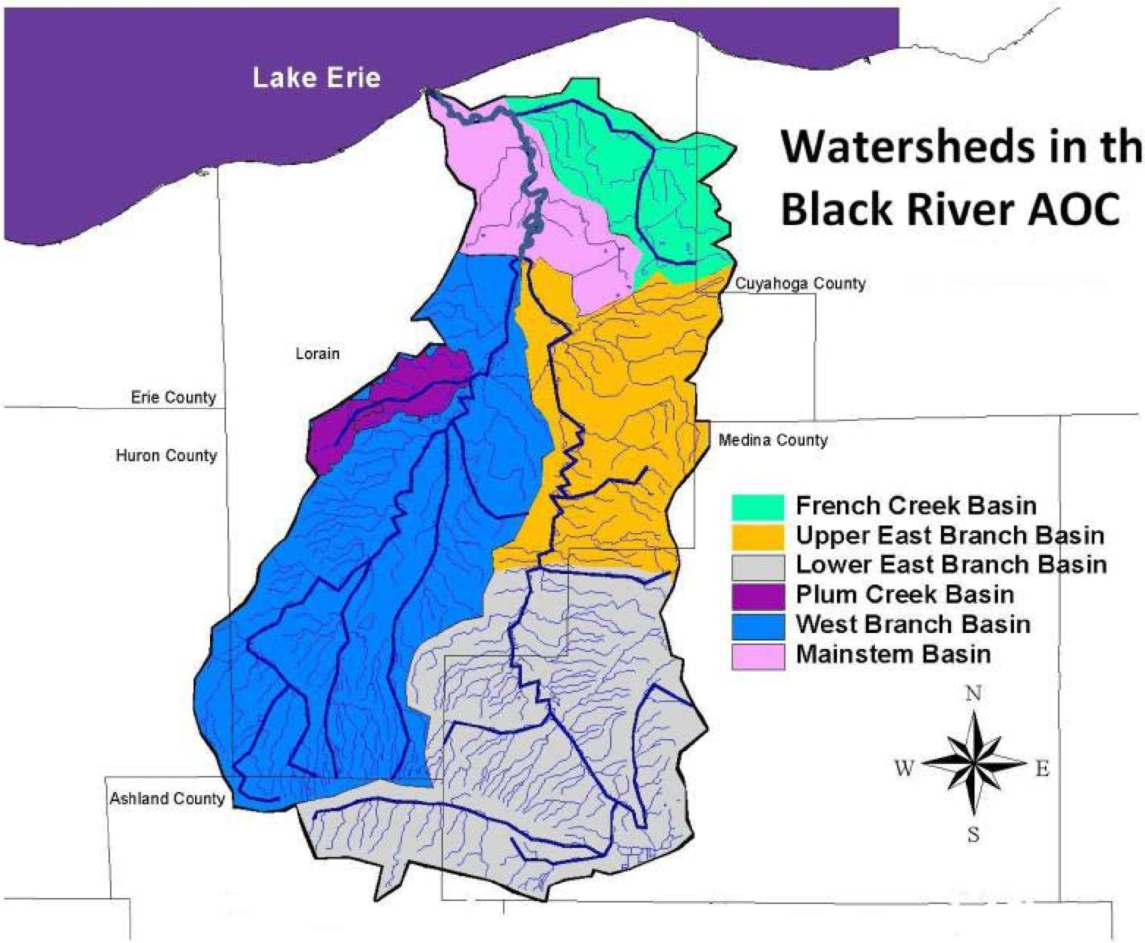


Figure 2. Watersheds of the Black River AOC
http://www.blackriverrap.com/cms/files/File/Black%20River%20RAP%20Stage%202.pdf

CASE STUDY NO. 7

Site Name: Duwamish/Diagonal Sediment Remediation Project, King County, Seattle, Washington

Site Description: The Duwamish/Diagonal Sediment Remediation Project (Du/Di Site) is located in the vicinity of the King County Duwamish Combined Sewer Overflow (CSO) and the City of Seattle Diagonal Way CSO/Storm Drain (SD) outfall on the east side of the Duwamish River, nearly two miles upstream from the confluence with Elliott Bay (Figure 1). The Duwamish CSO is a submerged outfall (36-inch diameter) and the Diagonal CSO/SD outfall is a large shoreline discharge (144-inch diameter). Besides the Duwamish CSO and the Diagonal CSO/SD, located at the upstream end of the Du/Di Site, there is a small storm drain pipe (12-inch diameter) and historic outfall associated with a former sewage treatment plant that operated nearby from 1940 to 1969. Combined sewers were built in the early- to mid-1900s to collect both sanitary sewage and storm water. In order to prevent sewage backup or damage to treatment plant infrastructure, a CSO served as a safety valve by allowing overflow into nearby receiving waters during periods of heavy or prolonged precipitation.

A 1991 Consent Decree settlement between the National Oceanic and Atmospheric Administration (NOAA) and the City of Seattle and King County for alleged natural resource damages resulted in establishment of the Elliot Bay/Duwamish Restoration Program (EBDRP), with responsibilities for sediment remediation, habitat development/improvements, and pollution source-control measures. In 1992, a Sediment Remediation Technical Working Group was established by the EBDRP to identify/rank candidate sites. The Du/Di Site was one of three high-ranking sites selected for sediment cleanup within the Lower Duwamish Waterway. From 1994 to 1996, field investigation activities were conducted to determine the extent of contamination around the outfalls. Based upon investigation findings, a draft Cleanup Study Report was completed in December 2001 and, after public comment, a Final Cleanup Action Decision was issued for the Du/Di Site in July 2002.

The U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), King County and City of Seattle have been working together on source control, project planning and design for the Du/Di Site. Notably, the Du/Di Site is designated as an Early Action cleanup area as part of the much larger Lower Duwamish Waterway Superfund Site, a 5.5 mile stretch of the Duwamish River entering Elliott Bay, which was added to USEPA's National Priorities List (NPL) in September 2001. The Early Action designation was made so that cleanup could be initiated as soon as possible due to the significant hazards posed and given the substantial progress made on cleanup plan development, which began in 1994 to that point in time. While the sediment remediation project is being coordinated with USEPA to ensure compliance with Superfund requirements, both USEPA and Ecology reportedly consider the Du/Di Site efforts to date to be a partial cleanup action due to the potential for additional cleanup of sediments immediately adjacent to the already remediated areas. The Draft Final Feasibility Study for the Lower Duwamish Waterway Superfund Site was made available for public comment in late 2010. USEPA and Ecology developed a Proposed Plan/Cleanup Action Plan for public review in 2012.

Contaminants: Polychlorinated biphenyls (PCBs), bis(2-ethyhexyl) phthalates, mercury, and butyl benzyl phthalates were identified as the primary contaminants of concern (COCs) at the Du/Di Site. In general, PCBs are of primary concern for the Lower Duwamish River sediment because these chlorinated compounds tend to bioaccumulate in organisms representing both ecological and human health risks. Applicable cleanup standards were determined based upon comparison to Washington State Sediment Management Standards (SMS). The Washington State SMS includes established cleanup standards for chemicals in marine sediments, while cleanup standards for low salinity sediments, freshwater sediments, and protection of human health are determined on a site-specific basis. The SMS marine sediment standards were identified as applicable to the Du/Di Site.

Size/Area of Site: In 2001, a cleanup study report was released that was followed by a public meeting in 2003 to discuss the proposed cleanup strategy. As a result, the size of the proposed cleanup area increased from five to seven acres, to include another area immediately upstream to minimize the potential for recontamination attributable to later remediation. The original area (Area A) is 260-feet wide and extends about 750 feet along the shoreline upstream and downstream of the Du/Di outfalls. The added area (Area B) is 160-feet wide and extends about 500 feet along (but not touching) the shoreline upstream and downstream of the former sewage treatment plant outfall and smaller storm drain outfall. An additional four acres were subsequently addressed due to contamination from dredging residuals. To date, a total of 11 acres of intertidal and subtidal habitat have been restored as a result of cleanup actions taken at the Du/Di Site (Figure 2).

Volume of Contaminated Sediments: Approximately 66,000 cubic yards of sediments were dredged from a depth of three to five feet and disposed at an approved off-site location. Over 91,500 tons of dredged sediment, all below the Toxic Substances Control Act (TSCA) PCB limit, were transported via train to the Roosevelt Regional Landfill in Klickitat County, Washington.

Ecological System(s) Impacted: Impacts or risks to ecological receptors were evaluated in detail for the Lower Duwamish River Superfund Site. The baseline ecological risk assessment estimated risks for the benthic invertebrate, fish, and wildlife species that could be exposed to contaminants in sediment, water, and aquatic biota. The Lower Duwamish River is known to provide critical habitat for both chinook and coho salmon as well as anadromous bull trout. Bald eagles and other migratory birds frequent or nest in the general area. For the majority of the Lower Duwamish Waterway, the contaminants appeared to have no effect on the benthic invertebrate community. Ecological risks to fish and wildlife were relatively low, with the exception of risks to river otter from PCBs. In general, despite significant alterations in habitat and the potential stressors from elevated levels of contaminants, the Lower Duwamish River contains a diverse assemblage of aquatic and wildlife species, and a robust food web that includes top predators.

Human Health Risk(s): As in the case of the Du/Di Site, identification of COCs based on screening comparison to Washington State SMS criteria does not account for potential human health impacts since SMS criteria were developed for the protection of aquatic organisms only. Therefore, to assess potential human health risks due to consumption of fish harvested in the area, a semi-quantitative human health risk assessment was initially conducted. Results of the initial human health risk assessment indicated that fish tissue concentrations did not present a non-carcinogenic risk; however, excess carcinogenic risks posed by PCBs in fish exceeded the acceptable carcinogenic risk probability range established by the regulatory agencies. At the time, however, there was acknowledgement of significant uncertainties in the human health risk estimates due to the limited database and given the use of several conservative exposure assumptions. Later, a baseline human health risk assessment was performed for the Lower Duwamish River Superfund Site in order to estimate risk for those human receptors that may be exposed to contaminants present in sediment, water, and aquatic biota. It was determined that the greatest human health risks would be associated with consumption of fish, crabs, and clams, with lower risks associated with activities that involve direct contact with sediment, such as clamming, beach play, and net fishing.

Summary of Remediation: Beginning in November 2003 until remediation was completed in March 2004, seven acres (Areas A and B) were dredged, backfilled with clean sand to isolate contamination located beneath the dredge depth (with some armoring added near an active slip), and topped with a special near shore habitat mix. The 2003/2004 project included removal of 3-5 feet of contaminated sediments from Areas A and B to allow for placement of an effective capping layer, thereby isolating remaining chemicals from the environment and returning the site to approximately the same bottom elevations that existed prior to dredging. Subsequently, some dredging residuals were identified outside of the dredge site during post-construction sampling, necessitating placement of a thin-layer cap (six to nine inches) on an additional four acres in 2005.

Monitoring continues for the combined 11-acre area to document: (a) whether the dredging of contaminated sediments has resulted in any increases in contaminant levels in sediments located beyond the cleanup site boundary; (b) whether contaminant levels in areas beyond the cleanup site boundary are high enough to act as a source of PCB recontamination to the cap, necessitating further remediation; (c) whether the potential exists for future recontamination of the cap due to continued point source CSO/SD discharges; and, (d) whether the cap is stable and isolates contaminants over time. Initial monitoring indicated that natural sediments were depositing on the capped areas and the surface layer was starting to return to grain-size distributions representative of preconstruction conditions (Figure 3). Most of the COC detections within the cap are believed to be attributable to input from other sources or general sediment remobilization/transport in the Duwamish River and not from the thin-layer cap placement action itself on the additional four acres mentioned above.

Similar conclusions have been drawn based on subsequent monitoring events, the most recent of which was in 2008 and 2009 where samples from stations in Areas A and B, the thin-layer cap area and the surrounding perimeter area, were collected. In addition, based on the bathymetric survey, the majority of the Du/Di Site has experienced net accretion after five years in the 0.5-1.5 foot range; however, in localized areas net accretion was up to 3+ feet (e.g., Diagonal Way CSO/SD). Overall, the number of contaminants with SMS exceedances declined from 2008 to 2009 especially in Area A. The thin-layer cap area only had one contaminant exceedance at one location. The perimeter stations continue to show decreases in the number of contaminant exceedances.

Lessons Learned:

- ***Best Management Practices:*** After completion of Early Action activities in 2004, both Ecology and EPA required King County to monitor for dredging residuals beyond the site boundary by measuring the pre- and post-construction sediment chemistry at 12 stations outside the 2003/2004 dredging and capping project boundary. Comparison of the pre- and post-data sets indicated that surface sediment PCB concentrations increased significantly in an area immediately to the west and south of Area B as compared to the dredging residuals adjacent to Area A (Figure 4). The occurrence of a greater amount of dredging residuals near Area B was consistent with the contractor's initial operations in this area, where best management practices (BMPs) were not utilized to minimize spread of dredging residuals. These increases are more than would have been expected from dredging operations using BMPs for environmental dredging of contaminated sediments. As a result, King County evaluated six prospective remedial actions to reduce elevated PCB levels caused by the dredging residuals and, after consultation with Ecology and EPA, selected the thin-layer placement remedy (also known as Enhanced Natural Recovery (ENR)) as the best way to quickly reduce the elevated PCB levels within the 4-acre dredge residual area around Area B. Perhaps the lesson learned would be to have more oversight and control of sediment remediation activities during the actual implementation to best ensure work plan and design documents are fully and consistently followed by contractors and project personnel.

- ***Potential for Sediment Recontamination:*** The two chemical groups of greatest interest for potential recontamination at the Du/Di Site are PCBs and phthalates. Modeling indicated that phthalate recontamination is likely even if discharge from the SDs would be completely eliminated. Current discharges are not a concern for PCB recontamination, but care must be taken to minimize the potential that the existing PCB-contaminated sediment could be disturbed in the future and pose a source of recontamination. Specifically, the greatest threat of PCB recontamination in this section of the river is from potential dredging activities that disturb and mobilize contaminated sediments. To minimize the risk of recontamination from nearby dredging activities, the various stakeholders recognize that efforts should be taken to minimize recontamination potential by coordinating when and how dredging projects are carried out in the Lower Duwamish Waterway, particularly near known source areas or areas of significant impact. In general, from the inception of this project, there has been significant effort in identifying potential point- and non-point sources and managing those accordingly to best reduce contaminant loading to the Lower Duwamish Waterway.

