ERDC/EL Project Report

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Executive Summary

The following report provides the results of a survey and evaluation of the potential beneficial uses of sediment dredged from the Cleveland Federal Navigation Channel. During 2010, various beneficial use alternatives were brought to the attention of the Cleveland Harbor Interim Dredge Disposal Task Force and the U.S. Army Engineer District, Buffalo that were evaluated to identify feasible and cost-effective short-term (through 2017) and long-term sediment management options. The following report provides a feasibility level review of the logistical and technical feasibility of these beneficial uses including an analysis of the engineering and ecological suitability, the environmental and regulatory acceptability, site-specific logistical considerations, and a preliminary estimate of the costs for implementing each of the beneficial use management options deemed feasible.

For Cleveland Harbor, capacity for disposal of dredged material is limited and additional capacity is required to continue the operation and economic viability of the port. Complicating the need for dredging and dredged material management is the fact that most, if not all, sediments dredged are currently considered unsuitable for open lake placement and are managed by placement in confined disposal facilities (CDFs), constructed along the Cleveland waterfront. To maintain (i.e., dredge) the federally authorized channel, approximately 300,000 CY of sediment must be dredged and managed each year. Due to the limited capacity for disposal, a reduced dredging program has been implemented for the Cleveland Harbor to maintain critical channel depths until a DMMP is completed and implemented. The current annual removal of dredged material from the navigation channel is approximately 225,000 CY/ year. In addition, the annual removal of dredged material outside of the navigation channel by non-federal interests to maintain access to docks is approximately 25,000 CY/ year. This short term requirement of 250,000 CY/year has been used as the design basis for evaluating beneficial use opportunities.

Previous data collected on the physical, chemical and biological characteristics of the Cuyahoga River Navigation Channel sediment were reviewed to establish whether sufficient information was available for evaluating the engineering and environmental suitability of dredged material for the beneficial use opportunities identified. Data gaps were identified for the assessment of beneficial use alternatives and a sediment sampling and analysis project was initiated in mid-November 2010 to fill

these data gaps. The preexisting data and newly collected data were then used to evaluate the environmental quality and engineering characteristics of the sediment and to assess suitability for each of the beneficial use alternatives.

The newly collected data on the environmental quality of navigation sediments indicated that the concentrations of contaminants were low and at concentrations typical for urban environments. A screening-level analysis of potential risk to human health demonstrated that the use of dredged material for topsoil or fill at commercial and industrial sites would be protective of human health. The potential risk and acceptability of using dredged material for surface soils at recreational sites will be dependent on the type of recreational activity and site construction methods. Construction methods can be used to reduce or eliminate potential risk to human health, further increasing the range of options for beneficial use of dredged material.

A screening level ecological risk analysis based on the newly collected data showed that no significant chemical risk to soil invertebrates, birds, or mammals would result from the use of dredged sediment at upland sites. In addition, laboratory testing of sediment samples collected during November 2010 indicated that no risk to aquatic life is expected when dredged material from the upper reach of the navigation channel is beneficially used. However, low levels of toxicity to aquatic life may be encountered when dredged material from areas located further downstream in the navigation channel is beneficially used. The source of this toxicity is currently unknown. Based on elutriate test results, the placement of dredged material in aquatic environments for beneficial use projects is not expected to have a significant impact on water quality or toxicity to aquatic life in the water column. Given these results, which show that dredged material from the upper reach of the navigation channel may be suitable for wetland habitat restoration projects while dredged material from locations further downstream appear to have low levels of toxicity, the U.S. Army Corps of Engineers (USACE) should consider conducting a Tier IV assessment prior to assessing the suitability of dredged material for wetland habitat restoration projects. Laboratory test results in 2007 were used to establish that open water placement of dredged material was not acceptable. The analysis and testing of sediment samples collected during the fall of 2010 show an improvement in quality compared to samples collected during the spring of 2007. Additional sediment sampling and testing are currently planned for the spring of

2012 to confirm the fall 2010 sediment quality results. The basis for future dredged material management decision-making will include the evaluation of all data including results from spring 2007, fall 2010 and spring 2012 sampling events.

Physical data collected during November 2010, data from past sediment sampling, and other project surveys were used to evaluate the suitability of dredged material as structural fill and construction aggregate. The dredged material tends to be dominated by silt and fine sand and is generally not suitable as a construction material. However, the physical characteristics of the dredged material vary from year to year and dredged material mined from CDF 10B has been successfully used as structural fill for redevelopment of a legacy industrial site. The dredged material is well-suited for establishing upland and wetland vegetation and restoring the fertility of degraded urban soils.

During 2010, 16 opportunities for potential beneficial use of dredged material were identified. From this list, two alternatives were identified that appeared feasible within the next three years. The closure and redevelopment of Brook Park and Silver Oak Landfills were determined to be the lowest cost alternatives that were most implementable. The Silver Oak Landfill is a 27-acre inactive construction and demolition landfill that requires re-contouring and placement of a cap and a soil cover for closure. The closure and recontouring of the landfill could result in the beneficial use of 200,000 CY of dredged material during the 2014 to 2015 timeframe at a cost of approximately $35/CY, including cost of dredging. Uncertainty in the timing on resolution of regulatory compliance and legal access to the site creates uncertainty in the schedule to implement this alternative. The Brook Park Landfill is a 28-acre non-operating landfill for construction demolition debris (CDD) requiring closure. The City of Cleveland owns the Brook Park Landfill and is currently developing plans for final closure and redevelopment to accommodate future industrial use. Preliminary planning for landfill closure indicated that 350,000 to 500,000 CY of dredged material may be needed. The closure and recontouring of Brook Park Landfill could result in the beneficial use of dredged material during the 2013 to 2014 timeframe, at a cost of approximately $35/CY, including cost of dredging.

Dredged material dewatering and material handling operations are significant components for the beneficial use of dredged material in upland environments. Material handling operations require scow unloading, material dewatering, stockpiling, and return flow water management. Mechanical unloading of dredged material at the waterfront CDFs was determined to be a potentially feasible alternative with a number of advantages over the current practice of hydraulic unloading. Mechanical unloading of dredged material allows stockpiling of dewatered dredged material and if proven feasible, could increase capacity for managing dredged material at the waterfront CDFs by more than 2 million CY. An active program of beneficial use with increased storage capacity at the existing CDFs may meet the need for developing a 20-year dredged material management plan.

There are a number of important engineering considerations and operational limitations associated with this material handling strategy that require consideration, including balancing the rates at which sediment can be mechanically dredged and the rate at which it can be offloaded from scows. A number of engineering aspects for this approach need to be reviewed including geotechnical stability of the berms for supporting the stockpiles, stability and angle of repose of the dredged material, analysis of the structural integrity and strength of storm and combined sewers residing under CDFs, and Federal Aviation Administration review of flight path transitional surfaces and potential impacts on airport electronic navigation and control systems. These engineering issues and regulatory approvals create uncertainty in the feasibility of this alternative as well as uncertainty in the schedule for implementation.

A number of long-term opportunities for beneficial use of sediment are identified in this report and recommendations for developing future projects are presented. Development of a strategic plan with local leadership and active commitment from the Cleveland-Cuyahoga County Port Authority and other Task Force Members, City of Cleveland, Cuyahoga County, Ohio Department of Natural Resources (ODNR), Ohio Environmental Protection Agency (OEPA), and Ohio Department of Transportation (ODOT) is critical for the successful beneficial use of dredged material in the Cleveland Federal Navigation Channel.

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Preface

This report summarizes the evaluation of Cleveland Harbor dredged material for beneficial use purposes. This project was funded by the Corps of Engineers Buffalo District. Mr. Frank A. O'Connor, P.E., US Army Corps of Engineers Buffalo District was the project manager.

Dr. Joseph P. Kreitinger, Mr. Richard A. Price, Mr. Alan J. Kennedy, Dr. Dennis L. Brandon, and Mrs. Michelle Bourne from the Environmental Risk Assessment Branch (ERAB), and Mr. Thomas D. Borrowman from the Environmental Engineering Branch (EEB) prepared this report. Both branches are within the Environmental Processes and Engineering Division (EPED) of the Environmental Laboratory (EL), US Army Engineer Research and Development Center (ERDC), Vicksburg, Mississippi. Technical review was provided by Dr. Trudy Estes of the Environmental Processes and Engineering Division (EPED).

This work was conducted under the general supervision of Mr. William T. Jones, Acting Chief, ERAB, Mr. Andy W. Martin, Chief, EEB, and Mr. Warren P. Lorentz, Chief, EPED.

At the time of publication of this report, Dr. Elizabeth (Beth) Fleming was Director of EL, COL Kelvin J. Wilson was Commander of ERDC, and Dr. Jeffery P. Holland was Director.

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1 Introduction

This report provides the results of a survey and evaluation of the potential beneficial uses of sediment dredged from the Cleveland Harbor Federal Navigation Channel. During 2010, various beneficial use alternatives were brought to the attention of the Cleveland Harbor Interim Dredge Disposal Task Force (Task Force) and the U.S. Army Engineer District, Buffalo that were evaluated to identify feasible and cost effective short-term (through 2017) and long-term sediment management options. The report provides a review of the logistical and technical feasibility of these beneficial uses including an analysis of the engineering and ecological suitability, the environmental and regulatory acceptability, site-specific logistical considerations, and a preliminary estimate of the costs for implementing each of the beneficial use management options deemed feasible.

1.1 Dredged material management problem statement

The US Army Corps of Engineers (USACE) is responsible for the maintenance of 58 federal navigation channels in the Great Lakes region. These navigation channels are each associated with a watershed with varying characteristics that impact required channel maintenance. The navigation channels in the Great Lakes are shown in Figure 1-1 along with project volumes, status of current dredged material management activities, and harbors where anticipated restrictions to navigation are expected due to limitations placed on dredged material management. As shown, three navigation projects in Ohio are at risk of channel restrictions within 5 years including Toledo, Cleveland, and Lorain. Toledo and Cleveland Harbors are the most critical in terms of risk to commercial navigation among the 58 federal channels in the Great Lakes. Prior to the mid 1960s, channel sediments were simply dredged and deposited into open lake water. Addressing concerns of water quality impacts from open water discharges of dredged material from polluted harbors, the USACE and the Water Pollution Control Administration (predecessor of the US Environmental Protection Agency) began to study dredged material disposal options in the Great Lakes. Although a report by the Buffalo District (1969) could not document substantial impacts to water quality or benthic communities, the report concluded such practice was undesirable. Following authorization provided by Sec. 123 of the Rivers and Harbor Act of 1970 (Public Law

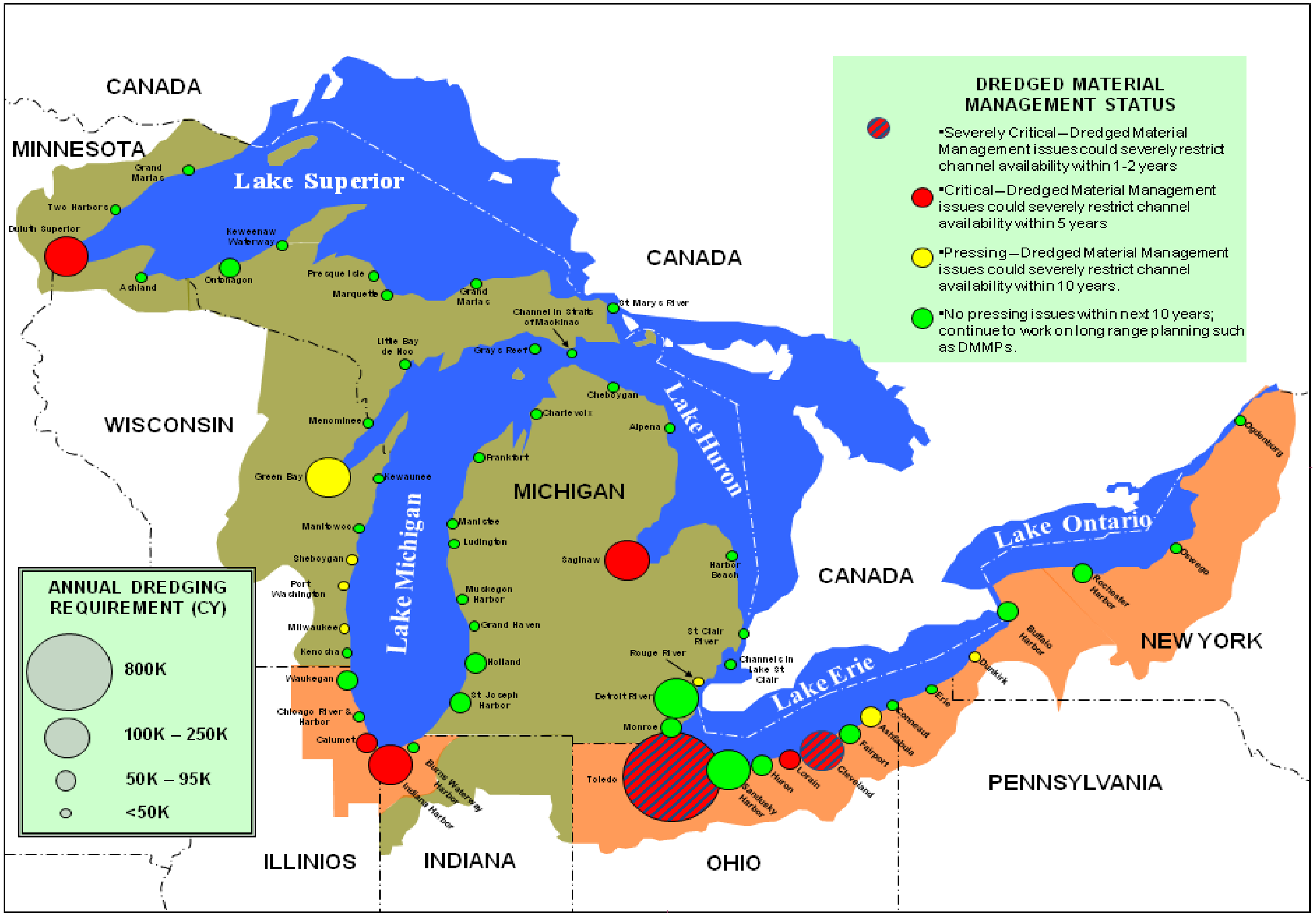

Figure 1-1. Status of dredged material management in the Great Lakes.

91-611), USACE constructed 28 confined disposal facilities (CDFs) to contain contaminated dredged material. Since 1960, at least 17 CDFs have been constructed under other authorities. The assumption that the Clean Water Act (CWA) would reduce contaminant and nutrient loadings into waterways and allow a return to more open water disposal has not been realized, and the need for upland disposal capacity remains. While contaminant reduction in the waterways has been achieved, knowledge about potential risks from anthropogenic contaminants has increasingly shifted the definition of 'contaminated' toward the analytical limits of detection, and the need for CDFs has persisted for more than 40 years. Disposal in CDFs has become the default management practice rather than science-based determination of dredged material suitability for open-water disposal or beneficial use. For this reason, CDF capacity is all but exhausted in some harbors while costs for new construction have increased, becoming an impediment to new CDF construction. For long-term sustainability, management options must include open-water placement in addition to aquatic and upland beneficial uses when dredged material is determined to be suitable by appropriate testing and evaluation.

For Cleveland Harbor, capacity for disposal of dredged material is limited and additional capacity is required to continue the operation and economic viability of the port. To maintain commercial navigation in Cleveland Harbor, a minimum of approximately 250,000 CY of sediment must be dredged and managed each year to maintain critical channel depths until a DMMP can be completed and implemented. Complicating the need for dredging and dredged material management is the fact that most, if not all, sediments dredged are currently considered "contaminated" and are managed by placement in CDFs constructed along the Cleveland waterfront. Since 2008, the original design capacity of the existing CDFs has been extended using fill management strategies internal to the CDFs (e.g., dewatering, consolidation of dredged material, construction of internal berms, etc). By the year 2015, a new disposal facility or other management method will have to be in place in order to continue dredging Cleveland Harbor.

The August 2009 draft Dredged Material Management Plan and Environmental Impact Statement (2009 DMMP-EIS) for the Cleveland Harbor specified construction of a new waterfront CDF; ultimately the facility could not be constructed due to the lack of financial support from the local, non-federal sponsor (Cleveland-Cuyahoga Port Authority).

Contained within the 2009 DMMP-EIS was a review of potential beneficial uses of dredged material that included mine land reclamation, littoral nourishment, soil manufacture, wetlands/habitat creation, and landfill cover. However, none of these alternatives were considered feasible nor carried forward for detailed analysis due to a lack of information and inability to refine the management concepts. The goal of this study was to explore in more depth the potential beneficial use options for management of dredged material from the Cleveland Federal Navigation Channel. The results and conclusions of this report will be used to inform a revised Dredged Material Management Plan for the Cleveland Harbor. The goal of this process is consistent with a regional strategy to provide long-term sustainability for management of dredged material from operations and maintenance activities in federal navigation channels in the Great Lakes.

1.2 Beneficial use study authority and process

Beneficial uses of dredged material involve the placement or use of dredged material for some productive purpose. Examples of beneficial uses of dredged material include habitat development (e.g., wetland restoration or creation, fishery enhancement); development of parks and recreational facilities (e.g., walking and bicycle trails, wildlife viewing areas); agricultural, forestry, and horticultural uses; strip-mine reclamation/solid waste management (e.g., fill for strip mines, landfill capping); shoreline construction (e.g., levee and dike construction); construction/industrial development (e.g., bank stabilization, Brownfield reclamation); and beach nourishment (e.g., restoration of eroding beaches).

The Water Resources Act of 1992, Section 204 – Beneficial Use of Dredged Material (Public Law 102-580), provided the authority for USACE to implement beneficial use projects for ecosystem restoration in connection with dredging. The Federal Water Control Act Amendments of 1972 (i.e., the CWA) are the primary federal environmental statutes governing discharge of dredged materials into inland and estuarine waters of the United States. Beneficial use projects involving habitat restoration and ecosystem restoration in inland and estuarine waters of the United States must also comply with the CWA. The CWA does not provide guidance for the protection of the environment when dredged material is placed in upland environments that are not waters of the United States (except where there is return flow, as in placement in a CDF). The regulation of beneficial uses of sediment in upland environments where there is no return flow falls under the State regulatory authorities. Currently, the

State of Ohio policy is to regulate dredged material not falling under the CWA Section 404 as an "other" waste.

Section 2005 of the Water Resources Development Act of 2007 (WRDA 2007) provided authority for USACE to enter into Project Partnership Agreements for the design, construction, operation, maintenance, and management of dredged material disposal facilities. Section 217 of WRDA 1996, as amended by section 2005 of WRDA 2007, provides that USACE, in managing dredged material from a federal navigation channel, may enter into Project Partnership Agreements with one or more non-federal interests for the acquisition, design, construction, management or operation of a dredged material processing, treatment, contaminant reduction, or disposal facility (including any facility used to demonstrate potential beneficial uses of dredged material, which may include effective contaminant reduction technologies) (USACE 2008). Dredged material processing facilities are eligible for funding and federal cost sharing as General Navigation Facilities if they meet the requirements of the Federal Standard and comply with operational limits of the Base Plan.

All proposed dredged material management activities regulated by the CWA must also comply with the applicable requirements of the National Environmental Policy Act (NEPA) and its implementing regulations. Federal agencies, state, and local government agencies, non-government organizations, private entities, and the general public all have opportunities to provide comment and identify impacts of beneficial use options during the planning effort. These opportunities are provided through the NEPA process, which mandates coordination among and input from interested stakeholders. NEPA recognizes the need for public review and provides a number of opportunities for agency and public input, starting with NEPA scoping at the beginning of the study process.

1.3 Federal Standard and Base Plan

The Federal Standard is defined in the USACE regulations as the least costly dredged material disposal or placement alternative (or alternatives) identified by USACE that is consistent with sound engineering practices and meets all federal environmental requirements, including those established under the CWA and the Marine Protection, Research, and Sanctuaries Act (MPRSA) (see 33 CFR 335.7, 53 FR 14902). The term "Base Plan" is a more useful operational description because it defines the disposal or placement costs that are assigned to the "navigational purpose" of the Federal

Navigation Project. The costs assigned to the navigational purpose of the project are shared with the non-federal sponsor of the project, with the ratio of federal to non-federal costs depending on the nature and depth of the project (USEPA, USACE 2007).

Sediment dredged from the Cleveland Harbor Federal Navigation Channel currently does not meet federal guidelines for open-lake placement; therefore, the least cost environmentally acceptable upland alternative(s) will satisfy the requirements of the Federal Standard. Fill management consisting of raising berms within the existing CDFs (CDFs 9, 10B, and 12) to maximize capacity is currently the least costly alternative for management of dredged material. However, these operational activities only provide a short-term increase in capacity that allows dredging operations to continue until 2014. After 2014, hydraulic placement within the CDFs will no longer be possible, and dikes cannot be raised further due to height limitations required by Burke Lakefront Airport (BLA). The Base Plan for Cleveland Harbor through 2014 has been established to be the continuation of fill management followed by the use of a proposed newly constructed CDF at the foot of East 55th Street (USACE 2010a). The Cleveland Harbor Federal Standard requirements can possibly change over time. If future testing determines dredged material is suitable for open-water placement, beneficial use, or other fill management options and these uses are identified as more cost effective than the proposal for a new CDF, changes to the Base Plan will be warranted.

1.4 Notice of intent to conduct beneficial use study

During 2010, the Cleveland-Cuyahoga County Port Authority, in collaboration with the USACE and other stakeholders, established the Cleveland Harbor Task Force to investigate short- and long-term management options for disposal of dredged materials. The Task Force recommended that the USACE undertake a study to identify potential beneficial uses of dredged material. The USACE Buffalo District requested the USACE Engineer Research and Development Center (ERDC), Environmental Laboratory conduct an assessment of the suitability of dredged material for beneficial uses and the feasibility of implementing a beneficial use project. As part of this study, the USACE published a Sources Sought notification on 4 June 2010 seeking parties interested in receiving dredged material for beneficial uses (USACE 2010b). Monthly meetings of the Task Force occurred during 2010 and 2011 to identify and discuss proposed beneficial use options.

1.5 Approach used to evaluate beneficial use alternatives

The evaluation of beneficial uses for Cleveland Harbor dredged material was conducted by identifying local opportunities for beneficial use, evaluating the suitability of the sediment for the proposed end uses that appeared feasible, assessing each project's unique characteristics for execution including volume and schedule requirements, and estimating the cost. The feasible beneficial uses were then ranked by cost and utility (Figure 1-2).

Preliminary threshold criteria were used for initial screening of the beneficial use opportunities identified. This was done so that resources could be focused on the most promising beneficial use alternatives, removing those alternatives that did not meet minimum threshold requirements from further evaluation (Chapter 2). These preliminary threshold criteria included:

1. Minimum volume requirement of 50,000 CY per project
2. Compliance with federal, state, and local laws and ordinances
3. Not previously rejected for technical reasons or lack of public support (i.e., alternatives that had already been determined to be unacceptable to stakeholders were not reconsidered)
4. Adequate available information to support a preliminary evaluation of project feasibility

Following the Preliminary Threshold Screening, the alternatives were then categorized for their potential to be executed in the short term (2012 through 2016) or in the long term (2017 and after).

Previous data collected on the physical, chemical, and biological characteristics of the Cuyahoga River Navigation Channel sediment were reviewed to establish whether sufficient information was available for evaluating the engineering and environmental suitability of dredged material for the beneficial use opportunities identified (Chapter 3). Data gaps were identified for the assessment of beneficial use alternatives and a sediment sampling and analysis project was initiated mid-November 2010 to fill these data gaps. The preexisting data and newly collected data were then used to evaluate the environmental quality and engineering characteristics of the sediment and to assess suitability for each of the beneficial use alternatives.

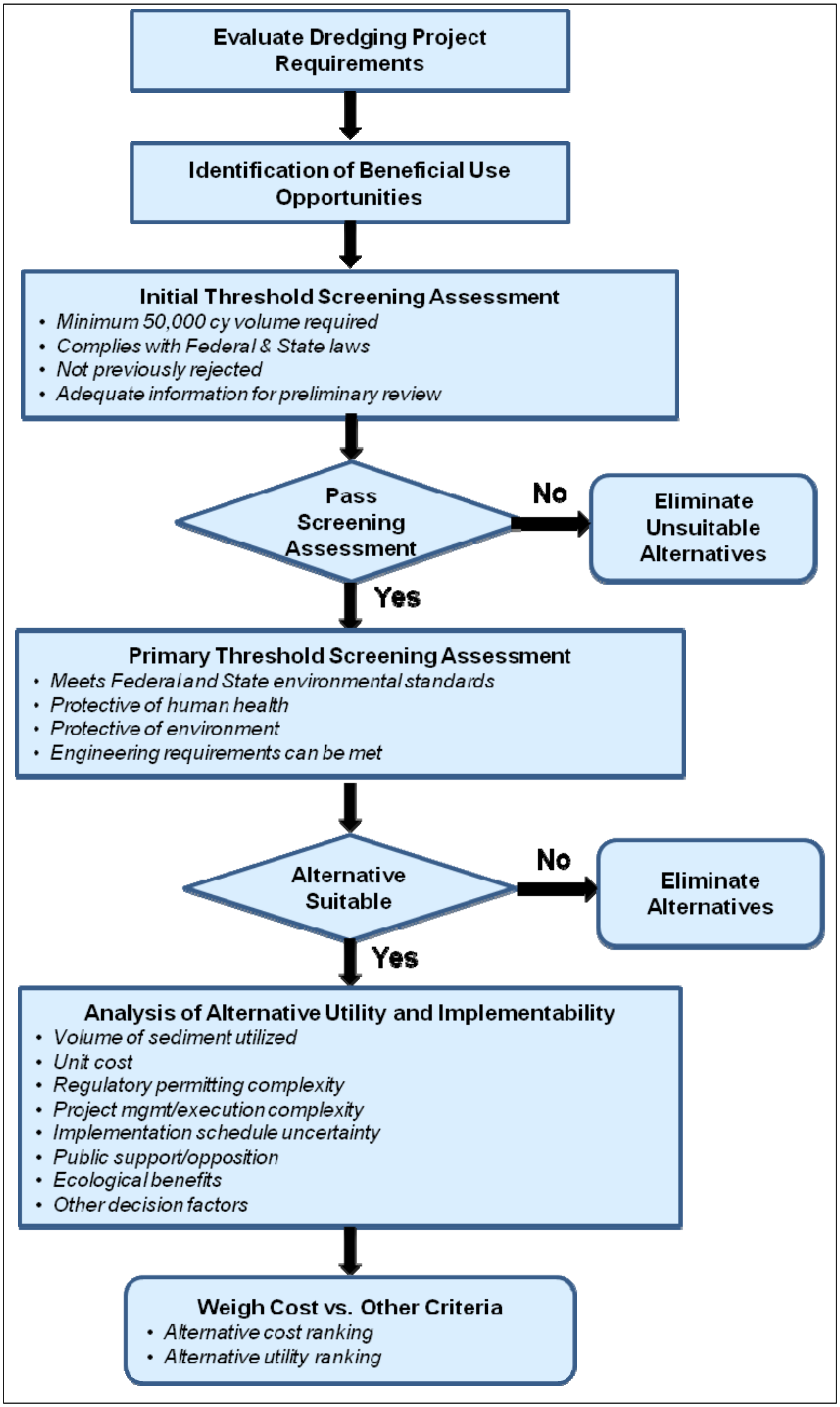

Figure 1-2. Approach used to evaluate beneficial uses of dredged material.

A second tier of screening was then conducted for evaluating the feasibility and acceptability of each management option using a set of Primary Threshold Criteria; these criteria were:

1. Protection of human health (Chapter 4)
2. Protection of the environment (Chapter 5)
3. Engineering suitability of the dredged material for the proposed end use (Chapter 6) and feasibility of material handling (Chapter 7)
4. Permitting and legal constraints impacting project schedule and execution (Chapter 8)

For each feasible alternative meeting the threshold requirements, a cost estimate was prepared (Chapter 9) and the alternatives were then weighed and ranked in terms of unit cost, volume managed, project complexity, and other factors contributing to uncertainty in project execution (i.e., utility; Chapter 10). Based on this analysis, a set of selected beneficial uses was identified for both interim dredged material management and consideration for long term sediment management planning (Chapter 11). Chapter 12 summarizes the report and makes recommendations for future beneficial use of dredged material.

2 Beneficial Use Opportunities and Initial Screening of Alternatives

Potential beneficial uses for Cleveland Harbor sediments were previously identified in the 2009 DMMP-EIS. Additional beneficial use concepts were brought to the attention of the USACE and the Task Force during meetings in 2010. These potential beneficial use opportunities were then screened using four preliminary threshold criteria in order to identify those alternatives that were considered potentially feasible and that should be further evaluated. The following summarizes the beneficial use opportunities identified and the results of the initial threshold screening.

2.1 Beneficial use opportunities identified in the 2009 draft DMMP-EIS

The 2009 DMMP-EIS identified mine land reclamation, littoral nourishment, soil manufacture, wetlands/habitat creation, and landfill cover as potential beneficial uses of Cleveland Harbor dredged sediment. However, none of these alternatives were considered feasible nor carried forward for detailed analysis due to a lack of information and inability to refine the management concepts for beneficial use. Data gaps were subsequently identified and additional data were collected permitting refinement and reevaluation of these beneficial use alternatives.

2.1.1. Mine land reclamation –

Mine land reclamation was not further developed in the 2009 DMMP-EIS due to the inherent high cost associated with transporting dredged sediment from Cleveland to distant mine sites in southern Ohio. However, new opportunities have been identified that are local to the Cleveland area. The restoration of several quarry sites used for sand and gravel production in Cuyahoga and Erie Counties have been reviewed and are considered in more detail in this report.

2.1.2. Littoral nourishment –

Littoral nourishment was not carried forward for detailed planning in the 2009 DMMP/EIS because dredged material did not meet Ohio Department of Natural Resources (ODNR) and OEPA generic guidance for beach nourishment projects. ODNR guidance specifies that materials used for beach littoral nourishment consist of sand (> 60 percent coarse-grained sediment) and have low total organic carbon (TOC) content (< 0.5 percent). In this study, sediments located at Edgewater Park (along the Cleveland waterfront - Perkins Beach) were characterized for grain size and TOC; these data were then compared to the coarser-grained sediment deposited at the head of the Cuyahoga River navigation channel. The site-specific data on Cleveland waterfront beaches collected in this study provide a better definition of the suitability of dredged sediment for local beach nourishment projects, which may have more fine-grained sediment or higher TOC than state-wide average values.

2.1.3. Top soil and soil manufacture –

The use of sediment for top soil and soil manufacture was not carried forward for detailed planning in the 2009 DMMP-EIS due to the presence of trace level contaminants in dredged sediment and the potential risk to human health. However, only limited data were available on the concentration of trace level contaminants present in channel sediment during preparation of the 2009 DMMP-EIS. No additional data had been collected on sediment quality since 2007, and the analyte groups measured were not sufficient for conducting a detailed assessment of potential risk to human health. A detailed analysis of trace level contaminants was conducted in 2010 to fill this data gap. In addition, the potential risk to human health under various land use scenarios, including residential, recreational, and commercial/industrial, was evaluated in this study to determine the suitability of dredged material as soil.

2.1.4. Wetlands/habitat creation –

The use of dredged material for wetlands/habitat creation is evaluated in more detail within this report. The concept of using dredged material for wetland habitat creation was not carried forward in the 2009 DMMP-EIS due to the presence of trace level contaminants and the need to prevent the transport of fine-grained material in high energy environments along the Erie lakeshore, particularly outside of Cleveland Harbor property. This report has included a more detailed characterization of the trace level contaminants present in the navigation channel sediment, including the assessment of contaminant bioavailability and potential for toxicity. In addition, potential use of dredged material has been expanded to include the assessment of using dredged sediment beneficially for the restoration of upland habitats.

2.1.5. Landfill cover –

Landfill cover was not carried forward in the 2009 DMMP-EIS because the only active landfills available to accept dredged material as daily cover were located in Ashtabula, Lake, and Lorain Counties. These landfills ranged from 30 to 50 miles from Cleveland. Use of dredged material as cover for active landfills was deemed infeasible due to the high cost of material handling and transportation as well as the potential community impacts associated with the volume of truck traffic. Since the 2009 DMMP-EIS, several inactive landfills located in Cuyahoga County have been identified that require final cover for closure and redevelopment. The transportation cost to these sites is substantially lower than the cost to sites located outside of Cuyahoga County. In addition, approximately 300,000 CY of material was harvested from CDF 10B during 2010 (Figure 2-1) and transported by truck to the Cuyahoga Valley Industrial Center Brownfield redevelopment project; therefore, current, reliable transport cost information was available for this study. The use of dredged material for local landfill closure and redevelopment projects is evaluated in detail in this report.

Figure 2-1. Excavation in 2010 at existing CDF 10B for re-use at the Cuyahoga Valley Industrial Center.

2.2 Preliminary threshhold screening criteria

Preliminary threshold criteria were used for initial screening of opportunities so that the most promising beneficial use alternatives could be identified while those opportunities that did not meet minimum threshold requirements could be removed from further consideration. The preliminary threshold criteria included:

1. Volume > 50,000 CY per project

   To be selected for further consideration, a beneficial use opportunity needed to utilize more than 50,000 CY of material; this volume was considered the threshold necessary for covering the associated project management and administration costs. Some beneficial use concepts consisted of continuous operations such as the Streamside proposal for harvesting coarse grained sediment and use for construction aggregate or beach nourishment. The volume of material beneficially used by these projects was not considered on an annual basis.

2. Compliance with Federal, State, and local laws and ordinances

   A beneficial use alternative must comply with Federal, State, and local laws and ordinances. If a project was deemed to fundamentally violate existing laws or ordinances, it was removed from further consideration. In some cases, technical modifications to a proposed plan not in compliance or compensatory actions included in the plan may bring the proposed project into compliance.

3. Alternative has not been previously rejected

   Opportunities that have been previously determined to be unacceptable following an analysis of engineering suitability, concerns regarding protection of human health or the environment, acceptability to regulatory agencies or cost were not reconsidered in this effort. New data or modifications to the proposed approach for beneficial use of dredged sediment warrant review of beneficial use opportunities that may have been previously determined to be not feasible.

4. Information available is adequate for a preliminary evaluation of project feasibility

Proposed projects with inadequate information for initial threshold screening following the 2010 sediment sampling and analysis program were not carried forward for detailed review at this time.

2.3 Beneficial use opportunities identified by the Task Force

During 2010, the Task Force and USACE identified 16 opportunities that warranted additional investigation for potential beneficial use of dredged material. In addition, several unsolicited proposals were brought to the attention of the Cleveland-Cuyahoga County Port Authority and the USACE during the 2010 meetings. The beneficial use opportunities and sites identified included:

Mine land reclamation

- Kelleys Island Quarry closure (Kelleys Island Quarry)
- Mill Creek Quarry closure (Mill Creek Quarries Restoration)

Structural fill and top soil - Brownfield/Urban Construction Projects

- Cuyahoga County/Cleveland vacant property rehabilitation (Cleveland Vacant Properties)
- General Chemical and other Brownfield redevelopment projects (Ditchman Brownfield Proposal)
- Kingsbury Run Brownfield redevelopment (HGC Brownfield Proposal)
- ODOT Innerbelt and Lakefront West road construction projects (Innerbelt & Lakefront West Projects)

Structural fill and top soil – Landfill closure and redevelopment

- Brook Park Landfill redevelopment (Brook Park Landfill)
- Harvard Landfill closure (Harvard Landfill)
- Silver Oak Landfill closure (Silver Oak Landfill)

Wetland/Submerged sediment environmental remediation

- Dike 14 hotspot cap (Dike 14 Hotspot Cap)
- Old River Channel remedial cap (Old River Cap)

Wetland Aquatic Habitat Restoration

- No site defined

Beach Nourishment

- Perkins Beach and other sites

Construction Aggregate

- In-situ harvesting of coarse-grained sediment (Streamside Proposal)
- Manufacturing of lightweight aggregate (Harbor Rock Proposal)

Create additional CDF capacity

- Extend CDF 10B for Burke Airport expansion

In addition to evaluating the potential end uses for dredged material, a key component for evaluating the feasibility of any beneficial use alternative is the material handling required to dewater and prepare the dredged material for transportation and placement. A detailed description of the sites proposed for material handling is presented in Chapter 6. The four material handling sites considered include:

- Cuyahoga Valley Industrial Center Brownfield redevelopment project (CVIC Material Handling)
- Continued use of existing waterfront CDFs (Lakefront CDFs)
- Industrial recycling property along upper Cuyahoga River (Upper River site)
- Industrial Brownfield property at Cuyahoga River turning basin (Zaclon Site)

The following sections provide a brief description of the beneficial use opportunities identified for consideration and an assessment on the feasibility of a project based on preliminary screening criteria. The locations of sites described below are identified in Figure 2-2.

2.3.1 Kelleys Island Proposal

The Kellstone Quarry is a 62.5 acre inactive limestone quarry on Kelleys Island in Erie County, OH located approximately 55 miles from Cleveland. LaFarge, which owns the quarry, is an international building materials company specializing in cement, aggregate, concrete, and gypsum manufacturing. LaFarge has proposed that the inactive quarry be used for placement of dredged materials from the Toledo and Cleveland harbors as a means to close and ultimately redevelop the mine site for other uses. The

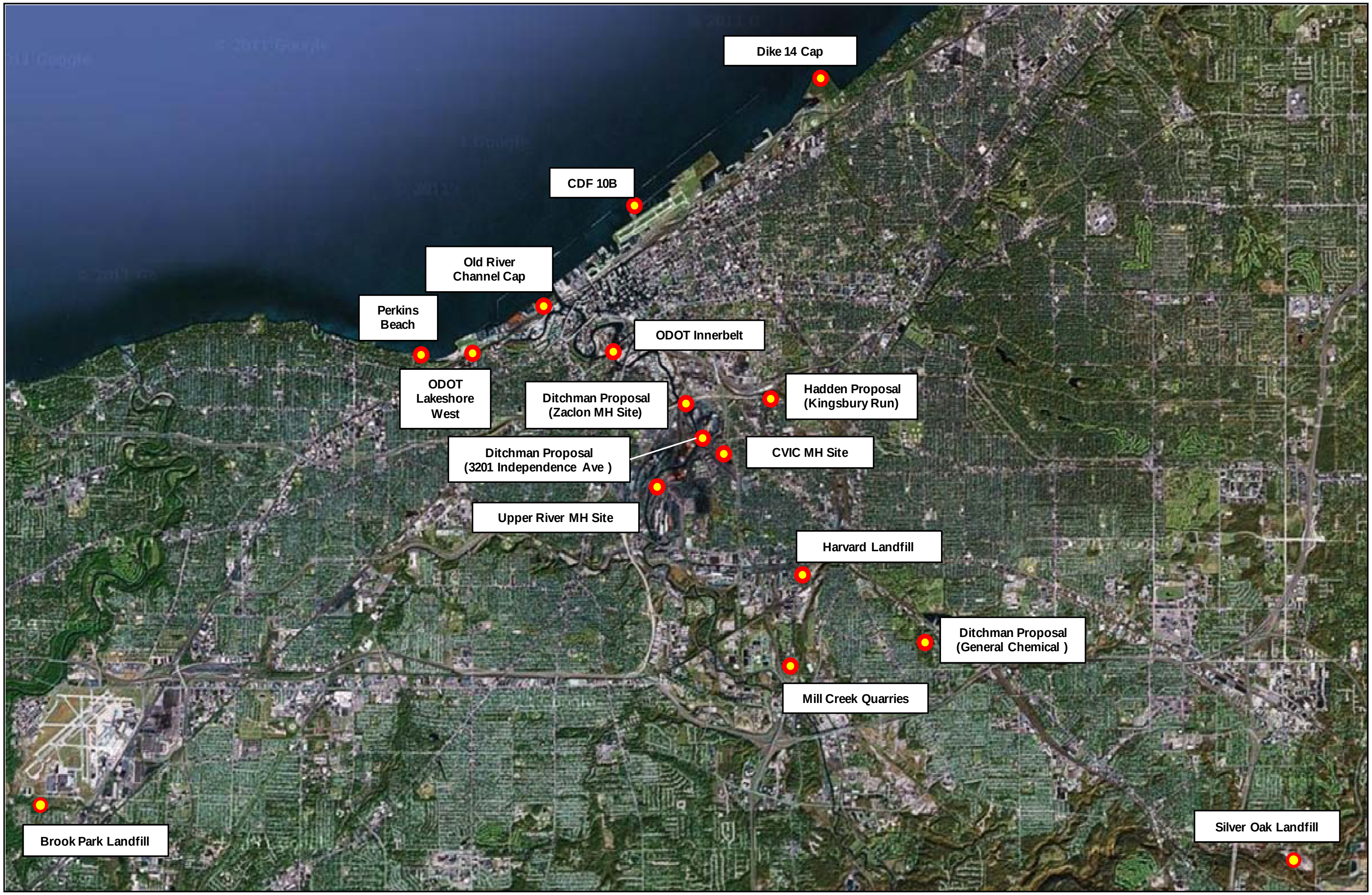

Figure 2-2. Area locations of beneficial use opportunities and material handling sites.

quarry is capable of receiving nearly 7 million CY of dredged material. LaFarge has prepared conceptual plans for transporting dredged material from Cleveland Harbor via barge and placing it in the quarry as fill. Preliminary engineering, human health, and ecological risk assessments have been conducted by LaFarge to evaluate the feasibility of the project. The OEPA has rejected LaFarge's analysis that there will be no significant impact to the local groundwater aquifer used for drinking water. OEPA has concluded that the quarry is not a suitable disposal site for dredged material due to the sensitive nature of the site's hydrogeologic setting (Baker 2010). Additional analysis of engineering designs to minimize the hydraulic transport of trace level contaminants and potential impact to the groundwater aquifer surrounding the quarry have not been proposed. Given the current lack of State regulatory support for the current proposal, this beneficial use opportunity is not deemed feasible at this time.

2.3.2 Ditchman Brownfield Proposal

The Ditchman Brownfield Proposal (Figure 2-3) is an unsolicited proposal provided by Joseph P. Ditchman, Jr., of Ditchman Holdings, LLLP. The proposal includes dewatering and material handling of dredged material at 2981 Independence Road (Zaclon property located adjacent to the Turning Basin), transportation, and beneficial use of dredged material as fill at several industrial Brownfield sites. The industrial Brownfield sites include 3201 Independence Road and/or the General Chemical site located at 5000 Warner Road. All three properties are owned by third parties and execution of the proposal by Ditchman Holdings will require completion of real estate transfer and/or use agreements. Mr. Ditchman has secured options to buy/use these properties. The 3201 Independence Avenue site covers approximately 11 acres and is located 1.3 miles from the Zaclon site. The General Chemical Brownfield site is a 54-acre parcel that is 5.2 miles from the Zaclon site. The concept provided by Mr. Ditchman includes placement of 225,000 CY of dredged material per year for 10 years at these Brownfield sites, providing a potential estimated total capacity greater than 3 million CY. The end use of these Brownfield sites is expected to be commercial/industrial. A conceptual plan has been prepared by Mr. Ditchman that includes design of a mechanical dewatering system and construction of a material handling facility for receipt of dredged sediment hydraulically delivered to the Zaclon site by others. Redevelopment of the Zaclon site will require coordination with ongoing Resource Conservation and Recovery Act (RCRA) environmental regulatory actions by the responsible parties and demolition of several buildings prior to

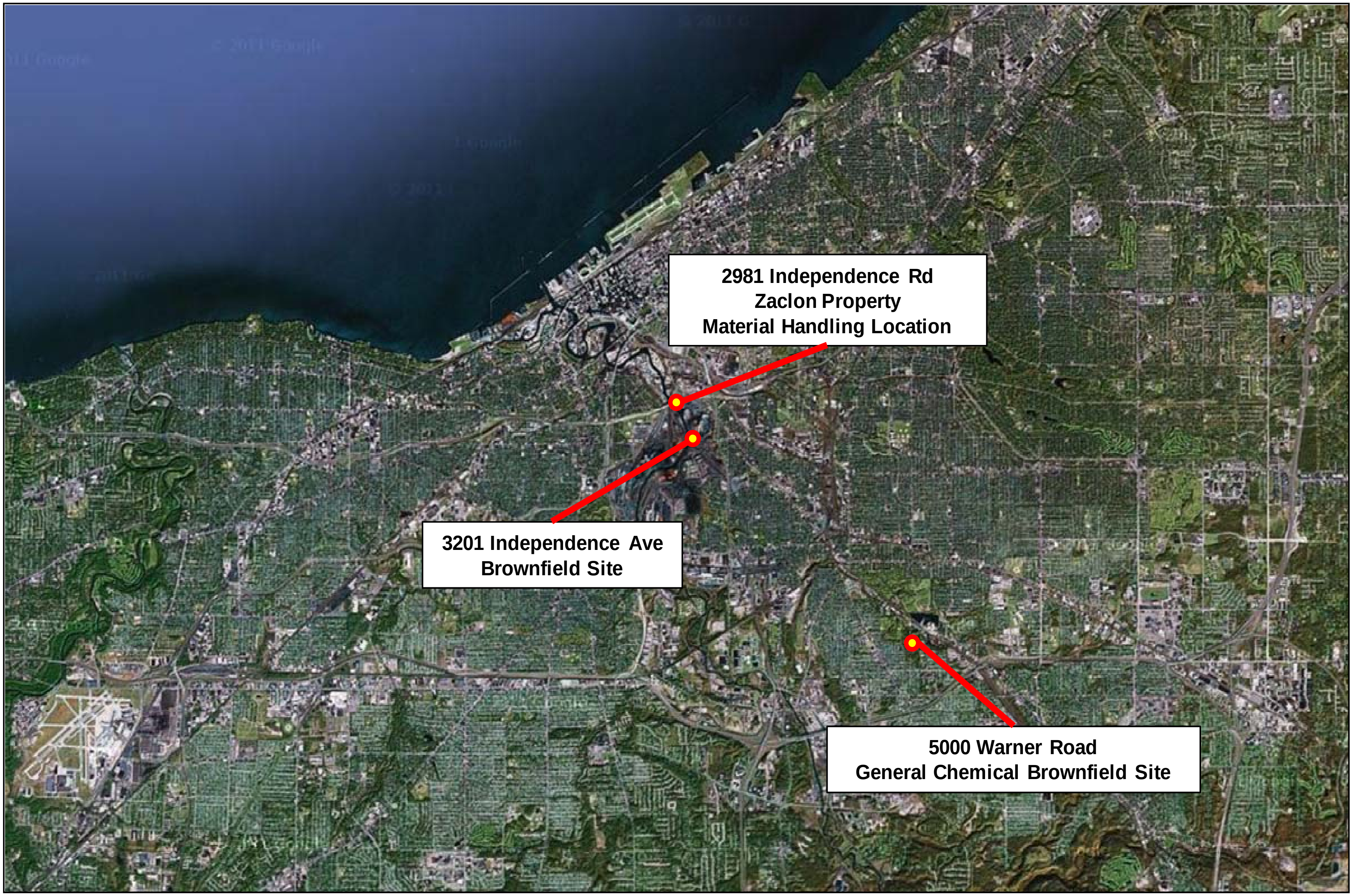

Figure 2-3a. Ditchman Proposal – Location of material handling and brownfield redevelopment sites.

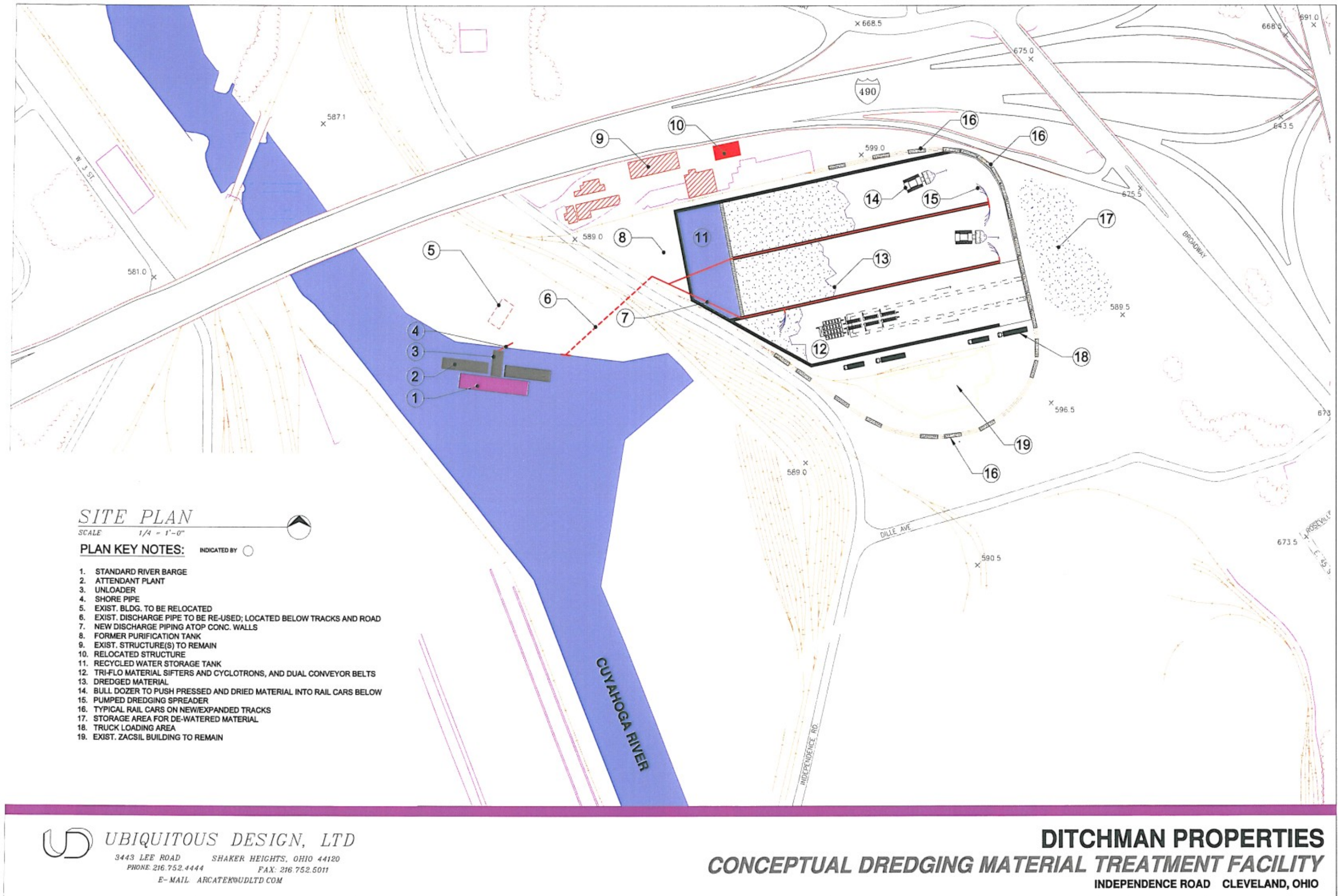

Figure 2-3b. Ditchman Proposal – Cuyahoga River Material Handling Facility conceptual design.

construction. Anticipated costs, financing requirements, and schedule for developing an operating facility have been provided in an informal proposal. The information provided is adequate for preliminary feasibility evaluation of this beneficial use opportunity.

2.3.3 Mill Creek Quarries

The Mill Creek Quarries are located at the intersection of East 131st Street and Broadway. The quarries are owned by Garfield Alloys and Catholic Cemeteries Association. A series of studies have been conducted that provide a comprehensive look at restoration of the quarries, adjacent wetlands, and surface stream. The project area contains a 50-acre former sand quarry having two borrow pits surrounded by a 17-acre stream corridor. Fill plans have been developed that include placing more than 20 feet of material into the pits providing approximately 1,300,000 CY of capacity for the beneficial use of dredged sediment. The OEPA has rejected the proposed use of dredged sediment as fill for this project due to the contaminant levels in the material, the sensitive nature of the hydrologic setting of the former sand quarries, and the potential impact on ground water resources. Dredged material placed into quarries would be in direct communication with highly permeable sand and gravel or fractured bedrock aquifers. For this reason this beneficial use alternative was not deemed feasible.

2.3.4 Extend CDF 10B

One of the significant features associated with the location of Cleveland's shoreline CDFs is the presence of Burke Lakefront (BKL). The BKL Airport (Figure 2-4) was constructed entirely on fill placed on the Lake Erie bottom. Officially opening in 1947 as the Cleveland Lakefront Municipal Airport, it has been expanded in size over the years by the disposal of dredged material and construction debris. Today the airport is approximately 480 acres in size and has modern airport facilities to land commercial jetliners and serves as a reliever airport for Cleveland Hopkins International airport. The extension of CDF 10B (Figure 2-5) to the west and creating new land to the northwest of the airport will provide an additional margin of safety for landings and takeoffs. The proposed extension for CDF 10B would create approximately 1 million CY of additional storage capacity. The information necessary for evaluating this beneficial use opportunity is adequate for preliminary screening.

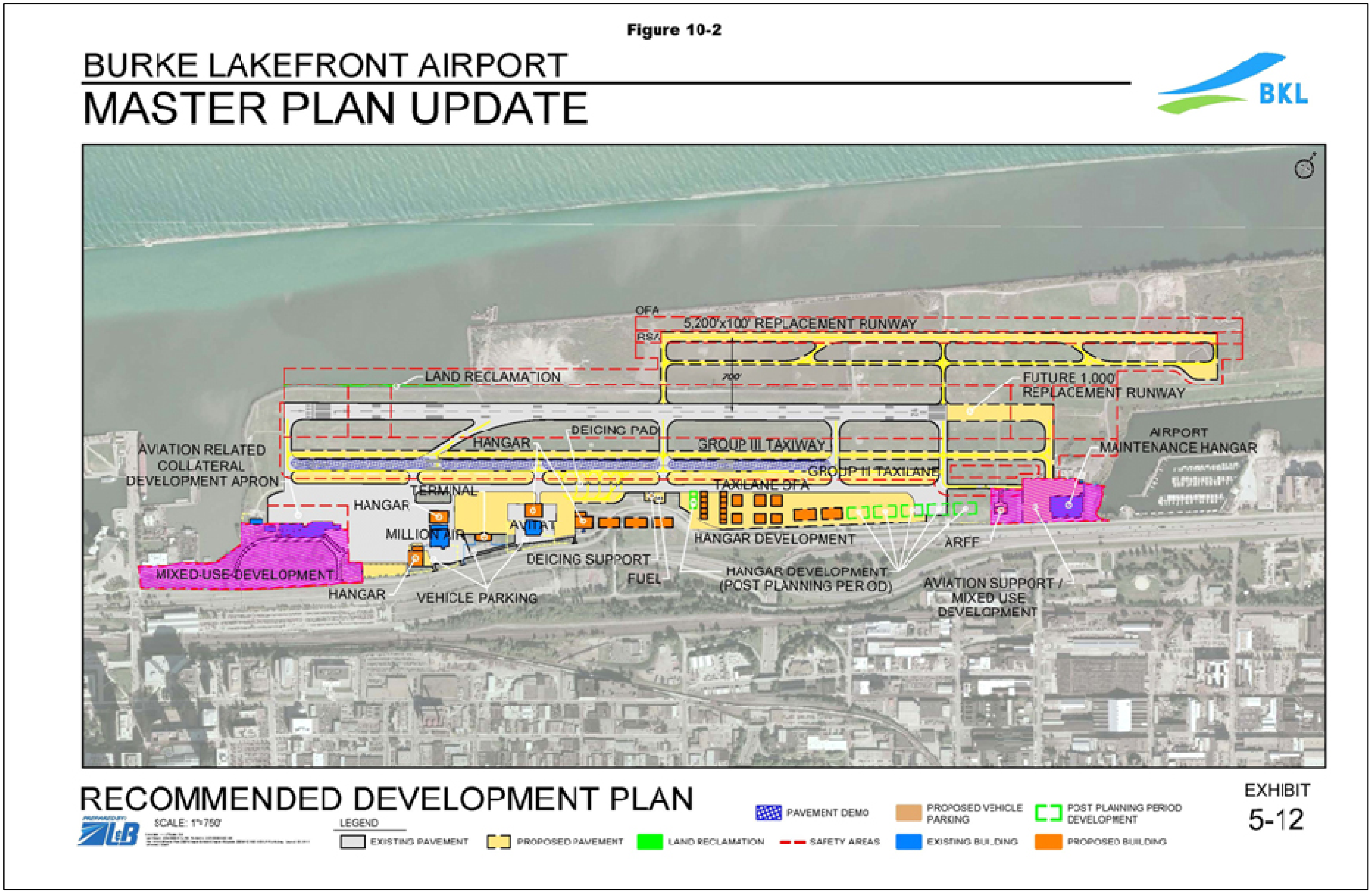

Figure 2-4. Burke Lakefront Airport Master Plan.

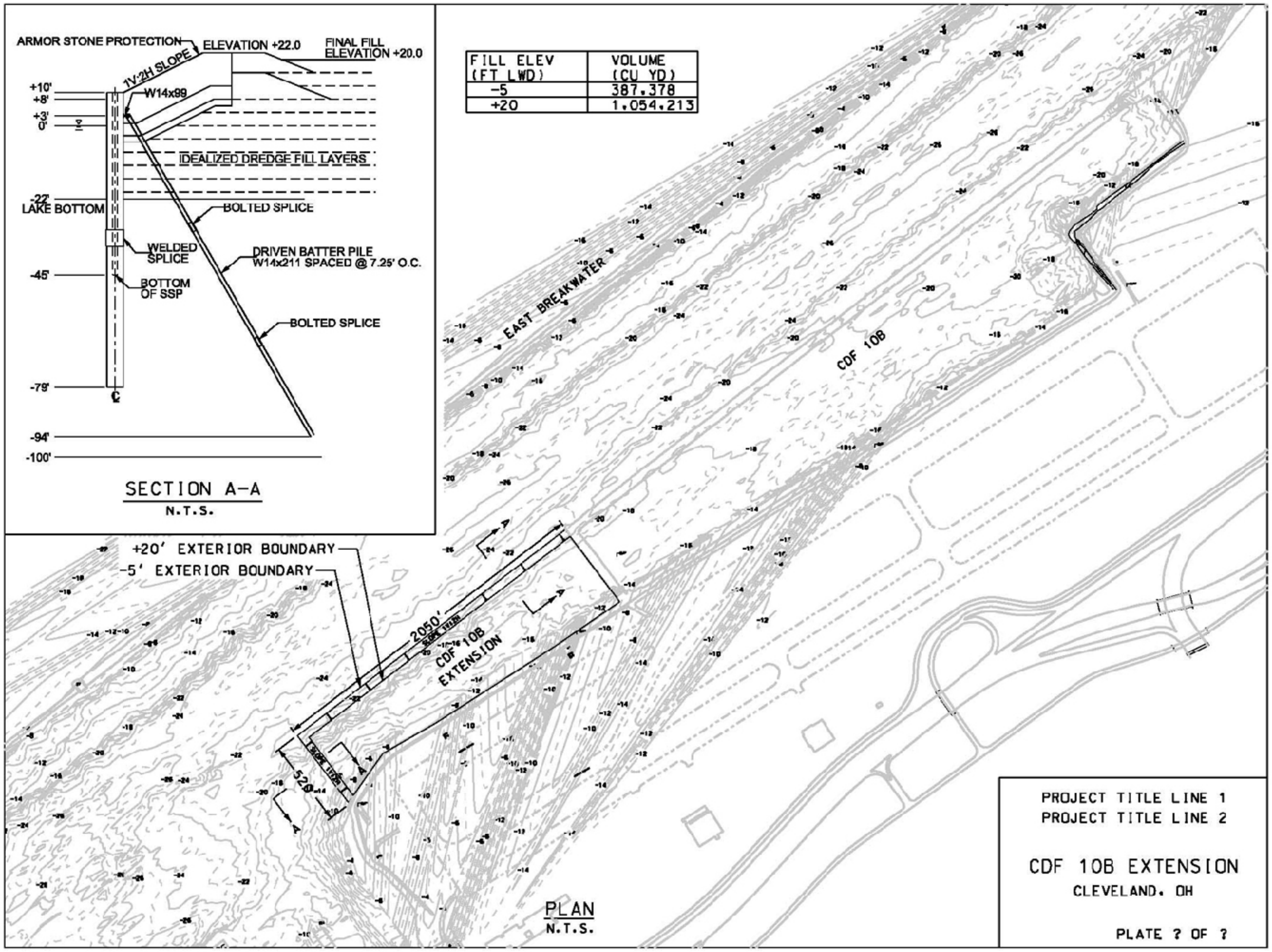

Figure 2-5. CDF 10B extension.

2.3.5 Brook Park Landfill

The Brook Park Landfill is a 28-acre site located south of Hopkins Airport that is owned by the City of Cleveland (Figure 2-6). The City is currently developing plans for capping and filling the former landfill in order to accommodate industrial redevelopment of the site and potential use as a solar collection farm. The site is easily accessible for truck transportation and has a capacity for accepting 350,000 to 500,000 CY of dredged material depending on the final site redevelopment plans. Redevelopment of the site will require geotechnical survey and engineering analysis of site stability, storm water control, and protection of the adjacent Abrams Creek. The City intends to conduct environmental and geotechnical assessments in 2011 to confirm the feasibility of redeveloping the site. The site is anticipated to be ready for receiving dredged material as early as 2012, pending studies and preparations by the City. The information provided is adequate for preliminary evaluation of the potential feasibility of this beneficial use opportunity.

2.3.6 Silver Oak Landfill

Silver Oak Landfill is a 27-acre inactive construction and demolition landfill located on a 49 acre site at 26101 Solon Road (Figure 2-7). The landfill is licensed to Silver Oak Land Development Inc. and owned by Glenda Grezlek. Negotiations for closure of the landfill under OEPA rules are currently underway between the landfill owner's representative and the Cuyahoga County Board of Health. Closure of the landfill will require recontouring the landfill and construction of a recompacted cap requiring a minimum of 100,000 CY of suitable imported fill. Due to the current configuration of the landfill and waste present, construction of the final cap and vegetative cover may require a modification to the original landfill design and permit. The site is adjacent to the Cleveland MetroPark Bedford Reserve, which follows Tinker Creek. This is a high quality recreation area that includes picnic areas, hiking trails, and horseback riding trails. Upstream of the landfill, Tinkers Creek drops 220 feet over a 2-mile reach where a steep, walled gorge is the dominant landform surrounding the Creek. The gorge, declared a National Natural Landmark, is a unique area with numerous tree, shrub and flower species. Additional dredged material could be used for recontouring and landscaping the closed landfill for use as an upland nature preserve, creating the opportunity to use an additional 200,000 CY of dredged material beneficially. The information currently available is adequate for preliminary screening of the feasibility of this beneficial use opportunity.

Figure 2-6. Brook Park site map.

Figure 2-7. Inactive Silver Oak Landfill.

2.3.7 Dike 14 Cap

The Cleveland Lakefront Nature Preserve (Dike 14) is an 88-acre CDF on Cleveland's eastside along Lake Erie. Approximately 6 million CY of sediment dredged from Cleveland Harbor was placed into Dike 14 from 1979 to 1999. In 1999, the site was turned over to the Cleveland-Cuyahoga County Port Authority and is currently managed as a nature preserve. In 2007, soil and water samples were collected from Dike 14 to determine the concentration of trace level pollutants present and to evaluate potential risks to humans (adults and children) and wildlife that might use the site. The results of the study conducted by OEPA showed that the site can be used safely as a nature preserve and recreation site for hiking and bird watching. A 5-acre portion of the Dike has pollutants that include polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and lead. These pollutants are present at levels above standards established by OEPA for residential land use. Remedial action at the 5-acre portion of Dike 14 has been proposed to reduce potential future exposure to humans and wildlife. The preliminary remedial plan is to place a 4-foot cap of clean soil on top of the area that has elevated concentrations of contaminants. Approximately 28,500 CY of material would be needed to cover the 5-acre area. The information currently available is adequate for preliminary evaluation of the feasibility of this beneficial use opportunity; however, the alternative does not meet the minimum volume requirements established in the screening specifications.

