FINAL

Feasibility Study for the Buffalo River, New York

Prepared on behalf of:

Buffalo River Great Lakes Legacy Act Project Coordination Team

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EXECUTIVE SUMMARY
FEASIBILITY STUDY FOR THE BUFFALO RIVER, NEW YORK

Introduction

The *Feasibility Study for the Buffalo River* (*FS*), prepared on behalf of the Buffalo River Project Coordination Team (PCT), presents remedial alternatives for addressing historical deposition of contaminants in the river sediments. It builds on the historical information presented in the *Sediment Remedial Investigation Report (SRIR) for the Buffalo River* (ENVIRON et al. 2009), and relies on the analyses of hydrological, ecological, and sediment conditions within the Buffalo River to support the evaluation of potential remedial measures. The two primary objectives of the *FS* are:

1. Identify and screen sediment technologies that address the occurrence of elevated concentrations of chemicals of concern (COCs) in the Buffalo River Area of Concern (AOC) sediments.
2. Evaluate viable remedial alternatives against the Remedial Action Objectives (RAOs) and against the full range of National Contingency Plan (NCP) criteria.

By completing these objectives, the *FS* identifies an appropriate remedial alternative that cost effectively manages the potential ecological and human health risks associated with the presence of elevated concentrations of COCs in Buffalo River AOC sediment.

Summary of Sediment Investigation Results

Sediment sampling was conducted in the Buffalo River AOC in 2008 to supplement existing geochemical and geotechnical data, and to further characterize the distributions of total polycyclic aromatic hydrocarbon (PAH), total polychlorinated biphenyl (PCB), lead (Pb), and mercury (Hg) concentrations in the river sediments. Sediment sampling locations for the 2008 study were selected based on results from New York State Department of Environmental Conservation (NYSDEC) and Great Lakes National Program Office (GLNPO) sediment sampling. These sampling efforts were conducted in 2005 and 2007. Together, they provide a more refined delineation of chemical concentrations and distributions in the river sediments, both laterally and vertically.

Results of the 2005, 2007, and 2008 sediment sampling and analysis demonstrate that sediment samples with a start depth of 0 feet (ft) generally had lower concentrations in both the Buffalo River and the City Ship Canal as compared to sediment samples with a start depth of 0.5 ft or greater. The lower chemical concentrations measured at the sediment surface are likely due to the ongoing deposition of sediments with low chemical concentrations.

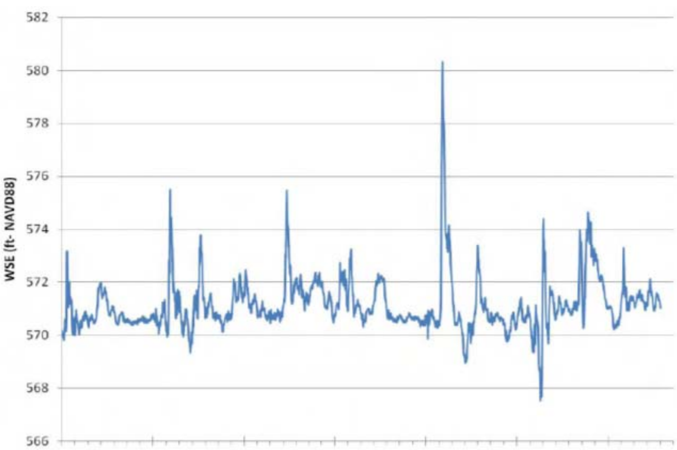
Buffalo River AOC

The sediment chemistry results show a lateral distribution of sediment concentrations for total PAHs, total PCBs, Pb, and Hg, the four indicator COCs for the Buffalo River AOC. In general, the highest sample concentrations for each of these chemicals are located at River Mile (RM) 3.5–5.5 and in the City Ship Canal. Chemical concentrations upstream of the AOC, both in the Buffalo River and Cazenovia Creek, are typically lower than the average concentrations in the Buffalo River AOC.

As part of the 2008 investigation, hydrodynamic and water quality parameters were measured along three transects of the Buffalo River AOC. In addition, bathymetric surveys were conducted upstream of the navigation channel to supplement existing Army Corps of Engineers (USACE) bathymetric data. This information was used in the development and calibration of hydraulic and hydrodynamic models for the Buffalo River. The hydrodynamic model, a three-dimensional Environmental Fluid Dynamics Code (EFDC) model, provides three-dimensional velocity and shear stress distributions along the river over a range of flow conditions. The hydraulic model, a one-dimensional Hydraulic Engineering Center-River Analysis System (HEC-RAS) model approved by the Federal Emergency Management Agency (FEMA), predicts changes in flood elevation and potential flooding under various flow conditions and seiche events.

The velocities and shear stresses computed by the EFDC model for the various flow conditions and events are consistent with the river's function as a dredged navigation channel. Results from model simulations demonstrate low velocities and bottom shear stresses throughout the AOC during low flow conditions. An increase in velocities and shear stress was demonstrated during high flow events (10-yr and 100-yr intervals), but these increases were most notable in narrow sections of the river including RM 1.0–2.0, RM 2.9, and RM 5.2.

Recently collected bathymetry and topography data was applied to the HEC-RAS model to demonstrate potential flooding within the Buffalo River AOC under current conditions. Results demonstrate that the river does not flood in the majority of the downstream reaches under the 100-year event. High wet weather flows are contained within the river's banks and flooding potential is primarily upstream of the confluence with Cazenovia Creek.



Water surface elevation measurements at the mouth of the Buffalo River show oscillations resulting from Lake Erie seiche events

Ecological sampling conducted as part of the 2008 field investigation included aquatic habitat surveys, benthic community assessment surveys, fish community assessment surveys, and fish histopathology analysis. Results of the ecological sampling are being used to supplement the existing body of knowledge regarding current ecological conditions. This information helps support remedy selection and the evaluation of habitat restoration projects.

The aquatic vegetation survey identified 29 Submerged Aquatic Vegetation (SAV) beds and 15 Emergent Vegetation (EV) beds. As part of the benthic community assessment survey, both sediment grab samples and Hester-Dendy artificial substrate samples were taken from the Buffalo River AOC and two reference locations. The 2008 analyses show that benthic habitat is fairly similar between the Buffalo River and the PCT-selected reference sites. These results and the similarity between the Buffalo River and the reference sites give insight into the extent to which habitat quality contributes to the benthic community structure.

Fish community sampling conducted in 2008 provided taxonomic information on the population and community structure of Buffalo River and Cazenovia Creek, as well as information on the pre-remediation conditions. Fish collected during the survey (a total of 23 distinct species) generally exhibited healthy characteristics. However, approximately 2% of the fish collected showed evidence of external deformities, eroded fins, lesions, and tumors (DELTs). Locations within the AOC were observed to have a slightly higher incidence of fish with DELTs (4%) compared to the locations upstream of the AOC (1%). The prevalence of liver tumors and external lesions was assessed in brown bullheads collected from the Buffalo River AOC. In summary, about 8% of brown bullhead fish collected from the Buffalo River contained hepatic neoplastic lesions.

Remedial Action Objectives and Goals

RAOs and remedial goals (RGs) provide the framework for developing 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 RAOs identified by the PCT for this project are as follows:

- **RAO 1:** Reduce human exposures for direct sediment contact and fish consumption from the Buffalo River by reducing the availability and/or concentration of COCs in sediment
- **RAO 2:** Reduce the exposure of wildlife populations and the aquatic community to sediment COC concentrations that are above protective levels
- **RAO 3:** Reduce or otherwise address legacy sediment COC concentrations to improve the likelihood that future dredged sediments (for routine navigational, commercial, and recreational purposes) will not require confined disposal
- **RAO 4:** Implement a remedy that is compatible with the Buffalo River Remedial Advisory Committee's goal of protecting and restoring habitat and supporting wildlife

Supporting goals are integrated into the evaluation and selection of remedy alternatives; however they are not used to assess project performance. Rather, supporting goals will provide an overarching framework to be considered during the assessment of remedial alternatives, and include the following:

- **Supporting Goal 1:** Reduce the long-term potential of COC contaminated sediments to migrate outside of the Buffalo River AOC
- **Supporting Goal 2:** Implement a sediment remedy that is compatible with and complements ongoing regional redevelopment goals, upland remediation, and restoration activities

Members of the PCT collaborated to identify RGs for use in this *FS*. RGs are established for the four indicator chemicals (i.e., PAHs, PCBs, Hg, and Pb) and are derived using a variety of site-specific lines of evidence. The RGs provide numerical goals for sediments in the upper 0-1 ft interval, and are used to develop sediment remedy alternatives that reduce ecological and human exposures to sediment chemicals and achieve RAOs. The RG for total PAHs is based on point concentrations in the upper 1 ft of sediment, whereas the RGs for the other chemicals are based on surface-weighted average concentrations (SWACs). The site-specific RGs for the four indicator chemicals for the Buffalo River AOC are provided below.

Chemical	RG
Total PAHs	1 Toxicity Unit (16 mg/kg)
Pb	90 mg/kg SWAC
Hg	0.44 mg/kg SWAC
Total PCBs	0.20 mg/kg SWAC

Screening of Available Sediment Remedy Technologies and Process Options

General response actions (GRAs) are broad categories of possible sediment remedy actions such as containment, removal, treatment, disposal, or combinations of these actions. The following GRA categories are identified to address the Buffalo River sediments: 1) no action, 2) institutional controls, 3) natural recovery, 4) sediment capping, and 5) sediment removal. Effectiveness, implementability, and cost are the major criteria considered as part of the initial screening of the GRAs. Results of the GRA screening analysis for the Buffalo River AOC are as follows:

- **No Action:** No Action is retained for further evaluation to serve as a baseline for comparison with other response actions as required by the NCP.
- **Institutional Controls:** Institutional controls are not retained as a sole remedy, but may be evaluated as components of other remedial alternatives.
- **Natural Recovery:** Lines of evidence, including the depositional nature of the river, demonstrate natural recovery processes can contribute to reduced risks in the Buffalo River AOC over time. However, current surface sediment levels continue to be above the site-specific RGs. Nonetheless, Monitored Natural Recovery (MNR) is a feasible and implementable remedy alternative for the site and is retained for further analysis.
- **Sediment Capping:** Areas suitable for capping within the Buffalo River AOC are limited to areas outside of the federally-defined navigational channel in the Buffalo River and City Ship Canal. To the extent that routine disturbance of the Buffalo River AOC (e.g., maintenance dredging) could impact cap stability, and concerns regarding reduction on river conveyance capacity, isolation capping along the non-navigable areas of the Buffalo River AOC is not considered further in this *FS*, except possibly for areas that cannot be dredged due to limited accessibility, protection of bulkheads, or protection of sensitive habitat. However, capping is considered for the non-navigable portion at the end of the City Ship Canal, beyond the terminus of the authorized dredge channel.
- **Sediment Removal:** Dredging is a mature technology used primarily for sediment mass removal and is retained for further evaluation. Due to dredge residuals, dredging may have little positive impact on short-term risk reduction, but the removal of target sediment mass is expected to effectively reduce long-term risks. For the purposes of this *FS*, and consistent with current USACE dredging program in the Buffalo River, it is assumed that the CDF No. 4 will be used for the disposal of dredged sediment. The selected methods for dredging, transportation, and placement of material in the CDF will be resolved during remedy design or construction bidding, as appropriate.

Description of Remedial Alternatives

Results of the GRA screening are used to develop five different remedy alternatives for addressing sediments in the Buffalo River AOC. Each of the remedy alternatives includes source control as a component of the final remedy. The five remedy alternatives are described below.

Alternative 1 – No Action

Remedy Alternative 1 is the No Action alternative, which is included in the analysis for comparison to other alternatives, as required by NCP to identify baseline environmental conditions in the absence of remediation.

This remedial alternative reflects baseline river sediment conditions as described in the *SRIR*, and would entail no further action for remediation of Buffalo River AOC sediments. Natural recovery processes are expected to continue, such as the deposition of cleaner sediments, but these processes would not be monitored.

Alternative 2 – Monitored Natural Recovery

Remedy Alternative 2, MNR, uses the ongoing, naturally occurring processes that contain or reduce the bioavailability or toxicity of chemicals in the sediment. Multiple lines of physical and biological evidence, including the deposition of sediments originating from upstream, are used to evaluate MNR. The long-term monitoring component of the MNR remedy is used to demonstrate the ability of MNR to achieve RGs in surface sediments and to reduce the risks to human health and the environment over time.

Alternative 3 – Basic Dredging

Remedy Alternative 3 targets the removal of surface and subsurface sediments in the Buffalo River AOC with a PAH TU > 1, and targets SWAC RGs for total PCBs, Hg, and Pb. Capping is introduced for remediation of the end of the City Ship Canal, beyond the limits of the authorized navigation channel. By targeting the removal of all sediments with PAH TU > 1, Remedy Alternative 3 would remove the largest volume of sediment from the Buffalo River AOC compared to the other dredge remedies (Remedy Alternatives 4 and 5) , and requires the longest amount of time to implement (approximately 5 to 6 years).

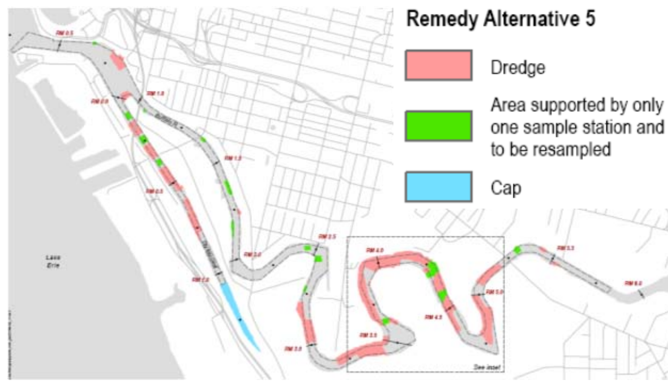
Alternative 4 – Protectiveness Dredging

Remedy Alternative 4 targets the removal of sediments from areas with total PAH concentrations > 1 TU in the upper 0 – 1 ft sediment interval, and achieves SWAC RGs for PCBs, Hg, and Pb. Capping is introduced for remediation of the end of the City Ship Canal, beyond the limits of the authorized navigation channel. By focusing sediment removal from areas with surface sediment total PAH concentrations > 1 TU, and achieving SWAC RGs, Remedy Alternative 4 would remove the smallest volume of sediment from the Buffalo River AOC compared to the other dredge remedies (Remedy Alternatives 3 and 5) , and requires the shortest amount of time to implement (approximately 2.5 to 3 years).

Alternative 5 – Enhanced Protectiveness Dredging

Remedy Alternative 5 targets the removal of sediments from areas with total PAH concentrations > 1 TU in the upper 0 – 1 ft sediment interval, and achieves SWAC RGs for PCBs, Hg, and Pb. Similar to Remedy Alternative 4, Remedy Alternative 5 achieves the RGs and reduces the current ecological and human health risks associated with elevated surface sediment chemical concentrations. Remedy Alternative 5 also targets the removal of sediments from areas with elevated point concentrations of PAHs, PCBs, Pb, and Hg at depths of 0-4 ft.

In addition, Remedy Alternative 5 targets the removal of areas that are associated with the presence of oil and grease, as identified in core logs from the 2005, 2007, and 2008 sediment investigations. Additional evaluations also confirm Remedy Alternative 5 is protective of risk in areas frequently accessed by the public, in sediment areas that may scour during high flow events, and in areas where sediment has been historically disturbed by ship traffic.



Remedy Alternative 5 Footprint

Evaluation of Remedial Alternatives

Remedy Alternatives 1 through 5 are evaluated against the nine criteria established under NCP. This evaluation also serves as a comparison of the five Remedy Alternatives against the RAOs. The results of the remedy alternative evaluation against the nine NCP criteria are provided below.

Overall Protection of the Human Health and the Environment

Each of the Remedy Alternatives provides varying degrees of overall protection of human health and the environment. Remedy Alternatives 1 and 2 contribute to the protection of human health and the environment over time and contribute to the RAO goals through ongoing recovery processes and current institutional controls that protect public health. However, Remedy Alternatives 1 and 2 do not satisfy the RAO goals in the near-term and rely on ongoing natural processes to achieve RGs and reduce risks. MNR (Remedy Alternative 2) differs from the No Action alternative (Remedy Alternative 1) by including long-term monitoring to assess the continuation of natural recovery processes and the achievement of RGs over time.

Dredge remedies (Remedy Alternatives 3, 4, and 5) contribute to RAO goals by decreasing the mass of chemicals in the river and by improving long-term surface sediment conditions that contribute to reduced risks to human health and the environment. However, dredge remedies will negatively impact short-term surface sediment concentrations through sediment suspension and dredge residuals, and will disturb existing vegetation beds and benthic habitat.

Capping remedies (included with Remedy Alternatives 3, 4, and 5) contribute to RAO goals by immediately reducing chemical concentrations in the biological active zone of the sediment bed surface, and thus reducing the mass of chemicals available for biological exposures.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Remedy Alternatives 1 and 2 are expected to comply with ARARs because they require no construction, and thus require no permitting.

Dredging and capping are incorporated into Remedy Alternatives 3, 4, and 5 and these alternatives would be designed and implemented to comply with ARARs. Best management practices would be used during dredging to minimize the potential for contaminant suspension and offsite transport. Work would be scheduled to minimize impacts to fish species in the Buffalo River AOC during remedy implementation by adhering to designated fish windows and employing best management practices that minimize ecological impacts to the extent practicable. Action-specific ARARs for dredging alternatives would be complied with by disposing of wastes in accordance with federal, state, and regional requirements.

Short-Term Effectiveness

Short-term effectiveness includes an evaluation of short-term impacts on ecological and human health risks, including environmental impacts of remedy implementation, and potential impacts to the community and site workers during remedy implementation. Remedy Alternatives 1 and 2 would result in little to no short-term risk reduction, since risk reduction will be dependent on natural sedimentation, but would create no increased risks to the community associated with onsite construction and remediation operations. Remedy Alternatives 3, 4, and 5 achieve long-term risk reduction through the removal of surface sediments contributing to ecological and human health risks, but pose potentially adverse short-term risks to the Buffalo River and risks to construction workers and the community via exposures to contaminated sediment, prolonged construction, and increased transportation to and from the site. These adverse impacts are expected to be greatest for Remedy Alternative 3, which targets the largest volume and area of sediment removal compared to Remedy Alternatives 4 and 5. Remedy Alternatives 3, 4, and 5 also include capping at the end of the City Ship Canal. Capping is expected to effectively reduce risks by isolating sediment contaminants and establishing a clean biological habitat at the sediment bed surface.

Long-Term Effectiveness and Permanence

This criterion determines the adequacy and reliability of sediment remedies to manage human health and ecological risks associated with sediment contaminants. Remedy Alternatives 1 and 2 provide no additional reduction in risk to humans or the environment beyond the current ongoing and natural depositional processes in the Buffalo River AOC. MNR differs from the No Action alternative by including long-term monitoring.

Remedy Alternatives 3, 4, and 5 all provide long-term reduction in risk by targeting the RG of 1 TU for total PAHs across surface sediments and the SWAC RGs for Pb, Hg, and total PCBs. Remedy Alternatives 3 and 5 also target the removal of areas with elevated sediment chemical concentrations below the surface (> 1 ft depth), further reducing future risk by permanently preventing these sediments from being exposed. Remedy 3, 4, and 5 also including capping of a portion of the City Ship Canal, which will be designed to isolate sediment contaminants with long-term reliability and permanence.

Reduction of Toxicity, Mobility, or Volume

This criterion addresses the anticipated efficiency of the remedy alternatives at reducing risks associated with elevated sediment chemical concentrations in the Buffalo River AOC. Remedy Alternatives 1 and 2 do not provide additional reduction in toxicity, mobility or volume of chemicals in the Buffalo River AOC sediments beyond the current ongoing recovery processes. Remedy Alternative 3 removes that largest volume of contaminated sediment from the AOC, followed by Remedy Alternative 5. However, Remedy Alternatives 4, which focuses on the removal of sediments from areas with elevated surface sediment concentrations, also achieves the RGs established for this *FS*, but requires a smaller volume of sediment removal compared to Remedy Alternatives 3 and 5.

Implementability

Implementability encompasses the feasibility of employing a remedial alternative. All five Remedy Alternatives are considered feasible and implementable. Dredging and capping, which are components of Remedy

Alternatives 3, 4, and 5, are established technologies that have been implemented at other sites and can be implemented at the Buffalo River. However, in proposed dredge areas that adjoin rigid bulkheads or structures, appropriate off-sets from the shoreline would be established to maintain shoreline integrity by allowing those sediments to remain in place. The presence of these structures, as well as bridge abutments and piers, limits dredging implementability in these areas. Furthermore, implementation of Remedy Alternative 3 would impose a strain on the existing CDF, by consuming approximately 80% of the available CDF capacity.

Cost

Besides the No Action alternative, Remedy Alternative 2 (MNR) has the lowest cost. Remedy Alternative 4 has the lowest cost of the dredge remedies followed by Remedy Alternative 5, and Remedy Alternative 3, which targets the largest volume of sediment removal, has the highest cost.

State Acceptance

This criterion evaluates the issues and concerns that state agencies may have regarding each sediment remedy alternative. As a member of the Buffalo River PCT, NYSDEC has participated in and has been involved with the various tasks and decisions that have been incorporated into the development of the Remedy Alternatives outlined in this *FS*. These Remedy Alternatives aim to provide a balance, to varying degrees, of remediating contaminated sediments that may pose a risk to human health and the environment, and preserving existing habitat and ecological communities within the Buffalo River AOC, both of which are important criteria to NYSDEC.

Community Acceptance

This criterion addresses the issues and concerns the general public may have regarding each sediment remedy alternative. Buffalo Niagara Riverkeeper, which is a member of the PCT, serves as a representative of community interests and concerns with regards to the selection of a sediment remedy, and has played a central role in the various tasks and decisions that have been incorporated into the development of the Remedy Alternatives outlined in this *FS*. In addition, there have been a number of community outreach and communication efforts related to addressing sediments in the Buffalo River. Remedy Alternatives 1 and 2 would have minimal or no short-term community impacts or increased risks to the community as a result of onsite construction or transportation of contaminated sediments. No community short-term impacts such as noise or odors are anticipated. However, current sediment chemical concentrations would be left in place.

Remedy Alternatives 3, 4, and 5 include sediment excavation, handling, offsite transportation, and disposal, which may increase short-term impacts to the community through construction noise, odors, and diesel emissions. Such community impacts are expected to be greater for Remedy Alternative 3, due to the large volume of sediment targeted for removal and the duration of remedy construction, as compared to Remedy Alternatives 4 and 5.

Proposed Remedy

Remedy Alternative 5, Enhanced Protectiveness Dredging, achieves the sediment-related ecological and human health RAOs of the Buffalo River AOC. The PCT recommends design and implementation of the Enhanced Protectiveness Dredging alternative at the Buffalo River AOC site.

Remedy Alternative 1 (No Action) and Alternative 2 (Monitored Natural Recovery) are implementable, low cost alternatives. However, neither of these alternatives satisfies the RAO goals in a reasonable timeframe. Remedy Alternative 3, Alternative 4, and Alternative 5 all contribute to RAO goals by permanently decreasing the mass of chemicals in the river and by improving long-term surface sediment concentrations that reduce risks to human health and the environment. However, dredge remedies are expensive to implement and are accompanied by short-term impacts, including short-term increases in contaminant concentrations in the water column, surface sediment, and fish tissues resulting from sediment suspension and dredge residuals. Additionally, dredging and transport operations are accompanied by short-term risks to construction workers. Greater volumes of dredging are associated with higher costs, greater short-term impacts, and an increase for potential accidents.

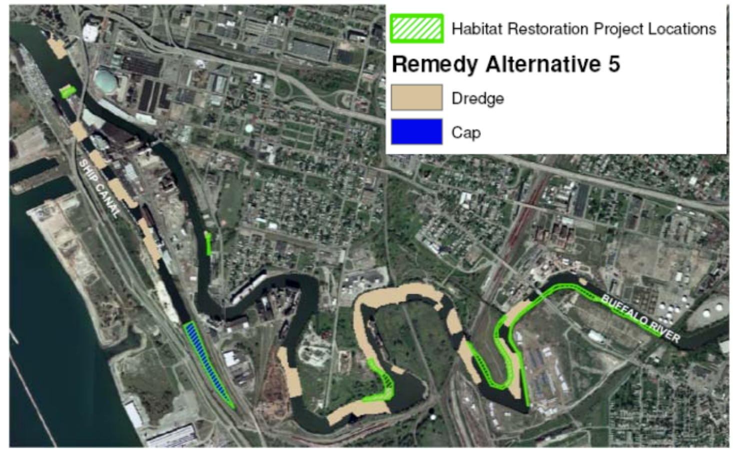
Remedy Alternative 5 is recommended for design and implementation because this alternative effectively and efficiently achieves risk reduction goals in both the surface and subsurface sediments without the diminishing returns of a larger-scale cleanup. Remedy Alternative 5 also can be completed within a reasonable timeframe.

Remedy Alternative 5 includes confirmation and operation monitoring during remedy implementation, and long-term monitoring following the completion of the remedy. Detailed monitoring plans, including a Residuals Management Plan, will be provided as part of remedial design. When dredging is complete, and at Year 2 and Year 5 following the completion of the remedy, surface sediment (0–1 ft) chemical concentrations will be measured to confirm that the total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs are achieved. If the RGs have not been achieved, additional measures may be implemented in accordance with decision rules identified in the FS.

Habitat Restoration

Habitat restoration project locations are presented in this *FS* to facilitate the permit compliance for remedy implementation and to provide a conceptual approach for mitigation agreed upon by the PCT. The scale of potential impacts was determined based on Preferred Remedy Alternative 5. The projects will be finalized during the remedy design phase and are described in detail in the E*cology and Engineering Evaluation* (*EEE*) *Report*.

Potential restoration projects are located within 0.75 miles of the impacted area in order to ensure that the restored system addresses the same functions that may have been impacted by the remedy. Subaquatic vegetation restoration has been proposed in six locations. These projects are expected to mitigate the remedy impacts while providing additional restoration above and beyond mitigation. The project locations include Kelly Island, City Ship Canal, Ohio Street shoreline, Katherine St. Peninsula, Buffalo Color Peninsula shoreline, and the Riverbend parcel. Land owner acceptance of these potential projects will be necessary prior to project implementation. It is anticipated that additional due diligence (including any necessary access negotiations with land owners) will be conducted during the design phase. If any of the selected sites are unable to be constructed, then a project of equal scope shall be considered in its place, including the potential expansion of one of the remaining projects, if such an expansion provides comparable scope. It is envisioned that a portion of the projects will be funded under the GLNPO Great Lakes Legacy Act (GLLA) with matching federal and non-federal funding. The remaining projects will be funded using other programs such as grants under the USEPA's Great Lakes Restoration Initiative (GLRI) or other programs.



Potential Habitat Restoration Areas

The EEE Report, appended to the FS, includes a description of restoration techniques considered, example restoration projects for selected general shoreline types, proposed restoration projects for the selected locations, and a thorough evaluation of the restoration alternatives using the evaluation criteria. These evaluation criteria are intended to provide a basis for design, allow comparison of relative costs and benefits of project alternatives, and allow the selection of a preferred restoration alternative at each location.

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ACRONYMS AND ABBREVIATIONS

%	Percent
AOC	Area of concern
ARARs	Applicable or relevant and appropriate requirements
ARCS	Assessment and Remediation of Contaminated Sediment
AVS	Acid volatile sulfides
BERC	Buffalo Economic Renaissance Corporation
BNR	Buffalo Niagara Riverkeeper
BOA	Brownfield Opportunity Area
BUIs	Beneficial use impairments
CC	Cazenovia Creek
CDF	Confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	Centimeters
cm/km	Centimeters per kilometer
cm/sec	Centimeters per second
COC	Chemicals of concern
CSO	Combined sewer overflow
CWM	Chemical waste management
CY	Cubic yards
DELTs	Deformities, eroded fins, lesions, and tumors
DoD	US Department of Defense
$dynes/cm^2$	Dynes per square centimeter
Eco-Group	The Ecology Subgroup
EEE	Ecology and engineering evaluation
EFDC	Environmental Fluid Dynamics Code
ENVIRON	ENVIRON International Corporation
EPT	Ephemeroptera, Plecoptera, and Trichoptera
EqP	Equilibrium partitioning
EV	Emergent vegetation
f_{oc}	Fraction of organic carbon
FEMA	Federal Emergency Management Agency
FIRMs	Flood insurance rate maps
FIS	Flood insurance study
fps	Feet per second

FS	Buffalo River Feasibility Study
ft	Foot or feet
g	Gram
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
GRAs	General response actions
HEC-RAS	Hydraulic engineering center-river analysis system
Hg	Mercury
HI	Hazard Index
Honeywell	Honeywell International Inc.
IBI	Index of Biotic Integrity
IDW	Inverse Distance Weighting
IGLD	International Great Lakes Datum
IJC	International Joint Commission
K_{oc}	Organic carbon-water partitioning coefficient
kg	Kilogram
km	Kilometer
MACTEC	MACTEC Engineering and Consulting, Inc.
µm	Micrometer or micron
mg	Milligram
mg/kg	Milligram per kilogram
mg/L	Milligram per Liter
µmol/gOC	Micromole per gram organic carbon
m^2	Square meters
mm	Millimeter
MNR	Monitored natural recovery
n	Sample size
ng/L	Nanogram per liter
NCP	National Contingency Plan
NPV	Net present value
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and maintenance
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCOI	Potential constituents of interest
PCT	Project coordination team

PECs	Probable effects concentrations
PID	Photoionization device
ppm	parts per million
PRGs	Preliminary remediation goals
RAC	Remedial Advisory Committee
RAOs	Remedial action objectives
RAP	Remedial action plan
RI	Remedial investigation
RG	Remedial Goal
RM	River Mile
SAV	Submerged aquatic vegetation
SEM	Simultaneously extracted metals
SGVs	Sediment guidance values
SPARC	Sparc Performs Automated Reasoning in Chemistry
SRIR	Sediment Remedial Investigation Report
SWAC	Surface weighted average concentration
TBP	Theoretical bioaccumulation potential
TOC	Total organic carbon
TSCA	Toxic Substance Control Act
TU	Toxicity Units
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USDOE	United States Department of Energy

1 INTRODUCTION

This *Buffalo River Feasibility Study* (*FS*) has been prepared by ENVIRON International Corporation (ENVIRON), MACTEC Engineering and Consulting, Inc. (MACTEC), and LimnoTech on behalf of the Buffalo River Great Lakes Legacy Act (GLLA) Project Coordination Team (PCT), including the United States Environmental Protection Agency (USEPA) Great Lakes National Program Office (GLNPO), the Buffalo Niagara Riverkeeper (BNR), New York State Department of Environmental Conservation (NYSDEC), United States Army Corps of Engineers (USACE), USEPA Region 2, and Honeywell International, Inc. (Honeywell). The preparation of this *FS* is pursuant to the Buffalo River GLLA Project Agreement, and it has been submitted to and reviewed by the GLLA PCT.

Building on the sediment investigations, historical information, and information presented in the *Sediment Remedial Investigation Report (SRIR) for the Buffalo River* (ENVIRON et al. 2009), this *FS* relies on the analyses of hydrological, ecological, and sediment conditions within the Buffalo River to support the evaluation of potential remedial measures. This report:

- identifies Remedial Action Objectives (RAOs);
- considers the range of available remediation technologies;
- evaluates those technologies considered relevant to remediation of Buffalo River Area of Concern (AOC) sediments; and
- compares remediation alternatives to help identify a preferred remedy for sediments in the Buffalo River AOC.

1.1 Feasibility Study Objectives

The work embodied in the *FS* is based on the following two primary objectives:

- Identify and screen sediment technologies that address the occurrence of elevated concentrations of chemicals of concern (COCs) in the Buffalo River AOC sediments.
- Evaluate viable remedial alternatives against the RAOs and against the full range of National Contingency Plan (NCP) criteria.

This *FS* identifies an appropriate remedial alternative that cost effectively manages the potential risks associated with the presence of elevated concentrations of COCs in Buffalo River AOC sediment. Meeting the *FS* objectives will result in long-term reduction of ecological or human health risks.

1.2 Report Organization

This introduction to the *FS* (Section 1.0) is followed by a summary of the sediment investigation results (Section 2). Section 3 identifies the RAOs for the Buffalo River AOC, and Section 4 presents a screening of available sediment remedy technologies and process options. Site-specific remedy alternatives developed for Buffalo River sediments are presented in Section 5, and evaluations of the remedial alternatives against the site-specific RAOs using the nine criteria established by the NCP are provided in Section 6. Section 7 identifies the preferred remedy alternative recommended by the PCT and selected by USEPA GLNPO. An overview of possible post-remedy habitat restoration options is provided in Section 8, and references are provided in Section 9.

This *FS* also includes the following appendices: Appendix A describes the development of remedial goals (RGs) by the PCT for the Buffalo River AOC; Appendix B which provides the Human Health Risk Evaluation for the Buffalo River AOC; Appendix C includes several Technical Memoranda exchanged among the PCT members and supporting the remedial alternatives analysis and selection processes; Appendix D provides various technical guidelines that were used to develop Remedy Alternative 5; Appendix E provides cost details for the development of the remedial alternative cost estimates, and Appendix F provides the Ecology and Engineering Evaluation (EEE) Report that outlines potential Buffalo River habitat restoration projects.

2 SUMMARY OF SEDIMENT INVESTIGATION RESULTS

The analysis of alternatives presented in this *FS* is supported by an understanding of the distribution of COCs in the Buffalo River sediments, river hydrological conditions, and ecological conditions based on historical data and data collected in 2008. This section summarizes the results of sediment, surface water, and biological investigations conducted at the Buffalo River and reported in the *SRIR*, submitted March 6, 2009 (ENVIRON et al. 2009). These results supplement the existing body of knowledge of the river, and support the development of multiple lines of evidence to support remedy decision making, as recommended in USEPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005a). Specific tasks completed during fall 2008 include:

- Sediment sampling and analysis
- Pore water sampling and analysis
- Sub-bottom thickness surveys
- Bathymetry surveys
- Surface water hydrologic monitoring
- Hydrodynamic modeling
- Aquatic habitat surveys
- Benthic community assessment surveys
- Fish community assessment surveys
- Fish histopathology analysis

2.1 Site Background

The Buffalo River AOC is located in Buffalo, New York (Figure 2-1). The Buffalo River flows from the east and discharges into Lake Erie. There are three major streams in the watershed that feed the Buffalo River: Cayuga Creek, Buffalo Creek, and Cazenovia Creek (Figure 2-2). The total drainage area for the Buffalo River Watershed is approximately 1,150 square kilometers (km^2).

The Buffalo River has served as an industrial, commercial, and urban waterway for almost two centuries, beginning with the completion of the Erie Canal in 1825. The US and Canadian International Joint Commission (IJC) designated a portion of the Buffalo River as an AOC pursuant to the US-Canada Great Lakes Water Quality Agreement. The Buffalo River AOC (Figure 2-1) includes approximately 10 km (6.2 miles) of the Buffalo River and the entire 2.3 km (1.4 mile) stretch of the City Ship Canal, located adjacent to the river. The IJC identified 14 possible beneficial use impairments (BUIs) that could impact an AOC. The 1989 Remedial Action Plan (RAP) determined that eight beneficial uses were either "impaired" or "likely impaired". Table 2-1 identifies the BUI status in 1989, and the results of additional

BUI status reviews conducted in 2005 and 2008 (BNR 2008, Ecology and Environment 2008). Nine beneficial uses were listed as “impaired” in the 2008 RAP.

2.2 Delineation of Chemicals of Concern in Sediment

Sediment sampling was conducted in the Buffalo River in fall 2008 to supplement results from the 2005 and 2007 sediment sampling programs conducted by GLNPO and NYSDEC (NYSDEC 2006, 2008a) and to provide a more refined delineation of chemical concentrations and distributions in the river sediments, both laterally and vertically. Sediment samples collected in fall 2008 were analyzed for concentrations of polycyclic aromatic hydrocarbon (PAHs), polychlorinated biphenyl (PCBs), lead (Pb), and mercury (Hg), which were identified as the four primary indicator chemicals in the Buffalo River AOC (GLNPO 2008). Results from the 2005, 2007, and 2008 sediment sampling programs were combined to show the distributions of total PAH, total PCB, Pb, and Hg concentrations in Buffalo River sediments. Tables 2-2 through 2-5 provide a summary of the 2005/2007 and 2008 sediment chemical concentrations along the Buffalo River (by River Mile (RM)), in the Buffalo Harbor, in the City Ship Canal, and in the downstream end of Cazenovia Creek. The tables summarize the sediment concentrations for total PAHs, total PCBs, Pb, and Hg. For each of these chemicals, a summary of sediment concentrations is provided for sediment samples with a start depth of 0.0 feet (ft), and for sediment samples with a start depth equal to or greater than 0.5 ft.

Figures 2-3 through 2-6 present the distribution of sediment concentrations for total PAHs, total PCBs, Pb, and Hg based on an inverse distance weighting (IDW) interpolation of the of the 2005/2007 and 2008 surface sediment data. For IDW interpolation, subsurface samples were defined as any sample with a start depth greater than 1.0 ft.

2.2.1 Total PAHs

Total PAH sediment concentrations were determined by summing the concentrations of the 16 individual Target Compound List PAHs; for non-detect values, one-half the reporting limit was used to estimate PAH concentrations.

A summary of total PAH sediment concentrations, including minimum, maximum, and average concentrations, is provided in Table 2-2. Average total PAH concentrations were typically higher in the subsurface sediments compared to surface sediments across each RM segment. The highest average surface total PAH concentration was located in the Buffalo River at RM 4.0-4.5 (27 milligram per kilogram (mg/kg), sample size n=30). The geometric mean concentration in RM 4.0-4.5 was 12 mg/kg. The highest average subsurface total PAH concentration occurred at RM 4.5-5.0 (120 mg/kg, n=66; geometric mean of 14 mg/kg). The lowest average surface and subsurface total PAH concentrations were located at Cazenovia Creek (2.8 mg/kg, n=2) and at the mouth of Buffalo River, downstream of the AOC (3.8 mg/kg, n=3), respectively. The average surface total PAH concentration in the City Ship Canal was 21 mg/kg (n=59; geometric mean of 11 mg/kg), and the average subsurface concentration in the City Ship Canal was 25 mg/kg (n=55; geometric mean of 14 mg/kg).

2.2.2 Total PCBs

Total PCB sediment concentrations were determined by summing the concentrations of all detected individual Aroclors; for non-detect values, one-half of the reporting limit was used to estimate Aroclor concentrations for Aroclors 1242, 1254, and 1260 and a value of zero is assigned to non-detect values for all other Aroclors, which were detected in less than 5 percent (%) of the samples.

Average total PCB concentrations were typically higher in the subsurface sediments compared to surface sediments across each RM segment (Table 2-3). The highest average surface total PCB concentration was located in the Buffalo River at RM 4.0-4.5 (0.62 mg/kg, n=30; geometric mean of 0.13 mg/kg), while the highest average subsurface total PCB concentrations occurred at RM 5.0–5.5 (4.5 mg/kg, n=55; geometric mean of 0.19 mg/kg). The lowest average total PCB subsurface concentration was located at RM 5.5-6.0 (0.10 mg/kg, n=29; geometric mean of 0.061 mg/kg), and the lowest average total PCB surface concentration was located in Cazenovia Creek (0.038 mg/kg; n=2). The average surface total PCB concentration in the City Ship Canal was 0. 20 mg/kg (n=59; geometric mean of 0.13 mg/kg), and the average subsurface concentration in the City Ship Canal was 0.54 mg/kg (n=55; geometric mean of 0.19 mg/kg).

2.2.3 Lead

Average Pb concentrations were higher in the subsurface sediments compared to surface sediments across each RM segment (Table 2-4). The highest average surface and subsurface Pb concentrations within the Buffalo River were located at RM 4.5-5.0. Average surface and subsurface concentrations at RM 4.5-5.0 were 160 mg/kg (n=35; geometric mean, 59 mg/kg), and 390 mg/kg (n=66; geometric mean of 110 mg/kg), respectively. The lowest average surface Pb concentration is located in Cazenovia Creek (15 mg/kg, n=2), and the lowest average subsurface Pb concentration is located at RM 6.0 and 6.2 (29 mg/kg, n=2; geometric mean 28 mg/kg). The average surface sediment Pb concentration for the City Ship Canal is 130 mg/kg (n=59; geometric mean 68 mg/kg), and the average subsurface concentration is 160 mg/kg (n=55; geometric mean 97 mg/kg).

2.2.4 Mercury

Average Hg concentrations were higher in the subsurface sediments compared to surface sediments across each RM segment (Table 2-5). The highest average surface Hg concentrations within the Buffalo River were located at RM 3.5-4.0 (0.85 mg/kg, n=41; geometric mean, 0.22 mg/kg). The highest average subsurface Hg concentrations within the within the Buffalo River occurred at RM 1.5-2.0 (3.0 mg/kg, n=16; geometric mean of 0.92 mg/kg), and RM 4.5–5.0 (3.0 mg/kg, n=64; geometric mean of 0.43 mg/kg). The lowest average Hg surface and subsurface concentrations were located at RM 6.0-6.2. This segment of the Buffalo River had an average surface concentration of 0.023 mg/kg (n=13) and an average subsurface concentration of 0.077 mg/kg (n=2; geometric mean 0.043 mg/kg). The average surface Hg concentration in the City Ship Canal was 0.78 mg/kg (n=59; geometric mean of 0.37 mg/kg), and the average subsurface concentration was 3.2 mg/kg (n=55; geometric mean of 0.80 mg/kg).

2.2.5 AVS SEM

A subset of sediment samples (25 surface samples, 0–0.5 ft, and 20 sediment samples with a depth interval of 0.5–1.0 ft) were analyzed for acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) to assess the bioavailability of divalent metals (USEPA 2005b). If the molar concentration of AVS in a particular sediment sample exceeds the summed SEM molar concentration, then bioavailability related to the presence of divalent metals in pore water is likely to be low[1].

Results of the AVS SEM analysis showed that five of the 45 sediment samples had SEM concentrations greater than AVS (∑SEM-AVS is $\geq$0.0). An additional evaluation of organic-carbon normalized concentration of "excess" metals ([ΣSEM-AVS]/ fraction of organic carbon [f_{oc}]) was conducted for those five samples where SEM concentrations were greater than AVS, in accordance with USEPA (2005b) guidance. For four of the five samples, the concentration of excess metals was less than the USEPA's low-end threshold for effects of 130 micromole per gram organic compound (µmol/gOC) (USEPA 2005b). Only one buried subsurface sediment sample (RM 3.8) slightly exceeded the low-end threshold of 130 µmol/gOC, with a concentration of 133 µmol/gOC, but was well below the high-end threshold of 3,000 µmol/gOC, considered by the USEPA (2005b) likely to cause toxicity.

2.2.6 PAH and PCB Concentrations in Pore Water

In addition to the collection of whole-sediment samples, pore water was collected from a subset of 20 sediment samples (0–0.5 ft) and analyzed for pore water concentrations of parent and alkylated PAHs and PCB congeners. The pore water samples locations targeted a range of PAH and PCB concentrations in surface sediments from highest to mid-range concentrations based on the 2005/2007 sediment chemistry data. Results from pore-water sampling and analyses are used as a line of evidence to estimate the bioavailability of chemicals in the surface sediments[2].

A summary of PAH pore water concentrations in Buffalo River AOC is provided in Table 2-6. Thirteen of the 34 parent and alkylated PAHs, typically the higher-molecular-weight PAHs, were not detected in any of the 20 surface sediment samples. The remaining compounds were typically detected in less than half of the pore water samples. Parent and alkylated PAH concentrations in sediment and pore water and sediment total organic compound (TOC) concentrations were used to determine log sediment organic carbon–water partitioning coefficients (K_{OC}) values for each measured parent and alkylated PAH in pore water. A summary of the Buffalo River log K_{OC} for each compound is provided in Table 2-6. The experimentally-derived, site-specific log K_{OC} values from the Buffalo River, in general, show a greater partitioning of PAHs to sediments than what would be predicted by the USEPA Sparc Performs Automated Reasoning in Chemistry (SPARC) model (USEPA 2003).

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[1] It is acknowledged that representatives of NYSDEC have stated the agency does not fully accept the USEPA (2005b) method of metals equilibrium partitioning (EqP) to AVS. NYSDEC representatives also stated that in the presence of toxicity testing results, AVS SEM can be used to show metals are not causing toxicity (i.e., negative toxicity testing results and AVS SEM showing metals are not bioavailable), but the AVS-SEM approach is not yet considered acceptable by NYSDEC to exclude metals as causing toxicity in the absence of toxicity testing.

[2] It is acknowledged that representatives of NYSDEC have stated the agency does not fully accept the use of pore water analyses to support an estimate of chemical bioavailability in surface sediments.

The *SRIR* also reported Buffalo River sediment pore water PCB congener concentrations. For each pore water sample, concentrations of 52 individual PCB congeners were analyzed. A summary of pore water concentrations for the 52 PCB congeners is provided in Table 2-7. In general, pore water concentrations were higher for the lower molecular weight PCB congeners (di-, tri-, and tetrachlorophenyls) and lower for the higher molecular weight compounds (hepta-, hexa- and octachlorophenyls). The highest total PCB concentration (sum of all 52 congeners) measured in the pore water was at sample location 54 (RM 3.5-4.0), which had total PCB concentration of 13.5 nanograms per liter (ng/L), while all other samples had total PCB concentrations less that 3.8 ng/L, and 12 of the 20 samples had PCB congener concentrations less than 1.0 ng/L.

PCB congener concentrations in sediment and pore water and sediment TOC concentrations were used to determine log K_{OC} values for each PCB congener measured in pore water. A summary of the Buffalo River log K_{OC} values for each congener is reported in the Table 2-7. The log K_{OC} values tend to increase with an increase in the molecular weight of the compound, similar to the trend across PAH compounds. The log K_{OC} values calculated for the Buffalo River sediments are typically higher than values reported y Krauss and Wilcke (2001) who used spiking studies to determine log K_{OC} values.

2.3 Hydrodynamic Conditions and Sediment Stability

Three main tributaries, the Cayuga, Buffalo, and Cazenovia Creeks contribute flow to the Buffalo River. The Buffalo River flows through the southern part of Buffalo, New York, and discharges into Lake Erie The hydrodynamics of the Buffalo River are influenced by both the upstream watershed hydrology and the 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 river are more strongly influenced by Lake Erie seiche events, which can result a reversal of flows, creating a back-and-forth oscillation in the river. During high flow events (i.e., rain events or spring runoff conditions), tributary flows dominate the hydrodynamics of the river, with diminished influence from Lake Erie water seiche.

As part of the 2008 hydrodynamic and physical sampling and monitoring, long-term (six weeks) and short-term hydrodynamic and water quality measurements were collected at three transects in the Buffalo River; measurements included current velocity profiles, surface water elevation, turbidity, and temperature. Bathymetric and cross-channel current-velocity surveys also were conducted in the and along the downstream end of Cazenovia Creek. This information was used in the development and calibration of hydraulic and hydrodynamic models for the Buffalo River, including a three-dimensional Environmental Fluid Dynamics Code (EFDC) model, and a one-dimensional Hydraulic Engineering Center-River Analysis System (HEC-RAS) model. The HEC-RAS model was used to calculate changes in flood elevation and demonstrate potential flooding under various flow conditions and seiche events. The calibrated EFDC model provided three-dimensional velocity and shear stress distributions along the river over a range of flow conditions, thus highlighting in-channel areas that may be prone to erosion under high flow conditions.

2.3.1 Bathymetry

Hydrodynamic conditions of the Buffalo River are also influenced by river bathymetry. The bathymetry of the Buffalo River, downstream areas of Cazenovia Creek, and the City Ship Canal are presented on Figure 2-7. The bathymetric data presented in this figure is based on surveys conducted by USACE in 2007 and 2008 and the bathymetric surveys conducted as part of the fall 2008 hydrodynamic and physical monitoring.

The bathymetry of the Buffalo River AOC is dominated by the federally authorized navigational channel, which extends from the mouth of the river to approximately 1,500 ft downstream of the confluence with Cazenovia Creek. The navigation channel is generally maintained to authorized depths of 22 to 23 ft below the Low Water Datum, which is 569.2 ft above Mean Water Level (International Great Lakes Datum (IGLD) 1985), and includes approximately two-thirds of the cross-sectional area of the river. At the upstream end of the navigational channel (approximately RM 5.8), the water depth transitions from a depth to 22 ft to approximately 5 to 10 ft, near the confluence with Cazenovia Creek. The navigation channel in the City Ship Canal is also maintained to authorized depths of 22 ft to 23 ft below the Low Water Datum (569.2 ft), and extends approximately 1.0 mile from its confluence with the Buffalo River.

2.3.2 Flooding Potential

Simulations from the one-dimensional HEC-RAS model and information gathered from the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMs) show limited flooding is expected in the Buffalo River AOC under current conditions. Flooding is confined to low elevation areas, such as Smith Street Pocket Park located near RM 4.25. The Lake Erie 100-year flood elevation (580.2 ft NAVD 1988) controls the flood elevation on the Buffalo River for a distance of approximately 4.0 miles inland from the lake. At approximately RM 4.0, the riverine 100-year flood event surface-water elevation rises above 581 ft NAVD and controls the 100-year flood elevation along the river and along Cazenovia Creek from that point upstream. Near the junction of Cazenovia Creek and the Buffalo River, the September 2008 FIRM indicates that the Creek and River 100-year flood elevations do not extend far beyond the stream banks, with only moderate to low-risk shallow flooding occurring in this area.

According to the FEMA Flood Insurance Study (FIS) mapping, the entire AOC segment, as well as the lower portion of Cazenovia Creek, is a FEMA-designated floodway. For communities that participate in the Flood Insurance Program, development may occur in the 100-year floodplain fringe outside the floodway with certain minimum regulatory controls, but development activities within the floodway must result in no increase in 100-year water surface elevations without prior federal authorization (Code of Federal Regulations, Title 44, Section 60.3 (d)(3)).

2.3.3 Three-Dimensional EFDC Model and Assessment of Hydrodynamics

The three-dimensional EFDC model was developed to demonstrate three-dimensional velocity and shear stress distributions along the Buffalo River over a range of flow conditions, thus highlighting in-channel areas that may be prone to sediment armoring and erosion under high flow conditions. The EFDC model was calibrated with the velocity data collected along three transects of the river in fall 2008, and the calibrated model was run for a range of flow and seiche conditions, including several higher-flow conditions, to explore the potential range of velocities and bottom shear stresses in the AOC.

The data collected for model calibration show a smaller seiche-like effect within the navigational channel that is distinct (that is, having its own characteristic period) from the seiche of Lake Erie. The EFDC model accurately simulated measured current velocities and accurately predicted the influence of the seiches on velocities for the range of flow conditions monitored in 2008.

During low-flow conditions, downstream velocities do not exceed 5 centimeters per second (cm/sec) (0.16 fps), and shear stresses do not exceed 0.08 dynes per square centimeter (dynes/cm^2). However, the seiche can produce higher velocities than those induced by downstream flows; seiche velocities greater than 60 cm/sec were measured and predicted through much of the AOC. However, the peak seiche-induced velocities are not sustained for more than five minutes at a time, and instead oscillate through the channel. This oscillation, which occurs at a period of approximately 1.75 hours, was recorded in the field velocity monitoring data and was captured by the EFDC model.

Peak velocities and shear stresses associated with a moderate flow event (an estimated return period of slightly less than a year) are mapped on Figures 2-8 and 2-9, respectively. While the general magnitudes are similar to the peak seiche induced velocities, the distributions are different; the wet weather event has higher velocities in the upstream reaches of the AOC (above RM 5.0), where the seiche-induced velocities are attenuated. Higher velocities are seen in both cases at the narrowest downstream section, near the Buffalo Skyway Bridge and RM 1.0. In this location, the channel is somewhat deeper along the right bank (looking downstream), which is also on the inside of a relatively gradual bend, and the highest velocities and shear stresses are seen here.

A larger wet weather event corresponding to return a period of 10 years also was simulated. Under wet weather conditions like this, the flow of water overwhelms any potential for a reversal of flows cause by the lake seiche. The peak velocities and shear stresses from the 10-year event are mapped on Figures 2-10 and 2-11. The distribution of the highest velocities and shears are similar to the moderate wet weather event, although the values are higher. Peak velocities along the narrow reach between RM 1.0 and RM 2.0 exceed 200 cm/sec and shear stresses can reach 150 dynes/cm^2 in localized areas for the 10-year event.

2.3.4 Sediment Characteristics and Sediment Transport

Results from the 2008 sampling show that fine sediment grains (particle diameter less than 0.074 millimeter (mm)) dominated the composition of sediments in the Buffalo River AOC. Average composition of fine-grain sediments across half-mile increments ranged from 72.2 to 94.7%. In general, fine-grained sediments generally comprised a smaller fraction of the Buffalo River sediments with increasing distance from the river mouth, indicating the larger-sized particles deposit in the upstream reaches of the AOC while finer particles continue to deposit from the water column moving downstream toward the mouth of the river.

Model development focused on the prediction of hydrodynamics, allowing for water surface elevations, velocities, and river bottom shear stresses to be predicted. While explicit modeling of sediment transport has not been conducted, the hydrodynamic results provide insight into likely patterns of suspended solids deposition. Deposition, accretion, and sediment armoring is governed by velocities available to convey sediment and shear stresses that act to transport sediment. Because the channel is regularly dredged, the channel areas are maintained in a state of disequilibrium with respect to erosion and deposition, creating an environment that is generally depositional. Deposition will tend to be greater in areas that have been recently dredged, have lower velocities, and lower shear stresses.

Several historical studies have been conducted to assess the rate of sediment mass transport (sediment loading) into the lower Buffalo River and Lake Erie, and also to estimate rates of sediment accretion, or shoaling, within the dredged portion of the lower river (USACE 1988, USEPA 1994). These studies and historical dredge data provide relatively consistent independent estimates of the total sediment load to the lower Buffalo River ranging from 45,000 to 70,000 cubic yards (CY) per year, and provide a basis for a preliminary description of sediment transport in the Buffalo. The deposition of solids in the navigational channel will occur in two different ways: as suspended solids deposited from the water column, and as bedload progressing from the upstream end of the navigational channel. It is expected that bed load will make up a significant component of the total solids load transported to the river. In navigationally dredged systems like the Buffalo River, bed load deposition tends to be focused at the upstream limit of navigational dredging, and deposits in a focused “wedge” of relatively coarse materials. If allowed to proceed, this wedge of relatively rapid deposition moves the upper boundary of the navigational channel downstream with successive years of deposition. At the same time, deposition of finer suspended materials occurs at locations downstream, where the greater depths and slower velocities make conditions favorable for solids deposition.

2.4 Ecology

Ecological sampling conducted as part of the 2008 field investigation included aquatic habitat surveys, benthic community assessment surveys, fish community assessment surveys, and fish histopathology analysis. Results of the ecological sampling are being used to supplement the existing body of knowledge regarding current ecological conditions and to support multiple lines of evidence to support remedy selection and the consideration of possible habitat restoration.

2.4.1 Aquatic Vegetation

The aquatic vegetation survey conducted in August 2008 identified 29 Submerged Aquatic Vegetation (SAV) beds (23 in shallow water areas outside the navigation channel and 6 within the navigational channel). All SAV beds were represented by narrow linear fringing beds along shorelines within the AOC. The most upstream SAV bed was located 0.7 miles downstream of the confluence with the Cazenovia Creek. Eight species of SAV were identified: coontail (*Ceratophyllum dermersum*), Canadian waterweed (*Elodea canadensis*), American waterwillow (*Justicia americana*), Eurasian watermilfoil (*Myriophyllum spicatum*), curlyleaf pondweed (*Potamogeton crispus*), American pondweed (*Potamogeton nodosus*), sago pondweed (*Potamogeton pectinatus*), and wild celery (*Vallisneria americana*). Sago pondweed, wild celery, and coontail were the most common species found within the SAV beds. Substrate type within the identified beds was typically silt with clay.

The aquatic vegetation survey conducted in August 2008 resulted in the identification of 15 Emergent Vegetation (EV) stands (10 within the AOC, 4 within the navigational channel, and 1 outside the AOC). The most upstream EV stand was located 0.8 miles downstream of the confluence with the Cazenovia Creek. Only one EV stand was located within the Buffalo River, upstream of the AOC. This EV stand was located approximately 0.7 miles upstream from the confluence with Cazenovia Creek. Seven species of EV were identified: purple loosestrife (*Lythrum salicaria*), common reed (*Phragmites australis*), Japanese knotweed (*Polygonum cuspidatum*), broadleaf arrowhead (*Sagittaria latifolia*), softstem bulrush (*Scirpus validus*), broadleaf cattail (*Typha latifolia*), and pickerelweed (*Pontederia cordata*). Purple loosestrife, Japanese knotweed, and common reed were the most common species found in the EV stands.