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http://www.ecy.wa.gov/programs/tcp/sites/lower_duwamish/sites/duwamish_diagonal/d_d.html

http://www.ldwg.org/index.htm

http://yosemite.epa.gov/r10/cleanup.nsf/sites/lduwamish

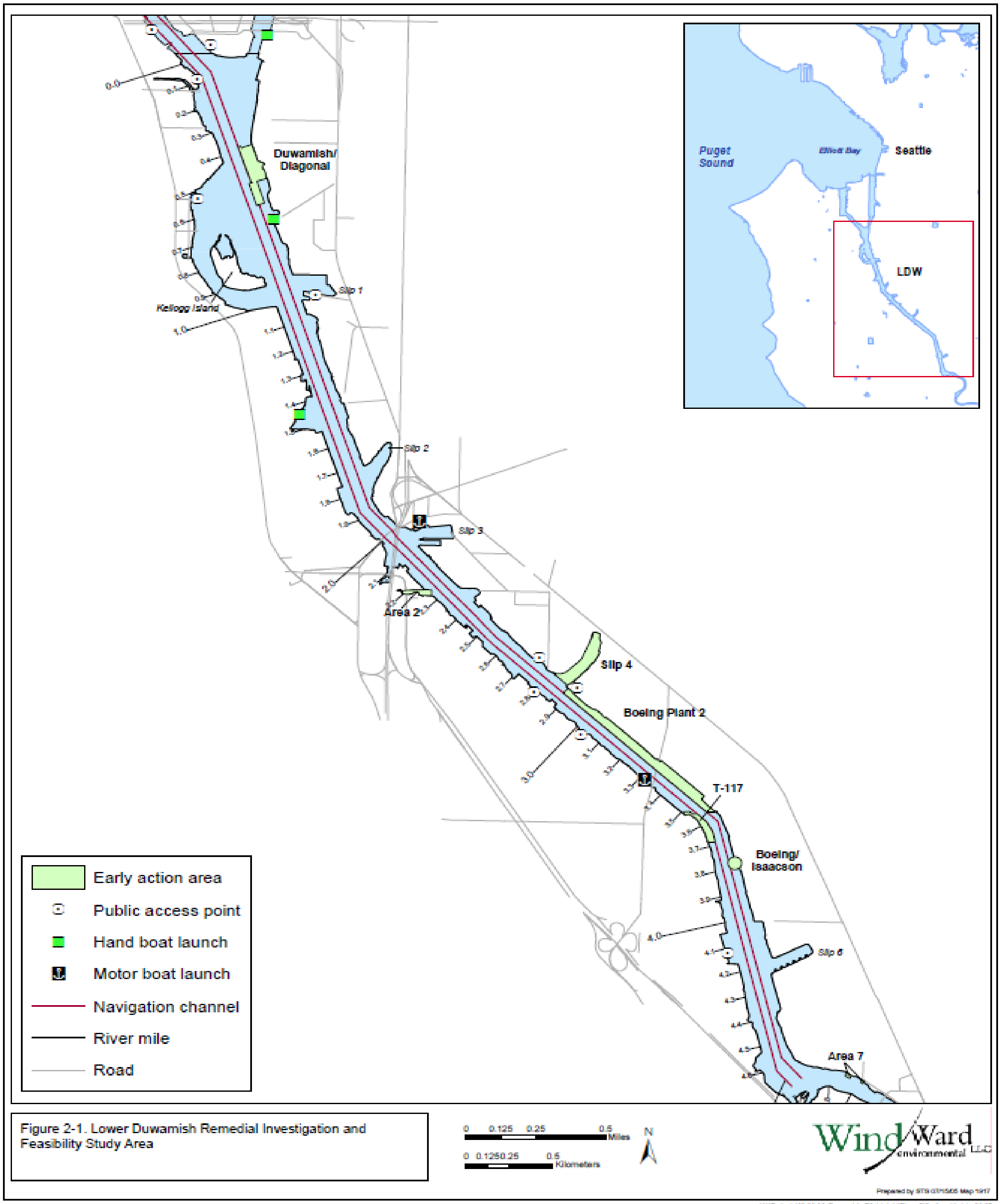

FIGURE 1: Lower Duwamish Study Area. (from RETEC, December 2005. *Lower Duwamish Waterway Remedial Investigation/Feasibility Study: Identification of Candidate Cleanup Technologies for the Lower Duwamish Waterway Superfund Site (Final)*)

Duwamish/Diagonal Sediment Remediation Project - 2008/2009 Monitoring Report

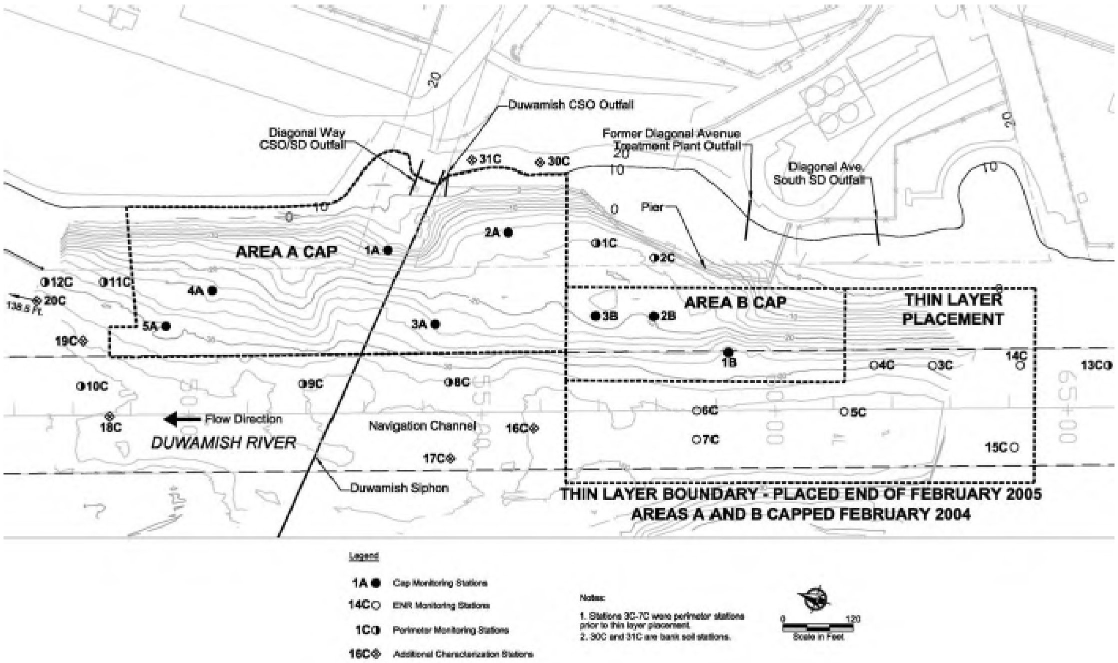

Figure 1. Duwamish Diagonal Site and Monitoring Stations

King County 2 *May 2010*

FIGURE 2: Duwamish/Diagonal Monitoring Stations. (from King County. May 2010. *Duwamish/Diagonal Sediment Remediation Project: 2008/2009 Monitoring Report*. Elliott Bay/Duwamish Restoration Program Panel Publication 42.)

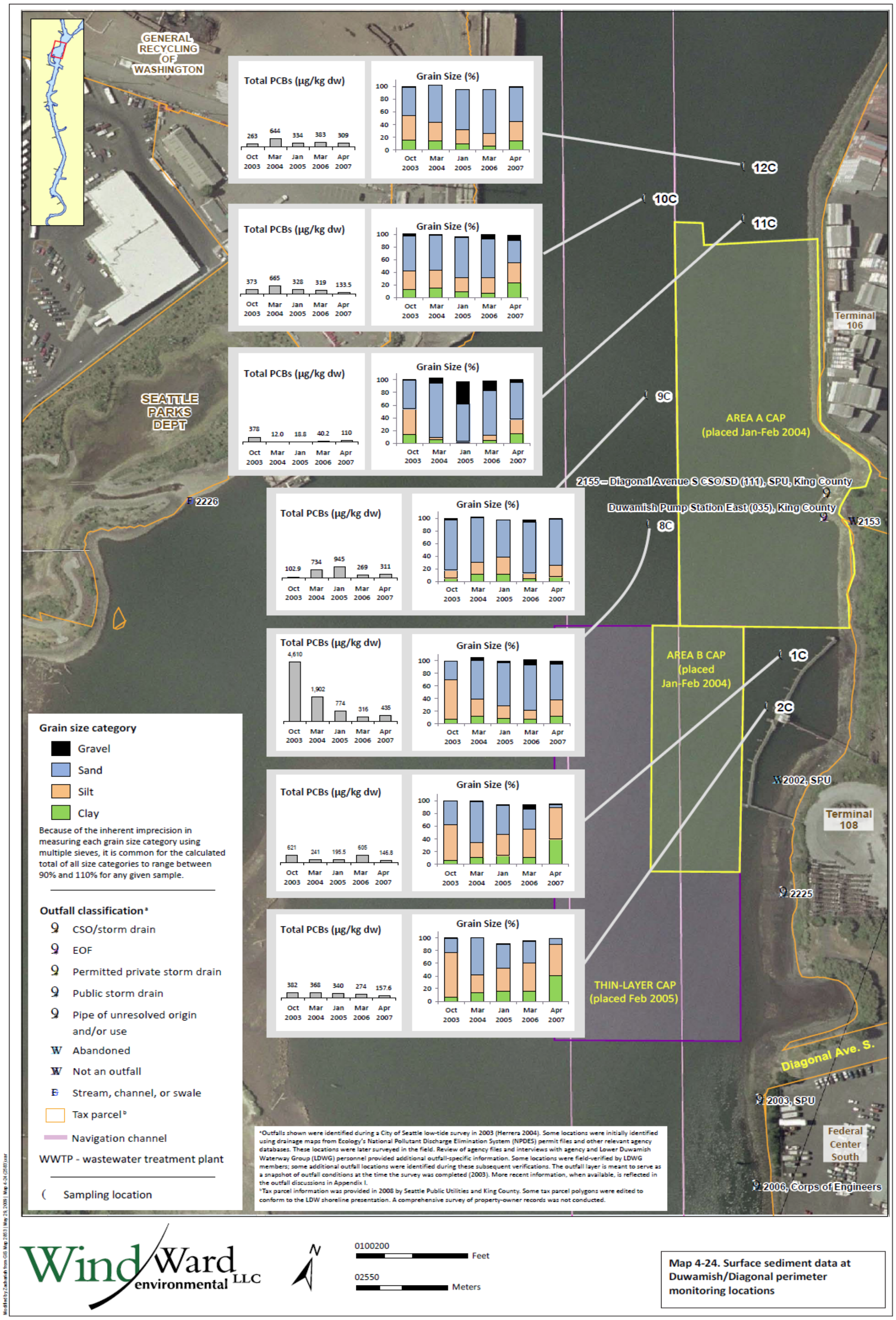

FIGURE 3: Duwamish/Diagonal Suface Sediment Data. (from Windward Environmental LLC, July 2010. *Lower Duwamish Waterway Remedial Investigation Report (Final)*)

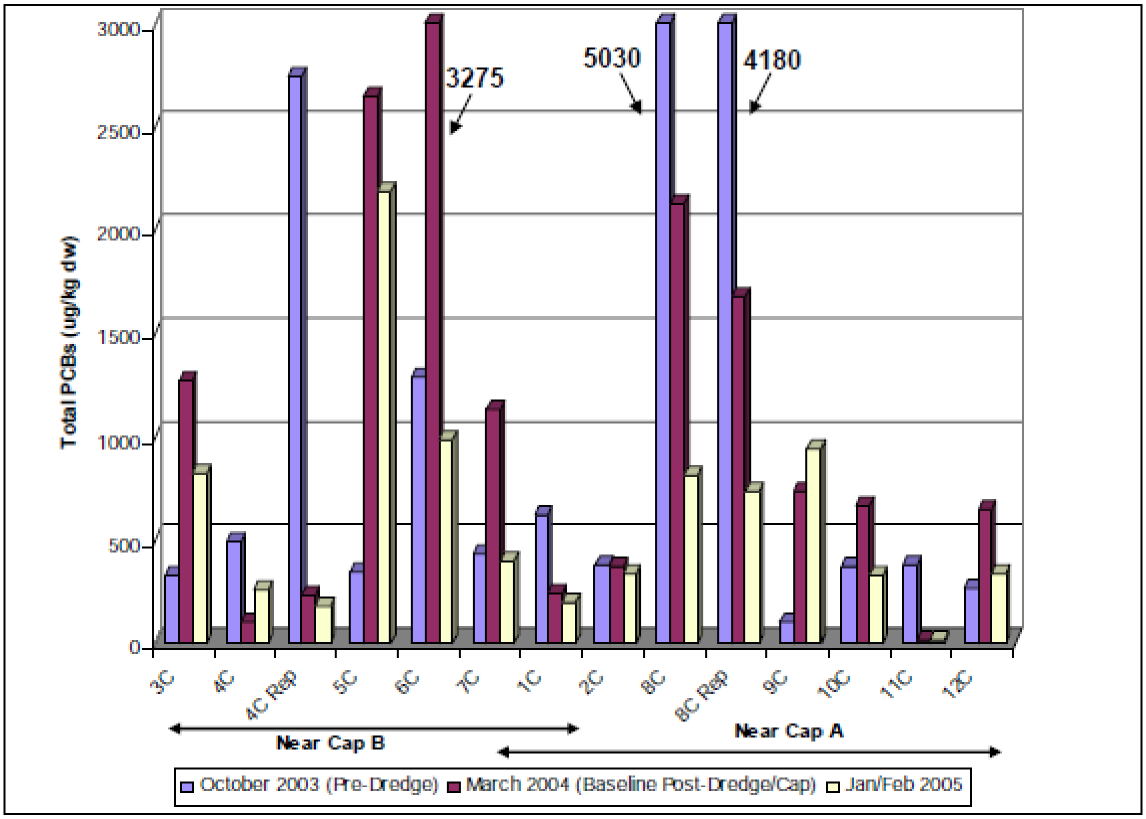

Figure 2. Changes in PCB Concentrations at Duwamish Diagonal Perimeter Stations (2003-2005)

FIGURE 4: Duwamish/Diagonal Pre-/Post-Dredging PCB Concentrations. (from King County. May 2010. *Duwamish/Diagonal Sediment Remediation Project: 2008/2009 Monitoring Report*. Elliott Bay/Duwamish Restoration Program Panel Publication 42.)

CASE STUDY NO. 8

Site Name: The United Heckathorn Superfund Site, Richmond Harbor, Contra Costa County, California.

Site Description: The United Heckathorn Superfund Site (site) is located in Richmond Harbor (Figure 1), an inlet of San Francisco Bay, in Contra Costa County, California. It includes five acres of land and about 15 acres of marine sediments in two channels (Lauritzen and Parr) of Richmond Harbor (Figure 2). From 1947 through 1966, several companies, including R.J. Prentiss, Heckathorn and Company, United Heckathorn, United Chemetrics, and Chemwest Inc., used the Site to formulate, package, and ship pesticides. No chemicals were manufactured on-site. United Heckathorn filed for bankruptcy in 1966. By 1970, the facility buildings had been demolished and cleared from the Site. The Levin-Richmond Terminal Corporation purchased the Site in 1981 and currently operates a marine shipping terminal at the location of the former United Heckathorn facility.

In 1980, the California Department of Health Services inspected and sampled the Site as part of the Abandoned Site Project. Chlorinated pesticides and metals were detected in soil samples. In 1983, workers at the Site laying piles and clearing soils encountered pesticide residues containing up to seventy-seven percent dichlorodiphenyl trichloroethane (DDT), and in 1986, during the excavation for a train scale at the Site, an oily residue was encountered that contained up to 44% DDT (EPA, 1994). The area was designated a State Superfund Site in March 1982. In March 1990, the U.S. Environmental Protection Agency (EPA) placed the Site on the National Priorities List, and in August of that year assumed lead agency status. Remedial actions at the Site took place from 1990 through 1999.

