C.3 Wyckoff/Eagle Harbor, Washington

C.3.1 Site Description

The 3,780 acre Wyckoff/Eagle Harbor site (Figure C.2) is located in central Puget Sound on the eastern border of Bainbridge Island, Washington. The source of sediment contamination originated from the shipyard and a former wood-treating plant. The site currently consists of the four Operable Units (OUs): OU 1, Wyckoff Facility; OU 2, East Harbor; OU 3, West Harbor; and OU 4, Wyckoff Groundwater. The West Harbor, OU 3, includes contaminated intertidal and subtidal sediments in the western portions of Eagle Harbor, as well as upland sources of contamination to the West Harbor.

C.3.2 Problem

The shipyard released metals and organic contaminants, and the wood treating operations involved pressure treatment with creosote and pentachlorophenol. Preservative chemicals delivered to the facility by barge and ship and were stored in tanks nearby. The primary contaminants of concern are organics, including PAHs, and metals, including arsenic, chromium, and lead. Remedial goals focused on the reduction of human health risks, and were evaluated using cleanup goals for PAHs and mercury in sediment and fish. On the basis of their widespread prevalence above apparent effects thresholds (AETs), mercury and the sixteen PAH were selected as indicator contaminants to define areas for remediation.

C.3.3 Description of Selected Remedy

The selected remedial actions for OU1 in the East Harbor are: (a) capping of the sediment in areas of high concern with a 1-meter layer of clean sediment and placing a thin layer of clean sediment in subtidal areas of low to moderate concern to enhance natural sediment recovery; (b) institutional source control; (c) natural recovery; and (d) long-term environmental monitoring.

- Phase I (1993-1994): Contaminated subtidal harbor sediments were covered by a 3-ft cap consisting of clean river sediment (approximately 275,000 cy). The objective was to reduce immediate risk until upland source control was achieved via the installation of a sheet pile wall. After Phase I cap placement, chemical migration appeared to be under control, although pools of creosote were observed at cap edges. Creosote pools likely migrated from the Phase II/III area, which was not contained at the time; divers extracted the pools regularly.

- Phase II (2000-2001): Contaminated nearshore sediments at depths of up to 45 ft were capped by a 3-ft cap consisting of upland fill (clean sand) (approximately 120,000 cy). The objective was to extend the Phase I cap from to the northern shoreline of the Wyckoff facility.

- Phase III (2001-2002): Additional material (upland fill, approximately 80,000 cy) was placed on the Phase II area (slightly smaller footprint). Capping material used was upland fill (80,000 cy). The objective was to construct an intertidal area

connecting the Phase II area to the north shoal and to add more confinement material to the cap. A NOAA study documented rapid and substantial increase in quality of habitat

C.3.4 Retrospective Application of the Matrices to Wyckoff/Eagle Harbor Remedial Monitoring

C.3.4.1 Introduction

The following section provides a comparison of the monitoring needs and tools identified for the site remedies by the matrices to the actual monitoring conducted on the site. This section illustrates how information in the matrices relates to "real world" remedial monitoring plans and how site-specific conditions must be considered when reviewing information provided by the matrices.

For each monitoring phase relevant to the site (e.g., dredging performance monitoring, capping construction monitoring, etc.), tables are provided that contain the following information:

- **Potential monitoring needs and tools:** Possible monitoring needs identified by the matrices and the list of tools provided in the matrices that are associated with each monitoring need.
- **Site:** Whether the monitoring need was relevant to the site or a particular monitoring tool was used at the site.
- **Critical considerations identified in the matrices:**
  - For all monitoring needs, this field contains a brief description of the need, as presented in the matrices.
  - For monitoring tools used at the site, this field contains a sample of the information from the matrices that is particularly relevant to the site monitoring program. Information was obtained directly from matrices monitoring tool fields (e.g., "Special Considerations", "Uncertainty in Addressing Monitoring Need", "Difficulty in Locating Tool in Marketplace", etc.).
- **Notes on actual site-specific monitoring program:** Information on actual monitoring needs identified or monitoring tools used at the Site.