2.3.8 Beach Nourishment

USACE, in coordination with USEPA and OEPA, have previously determined that some sandy material accumulated at the upstream limit of the Cuyahoga River Navigation Channel may be used for beach nourishment, depending on future chemical characterization and toxicity test results. However, the Ohio Department of Natural Resources (ODNR) and OEPA have determined that the dredged material does not meet generic specifications requiring the use of coarse-grained materials having a low TOC for littoral nourishment. Consequently, beach nourishment was not carried forward to detailed planning in the 2009 DMMP-EIS. Additional data have been collected in this study to characterize the grain size and TOC present in the submerged sediments located at Edgewater Park along the Cleveland waterfront (Perkins Beach, Figure 2-8) and to compare these data to the coarse-grained sediments deposited at the head of the Cuyahoga River navigation channel. The additional information on the characteristics of sediment located at Edgewater Park will provide the data necessary for assessing the suitability and acceptability of using dredged material for beach nourishment specific to Cleveland's waterfront parks. The available information, supplemented with the new data, is adequate for preliminary evaluation of this beneficial use alternative.

2.3.9 Wetland Habitat Restoration

The use of dredged material for wetland habitat creation was originally considered as part of the 2009 DMMP-EIS. However, the concept was not carried into detailed planning due to the presence of trace-level contaminants and the potential for transport of fine-grained material when placed outside of Cleveland Harbor proper. This report provides a more in-depth analysis of the trace level contaminants present in recently deposited sediments that required dredging, including contaminant bioavailability and potential to result in toxicity to both aquatic and terrestrial organisms.

Figure 2-8. Location of Perkins Beach on the Cleveland waterfront.

The potential use of dredged material has been expanded to also include restoration of upland habitat for birds and wildlife. Creation of wetland habitat with emergent and submerged aquatic vegetation requires low energy environments where fine-grained sediment will remain in place with only modest levels of on-shore drift. Areas within the existing Cleveland Harbor breakwater may be suitable for creation of emergent wetland habitat following the construction of low dikes to maintain sediment beds for aquatic vegetation. One potential area suggested for wetland habitat restoration by stakeholders includes the backwater adjacent to Whiskey Island and the historic Coast Guard Station. Since no specific sites for wetland creation have been identified to date, the information currently available is considered inadequate for preliminary evaluation of this beneficial use opportunity. However, creation of wetland habitat could potentially use large volumes of dredged material. This study therefore included an assessment of the suitability of dredged material for wetland habitat creation for future Dredged Material Management Planning.

2.3.10 HarborRock Proposal

In April 2010, HarborRock provided an unsolicited proposal to the Task Force and USACE for manufacturing an extruded lightweight aggregate from dredged material. The Company has developed a high temperature process that is capable of producing a chemically inert lightweight aggregate that meets American Society for Testing and Materials (ASTM) standards for structural concrete and concrete masonry units (ASTM C330 and C331). Lightweight aggregates are intended for use where the prime consideration is reducing product density while maintaining compressive strength. Products using lightweight aggregate include masonry block, ready mix concrete, pre-cast concrete, asphalt, and engineered fill. The HarborRock manufacturing process requires (i) screening to remove unusable materials, (ii) grinding and extrusion to form pellets, (iii) firing the material in a rotary kiln operating at 2,000°F, and (iv) crushing and grading the material to meet customer requirements. Manufacturing lightweight aggregate would require development of a manufacturing facility on a 12-acre industrial site adjacent to the Cuyahoga River. The manufacturing facility would generate local construction, manufacturing, and transportation jobs. A preliminary estimate of the cost for managing sediment using the HarborRock process is approximately $35 CY. To (1) evaluate the feasibility of manufacturing lightweight aggregate and (2) design the manufacturing process, HarborRock proposed conducting a material testing and a pilot demonstration project at a cost of $510,000. Until this pilot-scale testing is conducted, the information currently available is inadequate for preliminary evaluation of this beneficial use opportunity.

2.3.11 HGC Kingsbury Run Proposal

An unsolicited proposal was provided to USACE from Ken Hadden of HGC Inc to perform a multiphase program designed to develop a material handling strategy for hydraulic transport of dredged sediment from the Cuyahoga River to dewatering facilities located in Kingsbury Run, return of the dredge water back to the Cuyahoga River, and placement of dewatered sediment in the Kingsbury Run, local landfills, and other Brownfield redevelopment sites. The Kingsbury Run Valley is a former industrial area approximately 3 miles from the Cuyahoga River. It is located between the North Broadway and Kinsman neighborhoods, extending south and east from the rail lines to East 79th Street. HGC proposes to conduct a demonstration project and develop the data necessary to estimate the cost and feasibility of the project. HGC Inc. have requested $50,000 from the Task Force for conducting the demonstration project. The information currently available is inadequate for preliminary evaluation of the feasibility of this beneficial use opportunity until additional engineering analysis and demonstration a project are conducted.

2.3.12 ODOT Innerbelt and Lakefront Projects

The Ohio Department of Transportation (ODOT) Innerbelt and Lakefront West projects are major roadway construction projects being initiated in Cleveland. The ODOT Cleveland Innerbelt Modernization Plan is focused on improving safety, reducing congestion and traffic delays, and modernizing interstate travel along I-71, I-77, and I-90 through Downtown Cleveland. These projects will rehabilitate and reconstruct the Innerbelt Freeway system, including construction of two new bridges to carry I-90 traffic. The Lakefront West Project is designed to connect Cleveland's west side neighborhoods with the lakefront along the West Shoreway between West Boulevard and the Main Avenue Bridge. The Lakefront West Project will increase access to Lake Erie, improve green space, biking and pedestrian facilities and simplify connections along the now limited-access freeway. During Phase II of the proposed project, this 2.5-mile freeway will be transformed into a scenic, tree-lined boulevard. During the fall of 2010, the Innerbelt bridge project was initiated by award of a design-build contract to the Walsh Group. Construction of the new I-90 westbound bridge will begin during the spring of 2011, and completion of the new eastbound bridge is scheduled for 2016. Although the design for the new bridge has not been finalized, approximately 80,000 CY of top soil will be required in 2015 near the end of construction. Landscaping associated with the Lakefront West project is anticipated to require additional large quantities of top soil as this project proceeds. The information currently available is inadequate to establish the feasibility of this beneficial use opportunity until the volume requirements and specifications for top soil and fill material are developed by the General Contractor and agreed upon by ODOT.

2.3.13 Harvard Landfill

The Harvard Landfill is at 7720 Harvard Avenue in the Garfield Heights and Cuyahoga Heights neighborhoods of Cleveland. The landfill consists of an operating construction and demolition debris (C&DD) landfill, a closed C&DD landfill, and a closed municipal solid waste landfill located within the jurisdiction of the City of Cleveland and Cuyahoga County health departments. The landfills are located on both sides of Mill Creek with steep embankments that drop 50 to 100 feet down to the creek. In some locations, the landfill contents are exposed on the current landfill embankments that drop to the creek bed. One concept that has been proposed for landfill closure is the routing of Mill Creek through a culvert and placing fill above the section of the creek bed that would be modified. The fill required for this site-closure strategy would be substantial and is estimated to require more than several million cubic yards of imported material. The OEPA has indicated that routing Mill Creek through a culvert and eliminating aquatic habitatwould potentially violate Ohio law developed to prevent the degradation of the State's water resources (OAC Chapter 3745-1-05 (C) (1)). This landfill closure plan would require an environmental review, and if permitted, is expected to require significant engineering associated with the culvert design and environmental mitigation costs for loss of the State's water resources. With the potential for significant environmental mitigation costs, noncompliance with State environmental law, and current lack of OEPA regulatory support for the proposed project, this alternative is not currently deemed feasible.

2.3.14 Streamside Proposal

An unsolicited proposal to selectively harvest coarse-grained sediment (sands and gravels) as a means of reducing shoaling and associated dredged material volumes was given to the Task Force by James White, Executive Director of the Cuyahoga River Community Planning Organization and John McArthur, president of Streamside Systems, Inc. The proposal included payment to the vendor for dredging costs avoided by USACE based on the volume of sand and gravel selectively removed from the Cuyahoga River. Streamside technology for harvesting sediment consists of a mechanical box collector placed on the bottom of the river. The system is specifically designed to capture the bed load of sediment as it traverses along the bottom of the stream. The design of the collector is specific to stream hydrology and is a function of seasonal flows and sediment grain size of the stream bed load under the various flow regimes. Harvesting of sediment from the river was originally proposed for a location directly upstream of the Navigation Channel as a means to capture sand and gravel that would have economic value and to minimize collection of fine-grained sediment. Exclusion of the fine-grained sediment has been assumed to also result in a reduced concentration of trace-level contaminants in the harvested sand, thus increasing the suitability of the material for more end uses. A small-scale field pilot project was conducted by Streamside Systems that demonstrated the proof-of-concept. However, preliminary engineering analysis of the Cuyahoga River flow characteristics and characteristics of sediment in the Navigation Channel indicate that the majority of sediment requiring dredging consists of fine sand and silt that would not be collected by the Streamside System technology as currently proposed. Preliminary analysis of river flow characteristics indicated that fine sand and silt is not expected to be part of the stream bed load during the flow events responsible for the majority of sediment transport. Rather, during high flow events, fine sand and silt are predicted to be suspended in the water column and transported into the Navigation Channel, at which point they would be expected to settle out, resulting in infilling and shoaling in the Navigation Channel. The design requirements and equipment configuration required to capture fine sand and silt have not been developed. The technology vendor, Streamside Systems, and James White have proposed a pilot-scale demonstration of the technology prior to full-scale design and implementation. Until additional engineering and a pilot demonstration project are conducted, the information is inadequate for preliminary screening of this beneficial use opportunity.

2.3.15 Cleveland Vacant Properties

The abundance of vacant land and foreclosed properties in Greater Cleveland is seen as a serious problem. Pilot projects have been funded to turn vacant properties into community gardens, market gardens, orchards, vineyards, native plant projects, phytoremediation projects, stormwater management projects, pervious pavement parking lots, pocket parks, and side-yards. These pilot projects are being managed by Neighborhood Progress, Inc. with technical assistance from the Ohio State University Extension, ParkWorks, and the Cleveland Botanical Garden. The Cuyahoga County Land Reutilization Corporation (CCLRC), also known as the Cuyahoga County Land Bank, was formed to help return vacant and abandoned properties in Cuyahoga County to productive use, including urban agriculture. Over the past several years, an average of 1,000 residential properties have been demolished per year, requiring approximately 185 CY of fill for each foundation and site restoration. The City of Cleveland bids each job separately, spending approximately $2,500 to $4,000 per residential property to excavate foundations, fill, and reseed each site. The suitability of the dredged material for use in residential, recreational, and commercial/industrial land uses can be evaluated; however, the CCLRC and City face significant logistical constraints associated with the restoration of many small vacant land projects that may not be compatible with the needs for managing large volumes of dredged material by the Cleveland-Cuyahoga County Port Authority. Due to the logistical constraints of the vacant land rehabilitation programs, the current information is considered inadequate for evaluation of this end use. However, this study includes an assessment of the suitability of dredged material for residential, recreational and commercial/industrial land uses for future Dredged Material Management Planning.

2.3.16 Old River Channel

The use of dredged material for construction of a cap designed to cover contaminated sediments in the Old River Channel and the filling of a former industrial slip have been proposed as a future USEPA/Great Lakes Legacy Act (GLLA) remedial project or Great Lakes Restoration Initiative (GLRI) project. To date, preliminary engineering and volume estimates of material needed for a subaqueous remedial cap and fill for the slip have not been developed. Development of such a project by the USEPA or OEPA will take a number of years to initiate, develop remedial designs, and begin construction. The information currently available is inadequate for preliminary screening of this beneficial use opportunity. This alternative was therefore not carried forward for further analysis in this report.

2.4 Screening of Opportunities to Identify Alternatives for Detailed Consideration

Table 2-1 summarizes the opportunities listed in order of the volume of material that can be used beneficially. Four opportunities have been identified that meet the established screening criteria and warrant additional review and analysis. These include:

- Ditchman Brownfield sites,
- CDF 10B extension,
- Brook Park Landfill, and
- Silver Oak Landfill.

A number of beneficial use opportunities have been identified for which information is currently inadequate for initial screening. Many of these opportunities require significant technology evaluation, engineering design work, or a pilot-scale demonstration project prior to evaluating the feasibility of the opportunity. As additional information becomes available and the economics for dredged material management change over time, these opportunities should be reviewed as potential long-term options for dredged material management. Beach nourishment with coarse-grained sediment, manufacturing of light weight aggregate, creating a material handling facility/CDF at Kingsbury Run, use of dredged material for the ODOT Innerbelt and Lakefront Projects and in-situ harvesting of coarse-grained sediment for construction aggregate or beach nourishment all fall into this category and have the potential for using significant volumes of dredged material beneficially.

Table 2-1. Beneficial use opportunities identified

Beneficial Use	Site	Dredged Material Volume Requirements	Alternative is consistent with Federal, State or local laws & ordinances	Alternative has not been previously rejected	Information available is adequate for beneficial use assessment
Mine Land Reclamation	LaFarge Kelleys Island Quarry	~7,000,000	No - Placement of dredged sediment in quarries violates State law unless DM is no longer classified as a waste[1]	✓	✓
Industrial Brownfield Redevelopment	Ditchman Brownfield Proposal	~ 3,000,000	✓	✓	✓
Mine Land Reclamation	Mill Creek Quarries Restoration	~1,300,000	No- Placement of dredged sediment in quarries violates State law unless DM is no longer classified as a waste[1]	✓	✓
Waterfront development	Extend CDF 10B	~ 1,000,000	✓	✓	✓
Land Fill Closure/Redevelopment	Brook Park Landfill	350,000 – 500,000	✓	✓	✓
Land Fill Closure/Redevelopment	Silver Oak Landfill	~ 150,000	✓	✓	✓
Environmental Remediation	Dike 14 Cap	~28,500	✓	✓	✓
Littoral Habitat Restoration	Beach Nourishment	Potentially large	✓	Review site-specific data	Review site-specific data
Wetland Habitat Restoration	No site defined	Potentially large	✓	✓	No
Construction/Aggregate	HarborRock Proposal	Potentially large Market driven	✓	✓	No

Table 2-1. Beneficial use opportunities identified (continued).

Beneficial Use	Site	Dredged Material Volume Requirements	Alternative is consistent with Federal, State or local laws & ordinances	Alternative has not been previously rejected	Information available is adequate for beneficial use assessment
Industrial Brownfield Redevelopment	HGC Kingsbury Run Proposal	Potentially large	✓	✓	No
Construction/Top soil	ODOT Innerbelt & Lakefront Projects	Potentially large	✓	✓	No
Land Fill Closure/Redevelopment	Harvard Landfill	Potentially large	No – Diversion of Mill Creek into culvert is expected to violate antidegradation provisions of State law that protect existing beneficial uses of water resources. unless environmental impacts are mitigated[2]	✓	No
Construction/Aggregate	Streamside Proposal	Potentially large	✓	✓	No
Vacant Land Redevelopment	Cleveland Vacant Properties	Unknown	✓	✓	No
Environmental Remediation	Old River Channel	Unknown	✓	✓	No

Note:

1) Ohio EPA classifies dredged material as “other waste" under ORC Chapter 6111-01. The current (2003) siting criteria limit the siting of solid waste landfills over sensitive ground water aquifers includes preventing solid waste landfills from operating within sand and gravel pits or limestone or sandstone quarries.

2) Ohio Administrative Code (OAC) Chapter 3745-1-05 (C) (1) Protection of water body uses. Existing uses, which are determined using the use designations defined in rule 3745-1-07 of the Administrative Code, and the level of water quality necessary to protect existing uses, shall be maintained and protected.

3 Analysis of Sediment Quality

3.1 Summary of Data Sources

As discussed in Chapter 2, preliminary screening identified four beneficial use alternatives for Cuyahoga River sediments that warrant additional review and analysis. These include 1) the Ditchman Brownfield Proposal for redevelopment of industrial Brownfield sites, 2) extension of CDF 10B to improve airport safety, 3) closure and redevelopment of Brook Park Landfill for future industrial use, and 4) closure of Silver Oak Landfill and site redevelopment for potential recreational use. Available physical, chemical, and biological data for the Cuyahoga River sediments were used to assess physical suitability of the material and contaminant mobility pathways associated with these beneficial use options, and to identify critical data gaps relevant to the beneficial use evaluation.

Before sampling in November 2010, four primary sources of data were available: 1) USACE 2002 Harbor Condition Report, 2) USACE 2007 Harbor Condition Report, 3) USACE 2007 Contaminant Monitoring Assessment Report for CDF 10B, and 4) Hull 2010 Materials Management Plan. Table 3-1 summarizes the data available in these individual reports.

3.1.1 Cuyahoga River Data

Historical Cuyahoga River sediment physical and chemical data from 2002 and 2007 were reviewed. In 2002, 30 sampling locations were used to characterize the river, and surface sediment sampling was conducted using a Petite Ponar dredge. Sediment samples taken in 2002 (CH-1 through CH-30 in Table 3.1) were characterized for grain size, and the following contaminants: PCBs (individual and total Aroclors), PAHs (individual and total), Total organic carbon (TOC), metals, ammonia nitrogen, and pesticides. Sediment samples were also composited into four sampling groups (i.e., CH-UPPER, CH-LOWER, CH-OLD, and CH-HARBOR) to be analyzed for standard elutriates, along with samples CH-1 and CH-2; sample locations making up each composite are provided in the footnotes of Table 3-1. The total and dissolved elutriate data include metals for the composite samples (i.e., CH-UPPER, CH-LOWER, CH-OLD, and CH-HARBOR), CH-1 and CH-2. Additionally, the CH-1 and

Table 3-1. Summary of Data Sources Prior to November 2010 Sampling

Location	*Media Type(s)*	*Parameter(s)*	*Label(s)*
		USACE 2002 Harbor Condition Report	
Channel	Sediment	Pesticides, PCBs, PAHs, metals, TOC, particle size, ammonia nitrogen	CH-1 through CH-30
Lake Reference	Sediment	Pesticides, PCBs, PAHs, metals, TOC, particle size, ammonia nitrogen	CL-1 through CL-4
Channel	Standard elutriate	Metals	CH-UPPER[6]; CH-LOWER[7]; CH-OLD[8]; CH-HARBOR[9]
		Metals, PCBs, Pesticides	CH-1; CH-2
		USACE 2007 Harbor Condition Report	
Channel	Sediment	Pesticides, PCBs, PAHs, metals, TOC, particle size, ammonia nitrogen, total cyanide	CH-1 through CH-30
	Bioassay	% Survival, wt	CH-UEMU
Lake Reference	Sediment	Pesticides, PCBs, PAHs, metals, TOC, particle size, ammonia nitrogen, total cyanide	CL-1 through CL-4
	Bioassay	% Survival, wt	CL-1 thru CL-4
Channel	Standard elutriate	Metals, PAHs, PCBs, pesticides, total cyanide, ammonia nitrogen	CH-UEMU[1]; CH-URMU[2]; CH-LRMU[3]; CH-OHMU[4]; CH-ORMU[5]
		USACE 2007 Contaminant Monitoring Assessment Report	
CDF10B	Soil	B/N/A, metals, volatiles, PCBs, pesticides, TOC, total cyanide	CCDF-1 through CCDF-3
	Sediment	B/N/A, metals, volatiles, PCBs, pesticides, TOC, total cyanide	CCDF-4 through CCDF-6
		Dioxin	CCDF-4
Dike Ponded Water	Water	B/N/A, metals, volatiles, PCBs, pesticides, total cyanide	CCDF-7
		Metals, total cyanide	CCDF-8, CCDF-9
Lake Reference	Water	B/N/A, metals, volatiles, PCBs, pesticides, total cyanide	CCDF-10
		Metals, total cyanide	CCDF-11, CCDF-12
CDF10B	Plant Bioassay	Select metals: As, Ag, Cd, Cr, Cu, Hg, Ni, Pb, Zn	CDF10B
	Earthworm Bioassay	% Survival, wt , PCBs	CDF10B
		Hull 2010 Materials Management Plan	
CDF10B	Soil	Volatiles, semi-volatiles, PCBs, pesticides, VAP metals	SB-1 through SB-8, SB10, SB-11
CDF10B	Soil	Soil profile descriptions, natural moisture content, organic content, optimum moisture content	TP#1 through TP#25

Notes:

[1] CH-UEMU: Composite from CH-1 - CH-5

[2] CH-URMU: Composite from CH-6 - CH-11

[3] CH-LRMU: Composite from CH-12 - CH-19

[4] CH-OHMU: Composite from CH-20 - CH-22

[5] CH-ORMU: Composite from CH-23 - CH-30

[6]CH-UPPER: Composite from CH-6-CH - 11

[7]CH-LOWER: Composite from CH-12, CH-14 - CH-19

[8]CH-OLD: Composite from CH-20 - CH-22

[9]CH-HARBOR: Composite from CH-23, CH-24, CH-26 - CH-29

CH-2 analyses included PCBs (individual and total Aroclors) and pesticides. Tables summarizing the results of the physical, chemical, and elutriate analysis for each sample are located in Appendices B, C, and D, respectively, of Engineering and Environment, Inc., 2002 (EEI 2002).

In 2007, 30 surface sediment samples were collected to characterize sediment quality using a Petite Ponar and/or Peterson Grab Sampler. The physical parameters included particle size and hydrometer analysis. The chemical parameters included PCBs (i.e., individual and total), PAHs (i.e., individual and total), TOC, metals, ammonia nitrogen, pesticides, and total cyanide. Also, sediments from several sampling locations were composited (i.e., CH-UEMU, CH-URMU, CH-LRMU, CH-OHMU, and CH-ORMU) for the analysis of standard elutriates; sample locations making up each composite are provided in the footnotes of Table 3-1. Total and dissolved elutriate data include metals, PAHs (i.e., individual and total), PCBs (i.e., individual and total Aroclors), pesticides, ammonia nitrogen, and total cyanide. Data tables summarizing the results of the chemical, elutriate, and physical analyses for each sample are found in Appendices B, C and D, respectively, of EEI (2007). Ten-day tests were conducted using the amphipod *Hyalella azteca* and the midge *Chironomus tentans*. The test endpoint for *H. azteca* was survival and the test endpoints for *C. tentans* were survival and growth (EEI 2007).

Based on the USACE 2007 Federal navigation channel sediments data reported by EEI, the USACE Buffalo District evaluated the Cleveland Harbor Federal Navigation Channel sediments and found sediment did not meet Federal guidelines for open-water placement; according to the preliminary tiered evaluation (based on existing information), this was true for all sediments dredged from all Cleveland Harbor Federal navigation channels (represented by sites CH-1 through CH-30) (USACE Tiered Evaluation).

3.1.2 Confined Disposal Facility (CDF) 10B

In 2007, the USACE conducted an assessment of Cleveland Harbor CDF 10B to determine if contaminants were migrating from dredged material within the CDF into the environment outside the facility, at levels that would pose a risk to human health or the environment. These data are relevant to the current beneficial use assessment in that much of the contaminant transport analysis could be applicable to a beneficial use site; the physical data gathered provide a basis for comparison to engineering specifications. “Data available for this assessment were from samples that were collected from CDF 10B media in 2004, and analyzed for organic and inorganic constituents, including VOCs, PAHs, PCBs, pesticides, metals, BNAs, cyanide, and dioxin. Media sampled included soils and sediments (and corresponding leachate), ponded water within the dike, water just outside the dike, and lake water.” The results of these analyses are located in Appendix A of the Contaminant Monitoring Assessment (2007). “The Tier I evaluation concluded that there is enough information to dismiss from further concern some of the contaminants in the CDF.” However, Tier II and Tier III evaluations were recommended to eliminate uncertainty for adverse effects of some contaminants where potentially complete exposure pathways were possible. The Tier III evaluation concluded that “contaminants in the Cleveland Harbor CDF 10B dredged material are below numerical criteria deemed suitable for beneficial uses. However, at this time, the suitability for beneficial uses may not be determined acceptable by such comparisons alone. Tier III plant and earthworm bioassays were conducted on CDF 10B dredged material and compared to the Cleveland Lakefront State Park (Reference)” (USACE 2007). Biological exposure tests following methods described in the Upland Testing Manual (USACE 2003) were conducted to evaluate soil-to-plant and soil-to-invertebrate pathways that could potentially result in biomagnification of contaminants into higher animals. Plant uptake of metals by *Cyperus esculentus* grown in dredged material from the CDF 10B did not exceed uptake from the reference material. Since the availability of metals-to-plant uptake in the CDF 10B was lower than from the reference soil, there is no increased risk associated with the plant uptake of contaminants from the CDF 10B. Other plant species, such as trees, may increase the uptake of some metals while others, such as fine fescues, can minimize uptake of metals. A lowering of pH over time may also increase metal uptake by plants. Management options to preclude conditions attributable to higher plant uptake of metals may include establishment of grasses, such as fine fescues, and monitoring of pH and subsequent liming to maintain pH levels above 6.5. Earthworms exposed to CDF 10B dredged material and reference material were analyzed for PCBs and DDT pesticides. While uptake of PCB (as Arochlor 1248) in the dredged material exceeded that of the reference material, the concentrations were determined to be well below minimum dietary concentration posing adverse risks to higher animals. DDT, DDE and DDD were also higher in earthworms exposed to dredged material compared to the reference material, but these concentrations were two orders of magnitude less than minimum dietary concentrations causing adverse effects to higher animals (USACE 2007). Water quality associated with discharge of runoff, effluent and leaching outside the CDF was compliant with Federal and State water quality standards.

The Draft Cleveland Dredged Material Management Plan and Environmental Impact Statement of 2009 (Draft DMMP-EIS, 2009) is based on EEI 2007 data. Results of the 2007 CDF 10B assessment concluded beneficial use of CDF 10B for its intended post-closure purpose for airport expansion would not result in elevated migration of contaminants to wildlife (USACE 2009). However, dredged material removed from the CDF and used for habitat creation or recreation was not evaluated in terms of beneficial uses and existing data were determined insufficient to address potential adverse impacts of dredged material used beneficially outside the Corps-managed CDF.

Hull and Associates, Inc. produced a Materials Management Plan (MMP) for Beneficial Use of CDF 10B Borrow Material in June 2010 that referenced four separate data collection efforts conducted in 2004, 2006, 2007 and 2009. Those data collection efforts are summarized in 1) an August 2007 Contaminant Monitoring Assessment, 2) a June 2008 Army Corps of Engineers Internal Memorandum on CDF 10B Beneficial Use, 3) an August 2007 Fill Material Evaluation, and 4) a September 2009 Independence Excavating In-situ Soil Assessment. Conclusions from the Contaminant Monitoring Assessment can be found above. According to the file memorandum, “the concentrations of constituents measured in the Cleveland 10B CDF dredged material would not preclude its use in a beneficial manner. The material in CDF 10B should be acceptable to use under Ohio EPA’s VAP for Brownfield reclamation in a construction, industrial, or commercial setting. However, the material in CDF 10B may not be acceptable to use under Ohio EPA’s VAP for Brownfield reclamation in a residential setting without further site-specific evaluation” (Keil 2008). The purpose of the Fill Material Evaluation “was to identify the various soil profile component and engineering characteristics of the subsurface materials encountered design engineers and architects to formulate design criteria for the fill placement.” Eight samples were submitted for TCLP VOCs, TCLP SVOCs, TCLP metals, and PCB analysis; the results of these parameters were less than the laboratory’s reporting limit. The Independence Excavating Assessment collected and analyzed six soil samples for pesticides, and all results were less than the laboratory’s detection limit (Hull and Associates 2010).

In addition to the four data sources above, Hull provided geochemical and geotechnical data. In November 2009, Hull drafted the "VAP Preliminary Data Summary and Risk Evaluation for the Use of Soil Materials from the Cleveland Harbor Dike 10B Confined Disposal Facility as Off-Site Fill" report. The report concludes: "based on the preliminary risk evaluation, the CDF materials are suitable for re-use in the specific commercial/industrial setting represented by the CVIC site, and construction workers will not be exposed to unacceptable hazards or risks during their work as a result of exposure to the CDF soil. The potential exposures of future commercial / industrial workers at the CVIC site to soil and groundwater to indoor air will need to be further evaluated as part of a voluntary action conducted at the CVIC property." A copy of the "VAP Preliminary Data Summary and Risk Evaluation" report is provided in Appendix M of Hull's 2010 MMP. In June 2009, two rounds of geotechnical explorations were completed by Hull at CDF 10B. The initial memo summarized that "usable dredge material could be used as compactable fill" and recommended the installation of additional sample locations to supplement the data. The later memorandum concluded that "based on the information collected by Hull and Joe Dirt (i.e., local contractor), approximately 190,000 cubic yards (CY) of sand may be available from the CDF, and as much as 826,000 CY of additional silt and silty sand material may also be available." Copies of both memoranda and associated attachments are provided in Appendix N of Hull's 2010MMP (Hull and Associates 2010).

3.1.3 Dike 14 CDF

Dike 14 was used as a disposal facility for Cuyahoga dredged material from 1979 until filled to capacity in 1999. After closing in 1999, it became known as a nature preserve for its extensive use by wildlife, particularly birds, in the heavily urban area. Interests by local citizens to have access to the site prompted the Cleveland Port Authority to investigate ecological and human risks associated with exposure to Cuyahoga dredged material historically disposed in the site. The 2007 Level I Ecological Risk Assessment (ERA) conducted on Dike 14 by Davey Resource Group and Partners Environmental Consulting, Inc. concluded that ecological stressors could be present in the soil found at the Dike 14 CDF. It was also concluded that important ecological resources are located at or in the vicinity of the site "due to the wetlands that exist on the site and the function this area serves as a refuge for migrating bird and butterfly populations, some of which are included on Federal and State rare, threatened, and endangered species lists." Partners Environmental Consulting, Inc. and Davey Resource Group recommended "that due to the soil contamination present at the Property, a Level II Ecological Risk Assessment (ERA) should be performed to determine any effects that the contamination may have on ecological receptors present on the site" (Davey Resource and Partners Environmental 2007).

"Based on the results of the soil screening performed by Partners Environmental Consulting, Inc. in the 2007 Level II Dike 14 ERA, the contaminants of potential ecological concern (COPECs) identified include: chromium, lead, selenium, mercury, and total PCBs. Candidate assessment endpoint species to be further evaluated for their impact from the identified COPECs include the American Robin, the Short-tailed Shrew, and the Meadow Vole. The exposure pathways present for the ecological receptors include exposure through incidental ingestion of soil and uptake of contaminants through predation of plants and soil invertebrates exposed to contaminated soil. Partners Environmental recommended further evaluation of the ecological risks posed by site related COPECs through the completion of a Level III ERA" (Partners Environmental 2007a).

"The results of the 2008 Level III ERA, completed by Partners Environmental Consulting, Inc at Dike 14, risk calculations show elevated risk levels present for the ecological receptors in Exposure Unit 2 (i.e., area surroundding sample locations 0204 and 0305). Reported risk calculations show somewhat elevated risk levels for the ecological receptors in Exposure Unit 1 (i.e., the area surrounding all sample locations except 0204 and 0305) for PCBs. A remediation goal level for PCBs was determined by manipulating the concentration of PCBs which posed unacceptable risk to obtain a hazard quotient, lowest observed adverse effects level (HQ_{LOAEL}) of equal to or less than one. The concentrations at which the HQ was <1 was achieved, sets the soil concentration remediation goal. For PCBs at the property, this value was calculated to be 0.3 mg/kg for the Meadow Vole and Short-tailed Shrew and 0.1 mg/kg for the American Robin. However, the ecologically based Preliminary Remediation Goal screening level is 0.37 mg/kg (i.e., EPA regional guidance). The current 95% UCL mean concentration is 0.37 mg/kg. The USEPA Toxic Substances Control Act regulatory level for PCBs is 1 mg/kg in unrestricted use scenarios. Therefore, the levels present in Exposure Unit 1 are thought to be adequately protective of the ecological receptors at Dike 14. Based on the HQ_{LOAEL} and the hazard quotient, toxicity reference value ($HQ_{TRV\ High}$), values in Exposure Unit 1, and the conservative nature of the risk calculations, no significant adverse health effects are expected to the ecological receptors in Exposure Unit 1" (Partners Environmental 2008).

In 2007, Partners Environmental Consulting, Inc. also performed a Property Specific Human Health Risk Assessment on Dike 14 CDF indicating that, "with the exception of Exposure Unit 2, the Property currently complies with applicable standards for exposures to soils (dermal, ingestion, and inhalation) by all identified (human) receptor populations. This is consistent with the reasonably anticipated future uses of the Property, including recreational land use and construction or excavation activities. In this risk assessment, there were no unacceptable non-cancer hazards or excess lifetime cancer risks attributable to dermal, ingestion, or inhalation exposures to the Recreational Visitor and Construction/Excavation Worker receptor populations in Exposure Unit 1. In Exposure Unit 2, compliance with applicable standards requires the implementation of a remedy to eliminate any potentially unacceptable exposures of the identified receptor populations to the levels of PCBs, benzo(a)pyrene, and benzo(b)fluoranthene" (Partners Environmental 2007b, 2007c).

Since the dredged material in Dike 14 predates material contained in the CDFs adjacent to the Burke Lakefront Airport and sediment currently present in the Federal navigation channels, it is logical to assume that contaminant concentrations going into Dike 14 represent worse-case contaminant loads present in USACE dredged material management activities in the Cuyahoga area of concern (AOC). However, bioavailability of contaminants present in Dike 14 may not be assumed to have the same bioaccumulation potential as dredged material currently in the Cuyahoga River, given the Dike 14 material has been exposed to aging and biological interaction (development of a soil rhizosphere) for more than 10 years. It may be expected that bioavailability of contaminants may have increased, decreased or become stable over that period of time. While it may be assumed that Dike 14 would represent a worse-case ecological/human health risk for wildlife and recreational use, further evaluation would be necessary to confirm.

3.2 Sediment Quality Results

3.2.1 Sample Collection Locations

The project study area is the upper reach of the Cuyahoga River, which is defined as approximately the first mile of the Cleveland Harbor Federal Navigation Channel, extending from the head of navigation to the turning basin. Samples were collected from the following areas for this project:

Upper Reach: The upper reach consists of the area of the Cuyahoga River, which extends from the head of navigation downstream to Station 728, located at the terminus of the turning basin. The area is approximately one mile in length. Based on the 2007 distribution of sediment grain size and contaminant levels, the study area was divided into two proposed dredged material management units (DMMUs). Five discrete samples were desired from each proposed DMMU. However, within the targeted reach of the channel only eight historic sample locations existed (CH-1 through CH-8). CH-1 through CH-5 was proposed for DMMU-1. Two sample locations (in addition to the 2007 locations) were added at locations CH-6 and CH-7 to provide a more representative sample distribution creating a CH-6a, CH-6b, CH-7a, CH-7b and CH-8 collected for DMMU-2 (Figure 3-1a). One QA/QC sample was collected at CH-5.

Surface grab samples were collected from each sampling location and assumed to be representative of the dredged material that is routinely (once or twice each year) removed from this stretch of the navigation channel. The depth of sediment requiring removal during each dredging cycle ranges from year to year but is typically less than 6 feet in depth. Vertical trends in sediment physical or chemical properties are not expected to be significant in this waterbody over this depth interval.

Sample locations for the discrete samples are provided in Table 3-2, and their approximate location is shown on Figure 3-1a. After sample collection and delivery, an initial inspection of discrete samples indicated sand distribution between sample locations was not as previously indicated. An initial in-house particle size analysis was performed on samples CH-1 through CH-5, and the study area was divided according to coarse grain content. To represent the coarse grain sediment, DMMU-1 was changed to consist of samples from the same positions as samples CH-1 through CH-3 that were previously collected in 2007, and DMMU-2 was changed to consist of the remaining samples, found in the same positions as samples

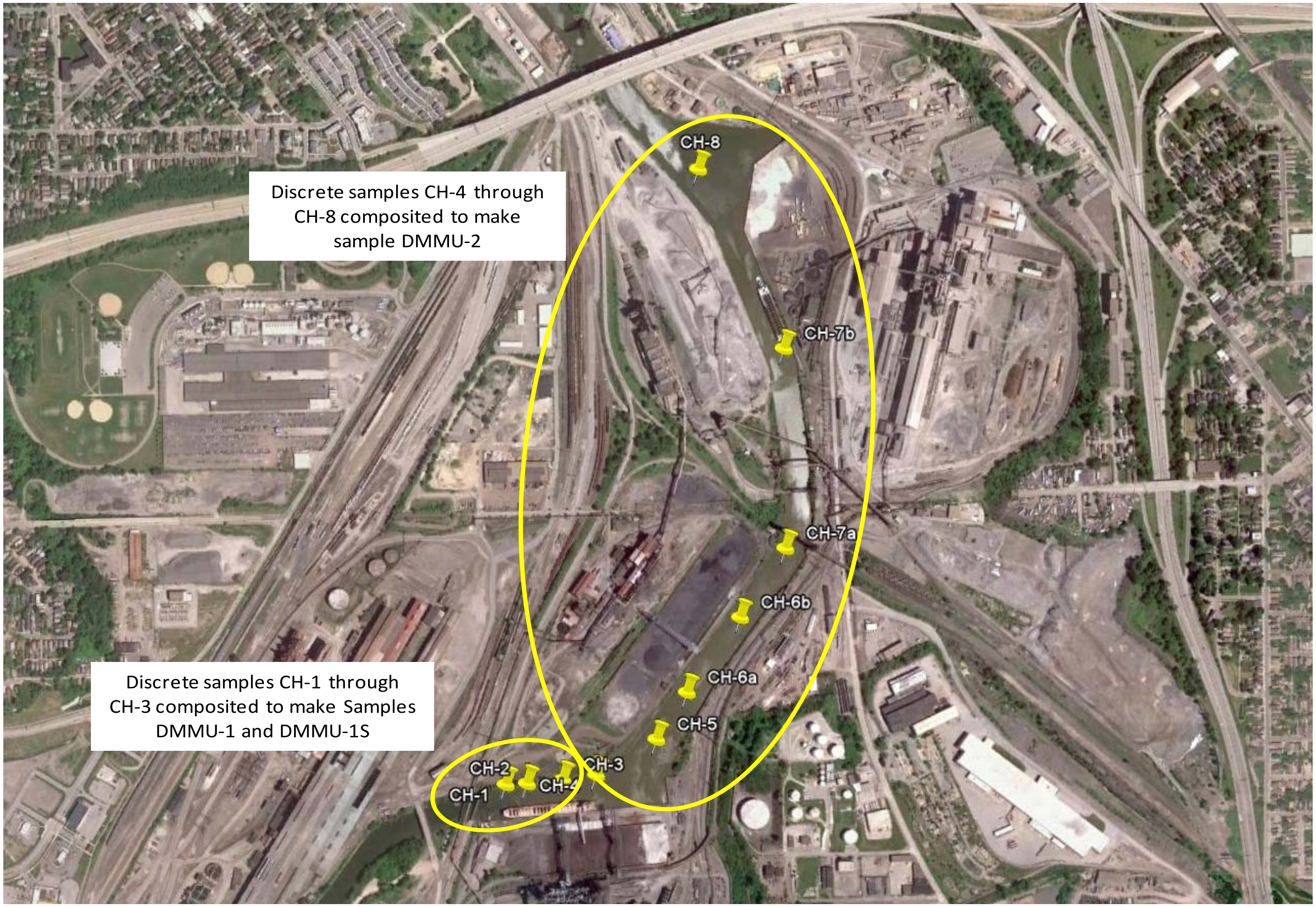

Figure 3-1a. Cuyahoga River upper reach sample locations

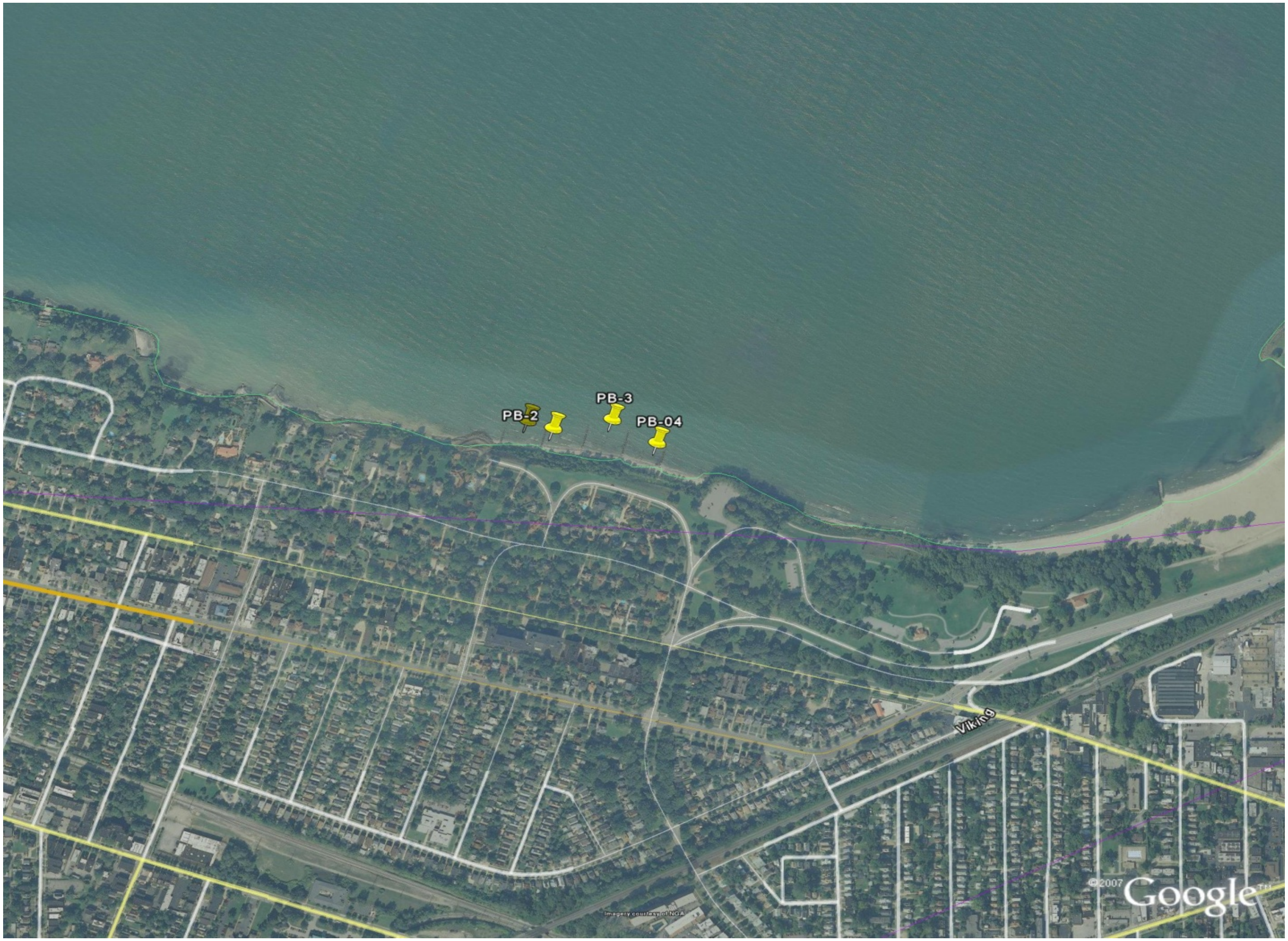

Figure 3-1b. Perkins Beach littoral reference sediment sample locations.

Figure 3-1c. Bratenahl upland reference soil sample locations.

Figure 3-1d. Perkins Beach reference water sample locations.

Table 3-2. Sample Collection Locations

Sample ID	Dredged Material Management Unit	Station	Approx. Cumulative Distance From Head of Navigation Channel	Latitude (NAD83)	Longitude (NAD83)
			(ft)		
CH-1	DMMU-1	799+00	60	41° 27' 53.64" N	81° 40' 34.98" W
CH-2	DMMU-1	796+53	307	41° 27' 53.76" N	81° 40' 31.74" W
CH-3	DMMU-1	793+30	630	41° 27' 54.24" N	81° 40' 27.54" W
CH-4	DMMU-2	790+55	905	41° 27' 54.48" N	81° 40' 23.82" W
CH-5	DMMU-2	787+65	1195	41° 27' 56.70" N	81° 40' 21.30" W
CH-6a	DMMU-2	783+81	1579	41° 27' 59.88" N	81° 40' 18.54" W
CH-6b	DMMU-2	777+49	2211	41° 28' 4.96" N	81° 40' 13.71" W
CH-7a	DMMU-2	771+79	2781	41° 28' 9.66" N	81° 40' 9.60" W
CH-7b	DMMU-2	757+66	4194	41° 28' 23.19" N	81° 40' 9.76" W
CH-8	DMMU-2	743+81	5579	41° 28' 35.34" N	81° 40' 17.52" W
PB-1	Perkins Beach Reference	_	_	41° 29' 22.45" N	81° 45' 18.20" W
PB-2	Perkins Beach Reference	_	_	41° 29' 21.95" N	81° 45' 16.27" W
PB-3	Perkins Beach Reference	_	_	41° 29' 22.52" N	81° 45' 11.86" W
PB-4	Perkins Beach Reference	_	_	41° 29' 21.02" N	81° 45' 8.51" W
BS-1	Bratenahl Reference	_	_	41° 33' 28.76" N	81° 35' 52.14" W
BS-2	Bratenahll Reference	_	_	41° 33' 28.68" N	81° 35' 52.64" W
BS-3	Bratenahl Reference	_	_	41° 33' 29.44" N	81° 35' 52.06" W
BS-4	Bratenahl Reference	_	_	41° 33' 29.13" N	81° 35' 52.47" W
Water	November 9, 2010	_	_	41° 29' 34.44" N	81° 44' 8.16" W
Water	December 7, 2010	_	_	41° 29' 40.56" N	81° 43' 41.22" W

CH-4 through CH-8 previously collected in 2007. DMMU-1 was further divided by taking a portion of the composite and attempting to separate the finer grained sediment from the sand and designated DMMU-1S. The purpose of this process was to simulate hydraulic separation of the assumed more contaminant-laden clay fractions, allowing less contaminated sands and silts to be used for aquatic beneficial uses. Coarse- grained fractions in DMMU-1 consisted of mostly fine to very fine-grained sand (in the 50-200 µm size) leading to the conclusion that separation may not be feasible under field conditions with the sediment currently in the upper reach CH-1 through CH-3. In addition, considerable organic debris (leaf litter) was present in these samples and could potentially result in higher concentrations of organics and some metals, despite lower clay content.

However, DMMU-1S was used for whole sediment and elutriate evaluations as originally planned.

Littoral Reference Sediment: Littoral reference sediment samples from the Perkins Beach site were compared to the upper reach sediment samples to assess beneficial use in the littoral zone. Water from this location was used for elutriate testing along with two additional water samples taken at a later date (see Figure 3-1d for locations). Elutriate testing was performed when it was deemed acceptable to place sediments from the Navigation Channel at this potential littoral site. The approximate locations of the littoral reference sediments from Perkins Beach site (PB1 through PB-4) are shown in Figure 3-1b. Surface (0-1 foot) grab samples were collected from four discrete locations and composited.

Upland Reference Soil: The upland reference soil was used as the field reference sample for earthworm toxicity and bioaccumulation testing. The upland reference soil was collected from Bratenahl, OH at the site previously used to establish background conditions for soil metals by OEPA (Figure 3-1c). The site soils consisted of silty to sandy clay and fines originating from post-glacial Lacustrine Plain deposits. Surface (0-1 foot) grab samples were collected from four discrete locations and composited.

The latitudes and longitudes of the sample locations are provided in Table 3-2. , A copy of the Sampling and Analysis Plan (SAP), Quality Assuarnce Project Plan (QAPP), and field notes taken during sampling are provided in Appendices, A, B and C, respectively.

3.2.2 Chemical Data

November 2010 Cuyahoga River sediment and elutriate samples, Perkins Beach reference sediment samples, and Bratenahl reference soil samples were chemically analyzed for this study. Terrestrial and aquatic bioassays were also performed using *Eisenia fetida* and *Lumbriculus variegatus*, respectively. Table 3-3 summarizes sediment, elutriate, and tissue chemical analyses. The spatial distributions of the following constituents of concern (COCs) in the river sediments are provided in Figures 3-2 (a-e): copper, zinc, ammonia, toluene, benxo(a)pyrene, and Total PAHs (sum of 16). Data summary tables for all whole sediment and elutriate chemical analysis are located in Appendices D1 and D2, respectively.

Table 3-3. Summary of Chemical Data Collected from November 2010 Sampling

Laboratory Test Description	Navigation Channel Sediment		Lake Reference Site Sediment		Soil Reference Site		Littoral Water	
	Discrete	Composite[1]	Discrete	Composite[2]	Discrete	Composite[3]	Littoral Water	
	Samples CH-1 through CH-8	Samples DMMU-1; DMMU-2; DMMU-1S	Samples PB-01 through PB-04	Sample PB Composite	Samples BS-01 through BS-04	Sample BS Composite	Sample Water	Location of Results
Baseline Analytical Chemistry and Physical Analysis								Appendix D1
Metals and Inorganic Analytes								Appendix D1
Metals (EPA 6000/7000)	X[4]	X	X	X	X	X	-	Appendix D1
Chromium VI	-	X	-	-	-	-	-	Appendix D1
Metals AVS/SEM	X	X	X	X	X	X	-	Appendix D1
Total CN (EPA 9010B/9012A)	X	X	X	X	X	X	-	Appendix D1
TKN (EPA 351)	X	X	X	X	X	X	-	Appendix D1
Ammonia Nitrogen (EPA 350)	X	X	X	X	X	X	-	Appendix D1
Total Phosphorus (EPA 6000/7000)	X	X	X	X	X	X	-	Appendix D1
Organic Analytes								Appendix D1
Volatile Organics - TCL (EPA 8260B)	X	X	X	X	X	X	-	Appendix D1
B/N/A (Semi-volatile organics) - TCL (EPA 8270C)	X	X	X	X	X	X	-	Appendix D1
Dissolved & Total PAHs (Parent and Alkylated, ASTM D7363)	X	-	X	-	-	-	-	Appendix D1
PCBs - (Arochlors, EPA 8082)	X	X	X	X	X	X	-	Appendix D1
Pesticides (EPA 8081A)	X	X	X	X	X	X	-	Appendix D1
Total Organic Carbon (EPA 9060)	X	X	X	X	X	X	-	Appendix D1
Physical Characteristics								Appendix D1
Grain Size (ASTM D421, D422)	X	X	X	X	X	X		Appendix D1
Atterberg Limits (ASTM 4318)	-	X[5]	-	-	-	-	-	Appendix D1
Proctor (ASTM D698)	-	X[6]	-	-	-	-	-	Appendix D1

Table 3-3. Summary of Chemical Data Collected from November 2010 Sampling (continued).

Laboratory Test Description	Navigation Channel Sediment		Lake Reference Site Sediment		Soil Reference Site		Littoral Water	Location of Results
	Discrete	Composite[1]	Discrete	Composite[2]	Discrete	Composite[3]		
	Samples CH-1 through CH-8	Samples DMMU-1; DMMU-2; DMMU-1S	Samples PB-01 through PB-04	Sample PB Composite	Samples BS-01 through BS-04	Sample BS Composite	Sample Water	
Permeability (ASTM D5084)	-	X[6]	-	-	-	-	-	Appendix D1
Percent Moisture (ASTM D2216)	-	X[5]	-	-	-	-	-	Appendix D1
Percent Organic Matter (ASTM D 2974-00)	-	X[5]	-	-	-	-	-	Appendix D1
Standard Elutriate Water Chemistry Tests (filtered and unfiltered)								Appendix D2
Effluent Elutriate Test (USACE UTM, Appendix B)		X						Appendix D2
Metals - 13 PP Metals (EPA 6000/7000)		X					X	Appendix D2
Total CN (EPA 9010B/9012A)		X					X	Appendix D2
Ammonia Nitrogen (EPA 350)		X					X	Appendix D2
Total Phosphorus (EPA 6000/7000)		X					X	Appendix D2
Volatile Organic Compounds (VOCs, EPA 8260B)		X					X	Appendix D2
Semi-volatile Organic Compounds (SVOCs, (EPA 8270C)		X					X	Appendix D2
Total Organic Carbon (EPA 9060)		X					X	Appendix D2
Pesticides (EPA 8081A)		X					X	Appendix D2
PCBs (Arochlors, EPA 8082)		X					X	Appendix D2
Turbidity (SM 2130)		X					X	Appendix D2
Total suspended Solids (SM 2540D or 2540)		X					X	Appendix D2
Whole Sediment Aquatic Toxicity Tests								Appendix D3
C. dilutus 10-day survival and weight	-	X	-	X	-	-	-	Appendix D3
H. azteca 10-day survival bioassay	-	X	-	X	-	-	-	Appendix D3

Table 3-3. Summary of Chemical Data Collected from November 2010 Sampling (continued).

Laboratory Test Description	Navigation Channel Sediment		Lake Reference Site Sediment		Soil Reference Site		Littoral Water	Location of Results
	Discrete	Composite[1]	Discrete	Composite[2]	Discrete	Composite[3]	Water	
	Samples CH-1 through CH-8	Samples DMMU-1; DMMU-2; DMMU-1S	Samples PB-01 through PB-04	Sample PB Composite	Samples BS-01 through BS-04	Sample BS Composite	Sample Water	
Whole Sediment Aquatic Bioaccumulation Tests								Appendix D3
Lumbriculus variegatus 28-day bioaccumualtion	-	X	-	X	-	-	-	Appendix D3
Percent Lipid (Gravmetric)	-	X	-	X	-	-	-	Appendix D3
Pesticides (ΣDDT, EPA 8081A)	-	X	-	X	-	-	-	Appendix D3
PCBs - Aroclors (EPA 8082)	-	X	-	X	-	-	-	Appendix D3
Elutriate Aquatic Toxicity Tests								Appendix D3
Pimephales promelas, 4-day (GLTM, Appendix G)		X					X	Appendix D3
Ceriodaphnia dubia, 2-day (GLTM, Appendix G)		X					X	Appendix D3
Terestrial Toxicity/Bioaccumulation Tests								Appendix D4
Esenia fetida 28-day toxicity/bioaccumuation (USACE UTM, Appendix G)		X[5]			X	X		Appendix D4
Standard Soil Fertility Testing (plus nitrate and sodium)		X[5]				X		Appendix D4
Percent Lipid (Biological Tissue)		X[5]			X	X		Appendix D4
Pesticides (ΣDDT, EPA 8081A)		X[5]			X	X		Appendix D4
Metals - 13 PP Metals (EPA 6000/7000 series)		X[5]			X	X		Appendix D4
PCBs - Arochlors (EPA 8082; Biological Tissues)		X[5]			X	X		Appendix D4

Notes:1. DMMU-1 is composite of samples CH-1 - CH-3; DMMU-1S is composite of samples CH-1 - CH-3 coarse material; DMMU-2 is composite of samples CH-4 - CH-8

2. PB Composite is a composite of samples PB-1 – PB-4

3. BS Composite is a composite of samples BS-1 – BS-4

4. All samples tested identified in column heading unless otherwise noted

5. Samples DMMU-1 and DMMU-2 tested

6. Sample DMMU-2 tested

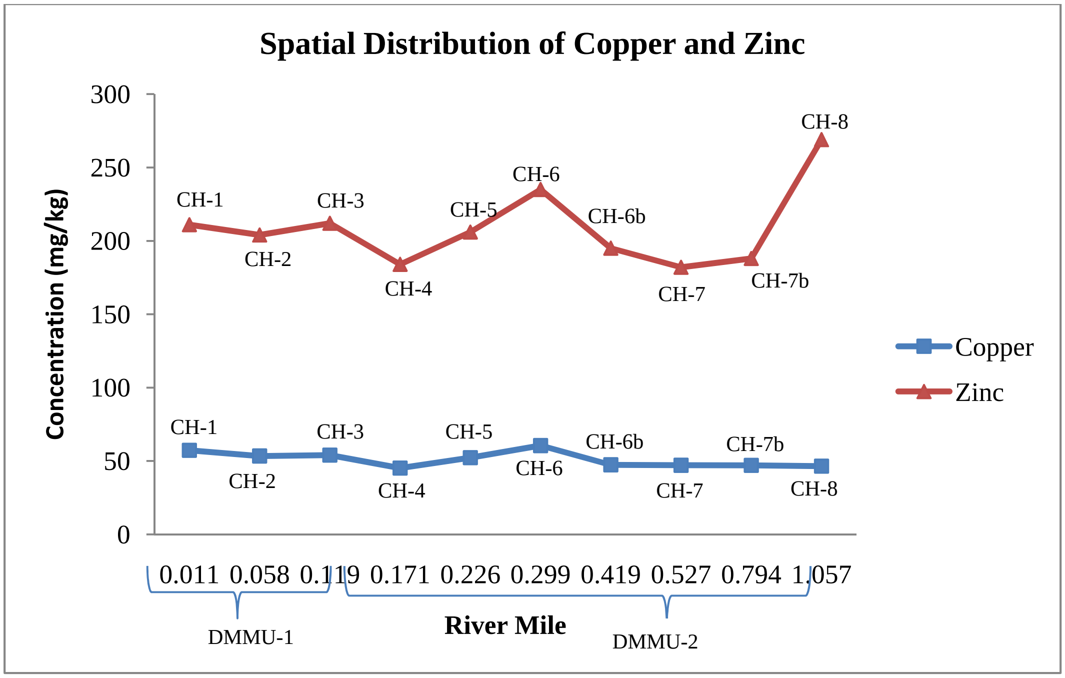

Figure 3-2a. Spatial Distribution of Copper and Zinc in Cleveland Harbor Sediment Samples

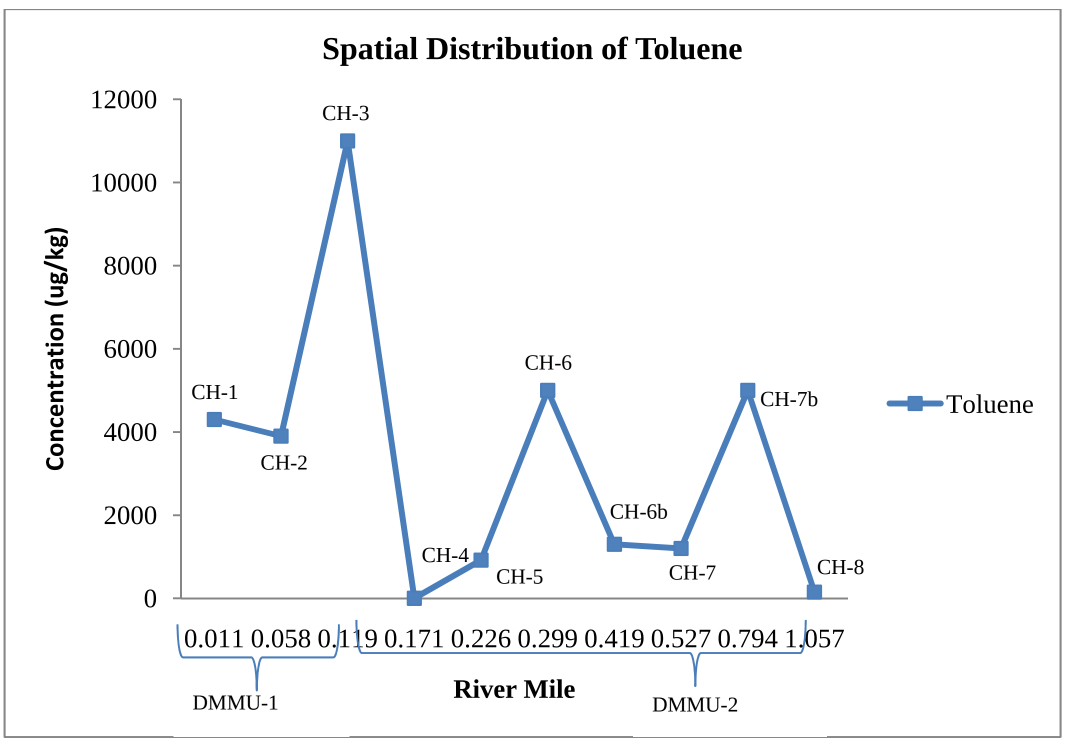

Figure 3-2b. Spatial Distribution of Toluene in Cleveland Harbor Sediment Samples

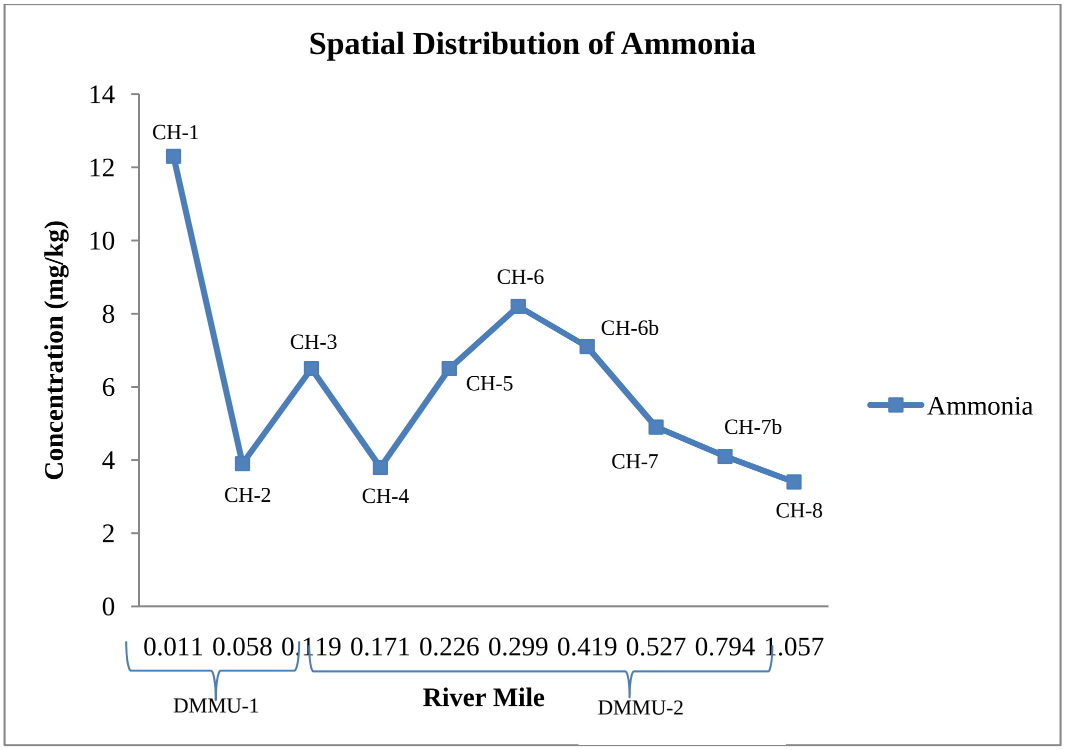

Figure 3-2c. Spatial Distribution of Ammonia in Cleveland Harbor Sediment Samples

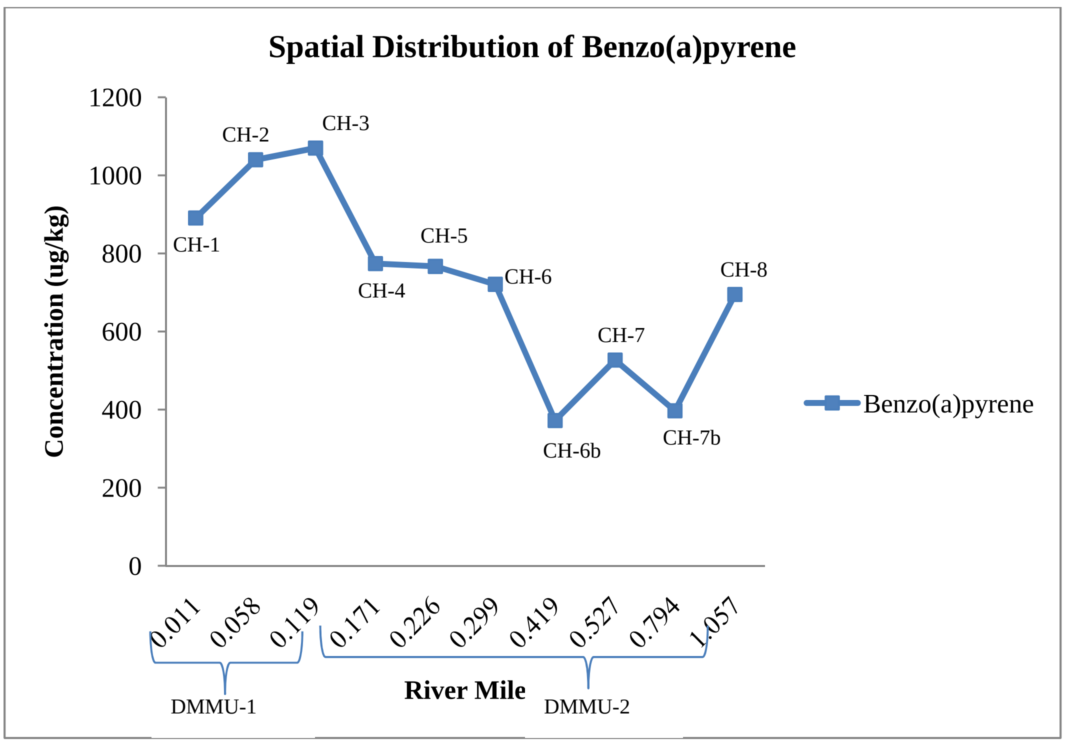

Figure 3-2d. Spatial Distribution of Benzo(a)pyrene in Cleveland Harbor Sediment Samples

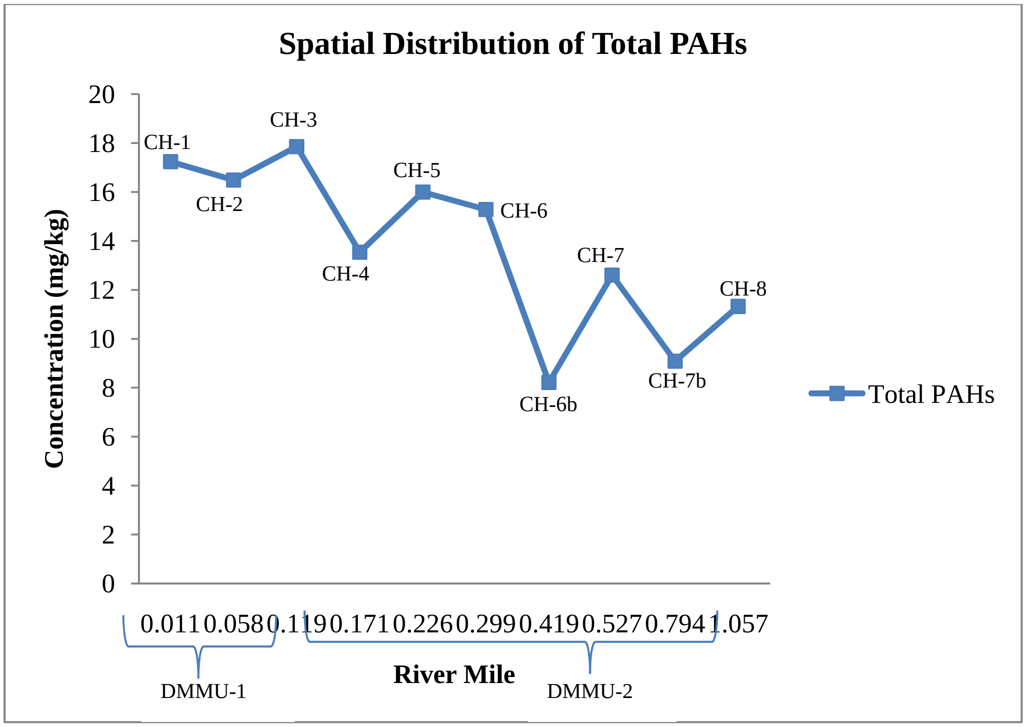

Figure 3-2e. Spatial Distribution of Total PAHs (Sum of 16) in Cleveland Harbor Sediment Samples

Sediment Analysis Holding Times. During the analysis of whole sediment samples, the prescribed holding times prior to extraction were exceeded for some analytes. The extraction of VOCs (8260B), of dissolved PAHs (ASTM D7363), total cyanide (9012A), acid volatile sulfides (AVS), total organic carbon (Loyd Kahn), ammonia nitrogen (SM 4500 NH_3), and Kjeldahl nitrogen (SM 4500 Norg C) exceeded standard sample holding times by 14 to 27 days. Samples were stored in the laboratory at 4° C in sealed jars during this period

The stability of labile analytes is much greater in properly samples contained in sealed jars that are refrigerated at 4°C than when dredged material is placed in a CDF under ambient environmental conditions. Although the holding times were exceeded, the loss and degradation of environmentally persistent chemicals would be expected to be minimal in samples appropriately stored to limit volatile losses and biological degradation. Volatile contaminants could potentially suffer higher losses as a result of extended holding times, but volatile contaminants are also very labile in the environment and unlikely to persist in materials exposed to the atmosphere during dredging, offloading and storage. The measurement of less labile contaminants would not be expected to be as significantly affected.