Contaminants: United Heckathorn received technical grade pesticides from chemical manufacturers, ground them in air mills, mixed them with other ingredients such as clays or solvents, and packaged them for final use in liquid or powder form. Although many pesticides were handled at United Heckathorn, DDT accounted for approximately 95% of the United Heckathorn operations.

Size/Area of Site: The Site is divided into an Upland area (approximately 5 acres) and Marine Area, which includes 15 acres of marine sediment in two areas, the Lauritzen Channel and Parr Canal.

Volume of Contaminated Sediments: The selected remedy of the Marine Area consisted of dredging of the Parr and Lauritzen Channel. Dredging operations from August 1996 to March 1997 removed approximately 2,650 cubic yards of contaminated sediment from the Parr Canal. Approximately 187 tons of salvaged metal debris was removed from the Lauritzen Channel in the process of dredging 105,000 cubic yards of contaminated sediments.

Ecological System(s) Impacted: "Although Richmond Harbor encompasses only a fraction of a percent of the area of San Francisco Bay, and contains less diverse habitat than the Bay as a whole, its open-water channels support a wide variety of resident and migratory species of fish, shellfish and wildlife. Common organisms include clams, mussels, crabs, shrimp, marine and estuarine fish, such as anchovies, smelt, perch, croaker and gobies, and fish-eating birds, such as cormorants and grebes. Harbor seals and the endangered California brown pelican are also seen in the harbor. Brooks Island, at the mouth of the harbor, provides habitat for shorebirds and supports nesting black-crowned night-herons, Caspian terns, snowy egrets and gulls." (EPA, 1994; Section 2.3).

The National Academy of Sciences (NAS) action level for DDT in fish is 0.05 milligrams per kilogram (mg/kg) for the protection of fish-eating birds.

In 2010, EPA completed updated risk assessments for the Site using more recent data including sediment, mussel and fish tissue data collected between 2007 and 2008. The results of the risk assessment indicated that concentrations within the Lauritzen Channel still pose a risk to human and ecological receptors but were significantly reduced with distance from the Channel.

A reassessment of remediation levels to address risks to ecological receptors concluded that concentrations lower than the 1994 remedial goal may be needed to be protective of invertebrates, fish, birds, and mammals (CH2M HILL, 2010b). Total DDT concentrations as low as 150 μg/kg, and sediment concentrations of dieldrin as low as 34 μg/kg, would be protective of all modeled ecological receptors.

The Third Five-Year Review (EPA, 2011) ecological risk assessment review indicates:

- Risks to fish and wildlife from total DDT and dieldrin persist in the Lauritzen Channel.
- All surface sediment concentrations of total DDT and dieldrin in the Parr Canal, Sante Fe Channel mouth, and Richmond Inner Harbor Channel fall below the minimum risk-based sediment concentrations calculated for fish and wildlife receptors. Dieldrin in the Santa Fe Channel mouth is also below minimum risk-based sediment concentrations.

Human Health Risk(s): Although this is an industrial area, approximately 10,900 people live within one mile of the Site (U.S. EPA, Region 9 Superfund Site). Building demolition, capping, and institutional controls of the terrestrial portions of the Site have controlled on-site and off-site human exposure. A 'do not consume' fish advisory for the Lauritzen Channel and portions of the San Francisco Bay is currently in place as an interim exposure control measure for human exposure. The fish advisory was issued by the California Office of Environmental Health Hazard Assessment (OEHHA) in May 2011.

The Food and Drug Administration (FDA) action levels for the marketability of fish and shellfish are To-Be-Considered criteria (TBCs) for protecting human health. These levels are less stringent than the levels that would be achieved by meeting the surface water applicable or relevant and appropriate requirements (ARARs) (FDA action levels: DDT = 5.0 parts per million; dieldrin = 0.3 parts per million).

In 2010, EPA completed updated risk assessments for the Site using more recent data including sediment, mussel and fish tissue data collected between 2007 and 2008. The results of the risk assessment indicated that concentrations within the Lauritzen Channel still pose a risk to human and ecological receptors but were significantly reduced with distance from the Channel. The human health sediment Risk-Based Concentration (RBC) (CH2M HILL, 2010a) for dieldrin is 13 μg/kg based on a cancer endpoint of $1x10^{-4}$, and the sediment RBC for DDT is 450 μg/kg based on a noncancer endpoint (Hazard Quotient=1).

The Third Five-Year Review (EPA, 2011) human health risk assessment review indicates:

- Concentrations of DDT and dieldrin in some fish species have increased from 1994 to 2008 in the Lauritzen Channel.
- Fish tissue concentrations of total DDTs and dieldrin in the Lauritzen Channel are still present at levels that could pose unacceptable risk to people consuming fish.

The current "do not eat" fish advisory for the Lauritzen Channel and portions of San Francisco Bay, issued in May 2011 by the State of California Office of Environmental Health Hazard Assessment (OEHHA), is one of the important mechanisms to control human exposure at the Site.

Summary of Remediation: As an initial response, under a Unilateral Order issued by EPA September 1990, the potentially responsible parties removed approximately 1,450 cubic yards of pesticide residue and contaminated soil from the shoreline to the foundation of the former United Heckathorn Building 1. Another 1,800 cubic yards of pesticide residue and contaminated soil were excavated in April 1991. A final soil removal action occurred in 1993. Excavated material contained as much as one-hundred percent DDT.

In 1994, EPA completed investigations that more fully determined the nature and extent of contamination at the Site. Based on the results of this investigation, late in 1994 EPA recommended dredging marine sediments contaminated with DDT and dieldrin and shipping them to an approved disposal facility. EPA recommended capping the area of the former facility with an impermeable barrier to prevent erosion and exposure to residual amounts of pesticide in soils.

Based on established criteria, the human health risk assessment 1×10^{-6} lifetime excess cancer risk, and the Ecological Risk Assessment, the Record of Decision (ROD) Remedial Goals for surface water and sediment for the Site were set (EPA, 2006: Table 4-1) at:

Medium	Constituents	Level	Basis	Cancer Risk Level
Surface Water	DDT	0.59 ng/L	USEPA AWQC	1×10^{-6}
	Dieldrin	0.14 ng/L		1×10^{-6}
Sediment	DDT	590 µg/kg	Ecological Assessment	1×10^{-6}
Source: USEPA 1995.				

Dredging of Parr Canal and Lauritzen Channel occurred from August 1996 to March 1997. Approximately 2,620 cubic yards of sediment were removed from Parr Canal in August 1996. Dredging of Lauritzen Channel proved more difficult because of the extensive amount of debris found in the channel. Approximately 187 tons of salvaged metal were retrieved from the channel in addition to the 105,000 cubic yards of sediment. After dredging, an 18-inch layer of sand was placed over the dredged area.

Confirmation sampling in 1997 indicated that sediment median total DDT concentrations (median total DDT) at the head of the Lauritzen Channel was reduced from 47,000 micrograms per kilogram (µg/kg) to 263 µg/kg (average DDT) and the Parr Canal was reduced from 840 µg/kg (median total DDT) to 200 µg/kg (average DDT). The dredged sediment was disposed of off-site at designated disposal facilities. Clean sand was placed to an average depth of 6 inches over dredged portions of the Lauritzen Channel and placed to an average depth of 18 inches throughout the Parr Canal (Chemical Waste Management, Inc., 1997).

The Record of Decision requires annual post-remediation sampling for at least five years or until the remediation goals have been achieved. As of June 2006, six sampling and analysis events have been conducted at designated stations along the Lauritzen Channel and Parr Canal by EPA and Battelle Marine Sciences Laboratory.

Confirmation samples taken immediately after dredging indicated the DDT cleanup goal of 590 µg/kg was reached. However, post-remediation monitoring of surface water, sediment, and mussels indicated exceedances of the DDT cleanup goal for sediment and elevated concentrations in muscle tissue.

The latest post-remediation monitoring (Summer 2007) results showed the following:

	Total DDT (ug/kg)	Dieldrin (ug/kg)
Young Bay Mud & Surface Sediments (dw)	6.7 – 88,830	2.4 – 2,800
Old Bay Mud (dw)	1.1 – 37,600	1.5 – 130
Embankment (dw)	26.7 – 4,525	4.1 – 97
Mussel Tissue (ww) [Lauritzen Channel]	323.3 – 1,268	24 – 81
Fish Tissue (ww) [2008 Lauritzen Channel]	28 – 11,000	10 – 150
dw= dry weight; ww= wet weight		

A cap for the upland 4.5 acre area of the Site was completed in 1999. A reinforced concrete cap was installed in areas used for material stockpiling, and a geotextile fabric and gravel cap was installed in low traffic areas after grading and installation of a surface water drainage system. The Second Five-Year Review (EPA, 2006) and the Third Five-Year Review (EPA, 2011) indicated that, although surface cracks are present in the concrete cap, visual inspection supports the conclusion that the upland cap is still protective and functioning as intended.

The Third Five-Year Review of the Site (EPA, 2011) determined that: 1) Sediment within the Lauritzen Channel contains DDT and dieldrin at concentrations above ROD remediation goals; 2) Surface water DDT and dieldrin concentrations remain above ROD remediation goals of 0.59 nanograms per liter (ng/L) and and 0.14 ng/L, respectively, and do not exhibit any trend; 3) Mussel tissue DDT concentrations do not exhibit a declining trend between 2002 and 2009; and, 4) Fish sampling results indicate that DDT concentrations in fish pose an unacceptable risk and an OEHHA Fish Advisory issued in May 2011 recommends no consumption of fish from the Lauritzen Channel.

Lessons Learned:

- ***Incomplete Characterization:*** New contaminant sources were identified during the Phase I and Phase II Source Investigations (PNNL, 2004). These investigations identified a broken concrete outfall below the riprap on the eastern shore about 180 feet north of the Levin Pier, which is a continuing source of sediment contamination. The Phase II Source Investigation also confirmed and delineated the sediment hotspot beneath the north end of Levin Pier (EPA, 2006; Appendix F). During the 2002 investigation, some of the embankment samples were above the cleanup goals. Additionally, during sampling a buried outfall only visible during low tide was first located. High levels of DDT were detected in nearby sediments.

- ***Physical Limits on Removal of Contaminated Sediment:*** It is suspected that some of the remaining contamination could not be removed because of the physical obstructions associated with the approximately 187 tons of metal debris removed from the Lauritzen Channel and the difficult dredging beneath and around piers.

- ***Non-Mobile Tissue can be an Indicator of Remedial Success:*** Periodic deployment and subsequent collection and analysis of mussels determine the bioaccumulation of chemical concentration based on tissue residues. The post-remediation tissue monitoring data are compared with pre-remediation tissue concentration from the California State Mussel Watch program and the ecological risk assessment of the United Heckathorn Site.

- ***Evaluation of Newly-Identified Contaminants and Pathways is Important:*** No new human health routes of exposure were identified that would challenge the accuracy of the protectiveness of the remedy. No new contaminants have been identified.

- ***Operations and Maintenance (O&M) Costs may Exceed Estimates:*** Although not directly related to performance of the remedy or recontamination of sediment, increased O&M costs can have a significant effect on the funds available for post-remediation O&M and monitoring.

Actual United Heckathorn annual O&M costs exceeded the original estimated O&M costs due to expansion of control efforts to cover the entire marine terminal and associated railroad operations (EPA, 2006; Table 4-2):

Year	**Original Annual O&M Cost Estimate**	**Annual O&M Cost [a]**	**25% of Annual O&M Cost**
From 07/01/2001 To 06/30/2002	$5,750	$32,000	$8,000
From 07/01/2002 To 06/30/2003	$5,750	$11,800	$2,950
From 07/01/2003 To 06/30/2004	$5,750	$71,400	$17,850
From 07/01/2004 To 06/30/2005	$5,750	$71,600	$17,900
From 07/01/2005 To 03/31/2006	$5,750	$86,400	$21,600
Note a: Annual O&M Cost for the 42-acre marine terminal. The original O&M cost estimate only included stormwater sampling, analysis, and reporting of the O&M activities of the 5-acre upland cap. The actual annual costs provided by LRTC include purchases and labor charges on the O&M and stormwater management activities of the entire 42-acre marine terminal and all railroad operations. The total expenses also include additional items, such as purchases of absorbent materials and inserts, hay, booms, emergency supplies, permits, testing, consultants, and disposal. Source: LRTC, 2006.			

References:

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CH2MHill, 2010a. *Reassessment of Total DDT and Dieldrin Remediation Levels to Address the Fish Consumption Pathway*. Technical Memorandum. February

CH2MHill, 2010b. *Draft Reassessment of Remediation Levels to Address Risks to Ecological Receptors at the United Heckathorn Superfund Site, Richmond, California.* Technical Memorandum Prepared for USEPA, Region 9. February.

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U.S. EPA. 2011. *Third Five-Year Review Report for United Heckathorn Superfund Site, Richmond, California*. September.

Related Links:

http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dec8ba3252368428825742600743733/809066aa6131970088257007005e9450!OpenDocument

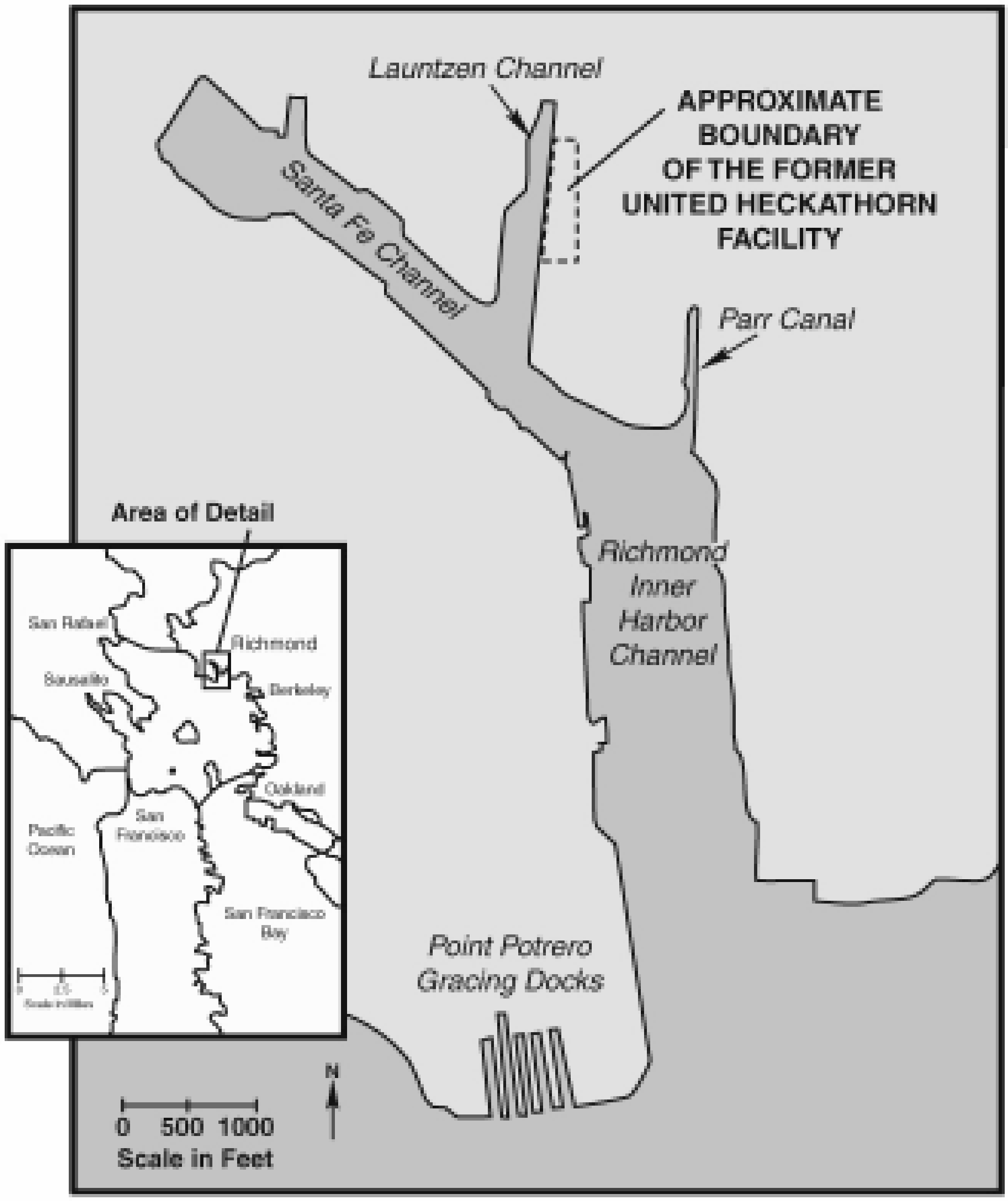

Figure 1: Location of United Heckathorn Superfund Site in Richmond, California. (from Figure 1, U.S. EPA Five Year Review United Heckathorn Superfund Site, 2006).