Tables are provided at the end of this case study (all four possible monitoring phases are represented in this case study due to the application of capping and MNR at Eagle Harbor):

- Table C.6. Monitoring needs and tools identified by the matrices for capping construction monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.
- Table C.7. Monitoring needs and tools identified by the matrices for capping performance monitoring compared to the Wyckoff/Eagle Harbor monitoring plan
- Table C.8. Monitoring needs and tools identified by the matrices for MNR

performance monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

- Table C.9. Monitoring needs and tools identified by the matrices for remedial goal monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

C.3.4.2 Key Considerations for Using the ISRAPs: Highlights from Wyckoff/Eagle Harbor Remedial Monitoring

This section highlights how information presented in the ISRAP should be evaluated in the context of site-specific considerations, using the Wyckoff/Eagle Harbor remedial monitoring program as an example.

- **All monitoring needs listed in the ISRAP may not be relevant to the site**. For example, ground water was not addressed by cleanup actions in the East Harbor and therefore is not identified as a medium of concern. Monitoring needs or tools in the matrix that are focused on addressing ground water interactions with sediment are not relevant.

- **Information for monitoring tools may not always be relevant to the site.** For example, sediment profile photography was chosen as one of the tools to assess ecological recovery at Wyckoff/Eagle Harbor (Table C.9). Information provided for this monitoring tool in the "Monitoring Tool Logistical Complexity" field of the matrices is not an important consideration for selecting this tool because it notes that the tool is "Limited to use in soft-bottom sediments". As all sediment at Eagle Harbor were relatively soft (slits and sands), this information would likely be of minor importance when considering this tool for use at a site like Eagle Harbor.

- **Several monitoring tools are often selected to address a single monitoring need**. For example, four of the six monitoring tools identified in the matrices for addressing capping design specifications during the construction monitoring phase for capping were used at Eagle Harbor (Table C.7). Several tools were selected because each tool offered its own advantages and disadvantages relative to site-specific monitoring conditions. Some of the information provided in the matrices highlights these advantages and disadvantages, and a sample of this information is presented in the "Critical considerations identified in matrices" column of Table C.7. For example, the matrices note that information provided by bathymetric survey is easily interpreted and widely available tool for assessing coverage of caps, although it lacks resolution and accuracy of the more advanced acoustic sub-bottom profiling monitoring tool (Table C.7). A disadvantage of acoustic sub-bottom profiling noted in the matrices was relevant to areas of Eagle Harbor where the texture and composition of cap materials were similar to the underlying sediment, making interpretation of acoustic sub-bottom profiling data to assess cap presence and thickness difficult. To supplement this information, sediment coring and sediment surface photography was used to provide easily-interpreted visual information regarding cap thickness and/or coverage; however, these tools provided information only at a few discreet points rather than the continuous, site-wide coverages provided by bathymetric survey and acoustic sub-

bottom profiling.

- **Monitoring tools can be used to address more than one monitoring need**. For example, at Eagle Harbor, bioaccumulation in organisms was used to address remedial goals associated with human health risks, but could be used to address potential ecological concerns.
- **Among the information and references provided by the ISRAP, a single piece of information may be the key to identifying monitoring tools**. Sediment coring was one of the monitoring tools selected to address capping design specification during the construction monitoring phase of capping at Wyckoff/Eagle Harbor (Table C.8). The matrices note that this monitoring tool may damage the cap ("Special Considerations" field). As coring would likely damage thin caps, RPMs did not utilize this monitoring tool in all areas at Wyckoff. Coring was restricted to assessing the performance of thick caps (3-ft) and shallow (non-penetrating) coring techniques were used to avoid damage or release of underlying contaminated sediment.
- **Selection of monitoring tools should consider prior monitoring tools used at the site**. At Eagle Harbor, bioaccumulation in organisms was used for both the ecological and human health risk assessments conducted during the remedial investigation. To enable pre-remedial comparisons, analysis of edible biota tissues was selected as a monitoring tool to assess the reduction of human health risks in the remedial goal monitoring phase (Table C.9). These data were directly compared with risk-based cleanup levels and human health criteria identified in the remedial investigation and feasibility study, facilitating the interpretation of remedial goal attainment that enabled decisions regarding the termination or continuation of remedial goal monitoring