2.4.2 Benthic Community Assessment

During the 2008 field investigation both sediment grab samples and Hester-Dendy artificial substrate samplers were analyzed as part of the benthic community assessment survey. Benthic community metrics were calculated separately for sediment grab and Hester-Dendy samples. Mean location-specific metric summaries for the sediment grab samples and Hester-Dendy samples are presented in Table 2-8 and 2-9, respectively. The *SRIR* provides a detailed discussion of the results for each sampling method in terms of individual metrics and combined metrics using NYSDEC (2002) and USEPA (1999) community assessment methods, which compare results to an unimpacted reference and urban watershed references, respectively. Overall, the results indicated the benthic community in the Buffalo River showed moderate to severe impairment when sediment grabs were compared to an unimpacted reference condition and slight to moderate impairment when Hester-Dendy samples were compared to an unimpacted reference (NYSDEC 2002). Cattaraugus and Tonawanda reference locations, which were selected to represent urban watershed conditions similar to the Buffalo River (excluding industrial influences) also showed moderate to severe impairment for sediment grab samples compared to the unimpacted reference and some areas of slight impairment for Hester-Dendy samples compared to the unimpacted reference (NYSDEC 2002). The Buffalo River results generally showed unimpacted to slight impairment for sediment grabs compared to the Cattaraugus and Tonawanda urban watershed references, and showed slight impairment to isolated moderate impairment for Hester-Dendy samples compared to these urban watershed references (USEPA 1999). A comparison of sediment grab metric and Hester-Dendy metric results for species/family richness indicates species richness is significantly higher in the Hester-Dendy samplers than those seen in the sediment grab samples. These findings show that organisms lacking habitat in fine grained sediment (i.e., organisms that are not typically sampled using the sediment grab approach) are present in the river but are not well represented in the sediment grab samples. These results are consistent with previous studies that focused on fine grained sediments and have not identified the presence of these species in the river (Diggins and Snyder 2003; Irvine et al. 2005.

Sampling with the Hester-Dendy provided insight into the benthic community structure that has not been generally considered in studies of the Buffalo River over time (e.g., Diggins and Snyder 2003; Irvine et al. 2005). The Hester-Dendy sampling results showed greater species and family diversity than measured in the sediment grab samples. Other metrics also showed more favorable community structure in the Hester-Dendy samplers than sediments. Differences between sediment grab and Hester-Dendy metric results are at least in part due to the fact that depositional areas included in sediment grab samples, are composed primarily of fine silts and sands mixed with organic matter. This type of substrate offers little diversity in benthic community habitat. Additional differences also may be due to the differences chemical exposures for the two sampling approaches. On the other hand, Hester-Dendy samplers provide a hard surface for organisms that otherwise preferentially use cobble and woody debris surfaces in the natural environment.

Percent dominance is another metric that is important to compare between sediment grab samples and Hester-Dendy samples, because it provides information about diversity of the benthic community. Past studies relying on sediment grab samples from the Buffalo River have demonstrated the majority of the benthic community is dominated by only a few tolerant species. The 2008 findings in sediment grab samples also show dominance by tolerant species, particularly at RM 4.75 where the highest percent dominance by tolerant species was seen from any grab sample. As to be expected based on the species and family richness results, the percent dominance by tolerant species was lower in many of the Hester-Dendy samplers compared to corresponding sediment grab samples collected in the vicinity of the Hester Dendy samplers.

Results of the chironomid mouthpart deformities analysis showed that all of the locations sampled had deformities within the range of deformities seen at reference locations. Hester-Dendy samplers showed lower chironomid deformities than seen in sediment grab samples. There were no apparent trends in deformities within the 2008 data sets, but it is notable that the overall percentages of mouthpart deformities were lower than the 54% deformities reported by Irvine et al. (2005) for samples collected in 2003/2004. Results from the 2008 study show that reference locations, such as Cattaraugus Creek, can have up to 15% deformities, and the majority of locations typically fell below that percentage with one exception at RM 2.1, which had 33% deformities.

The urban, industrialized, and channelized nature of the river, the high degree of siltation, and the lack of riparian vegetation at many locations, create an altered physical habitat that likely influences the structure, abundance, and diversity of benthic macroinvertebrate communities. The 2008 results indicate that benthic habitat is fairly similar between the Buffalo River and the reference sites. The results of the 2008 sampling and the similarity between the Buffalo River and the reference sites give insight into the extent to which habitat quality contributes to the benthic community structure seen in the sediment grab samples.

2.4.3 Fish Community Assessment

Fish community sampling conducted in 2008 provided taxonomic information on the population and community structure of Buffalo River and Cazenovia Creek, as well as information on the pre-remediation conditions. Fish communities were evaluated within five locations in Buffalo River and one location in Cazenovia Creek, upstream of the AOC. During the 2008 fish community survey, a total of 23 distinct species were collected by electroshocking. Seining was only conducted at one upstream location (RM 7.25) and resulted in the collection of six species. A list of the fish caught at each location is presented in Table 2-10. Eleven species were collected on the Buffalo River at the three locations upstream of the AOC (RM 6.25 to RM 7.5), while 13 species were collected in the Buffalo River at the two locations within the AOC (RM 4.5 and RM 5.5). The one electroshocking location on Cazenovia Creek (CC) resulted in the collection of 12 species. Calculated metrics for the fish community at each sampling location within the Buffalo River and Cazenovia Creek are presented in Table 2-11.

Fish collected during the fish community survey generally exhibited healthy characteristics. However, a small portion did exhibit some abnormalities. Approximately 2% of the fish collected during the fish community assessment showed evidence of external deformities, eroded fins, lesions, and tumors (DELTs), as described by Ohio EPA (1987). Spatially, the locations within the AOC were observed to have a slightly higher incidence of fish with DELTs (4%) compared to the locations upstream of the AOC

(1%). A summary of the DELTs observed in the fish collected during the fish community assessment is presented in Table 2-12.

2.4.4 Brown Bullhead Histopathology Assessment

The prevalence of liver tumors and external lesions has been assessed in brown bullheads collected from the Buffalo River AOC for several decades, including a study conducted in 2008 and reported in Lauren et al. (2010). Lauren et al. (2010) reported that the prevalence of liver neoplasms in brown bullhead form the Buffalo River has shown a chronological decrease since the 1980s. In 1983-1986 Black and Baumann (1991) reported a 5.5% incidence of hepatocellular neoplasia and an 11.1% incidence of “bileductular” neoplasia, (which combined equal 16.6% total liver tumors). In 1988, Baumann et al. (1996) reported a 5% incidence of “malignancies” and a 19% incidence of “neoplasms” (which combined is 24% total liver tumors). Results of the 2008 histopathological evaluation are provided in Table 2-13. In summary, a total of three of the thirty-seven fish (i.e., 8.1%) collected from the Buffalo River contained hepatic neoplastic lesions. One tumor was found in each of the river reaches evaluated.

2.5 Findings Supporting Remedy Evaluation

2.5.1 Chemical Concentrations in Sediment

Results of the 2005, 2007, and 2008 sediment sampling and analysis were combined to demonstrate the lateral and vertical distribution of chemical concentrations in the Buffalo River, City Ship Canal, and Cazenovia Creek including total PAHs, total PCBs, Hg and Pb. These results are used to identify areas that have sediment chemical concentrations exceeding the risk-based RGs identified in Section 3 of this *FS*. This information was used to develop the sediment remedial alternatives outlined in Section 5, and will inform the selection of the most appropriate remedial alternative on an area-specific basis.

Results of these studies show that surface sediment concentrations for all four chemicals are typically lower than subsurface concentrations. This trend is clearly demonstrated in the vertical profiles provided for each chemical along the Buffalo River and City Ship Canal. In addition, Tables 2-2 through 2-5 show that the average and geometric mean concentrations for each half-mile segment of the Buffalo River and the City Ship Canal are typically greater for subsurface samples as compared to surface samples for total PAHs, total PCBs, Pb, and Hg. The reduced chemical concentration in the surface sediments of the Buffalo River AOC is likely due to the more recent and ongoing deposition of sediments with decreasing chemical concentrations over time. The Buffalo River AOC is a depositional environment, and sediments with low chemical concentrations originating from upstream of the AOC have likely been transported and deposited within the AOC, creating a surface layer with lower chemical concentrations as compared to the subsurface sediments.

2.5.2 Hydrodynamics and Sediment Transport

Based on the present knowledge of hydrodynamics and sediment transport, the river can be subdivided into distinct reaches with unique characteristics. Other factors that support subdivision of the river into distinct reaches include river morphology, cross-sectional and navigational channel configuration, shoreline characteristics, and contaminant levels. Table 2-14 provides a simplified subdivision of the

AOC into river reaches with distinct physical characteristics, and corresponding differences in chemical distributions. In summary, an assessment of the relevant physical and chemical characteristics by reach shows the following:

- The *mouth reach (RM 0-1)* is shallower and broader than other reaches, with a defined navigational channel and adjacent shoulders. Because of the moderating effect of the lake, this reach is relatively slow moving and sees relatively low stresses on the bottom sediments, even during high flow event conditions. Consequently, the mouth reach sediments contain a high proportion of fines, much of which may be lacustrine in origin. However, the mouth of the Buffalo River also experiences more boat traffic compared to other reaches in the river, which may contribute to erosion in boat traffic areas. Observed contaminant levels in this reach are generally lower than in other reaches, possibly due to dilution of historically deposited contaminants by lake-derived sediments.

- *RM 1-2* is a much narrower and generally deeper reach, with steeper side slopes and narrow shoulders. Under high flow conditions, velocities in this reach are elevated relative to other reaches, and stresses exerted on the bottom sediments are also correspondingly high. The effect of these elevated flows and stresses is apparent in the sediment type, which shows a higher proportion of gravel than other reaches, likely due to local armoring of the sediments to the stresses of high flow events. This reach is minimally depositional due to its high energy environment. Contaminant levels in this reach are low to moderate, due to the limited potential for deposition in the reach.

- *RM 2-3.5* is the lower of two highly sinuous reaches of the AOC. In this reach, water depths vary significantly with location along the major bends of the reach, and also laterally, with indications of point bar formation in lower energy areas and bathymetric depressions in other areas. Flow velocities are moderate in this reach and bottom stresses created by flow events are variable, with some areas of high stress. Consequently, sediment type is also variable, but still shows a high proportion of fines, some sands, and gravels in areas of elevated stress. Some net deposition of sediments occurs in this reach, primarily in the upper half as indicated by historical dredging activities by the Army Corps of Engineers. Moderate levels of contaminants in this reach appear to be associated with historical sediment deposition in the area.

- *RM 3.5-5* is similarly sinuous to the preceding reach, again with highly variable water depth and bar formation consistent with a highly sinuous morphology. Flow velocities and corresponding levels of bottom shear stress are lower than the neighboring downstream reach, resulting in a more limited occurrence of armored sediments (gravels) and a more generally depositional environment. Due to its closer proximity to the upper river source of sediments, this reach appears to receive a greater proportion of settled sediment and bed load than the downstream reaches, as evidenced by the high fraction of fine sands in the reach and the need for extensive navigational dredging throughout. The higher rates of deposition in this reach correspond with generally elevated contaminant levels.

- The *upper reach (RM 5 – upstream terminus of dredging)* is a return to a lower sinuosity with a defined navigational channel and distinct shoulders, and a predominantly engineered shoreline. Velocities in this reach are low to moderate through the range of flow events, and bottom shear stresses are low relative to other reaches in the AOC. Consequently, the high proportion of sands found in this reach is not due to armoring of the bed, but rather to deposition of bed load material delivered from the upstream, undredged portions of the river and tributaries. A higher frequency of maintenance dredging at the upstream end of the navigation channel may contribute to moderate chemical concentrations in this reach of the river.

The distinct characteristics of the reaches described above suggests selected sediment remedy alternative will need to be based on an understanding of the range of hydrodynamic conditions and sedimentation environments operating in the Buffalo River AOC, and their implications for long-term sediment stability and remedy effectiveness.

2.5.3 Ecology

Ecological findings from the 2008 field investigation, in addition to a wide range of historical ecological studies conducted on the Buffalo River over the last few decades, are relevant to the context of this *FS*. Results of these studies begin to provide a baseline for ecological conditions within the Buffalo River AOC with respect to aquatic vegetation, benthic communities, and fish communities, which are used in the evaluation of short-term and long-term effectiveness for each remedy. For example, benthic invertebrate sampling and analysis supports an understanding of existing conditions of resident assemblages within the AOC as well as within locations upstream of the AOC and in two reference areas. Although this effort is not an effective means to assess the level of sediment contamination within the AOC, it facilitates the identification of expected and reasonable remediation endpoints and provides information on the presence of taxa that could potentially colonize the Buffalo River AOC. The physical conditions of the Buffalo River AOC, including the urban, industrialized, channelized nature of the Buffalo River (and the other water bodies), the high degree of siltation in all water bodies, and the lack of riparian vegetation at many locations, can be factors, among others, that limit the diversity of benthic macroinvertebrate communities. Furthermore, the analyses show that the benthic habitat is somewhat homogeneous in the Buffalo River and fairly similar to the reference sites. These results indicate that habitat quality may be a factor determining the benthic community structure seen in the sediment grab samples. These results also demonstrate that with limited exceptions, habitat conditions are consistent among sampling locations and there are no particularly optimal habitat locations (based on physical conditions) identified as part of the benthic community assessment.

In addition to characterizing current conditions for the Buffalo River AOC, an evaluation of results from historical Buffalo River studies along with ecological data collected in 2008 demonstrate potential changes in biological communities over time. For example, the 2008 fish population and community data were compared to results from historical studies including Irvine et al (2005) and Greer et al (2002). Using the 2008 fish population and community data, index profile values (NYSDEC 2002) and Index of Biotic Integrity (IBI) scores (Irvine et al. 2005) were calculated. Irvine et al. (2005) calculated IBI scores, based on 2003/2004 fish community data, for several locations within Buffalo River – three of these locations correspond to 2008 fish community sampling locations at RM 4.5, RM 5.5, and RM 6.25. In 2003/2004, IBI scores indicated that the Buffalo River fish community at locations RM 5.5 and RM 6.25 was very poor. In 2008, IBI scores at these same locations improved to a poor to fair rating. Similarly, in 2003/2004, the IBI score at RM 4.5 indicated that the quality was poor, whereas in 2008, the quality improved to fair at this same location. However, Greer et al. (2002) calculated IBI scores for several locations within Cazenovia Creek, one of which corresponds to the 2008 fish community sampling location (CC). The IBI scores calculated for Cazenovia Creek indicate that the quality has remained the same (poor rating) from 1999 to 2008. Because IBI scores are only available for two fish community surveys, additional surveys may be warranted to further validate trends in the quality of the fish community. Additionally, recent peer-reviewed publications indicate that the fish community in the Buffalo River AOC is improving. For example, Lauren et al. (2010) found that the prevalence of liver neoplasms in brown bullhead form the Buffalo River has shown a chronological decrease since the 1980s and states that the prevalence is at or near that reported in “recovery stage” AOCs across the Great Lakes.

Results of the historical and 2008 ecological studies along the Buffalo River AOC, historical toxicity studies and risk assessments, and the delineation of sediment chemical concentrations throughout the Buffalo River AOC have also contributed to the evaluation of the potential risks to benthos, fish, and wildlife communities associated with sediment contaminants in the Buffalo River. The assimilation of this information has led to the development of site-specific remedial target chemical concentrations in sediment that are protective of ecological communities, which have in turn driven the development of remedial alternatives for the Buffalo River AOC. The methods and data used to derive the site-specific sediment RGs are further detailed in Section 3 and Appendix A.

3 REMEDIAL ACTION OBJECTIVES AND GOALS

The development of RAOs and 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 FS 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.

Potential COCs in the Buffalo River sediments were identified based on results of a screening-level ecological and human health risk assessments (SulTRAC 2007a, b). Geostatistical analyses of the potential COCs (arsenic, cadmium, chromium, copper, Pb, Hg, total PAHs, total PCBs, benzo(a)pyrene, benzo(a)anthracene, DDT, and gamma chlordane) were conducted were used to identify indicator chemicals for the river that could be used to streamline the remedial investigation (RI) and FS processes, with the intention that, by addressing risks associated with the indicator chemicals, the FS remedy would, in turn, address the risks posed by the full suite of potential COCs (CSC 2007).[3] The indicator chemicals identified by USEPA include total PAHs, total PCBs, Pb, and Hg.

Based on results of the SulTRAC (2007b) risk assessment, the 2008 Buffalo River field investigation (ENVIRON et al. 2009), the USACE (2009a) toxicity study, and site specific risk analyses (Appendix A), the PCT developed RGs for the four indicator chemicals; the PCT returned to the other seven chemicals by evaluating their respective post-remedy residual concentrations (Appendix C). For the purposes of this *FS*, RAOs and supporting goals are presented in Section 3.1 and RGs are discussed in Section 3.2.

3.1 Remedial Action Objectives and Supporting Goals

The RAOs for the Buffalo River AOC were developed by the GLLA PCT RAO subgroup. Multiple project objectives were selected to address the goals identified by the PCT. These objectives were then consolidated and prioritized into RAOs (Table 3-1) for the remediation of Buffalo River AOC sediments.

The RAOs and supporting goals were related to the Buffalo River AOC BUIs identified in the Remedial Action Plan (BNR 2008) whenever possible (Table 3-2). It is recognized that a number of factors unrelated to chemical concentrations in sediments contribute to BUIs. The Buffalo River BUIs likely will not be delisted solely based on this sediment remediation project due to the presence of other stressors. However, the status of the BUIs is likely to improve following remedy implementation. RAOs that address multiple BUIs were considered to be of higher priority than those that addressed fewer BUIs.

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[3] Appendix C includes the technical memorandum titled *Seven Additional Chemicals of Potential Concern*. This memorandum delineates post-remedy residual concentrations for arsenic, cadmium, chromium, copper, benzo(a)pyrene, benzo(a)anthracene, DDT, and gamma chlordane (i.e., the seven COCs not included with the four indicator COCs), to demonstrate that the preferred remedy also is protective of the seven additional COCs.

3.1.1 Remedial Action Objectives

The RAOs for this project are as follows:

RAO 1: *Reduce human exposures for direct sediment contact and fish consumption from the Buffalo River by reducing the availability and/or concentration of COCs in sediments.*

Sediment remedies will be evaluated for their ability to reduce long-term human health risk at the site. To the extent that sediment contaminants contribute to Buffalo River AOC BUIs associated with human health, achieving this RAO will contribute to the improvements associated with the following BUIs:

- Restrictions on Fish & Wildlife Consumption
- Tainting of Fish & Wildlife Flavor

Sport fishing advisories exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). NYSDOH issues advisories on eating sport fish and game because some of these foods contain chemicals at levels that may be harmful to health. When reviewing fish contaminant data to derive fish advisories, NYSDOH considers the fish contaminant levels and fish physical characteristics, health risks and health benefits, populations at greater potential risk, US Food marketplace standards, and risk communication issues. For this *FS*, it is assumed that the current fish advisories will be used in conjunction with other remedial actions in the Buffalo River.

Current concentrations of Hg and Pb in fish have not led the State to list Hg or Pb in their fish consumption advisories. These current conditions are considered closely in the *FS*, so that the remedial action does not result in significant long term increases in average surficial concentrations of Hg and Pb.

RAO 2: *Reduce the exposure of wildlife populations and the aquatic community to sediment COC concentrations that are above protective levels.*

This RAO addresses ecological exposures based on COCs in sediment. Therefore, the NCP criteria that address remedy short-term and long-term effectiveness as well as reductions in toxicity, mobility, and/or volume of sediments will impact this RAO. Remedy evaluation should consider not only long-term risk reduction associated with reduced human and ecological exposure to chemicals in sediment, but also short-term risks introduced by implementing a remedy alternative (USEPA 2005a).

To the extent that sediment contaminants contribute to Buffalo River AOC BUIs, achieving this RAO will contribute to the improvements associated with the following BUIs:

- Degradation of Fish & Wildlife Populations
- Fish Tumors and Other Deformities
- Bird or Animal Deformities or Reproductive Problems
- Degradation of Benthos
- Loss of Fish & Wildlife

Achieving this RAO will help reduce toxicity associated with Buffalo River sediment COC exposure to biota, and will reduce the potential for fish tumors and deformities, to the extent they occur due to exposure to sediment COCs within the Buffalo River. Evaluation of this RAO would include monitoring of surficial sediment following remedy implementation to assess changes in residual contamination and possible recontamination, as well as monitoring of biota and ecological recovery. Sediment remedies that result in an unacceptable increased ecological risk relative to pre-remedy conditions should be avoided, particularly those that negatively impact BUIs associated with ecological receptors, such as remedies that contribute to the "Loss of Fish and Wildlife Habitat."

RAO 3: *Reduce or otherwise address legacy sediment COC concentrations to improve the likelihood that future dredged sediments (for routine navigational, commercial, and recreational purposes) will not require confined disposal.*

This goal applies to sediment COCs within the AOC at the time of remediation and does not include new or on-going sources of contamination within the watershed. The goal of this RAO is to achieve, in the future, quality of dredged material to allow either open lake placement or beneficial use in a Brownfield or other setting, so that confined disposal facility (CDF) disposal is no longer required for routine dredging. Achieving this RAO will contribute to the improvements associated with the following BUI:

- Restrictions on Dredging

RAO 4: *Implement a remedy that is compatible with the Buffalo River Remedial Advisory Committee's goal of protecting and restoring habitat and supporting wildlife.*

The Buffalo River GLLA PCT will work to implement a remedy in a manner that is consistent with the Remedial Advisory Committee's goal of protecting and restoring habitat and supporting wildlife. The Buffalo River AOC remediation is intended to improve specific BUIs, which may have a direct impact on the Buffalo River Remedial Advisory Committee's remediation, restoration, and delisting activities. The following BUIs that will be affected:

- Degradation of Fish and Wildlife Populations
- Loss of Fish and Wildlife Habitat
- Degradation of Benthos

3.1.2 Supporting Remedial Selection Goals

Supporting goals are intended to provide an overarching framework to be considered during the assessment of remedial alternatives. These are goals that will be integrated into the evaluation and selection of remedy alternatives; however they will not be used to assess project performance. Rather they will provide supplemental information to provide regional and ecosystem context for this remedial project. The supporting goals include the following:

Supporting Goal 1: *Reduce the long-term potential of COC contaminated sediments to migrate outside of the Buffalo River AOC.*

Although the RAOs will address sediment COC concentrations within the AOC, this supporting goal is intended to reduce potential off-site migration of sediment COCs that may occur during remedy implementation.

Supporting Goal 2: *Implement a sediment remedy that is compatible with and complements ongoing regional redevelopment goals, upland remediation, and restoration activities.*

The remedy should contribute to and build off of existing and planned restoration activities for the AOC. Furthermore, the sediment remedy should not interfere with remedy activities currently underway by other regional groups and agencies, and should not jeopardize the integrity of existing on-site containment structures. Remedy components that could impact ongoing activities include on-site transportation, logistics, site staging, contaminated sediment and water management, dewatering, removal of sediments immediately adjacent to the slurry wall and other waterfront areas, and other construction related activities.

3.2 Remedial Goals

The Ecology Subgroup (Eco-Group) of the GLLA PCT collaborated on efforts to identify RGs that are protective of ecological receptors, for use in this *FS*. RGs were established for the four indicator chemicals (i.e., PAHs, PCBs, Hg, and Pb) identified by USEPA for Buffalo River in sediments (CSC 2007). NYSDEC numerical screening guidance values were used as initial preliminary remediation goals (PRGs) and site-specific RGs were developed using multiple lines of site-specific evidence, including results of the USACE 2005 toxicity tests (USACE 2009a), literature, and a variety of comprehensive analyses performed by the Eco-Group. The RGs were identified and documented by the Eco-Group in a series of memoranda developed collectively based on Eco-Group meetings, literature reviews, and USEPA and NY State guidance. A compilation of these memoranda are provided in Appendix A. The RGs were derived using a variety of site-specific lines of evidence, as identified in detail in Appendix A and briefly discussed in this section.

The RGs developed by the Eco-Group also were reviewed by the PCT Human Health Group to compare eco-risk derived RGs to human health risk reduction goals (see Appendix B). In all cases, the eco-risk derived RGs satisfied the Human Health risk reduction goals.

The RGs provide numerical goals for sediments that were used to develop and design the sediment remedy alternatives to reduce ecological and human exposures to sediment chemicals and to achieve the RAOs.

The RG development process involved transparent, scientific collaboration among stakeholders, wherein electronic calculation files were widely distributed and reviewed. Throughout this process, input from various stakeholders was incorporated both quantitatively and qualitatively. NYSDEC-designated criteria for wildlife and fish tissue were incorporated into the criteria when applicable. A single site-specific RG was developed for PAHs and ranges of site-specific RGs[4] were developed for PCBs, mercury, and lead. The RGs discussed below reflect the range of site-specific values identified by various stakeholders

[4] NYSDEC screening numerical guidance values are provided in Appendix A; the range and averages discussed herein reflect site-specific RGs.

within the Eco-Group. While the lower end of the site-specific range is typically presented in this *FS* with regard to all remedy alternatives, it is noted that average and/or upper values within these ranges are considered by USEPA GLNPO to be equally protective of wildlife within the river for numerous reasons described in Appendix A. The single value surface-weighted average concentration (SWAC) RGs provided for lead, mercury, and PCBs for this *FS* fall within the range of SWAC RGs determined by the Eco-Group. The following general statements can be made regarding the site-specific RGs for each of the four Buffalo River indicator chemicals:

- **Total PAHs:** The RG for PAHs is to reduce sediment exposures to below a PAH toxicity unit (TU) of 1. A PAH TU of 1 equates to 16 mg/kg in Buffalo River sediments. The RG developed for total PAHs is based on the USEPA's (2005) Equilibrium Partitioning Approach using multiple data sets, including sediment toxicity testing with and without toxic responses, and site-specific K_{OC} values. It also includes evaluation of USEPA's target lipid model approach using bioaccumulation data developed by the USACE.

- **Total PCBs:** The RG for PCBs is to achieve a surface-weighted average concentration (SWAC) for PCBs equal to or below a 0.20 mg/kg. The range of RGs for PCBs s identified by various stakeholders within the Eco-Group was from 0.18 to 0.44 mg/kg (with an approximate mean of 0.3 mg/kg). The lower end of this range in based on a PCB PRG calculated from an extrapolation from the Theoretical Bioaccumulation Potential (TBP) model, an established USACE mathematical bioaccumulation model for benthic organisms. This model used site-specific data and a Great Lakes Water Quality Agreement criterion to determine a level of total PCBs in fish that would be protective of fish eating birds and mammals. An additional risk-based evaluation using site-specific fish tissue data, and using NYSDEC and USEPA fish tissue criteria considered protective of piscivorous wildlife, was conducted (Appendix A).

- **Mercury:** Recently sampled fish tissues from the river have chemical concentrations that are well below the NYSDEC and USEPA fish tissue criterion for mercury, as described in Appendix A. Maximum fish tissue concentrations are approximately half the NYSDEC and USEPA criterion of 0.5 mg/kg, and average concentrations (i.e., those most relevant to wildlife exposure) are approximately an order of magnitude lower than the NYSDEC/USEPA criterion. A RG was identified for consideration in the *FS* so that remedial options could be evaluated against current conditions, and as to whether they might result in elevated SWACs beyond levels currently measured. On this basis, the RG for mercury is to achieve a SWAC equal to or below 0.44 mg/kg. The range of RGs for mercury identified by various stakeholders within the Eco-Group range was 0.43 to 0.54 mg/kg (with an average of approximately 0.5 mg/kg). This RG is considered highly protective, considering how much lower current fish tissue conditions exist compared to the NYSDEC/USEPA fish tissue criterion and the fact that the lower end of the range is derived from a very conservative data management approach.

- **Lead:** Based on recently sampled fish tissue from the river, lead concentrations are below the NYSDEC fish tissue criteria for wildlife, and are below the USEPA threshold[5] considered protective of wildlife, as discussed in Appendix A. In general, sediment toxicity testing results that showed no toxicity associated with Buffalo River sediment (Appendix A). A RG was identified for consideration in the *FS* so that remedial options could be evaluated against current conditions, and as to whether they might result in elevated SWACs beyond levels currently measured. On this basis, the RG for lead is to achieve a SWAC equal to or below 90 mg/kg, which is reflective of current average

[5] USEPA hazard quotient of 1.

surface conditions in the river. This RG value is considered protective given that current conditions do not pose adverse risks to fish and wildlife, the fact that the lower end of the range is derived from a very conservative data management approach, and that the RG is above the observed basin background input concentration UPL of 42.4 mg/kg (new basin inputs will therefore not adversely affect the long-term goals for lead).

The site-specific RGs established for total PAHs, Pb, Hg, and total PCBs apply to surface sediments, which are defined as sediment depths beginning at the sediment / water interface and extending 1 foot below the sediment surface (i.e., 0 – 1 ft depth). The upper 6 inches is commonly considered the biologically active zone in Great Lakes freshwater sediments. The vast majority of sediment-dwelling macroinvertebrates occur in the upper 6 inches (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. Recognizing that a site-specific analysis of the biological active zone has not been performed for the Buffalo River, the RGs are applied to sediments in the upper 1 ft (i.e., upper 12 inches).

For the purposes of this *FS*, SWACs are calculated over an area of 1/3-mile segments, across the width of the river. The site-specific SWAC RGs established by the Eco-Group for total PCBs, Pb, and Hg, were developed to be protective of piscivorous wildlife. Thus, fish life history information was considered in determining appropriate SWAC areas. Although many of the fish that inhabit the Buffalo River have large home ranges, non-specific home ranges, or are opportunistic in their use of the river, for the purposes of this *FS*, small home range fish species and life stages were evaluated. By using the shortest fish range reported, this constitutes a highly conservative approach that is consistent with our understanding of fish behavior in the river, and is adequately protective of ecological and human receptors. The details of this evaluation are presented in the Technical Memorandum, *Rationale for SWAC Areas for the Buffalo River AOC,* provided in Appendix C[6].

The timeline under which the Buffalo River site-specific RGs are expected to be achieved is dependent on the remedial technology that is selected. For example, a sediment cap may achieve reduced surface sediment chemical concentrations shortly following remedy implementation, while dredging often relies, in part, on natural deposition to meet RGs due to the deposition of dredge residuals. Long-term monitoring of surface sediment (0–1 ft) chemical concentrations will be conducted at Year 2 following the completion of the remedy. The target is to achieve the site-specific total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs at the 2-year review. An evaluation of the surface sediment chemical concentrations at the 2-year monitoring period will be used to demonstrate the extent to which the RGs have been achieved. Additional chemical monitoring may be conducted at Year 5, depending on the results of the Year-2 monitoring and the need for additional action.

[6] Representatives of NYSDEC expressed concern that measuring 1/3-mile SWAC areas across the width of the river has the potential to dilute elevated point concentrations of Pb, Hg, or total PCBs along the river banks. Per the request of NYSDEC, post-remedial SWACs were calculated based on 1/3-mile SWAC areas divided by the left bank, right bank, and navigation channel. The results of this SWAC analysis, presented in Appendix C, demonstrated that calculating SWACs across of the Buffalo River and City Ship Canal does not dilute elevated surface sediment chemical concentrations along the banks to the extent that elevated deposits are being ignored that would otherwise be captured by dividing the river to separate bank areas and the navigation channel.

4 SCREENING OF AVAILABLE SEDIMENT REMEDY TECHNOLOGIES AND PROCESS OPTIONS

The technology and process screening approach described in this section is consistent with USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (1988), and the technologies screened are consistent with USEPA sediment remediation guidance (USEPA 1998, 2005a). Technologies and process options that do not achieve the criteria of safety, effectiveness, and implementability, or do not meet the RAOs specified in Section 3, are eliminated from further consideration for the purposes of this *FS*.

General response actions (GRAs) are broad categories of possible sediment remedy actions such as containment, removal, treatment, disposal, or combinations of these actions. The following GRA categories were identified to address the Buffalo River sediments:

a) No action

b) Institutional controls

c) Natural recovery

d) Sediment capping

e) Sediment removal

Table 4-1 lists the range of possible sediment remediation technologies and process options associated with each of the categories above. Effectiveness, implementability, and cost are the major criteria considered as part of the initial screening:

- *Effectiveness* is evaluated based on the ability of the technology or process option to meet the RAOs, 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 the Buffalo River. 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 negative impact to community residents, 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.

- *Implementability* encompasses both the technical and administrative feasibility of implementing a technology or process option. This includes the ability to obtain necessary permits, equipment, and labor to implement the remedy; and industry experience in implementing the remedy.

- *Costs* for each option are estimated as to whether they are low, moderate, or high. For this section, costs are based on engineering judgment and available historical information associated with each option. In many cases, more efficient and cost-effective remedies can accomplish the same result or can outperform less efficient, more costly remedies.

4.1 No Action

The No Action GRA is required by the NCP as the baseline case to which all other response actions and alternatives are compared.

4.1.1 Applicability to the Buffalo River

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 Buffalo River site conditions as they exist. No Action may be appropriate if a site currently meets the all of the RAOs or if a previous response (e.g., ongoing upland remedial activities and source control) eliminates the need for further action.

4.1.2 Screening Criteria

- *Effectiveness.* This response would not change baseline sediment conditions reported in the *SRIR* (ENVIRON et al. 2009), except for changes that occur naturally. Construction hazards and health risks to remediation workers and residential communities 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 remedial targets developed for the increased protection of ecological and human health would be left in place in both surface and subsurface sediments.

- *Implementability*. Because no action is taken, this response is readily implementable.

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

4.1.3 Screening Results

No Action is retained for further evaluation to serve as a baseline for comparison with other response actions as required by the NCP.

4.2 Institutional Controls

Institutional controls are documents, informational devices, and legal restrictions that minimize, limit, or prevent potentially unacceptable exposures to contaminated media. The use of institutional controls can reduce risks associated with complete ecological and human health exposure pathways by limiting the amount of direct contact with contaminated sediments. Institutional controls may include waterway use restrictions (i.e., no-dredging areas or no-anchoring areas), fish consumption advisories or bans, use of permitting processes (i.e., Section 404 permits), and deed restriction/environmental easements or notices. Existing NYSDOH public health advisories are in place for the Buffalo Harbor and River; supplemental fish advisories may be employed to reduce exposures to organic and inorganic chemicals, similar to these existing advisories (NYSDOH 2009).

4.2.1 Applicability to the Buffalo River

Sport fishing advisories exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). These restrictions will likely be maintained by NYSDOH until such time that the criteria for delisting are attained. Current concentrations of mercury in fish have not led the state to list mercury in their fish consumption advisories. For this *FS*, it is assumed that the current fish advisories will be used in conjunction with other remedial actions at the Buffalo River.

Currently permits are required for dredging, filling, or other construction activities along the Buffalo River AOC. The USACE administers Section 404 of the Clean Water Act, which requires that a permit be obtained for the discharge of fill or dredged material in waters of the United States. Under Section 401 of the Clean Water Act, NYSDEC must certify that proposed Section 404 discharges comply with State water quality standards. The USACE also administers Section 10 of the Rivers and Harbors Act, which requires that a permit be obtained for dredging and other activities in navigable waters. These permits requirements may be used as effective institutional controls for construction in and adjacent to the Buffalo River AOC.

4.2.2 Screening Criteria

- *Effectiveness.* Institutional controls may supplement other engineering controls or response actions during development and evaluation of the remedial alternatives.
- *Implementability.* This response action is readily implementable.
- *Cost.* Only administrative actions would be taken for this response action; therefore, capital and Operations and Maintenance (O&M) costs would be very low.

4.2.3 Screening Results

Institutional controls are not retained as a sole remedy, but may be evaluated as components of other remedial alternatives.

4.3 Monitored Natural Recovery

Monitored natural recovery (MNR) involves leaving contaminated sediments 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 (e.g., off-channel areas such as river banks and turning basins), chemical transformation (e.g., chemical reduction), and sequestration and stabilization (e.g., the precipitation of metals and hydrophobic chemical partitioning, and corresponding reduced bioavailability and risk).

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.

4.3.1 Applicability to the Buffalo River AOC

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 Buffalo River AOC contribute to the ongoing natural recovery of the Buffalo River sediment and ecology. This *FS* assumes that additional source recovery measures, if needed, will be implemented before implementing the final remedy.

Natural sedimentation and mixing can create a surface sediment layer with lower chemical concentrations through the physical burial of contaminated buried 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. At the Buffalo River AOC, historically reduced surface sediment concentrations provide the strongest evidence of natural recovery via sedimentation and contaminant burial. The *SRIR* (ENVIRON et al. 2009) reported lower surface sediment concentrations compared to buried concentrations for all four indicator chemicals (PAHs, PCBs, Hg, and Pb). Average concentrations are typically higher in the subsurface sediments compared to surface sediments across each RM segment. Large portions of the Buffalo River AOC demonstrate depositional behavior, making these areas suited to MNR.

Ongoing maintenance dredging in the navigational channel of the Buffalo River may disrupt "natural caps" that form as a result of natural sedimentation processes. The long-term monitoring component of an MNR remedy will demonstrate if unacceptable levels of chemical concentrations are present in surface sediments as a result of maintenance dredging. If so, the decision criteria outlined in an MNR long-term monitoring plan will be followed. In addition, to help USACE make informed decisions regarding the removal of sediments within the navigation channel, data and information regarding the delineation of buried sediment chemical concentrations will be made available. It is also common practice for USACE to collect sediment samples from the proposed dredged areas prior to dredging and analyze these samples for chemical concentrations to assist with the management of dredged material.

4.3.2 Screening Criteria

- *Effectiveness.* Depositional areas in the Buffalo River AOC are reasonably well suited for MNR. The sediment bed is generally stable and resistant to erosion, and natural recovery processes are expected to continue to reduce contaminant bioavailability. Current human and ecological exposures are relatively low in many areas of the AOC, but in other areas surface sediment concentrations have not yet achieved the risk-based RGs identified for the Buffalo River. Effectiveness of MNR is reinforced by long-term monitoring of sediment, chemical, geochemical, and biological conditions.

- *Implementability.* MNR is readily implementable because it requires no action beyond detailed site characterization, monitoring, and possible execution and maintenance of institutional or engineering controls. Site characterization already has been implemented at the Buffalo River AOC, resulting in multiple lines of evidence in support of MNR.

- *Cost.* MNR has a relatively low cost compared to other, more active remedial technologies. 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, even when considering monitoring and institutional control costs.

4.3.3 Screening Results

The lines of evidence demonstrating natural recovery processes contributing to reduced risks over time in the Buffalo River AOC establish MNR as a feasible sediment remedy for the site. However, the presence of surface sediment concentrations above the risk-based RGs indicates natural recovery has not yet achieved the site-specific RGs and thus has not yet achieved RAOs. MNR is an implementable alternative and therefore is retained for further analysis.

4.4 Sediment Capping

Sediment capping involves the controlled placement of suitable material over contaminated sediment. Capping is a relatively mature, proven technology. USEPA (2005a) identifies the following three primary cap functions: physical isolation, stabilization/erosion protection, and chemical isolation. Physical and chemical isolation separate contaminants from the surrounding environment, protect human or ecological receptors from chemical exposures, and minimize the potential for resuspension and transport. 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.

Materials commonly used in conventional sediment caps include clean sediment, sand, or gravel (USEPA 1998). Sediment cap materials can be dredged from nearby waterways or obtained from upland sources. In certain instances, a more complicated engineered capping system can involve geosynthetics (e.g., geomembranes or geotextiles), multiple layers of various materials, or specialty amendments (USEPA 1998).

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.

Sediment capping can be implemented as a sole remedy, or in conjunction with other remedial techniques. Institutional or engineering controls are commonly employed in conjunction with caps; these include navigational restrictions, physical access restrictions, and future dredging restrictions. Such controls minimize the potential for cap disturbance and subsequent exposure to sediment contamination by human or ecological receptors.

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. Biological monitoring may be conducted to evaluate biological recovery of the cap surface, and surface sediment sampling may be conducted to monitor surface sediment deposition and recontamination potential.

Advantages and limitations of sediment capping are discussed in the USACE (2005a) *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.

In addition to conventional isolation caps, which were described at the beginning of this section, cap types include synthetic caps such as geomembranes or geotextiles; amended caps (also known as reactive caps) where amendments (e.g., activated carbon, organo-clays, or other natural or synthetic sorbents) are added to enhance certain physical or geochemical properties; and thin-layer caps.

Thin-layer caps are generally less than 30 cm (12 inches) thick and are used to enhance ongoing natural recovery processes. They serve many of the same purposes as isolation caps (namely, creating a clean sediment surface, reducing sediment scour potential, and increasing the physical barrier between contaminated sediment and the ecological environment), but generally do not include armoring. A thin-layer cap can accelerate natural recovery processes by rapidly providing a cleaner sediment surface and benthic environment. Optimum thin-layer cap thickness is determined on the basis of site-specific characterization information, natural recovery characteristics, and RAOs.

4.4.1 Applicability to the Buffalo River AOC

Sediment capping satisfies the RAO goals that seek risk reduction while minimizing construction hazards and implementation risks to the City of Buffalo community, construction workers, and the environment. 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.

4.4.2 Screening Criteria

- *Effectiveness.* Portions of the Buffalo River AOC have conditions suitable for capping, including relatively low-energy environments along the sediment banks and in the turning basins. However, given that the navigational channel encroaches upon many of these areas by occupying over two thirds of the width of the river and that the navigational channel is periodically dredged for maintenance, areas suitable for capping are narrow and limited. Capping could be effective in areas outside of the navigation channel where it can be assured that maintenance dredging would not compromise the integrity of the cap.

  Ice jams have been identified as causes of cap erosion at other remediated sites. An ice jam evaluation was conducted for the Buffalo River AOC, and, as reported in the *SRIR*, the results of this evaluation show no ice jams along the AOC have occurred since 1966, likely as a result of the ice management strategies implemented along the AOC and in upstream tributaries. The findings from this evaluation indicate that ice jams are not expected to pose a risk to the integrity or effectiveness of capping at the Buffalo River.

  Thin-layer capping could be effective in the low-energy environments within the Buffalo River AOC. The benefit of thin-layer capping would be to minimize negative ecological impacts of sediment capping, such as loss of aquatic habitat in the river, and to minimize loss of flow conveyance. Thin-layer capping accelerates MNR processes—particularly contaminant burial—which already have been shown to be occur in the Buffalo River AOC, decreasing surface sediment contaminant concentrations and reducing risks to human health and the environment. Thin-layer capping may be effective in areas that cannot be dredged due to limited accessibility, protection of bulkheads, or protection of sensitive habitat where the benefits of conserving existing habitat outweigh the benefits of dredging.

Cap effectiveness is reinforced by long-term monitoring of cap integrity and biological recovery following remedy implementation.

- *Implementability.* In general, sediment capping is readily implementable, although the areas suitable for capping within the Buffalo River AOC are limited, and the routine disturbance of the Buffalo River AOC (e.g., maintenance dredging) could impact cap stability. Though dredging impacts on a sediment cap can be avoided, doing so might require congressional reauthorization of portions of the navigation channel. In addition, an evaluation would need to be conducted to ensure placement of fill within the floodplain does not increase the potential for flooding due to a reduction in the river's flow conveyance capacity. Capping is field proven, and the Buffalo River AOC is accessible from land or water.

- *Cost.* Capping costs are generally moderate. Capping usually has a lower cost than dredging 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.

4.4.3 Screening Results

Areas suitable for capping within the Buffalo River AOC are limited to areas outside of the federally-defined navigational channel in the Buffalo River and City Ship Canal. This includes the narrow portions of the river and ship canal that border the navigational channel and the non-navigable portion at the end of the City Ship Canal. To the extent that routine disturbance of the Buffalo River AOC (e.g., maintenance dredging) could impact cap stability, and concerns regarding reduction on river conveyance capacity, isolation capping along the non-navigable areas of the Buffalo River AOC is not considered further in this *FS*, except possibly for areas that cannot be dredged due to limited accessibility, protection of bulkheads, or protection of sensitive habitat. However, capping is considered for the non-navigable portion of the City Ship Canal (i.e., at the end of the ship canal, beyond the terminus of the authorized dredge channel), and thin-layer capping may be considered to augment remedies if it can be demonstrated that thin-layer capping does not exceed FEMA restrictions on increased flood potential during a 100-year flood event, or if thin capping can support a restoration alternative.

4.5 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).

Disadvantages include (USACE 2008a, USEPA 2005):

- Implementation is usually more complex and costly than in situ remedies.
- Treatment technologies for contaminated sediment frequently offer implementation challenges because of limited full-scale experience and high cost.
- Local disposal capacity may be limited.
- Dredging or excavation may also be more complex and costly than other approaches due to accommodation of equipment maneuverability and portability/site access.
- 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.
- As for in situ capping, 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 sediments 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, dredging alone often has a limited ability to achieve reduced surface sediment chemical concentrations. In high depositional environments natural sedimentation may be used to achieve remedial goals after dredging. Dredging may enhance deposition rates (i.e., dredged areas often act as traps for sediment deposition) and accelerating natural recovery processes.

Sediment removal technologies and components are varied and complex. In this section, the different dredging options are described and components of the sediment removal process are reviewed in Sections 4.5.1 and 4.5.2). Subsequently, applicability to the Buffalo River AOC is discussed (Section 4.5.3), and the options and processes are screened per the evaluation criteria (Section 4.5.4). Screening results are provided in the final subsection (Section 4.5.5).

4.5.1 Dredging Technology Overview

Dredging is a relatively mature technology for sediment mass removal and has long been used for ship navigation in rivers and harbors, including in the Buffalo River. A primary function of dredging is to physically remove sediment from the aquatic environment. By removing contaminants from an impacted environment, dredging and excavation have the potential to reduce mobility and exposure of contaminants to humans and ecological receptors. However, dredging often is confounded by an inability to achieve very low target chemical concentrations due to concurrent surface sediment mixing, and residuals deposition. For this reason, dredging often relies on natural deposition to meet target remediation goals.

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).

4.5.2 Sediment Removal Component Overview

Apart from actual dredging, sediment removal involves transportation of dredged material from the contaminated site and to the disposal site, dewatering, and disposal of dredged material. Treatment and disposal of the dredged material account 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 links all dredging or excavation components and may involve several different technologies or modes of transport (USACE 2008a). When dredged sediment can be disposed at a CDF, the CDF itself can be used for sediment dewatering. This section discusses considerations relating to dewatering and/or sediment stabilization, transportation of dredged material from the contaminated site, and disposal of dredged material.

4.5.2.1 Dredged 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. These sediments may require dewatering, which requires permitting to regulate the discharge of treated waters, and is usually a component of the management of contaminated dredge sediments when these are 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 sediments 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 dredged sediments 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 detailed design and from a site-specific bench-scale treatability study that tests the dewaterability of the sediments, 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.

Staging Dewatering Activities. Staging of dewatering activities could require areas for multiple sediment transfers, dewatering equipment, decontamination, and water treatment. The presence of CDF No. 4, specifically designed for the management and disposal of sediments from the Buffalo River within 3 to 9 miles of the AOC, makes this alternative more attractive than onsite staging or barge mounted staging. The availability of CDF No. 4 also makes upland disposal and associated dewatering, staging, transportation unnecessary.

Offsite dewatering requires the construction of upland staging areas, creating additional challenges, because the site would need to be conditioned for staging the dewatering activities and careful coordination with neighboring properties. Dewatering requires barge transport of wet sediments to an the staging area, which increases risks associated with wet sediment releases into the environment during transport or sediment offloading, contamination of the docking facility or adjacent aquatic environment during sediment transfer from the barge to the docking facility. Other disadvantages could include construction of anchoring and docking facilities, shoreline and marine construction upgrades, permitting requirements, and potential disruption of navigable waterways.

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.

4.5.2.2 Transportation and Disposal Response Actions

Dredged materials can be transported using barges, trucks, railroads, or pipelines. Barges transport dredged or clean sediment over water. Sediments can be loaded directly onto barges during dredging operations, after which the barge would transport sediments directly to a CDF or to a transfer facility where the sediment could be offloaded. Because dredging in the Buffalo district already employs the use of barges for sediment transport to CDF No. 4, bulkheads and retaining systems to protect against spillage already exist. 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.

Considering the proximity of the CDF to the area of concern and that the CDF was designed to handle sediments from the Buffalo River AOC, barge transport to the CDF is the recommended alternative for the following reasons:

- *Schedule.* Barge transport would only be limited by bridge opening schedules, which can be accommodated.
- *Permitting.* The CDF is a permitted facility that was specifically designed for the management and disposal of sediments from the Buffalo River AOC. Authorization for use of the CDF facility would be required from the USACE.
- *Sediment Disposal.* Since considerable sediment dredging is anticipated for the Buffalo River AOC and the CDF has barging facilities, the CDF is considered the most suitable, cost effective, and environmentally protective sediment disposal site. For purposes of this *FS*, it is assumed that the USACE will grant use of the CDF. If this assumption is incorrect, the feasibility of a dredge remedy, in whole or in part, would need to be reassessed.
- *Operational Considerations.* Barging facilities exist at the CDF, although the material off-loading facilities at the CDF will require some improvements.
- *Environmental.* The CDF is a permitted facility specifically designed for the management and disposal of sediments from the Buffalo River AOC. For example, CDF No. 4 was used as the disposal facility for the dredge project conducted at Smokes Creek in 2008–2009. By carefully managing the sediment entering the CDF (e.g., segregation of elevated chemical concentrations within the CDF, and placing a clean cover of material after sediment placement within the CDF), the CDF can be environmentally protective, and reduces or eliminates risks associated with excess sediment handling, transportation, and disposal. By retaining contaminated sediment within the community from which it originated, use of CDF No. 4 prevents the export the Buffalo River contaminants to another community and another ecological environment.
- *Human Health Risk.* Dredging and sediment disposal in CDF No. 4 lowers worker and community risks associated with sediment handling, dewatering, and transport, and lowers the energy demand and air emissions resulting from the operation of cranes, tugboats, and other heavy equipment, resulting in lower community impacts. The use of the CDF also ensures subsequent access to cover contaminated sediments with cleaner (basin derived) dredged material under the USACE cognizance, as well as subsequent monitoring of the confinement performance.
- *Local Impact of Trucks.* Considering the anticipated dredged sediment volumes, use of the CDF would serve to avoid substantial truck traffic and adverse impacts to traffic flow in the vicinity of an off-loading facility.

Each of these reasons must be considered among the transportation alternatives for each selected remedy.

4.5.3 Screening Criteria

- *Effectiveness.* Dredging has been demonstrated at numerous sites. As a mass-removal or source-removal technology, dredging is effective. However, dredging typically relies on natural recovery processes to establish long-term, site-specific RGs. Natural recovery after dredging can be an effective means of achieving RAO goals, via natural sedimentation and reduction of surface sediment chemical concentrations. In areas where relatively high deposition rates were reported in the USACE shoaling study, natural deposition will quickly bury exposed dredged surfaces in the Buffalo River. In areas where surface sediment contaminants are exposed in dredged areas and natural deposition rates are too slow to rely solely on natural recovery, thin capping may be used to accelerate natural recovery. Post-remedy placement of acceptable (basin-derived) sediment dredged from the upper AOC can be cast into remedy excavations to advance recovery efforts. The potential use of dredged sediments from USACE maintenance activities as casting material in remediated areas will follow the state management requirements for dredged material.

- *Implementability.* Dredging can be implemented at the Buffalo River AOC using the existing CDF facility at the Buffalo Harbor. The industry and the region have substantial experience with each of the dredging unit processes and all are considered implementable, though different unit processes present unique challenges at the Buffalo River. A combination of dredging techniques may be required to dredge around piers and abutments, submerged debris, cross channel utilities, and near bulkheads. Special consideration will be required for slope backs from existing bulkheads so as to not compromise their structural integrity. These issues will be resolved in the detailed design.

  CDF No. 4 is an attractive alternative for dredged material disposal given its design for the disposal/management of dredged material and location within 3 to 9 miles of the AOC. CDF No. 4 has been used for other dredge projects (i.e., the Smokes Creek project), and therefore, use of the CDF is implementable. Barging and material off-loading facilities exist at the CDF. The presence and purpose of the CDF eliminates from consideration other upland disposal facilities, such as landfills, which would require truck transport of dewatered and possibly solidified dredged materials.

  Monitoring of sediment chemistry would be required during and after dredging to determine attainment of cleanup goals, and for post-dredging sediment processing. Monitoring dredging performance and monitoring sediments after dredging is readily implementable.

- *Cost.* Dredging is generally more costly than MNR and capping. However, by eliminating dewatering, water treatment, and upland sediment transport and disposal, cost associated with these activities would be substantially lower than conventional environmental dredging projects.

  Dredging costs also are reduced by focusing dredging to remove contaminants from target areas, such as areas with elevated chemical concentrations, while relying on in situ remedies to achieve overall risk reduction. Such an approach greatly reduces the volume of material that requires dredging and off-site disposal, and reduces some of the negative environmental impacts associated with larger scale dredging.

4.5.4 Screening Results

Dredging is a mature technology, used primarily for sediment mass removal. Though dredging may have little positive impact on short-term risk reduction, the removal of target sediment mass is expected to effectively reduce long-term risks.

For the purposes of this *FS*, and consistent with current USACE dredging program in the Buffalo River, it is assumed that the dredged sediment can be placed in CDF No. 4, and barge transport to the CDF is the recommended means of transport to the CDF. This *FS* does not critically evaluate dredge methods, and it is assumed that both mechanical and hydraulic dredge methods are applicable, although mechanical dredging is likely to be the preferred dredge method if the dredged material is to be transported via barge to the CDF. The selected methods for dredging, transportation, and placement in the CDF will be resolved during detailed design or construction bidding, as appropriate.

4.6 Results of the Remedy Screening Process

Technologies and process options that are retained from the screening process are listed in Table 4-1. These technologies and process options are carried forward for the development of remedial alternatives in Section 5. The screened sediment remedy technologies to be evaluated as part of remedial alternatives for addressing sediment contamination in the Buffalo River AOC include the following:

1. No action
2. MNR
3. Capping in non-navigational areas
4. Dredging and disposal at CDF No.4.

The No Action alternative was identified and retained as required by the NCP. MNR is readily implementable and effective at sites with strong evidence for natural recovery processes. Lines of evidence developed for the Buffalo River indicate that natural recovery processes are ongoing in the river, resulting in reduced surface sediment contaminant concentrations and ecological improvements with time. However, current surface sediment levels continue to be above the site-specific RGs established by the PCT Eco and Human Health Risk Subgroups. Capping may be employed in non-navigation areas. Capping is considered very effective because it rapidly reduces surface sediment COC concentrations and thus reduces or eliminates chemical exposures in capped areas. Targeted dredging and sediment disposal in CDF No. 4, followed by sediment deposition in dredged areas, removes contaminant mass from the river and is expected to provide long-term effectiveness when combined with natural sedimentation processes by reducing surface sediment concentrations with time.

5 DESCRIPTION OF REMEDY ALTERNATIVES

Using the results of the technology and process option screening presented in Section 4, this section describes five different remedial alternatives for addressing sediments in the Buffalo River AOC. Although the Buffalo River AOC is not a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, CERCLA and NCP criteria are being followed in the evaluation of remedy alternatives. The alternatives include combinations of remedial technologies and process options (e.g., MNR, dredging, and sediment management) and control measures (e.g., monitoring programs and institutional controls) identified as plausible based on the CERCLA criteria of effectiveness, implementability, and cost.

The primary goal of this section is to describe the engineering scope and implementation considerations of each of the five remedial alternatives. The evaluation process presented in this section is consistent with USEPA guidance (2005a) and CERCLA requirements to evaluate a range of remedial strategies for a given site. In Section 6, the sediment remedies are evaluated and compared to NCP evaluation criteria.

The five remedial alternatives are listed below. Each remedial alternative includes source control as a component of the final remedy.

- Remedy Alternative 1: No action
- Remedy Alternative 2: Monitored Natural Recovery
- Remedy Alternative 3: Basic Dredging
- Remedy Alternative 4: Protectiveness Dredging
- Remedy Alternative 5: Enhanced Protectiveness Dredging

Sections 5.1 through 5.5 describe each of the five sediment remedies. Detailed design and construction of the sediment remedies will be required to meet substantive State of New York and federal permit requirements for waterfront activities associated with disturbance to state and federal navigable waters. It is possible that state and/or federal permitting requirements could alter the engineering specifications for any of the remedies described in this section. The nature of changes to one or more of the sediment remedy alternatives 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 *FS*.

Furthermore, the selected sediment remedial alternative includes a habitat restoration component to restore lost or temporarily impaired ecological resources or services. Ecological restoration options are likely to be applicable to most, if not all of the different sediment remedy alternatives, and are addressed in Section 8. It is assumed, therefore, that incorporating habitat restoration and/or shoreline enhancement activities will not fundamentally change the conclusions and recommendations presented in this *FS*, except insofar as some remedies may be better suited to habitat recovery than others, and insofar as some remedies may have a lesser impact on habitat than others while still achieving the same level of risk reduction and remedy effectiveness.

The areas identified for sediment remediation in Remedy Alternatives 2 through 5 were based on the delineation of sediment chemical concentrations resulting from the IDW interpolation presented in Figures 2-3 through 2-6. Surface sediment concentrations were used to develop a two-dimensional IDW interpolation of surficial concentrations, and surface plus subsurface concentrations (all samples) were used as inputs to a three-dimensional IDW interpolation of the remaining concentrations at depth. The IDW interpolations provide estimated concentrations at points that are evenly spaced in the horizontal, 20 ft apart in a regular grid, and represent 1-ft slices of sediment in the vertical. SWACs were calculated by averaging the surface sediment concentrations in the 20 ft cells over 1/3-mile segments of the river, as discussed in Section 3.2.

5.1 Sediment Remedy Alternative 1: No Action

Pursuant to the requirements of the NCP to identify baseline environmental conditions in the absence of remediation, the No Action remedial alternative is included in the analysis for comparison to other alternatives. This remedial alternative reflects baseline river sediment conditions as described in the *SRIR* (ENVIRON et al. 2009), and would entail no further action for remediation of Buffalo River AOC sediments. Natural recovery processes are expected to continue, such as the deposition of cleaner sediments, but these processes would not be monitored. In addition, the removal of contaminated sediments through maintenance dredging of the navigational channel is expected to continue, but monitoring of chemical concentrations for sediments left in place would not be monitored. The No Action alternative would likely be accompanied by institutional controls, namely fish advisories already in place for the Buffalo River. With time, if and when fish PCB concentrations fall below the criteria to maintain the fish advisories, the State of New York may elect to remove the advisories.