The analysis of elutriates prepared from sediment samples did not exceed sample holding times and these data were used to evaluate the potential risk and toxicity that may result from release of contaminants to the water column from dredged material.

It is important to recognize that the assessment of potential risk resulting from the beneficial use of dredged material in aquatic environments has included Tier III toxicity testing data in addition to the evaluation of sediment chemistry. The laboratory toxicity testing met the prescribed holding times prior to test initiation and the test results provide direct evidence for the absence or presence of toxic concentrations of contaminants in sediment samples

3.2.3 Physical Data

The Cuyahoga River sediment samples, Perkins Beach reference sediment samples, and Bratenahl reference soil samples were also physically characterized for this study. A summary of the physical data collected on all these samples can be found in Table 3-4. Table 3-5 summarizes the grain size distribution data, and Figures 3-3a and 3-3b summarize the spatial distribution of grain size throughout the river. A data table summarizing physical analysis results is located in Appendix D1.

Table 3-4. Summary of Physical Data Collected from November 2010 Sampling

<table>
<tr><th>Location</th><th>Media Type(s)</th><th>Parameter(s)</th><th>Label(s)</th></tr>
<tr><td colspan="4">USACE 2010 Physical Data</td></tr>
<tr><td rowspan="2">Cuyahoga River</td><td rowspan="2">Sediment</td><td>Particle size, percent moisture, and percent solids</td><td>CH-1 through CH-8, DMMU-1[1], DMMU-1S[2], DMMU-2[3]</td></tr>
<tr><td>Total organic matter, plastic limit, plasticity index, liquid limit, moisture content, and ash content</td><td>DMMU-1, DMMU-1S, DMMU-2</td></tr>
<tr><td>Perkins Beach Lake Reference</td><td>Sediment</td><td>Particle size, percent moisture, and percent solids</td><td>PB-1 through PB-4, PB Composite[4]</td></tr>
<tr><td>Bratenahl Reference</td><td>Soil</td><td>Particle size, percent moisture, and percent solids</td><td>BS-1 through BS-4, BS Composite[5]</td></tr>
</table>

Notes:

[1] DMMU-1: Composite from CH-1 - CH-3

[2] DMMU-1S: Composite from CH-1 - CH-3 coarse material

[3] DMMU-2: Composite from CH-4 - CH-8

[4] PB Composite: Composite from PB-1 – PB-4

[5] BS Composite: Composite from BS-1 – BS-4

Table 3-5. Data Summary of Grain Size Distribution in Cleveland Harbor Sediment Samples

ANALYTE	CARSN	UNIT	CH-1	CH-2	CH-3	CH-4	CH-5	CH-5 DUP	CH-6A	CH-6B	CH-7A	CH-7B	CH-8	DMMU-1
Clay	Clay	%	16.9	19	21.6	28.9	26.4	25.7	25.8	24.5	24	22	22	21.2
Silt	Silt	%	60.8	63.5	60.2	64.2	67.7	68.5	69	67	64.8	70.2	66.9	61.1
Fine Sand	Fine Sand	%	16.8	12.3	14.1	6.4	5.5	5.5	4.6	8.3	9.1	7.6	10	14.9
Medium Sand	Medium Sand	%	1.3	1.2	1.2	0.4	0.1	0.3	0.3	0.2	1.1	0.1	0.4	1.2
Coarse Sand	Coarse Sand	%	1	1.7	0.9	0.1	0.1	0	0.2	0	0.3	0.1	0.3	1.4
Sand	Sand	%	19.1	15.2	16.2	6.9	5.7	5.8	5.1	8.5	10.5	7.8	10.7	17.5
Gravel	Gravel	%	3.2	2.3	2	0	0.2	0	0.1	0	0.7	0	0.4	0.2

ANALYTE	CARSN	UNIT	DMMU-1S	DMMU-2	PB COMPOSITE	PB-1	PB-2	PB-3	PB-4	BS COMPOSITE	BS-1	BS-2	BS-3	BS-4
Clay	Clay	%	17.6	32.8	1.1	1.1	1.2	1	1.1	28.2	38.7	37	21.8	23.7
Silt	Silt	%	64.6	59.7	0.3	1.1	0.4	1.3	4.2	42.5	48.5	46.6	47.4	25.2
Fine Sand	Fine Sand	%	16.6	6.9	84.8	71.1	84.9	81	92.2	10.8	7.6	10.4	17.1	11.1
Medium Sand	Medium Sand	%	1.2	0.5	10.7	21.5	11.9	12.9	2.1	10.4	4.9	6	12	12.5
Coarse Sand	Coarse Sand	%	0	0.1	2.8	4.8	1	2.8	0.4	2.3	0.3	0	0.7	16.7
Sand	Sand	%	17.8	7.5	98.3	97.4	97.8	96.7	94.7	23.5	12.8	16.4	29.8	40.3
Gravel	Gravel	%	0	0	0.3	0.3	0.6	0.9	0	5.8	0	0	1	10.8

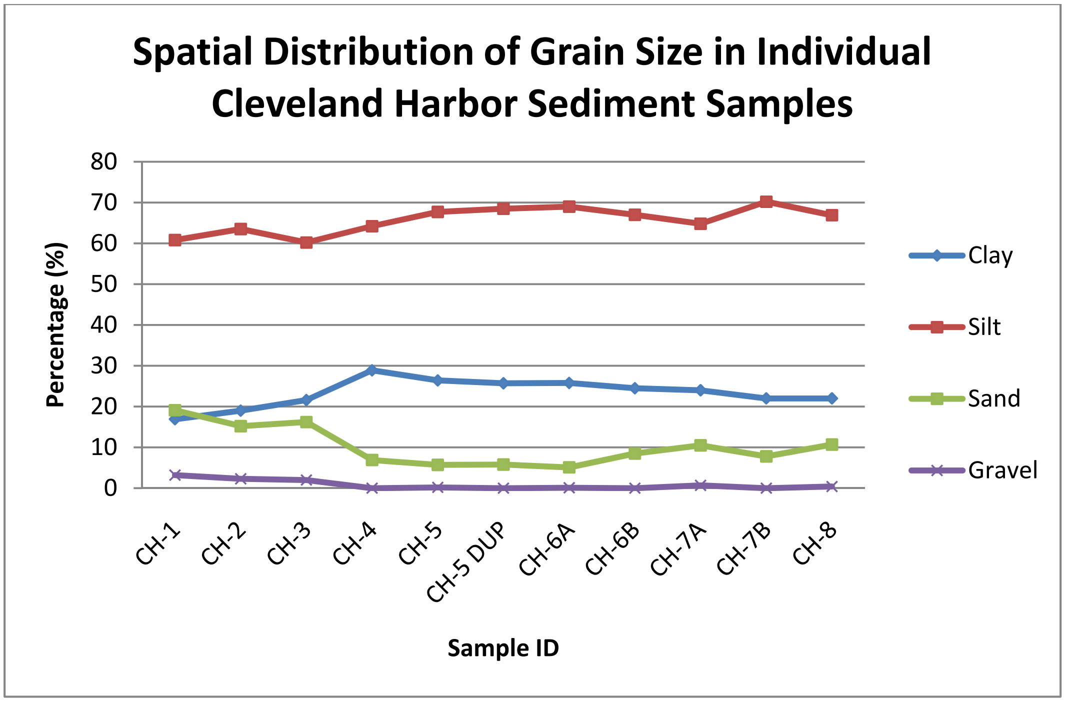

Figure 3-3a. Spatial Distribution of Grain Size in Individual Cleveland Harbor Sediment Samples

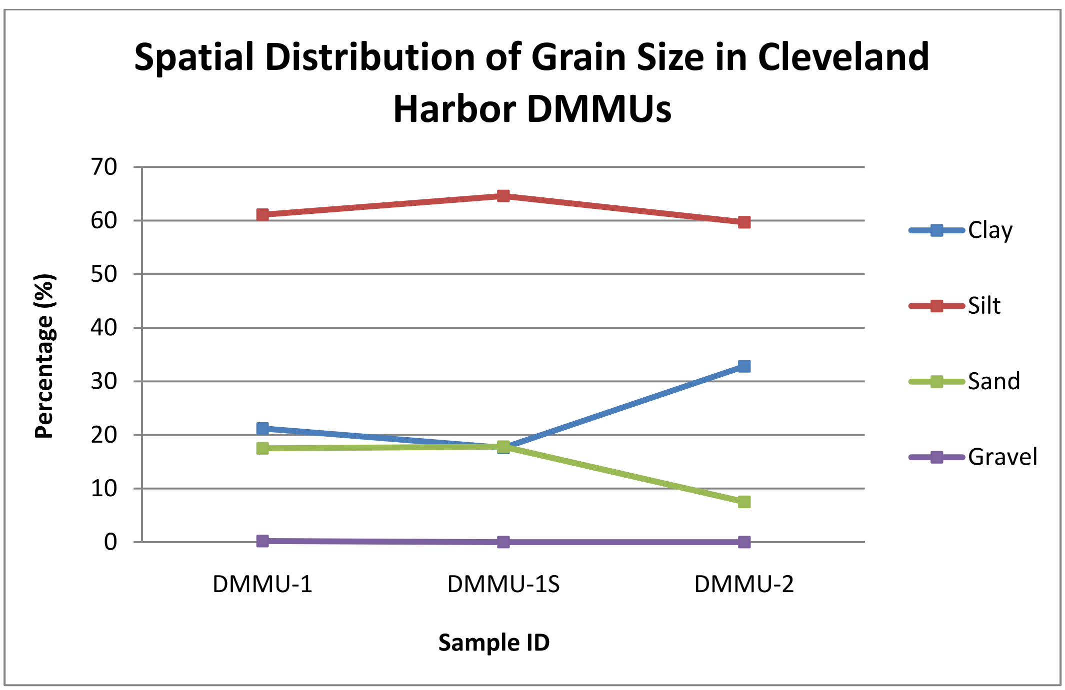

Figure 3-3b. Spatial Distribution of Grain Size in Cleveland Harbor DMMUs

3.2.4 Toxicity and Bioaccumulation Data

3.2.4.1 Whole Sediment

Sediment toxicity and bioaccumulation tests were performed using samples collected during 2010 to simulate the potential for biological effects of dredged material placed at disposal or beneficial use sites. The sediment toxicity tests employed the amphipod *Hyalella azteca* and the midge *Chironomus dilutus*. The bioaccumulation tests used the oligochaete *Lumbriculus variegatus*. The whole sediment toxicity test methodology, test results and data analysis are shown in Appendix D3. Sediment toxicity bioassay results:

- Acute toxicity was observed with *Hyalella azteca* following exposure to DMMU-2 sediment. No acute or sublethal toxicity was observed for *Chironomus dilutus* for any DMMU evaluated.
- No toxicity was observed for sediment from DMMU-1 and DMMU-1S; these materials could potentially meet the guidelines for open-water disposal or placement in unconfined aquatic environments for habitat restoration.
- Since toxicity was observed, sediment from DMMU-2 may fail guidelines for open-water disposal or placement in unconfined aquatic sites for habitat restoration (USACE 2011).
- Bioaccumulation of Total PCBs and chlorinated pesticides, such as dieldrin and DDT, was not observed in bioassays using the aquatic worm *Lumbriculus variegatus*.

3.2.4.2 Elutriate

Elutriate toxicity tests were performed to simulate the potential for biological effects of dredged material released into the water column during open-water placement. The elutriate toxicity tests used the larval fathead minnow *Pimephales promelas* and the cladoceran *Ceriodaphnia dubia*. The elutriate toxicity test methodology, test results and data analysis are shown in Appendix D3. Elutriate bioassay results:

- No acute toxicity predicted for the cladoceran *Ceriodaphnia dubia* for any of the Dredged Material Management Units (DMMU).
- No acute toxicity predicted for the fish larva *Pimephales promelas* for DMMU-1 or DMMU-1S.

- Acute toxicity was observed for *P. promelas* exposed to DMMU-2. However, mortality (<50%) was not great enough to calculate a lethal median concentration (LC50).

Ammonia is an important contaminant to consider in toxicity bioassays employing fish species (USEPA 2009). The unionized fraction of ammonia, which is dependent on water temperature, pH and, to a lesser extent, salinity, is often most responsible for causing toxicity. The measured total ammonia value in DMMU-2 was 10 mg/L. At the mean pH and temperature recorded in the bioassay, the unionized ammonia concentration was calculated to be approximately 0.5 mg/L. Several studies (Nimmo et al., 1989; Diamond et al., 1993; Buhl et al., 2002) in the available literature provide toxicity reference values for larval *P. promelas* exposed to ammonia for 96hours. Among these studies, Diamond et al. (1993) reported the lowest LC50 value of 0.25 (0.21 – 0.30) mg/L as unionized ammonia. Nimmo et al. (1989) reported LC50 values ranging from 0.56 (0.52 – 0.61) to 0.94 (0.87 - 1.02) mg/L, as unionized ammonia, in two different field waters. Additionally, Buhl et al. (2002) reported a 96-h LC50 of 1.01 (0.83 – 1.18) mg/L as unionized ammonia (or 14.4 (10.4 – 18.5) mg/L as total ammonia at pH 8 and a temperature of 25 °C). While it cannot be stated, the ammonia was the only driver of toxicity in DMMU-2. The measured ammonia levels in this elutriate water approached literature reported LC50 values for *P. promelas*, providing a line of evidence that ammonia could be a contributor to the observed mortality (USACE 2011).

3.2.4.3 Soil Bioassay

The terrestrial earthworm *Esenia fetida* was used for the soil bioassay. Survival results are shown in Table 4s of Appendix D4. Mean earthworm survival was greater than 95% in all media. The data analysis procedures and results are shown in Appendix D4. The survival of earthworms exposed to DMMU1 or DMMU2 was not statistically different from the survival of earthworms exposed to the reference. One route for contaminant migration is soil to earthworm to predator. The survival of earthworms is important in being able to acquire bioaccumulation data for assessing risk associated with that pathway. If the test material is toxic to the earthworm, the soil to earthworm to predator pathway for contaminant migration becomes incomplete and no longer a pathway of concern. However, toxicity to earthworms would not be a quality desired for beneficial use of dredged material for habitat or other use by wildlife. Dredged material suitable for habitat use would be expected to support soil invertebrates for development of a functional rhizosphere. Comparison of toxicity to a reference soil can demonstrate that the test material has the physical and chemical qualities to support normal soil functions, such as earthworm colonization.

3.2.4.3.1 Bioaccumulation

Earthworms were exposed to DMMU-1, DMMU-2 and the Upland Reference soil for 28 days prior to analysis of potential contaminants s of concern (Appendix D4). Bioaccumulation of Ag, As, Ni, Se, Zn, DDD, and gamma Chlordane from DMMU-1 exceeded bioaccumulation from the Upland Reference while As, Ni, Se, Zn, DDT, DDD, Dieldrin and gamma Chlordane exceeded uptake in the reference materials for DMMU-2. The implications of these results are further evaluated and discussed later in Section 5.3.

4 Human Health Chemical Risk Evaluation

Sediment samples collected from the Navigation Channel study area have been evaluated for potential risk to human health following the guidance provided by the Ohio EPA for evaluating sediment contaminant results, and procedures previously developed for characterizing potential risk associated with the beneficial use of dredged sediment at the CVIC site (Ohio EPA Division of Surface Water 2010; Skowronski 2011).

4.1 Pathway Analysis for Each Beneficial Use

The primary pathways by which humans may be exposed to trace level contaminants present in dredged materials when placed at beneficial use sites include:

- direct contact with soil through dermal contact, ingestion, or inhalation when the dredged material is used beneficially for surface soils,
- leaching of trace level contaminants from surface and subsurface soils that could potentially impact groundwater used for drinking,
- direct contact with the sediment when it is placed in aquatic environments where beach nourishment or wetland habitat restoration is the proposed end use, and
- consumption of fish that may have bioaccumulated chemicals following placement in or near littoral or wetland environments.

The potential for exposure and impacts to human health through each pathway is site specific (Table 4-1). For example, groundwater may be less likely to be impacted at littoral sites where the sediment is used for beach nourishment than at sites where sediment is used for urban wetland habitat restoration or upland soils. The potential for human exposure from groundwater contamination depends upon whether it is used as a drinking or industrial water supply. In any aqueous environment, there is potential for contaminant leaching to surface water, the bioaccumulation of contaminants by fish (assuming bioaccumulative contaminants are present), and then consumption of fish by humans. Likewise, the potential risk to human health resulting from the consumption of drinking water impacted by contaminants that may leach from dredged material will vary from site to site. The potential for leaching and impacts to drinking water is site specific. For example, the potential risk to humans from

Table 4-1. End use and potential receptors for evaluating risk to human health

Placement Option	*End Use*	*Site*	*Note*	*Exposure Type*	*Exposure Media*	*Risk Endpoints*				
						Direct Contact	*Consumption of Drinking Water*		*Consumption of Fish*	
						Measurement Endpoints				
						Bulk Sediment Chemistry[1]	*Bulk Sediment Chemistry*[2]	*Sediment Porewater or Elutriate Chemistry*[3]	*Sediment Porewater or Elutriate Chemistry*[3]	*Aquatic Bioaccumulation Tests*
						Criteria				
						USEPA RSLs	*OEPA WQS*	*OEPA WQS*	*OEPA WQS*	*Fish tissue Conc.*[4]
Lake Littoral Zone	Beach Nourishment	Perkins Beach		Recreational Users	Sediment	✓	-[5]	-	✓	✓
	Wetland Habitat Restoration	Not Defined		Recreational Users	Sediment	✓	-	-	✓	✓
Intermediate Material Handling	Material Processing Required Prior to Final End Use	Waterfront CDF Upper River Site CVIC Site Zaclon Site	Regulated by OSHA & OEPA Air Permits[6]	Industrial Workers	Sediment	✓[6]	-	-	-	-
Urban/Industrial Land Reclamation	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Landfill recompacted cap & vegetative cover	Industrial Workers (landfill closure)	Surface Soil & Groundwater	✓	✓[7]	✓[7]	-	-
			Potential upland nature preserve	Recreational Users						
		Brook Park Landfill	Future industrial or commercial use	Industrial, Commercial Workers	Surface Soil & Groundwater	✓	✓[7]	✓[7]	-	-

Table 4-1. End use and potential receptors for evaluating risk to human health (continued).

Placement Option	*End Use*	*Site*	*Note*	*Exposure Type*	*Exposure Media*	*Risk Endpoints*				
						Direct Contact	*Consumption of Drinking Water*		*Consumption of Fish*	
						Measurement Endpoints				
						Bulk Sediment Chemistry[1]	*Bulk Sediment Chemistry*[2]	*Sediment Porewater or Elutriate Chemistry*[3]	*Sediment Porewater or Elutriate Chemistry*[3]	*Aquatic Bioaccumulation Tests*
						Criteria				
						USEPA RSLs	*OEPA WQS*	*OEPA WQS*	*OEPA WQS*	*Fish tissue Conc.*[4]
	Industrial Site Redevelopment	Ditchman LLLC Proposal (General Chemical and other sites)	Future industrial or commercial use	Industrial, Commercial Workers	Surface Soil & Groundwater	✓	✓	✓	-	-
		HGC Kingsbury Run Proposal	Future industrial or commercial use	Industrial, Commercial Workers	Surface Soil & Groundwater	✓	✓	✓	-	-
	Burke Airport Expansion	CDF 10B	Future industrial or commercial use	Industrial, Commercial Workers	Surface Soil	✓	-	-	-	-
	Vacant Property Rehabilitation	City/County Vacant Land Reclamation	End use not defined	Industrial, Commercial, Recreational, or Residential Use	Surface Soil & Groundwater	✓	✓	✓	-	-
Environmental Remediation	Contaminated Sediment Remediation	Old River Channel	Subaqueous Aquatic Cap	Recreational Users	Sediment	✓	-	-	✓	✓
Construction Material	Construction Aggregate (Streamside Proposal)	Unrestricted		Residential	Sediment	✓[6]	✓	✓	-	-
	Fill / Topsoil	Unrestricted		Residential	Surface Soil & Groundwater	✓[6]	✓	✓	-	-

Table 4-1. End use and potential receptors for evaluating risk to human health (continued).

Placement Option	*End Use*	*Site*	*Note*	*Exposure Type*	*Exposure Media*	*Risk Endpoints*				
						Direct Contact	*Consumption of Drinking Water*		*Consumption of Fish*	
						Measurement Endpoints				
						Bulk Sediment Chemistry[1]	*Bulk Sediment Chemistry*[2]	*Sediment Porewater or Elutriate Chemistry*[3]	*Sediment Porewater or Elutriate Chemistry*[3]	*Aquatic Bioaccumulation Tests*
						Criteria				
						USEPA RSLs	*OEPA WQS*	*OEPA WQS*	*OEPA WQS*	*Fish tissue Conc.*[4]

Notes:

[1] *Includes Regional Screening Levels adjusted for recreational exposure*

[2] *Bulk sediment chemistry used to predict drinking water quality in near-surface aquifer at point of compliance*

[3] *Direct measurement of sediment porewater chemistry or elutriate chemistry is used to predict drinking water quality at point of compliance*

[4] *Fish tissue concentrations for determining impairment. Ohio EPA. 2008. Integrated Water Quality Monitoring and Assessment Report. Section E. Division of Surface Water. May 5, 2008.*

[5] *Exposure pathway not considered significant*

[6] *Worker and community health protection at processing facility based on OSHA and Ohio EPA Division of Air Pollution control regulations*

[7] *Ingestion of groundwater at former landfill sites is not considered significant due to institutional controls preventing installation of drinking water supply wells and likelihood of preexisting groundwater contamination*

consumption of contaminated groundwater produced by water supply wells located at landfill sites is very low; OEPA laws restrict siting public water supplies near landfills. In addition, deed notifications that are required for landfill closure create an administrative barrier to the potential future construction of drinking water wells at these landfill sites. However, the potential for transport of contaminants from such locations to more distant groundwater wells must be considered and evaluated.

Table 4-1 summarizes each of the beneficial use options evaluated, the type of land use associated with the proposed beneficial use, and the potential receptor populations (residential, recreational, commercial, and industrial) that are evaluated in this report.

4.2 Background Considerations

Chemicals having a maximum concentration below the maximum value measured at the reference sites or the regional background values were not identified as constituents of concern nor included in estimates of human health risk. The maximum concentrations of contaminants in samples collected in November 2010 were compared to the maximum concentrations measured in samples collected from soil and lake reference site locations and to OEPA Erie Ontario Lake Plain (EOLP) regional sediment reference values (Ohio EPA Division of Emergency and Remedial Response 2008). The maximum concentration of arsenic and vanadium detected in sediment samples is of interest because the concentration of these metals exceeded human health risk screening values (Table 4-2); however, the concentrations measured in the sediment were within the range considered normal background for uncontaminated sediments and were below OEPA EOLP values. As such, arsenic and vanadium are not considered potential COCs. The maximum concentration of total mercury detected in sediment (CH-6a, 0.135 mg/kg) was only marginally higher than the OEPA Regional EOLP value for sediments of 0.120 mg/kg and less than the maximum concentration detected in the soil reference samples (0.168 mg/kg). All of the samples, with the exception of sample CH-6a, were determined to have total mercury concentrations less than the Regional EOLP value, with an average mercury concentration of 0.0992 mg/kg measured in Navigation Channel sediments. These data indicate that the average concentration of mercury is not likely to exceed background concentrations in dredged material, and the potential for fish to bioaccumulate mercury above background levels is unlikely. The maximum concentration of mercury in sediment did not exceed risk-based screening values for direct contact with soils.

Table 4-2a. Tier II Human health risk evaluation for use of dredged sediment at residential sites.

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	COC[b]	Regional Screening Levels For Residential Land Use[c]			Hazard Ratio for Non-Cancer Toxicity[d]	Excess Cancer Risk Ratio[e]
					(mg/kg)		Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Inorganic Compounds											
Cyanide, Total	57-12-5	14	4.42E-01	CH-2	6.30E-01		1.60E+03	NA	1.60E+03	3.94E-04	NA
Aluminum	7429-90-5	14	8.60E+03	CH-6a	9.43E+03 [1,2]		7.70E+04	NA	7.70E+04	- [1]	-
Antimony	7440-36-0	2	5.94E-02	DMU-1	1.19E-01 [1,2]		3.10E+01	NA	3.10E+01	-	-
Arsenic	7440-38-2	14	1.23E+01	DMMU-2; CH-6a, CH-4	1.26E+01 [1,2]		2.20E+01	3.90E-01	3.90E-01	-	-
Barium	7440-39-3	14	7.70E+01	CH-6a	8.44E+01 [1,2]		1.50E+04	NA	1.50E+04	-	-
Beryllium	7440-41-7	14	6.16E-01	CH-5 DUP	6.97E-01 [1,2]		1.60E+02	1.40E+03	1.60E+02	-	-
Cadmium	7440-43-9	14	9.59E-01	CH-6a	1.15E+00		7.00E+01	1.80E+03	7.00E+01	1.64E-02	6.39E-04
Calcium	7440-70-2	14	1.50E+04	CH-6a	1.83E+04 [1, 3]		NA	NA	NA	-	-
Chromium (III)f	16065-83-1	14	2.67E+01	CH-8	3.10E+01		1.20E+05	NA	1.20E+05	2.58E-04	NA
Cobalt	7440-48-4	14	1.16E+01	CH-4	1.27E+01		2.30E+01	3.70E+02	2.30E+01	5.52E-01	3.43E-02
Copper	7440-50-8	14	5.18E+01	CH-6a	6.05E+01		3.10E+03	NA	3.10E+03	1.95E-02	NA
Iron	7439-89-6	14	2.64E+04	CH-6a	2.81E+04 [1,2]		5.50E+04	NA	5.50E+04	-	-
Leadg	7439-92-1	14	4.57E+01	CH-1	5.29E+01 [2]		NA	NA	NA	NA	NA
Magnesium	7439-95-4	14	5.69E+03	CH-6a	6.30E+03 [1]		NA	NA	NA	-	-
Manganese	7439-96-5	14	6.49E+02	CH-4	7.28E+02 [1]		1.80E+03	NA	1.80E+03	-	-
Mercury	7439-97-6	14	9.92E-02	CH-6a	1.35E-01 [2,]		5.60E+00	NA	5.60E+00	2.41E-02	NA
Nickel	7440-02-0	14	3.53E+01	CH-6a	3.93E+01		1.50E+03	1.30E+04	1.50E+03	2.62E-02	3.02E-03
Phosphorus (total)	7723-14-0	14	4.35E+02	CH-3	4.97E+02		NA	NA	NA	NA	NA
Potassium	7440-09-7	14	1.72E+03	CH-6a	1.92E+03 [1]		NA	NA	NA	-	-
Selenium	7782-49-2	14	7.35E-01	CH-6a	8.57E-01 [1,2]		3.90E+02	NA	3.90E+02	-	-
Silver	7440-22-4	14	3.63E-01	CH-6a	4.67E-01		3.90E+02	NA	3.90E+02	1.20E-03	NA

Table 4-2a. Tier II Human health risk evaluation for use of dredged sediment at residential sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	COC[b]	Regional Screening Levels For Residential Land Use[c]			Hazard Ratio for Non-Cancer Toxicity[d]	Excess Cancer Risk Ratio[e]
					(mg/kg)		Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Sodium	7440-23-5	14	2.30E+02	CH-3	2.77E+02		NA	NA	NA	NA	NA
Thallium	7440-28-0	14	3.57E-01	CH-6a	3.97E-01 [1,2]		NA	NA	NA	-	-
Vanadium	7440-62-2	14	2.01E+01	CH-6a	2.20E+01 [1,2]		5.50E+00	NA	5.50E+00	-	-
Zinc	7440-66-6	14	2.10E+02	CH-8	2.69E+02		2.30E+04	NA	2.30E+04	1.17E-02	NA
Chlorinated Pesticides											
4,4´-DDD	72-54-8	2	7.88E-04	CH-8	5.36E-03 [2]			2.00E+00	2.00E+00		2.68E-03
4,4´-DDE	72-55-9	14	3.43E-03	CH-8	8.29E-03 [2]			1.40E+00	1.40E+00		5.92E-03
4,4´-DDT	50-29-3	14	5.87E-03	DMU-1	8.62E-03 [2]		3.60E+01	1.70E+00	1.70E+00	2.39E-04	5.07E-03
DDT, Total	DDT, Total	14	1.01E-02	CH-8	2.16E-02 [2]		NA	NA	NA	NA	NA
alpha-Chlordane	5103-71-9	3	1.33E-03	CH-2	1.16E-02		NA	NA	NA	NA	NA
Chlordane - isomer mixture	12789-03-6	14	4.98E-03	CH-2	2.16E-02		3.50E+01	1.60E+00	1.60E+00	6.16E-04	1.35E-02
gamma-Chlordane	5566-34-7	14	3.62E-03	CH-2	9.97E-03		NA	NA	NA	NA	NA
delta-BHC	319-86-8	12	2.26E-03	CH-8	4.58E-03		NA	NA	NA	NA	NA
Dieldrin	60-57-1	13	2.06E-03	CH-2	1.20E-02		3.10E+00	3.00E-02	3.00E-02	3.87E-03	4.00E-01
Semivolatile Organic Compounds									NA		
2-Methylnaphthalene	91-57-6	14	1.12E-01	CH-7a	1.94E-01 [2]		3.10E+02	NA	3.10E+02	6.26E-04	NA
2-Methylphenol	95-48-7	5	2.72E-02	DMU-1	9.62E-02		3.10E+03	NA	3.10E+03	3.10E-05	NA
4-Chloroaniline	106-47-8	14	3.10E-01	DMU-1	4.21E-01		2.40E+02	2.40E+00	2.40E+00	1.75E-03	1.75E-01
4-Methylphenol	106-44-5	14	9.41E-01	DMU-1	3.51E+00		3.10E+02	NA	3.10E+02	1.13E-02	NA
Acenaphthene	83-32-9	14	1.08E-01	DMU-1	3.07E-01		3.40E+03	NA	3.40E+03	9.03E-05	NA
Acenaphthylene	208-96-8	11	3.15E-02	CH-1	7.00E-02		NA	NA	NA	NA	NA

Table 4-2a. Tier II Human health risk evaluation for use of dredged sediment at residential sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	COC[b]	Regional Screening Levels For Residential Land Use[c]			Hazard Ratio for Non-Cancer Toxicity[d]	Excess Cancer Risk Ratio[e]
							Total Direct Contact Exposure Non-Cancer Endpoint	Total Direct Contact Exposure Cancer Endpoint	Direct Contact Screening Level		
					(mg/kg)		(mg/kg)	(mg/kg)	(mg/kg)		
Anthracene	120-12-7	14	3.16E-01	DMU-1S	1.09E+00		1.70E+04	NA	1.70E+04	6.41E-05	NA
Benzo (a) anthracene	56-55-3	14	9.59E-01	DMU-1	1.30E+00	Yes	NA	1.50E-01	1.50E-01		8.67E+00
Benzo (a) pyrene	50-32-8	14	7.68E-01	CH-3	1.07E+00	Yes	NA	1.50E-02	1.50E-02		7.13E+01
Benzo (b) fluoranthene	205-99-2	14	1.07E+00	CH-2	1.52E+00	Yes	NA	1.50E-01	1.50E-01		1.01E+01
Benzo (g,h,i) perylene	191-24-2	14	5.12E-01	CH-3	7.70E-01		NA	NA	NA	NA	NA
Benzo (k) fluoranthene	207-08-9	14	8.16E-01	DMU-1	1.17E+00		NA	1.50E+00	1.50E+00		7.80E-01
Bis(2-ethylhexyl) phthalate	117-81-7	14	8.85E-01	CH-3	1.55E+00		1.20E+03	3.50E+01	3.50E+01	1.29E-03	4.43E-02
Butyl benzyl phthalate	85-68-7	10	4.27E-02	CH-3	1.14E-01		1.20E+04	2.60E+02	2.60E+02	9.50E-06	4.38E-04
Chrysene	218-01-9	14	1.48E+00	DMU-1	1.97E+00		NA	1.50E+01	1.50E+01		1.31E-01
Dibenz (a,h) anthracene	53-70-3	14	8.42E-02	CH-3	1.27E-01	Yes	NA	1.50E-02	1.50E-02		8.47E+00
Dibenzofuran	132-64-9	12	1.01E-01	CH-1	2.87E-01		7.80E+01	NA	7.80E+01	3.68E-03	NA
Diethyl phthalate	84-66-2	2	1.03E-02	DMU-1	3.90E-02		4.90E+04	NA	4.90E+04	7.96E-07	NA
Di-n-butyl phthalate	84-74-2	13	4.58E-02	CH-3	8.41E-02 [2]		6.10E+03	NA	6.10E+03	1.38E-05	NA
Di-n-octyl phthalate	117-84-0	14	3.24E-01	CH-2	4.04E-01		NA	NA	NA	NA	NA
Fluoranthene	206-44-0	14	4.16E+00	DMU-1	7.98E+00		2.30E+03	NA	2.30E+03	3.47E-03	NA
Fluorene	86-73-7	14	1.71E-01	CH-1	4.66E-01		2.30E+03	NA	2.30E+03	2.03E-04	NA
Indeno(1,2,3-cd)pyrene	193-39-5	14	6.25E-01	CH-3	9.31E-01	Yes	NA	1.50E-01	1.50E-01		6.21E+00
Naphthalene	91-20-3	14	1.79E-01	CH-1	4.95E-01		1.40E+02	3.60E+00	3.60E+00	3.54E-03	1.38E-01
PAHs, High Molecular Weight	PAHs, HMW	14	1.07E+01	DMU-1	1.61E+01		NA	NA	NA	NA	NA
PAHs, Low Molecular Weight	PAHs, LMW	14	2.39E+00	DMU-1	3.99E+00		NA	NA	NA	NA	NA

Table 4-2a. Tier II Human health risk evaluation for use of dredged sediment at residential sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg) (mg/kg)	COC[b]	Regional Screening Levels For Residential Land Use[c]: Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)	Hazard Ratio for Non-Cancer Toxicity[d]	Excess Cancer Risk Ratio[e]
PAHs, Total	130498-29-2	14	1.48E+01	DMU-1	2.25E+01		NA	NA	NA	NA	NA
Pentachlorophenol	87-86-5	7	2.06E-01	CH-3	4.43E-01		2.30E+02	8.90E-01	8.90E-01	1.93E-03	4.98E-01
Phenanthrene	85-01-8	14	1.47E+00	DMU-1	2.28E+00		NA	NA	NA	NA	NA
Phenol	108-95-2	14	7.96E-02	CH-7b	2.28E-01		1.80E+04	NA	1.80E+04	1.27E-05	NA
Pyrene	129-00-0	14	2.08E+00	CH-3	3.27E+00		1.70E+03	NA	1.70E+03	1.92E-03	NA
Volatile Organic Compounds (VOCs)											
1,2,3-Trichlorobenzene	87-61-6	2	2.22E-02	CH-8	4.00E-03		4.90E+01	NA	4.90E+01	8.16E-05	NA
1,2,4-Trichlorobenzene	120-82-1	3	1.57E-02	CH-1	3.70E-02		6.20E+01	2.20E+01	2.20E+01	5.97E-04	1.68E-03
1,2,4-Trimethylbenzene	95-63-6	2	3.00E-02	CH-8	2.10E-03		6.20E+01	NA	6.20E+01	3.39E-05	NA
1,2-Dichlorobenzene	95-50-1	2	2.46E-02	CH-8	1.60E-03		1.90E+03	NA	1.90E+03	8.42E-07	NA
1,3,5-Trimethylbenzene	108-67-8	1	2.81E-02	CH-8	1.00E-03		7.80E+02	NA	7.80E+02	1.28E-06	NA
1,3-Dichlorobenzene	541-73-1	2	2.20E-02	CH-8	1.40E-03		NA	NA	NA		NA
1,4-Dichlorobenzene	106-46-7	3	2.41E-02	CH-7A	7.30E-02		3.50E+03	2.40E+00	2.40E+00	2.09E-05	3.04E-02
2-Butanone	78-93-3	2	9.94E-02	CH-4	2.90E-02		2.80E+04	NA	2.80E+04	1.04E-06	NA
4-Isopropyltoluene	99-87-6	2	1.58E-02	CH-8	1.30E-03		NA	NA	NA	NA	NA
Acetone	67-64-1	2	1.02E-01	CH-4	1.20E-01 [2]		6.10E+04	NA	6.10E+04	1.97E-06	NA
Benzene	71-43-2	1	2.72E-02	CH-8	3.60E-04		8.60E+01	1.10E+00	1.10E+00	4.19E-06	3.27E-04
Bromobenzene	108-86-1	1	3.24E-02	CH-8	4.90E-04		3.00E+02	NA	3.00E+02	1.63E-06	NA
Bromomethane	74-83-9	1	3.39E-02	CH-1	8.50E-02		7.30E+00	NA	7.30E+00	1.16E-02	NA
Carbon disulfide	75-15-0	3	1.87E-02	CH-1	4.80E-02		8.20E+02	NA	8.20E+02	5.85E-05	NA
Chlorobenzene	108-90-7	1	2.28E-02	CH-7A	5.80E-02		2.90E+02	NA	2.90E+02	2.00E-04	NA
Ethylbenzene	100-41-4	1	4.38E-02	CH-8	7.90E-04		3.50E+03	5.40E+00	5.40E+00	2.26E-07	1.46E-04

Table 4-2a. Tier II Human health risk evaluation for use of dredged sediment at residential sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	COC[b]	Regional Screening Levels For Residential Land Use[c]			Hazard Ratio for Non-Cancer Toxicity[d]	Excess Cancer Risk Ratio[e]
							Total Direct Contact Exposure Non-Cancer Endpoint	Total Direct Contact Exposure Cancer Endpoint	Direct Contact Screening Level		
					(mg/kg)		(mg/kg)	(mg/kg)	(mg/kg)		
Hexachlorobutadiene	87-68-3	1	4.39E-02	CH-8	1.60E-03		6.10E+01	6.20E+00	6.20E+00	2.62E-05	2.58E-04
m&p-Xylene	179601-23-1	1	4.38E-02	CH-8	7.10E-04		NA	NA	NA	NA	NA
Methyl acetate	79-20-9	12	6.33E-01	DMU-1	1.30E+00		7.80E+04	NA	7.80E+04	1.67E-05	NA
Methylcyclohexane	108-87-2	2	4.42E-02	CH-8	3.30E-03		NA	NA	NA	NA	NA
n-Butylbenzene	104-51-8	1	4.39E-02	CH-8	1.60E-03		NA	NA	NA	NA	NA
sec-Butylbenzene	135-98-8	1	4.38E-02	CH-8	9.90E-04		NA	NA	NA	NA	NA
Toluene	108-88-3	14	4.29E+00	CH-3	1.10E+01		5.00E+03	NA	5.00E+03	2.20E-03	NA
Xylenes, Total	1330-20-7	1	4.38E-02	CH-8	7.10E-04		6.30E+02	NA	6.30E+02	1.13E-06	NA
							Cumulative Risk Ratio h			7.0E-01	1.1E+02

Notes:

a. Average sediment concentration represents the arithmatic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S. One half of the detection limit was used for estimating the chemical concentration when the measured concentration was less than the detection limit. Only chemicals with at least one measurement above the detection limit were evaluated.

b. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

c. USEPA Region 9. 2010. Regional Screening Levels (RSL) Tables: Composite table. (http://www.epa.gov/region9/superfund/prg/ accessed December 2010; Filename: composite_sl_table_bwrun_NOVEMBER2010.xls). The regional screening level for the direct contact cancer endpoint are set at an excess cancer risk of 1x10-6. Screening levels for residential and commercial/industrial exposure scenarios are taken directly for USEPA. Recreational use screening levels are based on the residential exposure assumptions adjusted for a reasonable maximum exposure maximum (RME) of 90 days year. Residential exposure assumes a RME of 350 days per year. The Direct Contact Screening Level is the lower value of the Non-cancer and Cancer endpoint values.

c. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

d. Hazard ratio for non-cancer endpoint of 1 is equivalent to a hazard index of 1.

e. A cancer risk-ratio of 1 is equivalent to an excess lifetime cancer risk of 1 x 10-6. A cancer risk ratio of 10 is equivalent to the Ohio EPA excess lifetime cancer risk (ELCR) goal of 1 x 10-5.

f. Chromium in sediment is present in the trivalent form (Cr III) based on analysis of Total Chromium and Hexavalent Chromium (CrVI) in composite samples DMMU-1, DMMU-2. Hexavalent chromium was not detected in these sediment samples.

g. Lead is not included in the cumulative assessment of risk. The USEPA has no consensus reference dose or cancer slope factorfor inorganic lead, so it is not possible to calculate screening levels. The USEPA recommends that soil lead levels less than 400 mg/kg are generally safe for residential use.

h. A hazard ratio for non-cancer toxicity of less than 1 and a cancer risk-ratio of less than 10 are considered acceptable by Ohio EPA.

1. Maximum sediment concentration is less than OEPA Erie Ontario Lake Plain (EOLP) regional sediment reference value. No risk ratio is calculated
2. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Soil Reference site.
3. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Lake Reference site.

Table 4-2b. Tier II Human health risk evaluation for use of dredged sediment at recreational sites.

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Recreational Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Inorganic Compounds										
Cyanide, Total	57-12-5	14	4.42E-01	CH-2	6.30E-01	6.22E+03	NA	6.22E+03	1.01E-04	NA
Aluminum	7429-90-5	14	8.60E+03	CH-6a	9.43E+03 [1,2]	2.99E+05	NA	2.99E+05	- [1]	-
Antimony	7440-36-0	2	5.94E-02	DMU-1	1.19E-01 [1,2]	1.21E+02	NA	1.21E+02	-	-
Arsenic	7440-38-2	14	1.23E+01	DMMU-2; CH-6a, CH-4	1.26E+01 [1,2]	8.56E+01	1.52E+00	1.52E+00	-	-
Barium	7440-39-3	14	7.70E+01	CH-6a	8.44E+01 [1,2]	5.83E+04	NA	5.83E+04	-	-
Beryllium	7440-41-7	14	6.16E-01	CH-5 DUP	6.97E-01 [1,2]	6.22E+02	5.44E+03	6.22E+02	-	-
Cadmium	7440-43-9	14	9.59E-01	CH-6a	1.15E+00	2.72E+02	7.00E+03	2.72E+02	4.22E-03	1.64E-04
Calcium	7440-70-2	14	1.50E+04	CH-6a	1.83E+04 [1, 3]	NA	NA	NA	-	-
Chromium (III)[f]	16065-83-1	14	2.67E+01	CH-8	3.10E+01	4.67E+05	NA	4.67E+05	6.64E-05	NA
Cobalt	7440-48-4	14	1.16E+01	CH-4	1.27E+01	8.94E+01	1.44E+03	8.94E+01	1.42E-01	8.83E-03
Copper	7440-50-8	14	5.18E+01	CH-6a	6.05E+01	1.21E+04	NA	1.21E+04	5.02E-03	NA
Iron	7439-89-6	14	2.64E+04	CH-6a	2.81E+04 [1,2]	2.14E+05	NA	2.14E+05	-	-
Leadg	7439-92-1	14	4.57E+01	CH-1	5.29E+01 [2]	NA	NA	NA	NA	NA
Magnesium	7439-95-4	14	5.69E+03	CH-6a	6.30E+03 [1]	NA	NA	NA	-	-
Manganese	7439-96-5	14	6.49E+02	CH-4	7.28E+02 [1]	7.00E+03	NA	7.00E+03	-	-
Mercury	7439-97-6	14	9.92E-02	CH-6a	1.35E-01 [2,]	2.18E+01	NA	2.18E+01	6.20E-03	NA
Nickel	7440-02-0	14	3.53E+01	CH-6a	3.93E+01	5.83E+03	5.06E+04	5.83E+03	6.74E-03	7.77E-04
Phosphorus	7723-14-0	14	4.35E+02	CH-3	4.97E+02	NA	NA	NA	NA	NA
Potassium	7440-09-7	14	1.72E+03	CH-6a	1.92E+03 [1]	NA	NA	NA	-	-
Selenium	7782-49-2	14	7.35E-01	CH-6a	8.57E-01 [1,2]	1.52E+03	NA	1.52E+03	-	-
Silver	7440-22-4	14	3.63E-01	CH-6a	4.67E-01	1.52E+03	NA	1.52E+03	3.08E-04	NA

Table 4-2b. Tier II Human health risk evaluation for use of dredged sediment at recreational sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Recreational Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Sodium	7440-23-5	14	2.30E+02	CH-3	2.77E+02	NA	NA	NA	NA	NA
Thallium	7440-28-0	14	3.57E-01	CH-6a	3.97E-01 [1,2]	NA	NA	NA	-	-
Vanadium	7440-62-2	14	2.01E+01	CH-6a	2.20E+01 [1,2]	2.14E+01	NA	2.14E+01	-	-
Zinc	7440-66-6	14	2.10E+02	CH-8	2.69E+02	8.94E+04	NA	8.94E+04	3.01E-03	
Chlorinated Pesticides										
4,4´-DDD	72-54-8	2	7.88E-04	CH-8	5.36E-03 [2]	NA	7.78E+00	7.78E+00	NA	6.89E-04
4,4´-DDE	72-55-9	14	3.43E-03	CH-8	8.29E-03 [2]	NA	5.44E+00	5.44E+00	NA	1.52E-03
4,4´-DDT	50-29-3	14	5.87E-03	DMU-1	8.62E-03 [2]	1.40E+02	6.61E+00	6.61E+00	6.16E-05	1.30E-03
DDT, Total	DDT, Total	14	1.01E-02	CH-8	2.16E-02 [2]	NA	NA	NA	NA	NA
alpha-Chlordane	5103-71-9	3	1.33E-03	CH-2	1.16E-02	NA	NA	NA	NA	NA
Chlordane - isomer mixture	12789-03-6	14	4.98E-03	CH-2	2.16E-02	1.36E+02	6.22E+00	6.22E+00	1.58E-04	3.47E-03
gamma-Chlordane	5566-34-7	14	3.62E-03	CH-2	9.97E-03	NA	NA	NA	NA	NA
delta-BHC	319-86-8	12	2.26E-03	CH-8	4.58E-03	NA	NA	NA	NA	NA
Dieldrin	60-57-1	13	2.06E-03	CH-2	1.20E-02	1.21E+01	1.17E-01	1.17E-01	9.95E-04	1.03E-01
Semivolatile Organic Compounds										
2-Methylnaphthalene	91-57-6	14	1.12E-01	CH-7a	1.94E-01 [2]	1.21E+03	NA	1.21E+03	1.61E-04	NA
2-Methylphenol	95-48-7	5	2.72E-02	DMU-1	9.62E-02	1.21E+04	NA	1.21E+04	7.98E-06	NA
4-Chloroaniline	106-47-8	14	3.10E-01	DMU-1	4.21E-01	9.33E+02	9.33E+00	9.33E+00	4.51E-04	4.51E-02
4-Methylphenol	106-44-5	14	9.41E-01	DMU-1	3.51E+00	1.21E+03	NA	1.21E+03	2.91E-03	NA
Acenaphthene	83-32-9	14	1.08E-01	DMU-1	3.07E-01	1.32E+04	NA	1.32E+04	2.32E-05	NA
Acenaphthylene	208-96-8	11	3.15E-02	CH-1	7.00E-02	NA	NA	NA	NA	NA
Anthracene	120-12-7	14	3.16E-01	DMU-1S	1.09E+00	6.61E+04	NA	6.61E+04	1.65E-05	NA

Table 4-2b. Tier II Human health risk evaluation for use of dredged sediment at recreational sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Recreational Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Benzo (a) anthracene	56-55-3	14	9.59E-01	DMU-1	1.30E+00	NA	5.83E-01	5.83E-01	NA	2.23E+00
Benzo (a) pyrene	50-32-8	14	7.68E-01	CH-3	1.07E+00	NA	5.83E-02	5.83E-02	NA	1.83E+01
Benzo (b) fluoranthene	205-99-2	14	1.07E+00	CH-2	1.52E+00	NA	5.83E-01	5.83E-01	NA	2.61E+00
Benzo (g,h,i) perylene	191-24-2	14	5.12E-01	CH-3	7.70E-01	NA	NA	NA	NA	NA
Benzo (k) fluoranthene	207-08-9	14	8.16E-01	DMU-1	1.17E+00	NA	5.83E+00	5.83E+00	NA	2.01E-01
Bis(2-ethylhexyl) phthalate	117-81-7	14	8.85E-01	CH-3	1.55E+00	4.67E+03	1.36E+02	1.36E+02	3.32E-04	1.14E-02
Butyl benzyl phthalate	85-68-7	10	4.27E-02	CH-3	1.14E-01	4.67E+04	1.01E+03	1.01E+03	2.44E-06	1.13E-04
Chrysene	218-01-9	14	1.48E+00	DMU-1	1.97E+00	NA	5.83E+01	5.83E+01	NA	3.38E-02
Dibenz (a,h) anthracene	53-70-3	14	8.42E-02	CH-3	1.27E-01	NA	5.83E-02	5.83E-02		2.18E+00
Dibenzofuran	132-64-9	12	1.01E-01	CH-1	2.87E-01	3.03E+02	NA	3.03E+02	9.46E-04	NA
Diethyl phthalate	84-66-2	2	1.03E-02	DMU-1	3.90E-02	1.91E+05	NA	1.91E+05	2.05E-07	NA
Di-n-butyl phthalate	84-74-2	13	4.58E-02	CH-3	8.41E-02 [2]	2.37E+04	NA	2.37E+04	3.55E-06	NA
Di-n-octyl phthalate	117-84-0	14	3.24E-01	CH-2	4.04E-01	NA	NA	NA	NA	NA
Fluoranthene	206-44-0	14	4.16E+00	DMU-1	7.98E+00	8.94E+03	NA	8.94E+03	8.92E-04	NA
Fluorene	86-73-7	14	1.71E-01	CH-1	4.66E-01	8.94E+03	NA	8.94E+03	5.21E-05	NA
Indeno(1,2,3-cd)pyrene	193-39-5	14	6.25E-01	CH-3	9.31E-01		5.83E-01	5.83E-01		1.60E+00
Naphthalene	91-20-3	14	1.79E-01	CH-1	4.95E-01	5.44E+02	1.40E+01	1.40E+01	9.09E-04	3.54E-02
PAHs, High Molecular Weight	PAHs, HMW	14	1.07E+01	DMU-1	1.61E+01	NA	NA	NA	NA	NA
PAHs, Low Molecular Weight	PAHs, LMW	14	2.39E+00	DMU-1	3.99E+00	NA	NA	NA	NA	NA
PAHs, Total	130498-29-2	14	1.48E+01	DMU-1	2.25E+01	NA	NA	NA	NA	NA
Pentachlorophenol	87-86-5	7	2.06E-01	CH-3	4.43E-01	8.94E+02	3.46E+00	3.46E+00	4.95E-04	1.28E-01

Table 4-2b. Tier II Human health risk evaluation for use of dredged sediment at recreational sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Recreational Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Phenanthrene	85-01-8	14	1.47E+00	DMU-1	2.28E+00	NA	NA	NA	NA	NA
Phenol	108-95-2	14	7.96E-02	CH-7b	2.28E-01	7.00E+04	NA	7.00E+04	3.26E-06	NA
Pyrene	129-00-0	14	2.08E+00	CH-3	3.27E+00	6.61E+03	NA	6.61E+03	4.95E-04	NA
Volatile Organic Compounds (VOCs)										
1,2,3-Trichlorobenzene	87-61-6	2	2.22E-02	CH-8	4.00E-03	1.91E+02	NA	1.91E+02	2.10E-05	NA
1,2,4-Trichlorobenzene	120-82-1	3	1.57E-02	CH-1	3.70E-02	2.41E+02	8.56E+01	8.56E+01	1.53E-04	4.32E-04
1,2,4-Trimethylbenzene	95-63-6	2	3.00E-02	CH-8	2.10E-03	2.41E+02	NA	2.41E+02	8.71E-06	NA
1,2-Dichlorobenzene	95-50-1	2	2.46E-02	CH-8	1.60E-03	7.39E+03	NA	7.39E+03	2.17E-07	NA
1,3,5-Trimethylbenzene	108-67-8	1	2.81E-02	CH-8	1.00E-03	3.03E+03	NA	3.03E+03	3.30E-07	NA
1,3-Dichlorobenzene	541-73-1	2	2.20E-02	CH-8	1.40E-03	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	2.41E-02	CH-7A	7.30E-02	1.36E+04	9.33E+00	9.33E+00	5.36E-06	7.82E-03
2-Butanone	78-93-3	2	9.94E-02	CH-4	2.90E-02	1.09E+05	NA	1.09E+05	2.66E-07	NA
4-Isopropyltoluene	99-87-6	2	1.58E-02	CH-8	1.30E-03	NA	NA	NA	NA	NA
Acetone	67-64-1	2	1.02E-01	CH-4	1.20E-01 [2]	2.37E+05	NA	2.37E+05	5.06E-07	NA
Benzene	71-43-2	1	2.72E-02	CH-8	3.60E-04	3.34E+02	4.28E+00	4.28E+00	1.08E-06	8.42E-05
Bromobenzene	108-86-1	1	3.24E-02	CH-8	4.90E-04	1.17E+03	NA	1.17E+03	4.20E-07	NA
Bromomethane	74-83-9	1	3.39E-02	CH-1	8.50E-02	2.84E+01	NA	2.84E+01	2.99E-03	NA
Carbon disulfide	75-15-0	3	1.87E-02	CH-1	4.80E-02	3.19E+03	NA	3.19E+03	1.51E-05	NA
Chlorobenzene	108-90-7	1	2.28E-02	CH-7A	5.80E-02	1.13E+03	NA	1.13E+03	5.14E-05	NA
Ethylbenzene	100-41-4	1	4.38E-02	CH-8	7.90E-04	1.36E+04	2.10E+01	2.10E+01	5.80E-08	3.76E-05
Hexachlorobutadiene	87-68-3	1	4.39E-02	CH-8	1.60E-03	2.37E+02	2.41E+01	2.41E+01	6.74E-06	6.64E-05
m&p-Xylene	179601-23-1	1	4.38E-02	CH-8	7.10E-04	NA	NA	NA	NA	NA

Table 4-2b. Tier II Human health risk evaluation for use of dredged sediment at recreational sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Recreational Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Methyl acetate	79-20-9	12	6.33E-01	DMU-1	1.30E+00	3.03E+05	NA	3.03E+05	4.29E-06	NA
Methylcyclohexane	108-87-2	2	4.42E-02	CH-8	3.30E-03	NA	NA	NA	NA	NA
n-Butylbenzene	104-51-8	1	4.39E-02	CH-8	1.60E-03	NA	NA	NA	NA	NA
sec-Butylbenzene	135-98-8	1	4.38E-02	CH-8	9.90E-04	NA	NA	NA	NA	NA
Toluene	108-88-3	14	4.29E+00	CH-3	1.10E+01	1.94E+04	NA	1.94E+04	5.66E-04	NA
Xylenes, Total	1330-20-7	1	4.38E-02	CH-8	7.10E-04	2.45E+03	NA	2.45E+03	2.90E-07	NA
						Cumulative Risk Ratio h			1.8E-01	2.8E+01

Notes:

a. Average sediment concentration represents the arithmatic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S. One half of the detection limit was used for estimating the chemical concentration when the measured concentration was less than the detection limit. Only chemicals with at least one measurement above the detection limit were evaluated.

b. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

c. USEPA Region 9. 2010. Regional Screening Levels (RSL) Tables: Composite table. (http://www.epa.gov/region9/superfund/prg/ accessed December 2010; Filename: composite_sl_table_bwrun_NOVEMBER2010.xls). The regional screening levels for the direct contact cancer endpoint are set at an excess cancer risk of 1x10-6. Screening levels for residential and commercial/industrial exposure scenarios are taken directly for USEPA. Recreational use screening levels are based on the residential exposure assumptions adjusted for a reasonable maximum exposure (RME) of 90 days/year. Residential exposure assumes an RME of 350 days/year. The Direct Contact Screening Level is the lower value of the Non-cancer and Cancer endpoint values.

c. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

d. Hazard ratio for non-cancer endpoint of 1 is equivalent to a hazard index of 1.

e. A cancer risk-ratio of 1 is equivalent to an excess lifetime cancer risk of 1 x 10-6. A cancer risk ratio of 10 is equivalent to the Ohio EPA excess lifetime cancer risk (ELCR) goal of 1 x 10-5.

f. Chromium in sediment is present in the trivalent form (Cr III) based on analysis of Total Chromium and Hexavalent Chromium (CrVI) in composite samples DMMU-1, DMMU-2. Hexavalent chromium was not detected in these sediment samples.

g. Lead is not included in the cumulative assessment of risk. The USEPA has no consensus reference dose or cancer slope factorfor inorganic lead, so it is not possible to calculate screening levels. The USEPA recommends that soil lead levels less than 400 mg/kg are generally safe for residential use.

h. A hazard ratio for non-cancer toxicity of less than 1 and a cancer risk-ratio of less than 10 are considered acceptable by Ohio EPA.

1. Maximum sediment concentration is less than OEPA Erie Ontario Lake Plain (EOLP) regional sediment reference value. No risk ratio is calculated
2. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Soil Reference site.
3. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Lake Reference site.

Table 4-2c. Tier II Human health risk evaluation for use of dredged sediment at commercial and industrial sites.