FIGURE 4-2
Sampling Locations for Marine Biomonitoring Program

Figure 2: Aerial photograph of United Heckthorn Site with sampling locations for marine biomonitoring (from EPA, 2006; Figure 4-2).

CASE STUDY NO. 9

Site Name: The Los Angeles District of the U.S. Army Corps of Engineers (Corps_ Initiated the Los Angeles County Regional Dredge Management Plan Pilot Studies (2001) – Aquatic Capping Study.

Site Description: The aquatic capping component of the Corps Pilot Study was planned as dredging of 130,000 cubic meters of contaminated sediment from the Los Angeles River Estuary, located in Long Beach Harbor near (immediately upstream of) the Queensway Bridge and the existing Los Angeles River navigation channel, and placing the material in the North Energy Island Borrow Pit (NEIBP) east of Island White offshore of Long Beach (Figure 1). The dredge site was capped with approximately 130,000 cubic meters of clean material dredged from the South Energy Island Borrow Pit (SEIBP).

Contaminants: Contaminated sediment containing elevated concentrations of some metals, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were found at concentrations above Effects Range-Low (ER-L) toxicity guidelines (Long et al., 1995) in both the coarser surface sediments and finer subsurface sediments. Some chemicals in the subsurface sediments also exceeded the Effects Range-Median (ER-M) for several pesticides and zinc.

Size/Area of Site: The dredge site was within a polygon approximately 200 meters (m) long by 150 m wide, which was dredged to a depth of elevation -4m to -6m mean lower low water (MLLW).

Volume of Contaminated Sediments: The planned dredge volume of 130,000 cubic meters was nominally dredged as 105,000 cubic meters.

Ecological System(s) Impacted: Two borrow pits were created in Long Beach Harbor to create North Energy Island and South Energy Island as above water artificial islands (Figure 1). The borrow pits were excavated to approximately 60 to 70 feet below water surface. The ecological systems present in each of the borrow pits was described as fairly depauperate by staff of the Los Angeles Regional Water Quality Control Board (LARWQCB) at the time, the Los Angeles River Estuary sediments were placed.

Human Health Risk(s): Human health risk concerns were addressed by eliminating human exposure pathways with measures of success based on successful design, accurate areal and vertical placement of capping material, maintenance of the cap material over time and a lack of soluble release from capped material.

Summary of Remediation: Contaminated sediments were mechanically dredged from the Los Angeles River Estuary in the City of Long Beach and placed into an existing pit located in the inner harbor off the coast of Long Beach. Dredge material was transported via split-hull barge to a large, pre-existing, sub-tidal borrow pit located in Long Beach Harbor, where it was deposited into a demonstration cell termed the North Energy Island Borrow Pit (NEIBP). After allowing the approximately 2.5m layer of contaminated material to consolidate in the disposal pit for three months, clean cap material was dredged from a second borrow pit, the South Energy Island Borrow Pit (SEIBP), and used to cover the contaminated material with a 1.0m to 1.5m layer cap. Water quality monitoring was conducted during all phases of construction to evaluate potential environmental impacts.

Following construction, the capped site was monitored annually for three years to evaluate long-term cap stability, containment/isolation of the contaminated sediments, and biological recolonization of the cap surface. Three years of intensive monitoring, as of 2005, has shown that the cap has maintained its structural integrity. There has been no measurable erosion of cap material or fissures visible in the cap surface. An accumulation of newly deposited material is now present, suggesting a net positive rate of deposition is occurring.

Chemical containment also appears to have been maintained. Elevated concentrations of contaminants have not been detected in overlying cap material or in the cap pore water at concentrations, suggesting that contaminant migration is occurring. Biological re-colonization of the cap was rapid during the first two years of monitoring and maintained in Year 3 post-placement.

Lessons Learned:

- ***Aquatic Capping in Low-Energy Environments at Greater Depths can be Successful:*** Containment for the three years subsequent to capping appears to have been successful. Low energy environments (e.g., behind islands or peninsulas) and/or at greater depths appear to be positively associated with the successful sequestration of the contaminated sediments.

- ***Selection of 'Marker' Contaminants can Lower Cost of Monitoring:*** Comparison of concentrations in the material to be dredged to the proposed capping material led to the selection of total PAHs as the best marker of the boundary of the cap and dredge material as the PAH concentration in the cap material, was orders of magnitude less than in the dredged material.

- ***Visual Survey of Cap is a Significant Monitoring Tool:*** Observation of surface disturbance by burrowing organisms (e.g., mounded burrowing material) as well as detection of burrowing organisms (e.g., ghost shrimp) in cores should be performed to evaluate cap integrity.

References:

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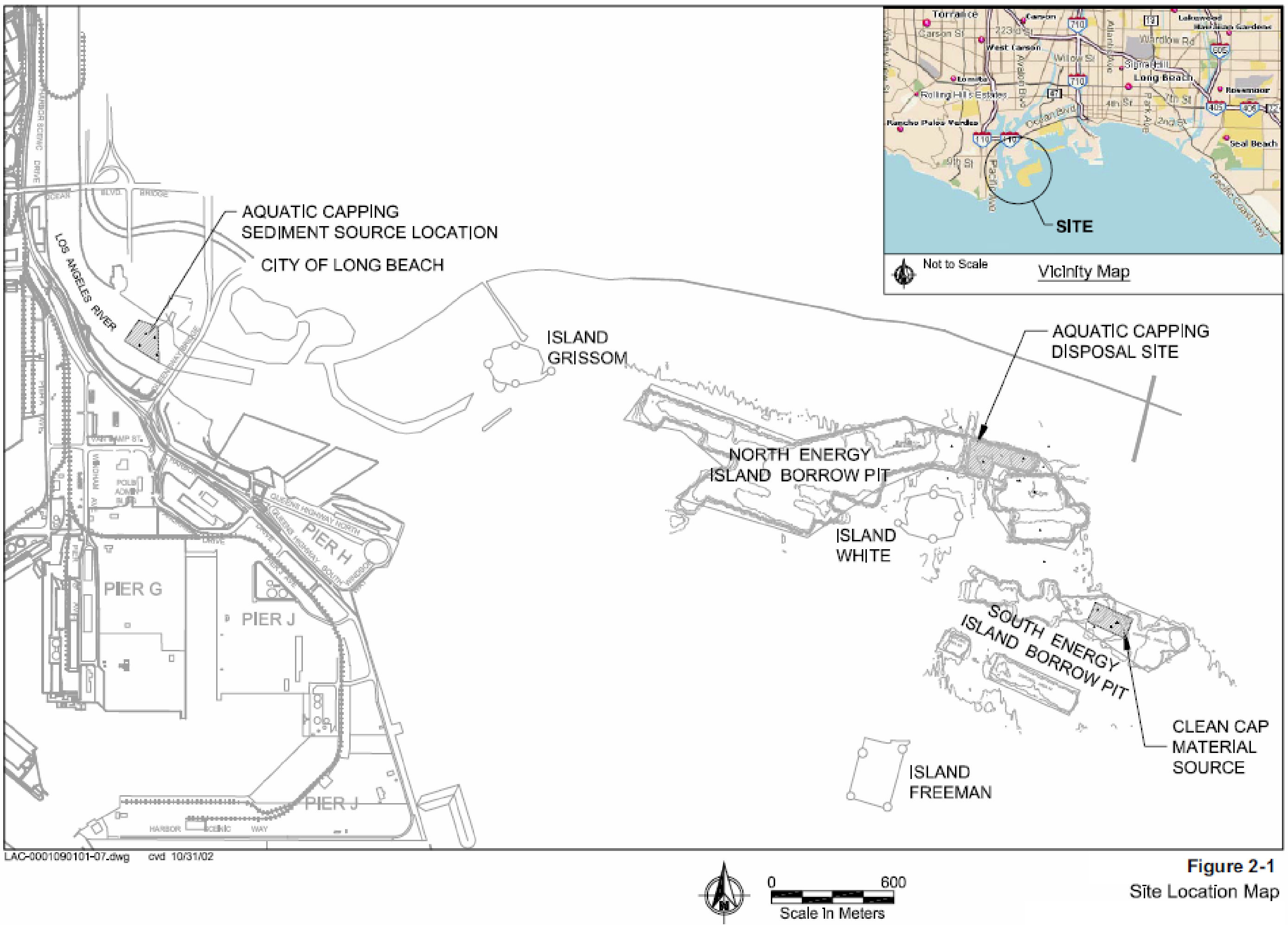

Figure 1: Army Corps of Engineers (2005) Pilot Project Port of Long Beach and Los Angeles River Estuary Sediment Excavation and Containment Locations in Southern California. [from Figure 2-1, Site Location Map, page 8].

CASE STUDY NO. 10

Site Name: Pine Street Canal Superfund Site

Site Location: Burlington, Vermont

Site Description: The 38-acre Pine Street Canal Site (Site) consists of the following: Pine Street Canal; turning basin; an adjacent wetland, an area formerly known as Maltex Pond; and an additional portion of land. Around 1908, a coal gasification plant began operating on Pine Street, southeast of the canal. The plant ceased operations in 1966. Plant wastewaters and residual oil and wood chips saturated with organic compounds were directly discharged or disposed of in the Pine Street Canal wetland. During the 1960s and 1970s, an oil-like material was detected seeping from the wetland into Pine Street Canal, the turning basin, and Maltex Pond. The State detected high levels of organic compounds associated with coal tar at several locations while investigating the Site for a then proposed major highway. The State was concerned that construction would release organic compounds into the canal and possibly into Lake Champlain, the source of Burlington's drinking water. The area is surrounded by large and small businesses, as well as several single and multiple-family dwellings, including apartment buildings located within one mile of the Site. Burlington has a population of approximately 39,100.

Contaminants: Contaminants in the groundwater include polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) including benzene, toluene, and xylenes. Canal sediments are contaminated with PAHs, VOCs, and metals. The soil contains PAHs, VOCs, and heavy metals including lead. Cyanide has also been detected in the soil. There is unrestricted public access to the Site, although access is difficult because of the marshy terrain. Portions of the Site are seasonally flooded, permitting the potential spread of contamination.

Size/Area of Site: 38 acres.

Volume of Contaminated sediments: 500 cubic yards removed in 1985. Site has up to 24 feet of peat and fill layer of contamination.

Ecological Systems Impacted:

Animals: Benthic organisms, fish and other wildlife at the Site have been adversely affected by contaminants, especially by the canal sediments.

Plants: Palustrine open water, emergent wetland, scrub – shrub plants.

Human Health Risk(s): Contaminant migration into Lake Champlain could threaten a source of drinking water for the City of Burlington.

Summary of Remediation: In 1985, the U.S. Environmental Protection Agency (EPA) excavated 500 cubic yards of coal tar, solidified it, and disposed of it in an approved facility. The Maltex Pond area also was capped with clay and covered with topsoil and seeded. A temporary fence was erected, warning signs were posted, and sampling was conducted.

By early 1991, EPA had conducted field investigations, including a soil gas survey, a geophysical survey, air sampling, ecological studies, surface water and sediment sampling, soil sampling, installation of monitoring wells, and groundwater sampling to determine the nature and extent of the Site contamination. Treatability studies to aid in remedy selection were completed in 1992. An investigation to determine cleanup alternatives was completed in late 1992 and EPA proposed a cleanup plan. The cleanup plan was withdrawn in 1993 in response to the comments received during the public comment period. Additional studies focusing on ecological risk and contaminant migration were then completed by the potentially responsible parties. EPA completed a supplemental ecological risk assessment based on new data. EPA evaluated alternative cleanup measures in late 1997 through 1998.

A cleanup proposal was released for public comment in June 1998. A Record of Decision (ROD) was signed on September 29, 1998. The ROD contains the remedy supported by the public. Elements of the remedy include: capping contaminated sediments in portions of the canal, turning basin and adjacent wetlands, institutional controls to prohibit potable use of groundwater below the Site, institutional controls for certain land-use development such as residential and children's day care centers, site boundary definition to allow for redevelopment of certain adjacent parcels, long-term performance monitoring, and five-year reviews. The ROD goals were to address risk to ecological receptors and to prevent migration or unacceptable human exposure to contaminants.

The remedy was implemented in two phases. The first involved the installation of a weir where the canal empties into Lake Champlain. The weir will maintain desired water levels in the canal to prevent future erosion of the subaqueous cap. Construction of the weir was completed in November 2001. The second phase involved capping contaminated soils at the southern end of the Site, placing the subaqueous cap over contaminated sediments in the canal and turning basin, making improvements to the storm water control system, and wetlands restoration. Work began in July 2002, and was completed in March 2003.

In June 2003, a breakout of coal tar and oil was discovered in an uncapped area immediately adjacent to, but not in, the canal. During the summer of 2004, the sand cap was extended over a portion of the canal's west bank where coal tar and oil was being released to the ground surface via macro pores (e.g., historic cribbing, root system of dead trees). The expanded cap appeared to address the release of contamination until oily sheens and globules of coal tar were observed floating on the surface water at the southern end of the canal during routine compliance monitoring in the spring of 2005. Subsequent studies conducted by the parties responsible for the implementation of the cleanup, under the supervision of EPA and VT DEC, concluded that the coal tar and oil is migrating upwards through the sand cap, primarily when gas bubbles are released from the peat below the cap.