5.2 Sediment Remedy Alternative 2: Monitored Natural Recovery

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 sediments and reduce the risks to human health and the environment associated with current sediment conditions. MNR would likely be accompanied by institutional controls, namely fish advisories already in place for the Buffalo River, and existing federal and state permit requirements for construction in and adjacent to the Buffalo River AOC.

5.2.1 Physical Lines of Evidence Supporting MNR

The remediation of sediments in the Buffalo River AOC through MNR uses ongoing, naturally occurring processes that contain or reduce the bioavailability or toxicity of chemicals in the sediment. Natural physical processes that contribute to MNR remedy for the Buffalo River AOC include the deposition of suspended sediments originating from watershed sources upstream of the AOC. Because the Buffalo River channel is dredged regularly, the channel areas are maintained in a state of disequilibrium with respect to erosion and deposition, creating an environment that is generally depositional. The deposition of suspended material provides a physical barrier of sediments with lower chemical concentrations as compared to the buried sediments, thus isolating elevated chemical concentrations in the sediment and reducing the potential exposure of elevated concentrations to humans and biota. Evidence that natural sedimentation leads to reduced chemical concentrations in surface sediments in the Buffalo River AOC is demonstrated in the 2005/2007 and 2008 sediment chemistry data; in every half-mile increment of the river, average surface sediment concentrations for total PAHs, total PCBs, Hg, and Pb are lower than average subsurface concentrations for each respective chemical (ENVIRON et al. 2009).

The Buffalo River AOC is characterized as a low-energy, depositional system that is not subject to significant scour of the sediment. Both the direction and magnitude of flow in the lower Buffalo River are frequently affected by seiche-related changes in Lake Erie water levels. Results from model simulations demonstrated low velocities and bottom shear stresses throughout the AOC during low to moderate flow conditions. An increase in velocity was shown for low flow conditions with a large seiche influence, but these elevated velocities were typically short in duration and resulted in relatively low bottom stresses, relative to watershed-driven events that can create high, sustained flows. During moderate flow events (1-yr recurrence interval) model results demonstrated higher velocities throughout the river, with highest velocities in the upstream areas and in the relatively narrow reach between RM 1.0 and 2.0. Under all high flow events, seiche impacts were observed to be small relative to the effect of watershed flows. Further increases in velocities and shear stress were demonstrated during modeled high flow events (10-yr and 100-yr intervals). These increases were most notable in the narrow section of the river between RM 1.0–2.0, and at intermittent locations in the sinuous upper portion of the river, e.g., near RM 2.9, and RM 5.2. A discussion of river hydrodynamics and velocity/shear stress conditions under a range of flow and seiche conditions is presented in the *SRIR* (ENVIRON et al. 2009).

The hydrodynamic modeling studies and investigation of sediment bed properties supports an improved understanding of the sediment transport within the Buffalo River AOC and an understanding of the long-term stability of the system under wet weather and high seiche conditions. A technical memorandum on sedimentation in the Buffalo River and long-term sediment stability is provided in Appendix C. In summary, a generally high rate of sedimentation occurs throughout the river, as indicated by USACE dredging activities and supporting modeling studies (USACE 1988). Post-dredging rates of sedimentation vary significantly from 0.2 – 0.4 ft/year depending on the reach of the river. Bed load deposition predominantly occurs upstream, and deposition of suspended sediment materials is more broadly distributed throughout the river, generally decreasing from upstream to downstream. Deposition will tend to be greater in areas that have been recently dredged, have lower velocities, and lower bottom shear stresses. The artificially deep river cross-sections maintained by ongoing dredging activities contributes to the lower velocities and a generally depositional environment in the Buffalo River AOC.

An analysis to provide a quantitative estimate of the degree of scour was conducted based on hydrodynamics, available information regarding sediment properties, and mixing and deposition characteristics of the Buffalo River AOC (Appendix C). Results show that, during 100-year flow events, isolated localized zones have an elevated probability of sediment scour due to local hydrodynamics, caused primarily by river geomorphology changes in bathymetry. Site-specific measurements of sediment cohesiveness and armoring, and data on storm event watershed solids loads for the Buffalo River are not available, making it difficult to predict the precise depth of scour in the identified areas of high erosion potential. However, a model of a similar Great Lakes tributary with similar bed characteristics and watershed geology (Lower Don River, Toronto) shows maximum scour depths of less than 1.5 feet (0.5 meter) under shear stress conditions similar to the 100-year event on the Buffalo River. The same model also shows broad areas of solids deposition due to greatly increased loads of watershed solids under high event flow conditions, demonstrating that large flow events are often more likely to be net depositional than net erosional. Similar scour and erosion depths can be expected in localized zones of the Buffalo River AOC that are shown to have a higher probability of sediment scour. Based on the model analysis, the net depth of sediment scour in the Buffalo River is generally expected to be less than 1.0 ft, not to exceed 1.5 feet during a 100-year storm event. Elevated chemical concentrations in the Buffalo River sediments are typically buried beneath the top foot of sediment, and are thus not expected to be exposed during scour events in localized areas.

5.2.2 Ecological Lines of Evidence Supporting MNR

Various ecological metrics provide some evidence of ongoing habitat recovery in the Buffalo River. These lines of evidence include improvements in benthic community metrics, reductions in fish liver lesions, and reduced chemical concentrations in edible fish. Additional studies would be required to determine the long term ecological improvements suggested by these lines of evidence.

5.2.2.1 Benthic Community Improvements

Researchers of the Buffalo River have reported recovery in the benthic community over the past two decades, in part due to improvements in water quality (e.g., dissolved oxygen, suspended solids, and water temperature) and possibly through navigational dredging, stormwater management, and natural attenuation (Irvine et al. 2005). Blum (1964) found no benthic invertebrates in the dredged section of the Buffalo River, but the benthic community demonstrated a notable improvement by the late 1970s to early 1980s (Canfield et al. 1992). This improvement was most significant at the upstream and downstream extents of the AOC, but the benthic community within the middle section was still considered to be degraded.

In a review of mostly unpublished historical Buffalo River benthic invertebrate data (1964 to 1993), Diggins and Snyder (2003) documented recolonization and expansion of the benthos from the barren conditions reported previously. According to Diggins and Snyder, many of the early benthic community improvements were likely due to water quality improvements, such as dissolved oxygen, temperature, and suspended solids. However, according to Irvine et al. (2005), the benthic community quality declined between 1993 and 2004, based on a comparison of invertebrate family richness. The findings of the 2008 benthic community assessment show the family richness of the sediment grab samples is generally similar to that seen in the 2003/4 study. It is unclear whether the current findings reflect degraded benthic community conditions related to chemical contamination or those conditions related to the influences of an urban watershed.

A NYSDEC 30 Year Trend Report (1972-2002) indicated that water quality has improved dramatically in the Buffalo River since it was first sampled in 1976 (NYSDEC 2004). The river has progressed from severely impacted in 1976 to moderately impacted in 1988 to slightly impacted in 1993 and 2000, based on resident macroinvertebrate communities. This report indicates that caddisflies were first collected in 1988, and more sensitive mayflies were first collected in 2000. In the 2000 multi-plate samples (presumably Hester-Dendy samplers, but if not, something similar), four species of clean-water mayflies were found at the Ohio Street bridge site. The 2008 Hester-Dendy sampling showed that the location nearest this bridge (BR06) had the highest caddisfly count of any location (approximately 33 individuals on just one sampler). Mayflies, caddisflies, and stoneflies are the basis of the ephemeroptera, plecoptera, and trichoptera (EPT) Index, and the 2008 study showed that EPT were seen at every location sampled in at least one of the replicates.

5.2.2.2 Historical Trends In Fish Liver Tumors

The Fish Tumors and Other Deformities BUI was listed as impaired based on the Black et al. (1985) report that Buffalo River sediment extracts induced fish tumors and that Buffalo River brown bullhead had a high prevalence of neoplasms. Irvine et al. (2005) summarized the most recent histopathological analyses of Buffalo River fish but only mentioned a high incidence of DELTs (87%) in brown bullhead.[7] As described in Section 5.3.5.2, DELTs have subsequently been shown to be non-discriminatory biomarkers and have been recommended against in establishing BUIs. While DELTs were noted in the 2008 sampling event, they were not histologically verified, and therefore, are not used to evaluate this BUI. However, it should noted that the incidence of raised skin lesions, the only DELTs evaluated by Baumann et al. (1996) and Yang (2004), decreased substantially in the ten years since the previous evaluation.

Previous studies showed a decrease in total liver tumors in response to natural attenuation and remediation in the Black River (Baumann and Harshbarger 1998, USEPA 2000a). Between 1982 and 1987, natural attenuation was associated with a decrease in liver tumors from 60% to 33%. Following dredging, the tumor incidence rose again to a high of 64%, but then decreased to 0% in one year (1994), and rose again in 1998 to 7%, showing variability among years.

Based on 1983 and 1986 data, Black and Baumann (1991) reported a liver neoplasm incidence of 16.6% in the Buffalo River. This Buffalo River liver neoplasm incidence subsequently rose to 19% in 1988 (Baumann and Harshbarger 1995). Between 1988 and 2008, the incidence of liver neoplasms decreased to 8.1% (ENVIRON et al. 2009), which is similar to the 1998 incidence in the Black River. In comparison, the incidence of liver neoplasms in brown bullhead from two reference areas in the Great Lakes (Baumann et al. 1996) is 5.9% and 5.6%.

5.2.2.3 Reduced PCB Concentrations in Edible Fish

No fish tissues were collected as part of the fall 2008 sampling event. However, PCB concentrations have been measured in carp from the Buffalo River during the period of 1977 through October 2007 (NYSDEC 1989, Loganathan et al. 1995, NYSDEC 2006, Skinner et al. 2009). These data indicate that PCB concentrations in carp have been declining over this monitoring period. NYSDEC (1989) reported PCB concentrations in Buffalo River carp from sampling events that occurred from 1977 to 1984. Mean PCB concentrations in 1977 were reported to be 4.26 mg/kg carp, in 1980 PCB concentrations ranged from 0.69 to 0.82 mg/kg, in 1983 PCB concentrations ranged from 3.63 to 14.5 mg/kg, and in 1984 mean PCB concentration in Buffalo River carp was reported to be 6.67 mg/kg[8]. In 1995, Loganathan et al. reported that PCB concentrations in carp fillets ranged from 2.4 to 5 mg/kg. Further, data collected in October 2007 by Skinner et al. (2009) indicate that the mean PCB concentrations in the edible fillet portion of carp sampled from the Buffalo River is 1.04 mg/kg (range from 0.22 to 2.7 mg/kg). The mean and upper end of the range of detected PCB concentrations in the edible portion of carp exceeds the limit used by NYSDOH for establishing the current AOC-specific fish advisory (1 mg/kg) and slightly exceeds

[7] Snyder collected a total of 68 brown bullhead in 2003 and 2004. The length of the fish ranged from 20 to 56 cm with a mean greater than 30 cm. Since DELT incidences of 100% were reported in the oldest brown bullhead from the Detroit River, this suggests that DELT incidence, like liver lesion incidence, is also correlated with age.

[8] Sample type (fillet vs whole body) was not specific in the indicated reference.

the FDA limit (2 mg/kg) (NYSDOH 2009). The NYSDOH AOC-specific fish advisory of 1 mg/kg is intended to be protective of human health.

5.2.3 Long-Term Monitoring Requirements for Remedy Alternative 2

Long-term monitoring of the Buffalo River as part of an MNR remedy would continue examination of ecological exposures. Furthermore, long-term monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and to evaluate changes in conditions that are used to identify and delist BUIs. Long-term monitoring requirements will be defined in a project specific long-term monitoring plan during remedy design.

Monitoring in MNR areas would likely include the measurement surface sediment (0–1 ft) chemical concentrations to confirm that the total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs are achieved over time, focusing on areas where RGs are not yet achieved. In addition, bathymetric surveys would be conducted to assess the long-term integrity of the sediment bed. In MNR areas where the top 12 inches of sediment have been scoured, sediment coring and chemical analysis of the surface sediments will be conducted.

In addition to monitoring for chemical isolation and sediment stability, long-term biological monitoring of the Buffalo River AOC would include habitat surveys, benthic community surveys, fish community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. The Long Term Monitoring Plan will further define performance objectives. The proposed MNR monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and evaluating changes in conditions that are used to identify BUIs.

5.3 Remedy Alternative 3: Basic Dredging

Remedy Alternative 3 targets the removal of surface and subsurface sediments in the Buffalo River AOC with a PAH TU >1, and targets SWAC RGs for total PCBs, Hg, and Pb, and primarily relies on natural sedimentation processes after dredging to achieve dredge residual performance standards established during detailed design. Capping is introduced for remediation of the end of the City Ship Canal, beyond the limits of the authorized navigation channel. The limits of dredging and capping for Remedy Alternative 3 are shown in Figure 5-1a.

5.3.1 Dredging Remedy Design

Remedy Alternative 3 includes the removal of sediments with total PAH concentrations >1 TU at any depth and achieves SWAC RGs for PCBs, Pb, and Hg, and capping at the end of the City Ship Canal. Engineering considerations addressed as part of this remedial alternative include:

- Aerial extent and depth of dredging
- Dredging methods and dredged material disposal
- Aerial extent of capping
- Post-dredging natural sedimentation and surface sediment recovery

- Habitat impacts

Extent and Depth of Dredging. Remedy Alternative 3 dredge and cap footprints are defined on the basis of the PAH TU of 1 at any sediment depth and SWAC RGs for PCBs, Hg, and Pb. The limits of dredging and capping for Remedy Alternative 3 are shown in Figure 5-1a. The proposed remediation area for Remedy Alternative 3 is approximately 164 acres, including 138 acres in the Buffalo River and 26 acres in the City Ship Canal, as provided in Table 5-1b. This acreage includes the proposed cap area at the end of the City Ship Canal, which is approximately 6.7 acres. For the purposes of this *FS*, isolated areas supported by one sample location with surface sediment concentrations greater than 1 TU, are not included in the remedy footprint, but will be resampled as part of remedy design, as indicated in Figure 5-1a.

In proposed dredge areas, sediment removal will be delineated to depths where the sediment chemistry is expected to be compliant with the RGs at the 2-year review period. The estimated in-place sediment volumes targeted for removal in Remedy Alternative 3 are shown in Table 5-2a, and include 1.57 million CY from the Buffalo River (this includes 1,010,000 CY from outside the federally-defined navigation channel boundary and 560,000 CY from within the navigation channel) and 180,000 CY from the City Ship Canal (this includes 150,000 CY from outside the navigation channel boundary and 30,000 CY from within the navigation channel). These volume estimates assume removal to shoreline and do not consider a dredge slope factor. Dredge volume estimates will be revised during remedy design once an updated understanding of dredge delineation boundaries and shoreline offset requirements are established.

Dredging Methods and Dredged Material Disposal. Both mechanical and hydraulic dredging could be used to remediate the Buffalo River sediments for Remedy Alternative 3. Physical constraints (i.e., debris, bulkheads, bridge abutments and piers, or cross-channel utilities) can hinder dredging and should be evaluated during remedy design.

Best management practices, such as operational controls and specialty equipment, will be used during dredging operations to reduce potential contaminant release. Careful boat operation and operation during off-peak flow velocities can also minimize sediment disturbances. The remedy design for the Buffalo River can establish a systematic dredging approach that targets off-channel areas or high concentration areas first, followed by dredging of the navigational channel to capture sediment that may get resuspended and subsequently migrate into the main channel of the river. Due to bidirectional flow of the Buffalo River, USACE has found the use of silt curtains to be ineffective along the AOC. In addition, silt curtains greatly slow dredging progress, thus prolonging ecological exposures during dredging. The exact methods to be used to reduce potential sediment suspension and contaminant release will be assessed during remedy design.

The presence of a CDF specifically designed for the management and disposal of sediments from the Buffalo River within 3 to 9 miles of the AOC makes the CDF the most appropriate alternative for the dewatering/stabilization and disposal of dredged sediments, and barge transport or hydraulic conveyance the preferred sediment transport alternatives. CDF No. 4 was used as the disposal facility for the dredge project conducted at Smokes Creek in 2008–2009. Dredged materials would be transported to CDF No. 4 via barge or hydraulic conveyance systems, depending on the dredging method and the transport distance. Dredged material will be placed in the CDF in a manner that is protective of human health and the environment, and material placement will meet applicable and promulgated State water quality standards, as well as any other applicable Federal/State environmental laws and regulations.

Barging facilities exist at CDF No. 4, although the material off-loading facilities at the CDF may require some improvements. Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges). For pipeline systems, potential significant constraints include the presence of railroads and highways between the AOC and the CDF. These considerations will be resolved during remedial design.

CDF No. 4 does not accept dredge material that is classified as Toxic Substance Control Act (TSCA) waste. Only one sample location target for removal in Remedy Alternative 3 has sediment chemical concentrations that would be classified as TSCA material (total PCB concentration >50 mg/kg). Thus, a small volume of dredge material (<1,000 CY) is expected to require disposal at a TSCA-approved disposal facility. The Chemical Waste Management (CWM) facility located in Model City, NY, approximately 30 miles from the Buffalo River AOC, is closest TSCA-approved facility permitted to dispose of PCBs. Dredged TSCA material would likely be transported to the CWM facility via truck from CDF staging area. Management of the TSCA material will be resolved during detailed design.

Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation. Within routinely dredged areas, the anticipated distribution of submerged debris is expected to be relatively small. However, the occurrence of debris is likely to increase in off-channel areas, which may hinder or slow dredging.

Post-dredging Natural Sedimentation and Surface Sediment Recovery. Remedy Alternative 3 primarily relies on natural sedimentation after dredging to satisfy long-term RAO goals. In some dredge areas, the placement of a thin layer of material upon the sediment surface may be necessary accelerate natural recovery processes and further protect the biological active zone. Sediment dredging is often ineffective at reducing surface sediment concentrations to below target concentrations because of concurrent surface sediment mixing and dredge residuals deposition (USACE 2008a). Due to dredge residuals, a common rule of thumb is that the immediate post-dredge surface sediment concentration resembles the average concentration in the sediment column before dredging (USACE 2008b). Over the last two decades, natural sedimentation has occurred at a significant rate throughout the study area (USACE 1988), and has led to measurably decreased surface sediment contaminant concentrations. Surface sediment concentrations of PAHs and PCBs are below RGs in most areas of the river, and current Hg and Pb levels do not pose adverse ecological or human health risks; Hg and Pb RGs were established to ensure that the sediment remedy does not increase long-term exposures and risk. This historical evidence of natural sedimentation processes and correspondingly reduced surface sediment concentrations lends confidence to relying on natural sedimentation processes after dredging to meet long-term RAO goals. However, due to dredge residuals, it should be recognized that the RGs will likely not be achieved for 2 years following completion of the sediment removal portion of the dredge remedy. During the short term, dredging could actually increase ecological and human exposures for several years, such as occurred after dredging in the Black River (ENVIRON et al. 2009).

5.3.2 Sediment Cap Remedy Design for Remedy Alternative 3

The downstream end of the City Ship Canal is targeted for sediment remediation as part of Remedy Alternative 3 (Figure 5-1a). This segment of the City Ship Canal (approximately the last 1,800 ft of the canal) is beyond the downstream boundary of the navigation channel and represents a low energy environment that is not susceptible to sediment scour from the overlying flow or ice events. A sediment cap is targeted for this area to isolate underlying sediment contaminants, provide a clean sediment surface, and provide an appropriate substrate for habitat restoration in this portion of the AOC (see Section 8). Capping depths and cap materials would be designed to optimize and enhance habitat restoration plans while providing adequate protection against damage from root penetration. Native sediments from the Buffalo River that meet State criteria may serve as cap material at the end of the City Ship Canal. The use of in-stream borrow material for the sediment cap will be further evaluated during remedial design. Cap placement could be performed by either (a) extending a navigational channel to the downstream end of the City Ship Canal to allow for barge traffic, which would require the removal of approximately 50,000 CY; (b) hydraulic means; or (c) in dry conditions using earth moving equipment, by temporary sheeting and dewatering the proposed cap area and using the adjoining upland areas (e.g., sand processing plant along Fuhrmann Boulevard or the upland area at the end of the City Ship Canal) for material handling.

5.3.3 Short- and Long-Term Monitoring Requirements for Remedy Alternative 3

Remedy Alternative 3 includes short-term confirmation and operation monitoring during remedy implementation, and long-term monitoring following the completion of the remedy. General short-term and long-term monitoring components are provided below and detailed monitoring plans will be provided as part of remedial design. A Confirmation Management Plan will be included as part of the remedial design and will outline decision criteria for determining what, if any, additional measures may be warranted to complete remedy implementation. Additional measures may be necessary if the implemented remedy does not meet design specifications or if post-remedy sediment chemistry is not expected to achieve compliance with the RGs at the 2-year review period.

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 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. In addition to the DGPS and real-time monitoring software, bathymetric surveys will be conducted following the completion of the dredge remedy to ensure sediment was removed according to dredge design specifications. Post dredge confirmation bathymetric surveys may be coordinated with the annual bathymetric surveys routinely conducted by USACE. Bathymetric surveys will also be conducted in cap areas to ensure cap depth and surface coverage meets cap design specifications. In the event that confirmation monitoring demonstrates the remedy was not implemented per remedy design specifications, the Confirmation Management Plan will outline the decision criteria for determining what, if any, additional measures are warranted.

Surface sediment chemical concentrations would also be measured in dredge and cap areas immediately following remedy implementation. In proposed dredge areas sediment will be removed to depths where sediment chemistry is expected to result in the long-term compliance with the total PAH and SWAC RGs at the 2-year review period. If surface sediment concentrations immediately following remedy implementation are not expected to achieve RG compliance at the 2-year review period, the Confirmation Management Plan will outline additional measures that may be implemented to further ensure RG compliance in 2 years. Additional remedial measures may include additional dredging, the placement of backfill material, or reliance on ongoing natural sedimentation processes.

Operational monitoring will also be conducted during remedy implementation to ensure the water and air 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.

Long-Term Monitoring. Long-term monitoring of the Buffalo River would confirm the continuation of natural processes that reduce risk and ecological exposures. Furthermore, long-term monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and to evaluate changes in conditions that are used to identify and delist BUIs. The *SRIR* (ENVIRON et al. 2009) characterizes the current physical, chemical and biological conditions of the Buffalo River AOC through the evaluation of recent sediment investigations and historical information. This characterization, along with any additional data collected from the Buffalo River AOC prior to remedy implementation, can serve as a baseline conditions for the Buffalo River AOC, to which post-remediation data collected during long-term monitoring can be compared. An evaluation of post-remedy conditions against baseline conditions will demonstrate any changes in the physical, chemical and biological conditions as they relate to RAOs and the delisting BUIs.

At Year 2 following the completion of the remedy, surface sediment (0–1 ft) chemical concentrations will be measured to confirm that the total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs were achieved. As outlined in Section 3, SWAC RGs are based on 1/3-mile segments of the river. If the RGs have not been achieved at the 2-year review period, additional remedial measures may be implemented. The following three decision alternatives have been established to provide flexibility in response to results obtained from Year 2 surface sediment sampling and analytical results:

- ***Case 1****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs have been achieved at the two-year monitoring period* – No further action is required.
- ***Case 2****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, but evidence indicates progress toward the site-specific RGs* – Monitoring may be continued through Year 5 in areas where progress toward the RGs has occurred, particularly in areas that demonstrate natural ongoing processes have led to a decrease in surface sediment concentrations as compared to concentrations measured immediately following remedy implementation.
- ***Case 3****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, and monitoring results suggest unacceptably slow progress toward meeting RGs* – Additional dredging or the placement of clean material may be employed to achieve compliance with RGs, particularly in areas that do not demonstrate an acceptable decrease in surface sediment concentration as compared to concentrations measured immediately following remedy implementation, assuming that the lack of progress observed is not attributable to an ongoing source.

In areas where the RGs are not achieved at Year 2 and additional remedial measures are implemented, monitoring will be conducted at Year 5 to confirm compliance with the RGs.

At Year 2, long-term monitoring of capped areas will include one or more of the following metrics: bathymetric or visual surveys to evaluate cap integrity, and/or surface sediment chemical concentrations in the cap to evaluate sediment deposition and recontamination potential.

Long-term biological monitoring of the Buffalo River AOC will be conducted at Years 1 and 5 following the remedy implementation. Biological monitoring will include one or more of the following metrics: benthic community surveys, fish community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. Biological monitoring and sampling locations will be established during remedial design and, to the extent practicable, will correspond to areas monitored during previous biological studies conducted in the Buffalo River (ENVIRON et al. 2009, Irvine et al. 2005). This information is will be used to evaluate changes in conditions that used to identify and delist BUIs.

5.4 Remedy Alternative 4: Protectiveness Dredging

Remedy Alternative 4 targets the removal of all sediments from areas with surface sediment (0 – 1 ft) total PAH concentrations >1 TU, achieves SWAC RGs for PCBs, Hg, and Pb, and primarily relies on natural sedimentation processes after dredging to achieve dredge residual performance standards established during detailed design. Capping is introduced for remediation of the end of the City Ship Canal, beyond the limits of the authorized navigation channel.

Surface sediments are defined as sediment depths beginning at the sediment-water interface and extending 1 foot below the sediment surface (i.e., 0 – 1 ft depth) to calculate SWAC metrics. In areas targeted for dredging sediment removal will be delineated to a depth where the sediment chemistry is expected to be compliant with the RGs at the 2-year review period. The performance criteria for achieving this goal will be resolved during detailed design. The limits of dredging and capping for Remedy Alternative 4 are shown in Figure 5-1b.

5.4.1 Dredging Remedy Design for Remedy Alternative 4

Remedy Alternative 4 includes the removal of sediments in areas with surface sediment total PAH concentrations >1 TU. As with Remedy Alternative 3, the removal areas targeted for Remedy Alternative 4 target RG SWACs for PCBs, Pb, and Hg. Remedy Alternative 4 relies on natural sedimentation after dredging to meet RG SWACs associated with PCBs, Pb, and Hg. Engineering considerations addressed as part of this remedial alternative include:

- Aerial extent and depth of dredging
- Dredging methods and dredged material disposal
- Aerial extent of capping
- Post-dredging natural sedimentation and surface sediment recovery
- Habitat impacts

Extent and Depth of Dredging. Dredging areas and depths are defined on the basis of the PAH TU of 1 and SWAC RGs for PCBs, Hg, and Pb in surface sediments. The limits of dredging and capping for Remedy Alternative 4 are shown in Figure 5-1b. The proposed plan area for Remedy Alternative 4 is approximately 56 acres, including 41 acres in the Buffalo River and 15 acres in the City Ship Canal, as provided in Table 5-1c. This acreage includes the proposed cap area at the end of the City Ship Canal, which is approximately 6.7 acres.

Most areas targeted for sediment removal are located between RM 3.6 and RM 5.2 and from within the City Ship Canal, with some additional areas located just downstream of RM 3.5. For the purposes of this *FS*, isolated areas supported by one sample location with surface sediment concentrations greater than 1 TU, or areas with insufficient sediment chemistry data are not included in the remedy footprint, but will be resampled as part of remedy design. These areas are designated in green in Figure 5-1b.

In proposed dredge areas, sediment removal will be delineated to depths where the sediment chemistry is expected to be compliant with the RGs at the 2-year review period. The estimated in-place sediment volumes targeted for removal in Remedy Alternative 4 are shown in Table 5-2b, and include 560,000 CY from the Buffalo River (this includes 420,000 CY from outside the federally-defined navigation channel boundary and 140,000 CY from within the navigation channel) and 80,000 CY from the City Ship Canal (this includes 60,000 CY from outside the navigation channel and 20,000 CY from within the navigation channel).

Dredging Methods and Dredged Material Disposal. Both mechanical and hydraulic dredging could be used to remediate the Buffalo River sediments for Remedy Alternative 4. Physical constraints (i.e., bulkheads, bridge abutments and piers, or cross-channel utilities) can hinder dredging and must be evaluated during remedy design.

As with Remedy Alternative 3, best management practices, such as operational controls and specialty equipment, will be utilized during dredging operations to reduce potential contaminant release. Careful boat operation and operation during off-peak flow velocities can also minimize sediment disturbances. The remedy design for the Buffalo River can establish a systematic dredging approach that targets off-channel areas or high concentration areas first, followed by dredging of the navigational channel to capture sediment that may get resuspended and subsequently migrate into the main channel of the river. Due to bidirectional flow of the Buffalo River, USACE has found the use of silt curtains to be ineffective along the AOC. The exact methods to be used to reduce potential sediment suspension and contaminant release will be assessed during remedy design.

As with Remedy Alternative 3, the presence of a CDF specifically designed for the management and disposal of sediments from the Buffalo River within 3 to 9 miles of the AOC makes the CDF the most appropriate alternative for the dewatering/stabilization and disposal of dredged sediments and barge transport or hydraulic conveyance the preferred sediment transport alternatives. CDF No. 4 was used as the disposal facility for the dredge project conducted at Smokes Creek in 2008–2009. Dredged materials would be transported to CDF No. 4 via barge or hydraulic conveyance systems, depending on the dredging method and the transport distance. Dredged material will be placed in the CDF in a manner that is protective of human health and the environment, and material placement will meet applicable and promulgated State water quality standards, as well as any other applicable Federal/State environmental laws and regulations.

Barging facilities exist at CDF No. 4, although the material off-loading facilities at the CDF may require some improvements. Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges). For pipeline systems, potential significant constraints include the presence of railroads and highways between the AOC and the CDF. These considerations will be resolved during remedial design.

Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation. Within routinely dredged areas, the anticipated distribution of submerged debris is expected to be relatively small. However, the occurrence of debris is likely to increase in off-channel areas, which may hinder or slow dredging.

Post-dredging Natural Sedimentation and Surface Sediment Recovery. Remedy Alternative 4 relies on natural sedimentation after dredging to satisfy long-term RAO goals. Sediment dredging is often ineffective at reducing surface sediment concentrations to below target concentrations because of concurrent surface sediment mixing and dredge residuals deposition (USACE 2008b). Over the last two decades, natural sedimentation has occurred at a significant rate throughout the study area (USACE 1988), and has led to measurably decreased surface sediment contaminant concentrations. A technical memorandum on sedimentation in the Buffalo River and long-term sediment stability is provided in Appendix C, which reports a generally high rate of sedimentation occurs throughout the river, and post-dredging rates of sedimentation vary from 0.2 – 0.4 ft/year depending on the reach of the river. Deposition will tend to be greater in areas that have been recently dredged, have lower velocities, and lower bottom shear stresses. In some dredge areas, the placement of a layer of material upon the sediment surface may be necessary to accelerate natural recovery processes and further protect the biological active zone. Surface sediment concentrations of the four primary indicator chemicals (PAHs, PCBs, Pb, and Hg) are below RGs in most areas of the river. This historical evidence of natural sedimentation processes and correspondingly reduced surface sediment concentrations lends confidence to relying on natural sedimentation processes after dredging to meet long-term RAO goals. However, due to dredge residuals, it should be recognized that the RGs will likely not be achieved for 2 years following implementation of the dredge remedy. During the short term, dredging could actually increase ecological and human exposures, such as occurred after dredging in the Black River (ENVIRON et al. 2009).

5.4.2 Sediment Cap Remedy Design for Remedy Alternative 4

The downstream end of the City Ship Canal is target for sediment remediation as part of Remedy Alternative 4 (Figure 5-1b). This segment of the City Ship Canal (approximately the last 1,800 ft of the canal) is beyond the downstream boundary of the navigation channel and represents a low energy environment that is not susceptible to sediment scour from the overlying flow or ice events. A sediment cap is targeted for this area to isolate underlying sediment contaminants, provide a clean sediment surface, and provide an appropriate substrate for habitat restoration in this portion of the AOC (see Section 8). Capping depths and cap materials would be designed to optimize and enhance habitat restoration plans while providing adequate protection against damage from root penetration. Native sediments from the Buffalo River may serve as cap material at the end of the City Ship Canal. The use of in-stream borrow material for the sediment cap will be further evaluated during Remedial Design. Cap placement could be performed by either (a) extending a navigational channel to the downstream end of the City Ship Canal to allow for barge traffic, which would require the removal of approximately 50,000 CY; (b) hydraulic means; or (c) in dry conditions using earth moving equipment, by temporary sheeting and dewatering the proposed cap area and using the adjoining upland areas (e.g., sand processing plant along Fuhrmann Boulevard or the upland area at the end of the City Ship Canal) for material handling.

5.4.3 Short- and Long-Term Monitoring Requirements for Remedy Alternative 4

Remedy Alternative 4 includes short-term confirmation and operation monitoring during remedy implementation, and long-term monitoring following the completion of the remedy. General short-term and long-term monitoring components are provided below and detailed monitoring plans will be provided as part of remedial design. A Confirmation Management Plan will be included as part of the remedial design and will outline decision criteria for determining what, if any, additional remedial measures may be warranted to complete remedy implementation. Additional measures may be necessary if the remedy was not implemented per design specifications or if post-remedy sediment chemistry is not expected to achieve compliance with the RGs at the 2-year review period.

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 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. In addition to the DGPS and real-time monitoring software, bathymetric surveys will be conducted following the completion of the dredge remedy to ensure sediment was removed according to dredge design specifications. Post dredge confirmation bathymetric surveys may be coordinated with the annual bathymetric surveys routinely conducted by USACE. Bathymetric surveys will also be conducted in cap areas to ensure cap depth and surface coverage meets cap design specifications. In the event that confirmation monitoring demonstrates the remedy was not implemented per remedy design specifications, the Confirmation Management Plan will outline the decision criteria for determining what, if any, additional measures are warranted.

Surface sediment chemical concentrations would also be measured in dredge and cap areas immediately following remedy implementation. In proposed dredge areas, sediment will be removed to depths where sediment chemistry is expected to result in the long-term compliance with the total PAH and SWAC RGs at the 2-year review period. If surface sediment concentrations immediately following remedy implementation are not expected to achieve RG compliance at the 2-year review period, the Confirmation Management Plan will outline additional measures that may be implemented to further ensure RG compliance in 2 years. Additional remedial measures may include additional dredging, the placement of backfill material, or reliance on ongoing natural sedimentation processes.

Operational monitoring will also be conducted during remedy implementation to ensure the water and air 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.

Long-Term Monitoring. Long-term monitoring of the Buffalo River would confirm the continuation of natural processes that reduce risk and ecological exposures. Furthermore, long-term monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and to evaluate changes in conditions that are used to identify and delist BUIs. The *SRIR* (ENVIRON et al. 2009) characterizes the current physical, chemical and biological conditions of the Buffalo River AOC through the evaluation of recent sediment investigations and historical information. This characterization, along with any additional data collected from the Buffalo River AOC prior to remedy implementation, can serve as baseline conditions for the Buffalo River AOC, to which post-remediation data collected during long-term monitoring can be compared. An evaluation of post-remedy conditions against baseline conditions will demonstrate any changes in the physical, chemical and biological conditions as they relate to RAOs and the delisting BUIs.

At Year 2 following the completion of the remedy, surface sediment (0–1 ft) chemical concentrations will be measured to confirm that the total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs were achieved. As outlined in Section 3, SWAC RGs are based on 1/3-mile segments of the river. If the RGs have not been achieved at the 2-year review period, additional remedial measures may be implemented. The following three decision alternatives have been established to provide flexibility in response to results obtained from Year 2 surface sediment sampling and analytical results:

- ***Case 1****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs have been achieved at the two-year monitoring period* – No further action is required.

- ***Case 2****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, but evidence indicates progress toward the site-specific RGs* – Monitoring may be continued through Year 5 in areas where progress toward the RGs has occurred, particularly in areas that demonstrate natural ongoing processes have led to a decrease in surface sediment concentrations as compared to concentrations measured immediately following remedy implementation.

- ***Case 3****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, and monitoring results suggest unacceptably slow progress toward meeting RGs* – Additional dredging or the placement of clean material may be employed to achieve compliance with RGs, particularly in areas that do not demonstrate an acceptable decrease in surface sediment concentration as compared to concentrations measured immediately following remedy implementation, assuming that the lack of progress observed is not attributable to an ongoing source. In areas where the RGs are not achieved at Year 2 and additional remedial measures are implemented, monitoring will be conducted at Year 5 to confirm compliance with the RGs.

At Year 2, long-term monitoring of capped areas will include one or more of the following metrics: bathymetric or visual surveys to evaluate cap integrity, and/or surface sediment chemical concentrations in the cap to evaluate sediment deposition and recontamination potential.

Long-term biological monitoring of the Buffalo River AOC will be conducted at Years 1 and 5 following the remedy implementation. Biological monitoring will include one or more of the following metrics: benthic community surveys, fish community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. Biological monitoring and sampling locations will be established during remedial design and, to the extent practicable, will correspond to areas monitored during previous biological studies conducted in the Buffalo River (ENVIRON et al. 2009, Irvine et al. 2005). This information is will be used to evaluate changes in conditions that used to identify and delist BUIs.

5.5 Remedy Alternative 5: Enhanced Protectiveness Dredging

Remedy Alternative 5 provides for additional sediment removal beyond Remedy Alternative 4, by targeting the removal of subsurface sediments (0-4 ft deep) that exceed specific chemistry criteria and targets the removal of sediments associated with oil and grease. Similar to Remedy Alternative 4, Remedy Alternative 5 also targets the removal of all sediments from areas with surface sediment (0 - 1 ft) total PAH concentrations >1 TU, and achieves SWAC RGs for PCBs, Hg, and Pb, and primarily relies on natural sedimentation processes after dredging to achieve dredge residual performance standards established during detailed design. Capping is introduced for remediation of the end of the City Ship Canal, beyond the limits of the authorized navigation channel. By achieving the point concentration RG for total PAHs and SWAC RGs for PCBs, Hg, and Pb, Remedy Alternative 4 was developed to address ecological and human health risks associated with elevated surface sediment chemical concentrations. To further reduce ecological and human health risks, members of the GLLA PCT collaborated to develop additional guidelines for sediment chemistry at depths of 0-4 ft, areas associated with oil and grease, areas of elevated erosion potential, public access areas, and high ship-traffic areas. These guidelines were applied to Remedy Alternative 4 for the development of Remedy Alternative 5.

- **Sediment Chemistry Guidelines:** The Sediment Chemistry Guidelines are provided in Appendix D1. In summary, in addition to being protective of all sediments from areas with surface sediment (0 – 1 ft) total PAH concentrations >1 TU, and achieving the risk-based SWAC RGs for PCBs, Hg, and Pb, Remedy Alternative 5 provides additional risk reduction by targeting the removal of surface and subsurface sediments that exceed the following point sediment chemistry concentrations:

  <u>Sediment depth of 0–2 ft</u>

  - Total PAHs, 2 TU (32 mg/kg)
  - Pb, 400 mg/kg
  - Hg, 3 mg/kg
  - Total PCBs, 3 mg/kg[9]

  <u>Sediment depth of 2–4 ft</u>

  - Total PAHs, 5 TU (80 mg/kg)
  - Pb, 800 mg/kg
  - Hg, 6 mg/kg
  - Total PCBs, 6 mg/kg

- **Oil and Grease:** Remedy Alternative 5 targets the removal of areas that are associated with the presence of elevated levels of oil and grease. The following features were considered in identifying sediments that may be associated with oil and grease: 1) chemical and petroleum odors, 2) sediment staining, 3) the presence of sheen, and 4) photoionization device (PID) readings greater than 50 parts per million (ppm). Sediment cores collected from the 2005, 2007, and 2008 sediment investigations that were identified as containing at least three of these features are targeted for removal in Remedy Alternative 5. These sediment cores are listed in Appendix D2.

[9] This is based on an average PCB concentrations driving remediation at 19 sediment sites across the US, where target PCB concentrations driving remediation were below TSCA levels. The average concentration was 3 ppm ± 4 ppm

- **Potential Sediment Scour Areas:** An evaluation of surface sediment concentrations, assuming a net scour depth of 1 ft in the potential scour areas, was conducted to assess the potential exposure of elevated chemical concentrations following a scour event. Areas of potential sediment scour during a high flow event are identified in the Technical Memorandum, *Buffalo River Sedimentation and Long-Term Sediment Stability* in Appendix C. Under post Remedy Alternative 5 conditions, Pb, Hg, and total PCB SWACs are not expected to exceed the RGs in the AOC following a scour event, and only few surface locations indicated the potential minor exceedances of the PAH RG of 1 TU. The specific results of this analysis are provided in Appendix D3. Most potential scour areas that may expose PAH concentrations greater than 1 TU following a high flow event are currently targeted for resampling as part of Remedy Alternative 5, as discussed in Section 5.5.1.

- **Public Access Areas:** Recreational and conservation areas frequently used by the public were identified by BNR, and are shown in Appendix D4. A human health risk evaluation was conducted for these public access areas, and the results of the human health evaluation are presented in Appendix B. In summary, the cumulative cancer risk and the noncancer hazard index (HI) estimates using maximum sediment concentrations in public access areas meet the USEPA cancer risk and HI limits of 10^{-4} and 1, respectively, under current conditions, and are below 10^{-6} and 1 under post Remedy Alternative 5 conditions. Extra precautions were undertaken to ensure low risks in areas identified as recreational and prone to frequent public use.

- **Ship Traffic Areas:** Commercial and freighter traffic may cause sediment resuspension and the exposure of buried sediments, particularly if the vessels make physical contact with the sediment surface. BNR identified two areas in the Buffalo River AOC where sediments have historically been disturbed as a result of ship and commercial traffic. These areas are Kelly Island, which is located at the confluence of the City Ship Canal and the Buffalo River, and the area under the railroad bridge just upstream of RM 4.0. Both of these areas are targeted for remediation in Remedy Alternative 5 per the Sediment Chemistry Guidelines and Oil and Grease Guidelines. No additional areas were identified as prone to elevated ship traffic that could disrupt post-Remedy Alternative 5 residual sediments.

- **River Mile 4.6 Assessment:** In 1997, during construction of a cap and a slurry wall around the perimeter of a peninsula of land formerly owned by the Buffalo Color Corporation, contaminated material was identified in the Buffalo River, on a localized area of the western side of the peninsula at RM 4.6. The peninsula has been identified as Area D by the NYSDEC. The majority of the contaminated sediment deposit was removed and placed within the confines of the cap/slurry wall on Area D proper, but a portion of this material could not be removed from the river without potentially jeopardizing the stability of the slurry wall (Parsons 2003). The remaining contaminated sediment material in the river was capped with a geotextile layer, sand, and a surface layer of shot rock and rip rap. The cap has been in place for approximately 12 years.

  The PCT has considered the potential for this material to negatively impact the river. Although the sediment chemical concentrations in two sediment cores collected in 2005 from the vicinity of the Area D peninsula (cores 702+50-R and 705+00-R) met both the site-specific RGs and the sediment chemistry guidelines developed for this *FS*, additional assessment is required.

  A focused feasibility study will be conducted for this specific area at RM 4.6. The focused feasibility study will be conducted independent of this *FS* but the results will be incorporated into the Buffalo River remedy design.

The focused feasibility study for the underlying sediment deposit off of Area D will include the following considerations:

- ○ The overall goal of the focused feasibility study is to determine whether additional remediation of the sediment deposit is necessary and warranted, and if necessary, how best to integrate additional remediation measures into the selected remedy for the river. Additional remediation measures that will be evaluated may include: leaving the cap in place and monitoring ongoing natural recovery processes (i.e., clean sediment deposition on top of the cap) over time; augmenting the cap; or removing the cap, cap armoring, and geotextile containment, followed by removal of the underlying deposit. Some remedy alternatives may require structural support for the bank material along the Area D peninsula, to protect the existing upland remedy.

- ○ As part of the remedy assessment process, and consistent with NYSDEC Division of Fish, Wildlife and Marine Resources *Technical Guidance for Screening Contaminated Sediments* (NYSDEC 1999), the various remedy alternatives will be compared using such criteria as their effectiveness regarding short and long-term risk reduction, remedy implementability, and the risks associated with remedy implementation. Parameters for this analysis are expected to include documentation of existing conditions and changes to those conditions over the past 12 years, assessment of existing hydrologic and geotechnical conditions of the river and adjacent upland soils, and an assessment of existing habitat in the vicinity of the capped area. The analysis will examine the potential impact of any remedial action on the continued performance of the slurry wall around Area D. The risks to the slurry wall, from cracking to catastrophic failure, will be evaluated based on the geotechnical properties of the surrounding and underlying soils, the anticipated change in loadings from remedial action, and the feasibility of successfully addressing identified risks during construction.

- ○ A sampling plan will be developed that identifies the number of sediment cores, the appropriate sample depths, and chemical constituents. Chemical constituents will be consistent with the range of chemicals originally considered to have contributed to sediment contamination beneath the cap and will consider the range of chemicals identified in the 1991 Record of Decision for the Buffalo Color Area D site. The derivation of sediment quality criteria will be consistent with NYSDEC's *Technical Guidance for Screening Contaminated Sediments* (NYSDEC 1999).

In addition to these guidelines, the quality and area of habitat that would be impacted by Remedy Alternative 5 was evaluated. The results of this evaluation, and the mitigation and restoration measures proposed for the habitat areas likely to be disturbed by Remedy Alternative 5 are presented in Section 8, Habitat Restoration.

5.5.1 Dredging Remedy Design

Remedy Alternative 5 targets the removal of all sediments from areas with surface sediment (0 – 1 ft) total PAH concentrations >1 TU, achieves SWAC RGs for PCBs, Hg, and Pb, targets the removal of all sediments with elevated point concentrations of total PAHs, total PCBs, Hg and Pb at depths of 0 – 4 ft, . Engineering considerations addressed as part of this remedial alternative include:

- Aerial extent and depth of dredging
- Dredging methods and dredged material disposal
- Post-dredging natural sedimentation and surface sediment recovery

- Habitat impacts and habitat recovery time

Extent and Depth of Dredging. Dredging areas are defined on the basis of the PAH TU of 1 and SWACs for PCBs, Hg, and Pb in surface sediments, and elevated point concentrations of total PAHs, total PCBs, Hg, and Pb at depths of 0 – 4 ft. For this remedy, surface sediments are defined as sediment depths beginning at the sediment / water interface and extending 1 foot below the sediment surface (i.e., 0 – 1 ft depth).

The limits of dredging for Remedy Alternative 5 are shown in Figure 5-1c. The proposed plan area for Remedy Alternative 5 is approximately 76 acres, including 57 acres in the Buffalo River and 19 acres in the City Ship Canal, as provided in Table 5-1d. This acreage includes the proposed cap area at the end of the City Ship Canal, which is approximately 6.7 acres.

The majority of sediments targeted for removal are located within the City Ship Canal and between RM 2.75 and RM 5.5 of the AOC. For the purposes of this *FS*, isolated areas supported by one sample location with surface sediment concentrations greater than 1 TU, or areas with insufficient sediment chemistry data are not included in the remedy footprint, but will be resampled as part of remedy design. These areas are designated in green in Figure 5-1c.

In proposed dredge areas, sediment removal will be delineated to depths where sediment the chemistry is expected to be compliant with the RGs at the 2-year review period. The estimated in-place sediment volumes targeted for removal in Remedy Alternative 5 are shown in Table 5-2c, and include 720,000 CY from the Buffalo River (this includes 530,000 CY from outside the federally-defined navigation channel boundary and 190,000 CY from within the navigation channel) and 100,000 CY from the City Ship Canal (this includes 80,000 CY from outside the navigation channel and 20,000 CY from within the navigation channel). The volume of sediment targeted for removal in Remedy Alternative 5 is approximately 28% greater than the volume targeted in Remedy Alternative 4.

Dredging Methods and Dredged Material Disposal. Both mechanical and hydraulic dredging could be used to remediate the Buffalo River sediments for Remedy Alternative 5. Physical constraints (i.e., bulkheads, bridge abutments and piers, or cross-channel utilities) can hinder dredging and must be evaluated during remedy design.

As with Remedy Alternatives 3 and 4, best management practices, such as operational controls and specialty equipment, will be used during dredging operations to reduce potential contaminant release. Careful boat operation and operation during off-peak flow velocities can also minimize sediment disturbances. The remedy design for the Buffalo River can establish a systematic dredging approach that targets off-channel areas or high concentration areas first, followed by dredging of the navigational channel to capture sediment that may get resuspended and subsequently migrate into the main channel of the river. Due to bidirectional flow of the Buffalo River, USACE has found the use of silt curtains to be ineffective along the AOC. The exact methods to be used to reduce potential sediment suspension and contaminant release will be assessed during remedy design.

As with Remedy Alternatives 3 and 4, the presence of a CDF specifically designed for the management and disposal of sediments from the Buffalo River within 3 to 9 miles of the AOC makes the CDF the most appropriate alternative for the dewatering/stabilization and disposal of dredged sediments and barge transport or hydraulic conveyance the preferred sediment transport alternatives. CDF No. 4 was used as the disposal facility for the dredge project conducted at Smokes Creek in 2008–2009. Dredged materials would be transported to CDF No. 4 via barge or hydraulic conveyance systems, depending on the dredging method and the transport distance. Dredged material will be placed in the CDF in a manner that is protective of human health and the environment, and material placement will meet applicable and promulgated State water quality standards, as well as any other applicable Federal/State environmental laws and regulations.

Barging facilities exist at CDF No. 4, although the material off-loading facilities at the CDF may require some improvements. Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges). For pipeline systems, potential significant constraints include the presence of railroads and highways between the AOC and the CDF. These considerations will be resolved during remedial design.

CDF No. 4 does not accept dredge material that is classified as TSCA waste. Only one sample location target for removal in Remedy Alternative 5 has sediment chemical concentrations that would be classified as TSCA material (total PCB concentration >50 mg/kg). Thus, a small volume of dredge material (<1,000 CY) is expected to require disposal at a TSCA-approved disposal facility. The Chemical Waste Management (CWM) facility located in Model City, NY, approximately 30 miles from the Buffalo River AOC, is closest TSCA-approved facility permitted to dispose of PCBs. Dredged TSCA material would likely be transported to the CWM facility via truck from the CDF staging area.

Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation. Within routinely dredged areas, the anticipated distribution of submerged debris is expected to be relatively small. However, the occurrence of debris is likely to increase in off-channel areas, which may hinder or slow dredging.

Post-dredging Natural Sedimentation and Surface Sediment Recovery. Remedy Alternative 5 primarily relies on natural sedimentation after dredging to meet long-term RAO goals. In some dredge areas, the placement of a layer of material upon the sediment surface may be necessary accelerate natural recovery processes and further protect the biological active zone. Sediment dredging can be ineffective at reducing surface sediment concentrations to below target concentrations because of concurrent surface sediment mixing and dredge residuals deposition (USACE 2008b). Over the last two decades, natural sedimentation has occurred at a significant rate throughout the study area (USACE 1988), and has led to measurably decreased surface sediment contaminant concentrations. Surface sediment concentrations of PAHs and PCBs are below RGs in most areas of the river, and current Hg and Pb levels do not pose adverse ecological or human health risks; Hg and Pb RGs were established to ensure that the sediment remedy not increase long-term exposures and risk. This historical evidence of natural sedimentation processes and correspondingly reduced surface sediment concentrations lends confidence to relying on natural sedimentation processes after dredging to meet long-term RAO goals. However, due to dredge residuals, it should be recognized that the RGs will likely not be achieved for 2 years following implementation of the dredge remedy. During the short term, dredging could actually increase ecological and human exposures for several years, such as occurred after dredging in the Black River (ENVIRON et al. 2009).

5.5.2 Sediment Cap Remedy Design for Remedy Alternative 5

The downstream end of the City Ship Canal is target for sediment remediation as part of Remedy Alternative 3 (Figure 5-1c). This segment of the City Ship Canal (approximately the last 1,800 ft of the canal) is beyond the downstream boundary of the navigation channel and represents a low energy environment that is not susceptible to sediment scour from the overlying flow or ice events. A sediment cap is targeted for this area to isolate underlying sediment contaminants, provide a clean sediment surface, and provide an appropriate substrate for habitat restoration in this portion of the AOC (see Section 8). Capping depths and cap materials would be designed to optimize and enhance habitat restoration plans while providing adequate protection against damage from root penetration. Native sediments from the Buffalo River may serve as cap material at the end of the City Ship Canal. The use of in-stream borrow material for the sediment cap will be further evaluated during Remedial Design. Cap placement could be performed by either (a) extending a navigational channel to the downstream end of the City Ship Canal to allow for barge traffic, which would require the removal of approximately 50,000 CY; (b) hydraulic means; or (c) in dry conditions using earth moving equipment, by temporary sheeting and dewatering the proposed cap area and using the adjoining upland areas (e.g., sand processing plant along Fuhrmann Boulevard or the upland area at the end of the City Ship Canal) for material handling.

5.5.3 Short- and Long-Term Monitoring Requirements for Remedy Alternative 5

Remedy Alternative 5 includes short-term confirmation and operation monitoring during remedy implementation, and long-term monitoring following the completion of the remedy. General short-term and long-term monitoring components are provided below and detailed monitoring plans will be provided as part of remedial design. A Confirmation Management Plan will also be included as part of the remedial design and will outline decision criteria for determining what, if any, additional remedial measures may be warranted immediately following remedy implementation. Additional measures may be necessary if the remedy was not implemented per design specifications or if post-remedy sediment chemistry is not expected to achieve compliance with the RGs at the 2-year review period.

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 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. In addition to the DGPS and real-time monitoring software, bathymetric surveys will be conducted following the completion of the dredge remedy to ensure sediment was removed according to dredge design specifications. Post dredge confirmation bathymetric surveys may be coordinated with the annual bathymetric surveys routinely conducted by USACE. Bathymetric surveys will also be conducted in cap areas to ensure cap depth and surface coverage meets cap design specifications. In the event that confirmation monitoring demonstrates the remedy was not implemented per remedy design specifications, the Confirmation Management Plan will outline the decision criteria for determining what, if any, additional measures are warranted.

Surface sediment chemical concentrations would also be measured in dredge and cap areas immediately following remedy implementation. In proposed dredge areas sediment will be removed to depths where sediment chemistry is expected to result in the long-term compliance with the total PAH and SWAC RGs at the 2-year review period. If surface sediment concentrations immediately following remedy implementation are not expected to achieve RG compliance at the 2-year review period, the Confirmation

Management Plan will outline additional measures that may be implemented to further ensure RG compliance in 2 years. Additional remedial measures may include additional dredging, the placement of backfill material, or reliance on ongoing natural sedimentation processes.

Operational monitoring will also be conducted during remedy implementation to ensure the water and air 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.

Long-Term Monitoring. Long-term monitoring of the Buffalo River would confirm the continuation of natural processes that reduce risk and ecological exposures. Furthermore, long-term monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and to evaluate changes in conditions that are used to identify and delist BUIs. The *SRIR* (ENVIRON et al. 2009) characterizes the current physical, chemical and biological conditions of the Buffalo River AOC through the evaluation of recent sediment investigations and historical information. This characterization, along with any additional data collected from the Buffalo River AOC prior to remedy implementation, can serve as a baseline conditions for the Buffalo River AOC, to which post-remediation data collected during long-term monitoring can be compared. An evaluation of post-remedy conditions against baseline conditions will demonstrate any changes in the physical, chemical and biological conditions as they relate to RAOs and the delisting BUIs.

At Year 2 following the completion of the remedy, surface sediment (0–1 ft) chemical concentrations will be measured to confirm that the total PAH RG and the SWAC RGs for Pb, Hg, and total PCBs were achieved. As outlined in Section 3, SWAC RGs are based on 1/3-mile segments of the river. If the RGs have not been achieved at the 2-year review period, additional remedial measures may be implemented. The following three decision alternatives have been established to provide flexibility in response to results obtained from Year 2 surface sediment sampling and analytical results:

- ***Case 1****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs have been achieved at the two-year monitoring period* – No further action is required.
- ***Case 2****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, but evidence indicates progress toward the site-specific RGs* – Monitoring may be continued through Year 5 in areas where progress toward the RGs has occurred, particularly in areas that demonstrate natural ongoing processes have led to a decrease in surface sediment concentrations as compared to concentrations measured immediately following remedy implementation.
- ***Case 3****: The total PAH RG of 1 TU and SWAC RGs for Pb, Hg, and total PCBs are not achieved at the two-year monitoring period, and monitoring results suggest unacceptably slow progress toward meeting RGs* – Additional dredging or the placement of clean material may be employed to achieve compliance with RGs, particularly in areas that do not demonstrate an acceptable decrease in surface sediment concentration as compared to concentrations measured immediately following remedy implementation, assuming that the lack of progress observed is not attributable to an ongoing source. In areas where the RGs are not achieved at Year 2 and additional remedial measures are implemented, monitoring will be conducted at Year 5 to confirm compliance with the RGs.

At Year 2, long-term monitoring of capped areas will include one or more of the following metrics: bathymetric or visual surveys to evaluate cap integrity, and/or surface sediment chemical concentrations in the cap to evaluate sediment deposition and recontamination potential.

Long-term biological monitoring of the Buffalo River AOC will be conducted at Years 1 and 5 following the remedy implementation. Biological monitoring will include one or more of the following metrics: benthic community surveys, fish community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. Biological monitoring and sampling locations will be established during remedial design and, to the extent practicable, will correspond to areas monitored during previous biological studies conducted in the Buffalo River (ENVIRON et al. 2009, Irvine et al. 2005). This information is will be used to evaluate changes in conditions that used to identify and delist BUIs.

