Final Focused Feasibility Study
Duck and Otter Creeks
Toledo, Ohio

Prepared for:
Duck and Otter Creek Industrial Partners

Prepared by:
ENVIRON International Corporation

Date:
August 2013

Project Number:
21-23671E

ENVIRON

Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

%	Percent
AOC	Area of concern
BUI	Beneficial use impairments
CDF	Confined disposal facility
COC	Chemicals of concern
CY	Cubic yards
DGPS	Differential global positioning system
DRO	Diesel Range Organics
ENVIRON	ENVIRON International Corporation
FFS	Duck and Otter Creeks Focused Feasibility Study
Ft	Foot or feet
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
IBI	Index of Biotic Integrity
mg/kg	Milligram per kilogram
MNR	Monitored natural recovery
NAPL	nonaqueous phase liquid
NCP	National Contingency Plan
NPV	Net Present Value
OEPA	Ohio Environmental Protection Agency
O&M	Operation and maintenance
PAH	Polycyclic aromatic hydrocarbon
Partners	Duck and Otter Creeks Industrial Partners
PECs	Probable effect concentrations
RAOs	Remedial action objectives
RAP	Remedial action plan
RCRA	Resource Conservation and Recovery Act
RGs	Remedial Goals
RM	River Mile
TOC	Total organic carbon
TU	Toxic Unit
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USDOE	United States Department of Energy

1 Introduction

This Duck and Otter Creek Focused Feasibility Study (FFS) has been prepared by ENVIRON International Corporation (ENVIRON) on behalf of the Duck and Otter Creeks Industrial Partners (Partners), including BP-Husky, Chevron, Pilkington North America, and Sunoco. The FFS has been prepared voluntarily by the Partners to facilitate and define potential voluntary work in coordination with the United States Environmental Protection Agency (USEPA). Duck and Otter Creeks are located in the cities of Toledo and Oregon, Ohio, and are both part of the Maumee Area of Concern (AOC). This FFS has been prepared in accordance with the recommendations included in the *Duck and Otter Creeks Data Gap Investigation Report* (Cardno Entrix 2012), prepared jointly with the Great Lakes National Program Office of the United States Environmental Protection Agency (USEPA) under Great Lakes Legacy Act (GLLA) funding, which recommendations are as follows:

- Further evaluate potential remedies for Segment A of Otter Creek (i.e., Otter Creek downstream of Millard Avenue); and
- Further evaluate the combined 2007 and 2010 data sets for the remaining stream sections.

The main body of this FFS report addresses the first of these recommendations, considering both lower Otter Creek and the confluence area where Otter Creek flows into Maumee Bay. The second recommendation is addressed through a supplemental data evaluation, presented in Appendix A of this FFS. The Supplemental Data Evaluation also addresses the data collected in a separate Great Lakes National Program Office (GLNPO) project for the confluence areas and is based on the data and evaluation methods from the joint Data Gap Investigation Report (Cardno Entrix 2012).

The main FFS relies on the data compilation and analysis of sediment chemistry and biological effects presented in the Supplemental Data Evaluation to support the evaluation of potential voluntary remedial measures. This FFS report:

- Identifies remedial action objectives (RAOs);
- Considers the range of available remediation technologies;
- Evaluates those technologies considered relevant to remediation of Otter Creek sediment of concern; and
- Compares remediation alternatives to help identify a preferred remedy for sediment in Otter Creek.

As described in the Supplemental Data Evaluation, the sediment conditions in Duck Creek and the confluence area where Duck Creek enters the Maumee River do not warrant sediment management actions. Therefore, remediation alternatives are not considered for Duck Creek.

1.1 Study Area Background

Duck and Otter Creeks are small streams that flow from southwest to northeast through portions of Toledo and Oregon, Ohio (Figure 2-1). Duck Creek discharges to the mouth of the Maumee River, while Otter Creek discharges to Maumee Bay, part of the western basin of Lake Erie. Both creeks are located within the 775 square mile Maumee AOC (Figure 2-1).

The creeks run through highly industrial areas. Various pipelines, closed and capped landfills, and commercial and industrial properties currently are, and have been in the past, located adjacent to the creeks. Many municipal, as well as, industrial storm water outfalls also discharge directly into Otter Creek. The lower portions of both creeks flow through extensive railroad yards.

1.2 Objectives

The work embodied in the FFS is based on the following primary objectives.

- Identify and screen sediment technologies that address the occurrence of elevated concentrations of chemicals of concern (COC) in Otter Creek sediment.
- Evaluate viable remedial alternatives against the RAO criterion.

This FFS identifies an appropriate remedial alternative that cost-effectively manages the potential risks associated with the presence of elevated concentrations of COCs in Otter Creek sediment. Meeting the FFS objectives will result in reduction of impacts to the benthic community.

1.3 Report Organization

This introduction to the FFS (Section 1.0) is followed by a summary of the sediment investigation results and proposed sediment management areas (Section 2). Section 3 identifies the RAO for the site, and Section 4 presents a description of site-specific remedy alternatives developed for Otter Creek sediment. These remedial alternatives are evaluated against the site-specific RAO using criteria established in Section 5. Section 6 identifies the preferred remedy alternative, and references are provided in Section 7.

2 Summary of Sediment Investigation Results

The analysis of alternatives presented in this FFS is supported by an understanding of the distribution of COCs in Duck and Otter Creek sediment, stream conditions, and ecological conditions based on data collected from 2006 through 2011.

This section summarizes the results of sediment, surface water, and biological investigations and surveys conducted at the project area. These results supplement the existing body of knowledge of the creeks and confluence areas, and support the development of multiple lines of evidence to support remedy decision making, as recommended in the USEPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005a).

2.1 Data Sources

Although the *Data Gap Investigation Report* (Cardno Entrix 2012) recommended evaluation of data collected in 2007 and 2010, additional data sets were included in the Supplemental Data Evaluation, in the interest of completeness. Specific data sets included in the summary of sediment investigation results are further discussed in the Supplemental Data Evaluation located in Appendix A and include:

- **Great Lakes Legacy Act (GLLA) Sediment Sampling.** The EPA and Duck and Otter Creek Industrial Partners signed a Project Agreement on March 28, 2010 for a GLLA Data Gap Investigation. In 2010, this investigation was undertaken to fill data gaps in previous investigations of Duck and Otter Creek sediments (Cardno Entrix 2012). The data gap investigation sampling was performed by Weston Solutions, Inc., on behalf of the Duck and Otter Creek Industrial Partners (i.e., BP-Husky, Chevron, Sunoco, and Pilkington North America) and the USEPA Great Lakes National Program Office (GLNPO). Concurrently, GLNPO also initiated a separate investigation of sediment quality in the confluence areas where Duck Creek joins the mouth of the Maumee River and Otter Creek joins Maumee Bay. The confluence area sampling was conducted by Weston in 2010 and 2011 (Weston 2012a,b). Collectively, the GLLA 2010-2011 data set includes 645 sediment, 120 porewater, and 8 invertebrate tissue samples analyzed for chemical constituents. Sediment toxicity testing was performed for 49 sediment samples, and the benthic invertebrate community was characterized at 13 locations. The data gap investigation sampling included two urban comparison stream locations, which were sampled for all data gap investigation parameters; no comparison locations were sampled in the confluence area sampling program.
- **U.S. Fish and Wildlife Service (USFWS) Fish Sampling.** In August 2010, the USFWS collected fish from Duck and Otter Creeks for tissue analysis (USFWS 2011). In addition to representing the creeks, one of the sampling zones extended into the Otter Creek confluence area.
- **Westover Landfill Sediment Sampling.** On behalf of USEPA's Region 5 Emergency Response Branch, Weston investigated environmental conditions at the Westover Landfill, located adjacent to Otter Creek (Weston 2009). The investigation, conducted in August 2009, included collection of two sediment samples from locations upstream and downstream of the Westover Landfill Site.

- **Ohio EPA Sediment Sampling.** Ohio EPA collected six sediment samples from three locations in upper Duck Creek in 2008. In 2006, Ohio EPA collected seven sediment samples from four locations in Otter Creek. Ohio EPA also evaluated fish and invertebrate communities at the same sample locations (Ohio EPA 2010).
- **GLNPO 2007 Sediment Sampling.** On behalf of GLNPO, SulTRAC conducted sediment sampling from Duck and Otter Creeks in 2007, under a grant awarded to the Duck and Otter Creeks Partnership. A total of 62 sediment samples were collected, and a subset of samples was tested for toxicity (SulTRAC 2007).
- **Envirosafe Sediment Sampling.** As part of a Resource Conservation and Recovery Act (RCRA) Facility Investigation for Envirosafe's Otter Creek Road facility (ENVIRON 2009), ENVIRON collected sediment samples from Otter Creek adjacent to the Millard Road Landfill. Sediment sampling was conducted between 2002 and 2007. The Supplemental Data Evaluation incorporates Envirosafe data from 2006-2007. The data set includes 27 sediment samples from 11 locations.

Complete analytical results are provided in Appendix A.

2.2 Summary of Chemicals of Concern in Sediment

The Supplemental Data Evaluation analyzed the relationship between sediment chemistry – including the chemistry of sediment porewater – and sediment toxicity for all chemicals analyzed and detected in Duck and Otter Creeks, using the data sets described above. This analysis identified the primary cause of sediment toxicity in lower Otter Creek and the Otter Creek confluence area as bioavailable polycyclic aromatic hydrocarbons (PAHs) (i.e., PAHs available for uptake by organisms, as indicated by dissolved PAH concentrations in sediment porewater). Porewater was analyzed in the 2010-2011 GLNPO-Industry Partner projects and confluence sampling only for surface sediment samples. Porewater bioavailability has generally been evaluated for surface sediment, with other indicator parameters being used for subsurface sediment. For the combined data set (i.e., Duck and Otter Creeks and respective confluence areas), diesel range organics (DRO) provide the best indicator of porewater PAH concentrations, where DRO was measured. The sum of 16 PAH concentrations (total PAH-16) provides an additional line of evidence, particularly where neither porewater PAHs nor DRO were measured. Details of this analysis are provided in Appendix A.

The Supplemental Data Evaluation determined that sediment conditions in Duck Creek do not warrant sediment management. Similarly, the Supplemental Data Evaluation did not recommend sediment management for areas of Otter Creek located upstream of Millard Avenue. Therefore, the delineation of COCs is described in this section only for lower Otter Creek and the Otter Creek confluence area.

The 2010-2011 GLLA investigation results are particularly useful for delineation purposes, because:

- Porewater PAHs were analyzed for surface sediments throughout the confluence area and at several locations in lower Otter Creek.

- Both surface and subsurface sediment samples were collected and analyzed. Surface grab samples representing the top 6 inches of sediment were collected from most sample locations in the area of interest. Sediment core samples were also collected from most locations and were analyzed in 2-foot depth increments.
- DRO was analyzed in all surface and subsurface samples from lower Otter Creek, as well as many of the surface and subsurface samples from the Otter Creek confluence area. Earlier investigations that analyzed total petroleum hydrocarbons (notably the 2007 GLNPO sampling event) used different analytical methods that are not comparable to the 2010-2011 DRO analyses.

Figures displaying porewater PAH, DRO, and total PAH-16 results from sampling events conducted between 2006 and 2011 in Duck and Otter Creeks can be found in the Supplemental Data Evaluation (Appendix A). Analytical results for lower Otter Creek and the Otter Creek confluence area are summarized below.

2.2.1 PAHs

PAHs in sediment porewater are the primary factor explaining sediment toxicity in lower Otter Creek and the Otter Creek confluence area. Bulk sediment PAH concentrations are not closely correlated with porewater PAH concentrations but provide a supplemental line of evidence in the delineation of sediment management areas.

2.2.1.1 Porewater PAHs

Porewater PAH concentrations are measured in toxic units (TUs), which are calculated for individual PAHs as the freely dissolved porewater concentration divided by the corresponding benchmark concentration. The individual PAH TUs are then summed for each sample to derive a final porewater TU value.

The Supplemental Data Evaluation (Appendix A) reviewed the data available for Duck and Otter Creeks and concluded that concentrations of PAHs in sediment porewater are sufficient to explain the observed toxicity in this area, even though bulk sediment PAH concentrations are not predictive of toxicity. A threshold for sediment toxicity was identified as a porewater PAH TU value of 5. This threshold TU level is based on site-specific laboratory sediment toxicity test results and corresponds to a 20% reduction in midge biomass, compared to those portions of Duck and Otter Creeks not affected by elevated porewater PAH concentrations or sediment toxicity.

The minimum, maximum, and average porewater PAH concentrations for lower Otter Creek surface sediments (Millard Avenue to mouth) are 0.2 TU, 87.2 TU, and 29.6 TU, respectively. The minimum, maximum, and average porewater PAH concentrations for surface sediments in the Otter Creek Confluence (all confluence samples) are 0.2 TU, 170 TU, and 21.9 TU, respectively.

2.2.2 Sediment PAHs

Total concentrations of PAHs in sediment can be expressed using several different methods. Total PAH-16 concentrations for surface grab samples and sediment core samples[1] for all sampling events were determined by summing the concentrations of the 16 individual Target Compound List PAHs. In the Supplemental Data Evaluation, total PAH-34 concentrations were also calculated by summing the concentrations of an extended PAH analyte list, and both total PAH-16 and PAH-34 concentrations were calculated with and without normalization to total organic carbon (TOC) concentrations. Bulk sediment PAH TUs were also calculated using a method analogous to that described above for porewater PAHs. Total PAH-34 and bulk sediment TUs can only be calculated for surface samples where the extended PAH list was analyzed. For the purposes of this FFS, total PAH-16 concentrations are most useful, because they can be calculated for all sediment samples analyzed for PAHs.

Considering the entirety of Duck and Otter Creeks, there is no discernible relationship between total PAH-16 concentrations and porewater PAH TU values (see Figure 4-6 of Appendix A). This finding appears to be a consequence of interactions between PAHs and DRO in sediment, perhaps due to a solvent effect of hydrocarbons (see Section 4.3 of Appendix A). The relationship between total PAH-16 and porewater PAH TU was also explored for data from lower Otter Creek and the Otter Creek Confluence only; however, this relationship was not useful for delineation purposes. That is, a relationship that holds only within areas warranting sediment management cannot be used to define the boundary of the sediment management area. Therefore, total PAH-16 concentrations are compared to the Probable Effect Concentration (PEC) of 22.8 milligram per kilogram (mg/kg) from MacDonald et al. (2000), for reference purposes. For the purposes of this FS, comparisons to the PEC of 22.8 mg/kg total PAH-16 are considered only within sediment management areas that have been defined based on multiple lines of evidence (see Section 2.1). In other portions of Duck and Otter Creeks where DRO concentrations are not elevated, total PAH-16 concentrations exceeding the PEC have been shown not to be associated with elevated porewater PAH concentrations or toxicity (see Section 4.7 of Appendix A).

The minimum, maximum, and average total PAH-16 concentrations for lower Otter Creek surface grab samples are 0.42 mg/kg, 55.6 mg/kg, and 10.8 mg/kg, respectively. The minimum, maximum, and average total PAH-16 concentrations for lower Otter Creek sediment core samples are 2.6 mg/kg, 166.7 mg/kg, and 14.1 mg/kg, respectively. Within lower Otter Creek, the highest total PAH-16 concentrations are found near the creek mouth.

The minimum, maximum, and average total PAH-16 concentrations for surface grab samples in the Otter Creek Confluence are 0.2 mg/kg, 40.7 mg/kg, and 6.4 mg/kg, respectively. The minimum, maximum, and average total PAH-16 concentrations for sediment core samples in the Otter Creek Confluence are 0.05 mg/kg, 45 mg/kg, and 4.8 mg/kg, respectively.

---

[1] Surface grab samples targeted the top six inches to one foot of sediment, depending on the sampling program. Sediment core samples represent two-foot depth intervals, including 0 to 2 feet and subsurface depth intervals.

2.2.3 Diesel Range Organics

Method SW-846 8015 was used to analyze DRO. Based on analysis presented in the Supplemental Data Evaluation (Section 4.3 of Appendix A), DRO concentrations showed a strong correlation with porewater PAH TUs (hockey-stick regression, $r^2=0.84$, $p < 0.0001$), and site-specific threshold DRO concentrations were calculated based on this relationship. These site-specific threshold DRO concentrations help to relate chemistry results from porewater samples to bulk sediment concentrations at non-porewater sampling locations. A sediment DRO concentration of 3,100 mg/kg dry weight corresponds to the site-specific porewater PAH TU benchmark of 5.

The minimum, maximum, and average DRO concentrations for lower Otter Creek surface grab samples are 120 mg/kg, 6,000 mg/kg, and 2,876 mg/kg, respectively. The minimum, maximum, and average DRO concentrations for lower Otter Creek sediment core samples are 280 mg/kg, 60,000 mg/kg, and 10,582 mg/kg, respectively.

The minimum, maximum, and average DRO concentrations for surface grab samples in the Otter Creek Confluence area are 110 mg/kg, 13,000 mg/kg, and 2,731 mg/kg, respectively. The minimum, maximum, and average DRO concentrations for sediment core samples in the Otter Creek Confluence are 16.5 mg/kg, 7,700 mg/kg, and 779 mg/kg, respectively.

2.3 Delineation of Remedy Areas

The Supplemental Data Evaluation (Appendix A) defines the lateral and vertical extent of recommended sediment management areas based on several lines of evidence, including:

- Porewater PAH TU values
- Sediment toxicity test results
- DRO concentrations
- Total PAH-16 concentrations
- Physical features (i.e., sediment to the east of the jetty and BP-Husky outfall may be affected by ship/barge operations at the adjacent slip or other sources)
- Field observations (e.g., sheen)
- PAH chemical fingerprint

In the Otter Creek confluence area, sediment management is recommended for the area defined in Figure 2-2. The depth of contamination is generally 2 feet or less, with the exception of location OC-54 where Total PAH-16 concentrations exceed the PEC of 22.8 mg/kg to 65 inches below surface. The sediment management area recommended for lower Otter Creek is shown in Figure 2-3. The specific basis for the delineation of sediment management areas is provided in Section 4.7 of Appendix A.

As shown on Figure 2-2, porewater PAH values were above 5 TU in the surface grab samples at twelve locations within the confluence sediment management area. DRO data is available for seven of the twelve locations; however, data for only one sample (OC-28) identifies DRO as exceeding the 3,100 mg/kg threshold at a depth deeper than a surface grab sample. When

DRO data was not available to determine horizontal delineation, then the PEC of 22.8 mg/kg was used for comparison purposes. Only at location OC-54 do total PAH-16 concentrations exceed the PEC at the deepest interval sampled within the confluence area; DRO data are not available for this location, but field observations suggest the presence of DRO. The deepest exceedance at OC-54 is in the 48 to 65 inch interval.

Figure 2-3 identifies the porewater PAH, DRO, and PAH-16 data for each sample point within the lower Otter Creek sediment management area. There is limited porewater PAH information within the lower Otter Creek reach. Only five sediment sample locations in lower Otter Creek were analyzed for porewater PAHs; four of these locations had porewater results exceeding the threshold of 5 TU and are included in the sediment management area. DRO data is available for all but one sample location, although DRO data is not always available with each sample depth interval. Of the data available, eight of the sample locations exceed the DRO threshold for surface sediment at the deepest interval up to 4 feet. These samples are located from OC-2 upstream to OC-6/7(1). Of the data available downstream of OC-2, DRO exceeds the surface threshold for surface sediment for samples at the 0-24, 0-25, and 0-27 inch intervals (i.e., the depth of sediment that could be collected). The PAH-16 threshold of 22.8 mg/kg is only exceeded at three locations, all of which are located downstream of OC-2.

The sediment management areas recommended for lower Otter Creek and the Otter Creek confluence area are separated by an area of cleaner sediment. This distribution of COCs is likely related to water flow patterns in the confluence area. As shown on Figure 2-8, aerial imagery provides evidence of an eddy that coincides with the location of the confluence sediment management area.

Because sediment management was not recommended for Duck Creek or the Duck Creek Confluence, hereinafter, references to “creek” or “confluence” will refer to Otter Creek and Otter Creek Confluence.