EPA signed an Explanation of Significant Differences (ESD) on April 7, 2009. The ESD provides that, in the areas where the seepage is occurring, the existing cap will be redesigned and reconfigured to capture the non-aqueous phase liquid (NAPL) before it is released in to the canal. The new cap will require more maintenance and monitoring than the original ROD. The cap will include a high-permeability layer to facilitate passive collection and removal of NAPL. The NAPL that accumulates will periodically be removed and shipped off-site for treatment or disposal in an approved facility. Environmental controls, such as absorbent booms, keep the contamination from entering Lake Champlain.

The first five-year review of the remedial action was completed in October 2006. The remedy is currently protective of human health and the environment except for ongoing release of coal tar in a limited area of the subaqueous cap in the canal. The remedy will not be protective in the future without a mechanism in place to monitor and determine compliance with institutional controls that have been established to restrict land and groundwater use at the Site. Two issues that must be evaluated in order to determine protectiveness in the future are: 1) the vapor intrusion to indoor air pathway with the potential to impact current or future indoor receptors, and 2) the ability of the existing compliance monitoring program to adequately monitor performance standards for contaminant migration given new site conditions.

Long-Term Monitoring: The monitoring included groundwater, surface water, storm water inflow, sediment transport, and physical and chemical monitoring of the cap; aquatic and wetland habitat restoration areas. Additional monitoring was performed to assess the impact of NAPL seeps that appeared after construction of the cap.

Groundwater Quality (since 2000):

NAPL: Results have indicates that NAPL is not migrating downwards off site nor into Lake Champlain.

Volatile Organic Compounds: Most of the groundwater samples have shown non-detect or occasional trace detections of benzene, toluene, ethylbenzene or xylenes (BTEX compounds). One well shows significant impacts by PAHs and BTEX, and benzene consistently exceeds maximum contaminant levels (MCLs). However, a concentration trend over time is not evident. The results indicate the mass flux of plume is not increasing.

PAHs: Most of the groundwater samples have shown non-detect or occasional trace detections of various PAHs. Four wells shown detection of PAH compounds. The results indicate the mass flux of plume is not increasing.

Metals: Metals have been detected in all samples. Most are at levels below MCLs. The results indicate that the contaminants are not migrating nor that mass flux of the plume is increasing in the area.

Surface Water Data Review: Surface water was monitored to ensure that the engineering controls at the outlet to Lake Champlain are functioning as intended to protect surface water from cap construction impacts. Samples are collected and PAH results are compared to the ambient water quality criteria (AWQC) for protection of human health. Attainment of AWQC is not a performance standard; those criteria are to be considered, along with other relevant factors, to determine whether additional work will be required. The monitoring consisting of grab samples (unfiltered) from the outlet channel to the lake for the analysis of PAHs was conducted once and no PAHs were detected.

Environmental controls (i.e., booms) in the southern portion of the canal prevent ongoing releases of NAPL from migrating towards Lake Champlain. Based on surface water results, additional work to control surface water contamination is not required at this time.

Storm Water Inflow Data Review: As part of the remedy, storm water management features were enhanced to reduce the potential for recontaminating the remediated portions of the Site. The remedy was to ensure that suitable retention time be provided to remove sediment from storm water passing through the wetland, before it reached the cap to determine whether it may create an unacceptable risk to ecological receptors. Storm water inflow monitoring is conducted through the use of sediment traps. PAHs and metals were analyzed in the first sample event. Two trap samples had relatively high concentrations of PAHs compared to other trap samples. NAPL droplets were observed on one sample. The elevated PAH concentrations are attributed to the fact that the samples were taken from the area of ongoing NAPL releases. Samples from the remaining traps had reported concentrations of total PAHs ranging from 18 to 45 parts per million (ppm) with the two highest concentrations near the ongoing NAPL releases. The contaminant concentrations in the sediment trap samples exceeded cap monitoring benchmarks for total PAHs, individual PAHs, and zinc. The concentrations of arsenic and chromium also exceeded ecological benchmarks in one sample each, although these metals did not have performance standards.

The levels of PAHs and metals, particularly in the three samples collected in the area of ongoing NAPL releases, exceed concentrations that correspond to probable risk for aquatic organisms exposed to sediments. Deposition of particulates with the concentrations observed could create an unacceptable risk to ecological receptors in remediated areas as these materials accumulate on the surface of the sediment in the canal and turning basin. The impact of the ongoing NAPL releases on data collected from sediments traps has not been quantified, but is likely significant and will continue to be significant until such time as the releases are addressed.

Sediment Transport Data Review: The performance standard for sediment transport includes monitoring to verify that the remedy is preventing sediment transport to Lake Champlain at levels that would create an unacceptable risk to receptors in Lake Champlain. An ISCO sampler was installed in the outlet from the turning basin to Lake Champlain to collect unfiltered water samples. Since the installation of the sampler, there was only one storm event that exceeded the ARI peak storm through late December 2005. However, no samples were collected due to an incorrect application of the modeled trigger stage to the data logger program. No conclusion can be drawn at this time regarding whether this performance standard is being met. Peak storm events will continue to be monitored and a conclusion regarding protectiveness will be drawn in the next five-year review.

Cap Compliance Monitoring Summary: Across much of the Site, compliance monitoring data collected to date indicates that the cap has met the performance standards. That it contains and isolates the contaminated sediment and is resistant to erosion or bioturbation that would expose contamination, with the following qualifications: Cap interstitial water has not been directly assessed as seepage collection devices did not collect sufficient water to analyze. Modeling and seepage meter tests indicate that upward flow of groundwater through the cap is negligible and that recontamination of the cap via contaminated groundwater would be insignificant. Surface water monitoring results also indicate that there is no significant contaminated groundwater migration through the cap. It is possible, however, that benthic organisms may be exposed to contaminated cap interstitial water if it exists. Some top-cap core samples exceed ecologically-protective sediment benchmarks for PAHs. Elevated PAHs are attributed to NAPL droplets observed in the sample or, in those instances where NAPL droplets were not observed in the sample, the proximity of the sample to the area of NAPL releases. Free-phase coal tar (NAPL) continues to seep through discrete channels in the subaqueous cap in the southern portion of the Site, and is being deposited on the water and cap surface.

NAPL Release Summary: The cap performance standard has not been met for the subaqueous cap in all areas because the cap has not isolated or prevented the migration of NAPL contamination to the water and cap surface. In this area, the cap has not prevented contact between the contamination and benthic organisms and fish in the biologically active portion of the benthic habitat. Cores taken from the NAPL release area have concentrations of PAHs that exceed sediment benchmark values for ecological protection. Fish, frogs, turtles, waterfowl, muskrat, and other fauna that live in and around the canal are exposed to free-phase NAPL with total PAH concentrations as high as 147,000 ppm. In addition to presenting a potential ecological risk, the presence of NAPL may also constitute a loss of habitat. Benthos has not been observed where free-phase NAPL is present. For these reasons, EPA is making the determination that the subaqueous cap in some locations is not protective. Information collected during and since the extension of the cap over the west bank in 2004 suggests that there is a significant accumulation of NAPL in the subsurface in the southern portion of the Site. In at least one location the NAPL appears to be quite mobile, moving perhaps in response to water levels in the canal. Probes show no evidence of NAPL migrating towards the Class IV boundary, nor Lake Champlain. However, unlike the northern portion of the Site, there are no shallow monitoring wells between the contamination and the Class IV boundary or Lake Champlain in this area. The current compliance monitoring program should be evaluated to determine whether the performance standard for contaminant migration across an expanded Class IV boundary or into Lake Champlain can be adequately monitored at the southern portion of the Site.

Aquatic Habitat Summary: Compliance monitoring for aquatic habitat restoration consists of benthic invertebrate community sampling and qualitative plant surveys. Benthic macro invertebrate data collected to date indicates the development of a low-diversity benthic community dominated by oligochaete and tubificid worms, and chironomid midge larvae. Performance standards for habitat restoration have generally been met. In one area, additional data are needed to determine the full extent of the impact NAPL releases have had on habitat quality.

Wetland Habitat Restoration: Restoration of habitat functions and values was monitored. Monitoring has included documentation of water levels suitable for each wetland habitat, development of a plant community dominated by wetland plants, and monitoring of soils for a trend toward hydric (saturated wetland conditions) soil morphology. The performance standards in one area have generally been met, indicating the habitat restoration for the remedy has been successful. For the other area, it is anticipated that performance standards will be met there as well.

Lessons Learned:

- Inspections and visual monitoring can be an important component of O&M. Post-ROD releases of contamination were identified and additional remedial action was initiated due to the discovery of additional releases.
- Having adequate locations, sampling rounds, and numbers of samples is critical to a good monitoring plan. Any monitoring plan should flexible enough to increase (or decrease) the sampling depending on the previous results.
- On site where contamination remains, chemical and physical monitoring may be required. If the post-ROD releases at this Site were not seen, then chemical monitoring would have been the only method to determine that releases were occurring.

References:

Record of Decision, Pine Street Canal Superfund Site, September 29, 1998
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http://www.epa.gov/region1/superfund/sites/pinestreet/443273.pdf
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http://www.epa.gov/region1/superfund/sites/pinestreet/493729.pdf

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http://yosemite.epa.gov/r1/npl_pad.nsf/701b6886f189ceae85256bd20014e93d/f8cfe11e53efa23c8525691f0063f6e8!OpenDocument

Personnel Communication with EPA Project Manager Karen Lumino e-mail dated March 23, 2011.

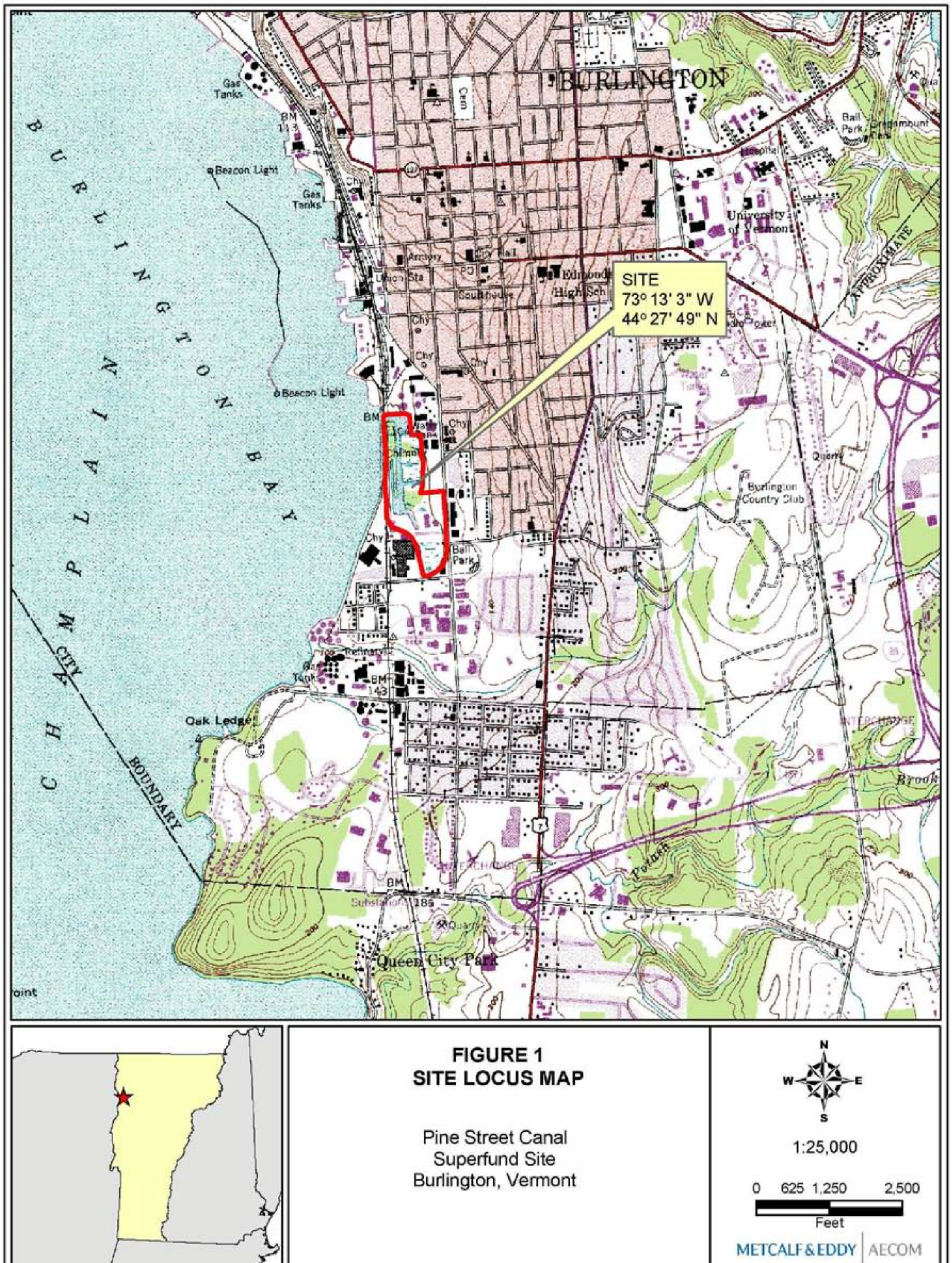

FIGURE 1
SITE LOCUS MAP

Pine Street Canal
Superfund Site
Burlington, Vermont

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CASE STUDY NO. 11

Site Name: Torch Lake/Quincy Smelter NPL Superfund Site, Houghton County, Franklin Township, Michigan. The case study focuses only on the Torch Lake portion of the Site.

Site Description: For the purposes of this case study, the Site, also referred as Operable Unit 2 (OU2), is considered to be the sediments in Torch Lake, the west Shore of Torch Lake, the northern portion of Portage Lake, the Portage Lake Canal, Keweenaw Waterway, the North Entry to Lake Superior, Boston Pond, Calumet Lake, and other areas associated with the Keweenaw Basin. Torch Lake is used for fishing, boating, contact recreation (swimming), non-contact cooling water, treated municipal waste assimilation, and fish and wildlife habitat.

Due to a continuing erosion problem and receding water line in the lakes, the sediments do not seem to have recovered to any significant levels. If natural recovery is the sole remedy selected, it may take many decades for sediment recovery to be completed.

Contaminants: Polychlorinated biphenyls (PCBs), various metals (Al, As, Cr, Co, Cu, Fe, Li, Mg, Mn, Hg, Se, Ag, V, and Zn), and several polycyclic aromatic hydrocarbons (PAHs) (chrysene, fluoranthene, phenanthrene, and pyrene).

Size/Area of the Site: Torch Lake has a surface area of approximately 2,700 acres, a mean water depth of 56 feet, a maximum depth of 115 feet, and a volume of 5.2 X 10^9 cubic feet. The Trap Rock River and several small creeks discharge into Torch Lake.

Volume of Contaminated Sediments: No physical work was required as part of the OU2 as the Record of Decision (ROD) called for no action.

Ecological Systems Impacted: Surface water, and sediments within Torch Lake and other waterways include benthic communities. There are on-going fish consumption advisories for PCBs on walleye and smallmouth bass for Portage Lake and Torch Lake.