6 EVALUATION OF REMEDIAL ALTERNATIVES

This section provides a comparative evaluation of sediment Remedy Alternatives 1 through 5 against the nine evaluation criteria established under NCP (40 CFR 300.430(e)(9)). The remedy evaluation in this section expands upon the preliminary engineering scoping information presented in Section 5. This section organizes the remedy evaluation according to the NCP criteria, so that remedial alternatives can be compared according to each criterion. Analyses used to support the remedy evaluations in this section are presented in Table 6-1a (habitat recovery times), Table 6-1b (impact of remedies on aquatic vegetation and habitat), Table 6-2 (baseline and remedy SWAC calculations), Table 6-3 (mass removal calculations), and Table 6-4 (estimated remedy costs).

6.1 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 goals of the RAOs established in Section 3 of this document.

Each of the Remedy Alternatives provides varying degrees of overall protection of human health and the environment. While dredging of sediments may be contribute to RAO goals by removing sediment contaminants from the river, it poses dredged material management and disposal challenges and creates unique ecological risks not realized by MNR. MNR, on the other hand, does not immediately satisfy the RAO goals and relies on ongoing sedimentation processes to achieve remedial goals and reduce risks, which may take longer than capping or dredging. Capping is very well suited to sediment remediation and ecological recovery, but is limited to areas outside the navigation channel in the Buffalo River AOC.

6.1.1 Remedy Alternative 1

Baseline human health risk estimates for potential exposure to sediment at the Buffalo River AOC are within USEPA’s risk limits (1991) with the exception of PCB concentrations in fish tissue, specifically regarding carp consumption. Based on the latest fish sampling data (NYSDEC 2007), the estimated human health risks associated with carp consumption are greater than the USEPA acceptable risk range (see Appendix B). PCB concentrations in carp also continue to be greater than the NYSDOH level for which the fish advisory was originally established. Existing advisories that restrict fish consumption from the Buffalo River are expected to minimize the potential adverse impacts on human health.

The No Action alternative contributes to the RAO goals insofar as existing baseline sediment conditions in most areas of the river are protective of birds, fish, and benthic organisms with respect to total PAHs, Pb, Hg, and total PCBs in surface sediments. However, RGs have not been met in portions of the river, such as in the vicinity of RM 3.0-5.0 and in the City Ship Canal. Construction hazards and health risks to local residents and remediation workers during remediation activities would be nonexistent, because no intrusive remedial action is taken.

6.1.2 Remedy Alternative 2

Remedy Alternative 2 contributes to the protection of human health and the environment over time and contributes to the RAO goals through ongoing recovery processes, monitoring, and institutional controls that protect public health. Natural sedimentation is the primary line of evidence demonstrating historical recovery trends, and supporting MNR.

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 the decreasing concentrations of total PAHs, total PCBs, Pb, and Hg in the surface sediment and the associated decline in health and ecological risks related to total PAHs, total PCBs, Pb, and Hg in sediments in the AOC. 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 contribute to the goals of RAO 1, but in the long-term RAO 1 goals could be achieved by effectively managing and reducing risks to human and ecological receptors, and limiting implementation risks associated with more active remedial approaches.

Remedy Alternative 2 contributes to the goal of RAO 1 insofar as sediment conditions with respect to total PAHs, Pb, and Hg are protective of human health. Sport fishing advisories exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). These restrictions will likely be maintained by NYSDOH until the criteria for delisting are attained. Current concentrations of Hg in fish have not led the state to list Hg in their fish consumption advisories. Hg and Pb concentrations are less than the NYSDEC fish tissue criteria for wildlife, and are below the USEPA threshold for both chemicals; thus, RAOs are effectively met for Hg and Pb. For this *FS*, it is assumed that the current fish advisories will be used in conjunction with MNR until the proper criteria are attained. Construction hazards and health risks to local residents and remediation workers during remediation activities would be minimal because no intrusive remedial action is taken.

MNR contributes to the goal of RAO 2 in areas where baseline sediment conditions are protective of birds, fish, and benthic organisms with respect to total PAHs, Pb, Hg, and total PCBs. However, surface sediment concentrations presently exceed the PAH RG of 1 TU and SWAC RGs for PCBs, Pb, such as in the vicinity of RM 3.0-5.0 and in the City Ship Canal. SWACs also exceed the RGs for Hg in some areas of the AOC, which were conservatively established to be protective against adverse conditions that could be created during remediation. Ongoing sedimentation is expected to continue to contribute to reduce surface sediment chemical concentrations, leading to ecosystem recovery and reduced human exposures with time, but the time required to reduce surface sediment concentrations below RGs is expected be significantly longer than the time via MNR as compared to sediment removal remedies. The long-term monitoring component of an MNR remedy may be used demonstrate if unacceptable levels of chemical concentrations are present in surface sediments as a result of maintenance dredging or a significant scour event. If so, the decision criteria outlined in an MNR long-term monitoring plan would be followed to reduce potential human and ecological exposures. In areas where site-specific RGs have been achieved for total PAHs, total PCBs, Pb, and Hg, MNR is expected to continue to maintain current conditions via ongoing sediment deposition and consolidation. The well-armored and cohesive nature of the sediments, the depositional environment, the history of sediment deposition and contaminant burial, the relatively low to moderate routine flow conditions in the river combined with armoring in more energetic areas, all attest to the long-term stability of river sediment in the Buffalo River and the ability of MNR to continue to maintain and improve conditions.

MNR alone does not contribute to the goal of RAO 3. Although chemical concentrations in dredged material are expected to continue to decrease with time as dredging continues to export chemicals from the river, the time to achieve concentrations that allow either open lake placement or beneficial use in a Brownfield or other setting is likely to be long.

MNR is consistent with the goal of RAO 4 insofar as the MNR remedy does not interrupt restoration goals. However, the time required for MNR alone to improve some BUIs would be longer than the Remedial Advisory Committee goals for restoration of the river.

6.1.3 Remedy Alternative 3

Remedy Alternative 3 targets the removal of surface and deep sediment with PAH concentrations >1 TU, thus immediately decreasing the mass of PAHs and other chemicals in the river; Remedy Alternative 3 also targets SWACs to levels below the RGs for total PCBs, Pb, and Hg. With time, this remedy reduces chemical exposures of benthic organisms and fish.

Sediment dredging contributes to the RAO goals of overall protection of human health and the environment by removing contaminated sediment to improve long-term surface sediment conditions that reduce risks to human health, birds, fish, and benthic organisms. Notably, short-term surface sediment concentrations will be negatively impacted by this remedy, which requires an approximate 5-year construction period, followed by post-remedy surface sediment deposition processes that contribute to reduced chemical concentrations to achieve RGs and RAO goals.

Remedy Alternative 3 contributes to the goal of RAO 1 insofar as it achieves the site-specific RGs for surface sediment conditions in the river. Sport fishing advisories exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). These restrictions will likely be maintained by NYSDOH until such time that the criteria for delisting are attained. Current concentrations of Hg in fish have not led the state to list Hg in their fish consumption advisories. Hg and Pb concentrations are below the NYSDEC fish tissue criteria for wildlife, and are below the USEPA threshold for both chemicals. Remedy Alternative 3 was delineated such that it is not expected to increase long-term surface sediment Hg or Pb levels. Construction hazards and health risks to local residents and remediation workers during the construction period and during post-remedy recovery would be managed through site-specific health and safety plans and public communication.

Remedy Alternative 3 contributes to the goal of RAO 2 by removing sediments in areas where surface sediment COC concentrations are greater than the RGs. However, in areas where RGs have been achieved via natural recovery, dredging surface sediments introduces negative short-term ecological impacts through the disruption of the existing sediment bed surface and benthic environment, sediment suspension, and exposed residuals after dredging.

Remedy Alternative 3 will contribute to RAO 3 by targeting the removal of all sediment concentrations >1 TU. However, Remedy Alternative 3 also displaces approximately 80% of the existing capacity of

CDF No. 4. Thus, after the remedy is complete, USACE may have to find alternative disposal methods for future dredge spoils.

Remedy Alternative 3 is generally inconsistent with the RAO 4 insofar as dredging severely disrupts the natural environment and interrupts restoration goals. All dredging and capping remedies disrupt the natural environment to some degree. Remedy Alternative 3, which has a greater interruption of the environment than Remedy Alternatives 4 and 5, may be inconsistent with the RAO 4 by disrupting a disproportionately large portion of the natural environment compared to Remedy Alternatives 4 and 5. The time required for habitat recovery is discussed below, in the discussions of short- and long-term effectiveness.

6.1.4 Remedy Alternative 4

Remedy Alternative 4 targets the removal of surface sediment with PAH concentrations >1 TU, thus immediately decreasing the mass of PAHs and other chemicals in the river, and achieves SWACs to levels below the RGs for PCBs, Pb, and Hg, thus reducing chemical exposures of benthic organisms and fish. Sediment dredging contributes to RAO goals and achieves overall protection of human health and the environment by removing contaminated sediment to improve long-term surface sediment conditions that reduce risks to human health, birds, fish, and benthic organisms. Notably, short-term surface sediment concentrations will be negatively impacted by this remedy, which requires approximately 2.5 to 3 years to implement, followed by post-remedy surface sediment deposition processes that contribute to reduced chemical concentration reductions and the RAO goals. However, the short-term impacts of Remedy Alternative 4 are much less than Remedy Alternative 3.

Remedy Alternative 4 effectively contributes to the RAO goals of achieving overall protection of human health and the environment. By targeting surface sediment exposures and RGs, Remedy Alternative 4 is expected to contribute to the RAO goals more quickly than Remedy Alternative 2 (MNR), particularly in areas where surface sediment PAH concentrations >1 TU, and SWACs for total PCBs, Pb, and Hg exceed the RGs. Further, because Remedy Alternative 4 does not disrupt areas where natural recovery processes already achieved RGs (i.e., in areas where surface sediment PAH concentrations <1 TU cover buried deposits with PAH concentrations >1 TU, and in areas where total PCBs, Pb, and Hg SWACs achieve the RGs).

Remedy Alternative 4 satisfies the goal RAO 1 insofar as it achieves the site-specific RGs for surface sediment conditions in the river. Meeting PCB SWAC RGs is expected to contribute to ongoing trends toward reduced PCB concentrations in carp (NYSDEC 1989, Loganathan et al. 1995, NYSDEC 2006, Skinner et al. 2009). Sport fishing advisories exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). These restrictions will likely be maintained by NYSDOH until such time that the criteria for delisting are attained. Current concentrations of Hg in fish have not led the state to list Hg in their fish consumption advisories. Hg and Pb concentrations are below the NYSDEC fish tissue criteria for wildlife, and are below the USEPA threshold for both chemicals. Remedy Alternative 4 was delineated such that it is not expected to contribute to increased long-term surface sediment Hg or Pb levels. Construction hazards and health risks to local residents and remediation workers during the 2.5-year construction period and during post-remedy recovery would be managed through site-specific health and safety plans and public communication.

Remedy Alternative 4 will contribute to RAO 3 by targeting the removal of surface sediments with concentrations that exceed the RGs, and reducing sediment mass that contributes to CDF disposal requirements. Remedy Alternative 4 displaces much less of the existing capacity of CDF No. 4 than Remedy Alternative 3, thus leaving more capacity in the CDF.

Although dredging disrupts the natural environment and may interrupt restoration goals, limited dredging focused on surface sediment exposures limits the impacts of dredging on the natural environment by not dredging in areas that do not pose unacceptable levels of risk. Thus, Remedy Alternative 4 is generally more consistent with the RAO 4 than Remedy Alternative 3. The time required for habitat recovery is discussed below, in discussions of short- and long-term effectiveness.

6.1.5 Remedy Alternative 5

Remedy Alternative 5 targets the removal of sediments exceeding the PAH RG of 1 TU in surface (0-1 ft) sediment, surface sediments exceeding SWAC RGs for PCBs, Pb, and Hg, and sediments with elevated point concentrations of total PAHs, total PCBs, Hg, and Pb at depths 0-4 ft. By achieving surface sediment RGs for total PAHs, total PCBs, Pb, and Hg, Remedy Alternative 5 thus reduces chemical exposures of benthic organisms and fish. Sediment dredging contributes to the RAO goals of achieving overall protection of human health and the environment by removing contaminated sediments to improve long-term surface sediment conditions that reduce risks to human health, birds, fish, and benthic organisms. Notably, short-term surface sediment concentrations will be negatively impacted by this remedy, which requires approximately 3 years to implement, followed by post-remedy surface sediment deposition processes that contribute to reduced chemical concentration reductions to achieve RGs and contribute to the RAOs. The short-term impacts of Remedy Alternative 5 are longer than those for Remedy Alternative 4, but are much less than for Remedy Alternative 3.

Remedy Alternative 5 effectively contributes to the RAO goals of achieving overall protection of human health and the environment. By targeting surface sediment exposures and RGs, Remedy Alternative 5 is expected to contribute to RAOs more quickly than Remedy Alternative 2 (MNR). Remedy Alternatives 4 and 5 are considered similar in their ability to achieve RGs and contribute to RAOs, inasmuch as they comparably achieve reduced ecological and human health risks. However, in addition to achieving the RGs, Remedy Alternative 5 also targets the removal of elevated COC concentrations at depths of 0–4 ft. Thus, Remedy Alternative 5 further reduces long-term ecological and human health risks as compared to Remedy Alternative 4 by removing sediments with elevated chemical concentrations that may be exposed in the future resulting from the ongoing maintenance dredging of the Buffalo River navigation channel. In addition, Remedy Alternative 5 thus removes more overall chemical mass from the river, and will thus outperform Remedy Alternative 4 with respect to improving the likelihood that future dredged sediments will not require confined disposal (RAO 3).

Remedy Alternative 5 contributes to the goal of RAO 1 insofar as it achieves the site-specific RGs for surface sediment conditions in the river. Remedy Alternative 5 is similar to Remedy Alternative 4, except that it also targets elevated concentrations of total PAHs, total PCBs, Pb, and Hg at depths of 0–4 ft. Meeting PCB SWAC RGs is expected to contribute ongoing trends toward reduced PCB concentrations in carp. Sport fishing advisories currently exist to prevent exposures to PCBs through consumption of carp from the Buffalo River (NYSDOH 2009). These restrictions will likely be maintained by NYSDOH until such time that the criteria for delisting are attained. Current concentrations of Hg in fish have not led the state to list Hg in their fish consumption advisories. Hg and Pb concentrations are below the NYSDEC fish tissue criteria for wildlife, and are below the USEPA threshold for both chemicals. Remedy Alternative 5 was delineated such that it is not expected to contribute to increased long-term surface sediment Hg or Pb levels. Construction hazards and health risks to local residents and remediation workers during the 3-year construction period and during post-remedy recovery would be managed through site-specific health and safety plans and public communication.

Remedy Alternative 5 contributes to the goals of RAO 2 by removing sediments in areas where surface sediment chemical concentrations are greater than the RGs. In areas not targeted for dredging, RGs have been achieved via MNR. Ongoing natural recovery processes will continue to contribute to RAOs. Dredging surface sediments introduces negative ecological impacts through the disruption of the existing sediment bed surface and benthic environment, sediment suspension, and exposed dredge residuals.

Remedy Alternative 5 will contribute to RAO 3 by targeting the removal of surface sediments that exceed the RGs, removing elevated point concentrations of COCs at depths of 0–4 ft, and thus reducing sediment mass that contributes to CDF disposal requirements. Remedy Alternative 5 displaces much less of the existing capacity of CDF No. 4 than Remedy Alternative 3, although more than Remedy Alternative 4, thus leaving more capacity in the CDF.

Although dredging and capping disrupts the natural environment and may interrupt restoration goals, limited remediation focused on surface sediment exposures limits the impacts of dredging and capping on the natural environment by not remediating in areas that do not pose unacceptable levels of risk. Thus, like Remedy Alternative 4, Remedy Alternative 5 is generally more consistent with the RAO 4 than Remedy Alternative 3. The time required for habitat recovery is discussed below, in discussions of short- and long-term effectiveness.

6.2 Compliance with ARARs

Although the identification of Applicable or Relevant and Appropriate Requirements (ARARs) is not required for remediation projects under GLLA, for the purposes of this *FS*, CERCLA and NCP criteria are being followed in the evaluation of remedy alternatives. The NCP criteria include an evaluation of the extent to which each remedy alternative is compliant with ARARs. ARARs for the Buffalo River AOC are provided in Table 6-5. The remedy alternatives are designed to comply with ARARs and all federal and state permits required for remedy implementation.

6.2.1 Remedy Alternatives 1 and 2

Remedy Alternatives 1 and 2 are expected to comply with ARARs, because they require no construction, and thus requires no permitting. There are no action-specific ARARs associated with the No Action and MNR alternatives. Surface water quality conditions in the Buffalo River AOC are not expected to change beyond current ongoing trends.

6.2.2 Remedy Alternatives 3, 4, and 5

Remedy Alternatives 3, 4 and 5 are designed to comply with ARARs. It is recognized that dredge remedies may cause disturbances of contaminated sediments during remedy implementation and that such disturbances may result in short-term exceedances of chemical-specific surface water ARARs. Permitting rules typically require that best management practices be used during dredging to minimize the potential for contaminant suspension and offsite transport.

Work would be scheduled to minimize impacts to fish species in the Buffalo River AOC during remedy implementation by adhering to designated fish windows and employing best management practices that minimize ecological impacts to the extent practicable. In addition, all appropriate permits and approvals would be obtained for dredging Buffalo River AOC sediments. Action-specific ARARs for dredging alternatives would be complied with by disposing of wastes in accordance with federal, state, and regional requirements.

Potential water quality impacts associated with dredging are minimized under Remedy Alternatives 4 and 5 by targeting only areas with surface sediments with PAH concentrations >1 TU, thus reducing the area and time over which impacts may occur as a result of the lower dredge areas and volumes. However, because Remedy Alternative 5 removes approximately 28% more sediment than Remedy Alternative 4, water quality impacts would be greater in Remedy Alternative 5 than in Remedy Alternative 4.

6.3 Short-Term Effectiveness

Short-term effectiveness includes an evaluation of short-term impacts on ecological and human risks, including environmental impacts of remedy implementation, potential impacts to the community and site workers during remedy implementation, and time until the remedy is achieved (Magar et al. 2008, Wenning et al. 2005, 2007). 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 may include removal of existing vegetation beds, removal of benthic organisms, alteration of water column depth, elimination of possible shallow habitat within the river, and short-term impacts on water quality. Short-term physical disturbances and water quality impacts are evaluated only for Remedy Alternatives 3, 4, and 5, because the No Action (Remedy Alternative 1) and MNR (Remedy Alternative 2) remedial alternatives are not intrusive and therefore do not affect habitat 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 area of required dredging for each specific remedy alternative the time required to physically remove the sediment. 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. Any state or federal requirements regarding restoration activities will be identified and addressed during the permitting process and a comprehensive habitat restoration plan is provided in Section 8, Habitat Restoration. However, because recovery takes time, short-term ecological risks and habitat impacts require careful evaluation.

Recolonization time is dependent on factors such as the spatial scale that would be physically disturbed by the remedial alternative (e.g., the length of shoreline) and consideration of the type of habitat impacted (e.g., emergent vegetation and submergent vegetation), and comparing those impacts to the observations of similar impacts as reported in literature for similar environments. The USEPA and the Natural Resources Research Institute performed a review of recovery in rivers that is relevant to estimates of habitat recovery for the Buffalo River (Yount and Niemi 1990). Table 6-1a provides a summary of recovery times seen in rivers following a variety of disturbances, as described by Yount and Niemi (1990).

Generally, initial recovery times shown from these studies in Table 6-1a range from six months to five years depending upon the type of disturbance and the size of the area, the endpoint being evaluated, and other various site-specific characteristics. With regard to specific recovery rates for the Buffalo River, estimates of the percentage of vegetation communities that are likely be impacted by the remedies are provided in Table 6-1b. The percent of impact to the vegetative community is important due to physical removal of habitat but also the fragmentation of impact is important because the areas of vegetation that remain following the remedial action seed the plant and invertebrate community in disturbed areas. It is also noted that recolonization contributions occur due to drift from upstream portions of the Buffalo River and Cazenovia Creek, as well as the seiche effect from Lake Erie. Overlays of the remedies with the vegetation communities are discussed in this section. Another factor of recovery is the depth of the water column, but this is more likely to affect the characteristic of the recovered community rather than the recovery time itself. Deeper water would influence the types of community that returns; recovery does not necessarily require a return to current use, but rather a return to functional use. Habitat recovery time for each remedy is described in the following sections.

6.3.1 Remedy Alternative 1

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 sediments with sediments 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.

6.3.2 Remedy Alternative 2

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 sediments with sediments having lower constituent concentrations.

The MNR remedy creates no increased risks 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 is not expected to negatively impact the community.

The MNR remedy poses negligible transportations risk because of minimal miles traveled, and no construction risk, because MNR does not require construction. However, MNR would pose negligible risks associated with long-term monitoring. Effective health and safety plans and experience can adequately manage risks 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.

6.3.3 Remedy Alternative 3

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 Buffalo River community. This is especially true for Remedy Alternative 3, which requires the removal, transportation, and disposal of more than 1.75 million CY of contaminated sediment material. The time required to complete the implementation of Remedy Alternative 3 is expected to be approximately 5 years.[10] During this time, sediment excavation, handling, transportation, and disposal increase community impacts, such as odors and noise. 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 and 5.

Dredging poses potential adverse risks to the Buffalo River community 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 dredged material increases human exposure risks due to the increased sediment handling requirements.

[10] The 5-year estimate is based on a removal rate of 3,000 CY / day, 5 months / year, and 6 days / week, and 12 hours / day. For the purposes of this *FS*, and based on discussions with USEPA and USACE PCT members, the 3,000 CY / day estimate is considered reasonable, but could very easily be lower, thus prolonging the overall time for construction. The 5-year estimate also includes mobilization, demobilization, and relocation between dredge areas.

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 targeting both surface and buried chemical deposits, Remedy Alternative 3 may exacerbate risks when targeting buried, sequestered sediment that is not currently bioavailable or bioaccessible, and in areas where MNR processes have achieved surface sediment RGs. The large dredge volume associated with Remedy Alternative 3 also prolongs the construction and ecological recovery times and the time required to achieve long-term RGs and RAOs, and virtually depletes the capacity of CDF No. 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 sediments 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.

Removing all sediments with PAH concentrations >1 TU as part of Remedy Alternative 3 increases the duration of negative short-term habitat impacts, in part due to the longer construction and recovery times. Figure 6-1a shows limits of dredging for Remedy Alternative 3 in relation to existing areas of emergent and submergent aquatic vegetation, and Table 6-1b provides the length shoreline with aquatic vegetation that would be disrupted by this remedy. In summary 72% of the aquatic vegetation in the Buffalo River would be impacted by Remedy Alternative 3 and 69% of the aquatic vegetation would be disrupted in the City Ship Canal.

At an estimated dredging rate of 3,000 CY / day, removal of 1.75 million CY would require approximately 5 to 6 years of dredging, assuming 5 month dredge windows annually. Given the volume of removal, it is estimated that the recovery time for the river as a whole will be approximately 7 to 10 years. This estimate is based on the amount of time it would take to complete required dredging, the sediment deposition rate, and the recolonization of vegetation and benthic organisms.

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 the other dredge remedies, (Remedy Alternatives 4 and 5) 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.

Existing advisories that restrict fish consumption from the Buffalo River are expected to minimize the potential adverse impacts on human health. Impacts would be minimized further by scheduling work in accordance with fish windows, and by employing best management practices that minimize surface sediment releases and ecological impacts to the extent practicable.

6.3.4 Remedy Alternative 4

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. Similar to Remedy Alternative 3, dredging of sediment as part of Remedy Alternative 4 increases the potential for negative short-term impacts to the environment and to the surrounding Buffalo River community. However, Remedy Alternative 4 helps minimize community- and worker-related risks via reduced dredging requirements, by focusing on surface sediments that exceed the RGs for total PAHs, total PCBs, Pb, and Hg. Targeting surface sediments is consistent with the understanding that the sediment surface represents the bioavailable fraction of the sediment column, and that buried sediment is not bioavailable (USACE 2008a, NRC 2007, USEPA 2005). Remedy Alternative 4 requires the removal, transportation, and disposal of 640,000 CY of contaminated sediment material, which is approximately 35% of the volume removed in Remedy Alternative 3. The time required to complete the implementation of Remedy Alternative 4 is expected to be approximately 2.5 to 3 years, compared to 5 to 6 years for Remedy Alternative 3.[11]

During remedy implementation, sediment excavation, handling, transportation, and disposal increase community impacts, such as odors, noise, and local traffic. Community impacts would be in proportion to the volume of dredged material, onsite sediment handling requirements, and time required to complete remedy implementation. In addition, impacts to site workers, including risks associated with operating heavy equipment, transportation of dredge material, and potential exposure to contaminated sediments during excavation and transportation, would also be in proportion to the volume of dredge material.

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 targeting surface sediment exposures, Remedy Alternative 4 would pose reduced adverse impacts and risks to the community and site workers compared to Remedy Alternative 3, while still achieving site specific RGs and contributing to the goals of the RAOs.

By removing only sediments from areas with surface concentrations exceeding the RGs, Remedy Alternative 4 decreases the duration of negative short-term habitat impacts, in part due to the shorter construction and recovery times as compared to Remedy Alternative 3. Figure 6-1b shows limits of dredging for Remedy Alternative 4 in relation to existing areas of emergent and submergent aquatic vegetation, and Table 6-1b provides the length shoreline with aquatic vegetation that would be disrupted by this remedy. In summary, 29% of the aquatic vegetation in the Buffalo River would be impacted by Remedy Alternative 4 and 49% of the aquatic vegetation would be disrupted in the City Ship Canal, as compared to 72% and 69% of the aquatic vegetation that would be impacted by Remedy Alternative 3 in the Buffalo River and City Ship Canal, respectively.

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[11] The 2.5 to 3-year estimate is based on a removal rate of 3,000 CY / day, 5 months / year, and 6 days / week, and 12 hours / day. For the purposes of this *FS*, and based on discussions with USEPA and USACE PCT members, the 3,000 CY / day estimate is considered reasonable, but could very easily be lower, thus prolonging the overall time for construction. The 2.5 to 3-year estimate also includes mobilization, demobilization, and relocation between dredge areas.

The remedy implementation time for Remedy Alternative 4 is estimate at approximately 2.5 to 3 years with an estimated dredging rate of 3,000 CY / day, removal of 640,000 CY would require of dredging, assuming 5 month dredge windows annually. Among the dredge remedies, habitat recovery time is expected to be lowest for Remedy Alternative 4 primarily because of the smaller area impact for dredging to achieve surface sediment RGs and the patchiness of the remaining vegetation communities that can provide a basis for organism dispersal. As such, the recovery time for Remedy Alternative 4 for the river as a whole is estimated as approximately 3 to 5 years based on the sediment volume removal required and estimates of the rate of removal per day (discussed further in Section 6.4).

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 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. Existing advisories that restrict fish consumption from the Buffalo River are expected to minimize the potential adverse impacts on human health. Impacts would be minimized further by scheduling work in accordance with fish windows, and by employing best management practices that minimize surface sediment releases and ecological impacts to the extent practicable.

6.3.5 Remedy Alternative 5

The evaluation of short-term effectiveness of Remedy Alternative 5 is similar to the resulting evaluation for Remedy Alternative 4. Similar to Remedy Alternative 4, Remedy Alternative 5 targets the removal of all sediments from areas with surface sediments (0 – 1 ft) in the Buffalo River AOC with a PAH concentration >1 TU, and targets SWAC RGs for total PCBs, Hg, and Pb. However, in addition, Remedy Alternative 5 also targets the removal of sediments with elevated point concentrations of the total PAHs, total PCBs, Pb, and Hg at depths of 0–4 ft. As a result, the dredge volume of Remedy Alternative 5 is 820,000 CY, which is 180,000 CY (~28%) greater than Remedy Alternative 4, and the limits of dredging increases by 20 acres as compared to Remedy Alternative 4. The time required to complete the implementation of Remedy Alternative 5 is expected to be approximately 3 years, compared to 5 to 6 years for Remedy Alternative 3 and 2.5 to 3 years for Remedy Alternative 4.[12]

Impacts to the community, including odors, traffic, and noise, would be in proportion to the volume of dredged material, onsite sediment handling requirements, and time to complete remedy implementation. In addition, impacts to site workers, including risks associated with operating heavy equipment, transportation of dredge material, and potential exposure to contaminated sediments during excavation and transportation, would also be in proportion to the volume of dredge material. 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 targeting surface exposures, Remedy Alternative 5 would pose reduced adverse impacts and risks to the community and site workers compared to Remedy

[12] The 3-year estimate is based on a removal rate of 3,000 CY / day, 5 months / year, and 6 days / week, and 12 hours / day. For the purposes of this *FS*, and based on discussions with USEPA and USACE PCT members, the 3,000 CY / day estimate is considered reasonable, but could very easily be lower, thus prolonging the overall time for construction. The 3-year estimate also includes mobilization, demobilization, and relocation between dredge areas.

Alternative 3; however, by removing an approximately 28% greater volume to target buried deposits, Remedy Alternative 5 would pose greater community and worker impacts and risks than Remedy Alternative 4.

Figure 6-1c shows limits of dredging for Remedy Alternative 5 the in relation to existing areas of emergent and submergent aquatic vegetation, and Table 6-1b provides the length shoreline with aquatic vegetation that would be impacted by this remedy. In summary 38% of the aquatic vegetation in the Buffalo River would be impacted by Remedy Alternative 5 and 57% of the aquatic vegetation would be disrupted in the City Ship Canal, as compared to 72% and 69% of the aquatic vegetation that would be impacted by Remedy Alternative 3 and 29% and 49% that would be impacted by Remedy Alternative 4, in the Buffalo River and City Ship Canal, respectively.

The estimated recovery time for the river as a whole is considered 3 to 5 years for this remedy, given the similarities among dredge areas and an estimated dredging rate of 3,000 CY / day, removal of 820,000 CY would require approximately 3 years of dredging, assuming 5 month dredge windows annually. Additional time beyond 3 to 5 years is expected for the sediment surface to return to pre-dredge elevations outside of the navigation channel.

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 5 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. Existing advisories that restrict fish consumption from the Buffalo River are expected to minimize the potential adverse impacts on human health. Impacts would be minimized further by scheduling work in accordance with fish windows, and by employing best management practices that minimize surface sediment releases and ecological impacts to the extent practicable.

6.4 Long-Term Effectiveness and Permanence

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 2005a). 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 predicting future surface sediment chemical concentrations. Remedy permanence is determined by evaluating the physical permanence of the remedy.

6.4.1 Remedy Alternative 1

6.4.1.1 Long-Term Risk Reduction and Residual Risk

Remedy Alternative 1 provides no reduction in risk to humans or the environment beyond the current ongoing and natural processes in the Buffalo River AOC, and chemical concentrations for sediments left in place will not be monitored.

Table 6-2a lists the SWACs for total PAHs, total PCBs, Pb, and Hg, under current conditions (i.e., prior to any remedial action). The IDW interpolations of the 2005/2007 and 2008 surface sediment data are used to calculate SWACs under current conditions. The SWAC values are below the site-specific RGs outlined in Section 3.2 for most areas of the Buffalo River AOC, except in some areas at RM 2.5–5.0 and in the City Ship Canal. Under current conditions, the total PAH RG (1 TU) is generally not exceeded except in surface sediments at RM 3.25–5.25 of the Buffalo River, and in the City Ship Canal. As part of Remedy Alternative 1 (No Action) these elevated chemical concentrations would be left in place and without monitoring, meaning that potential reduction in surface sediment concentration resulting from ongoing processes could not be determined. Therefore, Remedy Alternative 1 (No Action) would likely continue to pose a risk to the environment, and would not successfully satisfy the goals of the RAOs outlined in Section 3.

Residual human health risks associated with existing sediment concentrations are within the USEPA's acceptable risk range (see Appendix B), although existing concentrations of PCBs in fish tissue result in potential risks above the acceptable risk range, depending on the frequency of exposure and actual fish tissue concentration. In addition, PCB concentrations in carp continue to exceed the NYSDOH level for which the fish advisory was originally established. Fish tissue concentrations are expected to decline as natural sediment deposition processes continue. Therefore, although Remedy Alternative 1 could eventually satisfy the RAO goals over the long-term, no monitoring would be performed to confirm this risk reduction.

6.4.1.2 Remedy Permanence

Overall the Buffalo River is characterized as stable and resistant to scour and sediment resuspension. Hydrodynamically, the Buffalo River is characterized as a slow-moving river, with a low river gradient of approximately 17 cm/km. Results from model simulations demonstrated low velocities and bottom shear stresses throughout the AOC during low to moderate flow conditions (Figures 2-8 and 2-9). An increase in velocity was shown for low flow conditions with a large seiche influence, but these elevated velocities were typically short in duration and resulted in relatively low bottom stresses relative to watershed-driven events that can create high, sustained flows.

During moderate flow events (1-yr recurrence interval) model results demonstrated higher velocities throughout the river, with highest velocities in the upstream areas and in the relatively narrow reach between RM 1.0 and 2.0. Under all high flow events, seiche impacts were observed to be small relative to the effect of watershed flows. Further increases in velocities and shear stress were demonstrated during high flow events (10-yr and 100-yr intervals). These increases were most notable in the narrow section of the river between RM 1.0–2.0, and at intermittent locations in the sinuous upper portion of the river, e.g., near RM 2.9, and RM 5.2.

The Buffalo River AOC is generally a depositional system. The hydrodynamic modeling studies and investigation of sediment bed properties supports an improved understanding of the sediment transport within the Buffalo River AOC and an understanding of the long-term stability of the system under wet weather and high seiche conditions, as discussed in Appendix C. In summary, a generally high rate of sedimentation occurs throughout the river, as indicated by USACE dredging activities and supporting modeling studies (USACE 1988). Post-dredging rates of sedimentation vary significantly from 0.2 – 0.4 ft/year depending on the reach of the river. The artificially deep river cross-sections maintained by ongoing dredging activities contributes to the lower velocities and a generally depositional environment in the Buffalo River AOC. Results of a simplified scour analysis show that during 100-year flow events isolated localized zones have a high probability of sediment scour. However, an analysis of sediment erosion potential shows maximum scour depths of 1 foot (30 cm) during high flow conditions similar to a 100-year wet weather event. The same model also shows broad areas of solids deposition due to greatly increased loads of watershed solids under high event flow conditions, indicating the net depth of sediment scour would be less than 1 foot. Elevated chemical concentrations in the Buffalo River sediments buried beneath the top foot of sediment are not expected to be exposed during scour events in localized areas.

6.4.2 Remedy Alternative 2

6.4.2.1 Long-Term Risk Reduction and Residual Risk

As described for Remedy Alternative 1 (No Action), and as demonstrated in Table 6-2a, the SWACs for total PCBs, Pb, and Hg under current conditions do not exceed the site-specific SWAC RGs for most areas of the Buffalo River AOC, except for in the vicinity of RM 2.5–5.0 and the City Ship Canal, and the total PAH RG of 1 TU is generally not exceeded except in surface sediments at RM 3.25–5.25 of the Buffalo River, and in the City Ship Canal. Therefore, Buffalo River sediments outside of these areas generally do not pose unacceptable ecological risks due to surface sediment concentrations of these four indicator chemicals under Remedy Alternative 2 (MNR).

In areas where the RGs are exceeded, the current ongoing and natural processes in the Buffalo River AOC 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. Evidence that natural sedimentation leads to reduced chemical concentrations in surface sediments in the Buffalo River AOC is demonstrated in the 2005/2007 and 2008 sediment chemistry data; in every reach of the river, average surface sediment concentrations for total PAHs, total PCBs, Hg, and Pb are lower than average subsurface concentrations for each respective chemical. Thus, sedimentation and physical processes can reduce the risk of exposure of biologically available COCs in surface sediment 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. Ongoing maintenance dredging in the navigational channel of the Buffalo River may disrupt “natural caps” that form as a result of natural sedimentation processes. The long-term monitoring component of an MNR remedy will demonstrate if unacceptable levels of chemical concentrations are present in surface sediments as a result of maintenance dredging. MNR would rely on institutional controls, such as ongoing fish advisories until PCB levels in fish decrease to below advisory levels, and increased source control (e.g., improved CSO management).

Through the processes and methods listed above (i.e., natural deposition, institutional controls, and long-term monitoring), Remedy Alternative 2 (MNR) is expected to achieve the RGs for the Buffalo River AOC over the long-term. Achieving these site-specific RGs in turn satisfies the goals of RAOs established for the Buffalo River AOC (Section 3), by reducing the exposure of wildlife and the aquatic community to sediment chemical concentrations that are above protective levels. Furthermore, Remedy

Alternative 2 is not intrusive and thus preserves existing aquatic habitat, which further complies with RAOs and Supporting Remedial Selection Goals (Section 3) that promote the protection and restoration of habitat and wildlife.

Residual human health risks associated with existing sediment concentrations are within the USEPA's acceptable risk range (see Appendix B), although existing concentrations of PCBs in fish tissue result in potential risks within to above the acceptable risk range, depending on the frequency of exposure and actual fish tissue concentration. In addition, PCB concentrations in carp continue to exceed the NYSDOH level for which the fish advisory was originally established. Fish tissue concentrations are expected to decline as natural sediment deposition processes continue. Therefore, Remedy Alternative 2 could eventually satisfy the RAO goals over the long-term. Monitoring conducted as part of this remedy would be used to demonstrate the rate of recovery and that long-term risk reduction is eventually achieved.

6.4.2.2 Remedy Permanence

The potential for sediment scour and resuspension, and subsequent chemical exposure for Remedy Alternative 2 is similar to the No Action alternative. However, in contrast to the Remedy Alternative 1 (No Action), the MNR remedy relies on long-term monitoring to reduce remedy uncertainty and verify stability, and can be used to provide information to the district USACE and other land owners so they can better manage their sediments and limit dredging that may expose buried contaminants. Monitoring is also used to demonstrate the continuation of natural and ongoing processes that reduce risk and ecological exposures.

As part of Remedy Alternative 2, MNR monitoring is likely to include the analysis of surface sediment samples for COCs, benthic community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. Following a major storm event, monitoring could be conducted to identify areas of potential scour, and to evaluate the change in surface sediment chemical concentrations caused by the scour event. In the unlikely event that sediment scour results in adverse human health or ecological risks, contingency actions such as increased monitoring, institutional controls, reanalysis of expected recovery times, or sediment capping can be employed to manage exposed areas and immediately attenuate risks. This contingency component may include additional biological monitoring should the primary components indicate excess risks to human health or the environment due to the presence of elevated chemical concentrations in surface sediment.

6.4.3 Remedy Alternative 3

6.4.3.1 Long-Term Risk Reduction and Residual Risk

Remedy Alternative 3 provides a secure long-term reduction in risk by targeting the site-specific RG of 1 TU for total PAHs across all sediment depths (Figure 5-1a), and achieves SWAC RGs for Pb, Hg, and total PCBs (Table 6-2)[13]. For Remedy Alternative 3, all sediments contributing to an exceedance of the PAH RGs would be targeted for removal from the Buffalo River AOC and transferred to CDF No. 4, thus in the Buffalo River permanently eliminating potential risk of exposure to the material removed from the river. Nonetheless, dredge residuals are frequently an uncontrollable byproduct of dredge remedies, and post-remedy residuals should be considered as a potential factor contributing to short-term residual risk at the site.

Remedy Alternative 3 would impact long-term ecological recovery of the river, and the scale of the remedy would require more time for surface sediment recovery. Predicted shoaling rates in high depositional areas are based on a sedimentation rate of approximately 70,000 CY / year. A larger volume of sediment removal, such as the 1.75 million CY identified for Remedy Alternative 3, would require a larger area and volume of sediment recovery with time, and thus would slow recovery. The slowest recovery would likely occur at RM 1.0– 2.5, where velocities are highest and the river is narrowest. The fact that Remedy Alternative 3 impacts approximately 71% of the SAV and EV habitat in the river also slows long-term recovery. Aquatic recovery, in part, depends on a resource's ability to reseed impacted areas; by destroying such a large footprint of the natural habitat, less residual / starter material is available to recolonize impacted areas.

Remedy Alternative 3 achieves the RGs for the Buffalo River AOC by targeting the removal of all surface and buried sediments with total PAH concentrations >1 TU, and achieving SWAC RGs for Pb, Hg, and total PCBs. Achieving these site-specific RGs in turn satisfies the RAO goals established for the Buffalo River AOC (Section 3), by reducing human and wildlife exposures to sediment chemical concentrations that are above protective levels. A reduction in exposure will, in turn, reduce acute and chronic toxicity, if any, to aquatic communities and piscivorous wildlife.

Residual human health risks associated with existing sediment concentrations are within the USEPA's acceptable risk range (see Appendix B), although existing concentrations of PCBs in fish tissue result in potential risks within to above the acceptable risk range, depending on the frequency of exposure and actual fish tissue concentration. In addition, PCB concentrations in carp continue to exceed the NYSDOH level for which the fish advisory was originally established. Relative to Alternatives 1 and 2, the removal of sediments as described for Alternative 3 is estimated to achieve an approximately 2.1- to 3.6-fold reduction in human health risks associated with fish ingestion. Therefore, Remedy Alternative 3 is expected to contribute to RAO goals sooner than Alternatives 1 and 2. Monitoring conducted as part of this remedy is used to demonstrate whether long-term risk reduction is achieved.

6.4.3.2 Remedy Permanence

Remedy Alternative 3, which targets the removal of all sediments with a total PAH concentration >1 TU, and achieves long-term SWAC RGs for Pb, Hg, and PCBs would be a permanent remedy insofar as sediment with chemical concentrations causing an exceedance of these criteria is targeted for permanent removal from the Buffalo River AOC.

[13] Post remediation SWACs are calculated by applying average upstream surface sediment concentrations to remediated areas. The average upstream surface sediment concentrations are total PAHs, 6.1 mg/kg; Pb, 21.7 mg/kg; Hg, 0.029 mg/kg; total PCBs, 0.014 mg/kg.

As part of Remedy Alternative 3, monitoring is also used to demonstrate the continuation of ongoing processes that reduce risk and ecological exposures. Long-term monitoring will include the analysis of surface sediment samples for COCs, and one more of the following biological metrics: benthic community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads.

6.4.4 Remedy Alternative 4

6.4.4.1 Long-Term Risk Reduction and Residual Risk

Remedy Alternative 4 provides long-term reduction in risk by targeting the RG of 1 TU for total PAHs across surface sediments (Figure 5-1b), and the SWAC RGs for Pb, Hg, and total PCBs (Table 6-2). Remedy Alternative 4 reduces the risk to human health and the environment by targeting the removal of sediments associated with surface sediment RG exceedances. This approach is consistent with the understanding that the sediment surface represents the bioavailable fraction of the sediment column, and that buried sediment is not bioavailable (USACE 2008b, USEPA 2005). Ongoing natural processes, such as the deposition of cleaner sediments, will continue to provide risk reduction by further burying and isolating sediments with elevated chemical concentrations that are left in place.

Similar to Remedy Alternative 3, dredge residuals are frequently an uncontrollable byproduct of dredge remedies, and the potential presence of post-remedy residuals should be considered as a short-term residual risk for Remedy Alternative 4. However, natural deposition is expected to cover sediments quickly, providing a relatively clean sediment surface in several years; USACE shoaling rates in the upper reaches of the river predict sedimentation rates of several feet in the first five years after dredging. The smaller footprint of Remedy Alternative 4, compared to Remedy Alternative 3, is expected to accelerate recovery, because more sedimentation can be dedicated to a smaller impacted area.

Remedy Alternative 4 achieves the PAH RG of 1 TU in surface sediments and the SWAC RGs for Pb, Hg, and total PCBs. Achieving these site-specific RGs in turn achieves compliance with the goals of the RAOs established for the Buffalo River AOC (Section 3), by reducing human and wildlife exposures to sediment chemical concentrations that are above protective levels. A reduction in exposure will, in turn, reduce acute and chronic toxicity, if any, to aquatic communities and piscivorous wildlife.

Similar to Remedy Alternative 3, the removal of sediments as described for Remedy Alternative 4 is estimated to achieve an approximately 2.1- to 3.6-fold reduction in human health risks associated with fish ingestion. While the risk reduction associated with this alternative is slightly less than estimated for Alternative 3, this level of risk reduction satisfies the long-term RAO goals for protection of human health. The short-term impacts associated with Alternative 4 also are less than projected for Remedy Alternative 3. Monitoring conducted as part of this remedy would confirm that long-term risk reduction is achieved.

6.4.4.2 Remedy Permanence

Remedy Alternative 4 permanently removes sediments to meet the ecologically relevant criteria targeting biologically available PAH concentrations >1 TU in surface sediments, and SWAC RGs for PCBs, Pb, and Hg. Ongoing natural processes, such as deposition of cleaner suspended sediments will continue to bury residual sediments in most areas and maintain the stability of the sediment bed surface. The deposition of suspended material provides a physical barrier of clean sediments which further isolates elevated chemical concentrations in the sediment, thus reducing the potential exposure of these chemicals to humans and biota. As part of Remedy Alternative 4, long-term monitoring is used to demonstrate the continuation of these ongoing processes. Long-term monitoring will include the analysis of surface sediment samples for COCs, and one more of the following biological metrics: benthic community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. As described for Remedy Alternative 2, the Buffalo River is relatively stable and generally resistant to scour and sediment resuspension. Contingencies could be taken in the unlikely event that sediment scour unacceptably increases human health and environmental exposures to elevated chemical concentrations, as described for Remedy Alternative 2.

Areas with buried sediment contaminants will be communicated to the USACE so they can be managed appropriately during routine dredging. The fact that the USACE does not currently dredge bank areas, and the fact that they have been stable for decades, resulting in sediment accumulation and burial, attests to their permanence in this river system. Long-term monitoring will be used to support this assessment.

6.4.5 Remedy Alternative 5

6.4.5.1 Risk Reduction and Residual Risk

Similar to Remedy Alternative 4, Remedy Alternative 5 provides long-term reduction in risk by targeting the site-specific RG of 1 TU for total PAHs across surface sediments, and SWAC RGs for Pb, Hg, and total PCBs; in addition, Remedy Alternative 5 also targets the removal of sediments with elevated point concentrations of total PAHs, total PCBs, Pb, and Hg at depths of 0–4 ft, as outlined in Section 5. As a result, Remedy Alternative 5 targets the removal of an additional 180,000 CY of sediment and provides enhanced long-term risk reduction as compared to Remedy Alternative 4. The removal additional sediments with elevated chemical concentrations, particularly sediments below the surface sediment (>1 ft depth), permanently prevents these sediments from being exposed. As with Remedy Alternative 4, natural deposition is expected to recover sediments,by providing a relatively clean sediment surface; USACE shoaling rates in the upper reaches of the river predict sedimentation rates of several feet in the first five years after dredging. The smaller footprint of Remedy Alternative 5, compared to Remedy Alternative 3, is expected to accelerate recovery, because more sedimentation will be dedicated to a smaller impacted area.

Similar to Remedy Alternatives 3 and 4, dredge residuals are frequently an uncontrollable byproduct of dredge remedies, and the potential presence of post-remedy residuals should be considered as a residual risk for Remedy Alternative 5.

Remedy Alternative 5 achieves the PAH RG of 1 TU in surface sediments and the SWAC RGs for Pb, Hg, and total PCBs. Achieving these site-specific RGs in turn achieves compliance with the RAO goals established for the Buffalo River AOC (Section 3), by reducing human and wildlife exposures to sediment chemicals. A reduction in exposure will, in turn, reduce acute and chronic toxicity, if any, to aquatic communities and piscivorous wildlife. Similar to the other dredge remedies, Remedy Alternative 5 would increase short-term risks of exposure through potential for contaminated sediment resuspension, re-deposition, and off-site transport. However, by targeting the removal of areas that address bioavailable surface sediments, and sediments with elevated point concentrations to a depth of 0–4 ft, Remedy Alternative 5 maintains compliance with the long-term RGs, and substantially decreases short-term risks, due to the substantial reduction in the volume of sediment removed as compared to Remedy Alternative 3. The decreased disruption of existing habitat compared to Remedy Alternative 3 is consistent with the RAOs and Supporting Remedial Selection Goals (Section 3) that promote the protection and restoration of habitat and wildlife.

Similar to Remedy Alternatives 4, the removal of sediments as described for Remedy Alternative 5 is estimated to achieve an approximately 2.1- to 3.6-fold reduction in human health risks associated with fish ingestion. While the risk reduction associated with this alternative is slightly less than estimated for Alternative 3, this level of risk reduction adequately satisfies the long-term RAO goals for protection of human health. The short-term impacts associated with Alternative 5 also are less than projected for Remedy Alternative 3. Remedy Alternative 5 is not estimated to provide any greater long-term risk reduction in comparison with Remedy Alternative 4, although Remedy Alternative 5 offers a greater degree of permanence with the removal of sediment deposits to depths of 4 ft with elevated COC concentrations. Remedy Alternative 5 also would have greater short-term impacts relative to Remedy Alternative 4. Monitoring conducted as part of this remedy would demonstrate whether long-term risk reduction is achieved.

6.4.5.2 Remedy Permanence

Remedy Alternative 5 permanently removes sediments to meet the criteria targeting biologically available PAH concentrations >1 TU in surface sediments, and to achieve SWAC RGs for PCBs, Pb, and Hg. 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. The deposition of suspended material provides a physical barrier of clean sediments which further isolates elevated chemical concentrations in the sediment, thus reducing the potential exposure of these chemicals to humans and biota. As part of Remedy Alternative 5, long-term monitoring is used to demonstrate the continuation of these ongoing processes. Long-term monitoring will include the analysis of surface sediment samples for COCs, and one more of the following biological metrics: benthic community surveys, the analysis of chemical concentrations in fish, and the analysis for the presence of liver lesions in brown bullheads. As described for Remedy Alternative 2, the Buffalo River is relatively stable and generally resistant to scour and sediment resuspension. Contingencies could be taken in the unlikely event that sediment scour unacceptably increases human health and environmental exposures to elevated chemical concentrations, as described for Remedy Alternative 2.

Areas with buried sediment contaminants will be communicated to the USACE so they can be managed appropriately during routine dredging. The fact that the USACE does not currently dredge bank areas, and the fact that they have been stable for decades, resulting in sediment accumulation and burial, attests to their permanence in this river system. Long-term monitoring will be used to support this assessment.

6.5 Reduction of Toxicity, Mobility, or Volume

This NCP criterion addresses the anticipated efficiency of the remedy alternative at reducing risks associated with elevated sediment chemical concentrations in the Buffalo River AOC. Toxicity, mobility, and volume reductions may be realized in situ as well as ex situ, and in some cases ex situ dredge alternatives may increase risks by mobilizing contaminants. To contribute to the understanding of how the proposed remedies reduce toxicity, mobility, or volume of chemical contamination, Tables 6-2 presents the SWACs that are expected to result following each dredge remedy (i.e., reduced toxicity and mobility); Table 6-3 shows the estimated mass of chemical removed as a result of each dredge remedy (i.e., reduced volume).

Section 6.5 focuses on the reduction of toxicity, mobility and volume of total PAHs, Pb, Hg, and total PCBs, which were identified as the four primary indicator chemicals in the Buffalo River AOC (GLNPO 2008). Additional COCs in Buffalo River AOC sediments include arsenic, chromium, copper, benzo(a)pyrene, benzo(a)anthracene, DDT, and gamma chlordane. Buffalo River AOC sediment concentrations of these additional COCs are compared to Draft NYS Sediment Guidance Values (SGVs) and Probable Effects Concentrations (PECs) routinely used by the USEPA, the Technical Memorandum *Seven Additional Chemicals of Potential Concern* provided in Appendix C. By identifying areas of the Buffalo River AOC where surface sediment chemical concentrations are above their respective SGVs and PECs and comparing those areas with the limits of dredging for Remedy Alternative 5, this memorandum shows the areas that will be targeted for removal by Remedy Alternative 5 and the extent to which this remedy achieves risk reduction with respect to the seven additional COCs.[14]

6.5.1 Remedy Alternative 1

The No Action Alternative does not provide additional reduction in toxicity, mobility or volume of chemicals in the Buffalo River AOC sediments, beyond the current ongoing recovery processes. These processes include the deposition of suspended material, which provides a barrier of clean sediments to further isolate elevated chemical concentrations in the sediment. However, the chemical concentrations for sediments left in place will not be monitored.

6.5.2 Remedy Alternative 2

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 in the Buffalo River AOC is demonstrated in the 2005/2007 and 2008 sediment chemistry data; in every reach of the river, average surface sediment concentrations for total PAHs, total PCBs, Hg, and Pb are lower than average subsurface concentrations for each respective chemical. Thus, sedimentation and physical processes can lead to reductions in the toxicity, mobility, and volume of biologically available chemicals in surface sediment.

[14] The NYS Draft SVGs and PECs typically used by the USEPA for arsenic, chromium, copper, benzo(a)pyrene, benzo(a)anthracene, DDT, and gamma chlordane have not undergone critical, site-specific analysis, comparable to the methods used for total PAHs, total PCBs, Pb, and Hg, to develop site-specific RGs for each of these chemicals. The decision to focus on total PAHs, total PCBs, Pb, and Hg as target chemicals was based on the understanding that by addressing these target chemicals, this *FS* also would address the additional COCs.

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.

6.5.3 Remedy Alternative 3

Remedy Alternative 3 targets the removal of the entire volume of sediment with PAH concentrations >1 TU in the Buffalo River AOC and achieves surface sediment SWAC RGs for PCBs, Pb, and Hg. The resulting SWACs for the four COCs as a result of Remedy Alternative 3 are presented in Table 6-2b. As shown in this table, the SWACs for each chemical along each reach of the river are below the chemical RGs developed for the Buffalo River AOC, as outlined in Section 3.2. Thus, Remedy Alternative 3 reduces the long-term toxicity and mobility associated with elevated concentrations of the four indicator chemicals in sediments.

Remedy Alternative 3 reduces the long-term mobility of contaminated sediments by targeting the removal of all sediments with total PAH concentrations >1 TU and surface sediment SWAC RGs for PCBs, Pb, and Hg. Although the in situ volume of contaminated sediment is reduced, short-term increases in mobility and toxicity can result from Remedy Alternative 3 via dredge materials management.

Approximately 1.75 million CY of sediment would be removed from the Buffalo River AOC as part of Remedy Alternative 3, contributing to the reduced volume of contaminated sediment in the AOC. The estimated mass of COCs (total PAHs, Pb, Hg, and total PCBs) removed from the Buffalo River AOC is provided in Table 6-3b.

6.5.4 Remedy Alternative 4

Remedy Alternative 4 targets the removal of all sediments from areas with surface sediment concentrations with total PAH concentrations >1 TU, thus removing the highest concentrations from the biologically active zone, and will acheive SWAC RGs for PCBs, Pb, and Hg. The resulting SWAC for the four COCs as a result of Remedy Alternative 4 are presented in Table 6-2c. Similar to Remedy Alternative 3, the post-Remedy Alternative 4 SWACs for each chemical, along each reach of the river, are well below the site-specific RGs developed for the Buffalo River AOC. Thus, Remedy Alternative 4 achieves a reduction in the long-term toxicity and mobility associated with elevated concentrations of the four indicator chemicals in sediments.

By targeting sediments in areas with total PAH concentrations >1 TU in surface sediment and SWAC RGs for PCBs, Pb, and Hg, Remedy Alternative 4 reduces the potential for mobility by removing contaminated sediments that are most susceptible to exposure and transport. Buried contaminated sediments are generally stable and not likely subject to resuspension, as demonstrated by the highly depositional nature of the Buffalo River AOC and the low velocities and bottom shear stresses throughout the AOC during low to moderate flow conditions. Even during high 100-yr flow events intervals, in isolated areas susceptible to scour the net depth of sediment scour is expected to be less than 1 ft.

Approximately 640,000 CY of sediment will be removed from the Buffalo River AOC as part of Remedy Alternative 4, contributing to the reduced volume of contaminated sediment in the AOC. The estimated mass of COCs (total PAHs, Pb, Hg, and total PCBs) removed from the Buffalo River AOC is provided in

Table 6-3c. Remedy Alternative 4 greatly reduces the volume of sediment requiring dredging, compared to Remedy Alternative 3, and thus reduces the short-term risks associated with contaminant toxicity and mobility that can result from offsite transport and potential sediment spills during dredging and dredge materials management.

6.5.5 Remedy Alternative 5

Similar to Remedy Alternative 4, Remedy Alternative 5 targets the site-specific RG of 1 TU for total PAHs across surface sediments and SWAC RGs for Pb, Hg, and total PCB, but also targets the removal sediments with elevated point concentrations of the four indicator chemicals at depths of 0–4 ft. The resulting SWAC for the four COCs as a result of Remedy Alternative 5 are presented in Table 6-2d. Similar to Remedy Alternatives 3 and 4, the post-Remedy Alternative 5 SWACs are below the chemical RGs developed for the Buffalo River AOC, and thus, Remedy Alternative 5 achieves a reduction in the long-term toxicity and mobility associated with elevated concentrations of the four indicator chemicals in sediments. The decrease in SWACs for each chemical as a result of Remedy Alternative 5 compared to Remedy Alternative 4 is minimal despite the additional removal of 180,000 CY of sediment. This is because the additional sediment volume removed as part of Remedy Alternative 5 targets elevated chemical concentrations in the subsurface, which do not necessarily contribute to elevated surface sediment concentrations and corresponding SWAC values, thus resulting in minimal reduction in the SWACs for each chemical.

NYSDEC, a member of the Buffalo River PCT, requested that post-Remedy Alternative 5 SWACs also be calculated based on one-third mile SWAC areas divided longitudinally by the left bank, right bank, and navigation channel. The results of this additional SWAC analysis are presented in Appendix C. In summary, when SWACs are calculated based on a 1/3-mile SWAC areas, divided longitudinally by the left bank, right bank and navigation channel, only three of the 192 SWAC areas are estimated to exceed the SWAC RGs under post-Remedy Alternative 5 conditions. Two of these three areas will be resampled prior to finalizing the Remedy Alternative 5 footprint, and the third area exceeded the SWAC RG by only 0.01 mg/kg. The results of this analysis demonstrated that calculating SWACs across of the Buffalo River and City Ship Canal does not dilute elevated surface sediment chemical concentrations along the banks.