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Commercial Industrial Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
					(mg/kg)	Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Inorganic Compounds										
Cyanide, Total	57-12-5	14	4.42E-01	CH-2	6.30E-01	2.00E+04	NA	2.00E+04	3.15E-05	NA
Aluminum	7429-90-5	14	8.60E+03	CH-6a	9.43E+03 [1,2]	9.90E+05	NA	9.90E+05	- [1]	-
Antimony	7440-36-0	2	5.94E-02	DMU-1	1.19E-01 [1,2]	4.10E+02	NA	4.10E+02	-	-
Arsenic	7440-38-2	14	1.23E+01	DMMU-2; CH-6a, CH-4	1.26E+01 [1,2]	2.60E+02	1.60E+00	1.60E+00	-	-
Barium	7440-39-3	14	7.70E+01	CH-6a	8.44E+01 [1,2]	1.90E+05	NA	1.90E+05	-	-
Beryllium	7440-41-7	14	6.16E-01	CH-5 DUP	6.97E-01 [1,2]	2.00E+03	6.90E+03	2.00E+03	-	-
Cadmium	7440-43-9	14	9.59E-01	CH-6a	1.15E+00	8.00E+02	9.30E+03	8.00E+02	1.44E-03	1.24E-04
Calcium	7440-70-2	14	1.50E+04	CH-6a	1.83E+04 [1, 3]	NA	NA	NA	-	-
Chromium (III)f	16065-83-1	14	2.67E+01	CH-8	3.10E+01	1.50E+06	NA	1.50E+06	2.07E-05	NA
Cobalt	7440-48-4	14	1.16E+01	CH-4	1.27E+01	3.00E+02	1.90E+03	3.00E+02	4.23E-02	6.68E-03
Copper	7440-50-8	14	5.18E+01	CH-6a	6.05E+01	4.10E+04	NA	4.10E+04	1.48E-03	NA
Iron	7439-89-6	14	2.64E+04	CH-6a	2.81E+04 [1,2]	7.20E+05	NA	7.20E+05	-	-
Leadg	7439-92-1	14	4.57E+01	CH-1	5.29E+01 [2]	NA	NA	NA	NA	NA
Magnesium	7439-95-4	14	5.69E+03	CH-6a	6.30E+03 [1]	NA	NA	NA	NA	NA
Manganese	7439-96-5	14	6.49E+02	CH-4	7.28E+02 [1]	2.30E+04	NA	2.30E+04	-	-
Mercury	7439-97-6	14	9.92E-02	CH-6a	1.35E-01 [2,]	3.40E+01	NA	3.40E+01	3.97E-03	NA
Nickel	7440-02-0	14	3.53E+01	CH-6a	3.93E+01	2.00E+04	6.40E+04	2.00E+04	1.97E-03	6.14E-04
Phosphorus	7723-14-0	14	4.35E+02	CH-3	4.97E+02	NA	NA	NA	NA	NA
Potassium	7440-09-7	14	1.72E+03	CH-6a	1.92E+03 [1]	NA	NA	NA	-	-
Selenium	7782-49-2	14	7.35E-01	CH-6a	8.57E-01 [1,2]	5.10E+03	NA	5.10E+03	-	-
Silver	7440-22-4	14	3.63E-01	CH-6a	4.67E-01	5.10E+03	NA	5.10E+03	9.16E-05	NA

Table 4-2c. Tier II Human health risk evaluation for use of dredged sediment at commercial and industrial sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Commercial Industrial Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
					(mg/kg)	Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Sodium	7440-23-5	14	2.30E+02	CH-3	2.77E+02	NA	NA	NA	NA	NA
Thallium	7440-28-0	14	3.57E-01	CH-6a	3.97E-01 [1,2]	NA	NA	NA	-	-
Vanadium	7440-62-2	14	2.01E+01	CH-6a	2.20E+01 [1,2]	7.20E+01	NA	7.20E+01	-	-
Zinc	7440-66-6	14	2.10E+02	CH-8	2.69E+02	3.10E+05	NA	3.10E+05	8.68E-04	NA
Chlorinated Pesticides										
4,4´-DDD	72-54-8	2	7.88E-04	CH-8	5.36E-03 [2]	NA	7.20E+00	7.20E+00	NA	7.44E-04
4,4´-DDE	72-55-9	14	3.43E-03	CH-8	8.29E-03 [2]	NA	5.10E+00	5.10E+00	NA	1.63E-03
4,4´-DDT	50-29-3	14	5.87E-03	DMU-1	8.62E-03 [2]	4.30E+02	7.00E+00	7.00E+00	2.00E-05	1.23E-03
DDT, Total	DDT, Total	14	1.01E-02	CH-8	2.16E-02 [2]	NA	NA	NA	NA	NA
alpha-Chlordane	5103-71-9	3	1.33E-03	CH-2	1.16E-02	NA	NA	NA	NA	NA
Chlordane - isomer mixture	12789-03-6	14	4.98E-03	CH-2	2.16E-02	4.00E+02	6.50E+00	6.50E+00	5.39E-05	3.32E-03
gamma-Chlordane	5566-34-7	14	3.62E-03	CH-2	9.97E-03	NA	NA	NA	NA	NA
delta-BHC	319-86-8	12	2.26E-03	CH-8	4.58E-03	NA	NA	NA	NA	NA
Dieldrin	60-57-1	13	2.06E-03	CH-2	1.20E-02	3.10E+01	1.10E-01	1.10E-01	3.87E-04	1.09E-01
Semivolatile Organic Compounds										
2-Methylnaphthalene	91-57-6	14	1.12E-01	CH-7a	1.94E-01 [2]	4.10E+03	NA	4.10E+03	4.73E-05	NA
2-Methylphenol	95-48-7	5	2.72E-02	DMU-1	9.62E-02	3.10E+04	NA	3.10E+04	3.10E-06	NA
4-Chloroaniline	106-47-8	14	3.10E-01	DMU-1	4.21E-01	2.50E+03	8.60E+00	8.60E+00	1.68E-04	4.90E-02
4-Methylphenol	106-44-5	14	9.41E-01	DMU-1	3.51E+00	3.10E+03	NA	3.10E+03	1.13E-03	NA
Acenaphthene	83-32-9	14	1.08E-01	DMU-1	3.07E-01	3.30E+04	NA	3.30E+04	9.30E-06	NA
Acenaphthylene	208-96-8	11	3.15E-02	CH-1	7.00E-02	NA	NA	NA	NA	NA
Anthracene	120-12-7	14	3.16E-01	DMU-1S	1.09E+00	1.70E+05	NA	1.70E+05	6.41E-06	NA

Table 4-2c. Tier II Human health risk evaluation for use of dredged sediment at commercial and industrial sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg) (mg/kg)	Regional Screening Levels For Commercial Industrial Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Benzo (a) anthracene	56-55-3	14	9.59E-01	DMU-1	1.30E+00	NA	2.10E+00	2.10E+00	NA	6.19E-01
Benzo (a) pyrene	50-32-8	14	7.68E-01	CH-3	1.07E+00	NA	2.10E-01	2.10E-01	NA	5.10E+00
Benzo (b) fluoranthene	205-99-2	14	1.07E+00	CH-2	1.52E+00	NA	2.10E+00	2.10E+00	NA	7.24E-01
Benzo (g,h,i) perylene	191-24-2	14	5.12E-01	CH-3	7.70E-01	NA	NA	NA	NA	NA
Benzo (k) fluoranthene	207-08-9	14	8.16E-01	DMU-1	1.17E+00	NA	2.10E+01	2.10E+01	NA	5.57E-02
Bis(2-ethylhexyl)phthalate	117-81-7	14	8.85E-01	CH-3	1.55E+00	1.20E+04	1.20E+02	1.20E+02	1.29E-04	1.29E-02
Butyl benzyl phthalate	85-68-7	10	4.27E-02	CH-3	1.14E-01	1.20E+05	9.10E+02	9.10E+02	9.50E-07	1.25E-04
Chrysene	218-01-9	14	1.48E+00	DMU-1	1.97E+00	NA	2.10E+02	2.10E+02	NA	9.38E-03
Dibenz (a,h) anthracene	53-70-3	14	8.42E-02	CH-3	1.27E-01	NA	2.10E-01	2.10E-01	NA	6.05E-01
Dibenzofuran	132-64-9	12	1.01E-01	CH-1	2.87E-01	1.00E+03	NA	1.00E+03	2.87E-04	NA
Diethyl phthalate	84-66-2	2	1.03E-02	DMU-1	3.90E-02	4.90E+05	NA	4.90E+05	7.96E-08	NA
Di-n-butyl phthalate	84-74-2	13	4.58E-02	CH-3	8.41E-02 [2]	6.20E+04	NA	6.20E+04	1.36E-06	NA
Di-n-octyl phthalate	117-84-0	14	3.24E-01	CH-2	4.04E-01	NA	NA	NA	NA	NA
Fluoranthene	206-44-0	14	4.16E+00	DMU-1	7.98E+00	2.20E+04	NA	2.20E+04	3.63E-04	NA
Fluorene	86-73-7	14	1.71E-01	CH-1	4.66E-01	2.20E+04	NA	2.20E+04	2.12E-05	NA
Indeno(1,2,3-cd)pyrene	193-39-5	14	6.25E-01	CH-3	9.31E-01	NA	2.10E+00	2.10E+00	NA	4.43E-01
Naphthalene	91-20-3	14	1.79E-01	CH-1	4.95E-01	6.20E+02	1.80E+01	1.80E+01	7.98E-04	2.75E-02
PAHs, High Molecular Weight	PAHs, HMW	14	1.07E+01	DMU-1	1.61E+01	NA	NA	NA	NA	NA
PAHs, Low Molecular Weight	PAHs, LMW	14	2.39E+00	DMU-1	3.99E+00	NA	NA	NA	NA	NA
PAHs, Total	130498-29-2	14	1.48E+01	DMU-1	2.25E+01	NA	NA	NA	NA	NA
Pentachlorophenol	87-86-5	7	2.06E-01	CH-3	4.43E-01	1.90E+03	2.70E+00	2.70E+00	2.33E-04	1.64E-01
Phenanthrene	85-01-8	14	1.47E+00	DMU-1	2.28E+00	NA	NA	NA	NA	NA

Table 4-2c. Tier II Human health risk evaluation for use of dredged sediment at commercial and industrial sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg)	Regional Screening Levels For Commercial Industrial Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
					(mg/kg)	Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Phenol	108-95-2	14	7.96E-02	CH-7b	2.28E-01	1.80E+05	NA	1.80E+05	1.27E-06	NA
Pyrene	129-00-0	14	2.08E+00	CH-3	3.27E+00	1.70E+04	NA	1.70E+04	1.92E-04	NA
Volatile Organic Compounds (VOCs)										
1,2,3-Trichlorobenzene	87-61-6	2	2.22E-02	CH-8	4.00E-03	4.90E+02	NA	4.90E+02	8.16E-06	NA
1,2,4-Trichlorobenzene	120-82-1	3	1.57E-02	CH-1	3.70E-02	2.70E+02	9.90E+01	9.90E+01	1.37E-04	3.74E-04
1,2,4-Trimethylbenzene	95-63-6	2	3.00E-02	CH-8	2.10E-03	2.60E+02	NA	2.60E+02	8.08E-06	NA
1,2-Dichlorobenzene	95-50-1	2	2.46E-02	CH-8	1.60E-03	9.80E+03	NA	9.80E+03	1.63E-07	NA
1,3,5-Trimethylbenzene	108-67-8	1	2.81E-02	CH-8	1.00E-03	1.00E+04	NA	1.00E+04	1.00E-07	NA
1,3-Dichlorobenzene	541-73-1	2	2.20E-02	CH-8	1.40E-03	NA	NA	NA		NA
1,4-Dichlorobenzene	106-46-7	3	2.41E-02	CH-7A	7.30E-02	2.50E+04	1.20E+01	1.20E+01	2.92E-06	6.08E-03
2-Butanone	78-93-3	2	9.94E-02	CH-4	2.90E-02	2.00E+05	NA	2.00E+05	1.45E-07	NA
4-Isopropyltoluene	99-87-6	2	1.58E-02	CH-8	1.30E-03	NA	NA	NA	NA	NA
Acetone	67-64-1	2	1.02E-01	CH-4	1.20E-01 [2]	6.30E+05	NA	6.30E+05	1.90E-07	NA
Benzene	71-43-2	1	2.72E-02	CH-8	3.60E-04	4.50E+02	5.40E+00	5.40E+00	8.00E-07	6.67E-05
Bromobenzene	108-86-1	1	3.24E-02	CH-8	4.90E-04	1.80E+03	NA	1.80E+03	2.72E-07	NA
Bromomethane	74-83-9	1	3.39E-02	CH-1	8.50E-02	3.20E+01	NA	3.20E+01	2.66E-03	NA
Carbon disulfide	75-15-0	3	1.87E-02	CH-1	4.80E-02	3.70E+03	NA	3.70E+03	1.30E-05	NA
Chlorobenzene	108-90-7	1	2.28E-02	CH-7A	5.80E-02	1.40E+03	NA	1.40E+03	4.14E-05	NA
Ethylbenzene	100-41-4	1	4.38E-02	CH-8	7.90E-04	2.10E+04	2.70E+01	2.70E+01	3.76E-08	2.93E-05
Hexachlorobutadiene	87-68-3	1	4.39E-02	CH-8	1.60E-03	6.20E+02	2.20E+01	2.20E+01	2.58E-06	7.27E-05
m&p-Xylene	179601-23-1	1	4.38E-02	CH-8	7.10E-04	NA	NA	NA	NA	NA
Methyl acetate	79-20-9	12	6.33E-01	DMU-1	1.30E+00	1.00E+06	NA	1.00E+06	1.30E-06	NA

Table 4-2c. Tier II Human health risk evaluation for use of dredged sediment at commercial and industrial sites (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Location of Maximum Concentration	Maximum Concentration (mg/kg) (mg/kg)	Regional Screening Levels For Commercial Industrial Land Use[b]			Hazard Ratio for Non-Cancer Toxicity[c]	Excess Cancer Risk Ratio[d]
						Total Direct Contact Exposure Non-Cancer Endpoint (mg/kg)	Total Direct Contact Exposure Cancer Endpoint (mg/kg)	Direct Contact Screening Level (mg/kg)		
Methylcyclohexane	108-87-2	2	4.42E-02	CH-8	3.30E-03	NA	NA	NA	NA	NA
n-Butylbenzene	104-51-8	1	4.39E-02	CH-8	1.60E-03	NA	NA	NA	NA	NA
sec-Butylbenzene	135-98-8	1	4.38E-02	CH-8	9.90E-04	NA	NA	NA	NA	NA
Toluene	108-88-3	14	4.29E+00	CH-3	1.10E+01	4.50E+04	NA	4.50E+04	2.44E-04	NA
Xylenes, Total	1330-20-7	1	4.38E-02	CH-8	7.10E-04	2.70E+03	NA	2.70E+03	2.63E-07	NA
						Cumulative Risk Ratio[h]			5.9E-02	7.9E+00

Notes:

a. Average sediment concentration represents the arithmatic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S. One half of the detection limit was used for estimating the chemical concentration when the measured concentration was less than the detection limit. Only chemicals with at least one measurement above the detection limit were evaluated.

b. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

c. USEPA Region 9. 2010. Regional Screening Levels (RSL) Tables: Composite table. (http://www.epa.gov/region9/superfund/prg/ accessed December 2010; Filename: composite_sl_table_bwrun_NOVEMBER2010.xls). The regional screening levels for the direct contact cancer endpoint are set at an excess cancer risk of 1x10-6. Screening levels for residential and commercial/industrial exposure scenarios are taken directly for USEPA. Recreational use screening levels are based on the residential exposure assumptions adjusted for a reasonable maximum exposure (RME) of 90 days/year. Residential exposure assumes an RME of 350 days/year. The Direct Contact Screening Level is the lower value of the Non-cancer and Cancer endpoint values.

c. Chemicals of concern have concentrations above EOLP background and the USEPA Direct Contact Screening Level for residential land use

d. Hazard ratio for non-cancer endpoint of 1 is equivalent to a hazard index of 1.

e. A cancer risk-ratio of 1 is equivalent to an excess lifetime cancer risk of 1 x 10-6. A cancer risk ratio of 10 is equivalent to the Ohio EPA excess lifetime cancer risk (ELCR) goal of 1 x 10-5.

f. Chromium in sediment is present in the trivalent form (Cr III) based on analysis of Total Chromium and Hexavalent Chromium (CrVI) in composite samples DMMU-1, DMMU-2. Hexavalent chromium was not detected in these sediment samples.

g. Lead is not included in the cumulative assessment of risk. The USEPA has no consensus reference dose or cancer slope factor for inorganic lead, so it is not possible to calculate screening levels. The USEPA recommends that soil lead levels less than 400 mg/kg are generally safe for residential use.

h. A hazard ratio for non-cancer toxicity of less than 1 and a cancer risk-ratio of less than 10 are considered acceptable by Ohio EPA.

1. Maximum sediment concentration is less than OEPA Erie Ontario Lake Plain (EOLP) regional sediment reference value. No risk ratio is calculated
2. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Soil Reference site.
3. Maximum sediment concentration is less than the maximum concentration measured in samples collected from the Lake Reference site.

Although polycyclic aromatic hydrocarbons (PAHs) were the only class of organic chemicals above background levels that exceeded risk-based screening levels, the concentrations measured were within the range typical of urban soils. PAHs are ubiquitous in both urban and rural soils. They are formed from the combustion of fossil fuels (e.g., coal, diesel fuel, gasoline, etc.) and natural materials (e.g., wood, leaves, charcoal, etc.). Many products in commercial trade have significant concentrations of PAHs that contribute to the background of these chemicals in urban environments including asphalt pavement sealer and black carbon present in automobile tires. The primary sources of human exposure to PAHs are the active or passive inhalation of tobacco smoke, wood smoke, contaminated air, and the ingestion of smoked/barbequed food (ATSDR 1995). The maximum concentration of total PAHs (the sum of 16 priority pollutant PAH compounds) measured in Navigation Channel sediments was 24.4 mg/kg, which is typical for urban soils and is similar to concentrations measured in other large urban cities such as Chicago and New York. The upper 95th percentile for the concentration of total PAHs measured in surface soils collected in Chicago and New York has been reported to be 14 and 25 mg/kg, respectively, with the upper 95th percentile for the concentration of benzo(a)pyrene, an important PAH when considering risk to human health, being 1.3 and 1.7 mg/kg, respectively (Tetra Tech 2003; RETEC 2007).

These background levels of benzo(a)pyrene considered typical in urban soils are important because the risk screening level considered acceptable by OEPA for residential soils is 0.015 mg/kg (Table 4.3). The concentration of benzo(a)pyrene in rural and urban soils, generally considered to be uncontaminated, is often significantly higher than these screening values. The New York State Department of Health recently conducted a survey of rural soils (excluding urban areas of the state) to establish soil cleanup objectives at Brownfield and environmental restoration sites (New York State Department of Health and New York State Department of Environmental Conservation, 2005). Surface soil samples were randomly collected from 125 rural locations that were designated as “Remote” (habitat that was only marginally impacted by human activity), “Source Distant” (areas where human contact may occur but at least 5 meters distant from potential pollution sources such as trash, roads, driveways or structures) and “Source Near” (areas approximately 2 meters distant from a road or driveway). The maximum concentration of total PAHs measured in these samples was 19, 23 and 39 mg/kg for the samples classified as “Remote,” “Source Distant,” and “Source Near,” respectively. In addition, the maximum concentration of

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards.

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Maximum Sediment Concentration (C_S)		Sample Location With Maximum Concentration	Leachable Fraction For Oxidized Sediment (LFox)[b]	Aqueous Partitioning Coefficient (Kd)[b]	Organic Carbon Partitioning Coefficient (Koc)[c]	Fraction Sediment Organic Carbon (Foc)[d]	Maximum Predicted Porewater Concentration[e] (C_{O_Max})	Average Predicted Porewater Concentration[f] (C_{O_Avg})	Ohio EPA Drinking Water Standard	Maximum Predicted Porewater Concentration Exceeds OEPA Drinking Water Quality Standard
Inorganic Compounds			(mg/kg))	(mg/kg) Note[g]				(L/kg)		(L/kg)	(ug/L)	(ug/L)	(ug/L)	
Cyanide, Total	57-12-5	14	0.44	0.63 JH[h]		CH-2	1	9.9	NA	NA	64	45	600	
Aluminum	7429-90-5	14	8,600	9400	1,2	CH-6a	0.005	1500	NA	NA	31	29	970	
Antimony	7440-36-0	2	0.059	0.12 J	1,2	DMU-1	0.1	170	NA	NA	0.070	0.060	9.7	
Arsenic	7440-38-2	14	12	13	1,2	CH-4/CH-6a/DMMU-2	0.2	20.6	NA	NA	120	120	10	Yes[k]
Barium	7440-39-3	14	77	84	1,2	CH-6a	1	41	NA	NA	2100	1900	2000	Yes[k]
Beryllium	7440-41-7	14	0.62	0.67	1,2	CH-5 DUP	0.6	40	NA	NA	10	9	17	
Cadmium	7440-43-9	14	0.96	1.2		CH-6a	0.5	30	NA	NA	19	16	14	Yes
Calcium	7440-70-2	14	15,000	18,300 B	1, 3	CH-6a	-	-	NA	NA	-	-	-j	
Chromium (III)i	16065-83-1	14	27	31		CH-8	0.01	121	NA	NA	2.6	2.2	-	
Cobalt	7440-48-4	14	12	13		CH-4	1	8	NA	NA	1600	1500	-	
Copper	7440-50-8	14	52	61		CH-6a	0.15	8.50	NA	NA	1100	920	790	Yes
Iron	7439-89-6	14	26,000	28,000	1,2	CH-6a	-	25	NA	NA	-		-	
Lead	7439-92-1	14	46	53	2	CH-1	0.05	300	NA	NA	8.8	7.6	-	
Magnesium	7439-95-4	14	5,700	6300	1	CH-6a	-	-	NA	NA	-	-	-	
Manganese	7439-96-5	14	650	730	1	CH-4	-	65	NA	NA	-	-	50	
Mercury	7439-97-6	14	0.099	0.14	2	CH-6a	0.08	100	NA	NA	0.11	0.08	0.0031	Yes[k]
Nickel	7440-02-0	14	35	39		CH-6a	0.3	20.4	NA	NA	580	520	470	Yes

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Maximum Sediment Concentration (C_S)		Sample Location With Maximum Concentration	Leachable Fraction For Oxidized Sediment (LFox)[b]	Aqueous Partitioning Coefficient (Kd)[b]	Organic Carbon Partitioning Coefficient (Koc)[c]	Fraction Sediment Organic Carbon (Foc)[d]	Maximum Predicted Porewater Concentration[e] (C_{O_Max})	Average Predicted Porewater Concentration[f] (C_{O_Avg})	Ohio EPA Drinking Water Standard	Maximum Predicted Porewater Concentration Exceeds OEPA Drinking Water Quality Standard
Phosphorus (total)	7723-14-0	14	440	500		CH-3	-	-	NA	NA	-	-	-	
Potassium	7440-09-7	14	1,700	1,900	1	CH-6a	-	-	NA	NA	-	-	-	
Selenium	7782-49-2	14	0.74	0.86	1,2	CH-6a	0.5	3	NA	NA	140	123	130	Yes[k]
Silver	7440-22-4	14	0.36	0.47 J		CH-6a	0.5	100	NA	NA	2.3	1.8	130	
Sodium	7440-23-5	14	230	280 B		CH-3	-	-	NA	NA	-	-	-	
Thallium	7440-28-0	14	0.36	0.40 J	1,2	CH-6a	0.2	40	NA	NA	2.0	1.8	-	
Vanadium	7440-62-2	14	20	22	1,2	CH-6a	1	1000	NA	NA	22	20	-	
Zinc	7440-66-6	14	210	270		CH-8	0.3	80	NA	NA	1000	790	5000	
Chlorinated Pesticides														
4,4´-DDD	72-54-8	2	0.00079	0.0054	2	CH-8	NA	NA	1.18E+05	0.029	0.0016	0.00023	-	
4,4´-DDE	72-55-9	14	0.0034	0.0083	2	CH-8	NA	NA	1.18E+05	0.029	0.0024	0.0010	-	
4,4´-DDT	50-29-3	14	0.0059	0.0080	2	CH-8	NA	NA	1.69E+05	0.029	0.0016	0.0012	0.00015	Yes[k]
DDT, Total	DDT, Total	14	0.010	0.022	2	CH-8	NA	NA	-	0.029	-	-	-	
alpha-Chlordane	5103-71-9	3	0.0013	0.012		CH-2	NA	NA	6.75E+05	0.037	0.00048	0.000053	-	
gamma-Chlordane	5566-34-7	14	0.0036	0.010		CH-2	NA	NA	5.89E+04	0.037	0.0046	0.0017	-	
Chlordane - Isomer mixture	12789-03-6	14	0.0050	0.022		CH-2	NA	NA	3.38E+04	0.037	0.017	0.0040	-	
delta-BHC	319-86-8	12	0.0023	0.0046		CH-8	NA	NA	2.81E+03	0.029	0.056	0.028	-	
Dieldrin	60-57-1	13	0.0021	0.012		CH-2	NA	NA	2.01E+04	0.037	0.016	0.0028	0.0000065	Yes

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Maximum Sediment Concentration (C_S)		Sample Location With Maximum Concentration	Leachable Fraction For Oxidized Sediment (LFox)[b]	Aqueous Partitioning Coefficient (Kd)[b]	Organic Carbon Partitioning Coefficient (Koc)[c]	Fraction Sediment Organic Carbon (Foc)[d]	Maximum Predicted Porewater Concentration[e] (C_{O_Max})	Average Predicted Porewater Concentration[f] (C_{O_Avg})	Ohio EPA Drinking Water Standard	Maximum Predicted Porewater Concentration Exceeds OEPA Drinking Water Quality Standard
Semivolatile Organic Compounds														
2-Methylnaphthalene	91-57-6	14	0.11	0.194	2	CH-7a	NA	NA	2.48E+03	0.027	2.9	1.7	-	
2-Methylphenol	95-48-7	5	0.027	0.096		DMMU-1	NA	NA	3.07E+02	0.039	8.0	2.3	-	
4-Chloroaniline	106-47-8	14	0.31	0.36		DMMU-2	NA	NA	1.13E+02	0.026	125	110	-	
4-Methylphenol	106-44-5	14	0.94	2.4		CH-7b	NA	NA	3.00E+02	0.024	326	130	-	
Acenaphthene	83-32-9	14	0.11	0.22		CH-7a	NA	NA	5.03E+03	0.027	1.6	0.79	570	
Acenaphthylene	208-96-8	11	0.031	0.070		CH-1	NA	NA	5.03E+03	0.037	0.37	0.17	850	
Anthracene	120-12-7	14	0.32	1.1		DMMU-1S	NA	NA	1.64E+04	0.040	1.7	0.49	590	
Benzo (a) anthracene	56-55-3	14	0.96	0.93		DMMU-2	NA	NA	1.77E+05	0.026	0.20	0.21	-	
Benzo (a) pyrene	50-32-8	14	0.77	0.81		DMMU-2	NA	NA	5.87E+05	0.026	0.053	0.051	0.00002	Yes
Benzo (b) fluoranthene	205-99-2	14	1.1	1.2		DMMU-2	NA	NA	5.99E+05	0.026	0.080	0.069	-	
Benzo (g,h,i) perylene	191-24-2	14	0.51	0.770		CH-3	NA	NA	1.95E+06	0.035	0.011	0.0075	-	
Benzo (k) fluoranthene	207-08-9	14	0.82	0.88		CH-4	NA	NA	5.87E+05	0.027	0.056	0.052	-	
Bis(2-ethylhexyl) phthalate	117-81-7	14	0.88	1.6		CH-3	NA	NA	1.20E+05	0.035	0.37	0.21	25	
Butyl benzyl phthalate	85-68-7	10	0.043	0.11		CH-3	NA	NA	7.16E+03	0.035	0.45	0.17	-	
Chrysene	218-01-9	14	1.5	1.5		DMMU-2	NA	NA	1.81E+05	0.026	0.32	0.32	-	
Dibenz (a,h) anthracene	53-70-3	14	0.084	0.1		CH-5	NA	NA	1.91E+06	0.027	0.0020	0.0016	-	
Dibenzofuran	132-64-9	12	0.10	0.23		CH-7a	NA	NA	9.16E+03	0.027	0.93	0.40	-	

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Maximum Sediment Concentration (C_S)		Sample Location With Maximum Concentration	Leachable Fraction For Oxidized Sediment (LFox)[b]	Aqueous Partitioning Coefficient (Kd)[b]	Organic Carbon Partitioning Coefficient (Koc)[c]	Fraction Sediment Organic Carbon (Foc)[d]	Maximum Predicted Porewater Concentration[e] (C_{O_Max})	Average Predicted Porewater Concentration[f] (C_{O_Avg})	Ohio EPA Drinking Water Standard	Maximum Predicted Porewater Concentration Exceeds OEPA Drinking Water Quality Standard
Diethyl phthalate	84-66-2	2	0.010	0.039 J		DMMU-2	NA	NA	1.05E+02	0.026	11	3.8	-	
Di-n-butyl phthalate	84-74-2	13	0.046	0.084	2	CH-3	NA	NA	1.16E+03	0.035	2.1	1.1	31	
Di-n-octyl phthalate	117-84-0	14	0.32	0.400		CH-2	NA	NA	1.41E+05	0.035	0.081	0.065	-	
Fluoranthene	206-44-0	14	4.2	8.0		DMMU-1	NA	NA	5.55E+04	0.039	3.7	1.9	9.4	
Fluorene	86-73-7	14	0.17	0.47		CH-1	NA	NA	9.16E+03	0.037	1.4	0.50	250	
Indeno(1,2,3-cd)pyrene	193-39-5	14	0.62	0.76		CH-5	NA	NA	1.95E+06	0.027	0.014	0.01	-	
Naphthalene	91-20-3	14	0.18	0.50		CH-1	NA	NA	1.54E+03	0.037	8.7	3.1	540	
PAHs, High Molecular Weight	PAHs, HMW	14	11	16		DMMU-1	NA	NA	-	0.039	-	-	-	
PAHs, Low Molecular Weight	PAHs, LMW	14	2.4	4.0		DMMU-1	NA	NA	-	0.039	-	-	-	
PAHs, Total	130498-29-2	14	15	22		DMMU-1	NA	NA	-	0.039	-	-	-	
Pentachlorophenol	87-86-5	7	0.21	0.37		CH-7b	NA	NA	4.96E+03	0.024	3.1	1.7	1	Yes
Phenanthrene	85-01-8	14	1.5	2.30		DMMU-1	NA	NA	1.67E+05	0.039	0.35	0.23	-	
Phenol	108-95-2	14	0.080	0.23		CH-7b	NA	NA	1.87E+02	0.024	51	18	1	Yes
Pyrene	129-00-0	14	2.1	3.3		CH-5	NA	NA	5.43E+04	0.027	2.1	1.41	15	
Volatile Organic Compounds (VOCs)								NA						
1,2,3-Trichlorobenzene	87-61-6	2	0.022	0.004 JHB		CH-8	NA	NA	1.38E+03	0.029	0.10	0.55	-	
1,2,4-Trichlorobenzene	120-82-1	3	0.016	0.037 JHB		CH-1	NA	NA	1.36E+03	0.037	0.73	0.31	-	

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards (continued).

Analyte	CAS	Number of Detects	Average Concentration[a] (mg/kg)	Maximum Sediment Concentration (C_S)		Sample Location With Maximum Concentration	Leachable Fraction For Oxidized Sediment (LFox)[b]	Aqueous Partitioning Coefficient (Kd)[b]	Organic Carbon Partitioning Coefficient (Koc)[c]	Fraction Sediment Organic Carbon (Foc)[d]	Maximum Predicted Porewater Concentration[e] (C_{O_Max})	Average Predicted Porewater Concentration[f] (C_{O_Avg})	Ohio EPA Drinking Water Standard	Maximum Predicted Porewater Concentration Exceeds OEPA Drinking Water Quality Standard
1,2,4-Trimethylbenzene	95-63-6	2	0.030	0.0021 JHB		CH-8	NA	NA	6.14E+02	0.029	0.12	1.68	49	
1,2-Dichlorobenzene	95-50-1	2	0.025	0.0016 JHB		CH-8	NA	NA	3.83E+02	0.029	0.14	2.21	2000	
1,3,5-Trimethylbenzene	108-67-8	1	0.028	0.001 JH		CH-8	NA	NA	6.02E+02	0.029	0.057	1.61	710	
1,3-Dichlorobenzene	541-73-1	2	0.022	0.0014 JHB		CH-8	NA	NA	3.75E+02	0.029	0.13	2.02	5200	
1,4-Dichlorobenzene	106-46-7	3	0.024	0.073 JH		CH-7A	NA	NA	3.75E+02	0.027	7.2	2.37	24	
2-Butanone	78-93-3	2	0.099	0.029 H		CH-4	NA	NA	4.51E+00	0.027	242.65	831.34	-	
4-Isopropyltoluene	99-87-6	2	0.016	0.0013 JHB		CH-8	NA	NA	1.12E+03	0.029	0.04	0.49	-	
Acetone	67-64-1	2	0.10	0.12 H	2	CH-4	NA	NA	2.36E+00	0.027	1916	1600	-	
Benzene	71-43-2	1	0.027	0.00036 JH		CH-8	NA	NA	1.46E+02	0.029	0.085	6.43	12	
Bromobenzene	108-86-1	1	0.032	0.00049 JH		CH-8	NA	NA	2.34E+02	0.029	0.07	4.78	-	
Bromomethane	74-83-9	1	0.034	0.085 JHB		CH-1	NA	NA	1.32E+01	0.037	172	69	39	Yes
Carbon disulfide	75-15-0	3	0.019	0.048 JH		CH-1	NA	NA	2.17E+01	0.037	59	23	-	
Chlorobenzene	108-90-7	1	0.023	0.058 JH		CH-7A	NA	NA	2.34E+02	0.027	9.2	3.60	470	
Ethylbenzene	100-41-4	1	0.044	0.00079 JH		CH-8	NA	NA	4.46E+02	0.029	0.061	3.39	2100	

Table 4-3 Preliminary comparison of the predicted concentrations of chemicals in sediment porewater to Ohio EPA Drinking Water Standards (continued).

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Hexachlorobutadiene	87-68-3	1	0.044	0.0016 JHB	CH-8	NA	NA	8.45E+02	0.029	0.065	1.79	0.22	
m&p-Xylene	179601-23-1	1	0.044	0.00071 JH	CH-8	NA	NA	-	0.029	-	-	-	
Methyl acetate	79-20-9	12	0.63	1.3 H	DMMU-1	NA	NA	3.06E+00	0.039	11000	52000	-	
Methylcyclohexane	108-87-2	2	0.044	0.0033 JH	CH-8	NA	NA	3.06E+00	0.029	37	498	-	
n-Butylbenzene	104-51-8	1	0.044	0.0016 JHB	CH-8	NA	NA	1.48E+03	0.029	0.037	1.0	-	
sec-Butylbenzene	135-98-8	1	0.044	0.00099 JHB	CH-8	NA	NA	1.33E+03	0.029	0.026	1.1	-	
Toluene	108-88-3	14	4.3	11 H	CH-3	NA	NA	2.34E+02	0.035	1300	521	5600	
Xylenes, Total	1330-20-7	1	0.044	0.00071 JH	CH-8	NA	NA	3.83E+02	0.029	0.064	3.9	31000	

Notes:

a. Average sediment concentration represents the arithmatic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S. One half of the reporting limit was used for estimating the chemical concentration when the measured concentration was less than the detection limit. Only chemicals with at least one measurement above the detection limit were evaluated.

b. The fraction available for aqueous partitioning in oxidizing environments (LF_{OX}) and aqueous partitioning coefficients for metals (Kd) and were obtained from the USACE Chemical Database provided in the Draft Tier II Screening Evaluation Model for Confined Disposal Facility Contaminant Pathway Migration Evaluations.

c. The aqueous organic carbon partitioning coefficients (K_{OC}) values for organic chemical were obtained from the USEPA Region 9 Regional Screening Levels (RSL) Tables: Chemical Specific parameters accessed November 2010 (http://www.epa.gov/region9/superfund/prg/). These values are based on model estimates using the U.S. EPA Estimation Programs Interface (EPISuites) KOCwin program. Where USEPA Region 9 Regional Screening Levels KOC values were not available, MCI model estimates were calculated using the EPISuites program. Kd values for organic chemicals were derived based on the sample sediment organic carbon content using the relationship K_{OC} x f_{OC}.

d. Fractional concentration of the sediment organic carbon content in the sample with maximum concentration of contaminant

e. Predicted concentration in sediment porewater based on the relationship $C_0 = (C_S * LF_{OX}) / Kd$ for metals and $C_0 = C_S / (K_{OC} \times f_{OC})$ for organic compounds

f. Predicted sediment porewater concentrations based on average sediment concentrations where samples with nondetectalbe concentrations were estimated using one half of the reporting limit.

g. Values denoted by 1 have maximum detected values less than OEPA EOLP regional background value. Values denoted by 2 have maximum detected values less than the maximum detected value measured in the Reference Site soils.

h. J = Estimated concentration, analyte detected below the quantitation limit H = Laboratory analysis procedures exceeding standard holding times prior to extraction. B = Analyte detected in laboratory quality control blank.

i. Chromium in sediment is present in the trivalent form (Cr III) based on analysis of Total Chromium and Hexavalent Chromium (CrVI) in composite samples DMMU-1, DMMU-2. Hexavalent chromium was not detected in these sediment samples.

j. Dash donates insufficient information to predicted soil pore concentrations or no OEPA drinking water quality standard is available.

k. Maximum sediment concentration is less than EOLP regional background or Soil Reference Site maximum detected value.

benzo(a)pyrene detected in rural soils was 1.1, 3.0 and 2.4 for the sample locations classified as “Remote,” “Source Distant,” and “Source Near,” respectively. Based on this survey of trace level contaminants in rural soils, the State regulatory agency (NYSDEC) established 1 mg/kg benzo(a)pyrene as the regulatory soil cleanup objective for unrestricted future use of Brownfield and environmental restoration sites (New York Codes, Rules, and Regulations 2006). The maximum concentration of benzo(a)pyrene measured in Navigation Channel sediment (1.07 mg/kg) is consistent with the measured background concentrations for benzo(a)pyrene in rural New York soils.

Recent data have been reported on the concentration of soil contaminants, including PAHs, at an 11-acre Cleveland neighborhood that is being considered for vacant land rehabilitation (URS 2011). The average concentration of benzo(a)pyrene in the surface soil of this neighborhood (1.47 mg/kg) is in the range considered typical for rural and urban soils and is twice the average concentration (0.73 mg/kg) observed in the recently collected navigation channel sediment samples (Chapter 3) . The maximum concentration of benzo(a)pyrene measured in the surface soil of this neighborhood was determined to be 4.10 mg/kg compared to the maximum concentration (1.07 mg/kg) measured in navigation channel sediment. These data indicate that the risk to human health from direct exposure to dredged material would be approximately one half the risk resulting from exposure to at least some of the urban soils in Cleveland. On the basis of the available data, it appears that the beneficial use of dredged material as surface soil in Cleveland’s highly urbanized environments could be used to reduce current risk levels to the community from exposure to PAHs.

4.3 Tier I Human Health Risk Evaluation – Constituents of Concern

To identify potential constituents of of concern (COCs) the maximum detected concentrations of analytes measured in the 2010 sediment samples were compared to the USEPA Residential Regional Screening Levels (RSLs; Table 4-2a) (USEPA Region 9 2010) and the predicted concentrations of the analytes in soil porewater that could leach to groundwater, were compared to Ohio primary drinking water quality standards (WQS, Ohio EPA Division of Surface Water, 2009). Constituents that exceeded regional EOLP background concentrations and exceeded either the residential RSL values or had predicted soil porewater concentrations exceeding Ohio primary WQS were considered COCs. Risk to human health through direct contact with dredged materials was then evaluated by assessing cumulative risk to human health through direct contact (Section 4-4) and protection of groundwater quality for drinking (Section 4-5).

The residential RSLs developed by the US EPA provide a conservative estimate of potential risk, assuming a generic reasonable maximum exposure (RME) from direct contact through dermal, ingestion, and inhalation exposure routes. These screening values, however, are not specific to Cleveland and have been developed to be conservative estimates of exposure applicable to many climatic zones within the United States. To make these screening values conservative for southern climates the US EPA has assumed that residents wear short-sleeved shirts and/or shorts throughout the year and that exposure to soil occurs 350 days per year for 30 years. These assumptions are highly conservative for estimating residential exposures to soil in Cleveland.

Polycyclic aromatic hydrocarbons (PAHs) were the only class of chemicals above background levels that exceeded the residential RSLs (Table 4-2a) for direct contact. Five individual PAH compounds (benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) were measured at concentrations ranging from 0.127 to 1.52 mg/kg. The maximum concentration of benzo(a)pyrene, the PAH contributing the most potential risk resulting from direct contact, as described in Section 4-4, was measured to be 1.07 mg/kg.

The predicted concentrations of metals in sediment porewater were developed using conservative estimates for the normalized leachable fraction for metals (LFOX) and aqueous partitioning coefficients (Kd) described in more detail in Section 4.5. Three metals and six organic compounds were identified that could potentially leach to groundwater from porewater in dredged material placed as surface soil; these were identified as potential COCs. Cadmium, copper and nickel had maximum detected concentrations in sediment exceeding EOLP background values that could potentially result in soil porewater exceeding drinking water WQS (Table 4-3).

To predict the concentration of organic compounds in porewater, aqueous organic carbon partitioning coefficients (KOC) and sample-specific determinations of total organic carbon concentration were used (Section 4.5). Six organic compounds were identified as potential COCs. DDT, dieldrin, benzo(a)pyrene, pentachlorophenol , phenol, and bromomethane were detected at low concentrations in sediment samples and predicted pore water concentrations exceeded Ohio EPA Drinking Water Standards (Table 4-3). Several of the organic compounds identified as potential COCs were either also detected at higher concentrations in the reference soil site samples however, or were detected in sediment samples infrequently, which may be mitigating factors in terms of relative risk.

The maximum and average concentrations of total DDT in sediment samples was 0.022 and 0.010 mg/kg, respectively; however, the maximum and average concentration of total DDT in the reference site soil was greater than that measured in river sediment (0.066 and 0.039 mg/kg, respectively). DDT was widely used in agriculture and by public health agencies for controlling mosquitoes in the Great lakes region from the 1950s to the 1970s. This widespread use has resulted in detectable concentrations (trace levels) of DDT and its degradation products in Cleveland's soils and sediments.

The volatile organic compound bromomethane was detected at trace level concentrations in one sediment sample as well as the analytical quality control blank sample. Bromomethane was therefore not identified as a potential COC.

Based on this preliminary screening of analytes, the potential COCs for human health through direct contact or leaching to groundwater have been identified as follows:

- Cadmium
- Copper
- Mercury
- Nickel
- DDT
- Dieldrin
- Benz(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Dibenz(a,h)anthracene,
- Indeno(1,2,3-cd)pyrene
- Pentachlorophenol
- Phenol

The potential for risk to human health and impact to groundwater quality resulting from these constituents is assessed in more detail below.

4.4 Tier III Human Health Risk Evaluation – Calculation of Cumulative Risk by Direct Contact

A Tier III screening level assessment was conducted to evaluate the potential cumulative risk to human health following OEPA guidance (Table 4-2a, b, and c). The USEPA RSLs for residential and commercial/industrial exposure scenarios were compared to the maximum chemical concentrations detected in Navigation Channel sediments. Human health screening criteria were developed for potential recreational exposure scenarios. Recreational screening criteria were based on the USEPA residential RSLs that adjusted for 90 days of exposure per year instead of the assumed residential exposure frequency of 350 days per year (USEPA Region 9 2010).

Consituents that exceeded the regional EOLP background values were used to calculate cumulative hazard ratios and cancer risk ratios for assessing potential impact to human health. The excess cancer risk ratio is the sum of the ratios for individual chemicals where the maximum detected contaminant concentration in soil is divided by the corresponding RSLs for potential carcinogenic effects. In a similar calculation, the cumulative hazard quotient (hazard ratio) is the sum of the ratios for individual chemicals where the maximum detected contaminant concentration in soil is divided by the corresponding RSLs for chemicals that may result in toxicity but are not carcinogenic. A cumulative hazard quotient of less than 1 and a cumulative excess cancer risk ratio less than 10 (i.e. less than 1 in 100,000 excess cancer risk) are the current target risk levels considered acceptable by the OEPA.

Under a residential exposure scenario, using the exposure and toxicity assumptions built into the USEPA RSLs, a hazard quotient and cancer risk ratio of 0.6 and 110, respectively, were calculated using the maximum detected sediment concentrations (Table 4-2a). The primary risk drivers contributing to a cancer risk ratio greater than 10 are the PAH compounds described above (benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene). Benzo(a)-pyrene is responsible for 67 percent of the total potential cancer risk (cancer risk ratio = 71) and is the primary risk driver in this analysis. If average concentration of analtyes (potentially more representative of actual direct exposure) is used to calculate the cumulative cancer risk ratio instead of the maximum detected contaminant concentration, the cancer risk ratio for residential exposures is 76, also exceeding the target risk level considered acceptable by the OEPA.

The estimated risk to human health from direct contact with dredged material is dominated by the potential for exposure to benzo(a)pyrene and other PAHs. These compounds are ubiquitous in urban and rural soils as described in Section 4.2 and navigation channel sediment appears to have concentrations that would be typical for Cleveland's urban soils. If the contribution of PAHs is removed from the estimate of cumulative risk, an excess cancer risk ratio of 0.5 is calculated for the residential exposure scenario. This indicates that use of dredged material for residential soil is not expected to increase the relative risk to human health.

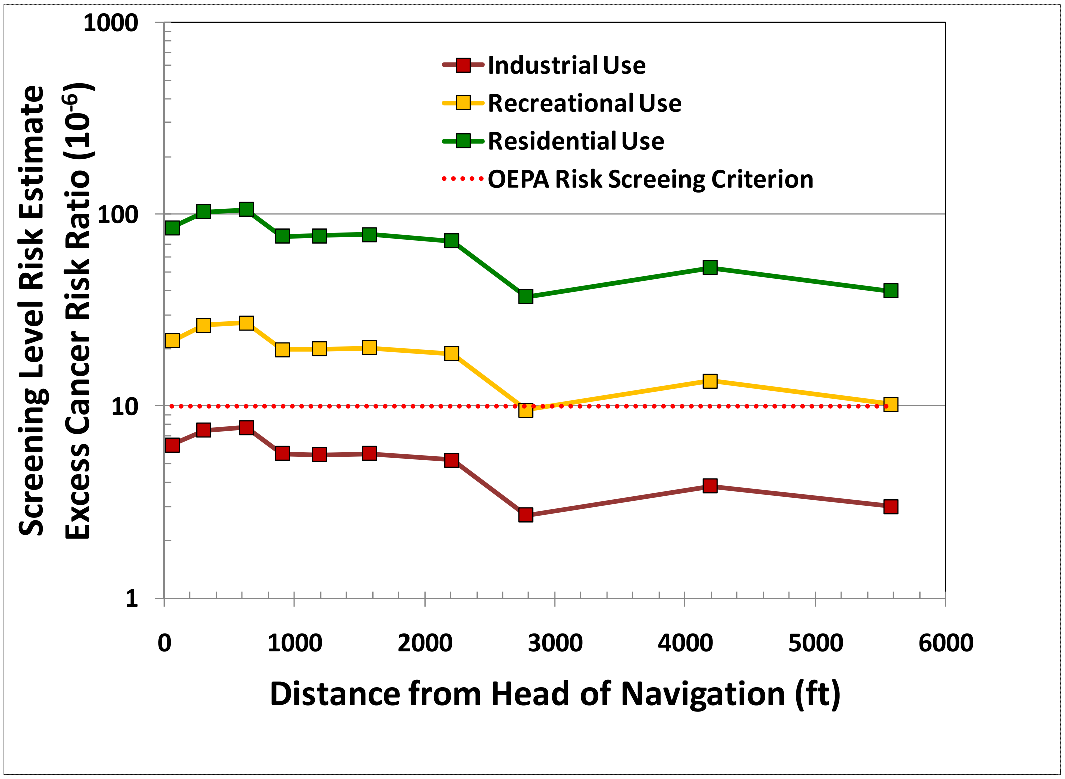
Under a recreational exposure scenario, a hazard quotient and cancer risk ratio of 0.17 and 28, respectively, were calculated (Table 4-2b). Under this analysis, using the maximum detected chemical concentrations, the dredged material would not be considered suitable for placement at a recreational site. However, it is important to recognize when interpreting this analysis of potential risk, that the end use of various recreational sites can be quite different, resulting in different potential for exposure to soil. The assumptions built into the development of these generic recreational screening values to protect human health may not provide a good representation of the actual reasonable maximum exposure for a specific recreational site. For example, one would expect that contact with soil would be very different for a site used for baseball or soccer fields compared to a site used as a golf course or a nature preserve designed for wetland habitat restoration. The screening values used in this analysis assume a maximum reasonable exposure based on 90 days of exposure each year for 30 years where recreational users have large areas of exposed skin (short-sleeved shirts and/or shorts). These maximum exposure assumptions may be reasonable for a baseball or soccer field; however, the potential for direct exposure to soil at a wetland restoration site or an upland nature preserve would be expected to be much lower. A reasonable maximum exposure for these types of sites would likely be less than 30 days per year for 30 years resulting in risks acceptable under OEPA guidance. It is important to note that grass and other vegetation covering the soil at recreational sites greatly reduces the potential for human contact. In addition, engineering approaches can be used during site redevelopment to manage the future risk. Risk management strategies could include using the dredged sediment as a subsoil, with the placement of cleaner soil on the surface, which would minimize the potential for direct contact with dredged sediment. Such a risk management strategy could be effectively used during construction of baseball or soccer fields to minimize the potential risks.

Given the very low percentage of sand in the sediments collected from the Navigation Channel in November 2010, the dredged material is not considered suitable for beach nourishment and an evaluation of potential risks under this recreational scenario was not reviewed.

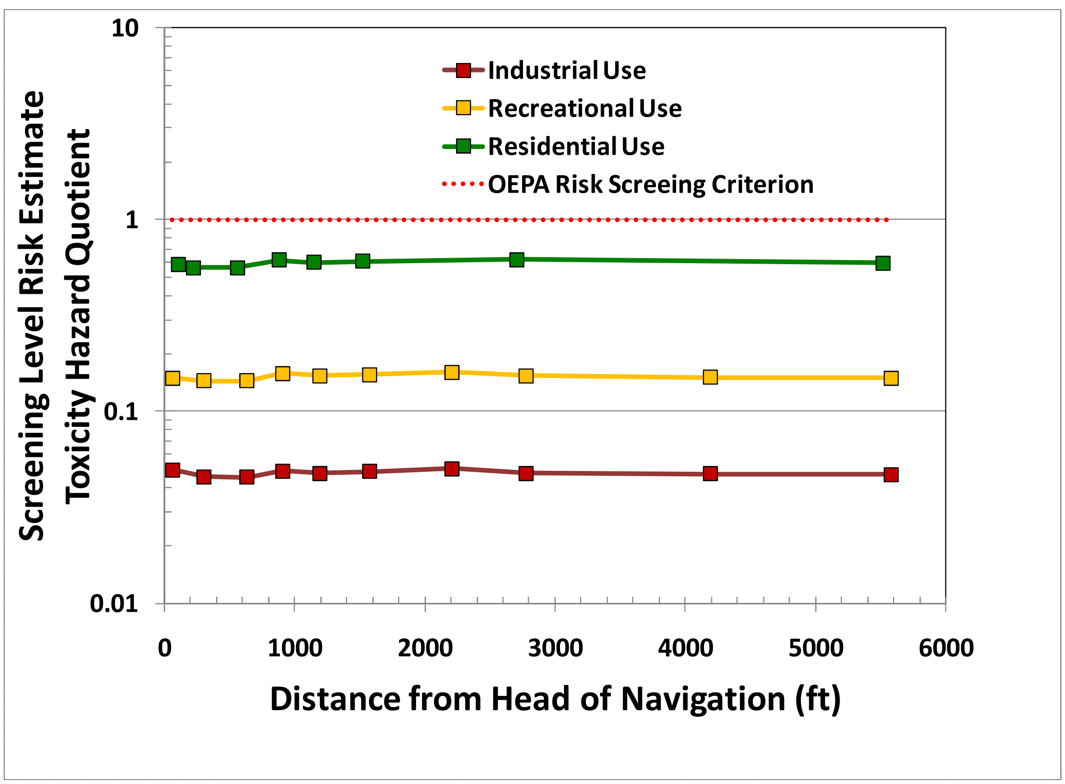
Under a commercial/industrial exposure scenario, a hazard quotient and cancer risk ratio of 0.05 and 7.9 are calculated when the maximum detected chemical concentrations are used (Table 4-2c). Based on this analysis, the dredged sediment would be considered suitable for use as surface soils at commercial and industrial redevelopment projects.

The spatial distribution of contaminants and the cumulative excess cancer risk ratios for individual samples were evaluated by plotting the calculated cumulative risk vs. distance from the head of the Navigation Channel (Figure 4-1a). The potential excess cancer risk level decreases for residential, recreational, and commercial/industrial beneficial end uses in samples collected downstream from the head of navigation. Sediment samples collected 3000 feet past the head of navigation are approaching the acceptable risk limits defined by the generic recreational screening values described above. The potential risk levels exceed the generic residential screening values by 4 to 10times for individual samples with the risk decreasing with distance from the head of navigation. It is important to recognize that the excess cancer risk levels shown in Figure 4-2 span the range that would be considered typical for surface soils in many urban residential settings.

The cumulative hazard quotients (non-cancer toxicity) for individual samples did not show a trend with distance from the head of navigation (Figure 4-1b). All samples were found to have low levels of non-cancer risk, with a hazard quotient less than 1for residential, recreational and commercial/industrial land uses.



a. Excess cancer risk ratio (OEPA acceptable risk level = 10)



b. Toxicity hazard quotient (OEPA acceptable risk level = 1)

Figure 4-1. Spatial distribution of human health screening level risk estimates for beneficial use of Navigation Channel sediment samples

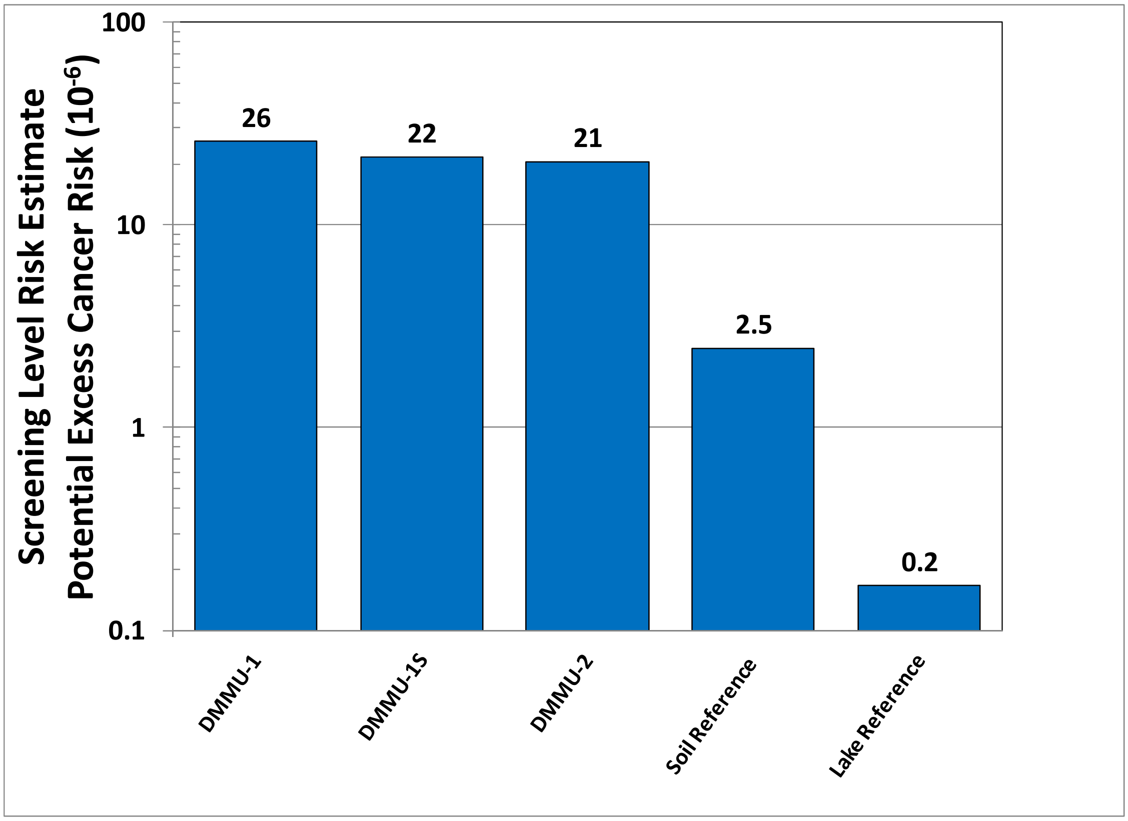


Figure 4-2. Potential excess cancer risk levels for recreational land use scenario calculated for composite sediment and soil samples

4.5 Evaluation of Groundwater Protection

The potential for leaching of trace level contaminants to near surface groundwater and the potential for degradation of drinking water quality were evaluated. To evaluate the risk of impacts to groundwater quality resulting from placement of dredged sediment at upland sites, an initial screening was conducted by comparing the predicted concentration of contaminants in sediment porewater to OEPA drinking water quality standards (Ohio EPA Division of Surface Water 2009). The predicted concentrations of metals in sediment porewater were developed using the normalized leachable fraction for metals (LFOX) and aqueous partitioning coefficients (Kd) previously developed by Palermo et al. (1993). To predict the concentration of organic compounds in porewater, aqueous organic carbon partitioning coefficients (KOC), obtained from the USEPA Region 9 RSL tables, were used along with sample-specific determinations of total organic carbon concentration. The KOC values provided by the USEPA are modeled values developed from chemical structure activity relationships generated by the Estimation Program Interface KOCwin program (EPISuites) (USEPA Region 9 2010). In the case of the organic compounds benzo(a)pyrene and dieldrin, direct measurements of the aqueous concentrations of these chemicals in either extracted sediment porewater (ASTM D7363) or filtered elutriates were used to estimate a minimum KOC value.

As chemicals leach from soil by rainfall and are transported to a surface water aquifer, they are reduced in concentration by natural dilution and soil attenuation processes. Dilution occurring within the aquifer itself may also be taken into consideration when assessing potential impacts of leachate on the quality of groundwater used for drinking. The potential for impacting groundwater quality was initially screened by comparing the conservative predictions of soil porewater concentrations of contaminants to the OEPA drinking water standards prior to leaching. This screening indicates that the metal compounds arsenic, barium, cadmium, copper, mercury, nickel and selenium could potentially result in groundwater quality that is not suitable for drinking (Table 4-3). However, arsenic, barium and selenium have maximum concentrations less than the regional EOLP background values for sediment and are not considered potential COCs. In addition, the initial screening indicated that the organic compounds 4, 4'-DDT, dieldrin, benzo(a)pyrene, pentachlorophenol, and phenol could also potentially leach, resulting in groundwater considered unacceptable for human consumption. Although bromomethane was detected in one sediment sample it was also detected in the quality control blank sample and is not considered a potential COC for leaching to groundwater. Constituents having a detectable concentration in sediment and the maximum predicted sediment porewater concentrations are presented in Table 4-3.

For those compounds having predicted soil porewater concentrations exceeding the drinking water standards, the peak concentration in soil porewater was predicted at the aquifer-vadose zone soil interface using simplified equations developed from the USACE Hydraulic Evaluation of Leachate Production and Quality (HELPQ) model (Schroeder 1999; see http://el.erdc.usace.army.mil/products.cfm?Topic=model&Type=drgmat for access to the model). The assumptions and simplified equations used to predict porewater concentrations at the surface aquifer-vadose zone soil interface and time of travel required to reach a specified depth and concentration are presented in equations 2, 7, and 8 by Schroeder and Aziz (2004).

The following model parameters for a generic site were used to develop conservative estimates of the peak concentration and the travel times that would be required to exceed Ohio Drinking Water Quality Standards at the point where the soil porewater meets the groundwater aquifer:

1. 240 inches (20 feet) of dredged material was assumed to be placed at an upland beneficial use site;
2. A minimum depth of 60 inches (5 feet) of native soil was assumed to reside between the imported sediment and the surface groundwater table; and
3. An average rainwater infiltration rate of 6 inches per year was assumed.

Details on these and other model parameters used for this analysis are provided in the notes for Table 4-4.

Results from this analysis show that six chemicals defined as COCs (mercury, 4, 4'-DDT, dieldrin, benzo(a)pyrene, pentachlorophenol, and phenol) could potentially leach at concentrations resulting in values exceeding drinking water standards at the aquifer-vadose zone interface. However, the amount of time necessary for the soil porewater to travel 5 feet and exceed the drinking water quality standard exceeds nearly two millennia (2,000 years) for all of the compounds except phenol. The long travel time required is an important consideration, as it provides the time necessary for the occurrence of natural geochemical and physical attenuation processes that reduce contaminant concentrations (e.g., adsorption, precipitation, volatilization, biodegradation, cation exchange and hydrolysis). These processes were not included in this simple screening analysis of chemical transport. It is also important to note that this analysis does not take into account the dilution and attenuation of contaminants between the point of entry to the surface groundwater table and production of water from a drinking water well.

Phenol has a short predicted travel time (less than one year) due to its chemical properties (i.e., high aqueous solubility and low KOC value). However, several important points for consideration in the review of the potential impacts to groundwater quality include:

The Ohio Water Quality Standard for phenol (1 mg/L) is based on protection of drinking water from organoleptic (taste and/or odor) effects. The peak porewater concentration is predicted to be approximately 50times lower than this risk-based value for drinking water. The risk-based US EPA RSL for groundwater protection from

Table 4-4. Evaluation of potential groundwater impacts from the beneficial use of dredged sediment

System Parameters		Value	Unit
f_{OCd}	Fraction of TOC in Sediment[a]	0.0314	unitless
f_{OCf}	Fraction of TOC in Foundation Soil[b]	0.003	unitless
φ_d	Porosity of Dredged Sediment[c]	0.6	unitless
φ_f	Porosity of Foundation Soil[d]	0.3	unitless
SG_d	Specific Gravity of Dredged Sediment	2.65	unitless
SG_f	Specific Gravity of Foundation Soil	2.65	unitless
T_d	Thickness of Dredged Sediment[e]	240	inches
T_f	Thickness of Foundation Soil[f]	60	inches
Q	Average Annual Recharge [g]	6	inches/yr

Contaminant Specific Parameters		Unit	Cadmium	Copper	Mercury	Nickel	4, 4'-DDT	Dieldrin	Benzo(a)pyrene	Pentachlorophenol	Phenol
C_S	Sediment Concentration[h]	μg/kg	959	51800	99.2[1]	35300	5.87	2.06	1071	206	79.6[2]
Kd_d	Partitioning Coefficient for Dredged Sediment[i]	L/kg	30	8.5	100	20.4	5294	2,865[4]	147580[5]	155.7	5.8781
Kd_f	Partitioning Coefficient for Foundation Soil[i]	L/kg	30	8.5	100	20.4	505.8	273.819	14100	14.877	0.5616
LF_{OX}	Leachable Fraction In Oxidized Sediment[j]	unitless	0.5	0.15	0.08	0.3	1	1	1	1	1
C_O	Initial Sediment Porewater Concentration[k]	μg/L	16	910	0.079	520	0.035	0.023	<0.008[5]	42	430
W_S	Ohio EPA Drinking Water Quality Standard[l]	μg/L	14	790	0.0031	470	0.00015	0.0000065[7]	0.00002	1	1
Predicted Leachate Concentrations at Aquifer Interface		Unit	Cadmium	Copper	Mercury	Nickel	4, 4'-DDT	Dieldrin	Benzo(a)pyrene	Pentachlorophenol	Phenol
C_P	Peak Leachate Concentration[m]	μg/L	14	797	0.069	453	0.034	0.022	0.008	42	430
t_P	Time to Reach Peak Concentration[n]	yr	240,000	27,000	2,000,000	123,000	38,000,000	13,000,000	12,000,000,000	81,000	265
t_{WQS}	Time to Reach Ohio EPA Drinking WQS[o]	yr	Never	27,000	89,000	Never	160,000	3,700	32,000,000	1,900	0.6

Notes:

[a] Soil organic carbon fraction of 0.0314 represents the arithmetic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S.

b Soil organic carbon fraction of 0.003 is representative of Soil Type 2 (silty sand and gravel) and Soil Type 3 (till and/or silty clays) from Ohio EPA Voluntary Action Program

Leach-based Soil Values: Appendix Technical Support Document, Ohio, EPA , October 2008, Table 13, p. 40.

[c] Porosity of dredged sediment determined from sample DMMU-1 standard proctor and permeability test data.

[d] A soil porosity of 0.3 represents the default value applied in the Ohio EPA Voluntary Action Program Leach-based Soil Values: Appendix Technical Support Document, Ohio, EPA , October 2008, p. 56.

[e] Maximum assumed thickness of dredged sediment placed above native soil is 240 inches (20 ft).

[f] Minimum assumed thickness of native foundation soil present above surface aquifer and below dredged sediment is 60 inches (5 ft) based on personal correspondence from Skowronski to O'Connor and Kreitinger (2011).

[g] An infiltration rate of 6 inches per year is representative of the recharge for Cuyahoga Valley, as cited in Pettyjohn, W. and Henning, R. , Preliminary Estimate of Regional Effective Groundwater Recharge Rates in Ohio, Ohio State Water Resources Center, 1979, p. 120. This value represents the midpoint of the range expected for Soil Type 2 and Soil Type 3, Ohio EPA Voluntary Action Program Leach-based Soil Values: Appendix Technical Support Document, Ohio, EPA , October 2008, Table 13, p. 40. The permeability for composite sediment sample DMMU-1 at maximum density was determined to be 0.8 inches per year.

[h] Sediment concentration represents the arithmetic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S.

[i] The aqueous bulk sediment partitioning coefficients for metals (Kd) were obtained from the USACE Chemical Database provided in the Draft Tier II Screening Evaluation Model for Confined Disposal Facility Contaminant Pathway Migration Evaluations. The aqueous organic carbon partitioning coefficients (KOC) values for organic chemical were obtained from the USEPA Region 9 Regional Screening Levels (RSL) Tables: Chemical Specific parameters accessed November 2010 (http://www.epa.gov/region9/superfund/prg/). These values are based on model estimates using the U.S. EPA Estimation Programs Interface (EPISuites) KOCwin program. Kd values for organic chemicals were derived based on the average sediment organic carbon content using the relationship KOCxfOC.

[j] The fraction available for aqueous partitioning in oxidizing environments is taken from the USACE Chemical Database provided in the Draft Tier II Screening Evaluation Model for Confined Disposal Facility Contaminant Pathway Migration Evaluation.

[k] The initial dredged sediment porewater concentration was determined based on the average sediment concentration using the following calculation $C_O=(C_S x F_{OX})/Kd_{d.}$

[l] Ohio EPA Lake Erie Drainage Basin Water Quality Standards provided by Mike McCullough, Division of Surface Water, Ohio EPA , December 12, 2010.

[m] Peak Leachate Concentration (C_P) determined using a simplification of the HELPQ model (Schroeder and Aziz, 1999) as described by Equation 2 in Schroeder and Aziz (2004).