2.4 Contaminant Source Review

Effective remediation must rely upon knowledge that contaminant sources have been sufficiently addressed. Some episodic contaminant inputs are inevitable given the presence of more than 50 storm water outfalls in upper Otter Creek. However, sediment toxicity test results for upper portions of Otter Creek provide an indication of whether stormwater-related sources would likely cause biologically significant recontamination of lower Otter Creek following a sediment remedy. This line of evidence is particularly relevant because the chemicals of concern in Otter Creek (i.e., PAHs) exert effects primarily at the base of the food web and do not bioaccumulate in higher trophic-level species. The lack of sediment toxicity in upper Otter Creek, despite the presence of some chemicals at concentrations above background, suggests that these urban inputs should not by themselves be obstacles to remediation and achieving remedial action objectives.

Appendix B presents the results of an Ohio EPA file review evaluating the potential for ongoing contaminant sources to affect the recommended sediment management areas. No effort was made to comprehensively identify historical contaminant sources (e.g., upstream of lower Otter Creek). No evidence of significant ongoing releases of PAHs and DRO was identified, but information gaps were identified. Nearly all the land surrounding the sediment management area in lower Otter Creek consists of the CSX rail yard. Based upon historical information, numerous oil wells were drilled and abandoned near and around Duck and Otter Creeks in this area. No information was available regarding adjacent soil or groundwater quality which could potentially impact Otter Creek. Limited historical information and no current information was available for the Gradel Landfill, which is indirectly linked to Otter Creek via a ditch, storm drains and a wetland (approximately 15 acres). Lastly, an area of nonaqueous phase liquid (NAPL)-saturated soils in the Otter Creek floodplain adjacent to Envirosafe's Millard Avenue Landfill is slated to be remedied in the near future based upon the Corrective Measures Study completed in 2012 for Envirosafe.

This FFS does not draw a definitive conclusion as to whether all significant sources have been controlled. However, for the purposes of evaluating and comparing remedial alternatives in this FFS, it is assumed that sources are sufficiently controlled to proceed with remediation.

2.5 Access Issues

Many factors affect remedy design and implementation at Otter Creek and Otter Creek Confluence. Some of these factors include utilities such as oil and gas pipelines, electrical lines, railroad tracks, gas lines, water lines, industrial outfall pipelines, etc.; the presence of wetlands throughout a major portion of Otter Creek; and adjacent property ownership. While this list is not exhaustive, it presents some of the main considerations that would need to be addressed prior to remedy implementation. Each of these issues is discussed further below.

2.5.1 Utilities

Otter Creek and Confluence are located within an area of industrial operations that utilize pipelines and various utilities to conduct business. As part of this feasibility study, ENVIRON contacted the City of Oregon, Ohio to obtain information on the utilities present in the proposed sediment management areas. Additional information was obtained from local industrial partners. The findings of this utility search are shown on Figure 2-4. As shown on the figure, the bulk of utility crossings are identified downstream of Millard Avenue. While the review of utilities was by no means comprehensive, for the purposes of this FFS, it was assumed that utilities in the Otter Creek sediment management area and the Otter Creek Confluence sediment management area would only minimally, if at all, impact remedy alternatives. It is recommended that additional utility information and/or surveys be obtained or completed prior to initiation of field activities.

2.5.2 Wetlands

The U.S. Fish and Wildlife Service National Wetlands Inventory was reviewed for the proposed sediment management areas. As shown on Figure 2-5, the sediment management area for Otter Creek is located within freshwater emergent and freshwater forested/shrub wetlands. Remedy alternatives presented in the following sections were developed to minimize disturbance to wetlands located within the Otter Creek sediment management area.

2.5.3 Adjacent Properties

In addition to utility location and adjacent wetlands, the proposed sediment management areas are also surrounded predominantly by railroad tracks and railroad owned property. One area, where the creek flows to the confluence area, is owned by the BP-Husky Refinery. Because of the location of railroad tracks and their proximity to the work area, care will need to be taken during the design phase to maintain the appropriate right of way and to retain track stability. Track stability and remedy alternative design will also need to take into account the steep bank slopes present through much of the Otter Creek sediment management area.

Options for accessing the creek are limited due to the challenges presented above. During the design phase, access considerations should address minimizing impact on wetland areas, including minimizing tree and fauna removal, coupled with maintaining a yet to be specified setback from railroad tracks. Specific local requirements will be evaluated during the permitting process. With these general limitations in mind, the FFS remedy alternatives assume access to the Otter Creek sediment management area will be via the BP-Husky Refinery property mentioned above. It has also been assumed for the purposes of this FFS, that minimal haul roads will be constructed and the majority of the travel will occur via the creek bed after re-routing the creek via pipeline to the confluence.

2.6 Hydrodynamic Conditions and Sediment Stability

Otter Creek flows through Oregon, Ohio, for a stretch of nearly 8 miles and then discharges into Maumee Bay, in the western basin of Lake Erie. The hydrodynamics of Otter Creek are influenced by both the upstream watershed hydrology and Lake Erie seiche events. The Lake Erie seiche is an oscillation in lake levels along the lake’s major axis that occurs on a near daily basis in response to winds and pressure changes acting on the lake. Occasionally, a more pronounced water level change results when strong winds from the southwest or abrupt changes in barometric pressure cause water levels to rise at the east end of Lake Erie. During normal flow conditions, the Lake Erie seiche can moderate downgradient flow velocities. During low flow conditions, velocities in the creek are more strongly influenced by Lake Erie seiche events, which can result a reversal of flows, creating a back-and-forth oscillation. During high flow events (i.e., rain events or spring runoff conditions), storm water flows dominate the hydrodynamics of the creek, with diminished influence from Lake Erie water seiche.

Otter Creek runs through urban land and is affected by urban runoff, industrial runoff, and channelization. Otter Creek receives inputs from many storm water outfalls, which contribute to surges in creek flow. According to the Total Maximum Daily Loads for the Maumee River (lower) Tributaries and Lake Erie Tributaries Watershed Final Report (OEPA 2012, page 24), this network of drains and ditches “…can increase the volume of water that reaches local streams during rainfall and snowmelt events, which leads to a rapid rise in stream levels during runoff events”.

Hydrodynamic conditions of Otter Creek and Otter Creek Confluence are also influenced by bathymetry. The bathymetry of the confluence is presented on Figure 2-6, and water depth information for the creek is presented on Figure 2-7. Both areas have shallow water in the range of less than one foot to over 3.5 feet in the creek and less than one foot to just over two feet in the sediment management portion of the confluence area as based upon the late 2012/early 2013 bathymetric survey and manual poling. Variability in water depth may be expected in the proposed work area due to precipitation/stormwater runoff, fluctuations in Lake Erie’s water level, and to a lesser extent due to Lake Erie seiche events.

3 Remedial Action Objectives and Goals

The development of RAOs and Remedial Goals (RGs) are common components of feasibility studies at sediment sites. RAOs provide the framework for developing safe, implementable, and effective remedial alternatives that are protective of human health and the environment. Additionally, RAOs define the basis for evaluating different sediment remedy options and describe, in general terms, what the selected sediment remedial action is intended to accomplish. RGs establish the targets necessary to achieve the RAOs. The remedy evaluation process of the FFS is used to identify and evaluate the feasibility of remedial action alternatives to determine the extent to which remedy implementation is feasible and the extent to which remedies are expected to achieve the RAOs.

COCs in Duck and Otter Creek sediment were identified based upon the results of the Supplemental Data Evaluation completed by ENVIRON in 2013 (Appendix A) as discussed in Section 2.2 above.

For the purposes of this FFS, the RAO and supporting goals are presented below.

3.1 Remedial Action Objective and Supporting Goals

The RAO and supporting goals were developed with the Beneficial Use Impairments (BUIs) identified in the Maumee River Remedial Action Plan (RAP) in mind. In 2001, this RAP listed six impaired BUIs that related directly or indirectly to sediment in Duck and Otter Creeks. These BUIs are listed as follows:

- Restrictions on Fish and Wildlife Consumption
- Degradation of Fish and Wildlife Populations
- Fish Tumors and Other Deformities
- Degradation of Benthos
- Degradation of Aesthetics
- Loss of Fish and Wildlife Habitat

It is recognized that conditions have likely changed since 2001; the 2001 BUI’s are not specific to Duck and Otter Creeks; and a number of factors unrelated to chemical concentrations in sediment can also contribute to BUIs.

3.1.1 Remedial Action Objective

RAO: *Reducing benthic invertebrate exposure to COCs and associated toxicity below levels of concern*.

Sediment remedies will be evaluated for their ability to reduce long-term benthic invertebrate exposure to COCs at the site. The focus will be on reducing benthic exposure by voluntary action. In addition, actions which improve the health of the benthic population may also serve to improve other fish and wildlife populations and the overall health of the creek.

The RAO addresses ecological exposures based on COCs in sediment. Therefore, remedy evaluation criteria that address short-term and long-term effectiveness as well as reductions in toxicity, mobility, and/or volume of sediments will impact this RAO.

3.1.2 Supporting Remedial Goals

The following RGs were established for the three indicator chemicals (porewater PAHs, DRO, and Total PAHs) discussed in Sections 2.2 and 2.3. These site-specific RGs were developed using multiple lines of site-specific evidence as discussed in Appendix A. The RGs provide numerical goals for sediment that were used to develop and design the sediment remedy alternatives to reduce ecological exposures to sediment chemicals and to achieve the RAO specifically for the identified sediment management areas.

The supporting RGs are as follows:

- Porewater PAH – less than or equal to 5 TU
- DRO – less than or equal to 3,100 mg/kg
- Total PAH (based upon PAH-16) – less than or equal to 22.8 mg/kg

The site specific RGs established for porewater PAHs, DRO, and total PAHs apply to surface sediment, which is defined as sediment depths beginning at the sediment/water interface and extending to 1 foot below the sediment surface (i.e., 0 – 1 feet (ft) depth). The vast majority of sediment-dwelling macroinvertebrates occur in the upper 6 inches, which is commonly considered the biologically active zone in Great Lakes freshwater sediment (USACE 2008b, US Navy 2003, WDE 2005). Therefore deeply deposited, sequestered chemicals beneath the biologically-active sediment-bed surface generally contribute little or no additional risk. The RGs are also relevant for subsurface sediment, to the extent that sediment may become exposed (for instance, due to removal of overlying sediment for remediation purposes).

Application of the RGs should consider the following limitations:

- The porewater PAH RG is not directly applicable to buried subsurface sediments.
- The DRO RG is only an indicator of potential PAH bioavailability and is not representative of any inherent toxicity of DRO. It is site-specific and is operationally defined based on the specific analytical method used for DRO in the 2010-2011 GLLA sampling program.
- The total PAH RG is not site-specific and is applied only in the defined sediment management areas. In other portions of Otter Creek, PAH concentrations above this RG have been demonstrated not to be associated with elevated porewater PAH concentrations.

4 Description of Remedy Alternatives

The technologies screened are consistent with USEPA sediment remediation guidance (USEPA 1998, 2005a). Technologies and process options that do not achieve criteria of safety, effectiveness, and implementability, or do not meet the RAO specified in Section 3, are eliminated from further consideration for the purposes of this FFS.

4.1 Alternative 1 – No Action

The No Action alternative is specified by the National Contingency Plan (NCP) as the baseline case to which all other response actions and alternatives are compared.

Under the No Action response, no remedial activities would be conducted and there would not be any short- or long-term monitoring. No Action reflects the Otter Creek site conditions as they exist. Under the No Action alternative contaminated sediment would remain in place. Natural sedimentation may occur in depositional environments and could provide sequestration to contribute to long term remediation and existing processes may reduce the bioavailability and/or toxicity of contaminants over time. However, the measure of these processes would be unknown.

The No Action response does not disturb the existing ecosystem and therefore will not jeopardize sensitive aquatic species or their habitat. No Action may be appropriate if a site currently meets the RAO or if a previous response (e.g., ongoing upland remedial activities and source control) eliminates the need for further action.

While this project is not bound by the requirements of the NCP, it is customary within the requirements of the NCP to identify baseline environmental conditions in the absence of remediation. Therefore, the No Action remedial alternative is included in the analysis for comparison to other alternatives. This remedial alternative reflects baseline creek and confluence sediment conditions and would entail no further action for remediation of sediment. Natural recovery processes are expected to continue, such as the deposition of cleaner sediments, but these processes would not be monitored.

4.2 Alternative 2 – Monitored Natural Recovery

Monitored natural recovery (MNR) involves leaving contaminated sediment in place and allowing existing processes (physical, chemical and/or biological) to contain, destroy, alter, or otherwise reduce the bioavailability and toxicity of contaminants (Magar et al. 2009, NRC 1997). A variety of natural processes can contribute to MNR, including natural sedimentation in depositional environments, chemical transformation, and sequestration and stabilization.

Monitoring is an integral component of the MNR remedy. Long-term monitoring of environmental restoration recognizes that uncertainty is inherent to any cleanup activity and must be managed through data collection and monitoring (US Department of Energy (USDOE) 1997).

Natural biological or chemical processes can attenuate contaminants to levels below concern through biotic or abiotic transformations and interactions. Typical forms of natural contaminant reduction include chemical precipitation, sequestration, and biotransformation and biodegradation. Amendments may also be added to the sediment to facilitate the in-situ biotic or abiotic attenuation of contaminants.

MNR can be implemented as a sole remedy or as part of a larger remedial strategy incorporating more intrusive sediment alternatives. For example, institutional and/or engineering controls are commonly employed in conjunction with MNR, such as navigational restrictions, physical access restrictions, and future dredging restrictions. These controls minimize the potential for disruption of the natural recovery processes.

Advantages and limitations of MNR are discussed in the USEPA (2005a) *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* and in the US Department of Defense (DoD) *Technical Guide: Monitored Natural Recovery at Contaminated Sediment Sites* (Magar et al. 2009). Advantages include:

- MNR reduces disturbances to the ecosystem that may jeopardize habitat and sensitive aquatic species.
- MNR is readily implementable.
- At sites where MNR satisfies risk-based remedial goals, MNR can effectively manage human and ecological risks.

Disadvantages include:

- Contaminants are left in place.
- The time frame for natural recovery is typically slower than that for invasive remedies, such as capping or removal.

MNR relies on source reduction. Similar to other remedial strategies, natural recovery processes can potentially be undermined if ongoing sources of contamination to sediment are not adequately controlled. Efforts to date to reduce or eliminate sources to the Maumee AOC contribute to the ongoing natural recovery of the Otter Creek and Confluence. This FFS assumes for remedy evaluation purposes that all sources are under control.

Natural sedimentation and mixing can create a surface sediment layer with lower chemical concentrations through the physical burial of contaminated sediments over time (USEPA 2004a, Brenner et al. 2004, Magar and Wenning 2006). Such “natural capping” can form a protective barrier that inhibits diffusion of chemicals into the water column, minimizes the potential of contaminated sediment resuspension, and helps isolate contamination from contact with ecological and human receptors.

MNR involves site characterization followed by long-term monitoring. Multiple lines of evidence are used to establish MNR as an effective alternative over time (Magar et al. 2009). Monitoring is used to demonstrate the ability of MNR to achieve RGs in surface sediment and reduce the risks to the environment associated with current sediment conditions.

Physical Lines of Evidence Supporting MNR

As contaminant sources have been controlled, sediment quality in lower Otter Creek may have improved through multiple mechanisms, including biodegradation of organic compounds (such as PAHs), burial of contaminated sediments by cleaner sediments, and dispersion of contaminated sediments (e.g., movement of sediments from the creek into the confluence area). Conditions favorable to biodegradation of PAHs include availability of oxygen and nutrients, as well as warm temperatures (Atlas, 1981). On this basis, biodegradation would be expected to occur most rapidly in shallow surface sediments and more slowly in buried sediments.

Deposition of suspended sediments originating from watershed sources upstream of lower Otter Creek is another natural process that would contribute to the MNR remedy. Although sediment burial may retard biodegradation, it facilitates physical isolation of contaminants from organisms, provided that newly settling sediments are relatively clean. Lower Otter Creek is a depositional environment, as indicated by significant sediment depth and prevalence of fine-grain sediment. These conditions are typical of lake estuary environments, where flow velocity slows as the stream approaches the lake. Movement of surficial sediments may occur under these conditions, but the net effect of sediment settling and erosion processes is depositional. Further, urban streams typically transport more sediment than streams in undeveloped areas (OEPA 2012). Also, channelization can create an environment that carries sediment faster and further than non-channelized creeks. These factors likely increase the amount of sediment carried into the lake-estuary portion of the creek, where flow slows and deposition may occur. The deposition of suspended material provides a physical barrier of sediment with lower chemical concentrations as compared to the buried sediment, thus isolating elevated chemical concentrations in the sediment and reducing the potential exposure of elevated concentrations to biota.

Evidence that natural biodegradation and/or sedimentation lead to reduced chemical concentrations in surface sediment in Otter Creek is demonstrated in the data shown on Figure 2-3. At every lower Otter Creek location where both a surface grab sample and a 0-24 inch sample were collected, PAH and DRO concentrations were lower in the surface grab sample, consistent with deposition of cleaner sediment over time. The fact that surface samples remain contaminated enough to warrant sediment management may be due to the fact that source control efforts have progressed incrementally. In contrast, there is no evidence of natural recovery through contaminant burial in the confluence area, where the highest concentrations are generally found at the surface.

Biological Improvements as Evidence Supporting MNR

Biological community quality data collected by OEPA[1] over the past two decades shows a strong trend of recovery over time, specifically for fish. In 1986, three fish monitoring efforts in lower Otter Creek (river mile (RM) 0.5) yielded only one fish per sampling event, on average. By 1993, more fish were present, but the quality of the fish community was low; the 1993 Index of Biotic Integrity (IBI) score was 12 (very poor). The abundance and quality of fish continued to

---

[1] Discussion of fish and invertebrate community monitoring is based on data provided by OEPA Division of Surface Water.

improve, such that by 2006, the IBI score at RM 0.5 was 38,[2] exceeding the applicable criterion for modified warm water habitat (20). Based on proposed lacustuary (i.e., lake estuary) benchmarks, OEPA (2010) rated the 2006 fish community at this location as fair. The lacustuary benchmarks do not account for effects of channelization and thus are not directly comparable to modified warm water habitat criteria.

Data to evaluate temporal trends in benthic invertebrate community quality are more limited, because OEPA's standard invertebrate monitoring techniques are not applicable due to slow water flow in lower Otter Creek. OEPA's most recent invertebrate community data from lower Otter Creek are from 1993 at RM 0.4. Those data provide a lacustuary Invertebrate Community Index (ICI) score of 28 (considered "fair"), although the accuracy of this score is uncertain due to slow water flow. More recently, qualitative sampling focusing on species presence/absence has been conducted over time at the Old Millard Road crossing (RM 2.10), upstream of the lower Otter Creek sediment management area. The number of species (13) at RM 2.10 was constant between 1986 and 2006, but the species composition shows evidence of some improvement. In 1986, most of the identified taxa were midge species, whereas the taxa identified in 2006 included more crustaceans and a mayfly species. Mayflies are generally considered positive indicators of invertebrate community quality. Nevertheless, benthic community quality at RM 2.10 continues to be rated qualitatively as very poor (OEPA 2010).

Long-Term Monitoring Requirements for Remedy Alternative 2

Long-term monitoring of Otter Creek and Confluence as part of an MNR remedy would involve periodic evaluation of ecological exposures. Long-term monitoring would also focus on gaining a better understanding of chemical and biological trends in the creek and confluence against the RAO and to evaluate changes in conditions that are used to identify and delist BUIs. Long-term monitoring requirements would be defined in a project-specific long-term monitoring plan during remedy design.

MNR in the proposed sediment remedy areas would likely include the measurement of surface sediment (0–1 ft) and porewater chemical concentrations to confirm that porewater PAH, DRO, and total PAHs achieve the site specific RGs over time. Further evaluation of sediment stability and natural recovery processes would likely be performed as part of the remedy design.

Long-term biological monitoring of the management area would be required. The need for sediment stability monitoring would be evaluated during the design phase. The Long Term Monitoring Plan would further define performance objectives. The MNR monitoring would focus on gaining a better understanding of chemical and biological trends against the RAO and RGs and evaluating changes in conditions that are used to identify BUIs.