By primarily targeting sediments in areas with total PAH concentrations >1 TU at the surface, and by targeting areas that exceed the SWAC RGs for total PCBs, Pb, and Hg, Remedy Alternative 5 reduces the potential for mobility by removing contaminated sediments that are most susceptible to resuspension. Buried residual sediment contaminants are generally stable and not likely subject to resuspension, as demonstrated by the highly depositional nature of the Buffalo River AOC and the low velocities and bottom shear stresses throughout the AOC during low to moderate flow conditions. Even during high 100-yr flow events intervals, in isolated areas susceptible to scour the net depth of sediment scour is expected to be less than 1 ft.

The vertical distributions of total PAH, Pb, Hg, and total PCB sediment concentrations expected following the implementation of Remedy Alternative 5 are provided in Figures 6-2a through 6-2d for the Buffalo River and Figures 6-3a through 6-3d for the City Ship Canal. Samples expected to be left in place following the implementation of Remedy Alternative 5 are designated by open circles. Areas targeted for remediation through dredging or capping per Remedy Alternative 5 are shaded in gray and the samples within these areas are marked with an "X". Areas of the AOC that are targeting for resampling per Remedy Alternative 5 are shaded in green. Vertical profiles for the Buffalo River are divided into three longitudinal river segments, the federally-defined navigation channel, the right bank of the navigation channel (looking downstream), and the left bank of the navigation channel. The vertical sediment concentration profiles of the City Ship Canal are provided for the east and west side of the canal. As shown in Figures 6-2 and 6-3, following the implementation of Remedy Alternative 5 chemical concentrations at the surface do not exceed the RGs and the majority of elevated concentrations in the subsurface are removed.

The target removal of maximum residual concentrations in Remedy Alternative 5 results in an additional 180,000 CY of sediment targeted for removal as compared to Remedy Alternative 4, resulting in a greater volume of mass removal compared to Remedy Alternative 4. The estimated mass of indicator chemicals (total PAHs, Pb, Hg, and total PCBs) removed from the Buffalo River AOC is provided in Table 6-3d.

Similar to Remedy Alternatives 3 and 4, there are short-term risks associated with Remedy Alternative 5 that result from dredging, including an increase in contaminant toxicity and mobility via sediment offsite transport and potential sediment spills during dredging and dredge materials management. However, by targeting total PAH concentrations >1 TU in surface sediment, SWAC RGs for total PCB, Pb, and Hg, and elevated chemical concentrations at depths to 4 ft, Remedy Alternative 5 greatly reduces the volume of sediment requiring dredging, and thus the associated risks, compared to Remedy Alternative 3. In turn, the increase in dredge volume for Remedy Alternative 5, compared to Remedy Alternative 4, increases these short-term risks accordingly.

6.6 Implementability

Implementability encompasses both the technical and administrative feasibility of implementing a remedial alternative. 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 sediments
- Types and quantity of submerged debris
- Available CDF capacity
- Available transportation and disposal routes
- Current and anticipated uses of the river

6.6.1 Remedy Alternative 1

There are no implementability constraints nor for the No Action alternative because no remedial action is taken. The No Action remedy is readily implementable.

6.6.2 Remedy Alternative 2

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. Outside the navigational channel, boat access would be necessary for monitoring purposes, but would involve use of a contractor in the same manner as for the previously completed site investigations. A long-term monitoring plan would be developed with agency approval, to confirm recovery predictions. The monitoring frequency is such that pre-established access or routine maintenance of access would not be necessary. Monitoring contingency actions can be established to respond readily to changes in baseline conditions, particularly in the unlikely event that chemical concentrations increase to unacceptable levels; such actions should begin with increased monitoring to verify the change, data evaluation, and development of an appropriate response, as needed.

6.6.3 Remedy Alternative 3

Sediment dredging, whether hydraulic or mechanical, is a proven technology that has been implemented at other sites and can be implemented at the Buffalo River. However, the removal, transportation, off-loading, management and disposal of 1,750,000 CY of contaminated sediment material under Remedy Alternative 3 presents implementation challenges. As shown in Figure 6-4a, over two thirds of the area to be dredged under Alternative 3 adjoins rigid bulkheads or structures (i.e., stone sloped shores, boat docks, capped piles or walls, and uncapped piles or walls) for which little to no design information is available to assess their structural integrity under the proposed dredging scenario. Remedy design would consider the presence of these structures, and appropriate off-sets from the shoreline would be established to allow existing sediment that maintains shoreline integrity to remain in place. The presence of these structures, as well as bridge abutments and piers, limits dredging implementability in these areas.

Remedy Alternative 3 would impose significant strains on the existing CDF, which according to the USACE has a total remaining air space of 2.2 million CY. Implementation of Remedy Alternative 3 would consume approximately 80% of the available CDF capacity. Considering timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January), implementation would require construction over multiple years (approximately five years is estimated).

Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges).

Areas that are periodically dredged by the USACE as part of the maintenance of the navigational channel are not expected to encounter large amounts of buried debris. However, approximately 65% of the sediment volume targeted in Remedy Alternative 3 would originate from areas not typically dredged by the USACE, where potentially large amounts of debris may be encountered. Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation. Alternatively, if debris is not actively removed before or concurrent with dredging, debris will likely interfere with dredging 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 CDF No. 4. Debris removal/segregation can take place within the upland areas of the CDF and the materials could either be disposed at the CDF or off-site. Since sediments would not be disposed off-site, dewatering is not required. Otherwise, dewatering and solidification requirements would significantly increase dredging complexity and cost. Should the CDF not be available for placement of the sediments, offsite transport and associated community and environmental risks would need to be evaluated.

The potential impact of dredge remedies on flooding within the Buffalo River AOC and at locations upstream of the AOC was evaluated under post-dredge conditions using the EFDC model. In all cases, dredging resulted in localized reductions in velocities under flood conditions, and had only minimal influence on the elevation of floodwaters. In cases where changes in floodwater elevation were observable, the effect of dredging was to decrease floodwater elevation.

6.6.4 Remedy Alternative 4

Similar to Alternative 3, sediment dredging can be implemented at the Buffalo River, with similar impediments resulting from the existing shoreline conditions. However, the removal, transportation, off-loading, management and disposal of 640,000 CY of contaminated sediment material under Remedy Alternative 4 (~35% of the volume targeted for Remedy Alternative 3) would have a substantially lower impact on the river, local communities, and the capacity of the existing CDF.

As shown in Figure 6-4b, almost half of the area to be dredged under Alternative 4 abut bulkheads or other shoreline structures (i.e., stone armored shoreline, boat docks, capped piles or walls, and uncapped piles or walls) for which little to no design information is available to assess their structural integrity under the proposed dredging scenario. Dredge design would consider the presence of these structures, and appropriate off-sets from the shoreline would be established to allow existing sediment that maintains shoreline integrity to remain in place. As such, the presence of these structures may limit the implementability of dredging in these areas.

Implementation of Remedy Alternative 4 would consume approximately 30% of the total remaining air space of the CDF (2.2 million CY). Considering that the CDF was designed specifically to accommodate materials from the Buffalo River and Harbor, implementation of Remedy Alternative 4 is considered viable with respect to its impact on the CDF. Considering timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January) implementation would require construction over multiple years (approximately 2.5 years is estimated).

Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges).

Areas that are periodically dredged by the USACE as part of the maintenance of the navigational channel are not expected to encounter large amounts of buried debris. However, approximately 75% of the sediment volume targeted for removal in Remedy Alternative 4 would originate from areas not typically dredged by the USACE, where potentially large amounts of debris may be encountered. Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation.

Sediment would be transported to CDF No.4, where it would either be unloaded directly into the open water of the CDF or placed within the upland areas of the CDF with additional confinement. Debris removal/segregation can take place within the upland areas of the CDF and the materials could either be disposed at the CDF or off-site. Since sediments would not be disposed off-site, dewatering would not be required. Otherwise, dewatering and solidification requirements would significantly increase dredging complexity. Should the CDF not be available for placement of the sediments, offsite transport and associated community and environmental risks would need to be evaluated.

6.6.5 Remedy Alternative 5

Similar to Alternatives 3 and 4, sediment dredging can be implemented at the Buffalo River, with similar impediments resulting from the existing shoreline conditions. Like Alternative 4, the removal, transportation, off-loading, management and disposal of 820,000 CY of contaminated sediment material under Remedy Alternative 5 (~47% of the volume targeted for Remedy Alternative 3) would be much more manageable and would have a substantially lower impact on the river, local communities, and the capacity of the existing CDF.

As shown in Figure 6-4c and comparable to Remedy Alternative 4, approximately half of the area to be dredged under Remedy Alternative 5 adjoins rigid bulkheads or structures (i.e., stone sloped shores, boat docks, capped piles or walls, and uncapped piles or walls) for which little to no design information is available to assess their structural integrity under the proposed dredging scenario. Dredging near these structures, as well as bridge abutments and piers, may compromise their structural integrity. Appropriate off-sets from the shoreline may be required to allow existing sediment that maintains shoreline integrity to remain in place. These options will be resolved at the remedy design phase.

Implementation of Remedy Alternative 5 would also consume approximately 37% of the total remaining air space of the CDF (2.2 million CY). However, its impact would be significantly lower than that of Alternative 3, which would consume approximately 80% of the available CDF capacity. Considering that the CDF was designed specifically to accommodate materials from the Buffalo River and Harbor, implementation of Remedy Alternative 5 is considered viable with respect to its impact on the CDF. Considering timing restrictions for dredging (January through June), bird nesting restrictions on the use of the CDF (March through July) and freezing of the river (typically December to January) implementation would require construction over multiple years (approximately three years is estimated).

Barge access and maneuverability would have to be evaluated at the remedy design phase, but may present unique implementability challenges given boat traffic in most of the Buffalo River and the presence of eight bridges across the remedial area (Skyway, Michigan Street, Ohio Street, South Park Avenue, and four railroad bridges).

Areas that are periodically dredged by the USACE as part of the maintenance of the navigational channel are not expected to encounter large amounts of buried debris. However, approximately 75% of the sediment volume targeted for removal in Remedy Alternative 5 would originate from areas not typically dredged by the USACE where potentially large amounts of debris may be encountered. Debris would need to be removed during dredging, either as dredging is ongoing or as part of a separate debris removal operation.

Sediment would be transported to CDF No.4, where it would either be unloaded directly into the open water of the CDF or placed within the upland areas of the CDF with additional confinement. Debris removal/segregation can take place within the upland areas of the CDF and the materials could either be disposed at the CDF or off-site. Since sediments would not be disposed off-site, dewatering would not be required. Otherwise, dewatering and solidification requirements would significantly increase dredging complexity. Should the CDF not be available for placement of the sediments, offsite transport and associated community and environmental risks would need to be evaluated.

6.7 Cost

Costs are calculated as present-value-worth costs for comparison of alternatives. The discount rate selected for the net-present-worth calculations is 7%. The costs of each alternative are estimated with as much accuracy as possible for capital and O&M. O&M costs were estimated for a 10-year period, discounted to a net present value (NPV) in 2009 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 7%. The cost estimates provided have an accuracy of +50 % to –30 %, in compliance with USEPA guidance (USEPA 1988).

Cost estimate details are provided in Appendix E, which also identifies references for unit costs and assumptions used to develop the cost estimates, including monitoring requirements. 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 6-4. Besides the No Action alternative, Remedy Alternative 2 has the lowest present worth cost of approximately $2.5 million. Remedy Alternative 3 has the highest present worth cost of $73.8 million. The present worth cost of Remedy Alternative 4 and 5 are $31.8 million and $38.7 million, respectively. The $73.8 million estimate for Remedy Alternative 3 is approximately 1.9 to 2.3 times more expensive than Remedy Alternatives 4 and 5, respectively.

6.8 State Acceptance

This criterion evaluates the issues and concerns that state agencies may have regarding each sediment remedy alternative. As a member of the Buffalo River GLLA PCT, NYSDEC has participated in and has been involved with the various tasks and decisions that have been incorporated into the development of the Remedy Alternatives outlined in this *FS*. These tasks include:

- Development and review of the RAOs for the Buffalo River AOC
- Development and review of the site-specific RGs for the Buffalo River AOC
- Development and implementation of the Remedial Investigation
- Review of the *SRIR*, which presents the results from the 2008 field investigation, and summarizes these results in the context of historical studies conducted on the Buffalo River AOC
- Preliminary review of the Remedy Alternatives presented in this *FS*

The Remedy Alternatives outlined in this *FS* aim to provide a balance, to varying degrees, of remediating contaminated sediments that may pose a risk to human health and the environment, and preserving existing habitat and ecological communities within the Buffalo River AOC, both of which are important criteria to NYSDEC. As a member of the Buffalo River AOC GLLA PCT, NYSDEC will continue to participate in the review and evaluation of the Remedy Alternatives presented in this *FS*, and in the selection of the most appropriate sediment remedy for the Buffalo River AOC.

6.9 Community Acceptance

This criterion addresses the issues and concerns the general public may have regarding each sediment remedy alternative. BNR, a community based organization whose predecessor was formed by local citizens in the 1980s, is a party to the GLLA Buffalo River Project Agreement, is a member of the PCT, and serves as the Remedial Action Plan coordinator for the Buffalo River AOC. As member of the Buffalo River GLLA PCT, BNR serves as a representative of community interests and concerns with regards to the selection of a sediment remedy, and has played a central role in the various tasks and decisions that have incorporated in the development of the Remedy Alternatives outlined in this *FS*. These tasks include:

- Development and review of the RAOs for the Buffalo River AOC
- Development and review of the site-specific RGs for the Buffalo River AOC

- Development and implementation of the Remedial Investigation

- Review of the *SRIR*, which presents the results from the 2008 field investigation, and summarizes these results in the context of historical studies conducted on the Buffalo River AOC

- Preliminary review of the Remedy Alternatives presented in this *FS*

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. As a member of the Buffalo River AOC GLLA PCT, BNR will continue to participate in the review of the Remedy Alternatives presented in this *FS*, and in the selection of the most appropriate sediment remedy for the Buffalo River AOC. The PCT has received input, and will continue to seek input, from other community organizations and from local government. The *FS* also will undergo public review before being finalized.

6.9.1 Remedy Alternative 1

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. However, 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.

6.9.2 Remedy Alternative 2

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, particularly regarding the low risks associated with chemical concentrations in the surface sediment, and the ongoing natural processes that will continue to reduce risk.

6.9.3 Remedy Alternative 3

Although property surrounding the Buffalo River AOC is predominantly commercial and industrial, dredging-related activities in Remedy Alternative 3 like sediment excavation, handling, offsite transportation, and disposal may increase short-term impacts to the community through construction noise, odors, and diesel emissions. Such community impacts must be considered for Remedy Alternative 3, due to the large volume of sediment targeted for removal and the 5-year duration of remedy construction. The larger volume of buried sediment removed for Remedy Alternative 3 does not appear to provide a proportionate reduction in risk compared to Remedy Alternatives 4 and 5, as the surface sediment PAH RG and SWAC RGs for PCBs, Pb, and Hg are met in these two lower-volume dredge remedy alternatives. Public education is necessary to support a dredging remedy, to inform the public, adjacent businesses, and other stakeholders of the physical and visual impacts of dredging on the river environment and adjoining communities.

6.9.4 Remedy Alternative 4

Similar to the other dredge remedies, Remedy Alternative 4 increases negative short-term community impacts, as compared to No Action and MNR, through construction noise, odors, and diesel emissions generated from remedy implementation. However, by targeting surface sediments to establish sediment removal volumes and achieve site specific RGs and RAO goals, Remedy Alternative 4 substantially reduces the volume and construction impacts associated with sediment removal compared to Remedy Alternative 3, while achieving comparable levels of human and ecological risk reduction. The reduction in dredge volume decreases the short-term impacts to the community by reducing the length of time required to complete the remediation (approximately 2.5 years compared to 5 years for Remedy Alternative 3), and still provides significant reduction in risk by meeting the PAH RG of 1 TU in surface sediments and SWAC RGs for total PCBs, lead, and mercury. Public education is necessary to support a dredging remedy, to inform the public, adjacent businesses, and other stakeholders of the physical and visual impacts of dredging on the river environment and adjoining communities.

6.9.5 Remedy Alternative 5

Similar to the other dredge remedies, Remedy Alternative 5 increases negative short-term community impacts, as compared to No Action and MNR, through construction noise, odors, and diesel emissions generated from remedy implementation. However, similar to Remedy Alternative 4, Remedy Alternative 5 reduces these short term risks by focusing on the removal of surface sediments, resulting in a much smaller volume of sediments targeted for removal compared to Remedy Alternative 3, while achieving comparable levels of human and ecological risk reduction. The removal of elevated sediment concentrations at depths of 0–4 ft included in Remedy Alternative 5 results in 28% more volume for removal compared to Remedy Alternative 4, and increases the estimated time for construction to 3 years. The additional dredge volume leads to an increase in short-term community impacts due to the increase in time required to complete remedy implementation, but achieves greater mass removal by targeting elevated concentrations at depths at 0–4 ft remaining after Remedy Alternative 4, and thus achieves greater long-term risk reduction. Public education is necessary to support a dredging remedy, to inform the public, adjacent businesses, and other stakeholders of the physical and visual impacts of dredging on the river environment and adjoining communities.

7 PREFERRED SEDIMENT REMEDY ALTERNATIVE

Remedy Alternative 5, Enhanced Protectiveness Dredging, is the remedy that most efficiently and effectively achieves the sediment-related ecological and human health RAOs of the Buffalo River AOC. The PCT recommends design and implementation of the Enhanced Protectiveness Dredging alternative at the Buffalo River AOC site.

7.1 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 goals in a reasonable 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 depositional processes. Therefore, both of these alternatives were removed from further consideration.

Remedy Alternative 3 (1,750,000 CY of dredging), Alternative 4 (640,000 CY of dredging), and Alternative 5 (820,000 CY of dredging) all contribute to RAO goals by permanently decreasing the mass of chemicals in the river and by improving long-term surface sediment concentrations and reducing risks to human health and the environment. Dredging is a proven technology and can be implemented at the Buffalo River. However, dredge remedies are expensive to implement and are accompanied by potentially significant short-term risks and short-term impacts. Dredging operations can negatively impact short-term surface sediment concentrations through sediment suspension and dredge residuals, and cause short-term increases of contaminant concentrations in the water column and in fish tissue. Additionally, dredging and transport operations are accompanied by short-term risks to construction workers as well as an increased risk of water vessel accidents due to the additional harbor traffic from dredging and transport vessels. Greater volumes of dredging are associated with higher costs, greater short-term impacts, and an increase for potential accidents.

Remedy Alternative 5 is recommended for design and implementation because this alternative most effectively and efficiently achieves risk reduction goals in both the surface and subsurface sediments without the diminishing returns of a larger-scale dredge remedy. Remedy Alternative 5 specifically targets the removal of areas that exceed the site-specific sediment chemistry guidelines, including elevated chemical concentrations at depth of 0-4 ft, and areas that are associated with the presence of oil and grease. Further evaluations also confirm that Remedy Alternative 5 reduces risks to human health and the environment in areas frequently accessed by the public, in sediment areas that may scour during high flow events, and in areas where sediment has been historically disturbed by ship traffic. Remedy Alternative 5 also can be completed within a reasonable timeframe and at a reasonable cost.

The evaluation of Remedy Alternative 5 against the nine criteria established under NCP, which also serves as a comparison of Remedy Alternative 5 against the RAOs, can be found in Section 6.

7.2 Description of Proposed Remedy

Remedy Alternative 5 proposes a combined remedy that includes sediment removal and capping (see Figure 5-1c) over a three year period and at an estimated cost of approximately $40 million. A description of Remedy Alternative 5 can be found in Section 5. The accuracy of the cost estimate is within the range of -30 percent to +50 percent, consistent with USEPA Guidance on FS development (USEPA 1988). The assumptions used in the volume and cost estimates are listed in Table 6-4 and in Appendix E. The main components of Remedy Alternative 5 are:

Sediment Removal and Disposal

- Sediment areas and depths targeted for removal are defined by the remedial goal of 1 TU for total PAHs in surface sediments, SWAC RGs for PCBs, Hg, and Pb, and maximum residual sediment concentrations of total PAHs, total PCBs, Hg, and Pb at depths of 0-4 ft. The sediment chemistry guidelines applied to Remedy Alternative 5 are provided in Section 5 and in Appendix D1.

- Based on the sediment chemistry guidelines, the estimated in-place sediment volumes targeted for removal include 720,000 CY from the Buffalo River (this includes 530,000 CY from outside the federally-defined navigation channel boundary and 190,000 CY from within the navigation channel) and 100,000 CY from the City Ship Canal (this includes 80,000 CY from outside the navigation channel and 20,000 CY from within the navigation channel).

- Both mechanical and hydraulic dredging could be used to remediate Buffalo River sediments. The most appropriate dredging method 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 dredging operations to reduce potential contaminant release.

- A CDF designed specifically for the management and disposal of sediments from the Buffalo River is located within 3 to 9 miles of the AOC. Thus, the CDF is the most appropriate site for the dewatering/stabilization and disposal of dredged sediments.

- A small volume of dredge material (<1,000 CY) is expected to require disposal at a TSCA- or RCRA-approved disposal facility. The PCT will work with the USEPA Region 2 Division of Enforcement and Compliance Assistance to identify the appropriate disposal requirements for this portion of the sediment volume targeted for removal.

Capping

- Approximately 1,800 feet of the City Ship Canal is beyond the downstream boundary of the navigation channel and represents a low energy environment that is not susceptible to sediment scour from overlying flow, ice events, or navigational dredging. A sediment cap is targeted for this area (approximately 292,800 square feet) to isolate underlying sediment contaminants, provide a clean sediment surface, and provide an appropriate substrate for habitat restoration in this part of the AOC.

Short- and Long-Term Monitoring

- Confirmation monitoring, including bathymetric surveys and surface sediment chemistry, will be conducted during remedy implementation to ensure the selected implementation methods meet the remedy design specifications. A Confirmation Monitoring Plan, which outlines the decision criteria for determining what, if any, additional remedial measures are warranted, will be included as part of the remedial design.

- Remedy Alternative 5 primarily relies on natural sedimentation after dredging to meet long-term RAO goals. In some dredge areas, the placement of a layer of material upon the sediment surface may be necessary to accelerate natural recovery processes and further protect ecological receptors.

- Long-term monitoring of the Buffalo River will assess the continuation of natural processes that reduce risk and ecological exposures. Furthermore, long-term monitoring focuses on gaining a better understanding of chemical and biological trends in the river against RAOs and to evaluate changes in conditions that are used to identify and delist BUIs.

Habitat Restoration

- An evaluation of the area and quality of existing habitat that would be impacted by Remedy Alternative 5 was conducted. Section 8 presents the results of this evaluation, and the mitigation and restoration measures proposed for the habitat areas likely to be disturbed by Remedy Alternative 5.

7.3 Next Steps

- BNR and NYSDEC have been active members of the PCT, and we plan to seek further State and community input on the proposed remedial technologies that make up Remedy Alternative 5. The first step toward accomplishing this goal is to submit the *FS* for public review.

- Further characterization is needed in various isolated areas identified in Figure 5-1c. These include confirmation sampling in areas supported by one sample location with surface sediment concentrations greater than 1 TU, additional sampling in areas with insufficient sediment chemistry data to delineate sediment chemistry, and confirmation sampling in the one area with potential TSCA-level PCB concentrations.

- The PCT will work with the USACE to coordinate remediation in areas that fall within the federally authorized navigation channel and to manage the disposal of contaminated material in the Buffalo Harbor Dike 4 CDF.

- Per the Great Lakes Legacy Act of 2002, the PCT will utilize all existing data/information to evaluate the sufficiency of source control and the potential for significant further or renewed contamination from existing sources of pollutants, which may lead to sediment contamination following completion of the project.

- The USEPA GLNPO will commence remedial design activities in close consultation with the PCT after completion of the *FS* following the public review period, and after the existing GLLA Project Agreement with USEPA, BNR, and Honeywell is modified accordingly.

The Buffalo River PCT will move the conceptual habitat restoration projects identified in the *FS* forward to the remedial design phase. Additional areas may be identified by the PCT to provide additional restoration above and beyond mitigation. The PCT will also coordinate closely on the Buffalo River Restoration Master Plan that is currently being developed by the USEPA GLNPO.

8 MITIGATION AND RESTORATION

8.1 Potential Remedy Impacts

For the purposes of this *FS*, the scale of potential impacts that may need to be mitigated was determined based on Preferred Remedy Alternative 5 (Section 7). The Preferred Remedy will likely impact 12,989 linear feet or 3.04 acres of aquatic vegetation beds (Tables 8-1 and 8-2, Figure 6-1c). It is important to note that the extent of these impacts may be modified during the remedial design, and as a result, mitigation area estimates may be updated to reflect any modifications.

Mitigation of impacted vegetation beds may occur as part of larger restoration projects described in detail in the EEE Report (described in Sections 8.3 and 8.4 and presented in Appendix F). The mitigation projects will be finalized during the remedy design phase and are anticipated to be comprised of the aquatic vegetation restoration components of the larger restoration projects described below. A more comprehensive ecosystem approach that maximizes ecological services can be achieved by combining mitigation with the restoration of aquatic habitat, bank, and riparian zones. Because of the close integration of mitigation and restoration, this chapter and the EEE report refer to them jointly as "restoration" projects. It may be feasible to incorporate some restoration projects into the remediation work. This will have the benefits of being cost effective and building the restoration project sooner. Some projects may take several years after construction/implementation to achieve 100% of their intended benefit.

Potential restoration projects are located within 0.75 miles of the impacted area in order to help ensure that the restored system addresses the same functions that may have been impacted by the remedy. Subaquatic vegetation restoration has been considered in six locations (Figure 8-1), totaling approximately 21 acres. The selected projects will mitigate the remedy impacts while providing additional restoration above and beyond mitigation requirements. Implementing only the aquatic portion of the restoration project at certain locations may also allow targeted mitigation independent of the bank and riparian restoration. However, areas where mitigation and restoration can be combined will enhance ecological benefits. The project locations include:

- Kelly Island (Section 8.3.1)
- City Ship Canal (Section 8.3.2)
- Ohio Street Shoreline (Section 8.3.3)
- Katherine St. Peninsula (Section 8.3.4)
- Buffalo Color Peninsula shoreline (Section 8.3.5)
- Riverbend (Section 8.3.6)

Land owner acceptance of these potential projects and project locations has not been resolved, but will be critical to project implementability and success. It is anticipated that additional due diligence (including any necessary negotiations with land owners) will be conducted during the design phase and prior to implementation.

8.2 Selected Habitat Types and Associated Benefits

Ecological services may still be limited before or following remediation due to: 1) water quality (e.g., low dissolved oxygen, high temperatures); 2) habitat fragmentation (due to hardened shorelines); 3) heavy industrial uses; and 4) hydraulic function (e.g., stream flow, stream volume). These habitat limitations, which are unrelated to the impacted sediment, will be taken into consideration during the evaluation process for potential restoration projects where feasible. Projects that address these limiting factors can maximize potential ecological benefits. In order to facilitate this process, different habitat types are considered in the context of potential ecological benefits. The selected habitat types are categorized and described as follows.

8.2.1 In-Stream Shallows

In-stream shallow areas offer numerous benefits to the aquatic ecological community. Shallow areas often limit water flow, thereby reducing turbidity and promoting sediment stability and the establishment of EV. These areas support community structure by providing a diverse habitat and prey base for aquatic organisms, such as invertebrates and fish, as well as many wildlife species, such as amphibians, reptiles, waterfowl, and mammals.

Shallowing portions of the Buffalo River AOC can provide opportunities for the creation or enhancement of in-stream shallows and/or fringe wetlands. Substrate improvements at appropriate elevations support and provide habitat for plant, fish, and wildlife communities. Enhanced SAV or EV provides feeding, nursery, and spawning grounds for fish. The addition of in-stream features can enhance roughness, which serves to inject oxygen into the surface water. The addition of in-stream structures (e.g., woody debris, boulders) also creates important habitat for aquatic organisms and increases the overall diversity and value of these shallow areas.

Existing in-stream shallow areas are limited within the Buffalo River AOC due to historical dredging and the extent of the authorized navigation channel. Since sediment erosion usually occurs on the outside bends of a meandering river shoreline, shallow areas are typically located on the inside bends of the riverbank where water velocity and scouring are minimized.

8.2.2 Bank Slopes

Stream bank erosion is influenced by several characteristics, including stream bank height and steepness, density and composition of vegetation within the riparian zone, soil structure, composition of the stream bank materials, and the relationship of the stream bank to the thalweg (i.e., stream banks erode more quickly on the outside of a curve than on the inside). While stream bank erosion is a natural process, anthropogenic activities can greatly alter this process, typically by accelerating erosion issues. In the Buffalo River AOC, channel modifications, creation of steep river banks, and a reduction in effective riparian zones have increased the potential for stream bank erosion.

Gently sloping stream banks increase the overall stability of a stream bank and retard or minimize bank erosion. Gently sloping banks may even increase productivity of in-stream shallow areas by reducing soil runoff and inundation and allowing access to the in-stream shallow areas by riparian organisms. Additionally, the utilization of in-stream structures can redirect the thalweg to minimize bank undercutting.

8.2.3 Riparian Areas

Riparian areas are defined as the terrestrial areas adjacent to and/or associated with a given water resource. Effective riparian areas provide a buffer between the aquatic and terrestrial portions of the watershed. An effective riparian zone is vegetated and consists of diverse habitat types, often including wetland areas. Riparian zones provide the following benefits to streams: 1) shade to moderate stream temperature; 2) improved water quality by retaining sediment; 3) improved sediment quality by filtering nutrients and/or chemicals; 4) stream bank stabilization; 5) erosion control; 6) a source of nutrients; 7) near-bank cover; and 8) near-shore habitat. Shading the river can reduce surface water temperature, thereby increasing the dissolved oxygen carrying capacity. Decreasing runoff potential (by increasing filtration capacity) can improve dissolved oxygen by reducing potential algal blooms due to eutrophication from nutrient inputs.

Since a majority of the Buffalo River AOC is characterized by industrial, commercial, and urban use, physical modification to the riparian zone has resulted in an overall reduction in the effectiveness of these areas. However, as part of the mitigation and/or restoration effort, improvements to portions of the Buffalo River AOC riparian zone may include the following: 1) creation of water runoff buffers in parking lots; 2) invasive species management; 3) revegetation of areas devoid of vegetation; and 4) selected plantings (e.g., trees) in areas with only herbaceous or non-native vegetation.

8.3 Selected Restoration Locations for EEE Report

The EEE Report was developed in consultation with the habitat restoration subgroup and is presented in Appendix F. The EEE Report includes a list of selected restoration techniques that may be suitable for use in the Buffalo River. These restoration techniques were combined into restoration project examples for general shoreline types, including: commercial parking lots, bulkheads, riprap, and natural/softened shoreline (e.g., parks and greenways). These generalized combinations of restoration techniques may be incorporated into the Buffalo River Master Plan (described in Section 8.5) and can be tailored to specific locations as future projects by various community groups to support the formal redevelopment of the Buffalo River Corridor initiative.

The restoration techniques were also combined in the EEE Report to provide a set of restoration alternatives and a preferred conceptual approach for multiple locations within the Buffalo River AOC. The habitat restoration subgroup, which includes representatives of USEPA, NYSDEC, BNR, USACE, and Honeywell and its consultants, selected six locations for evaluation of potential restoration projects[15].

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[15] Land owner acceptance of these potential projects will be necessary prior to project implementation. It is anticipated that additional due diligence (including any necessary access negotiations with land owners) will be conducted during the design phase.

The selected locations are: 1) Kelly Island, 2) City Ship Canal, 3) Ohio Street Shoreline, 4) Katherine Street Peninsula, 5) Buffalo Color Peninsula Shoreline, and 6) Riverbend.

8.3.1 Kelly Island

Kelly Island is located at the confluence of the City Ship Canal and the Buffalo River. The adjacent land is owned by General Mills. The toe of Kelly Island is characterized by a sloping concrete shoreline with a submerged stone apron. Portions of the aquatic area include SAV beds. This potential mitigation project location may be suitable for the creation or enhancement of in-stream shallows with EV and SAV beds.

This potential project location may be suitable for the creation or enhancement of in-stream shallows.

8.3.2 City Ship Canal

The head of the City Ship Canal is owned by CSX railroad and others. This area has been identified as one of the Buffalo River Habitat Opportunity Areas and is described as follows:

> "Although this is an artificial channel, it has increasing potential value as a habitat link between Lake Erie coastal and Buffalo River habitats, especially for waterfowl and fish in need of nesting and resting places off of Lake Erie. Native shoreline and aquatic vegetation has naturalized the western edge of the canal south of the active (ADM) industrial area. Buffering, removal of debris and slag piles from the eastern bank and sediment remediation would increase the habitat value of the canal." (BNR 2008).

This area is also directly named as part of the delisting targets developed by the Buffalo River Remedial Advisory Committee (RAC). Specifically, the delisting target includes "A minimum 25% of the AOC shoreline is restored to natural slope, shallows and aquatic (emerged and submerged) native vegetation, ***including naturalizing areas of the City Ship Canal shoreline***" [emphasis added]. Therefore, focusing on restoration of the head of the City Ship Canal could make significant progress towards a portion of this RAC delisting target.

Restoration of the Head of the City Ship Canal would enhance both ecological and human use of the site.

- Current Ecological Use: Numerous fish species have been observed at the Head of the City Ship Canal, including largemouth bass, rock bass, crappie, bullhead, carp, redhorse, sunfish, and goldfish.

- Current Human Use: It has been reported that local anglers access both sides of the City Ship Canal (south of the sand piles) on foot, bicycle, illegal vehicle access, canoe/kayak and powerboat; adolescents have been observed jumping, wading, and swimming off of old piers and pilings; and bass fisherman and other anglers fish in the area when the winds and waves on Lake Erie are too high (Jedlicka, personal communication 2008).

This potential project location may be suitable for the creation or enhancement of in-stream shallows, bank slopes, and riparian zones.

8.3.3 Ohio Street Shoreline

The Ohio Street Shoreline (formerly referred to as Dead Man's Creek) is part of the Buffalo River Urban Canoe Trail. Surrounding land ownership has to be verified, but it is believed that the City of Buffalo owns a narrow strip of property on either side of the canal that can be used for access. This remnant "canal" once connected the Buffalo River to what is now "Father Conway Park". The parcel now still functions as a combined sewer overflow (CSO) outfall. Due to river hydrology, this canal collects debris, trees, and litter. Schematics developed in the 1990s for the site called for a floating boom across the canal.

There is potential for a pocket wetland if debris control structures are installed. Shoreline improvements can be made along NYSDEC's Ohio Street Park, next to the historical Great Lakes Paper Fiber warehouse and the Bison Rod and Gun Club. There are ongoing discussions regarding future conversion of the warehouse into a boating club/recreation center.

Restoration of the Ohio Street Canal would enhance both ecological and human use of the site.

- Current Ecological Use: Fish species observed at this location include large mouth bass, small mouth bass, rock bass, and sunfish.

- Current Human Use: Anglers access the narrow strip on the north side of the "canal", many youth swim in this section of river; and recreational boats use the straight-away section of river with riders on inner-tubes. In addition, there is abundant fishing in this stretch in areas with natural and unnatural cover/overhanging vegetation.

This potential project location may be suitable for the limited creation or enhancement of in-stream shallows and more pronounced restoration of bank slopes and riparian zones.

8.3.4 Katherine Street Peninsula

This 4.8-acre parcel is owned by the City of Buffalo. It has been identified as one of the Buffalo River Habitat Opportunity Areas and is described as follows:

> "One of 15 publicly-owned Buffalo River habitat parcels identified by the Erie County DEP for restoration and the only one of the top 5 not completed. "Approximately 290 m (950 linear feet) of shoreline borders the east and south sides of the parcel. A 100 - foot floodplain has been delineated. The area is recognized as valuable fish habitat ... Many species of birds were observed." See EC DEP restoration recommendations (Poole, 1994)." (BNR 2008)

Restoration of Katherine Street Peninsula would enhance both ecological and human use of the site. The parcel provides an opportunity to provide upland public access. Additionally, potential shoreline restoration presents a potential for ecological enhancements. The site is being invaded by Japanese knotweed, comparable to surrounding disturbed areas, but many sections of the shoreline are naturalized, mature and have not been taken over by invasives yet. The proximity of shoreline invasive species must be taken into consideration prior to any shoreline disturbance above the water line.

This potential project location may be suitable for the creation or enhancement of bank slopes and riparian zones.

8.3.5 Buffalo Color Peninsula Shoreline

The Buffalo Color Peninsula site is located on the northern bank of the Buffalo River, between RM 4.5 and 5.0. In 1997, a remedy was implemented that consisted of the following measures: 1) installation of a slurry wall surrounding the entire site to isolate groundwater; 2) removal of wastefill from outside of the slurry wall, including sediment from the river bank; and 3) stabilization of the excavated river bank using riprap, geotextile liner, or concrete extending out to near the navigation channel dredge limit. Since the site has been remediated, additional restoration has not occurred to further enhance potential ecological value. This potential project location may be suitable for the creation or enhancement of SAV, EV, in addition to the enhancement of riparian zones.

8.3.6 Riverbend

The current title holder of the Riverbend property is the Buffalo Economic Renaissance Corporation (BERC). It also has been identified as one of the Buffalo River Habitat Opportunity Areas and is described as follows:

> "A major brownfield on the river that has been cleared for redevelopment. Depending on the extent of soil contamination, this site provides almost a mile of shoreline where natural slope and 100-200 foot vegetated buffers could be restored." (BNR 2008)

This site was the centerpiece of the South Buffalo Brownfield Opportunity Area (BOA) recently completed by the City of Buffalo. The final BOA report has plans and schematics for the vision of the site.

The site has a combination of steel bulkhead and sheet pile, but also large segments of naturalized shoreline. A comprehensive restoration approach could be taken along the mile of shoreline. Half of the site lies within the 3.25-5.5 mile stretch of the Buffalo River that includes areas targeted by the Preferred Remedy. Additionally, this location is adjacent to portions of the river that are authorized for deep navigational traffic, as well as a portion of the river at and upstream of the dredge limit for the authorized navigation channel.

Any new development along this section of the river must abide by the 100 foot setback ordinance. The landowner has expressed a willingness to cooperate with shoreline restoration/greenway implementation at this site and has also expressed a willingness to negotiate the amount of setback (i.e.: 50 feet trade off in one location, or 150 feet in another depending on its value).

This potential project location may be suitable for the creation or enhancement of in-stream shallows, bank slopes, and riparian zones.

8.4 Evaluation of EEE Restoration Alternatives

At each of the potential restoration locations, multiple alternatives were developed based on the selected restoration technique. These alternatives were then evaluated using criteria developed by the PCT habitat restoration subgroup. These evaluation criteria were intended to provide a basis for design and to allow comparison of relative costs and benefits of project alternatives (presented in the Appendix F) and for future proposed restoration projects (to be presented in the Master Plan).

The evaluation criteria were separated into screening criteria and scoring criteria. The screening criteria are similar in concept to the threshold criteria of the CERCLA Evaluation Criteria (40 CFR 300.430(e)(9)(iii)) in that they are required to be met for any given project to be evaluated as a mitigation alternative. The scoring criteria were used to rank or prioritize between various restoration alternatives at each of the project locations (Section 8.3). Members of the PCT habitat restoration subgroup independently scored each restoration alternative. The highest scoring alternative at each project location was selected as the Preferred Restoration Alternative. These Preferred Restoration Alternatives, to be implemented by the GLLA PCT and non-GLLA partners, will be constructed in parallel with the Preferred Remedy, or immediately following the remedy implementation.

8.5 Coordination with the Master Plan

The GLLA PCT and non-GLLA partners are not restricted to only implementing restoration projects at the six locations identified in Section 8.3. The Buffalo River Restoration Master Plan is currently being developed by the USEPA GLNPO in partnership with BNR. This master plan is intended to create a single list of potential restoration projects for the Buffalo River. The master plan will include, but is not limited to, a list of 12 projects within the Buffalo River AOC, and up to 37 potential habitat restoration projects for the Buffalo River watershed that have been identified by BNR (Figure 8-2). The majority of these projects fall within the AOC or the riparian zone of the AOC and thus, subject to evaluation using the criteria described above, may be considered for implementation under GLLA.

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Tables

Table 2-1
Buffalo River AOC Beneficial Use Impairment Indicators
Buffalo, NY

Impairment Indicator	1989 Status	2005 Status	2008 Status	Delisting Criteria/Restoration Target(s)
1. Restrictions on Fish & Wildlife Consumption	Impaired	Impaired	Impaired	1) There are no AOC-specific fish and wildlife consumption advisories by New York State (e.g. carp for PCBs); AND 2) When contaminant levels due to watershed or in-place contaminants in resident native and exotic fish and wildlife populations that could be consumed do not exceed current NYS standards.
2. Tainting of Fish & Wildlife Flavor	Likely Impaired	Likely Impaired	Impaired	1) No exceedances of water quality standards or criteria for compounds (specifically phenols) associated with tainting within the AOC; AND 2) No reports of tainting from fish and wildlife officials or informed public observers
3. Degradation of Fish & Wildlife Populations	Likely Impaired	Likely Impaired	Impaired	**Fish Populations** 1) Fish surveys find that the resident fish community is fair to good based on applicable fish community biolgical indices (IBI) for two consecutive surveys; AND 2) The frequency of occurrence of DELT anomalies in bottom-dwelling fish does not exceed recommended levels; AND 3) Whole-body concentrations of Endocrine Disruptors (including but not limited to: PCBs, dioxins, and pesticides) in bottom dwelling fish do not exceed critical tissue concentrations for adverse effects on fish; AND 4) Water quality measures meet state standards for at least a Class C river. **Wildlife Populations** 1) Wildlife surveys find that diversity and abundance of birds, mammals, reptiles, and amphibians in the AOC is comparable to a suitable reference site; AND 2) No change from September 2008 criteria; AND 3) Wildlife assessments confirm no significant toxicity from water column or sediment contaminants; AND 4) Diversity of amphibian populations in AOC pocket wetlands is similar to upstream and/or Tifft marsh levels; AND 5) Diversity of benthic populations in the AOC is comparable to upstream levels.
4. Fish Tumors and Other Deformities	Impaired	Impaired	Impaired	1) Survey data confirm the absence of neoplastic liver tumors in bullheads (as compared to control site) for two consecutive sampling events; AND 2) Contaminants in water and sediments in the AOC do not exceed NYS standards
5. Bird or Animal Deformities or Reproductive Problems	Likely Impaired	Likely Impaired	Impaired	1) Deformities or reproductive problem rates are not statistically different than inland background levels as reported from wildlife officials or trained observers; AND 2) Concentrations of bioaccumulative chemicals in fish do not exceed levels associated with reproductive problems in piscivorus wildlife; AND/OR 3) Concentrations in sediment do not exceed levels associated with benthic impairment that could result in reproductive problems in omnivorous and benthivorous birds and wildlife.
6. Degradation of Benthos	Impaired	Impaired	Impaired	1) Benthic macroinvertebrate communities are "non-impacted" or "slightly impacted" according to NYSDEC indices for two separate sampling events; OR 2) In the absence of conclusive community structure data, the toxicity of sediment-associated contaminants is not statically higher than controls.
7. Restrictions on Dredging	Impaired	Impaired	Impaired	1) There are no restrictions on routine commercial or recreational navigation dredging by the USACE or another entity across any part of the AOC, such that no special management measure or use of a confined disposal facility are required from the dredged material due to chemical contamination.
8. Eutrophication or Undesirable Algae	Not Impaired	Unknown	Not Impaired	None
9. Restrictions on Drinking Water Consumption or Taste and Odor Problems	Not Impaired	Not Applicable	Not Applicable	Not applicable
10. Beach Closings	Not Impaired	Not Applicable	Not Applicable	Not applicable

Table 2-1
Buffalo River AOC Beneficial Use Impairment Indicators
Buffalo, NY

Impairment Indicator	1989 Status	2005 Status	2008 Status	Delisting Criteria/Restoration Target(s)
11. Degradation of Aesthetics	Not Impaired	Impaired	Impaired	1) Minimize debris, general litter, floatables, or contaminants in the river or shoreline via point source or non-point sources through the implementation of Best Management Practices; AND 2) Organic, chemical, and biological contaminants should not persist in concentrations that can be detected as visible film, sheen, or discoloration on the surface, detected by odor, or form deposits on shorelines and bottom sediments.
12. Added Costs to Agriculture and Industry	Not Impaired	Not Impaired	Not Applicable	Not applicable
13. Degradation of Phytoplankton and Zooplankton Populations	Not Impaired	Not Impaired for Zooplankton; Unknown for Phytoplankton	Not Impaired	None
14. Loss of Fish & Wildlife Habitat	Impaired	Impaired	Impaired	**Restore Habitat Connectivity** 1) A minimum 100-foot buffer of native vegetation on new development on each riverbank is maintained and enforced upstream from the Ohio Street Bridge. 2) Significant floodplain, wetland, or riparian habitat areas in the AOC are protected and/or restored, 3) A minimum 25% of the AOC shoreline is restored to natural slope, shallows, and aquatic (emergent and submerged) native vegetation, including naturalizing areas of the City Ship Canal shoreline. **Improve Stream Quality Index scores from "poor" to at least "good"** 1) Basic water quality measures (based on NYS RIBS) consistently meet state standards for at least a Class C river. 2) Aquatic habitat scores are fair to good AND/OR the lower Buffalo River is no longer listed as "stressed" for aquatic life on the NYS Priority Waterbodies List. **Restore hydrologic function to support habitat and species goals listed in BUI #3** 1) Reduce navigational dredging in the AOC to support aquatic habitat and species goals (BUI #3) AND/OR 2) Restore and protect natural flows, meanders, and stream habitat in River Corridor opportunity areas upstream of the AOC.

Source: BNR 2008, Ecology and Environment 2008

AOC - Area of Concern
BUI - Beneficial use impairments
PCB - Polychlorinated biphenyl

Table 2-2a
Total PAH Surface Sediment Concentrations, Summary Statistics
Buffalo River, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	6	6	3.9	5.9	4.6	0.75	4.6
River Mile 0.5 - 1.0	33	33	2.0	48	8.4	10	6.1
River Mile 1.0 - 1.5	24	20	0.66	23	6.5	4.3	5.4
River Mile 1.5 - 2.0	24	23	0.66	15	5.7	3.0	5.0
River Mile 2.0 - 2.5	22	22	3.3	18	5.3	3.1	4.8
River Mile 2.5 - 3.0	26	26	3.2	39	6.9	7.1	5.6
River Mile 3.0 - 3.5	26	26	2.5	47	9.9	9.6	7.5
River Mile 3.5 - 4.0	41	41	3.5	91	16	22	8.7
River Mile 4.0 - 4.5	30	29	2.5	150	27	40	12
River Mile 4.5 - 5.0	35	35	2.5	85	13	21	6.9
River Mile 5.0 - 5.5	34	34	1.1	280	13	48	5.0
River Mile 5.5 - 6.0	23	23	1.2	10	5.5	2.3	5.0
River Mile 6.0 - 6.2	13	13	1.5	16	4.0	4.0	3.1
River Mile 6.2- 6.5, Upstream of the AOC	1	1	18	18	18	-	18
River Mile 6.5 - 7.0, Upstream of the AOC	1	1	3.8	3.8	3.8	-	3.8
Buffalo Harbor, Downstream of the AOC	9	9	1.8	42	7.1	13	3.6
City Ship Canal	59	56	1.7	300	21	41	11
Cazenovia Creek	2	2	2.1	3.4	2.8	0.94	2.7

mg/kg - milligrams per kilogram

Table 2-2b
Total PAH Subsurface Sediment Concentrations, Summary Statistics
Buffalo, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	12	12	3.1	41	15	16	9.3
River Mile 0.5 - 1.0	32	32	3.8	82	15	18	9.8
River Mile 1.0 - 1.5	38	36	0.62	110	23	27	12
River Mile 1.5 - 2.0	16	16	0.64	160	51	49	24
River Mile 2.0 - 2.5	21	21	3.1	58	12	16	7.0
River Mile 2.5 - 3.0	36	36	3.5	330	26	57	11
River Mile 3.0 - 3.5	25	25	2.2	42	11	9.9	8.0
River Mile 3.5 - 4.0	90	89	2.1	450	47	80	14
River Mile 4.0 - 4.5	62	60	2.4	410	56	90	18
River Mile 4.5 - 5.0	66	66	2.0	1800	120	330	14
River Mile 5.0 - 5.5	55	55	2.1	160	16	29	7.2
River Mile 5.5 - 6.0	29	29	2.1	13	5.5	2.8	5.0
River Mile 6.0 - 6.2	2	1	5.0	5.4	5.2	0.34	5.2
River Mile 6.2- 6.5, Upstream of the AOC	0	-	-	-	-	-	-
River Mile 6.5- 7.0, Upstream of the AOC	0	-	-	-	-	-	-
Buffalo Harbor, Downstream of the AOC	3	3	3.5	4.3	3.8	0.41	3.8
City Ship Canal	55	51	2.1	250	25	37	14
Cazenovia Creek	0	-	-	-	-	-	-

mg/kg - milligrams per kilogram

Table 2-3a
Total PCB Surface Sediment Concentrations, Summary Statistics
Buffalo, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	6	2	0.048	0.067	0.052	0.0074	0.052
River Mile 0.5 - 1.0	33	20	0.035	1.3	0.16	0.28	0.086
River Mile 1.0 - 1.5	24	9	0.030	0.70	0.10	0.14	0.065
River Mile 1.5 - 2.0	24	15	0.027	0.55	0.11	0.12	0.076
River Mile 2.0 - 2.5	22	10	0.044	0.54	0.094	0.11	0.071
River Mile 2.5 - 3.0	26	25	0.044	1.5	0.32	0.37	0.20
River Mile 3.0 - 3.5	26	15	0.038	0.60	0.16	0.16	0.10
River Mile 3.5 - 4.0	41	23	0.032	4.7	0.27	0.73	0.11
River Mile 4.0 - 4.5	30	18	0.012	10	0.62	1.9	0.13
River Mile 4.5 - 5.0	35	12	0.033	2.3	0.16	0.41	0.067
River Mile 5.0 - 5.5	34	12	0.032	1.1	0.12	0.20	0.075
River Mile 5.5 - 6.0	23	4	0.029	0.18	0.058	0.033	0.053
River Mile 6.0 - 6.2	13	2	0.027	0.36	0.063	0.090	0.042
River Mile 6.2- 6.5, Upstream of the AOC	1	0	0.069	0.069	0.069	0.00	0.069
River Mile 6.5 - 7.0, Upstream of the AOC	1	0	0.045	0.045	0.045	0.00	0.045
Buffalo Harbor, Downstream of the AOC	9	3	0.032	0.13	0.055	0.029	0.050
City Ship Canal	59	46	0.030	1.4	0.20	0.22	0.13
Cazenovia Creek	2	0	0.036	0.039	0.038	0.0021	0.037

mg/kg - milligrams per kilogram

Table 2-3b
Total PCB Subsurface Sediment Concentrations, Summary Statistics
Buffalo, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	12	11	0.038	1.0	0.33	0.36	0.18
River Mile 0.5 - 1.0	32	32	0.046	4.1	0.60	0.95	0.29
River Mile 1.0 - 1.5	38	32	0.029	3.1	0.47	0.82	0.17
River Mile 1.5 - 2.0	16	13	0.029	2.6	0.55	0.63	0.28
River Mile 2.0 - 2.5	21	16	0.039	1.4	0.22	0.32	0.12
River Mile 2.5 - 3.0	36	35	0.0033	2.9	0.41	0.56	0.22
River Mile 3.0 - 3.5	25	16	0.00087	1.6	0.22	0.35	0.080
River Mile 3.5 - 4.0	90	54	0.010	5.1	0.42	0.90	0.12
River Mile 4.0 - 4.5	62	40	0.032	10	1.0	2.1	0.20
River Mile 4.5 - 5.0	66	38	0.030	7.4	0.39	1.2	0.10
River Mile 5.0 - 5.5	55	33	0.035	160	4.5	22	0.19
River Mile 5.5 - 6.0	29	9	0.030	0.74	0.10	0.15	0.061
River Mile 6.0 - 6.2	2	1	0.047	0.86	0.45	0.58	0.20
River Mile 6.2- 6.5, Upstream of the AOC	0	-	-	-	-	-	-
River Mile 6.5- 7.0, Upstream of the AOC	0	-	-	-	-	-	-
Buffalo Harbor, Downstream of the AOC	3	3	0.083	0.22	0.13	0.073	0.12
City Ship Canal	55	40	0.029	4.9	0.54	0.96	0.20
Cazenovia Creek	0	-	-	-	-	-	-

mg/kg - milligrams per kilogram

Table 2-4a
Lead Surface Sediment Concentrations, Summary Statistics
Buffalo, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	6	6	26	38	33	5.0	33
River Mile 0.5 - 1.0	33	33	27	320	65	69	49
River Mile 1.0 - 1.5	24	24	10	490	69	99	43
River Mile 1.5 - 2.0	24	24	3.1	74	41	18	35
River Mile 2.0 - 2.5	22	22	26	250	45	47	38
River Mile 2.5 - 3.0	26	26	32	200	62	36	56
River Mile 3.0 - 3.5	26	26	25	250	70	57	56
River Mile 3.5 - 4.0	41	41	27	1100	120	180	69
River Mile 4.0 - 4.5	30	30	8.1	690	110	140	73
River Mile 4.5 - 5.0	35	35	19	2600	160	440	59
River Mile 5.0 - 5.5	34	34	14	430	51	71	38
River Mile 5.5 - 6.0	23	23	12	120	32	20	29
River Mile 6.0 - 6.2	13	13	6.2	98	26	26	19
River Mile 6.2- 6.5, Upstream of the AOC	1	1	24	24	24	0.00	24
River Mile 6.5 - 7.0, Upstream of the AOC	1	1	19	19	19	0.00	19
Buffalo Harbor, Downstream of the AOC	9	9	9.2	66	31	22	25
City Ship Canal	59	59	1.9	2700	130	350	68
Cazenovia Creek	2	2	12	18	15	4.2	15

mg/kg - milligrams per kilogram

Table 2-4b
Lead Subsurface Sediment Concentrations, Summary Statistics
Buffalo, NY

Location	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	12	12	34	260	85	71	65
River Mile 0.5 - 1.0	32	32	34	600	130	150	88
River Mile 1.0 - 1.5	38	38	9.1	730	160	170	94
River Mile 1.5 - 2.0	16	16	12	640	220	200	140
River Mile 2.0 - 2.5	21	21	31	530	110	130	71
River Mile 2.5 - 3.0	36	36	31	450	110	95	87
River Mile 3.0 - 3.5	25	25	11	230	76	51	61
River Mile 3.5 - 4.0	90	90	14	740	140	150	88
River Mile 4.0 - 4.5	62	62	14	1300	240	310	120
River Mile 4.5 - 5.0	66	66	24	8500	390	1100	110
River Mile 5.0 - 5.5	55	55	22	740	100	130	62
River Mile 5.5 - 6.0	29	29	14	120	39	22	35
River Mile 6.0 - 6.2	2	2	20	39	29	14	28
River Mile 6.2- 6.5, Upstream of the AOC	0	-	-	-	-	-	-
River Mile 6.5- 7.0, Upstream of the AOC	0	-	-	-	-	-	-
Buffalo Harbor, Downstream of the AOC	3	3	45	74	58	15	56
City Ship Canal	55	55	7.5	580	160	140	97
Cazenovia Creek	0	-	-	-	-	-	-

mg/kg - milligrams per kilogram

Table 2-5a
Mercury Surface Sediment Concentrations, Summary Statistics
Buffalo, NY

Mile Marker	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	6	6	0.053	0.17	0.11	0.047	0.10
River Mile 0.5 - 1.0	33	33	0.047	6.1	0.53	1.20	0.18
River Mile 1.0 - 1.5	24	20	0.0055	0.80	0.14	0.17	0.074
River Mile 1.5 - 2.0	24	22	0.0047	0.58	0.15	0.14	0.10
River Mile 2.0 - 2.5	22	22	0.031	0.37	0.10	0.075	0.087
River Mile 2.5 - 3.0	26	25	0.014	2.1	0.25	0.42	0.15
River Mile 3.0 - 3.5	26	24	0.013	1.8	0.25	0.36	0.14
River Mile 3.5 - 4.0	41	37	0.0085	9.5	0.85	1.70	0.22
River Mile 4.0 - 4.5	30	28	0.0090	7.1	0.81	1.60	0.21
River Mile 4.5 - 5.0	34	33	0.011	3.5	0.38	0.70	0.13
River Mile 5.0 - 5.5	34	33	0.0060	4.8	0.27	0.81	0.10
River Mile 5.5 - 6.0	23	18	0.0090	0.36	0.066	0.071	0.045
River Mile 6.0 - 6.2	13	4	0.0049	0.14	0.023	0.038	0.012
River Mile 6.2- 6.5, Upstream of the AOC	1	1	0.10	0.10	0.10	0.00	0.10
River Mile 6.5 - 7.0, Upstream of the AOC	1	1	0.019	0.019	0.019	0.00	0.019
Buffalo Harbor, Downstream of the AOC	9	9	0.026	0.44	0.11	0.13	0.078
City Ship Canal	59	55	0.0050	8.5	0.78	1.20	0.37
Cazenovia Creek	2	2	0.012	0.041	0.027	0.021	0.022

mg/kg - milligrams per kilogram

Table 2-5b
Mercury Subsurface Sediment Concentrations, Summary Statistics
Buffalo, NY