[n] Time of travel for peak leachate concentration (t_P) determined using a simplification of the HELPQ model as described by Equation 7 presented in Schroeder and Aziz (2004).

[o] Time of travel to reach Ohio EPA water quality drinking water standard (t_{WQS}) determined using a simplification of the HELPQ model as described by Equation 8 presented in Schroeder and Aziz (2004).

[1] Average and maximum sediment concentrations were below OEPA Erie Ontario Lake Plain (EOLP) background value.

[2] Sediment concentrations of phenol are less than the Ohio EPA VAP derived leach-based Soil Type II value (1,100 µg/kg) that incorporates additional natural attenuation processes.

[4] Kd value is the average Cleveland harbor Site-specific Koc value (> 9.1×10^4 L/kg) determined from direct measurement of elutriate samples (<0.0006 ug/L) and the simultaneous extraction of composite samples DMMU-1, DMMU-1S, and DMMU-2.

[5] Kd value is the average Cleveland harbor Site-specific Koc value (> 4.7×10^6 L/kg) based on the direct measurement of sediment porewater (<0.008 ug/L) using ASTM D7363 and the simultaneous extraction of 11 bulk sediment samples.

[6] Values shown in bold text exceed Ohio EPA Drinking water standard.

[7] Ohio EPA water quality standard is approximately 100 times lower than analytical method detection limits. Elutriate samples were determined to have <0.0006 µg/L dieldrin.

phenol is 6.3 ppm, which is about 30 times greater than maximum concentration (0.08 mg/kg) detected in sediment samples. The OEPA VAP Derived Leach-based soil value for phenol also uses a human health risk-based objective that results in a screening value of 1.1 to 1.2 mg/kg for phenol, which is significantly less than the measured concentration of phenol in the sediment samples. Finally, phenol and many other related phenolic compounds (e.g., catachol) are naturally found in soil porewater at low concentrations and are considered to be important precursors of soil humic substances. The trace levels of phenolic compounds detected in the Navigation Channel sediment may be associated with the decomposition of leaf litter that was present in the sediment at the time of sampling (Whitehead 1983). Regardless of the source of the phenol, this compound would rapidly biodegrade under aerobic conditions as the sediment weathers to become a soil, following placement in an upland setting.

The screening level analysis of sediment quality shows that there is a very small potential for contaminants associated with dredged material to impact the quality of groundwater that may be a future drinking water source when a separation of at least 5 feet is maintained between native soils and the surface groundwater aquifer. Additional analysis of the potential to impact groundwater quality using models (e.g., HELPQ or SESSOIL) that include more information on natural attenuation processes (volatilization, biodegradation, etc.) and site- specific data on aquifer characteristics such as groundwater flow may demonstrate that this attenuation layer could be reduced and still provide adequate protection of groundwater with potential for human consumption.

Finally, when reviewing an analysis of potential risk to drinking water quality, it is important to note that many Brownfield sites within the Cleveland metropolitan area reside within an Urban Setting Designation defined under the OEPA Voluntary Action Program. The Urban Designation Setting recognizes that applying drinking water standards to surface groundwater at these Brownfield sites is not necessary because no one is expected to be drinking the ground water.

4.6 Evaluation of Potential Risk from Consumption of Fish

A potential pathway by which humans may be exposed to trace level contaminants following placement of dredged material in littoral or wetland settings is through consumption of fish that have bioaccumulated chemicals. Polychlorinated biphenyl's (PCBs), chlorinated pesticides, and methyl mercury are the primary COCs that exhibit risk to humans through consumption of fish. Polychlorinated biphenyl's were not detected in sediment samples collected from the navigation channel.

Trace levels of the chlorinated pesticides 4,4´-DDD, 4,4´-DDE, 4,4´-DDT, alpha-chlordane, gamma-chlordane, delta-BHC, and dieldrin were detected in sediment samples at concentrations exceeding the maximum detected value in the lake reference samples. Laboratory bioaccumulation tests, using the aquatic worm *Lumbriculous variegates* exposed to sediment samples for 28days, demonstrated that none of the chlorinated pesticides nor PCBs were detected in worm tissues. The reporting limit for these bioaccumulation tests was at least two orders of magnitude lower than the FDA action limits for the edible portions of fish. These data indicate that there is little or no risk for increasing the concentrations of PCBs or chlorinated pesticides in fish that may be consumed by humans.

4.7 Data Gaps and Uncertainty

There are several important areas of uncertainty in the assessment of risks to human health that may result from the beneficial use of dredged sediment.

4.7.1 Relative Risk.

The chemicals present in navigation channel sediment that exhibit the greatest potential risk to human health through direct contact are PAHs. These compounds are present in the sediment at concentrations that may be lower than the concentration present in the surface soils of some Cleveland neighborhoods. In terms of relative risk to residents, recreational users, and commercial/industrial workers, the use of dredged sediment for land restoration projects in Cleveland may actually reduce exposure to the preexisting background levels of PAHs, thus reducing risks to the end-users of the beneficial use project site. Contaminant concentrations in the soils of proposed beneficial use sites are needed to permit comparison to sediments from the navigation channel, and assessment of net relative increase or decrease in risk.

4.7.2 Application of Screening Values for Risk Management Decision-Making.

The screening level analysis of risk performed in this study relies upon generic RSL values developed by the USEPA for direct contact with soil. These screening values have a number of conservative assumptions built into them, which define the Reasonable Maximum Exposure to contaminants. These screening values were not developed for locations having colder climates such as Cleveland. In particular, the assumptions used for estimating the Reasonable Maximum Exposure to soil contaminants include residents spending 350 days per year outdoors in short-sleeved shirts and shorts for 30 consecutive years. Snow cover and vegetation, which reduce direct contact with soil, have not been taken into account in this analysis. Careful site-specific consideration of the Reasonable Maximum Exposure and risk should be given to projects where recreational land use is proposed. The potential for direct exposure to soil can vary widely between various recreational land uses, and the risk associated with recreational use of a golf course or nature preserve would be considerably smaller than the recreational use of a ball field or motorsport track. Finally, the application of screening levels for risk-management decision-making used in this report does not incorporate site engineering or management strategies for reducing risk, such as placing clean soils over dredged sediment in areas where high direct contact is expected (e.g., baseball infields, soccer fields, visitor centers, picnic areas, etc.).

4.7.3 Drinking water protection.

The screening level analysis provided in this review demonstrates a very low risk for negative impacts to groundwater quality. A full analysis of the potential for trace level contaminants to leach from dredged sediment into groundwater and subsequent impacts to groundwater requires site-specific data on the aquifer flow characteristics and pre-existing data on groundwater quality at the placement site. Any additional review of risk to groundwater quality and human health will require site-specific data for the groundwater aquifer located at the beneficial use site.

4.7.4 Changes in Sediment Quality with Time

The analysis conducted in this report has relied upon the sediment quality associated with the November 2010 sampling event, which was limited to the upper reach of the Cuyahoga River Navigation Channel, from which the majority of sediment is dredged each year. The evaluation of human health risks is based on the laboratory measurements from this sampling event. The flow regime of the Cuyahoga River is dynamic and small changes in sediment chemistry should be anticipated from season to season and year to year. The concentrations of metals and organic contaminants in the sediment are anticipated to vary with the clay and organic carbon content of the dredged material. In addition, future changes in sediment chemistry may occur from unplanned chemical spills, changes to industrial operations along the river and permitted wastewater discharges, and modifications to the municipal storm and combined sewer outfalls.

4.8 Conclusions

The primary pathways by which humans may be exposed to trace level contaminants in dredged material used at beneficial use sites include ingestion, dermal contact, and inhalation of soil particulates, leaching of contaminants to groundwater that is used for drinking, and consumption of fish that may have bioaccumulated contaminants following placement at littoral or wetland habitat restoration projects. The assessment of risks through direct contact indicates that the beneficial use of the dredged sediment at commercial and industrial redevelopment projects would result in minimal potential risk to human health. The potential for exposure to soil contaminants and subsequent risk at sites that may have future recreational uses is dependent on the planned recreational activity. The potential for exposure to trace level contaminants will vary widely from one type of recreational activity to another. The reasonable maximum exposure should be considered at each project site in which recreational land use is proposed. Use of dredged material for unrestricted residential uses has been determined to be unacceptable when OEPA guidance was used to evaluate potential risk. However, estimates of risk for residential land use may be overly conservative for Cleveland because they are based on USEPA screening values (RSLs) that were not developed for land use in northern climates.

The concentration of PAHs measured in channel sediment, the primary contaminants resulting in potential risk to human health, are found at concentrations typical of urban soils. If PAHs are considered normal background and they are not included in the estimates of cumulative risk, an excess cancer risk ratio of less than 1 is calculated for the residential exposure scenario. This low level of risk would be considered acceptable for unrestricted residential use. The use of dredged material for rehabilitation of abandoned urban properties, including residential areas, may provide a net reduction in risk to public health where the dredged material is determined to have lower concentrations of trace level contaminants than the surrounding surface soils at the project site.

5 Ecological Contaminant Risk Evaluation

A tiered analysis of the risk to aquatic and terrestrial ecological receptors has been performed to assess potential impacts resulting from beneficial use of Cuyahoga River Navigation Channel dredged material. Sediment samples collected in November 2010 from the navigation channel study (Chapter 3) were evaluated using the assessment approach presented in the Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998b) and the Upland Testing Manual (USACE 2003).

5.1 Pathway Analysis for Beneficial Use Alternatives

The primary pathways by which aquatic and terrestrial receptors may be exposed to contaminants present in dredged materials at beneficial use sites include:

- Direct exposure of benthic organisms to sediment following beneficial use in aquatic environments.
- Release of contaminants into water column during placement of dredged material into aquatic environments.
- Release of contaminants into surface water following placement of dredged material in terrestrial environments.
- Direct exposure of terrestrial organisms to soils created from dredged material that is used for upland habitat restoration or vegetative cover at landfills.
- Uptake of persistent toxic compounds by invertebrates or plants that result in bioaccumulation by fish or wildlife.

The potential for exposure and risk to ecological receptors will vary based on the nature of the placement site where dredged material is beneficially used (Table 5-1a and b). For example, risk to aquatic life may exist when dredged material is used for beach nourishment or wetland habitat restoration; however, little exposure to soil invertebrates (e.g., earthworms) is likely under this beneficial use scenario. In addition, the beneficial use of dredged material at the active, urban, commercial and industrial sites being considered here is not likely to result in significant risk to ecological receptors due to the lack of habitat and ecological receptors present at these sites. Table 5-1 identifies each of the beneficial use options evaluated, the

Table 5-1a. Beneficial use alternatives, exposure pathways for ecological receptors and tiered evaluation criteria

Placement Option	*End Use*	*Site*	*Note*	*Exposure Media*	*Risk Endpoint*						
					Benthic Invertebrates		*Pelagic Invertebrates*		*Fish*		*Fish-eating Birds & Mammals*
					Measurement Endpoint						
					Bulk Sediment Chemistry	*Whole Sediment Toxicity Test*	*Elutriate Chemistry*	*Macro-invertebrate Elutriate Toxicity Test*	*Elutriate Chemistry*	*Fish Elutriate Toxicity Test*	*Macro-invertebrate Bio-accumulation Test*
					Criterion						
					Tier II PEC Screening Values	*Tier III Survival & Growth Data*	*Tier II OEPA OMZM & Federal CMC WQS*	*Tier III Survival Data*	*Tier II OEPA OMZM & Federal CMC WQS*	*Tier III Survival Data*	*Tier II/Tier III Theoretical Bioaccumulation Potential for Fish*
Lake Littoral Zone	Beach Nourishment	Perkins Beach		Sediment & Surface Water	✓[1]	✓	✓	✓	✓	✓	✓
	Wetland Habitat Restoration	Not Defined	Potential Long Term Beneficial Use Alternative	Sediment & Surface Water	✓	✓	✓	✓	✓	✓	✓
Intermediate Material Handling	Material Processing Required Prior to Final End Use	Waterfront CDF	Discharges to Lake Regulated Under Federal CWA	Surface Water	-[2]	-	✓	✓	✓	✓	-
		CVIC Site	Discharges to River Regulated Under Federal CWA								
		Upper River Site									
		Zaclon Site									
Urban/ Industrial Land Reclamation	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Landfill Recompacted Cap & Vegetative Cover	Surface Soil Water runoff	-	-	✓	-	-	-	-
	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Potential Upland Nature Preserve	Surface Soil Water runoff	-	-	✓	-	-	-	-
		Brook Park Landfill	Future Industrial Site	Surface Soil Water runoff	-	-	✓	-	-	-	-

Table 5-1a. Beneficial use alternatives, exposure pathways for ecological receptors and tiered evaluation criteria (continued).

Placement Option	*End Use*	*Site*	*Note*	*Exposure Media*	*Risk Endpoint*						
					Benthic Invertebrates		*Pelagic Invertebrates*		*Fish*		*Fish-eating Birds & Mammals*
					Measurement Endpoint						
					Bulk Sediment Chemistry	*Whole Sediment Toxicity Test*	*Elutriate Chemistry*	*Macro-invertebrate Elutriate Toxicity Test*	*Elutriate Chemistry*	*Fish Elutriate Toxicity Test*	*Macro-invertebrate Bio-accumulation Test*
					Criterion						
					Tier II PEC Screening Values	*Tier III Survival & Growth Data*	*Tier II OEPA OMZM & Federal CMC WQS*	*Tier III Survival Data*	*Tier II OEPA OMZM & Federal CMC WQS*	*Tier III Survival Data*	*Tier II/Tier III Theoretical Bioaccumulation Potential for Fish*
	Industrial/ Commercial Property Redevelopment	Ditchman Proposal (General Chemical and Other Sites)	Future Industrial or Commercial Sites	Surface Soil Water runoff	-	-	✓	-	-	-	-
	Vacant Property Rehabilitation	City/County Vacant Land Reclamation	Site Use Not Defined	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use
Construction Material	Construction Aggregate	Unrestricted	Site Use Not Defined	Construction Materials	NA	NA	NA	NA	NA	NA	NA
	Fill / Topsoil	Unrestricted	Site Use Not Defined	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use

Notes:

Exposure pathway considered complete and significant

Exposure pathway not considered significant or matrix is not appropriate for measurement endpoint

Table 5-1b. Beneficial use alternatives, exposure pathways for terrestrial life, and tiered evaluation criteria

Placement Option	*End Use*	*Site*	*Note*	*Exposure Media*	*Risk Endpoint*		
					Soil Invertebrates		Invertebrate-eating Terrestrial Birds & Mammals
					Measurement Endpoint		
					Bulk Sediment Chemistry	Earthworm Soil Toxicity Test	Earthworm Bioaccumulation Test
					Criterion		
					Tier II Soil Screening Values	Tier III Survival & Growth Data	Tier II Biological Screening Levels
Lake Littoral Zone	Beach Nourishment	Perkins Beach		Sediment & Surface Water	-[1]	-	-
	Wetland Habitat Restoration	Not Defined	Potential Long Term Beneficial Use Alternative	Sediment & Surface Water	-	-	-
Intermediate Material Handling	Material Processing Required Prior to Final End Use	Waterfront CDF	Construction site	No Habitat	-	-	-
		CVIC Site					
		Upper River Site					
		Zaclon Site					
Urban/ Industrial Land Reclamation *Urban/ Industrial Land Reclamation*	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Landfill Recompacted Cap & Vegetative Cover	Surface Soil	NA[2]	✓	✓
	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Potential Upland Nature Preserve	Surface Soil	NA	✓	✓
		Brook Park Landfill	Future Industrial Site	Surface Soil	NA	✓	✓
	Industrial/ Commercial Property Redevelopment	Ditchman Proposal (General Chemical and Other Sites)	Future Industrial or Commercial Sites	Surface Soil	NA	✓	✓
	Vacant Property Rehabilitation	City/County Vacant Land Reclamation	Site Use Not Defined	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use
Construction Material	Construction Aggregate	Unrestricted	Site Use Not Defined	Construction Material	-	-	-
	Fill / Topsoil	Unrestricted	Site Use Not Defined	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use	Dependent on Site Use

Notes:

Exposure pathway not considered significant. Screening evaluation for invertebrates in beach/wetland environments evaluated using aquatic invertebrates (Table 5-1a)

Tier II soil chemistry screening values are not applicable to sediment. Tier III toxicity evaluation is the primary test.

type of land use associated with the proposed beneficial use, and the potential for exposure to aquatic and terrestrial ecological receptors. The risk endpoint to be protected, testing conducted, and criteria used to assess potential risk to aquatic and terrestrial receptors are summarized in Table 5-1.

5.2 Evaluation of Risk to Aquatic Life

5.2.1 Tier I: Existing Data

Cleveland Harbor is located within the Cuyahoga River Area of Concern (AOC), which includes the lower 45 miles of the river between the Ohio Edison Dam and Lake Erie and approximately 10 miles of Lake shoreline between Edgewater Park eastward to Wildwood Park. Potential sources of contamination to bottom sediments include municipal and industrial wastewater discharges, atmospheric deposition, leachate from hazardous waste disposal sites, urban storm water runoff, combined sewer overflows, and wastewater treatment plant bypasses. Chemical contaminants typically found in the Cuyahoga River navigation channel sediments include heavy metals, nutrients, PAHs, PCBs and chlorinated pesticides. The USACE Buffalo District conducts sediment sampling in the Cuyahoga River Navigation Channels and Cleveland Outer Harbor approximately about every five years with the last set of samples collected in 2007. The 2007 investigation of sediment quality concluded that material dredged from all of the navigation channels would not meet Federal guidelines for open-lake placement. Additional samples were subsequently collected from the upper reach of the navigation channel in 2010 to fill data gaps identified in this study that were relevant to evaluating potential beneficial uses of dredged material (Chapter 3).

The sediment samples collected in 2007 were analyzed for heavy metals, total cyanide, ammonia, PAHs, PCBs and pesticides (EEI 2007). A modified elutriate test (MET) was also conducted on five composited sediment samples; elutriates were analyzed for the same inorganic and organic contaminants as was the sediment. In addition, two solid phase acute toxicity tests (bioassays) were conducted on composite sediment samples collected from the upper end of the river to evaluate whether the material dredged from this reach, which is typically comprised of coarser-grained sediment, meets Federal guidelines for open-lake (including nearshore) placement.

Based on the 2007 data, COCs identified in the navigation channel sediments include the metals arsenic, lead, mercury, and zinc. Ammonia-nitrogen and cyanide were also identified as inorganic compounds at concentrations that could result in potential toxicity. Total PAHs, total PCBs and ΣDDT were the organic compounds determined to be COCs based on exceedances of PEC screening value and theoretical bioaccumulation potential (TBP) modeling. PCBs were measured at all of the Federal navigation channel sites, with Aroclors 1242, 1254 and 1260 being the primary PCB mixtures detected. Individual Aroclors ranged in concentration from 22.2 to 260 µg/kg.

Predictions of potential bioaccumulation based on the 2007 data using TBP modeling suggested that total PCBs would bioaccumulate from Navigation Channel sediments at levels higher than the open-lake reference area. Most chlorinated pesticides were non-detectable in channel sediments with the exception of dieldrin, DDT, and its breakdown products DDE and DDD. DDD was detected in the open-lake reference area sediments with the ΣDDT reported to be 41.4 µg/kg. Bioassays exposing *Hyalella azteca* and *Chironomus dilutus* to sediments collected from the upper reach of the Navigation Channel demonstrated reduced survival compared to the Lake reference site.

Modified elutriate testing conducted in 2007 showed low levels of dissolved metals being released with copper and mercury at 1.5 µg/L and 0.0024 µg/L, respectively. Maximum ammonia-nitrogen (total) releases ranged from 5.2 mg/L to 11 mg/L. At a water pH of 8.1 and temperature of 21°C, and after consideration of mixing in the water column, ammonia concentrations were not expected to contravene applicable State Water Quality Standards of 7.3 mg/L for warm water habitat. PAHs were measured in several filtered elutriate samples in the 0.15 to 0.41 µg/L range. With respect to PCBs and chlorinated pesticides, no releases (dissolved) were demonstrated at the laboratory reporting limits.

5.2.2 Tier II: Analysis of Sediment Chemistry

The Tier II evaluation under the Great Lakes Dredged Material Testing and Evaluation Manual evaluates the potential impacts to the benthos and water column resulting from the proposed management of dredged material in an aquatic environment. A Tier II evaluation is based on an evaluation of sediment physical and chemistry data. Models are used to project worst-case conditions for water quality impacts and bioaccumulation in aquatic organisms. Tier II evaluations are intended to provide a reliable, rapid screening tool to determine whether more costly biological testing may be necessary. Based on the results of Tier II evaluations, additional testing may be reduced or eliminated.

5.2.2.1 Identification of Contaminants of Concern

Sediment samples collected in 2010 were subjected to comprehensive laboratory analysis resulting in measurement of more than 220 individual contaminants (Chapter 3). The screening of sediment chemistry was conducted to identify COCs and provide information regarding potential sources of toxicity in Navigation Channel sediment. Analytes that did not have a detectable concentration in any sediment samples were eliminated as potential COCs. Table 5-2 lists all of the analytes that were detected in sediment samples. Contaminants of concern were then identified by comparison of the maximum chemical concentration measured in Navigation Channel sediment to:

1. The maximum concentration measured in Lake reference samples collected near Perkins Beach (analytes having a maximum concentration exceeding the maximum concentration measured in the Lake reference samples were retained as COCs), and
2. OEPA Erie Ontario Lake Plain (EOLP; OEPA 2008) values, which represent the regional expected maximum concentration of toxic metals in uncontaminated sediments (analytes having a maximum concentration exceeding the ELOP value were retained as COCs), and
3. Consensus PEC screening values that are considered to be the concentration at which toxic effects are likely to occur (MacDonald et al., 2000); analytes having a maximum value that exceeded applicable PEC were retained as a potential COC.

All of the analytes detected were found to have maximum concentrations greater than the maximum concentration measured in the Lake reference sediment samples with the exception of calcium (Table 5-2). This is in part due to the fine grain size distribution of the navigation channel sediment compared to the Lake Reference site sediment. Navigation channel sediment consisted primarily of silt and fine sand with higher concentrations of clay than the sandy Lake Reference samples. The maximum concentration of several metals (cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, and zinc) exceeded the regional EOLP background value, indicating that sediments in the navigation channel are impacted by

Table 5-2 Comparison of sediment concentrations (mg/kg) to sediment Probable Effect Concentration (PEC) screening values and Reference Site concentrations.

Analyte	CAS	Number of Detects	Average Sediment Concentration[a]	Maximum Sediment Concentration	Sediment PEC Screeing Value	Sediment COC (> PEC)
Inorganic Compounds				Value[b]		
Cyanide, Total	57-12-5	14	0.442	0.63 JH	-	
Aluminum	7429-90-5	14	8600	9430	-	
Antimony	7440-36-0	2	0.0594	0.119 J	-	
Arsenic	7440-38-2	14	12.3	12.6	33	
Barium	7440-39-3	14	77	84.4	-	
Beryllium	7440-41-7	14	0.616	0.697	-	
Cadmium	7440-43-9	14	0.959	1.15	4.98	
Calcium	7440-70-2	14	15000	18300 B	-	
Chromium	16065-83-1	14	26.7	31	111	
Cobalt	7440-48-4	14	11.6	12.7	-	
Copper	7440-50-8	14	51.8	60.5	149	
Iron	7439-89-6	14	26400	28100	-	
Lead	7439-92-1	14	45.7	52.9	128	
Magnesium	7439-95-4	14	5690	6300	-	
Manganese	7439-96-5	14	649	728	-	
Mercury	7439-97-6	14	0.0992	0.135	1.06	
Nickel	7440-02-0	14	35.3	39.3	48.6	
Phosphorus (total)	7723-14-0	14	435	497	-	
Potassium	7440-09-7	14	1720	1920	-	
Selenium	7782-49-2	14	0.735	0.857	-	
Silver	7440-22-4	14	0.363	0.467 J	-	
Sodium	7440-23-5	14	230	277 B	-	
Thallium	7440-28-0	14	0.357	0.397 J	-	
Vanadium	7440-62-2	14	20.1	22	-	
Zinc	7440-66-6	14	210	269	459	
Chlorinated Pesticides						
4,4´-DDD	72-54-8	2	0.000788	0.00536	0.028	
4,4´-DDE	72-55-9	14	0.00343	0.00829	0.0313	
4,4´-DDT	50-29-3	14	0.00587	0.00862	0.0629	
DDT, Total	DDT, Total	14	0.0101	0.0216	0.572	
alpha-Chlordane	5103-71-9	3	0.00133	0.0116	-	
gamma-Chlordane	5566-34-7	14	0.00362	0.00997	-	
Chlordane - Isomer mixture	12789-03-6	14	0.00498	0.0216	0.0176	YES
delta-BHC	319-86-8	12	0.00226	0.00458	-	
Dieldrin	60-57-1	13	0.00206	0.012	0.0618	

Table 5-2 Comparison of sediment concentrations (mg/kg) to sediment Probable Effect Concentration (PEC) screening values and Reference Site concentrations (continued).

Analyte	CAS	Number of Detects	Average Sediment Concentration[a]	Maximum Sediment Concentration	Sediment PEC Screeing Value	Sediment COC (> PEC)
Semivolatile Organic Compounds (SVOCs)						
2-Methylnaphthalene	91-57-6	14	0.112	0.194	-	
2-Methylphenol	95-48-7	5	0.0272	0.0962	-	
4-Chloroaniline	106-47-8	14	0.31	0.421	-	
4-Methylphenol	106-44-5	14	0.941	3.51	-	
Acenaphthene	83-32-9	14	0.108	0.307	-	
Acenaphthylene	208-96-8	11	0.0315	0.07	-	
Anthracene	120-12-7	14	0.316	1.09	0.845	YES
Benzo (a) anthracene	56-55-3	14	0.959	1.3	1.05	YES
Benzo (a) pyrene	50-32-8	14	0.768	1.07	1.45	
Benzo (b) fluoranthene	205-99-2	14	1.07	1.52	-	
Benzo (g,h,i) perylene	191-24-2	14	0.512	0.77	-	
Benzo (k) fluoranthene	207-08-9	14	0.816	1.17	-	
Bis(2-ethylhexyl)phthalate	117-81-7	14	0.885	1.55		
Butyl benzyl phthalate	85-68-7	10	0.0427	0.114		
Chrysene	218-01-9	14	1.48	1.97	1.29	YES
Dibenz (a,h) anthracene	53-70-3	14	0.0842	0.127	-	
Dibenzofuran	132-64-9	12	0.101	0.287		
Diethyl phthalate	84-66-2	2	0.0103	0.039 J		
Di-n-butyl phthalate	84-74-2	13	0.0458	0.0841		
Di-n-octyl phthalate	117-84-0	14	0.324	0.404	-	
Fluoranthene	206-44-0	14	4.16	7.98	2.23	YES
Fluorene	86-73-7	14	0.171	0.466	0.536	
Indeno(1,2,3-cd)pyrene	193-39-5	14	0.625	0.931	-	
Naphthalene	91-20-3	14	0.179	0.495	0.561	
PAHs, High Molecular Weight	PAHs, HMW	14	10.7	16.1	-	
PAHs, Low Molecular Weight	PAHs, LMW	14	2.39	3.99	-	
PAHs, Total	130498-29-2	14	14.8	22.5	22.8	
Pentachlorophenol	87-86-5	7	0.206	0.443	-	
Phenanthrene	85-01-8	14	1.47	2.28	1.17	YES
Phenol	108-95-2	14	0.0796	0.228	-	
Pyrene	129-00-0	14	2.08	3.27	1.52	YES
Volatile Organic Compounds (VOCs)						
1,2,3-Trichlorobenzene	87-61-6	2	0.0222	0.004 JHB	-	
1,2,4-Trichlorobenzene	120-82-1	3	0.0157	0.037 JHB	-	
1,2,4-Trimethylbenzene	95-63-6	2	0.030	0.0021 JHB	-	

Table 5-2 Comparison of sediment concentrations (mg/kg) to sediment Probable Effect Concentration (PEC) screening values and Reference Site concentrations (continued).

Analyte	CAS	Number of Detects	Average Sediment Concentration[a]	Maximum Sediment Concentration	Sediment PEC Screeing Value	Sediment COC (> PEC)
1,2-Dichlorobenzene	95-50-1	2	0.0246	0.0016 JHB	-	
1,3,5-Trimethylbenzene	108-67-8	1	0.0281	0.001 JH	-	
1,3-Dichlorobenzene	541-73-1	2	0.022	0.0014 JHB	-	
1,4-Dichlorobenzene	106-46-7	3	0.0241	0.073 JH	-	
2-Butanone	78-93-3	2	0.0994	0.029 H	-	
4-Isopropyltoluene	99-87-6	2	0.0158	0.0013 JHB	-	
Acetone	67-64-1	2	0.102	0.12 H	-	
Benzene	71-43-2	1	0.0272	0.00036 JH	-	
Bromobenzene	108-86-1	1	0.0324	0.00049 JH	-	
Bromomethane	74-83-9	1	0.0339	0.085 JHB	-	
Carbon disulfide	75-15-0	3	0.0187	0.048 JH	-	
Chlorobenzene	108-90-7	1	0.0228	0.058 JH	-	
Ethylbenzene	100-41-4	1	0.0438	0.00079 JH	-	
Hexachlorobutadiene	87-68-3	1	0.0439	0.0016 JHB	-	
m&p-Xylene	179601-23-1	1	0.0438	0.00071 JH	-	
Methyl acetate	79-20-9	12	0.633	1.3 H	-	
Methylcyclohexane	108-87-2	2	0.0442	0.0033 JH	-	
n-Butylbenzene	104-51-8	1	0.0439	0.0016 JHB	-	
sec-Butylbenzene	135-98-8	1	0.0438	0.00099 JHB	-	
Toluene	108-88-3	14	4.29	11 H	-	
Xylenes, Total	1330-20-7	1	0.0438	0.00071 JH	-	

Notes:

a. Average sediment concentration represents the arithmetic average for Navigation Channel sediment samples CH-1 through CH-8, DMMU-1, DMMU2, and DMMU-1S. One half of the reporting limit was used for estimating the chemical concentration when the measured concentration was less than the detection limit. Only chemicals with at least one measurement above the detection limit were evaluated.

b. J = Estimated concentration, analyte deteced below the quantitation limit H = Laboratory analysis procedures exceeding standard holding times prior to extraction. B = Analyte detected in laboratory quality control blank.

c. Values denoted by 1 have maximum detected values less than OEPA EOLP regional background value. Values denoted by 2 have maximum detected values less than the maximum detected value measured in the Reference Site soils.

d. Dash denotes no screening value available.

e. ND indicates compound was not detected in sample group.

industrial and urban land use in the watershed. Copper and zinc were determined to exceed background concentrations by the largest percentage (47 and 40 percent, respectively); however, none of the metals concentrations exceeded the PEC value. Thus none of the metals have been identified as a potential COC nor would they be expected to result in toxicity to benthic aquatic life. Overall, in the comparison of contaminant concentrations in river sediments with listed PECs (MacDonald et al. 2000), only seven individual compounds (all PAHs and one chlorinated pesticide) were identified as potential COCs with maximum concentrations exceeding PEC values and with concentrations elevated relative to the Lake reference site. The six constituents that exceeded PEC values were anthracene, benzo(a)anthracene, chrysene, fluoranthene, phenanthrene, pyrene, and chlordane (Table 5-2).

It is important to note that, the maximum concentration of Total PAHs (sum of 16 individual PAHs) was 22.5 mg/kg, which is less than the PEC value of 22.8 mg/kg[1]). Total PAHs is the preferred measurement over the use of individual compounds for evaluation of sediment toxicity. This is due to the difficulty of estimating risk from complex mixtures of these hydrocarbons when screening values for individual compounds are used (MacDonald et al. 2000). All six of these PAHs were measured at higher concentrations in the DMMU-1 composite as compared to the DMMU-2 composite. Maximum analyte concentrations and the sample locations exceeding PEC values are summarized in Table 5-3.

Chlordane (sum of alpha and gamma isomers) was detected in one sample (CH-2) at a concentration of 21.6 µg/kg exceeding the PEC value of 17.5 µg/kg. All of the other sediment samples were determined to have chlordane concentrations less than 8.8 µg/kg, below the PEC value of 17.5 µg/kg.

Two metals (cobalt and silver) and four semi-volatile organic compounds (4-Chloroaniline, Bis(2-ethylhexyl)phthalate, Di-n-octyl phthalate, and Phenol) were detected and determined to have mean concentrations exceeding the Lake reference average concentration.[2] A PEC value does not exist for these metals, so they were compared to EPA Region 5 sediment screening levels (USEPA Region 5 2003) and the Dutch maximum permissible concentration (Verbruggen et al. 2001). The maximum concentrations

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[1] Note that the PEC for Total PAHs as reported by MacDonald et al. (2000) is based on the sum of 13 individual PAHs (Swartz 1999). The maximum concentration of Total PAHs in navigation channel sediment based on the sum of 13 individual compounds is 21.1 mg/kg (as compared to 22.5 mg/kg based on 16 Priority Pollutants).

[2] Contaminant concentrations in the navigation channel sediments were statistically compared to the Lake reference location by comparing the concentration in samples collected from the DMMU-1 area (i.e., samples CH-1, CH-2, CH-3) and DMMU-2 area (i.e., samples CH-4, CH-5, CH-6, CH-6b, CH-7, CH-7b, CH-08) to the Lake Reference area (i.e., samples PB-1, PB-2, PB-3, PB-4). A two-sample T-test was used to compare DMMU-1 and DMMU-2 mean concentrations to mean Lake Reference concentration, and one-sample T-tests were used to compare DMMU-1and DMMU-2 mean concentrations to Ohio EOLP and PEC values (Snedecor and Cochran 1980; SAS Institute Inc. 1989).

of cobalt and silver did not exceed the EPA Region 5 sediment screening levels of 50 and 0.5 mg/kg, respectively. The mean phenol concentration for DMMU-1 and DMMU-2 samples was 45 and 113 µg/kg, respectively, which

Table 5-3. Analytes and sample locations that exceeded consensus-based sediment quality guidelines for PECs

ANALYTE	Consensus-based PEC [1] (mg/kg)	Maximum Concentration in River Sediment (mg/kg)	Sediments Exceeding PEC
Anthracene	0.845	1.09 (DMMU-1s)	DMMU-1s
Benzo(a)anthracene	1.05	1.3 (DMMU1)	CH-1, CH-2, CH-3, DMMU-1, DMMU-1S
Chrysene	1.29	1.97 (DMMU-1)	CH-1, CH-2, CH-3, CH-4, CH-5, CH-6, DMMU-1, DMMU-1S, DMMU-2
Fluoranthene	2.23	7.98 (DMMU-1)	CH-1, CH-2, CH-3, CH-4, CH-5, CH-6, CH-7, DMMU-1, DMMU-1S, DMMU-2
Phenanthrene	1.17	2.28 (DMMU-1)	CH-1, CH-2, CH-3, CH-5, CH-6, CH-7, DMMU-1, DMMU-1S
Pyrene	1.52	3.27 (CH-3)	CH-1, CH-2, CH-3, CH-4, CH-5, CH-6, CH-7, DMMU-1, DMMU-1S, DMMU-2
Total PAHs[2]	22.8	22.5 (DMMU-1)	None
Chlordane – isomer mixture	0.0176	0.0216 (CH-2)	CH-2

Notes: [1] MacDonald et al. (2000);

[2]The PEC value for Total PAHs is the sum of 13 PAH compounds and the maximum concentration reported is the sum of 16 PAH compounds.

is lower than the Dutch maximum permissible concentration (MPC = 0.200 mg/kg) for sediments provided in Verbruggen et al. (2001).Reliable freshwater sediment screening values for the semi-volatile organic compounds 4-Chloroaniline, Bis(2-ethylhexyl)phthalate, and Di-n-octyl phthalate are not available.

One contaminant, toluene, not identified as a potential COC was found to have elevated concentrations,which is of interest. Toluene was detected in all of the sediment samples ranging in concentration from 0.0017 to 11.0 mg/kg with the maximum concentration measured in sample CH-3 (part of DMMU-1). A PEC screening value is not available for toluene; however the Equilibrium Partitioning Sediment Benchmark (ESB) screening value for toluene has been estimated to be 0.81 mg/kg organic carbon (USEPA 2008). Given the total organic carbon content for sample CH-3 of 3.5%, the ESB screening value (for potential narcotic effects) for toluene in sample

CH-3 would be 23.1 mg/kg. The maximum concentration of toluene measured in River samples would represent approximately 0.46 toxic units (e.g. TU = 11 mg kg^{-1} /23.1 mg/kg^{-1}) indicating that toluene on its own is not present at toxic concentrations; however, toluene would contribute to any potential narcotic toxicity resulting from hydrocarbon mixtures.

With the exception of Total PAHs, the concentrations of COCs measured during November 2010 were considerably lower as compared to the concentration of COCs measured in sediment samples collected during 2007. Sample location CH-6 was determined to have the highest concentration of mercury in both 2007 and 2010; however, 0.135 mg/kg was detected in 2010 compared to 2.88 mg/kg detected in 2007. During 2007, PCBs (Aroclor 1254) were detected in all of the samples located from CH-1 to Ch-6 with a maximum concentration detected being 126 ug/kg. PCBs were not detected in any of these same sediment sample locations in 2010. A Total DDTs concentration of 60 ug/kg was detected in sample CH-4 in 2007 while only 21.6 ug/kg (CH-8) was detected in 2010. The maximum ammonia concentration was significantly lower in 2010 (12 mg/kg) compared to 2007 (201 mg/kg). On the other hand, the maximum concentration of Total PAHs measured in 2010 (22.5 mg/kg) was higher than the maximum detected concentration in this same area during 2007 (7.18 mg/kg).

5.2.2.2 *Assessment of PAH Bioavailability and Narcotic Toxicity (ESBs for PAH mixtures)*

The bioavailability and potential hydrocarbon toxicity of the complex mixture of PAHs present in River sediments was further evaluated by developing ESB values for total PAHs following USEPA guidance (USEPA 2003). The dissolved concentration of 18 parent PAHs and 16 groups of alkylated PAH compounds (34 PAHs) was measured in sediment porewater using solid phase microextraction methods (SPME; ASTM method D7363). The concentration of dissolved PAHs was then used to estimate the potential narcotic toxicity of the bioavailable PAHs (Hawthorne et al. 2007, ASTM 2007). Sediment sample CH-1 was determined to have the highest concentration of dissolved PAHs (4.6 µg/L) in sediment porewater resulting in 0.14 Toxic Units (TU) where 1.0 TU is the ESB screening value for the PAH mixture in the sample (Tables 5-4 and 5-5). The potential narcotic toxicity in the Navigation Channel sediment samples ranged from 0.02 to 0.14 TU, indicating the PAHs in the bulk sediment have low bioavailability and are not expected to result in toxicity to benthic aquatic organisms.

Table 5-4. Sum of toxic units associated with dissolved PAHs in the sediment porewater for individual sediment samples

SAMPLE ID	Total Dissolved PAH Concentration[1] (μg/L)	Toxic Units (TU)
CH-1	4.64	0.14
CH-2	1.13	0.05
CH-3	1.20	0.09
CH-4	0.49	0.02
CH-5	0.43	0.02
CH-5 DUP	0.61	0.02
CH-6a	1.42	0.06
CH-6b	0.56	0.03
CH-7a	3.81	0.13
CH-7b	1.62	0.12
CH-8	0.76	0.04

[1]Total dissolved PAHs is the sum of 18 parent and 16 groups of alkylated PAH compounds.

5.2.2.3 Assessment of Metal Bioavailability and Toxicity (SEM/AVS)

To determine metal bioavailability in the Navigation Channel sediment, a comparison of simultaneously extracted metals (SEM) to acid volatile sulfides (AVS) was conducted per USEPA guidance for evaluating sediment contaminant results (USEPA 2005). The concentrations of each of six metals (Cd, Cu, Pb, Ni, Zn, Ag) were reported as µg/kg and converted to µmols/kg using the relevant molecular mass for each metal. The µmols/kg of each of the six metals was then summed, with the concentration of the monovalent metals (i.e., Ag^+) halved to calculate the divalent metal equivalent concentration. This was then directly compared to the measured µmols/kg AVS. The potential for metals to be in their soluble and bioavailable form is low when the AVS concentration exceeds the sum of the simultaneously extracted metals (SEM – AVS < 0) or when the ratio of SEM/AVS is less than one. Bioavailability of metals can be further normalized based on the fraction of organic carbon (f_{oc}) in the sediment. USEPA (2005) provides additional guidance as follows:

- If $(\Sigma SEM\text{-}AVS)/f_{oc} < 130$ µmol/g_{oc}: little risk to aquatic life is predicted.
- If $(\Sigma SEM\text{-}AVS)/f_{oc} = 130$ to 3000 µmol/g_{oc}: further testing is needed to determine risk to aquatic life.
- If $(\Sigma SEM\text{-}AVS)/f_{oc} > 3000$ µmol/g_{oc}: risk to aquatic life is predicted to be likely.

Table 5-5. Concentration of dissolved PAHs and narcotic potential expressed as toxic units in sample CH-1 (the sediment with the highest potential for inducing hydrocarbon narcotic toxicity)

PAH Analyte	CASRN	Sediment Porewater Concentration (µg/L)		Final Chronic Value (FCVi) (µg/L)	Toxic Units
naphthalene	91-20-3	2.54	J	194	0.013
2-methylnaphthalene	91-57-6	0.164	J	72.2	0.002
1-methylnaphthalene	90-12-0	0.238	J	75.4	0.003
C2 naphthalenes	C2N	0.300	J	30.2	0.010
C3 naphthalenes	C3N	0.223	J	11.1	0.020
C4 naphthalenes	C4N	0.150	U	4.05	-
acenaphthylene	208-96-8	0.050	J	307	0.000
acenaphthene	83-32-9	0.365	J	55.9	0.007
fluorene	86-73-7	0.205	J	39.3	0.005
C1 fluorenes	C1F	0.046	J	14.0	0.003
C2 fluorenes	C2F	0.050	U	5.31	-
C3 fluorenes	C3F	0.060	U	1.92	-
phenanthrene	85-01-8	0.192	J	19.1	0.010
anthracene	120-12-7	0.020	J	20.7	0.001
C1 phenanthrenes/anthracenes	C1P	0.044	J	7.44	0.006
C2 phenanthrenes/anthracenes	C2P	0.136	J	3.20	0.042
C3 phenanthrenes/anthracenes	C3P	0.04	U	1.26	-
C4 phenanthrenes/anthracenes	C4P	0.02	U	0.559	-
fluoranthene	206-44-0	0.052	J	7.11	0.007
pyrene	129-00-0	0.042	J	10.1	0.004
C1 fluoranthenes/pyrenes	C1F/P	0.016	J	4.89	0.003
benz[a]anthracene	56-55-3	0.002	J	2.23	0.001
chrysene	218-01-9	0.006	J	2.04	0.003
C1 chrysenes	C1C	0.005	U	0.856	-
C2 chrysenes	C2C	0.010	U	0.483	-
C3 chrysenes	C3C	0.010	U	0.168	-
C4 chrysenes	C4C	0.010	U	0.071	-
benzo[b+k]fluoranthene	205-99-2, 207-08-9	0.005	U	0.659	-
benzo[e]pyrene	192-97-2	0.005	U	0.901	-
benzo[a]pyrene	50-32-8	0.008	U	0.957	-
perylene	198-55-0	0.004	U	0.901	-
indeno[1,2,3-cd]pyrene	193-39-5	0.001	U	0.275	-
dibenz[ah]anthracene	53-70-3	0.002	U	0.283	-
benzo[ghi]perylene	191-24-2	0.001	U	0.439	-
		Sum of toxic Units (ΣTU_i)			0.14

The concentration of AVS was determined to far exceed the summed concentration of the six metals (Cd, Cu, Pb, Ni, Zn, Ag); that is ΣSEM – AVS was less than zero, indicating toxicity due to metals was not predicted (USEPA 2005, Table 5-6). To further illustrate this point, the ratio of summed SEM metals to acid volatile sulfide (ΣSEM/AVS) was much less than 1 for all sediments (0.01 to 0.17), indicating low probably of metals bioavailability. Finally incorporating the fraction of organic carbon into the analysis of metal bioavailability resulted in values that were less than 0 μmol/g_{oc}, demonstrating that the observed metal bioavailability was much lower than the 130 μmol/g_{oc} criterion, and indicating there is little risk to aquatic life from these metals.

Table 5-6. Comparison of simultaneously extracted metals (SEM) and acid volatile sulfide (AVS) for all sediment and soil samples

SAMPLE ID	AVS (mg/kg)	SEM (mmol/kg)	AVS (mmols/kg)	SEM-AVS	SEM/AVS Ratio	(SEM-AVS)/f_{oc}
BS COMPOSITE	36.2	0.02	0.89	-0.87	0.02	-13.17
BS-1	41.6	0.02	0.77	-0.75	0.02	-22.73
BS-2	36.6	0.01	0.88	-0.86	0.01	-47.47
BS-3	35	0.02	0.92	-0.90	0.02	-9.34
BS-4	38.4	0.03	0.83	-0.80	0.04	-7.78
CH-1	56	0.02	0.57	-0.55	0.04	-14.69
CH-2	55.4	0.08	0.58	-0.49	0.14	-13.31
CH-3	70.6	0.04	0.45	-0.42	0.08	-11.89
CH-4	61.7	0.07	0.52	-0.45	0.14	-16.83
CH-5	60.8	0.04	0.53	-0.48	0.08	-17.81
CH-5 DUP	62	0.09	0.52	-0.43	0.17	-14.09
CH-6A	58.9	0.05	0.54	-0.49	0.10	-14.74
CH-6B	58.3	0.05	0.55	-0.50	0.09	-17.83
CH-7A	47.1	0.02	0.68	-0.66	0.04	-24.21
CH-7B	50.7	0.06	0.63	-0.58	0.09	-24.00
CH-8	47.3	0.05	0.68	-0.63	0.07	-21.64
DMMU-1	80.4	0.07	0.40	-0.33	0.17	-8.48
DMMU-1S	66.9	0.05	0.48	-0.43	0.10	-10.88
DMMU-2	58	0.05	0.55	-0.51	0.08	-19.57
PB COMPOSITE	31.6	0.01	1.01	-1.00	0.01	-184.17
PB-1	37	0.03	0.87	-0.83	0.04	-86.01
PB-2	35.7	0.01	0.90	-0.89	0.01	-130.53
PB-3	36.9	0.03	0.87	-0.83	0.04	-113.71
PB-4	28.2	0.04	1.14	-1.10	0.03	-115.68

5.2.2.4 Assessment of Bioaccumulation Potential

Bioaccumulation of contaminants and movement through the food chain is an important consideration in the assessment of risk from contaminated sediments. Tier II evaluation of contaminant bioaccumulation in the Great Lakes Testing Manual relies upon conservative estimates of theoretical bioaccumulation potential (TBP). TBP represents a theoretical condition of equilibrium between lipids in the tissue of aquatic organisms and sediment organic carbon, which is rarely achieved in the field. An equilibrium condition defined as the Biota-sediment accumulation factor (BSAF) is most closely met by organisms that have constant, direct contact with the sediment, such as burrowing worms. The use of TBP to predict bioaccumulation from sediment in more mobile organisms, such as migratory fish, is complicated by a number of factors such as seasonal fluctuations in diet and size of foraging area. Predictions of bioaccumulation in fish using sediment chemistry should only be considered a worst-case estimate of potential bioaccumulation.

The BSAF used for TBP modeling can vary widely with contaminant chemical properties and the type of organic carbon present in the sediment and organism. Because of a lack of reliable BSAF data specific for the pesticides chlordane, dieldrin and Total DDT in sediments near Cleveland, direct measurement of the uptake of these compounds in laboratory tests was conducted (section 5.2.4.3).

5.2.3 Tier II: Analysis of Suspended Phase Chemistry (standard elutriate testing)

The placement of dredged material in aquatic environments for beneficial use projects may impact water quality and result in short-term risk to aquatic life. Dissolved contaminants present in sediment porewater will be released during placement of dredged material and potentially impact water quality. Tier II analysis of the potential for water quality impacts was conducted by evaluating the results of standard sediment elutriate tests (USEPA/USACE 1998b) and additional information has been collected on the dissolved concentration of PAHs present in sediment porewater (Section 5.2.2.2). Although elutriate concentrations should be reduced using a model such as STFate to reflect dilution resulting from mixing and dispersion at the proposed beneficial use site, a specific wetland habitat restoration or beach nourishment site has not been identified. The following analysis provides an initial screening level assessment to determine the potential for risk and the future need for site-specific modeling of attainable mixing and dilution to assess potential impacts to water quality and compliance with Section 401 certification requirements.

Water samples were prepared using the standard elutriate extraction method. Both filtered and unfiltered standard elutriate samples were then subject to a comprehensive analysis for environmental contaminants (Chapter 3). Inorganic and organic contaminants detected in the standard elutriate samples were then compared to OEPA Outside Mixing Zone Maximum (OMZM), Water Quality µg/kg Standards (WQS; OAC 3745-1), and National Recommended Water Quality Criteria (WQC, USEPA 2002). Unfiltered elutriate samples were initially screened against the relevant WQS. If an exceedance was identified, the dissolved concentration of chemical in the filtered elutriate sample was then reviewed and compared against National Recommended WQS, which are also reported as dissolved concentrations (USEPA 2002). The dissolved form of contaminants in water is the primary chemical phase responsible for toxicity to aquatic life.

5.2.3.1 Identification of Contaminants of Concern

The contaminant concentrations measured in unfiltered standard elutriate samples (i.e., DMMU-1, DMMU-1s, DMMU-2) were compared to OEPA OMZM and National WQC to identify COCs. All organic contaminants were either below analytical detection limits or less than OMZM and National WQC. Only total measureable aluminum, copper and zinc exceeded Ohio water quality standards and have the potential to impact water quality during placement of dredged material at beneficial use sites (Table 5-7). However, total measureable aluminum and copper were also determined to exceed these WQS in Lake water reference samples collected for comparison.

Contaminants measured in unfiltered elutriate samples represent the total metal concentration including both the dissolved and particulate associated phases (contaminants associated with suspended clay and other solid phases). Metals bound to mineral complexes are generally not considered to be bioavailable (as long as they remain sorbed) and do not contribute to bioavailable metal concentration that may result in toxicity to aquatic organisms.

Table 5-7. Comparison of analytes detected in standard unfiltered and filtered elutriate water(µg/L) with OEPA Outside Mixing Zone Maximum (OMZM) water quality standards and National Water Quality Criteria - Criteria Maximum Concentration (CMC)

Analyte	Outside Mixing Zone Maximum[1] (OMZM)	Criteria Maximum Concentration[2] (CMC)	DMMU- 1	DMMU- 1S	DMMU- 2	Lake Water
Aluminum (filtered)	750 750	750 750	4760 50U	3640 50U	4570 50U	2770 50U
Antimony	900	-	1.6J	1.2J	1.5J	1U
Arsenic	340	340	10.7	10	16.4	3.6
Barium	2,000	-	74.1	68	110	48
Cadmium[7]	4.5	2[5]	1.1J	1.1J	2J	1U
Chromium[7]	1,800	570[5]	12.8	10.7	20.1	7.8
Cobalt	220	-	3	3.1	5.3	2.1
Copper[7] (filtered)	13 14	13 13	38.6 1.3J	38.3 1.4J	60.6 1.3J	14.1 2.7
Iron	-[3]	1000 [4]	5940	6530	9670	3610
Lead[7]	120	65 [5]	48	52.8	79.8	13.3
Mercury	1.4	1.4	0.049B	0.098B	0.127B	0.005U
Nickel[7]	470	470	13.6	11.1	17.5	6.5
Selenium	5	CMC = 12.4 [6] CCC= 5 [4]	1.4J	1U	1.6J	1U
Vanadium	150	-	11.2	9.5	13.7	7.7
Zinc[7] (filtered)	120 120	120 120	141 2.1	160 3	250 3.4	41.9 4.7
Chlordane (isomer mixture)	-	2.4	0.031	0.026	0.05	0.0003U
DDTs, Total (sum of metabolites)	-	1.1	0.012	0.014	0.012	0.0003U
2,6-Dinitrotoluene	730	-	0.08U	0.08U	0.68	0.08U
4-Methylphenol	480	-	0.08U	0.08U	0.09J	0.08U
Acenaphthene	19	-	0.08U	0.27	0.08U	0.08U
Benzo (a) anthracene	42	-	0.08J	0.08U	0.08U	0.08U
Benzo (b) fluoranthene	23	-	0.13J	0.08U	0.08U	0.08U
Bis(2-ethylhexyl)phthalate	1,100	-	1.25B	0.83B	0.82B	0.08U
Butyl benzyl phthalate	130	-	0.17J	0.08U	0.1J	0.08U
Chrysene	42	-	0.15J	0.1J	0.08U	0.08U
Diethyl phthalate	980	-	0.08U	0.11J	0.87	0.08U
Fluoranthene	3.7	-	0.21J	0.19J	0.08U	0.08U
Fluorene	110	-	0.08U	0.12J	0.08U	0.08U
Naphthalene	170	-	0.08J	0.13J	0.08U	0.08U
Phenanthrene	31	-	0.08J	0.1J	0.08U	0.08U

Table 5-7. Comparison of analytes detected in standard unfiltered and filtered elutriate water(µg/L) with OEPA Outside Mixing Zone Maximum (OMZM) water quality standards and National Water Quality Criteria - Criteria Maximum Concentration (CMC) (continued).

Analyte	Outside Mixing Zone Maximum[1] (OMZM)	Criteria Maximum Concentration[2] (CMC)	DMMU- 1	DMMU- 1S	DMMU- 2	Lake Water
Pyrene	42	-	0.2J	0.15J	0.08U	0.08U
PCB, Total (sum of aroclors)	-	0.014 [4]	0.02U	0.02U	0.02U	0.008U
2-Butanone	200,000	-	7.2H	7.5H	9.7H	5U
Carbon disulfide	130	-	1UH	0.16JHB	1UH	1U
Methylene Chloride	11,000	-	4.2H	6H	6.3H	0.64J
Toluene	560	-	0.78JH	0.69JH	1.3H	1U
Ammonia-Nitrogen, Total (filtered)	4.5 (6.6)[8]	3.0 (3.8)	8.4B 0.095JB	2B 4.9B	11.7B 0.079B	0.21B 0.13B

Notes: Exceedences are indicated by boldface red font. For metals, state standards and national criteria are reported as total measureable and dissolved, respectively. Analytes not included in this table were below detection limits in all waters. U = undetected; J = value below laboratory reporting limits but above method detection limits; B = compound detected in blank

[1] Ohio EPA Water Quality OMZM Standard for aquatic life unless specified.

[2] National Water Quality Criteria - Criteria maximum concentration (CMC). The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration to which an aquatic community can be exposed briefly without an unacceptable effect.

[3] No water quality standard or criteria available for protection of aquatic life.

[4] National Recommended Water Quality Criteria - Criteria continuous concentration (CCC). No CMC available.

[5] Reported as dissolved concentration.

[6] Worst case CMC based upon 100% selenate and 0% selenite.

[7] Water quality standards and criteria for the metals cadmium, chromium, copper, lead, nickel, and zinc are dependent on water hardness. Values presented are based on 100 mg/L hardness expressed as $CaCO_3$.

[8] Water quality standards and criteria for the ammonia is temperature- and pH-dependent. Values presented assumed field conditions at an assumed temperature of 21^0C and water pH of 8.1. Value in parentheses represents standard or criterion for temperature (24°C)and pH (7.9) of elutriate bioassay tests.

Aluminum could not be detected in the filtered elutriate samples (<50 µg/L) and was clearly below the WQC CMC value of 750 µg/L (Table 5-7). Copper concentrations in the filtered elutriate samples were also below the national WQC CMC value of 13 µg/L, with low J-values (1.3 – 1.4 µg/L) in the DMMU samples and a concentration of 2.7 µg/L in the Lake water reference sample. Zinc was detected in the filtered elutriate at concentrations ranging from 2.1 – 4.7 µg/L, well below the WQC CMC value of 120 µg/L.

The low concentration of dissolved metal in filtered elutriates compared to unfiltered elutriate samples is not a surprise, considering the geochemistry of the Navigation Channel sediment. Results from the analysis of simultaneously extracted metals and acid volatile sulfides (SEM/AVS) using whole sediment samples (presented above in section 5.1.1.3) indicated that Cd, Cu, Pb, Ni, Zn, Ag and several other metals, including inorganic mercury, are likely to be tightly bound to sulfides present in sediment particles and will not rapidly disassociate to form soluble chemical species in the water column.

Relatively high concentrations of ammonia-nitrogen were measured in the unfiltered DMMU-1 and DMMU-2 elutriate samples (8.4 and 11.7 mg/L, respectively). These concentrations could potentially induce short-term toxic effects on fish and other pelagic aquatic life during placement of dredged material for habitat restoration projects; however, after consideration of Lake water pH and expected mixing in the water column, ammonia concentrations are not expected to contravene OEPA WQS of 4.5 mg/L in the field. Provided the analytically measured total ammonia concentration of 11.7 mg/L in the DMMU-2 elutriate and the calculated CMC of 6.5 mg/L occur, an approximate dilution factor of only 1.8 would be required within the mixing zone to reduce ammonia concentrations in dredged water to acceptable levels. A much greater dilution would be expected at the limits of the outer mixing zone following placement of dredged material. It is important to note, however, that undiluted elutriate ammonia concentrations induced toxic effects on fish during laboratory bioassays, which is discussed in more detail in Section 5.3.

Based on the dissolved concentration of contaminants present in standard elutriate samples, none of the chemicals detected are anticipated to have unacceptable short-erm impacts to water quality, result in significant degradation of existing site conditions, or result in significant risk to aquatic life during placement of dredged material in aquatic environments for beneficial use.

5.2.4 Tier III: Biological Effects Testing

Tier III testing was conducted to make definitive determinations with respect to the potential for adverse effects associated with contaminants in sediment placed in unconfined aquatic environments. Tier II testing is conducted through the use of effects-based biological tests. Effects-based biological tests are laboratory procedures in which organisms are exposed to a contaminated medium; The OEPA OMZA and Federal CMC water quality standards and criteria for specific contaminants were developed from effects-based tests.

Biological-effects tests for evaluation of dredged material must represent the physical and chemical conditions of contaminant exposure during, and following, dredged material placement. There are two exposure pathways to be tested for toxicity, water column and benthic. The water column exposure evaluates the toxicity of contaminants released into the water from dredged material as it is discharged and settles.[1] The benthic exposure is directed at the toxicity of contaminants in the dredged material after it has been placed at the beneficial use site. The Tier III benthic evaluations determine if contaminants in the dredged material have the potential to cause an unacceptable adverse impact on benthic aquatic life. The Tier III elutriate evaluations determine if the dredged material contaminants cause an unacceptable adverse short-term impact on organisms within the water column. 2007 biological effects testing demonstrated toxicity associated with some sediment samples and 2010 chemistry data showed elevated levels of hydrocarbons in some sediment samples. Based on the above as well as elevated levels of ammonia-nitrogen in elutriate water samples, it was determined that biological effects testing should be conducted on the 2010 DMMU composite samples.

Tier III biological testing of samples (DMMU-1, DMMU-1S and DMMU-2) was conducted to determine whether potential for adverse biological impacts might occur during beneficial use of dredged material for beach nourishment or wetland habitat restoration projects. Bioassays were conducted by exposing the *Pimephales promelas* and *Ceriodaphnia dubia* to standard elutriate samples. Whole sediment toxicity tests were also conducted using *Hyalella azteca* and *Chironomus dilutus*. The potential for bioaccumulation of organic contaminants was conducted using *Lumbriculus variegatus*. Results of the biological testing follow; a more detailed summary of procedures and results can be found in Appendix D3.

5.2.4.1 Assessment of Impacts to Organisms in Sediment

In whole sediment tests, no increase in mortality was found when the two benthic macroinvertebrate species were exposed to DMMU-1 and DMMU-1S sediment samples; however, a significant increase in mortality relative to the reference sediment was observed for one of the two organisms (*H.*

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[1] Note that leaching and migration of contaminants from soil porewater to surface water has been evaluated based on direct screening of contaminants in standard elutriates against water quality criteria. Additional discussion on potential for leaching of contaminants from soils to groundwater used for drinking water is presented in Chapter 4.

azteca) exposed to the DMMU-2 sediment. These data indicate that the use of DMMU-1 dredged material in the aquatic environment is unlikely to result in toxicity to benthic aquatic life, while toxicity may be observed if dredged material from DMMU-2 is placed aquatically.

It is important to note that a specific wetland restoration, beach nourishment, or other aquatic use project site has not been identified. The tiered analysis by which the USACE determines the acceptability of placing dredged material in an aquatic environment requires chemical and biological effects testingin which the test material is compared to reference sediment that is representative of the proposed dredged material placement site (due to potential confounding effects related to the sediment matrix itself – such as grain size effects). Interpretation of biological effects data is highly dependent on the variability in survival and growth of the test animals exposed to the reference sediment. The reference sediment used in this study was collected from Perkins Beach, in Edgewater Park, which may not be appropriate for an alternate site being considered for beneficial uses. Sediment from Perkins Beach consisted of over 98% sand and would not be representative of a wetland habitat restoration site where fine-grained sediments are desired for establishing emergent aquatic vegetation. Future testing and comparison of Navigation Channel sediment and the appropriate reference samples will be required for final tiered evaluation of the acceptability of using dredged material for other aquatic habitat restoration sites.

Additional sediment sampling and testing are currently planned for the spring of 2012 to confirm the apparent improvement in sediment quality suggested by the results of the chemical analysis and toxicity testing conducted on the fall 2010 sediment samples. However, the basis for future dredged material management decision-making will include the evaluation of all data including results from spring 2007, fall 2010, and spring 2012 sampling events.

5.2.4.2 Assessment of Impacts to Organisms within the Water Column

In elutriate tests, increased mortality was not observed when aquatic animals were exposed to DMMU-1 and DMMU-1S water samples; however, significantly reduced survival was observed in one of the two organisms (*P. promelas*) when it was exposed to the DMMU-2 sample (relative to the Lake reference and control water samples). During monitoring of elutriate bioassays, the concentration of total ammonia measured in DMMU-2 test water was 10 mg/L, which was considerably higher than the concentration measured in the DMMU-1 (8 mg/L) and DMMU-1S (4 mg/L) test water. The ammonia concentrations observed during test monitoring were consistent with the ammonia results reported by the analytical chemistry lab for the respective elutriate samples. The total ammonia concentrations measured in tests using fathead minnows with DMMU-2 elutriates exceeded the calculated National WQC of 6.5 mg/L for total ammonia (based on pH and temperature measured during the bioassay). A discussion on the potential contribution of ammonia to toxicity observed in DMMU-2 elutriates is discussed more fully below. Other contaminants were measured at concentrations below analytical detection limits, were not statistically significantly elevated relative to the Lake reference area, were below ELOP background levels, or were below applicable WQS (with three metals as exceptions). These three metals detected in the elutriates at elevated concentrations were based upon total measurable concentrations that included metals sorbed to suspended sediment articles. The dissolved concentrations of these three metals, which are more predictive of toxicity, were below the national WQC CMCs, which are reported as dissolved concentrations.

The elutriate toxicity data indicate that placement of the DMMU-1 dredged material in aquatic environments is unlikely to result in toxicity to organisms in the water column; however, ammonia toxicity may be observed during placement of dredged material from DMMU-2. The potential for toxicity to aquatic organisms in the water column depends on the actual mixing and dilution of the dredged water and toxicants following placement of the dredged material. The risk associated with placement of DMMU-2 dredged material will therefore require modeling that takes into account site- specific characteristics of the receiving water body at the beneficial use site, such as flow relative to the dredge discharge and background contaminant concentrations.

5.2.4.3 Assessment of Contaminant Bioaccumulation

In bioaccumulation tests, the concentration of PCBs and chlorinated pesticides measured in *L. variegates* tissues were non-detectablein worms exposed to navigation channel samples (DMMU-1, DMMU-1S and DMMU-2) (see Chapter 3). Because PCBs, DDT and other chlorinated – pesticides were not detected in *L. variegates*, an aquatic worm in direct contact with the sediment, uptake and bioaccumulation by other aquatic organisms at higher trophic levels is considered to be very low. The reporting limits for chlordane, dieldrin and Total DDT in *L. variegatus* tissue were used to calculate a potential maximum BSAF value. This analysis demonstrated that these compounds have BSAF values of less than 0.1 indicating that they have low bioavailability and are tightly bound to sediment. . Based on these data, the beneficial use of dredged material for beach nourishment, wetland habitat restoration, or other aquatic uses is not expected to have an unacceptable adverse effect on aquatic life due to contaminant bioaccumulation of PCBs or chlorinated pesticides such as DDT and chlordane.