Human Health Risks: A protectiveness determination for OU2 cannot be made at this time. A PCB fish consumption advisory has existed in Torch Lake since 1999. The remedial actions implemented at Lake Linden, Hubbell/Tamarack City, and Mason Sands (OU1) and Quincy Smelter property (OU3), which affect the recovery of OU2, are protective in the short term. For actions to be protective in the long-term, a review of institutional controls must be performed and modified as appropriate.

Summary of Remediation: The Superfund ROD for OU2, the lake, called for natural attenuation with monitoring. Recovery was assessed by monitoring sediment conditions such as benthic populations, sedimentation rate, and sediment quality (discussed below). OU2 is related to OU1 and OU3 primarily in that wind-blown and eroded tailings from OU1 and OU3 end up in OU2. These conditions serve as a continuing source of environmentally harmful contamination to the lake and diminish the effectiveness of the lake's natural sedimentation process. The remedy chosen for OU1 and OU3, stabilization and vegetation of the tailing piles near the lake, was in part selected because it addressed the erosion problem.

Recovery Assessment:

Sediment Quality: The five-year review sediment data (collected in 2004 and 2007) confirmed that sediment concentrations remain extremely high and exceed acute toxicity criteria. Therefore, Michigan DEQ (MDEQ) staff made the determination that additional toxicity studies were unlikely to reveal a significant change from the baseline study results and cancelled the corresponding sediment toxicity studies. Torch Lake sediment samples also indicate copper concentrations increased by 1.5 to 32 times compared to those identified in the Baseline study, especially along the east side of Torch Lake. While MDEQ conducted the study that identified additional metals, it is not clear who, if at all, will conduct the comparison of historical data to ecological criteria.

The results of the 2007 semi-permeable membrane devices (SPMD) study indicate, in addition to the metals, the presence of a potential source of PCBs within the northern side of Torch Lake. The PCB sediment concentrations in the north/northwest basin of Torch Lake are below levels requiring remedial action. However, given that low levels of PCBs are detected in the surficial sediment, an ongoing upland source of PCBs to Torch Lake cannot be ruled out. Therefore, a detailed upland source identification study could be conducted to make that determination. An evaluation of the relative risk of these low levels of PCB in sediment and water column would need to be completed before additional remedial work could be recommended.

Sample results throughout the study area showed concentrations of copper and lead above the MacDonald probable effect concentration (PEC) screening levels of Sediment Quality Guidelines (MacDonald *et al*, 2000).

Although the sediment present at the base of Torch Lake has exhibited significant toxicity, numerous zooplankton were observed in the sediment traps that were placed in Torch Lake during this study, indicating that the sediment toxicity is not necessarily contributing to water column toxicity. Also, the Torch Lake sediment flux and metals analysis study of March 2006 showed that since 1968, a thin, two-to four-inch thick organic layer has accumulated over the stamp sands and slime clays present in Torch Lake.

Biotic Recovery: Selected sediment cores were stratified and analyzed for porosity, organic content, copper and mercury concentrations, and organism microfossil remains. Both mercury and methylmercury were higher in recent (surficial) organic sediments and provide conditions favorable for mercury methylation. Microfossils of planktonic zooplankton were found to have increased following the cessation of mining, and viable banks of resting eggs (essential for spring recruitment) were also documented. However, unexpected elevated concentrations of metals were found in the organic sediments, which may represent flux from porewater from within the slime clays. This organic cap plays an important role in sediment recovery by binding copper into a presumably less bioavailable form. Low sedimentation rates also hinder recovery rates for the sediments.

Benthic Community: No dredging or other major disturbances to the benthos are known to have occurred at the Site.

The results of the 2004 sampling event indicate that the abundance and diversity of benthic organisms at the Site remains low, and it appears no appreciable changes in the health of the benthic community have yet occurred due to natural recovery processes. Differences in abundance and number of taxa between the samples collected in the baseline (2002) vs. monitoring studies (2004) could be explained by differences in water depth alone, as shallower lake areas have a greater abundance and diversity of benthic invertebrates due to greater habitat heterogeneity, more abundant food, warmer water temperatures, and higher dissolved oxygen concentrations.

Natural Recovery: Based on the results of the sediment trap study, the estimated sedimentation rates varied from 0.017 grams/cm2/year to 0.042 grams/cm2/year. Copper was detected in each of the samples collected in the sediment traps at concentrations ranging from 540 parts per million (ppm) to 1,200 ppm. Natural recovery does not appear to be occurring at an appreciable rate in Torch Lake sediments at this time. Sources of copper contamination, as well as other heavy metals, including lead, arsenic, and mercury, do not appear to be completely controlled. Based on 2004 monitoring data, the report states that "it has been estimated that it may take more than several hundred years for Torch Lake to recover based on the limited post-construction data so far."

Lessons Learned:

- The natural recovery for sediments should be selected only after adequately assessing the sedimentation rates.
- Natural remedy should not be the only remedy selected for sediment recovery especially when source control of contaminant is not adequately completed.
- Sediment contamination may not necessarily result in water column toxicity.

References:

Second Five-Year Review Report for the Torch Lake Superfund Site; Houghton County, Michigan, dated March, 2008. EPA Region 5 Record # 295649.
http://www.epa.gov/superfund/sites/fiveyear/f2008050002157.pdf

EPA Fact Sheet for Torch Lake/Quincy Smelter Superfund Site Franklin Township, Michigan, dated December 2008.

MacDonald D.D., Ingersoll C.G., and Berger T.A. 2000. Development of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Archives of Environmental Contamination and Toxicology. 39:20-31.

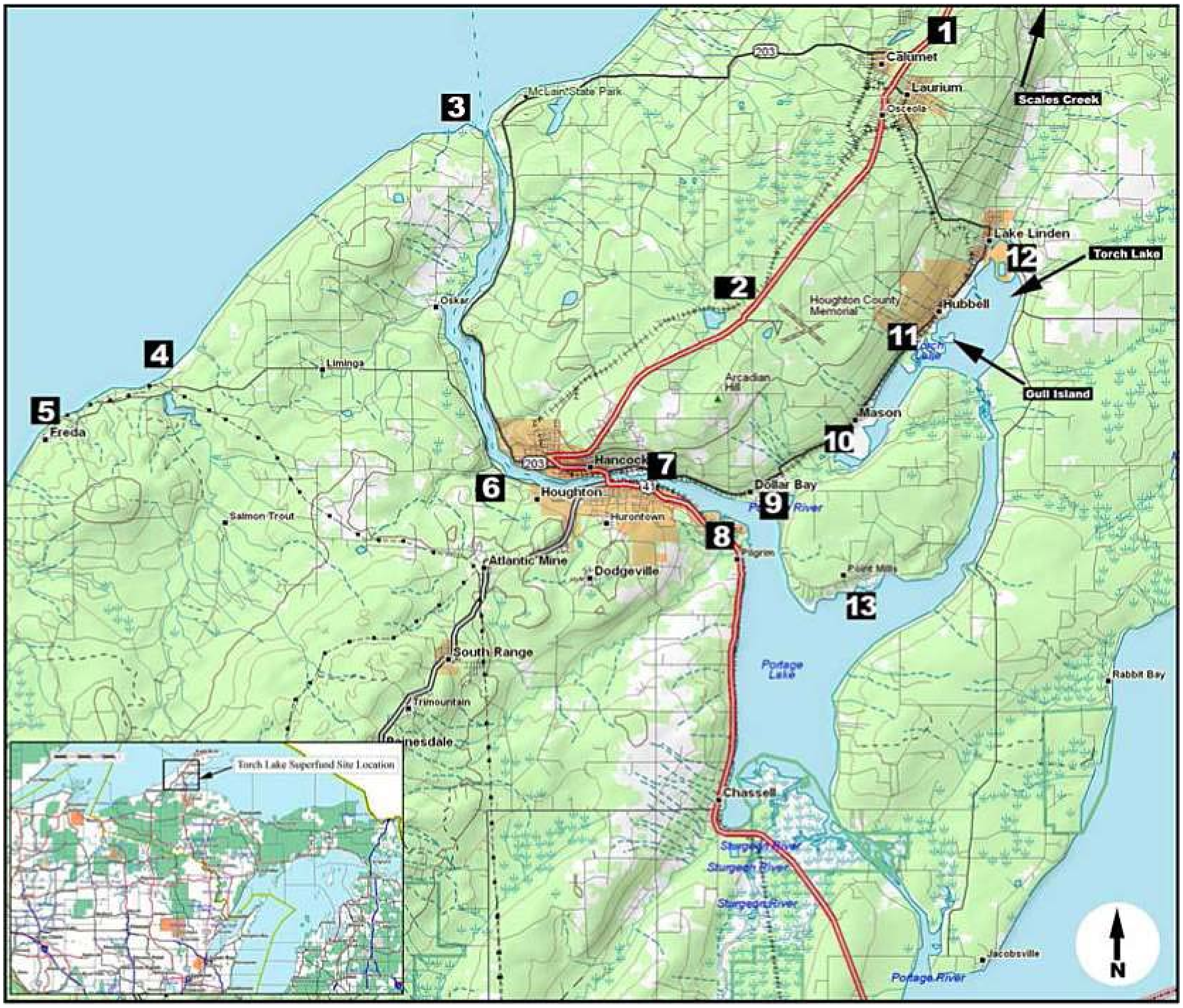

Figure 1. Torch Lake Location, from Second Five-Year Review Report, for Torch Lake Superfund Site, Houghton County, Michigan. March 2008.
http://www.epa.gov/superfund/sites/fiveyear/f2008050002157.pdf

CASE STUDY NO. 12

Site Name: Operable Unit 2 - Pine River Velsicol Chemical Superfund Site, St. Louis, Michigan

Site Description: The Velsicol Chemical Superfund Site is located at 500 Bankston Street, Gratiot County, St. Louis, Michigan and encompasses contaminated portions of the Pine River. There are two operable units (OUs) at the Velsicol Site. OU1 consists of the 52 acre main plant site, the location of the former chemical manufacturing facility. OU2 consists of contamination in sediments and fish in the St. Louis impoundment and Pine River. The sediments were contaminated with Polybrominated biphenyls (PBB), Hexabromobiphenyl (HBB) and total Dichlorodiphenyltrichloroethane (DDT) but total DDT was the basis for the human health and ecological risk assessments because it was found at the highest concentrations in fish tissue and sediments. The remedial action work at OU2 removed an estimated 640,000 cubic yards of DDT-contaminated sediments, and an estimated 222 tons of DDT from the Pine River. During the removal of sediment, seepage of dense non-aqueous phase liquid (DNAPL) was observed from the riverbank adjacent to the main plant site into the Hot Spot Cell. Recommendations for future remediation included: Continued operation and maintenance of NAPL collection system to prevent OU1 site contaminants from recontaminating OU2; keep the no-consumption fish advisory in place until DDT levels in fish have been demonstrated to have decreased to safe levels; and conduct long-term monitoring of DDT levels in fish and sediment.

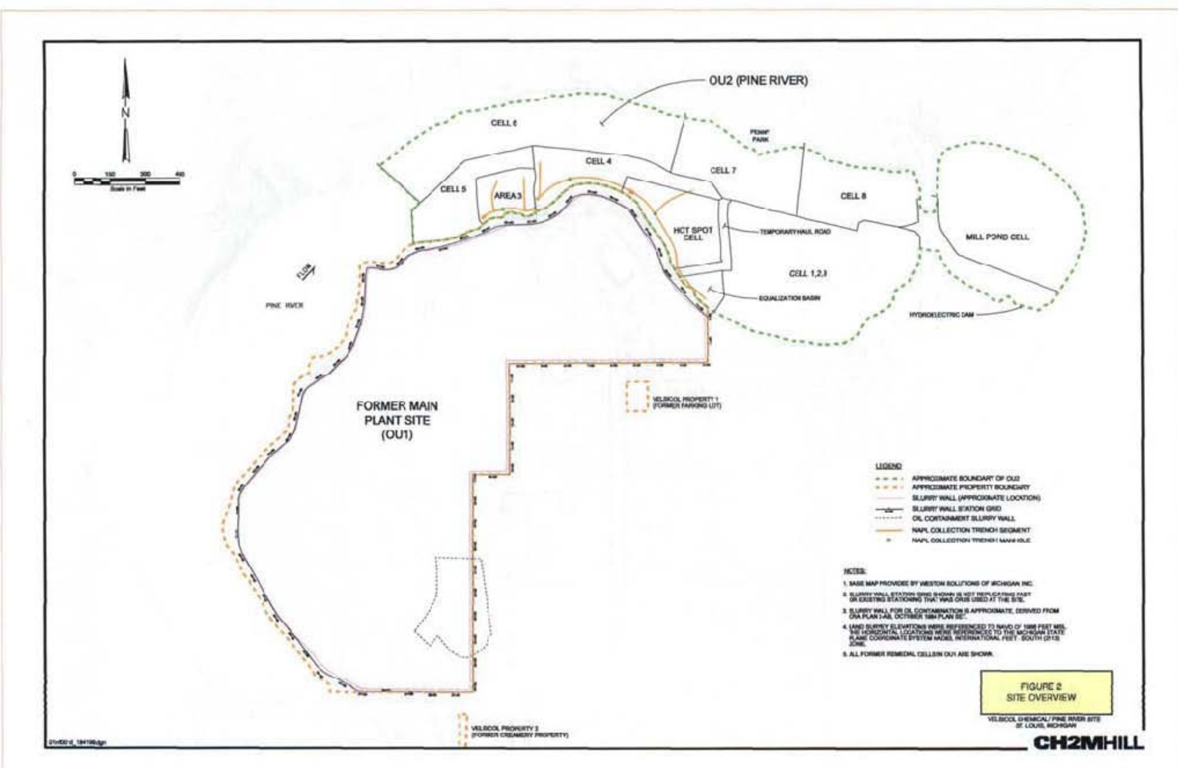

Figure 1: Site Overview.

Contaminants: Polybrominated Biphenyl (PBB), hexabromobenzene (HBB) and total dichlorodiphenyltrichloroethane (DDT).

Size/Area of the Site: The portion of the Pine River and St. Louis Impoundment subject to consideration in this document includes the Pine River from approximately the M-46 bridge to the Mill Street bridge. The total area of this stretch is approximately 25 acres.

Volume of Contaminated Sediments: Approximately 666,000 cubic yards.

Ecological Systems Impacted: Pine River, sediments, fish, and fish eating birds.

The Pine River is a navigable waterway. Current uses of the Pine River and St. Louis Impoundment are impaired due to the sediment contamination. While sportfishing is not strictly prohibited, anglers are limited to catch and release fishing by the no consumption fish advisory. The advisory, however, is not easily enforceable. Swimming and boating are considered undesirable due to the contamination. Generation of electricity is currently the only acceptable use of the river and impoundment. Within the St. Louis Impoundment, the water depth to sediment is generally between 7 and 10 feet.

Studies between 1978 to 1980 and 1992 showed that Pine River surface water did not contain measurable levels of contaminants associated with the Site and thus surface water is not further included in this review and analysis.

Sediments are contaminated with PBB, HBB and total DDT. Sediment total DDT concentrations ranged from 1.3 to 32,600 ppm where none of the samples indicated total DDT concentrations less than 1 ppm. Results from all sediment surveys (from 1978 until 1980, 1988, 1996, and 1997) indicated that the levels of total DDT in the Pine River and the St. Louis Impoundment were extremely high and had not decreased over time.