Mile Marker	Number of Samples	Number of Detects	Minimum Result (mg/kg)	Maximum Result (mg/kg)	Average Result (mg/kg)	Standard Deviation	Geometric Mean Result (mg/kg)
Buffalo River							
Downstream AOC Boundary - River Mile 0.5	12	12	0.066	4.0	1.1	1.4	0.41
River Mile 0.5 - 1.0	32	32	0.097	9.7	1.4	2.2	0.49
River Mile 1.0 - 1.5	38	37	0.0040	14	2.3	3.5	0.42
River Mile 1.5 - 2.0	16	15	0.0038	9.0	3.0	3.3	0.92
River Mile 2.0 - 2.5	21	21	0.066	5.8	0.89	1.7	0.27
River Mile 2.5 - 3.0	36	36	0.061	6.3	0.75	1.3	0.29
River Mile 3.0 - 3.5	25	25	0.036	2.7	0.53	0.77	0.23
River Mile 3.5 - 4.0	90	84	0.0043	15	1.9	3.2	0.43
River Mile 4.0 - 4.5	62	58	0.0081	9.2	1.8	2.6	0.43
River Mile 4.5 - 5.0	64	64	0.031	32	3.0	6.2	0.43
River Mile 5.0 - 5.5	55	55	0.044	44	1.9	6.4	0.25
River Mile 5.5 - 6.0	29	29	0.021	0.34	0.094	0.070	0.077
River Mile 6.0 - 6.2	2	1	0.014	0.14	0.077	0.089	0.043
River Mile 6.2- 6.5, Upstream of the AOC	0	-	-	-	-	-	-
River Mile 6.5- 7.0, Upstream of the AOC	0	-	-	-	-	-	-
Buffalo Harbor, Downstream of the AOC	3	3	0.10	0.37	0.21	0.14	0.18
City Ship Canal	55	50	0.0033	21	3.2	4.4	0.80
Cazenovia Creek	0	-	-	-	-	-	-

mg/kg - milligrams per kilogram

Table 2-6
Summary of Sediment Pore Water PAH Concentrations and Log Koc Values
Buffalo, NY

Chemical	Number of Detected Samples	Detection Limit	Pore Water Min Detected Sample	Pore Water Max Detected Sample	Pore Water Mean Detected Sample	Log Koc Minimum	Log Koc Maximum	Log Koc Mean
		ng/g	ng/g	ng/g	ng/g			
naphthalene	5	0.1	0.110	0.302	0.164	4.37	5.26	4.72
2-methylnaphthalene	1	0.05	0.078	0.078	0.078	4.86	4.86	4.86
1-methylnaphthalene	3	0.05	0.050	0.194	0.117	4.55	4.72	4.61
C2 naphthalenes	13	0.15	0.161	1.584	0.324	4.71	5.33	5.02
C3 naphthalenes	9	0.05	0.108	5.407	0.770	4.51	5.37	5.08
C4 naphthalenes	1	0.15	5.044	5.044	5.044	4.79	4.79	4.79
acenaphthylene	0	0.2	–	–	–	–	–	–
acenaphthene	3	0.1	0.037	0.430	0.194	4.45	5.11	4.74
fluorene	4	0.04	0.032	0.264	0.096	4.67	5.46	5.16
C1 fluorenes	10	0.02	0.038	0.646	0.137	5.21	5.59	5.42
C2 fluorenes	1	0.05	0.638	0.638	0.638	5.57	5.57	5.57
C3 fluorenes	0	0.06	–	–	–	–	–	–
phenanthrene	2	0.1	0.047	0.224	0.136	5.31	5.96	5.63
anthracene	2	0.05	0.014	0.184	0.099	5.54	6.34	5.94
C1 phenanthrenes/anthracenes	2	0.02	0.094	0.493	0.294	5.42	5.80	5.61
C2 phenanthrenes/anthracenes	1	0.05	0.938	0.938	0.938	5.92	5.92	5.92
C3 phenanthrenes/anthracenes	1	0.04	0.808	0.808	0.808	5.99	5.99	5.99
C4 phenanthrenes/anthracenes	0	0.02	–	–	–	–	–	–
fluoranthene	19	0.01	0.011	0.149	0.030	5.81	6.67	6.37
pyrene	18	0.01	0.010	0.151	0.028	5.77	6.62	6.33
C1 fluoranthenes/pyrenes	1	0.01	0.139	0.139	0.139	6.00	6.00	6.00
benz[a]anthracene	7	0.001	0.001	0.012	0.004	6.62	7.35	7.07
chrysene	7	0.001	0.002	0.016	0.005	6.57	7.74	7.16
C1 chrysenes	0	0.005	–	–	–	–	–	–
C2 chrysenes	0	0.01	–	–	–	–	–	–
C3 chrysenes	0	0.01	–	–	–	–	–	–
C4 chrysenes	0	0.01	–	–	–	–	–	–
benzo[b+k]fluoranthene	0	0.005	–	–	–	–	–	–
benzo[e]pyrene	0	0.005	–	–	–	–	–	–
benzo[a]pyrene	0	0.008	–	–	–	–	–	–
perylene	0	0.004	–	–	–	–	–	–
indeno[1,2,3-cd]pyrene	0	0.001	–	–	–	–	–	–
dibenz[ah]anthracene	0	0.002	–	–	–	–	–	–
benzo[ghi]perylene	0	0.001	–	–	–	–	–	–

ng/g - nanograms per gram

Table 2-7
Summary of Sediment Pore Water PCB Concentrations and Log Koc Values
Buffalo, NY

PCB Congener	Congener Number	Number of Detected Pore Water Samples	Detection Limit	Pore Water Min Detected Sample	Pore Water Max Detected Sample	Pore Water Mean Detected Sample	Log Koc Minimum	Log Koc Maximum	Log Koc Mean
			pg/L	pg/L	pg/L	pg/L			
2,2'-dichlorobiphenyl	4	17	34	27.5	1065	201	5.6	6.4	6.1
2,3'-dichlorobiphenyl	6	18	19	11.7	480	94.0	5.7	6.9	6.2
2,4'-dichlorobiphenyl	8	18	17	22.3	1400	178	5.5	6.5	6.0
4,4'-dichlorobiphenyl	15	20	8.1	89.3	978	196	6.1	6.9	6.5
2,2',3 (2,4',6)-trichlorobiphenyl	16+32	20	3.7	33.7	932	127	6.1	6.8	6.4
2,2',4-trichlorobiphenyl	17	18	3.4	18.0	602	85.6	5.9	6.7	6.3
2,2',5-trichlorobiphenyl	18	20	4.4	40.9	1933	234	5.6	6.7	6.2
2,3,4'-trichlorobiphenyl	22	19	2.4	14.0	460	62.6	6.2	7.1	6.5
2,3',5-trichlorobiphenyl	26	19	2.1	8.2	203	35.6	6.2	6.8	6.5
2,4,4'-trichlorobiphenyl	28	20	1.0	14.5	636	72.7	6.1	7.1	6.8
2,4',5-trichlorobiphenyl	31	20	1.8	24.2	898	107	6.0	6.9	6.6
2',3,4-trichlorobiphenyl	33	20	2.2	15.9	712	79.1	6.0	7.0	6.6
3,4,4'-trichlorobiphenyl	37	17	1.9	4.3	133	19.5	6.6	8.0	7.5
2,2',3,4'-tetrachlorobiphenyl	42	19	1.0	3.2	120	17.4	6.5	7.7	7.3
2,2',3,5'-tetrachlorobiphenyl	44	20	1.3	15.8	498	67.5	6.3	7.3	6.9
2,2',3,6-tetrachlorobiphenyl	45	15	2.4	4.5	185	32.4	6.3	7.4	6.9
2,2',4,4 (2,2',4,5)'-tetrachlorobiphenyl	47+48	20	1.2	7.4	139	34.6	6.2	7.3	6.9
2,2',4,5'-tetrachlorobiphenyl	49	20	0.8	8.3	264	39.7	6.4	7.7	7.1
2,2',5,5'-tetrachlorobiphenyl	52	20	1.1	25.9	535	80.1	6.7	7.6	7.1
2,3,3',4' (2,3,4,4')-tetrachlorobiphenyl	56+60	20	0.3	3.6	66.2	10.5	6.9	7.9	7.4
2,3,4',6-tetrachlorobiphenyl	64	20	0.8	9.7	175	28.0	6.2	7.2	6.8
2,3',4,4'-tetrachlorobiphenyl	66	20	0.5	4.2	167	19.5	6.9	7.6	7.4
2,3',4',5-tetrachlorobiphenyl	70	20	0.5	5.6	221	25.8	6.5	7.5	7.2
2,4,4',5-tetrachlorobiphenyl	74	20	0.4	3.2	97.1	11.7	7.1	7.7	7.5
2,2',3,3',4-pentachlorobiphenyl	82	15	0.4	1.4	14.5	3.6	7.4	7.9	7.6
2,2',3,3',6-(2,2',4,4',6pentachlorobiphenyl	84+101	20	0.2	3.0	46.4	8.9	7.4	8.0	7.8
2,2',3,4,4'-pentachlorobiphenyl	85	19	0.3	0.9	13.2	2.7	7.4	7.9	7.6
2,2',3,4,5'-pentachlorobiphenyl	87	20	0.4	2.2	38.3	7.3	7.2	8.1	7.8
2,2',3,5',6-pentachlorobiphenyl	95	20	0.7	10.1	126	25.1	6.8	7.3	7.1
2,2',3',4,5-pentachlorobiphenyl	97	20	0.5	2.1	36.5	6.5	7.0	8.0	7.5
2,2',4,4',5-pentachlorobiphenyl	99	20	0.3	1.5	31.3	5.9	7.2	7.8	7.6
2,3,3',4,4'-pentachlorobiphenyl	105	20	0.2	0.8	15.9	3.0	7.5	8.1	7.8
2,3,3',4',6-pentachlorobiphenyl	110	20	0.4	4.7	79.6	14.1	7.1	7.7	7.5
2,3',4,4',5-pentachlorobiphenyl	118	20	0.4	3.4	63.4	10.9	7.5	8.4	8.2
2,2',3,3',4,4'-hexachlorobiphenyl	128	18	0.1	0.2	2.2	0.8	8.5	8.5	8.5
2,2',3,3',4,6'-hexachlorobiphenyl	132	19	0.3	0.9	8.5	2.3	7.4	8.1	7.8
2,2',3,3',5,6'-hexachlorobiphenyl	135	19	0.5	0.6	7.4	2.4	7.4	8.1	7.7
2,2',3,3',6,6'-hexachlorobiphenyl	136	19	0.5	0.6	6.8	2.2	7.2	7.8	7.5
2,2',3,4,4',5'-(2,3,3',4',5,6)hexachlorobiphenyl	138+163	20	0.1	0.6	6.3	1.7	7.3	8.6	8.2
2,2',3,4,5.5'-hexachlorobiphenyl	141	19	0.2	0.2	3.4	1.1	7.5	8.2	7.8
2,2',3,4',5,5'-hexachlorobiphenyl	146	18	0.2	0.2	4.7	1.4	7.4	8.1	7.8
2,2',3,4',5',6-hexachlorobiphenyl	149	20	0.3	1.4	21.1	5.2	7.4	8.0	7.7
2,2',3,5,5',6-hexachlorobiphenyl	151	19	0.3	0.4	7.3	2.2	7.4	8.1	7.8
2,2',4,4',5,5'-hexachlorobiphenyl	153	20	0.1	0.8	8.4	2.1	7.7	8.5	8.1
2,3,3',4,4',5-hexachlorobiphenyl	156	16	0.1	0.1	1.4	0.6	8.4	8.8	8.6
2,2',3,3',4,4',5-heptachlorobiphenyl	170	16	0.1	0.2	3.4	1.3	8.5	8.8	8.6
2,2',3,3',4,4',6-heptachlorobiphenyl	171	16	0.1	0.1	1.3	0.6	8.1	8.7	8.4
2,2',3,3',4,5,6'-heptachlorobiphenyl	174	20	0.2	0.2	3.5	1.2	7.9	8.4	8.2
2,2',3,3',4',5,6-heptachlorobiphenyl	177	18	0.1	0.2	2.2	0.8	8.1	8.6	8.4
2,2',3,3',5,6,6'-heptachlorobiphenyl	179	16	0.3	0.2	2.6	1.0	7.4	8.6	8.1
2,2',3,4,4',5,5'-heptachlorobiphenyl	180	20	0.1	0.3	4.0	1.3	8.3	8.8	8.5
2,2',3,4,4',5',6-heptachlorobiphenyl	183	18	0.2	0.2	1.9	0.8	7.6	8.5	8.1
2,2',3,4',5,5',6-heptachlorobiphenyl	187	20	0.2	0.5	3.9	1.4	7.7	8.4	8.2
2,3,3',4,4',5',6-heptachlorobiphenyl	191	9	0.1	0.3	1.6	0.8	NA[a]	NA	NA
2,2',3,3',4,4',5,5'-octachlorobiphenyl	194	9	0.2	0.2	1.7	0.8	8.3	8.3	8.3
2,2',3,3',4,5,6,6'-octachlorobiphenyl	199	10	0.4	0.6	4.0	1.8	7.8	8.3	8.1
2,2',3,4,4',5,5'.6-octachlorobiphenyl	203	9	0.2	0.3	1.7	0.8	8.1	8.5	8.3

(a) 2,2',3,3',4,4',5,5'-octachlorobiphenyl was not detected in any of the sediment extracts (detection limit =1.0 ng/g).
Therefore log Koc values were not calculated for this chemical.

PCB - Polychlorinated biphenyl
pg/L - Picogram per liter
NA - Not Available
ng/g - nanograms per gram

Table 2-8
Summary of Mean Metrics Calculated for Sediment Grab Samples
Buffalo, NY

	All Buffalo River Stations	Buffalo River Upstream Stations	Buffalo River Downstream Stations	Cazenovia Creek	Cattaraugus Creek Reference Site	Tonawanda Creek Reference Site
Number of Stations	8	3	5	1	3	3
Species Richness	8.65	10	7.84	7.2	6.13	5.2
Abundance	158	76.5	206	93.6	54.9	25.4
EPT Richness	0.65	0.533	0.72*	0.6	0.2	0
Hilsenhoff Biotic Index	9.58	9.12	9.85	9.67	8.81	9.59
Percent Model Affinity	29%	27%	30%	26%	23%	16%
Species Diversity (base 2)	1.47	1.78	1.29	1.12	1.58	1.76
Dominance	67%	64%	69%	79%	60%	51%
Dominance-3	91%	85%	94%	94%	91%	89%
Non-Chironomid / Oligochaete Richness	5	4.6	5.24	3.2	2.6	3.13
Number of Deformities	22/471	5/249	17/222	3/36	14/416	5/95
	4.7%	2.0%	7.7%	8.3%	3.4%	5.3%

Notes:
*This EPT score includes the BR4-PP1 replicate which contained a large number of mayflies in comparison to the other replicates at that location.

EPT	Ephemeroptera, Plecoptera, and Trichoptera
Dominance-3	Dominance of the three most numerous organisms

Table 2-9
Summary of Mean Metrics Calculated for Hester-Dendy Samplers
Buffalo, NY

	All Buffalo River Stations	Buffalo River Upstream Stations	Buffalo River Downstream Stations	Cazenovia Creek	Cattaraugus Creek Reference Site	Tonawanda Creek Reference Site
Mean Number of Famillies	6.3	5.4	7.4	6.8	8.5	8.1
Mean Number of Species	18	17	20	21	19	21
Mean Number of Organisms	320	340	320	200	490	220
Mean EPT Species Richness	1.3	0.93	2.1	1.4	3.9	1.1
Mean Hilsenhoff Biotic Index	8	8.2	7.4	7.1	6.5	7.2
Mean Percent Model Affinity	46%	42%	47%	47%	38%	45%
Mean Species Diversity (Base 2)	3	2.9	3.1	3.4	2.7	3.4
Mean Dominance	35%	34%	34%	24%	43%	29%
Mean Dominance of top 3 organisms	64%	64%	62%	56%	68%	54%
Mean Non-Chironomid / Oligochaetes Richness	4.6	3.6	5.7	4.8	7	6.2
Total Number of Chironomid Deformities	54/7104	41/3144	13/3960	20/728	13/2388	20/2072
Percentage of deformed chironomids	0.8%	1.3%	0.3%	2.7%	0.5%	1.0%

Notes:
EPT - Ephemeroptera, Plecoptera, and Trichoptera

Table 2-10
Electrofishing Catch per Unit Effort (CPUE) on the Buffalo River and Cazenovia Creek during the Fish Community Assessment
Buffalo, NY

		Electrofishing Catch per Unit Effort (CPUE)					
Scientific Name*	**Common Name**	**BR1 RM 7.25**	**BR2 RM 6.6**	**BR3 RM 6.25**	**BR4 RM 5.5**	**BR5 RM 4.5**	**CC**
Hybopsis amblops	Bigeye chub						3.9
Lepomis macrochirus	Bluegill	3.9	7.9	3.9	10	47.5	7.9
Pimephales notatus	Bluntnose minnow	3.9	4	3.9	4	15.8	102.1
Ameiurus nebulosus	Brown bullhead	3.9					
Cyprinus carpio	Common carp	11.7	11.9	11.6	8	11.9	
Luxilus cornutus	Common shiner	19.5	4	11.6	4	4	11.8
Dorosoma cepedianum	Gizzard shad	3.9	27.7	19.3		27.7	
Moxostoma erythrurum	Golden redhorse	3.9			4		3.9
Notemigonus crysoleucas	Golden shiner	3.9			14	79.2	
Etheostoma nigrum	Johnny darter				2	7.9	
Micropterus salmoides	Largemouth bass	7.8	15.8	23.1	44.1	67.3	27.5
Hypentelium nigricans	Northern hogsucker					4	3.9
Lepomis gibbosus	Pumpkinseed	11.7	27.7	27	10	35.6	3.9
Oncorhynchus mykiss	Rainbow trout	3.9					3.9
Ambloplites rupestris	Rock bass	3.9		11.6		4	11.8
Micropterus dolomieui	Smallmouth bass	3.9					
Ictiobus bubalus	Smallmouth buffalo					4	
Notropis hudsonius	Spottail shiner			3.9			
Minytrema melanops	Spotted sucker					4	
Catostomus commersonii	White sucker		4	7.7		7.9	3.9
Ameiurus natalis	Yellow bullhead					4	
Perca flavescens	Yellow perch				8		3.9
CPUE Totals		**86**	**103**	**124**	**108**	**325**	**188**

Source
MACTEC 2008

Notes
* Only fish species that were collected via electrofishing are included.

BR - Buffalo River
CC - Cazenovia Creek
CPUE - Catch per unit effort (#1 hour)
RM - River mile

Table 2-11
Fish Community Metrics for Locations within the Buffalo River and Cazenovia Creek[(a)]
Buffalo, NY

	CC	BR1 RM 7.25	BR2 RM 6.6	BR3 RM 6.25	BR4 RM 5.5	BR5 RM 4.5
Total Taxa	12	15	8	10	10	15
Percent Centrarchids	27%	13%	50%	53%	59%	48%
Percent Catostomidae	6.3%	3.3%	3.8%	6.3%	3.7%	6.1%
Percent Cyprinidae	63%	80%	19%	25%	28%	34%
Percent Dominant Species	54%	49%	27%	22%	41%	24%
Similarity Index	NA	60%	75%	80%	70%	53%
Shannon-Wiener Diversity Index	1.7	1.7	1.8	2.1	1.9	2.2
Percent Tolerant Species	56%	56%	19%	19%	24%	37%
Percent Intolerant Species	2.1%	2.2%	0%	0%	0%	1.2%
Percent Omnivores	56%	56%	46%	34%	24%	44%
Percent Top Carnivores	23%	8.8%	15%	28%	41%	22%
Abundance (b)	0.052	0.099	0.029	0.034	0.060	0.090
Mean Condition Factor (K) (c)	0.98	1.1	1.3	1.4	1.3	1.3

Notes:

(a) Includes fish caught via electrofishing and seining.
(b) Only includes fish caught via electrofishing.
(c) Calculated based on Williams (2000).

AOC - Area of Concern
BR - Buffalo River
CC - Cazenovia Creek
NA - Not applicable
RM - River mile

Table 2-12
Summary of Fish Community Metrics: Buffalo River AOC, Buffalo River - Upstream, Cazenovia Creek[a]
Buffalo, NY

	Cazenovia Creek	Buffalo River AOC Mean	Buffalo River Upstream Mean
Number of Stations	1	2	3
Total Taxa	12	13	11
Percent Centrarchids	27%	54%	39%
Percent Catostomidae	6.3%	4.9%	4.5%
Percent Cyprinidae	63%	31%	41%
Percent Dominant Species	54%	33%	33%
Similarity Index	NA	62%	72%
Shannon-Wiener Diversity Index	1.7	2.0	1.9
Percent Tolerant Species	56%	31%	31%
Percent Intolerant Species	2.1%	0.60%	0.73%
Percent Omnivores	56%	34%	45%
Percent Top Carnivores	23%	32%	17%
Abundance (b)	0.052	0.075	0.054
Mean Condition Factor (K) (c)	0.98	1.3	1.3

Notes:
(a) Includes fish caught via electrofishing and seining.
(b) Only includes fish caught via electrofishing.
(c) Calculated based on Williams (2000).

AOC - Area of Concern
NA - Not applicable

Table 2-13
Histopathological Evaluation of Liver Lesions in Brown Bullhead
Buffalo, NY

n	37
Foci of Cellular Alteration (%)	29.8
Hepatocellular Carcinomas (%)	5.4
Cholangiocarcinomas (%)	0
Hepatocellular Tumors (%)	2.7
Bile Ductular Tumors (%)	0
Total Liver Tumors (%)	**8.1**

Notes:
% - Percent
n - Number of samples

Table 2-14
Physical and Chemical Characteristics of the Buffalo River by River Mile
Buffalo, NY

	RM 0.0 - 1.0	RM 1.0 - 2.0	RM 2.0 - 3.5	RM 3.5 - 5.0	RM 5.0+	City Ship Canal
Bathymetry / Cross-section	Shallower, with defined nav channel and shoulders	Narrow reach with deeper channel and narrow shoulders	Depths vary with bends; point bars and holes	Depths vary with bends; point bars and holes	Defined nav channel and shoulders	Shallower, U-shaped section
Hydrodynamics	Low velocity, lake impacted	High velocities	Moderate velocities	Moderate velocities	Low-moderate velocities	Low velocities
Bottom Stress	Low stress, moderated by lake	High event stress	Variable, zones of higher stress	Variable, generally lower stress	Low stress	Very low stress
Substrate Type	Fines (95%)	Fines/sand/gravel mix	Fines/ sand/ some gravel	Fines / sands/ limited gravel	Sand and fines	Fines
River Geomorphology	Mouth: wide, shallow	Straight, narrow reach	Highly sinuous	Highly sinuous	Lower sinuosity	
Sedimentation Rates	Deposition of fines from lake	Minimal deposition	Some deposition	Higher deposition of fines, some sands	Bedload deposition and some fines	Fines deposition, local biotic solids
Surficial Contaminant Distribution	Relatively low levels	Low to moderate levels	Moderate levels	Higher levels	Low to moderate levels	Moderate levels

% - Percent
RM River Mile

Table 3-1
Remedial Action Objectives and Supporting Goals for Buffalo River AOC
Buffalo, NY

	Target Environmental Medium or Receptor	Duration	RAO/Supporting Goal
RAO 1	Sediment and Human Health	Short-Term and Long-Term	Reduce human exposures for direct sediment contact and fish consumption from the Buffalo River by reducing the availability and/or concentration of COCs in sediments
RAO 2	Ecology	Short-Term and Long-Term	Reduce the exposure of wildlife populations and the aquatic community to sediment COC concentrations that are above protective levels
RAO 3	Sediment	Short-Term and Long-Term	Reduce or otherwise address legacy sediment COC concentrations to improve the likelihood that future dredged sediments (for routine navigational, commercial, and recreational purposes) will not require confined disposal
RAO 4	Ecology	Short-Term and Long-Term	Implement a remedy that is compatible with the Buffalo-River Remedial Advisory Committee's goal of protecting and restoring habitat and supporting wildlife goals
Supporting Goal 1	Sediment	Short-Term and Long-Term	Reduce the potential of COC contaminated sediments to migrate outside of the Buffalo River AOC.
Supporting Goal 2	Ecology	Short-Term and Long-Term	Implement a sediment remedy that is compatible with and complements ongoing regional redevelopment goals, upland remediation, and restoration activities

AOC - Area of Concern
COC Chemical of concern
RAO - Remedial Action Objective

Table 3-2
Comparison of Remedial Action Objectives and Supporting Goals to Beneficial Use Impairments for the Buffalo River AOC
Buffalo, NY

		Beneficial Use Impairments						
		Restrictions on fish and wildlife consumption	**Fish tumors or other deformities**	**Degradation of aesthetics**	**Degradation of benthos**	**Restrictions on dredging activities**	**Loss of Fish and Wildlife Habitat**	**Degradation of fish and wildlife populations**
Remedial Action Objectives (RAOs)								
RAO 1	Reduce human exposures for direct sediment contact and fish consumption from the Buffalo River by reducing the availability and/or concentration of COCs in sediments.	X						
RAO 2	Reduce the exposure of wildlife populations and the aquatic community to sediment COC concentrations that are above protective levels.		X		X			X
RAO 3	Reduce or otherwise address legacy sediment COC concentrations to improve the likelihood that future dredged sediments (for routine navigational, commercial, and recreational purposes) will not require confined disposal.					X		X
RAO 4	Implement a remedy that is compatible with the Buffalo-River Remedial Advisory Committee's goal of protecting and restoring habitat and supporting wildlife goals.	X	X	X	X		X	X
Supporting Goals								
Supporting Goal 1	Reduce the potential of COC contaminated sediments to migrate outside of the Buffalo River AOC.							
Supporting Goal 2	Implement a sediment remedy that is compatible with and complements ongoing regional redevelopment goals, upland remediation, and restoration activities.	X	X	X	X	X	X	X

Table 4-1
Summary of Technology and Process Options Retained for the Buffalo River Feasibility Study
Buffalo, NY

General Response Action	Appropriate Remedial Technology and Process Option	Reason for Consideration
No Action	No Action	Retain as required by the NCP for comparison to other alternatives.
Institutional Controls	Deed Restrictions	Routinely implemented and effective when combined with other process options to form an overall risk-management strategy. Retain as a component of other remedial alternatives.
	Recreational Use Restrictions	Routinely implemented and effective when combined with other process options to form an overall risk-management strategy. Retain as a component of other remedial alternatives.
Natural Recovery	Monitored Natural Recovery	MNR is readily implementable and can be highly effective at low-risk sites with strong evidence for natural recovery processes, such as the Buffalo River due to the natural depositional nature of large portions of the River Additional lines of evidence supporting MNR include historically reduced fish liver lesions, historical improvement in fish habitat, and historical decreases in edible fish PCB and mercury concentrations.
Sediment Capping	Isolation Capping an/or Thin Layer Capping	Areas suitable for capping within the Buffalo River are limited to non-navigable areas in the Buffalo River and City Ship Canal. This includes the narrow portions of the river and ship canal that border the navigational channel and the non-navigable portion at the end of the City Ship Canal. Thin-layer capping may also be considered in other areas of the AOC to augment remedies if it can be demonstrated that thin-layer capping does not exceed FEMA restrictions on increased flood potential during a 100-year flood event, or if thin capping can support a restoration alternative.
Sediment Removal	Mechanical and/or Hydraulic Dredging	Dredging can be implemented at the Buffalo River using the existing CDF facility at the Buffalo Harbor. As a mass-removal or source-removal technology, dredging is effective. However, dredging generally is ineffective at achieving low surface sediment concentrations. Apart from actual dredging, sediment removal involves transportation of dredged material from the contaminated site, and disposal of dredged material (see below). A combination of dredging techniques may be required to dredge around piers and abutments, submerged debris, cross channel utilities, and near bulkheads. Special consideration will be also required for slope backs from existing bulkheads so as to not compromise their structural integrity.
Dredged Material Dewatering, Transportation and Disposal	Confined Disposal Facility No. 4	The presence of CDF No. 4, specifically designed for the management and disposal of sediments from the Buffalo River, and within 3 to 9 miles of the area of concern, makes the CDF the most attractive alternative for the dewatering/stabilization and disposal of dredged sediments and barge transport or hydraulic conveyance the preferred sediment transport alternatives. The bulk of the materials can be off-loaded directly to the open water portion of the CDF. Staging areas may be required within the upland portions of the CDF to stage materials considered by USEPA and USACE as unsuitable for placement in the open water portion of the CDF. These materials can be placed within earthen berms to control sediment transport within the CDF. A much smaller fraction of material may require off-site disposal, if contaminant concentrations are considered by USEPA and USACE too high for CDF disposal. This material will likely require dewatering or physical stabilization and identification of a suitable upland disposal site. An alternative may be to add stabilizing materials to this subset of dredged sediment to allow CDF placement.

CDF Confined Disposal Facility
NCP National Contingency Plan
PCB Polychlorinated biphenyl

Table 5-1a
Surface Area of the Buffalo River AOC, Acres
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Main Channel	88	154	242
City Ship Canal	20	16	36
Total	108	170	**278**

Table 5-1b
Remedy Alterative 3 Surface Area, Acres
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Main Channel	43	95	138
City Ship Canal	15	11	26
Total	58	106	**164**

Table 5-1c
Remedy Alterative 4 Surface Area, Acres
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Main Channel	14	27	41
City Ship Canal	10	5	15
Total	24	32	**56**

Table 5-1d
Remedy Alterative 5 Surface Area, Acres
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Main Channel	22	35	57
City Ship Canal	12	7	19
Total	34	42	**76**

NOTE: Surface areas in the City Ship Canal, outside of the navigation channel, include the cap surface area of 6.7 acres for Remedy Alternatives 3, 4 and 5.

Table 5-2a
Remedy Alterative 3: Sediment Volumes Removed
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Buffalo River	1,010,000	560,000	1,570,000
City Ship Canal	150,000	30,000	180,000
Total	1,160,000	590,000	**1,750,000**

Table 5-2b
Remedy Alterative 4: Sediment Volumes Removed
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Buffalo River	420,000	140,000	560,000
City Ship Canal	60,000	20,000	80,000
Total	480,000	160,000	**640,000**

Table 5-2c
Remedy Alterative 5: Sediment Volumes Removed
Buffalo, NY

	Outside of Nav Channel	Inside Nav Channel	**Total**
Buffalo River	530,000	190,000	720,000
City Ship Canal	80,000	20,000	100,000
Total	610,000	210,000	**820,000**

Notes: Current volume estimates assume removal to shoreline and do not consider a dredge slope factor. Volumes are subject to change based an updated understanding of dredge delineation boundaries and shoreline offsets.

Table 6-1a
Time Recovery for Different Biological Health Metrics and Different Remediation Activities
Buffalo, NY

BUI	Location	Action	Recovery Time (Years)	Reference
Benthic Community	River Hull (UK)	Dredging	0.5	Pearson (1984)[a]
Benthic Community	James River (VA)	Dredging	0.25	Diaz 1994
Benthic Community	Ashtabula River (OH)	Dredging	5	OEPA (2006)
Vegetation	San Macros River (TX)	Dredging	0.5 to 1.0	Hannan and Doris (1970)[a]
Fish Tumors	Black River (OH)	Dredging	4	Baumann et al. 2000
Benthic Community	Un-named Stream (AK)	Construction	1	Peterson and Nyquist (1972)[a]
Benthic Community	Joe Wright Creek (CO)	Construction	Rapid	Cline et al. (1977)[a]
Benthic Community	Archibald Creek (BC)	Construction	2	Tsui and McCart (1981)[a]
Benthic Community	Coastal Plain stream (NC)	Restoration	2	Price and Roessler (2005)
Benthic Community	Reinikoski Rapids (Finland)	Restoration with Refugia	0.08	Korsu (2004)
Benthic Community	Headland Waters (Finland)	Restoration with Refugia	4 to 8	Muotka et al. (2002)
Benthic Community	Black River (OH)	Infrastructure	5	BRRAPCC (2005)
Benthic Community	North Platte River (WY)	Sedimentation	0.06	Gray and Ward (1982)[a]
Benthic Community	Rhone River (France)	Sedimentation	1	Roux (1984)[a]
Benthic Community	Black River E. Branch	WWTP improvements	5	BRRAPCC (2005)
Benthic Community	Cuyahoga River	WWTP decommissioning	4	Mack (2000)
Fish Tumors	Presque Isle Bay (PA)	WWTP improvements and curtailment of CSO overflows	5	Baumann et al. 2000

(a) References cited within Yount and Niemi 1990.

BUI - Beneficial use impairment
CSO - Combined sewer overflow
WWTP - Wasterwater treament facility

Table 6-1b
Aquatic Vegetation Impacted by Remedy
Buffalo, NY

	Buffalo River	City Ship Canal	Total
Current Conditions			
Length of Shoreline with EV and SAV, ft	22,468	8,012	30,480
Remedy Alternative 3			
Length of Shoreline with EV and SAV Impacted by Remedy, ft	16,118	5,516	21,634
Percent of Shoreline with EV and SAV Impacted by Remedy	72%	69%	71%
Remedy Alternative 4			
Length of Shoreline with EV and SAV Impacted by Remedy, ft	6,625	3,947	10,572
Percent of Shoreline with EV and SAV Impacted by Remedy	29%	49%	35%
Remedy Alternative 5			
Length of Shoreline with EV and SAV Impacted by Remedy, ft	8,461	4,528	12,989
Percent of Shoreline with EV and SAV Impacted by Remedy	38%	57%	43%

EV - Emergent Vegetation
SAV - Submerged Aquatic Vegetation

Table 6-2a
SWACs, Current Conditions
Buffalo, NY

River Miles	Total PAHs, mg/kg	Lead, mg/kg	Mercury, mg/kg	Total PCBs, mg/kg
Buffalo River				
0.33 - 0.67	5.0	38	0.17	0.09
0.67 - 1.0	10	70	0.76	0.19
1.0 - 1.33	6.0	77	0.15	0.08
1.33 - 1.67	6.1	39	0.12	0.08
1.67 - 2.0	4.8	38	0.12	0.09
2.0 - 2.33	4.5	34	0.11	0.08
2.33 - 2.67	6.8	62	0.21	0.17
2.67 - 3.0	5.7	64	0.17	0.31
3.0 - 3.33	7.0	56	0.17	0.13
3.33 - 3.67	10	100	0.38	0.15
3.67 - 4.0	24	129	0.81	0.36
4.0 - 4.33	31	136	1.02	0.75
4.33 - 4.67	19	67	0.42	0.12
4.67 - 5.0	17	173	0.49	0.27
5.0 - 5.33	19	64	0.39	0.15
5.33 - 5.67	4.6	29	0.08	0.05
5.67 -6.0	5.0	35	0.06	0.07
City Ship Canal				
0.0 - 0.33	13	331	0.65	0.21
0.33 - 0.67	13	73	0.60	0.15
0.67 - 1.0	10	62	0.82	0.20
1.0 - 1.33	13	116	1.00	0.21
1.33 - 1.45	70	156	0.60	0.30

Table 6-2b
SWACs Based on Remedy Alternative 3
Buffalo, NY

River Miles	Total PAHs, mg/kg	Lead, mg/kg	Mercury, mg/kg	Total PCBs, mg/kg
Buffalo River				
0.33 - 0.67	5.3	30	0.07	0.04
0.67 - 1.0	6.1	34	0.16	0.05
1.0 - 1.33	5.8	42	0.09	0.05
1.33 - 1.67	5.9	24	0.04	0.02
1.67 - 2.0	5.8	26	0.05	0.03
2.0 - 2.33	5.1	31	0.09	0.06
2.33 - 2.67	6.9	61	0.21	0.16
2.67 - 3.0	6.1	24	0.04	0.04
3.0 - 3.33	5.6	38	0.10	0.09
3.33 - 3.67	6.0	46	0.06	0.04
3.67 - 4.0	6.1	24	0.04	0.03
4.0 - 4.33	6.1	22	0.03	0.01
4.33 - 4.67	6.1	22	0.03	0.01
4.67 - 5.0	6.1	24	0.04	0.02
5.0 - 5.33	6.5	26	0.06	0.04
5.33 - 5.67	4.9	27	0.07	0.04
5.67 -6.0	5.0	35	0.06	0.07
City Ship Canal				
0.0 - 0.33	6.7	30	0.06	0.03
0.33 - 0.67	7.8	38	0.22	0.06
0.67 - 1.0	4.6	28	0.21	0.08
1.0 - 1.33	6.3	37	0.25	0.05
1.33 - 1.45	6.1	22	0.03	0.01

NOTES:
1) IDW interpolations of the 2005/2007 and 2008 surface sediment data are used to calculate SWACs.
2) Post remediation SWACs are calculated by applying average upstream surface sediment concentrations to remediated areas. The average upstream surface sediment concentrations are total PAHs, 6.1 mg/kg; Pb, 21.7 mg/kg; Hg, 0.029 mg/kg; total PCBs, 0.014 mg/kg.

Hg - Mercury
mg/kg - milligrams per kilogram
PAHs - Polycyclic aromatic hydrocarbons
PCBs - Polychlorinated biphenyl

Table 6-2c
SWACs Based on Remedy Alternative 4
Buffalo, NY

River Miles	Total PAHs, mg/kg	Lead, mg/kg	Mercury, mg/kg	Total PCBs, mg/kg
Buffalo River				
0.33 - 0.67	5.0	38	0.17	0.09
0.67 - 1.0	7.1	51	0.35	0.12
1.0 - 1.33	6.0	77	0.15	0.08
1.33 - 1.67	6.1	39	0.12	0.08
1.67 - 2.0	4.8	38	0.12	0.09
2.0 - 2.33	4.5	34	0.11	0.08
2.33 - 2.67	6.8	62	0.21	0.17
2.67 - 3.0	5.8	55	0.15	0.19
3.0 - 3.33	6.9	56	0.17	0.13
3.33 - 3.67	6.8	73	0.23	0.08
3.67 - 4.0	7.0	36	0.11	0.06
4.0 - 4.33	7.5	33	0.07	0.07
4.33 - 4.67	7.7	40	0.14	0.05
4.67 - 5.0	8.1	60	0.17	0.09
5.0 - 5.33	6.0	38	0.12	0.08
5.33 - 5.67	4.6	29	0.08	0.05
5.67 -6.0	5.0	35	0.06	0.07
City Ship Canal				
0.0 - 0.33	7.8	78	0.28	0.10
0.33 - 0.67	10	56	0.42	0.11
0.67 - 1.0	5.0	41	0.32	0.09
1.0 - 1.33	6.3	37	0.25	0.05
1.33 - 1.45	6.1	22	0.03	0.01

Table 6-2d
SWACs Based on Remedy Alternative 5
Buffalo, NY

River Miles	Total PAHs, mg/kg	Lead, mg/kg	Mercury, mg/kg	Total PCBs, mg/kg
Buffalo River				
0.33 - 0.67	5.0	38	0.17	0.09
0.67 - 1.0	7.1	51	0.35	0.12
1.0 - 1.33	6.0	77	0.15	0.08
1.33 - 1.67	6.1	39	0.12	0.08
1.67 - 2.0	4.8	37	0.11	0.08
2.0 - 2.33	4.5	34	0.11	0.08
2.33 - 2.67	6.8	62	0.21	0.17
2.67 - 3.0	5.6	43	0.08	0.11
3.0 - 3.33	6.0	40	0.10	0.08
3.33 - 3.67	6.4	64	0.20	0.07
3.67 - 4.0	6.8	32	0.09	0.04
4.0 - 4.33	7.5	32	0.07	0.07
4.33 - 4.67	7.6	38	0.13	0.04
4.67 - 5.0	7.9	36	0.11	0.07
5.0 - 5.33	5.8	34	0.10	0.07
5.33 - 5.67	4.7	28	0.08	0.05
5.67 -6.0	5.0	35	0.06	0.07
City Ship Canal				
0.0 - 0.33	7.3	50	0.24	0.08
0.33 - 0.67	8.9	46	0.31	0.08
0.67 - 1.0	4.9	38	0.29	0.09
1.0 - 1.33	6.3	37	0.25	0.05
1.33 - 1.45	6.1	22	0.03	0.01

NOTES:
1) IDW interpolations of the 2005/2007 and 2008 surface sediment data are used to calculate SWACs.
2) Post remediation SWACs are calculated by applying average upstream surface sediment concentrations to remediated areas. The average upstream surface sediment concentrations are total PAHs, 6.1 mg/kg; Pb, 21.7 mg/kg; Hg, 0.029 mg/kg; total PCBs, 0.014 mg/kg.

Hg - Mercury
mg/kg - milligrams per kilogram
PAHs - Polycyclic aromatic hydrocarbons
PCBs - Polychlorinated biphenyl

Table 6-3a
Current Conditions: Estimated Mass of Chemicals in Buffalo River AOC
Buffalo, NY

	PAH	Lead	Mercury	PCB
		Buffalo River		
Outside Nav Channel, kg	52,000	171,000	1,600	1,150
Inside Nav Channel, kg	13,400	57,700	470	230
		City Ship Canal		
Outside Nav Channel, kg	3,000	28,000	370	70
Inside Nav Channel, kg	600	7,000	60	13

Table 6-3b
Remedy Alternative 3: Estimated Mass of Chemicals Removed
Buffalo, NY

	PAH	Lead	Mercury	PCB
		Buffalo River		
Outside Nav Channel				
Mass removed, kg	51,000	163,000	1,500	1,100
Percent of Current Mass	98%	96%	97%	96%
Inside Nav Channel				
Mass removed, kg	12,700	50,300	440	220
Percent of Current Mass	95%	90%	94%	92%
		City Ship Canal		
Outside Nav Channel				
Mass removed, kg	2,200	19,800	290	50
Percent of Current Mass	72%	71%	78%	69%
Inside Nav Channel				
Mass removed, kg	500	5,700	40	10
Percent of Current Mass	81%	83%	77%	77%

Note: Volumes and mass removals are subject to change based an updated understanding of dredge delineation boundaries and shoreline offsets. Currently volumes and mass removal assume removal to shoreline and do not consider a dredge slope factor.

Table 6-3c
Remedy Alternative 4: Estimated Mass of Chemicals Removed
Buffalo, NY

	PAH	Lead	Mercury	PCB
		Buffalo River		
Outside Nav Channel				
Mass removed, kg	26000	70,300	730	180
Percent of Current Mass	50%	41%	46%	15%
Inside Nav Channel				
Mass removed, kg	4000	16,700	160	60
Percent of Current Mass	30%	30%	33%	25%
		City Ship Canal		
Outside Nav Channel				
Mass removed, kg	1300	12,600	180	30
Percent of Current Mass	41%	45%	48%	38%
Inside Nav Channel				
Mass removed, kg	300	3,900	20	6
Percent of Current Mass	44%	57%	43%	46%

Table 6-3d
Remedy Alternative 5: Estimated Mass of Chemicals Removed
Buffalo, NY

	PAH	Lead	Mercury	PCB
		Buffalo River		
Outside Nav Channel				
Mass removed, kg	37,000	99,000	930	450
Percent of Current Mass	71%	58%	59%	39%
Inside Nav Channel				
Mass removed, kg	8,000	24,300	230	90
Percent of Current Mass	58%	43%	49%	40%
		City Ship Canal		
Outside Nav Channel				
Mass removed, kg	1,600	14,700	200	30
Percent of Current Mass	53%	52%	54%	45%
Inside Nav Channel				
Mass removed, kg	400	4,500	30	6
Percent of Current Mass	59%	66%	52%	46%

Note: Volumes and mass removals are subject to change based an updated understanding of dredge delineation boundaries and shoreline offsets. Currently volumes and mass removal assume removal to shoreline and do not consider a dredge slope factor.

AOC - Area of Concern
kg - Kilogram
PAH - Polycyclic aromatic hydrocarbon
PCB - Polychlorinated biphenyl

Table 6-4
Remedial Alternative Cost Estimate Summary
Buffalo, NY

		Remedial Area	Remedial Volume	Cap Area	Total Cost	Unit Cost
Remedy 1	No Action	0 SF	0 CY	0 SF	$0	
Remedy 2	Monitored Natural Recovery of the Entire River	11,632,400 SF	0 CY	0 SF	$2,453,000	$0.21 /SF
Remedy 3	Sediment removal targeting the PAH RG of 1 TU at all sediment depths, and SWAC RGs for PCBs, Hg, and Pb and capping of the ship canal	6,309,200 SF	1,750,000 CY	292,400 SF	$73,883,000	$38 /CY dredged $9 /SF capped
Remedy 4	Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, and SWAC RGs for PCBs, Hg, and Pb and capping of the ship canal	2,074,800 SF	640,000 CY	292,400 SF	$31,817,000	$41 /CY dredged $9 /SF capped
Remedy 5	Sediment removal targeting the PAH RG of 1 TU in surface (0-1 ft) sediment, SWAC RGs for PCBs, Hg, and Pb, and maximum residual PAH, PCB, Hg, and Pb concentrations in buried and surface sediments and capping of the ship canal	2,780,800 SF	820,000 CY	292,800 SF	$38,733,000	$41 /CY dredged $9 /SF capped

Key assumptions

USACE performs the dredging and only turbidity monitoring is required.
The percent debris in the total volume of sediments is 2.5 percent.
The percent of the total volume of sediments requiring additional confinement within the CDF is 5 percent.
None of the excavated sediments will require off-site disposal as hazardous waste.
No shoreline stabilization or improvements will be performed as part of the remedy.
Additional confinement within CDF will be performed using on-site materials. No importation will be required.

CDF	Confined Disposal Facility
CY	Cubic yards
SF	Square feet
Hg	Mercury
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCB	Polychlorinated biphenyl

Table 6-5
ARARs for the Buffalo River Sediment Site
Buffalo, NY

Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
CHEMICAL-SPECIFIC ARARS AND TBCS			
Clean Water Act 40 [Federal Water Pollution Control Act; as amended], 33 USC §§ 1251- 1387	40 CFR Part 129	Toxic Pollutant Effluent Standards for aldrin/dieldrin, DDT, endrin, toxaphene, benzidene and PCBs.	Part 129 is a potential relevant and appropriate chemical-specific ARAR for purposes of on-site response.
Safe Drinking Water Act, 42 USC §§ 300f - 300j-26	40 CFR Part 141	National Primary Drinking Water Regulations	Part 141 is a potential relevant and appropriate chemical-specific ARAR for purposes of on-site response.
New York State Environmental Conservation Law (ECL) Article 15, Title 3 and Article 17, Titles 3 and 8	6 NYCRR Part 608, Section 608.5	Section 608.5 includes the requirement to obtain a SPDES permit for certain discharges in any navigable waters of the State.	Sections 608.5 is potential relevant and appropriate chemical-specific ARARs for purposes of on-site response.
	7 NYCRR Part 608, Sections 608.6(a) and 608.9(a)	Section 608.6(a) requires development and submission of a sufficiently detailed construction plan with a map. Section 608.9(a) requires that construction or operation of facilities that may result in a discharge to navigable waters demonstrate compliance with CWA §§ 301 – 303, 306 and 307 and 6 NYCRR §§ 751.2 (prohibited discharges) and 754.1 (effluent prohibitions; effluent limitations and water quality-related effluent limitations; pretreatment standards; standards of performance for new sources.)	Sections 608.6(a) and 608.9(a) are potential relevant and appropriate chemical-specific ARARs for purposes of on-site response.
	6 NYCRR Part 701	Part 701 establishes classifications for surface waters and groundwater.	Part 701 classifications of waters of the State, as well as a general prohibition on any discharge that impairs the receiving water for its assigned best usages are potential relevant and appropriate chemical-specific ARARs for purposes of on-site response.
	6 NYCRR Part 703	Part 703 establishes surface water and groundwater quality standards and groundwater effluent limitations.	Part 703 includes general and chemical-specific water quality standards that are potential relevant and appropriate chemical-specific ARARs.
	6 NYCRR Part 704	Part 704 establishes criteria for thermal discharges.	Part 704 is a potential relevant and appropriate chemical-specific ARARs for alternatives involving dredging and dewatering at elevated temperatures and discharge to the river or Lake Erie at elevated temperatures.
International Joint Commission – United States and Canada	Great Lakes Water Quality Agreement of 1978, as amended	The concentration of total PCBs in fish tissue (whole fish, wet weight basis) should not exceed 0.1 μg/g for the protection of birds and animals that consume fish. Criterion for mercury is 0.5 μg/g mercury in whole fish [wet weight basis].	TBC

Table 6-5
ARARs for the Buffalo River Sediment Site
Buffalo, NY

Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
NOAA – Damage Assessment Center	Reproductive, Developmental and Immunotoxic Effects of PCBs in Fish: A Summary of Laboratory and Field Studies, March 1999 (Monosson, E.)	The effective concentrations for reproductive and developmental toxicity fall within the ranges of the PCB concentrations found in some of the most contaminated fish. There are currently an insufficient number of studies to estimate the immunotoxicity of PCBs in fish. Improper functioning of the reproductive system and adverse effects on development may result from adult fish liver concentrations of 25 to 71 ppm Aroclor 1254. PCB Congener BZ #77: 0.3 to 5 ppm (wet wt) in adult fish livers reduces egg deposition, pituitary gonadotropin, and gonadosomatic index, alters retinoid concentration (Vitamin A), and reduces larval survival. 1.3 ppm in eggs reduces larval survival.	TBC
EPA Office of Emergency and Remedial Response	Guidance on Remedial Actions for Superfund Sites with PCB Contamination, EPA/540/G-90/007, August 1990 (OSWER Dir. No. 9355.4-01).	Provides guidance in the investigation and remedy selection process for PCB-contaminated Superfund sites. Provides preliminary remediation goals for various contaminated media, including sediment (pp. 34-36) and identifies other considerations important to protection of human health and the environment.	TBC
NOAA (compilation of other literature sources for Sediment Quality Guidelines [SQGs])	Screening Quick Reference Tables for Organics (SQRTs)	Tables with screening concentrations for inorganic and organic contaminants.	TBC
EPA Great Lakes National Program Office, Assessment and Remediation of Contaminated Sediments (ARCS) Program	Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod *Hyalella azteca* and the midge *Chironomus riparius,* EPA 905- R96-008, September 1996	Provides sediment effect concentrations (SECs), which are defined as the concentrations of a contaminant in sediment below which toxicity is rarely observed and above which toxicity is frequently observed.	TBC
DEC Division of Fish, Wildlife and Marine Resources	Technical Guidance for Screening Contaminated Sediment, January 1999	Includes a methodology to establish sediment criteria for the purpose of identifying contaminated sediments. Provides sediment quality screening values for non-polar organic compounds, such as PCBs, and metals to determine whether sediments are contaminated (above screening criteria) or clean (below screening criteria). Screening values are not cleanup goals. Also discusses the use of sediment criteria in risk management decisions.	TBC
DEC Division of Fish, Wildlife and Marine Resources	Draft Technical Memorandum, Numerical Guidance Values for Assessing Risk to Aquatic Life from Contaminants in Sediment, June 2007	Provides sediment guidance values for the protection of benthic organisms and other varieties of aquatic or marine life, and is intended to provide only one component for evaluation, assessment, and managment of contaminated sediment in New York State. Guidance values are not clean up goals.	TBC
DEC-Division of Environmental Remediation	Technical Administrative Guidance Memorandum No. 94- Remediation HWR-4046	Recommended Soil Cleanup Objectives	TBC
USEPA	USEPA Safe Drinking Water Act	MCLPs	TBC
USEPA	USEPA Federal Register, Volume 57, No. 246, December 22, 1992	Ambient Water Quality Criteria	TBC
DEC	DEC TOGS 1.1.2	New York State Groundwater Effluent Limitations	TBC

Table 6-5
ARARs for the Buffalo River Sediment Site
Buffalo, NY

Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
LOCATION-SPECIFIC ARARS AND TBCS			
Fish and Wildlife Coordination Act	16 USC § 662	Whenever the waters of any stream or other body of water are proposed or authorized to be impounded, diverted, the channel deepened, or the stream or other body of water otherwise controlled or modified for any purpose, by any department or agency of the United States, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State in which the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	Substantive portions of Section 662 are potential relevant and appropriate location-specific ARARs for purposes of on-site response.
Endangered Species Act	16 USC § 1531 et. seq.	Federal statute establishing programmatic protection for endangered and threatened species.	Substantive provisions in Sections 1538 is a potential applicable location-specific ARAR for on-site response. Substantive provisions in Sections 1539 is a potential relevant and appropriate location-specific ARAR for on-site response.
Section 404 of the Clean Water Act [Federal Water Pollution Control Act, as amended], 33 USC § 1344	33 CFR Parts 320-330	Includes requirements for issuing permits for the discharge of dredged or fill material into navigable waters of the United States.	Substantive portions of Parts 320 – 330 are potential relevant and appropriate location-specific ARAR for purposes of on-site response.
National Historic Preservation Act, 16 USC § 470 et seq.	36 CFR Part 800	Proposed remedial actions must take into account effect on properties in or eligible for inclusion in the National Registry of Historic Places. Federal agencies undertaking a project having an effect on a listed or eligible property must provide the Advisory Council on Historic Preservation a reasonable opportunity to comment pursuant to section 106 of the National Historic Preservation Act of 1966 (NHPA), as amended. While the Advisory Council comments must be taken into account and integrated into the decision-making process, program decisions rest with the agency implementing the under-taking. A Stage 1A cultural resource survey may be necessary for any active remediation to identify historic properties along the lakeshore to determine if any areas should be the subject of further consideration under NHPA.	Substantive portions of Part 800 are a potential applicable location-specific ARAR for purposes of on-site response.
Fish and Wildlife Coordination Act	40 CFR 6.302	Modification to Waterways that Affect Fish or Wildlife	A potential applicable or relevant and appropriate location-specific ARAR for purposes of on-site response.
Clean Water Act Section 401, 33 USC 1341	40 CFR Part 121	State Water Quality Certification Program	Substantive portions of Part 121 are potential relevant and appropriate location-specific ARAR for purposes of on-site response.
Clean Water Act	40 CFR Parts 122, 125 and 401	Wastewater Discharge Permits; Effluent Guidelines, Best Available Technology and BMPPT	Substantive portions of Parts 121, 125 and 401 are potential relevant and appropriate location-specific ARAR for purposes of on-site response.
Clean Water Act, Section 404, 33 USC § 1344	40 CFR Parts 230 and 231	No activity which adversely affects an aquatic ecosystem, including wetlands, shall be permitted if a practicable alternative that has less adverse impact is available. If there is no other practical alternative, impacts must be minimized.	Substantive portions of Parts 230 and 231 are potential relevant and appropriate location-specific ARAR for purposes of on-site response.

Table 6-5
ARARs for the Buffalo River Sediment Site
Buffalo, NY

Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
Clean Water Act	40 CFR § 403.5	Discharge to Publicly-Owned Treatment Works	Substantive portions of Section 403.5 are a potential relevant and appropriate location-specific ARAR for purposes of on-site response.
Toxic Substances Control Act (TSCA), Title 1,15 USC § 2601	40 CFR §§ 761.65 – 761.75	TSCA facility requirements: Establishes siting guidance and criteria *for* storage (761.65), chemical waste landfills (761.75), and incinerators (761.70).	Substantive portions of Sections 761.65 – 761.75 are potential relevant and appropriate location-specific ARAR for purposes of on-site response.
New York State ECL Article 24, Title 7 Freshwater Wetlands Law	6 NYCRR Parts 662-665	Defines procedural requirements for undertaking different activities in and adjacent to freshwater wetlands, and establishes standards governing the issuance of permits to alter or fill freshwater wetlands.	Substantive portions of Parts 662-664 are a potential relevant and appropriate location-specific ARAR for purposes of on-site response.
EPA Office of Solid Waste and Emergency Response	Policy on Floodplains and Waste and Wetland Assessments for CERCLA Actions, August 1985	Superfund actions must meet the substantive requirements of the Floodplain Management Emergency Executive Order (E.O. 11988) and the Protection of Response 1985 Wetlands Executive Order *(* E.O. 11990) (see Table 9-3: Location-Specific ARARs). This memorandum discusses situations that require preparation of a floodplain or wetlands assessment and the factors that should be considered in preparing an assessment for response actions taken pursuant to Section 104 or 106 of CERCLA. For remedial actions, a floodplain/wetlands assessment must be incorporated into the analysis conducted during the planning of the remedial action.	TBC
Executive Order No. 11988, 42 Fed. Reg. 26951 (May 25, 1977)	Floodplain Management	Executive Order describes the circumstances where federal agencies should manage floodplains.	TBC
Executive Order No. 11990, 42 Fed. Reg. 26961 (May 25, 1977)	Protection of Wetlands	Executive Order describes the circumstances where federal agencies should manage wetlands.	TBC
ACTION-SPECIFIC ARARS AND TBCS			
Section 10, Rivers and Harbors Act, 33 USC § 403	32 CFR Parts 320, 323, 325, 329 and 330	U.S. Army Corps of Engineers approval is generally required to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the United States.	Substantive portions of 33 CFR Parts 320, 323 325, 329 and 330 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Section 404(c) of the Clean Water Act, 33 USC § 1344	33 CFR Parts 320, 323, 325, 329 and 330	These regulations apply to all existing, proposed, or potential disposal sites for discharges of dredged or fill materials into U.S. waters, which include wetlands. Includes special policies, practices, and procedures to be followed by the U.S. Army Corps of Engineers in connection with the review of applications for permits to authorize the discharge of dredged or fill material into waters of the United States pursuant to Section 404 of the Clean Water Act.	Substantive portions of 33 CFR Parts 320, 323 325, 329 and 330 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Clean Air Act, 42 USC s/s 7401 et seq. (1970)	40 CFR Part 60	Standards of Performance for New Stationary Sources	Substantive portions of 40 CFR Part 60 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Clean Air Act, 42 USC s/s 7401 et seq. (1970)	40 CFR Parts 61 and 63	Part 61- National Emission Standards for Hazardous Air Pollutants. Part 63 - National Emission Standards for Hazardous Air Pollutants for Source Categories.	Substantive portions of 40 CFR Parts 61 and 63 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.