5.2.4.4 Assessment of Potential Sources of Toxicity

The biological effects testing conducted on sediment samples collected in 2010 indicates that adverse effects from the beneficial use of dredged materials collected from DMMU-1 is unlikely. However, significantly greater mortality relative to the reference condition was observed for at least one organism in both the DMMU-2 elutriate and sediment exposures. The environmental engineering of beneficial use projects can incorporate remedial designs that minimize or eliminate potential ecological risk from environmental contaminants. However, the engineering to develop these remedial approaches requires knowledge regarding the source of toxicity. In this study, various tests were employed including comparison of contaminant levels to background, water quality standards and criteria (WQS/WQC), and PECs in addition to determinations of the bioavailability of metals and PAHs in the sediment. These data are summarized below as a means to help elucidate the likely source of toxicity observed in DMMU-2 biological effects tests.

A more detailed risk characterization of the suspended phase materials (standard elutriates) and Navigation Channel sediment was performed to identify the potential cause for significantly reduced survival of larval fish *Pimephales promelas* (fathead minnow) and benthic amphipod (*Hyalella azteca*) exposed to DMMU-2 sediment samples. Among all project sediments (i.e., CH-1 to CH-8 and DMMUs), two metals and 16 organic compounds were determined to have higher average concentrations in sediment samples as compared to the Lake reference sediment samples. However, most of these contaminants were either not significantly greater than the regional EOLP background levels, were below available PEC sediment screening values, or were higher in DMMU-1 (relative to DMMU-2) in which no significant toxicity was observed in whole sediment or elutriate bioassays. The only compounds with a maximum detected concentration in sediment that exceeded consensus-based PECs were six individual PAHs. However, the concentration of Total PAHs (i.e., sum of 13 PAHs; 12.7 mg/kg) in sample DMMU-2 was lower than the consensus-based PEC (also sum of 13 PAHs) of 22.8 mg/kg. Furthermore, the analysis of dissolved PAHs in sediment porewater, representing the bioavailable concentration that is likely to result in toxicity, indicated that there was low potential for PAHs to be the source of toxicity in these samples (Table 5-4). Finally, it is unlikely that PAHs alone induced the observed mortality in *H. azteca* exposed to DMMU-2 since the Total PAH concentration in DMMU-2 (12.7 mg/kg) was lower than Total PAHs in DMMU-1 (21.1 mg/kg) and DMMU-1S (18.1 mg/kg); DMMU-1 and DMMU-1S induced no significant *H. azteca* mortality. These lines of evidence, taken together, make a strong case that PAHs are not the source of toxicity to fish in water column tests nor are they the toxicity source for amphipods in whole sediment tests.

It is unlikely that total measureable aluminum in the DMMU-2 elutriate (4,570 µg/L) was the cause of the observed mortality to *P. promelas*, since it was lower than aluminum concentrations in DMMU-1 elutriate (4,760 µg/L), where no significant *P. promelas* mortality occurred. Higher concentrations of total copper and zinc were detected in the unfiltered DMMU-2 elutriate relative to the unfiltered DMMU-1 elutriate. However, based on the dissolved metal concentrations measured in filtered elutriates, toxicity to fathead minnows would not be expected. The dissolved concentrations of aluminum, copper and zinc measured in the DMMU-2 elutriate samples were much lower than their corresponding National WQC (USEPA 2002), which are reported as dissolved concentrations. In sediment samples, copper and zinc were the only metals that were much larger than the EOLP regional background values and these metals did not exceed their respective PEC value. A comparison between simultaneously extracted metals (SEM) to acid volatile sulfide (AVS) indicated the available AVS was much higher than required to reduce bioavailability of metals making the potential for metals toxicity negligible when placed in aquatic environments. In addition, the highest SEM/AVS ratio was determined for DMMU-1 (0.17), where no toxicity was observed. A ratio less than one is generally considered to have low potential for toxicity. Given these lines of evidence, it is unlikely that metals resulted in the toxicity to *H. azteca* observed when exposed to DMMU-2 sediment nor the toxicity to *P. promelas* observed when exposed to DMMU-2 elutriate samples.

Although phenol was detected in sediment samples, the concentration measured in DMMU-2 (0.053 mg/kg) was only marginally higher than in DMMU-1 (0.044) and lower than the Dutch maximum permissible concentration (MPC = 0.200 mg/kg) for sediments. Therefore, it is unlikely that phenol is the source of toxicity measured in DMMU-2 samples.

Screening values for the semi-volatile organic compounds 4-Chloroaniline, Bis(2-ethylhexyl)phthalate, and Di-n-octyl phthalate are not available but these compounds may have toxic effects. However , all of these contaminants were detected at higher concentrations in the DMMU-1 sample relative to the DMMU-2 sample; thus, since no elevated *H. azteca* mortality was observed with exposure to the DMMU-1 sample, it is unlikely that these contaminants are the primary source of toxicity observed for the DMMU-2 sample.

Toluene was detected in all of the sediment samples ranging in concentration from 0.0017 to 11 mg/kg, with the maximum concentration measured in sample CH-3. The Equilibrium Partitioning Sediment Benchmark (ESB) value for toluene for this sample was 23 mg/kg and the measured concentration represented approximately 0.46 toxic units (TU). Toluene concentration measured in the DMMU-1 and DMMU-2 sediment samples was 9.6 and 4.4 mg/kg, respectively, with the concentration in DMMU-2 representing approximately 0.2 TUs. These data indicate that toluene is not likely to be the primary toxicant in DMMU-2 sediment samples. While detected in the sediments at elevated levels, toluene concentrations were relatively low in the elutriate waters (0.7 to 1.3 µg/L). These values are much lower than 96-h LC50 values (17 to 72 mg/L) for fathead minnows exposed to toluene (Devlin et al. 1982). The detected toluene values are also much lower than OMZM (560 µg/L) and NOAA Screening Quick Reference Table (120 µg/L; Buchman et al. 2008) screening value. Although toluene was detected in many sediment samples it was not identified as a COC (due to high variability in concentrations in the discrete sediments; 0.0017 to 11 mg/kg), and the lines of evidence suggest that it is not likely to be the source of toxicity observed in DMMU-2 whole sediment nor elutriate bioassays.

Ammonia, when present, is an important toxicant to consider in bioassays employing fish species (USEPA 2009). The unionized fraction of ammonia is often responsible for causing toxicity to fish. The fraction of total ammonia that is unionized is dependent on water temperature, pH, and, to a lesser extent, salinity. At the mean pH (7.9) and temperature (24 °C) recorded during monitoring of elutriate bioassays (Appendix D3), the unionized ammonia concentration was calculated to be approximately 0.5 mg/L. The total ammonia concentrations measured in fathead minnow bioassay for DMMU-2 (10 mg/L) exceeded the calculated ammonia WQC (6.5 mg/L based on pH and temperature measured during the bioassay). Several studies (Nimmo et al. 1989, Diamond et al. 1993, Buhl 2002) provide toxicity reference values for larval *P. promelas* exposed to ammonia for 96 h. Among these studies, Diamond et al. (1993) reported the lowest LC50 value of 0.25 (95% confidence limits: 0.21 – 0.30) mg/L as unionized ammonia. Nimmo et al. (1989) reported LC50 values ranging from 0.56 (0.52 – 0.61) to 0.94 (0.87 - 1.02) mg/L, as unionized ammonia, in two different field waters. Additionally, Buhl et al. (2002) reported a 96-h LC50 of 1.01 (0.83 – 1.18) mg/L as unionized ammonia or 14.4 (10.4 – 18.5) mg/L as total ammonia at pH 8 and a temperature of 25 °C. While it cannot be stated that ammonia was the only driver of toxicity in DMMU-2 elutriate samples, the measured ammonia levels in the water exceeded the calculated acute WQC and approached literature reported LC50 values for *P. promelas*, providing evidence that ammonia could be a contributor to the observed mortality.

While the porewater ammonia concentrations (80 – 91 mg/L as total ammonia) measured in the DMMU whole sediment samples would be expected to induce toxicity to *H. azteca*, the sediment samples were purged of ammonia (via overlying water exchanges) during the whole sediment toxicity tests to less than 20 mg/L (measured to be 8-15 mg/L) following the test method guidance (USEPA / USACE 1998, USEPA 2000). At a similar water hardness (approx. 80 mg/L as $CaCO_3$) and pH range (7.31 – 8.30), 96-h LC50 values for *H. azteca* ranged from 39.8 and 64.0 mg/L total ammonia (Ankley et al. 1995); the authors state that they observed little difference in *H. azteca* sensitivity to ammonia between 96-h and 10-d, the latter being the duration of the bioassay in the present investigation. Ankley et al. (1995) concluded that even under the worst case scenario (high temperature and pH), which did not occur in the current investigation, 10 mg/L total ammonia should not induce toxicity. Finally, the porewater ammonia in DMMU-2 (11 mg/L) was lower than that of DMMU-1 (15 mg/L), in which no reduction in *H. azteca* survival occurred. Thus, the reduced concentrations of total ammonia in sediment porewater in the bioassays are not likely to have induced the observed reduction in *H. azteca* survival.

Based on the review of sediment chemistry data and toxicity test results, it appears that ammonia may be the source of toxicity to *P. promelas* in DMMU-2 elutriate samples; however, it cannot be concluded that ammonia is the source of toxicity to *H. azteca* in DMMU-2 whole sediment samples. The initial and periodic renewal of water during the *H. azteca* bioassays should have maintained ammonia concentrations below toxic concentrations.

Finally, it should be noted that the pH from the bioassay (7.9) used to calculate unionized ammonia above was higher than pH values typically measured for the Cuyahoga River (mean: 7.17 ± 0.31; range 6.60 – 8.20; Independence, OH) by USGS (Real-time water 120-day data; accessed 10 May 2011). In addition, older pH data sets for the Cuyahoga River near the Third Street Bridge averaged 7.33 ± 0.55 ranging between 5.90 – 8.50 pH units. Employing these site-relevant mean pH values and assuming a worst case temperature of 25 °C and the same total ammonia concentrations released in the field (without dilution), the calculated unionized ammonia concentration would be much lower (0.08 – 0.12 mg/L) and unlikely to be toxic based on the literature toxicity reference values cited above.

5.2.4.5 Summary of Toxicity Potential in the Aquatic Environment

Water quality. For the suspended phase material (i.e., elutriates), the concentrations of organic compounds were below state of Ohio water quality standards (OMZM) and/or national water quality criteria (CMC), where available. The total measureable concentrations of most metals were below State OMZM and national CMC values, with the exceptions of Al, Cu and Zn in the unfiltered (and undiluted) elutriate water. However, this represents the worst case scenario in terms of concentration (i.e., total measureable concentrations include metals associated with the suspended sediment particles, although only the dissolved fraction is generally considered to be bioavailable, and mixing and dilution with River or Lake water would further reduce exposure concentrations in the field). It appears that toxicity to *P. promelas* in laboratory bioassays may result from high levels of unionized ammonia in the elutriate samples; however, toxicity and violation of water quality standards in the field during placement of dredged material is unlikely due to the lower pH, water temperature and the rapid dilution of ammonia that would occur during dredged material placement. Achievable dilution must be assessed, however, on a site-specific basis.

Sediment. No toxicity to *H. azteca* and *C. dilutus* was observed when these organisms were exposed to DMMU-1 or DMMU-1S sediment samples. The use of DMMU-1 dredged material for beach nourishment or restoration of wetland aquatic habitat is not expected to result in toxicity to benthic aquatic life. Toxicity was observed when *H. azteca* was exposed to the DMMU-2 sediment sample and toxicity may be observed if dredged material from DMMU-2 is used for aquatic beneficial use applications. Overall, a specific COC was not identified to cause the observed mortality of *H. azteca* exposed to DMMU-2 sediment. The other organism (*C. dilutus*) used to evaluate the sediments did not indicate toxicity. It can be concluded that the DMMU-1 and DMMU-1S have low potential to induce toxicity and have low potential to cause adverse risk due to bioaccumulation. The chemical analysis of DMMU-2, which predominately had lower concentrations of contaminants relative to DMMU-1, also suggests low risk of toxicity and bioaccumulation. However, the significant mortality for one of the two organisms (*H. azteca*) suggests that the potential for toxicity (albeit not chemically explained) may be encountered if dredged material from DMMU-2 is used beneficially for beach nourishment or wetland habitat restoration.

The theoretical bioaccumulation potential (TBP) modeling predicted low potential for PCBs and chlorinated pesticides to bioaccumulate in worm tissue and fish at adverse concentrations; the concentrations of these compounds in sediment were below or slightly above analytical detection limits. As confirmation, aquatic worms (*L. variegatus*) exposed to sediment samples did not accumulate PCBs or chlorinated pesticides at detectable concentrations. Further, the TBP concentrations calculated for fish using the maximum detected concentration or the minimum detection limit for sediment predicted tissue residues that were well below FDA action levels and state of Ohio advisory levels for consumption of fish.

5.3 Evaluation of Risk to Terrestrial Life

The evaluation of risk to terrestrial ecological receptors from exposure to COCs in the Cleveland Harbor sediments may include four main routes of exposure including (1) direct contact with soil, (2) uptake from soil by plants that are then consumed, (3) uptake from soil by invertebrates that are then consumed, and (4) leaching from soil to water that is consumed. For a pathway to be relevant three conditions must exist:

- There must be a stressor. A COC capable of causing adverse effects must be present.
- There must be a receptor of concern (ROC). A terrestrial organism is present that is determined to be the risk endpoint of interest.
- There must be an exposure route by which an ROC can come into contact with the COC, either directly or indirectly. Depending on the location of the beneficial use and site management practices, exposure routes could be altered or eliminated, thus reducing or eliminating the risk of exposure.

The approach in evaluating terrestrial risk associated with COCs in dredged material management in island, nearshore or upland CDFs is described in the Upland Testing Manual (UTM). The UTM provides guidance on using a tiered approach to evaluate potential risks and risk management decision-making. This tiered evaluation is commonly used for assessing the placement of contaminated dredged material into a CDF or potential contaminant migration from existing CDFs. While the UTM's main purpose is to identify the contaminant pathways that may result in exposure to receptors outside of the CDF, the testing methods and tiered approach for evaluating risks in terrestrial habitats can also be applied to dredged material placed in unconfined settings, including beneficial use sites. An evaluation of risk using the UTM is driven by requirements to comply with the CWA and NEPA. For projects where return flow does not exist, the regulatory authority for the beneficial use of sediment may be driven by State solid waste standards established under authority granted to states by USEPA to regulate reuse of solid waste. In the absence of State standards or where standards do not address risks to terrestrial wildlife, the evaluations established in the UTM are useful in addressing potential terrestrial ecological risk from beneficial use projects.

5.3.1 TIER I: Existing Information

A Tier 1 evaluation under the UTM includes a review of the existing information relevant to the assessment of risk and risk decision-making. Previous studies evaluating the potential terrestrial ecological risk of Navigation Channel dredged materials include a Contaminant Monitoring Assessment conducted for CDF 10B in 2007 and an Ecological Risk Assessment for Dike 14 (2008).

A Contaminant Monitoring Assessment using the protocols specified in the UTM was previously conducted for CDF 10B (USACE-Buffalo, 2007). Plant uptake of metals and earthworm uptake of PCBs and pesticides were evaluated by exposing plants and earthworms to composite samples collected from the CDF 10B and from a reference soil collected from the Cleveland Lakefront State Park. Evaluation of test materials for chemical and physical characteristics and biological exposure was conducted following the tiered approach specified by the UTM. Birds and small mammals were identified as ecological receptors at potential risk from exposure to contaminants in dewatered dredged material; consumption of plants and earthworms that have taken up contaminants from the dredged material are the primary routes of exposure. Plant bioassays were conducted, and results demonstrated that the dewatered and oxidized material in the CDF did not pose an unacceptable risk to animals consuming plants growing on the CDF (USACE-Buffalo, 2007). Plants grown on the Cleveland Lakefront State Park reference soil generally contained higher concentrations of toxic metals than the plants grown in Cuyahoga River dredged material. Earthworms exposed to CDF 10B dredged material contained higher concentrations of PCB (as Arochlor 1248) than the reference soil, but the concentrations were determined to be well below dietary concentrations potentially posing adverse risks to higher animals. DDT, DDE and DDD were also higher in earthworms exposed to dredged material as compared to the reference soil, but these concentrations were two orders of magnitude less than dietary concentrations potentially causing adverse effects to higher animals.

The Cleveland Lakefront Nature Preserve is an existing 88-acre former dredged material disposal site (Dike 14) that has been developed as a nature preserve adjacent to Gordon State Park/Cleveland Lakefront State Park. A portion of Dike 14 was formerly a solid waste landfill. From 1979 to 1999, dredged material was placed into the dike, which was then closed in 1999. Due to the time period, the dredged material placed in Dike 14 is expected to have higher concentrations of contaminants than material that is currently being placed in CDF 10B (due to improvements in water and sediment quality that occurred during the 1980s and 1990s). The OEPA conducted a tiered risk evaluation of surface soils at Dike 14 following OPEA guidance and found the primary risk was to invertivorious (invertebrate-eating) birds, such as the American Robin, from elevated soil levels of lead and PCBs (OEPA 2008). Based on these model results, remedial action has been proposed for a 5-acre portion of the site through construction of a cap using clean soil as a cover to reduce exposures to wildlife.

Local stakeholders have identified over 280 species of birds, numerous butterflies, 16 species of mammals (red fox, coyote, mink, deer), 2 species of reptiles, 26 Ohio plant species (wildflowers, grasses) and 9 species of trees and shrubs at the site. There have been no documented adverse effects to wildlife using the area for rest, food, shelter, or breeding. The development of a high quality habitat supporting a diverse array of bird species indicates that the risk to ecological receptors on Dike 14 is minimal despite the elevated concentrations of Pb measured in soils that exceeded ecological screening levels for birds (e.g. Robin).

Based on previous data from plant exposure evaluations, the uptake of contaminants by plants that may result from future beneficial use of dredged material is not considered a significant exposure pathway for ecological receptors (USACE-LRE 2007), and no further evaluation of the plant exposure pathway and risk to ecological receptors is justified. However, the 2007 Contaminant Monitoring Assessment did not conduct tests directly evaluating the bioaccumulation of metals by earthworms, and it is apparent that the potential for uptake of Pb and other metals by earthworms warrants further evaluation.

5.3.2 TIER II: Screening Level Evaluation

Tier II evaluations for ecological risks generally include numerical comparisons of dredged material contaminant concentrations to background concentrations, screening level limits, or other benchmark values. The validity of such evaluations in determining exposure risks associated with biological uptake depends on the matrix-specific bioavailability of the contaminants, which may vary significantly between soils having similar COC concentrations. The USEPA has developed Ecological Soil Screening Levels (Eco-SSLs) for evaluating contaminated soils and determining the need for further environmental assessment. It is emphasized that Eco-SSLs were not developed using dredged material, and their application to evaluating potential risks resulting from the beneficial use of dredged material in upland environments would be inappropriate. The bioavailability of metals in dredged material may be higher or lower than in soils due to the presence of sulfides, lower redox potential, and differences in organic matter content and character. Likewise, other criteria such as soil cleanup criteria that were developed based on site-specific properties related to exposure/effects for soils and not dredged materials would also not be appropriate.

Tier II evaluations may include chemical extractions or models to estimate bioavailable fractions. The UTM provides guidance for evaluating the Theoretical Bioaccumulation Potential of a dredged material and estimating the potential bioaccumulation of organic contaminants to earthworms in terrestrial environments. This procedure was originally developed for direct contact of aquatic organisms in anaerobic sediment and has limitations for predicting exposure and uptake of contaminants by terrestrial worms in aerobic soils. In addition, a Tier II method to predict metal availability to earthworms has not been evaluated. It is, therefore, necessary to evaluate earthworm exposures by direct exposure methods provided in Tier III.

5.3.3 TIER III: Upland Bioaccumulation Tests

The purpose of Tier III plant and animal toxicity and bioaccumulation tests is to determine the potential for toxicity and migration of contaminants from dredged material to the food chain. The bioavailability of contaminants to soil invertebrates or plants exposed to dredged material is a means of determining the potential risks to avian or mammalian predators that consume organisms having been exposed to soil contaminants. For most contaminants, there is not a linear relationship between the concentration in dredged material and bioavailability to soil invertebrates; thus, actual biological exposures to the dredged material in question must be conducted. The UTM recommends conducting bioassays on the dredged material in question as well as on a reference sediment or soil for comparison. Measured bioaccumulation in tissues exposed to dredged material and reference soil contaminants provides an indication of the relative potential risks posed to food webs through exposure to the dredged material.

The Tier III procedure for animals determines the potential bioaccumulation of any contaminant originating in freshwater dredged material that is intended to become a soil. Earthworms are used as a representative soil invertebrate that can accumulate a wide variety of contaminants from the soil in which it lives. This standardized test procedure has been published as ASTM Standard Procedure SE-1676 (ASTM 1997). The bioaccumulation assay provides information on (1) bioavailability and mobility of contaminants from soil to soil-dwelling earthworms, and (2) the potential for contaminant movement to higher organisms (e.g., birds, mammals, amphibians, reptiles) that are linked to earthworms in the food web.

5.3.3.1 Assessment of Toxicity and Potential Bioaccumulation in Terrestrial Animals

Earthworm bioassays were conducted using DMMU-1, DMMU-2 and the Reference soil samples collected in 2010 (Chapter 3) following the methods in the UTM (USACE, 2003), Section G.3 Tier III - Terrestrial Animal Bioaccumulation Test. The bioassays were conducted in the ERDC-Vicksburg laboratory facility and are described in detail in Appendix D4 of this report. Information on plant bioaccumulation was taken from the CDF 10B Assessment report (USACE-Buffalo, 2007).

Tissue concentrations of metals, chlorinated pesticides and PCBs in earthworms exposed to DMMU-1 and DMMU-2 were compared to tissue concentrations from the Reference soil, as well as to Ecological Biota Screening Levels (Eco-BSLs), where available. The Eco-BSLs were established by taking the Toxicity Reference Values (TRVs) for shrew (mammal) and woodcock (avian) used in the calculation of Ecological Soil Screening Levels (USEPA 2003-2007) and determining a maximum tissue concentration using the following formula:

$$\text{Eco-BSL} = (\text{TRV x BW})/(\text{F x CR})$$

Where: TRV = Toxicity Reference Value (mg dry weight/kg body weight per day), BW = the body weight of target receptor (kg), F = the fraction of tissue consumed, CR = the consumption rate (kg dry weight tissue per day)

Parameters used for body weight per day, fraction of tissue consumed, and consumption rate were as specified by the Ecological Soil Screening Level documentation.

Results from the earthworm bioaccumulation testing that exceeded either the Reference soil or the Eco-BSL are summarized in Table 5-8. Tissue concentrations of silver, arsenic, nickel, selenium, zinc, DDD and chlordane were statistically higher in worms exposed to DMMU-1 than in worms exposed to the Reference soil. The worm tissue concentrations exposed to DMMU-1 exceeded the mammal Eco-BSL only for selenium.

The tissue concentrations of worms exposed to DMMU-2 were statistically higher than the Reference soil for arsenic, nickel, selenium, zinc, DDT, DDD, dieldrin and chlordane. The average concentration of the sum of

Table 5-8. COCs in earthworms (mg kg^{-1}) exceeding reference or Eco-BSL.

COC	DMMU1 Mean	DMMU2 Mean	Reference Mean	Eco-BSL†	Exceeding Ref	Exceeding Eco-BSL
Ag	0.1932*	0.1414	0.1173		DMMU1	
As	4.610	6.498**	3.822	5.0 Mammal	DMMU1, DMMU2	DMMU2
Pb	0.2968	0.4114	9.304	7.6 Avian		Ref
Ni	0.8954	0.6788	0.5014		DMMU1, DMMU2	
Se	1.882	1.848	1.356	0.7 Mammal	DMMU1, DMMU2	DMMU1, DMMU2, Ref
Zn	20.54	20.30	17.32		DMMU1, DMMU2	
DDT	0.004	0.005	0.0045		DMMU2	
DDE	0.0012	0.002	0.0123			
DDD	0.001	0.001	ND		DMMU1, DMMU2	
Dieldrin	0.0037	0.003	0.0016		DMMU2	
Gamma-Clordane	0.013	0.0098	ND		DMMU1, DMMU2	

† Ecological Biota Screening Level. Earthworm tissue concentrations exceeding these levels are potentially harmful to receptors shown.

* Values in **bold** – DMMU statistically exceeds reference at P=0.05.

** Values in red – tissue concentration exceeds Eco-BSL.

DDT and its degradation products DDE and DDD (Total DDT) were found to be higher in worm tissue exposed to the Reference soil than in worm tissue exposed to either sediment sample, DMMU-1 or DMMU-2. The tissue concentration of worms exposed to DMMU-2 exceeded the mammal Eco-BSL for the metals arsenic and selenium.

In this study, arsenic and selenium uptake by earthworms in DMMU-1 exceeded that of the Reference soil despite the Reference having a higher total soil concentration of both these metals. It is important to note that the maximum concentrations of arsenic and selenium in the DMMU-1 and DMMU-2 sediment samples and the soil reference samples were less than the OEPA EOLP regional value, which is considered to be the regional upper limit concentration for uncontaminated sediment and soils. It should be noted that the tissue concentrations reported here represent a conservative estimate of exposure, assuming receptors consume 100% of their diet from earthworms colonizing dredged material at a beneficial use site. This would not likely be the case. In addition, these metals will become more stable as the organic matter and minerals oxidize and the dredged material becomes more soil-like. The dried and oxidized sediment used for these bioassays represents a worst case where metal as sulfides are being converted to more soluble species prior to the formation of more stable minerals. In addition, long-term cycling of metals and organic contaminants within the soil rhizosphere and biota will result in dilution over time, reducing the future potential for exposure and risk.

The uptake of DDD by earthworms exposed to DMMU-1 and DMMU-2 exceeded that of the Reference soil, and the uptake of DDT by earthworms in DMMU-2 exceeded that of the Reference soil despite the Reference Soil having a higher concentration of DDD, DDE, and DDT that of the sediment samples. In the report for CDF 10B (USACE-Buffalo, 2007), similar levels of DDT, DDE, and DDD were measured in the tissues of earthworms exposed to the CDF dredged material. It was determined that these levels were two orders of magnitude below dietary concentrations known to cause adverse effects. The CDF 10B report determined that metals were not a significant concern during the Tier I and II screening level assessments and were subsequently not evaluated for earthworms.

The concentration of Pb in worm tissues exposed to the Reference soil collected with sediment samples in 2010 were determined to be more than three times higher than in worm tissues exposed to DMMU-1 and DMMU2, resulting in higher estimates of potential bioaccumulation and adverse effects to mammalian insectivores and their prey in the Reference site soil.

Given these lines of evidence, the beneficial use of dredged material for creation of surface soils and upland habitat is not expected to result in significant risk to wildlife from exposure to contaminants in the dredged material.

5.4 Summary of Ecological Contaminant Risk Evaluation

The screening level ecological risk analysis based on the 2010 sediment quality toxicity testing and laboratory chemistry results shows that no significant risk to soil invertebrates, birds, or mammals is expected from exposure to contaminants in dredged sediment placed at upland sites. In addition, laboratory testing of sediment samples indicated that if dredged material from the upper reach of the navigation channel is used beneficially in aquatic habitat restoration projects, no adverse impacts to aquatic life are expected. However, low levels of toxicity to aquatic life may be encountered when dredged material from areas located further downstream in the navigation channel are beneficially used. The source of this toxicity is currently unknown.

Based on the elutriate test results, impacts to the water column during placement of dredged material for aquatic and littoral habitat restoration projects are not expected. Exceedances of water quality standards associated with short-term exposures during placement of dredged material are not expected.

Laboratory test results in 2007 were previously used to establish that open water placement of dredged material was not acceptable. The chemical analysis and toxicity testing of sediment samples collected during the fall of 2010 show in general an improvement in quality compared to samples collected during the spring of 2007. Additional sediment sampling and testing are currently planned for the spring of 2012 to confirm the fall 2010 sediment quality results. The basis for future dredged material management decision-making will include the evaluation of all data including results from spring 2007, fall 2010 and spring 2012 sampling events.

6 Sediment Physical Characterization and Suitability for Beneficial Use

Suitability for beneficial use was evaluated based on representative physical properties of Cuyahoga River Navigation Channel sediments, engineering specifications for various beneficial uses, and expected volumes of material meeting those specifications. Section 6.1 of this chapter contains an analysis of the physical data collected in the fall of 2010 along with data from past sampling efforts and other available information such as dredging volumes and bathymetric surveys. Suitability of dredged material for several beneficial uses was evaluated by comparing data from these analyses to engineering specifications for each use. Section 6.1 contains volume weighted grain size distributions calculated for Cuyahoga River Navigation Channel sediments from data available for various reaches and sampling years. Sediment classification performed for the Fall 2010 sediment samples was incorporated in the analysis. Collectively, the output of this analysis was then used to estimate volumes of material, suitable for the various beneficial use alternatives under consideration, expected to be produced by future maintenance dredging of the Navigation Channel (Section 6.2).

6.1 Historical dredging volumes and mass-weighted grain size distributions

The historical volumes of sediment removed from the Cuyahoga River were estimated in order to make projections of anticipated volumes of dredged material of a given size class that could be expected to be produced in future dredging operations. Volume estimates were reconstructed from multiple lines of evidence, including water depth, pre- and post-dredging bathymetric surveys, and project condition reports provided by the District. Representative grain size distribution was then assumed for the estimated dredged material volumes in order to estimate volumes of material expected to be suitable to specific beneficial uses. A more detailed discussion of this analysis follows.

6.1.1 Background

Grain size distribution and percent solids samples have been collected from the Cuyahoga River Navigation Channel by USACE three times over the past decade. Table 6-1 summarizes the dates of sampling, locations sampled, sources of the data, sediment characterization performed, and pertinent dates of associated bathymetric surveys and dredging operations obtained from the USACE Buffalo District Navigation Website (LRB 2011).

The water depths reported in the field notes from 2007 sediment sampling (E&E Inc 2007) suggest that very little shoaling occurred between the Spring 2007 after-dredging survey, conducted in mid-June, and the sample collection date of 1 August 2007. Significant shoaling was, however, observed between the mid-June surveys and the fall pre-dredging surveys taken between November 2007 and January 2008, suggesting that the vast majority of infilling occurred after August sediment sampling. It was therefore concluded that 2007 sediment samples were not representative of the material dredged in the fall dredging of 2007 (which was actually performed in early 2008). The 2007 sediment samples are therefore of questionable value for the estimation of sediment volumes in various grain-size classes dredged from the Navigation Channel in the fall of 2007.

6.1.2 Estimation of Upper River sediment removed by dredging in prior years (by mass and size class)

6.1.2.1 Cuyahoga River discretization

The USACE Surface Water Modeling System (SMS) was used to evaluate the volume and grain size distribution of the sediment removed from the Cuyahoga River for dredging years when in-river sediment samples were taken (2002, 2007, and 2010). A map of the Cuyahoga River was constructed using Buffalo District project condition, pre-dredging, and post-dredging surveys (USACE LRB 2011). These surveys contain channel and river boundaries in Ohio North Zone (3401) state-plane coordinates. Sediment grab sample locations for the three sampling events were then converted from latitude-longitude to state plane coordinates and imported into SMS. Influence areas for the sediment samples were constructed based on sample locations, river morphology, and professional judgment. The sediment properties (grain size, percent solids, etc.) in each influence area were assumed to be uniform throughout each discrete area since there were insufficient data to warrant a more complex approach. Figure 6-1A shows the uppermost reach of the Cuyahoga river (789+00 to 799+00) with areas of interest based on 2010 sample locations overlain; Figure 6-1B shows the areas of interest and the corresponding 2010 sediment sample locations in this reach.

Table 6-1. Summary of sediment sampling times and associated bathymetric surveys.

Locations Sampled	Physical Analysis Performed	Sampling Date	Spring Before-Dredging Survey	Spring After-Dredging Survey	Fall Before-Dredging Survey	Fall After-Dredging Survey	Data Associated with DM?	Before-Dredging Survey Avail?	After-Dredging Survey Avail?	Data Source
CH-01 thru CH-30	Grain Size, Percent Solids	5/1/2002	04/23/02 to 06/10/02	05/16/02 to 08/07/02	11/25/2002	12/17/2002	**Yes, Spring**	yes	yes	E&E Inc, 2002**
CH-01 thru CH-30	Grain Size, Percent Solids	8/1/2007	May thru June 2007	05/08/07 to 06/18/07[1]; 06/09/07 to 06/16/07[2]	11/26/07 to 01/10/08[1]; 01/10/2008[2]	01/10/08 to 01/16/08	**no**	no	no	E&E Inc, 2007***
CH-01 thru CH-08*	Grain Size, Percent Solids, Atterberg Limits, Standard Proctor Exam	11/9/2010	07/16/10 to 08/12/10	07/15/10 to 08/25/10	11/04/10 and 12/2/2010	NA	**Yes, Fall**	yes	no	ERDC, 2011

Notes:

*Two additional samples, CH-06B and CH-07B, were added to increase spatial resolution through the uppermost reach of the navigation channel.

**Engineering and Environment Inc., 2002. "Volume II. Laboratory Reports: Sediment Sampling for Chemical and Physical Analysis at Cleveland Harbor, Ohio," Contract Number W912P4-04-R-0002, Prepared for US Army Engineer District, Buffalo NY.

***Engineering and Environment Inc., 2007. "Volume II. Laboratory Reports: Sediment Sampling for Chemical and Physical Analysis at Cleveland Harbor, Ohio," Contract Number DACW49-00-D-0004, Prepared for US Army Engineer District, Buffalo NY.

[1] Uppermost reach of the river, Station 762+00 to 799+00.

[2] Near the turning basin, Station 749+00 to 762+00.

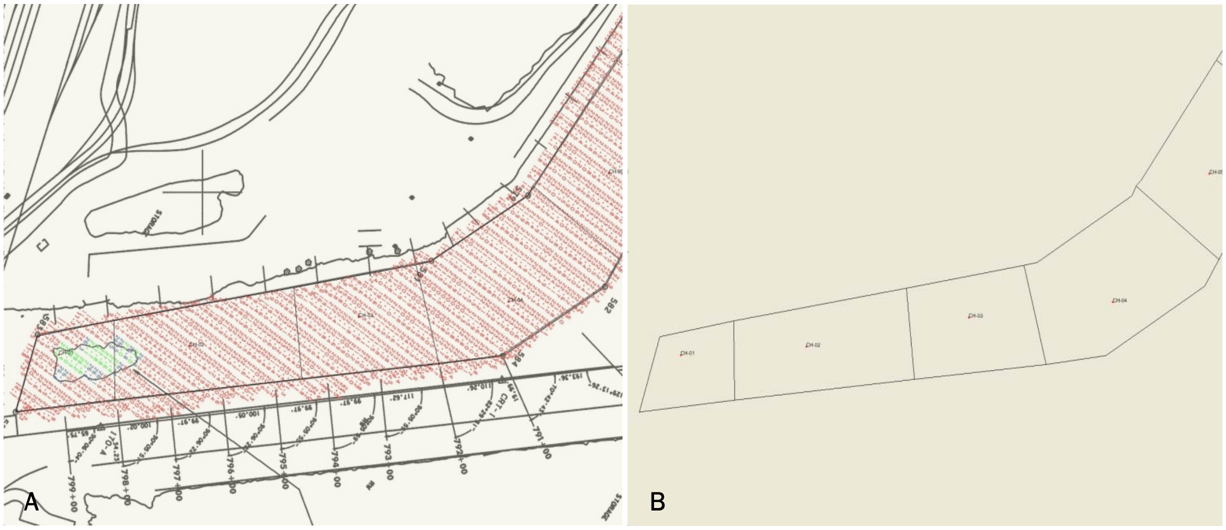


Figure 6-1. A and B: Cuyahoga River channel dimensions, river dimensions, areas of influence, and sample locations.

6.1.2.2 Bathymetry import and SMS calculations

Bathymetry in xyz format provided by the Buffalo District was imported into SMS and converted to Ohio state plane coordinates. Bathymetry from before- and after-spring dredging surveys was overlain for the years 2002 and 2007. As noted above, the grain size distribution data obtained in 2007 was concluded to be unrepresentative of material that was dredged in either the spring or fall of that year. For 2010, the fall before-dredging survey was imported and the anticipated project depths (using authorized depths, including overdepth) were used in lieu of an after-dredging survey. The average depth of an influence area for the respective years was determined by averaging the bathymetry scatter data set in SMS (Figure 6-2).

6.1.2.3 Volume removal calculations

The volume removed from an influence area in previous dredging operations was calculated by subtracting the average post-dredging depths from the average pre-dredging depths in an influence area, then multiplying by the influence area (calculated in SMS). Table 6-2 shows the spreadsheet calculations used to compute sediment volumes removed from the areas of influence. Volume data for upper and lower river sediments has been acquired from other Buffalo District sources; this data will be presented and compared to SMS calculated estimates in a subsequent section.

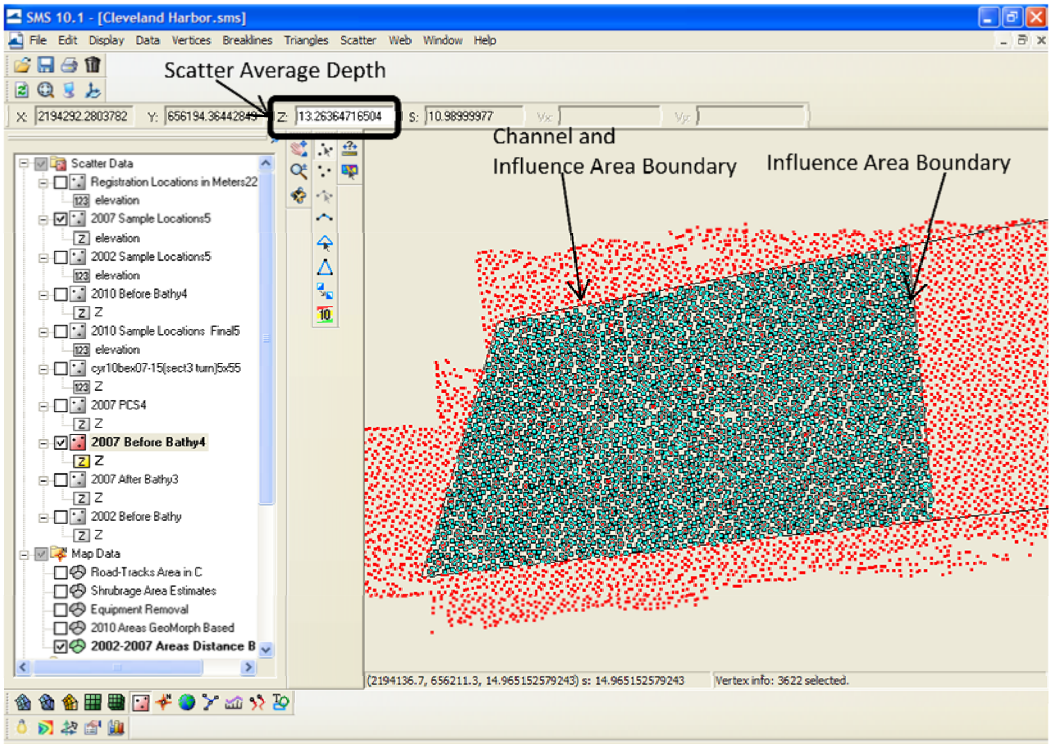


Figure 6-2. Assigning an average depth to an area of influence based on survey bathymetry.

Table 6-2. Use of SMS-derived values for estimation of sediment volume removed.

2002	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8
Surface Area for Polygon, ft^2	33069	41559	42071	68041	53810	150925	236982	84848
Pre-Dredging Ave Depth, ft	18.8	18.5	15.7	18.6	20.3	21.3	22.2	23.0
Post-Dredging Ave Depth, ft	19.6	20.5	21.2	26.7	29.5	28.5	25.6	22.6
Total Estimated Volume Removed, cy	906	3,000	8,650	20,400	18,300	40,400	29,700	0

6.1.2.4 Mass removal calculations

The volumes reported in Table 6-2 were imported into spreadsheets that used the measured percent solids and grain size distribution data from Cuyahoga River samples to calculate a mass of each size fraction removed from the corresponding areas of interest during previous dredging operations; for example:

Mass Clay Removed = (Dry Density CH-1, kg/CY) x (906, CY) x (Fract. Clay CH-1, by mass).

This analysis was performed for Spring 2002 and Fall 2010 dredging operations in the upper Cuyahoga River (approx. Station 800+00 to

Station 729+00). Estimates for sediment removal for the lower Cuyahoga River were made by different means due to a lack of survey data for this section, and lower historical dredging volumes, as is discussed in subsequent sections.

6.1.2.5 Mass-weighted grain size distribution calculation

The mass of all the Unified Soil Classification System USCS size classes (clay, silt, fine sand, medium sand, etc) for the CH-1 through CH-8 areas of interest were summed so that a mass-weighted grain size distribution for the upper Cuyahoga River as a whole could be calculated. A mass-weighted grain size distribution should be more representative of sediments that will be dredged and could potentially differ significantly from a simple average of grain size classes for all samples taken from the upper river. For example, the mass weighted percent clay for the upper river was calculated by:

$$Mass\,Wtd\ \%Clay = \frac{\sum_{1}^{8} ClayMassRemoved\ Area_i}{\sum_{1}^{8} MassRemoved\ Area_i} * 100$$

A simple average would be calculated as follows:

$$Average\ \%Clay = \frac{\%Clay_{Sample\,1} + \%Clay_{Sample\,2} + \ldots + \%Clay_{Sample\,n}}{n}$$

6.1.3 Estimation of historical dredging volumes from the lower river (by size class)

A more simple approach was employed for determining the volume and mass of sediment removed during past dredging operations from the lower Cuyahoga River and the associated grain size fractions. This decision was based on a lack of lower river survey data for 2002, 2007, and 2010 and the decreasing volumes of sediment dredged in downriver locations since 2002.

6.1.3.1 Volume determination

Two data sources were provided by the District for lower river sediment removal volumes; a spreadsheet showing dredging volumes 2002-2010 (Appendix E1), shows in-situ quantities of sediment dredged for both the upper and lower river during spring and fall dredging for 2002 and 2007;

the estimated in situ dredging volumes removed from the lower river during spring and fall by station in 2007 (Appendix E2). Additionally, the methods described in the following were applied to available 2002 lower river survey data, and a historical in-situ sediment removal volume was calculated; the spatial extent of this survey data was extremely limited and the volume estimates therefore have a high degree of uncertainty.

6.1.3.2 Grain size distribution determination

No downriver grain size distribution samples were collected in 2010; therefore, no downriver analyses were performed for that year. Grain size distribution data for 2002 and 2007 samples are available for the lower river. Instead of the mass-weighting methods described in Section 6.1.5, an arithmetic average was taken of the size fraction results for 2002 and 2007 samples and applied to the estimated removal volumes to obtain estimated mass removed for each grain size class.

6.1.4 Stockpiled sediment volumes by size class

The estimated mass of sediment removed for 2002, 2007, and 2010 dredging events was converted to a stockpiled volume of fines and sandy material by utilizing void ratios for hydraulically placed clayey silt and silty sands obtained from literature and professional judgment. A void ratio of 2.31 was used for clayey silts (leading to a calculated dry density of 800 kg/m^3), and a void ratio of 1.1 was used for silty fine sands (leading to a calculated dry density of 1260 kg/m^3). The estimated stockpile volumes were obtained by dividing the estimated mass of fines and sand for the 2002, 2007, and 2010 sediment samples by the associated dry densities.

6.1.5 Summary of sediment calculations and discussion

Table 6-3 presents the calculated and historical[4] in-situ sediment removal volumes, the corresponding mass of that sediment, the mass-weighted or averaged grain size distributions, and the estimated stockpile volumes of fines and sandy material based on 2002, 2007, and 2010 dredging efforts on the Cuyahoga River. The table includes footnotes for the various calculated and provided values summarizing sections 6.1.1 thru 6.1.3.

[4] Provided by Buffalo District

Table 6-3. Summary of average grain size distribution, volume removal, and calculated stockpile volumes.

Year		*2002*		*2007*		*2010*	
		Upper River	Lower River	Upper River	Lower River	Upper River	Lower River
CY Removed SMS Est.	Spring	121,314[1]	24,016[1]	138,250[4]	NA	NA	NA
	Fall	NA	NA	NA	NA	31,510[7]	NA
CY Removed "Asquith-ERG.xls"	Spring	NA	NA	133,748	14,674[5]	NA	NA
	Fall	NA	NA	NA	NA	NA	NA
CY Removed "Dredging Volumes 2002-2010.xls"	Spring	65,000	195,000[2]	100,000	50,000[6]	130,000	30,000
	Fall	35,000	0	70,000	5,000[6]	20,000	25,000
Est. Total kg Mass Removed		62,185,500[1]	12,008,000[1]; 97,500,000[2]	82,653,342[4]	7,232,200[5]; 27,107,110[6]	18,263,326[7]	NA
Percent Clay		35.7%[1]	38.6%[3]	11.6%[3]	29.4%[3]	23.8%[7]	NA
Percent Silt		50.7%[1]	39.3%[3]	44.1%[3]	58.9%[3]	64.4%[7]	NA
Percent Total Sand		12.1%[1]	20.6%[3]	44.3%[3]	8.3%[3]	11.9%[7]	NA
Percent Fine Sand		9.5%[1]	9.0%[3]	40.85%[3]	3.4%[3]	9.5%[7]	NA
Percent Medium Sand		1.6%[1]	5.4%[3]	3.3%[3]	2.2%[3]	0.7%[7]	NA
Percent Coarse Sand		0.4%[1]	2.5%[3]	0.1%[3]	1.1%[3]	0.6%[7]	NA
Percent Fine Gravel		0.5%[1]	3.7%[3]	0%[3]	0.1%[3]	1.0%[7]	NA
Percent Coarse Gravel		0%[1]	0%[3]	0%[3]	0%[3]	0%[7]	NA
Percent Cobbles		0%[1]	0%[3]	0%[3]	0%[3]	0%[7]	NA
Estimated Volume of Fines to Stockpile		67,160[1,8]	11,690[1,8]; 94,950[2,8]	57,550[3,8]	10,440[3,5,8] '39,135[3,6,8]	26,315[7,8]	NA
Estimated Volume of Sand to Stockpile		6,710[1,8]	2,100[1,8] 17,100[2,8]	29,060[3,8,]	625[3,5,8] 2,335[3,6,8]	2,250[7,8]	NA

[1] Based on 2002 spring before- and after-dredging bathymetry (seemingly incomplete for lower river) and measured 2002 GSD and percent solids data (an average of CH-09 to CH-30 for the lower river).

[2] Based on "Dredging Volumes 2002-2010.xls" yardage.

[3] Based on the arithmetic average of measured GSD data for the corresponding year, NOT mass weighted (CH-01 through CH-08 for "Upper River", CH-9 through CH-30 for "Lower River").

[4] Based on 2007 spring before- and after-dredging bathymetry.

[5] Dry mass based on "Asquith-ERG.xls" volume estimate and 46% solids (assumed from similar 2002 GSD and solids data).

[6] Dry mass based on "Dredging Volumes 2002-2010.xls" volume estimate and 46% solids concentration (assumed from similar 2007 GSD and solids data).

[7] Based on 2010 Bathymetry, 26' depth of dredging from 799+00 to 780+00, and 25' depth of dredging from 780+00 to Station 729+00.

[8] Dry density of 800 kg/m3 assumed for hydraulically separated clayey silts (void ratio = 2.31), dry density of 1260 kg/m3 assumed for silty-sand mound material (void ratio = 1.1).

Spring 2007 SMS in-situ sediment removal estimates for the upper Cuyahoga River Navigation Channel are extremely close to the values provided by the Buffalo (Appendix E2), differing by only 3.3 percent. Both values differ significantly from the spring upper river volumes provided inAppendix E1 Dredging Volumes 2002-2010.

6A) by approximately 36,000 CY, or 28 percent. This discrepancy may, in part, be due to what was defined as “upper river” and “lower river” in the respective records; the cumulative upper river and lower river removal estimates reported in Appendixes E2 and E1 were 148,400 and 150,000 CY, respectively.

If the 36,000 CY discrepancy is subtracted from lower river spring volume estimations and added to upper river volume estimates from Appendix E1, the upper river spring total reflected in this spreadsheet becomes 101,000 CY — a difference of approximately 20,300 CY from the SMS estimated volume. Lower river volume discrepancies are clearly not addressed by this adjustment, further reinforcing the previous assertion that the available 2002 lower river survey data is likely incomplete.

The SMS-estimated in-situ sediment removal volumes for Fall 2010 dredging (not yet initiated at the time of this analysis in March 2011) seem reasonable given the scale of "Dredging Volumes 2002-2010.xls" predictions, the uncertainties in the definition of “upper river” vs. “lower river” mentioned above, and the lack of data on actual removal volumes.

Given the uncertainty regarding the upper and lower river boundaries in "Dredging Volumes 2002-2010.xls" and the strong agreement between SMS and "Asquith-ERG.xls" removal estimates, SMS estimated volumes are concluded to be adequate for purposes of estimating the volume of sediment removed from the beneficial use study area (CH-01 to CH-08); therefore, the estimates of mass removal by size class for 2002 and 2007 that were based on mass-weighted grain size distribution estimates are also concluded to be reasonable given the resolution of data available.

The accuracy of stockpile volumes of fine- and coarse-grained material estimates is directly related to the assumptions built into the SMS- and sediment property-based estimates of mass, and the void ratios assumed for the various grain-size materials. The use of literature-derived void ratios provides material volume estimates that are preliminary and useful for assessment of the feasibility of various beneficial use alternatives; however, these estimates should not be considered adequate for final engineering design and construction.

6.1.6 ERDC 2010 sediment property sampling results

The grain size distribution and percent solids data obtained from the Fall 2010 ERDC sampling effort are presented in Chapter 3 (Table 3-5).

Atterberg limits and averaged sediment properties (and the solid classifications based on them) are presented in Table 6-4 for DMMU-1 (CH-01 thru CH-05) and DMMU-2 (CH-06 thru CH-08); mass-weighted-average (based on DMMU-1 and DMMU-2 location delineations and SMS modeling) Atterberg limits and other sediment properties are also presented.

Analysis of Table 6-4 shows that mass-weighted average results differ slightly from arithmetic mean results for DMMUs 1 and 2; this difference is not concluded to be significant. The ramifications of the soil classifications listed in Table 6-5 are discussed in more detail in Section 6.2.

6.2 Evaluation of dredged material suitability for beneficial use

The first part of this section compares the sediment sample properties to physical (i.e., grain size, Atterberg limits) screening values to determine the potential suitability of Cuyahoga River Navigation Channel sediments for various beneficial uses. An analysis of dredged material present in CDF 10B and its suitability for use as structural fill was also conducted by Lenhardt (2011, Appendix E3). The variability between river sediment samples and the character of in-CDF materials is then discussed. Chemical suitability is not evaluated in this chapter; see Chapters 4 and 5.

6.2.1 Screening beneficial uses based on physical criteria and approximate sediment properties

6.2.1.1 Use for municipal, industrial, and residential landfill cover

The final closure requirements for municipal, industrial, and residual landfills require a 2-ft recompacted cap constructed of material having a minimum of 25 percent clay and a recompacted maximum permeability of 1 x10^{-7} cm/sec. Sample DMMU2 collected in 2010 was determined to have a clay content of 32 percent and a permeability of 6.2 x 10^{-8} cm/sec which would meet this specification; however sample DMMU-1, was determined to have only 21 percent clay. These data indicate that fine-grained sediment taken from some locations of the Navigation Channel may be capable of meeting the requirements for municipal, caps; however, the

Table 6-4. Fall 2010 DMMU-1 and DMMU-2 average sediment properties and soil classification.

	DMMU-1	DMMU-2
Liquid Limit, LL	75%	60%
Plastic Limit, PL	40%	33%
Plasticity Index, PI	35%	27%
Water Content	136.5%	83.1%
Liquidity Index, LI	2.76	1.86
Total Organic Matter	8.6%	5.4%
Activity	3.04	1.42
Laboratory Reported % Solids	42.3%	54.6%
In Situ Dry Density, kg/m^3	574.2	827.2
In Situ Void Ratio, e	3.6	2.2
In Situ Porosity, n	0.78	0.69
Clay	21.2%	32.8%
Silt	61.1%	59.7%
Sand	17.7%	7.5%
Fine	14.9%	6.9%
Medium	1.2%	0.5%
Coarse	1.4%	0.1%
Gravel	0.2%	0.0%
SMS Mass-weighted %Solids	50.3%	56.3%
SMS Mass-weighted In Situ Dry Density, kg/m^3	734.4	868.6
In Situ Void Ratio, e	2.6	2.1
In Situ Porosity, n	0.73	0.67
SMS Mass-weighted %Clay	23.4%	24.9%
SMS Mass-weighted %Silt	63.4%	67.3%
SMS Mass-weighted %Total Sand	13.2%	7.8%
SMS Mass-weighted %Fine Sand	10.3%	7.1%
SMS Mass-weighted %Medium Sand	0.8%	0.4%
SMS Mass-weighted %Coarse Sand	0.8%	0.1%
SMS Mass-weighted %Fine Gravel	1.3%	0.2%
SMS Mass-weighted %Coarse Gravel	0.0%	0.0%
SMS Mass-weighted %Cobbles	0.0%	0.0%
USCS Soil Classification	silt of high plasticity, elastic silt (MH) or organic clay, silt (OH)	silt of high plasticity, elastic silt (MH) or organic clay, silt (OH), very close to clay of high plasticity (CH)
AASHTO Classification	clayey soils (A-7-5), General Rating as Subgrade: Fair to Poor	clayey soils (A-7-5), General Rating as Subgrade: Fair to Poor

year to year and location to location variability makes the feasibility of using dredged material for recompacted landfill caps questionable. However, municipal, industrial, and residual landfill closure also requires placement of a 30- to 36-inch soil protective layer above the recompacted cap that is capable of supporting vegetative cover. The DMMU-1 and DMMU-2 physical and chemical data demonstrate that the dredged materials will be highly suitable for a landfill protective layer that will support vegetative cover.

6.2.1.2 Use for construction and demolition debris landfill cover

6.2.1.2.1 Grain Size Suitability

Ohio Administrative Code (OAC) Chapter 3745-400-07 (G) (2) (a) (i) lists the grain size requirements for Construction and Demolition Debris (CDD) landfill cover material. The size requirements are listed below and applied to Cuyahoga River sediment grain size distribution data.

Ohio Administrative Code Chapter 3745-400-07 (G) (2) (a) (i)

4. The maximum soil particle size shall be six inches.

   Table 6-3 shows that the average grain size distribution results for the respective 2002, 2007, and 2010 sediment samples all had 100 percent passing a 6-inch sieve.

5. At least ninety five percent of the soil particles, by volume, shall pass the three inch sieve.

   Table 6-3 shows that the average grain size distribution results for the respective 2002, 2007, and 2010 sediment samples all had 100 percent passing a 3-inch sieve.

6. At least seventy five percent of the soil particles, by volume, shall pass the number four sieve.

   Table 6-3 shows that the maximum percentage (by mass) of material *not* passing a number four sieve (i.e., material larger than coarse sand) is 3.7 percent of the average 2002 lower river grain size distribution results. It is clear by inspection that 3.7 percent by mass (or less for the other average grain size distribution results) is very unlikely to occupy more than 25 percent by volume of that or any river sediment. Thus, all average grain size distribution results are concluded to pass this criterion.

7. At least fifty percent of the soil particles, by weight, shall pass the number two hundred sieve.

   Table 6-3 shows that all sets of average grain size distribution results have at least 50 percent passing the number 200 sieve (i.e., at least 50 percent clay and fines-sized particles).

6.2.1.2.1 The soil shall meet either of the following specifications

Ohio Administrative Code Chapter 3745-400-07 (G) (2) (a) (i) was to keep construction parallel.

8. Possess plasticity properties lying above the A-line in the "Unified Soil Classification System" described in ASTM D 2487.

   Atterberg limits were not available for 2002 and 2007 sediment samples, and the 2010 samples (Table 6-4) do not meet this criterion, thus criterion (ii) was used.

9. Consist of 0.002 inch [50.8 um]or finer clay[5] particles as determined in ASTM D 422 such that these clay particles shall comprise at least fifteen percent of the total soil dry mass.

   Table 6-3 shows that average grain size distribution results for all sets of sediment samples have at least 15 percent clay[6] by mass (and therefore more than 15 percent passing 50.8 um) with the exception of the 2007 upper river sediments. Table 6-5 lists the average percent passing 50.8 um by mass for 2007 upper river sediments (E&E Inc 2007).

Table 6-5. 2007 sediment data: Percent passing 50.8 um

Sample Location	CH-1	CH-2	CH-3	CH-4	CH-5	CH-6	CH-7	CH-8
2007 Percent finer than 0.002 in. (50.8 um)	25	35	40	40	32	57	56	63

[5] In the USCS, the distinction between clay and silt occurs at 5 um; the usage of the term "clay" here is a broader usage of the term; therefore, the comparison of particles less than 50.8 um in the 2007 sediment samples, though not technically classified as clay, satisfy the criterion.

[6] Clay as measured by hydrometer, meeting the USCS specification.

Table 6-5 shows that the average percent passing 50.8 um by mass for 2007 upper river sediments is 43.5 percent. Thus, the average grain size distribution results for all sets of sediment samples pass this criterion

6.2.1.2.2 Other suitability and conclusion.

OAC Chapter 3745-400-07 (G) (2) (a) (i) (g) states that the soil shall not be comprised of solid waste or construction and demolition debris. As this is not the case, all Cuyahoga River Navigation Channel sediment samples from 2002, 2007, and 2010 indicate that Cuyahoga River sediments will meet the criteria for use as CDD landfill cover.

6.2.1.3 Use for aggregate material, sand cover, pipe bedding, and backfill

The Ohio Department of Transportation (ODOT) lists grain size specifications for the beneficial use of material as aggregate, sand cover, and structural backfill for pipe bedding and backfill. Table 6-6 presents the ODOT table along with 2002, 2007, and 2010 Cuyahoga River sediment sample grain size distribution data.

Table 6-6 indicates that, if separated from the fine-grained fraction, dredged material removed during Spring 2002 from the CH-01, CH-11, and CH-20 influence areas would be suitable for use as pipe bedding and backfill. The estimated volume of material removed from the CH-01 influence area during Spring 2002 is small (906 CY) and less than 1 percent of the total volume removed during that dredging event (Table 6-3). No reliable volume estimates are available for CH-11 and CH-20 influence areas. All other individual sediment samples and CH-01 through CH-30 grain-size averages show the Cuyahoga River sediments sampled to be unsuitable as aggregate, sand cover, and structural backfill for pipe bedding and backfill without amendment.

6.2.1.4 Use for embankment material

ODOT 703.16-A states:

> *Do not use soils having a liquid limit in excess of 65 or soils identified as Department Group Classifications A-5, or A-7-5 in the work.*

Table 6-6. ODOT aggregate specifications (expressed as "percent finer than") and 2002, 2007, and 2010 Cuyahoga River sediment grain size distribution.

		2 inch (50 mm)	1 inch (25mm)	3/4 inch (19.0 mm)	1/2 inch (12.5 mm)	3/8 inch (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)	No. 30 (600 um)	No. 50 (300 um)	No. 100 (150 um)	No. 200 (75 um)
ODOT Aggregate Specifications	703.02 Fine Aggregate for Portland Cement Concrete.					100	95 to 100	70 to 100	38 to 80	18 to 60	5 to 30	0 to 10	0 to 5
	703.03 Fine Aggregate for Mortar or Grout. Natural Sand						100	95 to 100			10 to 40	0 to 15	0 to 5
	703.03 Fine Aggregate for Mortar or Grout. Manufactured Sand						100	95 to 100			20 to 40	10 to 25	0 to 10
	703.05 Aggregate for Asphalt Concrete (Intermediate and Surface Courses)					100	90 to 100	65 to 100	40 to 85	20 to 60	7 to 40	0 to 20	0 to 10
	703.06 Sand Cover (407 and 408).						90 to 100				7 to 40		0 to 10
	Concrete/Asphalt Sand/703.11 Type 2 (Combined Specification)					100	95-100	70-95	40-80	20-60	7-30	1-10	0-5
	703.11 Structural Backfill for 603 Bedding and Backfill			100		80 to 100	60 to 100	45 to 95			7 to 55		0 to 15
	703.17 Aggregate Materials	100	70 to 100	50 to 90			30 to 60			9 to 33			0 to 15
Spring 2002 Upstream	CH 1	100	100	100	94	84	74	59	50	42	38	36	33
	CH 2	100	100	100	100	98	97	95	90	76	48	26	21
	CH 3	100	100	100	100	100	100	100	100	100	100	100	92
	CH 4	100	100	100	100	100	100	100	100	100	100	100	96
	CH 5	100	100	100	100	100	100	100	100	100	99	97	91
	CH 6	100	100	100	100	100	100	100	100	100	100	96	84
	CH 7	100	100	100	100	100	100	100	100	100	100	100	97
	CH 8	100	100	100	100	100	100	100	100	100	100	100	98
	2002 Mass Wt. Average	100	100	100	100	100	99	99	99	98	97	94	87

Table 6-6. ODOT aggregate specifications (expressed as “percent finer than”) and 2002, 2007, and 2010 Cuyahoga River sediment grain size distribution (continued).

		2 inch (50 mm)	1 inch (25mm)	3/4 inch (19.0 mm)	1/2 inch (12.5 mm)	3/8 inch (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)	No. 30 (600 um)	No. 50 (300 um)	No. 100 (150 um)	No. 200 (75 um)
Spring 2002 Downstream	CH-09	100	100	100	100	100	100	99	98	96	92	86	83
	CH-10	100	100	100	100	100	100	100	100	100	98	94	92
	CH-11	100	100	100	100	87	70	62	56	54	51	50	48
	CH-12	100	100	100	100	100	100	100	100	100	100	100	96
	CH-13	100	100	100	100	100	100	100	100	100	100	96	91
	CH-14	100	100	100	100	100	100	98	91	83	76	71	70
	CH-15	100	100	100	100	98	98	98	96	93	91	90	88
	CH-16	100	100	100	100	99	97	96.2	94	92	90	89	88
	CH-17	100	100	100	100	96	94	92	87	81	77	74	72
	CH-18	100	100	100	100	97	93	90	86	83	81	79	78
	CH-19	100	100	100	100	100	100	100	99	96	96	94	91
	CH-20	100	100	85	83	81	67	63	55	49	46	43	40
	CH-21	100	100	100	100	100	100	99.8	98	96	82	55	49
	CH-22	100	100	100	99.7	99.6	96	91	80	72	57	41	33
	CH-23	100	100	100	100	100	100	99.9	100	100	99	95	88
	CH-24	100	100	100	98	96	92	88	79	71	65	63	61
	CH-25	100	100	100	100	100	100	100	100	99	97	94	78
	CH-26	100	100	100	100	100	100	100	100	100	100	100	95
	CH-27	100	100	100	100	100	100	100	100	100	100	100	97
	CH-28	100	100	100	100	100	100	100	100	100	100	100	94
	CH-29	100	100	100	100	100	100	100	100	100	100	100	95
	CH-30	100	100	100	100	100	100	100	100	100	100	100	93
	Average	100	100	99	99	98	96	94	92	89	86	82	78
2007 (neither Spring nor Fall) Upstream	CH 1	100	100	100	100	100	100	100	100	96	89	57	36
	CH 2	100	100	100	100	100	100	99	98	95	83	62	45
	CH 3	100	100	100	100	100	100	100	99	97	86	65	48
	CH 4	100	100	100	100	100	100	100	99	98	87	69	50
	CH 5	100	100	100	100	100	100	100	100	99	91	72	45
	CH 6	100	100	100	100	100	100	100	100	99	96	87	71
	CH 7	100	100	100	100	100	100	100	100	100	97	88	71
	CH 8	100	100	100	100	100	100	100	100	100	100	98	80
	2007 Arith. Average	100	100	100	100	100	100	100	99	98	91	75	56
	CH-09	100	100	100	100	100	100	100	100	100	99	98	97
	CH-10	100	100	100	100	100	100	100	100	100	99	98	94
	CH-11	100	100	100	100	100	100	100	100	100	99	98	93

Table 6-6. ODOT aggregate specifications (expressed as “percent finer than”) and 2002, 2007, and 2010 Cuyahoga River sediment grain size distribution (continued).