4.3 Alternative 3 – Sediment Removal and Cover

Alternative 3 was created to address all known COCs within the sediment management areas above the RGs as discussed in Section 3.1.2. This alternative includes removal of known COC

---

[2] IBI score listed by OEPA (2010) as 36, but listed as 38 in documentation from OEPA Division of Surface Water (received April 2010).

containing sediment via dredging or excavation and placement of a sand cover to ensure surface conditions meet the remedial objectives; support side slope stability; and thereby address potential residuals within the creek. Specifics of this alternative are shown on Figure 4-1 for the creek and Figure 4-2 for the confluence area. This alternative includes removal of four feet of sediment (or removal of sediment to the native clay layer, whichever is reached first) downstream of Millard Avenue (past OC-6/7(2)), except for locations OC-44, OC-45, and OC-1A where sediment will be removed to a depth of 2.5 feet (or the native clay layer, whichever is reached first). The confluence area will be addressed via removal of 1 or 2 feet of sediment at all locations except for location OC-54, where dredging will occur to approximately 5.5 feet or shallower if shown necessary during design evaluation. The proximity of OC-54 to the jetty (see Figure 4-2) requires additional design prior to implementation to ensure jetty stability is not compromised during dredging activities. Due to stability issues, backfill will be placed over OC-54.

4.3.1 Sediment Removal

Advantages and limitations of environmental dredging are discussed in the USACE (2008a) Technical Guidelines for Environmental Dredging of Contaminated Sediments. Advantages include (USACE 2008a, USEPA 2005):

- If the operation achieves cleanup levels for the site, dredging can reduce uncertainty regarding long-term cleanup effectiveness.
- Removal of the contaminated material can provide flexibility for future use of the water body.
- Sediment removal can allow for treatment and/or beneficial reuse of dredged or excavated material (although sediment treatment is not often cost-effective and therefore not often selected; furthermore, beneficial use of dredged sediment generally requires that processed sediment meets strict regulatory standards for reuse).

Disadvantages include (USACE 2008a, USEPA 2005):

- Dredging or excavation may be more complex and costly than other approaches, such as in situ remedies, due to accommodation of equipment maneuverability and portability/site access.
- Local disposal capacity may be limited in some cases; however, this potential disadvantage does not apply to Otter Creek as local disposal options are available.
- Operations and effectiveness may be affected by utilities and other infrastructure, surface and submerged structures (e.g., piers, bridges, docks, bulkheads, or pilings), overhead restrictions, and narrow channel widths.
- There is a level of uncertainty associated with estimating the extent of residual contamination following removal, often making the sediment removal processes and achievement of risk-based remediation goals difficult and costly.
- There is potential for contaminant losses through resuspension, dissolution, and volatilization.

- Disruption of the benthic environment normally is unavoidable during dredging or excavation, and usually includes at least a temporary destruction of the aquatic community and habitat within the remediation area.
- Removal of sediment near shoreline structures such as existing bank protection, retaining walls, and wharfs, has the potential to undermine the shoreline and/or structures, creating foundation instability and limiting the depth of sediment removal near these features.

Though dredging can offer long-term advantages, the dredging process typically leaves some residual contamination within the affected area. However this alternative includes the placement of a one foot sand cover throughout the creek sediment management area to address potential residuals and provide a clean environment for benthic invertebrates. Natural sedimentation will also assist with maintaining this sand cover after sediment removal. Also, sediment removal may enhance deposition rates (i.e., dredged areas often act as traps for sediment deposition) and may accelerate subsequent natural recovery processes.

Mechanical dredges for sediment remediation typically use digging buckets (e.g., clamshell buckets) suspended by cables from a crane, or backhoe. Mechanical dredges remove sediment at close to the in situ density; however some water is entrained in the bucket during filling (USACE 2008a; 2008b). Hydraulic dredges suspend sediment in water to create slurry that is pumped via pipeline to a staging area (e.g., a dewatering site or barge). The sediment is usually suspended in a large amount of water to allow for transport through the pump and pipeline. For hydraulic dredging, the volume of water produced could be 5 to 10 times the in-place volume of sediment removed (USACE 2008a). For the purposes of this FFS it has been assumed that this alternative will be completed by dry excavation in the creek after rerouting the creek flow via pipeline and wet mechanical dredging in the confluence.

Hydraulic dredging could be evaluated at the next stage of the project. This dredging option is more applicable if it is determined that the existing, local confined disposal facility (CDF) can be used for ultimate disposal. The process of dewatering the sediment after removal via hydraulic dredging is time intensive and costly if the material will be disposed of at a licensed landfill (i.e., not CDF). Various types of mechanical removal may also be applicable. For the purposes of this FFS, both removal via excavator and removal via Amphibex dredge technology were considered; other forms of mechanical removal could be evaluated during the next phase of the project.

Apart from actual dredging or excavation, sediment removal involves dewatering, transportation of removed material from the contaminated site to the disposal site, and disposal of the material. Treatment and disposal of the material accounts for a major proportion of the total cost of remediation projects, and the ability to process the sediment may be the rate-limiting step when planning the overall schedule (USACE 2008a). After removal, sediment often is transported to a staging or rehandling area for dewatering (if necessary), separation (if desired), and further processing, treatment, or final disposal. Transport may involve several different technologies or modes of transport. When dredged sediment can be disposed at a CDF, the CDF itself can be used for sediment dewatering. Following sections discuss considerations relating to dewatering and/or sediment stabilization, prior to transportation of material from the contaminated site and disposal of the material.

4.3.2 Material Dewatering

Unless the material can be barged or hydraulically conveyed to the disposal facility (e.g., CDF), dredged sediment may contain too much water to be safely transported off-site or placed at a disposal facility. Sediment may require dewatering, which requires permitting to regulate the discharge of treated waters, and is usually a component of the management of contaminated sediment when it is to be transported to upland disposal facilities. Dewatering can reduce the weight and volume of sediment designated for offsite disposal, controls and restrictions on transportation, and related transportation and disposal costs.

The management of water removed from wet sediment is inherent to the dewatering approach. The magnitude and extent of water management requirements depends on the dredging method and the dewatering method. In some cases, free water can be returned to the dredge site, which usually requires treatment prior to discharge.

Dewatering options for removed sediment generally range from passive (e.g., gravity dewatering or use of geotextile tubes) to mechanical dewatering methods; additives may be used to enhance dewaterability, but may increase the net sediment volume for disposal. The need for a water management system would be identified in a the design phase, as would a site-specific bench-scale treatability study that tests the dewaterability of the sediment, to identify and select an appropriate dewatering method and to determine the type and amount (if any) of additives required. Dewatering is generally time intensive, costly, and requires large operating areas. For the purposes of this FFS, it has been assumed that an amendment such as a super absorbent polyacrylamide would be used to assist in dewatering the sediment prior to transportation and ultimate disposal. The addition of an amendment will be completed after gravity draining at the dewatering pad mentioned below.

Water Treatment. Dewatering and upland sediment management activities require appropriate management of water produced during dredging and dewatering activities. Water management is likely to require removal of suspended solids and treatment of dissolved-phase contaminants. Water discharge will have to be permitted. For the purposes of this FFS, it has been assumed that a gravity dewatering pad will be constructed at the main staging area and this pad will slope to a sump where collected water will pump to on-site frac tanks for on-site treatment and/or off-site disposal. Additional evaluation of dewatering, treatment, and/or disposal options will be further evaluated during the design process.

4.3.3 Transportation and Disposal

Removed sediment can be transported using barges, trucks, railroads, or pipelines. Barges may transport dredged or clean sediment over water. Sediment can be loaded directly onto barges during dredging operations, after which the barge would transport sediment directly to a CDF or to a transfer facility where the sediment could be offloaded. Multiple transport methods, including truck, rail, and barge transport may be combined pending availability, access, efficiency, and cost. All transport methods generally require water- and spill-control systems (e.g., adequate freeboard or liners) to prevent uncontrolled sediment and water spills during transport. In general, sediment is dewatered before truck or rail transport.

Although a CDF is close to the work area, additional work needs to be completed to determine if space is available at the CDF and if the Otter Creek and Confluence removed sediment would be acceptable for placement at the CDF. The method used to transport the material to the CDF would also be reviewed. If the material is moved over water, additional haul roads and loading areas would likely need to be constructed. For the purposes of this FFS, it has been assumed that the sediment will be disposed of off-site, at a local landfill.

4.3.4 Restoration

During remedy implementation, the construction of access roads and staging areas may require removal of vegetation from upland, riparian, and/or wetland areas. Following the completion of remedy construction, these areas will be re-graded as needed, reseeded, and replanted with native tree or shrub species as appropriate. For the purposes of this FFS it has been assumed that minimal tree or shrub planting will be required, and this planting will only occur at the point of access to the creek from the staging area.

Instream habitat restoration will be considered as part of remedy design. It is assumed for this FFS that one foot of sand cover will be placed in the creek sediment management area, in part to address any residual contamination, as well as for instream habitat restoration purposes. Considerations in identifying and comparing instream restoration measures during remedy design can include factors such as physical stability, water depth and light penetration (e.g., as related to re-establishment of submerged aquatic vegetation), substrate suitability for benthic invertebrate colonization, and expected future sediment deposition patterns.

Depending on permit requirements and availability of funding, additional habitat enhancements may be considered beyond replacement of habitat directly impacted by the sediment remedy. A variety of restoration approaches may be evaluated. Options may include habitat expansion for submerged aquatic vegetation, streambank or shoreline habitat improvements, wetland enhancements, and riparian tree planting (potentially including areas somewhat upstream of the sediment management area).

Site-specific considerations in the identification and comparison of specific habitat restoration options may include ecological benefit, implementability, short-term and long-term effectiveness, and cost.

4.4 Alternative 4 – Shallow Sediment Removal and Capping

Alternative 4 includes removal of one foot of sediment from lower Otter Creek beginning just upstream of sample location OC-6/7(1) through sample location OC-44 and the placement of a cap which includes an activated organoclay mat and approximately one foot of clean sand cover. This alternative would address surface sediment above RGs in addition to providing additional water column depth for the placement of a cap. Remaining sediment exceeding RGs will be addressed via cap placement. Specifics of this alternative are shown on Figure 4-3 for the creek and Figure 4-4 for the confluence area. This option relies upon the completion of additional hydraulic studies and the potential additional sediment removal at select locations if required for design purposes and to support the hydraulic regime.

Capping is not envisioned for the confluence area, due to the combination of shallow water and shallow depth of contamination in most of the sediment management area. The confluence area will be addressed by removal of sediment to depths of 1 foot, 2 feet, and 5.5 feet as shown on Figure 4-4. The 5.5 foot depth interval may require shallower dredging if design requirements establish instability in the adjacent jetty which could be caused by this dredging. For stability purposes, backfill will be placed over the 5.5 foot depth interval.

Capping

The simplest type of cap consists of a layer of clean fill material, such as sand. A more complex cap design can include geotextiles, liners, and other permeable or impermeable elements in multiple layers that may include additions of material to attenuate the flux of contaminants. Caps also may require armoring to control cap erosion under high-flow conditions. Alternative 4 includes the placement of an organoclay mat to control vertical COC, including DRO, transport into the cap. The Alternative 4 cap is designed to reduce risk through the following primary functions:

- Physical isolation of the contaminated sediment sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface.
- Stabilization of contaminated sediment and erosion protection of sediment and cap, sufficient to reduce resuspension and transport to other sites.
- Chemical isolation of contaminated sediment sufficient to reduce exposure from dissolved and colloidally bound contaminants transported into the water column.

Partial removal (i.e., shallow dredging) is sometimes required in order to place the cap. Potential situations where this may apply include a need to preserve a minimum water body depth for navigation or flood control, or where it is desirable to leave deeper contaminated sediment in place to preserve bank or shoreline stability following removal. It is also recognized that some form of cap or cover is typically necessary to manage post-dredge residuals. As a result, shallow dredging followed by a cap can be more effective and less disruptive than deeper dredging. This is because deeper dredging typically involves the removal of sediment with the highest constituent concentrations. The higher concentration materials will result in more impacts associated with potential water column impacts, downstream migration of resuspended sediment and post-dredge residuals. In addition, shallow dredging followed by capping will be less disruptive to the local community in terms of project duration, truck or barge traffic, and use of available CDF or landfill capacity.

Alternative 4 is proposed for these reasons: to allow for a minimum water body depth to remain after placement of the cap, and to limit stability and erosion issues that would be associated with deeper excavation in the creek. This option will also provide chemical isolation of the COCs while providing a clean sand cover to create a favorable environment for benthic invertebrates. This capping option will enhance ongoing natural recovery (i.e., physical isolation through sediment burial). This option also does not alter the current bathymetry of the sediment bed in the creek, because the sediment bed is returned to grade after removal.

Sediment capping involves the controlled placement of suitable material over contaminated sediment and is a relatively mature, proven technology. Sediment capping is generally most appropriate for locations where routine disturbance (e.g., maintenance dredging) is not required to support local functions such as navigation, and the environment is relatively low-energy so the cap will be stable.

Cap armoring is employed, where required, to stabilize cap materials, and generally consists of the placement of gravel or riprap over the clean cap. This technique may be used in higher energy environments where currents, waves, or mechanical disturbance (e.g., propeller wash) could potentially scour the cap material. This alternative assumes that armoring may only be required to reduce erosion on the slopes of the creek, however additional hydrological studies should be completed in the design phase to address the potential need for armoring.

A monitoring program is commonly required when a cap is used to remediate contaminated sediment sites. Monitoring may include bathymetric surveying and visual observation (e.g., camera or video profiling) to evaluate cap integrity and the potential for cap displacement, shifting, or erosion. It is understood that GLNPO would not be responsible for, or part of, the monitoring program developed for this option.

Advantages and limitations of sediment capping are discussed in the USACE (2005) *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. Advantages include:

- It immediately provides a clean sediment surface and it quickly reduces exposure to chemicals in surface sediments.
- The potential for exposure to contaminants is reduced without material handling, treatment, and disposal.
- Cap material often provides a clean substrate for the recolonization of benthic organisms.
- Cap implementation is typically quicker and less expensive than sediment removal.

Disadvantages include:

- Limitations/restrictions may exist for future site use.
- Caps may require routine repair or periodic replenishment if they are damaged.
- Caps may alter water depths, reducing available habitat, navigation depths, and floodway conveyance capacity.

The primary benefit of capping would be to physically and chemically isolate site contaminants from the environment while enhancing natural recovery processes via stabilization and containment of in situ sediment. This option will meet the RAO established for the sediment management areas as it provides a clean environment for the benthic community.

Dredging and/or excavation, sediment handling and disposal, and restoration would be completed as discussed in Section 4.3. The exact methods to be used to reduce potential sediment suspension and contaminant release will be assessed during remedy design.

Modeling would also be required during the design phase to evaluate the potential impacts of subsurface gas formation and ebullition (if any) on the cap.

5 Evaluation of Remedy Alternatives

This section provides a comparative evaluation of sediment Remedy Alternatives 1 through 4 against the following evaluation criteria:

- Overall protection of human health and the environment
- Short-term effectiveness
- Long-term effectiveness
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- State and community acceptance

Note the nine criteria established under the National Oil and Hazardous Substances Contingency Plan are not used for the purposes of this FFS; specifically, applicable or relevant and appropriate requirements (ARARs) are not formally identified. There are no numerical standards for sediment quality that would apply. Other relevant requirements (e.g., related to water quality) will be considered as part of remedy design and permitting. Analyses used to support the remedy evaluations in this section are presented in Table 5-1 through 5-3 (mass removal calculations), and Tables 5-4 through 5-7 (estimated remedy costs)).

5.1 Overall Protection of Human Health and the Environment

As specified in the NCP, overall protection of human health and the environment is a threshold criterion, in that all alternatives must achieve this criterion to be considered viable. Evaluation of the overall protection of human health and the environment determines whether the alternative achieves adequate short- and long-term protection; describes how site risks are eliminated, reduced, or controlled through natural processes, treatment, engineering, or controls; and describes the extent to which each sediment remedy meets the goal of the RAO established in Section 3 of this document.

5.1.1 Remedy Alternative 1 – No Action

The No Action alternative does not assist in providing documented recovery of the stressed benthic community and therefore does not meet the RAO goal. While natural sedimentation and biodegradation processes would likely continue to occur as discussed in Section 4.1, which would reduce the surface sediment chemical concentrations with time, the measurement of these processes would not be completed and therefore the degree of reduction, control, or elimination of risk would not be known.

5.1.2 Remedy Alternative 2 – Monitored Natural Recovery

Remedy Alternative 2 contributes to the protection of the environment over time and contributes to the RAO goal through ongoing recovery processes and monitoring. Natural sedimentation and biodegradation are the primary natural processes contributing to historical recovery trends, as discussed in Section 4.2.

MNR differs from the No Action alternative by including long-term monitoring. Long-term monitoring is used to assess the continuation of ongoing natural processes that result in decreasing concentrations of porewater PAHs, DRO, and Total PAHs in the surface sediment and the associated improvement in the ecological receptors related to these compounds in the management area. By reducing uncertainty, long-term monitoring is used to provide assurance that long-term risks are appropriately managed and controlled. In the short-term, MNR alone is not expected to greatly contribute to the recovery of the benthic environment, but in the long-term the RAO goal could be achieved by effectively managing and reducing risk to ecological receptors, and mitigating implementation risks associated with more active remedial approaches.

Ongoing sedimentation is expected to continue to reduce surface sediment chemical concentrations, leading to ecosystem recovery with time, but the time required to reduce surface sediment concentrations below RGs is expected be significantly longer via MNR as compared to sediment removal remedies.

5.1.3 Remedy Alternative 3 – Sediment Removal and Cover

Remedy Alternative 3 in both the creek and the confluence area targets the removal of surface and deeper sediment with concentrations greater than the established RGs. The alternative also includes the placement of clean cover over the management area in the creek, while natural deposition will assist in improving benthic conditions in the confluence sediment management area.

This option provides a high degree of protection to the environment, as once sediment removal and cover placement have been completed, a clean environment is directly established for the benthic community. Alternative 3 would meet the goal of improving the benthic community. Pathway risks associated with this alternative are addressed by bulk removal of sediment containing COC’s above site specific RGs. However, short-term surface sediment concentrations would be negatively impacted during implementation of this remedy through disruption of the existing sediment bed surface and benthic environment and sediment suspension. This disruption will be minimized by removing the sediment in a dry environment (ie. via re-routing the creek).

5.1.4 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Remedy Alternative 4 in the creek targets the removal of surface sediment to a depth of one foot to allow for the placement of a cap. This alternative as implemented in the confluence management area includes removal of known sediment which exceeds the site specific RGs and natural sedimentation to address unknown delineation with depth.

In the creek, placement of an activated organoclay mat coupled with the sand cap would achieve the RAO goal for the creek after remedy completion; however excavation or dredging in the creek would negatively impact short term sediment concentrations due to disruption of the existing sediment bed surface and benthic environment and sediment suspension.

Sediment removal in the confluence area contributes to the RAO goal by reducing the quantity of sediment containing COCs at concentrations greater than the site specific RGs. Thus exposure to the benthic community would be reduced. However, short term, during remedy implementation the confluence area would be negatively impacted due to disruption of the sediment bed surface and sediment suspension. This alternative is also not as protective in the confluence area as alternative 3.

Although sediment removal and capping disrupts the natural environment, limited remediation focused on surface sediment exposures limits the short-term impacts of dredging and capping on the natural environment.

Remedy Alternative 4 effectively contributes to the goal of reducing benthic invertebrate exposure to COCs in the short term after remedy implementation. The long term risks associated with alternative 4 are greater than those identified within alternative 3, but less than those presented in alternative 2. Long-term risks related to cap integrity would be addressed through monitoring. Alternative 3 removes more of the known chemical mass from the environment than alternative 4 does, whereas Alternative 4 focuses on eliminating biological exposures in the surface sediment environment.