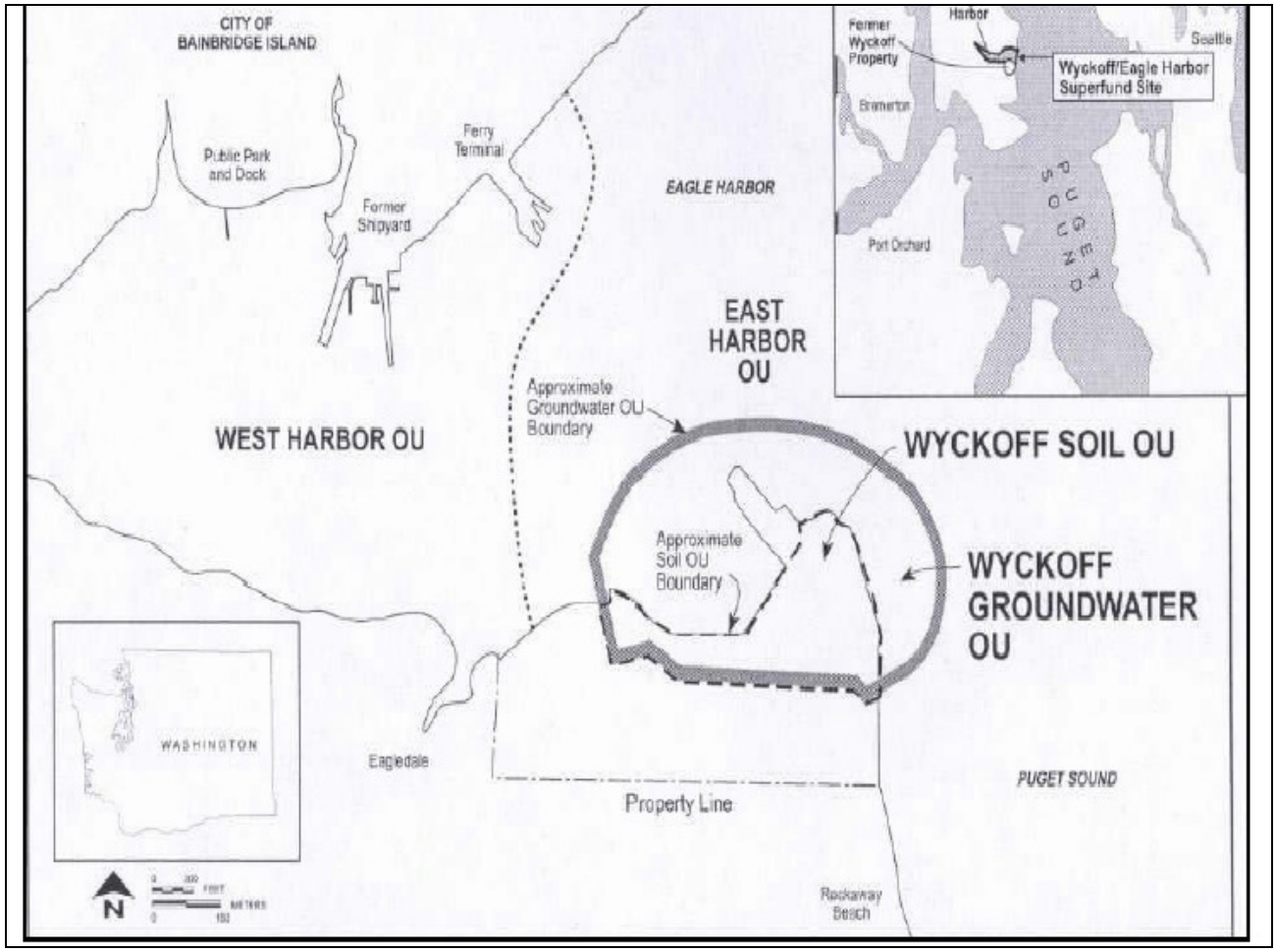

Figure C.2. Wyckoff/Eagle Harbor Site.