		2 inch (50 mm)	1 inch (25mm)	3/4 inch (19.0 mm)	1/2 inch (12.5 mm)	3/8 inch (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)	No. 30 (600 um)	No. 50 (300 um)	No. 100 (150 um)	No. 200 (75 um)
2007 Downstream	CH-12	100	100	100	100	100	100	100	100	100	100	99	96
	CH-13	100	100	100	100	100	100	100	100	100	100	100	98
	CH-14	100	100	100	100	100	100	100	100	100	100	99	95
	CH-15	100	100	100	100	100	100	100	100	99	98	98	95
	CH-16	100	100	100	100	100	100	99	99	98	97	96	95
	CH-17	100	100	100	100	100	100	97	95	94	90	89	86
	CH-18	100	100	100	100	100	100	100	99	98	97	96	94
	CH-19	100	100	100	100	100	100	100	99	97	96	95	92
	CH-20	100	100	100	100	99	94	95	87	83	66	49	42
	CH-21	100	100	100	100	100	100	98	97	95	80	50	36
	CH-22	100	100	100	100	99	96	92	87	84	75	66	60
	CH-23	100	100	100	100	100	100	100	100	100	100	98	92
	CH-24	100	100	100	100	100	100	100	100	100	99	98	97
	CH-25	100	100	100	100	100	100	100	100	100	100	99	97
	CH-26	100	100	100	100	100	100	100	100	100	100	99	95
	CH-27	100	100	100	100	100	100	100	100	100	100	100	99
	CH-28	100	100	100	100	100	100	100	100	100	99	98	97
	CH-29	100	100	100	100	100	100	100	100	100	100	99	98
	CH-30	100	100	100	100	100	100	99	98	97	96	95	91
	Average	100	100	100	100	100	100	99	98	98	95	92	88
Fall 2010 Upstream	CH 1	100	100	100	100	97	97	95	95	95	94	88	78
	CH 2	100	100	100	100	99	98	97	96	95	94	92	83
	CH 3	100	100	100	100	99	98	97	97	96	95	91	82
	CH 4	100	100	100	100	100	100	100	100	100	99	98	93
	CH 5	100	100	100	100	100	100	100	100	100	99	98	94
	CH 6 A	100	100	100	100	100	100	100	100	100	99	98	95
	CH 6 B	100	100	100	100	100	100	100	100	100	100	98	92
	CH 7 A	100	100	100	100	100	99	99	98	98	97	95	89
	CH 7B	100	100	100	100	100	100	100	100	100	100	99	92
	CH 8	100	100	100	100	100	100	100	99	99	99	98	89
	DMU 1	100	100	100	100	100	100	99	98	98	97	92	82
	DMU 2	100	100	100	100	100	100	100	100	100	99	98	93
	2010 Mass Wt. Average	100	100	100	100	99	99	98	98	98	97	95	88

Table 6-4 shows that 2010 samples were classified as A-7-5 and are therefore unsuitable for use as embankment material without amendment. No Atterberg limits data, and therefore no soil classification data, are available for 2002 and 2007 sampling events; further characterization of dredged material previously placed in the CDF could be done to assess suitability for embankment material based on this standard.

6.2.1.5 Use of material for compacted fill

The Soil Compaction Handbook (Multiquip Inc. 2011) contains a table of the relative desirability of different soils for use as various types of compacted fill. That table is reproduced here as Table 6-7. Table 6-4 shows the USCS classification of 2010 Cuyahoga River sediment to be MH or OH. Table 6-7 suggests that such soil is relatively undesirable as compacted fill. No soil classification data are available for 2002 and 2007 Cuyahoga River sediment samples. Cuyahoga River Navigation Channel dredged sediment mined from Cleveland Harbor CDFs, however, has been successfully mixed with coarser-grained materials to produce material suitable for structural fill (Hull 2010 MMP).

6.2.1.6 Use for land improvement and environmental enhancements

The physical characteristics of Navigation Channel sediment are suitable for land creation, restoration of urban soils, wildlife habitats, fisheries improvement, and wetland restoration. The relative percent of fine- to coarse-grained sediment required for specific applications and beneficial use sites will vary; however, the Navigation Channel dredged material will typically produce silt to sandy loam soils with sufficient organic matter and nutrient content to be considered suitable for establishing upland and wetland vegetation and restoring the fertility of degraded urban soils. Generally, sediments in harbor channels reflect the basic components of soils within the watershed and would be suitable for supporting soil functions common in the watershed. Winfield and Lee (1999) describe characterization tests that may be useful in determining suitability of dredged material for beneficial use. Particle size is used generally for determining basic suitability for various types of beneficial uses. Particle size data for clay, silt, and sand (sand+gravel) shown previously in Table 6.4 was plotted on the US Department of Agriculture (USDA) Soil Texture Triangle and resulted in DMMU-1 being classed as a silt loam and DMMU-2 classed as a silty clay loam (Figures 6-3 and 6-4).

Table 6-7. Relative desirability of different soils for use as various types of compacted fill.

Group Symbol		* if gravelly ** erosion critical *** volume change critical - not appropriate for this type of use	Relative Desirability for Various Uses (1=best; 14=least desirability)									
			Rolled Earth Fill Dams			Canal Sections		Foundations		Roadways		
										Fills		
		Soil Type	Homogenous Embankment	Core	Shell	Erosion Resistance	Compacted Earth Lining	Seepage Important	Seepage Not Important	Frost Heave Not Possible	Frost Heave Possible	Surfacing
GRAVELS	GW	Well-graded gravels, gravel/ sand mixes, little or no fines		-	1	1	-	-	1	1	1	3
GRAVELS	GP sand	Poorly-graded gravels, gravel/ mixtures, little or no fines	-	-	2	2	-	-	3	3	3	-
GRAVELS	GM	Silty gravels, poorly-graded gravel/sand/silt mixtures	2	4	-	4	4	1	4	4	9	5
GRAVELS	GC	Clay-like gravels, poorly graded gravel/sand/clay mixtures	1	1	-	3	1	2	6	5	5	1
SANDS	SW	Well-graded sands, gravelly sands, little or no fines	-	-	3*	6	-	-	2	2	2	4
SANDS	SP	Poorly-graded sands, gravelly sands, little or no fines	-	-	4*	7*	-	-	5	6	4	-
SANDS	SM	Silty sands, poorly-graded sand/ silt mixtures	4	5	-	8*	5**	3	7	6	10	6
SANDS	SC	Clay-like sands, poorly-graded sand/clay mixtures	3	2	-	5	2	4	8	7	6	2
CLAYS & SILTS – LEAN	ML	Inorganic silts and very fine sands, rock flour, silty or clay-like fine sands with slight plasticity		6	-	-	6**	6	9	10	11	-
CLAYS & SILTS – LEAN	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	5	3	-	9	3	5	10	9	7	7
CLAYS & SILTS – LEAN	OL	Organic silts and organic silt-clays of low plasticity	8	8	-	-	7**	7	11	11	12	-
CLAYS & SILTS – FAT	MN	Organic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	9	9	-	-	-	8	12	12	13	-
CLAYS & SILTS – FAT	CH	Inorganic clays of high plasticity, fat clays	7	7	-	10	8**	9	13	13	8	-
CLAYS & SILTS – FAT	OH	Organic clays of medium high plasticity	10	10	-	-	-	10	14	14	14	-

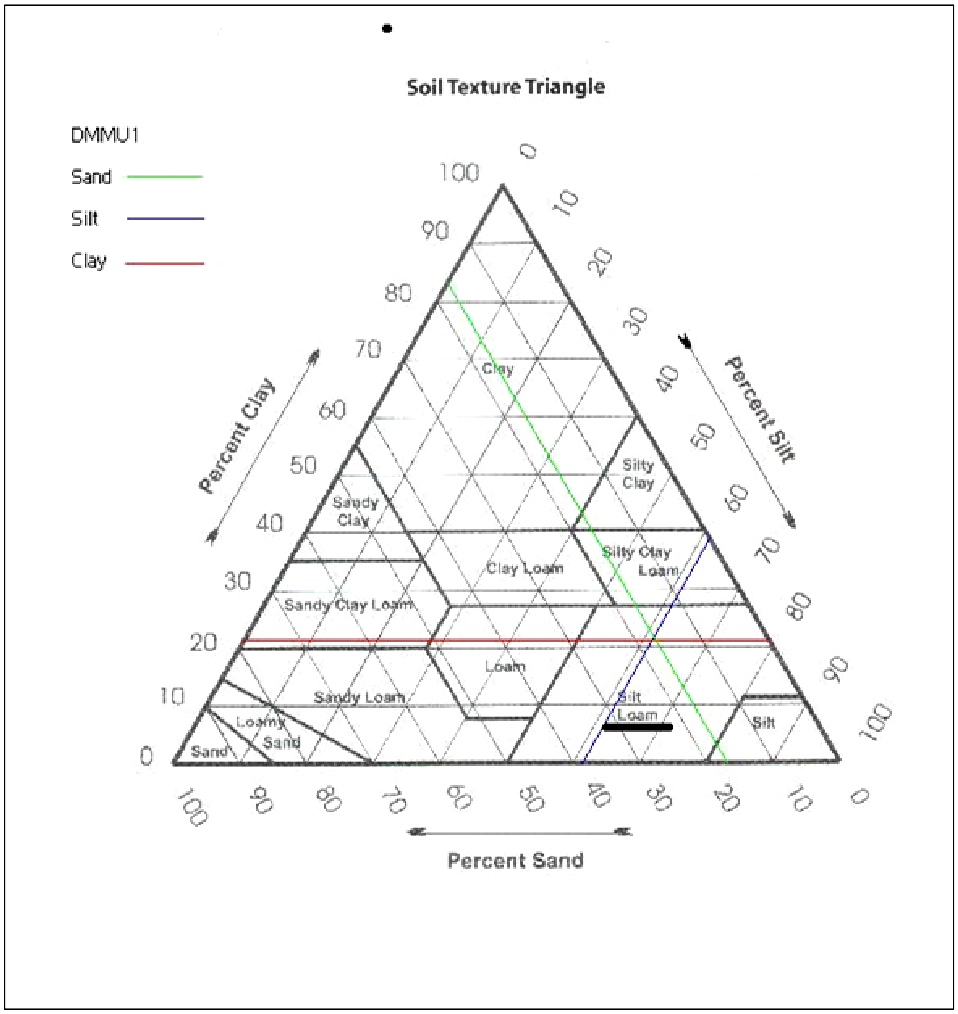


Figure 6-3. Soil texture for DMMU-1.

Under the dredged material sediment type described on the ERDC/USEPA Beneficial Use Website, sediment type would be classed as mixture or silt/soft clay. Either would be suitable for topsoil use or certain fill applications, depending on engineering properties desired. Both DMMU-1 and DMMU-2 would benefit from additions of residual materials such as organic matter (yard waste, wastepaper, storm debris, etc.) and biosolids (human sewage sludge or animal manure) to enhance organic matter content, improve tilth, moisture-holding capacity and nutrient exchange, if immediate robust vegetative cover is desired. However, previous studies have shown that dredged material from 10B can produce vegetative growth superior to area background soils (Figures 6-5). Dredged material from DMMU-1 and DMMU-2 was found to have superior essential nutrient qualities compared to the reference soil (Figures 6-6, 6-7, and 6-8).

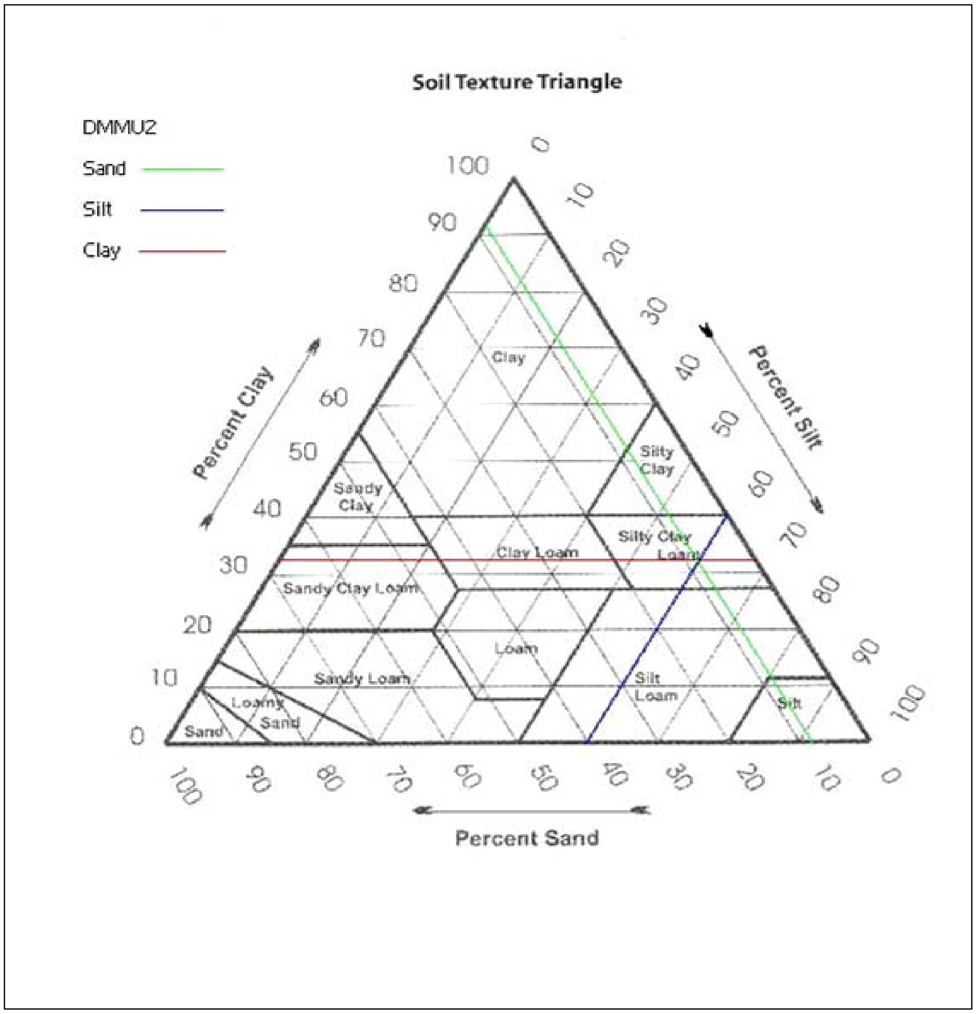
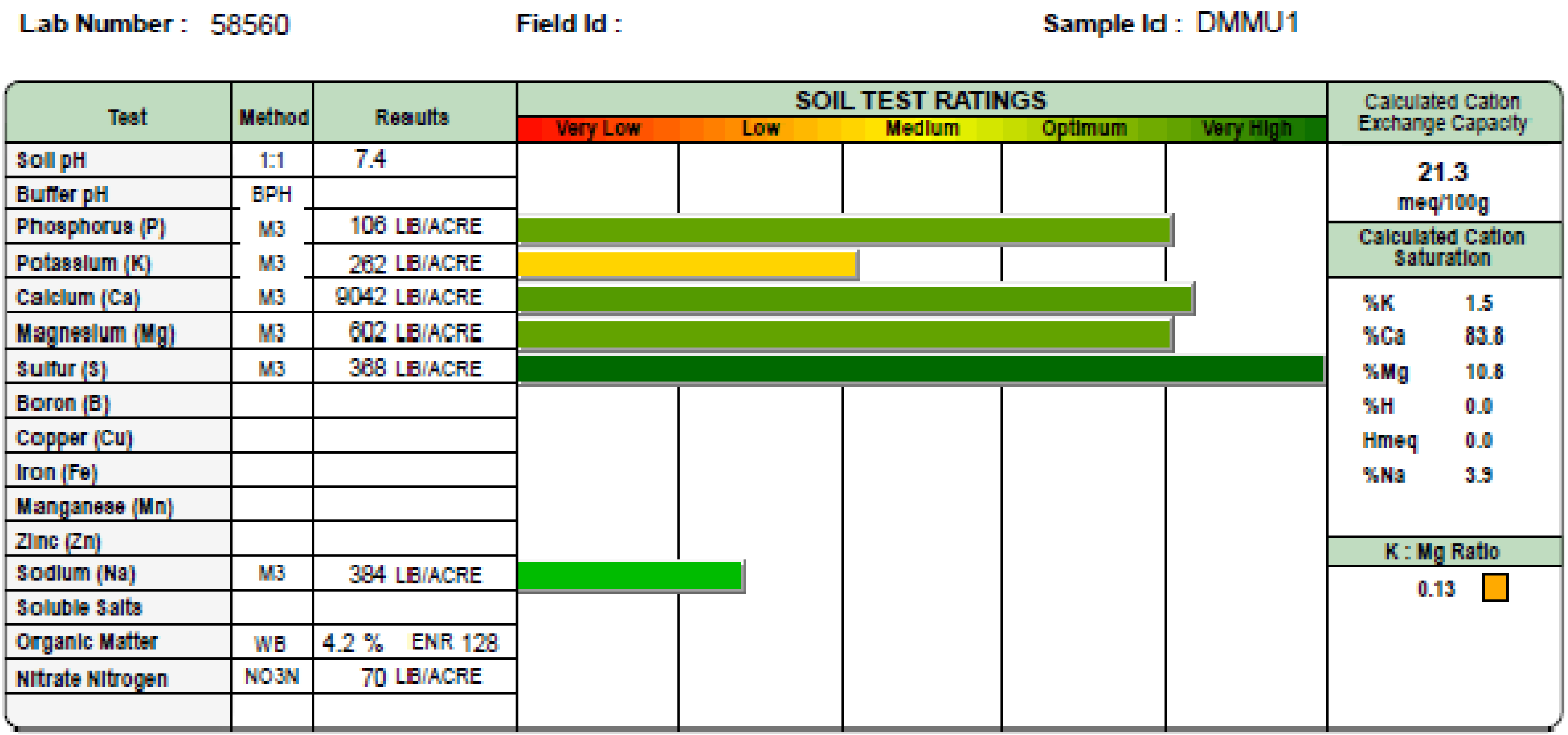


Figure 6-4. Soil texture for DMMU-2.

For wetland restoration, both DMMU-1 and DMMU-2 have the physical properties and meet the wide range of sediment types necessary to support wetland function. However, the low sand content in DMMU2 may not provide the desired results in the littoral zone of lake Erie without some type of structural confinement (i.e., geotubes, dikes, silt curtains) and is not similar to the sandy sediment at the Perkins Beach Reference. Still, neither DMMU-1 nor DMMU-2 are dissimilar to the daily discharge of sediments from the mouth of the Cuyahoga River, and separation and accumulation of the sand fraction along the downstream shoreline, and suspension and littoral drift of the silts and clays, would be expected as it occurs with natural sediment discharge into Lake Erie. Suitability then is driven by the desired location, persistence, and function of the wetland being created or enhanced. The most effective use may be for thin-layer enhancement of existing wetlands or confined/semi-confined wetland construction during the dredging process.

Figures 6-5. Yellow Nutsedge growing in CDF 10B dredged material (top) and Cleveland Lakefront Park soil (bottom).



Lab Number : 58560   Field Id :   Sample Id : DMMU1

Test	Method	Results
Soil pH	1:1	7.4
Buffer pH	BPH	
Phosphorus (P)	M3	106 LB/ACRE
Potassium (K)	M3	262 LB/ACRE
Calcium (Ca)	M3	9042 LB/ACRE
Magnesium (Mg)	M3	602 LB/ACRE
Sulfur (S)	M3	368 LB/ACRE
Boron (B)		
Copper (Cu)		
Iron (Fe)		
Manganese (Mn)		
Zinc (Zn)		
Sodium (Na)	M3	384 LB/ACRE
Soluble Salts		
Organic Matter	WB	4.2 % ENR 128
Nitrate Nitrogen	NO3N	70 LB/ACRE

SOIL TEST RATINGS: Very Low, Low, Medium, Optimum, Very High

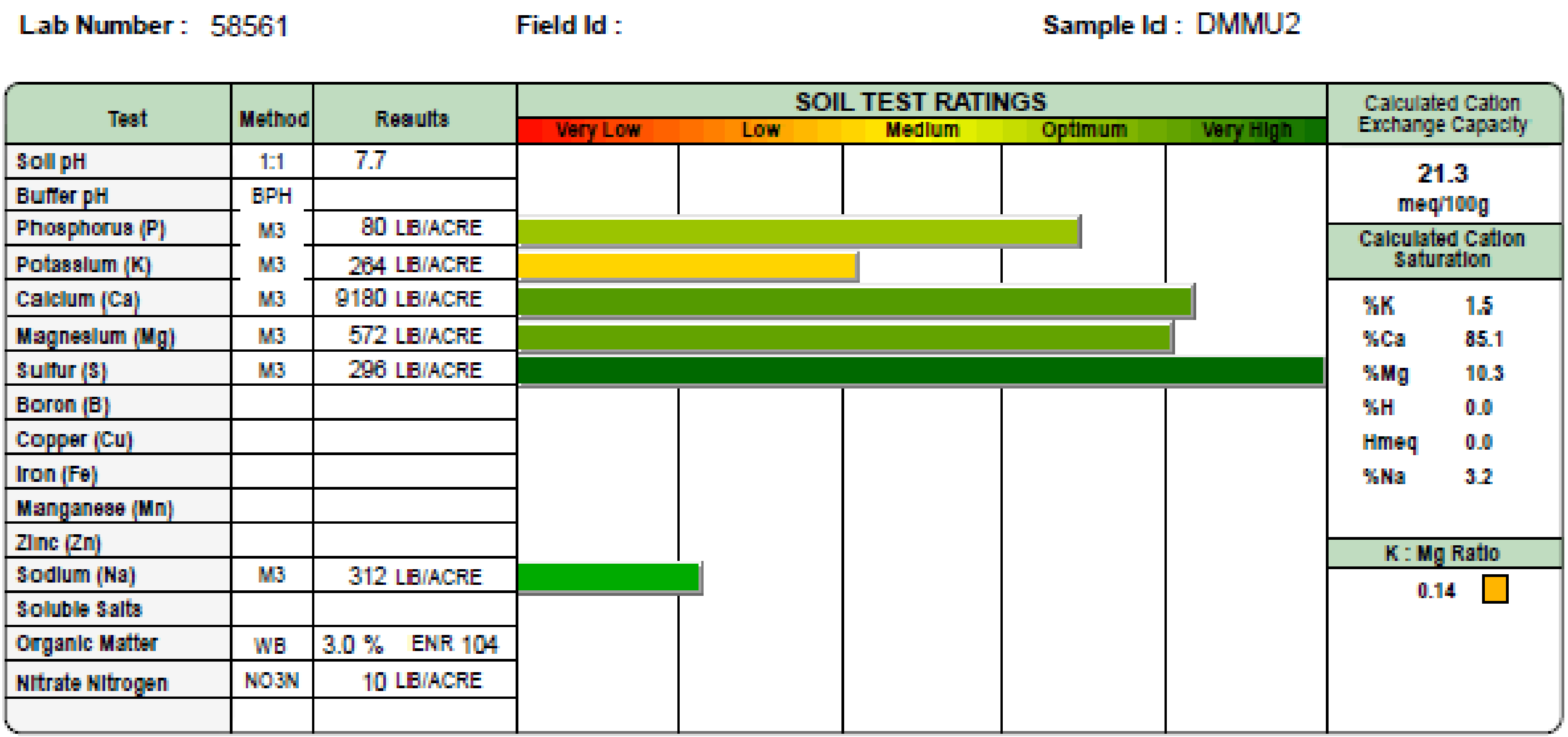
Calculated Cation Exchange Capacity: 21.3 meq/100g

Calculated Cation Saturation

%K	1.5
%Ca	83.8
%Mg	10.8
%H	0.0
Hmeq	0.0
%Na	3.9

K : Mg Ratio: 0.13

Figure 6-6. Agricultural analyses – DMMU-1.



Lab Number : 58561 Field Id : Sample Id : DMMU2

Test	Method	Results	SOIL TEST RATINGS (Very Low / Low / Medium / Optimum / Very High)
Soil pH	1:1	7.7	
Buffer pH	BPH		
Phosphorus (P)	M3	80 LB/ACRE	
Potassium (K)	M3	264 LB/ACRE	
Calcium (Ca)	M3	9180 LB/ACRE	
Magnesium (Mg)	M3	572 LB/ACRE	
Sulfur (S)	M3	296 LB/ACRE	
Boron (B)			
Copper (Cu)			
Iron (Fe)			
Manganese (Mn)			
Zinc (Zn)			
Sodium (Na)	M3	312 LB/ACRE	
Soluble Salts			
Organic Matter	WB	3.0 % ENR 104	
Nitrate Nitrogen	NO3N	10 LB/ACRE	

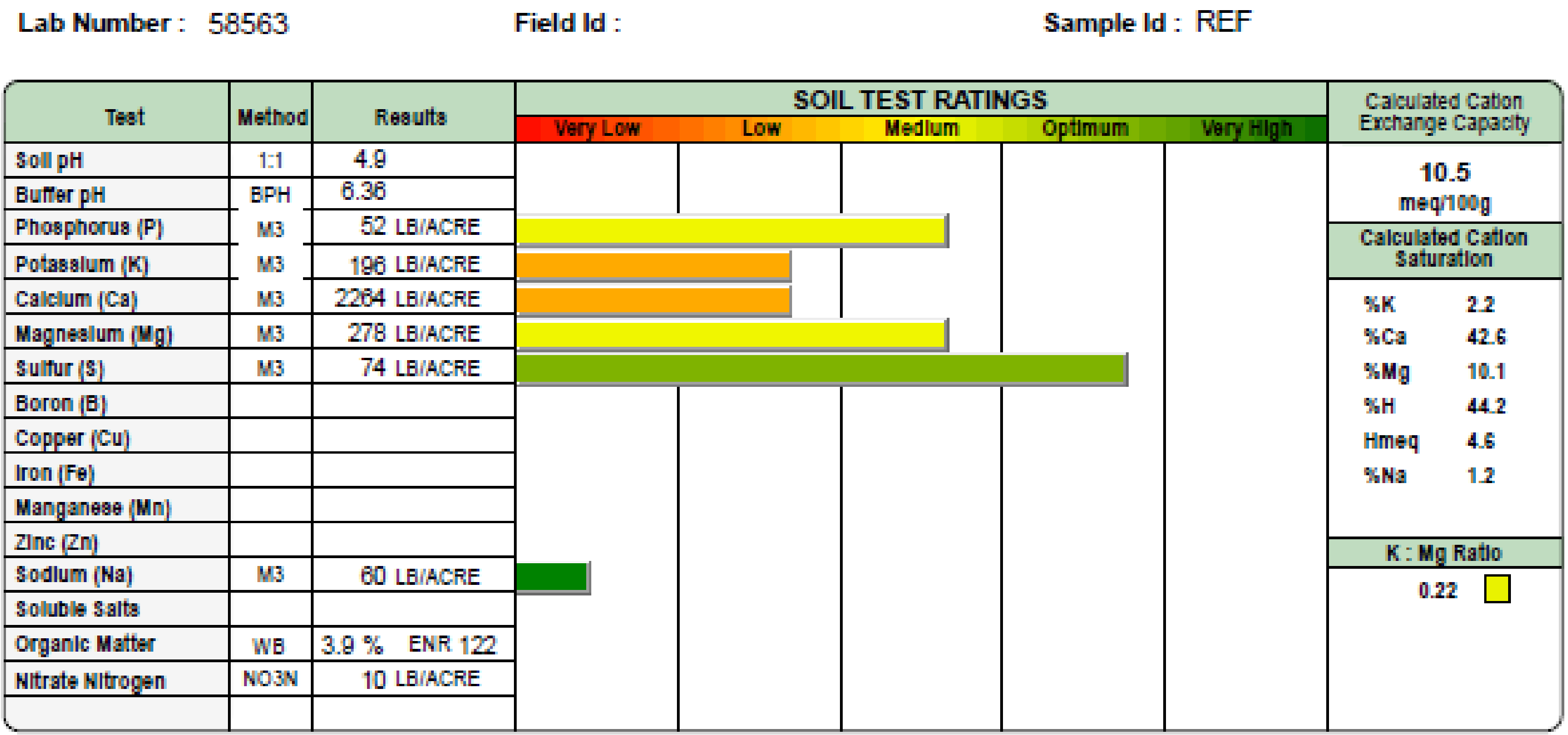
Calculated Cation Exchange Capacity: 21.3 meq/100g

Calculated Cation Saturation

%K	1.5
%Ca	85.1
%Mg	10.3
%H	0.0
Hmeq	0.0
%Na	3.2

K : Mg Ratio: 0.14

Figure 6-7. Agricultural analyses – DMMU-2.



Lab Number : 58563 Field Id : Sample Id : REF

Test	Method	Results
Soil pH	1:1	4.9
Buffer pH	BPH	6.36
Phosphorus (P)	M3	52 LB/ACRE
Potassium (K)	M3	196 LB/ACRE
Calcium (Ca)	M3	2264 LB/ACRE
Magnesium (Mg)	M3	278 LB/ACRE
Sulfur (S)	M3	74 LB/ACRE
Boron (B)		
Copper (Cu)		
Iron (Fe)		
Manganese (Mn)		
Zinc (Zn)		
Sodium (Na)	M3	60 LB/ACRE
Soluble Salts		
Organic Matter	WB	3.9 % ENR 122
Nitrate Nitrogen	NO3N	10 LB/ACRE

Calculated Cation Exchange Capacity

10.5 meq/100g

Calculated Cation Saturation

%K	2.2
%Ca	42.6
%Mg	10.1
%H	44.2
Hmeq	4.6
%Na	1.2

K : Mg Ratio

0.22

Figure 6-8. Agricultural analyses – Reference soil.

6.2.1.7 Use of sand fraction for beach nourishment

The US Army Corps of Engineers' *Shore Protection Manual* (EM 1110-2-1100) Part V, Chapter 4 provides guidance on the use of sediments for beach nourishment. A brief discussion of the applicable criteria follows.

6.2.1.7.1 River sediments in bulk:

The *Shore Protection Manual* states that material suitable for beach nourishment will generally have grain sizes predominantly in the fine to very coarse sand size range, with generally acceptable percentages of very fine sand, silt, and clay not exceeding 10 percent. Table 6-3 shows that sediment samples from the Cuyahoga River taken in spring 2002, summer 2007 and fall 2010 do not meet this criterion

6.2.1.7.2. Separated dredged material via hydraulic placement.

Hydraulic placement of dredged material in a CDF results in the separation of the coarser-grained fractions of sediment from the finer fractions; this material could be harvested where coarser materials are required. The Shore Protection Manual provides guidance for the compatibility of sand to a beach, stating:

> …the compatibility range varies depending on the characteristics of the native beach material, with coarse material being less sensitive to small variations between the native and borrow sediments than fine material. As a rule of thumb, for native beach material with a composite median grain diameter exceeding 0.2 mm, borrow material with a composite median diameter within plus or minus 0.02 mm of the native median grain diameter is considered compatible. For native beach material with composite median diameter between 0.15 and 0.2 mm, borrow material can be considered compatible if its composite median diameter is within plus or minus 0.01 mm of the native diameter. For native beach material with a composite median diameter less than 0.15 mm, use of material at least as coarse as the native beach is recommended.

Table 6-8 lists the median grain size and median grain size of the sand fraction of Perkins Beach (Cleveland, OH) sediments and 2002, 2007, and 2010 Cuyahoga River sediment samples.

Table 6-8. Median grain sizes for Perkins Beach and Cuyahoga River sediments.

	Perkins Beach Composite	2002 CH-01 thru CH-08: Mass-weighted Average	2002 CH-09 thru CH-30: Geometric Average	2007 CH-01 thru CH-08: Arithmetic Average	2007 CH-09 thru CH-30: Arithmetic Average	2010 CH-01 thru CH-08: Mass-weighted Average
Median Grain size, um	180	64	14	70	28	18
Median Sand-fraction Grain Size, um	185	220	610	171	175	125

Table 6-8 shows that none of the average median grain sizes for the respective 2002, 2007, and 2010 Cuyahoga River sediment sample are within the recommended 10 um envelope of the 180 um Perkins Beach median grain size. Thus, it appears that any use of Cuyahoga River sediments for beach nourishment will require separation of fine- and coarse-grained material.

The arithmetic average median grain size of the sand fraction of 2007 upper and lower sediment samples is within the 10 um suitability envelope, although (as mentioned previously) 2007 sediment samples are not thought to be representative of the material removed from the Cuyahoga River and placed in the Cleveland Harbor CDFs that year. The mass-weighted average of the sand fractions from the Spring 2002 upper and lower river sediment sample results is greater than the Perkins Beach median grain size, fulfilling that beach nourishment criterion. The grain size distribution analysis for Spring 2002 lower river sediments omitted an analysis of the sand fraction of six samples from CH-09 to CH-30 because the samples were less than 10 percent sand by mass. The mass-weighted sand content of Spring 2002 upper river samples is 12.1 percent, which demonstrates that only a small volume of the dredged material could be used beneficially for beach nourishment, thus not resulting in a significant reduction of sediment requiring placement in a CDF. It is difficult to estimate the quantity of material that would have been available for beach nourishment based on Spring 2002 lower river data since volumes and masses of material removed in that dredging cycle are not available. The Fall 2010 upper river sediment sample results indicate that the sediments would not be suitable for beach nourishment even if coarse-grained particle separation was performed, due to the very low sand content. Because the grain size distribution of material dredged from the river appears to be temporally varying, it is difficult to determine what volume of material would be suitable for beach nourishment on a consistent basis.

6.2.2 Existing material in CDFs

An analysis of the suitability of material harvested from CDF 10B for use as compacted fill was conducted by Lenhardt (2011) using data previously acquired and analyzed by Hull and Associates. CDF dredged material showed significantly higher percentages of coarse-grained material than in-channel sediments from 2002, 2007, and 2010; 50-60 percent of the material in CDF 10B was determined to be suitable for use as compacted structural fill (Lenhardt 2011). A rigorous screening of the material against all of the criteria in section 6.2.1 was not performed; however, knowledge of the criteria coupled with details from the analysis of the data for dredged material harvested from CDF 10B indicate the likely suitability of dredged material for other beneficial uses.

The differences in grain size distributions between channel sediments and dredged material in the CDF could be due to the event-driven nature of large-scale shoaling events in the Cuyahoga River that may generate coarser grained dredged materials. Considerable coarse grained sediment was obsevered in dredged material removed from the river at the end of February 2011 (O'Connor, personal communication). It can therefore be concluded that the CDF 10B data do not represent characteristics of dredged material that may be produced for a specific dredging event, and that dredge material suitability for compacted fill may vary on a seasonal or yearly basis.

6.2.3 Summary and conclusions

Cuyahoga River sediments have been screened for six beneficial use applications based on the grain size and sediment property results from three sampling efforts. Table 6-9 summarizes the suitability of Cuyahoga River sediments and the material present in CDF 10B (Lenhardt 2011) for the beneficial uses screened in this study: CDD landfill cover, aggregate material, embankment material, compacted fill, land improvement and environmental enhancements, and beach nourishment. Cuyahoga River sediment samples were found to be suitable for use as CDD landfill cover, land improvement/environmental enhancements, and all but Fall 2010 river sediment samples were suitable for beach nourishment following sand separation. According to Lenhardt (2011), all sediments in CDF 10B were concluded to be suitable for use for land improvements/environmental enhancements and likely suitable for use as CDD landfill cover;
50-60 percent of material in CDF 10B is suitable for use as embankment

material and compacted fill; and an unknown percentage is suitable for use in beach nourishment after sand separation.

Table 6-9 shows a discrepancy in the predicted suitability of material based on sediment samples from the river and sediment samples taken from CDF 10B. This is likely due to there being only one set of samples for spring dredging (Spring 2002) and fall dredging (Fall 2010) available to characterize in-river sediments. Additionally, detailed data on the removal of sediments from specific portions of the river are only available for the upper river, so the mass-weighted grain size distribution (which may indicate more volume/mass removal in coarser-grained influence areas) cannot be calculated.

Table 6-9. Summary of river sediment suitability.

	Cuyahoga River Sediment Samples					
Beneficial Use	Spring 2002 Upstream	Spring 2002 Downstream	Summer 2007 Upstream	Summer 2007 Downstream	Fall 2010 Upstream	Existing CDF 10B Material
CDD Landfill Cover	Suitable	Suitable	Suitable	Suitable	Suitable	Likely Suitable[1]
Aggregate Material	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
Embankment Material	No Data	No Data	No Data	No Data	Unsuitable	50 to 60% is Likely Suitable[1]
Compacted Fill	No Data	No Data	No Data	No Data	Unsuitable	50 to 60% is Suitable[2]
Land Improvement / Environmental Enhancements	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Beach Nourishment	Suitable After Sand Separation	Suitable After Sand Separation	Suitable After Sand Separation	Suitable After Sand Separation	Unsuitable	Unknown % Suitable After Sand Separation[3]

1 Based on the criteria listed in this chapter, the assessment in Lenhardt (2011), and professional judgment.

2 Based on Lenhardt (2011).

3 Material processing (size separation) would be required to separate sand and fine fractions of dredged material in order to recover the sand fraction for beneficial use.

7 Dredged Material Handling and Management

7.1 Background

As mentioned in Chapter 1, dredged material was successfully harvested from the Cleveland Harbor CDFs in 2010 and transported to a site upriver for use as industrial fill at the CVIC site (Hull and Associates 2010). The success of the CVIC beneficial use project, and the proximity of the CVIC site and other potential beneficial use sites (e.g., Silver Oak Landfill) to the upper river (where the greatest volume of sediment is dredged annually from the Cuyahoga River) led to the exploration of potential sites for material offloading, drying, and stockpiling. Availability of suitable material re-handling sites in proximity to potential BU sites would reduce scow transport and trucking costs, such that beneficial use could be comparable in cost, or less costly, than placement in the CDF.

ERDC was tasked by the Buffalo District to explore several potential upriver locations for a dredged material re-handling operation to facilitate beneficial use of dredged material. Two parcels of land located directly adjacent to east bank of the Cuyahoga River were identified as potential sites. An analysis of the construction of a material re-handling facility at the existing Cleveland Harbor CDFs was also conducted for cost comparison. All other factors being equal, overhead would be expected to be lower on existing CDFs, and the large amount of land available at the existing CDFs would allow for increased stockpiling capability; an advantage given the expected variability in demand for dredged material over time. In addition to the two analyses performed, two non-USACE-generated scenarios for material handling operations at upriver locations were also provided to the ERDC for consideration. This chapter gives background information on the material offloading and re-handling sites considered and descriptions of proposed operations. Planning level designs are provided when possible. Cost implications of the four material handling sites will be addressed in Chapter 9.

7.2 Cleveland Harbor CDF site

While locating re-handling facilities at the Cleveland Harbor CDFs would not minimize scow or trucking distances to beneficial use sites, this alternative offers the advantages of a significant available area for stockpiling dredged material and the lack of real estate acquisition costs. It was thought that, at a minimum, such an investigation would provide a basis for cost comparison to upper river material handling sites, and that the CDF may in fact provide viable placement and re-handling options.

7.2.1 Existing management practices

Since construction of various offloading methods and facilities are discussed in subsequent sections of this chapter, a description of the current, status quo methods of dredging and placement are described here for reference and comparison. Cuyahoga River Navigation Channel sediments are mechanically dredged because the distance from a majority of the shoaling to the CDF and narrowness and use of the channel are prohibitive to other forms of dredging. The Cleveland Harbor CDFs are in-water CDFs and no bulkhead or dock is available for mechanical offloading. Hydraulic dredges are therefore used, without recirculation, to offload material from scows to the CDFs.

7.2.2 Mechanical off-loading

The mechanical off-loading of dredged material at the Cleveland Harbor CDFs was evaluated as a potential management method due to the reduced drying time of mechanically dredged material and reduced ponding requirements, which allows more space for stockpiled dredged material. Figure 7-1 shows a conceptual schematic for an off-loading and material handling facility at the CDFs. Construction of a mechanical off-loading facility would require a dock for berthing scows where water depth is sufficient to accommodate them, a work pad for crane or backhoe transfer of sediment from scows to trucks, a truck staging area, and a haul road from the staging area to the drying beds inside the CDFs (Figure 7-2). It is proposed that dredged material be placed by trucks in 3-ft lifts at the CDFs, where it can be spread, turned over, and reworked as drying progresses. Once sufficiently dry, the dredged material could be placed into stockpiles until needed for beneficial use. Detailed features of this conceptual design and operation are contained in Appendix H5.

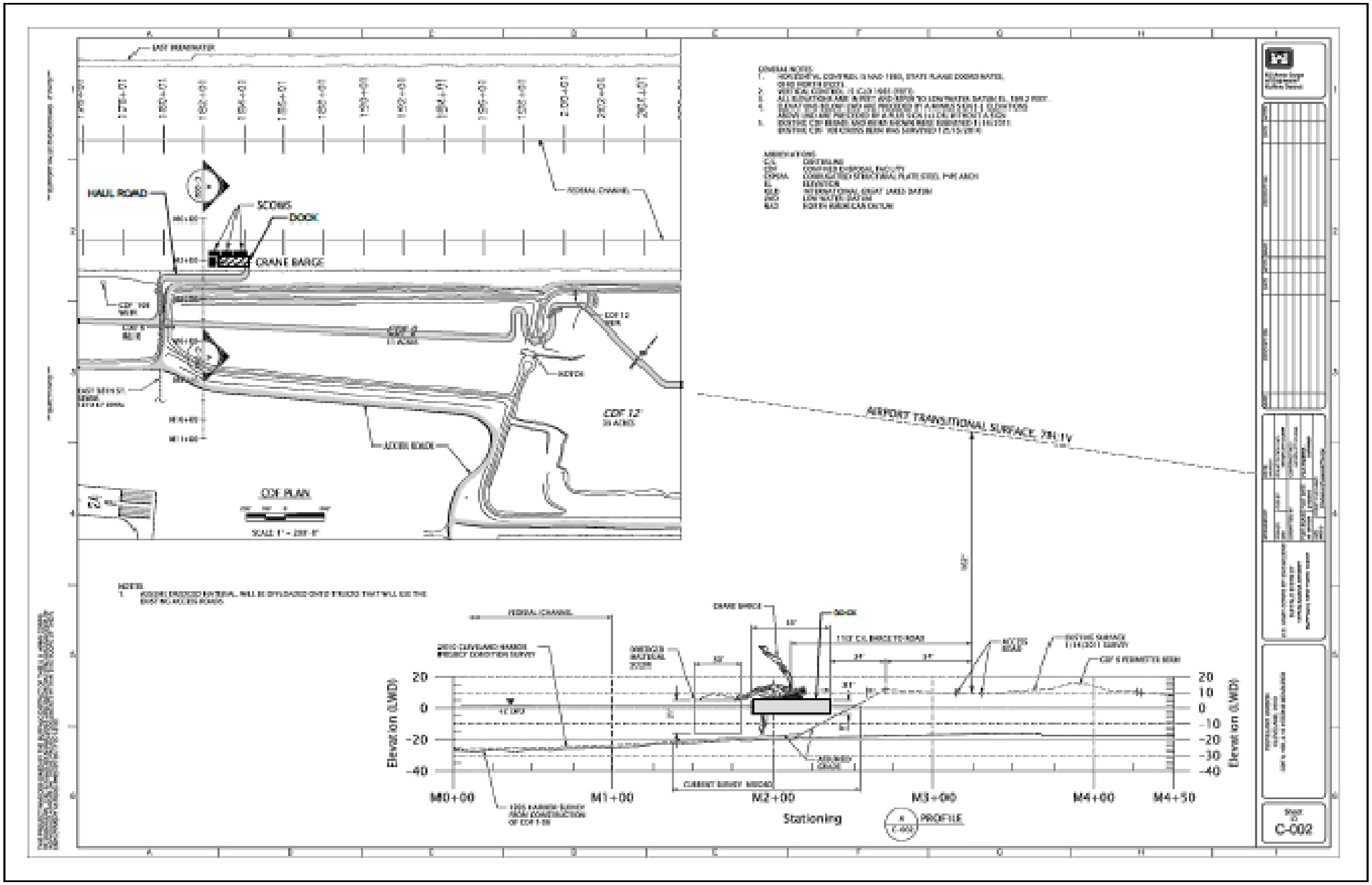


Figure 7-1. Schematic of mechanical offloading operation and material handling operation at Cleveland Harbor CDFs.

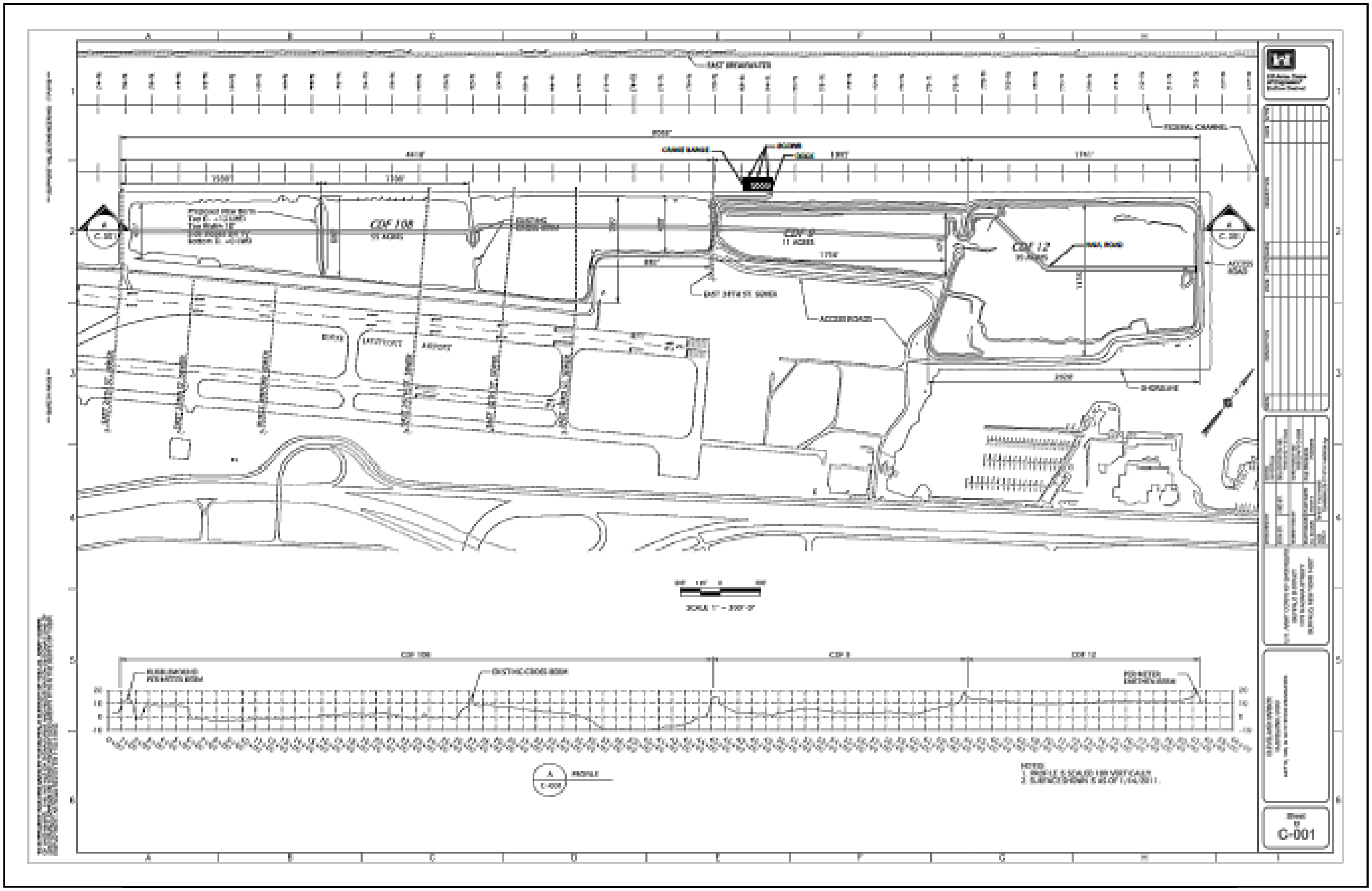


Figure 7-2. Schematic of Cleveland Harbor CDFs.

The potential increase in available storage achieved by mechanical placement and material handling at the CDFs is significant. Based on calculations and supporting assumptions provided by Hamm (2011), nearly 500,000 CY of CDF storage capacity is required for management of the large volumes of water associated with current hydraulic offloading practices; a transition to modified hydraulic placement, then to mechanical placement would make the entire volume available for dredged material storage. According to Hamm (2011, Appendix F1), ~1.2 million CY of airspace was available in the CDFs prior to Spring 2011 emergency dredging (the sum of residual space in Dikes 10B, 9, and 12). Assuming a dredging rate of 250,000 CY/yr, sufficient capacity would be available for approximately 5 years of dredging under this strategy (through 2015 spring dredging), without removal of material for beneficial use or any dike raising[7] Assuming the same dredging rate, the planned raising of dikes at CDF 12 (estimated in Hamm 2011 to provide an additional 400,000 CY of capacity) would allow for material handling and stockpiling for more than 6.0 years (through the 2016 dredging year), before capacity would be reached. This ability to stockpile large volumes of material would offer substantial flexibility in using the material beneficially.

Some operational limitations are associated with the use of mechanical offloading of dredged material. The rate at which sediment can be mechanically dredged and dropped into a scow is generally greater than the rate at which material can be removed, due to the need for a smaller, more articulated bucket and a more precise operation to remove material from a scow without damaging it. This could cause a bottleneck in the dredging and placement process at the mechanical offloading facility, delaying dredging and thus significantly impacting its cost . Mechanical offloading difficulties could potentially be mitigated by using additional offloading barges, stockpiling strategies at the offloading point, or using multiple offloading cranes (each of which have costs associated with them, but likely lower ones than would be incurred by delaying dredging).

Additionally, mechanically dredged and placed material does not undergo the grain size separation that hydraulically dredged material does. This can be advantageous where a more well-graded material is desired, but

[7] CDF capacity lost due to bulking of mechanically placed material and gained as a result of consolidation were both assumed to be comparatively small relative to the total volume dredged, and largely offsetting. These volume changes were therefore neglected for this preliminary analysis but should be taken into account in more detailed operational planning.

additional processing may also be required where specific size fractions are needed to meet a given beneficial use specification. Because material specifications are site specific, it is not possible to anticipate future needs in this regard, and the capacity gained with mechanical offloading would at least partially offset subsequent processing costs. Some degree of material blending may be required in any case, even after grain size fractions have been separated. The separation associated with hydraulic placement is therefore a questionable advantage. .

The possibility of stockpiling dried dredge material at a gradual grade above the crest of the CDF dikes was also investigated as a means of gaining further increases in capacity with the mechanical offloading option. This strategy potentially offers approximately 2 million CY of additional storage capacity at the CDFs without additional dike raising, or approximately 8 years of storage at 250,000 CY/yr. A number of important engineering considerations associated with this alternative require consideration; this placement method is therefore analyzed and discussed at length in Section 7.6 of this chapter.

7.2.3 Hydraulic off-loading with operational modifications.

Operational improvements to the existing hydraulic off-loading practice were evaluated for comparison to mechanical offloading and beneficial use alternatives. The alternative assumes use of the existing infrastructure at the waterfront CDFs (Figure 9-2). Alternating placement between cells to facilitate more rapid dewatering and removal was considered, in addition to measures such as wick drains and cell partitioning to accelerate dewatering and consolidation. Recycling of water used in the hydraulic offloading of dredged material to minimize ponding requirements was also considered. Detailed features of this conceptual design and operation are contained in Appendix H4.

There is significant uncertainty in the drying rate of hydraulically placed dredged material due to variation in the dredged material volume and characteristics from year to year (Section 6.2.2). Modeling can be used to reduce that uncertainty but was beyond the scope of this preliminary feasibility evaluation. If drying does not occur at the rate predicted, or near-term beneficial use opportunities do not come to fruition such that material is not periodically removed, there is a significant risk of exceeding the capacity of the CDF, at which time hydraulic offloading would no longer be possible. Appendix F1 shows capacity in the CDFs for material placed by the current hydraulic method exists only through part of the 2013 dredging year unless dikes are raised (insufficient capacity would be available for water management the following year). The existing fill management plan includes raising the exterior dikes for CDF 12 during 2012 to create 400,000 CY of additional capacity (enough for the 2014 dredging year) for hydraulic placement of dredged material. However, the dike raising would require dewatering of the dredged material in CDF 12 for use in dike construction, requiring repeated placement of hydraulically dredged material in CDFs 10B and 9 in consecutive years. Materials placed in CDFs 10B and 9 may not have a sufficient opportunity to dewater during this period unless placement methods were modified (e.g., water recycling), potentially hindering drying and material recovery, and thus precluding that material from beneficial use until sometime after CDF 12 was back in service and placement could again be alternated between the cells. This would create an untenable situation where the channel could only be dredged if a beneficial use opportunity existed that would allow excavation of the CDFs so that placement could again occur.

7.3 Upper River material handling site with mechanical offloading

The Upper River site is parcel of land near the terminus of Campbell Street located between the Cuyahoga River and the Norfolk Western rail yard, within the Arcelor Mittal steel manufacturing complex (Figure 7-3). The site is adjacent to the Cuyahoga River, immediately upstream of the federal navigation channel. The property, owned by Norfolk Western Railroad, consists of 13 acres currently used for scrap metal recycling and equipment storage and approximately 12 acres of unused land. Two scenarios were explored using this parcel of land: a ~12-acre material re-handling site and a ~25-acre material re-handling site.

Conservative assumptions were made to estimate the volume of sediment that could be managed at the Upper River site. It was assumed that only 80 percent of the area was available for material storage (the remainder being occupied by dikes, runoff control ponds, roads, etc.) and that dredged material would be mechanically offloaded and placed no more than 3 ft high to facilitate rapid dewatering. Resulting estimated storage volumes of ~40,000 CY and ~80,000 CY were obtained for the 12-acre and 25-acre parcels, respectively. The conceptual drawing shown in Figure 7-4 illustrates the proposed material handling operation for the 12-acre site; the proposed 25-acre site would enclose the two sections, with the access road passing through the entirety of the site.

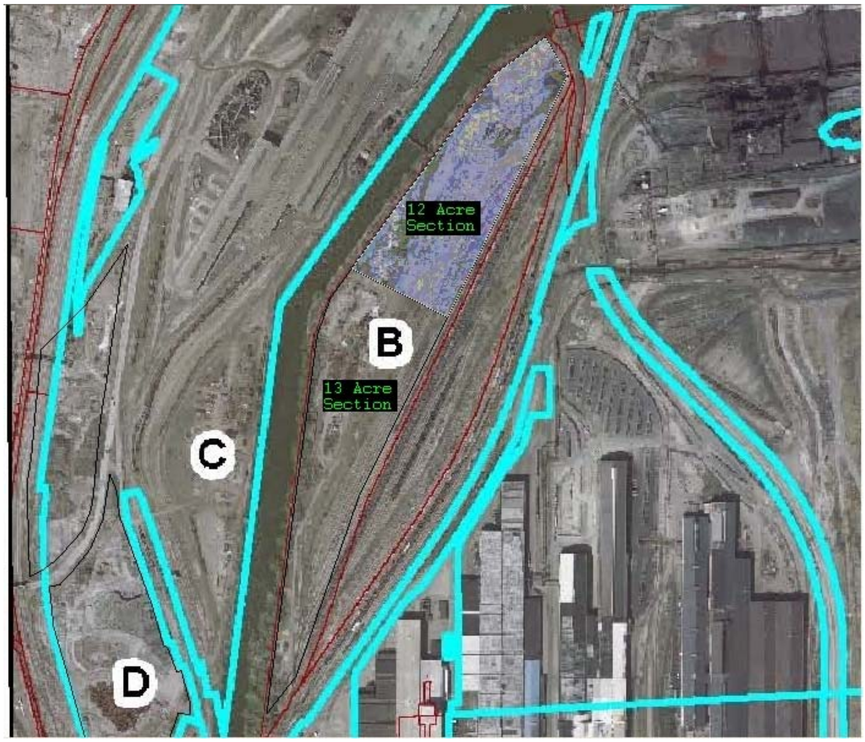


Figure 7-3. Parcels of land for potential upriver material re-handling facility at Norfolk Western Railroad property are shown in Area B.

Figure 7-4. Conceptual design of offloading, dewatering, and re-handling facility for dredged material at the Upper River site.

Re-handling site grading, confinement and runoff berms, and water management are necessary site improvements. A short access road must be constructed to connect the offloading facility to the storage and re-handling facility. Scow offloading is proposed to take place using docks located on the east or west side of the Cuyahoga River adjacent to the turning basin, which would then be followed by transfer to trucks for transport to a beneficial use site. A detailed list of the planning level design features of this facility are contained in Appendix H2 (12-acre site) and H3 (25-acre site). Once placed, the dredged material would be mechanically worked through plowing and disking to facilitate drying. Material would then be available for loading into sealed dump trucks with a front end loader or other similar equipment for transport to a beneficial use site.

This material handling site does not provide adequate capacity to accommodate the anticipated annual volumes of dredged material requiring management, which necessitates acquisition of another facility or placement of excess material in the CDFs. Additionally, if a beneficial use opportunity is not available in a given year and the re-handling site is filled with dredged material, the facility will essentially be dormant (while still having costs associated with it) until a beneficial use opportunity arises. There is uncertainty, and therefore risk, associated with both land acquisition and permitting for this material handling facility alternative. This uncertainty is accounted for by increased contingency factors in the Chapter 9 cost analysis.

7.4 CVIC site with mechanical off-loading

A conceptual plan for mechanical off-loading and dewatering of dredged material at the CVIC site was developed by Hull and Associates and documented in a Memorandum for Record to the Buffalo District (Appendix F2). The majority of the 58-acre CVIC site (Figure 7-5) is being filled for a commercial/industrial redevelopment and is operated by the Greater Cleveland Community Improvement Corporation. The southern portion of the CVIC site is occupied by a valley approximately 100–200 ft across and 2,600 ft long. A concrete box culvert lying beneath the 20–30-ft deep valley conveys the former Morgana Run stream westward to an outfall on the east bank of the Cuyahoga River. The long and narrow Morgana Run valley is not slated for redevelopment or construction of any significant structures, roads, etc. Therefore, potential for long-term dredged material dewatering and material handling operations exists for this portion of the CVIC site. The plan proposes that 150,000 CY of dredged material could be offloaded,

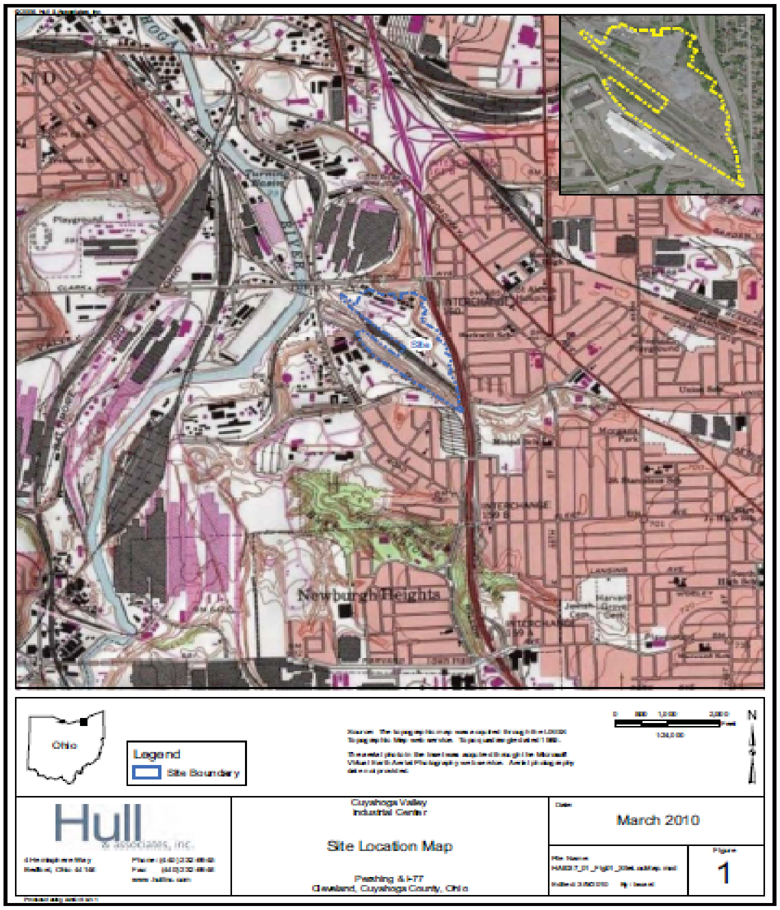


Figure 7-5. Map of Cuyahoga River and CVIC site (inset shows satellite view).

dried, re-handled, and loaded into trucks for transport to a beneficial use site starting as early as 2012-2013. Under this alternative, scow offloading would occur at docks located on either side of the Cuyahoga River adjacent to the turning basin; material would then be loaded into trucks for transport to the CVIC site. This would require the construction of a work pad and likely necessitate improvement/maintenance of haul roads. Since this is a non-USACE-generated alternative, detailed data similar to Appendices 9B thru 9D is not available.

This material handling alternative does not provide adequate capacity to accommodate the anticipated annual volumes of dredged material, which necessitates acquisition of another facility or placement of excess material in the CDFs. This re-handling facility alternative may provide capacity for year-to-year stockpiling of material that allows for some flexibility in material use; however, there are significant questions regarding the compatibility of the long-term bulk movement of dredged material and other industrial activities that may occur at the CVIC site. The objective of the Greater Cleveland Community Improvement Corporation is to redevelop the CVIC site to promote industrial manufacturing and jobs within the City of Cleveland. If material handling operations at the CVIC site (including haul roads, truck and loader traffic, etc.) prevented other industrial development at the site, operational constraints may be imposed or the lease for the re-handling facility terminated prior to the planned life of the facility.

7.5 Zaclon Properties site with hydraulic offloading

The Zaclon site is an industrial property located at 2981 Independence Road, adjacent to the navigation channel turning basin (Figure 7-6). An unsolicited proposal to accept, separate/dewater, stockpile, and transport dredged material to a beneficial use site was provided to the Buffalo District by Ditchman Holdings, LLLP and documented in a Memorandum for Record (Appendix F3). The proposal includes a conceptual plan for design and construction of a mechanical dewatering system (e.g., hydrocyclones/filter presses), storage cells for holding dewatered dredged material, a dredge water treatment and disposal system, and development of a docking facility for receipt of dredged material hydraulically delivered by USACE to the Zaclon site.

Several complicating factors raise questions about the feasibility of this proposal at the Zaclon site. Redevelopment of the Zaclon site for dredged material management will require coordination by the responsible parties with ongoing RCRA regulatory action and demolition of several buildings prior to construction. The timeframe necessary for construction of the material handling facility is estimated to be 1.5 years following creation of a public/private partnership and project capitalization. The Zaclon property is owned by a third party and execution of the proposal by Ditchman Holdings, LLLP will require completion of a real estate transfer and/or use agreement. Development of the Zaclon property by Ditchman Holdings, LLLP requires, among other things, a commitment by the USACE or Port of Cleveland to provide a minimum volume of 225,000 CY of dredged material per year for 10 years and the City of Cleveland to secure State funding for environmental restoration of the Zaclon property. There is a significant risk to feasibility associated with the project requirement that State funding be made available to the city for environmental restoration of the property. In addition, execution of the project based on long-term contracts committing the USACE and Port to provide dredged material and payment for material handling may be constrained by annual federal appropriation uncertainties.