5.2 Short-Term Effectiveness

Effectiveness is evaluated based on the ability of the technology or process option to meet the RAO goal, ensure long-term human health and environmental protection, protect against short-term human and environmental effects during construction, and proven reliability at sites with chemical constituents and conditions similar to those at Otter Creek and Confluence. Short-term effectiveness also considers safety. Safety is evaluated based on the potential for implementation of a technology or process option to generate higher, different, or unanticipated adverse human health effects or ecological impacts. Projected activities are evaluated for changes such as disruption of baseline sediment geochemical or biological conditions that alter chemical bioavailability, increased erosion, or increased likelihood of offsite migration of contaminated sediment.

Short-term effectiveness includes an evaluation of short-term impacts during the construction and implementation phase. Impacts evaluated include ecological and human risks, potential impacts to the community and site workers during remedy implementation, and time until the remedy is achieved (USEPA 2005). This evaluation determines whether the remedy alternatives negatively impact short-term risks, and whether those risks can be eliminated or controlled through proper remedy selection and best management practices during remedy implementation. Effects of implementation on the community include quality of life impacts, such as noise, odors (vehicles and sediment), and traffic. Impacts to site workers include safety risks during remedy implementation.

The short-term impact of the physical disturbance on the environment will include removal of existing vegetation beds, removal of benthic organisms, alteration of water column depth, temporary reduction of limited shallow habitat within the creek, and short-term impacts on water quality.

Habitat recovery time that can be expected following the remedial action primarily involves consideration for adequate vegetation and benthic recolonization times. Remedy implementation time is directly proportional to the volume of required dredging for each specific remedy alternative including the time required to install backfill and/or capping material. Implementation timeframes are discussed for each remedy in the following sections. Each sediment remedial alternative may include a habitat restoration component to restore lost or temporarily impaired ecological resources, function, or services. State or federal requirements regarding restoration activities will be identified and addressed during the design and permitting. However, because recovery takes time, short-term ecological risks and habitat impacts require careful evaluation.

5.2.1 Remedy Alternative 1 – No Action

This response would not change baseline sediment conditions except for naturally occurring changes such as sedimentation or biodegradation which would not be expected to significantly contribute to the RAO in the short term. Construction hazards and health risks to remediation workers during remediation would be nonexistent because no action is taken as part of this alternative. However, as a result of the No Action alternative chemical concentrations exceeding the RGs developed for the increased protection of ecological health would be left in place in both surface and subsurface sediment.

The No Action alternative would result in little to no short-term risk reduction, since risk reduction will be dependent on natural sedimentation which acts to cover existing sediment with sediment having lower constituent concentrations.

The No Action alternative would have no short-term community impacts. The No Action alternative does not create increased community risks associated with onsite construction and remediation operations, accidents or spills of site-related materials, or transportation. The alternative also creates no community short-term impacts such as noise, odors, or local traffic odors during construction.

The No Action remedy would pose no transportation or construction risk to site workers because no miles are traveled, and the No Action remedy does do not require construction. In addition, implementation of this remedy requires no ex-situ management of contaminated sediment.

The No Action remedy is not intrusive, thus, it does not affect habitat or water quality as a result of remedy implementation.

5.2.2 Remedy Alternative 2 – Monitored Natural Recovery

As discussed in Section 4.2, lower Otter Creek is a depositional environment, as indicated by significant sediment depth, prevalence of fine-grain sediment, and generally slow water flow. At every lower Otter Creek location where both a surface grab sample and a 0-24 inch sample were collected, PAH and DRO concentrations were lower in the surface grab sample, consistent with deposition of cleaner sediment over time and/or biodegradation in surface sediment. The biological community has shown a trend of recovery over time, especially regarding fish community. However the benthic community quality in lower Otter Creek continues to be rated qualitatively as very poor (OEPA 2010). This may be due in part to source control efforts which have progressed incrementally over time (Appendix B). However the area is expected to continue to recover with time and continued source control efforts. Effectiveness of MNR is reinforced by long-term monitoring of sediment, chemical, geochemical, and biological conditions. Therefore, this option is not particularly effective in the short term.

The MNR alternative would result in little to no short-term risk reduction, since risk reduction will depend on natural sedimentation which acts to cover existing sediment with sediment having lower constituent concentrations.

The MNR remedy creates no increased risk to the community associated with onsite construction and remediation operations, accidents or spills of site-related materials, or transportation. MNR creates no community short-term impacts such as noise or odors during construction. Routine monitoring and sampling would be required but would not negatively impact the community.

The MNR remedy poses negligible transportation risk and no construction risk, because MNR does not require construction. MNR would also pose low risk associated with long-term monitoring, because effective health and safety plans and experience can adequately manage risk during field sampling and analysis. Therefore, MNR is achievable without adverse community and worker impacts.

The MNR remedy is not intrusive; thus, it does not affect habitat or water quality as a result of remedy implementation.

5.2.3 Remedy Alternative 3 – Sediment Removal and Cover

Sediment removal has been demonstrated at numerous sites. As a mass-removal or source-removal technology, excavation and dredging are effective. However, sediment removal typically relies on some form of capping or cover coupled with natural recovery processes to address residual COC concentrations and achieve long-term, site-specific RGs. Alternative 3 includes a one foot protective cover in the creek management area to expedite recovery processes and increase the effectiveness of the remedy in the short term.

Dredging alternatives provide the opportunity to achieve risk reduction by the immediate removal of sediment contaminants contributing to ecological and human health exposures and risks. However, depending on the size and complexity of the project, dredging sediment increases the potential for negative short-term impacts to the environment and to the surrounding community. This is true for Remedy Alternative 3, which requires the removal, transportation, and disposal of more than 50,300 cubic yards (CY) of contaminated sediment material. The time required to complete the implementation of Remedy Alternative 3 is expected to be slightly longer than what is expected for Remedy Alternative 4. Community impacts would be in proportion to the volume of dredged material, onsite sediment handling requirements, and time required to complete remedy implementation. Thus, Remedy Alternative 3 would pose greater community impacts than Remedy Alternative 4 or Remedy Alternative 2.

Dredging poses potential adverse risks to the local area and construction workers via exposures to contaminated sediment, prolonged construction, and increased transportation to and from the site. The risks of sediment suspension and accidental spills of site-related materials increase during excavation and transportation. Transportation of contaminated material increases human exposure risks due to the increased sediment handling requirements. Greater volumes of contaminated material would need to be handled and transported in alternative 3 as compared to alternative 4.

Short-term risks associated with dredging should be commensurate with the long-term gains of dredging. The most frequent post-dredging measurement used to assess dredging effectiveness is contaminant concentrations in surface sediment. Surface concentrations (as opposed to concentrations in deeply buried sediments) are the most relevant to risk (NRC 2007). By addressing the COC deposits while adding a protective cover in the creek and a section of the confluence, Remedy Alternative 3 provides an effective short-term remedy. This statement assumes that excavation in the creek will occur in a dry environment where there is less potential for movement of sediment containing COCs than applicable in a wet dredge environment. Because this alternative removes known COC containing sediment from the creek and adds a sand cover, once the creek is re-routed back through its original location, short-term risk of resuspension or the ability to contact sediment at concentrations greater than the site specific goals in the creek should be minimal, if at all. However, complete depth information in regards to analytical data is not available for all of the confluence area (see Figure 2-2), which could mean that residuals left in place could reduce the short term effectiveness of both alternatives 3 and 4.

Dredging requires extensive heavy equipment use, including barge- or shoreline-mounted excavation equipment, and onsite sediment handling equipment (e.g., backhoes or cranes). Though the construction industry has extensive experience working with such heavy equipment, the increased risk of injury cannot readily be discounted. Dredging increases the risk of offsite transport of contaminated sediment during routine operation. Optimizing sediment removal reduces the potential for sediment scouring and offsite contaminant transport, and minimizes ecological exposures to chemicals in surface water resulting from sediment resuspension.

The short-term impact on water quality involves consideration of sediment resuspension and partition of compounds into dissolved phase as a result of dredging. Remedy Alternative 3, as well as Remedy Alternative 4, would minimize water quality impacts by employing best management practices that reduce surface sediment releases to the extent practicable, and all dredge remedies would adhere to site-specific permitting requirements.

Short-Term Monitoring. Confirmation monitoring will be conducted while remedy implementation is in progress to ensure the selected implementation methods are meeting design specifications. Dredge confirmation monitoring can include the use of real-time kinematic differential global positioning system (DGPS) linked to real-time monitoring software, which is integrated in the sediment removal equipment, to verify the area and depth of sediment removed in dredge areas. Methods such as simple in-place measurement can also be used. In the event that confirmation monitoring demonstrates the remedy was not implemented per remedy design specifications, the design will outline the decision criteria for determining what, if any, additional measures are warranted.

Operational monitoring will also be conducted during remedy implementation to ensure the water quality criteria outlined in the federal and state permits secured for the project are not exceeded. In the event these criteria are exceeded during remedy implementation, the remedial design will outline the decision criteria for determining whether remedy construction should be temporarily stopped or if alternative implementation methods should be employed.

5.2.4 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Capping can be an effective alternative when all sources are adequately controlled. It has been assumed for the purposes of this FFS that there are no on-going sources. Alternative 4 includes the removal of one foot of contaminated sediment in the creek where contaminated sediment has been documented to up to four feet. This option assumes that sediment in the creek will be excavated in a dry environment prior to placement of a cap, which should reduce the short term risks associated with removing only a portion of the contaminated sediment. Also alternative 4 includes the placement of an organoclay mat prior to placement of the one foot sand cover to address remaining COC concentrations in sediment above RGs. In the short term this cap should continue to reduce chemical concentrations in buried sediment as water moves through the buried sediment and ultimately through the adsorptive cap.

This thin-layer capping could be effective in the low-energy environment within Otter Creek. The benefit of thin-layer capping would be to minimize negative ecological impacts of sediment capping, such as loss of aquatic habitat in the creek, and to minimize loss of flow conveyance. Thin-layer capping accelerates MNR processes—particularly contaminant burial—which already occur in Otter Creek, decreasing surface sediment contaminant concentrations, and reducing risks.

Alternative 4 in the Otter Creek Confluence area includes the removal of approximately 11,300 CY of sediment, the same as that proposed for Alternative 3. However complete depth information in regards to analytical data is not available for all of the confluence area (see Figure 2-2), which could mean that residuals left in place could reduce the short term effectiveness of both alternatives 3 and 4.

The time required to implement Alternative 4 is slightly shorter than the time estimated for implementation for Alternative 3. Community impacts would be in proportion to the volume of dredged material, onsite sediment handling requirements, and time required to complete remedy implementation. Thus, Remedy Alternative 4 would pose slightly less community impacts compared to Remedy Alternative 3.

In addition, impacts to site workers, including risks associated with operating heavy equipment, transportation of material, and potential exposure to contaminated sediment during excavation, dredging, and transportation, would also be in proportion to the volume of material removed as well as the volume of cap placement.

The short-term impact on water quality involves consideration of sediment resuspension and partitioning of compounds into dissolved phase as a result of sediment removal. Remedy Alternative 4 would minimize water quality impacts by employing best management practices that reduce surface sediment releases to the extent practicable and would adhere to site-specific permitting requirements. The short term impact on water quality would be reduced in the creek where excavation and capping are assumed to occur in a dry environment. The impact on water quality in the confluence area would be similar to the impact identified in alternative 3.

Short-Term Monitoring. Confirmation monitoring will be conducted while remedy implementation is in progress to ensure the selected implementation methods are meeting design specifications. Dredge confirmation monitoring typically includes the use of real-time kinematic DGPS linked to real-time monitoring software, which is integrated in the sediment removal equipment, to verify the area and depth of sediment removed in dredge areas. In the event that confirmation monitoring demonstrates the remedy was not implemented per remedy design specifications, the design will outline the decision criteria for determining what, if any, additional measures are warranted.

Operational monitoring will also be conducted during remedy implementation to ensure the water quality criteria outlined in the federal and state permits secured for the project are not exceeded. In the event these criteria are exceeded during remedy implementation, the remedial design will outline the decision criteria for determining whether remedy construction should be temporarily stopped or if alternative implementation methods should be employed.

5.3 Long-Term Effectiveness

Long-Term Effectiveness refers to the ability of a remedial option to sustain reliable protection of human health and the environment once remediation goals have been met. This criterion also addresses how residual risk will be mitigated and controlled over time.

Effectiveness is evaluated based on the ability of the technology or process option to meet the RAO, ensure long-term human health and environmental protection, protect against short-term human and environmental effects during construction, and proven reliability at sites with chemical constituents and conditions similar to those at Otter Creek and Confluence. Effectiveness also considers safety. Safety is evaluated based on the potential for implementation of a technology or process option to generate higher, different, or unanticipated adverse human health effects or ecological impacts.

Long-term effectiveness is a measurement of long-term risk reduction and remedy permanence, including physical stability of the sediment. This criterion determines the adequacy and reliability of sediment remedies and controls to manage human health and ecological risks associated with sediment contaminants (USEPA 2005). Long-term effectiveness is determined by assessing potential residual human health and ecological risks likely to be present after response actions have been employed, and by determining potential future surface sediment chemical concentrations. Remedy permanence is determined by evaluating the physical permanence of the remedy.

5.3.1 Remedy Alternative 1 – No Action

This response would not change baseline sediment conditions except for naturally occurring changes. As a result of the No Action alternative, chemical concentrations exceeding the remedial targets developed for the increased protection of ecological health would be left in place in both surface and subsurface sediments.

Remedy Alternative 1 provides some reduction in risk to humans or the environment via the current ongoing and natural processes in Otter Creek and Confluence, but chemical concentrations for sediments left in place will not be monitored.

Table 5-1 identifies the known mass of COCs present in Otter Creek and the Confluence. As part of Remedy Alternative 1 (No Action) these elevated chemical concentrations would be left in place without monitoring, meaning that potential reduction in surface sediment concentration resulting from ongoing processes could not be determined.

5.3.2 Remedy Alternative 2 – Monitored Natural Recovery

As discussed in Section 4.2, lower Otter Creek is a depositional environment, as indicated by significant sediment depth, prevalence of fine-grain sediment, and generally slow water flow. At every lower Otter Creek location where both a surface grab sample and a 0-24 inch sample were collected, PAH and DRO concentrations were lower in the surface grab sample, consistent with deposition of cleaner sediment over time and/or biodegradation of PAHs in surface sediment. The biological community has shown a trend of recovery over time, especially regarding fish community. However the benthic community quality in lower Otter Creek continues to be rated qualitatively as very poor (OEPA 2010). This may be due in part to the incremental progress of source control efforts. However the area is expected to continue to recover with time and continued source control efforts. Effectiveness of MNR is reinforced by long-term monitoring of sediment, chemical, geochemical, and biological conditions.

In areas where the site specific RGs are exceeded, the current ongoing and natural processes in the creek and confluence are expected to continue reductions in exposures and risk to humans and the environment over time. These processes include the deposition of suspended material, which provides a physical barrier of clean sediments and further isolates elevated chemical concentrations in the sediment, thus reducing the potential chemical exposures to humans and biota.

The MNR alternative would result in long-term risk reduction. Risk reduction will depend in part on natural sedimentation, which acts to cover existing sediment with sediment having lower constituent concentrations. Additionally, PAHs will biodegrade over time.

MNR differs from the No Action alternative by including long-term monitoring. Monitoring is used to confirm the continuation of ongoing natural processes that can result in reduced risk of exposure to human health and the environment. Remedy Alternative 2 may someday achieve the site specific criteria and therefore satisfy the RAO; however, based upon the information gathered to date and the slow recovery period over the last twenty years (as discussed in Section 4.2), this timeline may be too extended.

5.3.3 Remedy Alternative 3 – Sediment Removal and Cover

Sediment removal has been demonstrated at numerous sites. As a mass-removal or source-removal technology, excavation and dredging are effective. Sediment removal typically relies on natural recovery processes or placement of backfill or cap material to achieve long-term, site-specific RGs. Alternative 3 includes a one foot protective cover in the creek to expedite recovery and increase the effectiveness of the remedy in the long term.

Remedy Alternative 3 provides a long-term reduction in risk by targeting all known sediment with concentrations greater than RGs. However, excavating to a greater depth may also cause slope stability issues over the long term which could reduce the long term effectiveness of the remedy. Because alternative 3 removes four feet of sediment but only replaces one foot in the creek where side slopes can be very steep, the potential for additional erosion is higher in alternative 3 than it is in alternative 4. Slope stability would be assessed during the design phase.

Aquatic recovery following remedy implementation depends in part on a resource's ability to reseed impacted areas, as well as the effectiveness of any restoration measures. Through removal of COC containing sediment and placement of a clean sand cover, this alternative will reduce acute and chronic toxicity to aquatic communities. Thus, achieving alternative 3 will satisfy the RAO.

Remedy Alternative 3, which targets the removal of all sediments exceeding site specific criteria, would be a permanent remedy insofar as source controls continue to be addressed.

Long-term monitoring is not included in Alternative 3.

5.3.4 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Capping could be an effective alternative in the creek if all sources are adequately controlled. Alternative 4 includes the removal of one foot of contaminated sediment in the creek where contaminated sediment has been documented to up to four feet. Alternative 4 includes the placement of an organoclay mat prior to placement of the one foot sand cover to contain potentially mobile remaining COC concentrations in sediment above site specific RGs.

This thin-layer capping alternative could be effective in the relatively low-energy environment within Otter Creek. Shallow sediment removal and capping achieves equivalent risk reduction more efficiently than deeper sediment removal. However in the longer term, unless source controls are continually adequately addressed, the organoclay in the cap will eventually reach the end of its useful life and will no longer prove effective as a remedy. The effectiveness of the cap will be in direct proportion to the effectiveness of source control, the mass of COCs remaining under the cap, and potential upwelling of affected groundwater. For the purposes of this FFS, it has been assumed that there are no on-going sources.

Unlike Remedy Alternative 3, Remedy Alternative 4 does not include removal of all sediment which contains COCs above RGs and therefore relies upon cap integrity to provide effectiveness in the long term in the creek. The confluence sediment management would rely on natural deposition to provide long term effectiveness.

Ongoing natural processes, such as deposition of cleaner suspended sediments will continue to bury residual sediments and enhance the stability of the sediment bed surface while enhancing the cap. The deposition of suspended material provides a physical barrier of clean sediment which further isolates elevated chemical concentrations in the sediment, thus reducing the potential exposure of these chemicals to humans and biota.

Long term monitoring is included as part of Remedy Alternative 4. While a maintenance and monitoring plan would be developed as part of the design of the remedy, for the purposes of this FFS, it has been assumed that monitoring would be conducted in a tiered manner so that any issues could be detected and addressed quickly. It has also been assumed that long term monitoring will consist of bathymetric surveys. These surveys will evaluate surface elevation and cap thickness against the measurements collected directly after remedy implementation. The evaluated cap monitoring schedule includes bathymetric surveys once per year for 3 years, at year 5, and then every 5 years thereafter for a total duration of approximately 20 years.

5.4 Reduction of Toxicity, Mobility, or Volume

The criterion “reduction of toxicity, mobility, or volume” addresses the anticipated efficiency of the remediation alternatives at reducing risks associated with elevated sediment chemical concentrations. This criterion will be evaluated based on historical information regarding the performance of each remedial option via other case studies and scientific calculations.

This section focuses on the reduction of toxicity, mobility and volume of porewater PAHs, DRO, and Total PAHs, which were identified as the three indicator chemicals in Otter Creek and Confluence. By identifying areas of Otter Creek and Confluence where surface sediment chemical concentrations are above their respective RGs and comparing those areas with the limits of removal or cap placement, the extent to which each alternative achieves the RAO will be identified. The pre sediment management mass of Total PAHs and DRO in both the creek and confluence areas are summarized in Table 5-1. A total of approximately 1,697 pounds of PAHs and almost 877,000 pounds of DRO are present in the creek and confluence.

5.4.1 Remedy Alternative 1 – No Action

MNR (Remedy Alternative 2) relies on natural ongoing recovery processes to reduce chemical toxicity and mobility. The deposition of clean suspended material provides a physical barrier which further isolates elevated chemical concentrations in the sediment, thus reducing the potential exposure of these chemicals to humans and biota. Evidence that natural sedimentation leads to reduced chemical concentrations in surface sediments overtime in Otter Creek has been demonstrated (see Section 4.2). Thus, sedimentation, biological, and physical processes can lead to reductions in the toxicity, mobility, and volume of biologically available chemicals in surface sediment.