Table 6-5
ARARs for the Buffalo River Sediment Site
Buffalo, NY

Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
Section 402 of the Clean Water Act	40 CFR Parts 121, 122, 125, 401 and 403.5	Provisions related to the implementation of the National pollutant Discharge Elimination System (NPDES) program	Substantive portions of 40 CFR Parts 121, 122, 125, 401 and 403.5 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Section 404(b) of the Clean Water Act	40 CFR Part 230	Guidelines for Specification of Disposal Sites for Dredged or Fill Material. Except as otherwise provided under Clean Water Act Section 404(b)(2), no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences. Includes criteria for evaluating whether a particular discharge site may be specified.	Substantive portions of 40 CFR Part 230 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act	40 CFR Part 257	Criteria for Classification of Waste Disposal Facilities	Substantive portions of 40 CFR Part 257 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act 42 USC s/s 6901 et seq. (1976)	40 CFR Part 261	Identification and listing of hazardous waste	Substantive portions of 40 CFR Parts 261 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act 42 USC s/s 6901 et seq. (1976)	40 CFR Part 262	Standards applicable to generators of hazardous waste	Substantive portions of 40 CFR Part 262 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act 42 USC s/s 6901 et seq. (1976)	40 CFR § 262.11	Hazardous waste determination	Substantive portions of 40 CFR § 262.11 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act, 42 USC s/s 6901 et seq. (1976)	40 CFR Part 262.34	Standards for Hazardous Waste Generators, 90-Day Accumulation Rule	Substantive portions of 40 CFR § 262.34 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act, 42 USC s/s 6901 et seq. (1976)	40 CFR Part 264 and 265, Subparts B-264.10 - .19 F-264.90 - .101 G-264.110 - .120 J-264.190 - .200 S-264.550 - .555 X-264.600 - .603	Standards for Owners/Operators of Hazardous Waste Treatment, Storage and Disposal Facilities. B- General Facility Standards F- Releases from Solid Waste Management Units G- Closure and Post Closure J- Tank Systems S- Special Provisions for Cleanup X- Miscellaneous Units	Substantive portions of the referenced Subparts of Parts 264 and 265 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Section 3004 of the Resource Conservation and Recovery Act (Solid Waste Disposal Act, as amended), 42 USC § 6924	40 CFR § 264. 13(b)	Owner or operator of a facility that treats, stores or disposes of hazardous wastes must develop and follow a written waste analysis plan.	Substantive portions of 40 CFR § 264.13(b) are potential relevant and appropriate action-specific ARARs for purposes of on-site response.

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Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
Resource Conservation and Recovery Act, 42 USC s/s 6901 et seq. (1976)	40 CFR Part 264 and 265, Subparts K-264.220 - .232 L-264.250 - .259 N – 264.300 - .317	Standards for Owners/Operators of Hazardous Waste Treatment, Storage and Disposal Facilities. K- Surface Impounds L- Waste Piles N- Landfills, Subtitle C	Substantive portions of the referenced Subparts of Parts 264 and 265 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Section 3004 of the Resource Conservation and Recovery Act, as amended, 42 USC § 6924	40 CFR § 264.232	Owners and operators shall manage all hazardous waste placed in a surface impoundment in accordance with 40 CFR Subparts BB (Air Emission Standards for Equipment Leaks) and CC (Air Emission Standards for Tanks, Surface Impoundments and Containers).	Substantive portions of 40 CFR § 264.232 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Resource Conservation and Recovery Act, 42 USC s/s 6901 et seq. (1976)	40 CFR Part 268	Land disposal restrictions C- Prohibitions on Land Disposal	Substantive portions of 40 CFR Part 268 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Toxic Substances Control Act (TSCA), Title 1,15 USC § 2605	40 CFR Part 761	Polychlorinated biphenyls (PCBs) manufacturing, processing, distribution in commerce, and use prohibitions	Substantive portions of 40 CFR Part 761 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Hazardous Materials Transportation Act, as amended, 49 USC §§ 5101 – 5127	49 CFR Part 170	Transport of hazardous materials program procedures.	Substantive portions of 49 CFR Part 170 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Hazardous Materials Transportation Act, as amended, 49 USC §§ 5101 – 5127	49 CFR Part 171	Department of Transportation Rules for Transportation of Hazardous Materials, including procedures for the packaging, labeling, manifesting and transporting of hazardous materials.	Substantive portions of 49 CFR Part 171 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Occupational Safety and Health Act	29CFR 1904, 1910, and 1926	Specifies minimum requirements to maintain worker health and safety during hazardous waste operations, including training and construction safety requirements.	Substantive portions of 29 CFR 1904, 1940, and 1926 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 17, Title 5	____	It shall be unlawful for any person, directly or indirectly, to throw, drain, run or otherwise discharge into such waters organic or inorganic matter that shall cause or contribute to a condition in contravention of applicable standards identified at 6 NYCRR § 701.1.	Substantive portions of 17-0501, 17-0503, 17-0505, 17-0507, 17-0509 and 17-0511 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 11, Title 5	NY ECL § 11-0503	Fish & Wildlife Law against water pollution. No deleterious or poisonous substances shall be thrown or allowed to run into any public or private waters in quantities injurious to fish life, protected wildlife, or waterfowl inhabiting those waters, or injurious to the propagation of fish, protected wildlife, or waterfowl therein.	Substantive portions of 11-0503 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 27, Title 3	6 NYCRR Part 364	Standards for Waste Transportation Regulations governing the collection, transport and delivery of regulated wastes, including hazardous wastes.	Substantive portions of 6 NYCRR Part 364 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 27, Title 9	6 NYCRR Parts 370 and 371	New York State regulations for activities associated with hazardous waste management.	Substantive portions of 6 NYCRR Parts 370 and 371 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 3, Title 3; Article 27, Titles 7 and 9	6 NYCRR Part 372	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities. Includes Hazardous Waste Manifest System requirements for generators, transporters, and treatment, storage or disposal facilities, and other requirements applicable to generators and transporters of hazardous waste.	Substantive portions of 6 NYCRR Part 372 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.

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Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
New York State ECL Article 27 Title 13	6 NYCRR Part 375	Inactive Hazardous Waste Disposal Sites. Establishes standards for the development and implementation of inactive hazardous waste disposal site remedial programs.	Substantive portions of 6 NYCRR Part 375 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 27, Title 9	6 NYCRR Part 376	Land Disposal Restrictions. PCB wastes including dredge spoils containing PCBs greater than 50 ppm must be disposed of in accordance with federal regulations at 40 CFR Part 761.	Substantive portions of 6 NYCRR Part 376 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL, Article 1. Title 1, Article 3 Title 3, Article 15 Title 3, Article 17 Title 1, 3, 8	6 NYCRR Part 700-706	New York limitations on discharges of sewage, industrial waste or other wastes.	Substantive portions of 6 NYCRR Parts 701 and 703 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL Article 17, Title 8	6 NYCRR Parts 750 – 758	New York State Pollutant Discharge Elimination System (SPDES) Requirements Standards for Storm Water Runoff, Surface Water, and Groundwater Discharges, In general, no person shall discharge or cause a discharge to NY State waters of any pollutant without a permit under the New York State Pollutant Discharge Elimination System (SPDES) program.	Substantive portions of 6 NYCRR Parts 750 - 758 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
New York State ECL, Article 8	6 NYCRR Part 617	State Environmental Quality Review, which provides general rules and actions for agencies to determine whether the actions they directly undertake, fund or approve may have a significant impact on the environment, and, if it is determined that the action may have a significant adverse impact, prepare or request an environmental impact statement.	Substantive portions of 6 NYCRR Parts 617 are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
Local County or Municipality Pretreatment Requirements	Local regulations	Local regulations	Local pretreatment requirements are potential relevant and appropriate action-specific ARARs for purposes of on-site response.
USEPA	Rules of Thumb for Superfund Remedy Selection (EPA 540-R-97- 013, August 1997)	Describes key principles and expectations, as well as "best practices" based on program experience for the remedy selection process under Superfund. Major policy areas covered are risk assessment and risk management, developing remedial alternatives, and groundwater response actions.	TBC
USEPA	Land Use in the CERCLA Remedy Selection Process (OSWER Directive No. 9355.7-04, May 1995)	Presents information for considering land use in making remedy selection decisions at NPL sites.	TBC
USEPA	Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (OSWER Directive 9285.6-08, February 2002)	Presents risk management principles that site managers should consider when making risk management decisions at contaminated sediment sites.	TBC
USEPA	Contaminated Sediment Strategy (EPA-823-R-98- 001, April 1998)	Establishes an Agency-wide strategy for contaminated sediments, with the following four goals: 1) prevent the volume of contaminated sediments from increasing; 2) reduce the volume of existing contaminated sediment; 3) ensure that sediment dredging and dredged material disposal are managed in an environmentally sound manner; and 4) develop scientifically sound sediment management tools for use in pollution prevention, source control, remediation, and dredged material management.	TBC
USEPA	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (EPA-540-R-05-012, December 2005)	Provides technical and policy guidance for addressing contaminated sediment sites nationwide primarily associated with CERCLA actions.	TBC

Table 6-5
ARARs for the Buffalo River Sediment Site
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Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
USEPA	Structure and Components of Five-Year Reviews (OSWER Directive 9355.7-02, May 1991) Supplemental Five-Year Review Guidance (OSWER Directive 9355.7-02A, July 1994) Second Supplemental Five-Year Review Guidance (OSWER 9355.7-03A, December 1995)	Provides guidance on conducting Five-Year Reviews for sites at which hazardous substances, pollutants, or contaminants remain on-site above levels that allow for unrestricted use and unlimited exposure. The purpose of the Five-Year Review is to evaluate whether the selected response action continues to be protective of public health and the environment and is functioning as designed:	TBC
USEPA	40 CFR Part 50	Clean Air Act, National Ambient Air Quality Standards	TBC
USACE	Notice on Issuance of Nationwide Permits, new general conditions and 13 new definitions, 72FR11092, Mar 12, 2007.	Reissuance of Nationwide Permits, new general conditions and 13 new definitions	TBC
USACE	Notice Announcing NWP Final Regional Conditions, July 28, 2008	New regional condtions for NWP regional conditions for the Buffalo District	TBC
DEC	New York Guidelines for Soil Erosion and Sediment Control		TBC
DEC	Technical and Operational Guidance Series (TOGS) 1.1.1 Ambient Water	Provides guidance for ambient water quality standards and guidance values for pollutants	TBC
DEC	Technical and Operational Guidance Series (TOGS) 1.2.1 Industrial SPDES Permit Drafting Strategy for Surface Waters	Provides guidance for writing permits for discharges of wastewater from industrial facilities and for writing requirements equivalent to SPDES permits for discharges from remediation sites.	TBC
DEC	Technical and Operational Guidance Series (TOGS) 1.3.1 Waste Assimilative Capacity Analysis & Allocation for Setting	Provides guidance to water quality control engineers in determining whether discharges to water bodies have a reasonable potential to violate water quality standards and guidance values.	TBC
DEC	Technical and Operational Guidance Series (TOGS) 1.3.2 Toxicity Testing in the SPDES Permit Program	Describes the criteria for deciding when toxicity testing will be required in a permit and the procedures which should be followed when including toxicity testing requirements in a permit.	TBC
DEC, Division of Environmental Remediation	Technical and Administrative Guidance Memorandum (TAGM) 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites	Provides guidance on fugitive dust suppression and particulate monitoring for inactive hazardous waste sites.	TBC
DEC	Interim Guidance on Freshwater Navigational Dredging, October 1994	Provides guidance for navigational dredging activities in freshwater areas.	TBC
DEC Division of Fish, Wildlife and Marine Resources	Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA), October 1994	Provides rationale and methods for sampling and evaluating impacts of a site on fish and wildlife during the remedial investigation and other stages of the remedial process	TBC

Table 6-5
ARARs for the Buffalo River Sediment Site
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Medium/Authority	Citation	Requirement Synopsis	Status for Buffalo River
DEC TAGM 3028	"Contained-In" Criteria for Environmental Media (November 30, 1992).	Provides "contained-in" concentrations/ action levels for environmental media and the basis for these criteria.	TBC

ARAR Applicable or relevant and appropriate requirement
CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
CFR Code of Federal Regulations
DEC Department of Environmental Conservation
ECL Environmental Conservation Law
NOAA National Oceanic and Atmospheric Administration
NYCRR New York Codes Rules and Regulations
OSWER Office of Solid Waste and Emergency Response
TAGM Technical and Administrative Guidance Memorandum
TBC To be considered
TOGS Technical and Operational Guidance Series
USACE United States Army Corps of Engineers
USC United States Code
USEPA United States Environmental Protection Agency

Table 8-1
SAV Beds Impacted by Remedy Alternative 5
Buffalo River

		Impacted by Dredging															Impacted by Capping		
Species Name	Common Name	SAV-3	SAV-4	SAV-5	SAV-6	SAV-15	SAV-17	SAV-18	SAV-19	SAV-20	SAV-25	SAV-26	SAV-27	SAV-28	SAV-29	**Total**	SAV-8	SAV-9	**Total**
Ceratophyllum demersum	coontail			X	X	X	X	X	X	X	X				X		X	X	
Elodea canadensis	Canadian waterweed		X		X	X							X				X		
Justicia americana	American waterwillow				X														
Myriophyllum spicatum	Eurasian watermilfoil		X	X	X	X		X	X	X	X	X	X	X	X		X	X	
Potamogeton crispus	curlyleaf pondweed	X	X			X		X	X			X	X		X		X	X	
Potamogeton nodosus	American pondweed	X				X	X	X	X	X		X	X	X	X				
Potamogeton pectinatus	sago pondweed	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	
Vallisneria americana	wild celery	X	X	X	X	X	X	X			X	X	X	X	X		X	X	
Water Depth (ft)		3	3.5	3	4.5	8	3	3	4.5	4	4.5	8	10	4	4		9	7	
Approximate Bed Width (ft)		18	10	10	7	10	5	12	10	12	7	8	8	10	14		7	6	
Approximate bed length disturbed by Remedy 5 (ft)		323	247	906	80	581	93	4,767	437	162	117	149	57	8	357	**8,284**	1,750	824	**2,574**
Approximate bed area disturbed by Remedy 5 (sq ft)		5,808	2,469	9,058	561	5,805	467	57,199	4,368	1,942	819	1,192	458	85	5,003	**95,234**	12,253	4,943	**17,197**

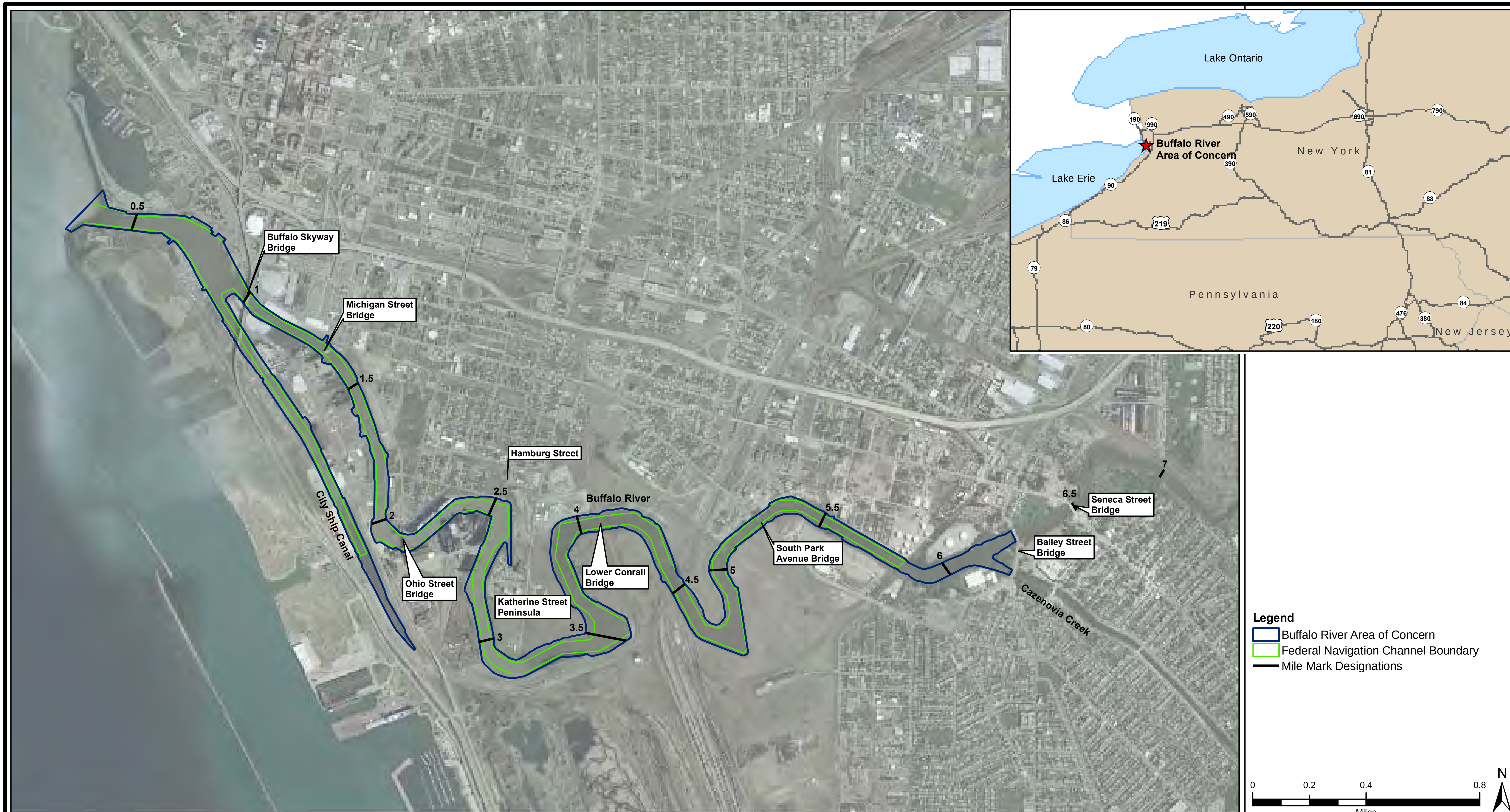
Notes:
AOC - Area of Concern
ft - feet
SAV - Submerged acquatic vegetation

Table 8-2
Emergent Vegetation Impacted by Remedy Alternative 5
Buffalo River, NY

		Impacted by Dredging										
Species Name	Common Name	EV-1	EV-2	EV-3	EV-4	EV-7	EV-9	EV-10	EV-11	EV-12	EV-13	**Total**
Lythrum salicaria	purple loosestrife	X	X	X	X		X			X	X	
Phragmites australis	common reed	X	X	X	X		X			X		
Polygonum cuspidatum	Japanese knotweed		X			X	X	X			X	
Sagittaria latifolia	broadleaf arrowhead										X	
Scirpus validus	softstem bulrush		X						X		X	
Typha latifolia	broadleaf cattail	X	X								X	
Pontederia cordata	pickerelweed										X	
Water Depth (ft)		1	1	0.5	0.5	0.5	0.5	0.5	1	0.5	1	
Approximate Bed Width (ft)		7.5	11	7	10	7.5	12	10	7	9	8.5	
Approximate bed length disturbed by Remedy 5 (ft)		67	38	28	587	570	507	51	79	77	125	**2131**
Approximate bed area disturbed by Remedy 5 (sq ft)		506	416	199	5872	4279	6089	510	552	694	1063	**20178**

Notes:
AOC - Area of Concern
EV - Emergent vegetation
ft - feet

Figures



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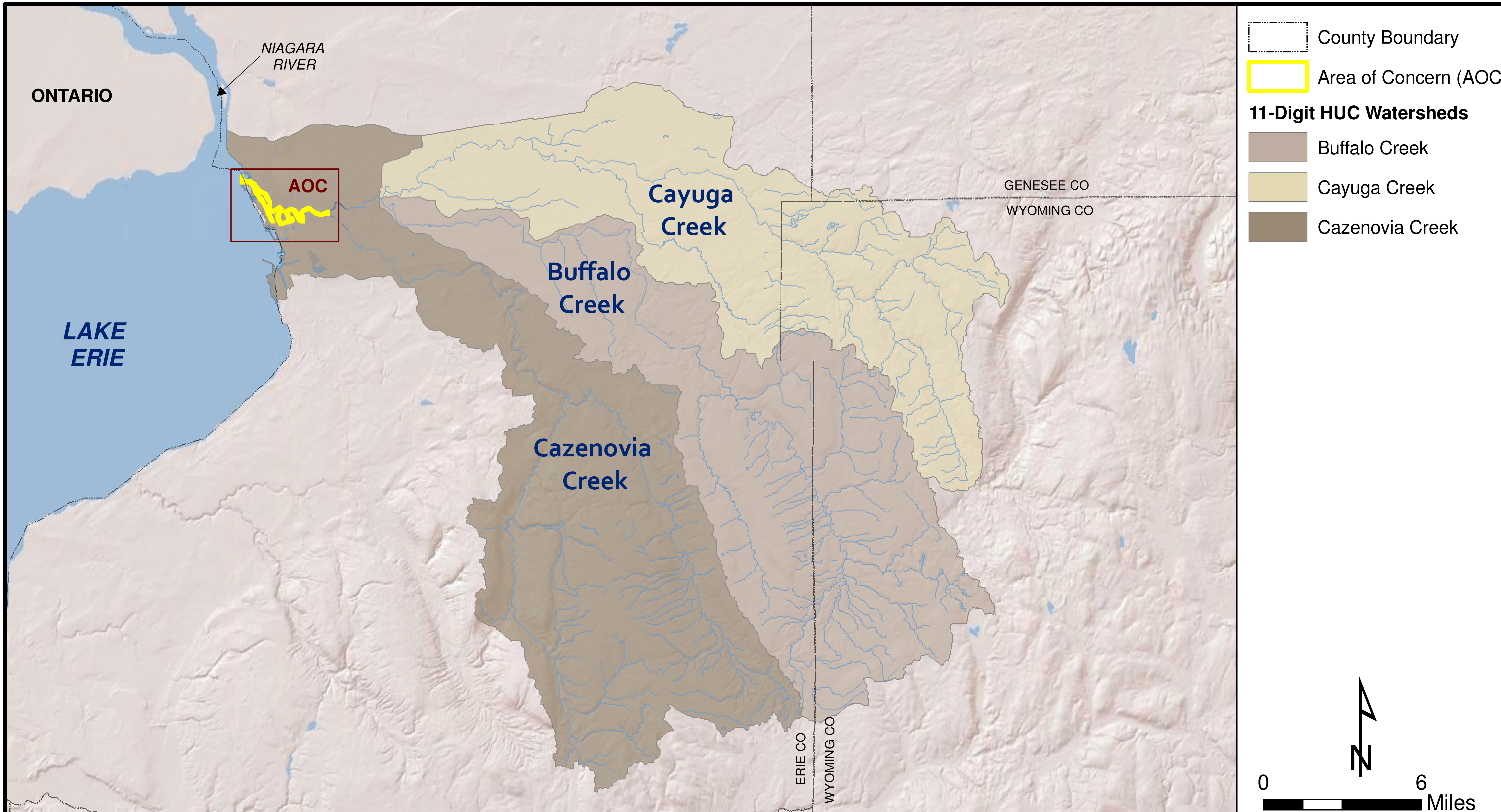
BUFFALO RIVER SITE LOCATION MAP
BUFFALO, NY

Figure
2-1

Drafter: B. Radakovich
Date: 10/15/2009
Name: 20090119_SiteLocation_Map.mxd



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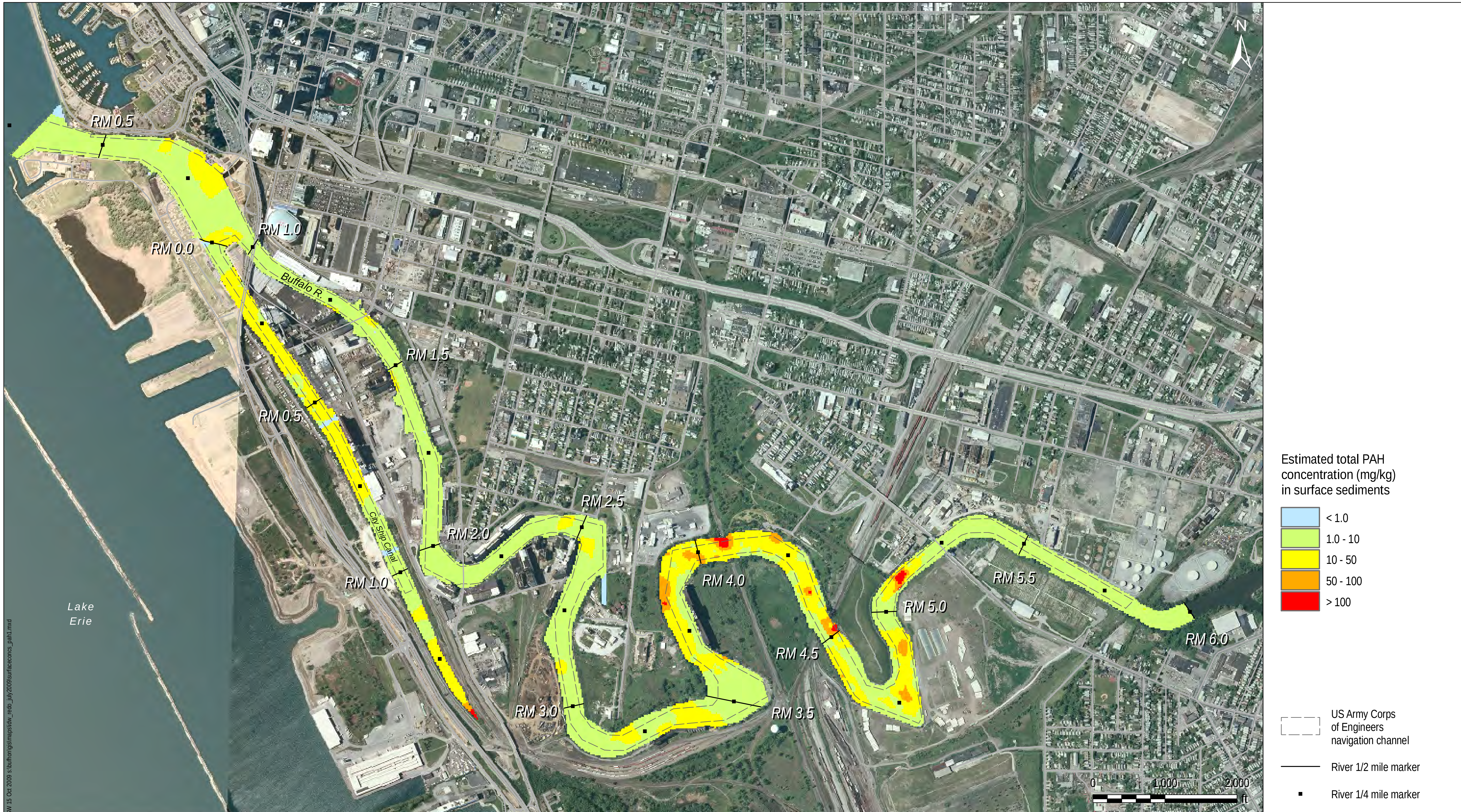
BUFFALO RIVER AOC AND ASSOCIATED WATERSHEDS

Figure 2-2

Monday, October 19, 2009 5:09:36 PM
\\mesrv02\Client_Files\Honeywell Buffalo River\GIS\Projects\MXD\Fig1-2_Watershed.mxd



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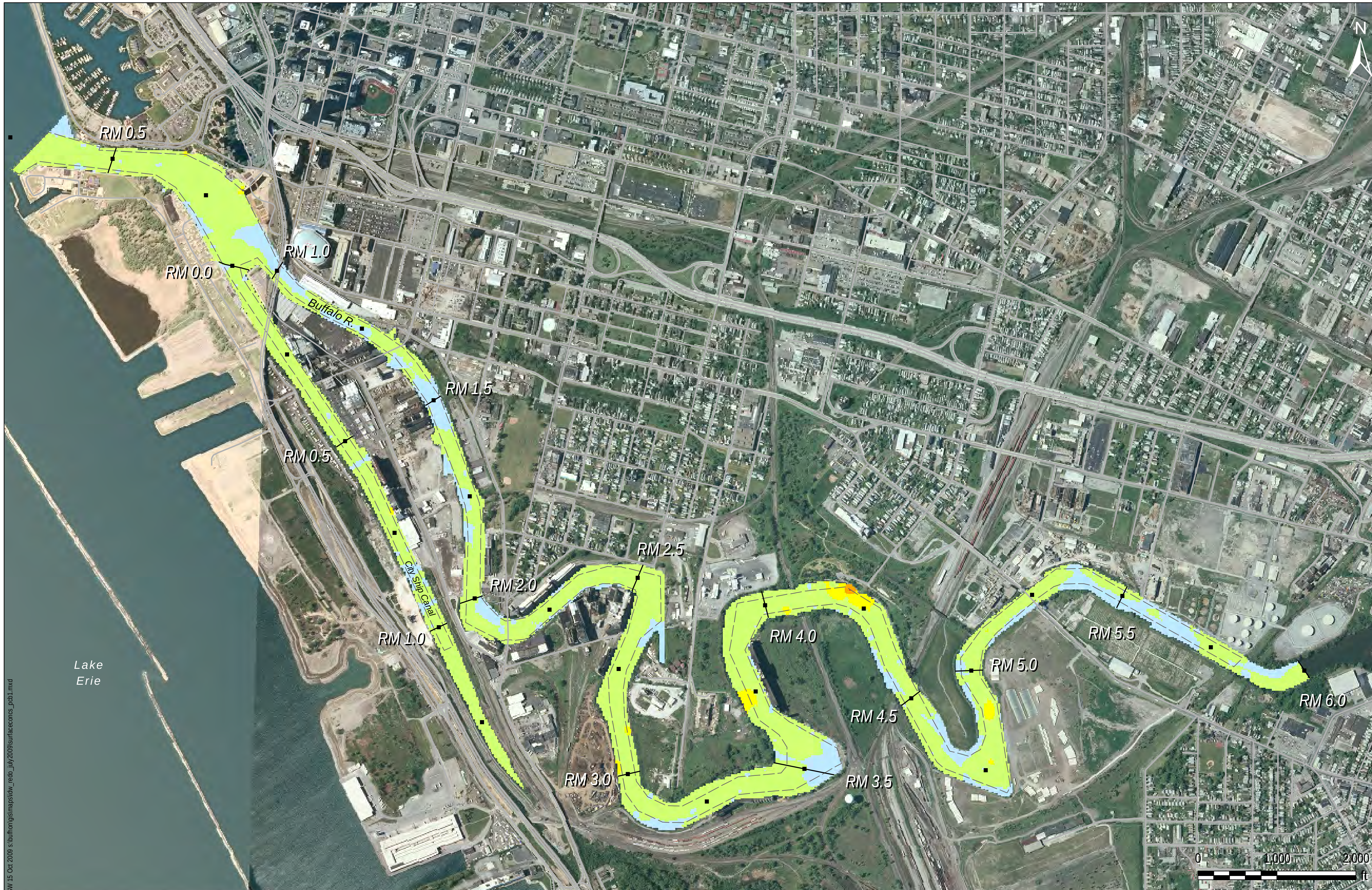
ESTIMATED TOTAL PAH CONCENTRATIONS IN BUFFALO RIVER SURFACE SEDIMENTS
BUFFALO, NY

Figure 2-3



Estimated total PCB concentration (mg/kg) in surface sediments

- < 0.05
- 0.05 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- > 10.0

US Army Corps of Engineers navigation channel

River 1/2 mile marker

River 1/4 mile marker

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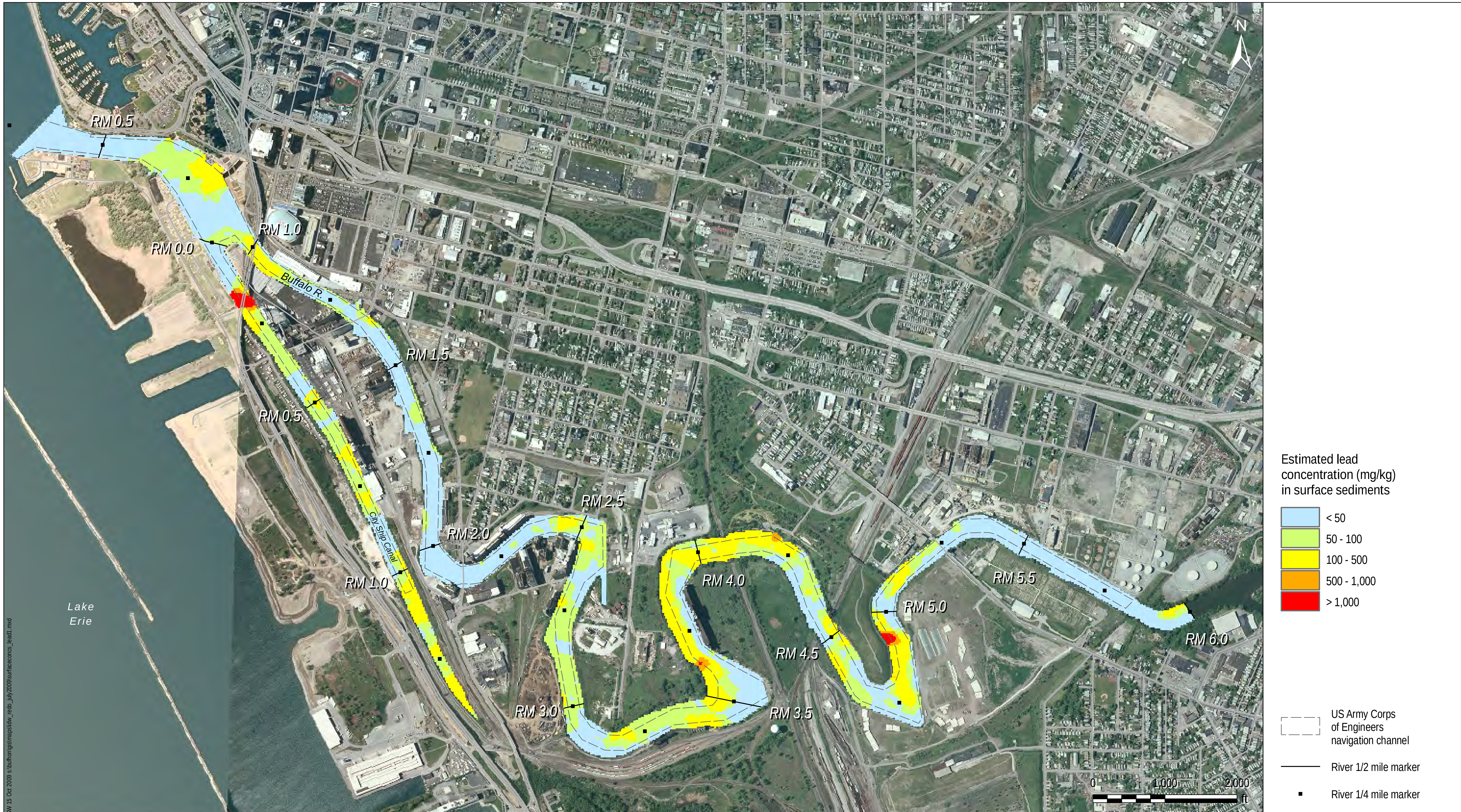
ESTIMATED TOTAL PCB CONCENTRATIONS IN BUFFALO RIVER SURFACE SEDIMENTS
BUFFALO, NY

Figure 2-4



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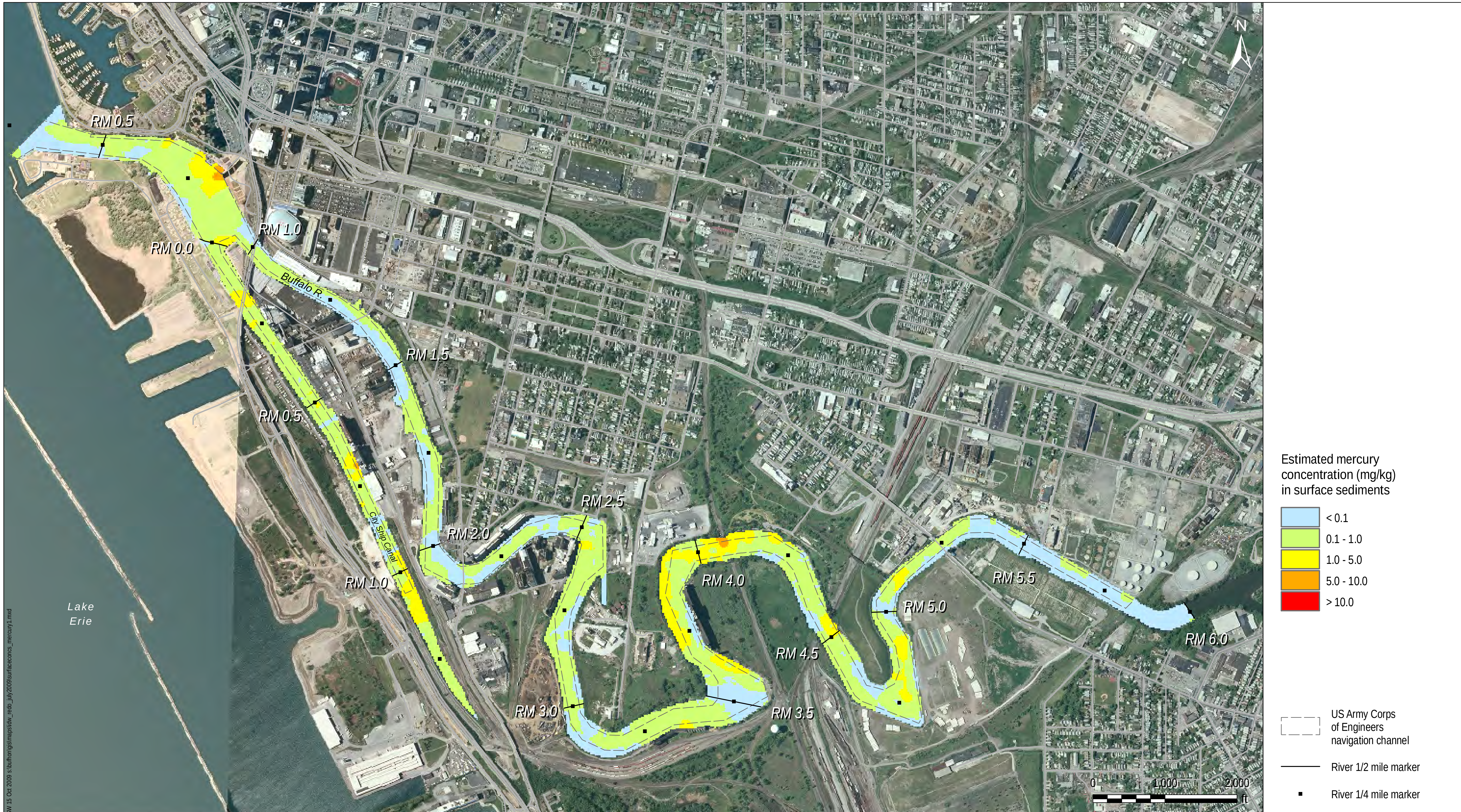
ESTIMATED LEAD CONCENTRATIONS IN BUFFALO RIVER SURFACE SEDIMENTS
BUFFALO, NY

Figure 2-5



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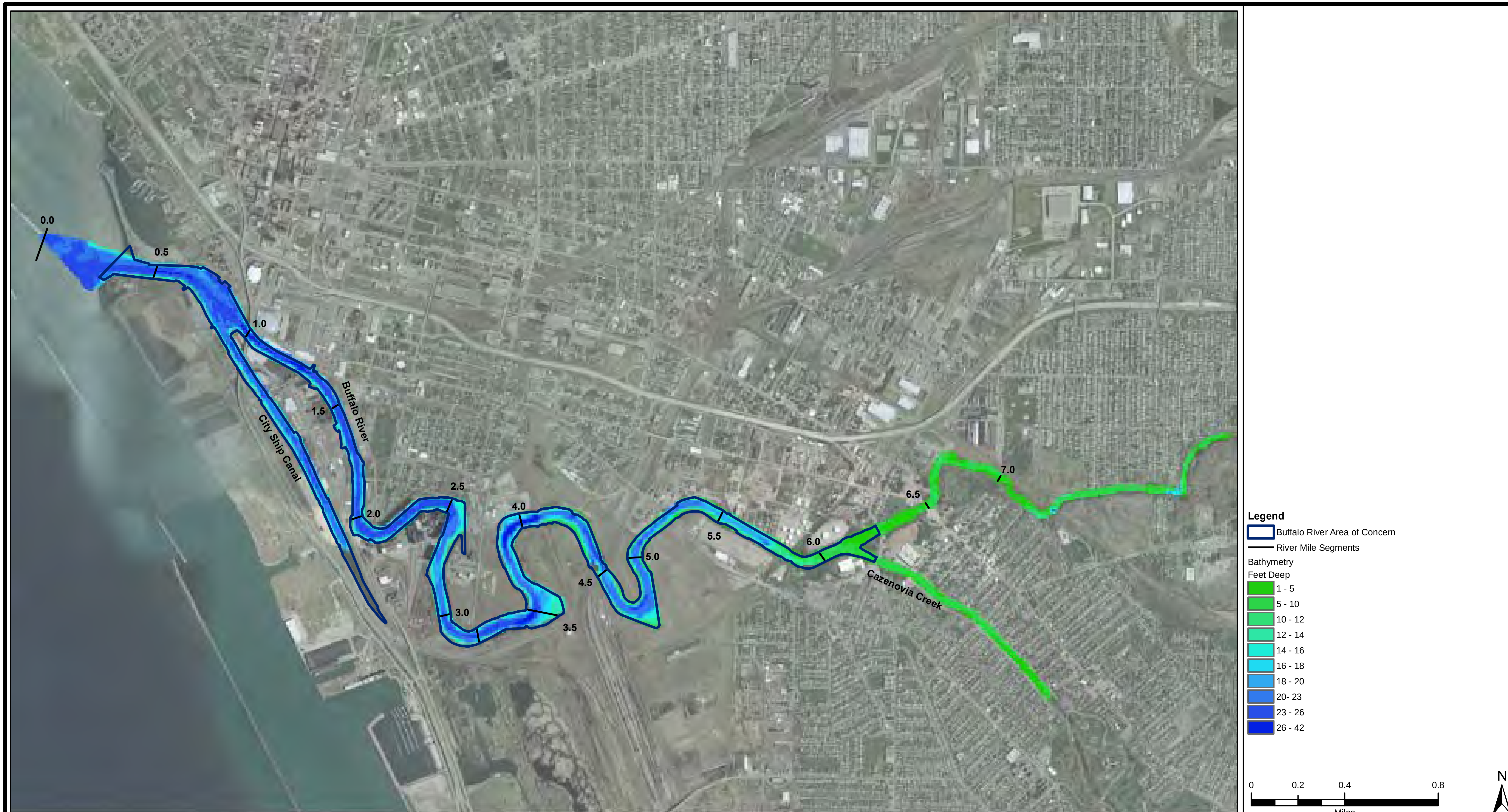
ESTIMATED MERCURY CONCENTRATIONS IN BUFFALO RIVER SURFACE SEDIMENTS
BUFFALO, NY

Figure 2-6



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BUFFALO RIVER BATHYMETRY FROM 2007 AND 2008 SURVEYS BUFFALO, NY

Figure 2-7

Drafter: B. Radakovich
Contract Number:
File Name: 20090226_Bathymetry.mxd

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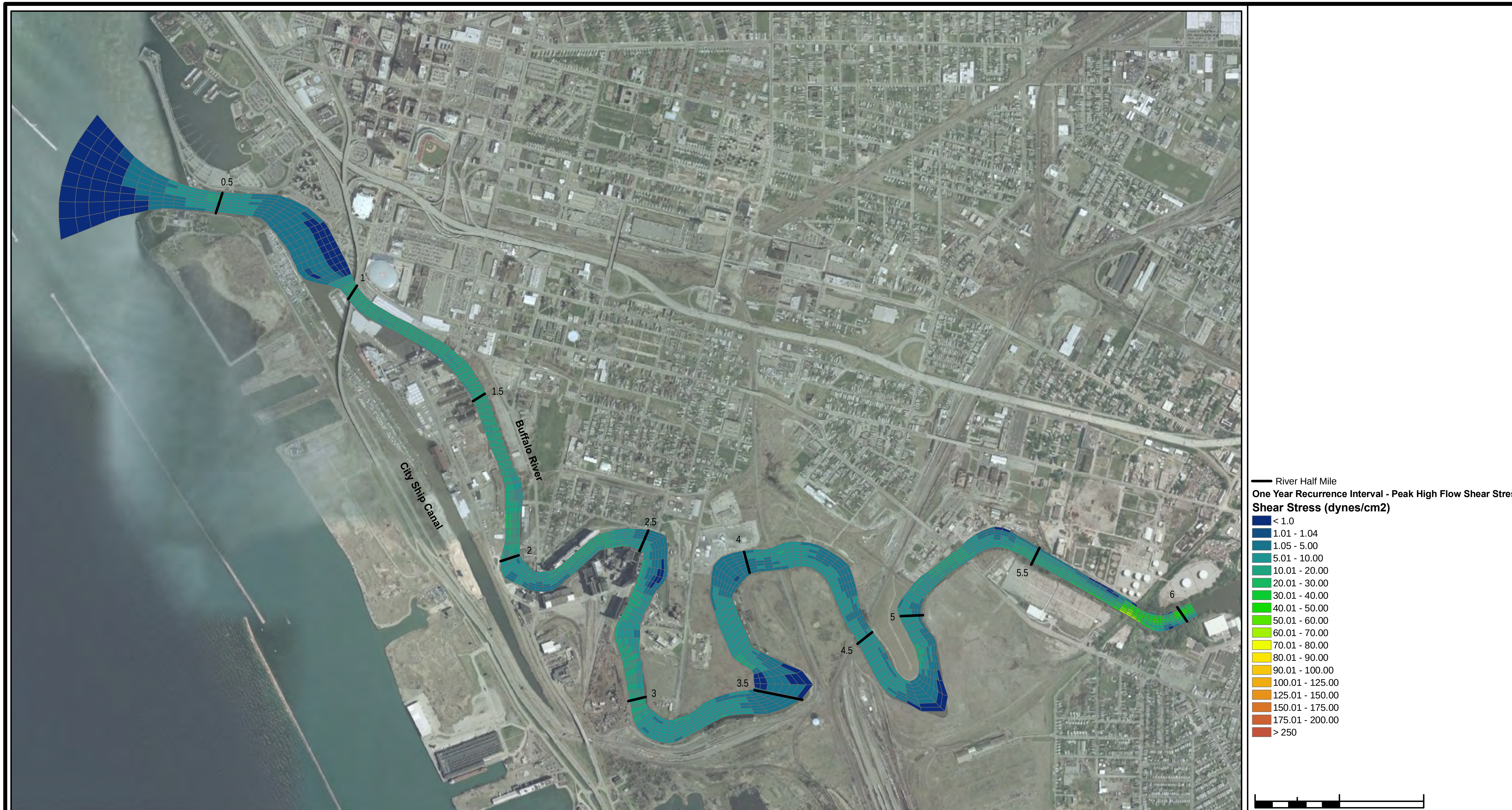
Buffalo River Model Predicted Velocity at the Peak of the October 16, 2008 High Flow Event (1-year Recurrence Interval)

Figure 2-8

Drafter: A. Motzny
Contract Number: BUFHON
File Name: Fig3_36_Velocity_HigFlow_Peak_1yr.mxd



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Buffalo River Model Predicted Bottom Shear Stress at the Peak of the October 16, 2008 High Flow Event (1-year Recurrence Interval)

Figure 2-9

Legend

River Half Mile

Ten Year Recurrence Interval - Peak High Flow Velocity

Velocity (cm/sec.)

- < 1.0
- 0.3 - 1.0
- 1.1 - 5.0
- 5.1 - 10.0
- 10.1 - 20.0
- 20.1 - 30.0
- 30.1 - 40.0
- 40.1 - 50.0
- 50.1 - 60.0
- 60.1 - 70.0
- 70.1 - 80.0
- 80.1 - 90.0
- 90.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- > 250

0 0.25 0.5

Miles

N

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Buffalo River Model Predicted Velocity at the Peak of the January 29, 2002 High Flow Event (10-year Recurrence Interval)

Figure 2-10

Drafter: A. Motzny
Contract Number: BUFHON
File Name: Fig3_38_Velocity_HigFlow_Peak_10yr.mxd

River Half Mile

Ten Year Recurrence Interval - Peak High Flow Velocity Shear Stress (dynes/cm2)

- < 1.0
- 1.01 - 1.00
- 1.01 - 5.67
- 5.68 - 10.00
- 10.01 - 20.00
- 20.01 - 30.62
- 30.63 - 40.00
- 40.01 - 50.00
- 50.01 - 60.00
- 60.01 - 70.00
- 70.01 - 80.00
- 80.01 - 90.00
- 90.01 - 100.00
- 100.01 - 125.00
- 125.01 - 150.00
- 150.01 - 175.00
- 175.01 - 200.00
- > 250

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Buffalo River Model Predicted Bottom Shear Stress at the Peak of the January 29, 2002 High Flow Event (10-year Recurrence Interval)

Figure 2-11

Remedy Alternative 3

Target the PAH remedy goal (RG) of 1 TU at all sediment depths, and SWAC RGs for PCBs, mercury, and lead.