Table C.6. Monitoring needs and tools identified by the matrices for capping construction monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
Bioaccumulation	Assessment of bioaccumulation potential to pelagic and possibly benthic species due to chemicals released due to sediment resuspension during remedial activity.	Bioaccumulation testing	Not used		Bioaccumulation was not investigated at in the context of re-suspended sediment.
		Caged organisms	Not used		
		Passive sampling devices	Not used		
		Sediment sample chemical analysis (bioavailability extraction)	Not used		
		Sediment and water sample chemical analysis	Not used		
Capping design specifications	Assess lateral extent, thickness, and/or uniformity of cap.	Acoustic sub-bottom profiling	Used	Used primarily to detect detecting extent, thickness, and uniformity of cap. One of the tools with highest levels of certainty in addressing monitoring need.	Acoustic sub-bottom profiling was conducted under an interagency agreement with the EPA. Bathymetric surveys were conducted to measure seafloor elevation. Sediment coring was done in order to establish a baseline for the cap by collecting undisturbed, representative samples (0-10 cm down). Underwater video was taken to analyze the presence, type, and density of epifauna.
		Bathymetric survey	Used	Other acoustic survey methods (e.g., side scan sonar, acoustic sub-bottom profiling) may be more accurate; Widely available, inexpensive, and easily interpreted.	
		Sediment coring	Used	May serve well as validation tool for continuous methods such as acoustic sub-bottom profiling. Coring may damage cap.	
		Sediment profile photography	Not used		
		Sediment surface photography	Used	Limited to sediment surface and limited by site conditions (turbidity). Easily interpreted visual method.	
Downstream deposition	Assessment of downstream deposition to surface sediment.	Sediment sample chemical analysis	Used	Although a routine method, analysis may not be able to separate recently deposited chemical residues from background sources of contamination.	Chemical analysis of off-site deposition of suspended material generated during cap construction was conducted using sediment traps. Sediment trap data was augmented by analysis of the upper 2 cm of off-cap sediments.
		Sediment profile photography	Not used		
		Sediment traps	Used	Accurate measure of sediment deposition with the lowest uncertainty of the potential tools used to investigation downstream or off-site deposition during construction.	
		Current velocity measurement	Not used		
Ecological suitability of cap material	Assessment of cap material for use as a clean substrate capable of supporting ecological recovery.	Toxicity testing	Unknown		Sediment for cap was characterized prior to use to ensure suitability for ecological recovery and if it would meet the State of Washington Sediment Management Standards.
		Bioaccumulation testing	Unknown		
		Cap sample chemical analysis	Likely used	Simple tool, although simple chemical analysis may overestimate toxicological and bioaccumulation risks.	
		Cap sample physical analysis	Unknown		

Table C.6, capping construction monitoring, *continued*

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
		Macroinvertebrate community census	Unknown		
Physical suitability of cap material	Assessment of cap material for engineering purposes.	Cap sample physical analysis	Used	Highly relevant tool for assessing physical characteristics of capping material.	Sediment used for cap was characterized prior to use to ensure engineering purposes.
Sediment resuspension	Assess physical water quality impairment due to sediment resuspension during remedial activity	Continuous suspended sediment monitoring	Not used		
		Discrete suspended sediment monitoring	Not used		
		Real-time biomonitoring	Not used		
Ecotoxicological risks	Assessment of toxicity to pelagic and possibly benthic species due to chemicals released due to sediment resuspension during remedial activity.	Toxicity testing	Not used		
		Caged organisms	Not used		
		Passive sampling devices	Not used		
		Sediment sample chemical analysis (bioavailability extraction)	Not used		
		Real-time biomonitoring	Not used		
		Sediment and water sample chemical analysis	Not used		