MNR differs from the No Action alternative by including long-term monitoring. Such monitoring is used to determine the continuation of natural processes that result in reduced toxicity, mobility, and volume of COCs as well as the absence of unacceptable risks to human health and the environment.

5.4.2 Remedy Alternative 3 – Sediment Removal and Cover

Remedy Alternative 3 targets the removal of the known volume of sediment with COC concentrations greater than site specific RGs in Otter Creek and Confluence. The resulting COC mass removal calculations are presented on Table 5-2. Approximately 89% of the total PAHs and 98% of the DRO known to be present in the creek and confluence would be removed if Remedy Alternative 3 were implemented. Thus, Remedy Alternative 3 reduces the volume and mobility associated with elevated concentrations of the indicator chemicals in sediments.

Approximately 50,300 CY of COC containing sediment would be removed from the AOC as part of Remedy Alternative 3, contributing to the reduced volume of contaminated sediment in the AOC.

Alternative 3 also includes the placement of a clean sand cover over the creek and a small portion of the confluence. This cover will also aid in reducing toxicity and mobility issues from any potential residuals. The volume of COC containing sediment in the creek which is available to the benthic community will also be reduced as natural sedimentation processes occur over time.

5.4.3 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Remedy Alternative 4 targets the removal of the top one foot of sediment in the creek and varying depths (1, 2, and 5.5 feet) in the confluence area as shown on Figure 4-4. This option reduces COC containing sediment volume with the intent of creating additional room for cap placement. The resulting COC mass removal calculations are presented on Table 5-3. Approximately 46% of the total PAHs and 31% of the DRO known to be present in the creek and confluence would be removed if Remedy Alternative 4 were implemented. Thus, Remedy Alternative 4 reduces the long-term toxicity and mobility associated with elevated concentrations of the indicator chemicals in sediment. However this reduction in volume is less than half of what would be removed under Remedy Alternative 3.

Over 25,200 CY of sediment would be removed from the AOC as part of Remedy Alternative 4, contributing to the reduced volume of contaminated sediment in the AOC. Remedy Alternative 3 will have a greater reduction in volume and associated mass removal than Remedy Alternative 4 as discussed above.

Alternative 4 also includes the placement an organoclay mat and clean sand cover (which comprise the cap) over the creek and a clean sand cover over a portion of the confluence. This cap and cover will aid in reducing toxicity and mobility issues from potential residuals. The natural sedimentation process will also assist in reducing the toxicity, mobility, and volume of sediment containing COCs from the benthic community over time.

Remedy Alternative 4 has less overall toxicity and mobility reduction than Remedy Alternative 3. While Remedy Alternative 4 uses a cap to reduce the toxicity and mobility of underlying sediment with concentrations greater than RGs, Alternative 3 removes the entire sediment column that exceeds these criteria. The potential for the organoclay mat portion of the cap to continue to remediate COCs as they move through the cap decreases with time.

5.5 Implementability

Implementability encompasses both the technical and administrative feasibility of implementing a technology or process option. It incorporates an evaluation of the technical difficulties associated with construction and operation of the remediation system, the reliability of the selected technologies, the ability to implement all facets of the remedial alternative, and challenges associated with process options that support each remedy, such as treatment, storage and disposal services, transportation, and equipment availability. The administrative feasibility of a remedy alternative or technology includes an assessment of the ability to obtain necessary permits and the impact of state and local regulations.

Examples of physical constraints that affect the remedial alternative implementability include:

- Accessibility
- Shoreline conditions and shoreline stability
- Cross-channel utilities and roadway or rail bridges
- River geometry and hydrodynamics
- Site topography and bathymetry
- Water depths and depths of sediment contamination
- Thickness and geotechnical properties of the sediment
- Types and quantity of submerged debris
- Available disposal options
- Available transportation and disposal routes
- Current and anticipated uses of the water body

5.5.1 Remedy Alternative 1 – No Action

There are no implementability constraints for the No Action alternative because no remedial action is taken. The No Action remedy is readily implementable.

5.5.2 Remedy Alternative 2 – Monitored Natural Recovery

MNR is readily implementable because it requires no action beyond detailed site characterization and monitoring.

There are no apparent implementability constraints for Remedy Alternative 2. MNR can be most effective in areas where physical constraints (e.g., accessibility, shoreline conditions, cross-channel utilities and bridges, shallow water depths) limit the implementability of other alternatives. A long-term monitoring plan would be developed with agency approval, to confirm recovery predictions. Monitoring contingency actions can be established to respond readily to changes in baseline conditions, particularly in the unlikely event that chemical concentrations increase; such actions should begin with increased monitoring to verify the change, data evaluation, and development of an appropriate response, as needed.

5.5.3 Remedy Alternative 3 – Sediment Removal and Cover

While sediment removal is implementable at Otter Creek and Confluence, a combination of sediment removal techniques will likely be required to meet the needs of the project. For the purposes of this FFS it has been assumed that the creek will be re-routed via pipeline prior to the start of work in the creek. This should allow for dry excavation from the creek bed, with the placement of a wooden access road through the creek or placement of swamp mats or similar devices. It has also been assumed that dredging will occur in the confluence, likely from a constructed pier or working platform due to shallow water depths.

The Toledo area has substantial experience with dredging and excavation processes and many different types are implementable, though different processes present unique challenges. Special consideration will be required for sloping requirements from the creek bed and existing jetty so as to not compromise structural integrity and to reduce the potential for erosional issues.

Remedy design would consider the presence of these issues, and appropriate slope factors in the creek and off-set distances from the jetty in the confluence would be established to allow continued stability in these areas. The presence of these issues limits the sediment removal implementability in these areas.

Dredging, excavation, and placement of the cover will require real time monitoring. This type of monitoring is frequently used and is readily implementable.

Utilities, wetlands, and other access issues are discussed in Section 2.6. Additional information will need to be gathered during the design stage to address these issues to maximize the implementability of Remedy Alternative 3. As discussed above, the impact of the removal action and associated cover placement may be minimized by using the dry creek bed as the main access point for creek activities. Haul roads will need to be carefully considered during the design phase to take into account the protection of existing utilities, wetland areas, and bridges. Access agreements and permits will also need to be addressed prior to the start of work.

Debris would likely be encountered during removal activities. Debris would need to be removed during sediment removal, either as removal is ongoing or as part of a separate debris removal operation. Alternatively, if debris is not actively removed before or concurrent with removal, debris will likely interfere with sediment removal activities by obstructing proper bucket closure, loosening and resuspending bedded sediment, dragging along the sediment, and releasing sediment through the water column during sediment collection.

Sediment would be transported to and placed in a local landfill. Dewatering of confluence sediment and creek sediment would be required. The design stage will address the potential moisture content of each sediment type and the degree of dewatering required for implementation. For the purposes of this FFS it has been assumed that dewatering will be completed with the application of an amendment such as a polyacrylamide. The local landfill is located approximately 2.5 miles from the confluence area, off of a main road. Transportation should not be an issue. Another alternative that should be evaluated in the design phase is the potential for sediment disposal at the local CDF.

5.5.4 Remedy Alternative 4 - Shallow Sediment Removal and Capping

While sediment removal is implementable at Otter Creek and Confluence, a combination of sediment removal techniques will likely be required to meet the needs of the project. For the purposes of this FFS it has been assumed that the creek will be re-routed via pipeline prior to the start of work in the creek. This should allow for dry excavation from the creek bed, with the placement of a wooden access road through the creek or placement of swamp mats or similar devices. It has also been assumed that (wet) dredging will occur in the confluence, likely from a constructed pier or working platform due to shallow water depths.

The Toledo area has substantial experience with sediment removal processes and many different types are implementable, though different processes present unique challenges. Special consideration will be required during the design phase for the existing jetty to maintain structural integrity.

Dredging, excavation, and placement of the cap will require real time monitoring. This type of monitoring is frequently used and is readily implementable.

Capping is also a readily implementable alternative and has been used at numerous locations. The organoclay mat and local sand resources are available to implement this portion of the remedy. During the design stage the hydrology and stresses associated with cap placement must be carefully considered to avoid failure. Additional hydraulic studies will likely be required in the design stage. It is also possible that additional sediment removal at select locations may be required for design purposes and to support the hydraulic regime. In addition, an evaluation would need to be conducted to ensure placement of fill does not increase the potential for flooding due to a reduction in the creek's flow conveyance capacity.

The placement of a thin layer cap in an environment where access is difficult will reduce implementability. The wetlands and railroad tracks which surround the work area will reduce the efficiency of cap placement due to limiting access. This could mean that additional man hours will be required to complete the placement of the cap and associated backfill placement.

Utilities, wetlands, and other access issues are discussed in Section 2.6. Additional information will need to be gathered during the design stage to address these issues so that they do not affect the implementability of Remedy Alternative 4. As discussed above, the impact of the removal action and associated cap placement may be minimized by using the dry creek bed as the main access point for creek activities. Haul roads will need to be carefully considered during the design phase to take into account the protection of existing utilities, wetland areas, and bridges. Access agreements and permits will also need to be addressed prior to the start of work.

Debris will likely be encountered during removal activities. Debris would need to be removed during sediment removal, either as removal is ongoing or as part of a separate debris removal operation. Alternatively, if debris is not actively removed before or concurrent with removal, debris will likely interfere with sediment removal activities by obstructing proper bucket closure, loosening and resuspending bedded sediment, dragging along the sediment, and releasing sediment through the water column during sediment collection.

Sediment would be transported to and placed in a local landfill. Dewatering of confluence sediment and possibly creek sediment would be required. The design stage will address the potential moisture content of each sediment type. For the purposes of this FFS it has been assumed that dewatering will be completed with the application of an amendment such as a polyacrylamide. The local landfill is located approximately 2.5 miles from the confluence area, off of a main road. Transportation should not be an issue. Another alternative that should be evaluated in the design phase is the potential for sediment disposal at the local CDF.

5.6 Cost

Costs are based on engineering judgment, discussions with vendors, and other available information associated with each option. Cost should not be viewed as a proxy for effectiveness. In many cases, more efficient and cost-effective remedies can accomplish the same result or can outperform less efficient, more costly remedies.

The costs of each alternative are estimated with as much accuracy as possible for capital and Operation and Maintenance (O&M). Long term monitoring costs for MNR were estimated for a 30-year period, discounted to a net present value (NPV) in 2013 dollars. The overall cost for each alternative is the sum of the capital and discounted annual costs. The discounted costs were calculated based on the NPV methods described in the USEPA guidance document, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA 2000b). The discount rate selected for the net present worth calculations is 6%. The cost estimates provided have an accuracy of +50 % to –30 %, in compliance with USEPA guidance (USEPA 1988).

Although considered reasonable to provide sufficient detail to compare technology costs, monitoring assumptions (e.g., quantities, frequencies, and durations) are not intended to be prescriptive for the various remedies.

Remedy costs are summarized in Table 5-4 and additional detail can be found on Tables 5-5 through 5-7. Besides the No Action alternative, Remedy Alternative 2 has the lowest present worth cost of approximately $203,000. Remedy Alternative 3 has the highest cost of $14.3 million and the cost of Remedy Alternative 4 is $11.6 million. Restoration costs included in Tables 5-6 and 5-7 include primarily structural restoration including the cost for grading and reseeding work areas and restoring staging areas in a manner similar to pre-work conditions.

5.6.1 Remedy Alternative 1 – No Action

Because no action is taken, no costs apply to this option.

5.6.2 Remedy Alternative 2 – Monitored Natural Recovery

MNR has a low cost compared to other, more active remedial technologies (Tables 5-4 and 5-5). However, monitoring costs associated with MNR can be significant, particularly if monitoring is required over a large area and long duration. Still, costs for MNR are generally low compared to other sediment remedies.

5.6.3 Remedy Alternative 3 – Sediment Removal and Cover

Sediment removal is generally more costly than MNR and capping. The volume of sediment removed via dredging and/or excavation in Alternative 3 is greater than the volume removed in Alternative 4, so the sediment removal portion of Alternative 3 will be a higher cost than Alternative 4. Table 5-6 shows the breakdown of costs for this alternative.

Choosing a type of dredging or excavation that limits the amount of water to be removed from the sediment (dewatering) and the amount of water to be treated can impact the remedy cost by substantially lowering it. For example, excavating in a dry creek bed should result in less dewatering and the treatment of less water than working within a wet excavation. Also, mechanical dredging should result in less sediment dewatering and overall water treatment than hydraulic dredging.

5.6.4 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Capping costs are generally moderate. Capping usually has a lower cost than sediment removal and is more expensive than No Action and MNR. Monitoring costs associated with capping can be appreciable, particularly if monitoring is required over a large area and a long duration, and if extensive chemical and biological monitoring are required. Initial monitoring determines whether cap installation meets design specifications. Long-term monitoring assesses long-term remedy integrity and for the purposes of this FFS assumes bathymetric surveys would be used to assess the integrity of the cap over a span of 20 years. Table 5-7 includes additional detail on the cost estimate for this alternative.

Choosing a type of sediment removal that limits the amount of water to be removed from the sediment (dewatering) and the amount of water to be treated can impact the remedy cost by substantially lowering it. For example, excavating in a dry creek bed should result in less dewatering and the treatment of less water than working within a wet excavation. Also, mechanical dredging should result in less sediment dewatering and overall water treatment than hydraulic dredging.

Sediment removal costs also are reduced by focusing sediment removal to remove contaminants from target surface areas, while relying on capping and MNR to achieve overall risk reduction. Such an approach greatly reduces the volume of material that requires sediment management and off-site disposal, and reduces some of the negative environmental impacts associated with larger scale dredging.

5.7 State and Community Acceptance

This criterion evaluates the issues and concerns that state agencies may have regarding each sediment remedy alternative. GLNPO, OEPA, and USEPA have been involved in historical work that has led to the chosen Remedy Alternatives outlined in this FFS. Community stakeholders include the Duck and Otter Creek Partnership and Partners for Clean Streams. The Duck and Otter Creek Partnership serves as a representative of local community interests and concerns with regard to the selection of a sediment remedy. Partners for Clean Streams is a non-profit organization tasked with coordination of the Maumee AOC Remedial Action Plan.

Effects of Remedy implementation on the community include safety issues associated with implementation, which could restrict use of areas in the vicinity of the remediation, and the generation of odors, construction noise, and diesel emissions during remedy implementation.

5.7.1 Remedy Alternative 1 – No Action

This alternative would have no short-term community impacts or increased risks to the community due to onsite construction and remediation operations, accidents or spills of site-related materials, or transportation. Chemical concentrations for sediments left in place will not be monitored, thus providing no assurance that risks to human health and the environment are reduced over time.

5.7.2 Remedy Alternative 2 –Monitored Natural Recovery

This alternative would have no short-term community impacts or increased risks to the community due to onsite construction and remediation operations, accidents or spills of site-related materials, or transportation. No community short-term impacts such as noise or odors are anticipated. Routine monitoring and sampling would be required as part of Remedy Alternative 2, but monitoring is not expected to negatively impact the community.

Community education programs can lead to increased understanding and acceptance of MNR as an in situ remedy and the ongoing natural processes that will continue to reduce risk. However the level of COCs left in place will reduce acceptance of this Remedy Alternative by both the State and the Community.

5.7.3 Remedy Alternative 3 – Sediment Removal and Cover

Sediment removal and cap placement related activities in Remedy Alternative 3 such as sediment excavation/dredging, handling, offsite transportation, disposal, and cap placement may increase short-term impacts to the community through construction noise, odors, and diesel emissions. Since the property surrounding the sediment management areas is predominantly industrial, this option would likely be accepted by the community. However, this alternative would impact a larger portion of designated wetlands than Remedy Alternative 4 which could reduce the potential for agency acceptance.

5.7.4 Remedy Alternative 4 – Shallow Sediment Removal and Capping

Sediment removal and cap placement related activities in Remedy Alternative 4 such as sediment excavation/dredging, handling, offsite transportation, disposal, and cap placement may increase short-term impacts to the community through construction noise, odors, and diesel emissions. Since the property surrounding the sediment management areas is predominantly industrial, this option would likely be accepted by the community. However leaving COC containing sediments in place, even with cap placement, could reduce the potential for community acceptance.

This Remedy Alternative does not remove all known COC containing sediment that is above site specific criteria in the creek but relies upon the cap to reach the RAO. In the confluence area, natural deposition is relied upon to reach the RAO. Since this cap is covering sediment containing COC concentrations above site specific criteria in the creek, Alternative 4 is less likely to be accepted by State and other regulatory agencies then Alternative 3.

6 Preferred Sediment Remedy Alternative

Remedy Alternative 3, Sediment Removal and Cover, is the remedy that most efficiently and effectively achieves the sediment-related ecological RAO and RGs of Otter Creek and Confluence.

6.1 Rationale

Remedy Alternative 1 (No Action) and Alternative 2 (Monitored Natural Recovery) are implementable, low cost alternatives. However, neither of these alternatives satisfies the RAO or RGs in a reasonable (5 to 10 year) timeframe. Additionally, neither of these alternatives provides any additional short- or long-term reduction in risk to humans or the environment beyond the current ongoing and natural processes, such as sediment deposition and biodegradation.

Remedy Alternative 3 (50,300 CY of removal) and Remedy Alternative 4 (25,200 CY of removal) both contribute to the RAO goal by improving long-term surface sediment concentrations which in turn will reduce risk to the benthic community. Both sediment removal and capping options are proven technologies and can be implemented in Otter Creek and the confluence area. Both options provide overall protection of human health and the environment. However, short term effectiveness for sediment removal includes a potential for sediment suspension and sediment removal residuals which can cause short term increases of contaminant concentrations in the water column and benthic environment. Remedy Alternative 3 addresses the risk from potential residuals in the creek by placement of a clean cover and in the confluence by natural sedimentation processes. Remedy Alternative 4 addresses COCs in the creek with cap placement and potential residual management in the confluence is addressed by natural sedimentation processes.

Remedy Alternative 3 removes almost twice the COC mass concentrations for Total PAHs and DRO than Remedy Alternative 4 does; in fact, Remedy Alternative 3 removes almost the total amount of COC mass identified in the creek and confluence areas. Remedy Alternative 4 entails greater uncertainty with regard to permanence, due to the potential for exhausting the adsorption capacity of the organoclay, especially in the event of any future COC loading.

Remedy Alternative 3 poses potential design issues for erosion and sediment stability because it increases the depth of creek bed by an additional three feet. While both alternatives 3 and 4 are implementable, alternative 4 may be more difficult to implement due to access issues associated with the placement of the cap. Alternative 4 will require less mechanical activity and greater man hours.

Remedy Alternative 3 is recommended for design and implementation because this alternative most effectively achieves the RAO and associated RGs. Remedy Alternative 3 targets the removal of areas that exceed the site-specific sediment chemistry guidelines, including elevated chemical concentrations at depths of 0-4 ft in the creek and up to 5.5 ft in the confluence. Remedy Alternative 3 also can be completed within a reasonable timeframe and at a reasonable cost.

6.2 Description of Proposed Remedy

Remedy Alternative 3 proposes a combined remedy that includes sediment removal and cover (see Figures 4-1 and 4-2) at an estimated cost of approximately $14.3 million. A description of Remedy Alternative 3 can be found in Section 4. The accuracy of the cost estimate is within the range of -30 percent to +50 percent, consistent with USEPA Guidance on Feasibility Study development (USEPA 1988). Further breakdown of the cost estimate is included as Table 5-6. The main components of Remedy Alternative 3 include:

Sediment Removal and Disposal

- Sediment areas and depths targeted for removal are defined by the RGs discussed in Section 3.1.2 above.

- The estimated in-place sediment volumes targeted for removal include 39,000 CY from Otter Creek and 11,300 CY from the confluence area.
- While it has been assumed that dry excavation in the creek and mechanical dredging in the confluence would be used for the purposes of this FFS, the most appropriate sediment removal methods will be evaluated during remedy design and by the construction contractor during construction bidding and implementation.

- Best management practices, such as operational controls and specialty equipment, will be used during sediment removal operations to reduce potential contaminant release.