Remedy Alternative 3

- Dredge
- Area supported by only one sample station and to be resampled
- Cap
- US Army Corps of Engineers navigation channel
- River 1/2 mile marker
- River 1/4 mile marker

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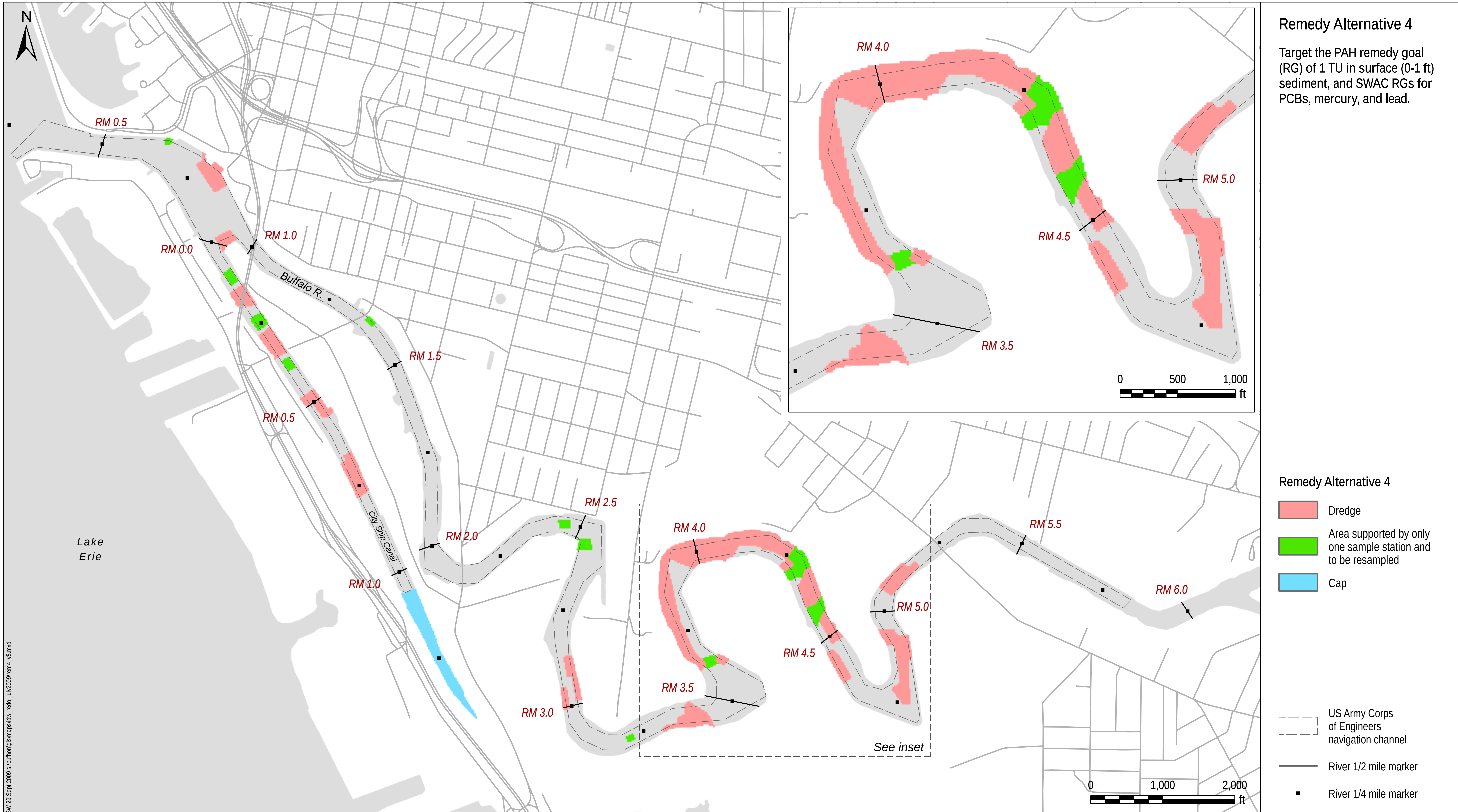
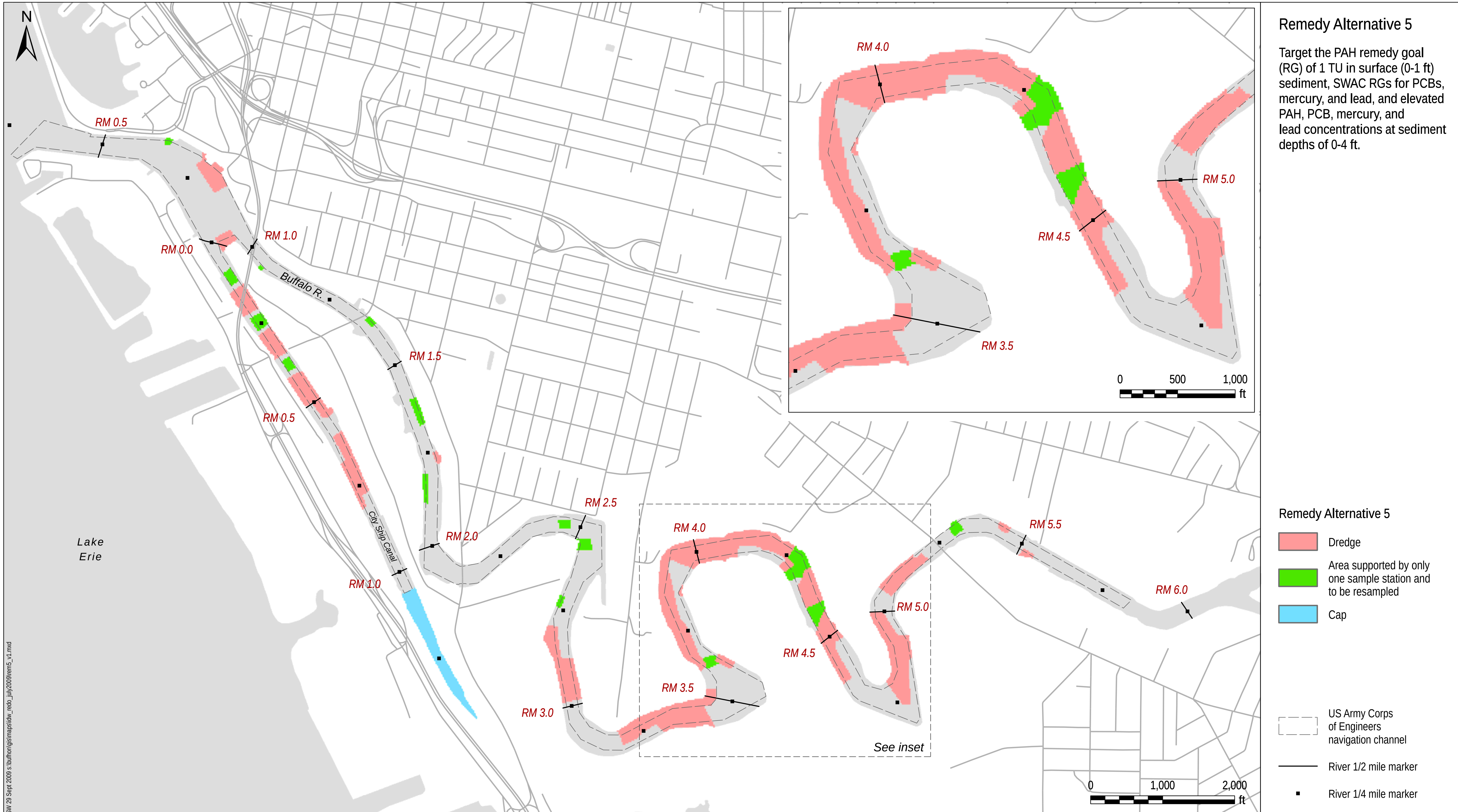
REMEDY ALTERNATIVE 3
BUFFALO, NY

Figure 5-1a



REMEDY ALTERNATIVE 4
BUFFALO, NY

Figure 5-1b



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REMEDY ALTERNATIVE 5
BUFFALO, NY

Figure 5-1c

Legend

Aquatic Vegetation Survey
- Emergent Aquatic Vegetation
- Subemergent Aquatic Vegetation

Remedy Alternative 3 Footprint

Remediation Type
- Dredge
- Cap

Notes:
--Aquatic vegetation provided by MACTEC 2008
--Aerial imagery provided by ESRI online services 09/2009

0 0.125 0.25 0.5
Miles

N

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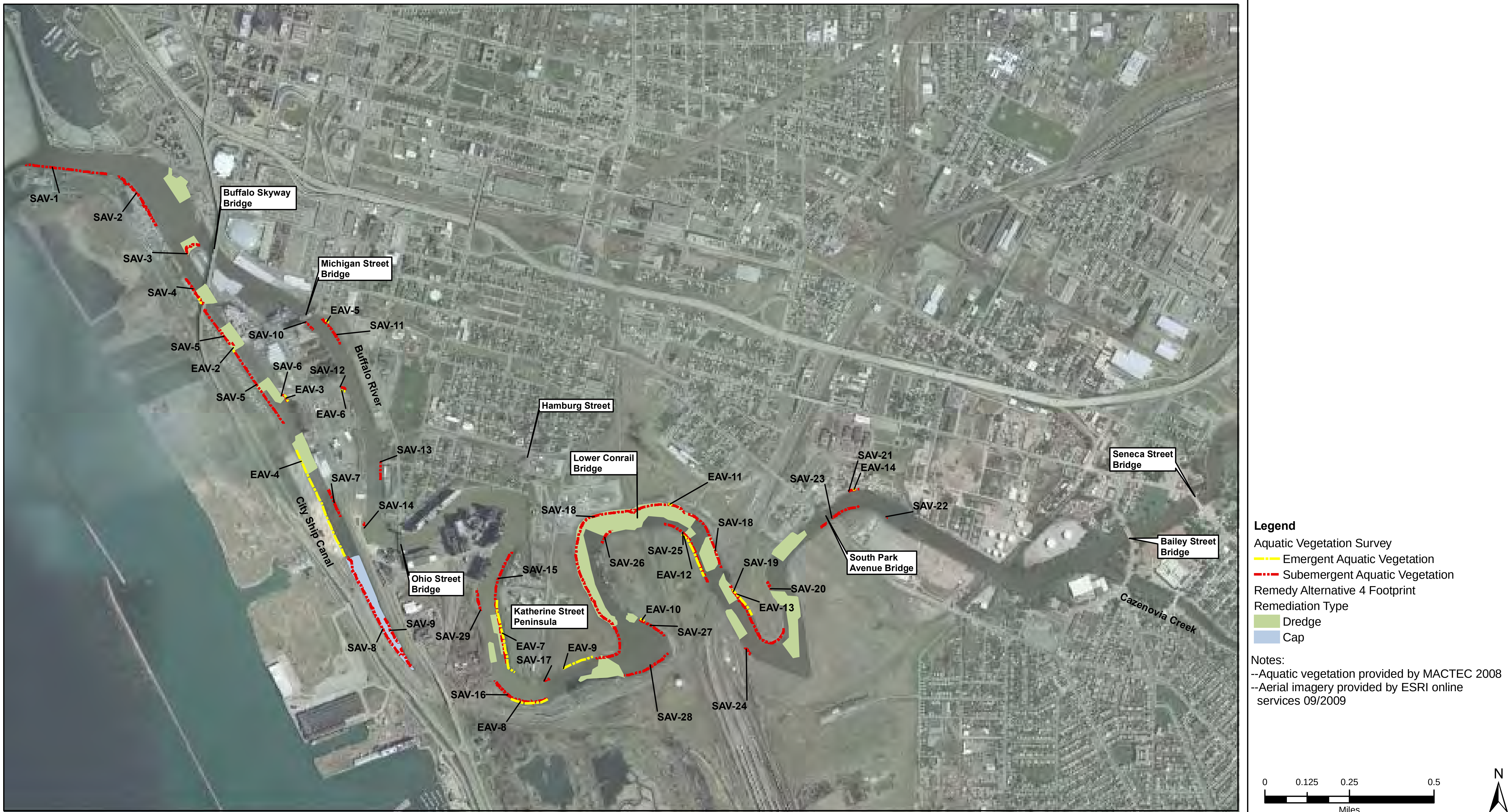
REMEDY ALTERNATIVE 3 - REMEDIATION LIMITS AND AQUATIC VEGETATION SURVEY
BUFFALO, NY

Figure 6-1a

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_AquaticVegetation_Remedy3.mxd



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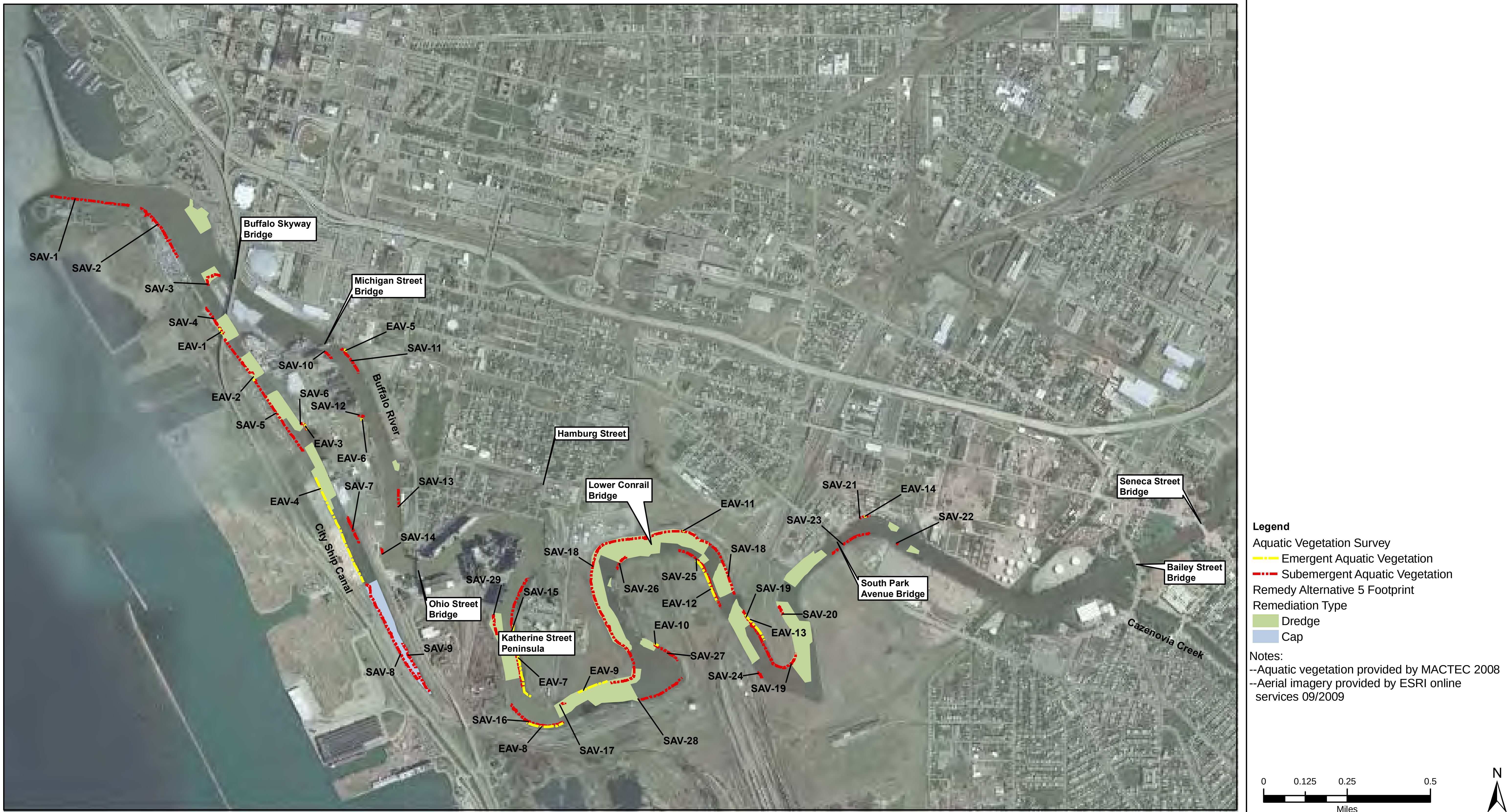
REMEDY ALTERNATIVE 4 - REMEDIATION LIMITS AND AQUATIC VEGETATION SURVEY BUFFALO, NY

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_AquaticVegetation_Remedy3.mxd

Figure 6-1b



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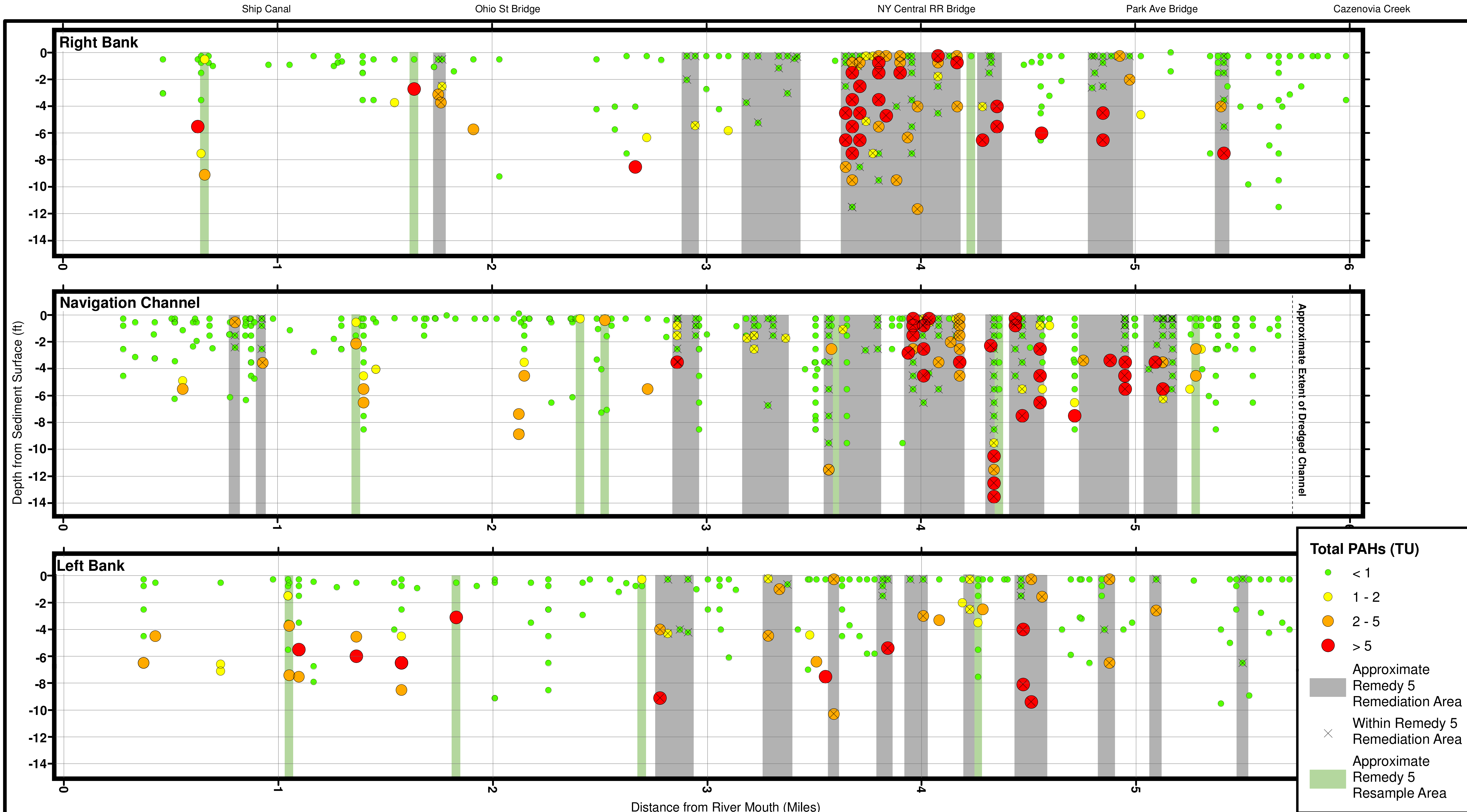
REMEDY ALTERNATIVE 5 - REMEDIATION LIMITS AND AQUATIC VEGETATION SURVEY BUFFALO, NY

Figure 6-1c

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_AquaticVegetation_Remedy5.mxd



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Remedy Alternative 5: Vertical Profiles of Total PAH Concentrations for the Buffalo River, Buffalo, NY

Figure 6-2a

Wednesday, October 21, 2009 3:51:01 PM
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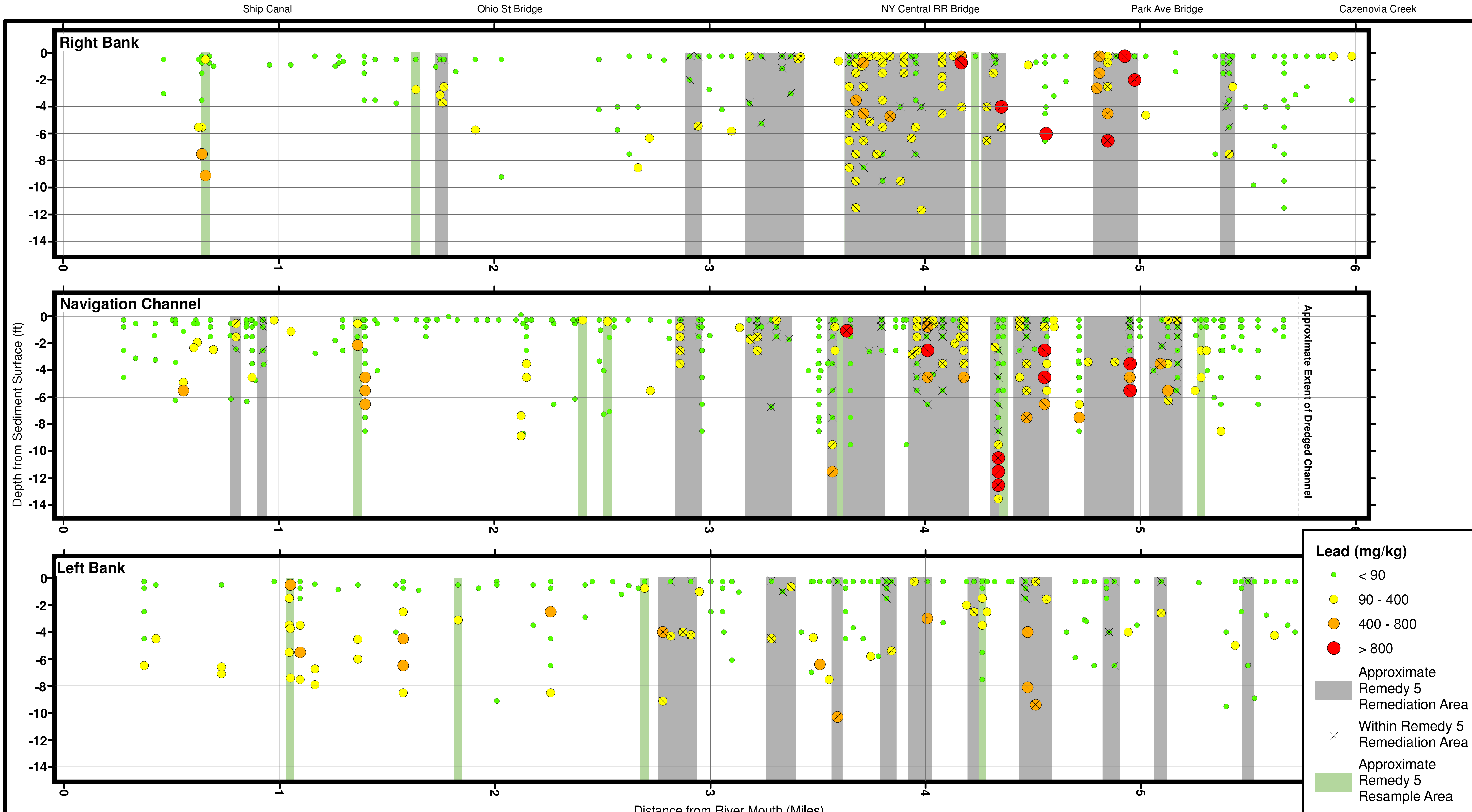

Remedy Alternative 5: Vertical Profiles of Lead Concentrations for the Buffalo River, Buffalo, NY

Figure 6-2b

Wednesday, October 21, 2009 3:51:01 PM
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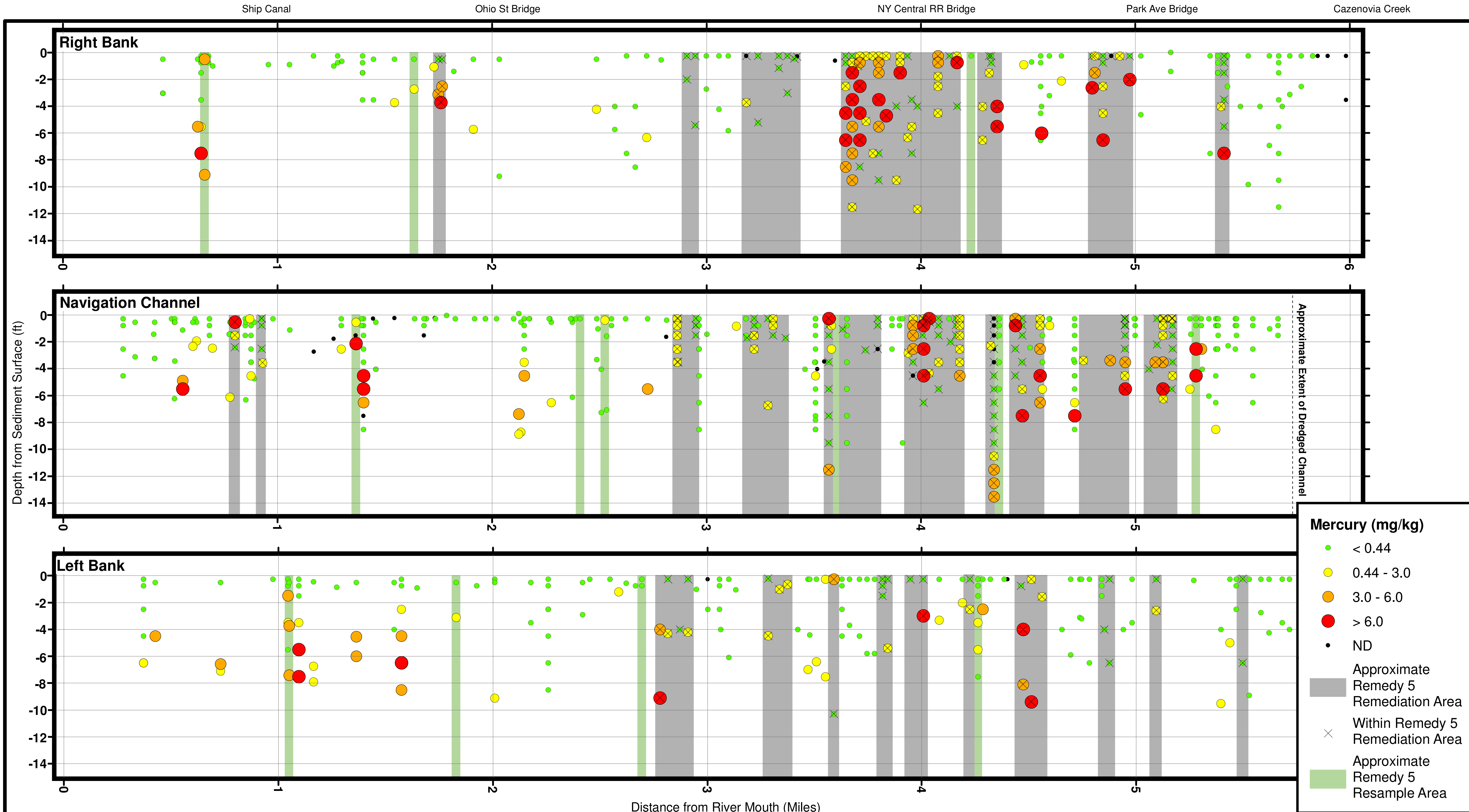

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Remedy Alternative 5: Vertical Profiles of Mercury Concentrations for the Buffalo River, Buffalo, NY

Figure 6-2c

Wednesday, October 21, 2009 3:51:01 PM
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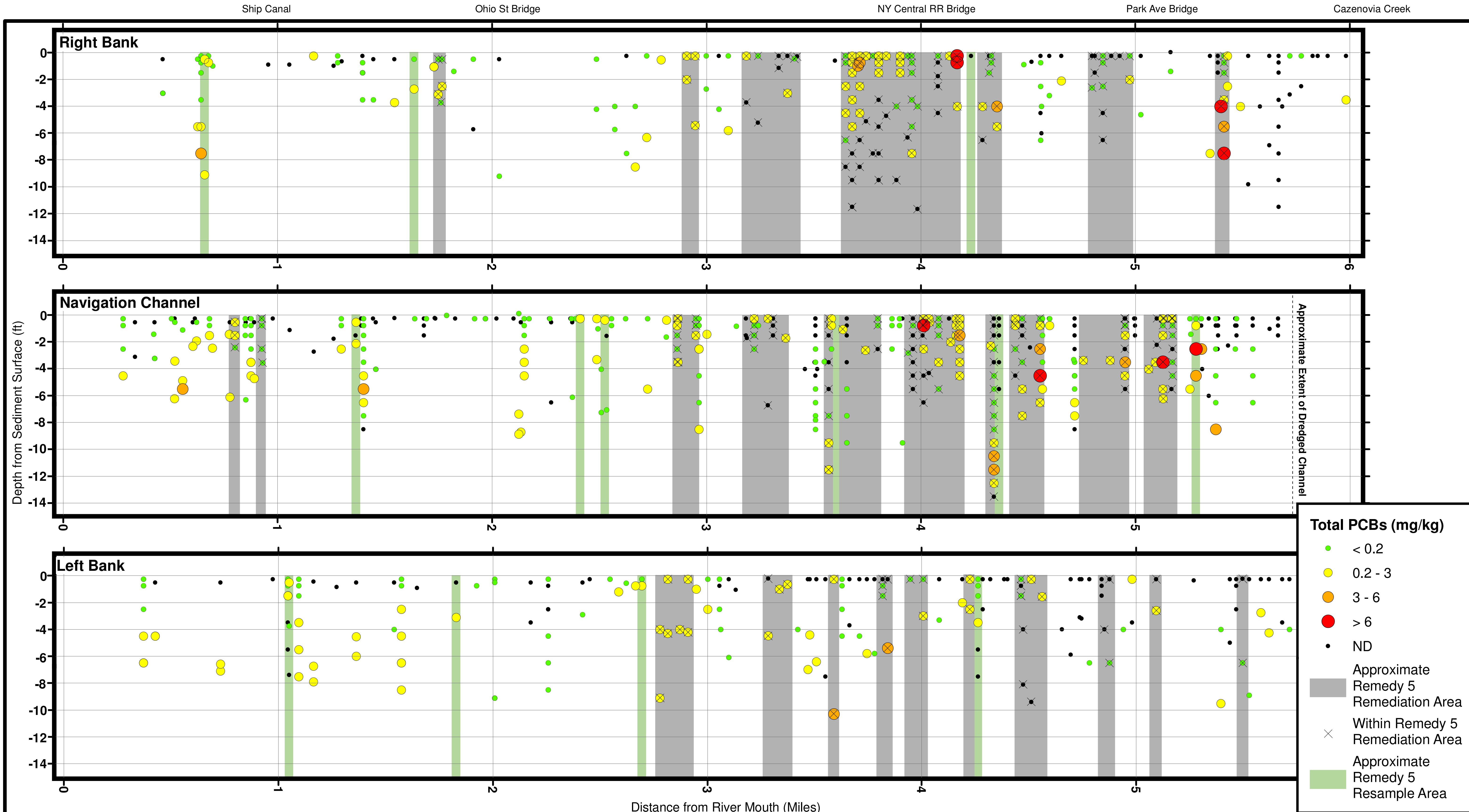

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Remedy Alternative 5: Vertical Profiles of Total PCB Concentrations for the Buffalo River, Buffalo, NY

Figure 6-2d

Wednesday, October 21, 2009 11:46:47 AM
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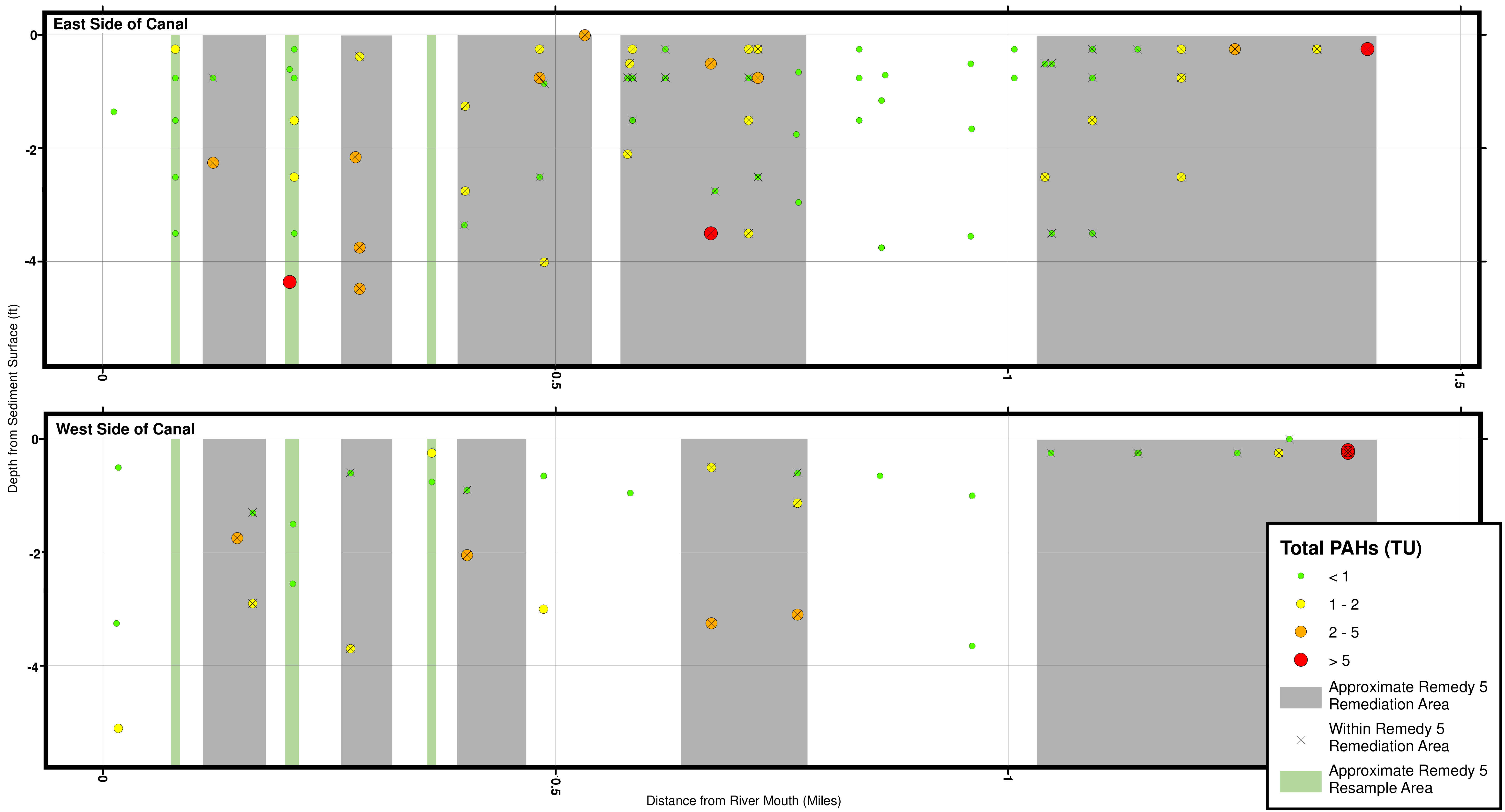

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Remedy Alternative 5: Vertical Profiles of Total PAH Concentrations for the City Ship Canal, Buffalo, NY

Figure 6-3a

Wednesday, October 21, 2009 4:32:46 PM
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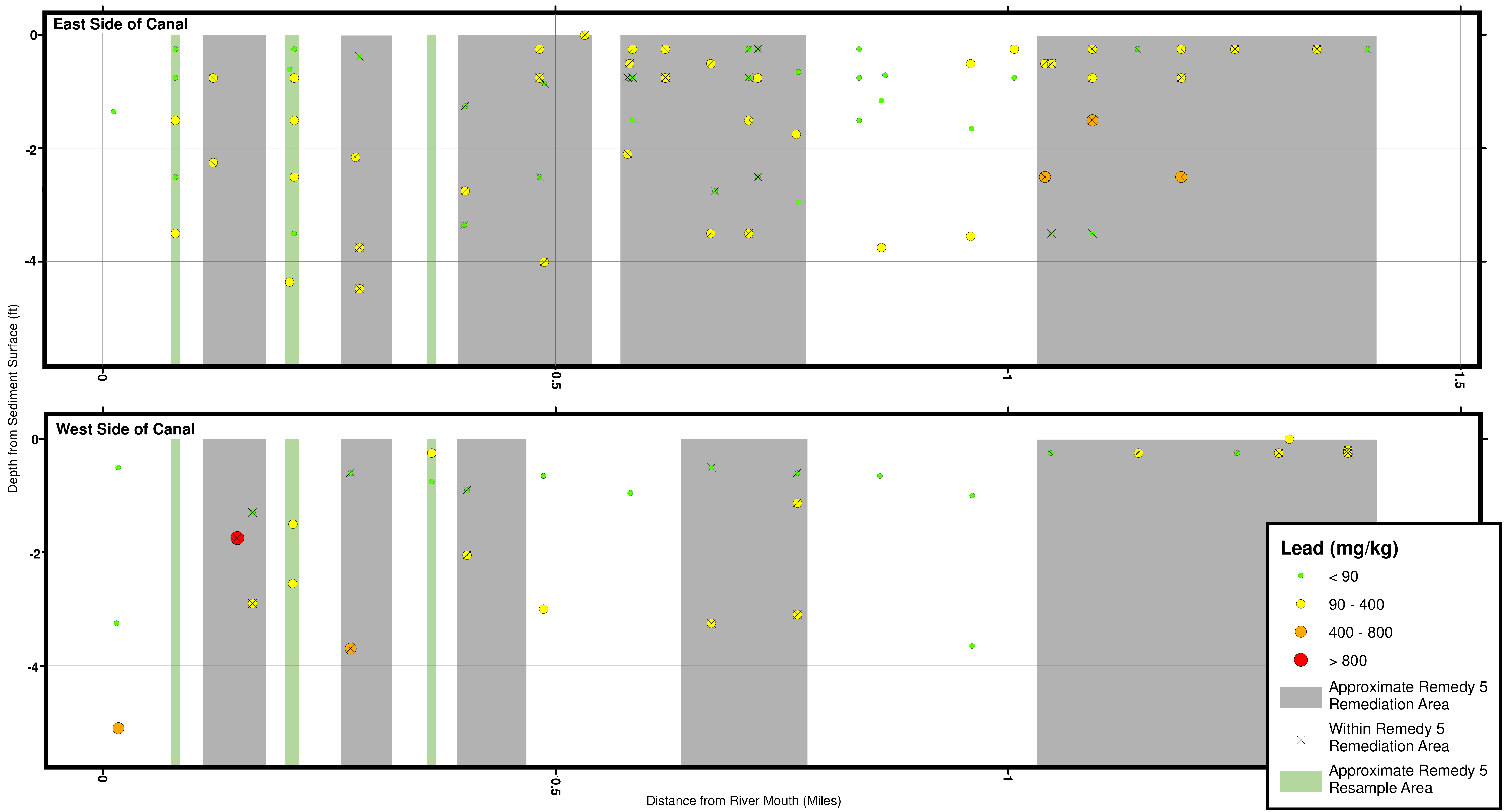

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Remedy Alternative 5: Vertical Profiles of Lead Concentrations for the City Ship Canal, Buffalo, NY

Figure 6-3b

Wednesday, October 21, 2009 4:32:46 PM
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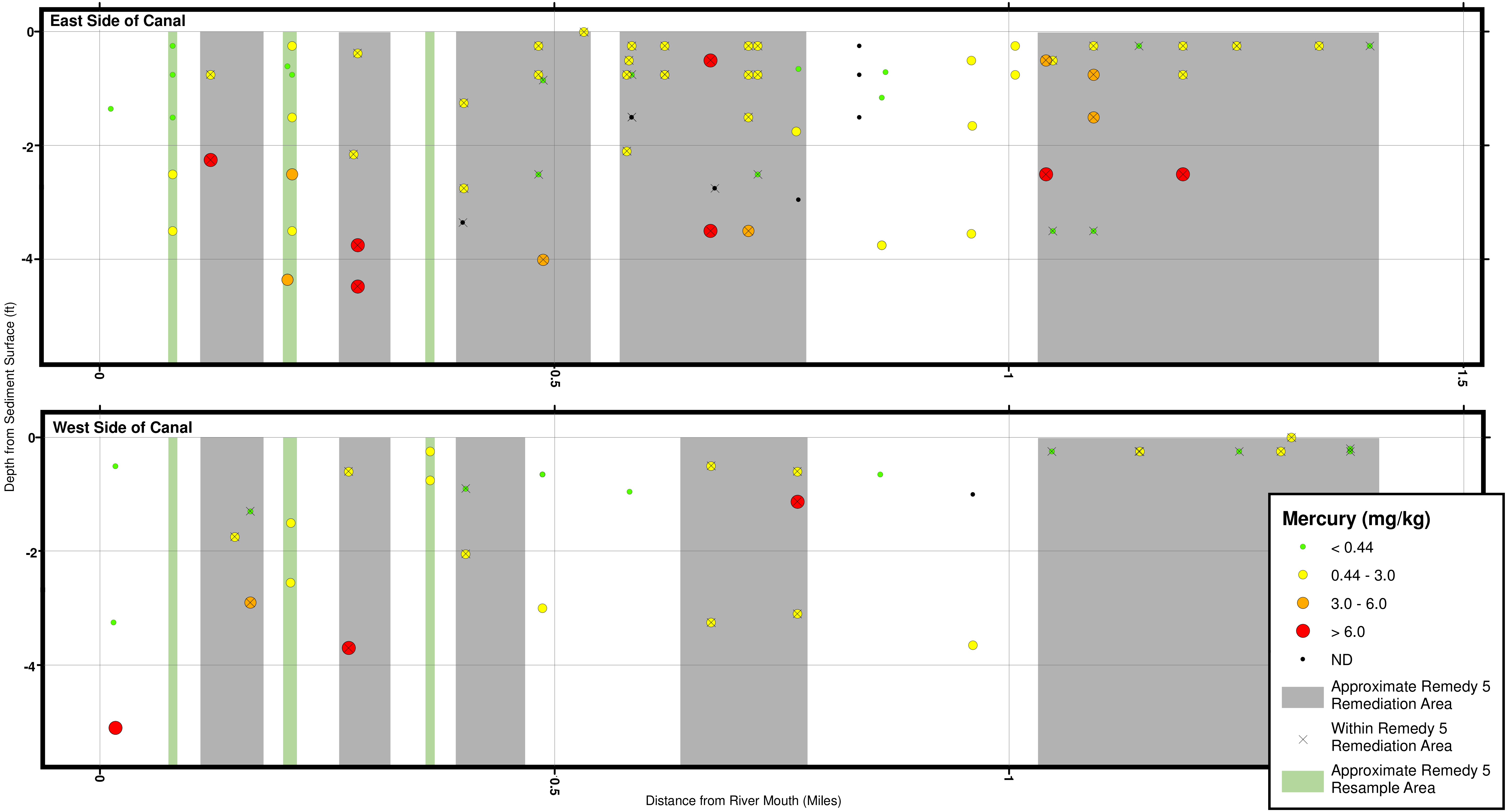

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Remedy Alternative 5: Vertical Profiles of Mercury Concentrations for the City Ship Canal, Buffalo, NY

Figure 6-3c

Wednesday, October 21, 2009 4:32:46 PM
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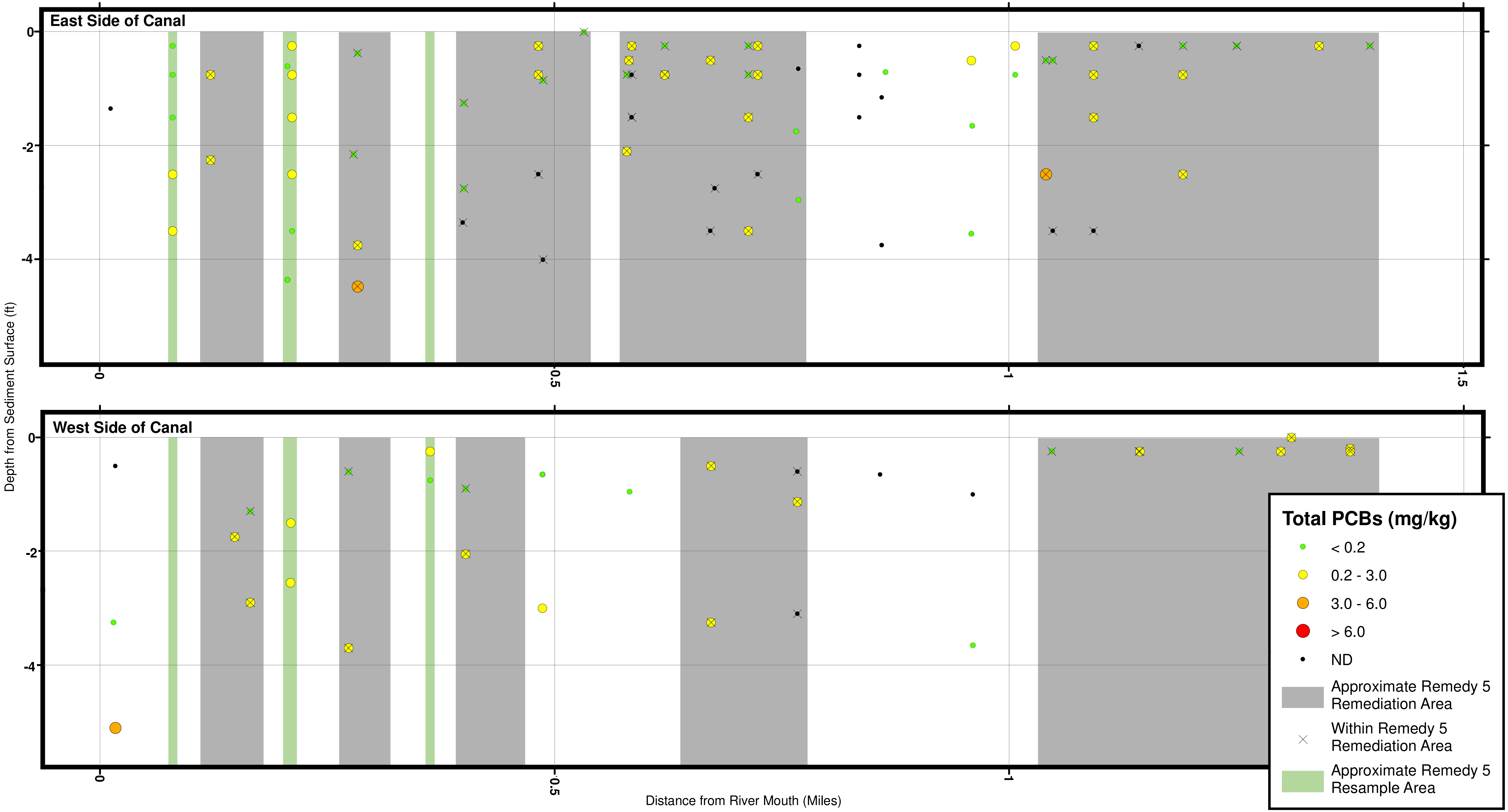

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Remedy Alternative 5: Vertical Profiles of Total PCB Concentrations for the City Ship Canal, Buffalo, NY

Figure 6-3d

Wednesday, October 21, 2009 4:32:46 PM
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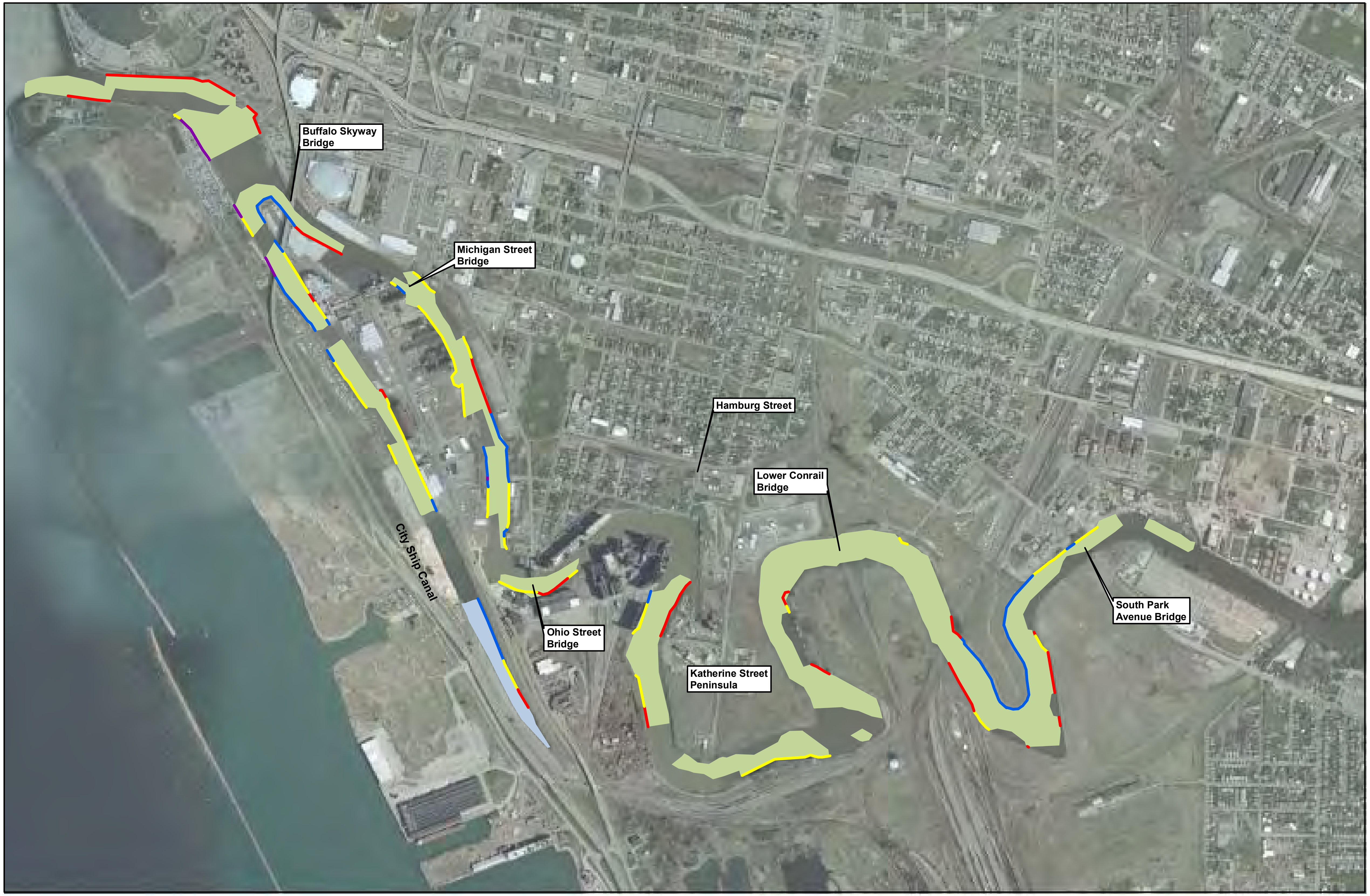

Legend

Shoreline Characteristics
- Capped Piles/Walls
- Uncapped Piles/Walls
- Sloped Stone
- Docks

Remedy Alternative 3 Footprint

Remediation Type
- Dredge
- Cap

Notes:
--Aerial imagery provided by ESRI online services 09/2009

0 0.1 0.2 0.4
Miles

N

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REMEDY ALTERNATIVE 3 - REMEDIATION LIMITS AND EXISTING SHORELINE CHARACTERISTICS BUFFALO, NY

Figure 6-4a

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_Shoreline_Remedy3.mxd

Legend

Shoreline Characteristics
- Capped Piles/Walls
- Uncapped Piles/Walls
- Sloped Stone
- Docks

Remedy Alternative 4 Footprint

Remediation Type
- Dredge
- Cap

Notes:
--Aerial imagery provided by ESRI online services 09/2009

0 0.1 0.2 0.4
Miles

N

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REMEDY ALTERNATIVE 4 - REMEDIATION LIMITS AND EXISTING SHORELINE CHARACTERISTICS BUFFALO, NY

Figure 6-4b

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_Shoreline_Remedy4.mxd

Legend

Shoreline Characteristics
- Capped Piles/Walls
- Uncapped Piles/Walls
- Sloped Stone
- Docks

Remedy Alternative 5 Footprint

Remediation Type
- Dredge
- Cap

Notes:
--Aerial imagery provided by ESRI online services 09/2009

0 0.1 0.2 0.4
Miles

N

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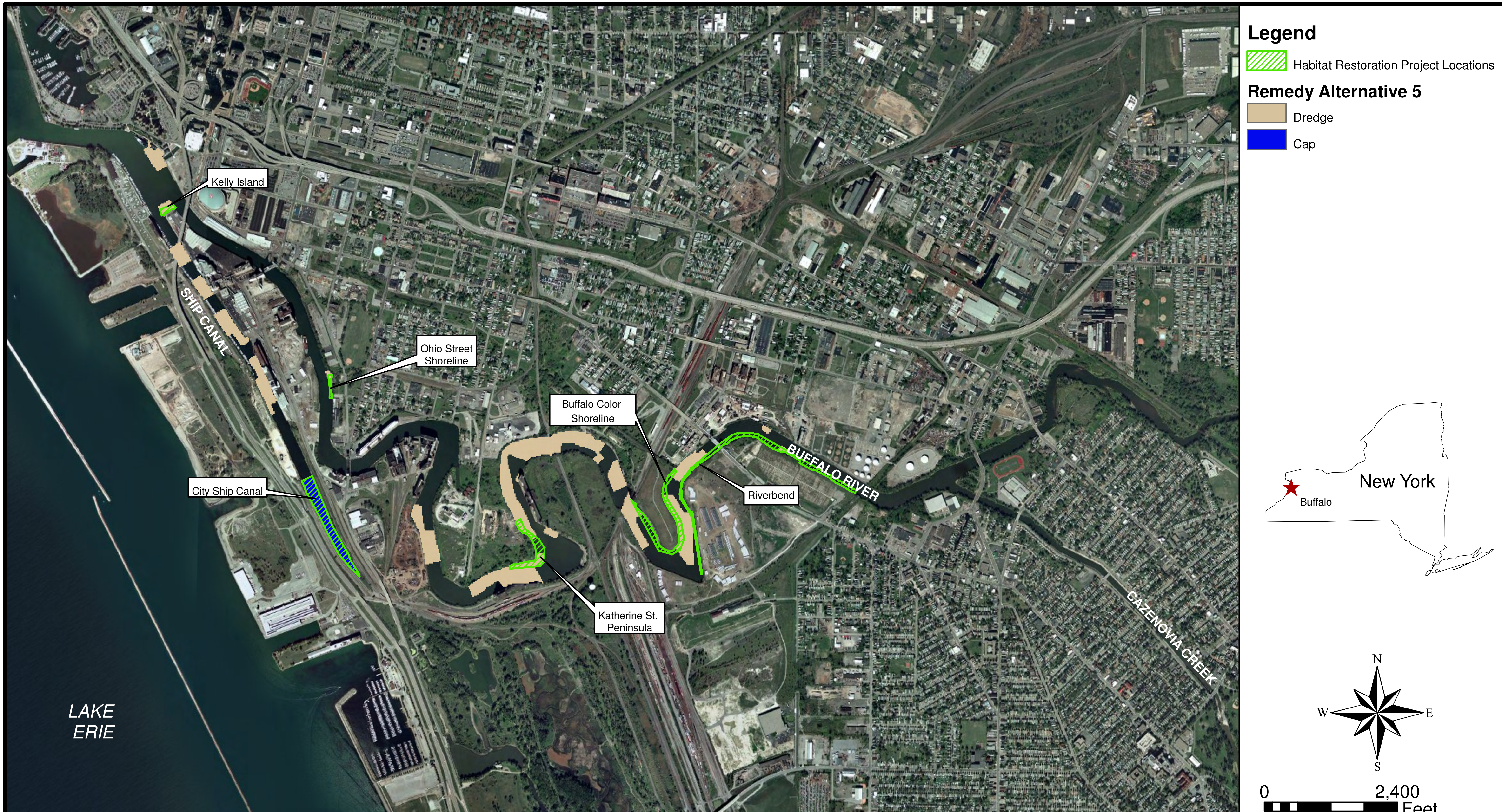
REMEDY ALTERNATIVE 5 - REMEDIATION LIMITS AND EXISITNG SHORELINE CHARACTERISTICS BUFFALO, NY

Figure 6-4c

Drafter: B. Radakovich
Contract Number: 02-20873B7
File Name: 20090929_Shoreline_Remedy5.mxd



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POTENTIAL RESTORATION PROJECT LOCATIONS
BUFFALO RIVER, NY

Figure 8-1

Monday, October 19, 2009 3:47:23 PM
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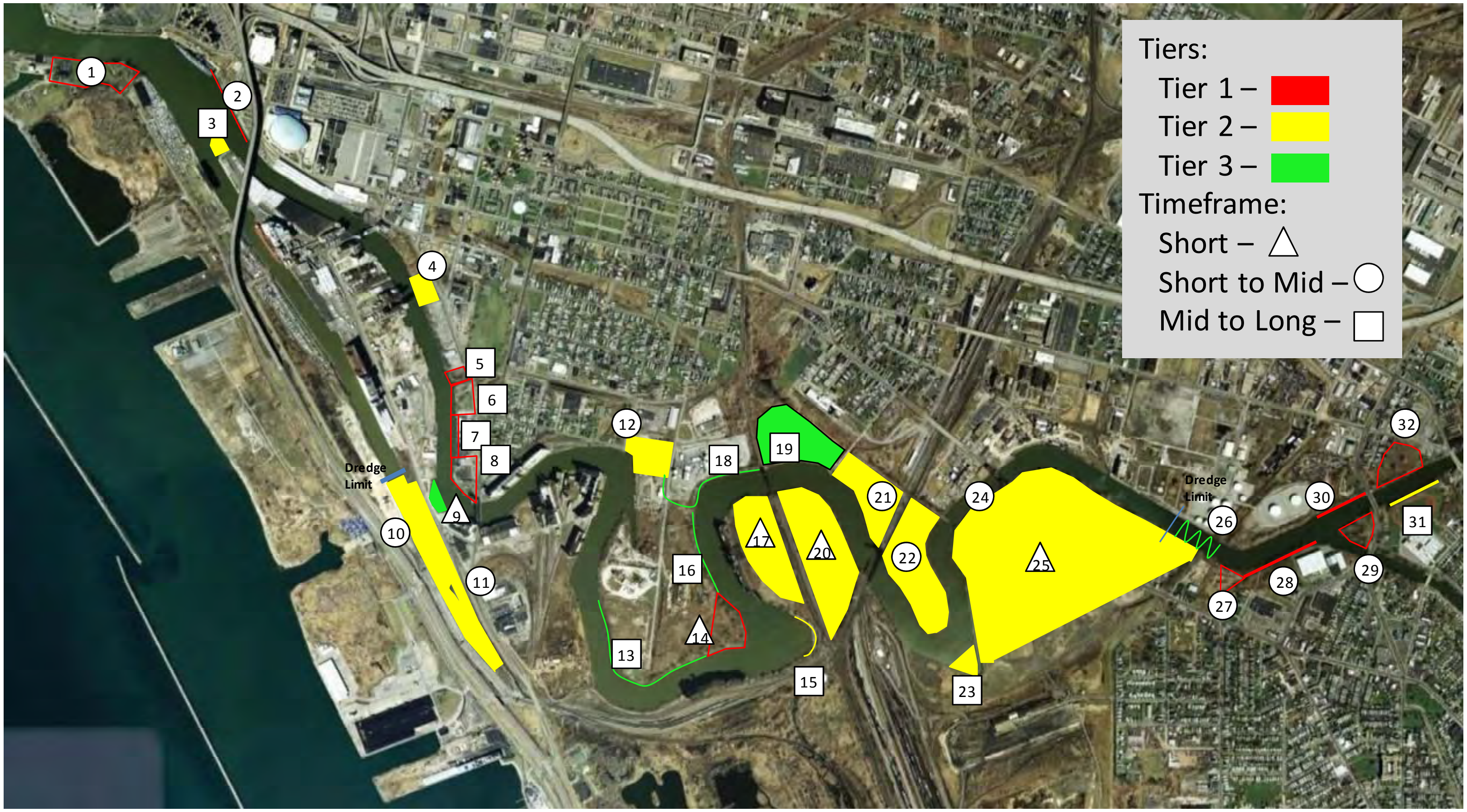

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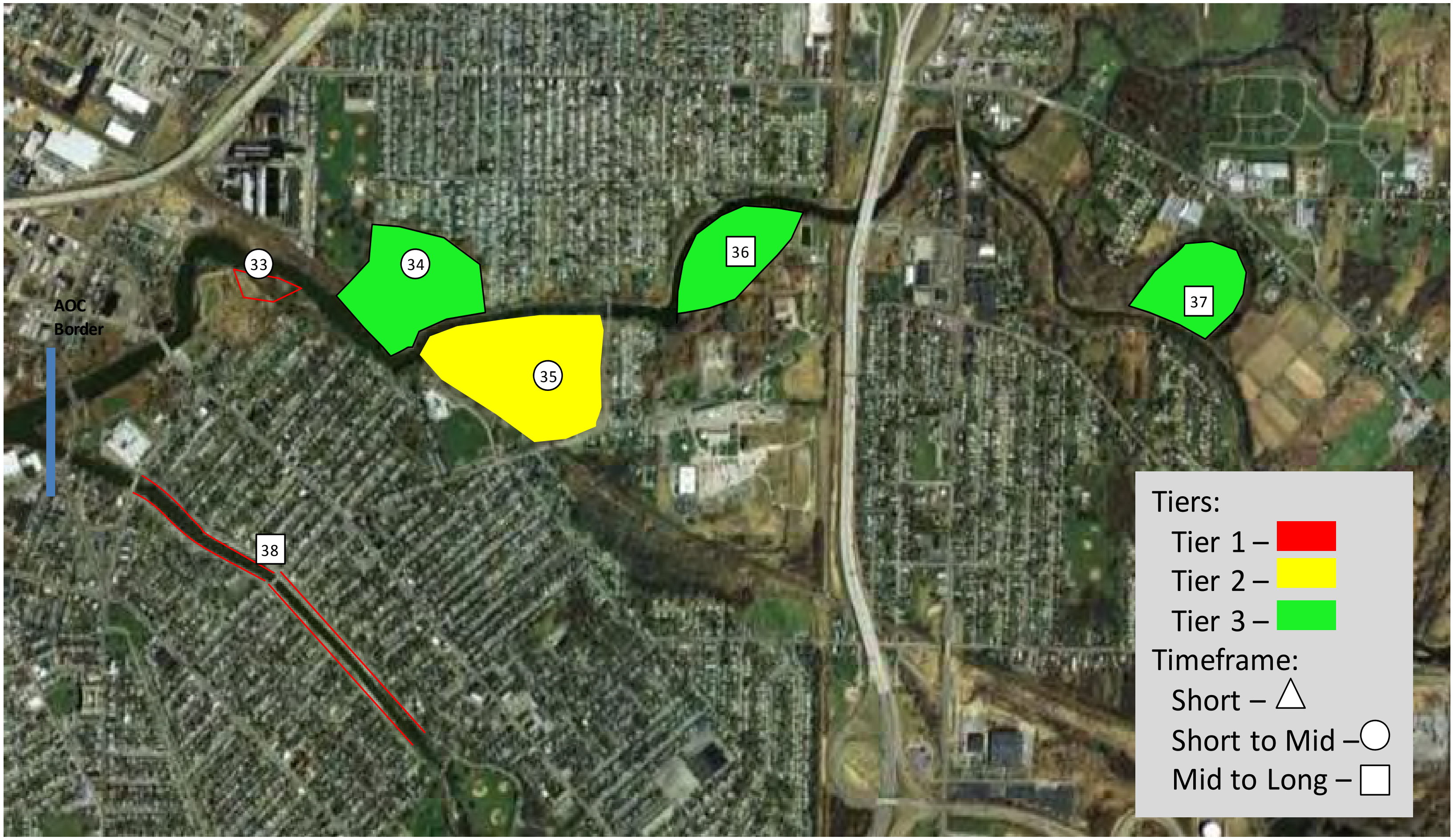
Potential Restoration Project Locations for Buffalo River Restoration Master Plan
(Provided by Buffalo-Niagara Riverkeeper)

Figure 8-2a



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Potential Restoration Project Locations for Buffalo River Restoration Master Plan
(Provided by Buffalo-Niagara Riverkeeper)

Figure 8-2b