Elevated levels of PBB and DDT in fish tissue have been observed in data collected by the MDNR in 1983, 1985, 1989, 1994, 1995 and 1997. Body burden of contamination in fish has been monitored by MDNR since 1983. Fish data focusing on trends in skin-off filet (Fs) carp samples (since this was the only sample type consistently collected) show that carp in the St. Louis Impoundment and below the St. Louis dam are bioaccumulating high levels of total DDT and there are no indications, from the 14 years of data, of a downward trend. It is difficult to draw more conclusions from the data due to variabilities in weight, age, % of fat, number of samples collected, and other variables.

Human Health Risks: Because DDT, dichlorodiphenyldichloroethane (DDD) and dichlorodiphenylethylene (DDE) are extremely bioaccumulative, the risk assessment determined that the main human health exposure pathway is through ingestion of contaminated fish. People may also be exposed to contaminants during wading (or other recreational activities) due to direct contact of their skin with sediment. While this may not occur frequently, it is thought to occur to some degree given the very close proximity of many homes to the river and lack of any appreciable barriers separating backyards from the River (including vegetation, presence of any banks, and dock faces). Other exposure routes such as inhalation or surface water ingestion are thought to be minimal and insignificant compared to ingestion of fish and direct contact with sediments, because of the low level volatility of DDT, DDD and DDE and their strong partitioning to sediment. Risk associated with dermal contact considered absorption of total DDT, PBB, and HBB.

Summary of Remediation: The remedial action work for OU2 was conducted in phases, with Phase I addressing the sediments in the southern half of the Pine River immediately adjacent to the former plant site, and Phase II addressing sediments in the river's northern portion and Mill Pond. Various remedial cells were constructed of sheetpiling during each phase. The remedial action work for OU2 involved dewatering within the cells, treating the sediments with a stabilizing/drying agent, excavating the sediments and disposing them off-site. The remedial action work also included treating the water removed from the cells at the on-site treatment plant after first being pumped to an equalization basin. The remedial action will be considered officially complete when EPA approves the final Remedial Action Report.

During the 2001 and 2002 construction season, USEPA observed seepage from the riverbank adjacent to the main plant site into the Hot Spot Cell and that in some areas the sand seams on top of and within the glacial till underlying the Pine River contained DNAPL. Two distinct types of DNAPL were identified: one containing primarily DDT and chlorobenzene ("hot spot cell DNAPL") and second containing primarily brominated and other halogenated organic compounds, with very small amounts of DDT ("Area 3 DNAPL"). Following these discoveries, EPA installed NAPL collection trenches along the southern shoreline of the Pine River, and also pumped DNAPL directly from pooled areas on the exposed glacial till.

The remedial action work at OU2 removed an estimated 640,000 cubic yards of DDT-contaminated sediments, and an estimated 222 tons of DDT from the Pine River. Usually, after all the sediment and sand were removed, confirmation sampling of the underlying glacial till showed remaining total DDT concentrations were less than the cleanup level of 5 ppm. In the areas where areas glacial till was heavily contaminated by DNAPL, final confirmation samples typically were not collected, and the till was capped with 2 feet of imported clay. Additionally, clean earthfill was used to backfill all sheet pile walls where sediment excavation had exposed the face of the wall. This clean earthfill was left in place when the sheetpiling was removed.

The only area of OU2 where contaminated sediments were not removed is an area of the river known as "Area 2." Area 2 is located along the southern edge of the river from just west of the Mill Street Bridge to the dam at the southeastern portion of the Mill Pond. Sample results showed that this area contained lower concentrations of DDT contamination that were considered ‘minimal’, and engineering design considerations determined that the area would be very difficult to work in. As a result, Area 2 was excluded from the cleanup. The average surficial DDT concentration in Area 2 is 13.8 ppm, and the average concentration for the entire sediment column is 15.7 ppm total DDT. An estimated 26,000 cubic yards of contaminated sediments remain in Area 2.

Based on all of the confirmation sampling that was conducted in remediated cells, and considering that any NAPL-impacted areas of glacial till were capped with 2 feet of compacted clay, EPA estimates that the total DDT surface weighted average concentration (SWAC) for all of OU2 (including the unremediated Area 2) is 1.38 ppm total DDT.7 This is slightly less than the total DDT SWAC that the ROD estimated would result from a 5 ppm cleanup standard. As discussed previously, the ROD estimated that utilizing a 5 ppm cleanup standard would, in practice, result in a post-cleanup concentration of 1.5 ppm total DDT.

The five-year review found that the remediation performed at the Site as a whole is not protective of human health and the environment. The remedy at OU2 is expected to be protective of human health and the environment once DDT levels in fish have decreased to safe levels and the existing fish consumption advisories are eliminated. However, it will likely take some time to achieve that objective because the OU1 containment system is not functioning as designed and is not preventing migration of contaminated groundwater from the main plant site. The non-aqueous phase liquid (NAPL) collection system must be operated and maintained until the protective remedy implemented for OU1 to ensure that site contaminants from OU1 do not recontaminate OU2.

DDT levels in fish have not yet been demonstrated to have decreased to safe levels, so the no-consumption fish advisory remains in effect. Long-term monitoring of DDT levels in fish and sediment is planned but has not yet begun following completion of the OU2 remedial action completed in September 2003. The need for institutional controls at OU2 is under review.

Lessons Learned: Recontamination of sediment can occur from other previously unknown areas of contamination, thereby making the recovery/removal of contamination difficult. Removal of sediment will remove known contamination but a significant time period may be required before potential ecological hazard is reduced, fish tissue concentrations decrease, and risk to human health is reduced.

References:

Record of Decision 1999: EPA Superfund, VELSICOL CHEMICAL CORP. (MICHIGAN) EPA/ROD/R05-99/161.

Third Five-Year Review Report for Velsicol Chemical Corporation Site, St. Louis
Gratiot County, Michigan, dated September 2007. EPA Region 5 – 279398.

CASE STUDY NO. 13

Site Name: Denny Way Combined Sewer Overflow (CSO) Facility Site, Seattle, Washington

Site Description: The Denny Way CSO Site (Site) is located along the northeastern shoreline of Elliott Bay and is adjacent to Myrtle Edwards Park at the foot of Denny Way in Seattle, Washington. The Denny Way Combined Sewer Overflow (CSO) in Seattle was constructed in the 1960s when Metro (now King County) built the greater Seattle area's wastewater treatment system. The Denny Way CSO contaminated sediment from a historic sewer outfall that discharged offshore for over 70 years (1895-1967). Until 2004, the Denny Way CSO outfall discharged stormwater and untreated wastewater at the shoreline. Sediments at or near the site, including off shore, were contaminated due to these discharge activities.

Contaminants: Mercury, silver, cadmium, copper, lead, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), bis (2-ethylhexyl) phthalate, and butyl benzate phthalate.

Size/Area of Site: 3 acres.

Volume of Contaminated Sediments: Estimated 20,000 cubic yards of sediment.

Ecological System(s) Impacted: Benthic organisms, fish, and other wildlife.

Human Health Risk(s): Consumption of seafood.

Summary of Remediation: King County implemented a voluntary cleanup action under which the dredging of as much contaminated sediment in the nearshore as practicable, and backfilling with clean sand at the dredged area, to restore the grade to pre-project conditions. About 20,000 cubic yards of sediment were removed from the Site and roughly 21,000 cubic yards of material replaced on the area. The dredged sediment will be transported to and disposed at a regulated landfill facility. Finally, habitat enhancing gravel will be placed on the sediment cap surface. To protect endangered fish species in the area, dredging can only occur between November through February.

Discharges from the Denny Way CSO are far less frequent and occur at a different location due to a 2005 King County construction project. As a result, the Denny Way CSO no longer affects the area targeted for remediation. King County will continue to monitor sediment quality conditions at the Site for ten years after the completion of the interim action, and will consider further remediation if monitoring results show evidence of any exceedances of the Sediment Management Standards (SMS) cleanup levels at the project area and vicinity. This remedial action will improve human and environmental health by removing the contaminated sediment at the Site.

In 1999, King County developed a preliminary sediment cleanup plan for contaminated sediments surrounding the Denny Way cap, and specifically identified the need to eliminate the contaminated sediment located on the inshore side of the cap before addressing other areas around the sediment cap (King County 1999). Also, conditions at the Denny Way cap changed as a result of the large CSO reduction project in which two new CSO outfalls were constructed. It was believed that these actions would provide a 50 percent reduction in the suspended solids discharged to the bay from Denny Way CSO by using a 7.2 million gallon storage tunnel. Treated CSO discharges continue to occur at a maximum of 20 times a year at a water depth of minus 60 feet Mean Lower Low Water (MLLW) from the new 600-foot long outfall pipe, which extends beyond the offshore edge of the sediment cap

(Symonds 2005). The long outfall pipe was driven through the cap and covered with an armoring blanket of concrete matting and rock to protect the pipe.

Lessons Learned: Source control would normally occur prior to sediment remediation; however, King County viewed the Denny Way cap as an economical way to create an immediate improvement in sediment quality within a large three acre area of Elliott Bay. Therefore, without waiting 10-15 years for a CSO reduction project to be completed at the Denny Way CSO, the Denny way cap was constructed prior to source control competitions. Re-suspension of contaminated historic sediment was identified as an important source of recontamination to the surface cap. The 3-foot thick cap was designed to use all clean sand to cover the largest surface area of the most contaminated sediments near the Denny Way CSO outfall. The inshore edge of the sand cap was set at a water depth of minus 20 feet MLLW to avoid erosion of the sand by wave generated currents at shallower water depths. The surface area of the contaminated sediment located inshore of the cap was about one acre, but the surface area of the clean cap was about three times larger than the area that was not capped. Re-suspension of this contaminated inshore sediment was also recognized as a potential recontamination source.

Another source of recontamination was the erosion and re-suspension of contaminated historic sediment that occurred when the CSO discharged at low tide because the CSO flow traveled across a small beach that was exposed at low tide. The highest chemical concentrations occurred at three stations inshore of the cap and many of the chemicals exceeded SMS values. Denny Way CSO discharge eroded contaminated beach sediment at low tide. At Denny Way, a sediment cleanup plan will eliminate the contaminated historic sediment located inshore of the Denny Way cap; this was found to be a significant source of recontamination to the Denny Way cap.

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Sediment Monitoring Plan: Denny Way/Lake Union Combined Sewer Overflow Project, May 18, 2000. (http://your.kingcounty.gov/dnrp/library/wastewater/sedman/Denny/Denny_200005.pdf)
May 18, 2000

Denny Way CSO Sediment Remediation Project.
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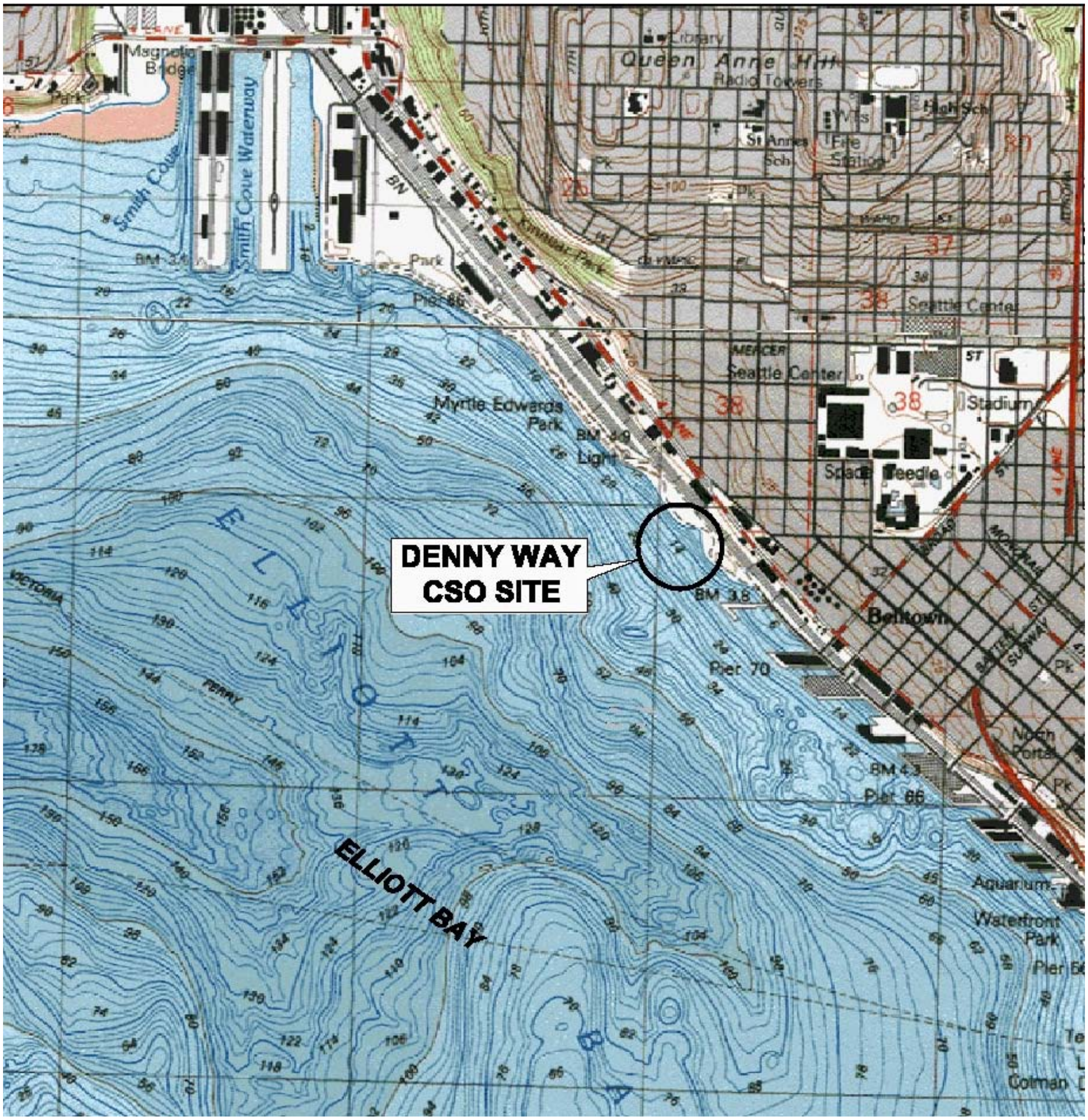
DENNY WAY
CSO SITE
ELLIOTT BAY
Queen Anne Hill
Radio Towers
Library
Magnolia Bridge
Smith Cove
Smith Cove Waterway
Park
Pier 86
Myrtle Edwards Park
BM 4.9
Light
BM 3.8
Pier 70
Seattle Center
Stadium
Belltown
BM 4.3
Pier 66
Aquarium
Waterfront Park
Colman

CASE STUDY NO. 14

Site Name: Allied Paper, Inc., Portage Creek/Kalamazoo River Superfund Site, MI, Kalamazoo and Allegan Counties

Site Description: The Allied Paper, Inc., Portage Creek/Kalamazoo River Superfund Site includes five disposal areas, five paper mill properties, an approximately 80-mile stretch of the Kalamazoo River from Morrow Dam, flowing west to Lake Michigan, and a three-mile stretch of Portage Creek. The Site is divided into five operable units (OUs):

- OU #1, Allied Paper Property/Bryant Mill Pond Area;
- OU #2, Willow Boulevard and A-Site Landfill;
- OU #3, King Highway Landfill;
- OU #4, 12th Street Landfill; and
- OU #5, the Portage Creek and Kalamazoo River sediments.