Table C.7. Monitoring needs and tools identified by the matrices for capping performance monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
Cap stability	Assess settlement and stability of cap over time.	Acoustic sub-bottom profiling	Used	Used primarily to detect detecting extent, thickness, and uniformity of cap. One of the tools with highest levels of certainty in addressing monitoring need.	Monitoring conducted to identify erosion of the cap, sediment movement, or mixing of cap with underlying sediment. For all tools, Site managers recommended that the same equipment and methods be used to assess cap design (construction) be used for this monitoring need. Acoustic sub-bottom profiling was conducted by the USGS under an interagency agreement with the EPA. Bathymetric survey was done to measure seafloor elevation. Sediment coring was done in order to test for contamination of the sediment cap. Sediment profile photography was used to visually inspect the cap profile and look for seeps.
		Bathymetric survey	Used	Other acoustic survey methods (e.g., side scan sonar, acoustic sub-bottom profiling) may be more accurate. Widely available and easily interpreted.	
		Sediment coring	Used	Subsurface profile easily interpreted from sediment core to yield information regarding cap thickness, although coring may damage cap.	
		Sediment profile photography	Used	Data are point based. Allows visual inspection. May be difficult to visually distinguish freshly deposited layers or identify cap material or contaminated sediments visually.	
		Sediment surface photography	Used	Benthic photography and videography of cap and sediment surface to detect damage to cap and changes in cap stability over time; does not assess changes in thickness and may only be useful for detecting severe damage.	
		Settlement plate	Not used		
		Side scan sonar	Not used		
		Cap sample physical analysis	Used	Relevant tool for assessing physical characteristics of cap useful for predicting susceptibility to erosion.	
Chemical flux through cap	Assessment of chemical flux through the cap.	Passive sampling devices	Not used		Monitoring focused on the transport of PAHs from underlying sediment.
		Sediment sample chemical analysis	Used	Chemistry of subsurface profile easily interpreted to address contaminant migration through cap, although potential to damage cap.	
		Seepage meter/Flux sampler	Not used		
		Trident Probe	Not used		
		Surface sediment pore water	Not used		
Impacts on hydrodynamics and sediment transport	Impacts on hydrodynamics and sediment transport.	Hydrodynamic analysis	Not used		Local hydrodynamics was assumed to be unaffected by the size and thickness of the cap relevant to size and depth of the basin.

Table C.8. Monitoring needs and tools identified by the matrices for MNR performance monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
Chemical flux from sediment	Assessment of chemical flux from sediment surface to water column.	Passive sampling devices	Not used		Not specifically addressed due to the stability of most areas of the site.
		Seepage meter/Flux sampler	Not used		
		Trident Probe	Not used		
		Surface sediment pore water	Not used		
Chemical natural recovery processes	Assess the progress of or potential for degradation, detoxification, or chemical sequestration of chemicals.	Sediment sample chemical analysis	Used	High confidence in method to describe contaminant degradation and transformation; No ability to provide information on chemical sequestration of contaminants.	East beach sediments were analyzed and results were compared to minimum cleanup levels and human health criteria. Concentrations in the top 10 cm of sediment were measured over time to investigate natural attenuation of PAHs.
		Passive sampling devices	Not used		
		Sediment sample chemical analysis (bioavailability extraction)	Not used		
		Surface sediment pore water	Not used		
		Laboratory biodegradation experiments	Not used		
		Sediment redox potential	Not used		
		Sediment profile photography	Not used		
Physical natural recovery processes	Assess stability of sediment during recovery and/or isolation of impacted sediment over time.	Acoustic sub-bottom profiling	Not used		Intertidal cap, habitat mitigation beach and North & East beach intertidal sediments were assessed to see if they were providing functioning habitat. Bathymetric survey was instigated to measure seafloor elevation and to detect changes in thickness of sediment profile over time due to sediment erosion and sedimentation. Core samples from the 10 cm for contaminants of concern to track the physical stability of surface sediments. Physical analysis of core samples was also conducted to determine the susceptibility for erosion. Sediment traps were deployed to estimate sediment accumulation rates affecting the physical isolation of sediments. Topological surveys to look for changes in grain size and beach elevation were done to identify additional engineering needs (for example: material added due to erosion).
		Bathymetric survey	Used	Routine monitoring tool that is widely available.	
		Sediment surface photography	Not used		
		Side scan sonar	Not used		
		Sediment coring	Used	Routine monitoring tool that is widely available, but usually must be coupled with chemical or physical analysis to draw conclusions regarding physical stability of sediment.	
		Sediment traps	Used	Accurate measure of sediment deposition, but limited ability to provide information regarding erosion.	
		Sediment sample physical analysis	Used	Relevant tool for assessing physical characteristics of sediment useful for predicting susceptibility to erosion, but does not provide information on deposition rates.	
		Isotope analysis	Not used		

Table C.9. Monitoring needs and tools identified by the matrices for remedial goal monitoring compared to the Wyckoff/Eagle Harbor monitoring plan.