- A CDF designed specifically for the management and disposal of sediment from the Maumee River area is located close to the proposed sediment management areas for Otter Creek and Confluence. While the use of the local landfill, located approximately 2.5 miles from the confluence area, has been included in this FFS for purposes of cost estimation, the potential use of this CDF should be evaluated during the design phase. Additional disposal locations may also be evaluated.

Cover

- A one foot sand cover would be placed along approximately one and a half miles of Otter Creek during implementation of this remedy. This cover would be placed to provide a clean sediment surface and appropriate substrate for habitat restoration.

- The area requiring sediment removal in the confluence area to a depth of 5.5 feet is targeted for backfill placement to assist with stability of the adjacent structure.

Long-Term Monitoring

- Remedy Alternative 3 does not rely on natural attenuation and sedimentation to meet long-term goals, although natural sedimentation will assist in maintaining the cover and or increasing the cover depth. The placement of the cover in the creek will meet the RAO. Therefore, long term monitoring is not required under this alternative.

6.3 Next Steps

If USEPA and the Industrial Partners continue remediation planning to the design stage, various activities should be completed to address project unknowns while working to increase the efficiency, effectiveness, and implementability of the remedy:

- Access issues such as working in wetlands, property ownership of adjacent properties, and the location of railroad tracks should be addressed.
- A plan should be created to minimize the impact on wetland areas including minimizing tree and fauna removal.
- Potential permits required due to working in wetland areas should be further investigated as allowed by the stage of the design effort.
- A utility survey of the sediment management areas should be completed and utility information should be field verified.
- Hydrological study(s) should be completed to verify cover placement will resist scour, ice issues, peak flows, etc.
- Stability study(s) should be completed to address how to appropriately remove sediment in the creek due to steep side slopes and how to appropriately remove sediment near the jetty in the confluence area.
- Further evaluation of potential alternatives for diverting water around the proposed dredge area of Otter Creek should be completed.
- Further review of the potential disposal, dewatering, and treatment options for dredged sediment and water (generated as a result of the dredging activities) should be completed.
- Remedy Alternatives 3 and 4 describe sediment remedies which require State and Federal permits. It is possible that State and/or Federal permitting requirements could alter the engineering specifics for these remedies. The nature of changes cannot be ascertained until the permitting process has been completed and regulatory requirements are known. However, at this time, it is not anticipated that permitting requirements would fundamentally alter the overall conclusions and recommendations presented in this FFS.
- Additionally, habitat restoration elements should be evaluated for potential project inclusion.

The estimated costs presented in this FFS may be outside of the ranges noted on Table 5-4, depending upon the outcome of the aforementioned items.

7 References

Atlas RM. 1981. Microbial degradation of petroleum hydrocarbons: An environmental perspective. Microbiol Rev 45:180-209.

Cardno Entrix. 2012. Duck and Otter Creeks Great Lakes Legacy Act Data Gap Investigation Report. Prepared For: Duck and Otter Creek Industrial Partners. April 25, 2012. Project No. 72606001

Gustavson, MA Mills. 2009. Technical Guide: Monitored Natural Recovery at Contaminated Sediment Sites. Published by the Environmental Security Testing and Certification Program (ESTCP). ESTCP-ER-0622. Virginia. Available at http://www.epa.gov/superfund/health/conmedia/sediment/documents.htm.

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

Magar, VS, DB Chadwick, TS Bridges, PC Fuchsman, JM Conder, TJ Dekker, JA Steevens, KE Gustavson, MA Mills. 2009. Technical Guide: Monitored Natural Recovery at Contaminated Sediment Sites. Published by Environmental Security Testing and Certification Program. ER-0622. http://www.epa.gov/superfund/health/conmedia/sediment/documents.htm.

National Research Council (NRC). 1997. Contaminated Sediments in Ports and Waterways – Cleanup Strategies and Technologies. National Academy Press, Washington, DC.

OEPA. 2010. Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006 – 2008. OHIO EPA Technical Report EAS/2010-4-4. March 2010.

OEPA. 2012. Total Maximum Daily Loads for the Maumee River (lower) Tributaries and Lake Erie Tributaries Watershed. Final Report. July 2012.

SulTRAC. 2007. Sediment Sampling Report for Duck and Otter Creeks. Toledo and Oregon, Ohio. Prepared for U.S. Environmental Protection Agency Great Lakes National Program Office. December 21, 2007.

Weston. 2009. Site Assessment Letter Report, Westover Landfill Site, Oregon, Lucas County, Ohio. To: Jon Gulch, United States Environmental Protection Agency. September 25, 2009. Technical Direction Document No.: S05-001-0906-025.

Weston Solutions. 2010a. Quality Assurance Project Plan Duck & Otter Creeks 2010 Data Gaps Investigation Wood and Lucas Counties, Ohio Revision 1. Prepared for U.S. Environmental Protection Agency, Great Lakes National Program Office.

Weston Solutions. 2010b. Field Sampling Plan Duck & Otter Creeks. 2010. Data Gaps Investigation Wood and Lucas Counties, Ohio Revision 1. Prepared for U.S. Environmental Protection Agency, Great Lakes National Program Office.

Weston. 2012. Data Evaluation Report for Duck and Otter Creeks Confluence Sediment Investigation, Toledo, Lucas County, Ohio. Revision 1. Prepared For: United States Environmental Protection Agency Great Lakes National Program Office. February 10, 2012.

USACE. 2008a. Technical Guidelines for Environmental Dredging of Contaminated Sediments. ERDC/EL TR-08-29. By M.R. Palermo, P.R. Schroeder, T.J. Estes, and N.R. Francingues.

USACE. 2008b. The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk. ERDC\E TR-08-4. February.

U.S. Department of Energy. 1997. Uncertainty Management: Expediting Cleanup Through Contingency Planning. DOE/EH/(CERCLA)-002. February.

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

USFWS. 2011. Unpublished fish tissue analytical data provided by U.S. Fish and Wildlife Service.

U.S. Navy. 2003. Implementation Guide For Assessing And Managing Contaminated Sediment At Navy Facilities. http://enviro.nfesc.navy.mil/erb/erb_a/restoration/fcs_area/con_sed/ug-2053/ug-2053- sed.pdf

Washington Department of Ecology (WDE). 2005. An Overview of the Contaminated Sediment Listing Process.
http://www.ecy.wa.gov/programs/wq/303d/2002/2004_documents/sed_9804- compare.pdf
Washington State Department of Ecology. 1991. Sediment Management Standards: Chapter 173-204 WAC.

Tables

Table 5-1
Known COC Mass Pre Sediment Management

Otter Creek	PAH-16 (lbs)	DRO (lbs)
OC-44	399	133,875
OC-45	109	36,806
OC-1A	80	29,067
OC-2	134	73,162
OC-2A	69	42,300
OC-3	53	23,014
OC-3A	38	105,250
OC-4	14	43,956
OC-4A	19	29,855
OC-5	35	137,116
OC-5A	31	60,830
OC-6	25	59,689
OC-6/7(1)	2	151
Creek Total	**1,011**	**775,072**

Otter Creek Confluence	PAH-16 (lbs)	DRO (lbs)
OC-42	45	15,270
OC-26	67	13,209
OC-28	84	31,346
OC-54	135	-----
OC-52	19	-----
OC-32	109	3,371
OC-51	8	-----
OC-30	68	8,791
OC-50	1	-----
OC-49	25	-----
OC-29	101	15,326
OC-27	24	14,411
Confluence Total	**686**	**101,724**
Creek and Confluence Total	**1,697**	**876,796**

Table 5-2
Alternative 3 Mass Removal

Otter Creek	PAH-16 (lbs)	DRO (lbs)
OC-44	399	133,875
OC-45	109	36,806
OC-1A	80	29,067
OC-2	134	73,162
OC-2A	51	32,700
OC-3	53	23,014
OC-3A	38	105,250
OC-4	14	43,956
OC-4A	19	29,855
OC-5	35	137,116
OC-5A	31	60,830
OC-6	25	59,689
OC-6/7(1)	2	151
Creek Total	**993**	**765,472**

Otter Creek Confluence	PAH-16 (lbs)	DRO (lbs)
OC-42	40	14,460
OC-26	50	6,685
OC-28	74	28,035
OC-54	135	-----
OC-52	3	-----
OC-32	83	3,073
OC-51	1	-----
OC-30	34	6,696
OC-50	1	-----
OC-49	9	-----
OC-29	52	9,381
OC-27	13	12,616
Confluence Total	**496**	**80,947**
Creek and Confluence Total	**1,488**	**846,419**
Percent Removal of Total Known Mass	***89.34***	***98.44***

Table 5-3
Alternative 4 Mass Removal

Otter Creek	**PAH-16 (lbs)**	**DRO (lbs)**
Otter Creek		
OC-44	139	40,125
OC-45	36	14,236
OC-1A	22	5,956
OC-2	11	16,537
OC-2A	6	12,900
OC-3	21	10,908
OC-3A	6	22,750
OC-4	3	11,756
OC-4A	4	6,242
OC-5	8	16,268
OC-5A	5	10,523
OC-6	7	18,889
OC-6/7(1)	2	151
Creek Total	**270**	**187,241**

Otter Creek Confluence	**PAH-16 (lbs)**	**DRO (lbs)**
OC-42	40	14,460
OC-26	50	6,685
OC-28	74	28,035
OC-54	135	-----
OC-52	3	-----
OC-32	83	3,073
OC-51	1	-----
OC-30	34	6,696
OC-50	1	-----
OC-49	9	-----
OC-29	52	9,381
OC-27	13	12,616
Confluence Total	**496**	**80,947**
Creek and Confluence Total	**765**	**268,187**
Percent Removal of Total Known Mass	***45.92***	***31.19***

Table 5-4
Summary of Cost Estimates

Alternative	Description	Sediment Removal Volume (CY)	Backfill/Cover/Cap Placement Volume (CY)	Monitoring Period (Years)	Cost (-30%)	Cost ($)	Cost (+50%)
1	No Action	-----	-----	-----	-----	-----	-----
2	Monitored Natural Recovery	-----	-----	30 (Events every 5 Years)	142,100	203,000	304,500
3	Sediment Removal and Cover	46,300	12,600	-----	10,010,000	14,300,000	21,450,000
4	Shallow Sediment Removal and Capping	24,420	12,600	20 (Events at years 1,2,3,5,10,15, and 20)	8,120,000	11,600,000	17,400,000

Notes/Assumptions

1. All costs should be considered preliminary and subject to revision in the future.
2. This cost estimate has been developed based upon a conceptual level design at an accuracy of -30% to +50%, in accordance with USEPA guidance.
3. Costs and volumes are rounded as appropriate.

Table 5-5
Monitored Natural Recovery (Alternative 2) Cost Estimate

Item	Description	Unit	No. of Units	Unit Cost	Estimated Cost ($)
MNR Per Event (Assumes a monitoring period of 30 years with events occuring every 5 years)					
1	Bathymetric survey to monitor sediment stability	EA	1	$20,000	$20,000
2	Porewater PAH analysis	EA	24	$225	$5,400
3	DRO analysis	EA	24	$70	$1,680
4	Total PAH analysis	EA	24	$100	$2,400
5	Sample Collection	Per Sample	24	$600	$14,400
6	MNR Report	EA	1	$20,000	$20,000
				Per Event Itemized Subtotal:	$63,880
				Engineering & Admin (10%) + Contingency (20%):	$19,164
				Net Present Value of 30 years of MNR w/Events every 5 years:	$202,779

Notes/Assumptions

- Assumes the entire creek sediment management area and confluence sediment management area will be monitored.
- Assumes 12 samples in the creek and 12 samples in the confluence per monitoring event
- 6% was used for NPV Calculation

Table 5-6

Sediment Removal and Cover (Alternative 3) Cost Estimate

Item	Description	Unit	No. of Units	Unit Cost	Estimated Cost ($)
Mobilization/Demobilization					
1	Mobilization/Demobilization	LS	1	$445,000	$445,000
Site Preparation					
2	Construction of Access/Staging/Laydown Areas	LS	1	$350,000	$350,000
3	Construction & Removal (at end of project) of Confluence Working Platform	LS	1	$300,000	$300,000
4	Turbidity Curtain (potential NAPL areas)	LF	1,300	$45	$58,500
5	Re-route creek flow & install dam at confluence	LS	1	$500,000	$500,000
Dredging/Excavation/Material Handling/Transportation and Disposal					
6	Dredge/Excavation	CY	50,300	$23	$1,156,900
7	Gravity Dewatering/Staging	CY	50,300	$7	$352,100
8	Free Water Treatment and/or Disposal	LS	1	$200,000	$200,000
9	Dewatering Amendment Purchase	LB	150,900	$2	$301,800
10	Amend (Dry) Sediment for Loading/Travel	CY	55,330	$20	$1,106,600
11	Transport to Landfill	Ton	82,995	$21	$1,742,895
12	Disposal	Ton	82,995	$48	$3,983,760
Backfill/Cover					
13	Cover material purchase/transport	Ton	18,900	$10	$189,000
14	Cover placement	CY	12,600	$12	$151,200
Post-Removal					
15	Restoration	Mile	2.0	$90,000	$180,000
				Construction Total:	$11,017,755
				Engineering Design & Admin (10%):	$1,101,776
				Construction Contingency (20%):	$2,203,551
				Grand Total:	**$14,323,082**

Notes/Assumptions

- A 10% bulking factor has been assumed for dewatering amendment added to excavated/dredged sediment.
- Assumes 1.5 tons/CY for conversion of backfill/cover and disposal estimate.
- Waste is assumed to be nonhazardous and pricing is based upon disposal at Envirosafe in Oregon, OH.
- Waste disposal does not include treatment for stability purposes, etc.

Table 5-7

Shallow Removal and Cap (Alternative 4) Cost Estimate

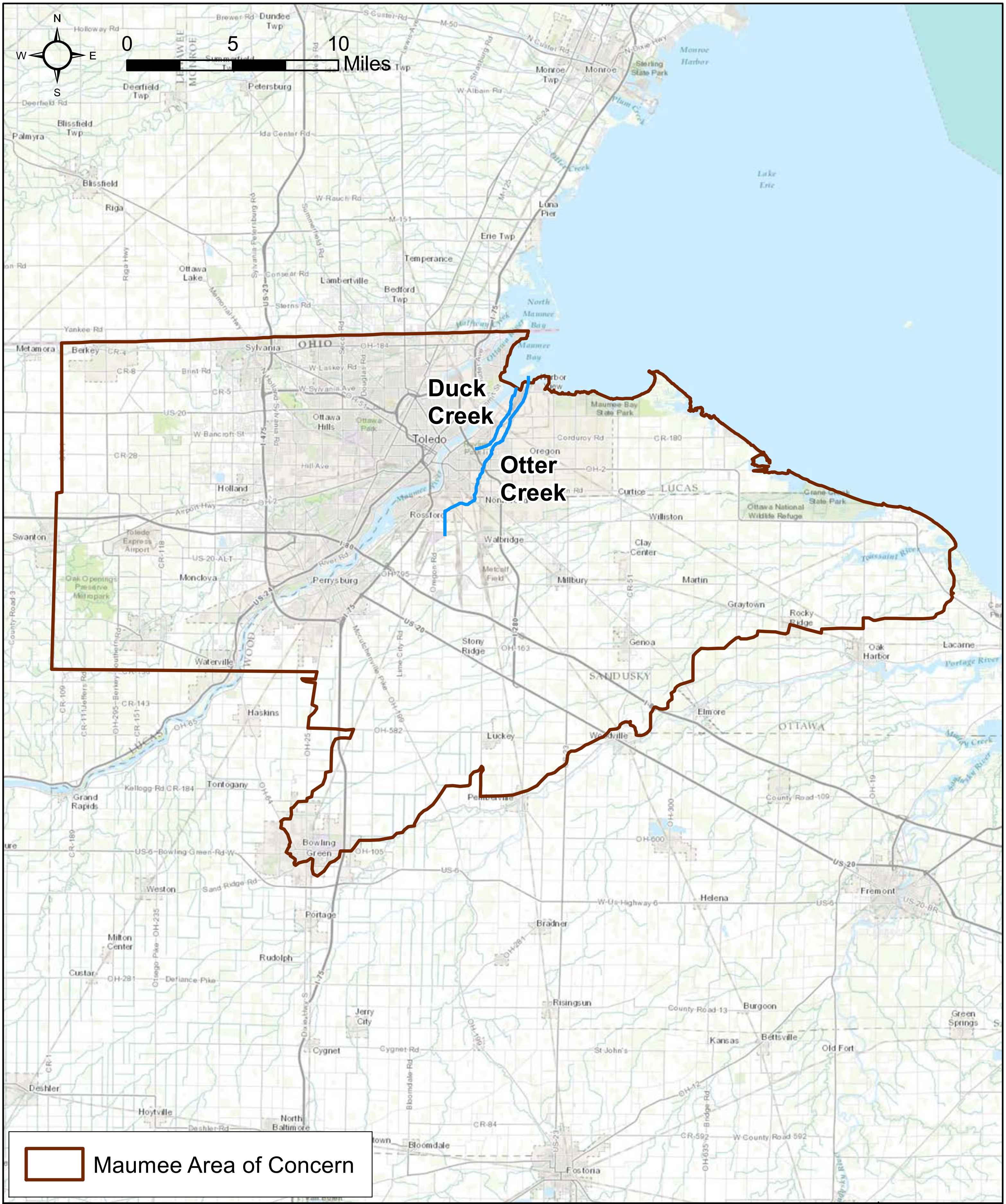
Item	Description	Unit	No. of Units	Unit Cost	Estimated Cost ($)
Mobilization/Demobilization					
1	Mobilization/Demobilization	LS	1	$445,000	$445,000
Site Preparation					
2	Construction of Access/Staging/Laydown Areas	LS	1	$350,000	$350,000
3	Construction & Removal (at end of project) of Confluence Working Platform	LS	1	$300,000	$300,000
4	Turbidity Curtain (potential NAPL areas)	LF	1,300	$45	$58,500
5	Re-route creek flow & install dam at confluence	LS	1	$375,000	$375,000
Dredging/Excavation/Material Handling/Transportation and Disposal					
6	Dredge/Excavation	CY	25,200	$23	$579,600
7	Gravity Dewatering/Staging	CY	25,200	$7	$176,400
8	Free Water Treatment/Disposal	LS	1	$75,000	$75,000
9	Dewatering Amendment Purchase	LB	75,600	$2	$151,200
10	Amend (Dry) Sediment for Loading/Travel	CY	27,720	$20	$554,400
11	Transport to Landfill	Ton	41,580	$21	$873,180
12	Disposal	Ton	41,580	$48	$1,995,840
Backfill/Cover					
13	Cover material purchase/transport	Ton	18,900	$10	$189,000
14	Cap Sand layer placement	CY	12,600	$12	$151,200
15	Organo-clay Mat Purchase	SF	260,000	$2	$520,000
16	Organo-clay Mat Placement	SF	260,000	$7	$1,820,000
Post-Removal					
17	Restoration	Mile	2.0	$70,000	$140,000
18**	Net Present Value of 20 Yrs of Cap Monitoring	LS	1.0	$135,129	$135,129
				Construction Total:	$8,889,449
				Engineering Design & Admin (10%):	$888,945
				Construction Contingency (20%):	$1,777,890
				Grand Total:	**$11,556,283**

Notes/Assumptions

- Assumes post-remedy monitoring of the creek and confluence areas.
- Assumes 12 samples in the creek and 12 samples in the confluence will be monitored per event.
- A 10% bulking factor has been assumed for dewatering amendment added to excavated/dredged sediment.
- Assumes 1.5 tons/CY for conversion of backfill/cap and disposal estimate.
- Waste is assumed to be nonhazardous and pricing is based upon disposal at Envirosafe in Oregon, OH.
- Waste disposal does not include treatment for stability purposes, etc.