The sediments, water column, soils and biota in and adjacent to an 80-mile stretch of the Kalamazoo River and a portion of Portage Creek are contaminated with polychlorinated biphenyls (PCBs). The primary industrial activity associated with the PCB releases into the environment was the recycling of PCB-containing carbonless copy paper at several area paper mills. In the process of de-inking and re-pulping recycled paper, paper mills produce substantial quantities of waste residuals. Kalamazoo-area paper mills that de-inked or re-pulped the PCB-containing carbonless copy paper thereby incorporated PCBs in their waste streams. Much of the dewatered paper waste was disposed of in landfills and sludge disposal areas located on the banks of the river. Erosion from these facilities and surface water runoff, as well as direct discharge of millions of gallons per day of effluent into the river, has resulted in releases of PCBs to the environment. PCBs are continually being released to the river from erosion of floodplain soils that exist behind the impounded areas and from in-stream sediments. Since the Kalamazoo River is an alternating series of free flowing sections and impoundments formed by low level dams, the impoundments serve as natural sinks for PCB-contaminated sediments.

The Site was placed on the National Priorities List (NPL) in August 1990 and was designated as a federal-lead site in February 2002. In February 2007, two Administrative Orders on Consent (AOCs) were signed by the U.S. Environmental Protection Agency (EPA) and Millennium Holdings, LLC and Georgia-Pacific, LLC (collectively known as the Kalamazoo River Study Group (KRSG)). One AOC requires the KRSG to conduct a supplemental remedial investigation/feasibility study (RI/FS) on the 80-mile stretch of the Kalamazoo River from Morrow Dam to Lake Michigan, and Portage Creek from Cork Street to the confluence with the Kalamazoo River, as it was determined that numerous areas required further investigation. For this investigation, the Kalamazoo River was divided into seven areas. Sampling has been completed for Area 1, a 21-mile stretch of the Kalamazoo River from Morrow Dam to the Plainwell Dam and 3 miles of Portage Creek. A supplemental Remedial Investigation report for Area 1 will be submitted to EPA in the spring of 2011. This includes a 1.8-mile stretch of the Kalamazoo River from the former Plainwell dam to the Otsego City dam. The other AOC called for a time-critical removal action (TCRA) of sediments in a portion of the Kalamazoo River near Plainwell, MI.

Site-wide concentrations of Total PCBs in abiotic and biotic media are as follows (from CDM, 2003a and 2003b):

Groundwater: No Detect (ND) – 3 micrograms per liter (ug/L)
Surface Water: ND - 0.23 ug/L
Streambed Sediment: ND – 156 milligrams per kilogram (mg/kg)
Floodplain Sediment: ND – 85 mg/kg

Surface Soil: 0.065 - 34.5 mg/kg
Whole Fish (mean concentrations): 0.054 – 13.2 mg/kg wet weight (ww)
Whole Fish (maximum concentrations): 0.8 – 36 mg/kg ww
Small mouth bass filets (range of concentrations): 0.09 – 5.8 mg/kg
Carp filets (range of concentrations): 0.099 – 17 mg/kg
Mink Whole Body and liver (maximum): 5.6 and 12.5 mg/kg ww
Bird Eggs: 0.0094 (red-winged blackbird) – 123.27 (bald eagle) mg/kg
Waterfowl Tissue: 4.8 mg/kg (max); 1.7 mg/kg (mean)

A fish-consumption advisory has been in place for the Kalamazoo River since the 1970s. The advisory is not legally binding, and local health officials and other local government representatives report observing frequent fishing activity within the contaminated zone of the river. Large portions of the river have "should not eat" designations for certain species of fish. The advisory is more restrictive for women of childbearing age and children under age 15.

Link for map: http://www.epa.gov/region5/sites/kalproject/pdfs/kalproject_map_200406.pdf.

Contaminants: Dissolved and particulate-sorbed PCBs occur within and adjacent to the Site. The primary chemicals or groups of chemicals of potential concern for the Site are PCBs, a hazardous substance and probable human carcinogen.

Size/Area of Site: The NPL site description boundary includes a 3-mile stretch of Portage Creek from Cork Street to its confluence with the Kalamazoo River, and 80 miles of the Kalamazoo River, from Morrow Lake Dam downstream to the mouth of the Kalamazoo River at Lake Michigan. The NPL site is the extent of Portage Creek and the Kalamazoo River including the 100-year floodplain prior to the removal of the Otsego, Plainwell, and Trowbridge Dams down to the sills. Also included in the site are five paper residual disposal areas and five paper mill properties.

Volume of Contaminated Sediments: It is estimated that that the river sediments contain over 120,000 pounds of PCBs and over 8 million cubic yards of contaminated river and floodplain sediments.

Ecological System(s) Impacted: The major habitat types within the Site are aquatic habitats, riparian habitats/wetlands, and terrestrial habitats. Aquatic habitats within the Site are found within Portage Creek, the Kalamazoo River, and their tributaries. The Kalamazoo River is a large, perennial river that drains a major portion of western Michigan. Riparian habitats exist adjacent to the Kalamazoo River and Portage Creek and include both upland and wetland habitats within the floodplain of the river. Terrestrial habitats beyond the riparian areas and beyond the areas subject to seasonal inundation include relatively flat open areas with varying amounts of vegetative cover, some of which are used for grazing cattle. Low rolling hills that are mostly thickly wooded and densely shaded are nearby. Terrestrial habitats in the Site are also found in portions of residential and industrial areas and represent ecological islands within urban areas. Finally, upland areas such as those identified in some cases as landfills are also considered terrestrial habitats.

Field surveys have revealed a large variety of plant and animal species utilizing all available habitat types in the study area. Several plant and animal species of special concern have potential to exist in the study area, including threatened, endangered, and sensitive species such as white false indigo, bald eagle, great blue heron, eastern box turtle, marbled salamander, black redhorse, lake sturgeon, frosted elfin, red-shouldered hawk, and elktoe mussel. Additionally, great blue herons have an established heron rookery along the Kalamazoo River downstream of Lake Allegan.

Human Health Risk(s): The Kalamazoo River, is a Class A water body and is used for swimming, boating, and fishing. Land use along the river includes urban commercial and industrial; urban, suburban, and rural residential; agricultural; and recreational. Exposure routes include ingestion of sediment or soil and surface water; dermal contact with sediment or soil and surface water; and inhalation of particulates and/or vapor emissions from exposed sediments. Ingestion of fish is also an important exposure pathway. Both recreational and subsistence fishers may be exposed to significant levels of PCBs via ingestion of fish taken from contaminated reaches of the river. Many of the impoundments along the river also attract waterfowl hunters, as evidenced by the duck blinds scattered throughout the Site.

Residents live immediately adjacent to former impoundment areas and may frequently use these areas much as other residents use their backyards. Vegetable gardens have been found in the impoundments and some gray residuals from paper wastes have been observed in residential yards, suggesting that exposures could take place in some areas outside the floodplain.

A human health risk assessment was prepared in 2003 (CDM, 2003). Cancer risks and hazard quotients in both central tendency and high-end sport and subsistence anglers exceed EPA and/or MDEQ risk limits for all scenarios in almost all areas evaluated (based on average fish concentrations, greatest carcinogenic risk: 2.2×10^{-3} for subsistence fishers; greatest hazard quotient: 130 (immunological endpoint) for subsistence fishers). Cancer risks and hazard quotients for residents living near exposed floodplain soils exceed MDEQ and/or EPA thresholds using average EPCs (greatest carcinogenic risk: 5.0×10^{-5}; greatest hazard quotient: 2.9 (immunological endpoint)). Cancer risks for recreational visitors exposed to floodplain soils are within the EPA target risk range and less than the MDEQ threshold using average EPCs.

Summary of Remediation: This case study focuses on remediation in OU #1 and OU #5. The cleanup approach for the Kalamazoo River is to first eliminate ongoing sources of PCBs, which includes the exposed paper wastes along the river banks and flood plain soils (or impoundments), and then address in-stream sediments. The exposed paper wastes are located behind dams along the river. The EPA plans to investigate upstream sources of PCBs (existing landfill OUs and paper mill properties) to ensure they are not a source of PCBs to the river, before evaluating cleanup options for in-stream sediments. Generally, the cleanup will begin upstream and work downstream on a reach-by-reach and dam-to-dam basis.

In 1998, Portage Creek was temporarily diverted from its normal streambed in order to conduct "dry" excavation of 150,000 cubic yards of the creek bed and floodplain soils. The area was estimated to have contained more than 20,000 pounds of PCBs and floodplains were found to contain PCB concentrations as high as 1,000 mg/kg. Excavation work was completed in May 1999. PCB concentrations remaining after the removal action were less than 1 mg/kg.

In June 2009, a time-critical removal action was completed to remove PCB-contaminated sediment from the Kalamazoo River's Plainwell Impoundment, a 1.5 mile stretch of the river near Plainwell, MI. A total of 130,000 cubic yards of contaminated in-stream and bank sediment were removed, which consisted of approximately 5,000 pounds of PCBs. This project also rerouted the Kalamazoo River to its original channel and removed the dam near Plainwell. The river is now free-flowing from Kalamazoo to Otsego City, MI.

During August 2009, another time-critical removal action commenced in the Plainwell #2 Dam area. The cleanup began in August 2009, approximately three miles upstream of the Plainwell Dam cleanup, and includes a two-mile stretch of the Kalamazoo River. During 2009, contaminated soil along the north side of the Kalamazoo River was removed. Approximately 4,900 linear feet of riverbank was cleared, excavated, and restored. All planned excavation activities were completed on the north side of the river in

2009. Cleanup activities along the south side of the Kalamazoo River are anticipated to be completed by the end of 2010. This removal action will remove 90 percent of the PCB-contaminated soil from the area.

Stabilization of stream bank materials is expected to decrease the potential chemical and physical effects of erosion. Surface water concentrations of PCBs are unlikely to return to safe levels without consideration of both stream bank and streambed sediments. For streambed and stream bank sediment, substantial decreases in total PCBs are warranted because these media will continue to provide a PCB source to the Kalamazoo River and resident aquatic and terrestrial biota. For surface soil, concentrations of PCBs need to be substantially reduced where such soils have potential to erode into aquatic environments.

Remediation is not complete as the supplemental RI/FS for the Kalamazoo River that was mandated by the 2007 AOC is largely unfinished.

Lessons Learned:

- Remediation is ongoing and source control is being factored into remedial decisions for the site.
- PCBs will continue to migrate into the environment from areas due to erosion and surface water runoff without remedial action. Migration of PCBs is contributing to the ongoing contamination of the water column and biota, in and near the Kalamazoo River and Lake Michigan.

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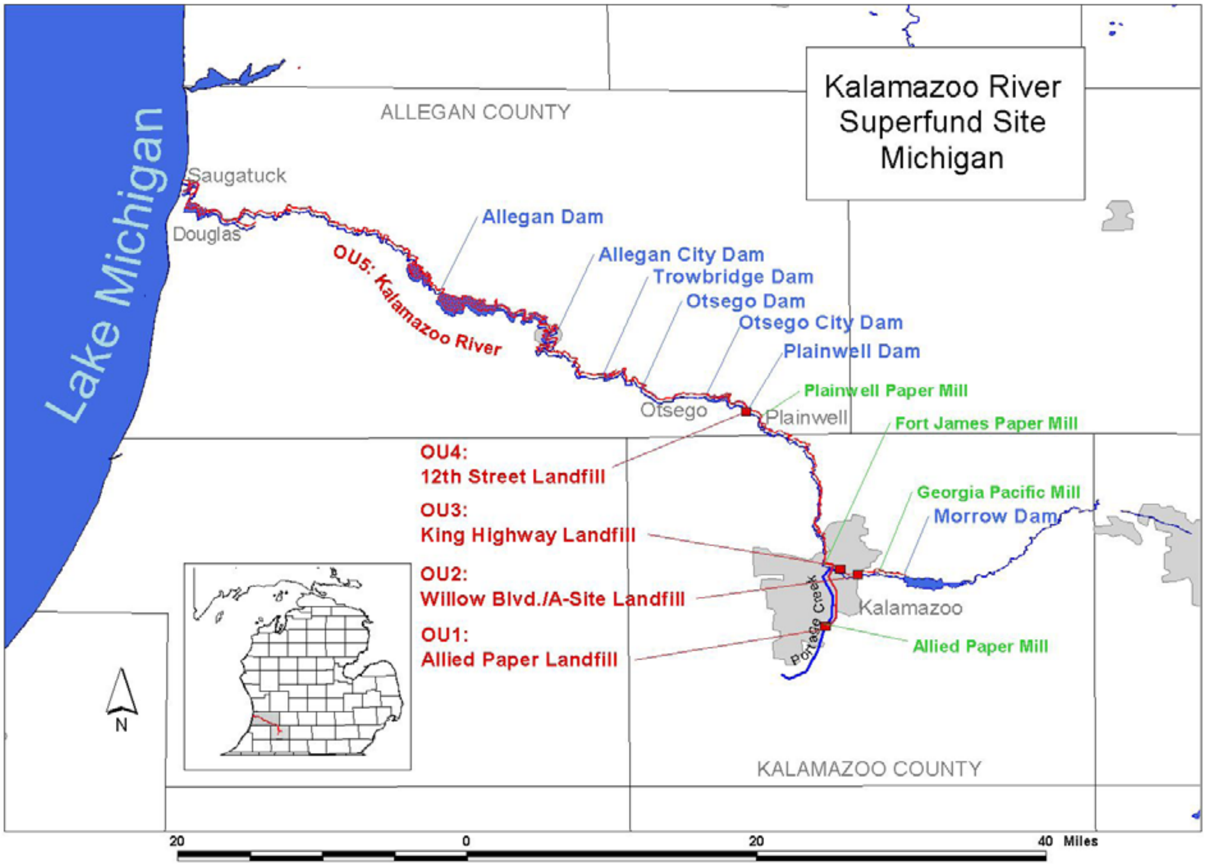
Kalamazoo River
Superfund Site
Michigan
Lake Michigan
ALLEGAN COUNTY
KALAMAZOO COUNTY
Saugatuck
Douglas
Otsego
Plainwell
Kalamazoo
Portage Creek
OU5: Kalamazoo River
Allegan Dam
Allegan City Dam
Trowbridge Dam
Otsego Dam
Otsego City Dam
Plainwell Dam
Plainwell Paper Mill
Fort James Paper Mill
Georgia Pacific Mill
Morrow Dam
Allied Paper Mill
OU4:
12th Street Landfill
OU3:
King Highway Landfill
OU2:
Willow Blvd./A-Site Landfill
OU1:
Allied Paper Landfill
N
20
0
20
40 Miles