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
Bioaccumulation	Assessment of bioaccumulation potential to benthic and/or pelagic species.	Bioaccumulation testing	Not used		Chemical analysis of clam tissue was interpreted in a human health risk assessment and to measure the effectiveness of remedy effectiveness. Sediment chemical analysis was also conducted, with comparison of results to sediment criteria based on site-specific risk assessment (bioaccumulation and human health risks).
		Caged organisms	Not used		
		Passive sampling devices	Not used		
		Sediment and water sample chemical analysis	Used	Requires interpretation and background data to predict bioaccumulation potential (risk assessment model), but simple and widely-applied tool.	
		Surface sediment pore water	Not used		
		Sediment sample chemical analysis (bioavailability extraction)	Not used		
		Avian chemical analysis	Not used		
		Chemical analysis of biota tissue	Used	Tissue residues in organisms easily interpreted to assess bioaccumulation potential.	
Human health risks	Assessment of exposure of bioavailable chemicals to humans via consumption of aquatic organisms.	Bioaccumulation testing	Not used		Human health risks for Eagle Harbor were primarily associated with the consumption of contaminated shellfish. Risk analysis was not required, but clam tissue data was collected in case further analysis of risk became warranted in the future. Clam tissue analyses focused on PAH body burden of clams (native littlenecks, geoduck clams & horse clams) on East Beach. Sediment chemical analysis was also conducted, with comparison of results to sediment criteria based on site-specific risk assessment (bioaccumulation and human health risks).
		Caged organisms	Not used		
		Passive sampling devices	Not used		
		Sediment and water sample chemical analysis	Used	Requires interpretation and background data to predict bioaccumulation potential (risk assessment model), but simple and widely-applied tool.	
		Surface sediment pore water	Not used		
		Sediment sample chemical analysis (bioavailability extraction)	Not used		
		Avian chemical analysis	Not used		
		Chemical analysis of edible biota tissue	Used	Best tool for estimating health risks posed by bioavailable chemicals in edible tissue of aquatic organisms consumed by humans.	
Physical benthic habitat quality	Assessment of benthic physical habitat.	Acoustic sub-bottom profiling	Not used		Cap material assessed for design specifications for shoreline restoration of physical habitat quality following dredging and capping. Bathymetric survey conducted to measure seafloor elevation.
		Bathymetric survey	Used	Widely available, routine monitoring tool, although data are point-based.	
		Sediment sample physical analysis	Used	Provides simple assessment of physical habitat, but does not predict physical habitat suitability for all species.	
		Laser Line Scan Imaging	Not used		
		Remote sensing	Not used		
		Sediment profile photography	Not used		
		Sediment surface photography	Not used		
		Side scan sonar	Not used		
Ecotoxicological risks	Assessment of toxicity to benthic and/or pelagic species.	Toxicity testing	Not used		Ecological risks were not identified as significant in remedial investigation.
		Caged organisms	Not used		
		Passive sampling devices	Not used		
		Real-time biomonitoring	Not used		

Table C.9. Remedial goal monitoring, *continued.*

Monitoring Matrices Output			Site Monitoring Plan	Critical Issues Identified in Matrices	Site Monitoring Program Notes
Potential Needs	**Need Description**	**Tools**			
		Sediment and water sample chemical analysis	Not used		
		Rapid Sediment Characterization Tools	Not used		
		Surface sediment pore water	Not used		
		Avian chemical analysis	Not used		
		Chemical analysis of biota tissue	Not used		
Ecological recovery	Assessment of benthic and/or pelagic ecological recovery over time.	Artificial substrate samplers	Not used		Visual surveys of bird, mammal and fish usages of the habitats were conducted.
		Avian community or productivity census	Used	Highly relevant tool for assessing ecological recovery.	
		Drift net sampling	Not used		
		Fish community census	Used	Highly relevant tool for assessing ecological recovery.	
		Macroinvertebrate community census	Used	Highly relevant tool for assessing ecological recovery.	
		Vegetation survey	Used	Highly relevant tool for assessing ecological recovery for sites with vegetation or the potential to support vegetation.	
		Sediment profile photography	Not used		
		Side scan sonar	Not used		