** Cost Would Not Be Applicable For GLLA Project Funding

Figures



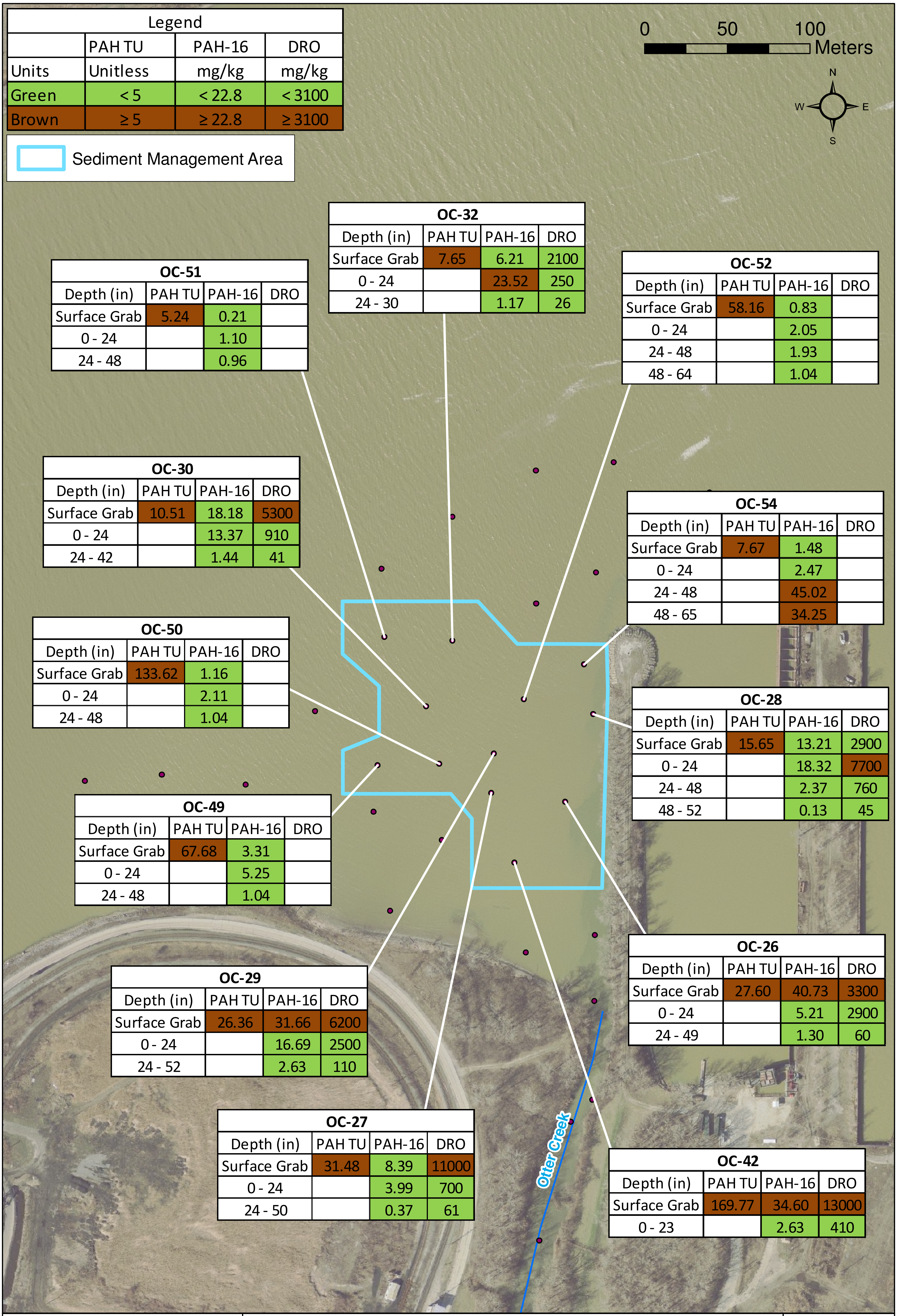
ENVIRON

Site Location
Maumee Area of Concern

Figure
2-1

Date: 1/9/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\Figure 2-1.mxd



Legend			
	PAH TU	PAH-16	DRO
Units	Unitless	mg/kg	mg/kg
Green	< 5	< 22.8	< 3100
Brown	≥ 5	≥ 22.8	≥ 3100

▭ Sediment Management Area

OC-32

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	7.65	6.21	2100
0 - 24		23.52	250
24 - 30		1.17	26

OC-51

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	5.24	0.21	
0 - 24		1.10	
24 - 48		0.96	

OC-52

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	58.16	0.83	
0 - 24		2.05	
24 - 48		1.93	
48 - 64		1.04	

OC-30

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	10.51	18.18	5300
0 - 24		13.37	910
24 - 42		1.44	41

OC-54

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	7.67	1.48	
0 - 24		2.47	
24 - 48		45.02	
48 - 65		34.25	

OC-50

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	133.62	1.16	
0 - 24		2.11	
24 - 48		1.04	

OC-28

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	15.65	13.21	2900
0 - 24		18.32	7700
24 - 48		2.37	760
48 - 52		0.13	45

OC-49

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	67.68	3.31	
0 - 24		5.25	
24 - 48		1.04	

OC-26

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	27.60	40.73	3300
0 - 24		5.21	2900
24 - 49		1.30	60

OC-29

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	26.36	31.66	6200
0 - 24		16.69	2500
24 - 52		2.63	110

OC-27

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	31.48	8.39	11000
0 - 24		3.99	700
24 - 50		0.37	61

OC-42

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	169.77	34.60	13000
0 - 23		2.63	410

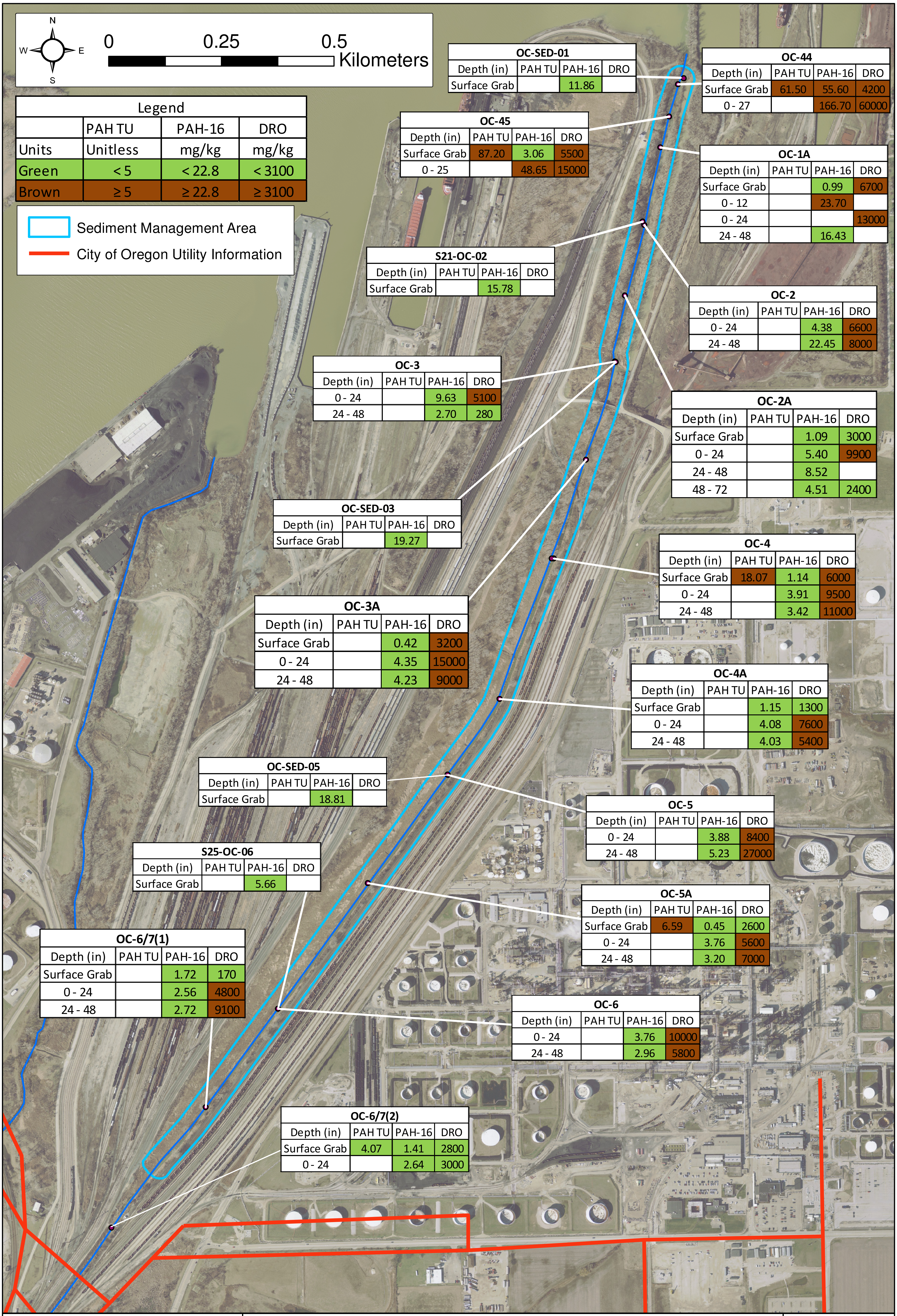
ENVIRON

Porewater PAH, Sediment PAH-16,
and DRO Concentrations:
Otter Creek Confluence Sediment Management Area

Figure
2-2

Date: 2/20/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\ConfTagMap_revised.mxd



Legend			
	PAH TU	PAH-16	DRO
Units	Unitless	mg/kg	mg/kg
Green	< 5	< 22.8	< 3100
Brown	≥ 5	≥ 22.8	≥ 3100

Sediment Management Area

City of Oregon Utility Information

OC-SED-01

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		11.86	

OC-44

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	61.50	55.60	4200
0 - 27		166.70	60000

OC-45

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	87.20	3.06	5500
0 - 25		48.65	15000

OC-1A

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		0.99	6700
0 - 12		23.70	
0 - 24			13000
24 - 48		16.43	

S21-OC-02

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		15.78	

OC-2

Depth (in)	PAH TU	PAH-16	DRO
0 - 24		4.38	6600
24 - 48		22.45	8000

OC-3

Depth (in)	PAH TU	PAH-16	DRO
0 - 24		9.63	5100
24 - 48		2.70	280

OC-2A

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		1.09	3000
0 - 24		5.40	9900
24 - 48		8.52	
48 - 72		4.51	2400

OC-SED-03

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		19.27	

OC-4

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	18.07	1.14	6000
0 - 24		3.91	9500
24 - 48		3.42	11000

OC-3A

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		0.42	3200
0 - 24		4.35	15000
24 - 48		4.23	9000

OC-4A

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		1.15	1300
0 - 24		4.08	7600
24 - 48		4.03	5400

OC-SED-05

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		18.81	

OC-5

Depth (in)	PAH TU	PAH-16	DRO
0 - 24		3.88	8400
24 - 48		5.23	27000

S25-OC-06

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		5.66	

OC-5A

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	6.59	0.45	2600
0 - 24		3.76	5600
24 - 48		3.20	7000

OC-6/7(1)

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab		1.72	170
0 - 24		2.56	4800
24 - 48		2.72	9100

OC-6

Depth (in)	PAH TU	PAH-16	DRO
0 - 24		3.76	10000
24 - 48		2.96	5800

OC-6/7(2)

Depth (in)	PAH TU	PAH-16	DRO
Surface Grab	4.07	1.41	2800
0 - 24		2.64	3000

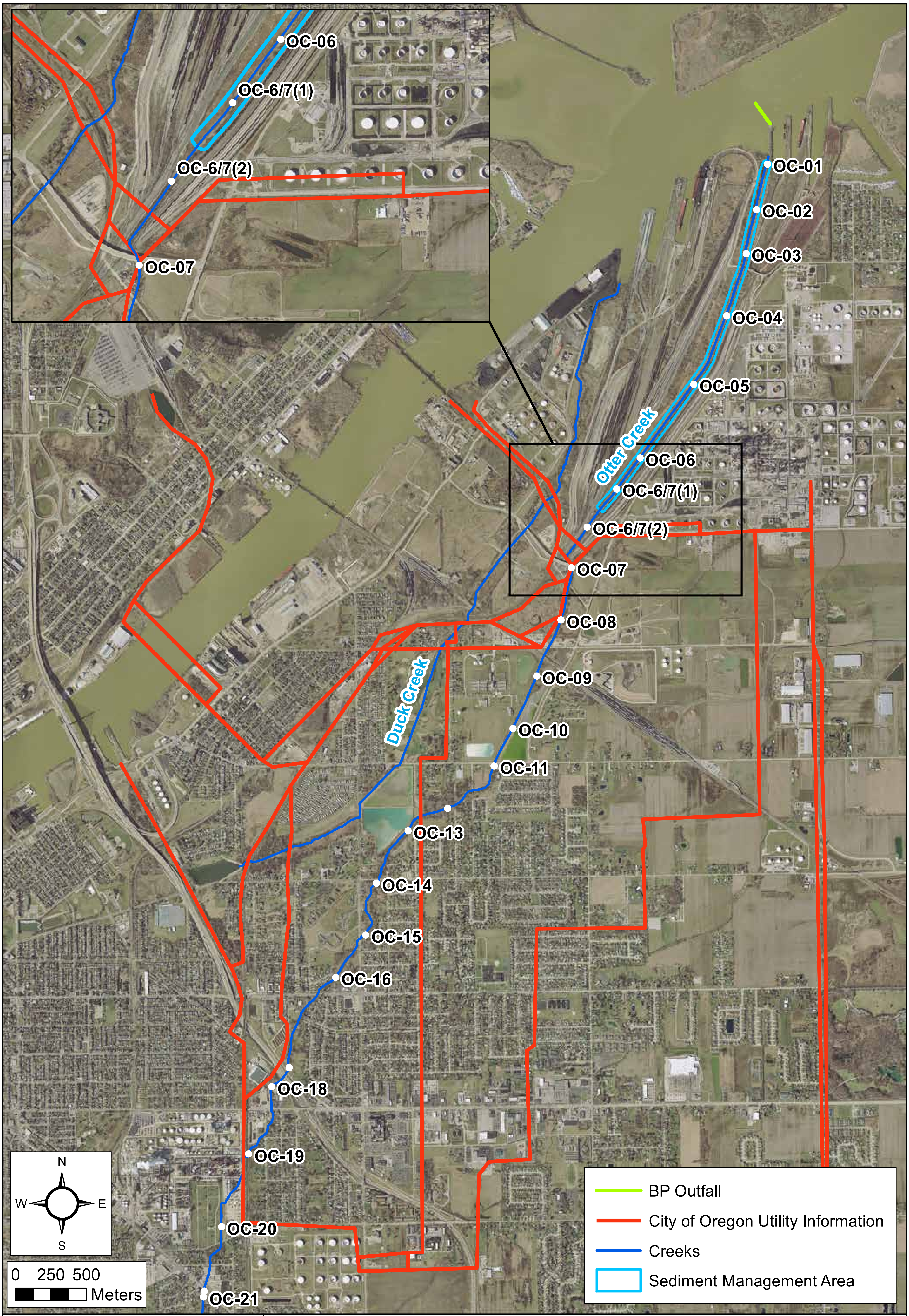
ENVIRON

Porewater PAH, Sediment PAH-16, and DRO Concentrations: Otter Creek Sediment Management Area

Figure 2-3

Date: 8/6/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\TagMap LOC revised.mxd



ENVIRON

Otter Creek Utility Information

Figure 2-4

Date: 4/24/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\Pipelines.mxd

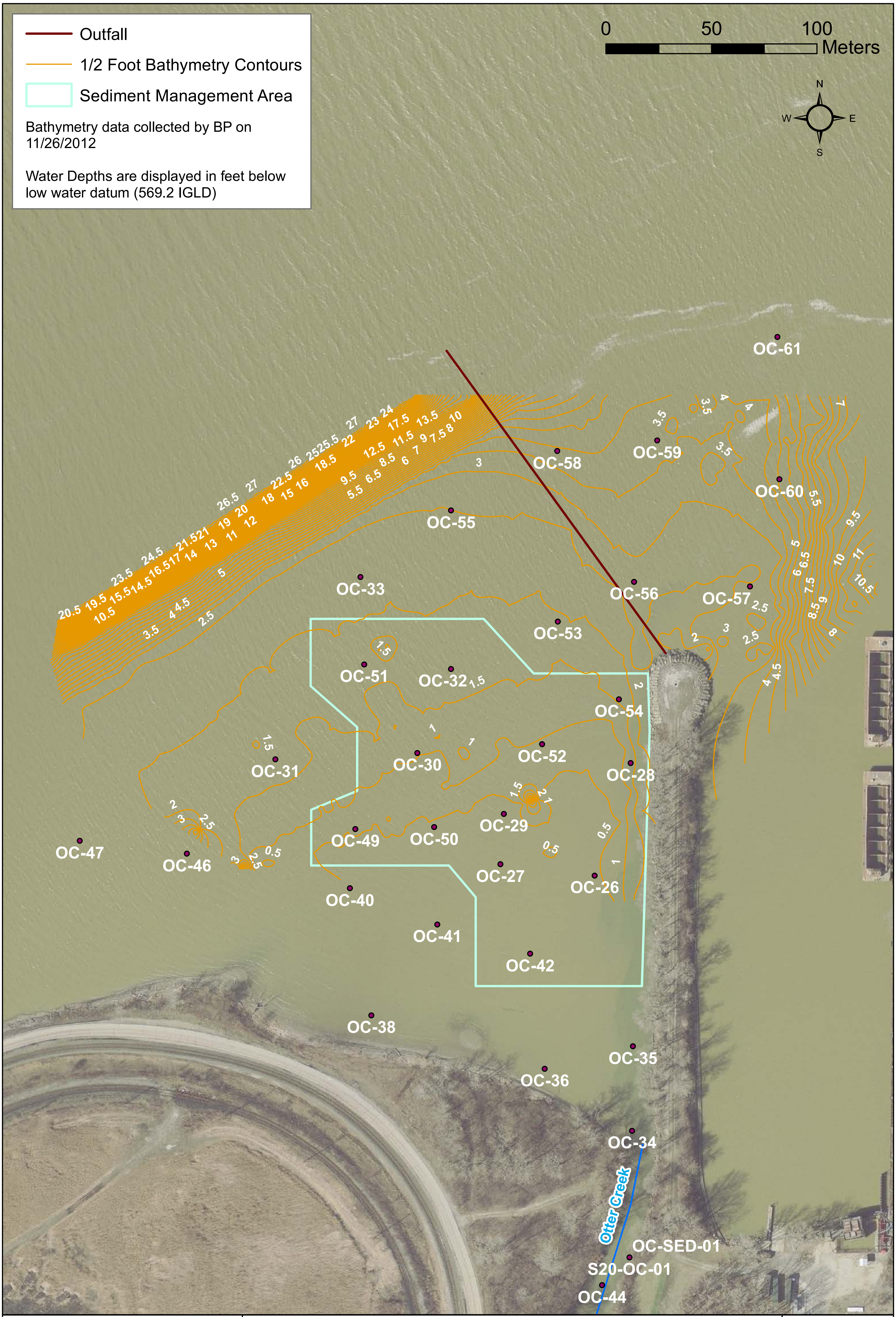
ENVIRON

Wetlands
Lower Otter Creek

Figure
2-5

Date: 2/19/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\Wetlands.mxd



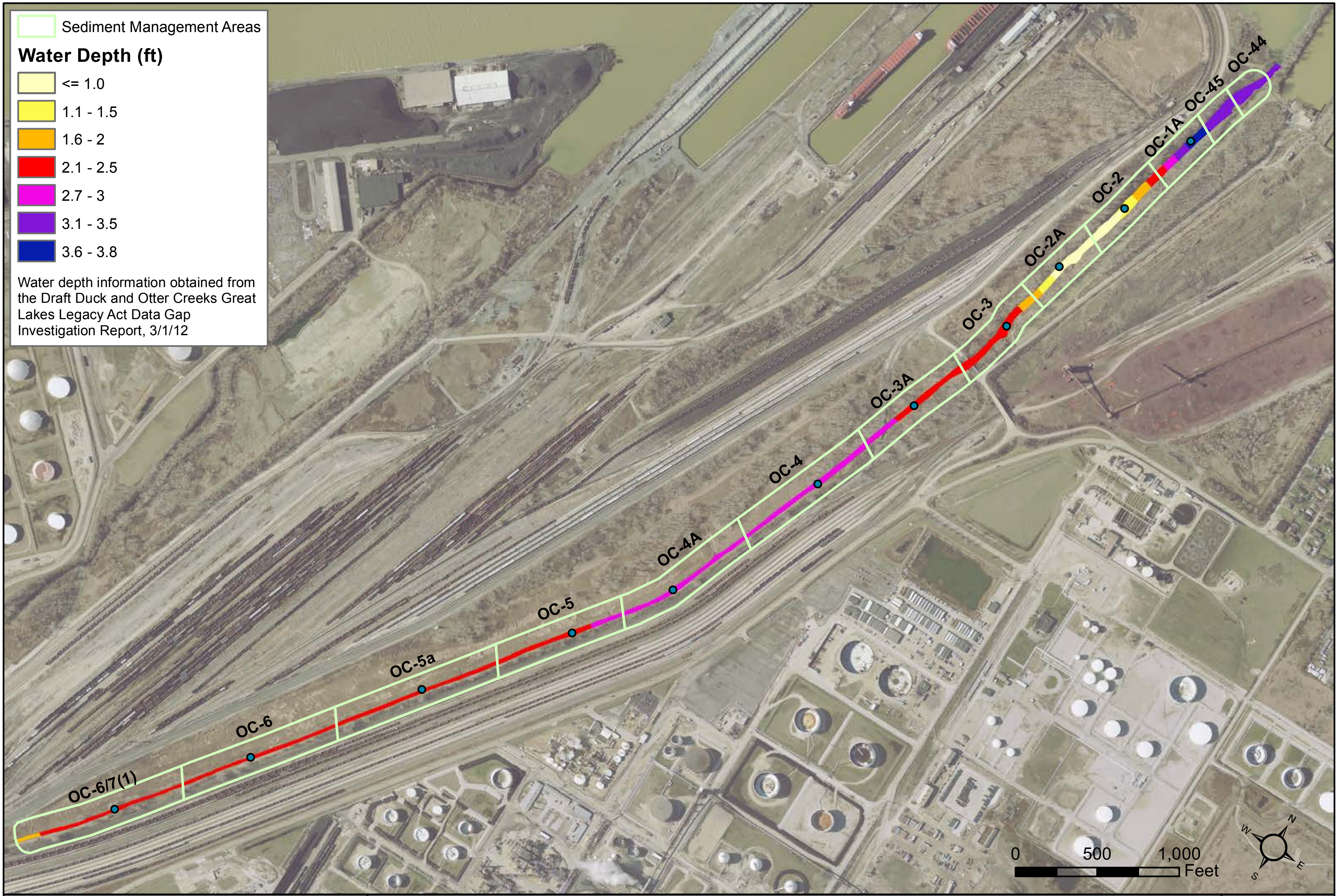
ENVIRON

Bathymetry Contours
Otter Creek Confluence

Figure
2-6

Date: 2/19/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\ConfluenceBathyFigure.mxd



Water Depth
Otter Creek

Figure 2-7

Date: 2/19/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\LOC Bathy.mxd

Imagery Date: 3/27/1999

Imagery Source: USGS DOQ

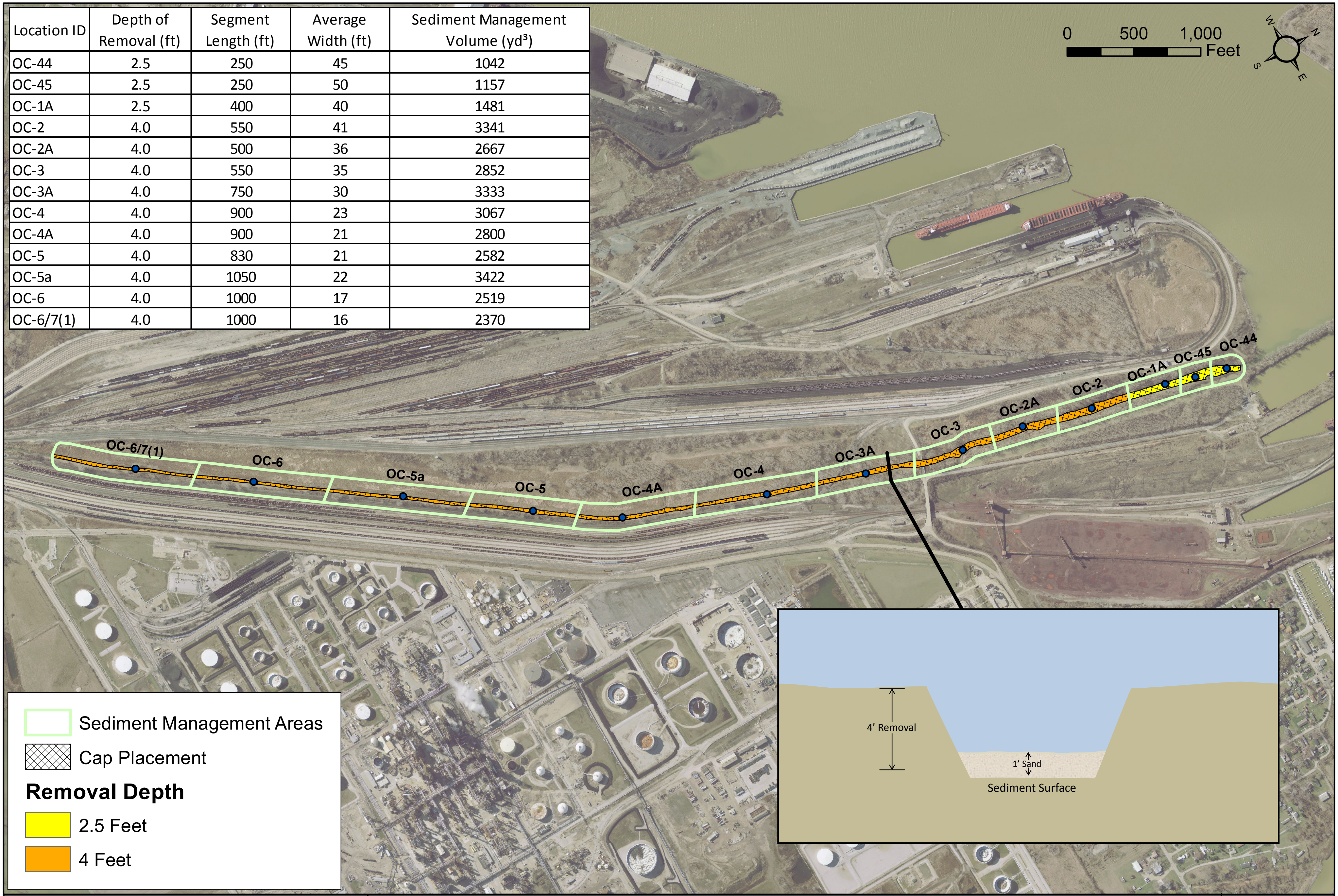
ENVIRON

Depositional Eddy
Otter Creek Confluence

Figure 2-8

Date: 2/19/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\figure 2-8.mxd



Location ID	Depth of Removal (ft)	Segment Length (ft)	Average Width (ft)	Sediment Management Volume (yd^3)
OC-44	2.5	250	45	1042
OC-45	2.5	250	50	1157
OC-1A	2.5	400	40	1481
OC-2	4.0	550	41	3341
OC-2A	4.0	500	36	2667
OC-3	4.0	550	35	2852
OC-3A	4.0	750	30	3333
OC-4	4.0	900	23	3067
OC-4A	4.0	900	21	2800
OC-5	4.0	830	21	2582
OC-5a	4.0	1050	22	3422
OC-6	4.0	1000	17	2519
OC-6/7(1)	4.0	1000	16	2370

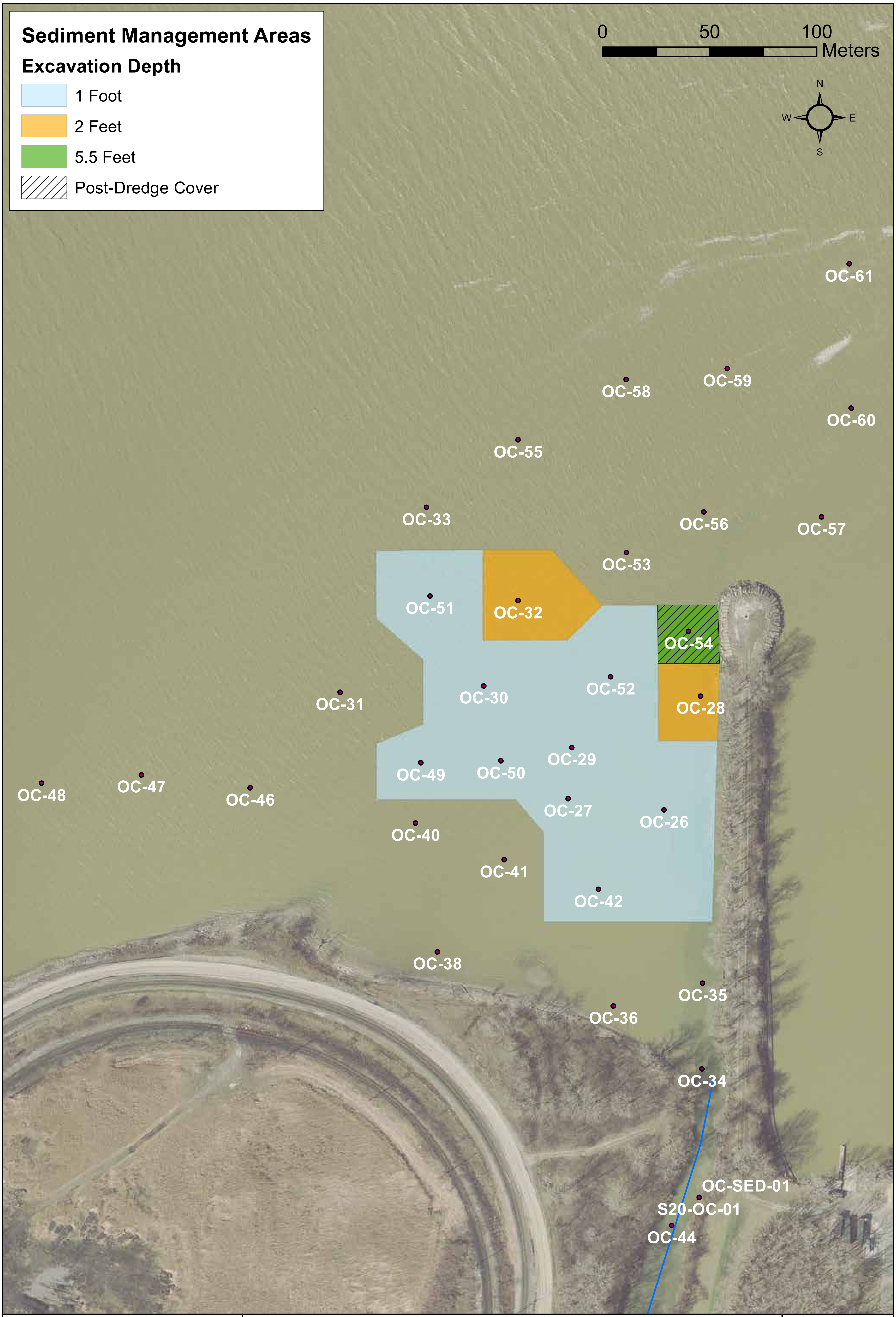
ENVIRON

Remedy Alternative 3
Otter Creek

Figure
4-1

Date: 8/15/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\RemedyAlt3 LOC.mxd



ENVIRON

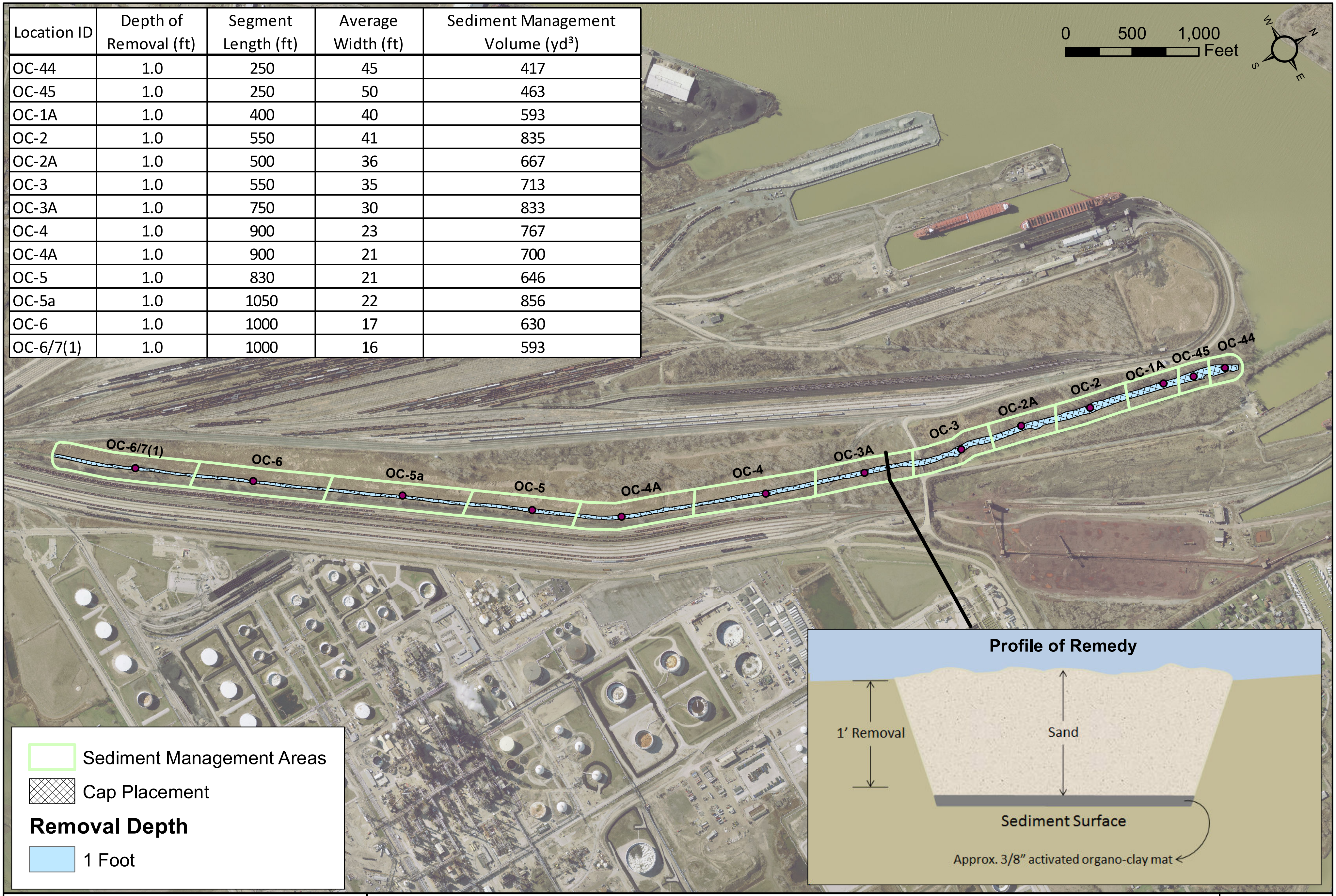
Remedy Alternative 3
Otter Creek Confluence

Figure
4-2

Date: 4/24/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\RemedyAlt4 Confluence.mxd

Location ID	Depth of Removal (ft)	Segment Length (ft)	Average Width (ft)	Sediment Management Volume (yd³)
OC-44	1.0	250	45	417
OC-45	1.0	250	50	463
OC-1A	1.0	400	40	593
OC-2	1.0	550	41	835
OC-2A	1.0	500	36	667
OC-3	1.0	550	35	713
OC-3A	1.0	750	30	833
OC-4	1.0	900	23	767
OC-4A	1.0	900	21	700
OC-5	1.0	830	21	646
OC-5a	1.0	1050	22	856
OC-6	1.0	1000	17	630
OC-6/7(1)	1.0	1000	16	593



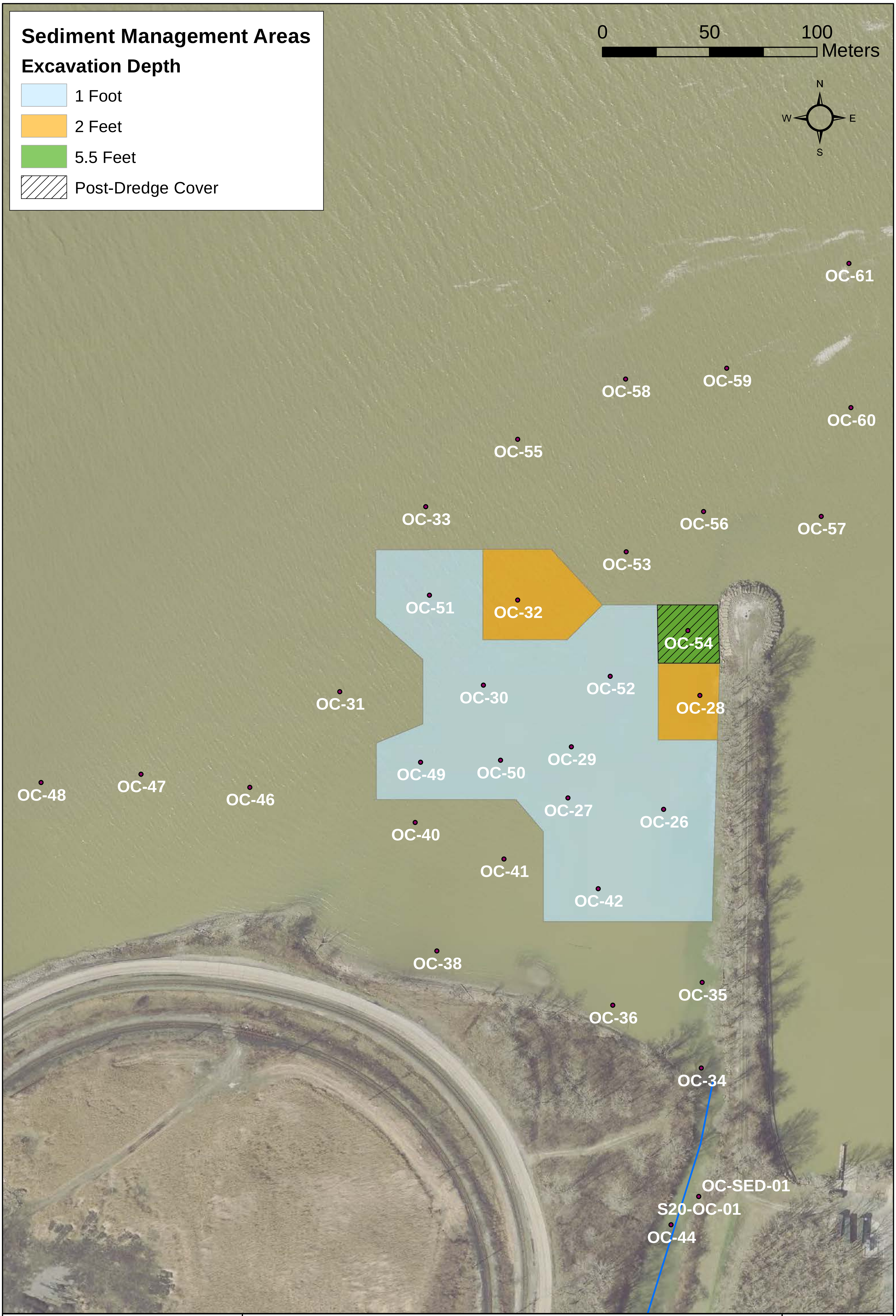
ENVIRON

Remedy Alternative 4
Otter Creek

Figure
4-3

Date: 8/6/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\RemedyAlt4 LOC.mxd



ENVIRON

Remedy Alternative 4
Otter Creek Confluence

Figure
4-4

Date: 1/24/2013

Document Path: M:\DuckandOtterCreek\GIS\MXD\RemedyAlt4 Confluence.mxd