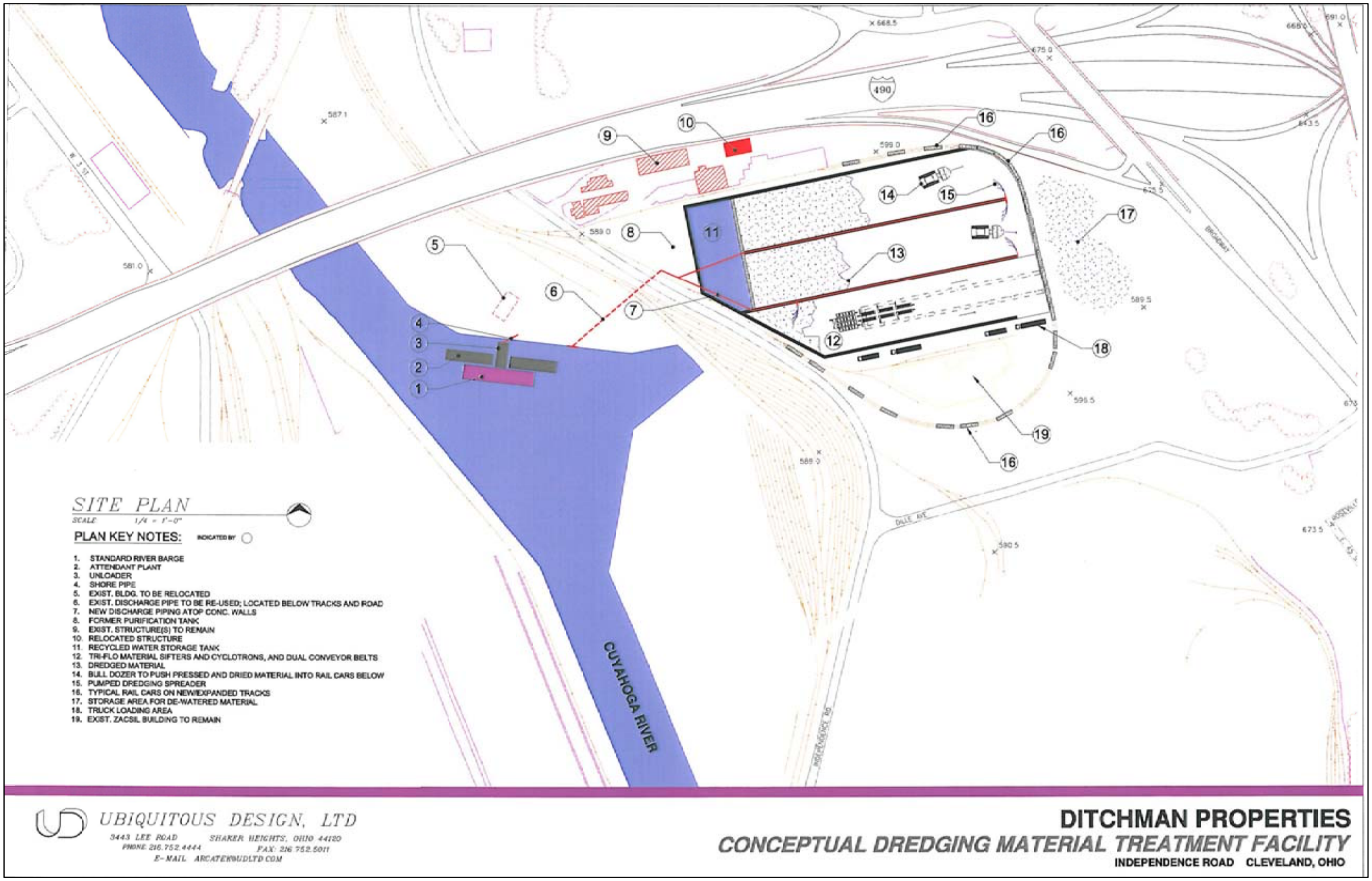


Figure 7-6. Conceptual design of offloading, dewatering, and re-handling facility for dredged material at the Zaclon site.

7.6 Material management strategy for long-term dredged material storage at Cleveland Harbor CDFs

7.6.1 Background

Previous sections of this chapter contain concepts for dredged material offloading, drying, and re-handling facilities that have little or no year-to-year stockpiling capacity; thus their feasibility is highly dependent on the relatively uncertain demand for beneficial use material from year to year. Coupled with evaluation of a mechanical offloading and re-handling facility at the Cleveland Harbor CDFs, this uncertainty prompted the conceptualization of a dredged material stockpiling strategy for the CDFs that could significantly increase storage/stockpile capacity (Borrowman 2011). The concept and analysis was submitted to the Buffalo District in a Memorandum for Record (Appendix F4) and is revisited in this chapter.

7.6.2 Concept

Appendix F1 shows historical and planned airspace capacity (excluding freeboard), existing dredged material volumes in the CDF, and a fill management strategy for the CDFs based on available space and scheduled dike raising. As indicated in Appendix F1, capacity for the current method of hydraulic placement in the CDFs will be insufficient after the 2013 dredging year (this could be extended through 2014 if the planned dike raising operation for CDF 12 is conducted). There is, however, capacity for nearly 2 years of material (without exceeding the 2-ft freeboard of the dikes) by transitioning to a modified hydraulic placement scheme (e.g., recycling water) and then mechanical placement. This scenario would provide capacity for dredged material placement in the CDFs through 2016.

The concept of spreading or stockpiling dredged material atop the completely filled CDFs was raised due to what would be a vast, flat area following CDF closeout. A plan to stack dredged material for dewatering, then spread it and grade it at very gradual slopes to stabilize the graded dredged material would provide significant capacity for dredged material placement and stockpiling due to the aforementioned acreage of the CDFs.

7.6.3 Parameterization and calculations

Cleveland Harbor CDFs are located directly adjacent to the Burke Lakefront Airport; therefore, they are subject to height restrictions based on Federal Aviation Administration (FAA) regulations. Computations were made to determine whether proposed stockpiles of dredged material would violate these restrictions. Slopes ranging from 1 on 20 to 1 on 10 were assumed in calculations to bound stable angles of repose for the dredged material, and to determine resulting mound height.

Appendix F5 contains the spreadsheet analysis performed to estimate the volumes of material that could be stored by stockpiling and calculations of the associated design life of the CDFs based on 2011 airspace volumes calculated in Appendix F1. The same parameterization methods and calculations were made for CDFs 10B, 9, and 12; for purposes of example, CDF 12 will be detailed here.

7.6.3.1 CDF 12 maximum allowable height calculations

Using the to-scale schematic (LWD datum) provided by the Buffalo District (Smith 2011, Appendix F5), the distance from the projected runway centerline to the centerline of CDF 12 was measured at ~900 ft. Per FAA regulations (Appendix F7), a formula assuming a 200-ft offset from the runway centerline and a plane defined by a 1-on-7 slope from this point (beginning at grade) was used to calculate an allowable total dredged material stockpile height of 100 ft at the centerline of CDF 12 (Figure 7-7). The width (or height limiting dimension) of a cell (~1000 ft for CDF 12) was divided by two. An assumed 1-on-10 stacking slope was applied to calculate a maximum stable stockpile height at the center of the cell; approximately ~51 ft for CDF 12. The 2 ft of freeboard and height of the CDF 12 dikes, ~18 ft (Appendix F5), were taken into account to calculate a maximum stockpile elevation for CDF 12, (18 – 2 + 51) ft = 67 ft, which is well below the 100-ft height restriction. The maximum stockpile elevation can then be assessed by simply adding the estimated increase in dike height (6 ft for CDF 12, O'Connor 2011a) to the stockpile height, or (67 + 6) ft = 73 ft. Since a 1-on-10 slope is the steepest evaluated in Borrowman (2011), this height can be considered a worst case estimate for CDF 12.

7.6.3.2 CDF 12 volume calculations

Using the CDF length, a volume for the triangular prism with semi-square pyramid ends (Figures 7-8 and 7-9) was calculated (Appendix F5). For CDF 12, with a length of ~1760 ft, the calculated volume of dredged material in the prism above the filled in CDF was 1,360,000 CY. Stockpiling material in this manner, beginning at the existing dikes, leaves the 2 ft of freeboard that currently exists for erosion and runoff control.

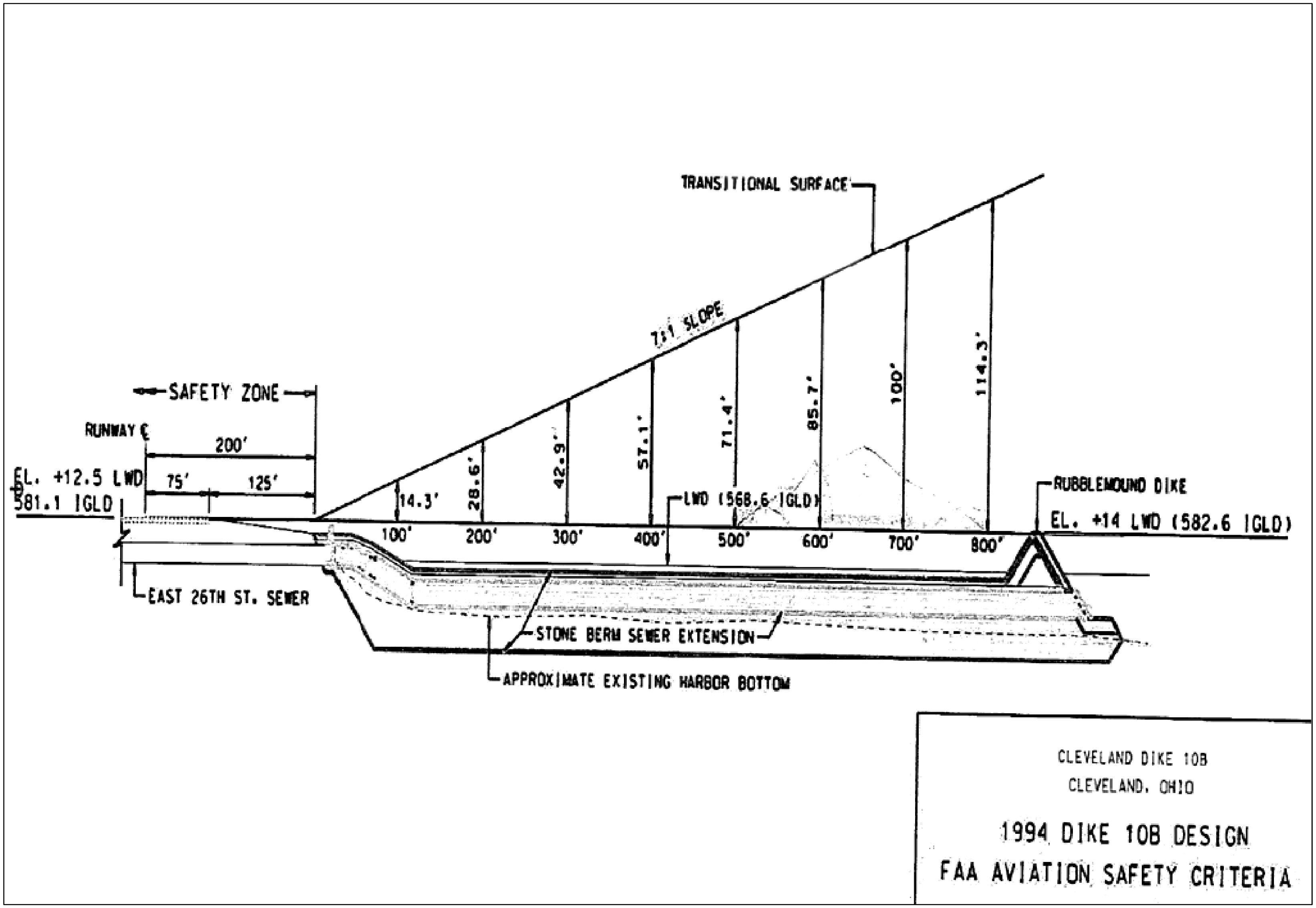


Figure 7-7. FAA height restrictions based on distance from runway centerline.

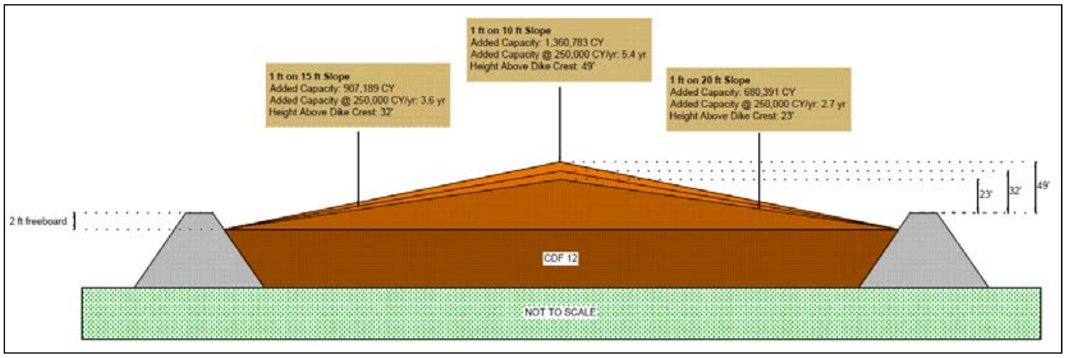


Figure 7-8. Conceptual drawing of stockpiling dredged material at CDF 12.

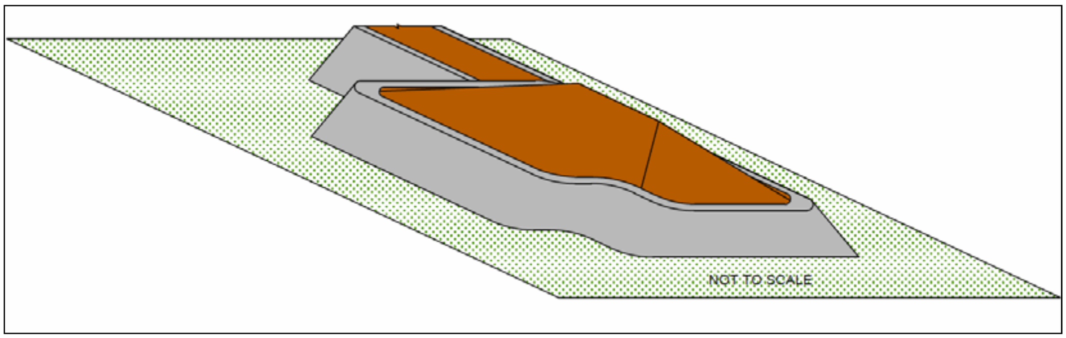


Figure 7-9. Dredged material mound created by stockpiling dredged material on a gradual slope.

7.6.4 Results

The same analysis was performed for the other CDFs, with two sets of calculations for CDF 10B for the two distinct plane view shapes that form it (a large trapezoid and a small rectangle). As shown in the summary cells of Appendix F4, there is an estimated capacity for the placement of nearly 2 million CY of material using this material management strategy, in addition to the airspace still available below the dikes, that could yield adequate capacity through 2016 (Section 7.6.2). This capacity does not depend on any excavation of material; such excavation would, however, extend the life of the facility. The spreadsheet used to make these calculations was modified to account for 1-on-15 and 1-on-20 stacking slopes to evaluate more conservative stockpiling strategies to ensure stability and lighten lateral loads on the dikes. Table 7-1 summarizes the dike heights of the three CDFs (Appendix F6), the calculated allowable height of material at the CDF centerlines, the total storage volume (existing plus stockpiled) for each CDF, and estimated years of CDF life for three stacking slopes. The maximum heights of all dredged material stockpiles were calculated to be below their respective FAA elevation limitations. The 1-on-20, 1-on-15, and 1-on-10 stockpile slopes were calculated to provide mechanically placed dredge material capacity through the 2022, 2024, and 2028 dredging years assuming an annual dredging volume of 250,000 CY/yr. Appendix F5 is set up to calculate CDF life based on smaller or larger annual dredging volumes, with the option for larger volumes being of interest to evaluate strategies to manage dredging backlogs. Figure 7-8 shows an end-view of the stockpiled dredged material and the centerline height above the dikes for the various stockpile slopes in CDF 12.

7.6.5 Implementation

This material management strategy could be readily integrated into the current Buffalo District fill management plans and material placement methods. Hydraulic placement can be conducted through the 2013 dredging year using current methods if dikes are not raised, and through the 2014 dredging year if the dikes are raised (associated costs are considered in Chapter 9). This implementation would provide time for funding acquisition and construction of the offloading facility and other site improvements (the same as the mechanical offloading beneficial use facility , Section 7.2.1) and would maximize the amount of time that hydraulic placement could be used (thus minimizing placement costs). A transition to mechanical placement could then take place and be used for the life of the facility, which could be extended indefinitely if material is regularly removed for beneficial use.

7.6.6 Discussion and pending stability analysis

It must be noted that no geotechnical analysis was performed to verify the stability of CDF dikes and suitable angle of repose for the dredged material. While the slopes analyzed are assumed to be stable in terms of self weight sloughing, this needs to be definitively determined with appropriate geotechnical testing. Further, the lateral and horizontal forces exerted on the dikes by stockpiled dredged material will be large, necessitating a stability analysis of the dikes for the assumed conditions. Additional concerns regarding the bearing capacity of combined sewer outfalls beneath CDFs must be addressed. Stability and consolidation evaluation of dredged material within the CDFs was not performed; however, this is thought to be of second order importance to evaluation of the CDF structure due to the small proposed slopes for the stockpiled dredged material and the periodic nature of dredged material placement that would allow for consolidation and strengthening of the material between placement operations. A screening-level cost analysis of this material management option utilizing the cost information provided by Buffalo District is included in Chapter 9.

CDF capacity lost due to bulking of mechanically placed material and gained as a result of consolidation were both assumed to be comparatively small relative to the total volume of dredged material, and largely offsetting. These volume changes were therefore neglected for this preliminary analysis, but should be taken into account in more detailed operational planning.

7.7 Summary

Five material handling options have been presented for four locations adjacent to the Cuyahoga River. The advantages, disadvantages, and risks involved with the various options were presented and discussed. Chapter 9 contains a detailed cost breakdown of these options. More detailed design features for the non-contractor-furnished placement options are also contained in Appendices H2 through H6. The assessment of the strengths and weaknesses of the material handling facility options presented in this chapter and the results of the Chapter 9 economic analysis are considered in Chapter 10.

A material management strategy utilizing stockpiling of mechanically dredged and offloaded material in the existing CDF (Borrowman 2011) appears to be the most viable and potentially cost-effective alternative of those considered. The alternative would utilize presently available real estate and could be integrated into the existing management plan for the waterfront CDFs such that adequate planning and design can be completed prior to making a change in material handling methodology. Significant increases in the capacity, and thus life, of the Cleveland Harbor CDFs may be possible through employment of this strategy. A geotechnical and structural analysis by Buffalo District personnel is pending (O'Connor 2011b) to verify stability of the CDF structure under the anticipated resulting loads and to verify stable stockpile slopes for the dredged material itself. The stockpiling strategy is expected to easily accommodate beneficial use of dredged material when opportunities arise, and the increased capacity acts as a "buffer" for stockpiling material during periods when compatible beneficial use opportunities are not available. The strengths and weaknesses of this and the other management alternatives and their cost implications are considered in Chapters 9 and 10.

Table 7-1. Increased CDF capacity at various stockpile slopes.

CDF			1-on-10 slope				1-on-15 slope				1-on-20 slope			
	Berm Height above Mean Lake Level (ft)	Allowable Height Based on Airport Clearance (ft)	Capacity (in CY)	Capacity in Years @ 250,000 CY/yr	Centerline Height Above Existing Berms (in ft)	Total Height Above MLL @ Berm Height (in ft)	Capacity (in CY)	Capacity in Years @ 250,000 CY/yr	Centerline Height Above Existing Berms (in ft)	Total Height Above MLL @ Berm Height (in ft)	Capacity (in CY)	Capacity in Years @ 250,000 CY/yr	Centerline Height Above Existing Berms (in ft)	Total Height Above MLL @ Berm Height (in ft)
10B	13.56	53.7	1,372,376	5.5	30.2	44	914,917	3.7	19.5	33	686,188	2.7	14.1	28
9	15.21	83.9	192,517	0.8	16.5	32	128,344	0.5	10.3	26	96,258	0.4	7.2	22
12	18.2	100.0	1,360,783	5.4	48.8	67	907,189	3.6	31.9	50	680,391	2.7	23.4	42
Capacity Through Year			2028				2024				2022			

8 Regulatory Authorities and Permitting

8.1 History of Dredging and Beneficial Use

Historically, dredged material disposal often resulted in beneficial use, either through productive use of the material or through improvements to the site on which it was placed. Until passage of current Federal laws, decisions on disposal of dredged material were based primarily on cost-effectiveness or local needs. Environmental or ecological impacts were generally not considered and the effects on wildlife and fisheries were not well understood. If the dredged material was considered physically suitable for any particular need, it was used as such. Many developed areas along coastlines, inland rivers, and lakes were constructed using dredged material.

Beneficial uses of dredged material have a productive history resulting in more than 2,000 man-made islands, 100 marshes, and nearly 1,000 habitat development projects. In many areas, Corps islands provide vital habitat for rare, threatened, or endangered species. It is estimated that 1,000,000 birds nest on dredged material islands each year (EM 1110-2-5026). These projects were completed with "uncontaminated" dredged material, or at least what was considered then to be uncontaminated. Dike 14 in Cleveland and the Times Beach CDF in Buffalo are examples of dredged material disposal sites that used what would be considered "contaminated" material by today's regulatory standards. These closed CDFs provide habitat for wildlife and are seen as a potential recreational areas for the community.

Increasing knowledge and understanding of the environmental and human health impacts of contaminants in some sediments led to ever-increasing Federal and State laws regulating the dredging and management of sediments during the last 40-plus years. These laws have increased dredging project planning and evaluation requirements and have also increased dredging and dredged material management costs. The Federal Standard, to minimize cost while providing for the greatest benefit, requires that the selection of dredged material management alternatives (including beneficial use) be based on the lowest cost that is consistent with sound engineering practices and compliant with the environmental standards established under Sec 404 of the CWA, or other applicable standards.

8.2 Federal Regulatory Authority and Permitting

The Water Resources Act of 1992, Section 204 – Beneficial Use of Dredged Material (Public Law (PL) 102-580) established USACE authority for implementing ecosystem restoration projects in connection with dredging. The regulation of dredged material disposal within waters of the United States is a shared responsibility of the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE). The National Environmental Policy Act (NEPA) and its implementing regulations provide the basic national charter for addressing short- and long-term impacts of proposed Federal actions. The primary Federal environmental statute governing discharge of dredged materials into inland and estuarine waters of the United States is the Federal Water Pollution Control Act Amendments of 1972 (i.e., the Clean Water Act (CWA)). . In addition to CWA and NEPA, there may be a number of other Federal laws and Executive Orders that must be considered; the laws and regulations depend on the location and potential impacts to natural resources. These laws and regulations apply to the planning, engineering, construction or operation and maintenance of a beneficial use project. These must be determined on a case-by-case approach depending on various site uses, locations and circumstances. [8]

Generally, the beneficial use of dredged material placed within the waters of the United States is evaluated under the CWA (USEPA/USACE 1998). The USEPA Office of Water has maintained that once dredged material is regulated under the CWA, it will always be regulated under the CWA. However, the CWA does not provide guidance for the protection of the environment after dredged material is placed in an upland environment (Childs et al. 2002). If biological testing indicates the material is suitable for open-water disposal, that material would likely be deemed suitable for a wide range of uses insofar as contaminant concentrations are concerned. Most beneficial uses involve placement in open water or confined placement with return flow to waters of the United States, requiring a Sec. 404 public notice and a 404(b)1 assessment following testing protocols in the Inland Testing Manual (USACE/USEPA 1998). While the USACE does not issue a 404 permit to itself, Sec. 401 of the CWA does require certification from the

[8] . Guidance can be found at http://www.usace.army.mil/CECW/Documents/cecwp/envdref/2002CorpsGuidanceTable.pdf

State that discharge of dredged material complies with State water quality standards.

For beneficial uses of dredged material in upland environments there is little guidance for determining suitability based on contaminant concentrations in the material. Brandon and Price (2007) summarized available guidance for aquatic and upland beneficial use and associated authorities. Essentially, a 401 water quality certification is required if dredged material is placed in an upland environment and there is direct return flow to waters of the United States. This would occur if effluent or surface water runoff is discharged from a weir into receiving waters. In the absence of return flow, a 401 Certification would not be required and determination of suitability for upland placement may be determined under the Resource Conservation and Recovery Act (RCRA) as regulated under State solid waste authority (the States may choose to regulate dredged material as a solid waste where there is not a return flow, although in some States there may be other criteria specific to beneficial use that would apply, and which recognize such materials as a resource rather than a waste).

To understand the complexities of the permitting requirements associated with dredging and dredged material management (Table 8-1), one must start with the basic authorities promulgated under Federal and State laws to regulate specific activities and impacts to various resources. Basically, regulated activities associated with beneficial use of dredged material and the applicable permitting authorities can be described as follows:

1. **Discharge of dredged or fill material into waters of the United States.** Generally, any activity involving discharge of fill or dredged material into waters of the United States must comply specifically with Sec. 404/401 of the CWA. The USACE is the regulatory authority for Sec. 404 while the jurisdictional State must provide a 401 certification that the discharge of fill into State waters is in compliance with water quality standards and resource protection. Once dredging and dredged material management are permitted under provisions of the CWA through Sec. 404/401, the dredged material remains regulated under the CWA. However, this does not mean that dredged material removed from a permitted facility is exempt from other jurisdictional laws regulating material classification, permitting, and use.

Table 8-1. Federal and State Requirements for Beneficial Use Alternatives

End Use		*Site*	*Note*	*Federal Compliance*		*State Compliance*				
				NEPA Review	404 Analysis	Material Management Plan	NPDES	401 Water Quality Certification	Coastal Zone Consistency Review	Shore Structures Review
Lake Littoral Zone	Beach Nourishment	Perkins Beach	Potential Long-term Beneficial Use Alternative	X	X			X	X	X
	Wetland Habitat Restoration	Not Defined	Potential Long-term Beneficial Use Alternative	X	X			X	X	X
Intermediate Material Handling	Material Processing Required Prior to Final End Use	CDF	Discharges Regulated Under Federa/State Authority	X	X			X		
		CVIC Site		X	X	X		X		
		Upper River		X	X	X		X		
		Zaclon Site		X	X	X		X		
Urban/ Industrial Land Reclamation	Landfill – Closure or Redevelopment	Silver Oaks Landfill	Landfill Recompacted Cap & Vegetative Cover	X		X	X	(X)		
			Potential Upland Nature Preserve	X		X	X	(X)		
		Brook Park Landfill	Future Industrial Site	X		X	X	(X)		
	Industrial/ Commercial Property Redevelopment	Ditchman Proposal (General Chemical and Other Sites)	Future Industrial or Commercial Sites	X		X	X	(X)		
	Vacant Property Rehabilitation	City/County Vacant Land Reclamation	Site Use Not Defined	X		X	X	(X)		
Construction Material	Construction Aggregate	Unrestricted	Site Use Not Defined	X		X				
	Fill / Topsoil	Unrestricted	Site Use Not Defined	X		X		(X)		

Notes: (X) means possible permit required depending on final project design. An ODNR shore structure permit is not required for Federal projects.

2. **Placement of dredged material onto lands under State jurisdiction.** If newly dredged sediments or dredged material is removed from a permitted CDF and placed in an upland environment, the permitting authority under the CWA may not be valid or no longer exist. When dredged material placement is not in waters of the United States and does not result in discharge or return flow of effluent or surface runoff

directly into U.S. waters, then the placement of dredged material for beneficial use may be regulated solely under State requirements for reuse of solid wastes or other regulations so promulgated by State law. These are described in more detail below.

Dredged material management alternatives fall into four categories that are determined by sediment quality:

- Open Water – aquatic placement. Regulated by CWA.
- Upland – Unrestricted Soil. Exempted by RCRA or other State authorities.
- Upland – Regulated Soil. Regulated by RCRA or other State authorities.
- Impaired – requiring confined disposal. Regulated under CWA if permitted under 404/401 or RCRA if not permitted under 404/401.

8.3 Authorities for Implementing Beneficial Use of Dredged Material

Section 1135, WRDA 1986 (PL 99-662), as amended by Section 202 of WRDA 1992 and Section 204 of WRDA 1996: Project Modifications for Improvement of Environment. This provides USACE authority to modify structures and operations of existing USACE Civil Works projects to improve the quality of the environment in the public interest as long as the following conditions are met:

- Modifications must be feasible and consistent with authorized project purposes
- Non-Federal cost share of 25 percent for incremental costs is required for project implementation
- Non-Federal sponsor 100% cost to operate, maintain, repair, rehabilitate, and replace the completed project.
- Federal costs per project for such modification do not exceed $5 million

Section 1135 authority has been used for ecosystem restoration projects that use material dredged from Federal navigation projects. However, use of Section 204 described below is the more commonly used authority for implementing projects that employ dredged material for ecosystem restoration (USEPA/USACE 2007).

Section 204, WRDA 1992 (PL 102-580) as amended by Section 2037 of WRDA 2007, Section 207 of WRDA 1996 and Section 209 of WRDA 1999: Beneficial Uses of Dredged Material. This provides authorization to carry out projects in connection with dredging for constructing, operating, or maintaining USACE navigation projects to create, protect, and restore aquatic and ecologically related habitats, including wetlands. Implementation guidance as provided by CECW-P Memorandum dated April 8, 2008 (Appendix G) provides the following:

- Regional sediment management plans to identify and evaluate opportunities for beneficial uses of sediment from the construction, operation or maintenance of authorized Civil Works projects are accomplished at Federal cost;
- The purposes for the beneficial use of sediments eligible for Federal participation are structural and non-structural flood control, hurricane and storm damage reduction, and environmental protection and restoration. Cost sharing for the incremental costs to achieve these purposes is established by Section 103 of the Water Resources Development Act of 1986, as amended;
- The 75-percent Federal and 25-percent non-Federal cost sharing for beneficial use of sediments for the protection, restoration and creation of aquatic habitats and "Section 207" projects is replaced by 65-percent Federal and 35-percent non-Federal cost sharing;
- Except for "Section 207" projects, beneficial use projects implemented under the authority of Section 204 are limited to $5 million total Federal cost;
- The U.S. Army Corps of Engineers can, at Federal cost, cooperate with any State in the preparation of a comprehensive State or regional sediment management plan and measures and projects identified in State and regional plans may be recommended to Congress for authorization;
- Projects for the purposes of protection, restoration, or creation of aquatic and ecologically related habitat, the costs of which do not exceed $750,000 and which are located in a disadvantaged community, may be carried out at Federal expense.

WRDA 2007 provides additional amendments to these authorities as described in the Implementation Guidance for Sec 2037 (CECW-P Memorandum dated Apr 8, 2008) provided in Appendix G Beneficial use projects may also be carried out under Operations and Maintenance authority if costs do not exceed the Federal Standard or are implemented in conjunction with other cost-shared authorities.

Other regulatory authorities exist with agencies that have permitting requirements for beneficial use projects, including State resource agencies. These may include:

- U.S. National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency
- State Fish and Game Agencies
- State Water Quality Certifying Agencies
- State Coastal Zone Management Agencies
- Other Federal and State Agencies

8.4 State Authorities and Permitting Applicable to the State of Ohio

The primary permit requirements for the beneficial use of dredged material in the State of Ohio reside within State authorities for resource conservation, water quality protection, and solid waste management.

8.4.1 Material Management Plan (MMP)

Ohio EPA requires the authorization of transportation of dredged materials from lakeshore CDFs or other material handling facilities for use at upland placement sites under its solid waste authority. A material management plan (MMP) describes the handling, management, and end use of dredged material documenting that the proposed beneficial use will be protective of human health and the environment and maximizes the beneficial reuse potential of the dredged material. The MMP includes a description of both the site at which dredged material is prepared for transportation, locations where additional material handling may be required, and the final placement site. The MMP defines the processes to be implemented for tracking and documentation of material movement from the source area and receipt at the placement site.

8.4.2 Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES)

An NPDES general permit is required at the placement site for management of stormwater associated with the major earthwork required for dredged material reuse. Associated with the MMP are a Notice of Intent (NOI) and Stormwater Pollution Prevention Plan (SW3P). The objective of this SWP3 is to comply with the requirements listed in Part III of the (NPDES) General Permit No. OHC000003 for Stormwater Discharges Associated with Construction Activity as regulated by the OEPA. The NPDES permit identifies potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharges from the beneficial use construction site. The SW3P describes the practices and ensures the implementation of practices that will be used to reduce the pollutants in stormwater discharges at the construction site and assure compliance with the terms and conditions of the general permit, ORC 6111.04, and OAC 3745-38-06.

8.4.3 Clean Water Act (CWA) 401 Water Quality Certification

Pursuant to the Federal CWA, discharge of dredged or fill material into waters of the United States under Section 404 requires a Section 401 Water Quality Certification (WQC) from the State of Ohio. Return flow of dredged water from material handling facilities located at the waterfront CDFs or adjacent to the Cuyahoga River navigation channel will require a 404 permit from the USACE and 401 certification from OEPA. For habitat restoration projects, any discharges of fill to isolated wetlands not considered to be waters of the United States by a jurisdictional determination are regulated by Ohio Revised Code (ORC) 6111.028. The discharge of dredged material into isolated wetlands is subject to OEPA 401 permit requirements. Water quality certifications from the OEPA often require 6 months to 1 year to be issued.

8.4.4 Coastal Zone Management Act (CZMA) Coastal Zone Consistency Review

The Federal Coastal Zone Management Act requires that Federal actions reasonably likely to affect any land or water use or natural resource of the coastal zone, including beneficial use projects, be consistent with approved State coastal management programs.

Federal actions requiring a CZMA review include:

- Federal agency activities and development projects;
- Private applicant activities that require Federal licenses, permits or other forms of approval;

- State and local government activities conducted with Federal assistance.

The term Federal “development project" means a Federal agency activity involving the planning, construction, modification, or removal of public works, facilities, or other structures, and includes the acquisition, use, or disposal of any coastal use or resource. On behalf of the State, ODNR informs the USACE of its agreement or disagreement with the consistency determination within 60 days from receipt of the determination and necessary information. A coastal zone consistency review would be required for placement of dredged material or fill material for wetland habitat restoration projects, construction of breakwaters or erosion control devices, beach replenishment, or alteration of navigable waters.

8.4.5 Ohio Coastal Management Shore Structures Permit

Ohio Revised Code 1506 requires Shore Structure Permits for compliance with all applicable State regulations (including Submerged Lands Leasing) when shore structures are constructed. Shore structures include placement of sand for beach nourishment and dune construction as well as construction of breakwaters, groins, revetments, bulkheads, and jetties. Shore Structure Permits can be issued within 120 days provided the ODNR has the required information for issuing permits; however, delays frequently occur because the application received is not complete or all applicable State regulations are not complied with. An Ohio Shore Structure Permit is not required for Federal projects; however, the information typically required for a Shore Structure Permit is generated through the Federal project design and review process.

9 Screening Level Cost Analysis for Dredged Material Handling and Management Options

9.1 Background

Chapter 7 describes five material handling facility alternatives, located at four separate sites, and a strategy for long-term dredged material management using mechanical placement at the Cleveland Harbor CDFs. This chapter contains a screening-level cost analysis of the material handling and stockpile facilities (MHSFs) presented in Chapter 7. The analysis was performed by Buffalo District personnel, including a summary table (Appendix 9A) and supporting information (Appendicies 9B through 9E), and sent to ERDC (Farrell 2011) for inclusion in this report. This chapter contains the Buffalo District cost analysis summary, a description of the summary line items, an analysis and discussion of the cost estimates, and a discussion of assumptions and uncertainties in the analysis and resulting cost estimates. The assumptions and results of the Buffalo District cost analysis were also utilized to generate a screening-level cost estimate for the long-term dredged material management strategy put forth in Section 7.6.

9.2 Methodology

At the time of this report, the material handling facility alternatives investigated in this study will serve two probable beneficial use projects: the Silver Oaks Landfill and the Brook Park Landfill. It is estimated that 650,000 CY of in-situ material can be used at these sites. Capital costs for MHSFs have been divided over this estimated beneficial use volume This result was then combined with unit costs to create a consistent, straightforward screening-level cost estimate to evaluate the cost implications of each MHSF conceptual design and to be able to compare them with non-USACE-furnished options. The approach of applying an equal volume and time period to all MHSF alternatives was intended to avoid the complications of discounts/markups for CDF capacity replacement costs ($54.65/CY to extend CDF 10B, Appendix 9F) and the amortization of capital costs over different time periods; consideration of these factors are appropriate for a planning-level effort.

9.3 Buffalo District cost analysis

Three alternatives were put forth by ERDC for comparison to non-USACE-furnished MHSF proposals:

- The Upper River site (outlined in Section 7.3)
- Mechanical offloading at the existing CDF (outlined in Section 7.2.2)
- Hydraulic offloading at the existing CDF (outlined in Section 7.2.3)

ERDC generated a conceptual design for the Upper River site, and a screening-level cost estimate was developed by the Buffalo District cost engineering section. Appendicies 9B and 9C detail the design features and associated costs for the Upper River site cost estimates for the 12- and 25-acre options, respectively. Since real estate acquisition costs were a significant facet of the Upper River site design, the question of converting the Cleveland Harbor CDFs into an MHSF was raised. Costs were therefore estimated for the conceptual mechanical (Section 7.2.2) and hydraulic (Section 7.2.3) offloading scenarios. Detailed conceptual design and cost data for the CDF hydraulic and mechanical offloading alternatives can be found in Appendixes 9D and 9E, respectively.

Two non-USACE furnished MHSF proposals were submitted to the District:

- CVIC Site with Mechanical Off-Loading (outlined in Section 7.4)
- Zaclon Properties Site with Hydraulic Offloading (outlined in Section 7.5)

Non-USACE-furnished MHSF proposals did not possess the transparency of the Buffalo District-generated screening-level cost analyses due to the proprietary nature of private industry. Buffalo District personnel utilized all available details provided by non-USACE parties to generate cost estimates that were compatible with the assumptions in the government-furnished analyses, modifying some values (e.g., dredging costs per cubic yard) that could have a range of reasonable assumed values in order that the alternatives would have a consistent basis. Table 9-1, reproduced from Appendix 9A, contains a summary of the Buffalo District screening-level cost analysis. Cost line items, results, and assumptions are described in subsequent sections.

Table 9-1. Summary of the Buffalo District screening level cost analysis

Cost Categories	Cost Item	Pershing Ave. Site (CVIC) (costs from John Hull) Unit Cost per CY*	Zaclon Property	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY* Option 1 12 Acre Site	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY* Option 2 25 Acre Site	Waterfront CDF (LRB Cost Estimate) Unit Cost per CY* Option 3 Hydraulic Placement	Waterfront CDF (LRB Cost Estimate) Unit Cost per CY* Option 4 Mechanical Placement
		Brook Park & Silver Oaks		Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks
Material Handling	LEERDs (includes RE Acquisition)	$3.50	**	$0.71	$1.49	$0.00	$0.00
Material Handling	Site Preparation	$4.30	**	$1.33	$1.64	$0.73	$2.27
Material Handling	Transport to Site	$7.10	**	$4.03	$4.03	$0.00	$4.03
Material Handling	Material Handling, Drying	$2.25	**	$4.02	$4.02	$5.78	$4.02
Material Handling	Transport to End Use (Silver Oaks or Brook Park)***	$9.16	**	$9.16	$9.16	$10.20	$10.20
Material Handling	Permitting & Regulatory	$1.80	**	$0.35	$0.38	$0.38	$0.38
	TOTAL MH	$28.11	$42.00**	$19.60	$20.72	$17.09	$20.90
Dredging	Dredging	$7.00	$11.17	$7.00	$7.00	$11.17	$7.65
	TOTAL MH & DREDGING	$35.11	$53.17	$26.60	$27.72	$28.26	$28.55
Project Management, Engineering & Design, Supervision & Administration	Project Management, Engineering & Design, Supervision & Administration	N/A	N/A	$1.38	$1.38	$1.38	$1.38
Contingency	Contingency	$0.00	N/A (No Costs Provided by Joe Ditchman)	$3.42	$3.50	$3.32	$4.83
	TOTAL CY COST	$35.11	$53.17	$31.41	$32.60	$32.96	$34.76

Table 9-1. Summary of the Buffalo District screening level cost analysis (continued).

Cost Categories	Cost Item	Pershing Ave. Site (CVIC) (costs from John Hull) Unit Cost per CY*	Zaclon Property	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY* Option 1 12 Acre Site	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY* Option 2 25 Acre Site	Waterfront CDF (LRB Cost Estimate) Unit Cost per CY* Option 3 Hydraulic Placement	Waterfront CDF (LRB Cost Estimate) Unit Cost per CY* Option 4 Mechanical Placement
		Brook Park & Silver Oaks		Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks
	Notes	Cost estimates for LEERDs (Airspace), Site Prep, Transport to Site, Material Handling, and Permitting provided by John Hull (Hull & Associates).	**Unverified cost supplied by site representative, Joe Ditchman, includes receipt of hydraulically dredged material, dewatering/processing, and truck transport to end use. Implementing this concept as early as 2012 is highly suspect due to ownership and remediation issues. As dredging costs were not originally included with overall cost, unit costs for dredging with hydraulic pump-out were added to be consistent with other alternatives evaluated.	Costs for 12-acre site option.	Costs for 25-acre site option.	Costs estimated for material handling at existing CDF. Wick drains included to accelerate dewatering of the dredged material; however, uncertainty exists regarding dewatering time.	Costs estimated for material handling at existing CDF.
		Transportation costs to End Use added by LRB to be consistent with costs estimated for other alternatives.		Due to site size constraints, implementation ability of this option may be limited due to volumetric restrictions.	Due to site size constraints, implementation ability of this option may be limited due to volumetric restrictions.	Costs for Hydraulic Placement and Material Handling. Implementability of hydraulic placement option in 2012 is unlikely due to dewatering time requirements.	Costs for Mechanical Placement and Material Handling.
		*Costs were averaged over 650,000 CY, or approximately 3 years of dredging **See "Notes" section for Zaclon Property ***Weighted costs developed for transportation to end-use site. A total of 450,000 CY to Brook Park and 250,000 CY to Silver Oaks was assumed. The following formula was used in determining the transportation costs: ((450,000 CY * Transportation cost for Brooke Park) + (200,000 CY * Transportation cost for Silver Oaks))/ 650,000 CY					

9.4 Discussion of Screening Level Cost Analysis and Results

9.4.1 Cost items

9.4.1.1 Line Item 1: Lands, Easements, Rights of Way and Disposal Sites

Lands, Easements, Rights of Way and Disposal sites (LEERDs) is a capital cost line item and it includes real estate acquisition costs where applicable. Appendix A summarizes site-specific assumptions. There are no anticipated LEERDs costs for the CDF material handling alternatives. LEERDs for the Upper River site fell between that of the CDFs and the CVIC site, with the 25-acre Upper River site approximately twice the cost per cubic yard than the 12-acre site. LEERDs for the CVIC site were furnished by Hull and Associates.

9.4.1.2 Site Preparation

Site preparation is a capital cost line item that was divided by the expected beneficial use volume of 650,000 CY. The highest site preparation costs were obtained for the CVIC site; lowest were obtained for the hydraulic offloading at the CDF (Table 9-1). Few site improvements were necessary to the CDFs for the hydraulic offloading alternative since that is the current mode of operation. Haul roads and staging areas for truck transport are examples of site improvements required for this option. The cost for site preparation at the CVIC site was provided by Hull and Associates. The estimate includes construction of a mechanical offloading facility, haul road construction, and site improvements similar to the Upper River site. Since no contingency (cost line item 9) is listed by Hull and Associates, it is possible that contingency costs were built into the site preparation costs, resulting in the highest site preparation cost of the five alternatives costed. Site preparation considerations for the Upper River site included grubbing and grading the site, installing confinement and runoff control berms and silt fences, improving a haul road, and constructing a work pad for mechanical offloading of sediments. Site preparation cost for mechanical offloading at the CDF is higher than that of the Upper River site due to the requirement for a more complex, in-water dock facility for unloading barges and the construction of a haul road that must traverse a steep grade at the CDF.

9.4.1.3 Transport to Site

This unit cost line item accounts for the cost of moving sediment from the scows at the mechanical offloading facility to the MHSFs for drying and reworking. Transport costs include costs for scow offloading, truck loading and offloading, and haul distance. Estimates for the Upper River site and the mechanical placement alternative at the CDF are the same due to the extremely short haul distance required. An increased haul distance is associated with the CVIC site alternative. As for CVIC site preparation costs, it is unknown if contingency is built into these non-USACE-furnished line items, which may have contributed to the higher transport cost for this alternative.

9.4.1.4 Material Handling, Drying

This unit cost line item summarizes various activities at each proposed site that dewater dredged material prior to transport and placement at a beneficial use site. The government-furnished estimates are the same; they include disking and turning over the sediment, forming it into stockpiles at the MHSF site, and loading into sealed dump trucks. The lower cost estimate provided by Hull and Associates is proprietary; no specifics were provided that would permit an evaluation of the comparative material handling costs for this alternative.

Highest cost was obtained for the hydraulic offloading MHSF alternative at the CDFs, which is due to the uncertainty in drying rates following hydraulic placement (see also Section 7.2.3). This uncertainty could directly affect the feasibility of this MHSF alternative; dewatering delays could result in exhaustion of CDF capacity before material was sufficiently dry to be removed from the facility. Therefore, conservative assumptions (i.e., high cost) were necessary to reasonably assure that this placement option was viable. The annual deployment of wick drains (at $1.15 per linear foot, installed) placed on a 10 ft by 10 ft grid for rapid dewatering was included in this cost line item for the hydraulic placement of material at the CDF.

9.4.1.5 Transport to End Use (Silver Oaks or Brook Park)

As indicated in the footnotes to Table 9-1, a weighting methodology was applied to this unit cost line to take into account the haul distances from the various proposed MHSF sites and the estimated volumes of material headed to each beneficial use site. The footnote states:

*"*Weighted costs developed for transportation to end-use site. A total of 450,000 CY to Brook Park and 250,000 CY to Silver Oaks was assumed. The following formula was used in determining the transportation costs:*

*((450,000 CY * Transportation cost for Brook Park) + (200,000 CY * Transportation cost for Silver Oaks))/ 650,000 CY"*

The unit transportation costs included mileage from MHSF to a beneficial use site, the number of truckloads necessary for material transport, etc. The results for the Upper River site were applied to the CVIC site in the screening cost analysis due to the lack of such costs in the non-USACE-furnished proposal, and the proximity of the two sites. The CDF MHSF alternatives have a higher transport cost since they are located adjacent to Lake Erie, making them substantially farther from the Silver Oaks Landfill (one of the motivating factors in undertaking this study) and slightly closer to the Brook Park Landfill (not a known opportunity at the beginning of this study).

9.4.1.6 Permitting and Regulatory

Permitting costs, including National Environmental Protection Act and Clean Water Act (Section 401 and possibly 404b) permits are necessary for the MHFS alternatives. Similar permitting costs are assumed for the Upper River and CDF sites, although there are existing 401 and 404b permits at the CDFs that may need only modification or may remain valid; thus these costs could prove to be lower. The CVIC permitting cost is notably higher than that of the other sites. As for the other line items associated with this non-USACE-furnished estimate, it is unknown if contingency was built into the unit cost.

9.4.1.7 Summary of Line Items 1 thru 6: Material Handling Cost Categories

Costs for the Upper River site and the two MHFS alternatives at the Cleveland Harbor CDFs were generated by Buffalo District personnel based on conceptual designs. Information for five of the six line items was provided by Hull and Associates to aide in a consistent cost comparison of MHSF alternatives. A cost of $42/CY was given by Ditchman Holdings, LLLP, for the Zachlon property, without any supporting cost detail. Unit cost for the material handling cost categories for the other alternatives were:

- $28.11/CY (CVIC site)
- $19.60/CY (Upper River site - 12 acres)
- $20.72/CY (Upper River site - 25 acres)
- $17.09/CY (hydraulic offloading at the CDF)
- $20.90/CY (mechanical offloading at the CDF)

9.4.2 Cost Item 2: Dredging Costs

The unit costs of mechanical dredging and barge transport to the offloading sites were combined in this line item. The increase in per yard cost due to barging material downriver is clearly illustrated in the difference between the cost of the mechanically offloaded MHSF at the CDFs and the upriver mechanically offloaded alternatives. The additional $3.52/CY cost of hydraulic placement at the CDFs is due to the associated mobilization, hydraulic offloading of scows and demobilization costs. The proposal for an MHSF at the Zaclon site includes USACE delivery of hydraulically placed material. While the dredging cost could be estimated to be lower than the hydraulic placement option for the CDFs, the same unit cost was used to account for the significant uncertainty surrounding the capability of the Zaclon site to accept the large volumes of sediment and water from hydraulic offloading in an efficient manner.

9.4.3 Cost Item 3: Project Management, Engineering & Design, Supervision & Administration

A flat capital cost was assumed for Buffalo District-generated estimates using $900,000/650,000 CY, resulting in a unit cost of $1.38/CY. This cost item was not broken out in the two non-USACE-furnished proposals, which may need to be adjusted for this factor. That could not be determined, however, due to the proprietary nature of the cost estimates.

9.4.4 Cost Item 4: Contingency

Buffalo District personnel generated contingency estimates by conducting a cost risk analysis for the conceptual designs of the Upper River and CDF MHSFs. The contingency capital cost resulting from the analysis was then divided by the 650,000 CY beneficial use volume to generate the unit costs given in Table 9-1. The notably increased contingency cost for the mechanical placement CDF MHSF alternative is due to the complex engineering requirements of the in-water offloading platform and staging area there. Since no dock design was performed, a broad assumption was made regarding the cost for construction of an offloading facility. Since the level of effort for design was expected to be significant, the cost risk resulted in a larger capital cost than a more standard, on-land offloading facility.

9.5 Total CY cost

The total cost per cubic yard for the MHSF alternatives in Table 9-1 shows that the Zaclon site has a significantly higher cost than other options. Given the assumptions used in the screening-level cost analysis and the uncertainty associated with all of the alternatives, the other MHSF alternatives can be considered comparable to each other at first glance. Further consideration of key assumptions is necessary to discriminate between these alternatives on the basis of cost.

A potential source of inaccuracy in the screening-level approach undertaken here pertains to potential processing and stockpiling limitations at the smaller material handling sites. It may not be possible to receive, process, and send out the selected volume of dredged material in the same amount of time as anticipated at the larger sites; further, if material is not removed at the expected rate, processing will cease when stockpiling capacity is exhausted. Capital costs have been normalized assuming 650,000 CY of dredged material processed over a 3-year period. As a result, cost estimates for the smaller sites will have been underestimated if they are not able to meet this processing timeline. Dredged material volumes that exceed the processing capacity of these small material handling sites would have to be disposed in the CDF, using hydraulic offloading (mechanical offloading operations at the CDF and alternate MHSF sites were considered mutually exclusive in this analysis). As hydraulic disposal cannot be sustained in the CDF, expansion or replacement of the CDF would ultimately be required. The timeline for this is difficult to predict, however, given the uncertainty of actual processing capacity at the respective sites. This information is needed in order to perform a more detailed assessment of the impact on total project cost, which also requires consideration of CDF capacity replacement costs, markups, and amortizations that are beyond the scope of this study. While it is not technically correct to simply normalize costs based on dredging volume and then directly compare the resulting unit costs, given that the most significant difference between the alternatives involves whether or not the CDF would need to be expanded or replaced, these simplifying assumptions appear to be sufficient for the purpose of screening out infeasible alternatives.

Chapter 7 noted that the assumed dredged material handling volume for the 12-acre and 25-acre Upper River MHSF alternatives is 40,000 CY and 80,000 CY, respectively. The assumed volume of the CVIC MHSF is 150,000 CY. Unfortunately, how capital costs were normalized or amortized for the CVIC site is not known. Thus, the following screening analysis cannot be applied to the CVIC alternative. Capital costs were re-normalized using volumes of material that are more representative of the expected capacities of Upper River sites, under two scenarios:

- The MHSF can dry sediments adequately for removal and beneficial use before the second round of dredging in a year, thus passing through two site volumes in a dredging year,
- The MHSF requires an entire year to dewater sediment adequately for removal and beneficial use, thus passing through one site volume in a dredging year.

These scenarios were then applied for 3 years so that they would be comparable (though not completely consistent) with cost estimates in Table 9-1 (to facilitate comparisons). For example, under the two site volume per year scenario for the 25-acre site, a capital cost would be normalized by:

$$\frac{Capital\,Cost}{80{,}000\,\frac{cubic\,yards}{site\,volume}\times 2\,\frac{site\,volumes}{year}\times 3\,years}$$

Similarly, the capital cost for the 12-acre site under the one site volume per year scenario would be:

$$\frac{Capital\,Cost}{40{,}000\,\frac{cubic\,yards}{site\,volume}\times 1\,\frac{site\,volumes}{year}\times 3\,years}$$

Table 9-2 shows that costs are likely prohibitively higher for the 12-acre alternative for both scenarios and for the 25-acre, one site volume per year alternative. The value of $35.45/yd for the 25-acre, two site volume of dewatered material per year alternative is within the range of other MHSF estimates given the level of uncertainty present; therefore, it is not considered to be screened out by this analysis. Table 9-2 also shows that the larger site enjoys increasing economies of scale for the two capacity/year scenario, an intuitive principle that was not observed in the unadjusted analysis. However, it should be emphasized that these costs are dependent upon the material being removed from the site so that processing can continue at the assumed rate. If there are delays in removing the processed material from the site, additional cost will likely be associated with expansion or replacement of the CDF because storage capacity will continue to be

Table 9-2 contains the results of this analysis, with modified normalized capital costs (highlighted in light blue).

Cost Categories	Cost Item	Two Site Volumes per Year		One Site Volumes per Year	
		Upper River Parcel (LRB Cost Estimate) Unit Cost per CY Option 1 12 Acre Site	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY Option 2 25 Acre Site	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY Option 1 12 Acre Site	Upper River Parcel (LRB Cost Estimate) Unit Cost per CY Option 2 25 Acre Site
		Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks	Brook Park & Silver Oaks
Material Handling	LERRDs (includes RE Acquisition)	$1.94	$2.02	$3.87	$4.03
Material Handling	Site Preparation	$3.60	$2.23	$7.19	$4.45
Material Handling	Transport to Site	$4.03	$4.03	$4.03	$4.03
Material Handling	Material Handling, Drying	$4.02	$4.02	$4.02	$4.02
Material Handling	Transport to End Use (Silver Oaks or Brook Park)*	$9.16	$9.16	$9.16	$9.16
Material Handling	Permitting & Regulatory	$0.35	$0.38	$0.35	$0.38
	TOTAL MH	$23.09	$21.83	$28.62	$26.07
Dredging	Dredging	$7.00	$7.00	$7.00	$7.00
	TOTAL MH & DREDGING	$30.09	$28.83	$35.62	$33.07
Project Management, Engineering & Design, Supervision & Administration	Project Management, Engineering & Design, Supervision & Administration	$3.75	$1.88	$7.50	$3.75
Contingency	Contingency	$9.27	$4.74	$18.55	$9.49
	TOTAL CY COST	$43.11	$35.45	$61.67	$46.31

consumed there in the interim. Further, what the analysis does not reflect is the relative period of time before the CDF must be replaced for each alternative; the longer this eventuality can be delayed, the lower the contribution to present value unit costs. A more detailed present worth analysis would verify these findings; however, preliminary calculations suggest that the rankings will not differ from the resulting rankings reported here.

9.6 Long-term material management by stacking cost analysis

A strategy for the long-term management of dredged material at the Cleveland Harbor CDFs that may significantly extend the life of the facilities has been sent to the Buffalo District (Borrowman 2011) and detailed in Chapter 7 (7.6). The generation of a screening-level cost estimate for this management strategy is difficult due to the extended life of the facility. The complexity of the analysis increases if one of the CDF MHSF alternatives is chosen due to sunk capital costs, an uncertain lifespan based due to uncertain beneficial use demand. Similarly, CDF MHSF costs could be discounted for extending the life of the CDF. These are, however, planning-level considerations that are beyond the scope of this effort. It was decided that the most straightforward means of generating a cost estimate for the long-term material management strategy would be the modification of the CDF MHSF with mechanical offloading. This would also allow for direct comparison to the MHSF cost estimates in Tables 9-1 and 9-2.

The cost per yard of the mechanical placement at the CDFs MHSF alternative ($34.76/CY) was modified by subtracting out the transport cost to a beneficial use site ($10.20/CY) to generate a conservative estimate of the dredging, mechanical offloading, and material handling and stockpiling costs per CY($24.56/yd) for the long-term dredged material management strategy for the CDFs. Several factors are expected to lead to a lower cost estimate when a cost analysis beyond screening level is performed:

- The unit cost (normalized to total dredging volume) of capital improvements (wharf, haul roads, crane staging area, etc) would be significantly reduced when normalized over the volume of dredged material that the CDFs will handle with extended storage capability from stacking (estimates range from 2022 to 2028 in Chapter 7)
- The extended life of the CDFs defers the large capital investment required for creation of new storage space (e.g., the proposed CDF 10B

extension at ~$54 million, Appendix 9F), which would lead to a discount in cost
- Contingencies will be significantly reduced following design and standardization of new operating modes

Additional cost savings from sunk costs from capital investment for the MHSF alternatives at the CDF would also be realized if one of those options is selected and constructed.

9.7 Conclusions

The relative alternative costs will vary somewhat with assumed total dredging volume and planning period, which would in turn determine at what point in time the CDF would have to be replaced. Assuming sufficient beneficial use opportunities to utilize a volume of dredged material equal to the amount dredged annually (on average), mechanical offloading and "stacking" at the existing CDF offers potentially the longest life of the facility. While the Upper River processing sites could be used indefinitely, because their capacity is limited (even if beneficial use opportunities are available to utilize all the material that was produced at these sites annually), some CDF capacity would continue to be needed to receive the excess. For this material, as well as for the hydraulic offloading alternative at the CDF, cycling through the cells and extended drying times complicate the material recovery operation, even if sufficient beneficial use demand exists to accept all the material. Because the CDFs are so near the end of their useful lives, small incremental decreases in permanent storage will gradually impair the water handling capability of the facility.

Mechanical offloading at the CDF largely avoids these issues and has the unique benefit of sharing the largest capital costs with the long-term material management strategy. Further, although the hydraulic offloading operation at the existing CDF appears to offer the lowest unit cost of all the alternatives, replacement of the CDF is then a near-term certainty, at an upfront cost that the federal and non-federal sponsors may be unable to support. The analysis conducted here should be confirmed with a more detailed, follow-up present value analysis, but it is expected that such an analysis will serve only to refine these findings, not change the relative cost rankings or the preferred alternative.

10 Selection of Short-term Beneficial Use Alternatives

A set of preliminary threshold criteria were used for initial screening of beneficial use opportunities so that the most promising beneficial use alternatives could be identified, while those opportunities that did not meet minimum threshold requirements could be removed from further consideration (Chapter 2). The preliminary threshold criteria included 1) capacity to use more than 50,000 CY of dredged material per project, 2) apparent compliance with Federal and State laws, 3) no evidence of previous consideration and rejection, 4) availability of information that was considered adequate for a preliminary evaluation of project feasibility. Several alternatives with inadequate information for a preliminary evaluation were reviewed as potential long-term strategies for beneficial use of dredged material (Chapter 11). Based on this initial screening, five short-term beneficial use alternatives were identified that warranted additional review and analysis. These included:

- Ditchman Brownfield Proposal for redevelopment of industrial Brownfield sites
- Extension of CDF 10B to improve airport safety
- Closure and redevelopment of Brook Park Landfill for future industrial use
- Closure of Silver Oak Landfill and site redevelopment for potential recreational use
- Beach nourishment

The selection of the best alternatives for beneficial use of sediment is a multidimensional problem requiring an evaluation of the suitability of the dredged material for the specific end use and an analysis of the potential project scope (i.e. volume of material managed), permitting requirements, schedule constraints, cost, and potential ecological and community benefits and impacts (Figure 1-2). The complexity and risks associated with executing a beneficial use project ultimately reflect the utility of the alternative, which must be weighed against the expected cost for dredged material management.

Analysis of the technical feasibility, project complexity and regulatory / schedule constraints, volume of material managed, and costs resulted in the selection of the Silver Oak landfill closure and Brook Park landfill redevelopment projects as the most feasible short-term opportunities for the beneficial use of dredged material. These two beneficial use alternatives provided the lowest cost means for managing approximately 550,000 to 700,000 CY of dredged material over a 3-year period. The review of material requirements for these landfill closures and redevelopment projects determined that the preferred method for dewatering and transport of the dredged material from the navigation channel to the sites includes mechanical offloading of barges and dewatering at the existing waterfront CDFs. This approach for material handling provides significant flexibility for year-to-year dewatering and stockpiling of dredged material between beneficial use projects, which are likely to have implementation schedules different from that of navigation channel dredging. Beneficial use of dredged material at the Silver Oak and Brook Park landfills using mechanical offloading at the existing CDFs for dewatering and material handling is estimated to cost $35/CY (Chapter 9). Mechanical offloading of barges and dewatering at the existing waterfront CDFs takes full advantage of the available volume at the CDFs due to minimal ponding requirements. In addition, capital improvement costs of the mechanical offloading and handing facility can be amortized over a significantly longer time frame than other rehandling facility alternatives due to the large increase in effective storage capacity. This is expected to result in a significantly lowered cost for the CDF mechanical offloading alternative in a planning-level economic analysis.

10.1 Description of Beneficial Use Alternatives

The following sections provide a description and analysis of the relative feasibility of the five alternatives initially identified in Chapter 2 as being potentially viable. Table 10-1 highlights the information used for identifying the low-cost beneficial use alternatives that are technically feasible and most implementable.

10.1.1 Ditchman Brownfield Proposal

An unsolicited proposal was received from Joseph P. Ditchman, Jr. (Ditchman Holdings, LLLP) to provide dredged material dewatering and material handling at 2981 Independence Rd., followed by transport and placement at several industrial Brownfield sites in Cuyahoga County. The

Table 10-1. Identifying low-cost beneficial use alternatives that are technically feasible and most implementable

Criterion	Short-term Beneficial Use Alternatives				
	Ditchman Brownfield Industrial Development	Brook Park Landfill Industrial Development	Silver Oak Landfill w/ Habitat Restoration	CDF 10B Extension	Beach Nourishment
Primary Screening Criteria					
Meets Federal/State Requirements	Yes	Yes	Yes	Yes	No
Protects Human Health	Yes	Yes	Yes	Yes	Yes
Protects Ecological Receptors	Yes	Yes	Yes	Yes	Yes
Meets Engineering Suitability Requirements	Yes	Yes	Yes	Yes	No
Implementation Factors					
Legal/Property Complexity (LERRs)[1]	Complex 10-year private PPA required with fixed minimum annual volume and unit price Real estate transaction requires OEPA VAP status	Not Complex Property owned by City	Average Private land owner Under CCBH legal review for enforcement action	Not Complex Public submerged land ownership	NA[3]
Project Mgmt/Execution Complexity	Complex Real estate transactions with multiple third parties required Public/Private financing required for LERRs and capital improvements Requires complex mechanical material handling system design & construction Requires placement site engineering design	Average Requires placement site investigation & engineering design	Average Requires placement site investigation & engineering design	Average Requires CDF engineering design	NA
Permitting Complexity	Complex Existing RCRA facility investigation (RFI) 401 and RCRA/NPDES water discharges at same site NEPA/404/401 MMP/NPDES	Average NEPA/404/401 MMP/NPDES Coastal zone review /Structures permit (possible)	Average Landfill permit modifications for closure anticipated NEPA/404/401 permitting Coastal zone review /Structures permit (possible)	Average NEPA/404/401 permitting Coastal zone review /Structures permit (possible)	NA

Table 10-1. Identifying low-cost beneficial use alternatives that are technically feasible and most implementable (continued).

Criterion	Short-term Beneficial Use Alternatives				
	Ditchman Brownfield Industrial Development	Brook Park Landfill Industrial Development	Silver Oak Landfill w/ Habitat Restoration	CDF 10B Extension	Beach Nourishment
Schedule Uncertainty	Complex Contingent on City receipt of Clean Ohio Fund Brownfield or other grants Contingent on multi-party real estate transactions that have environmental impairments	Average Site engineering and planning required	Average Resolution of LERRs may require CCBH regulatory enforcement Site engineering and planning required	Average Site engineering and planning required	NA
Ecological Benefits	Average Potential creek bank restoration	Average Potential creek bank restoration	Above Average Potential vernal pool/upland habitat restoration	Below Average Industrial development of aquatic submerged lands	NA
Public/Stakeholder Support	Unknown Public Support State, County, and MetroPark interest in Mill Creek recreational development	Unknown Public Support City interest in industrial redevelopment of landfill property	Unknown Public Support State and County interest in landfill closure	Unknown Public Support Burke Waterfront Airport interest in extending land adjacent to runways	NA
Volume managed	~3,000,000	350,000-500,000	~200,000	~1,000,000	NA
Unit Cost (CY)	$53	$33 to $35[2]	$33 to $35[2]	$55	NA
Beneficial Use Alternative Ranking					
Cost	High Cost	Low cost	Low Cost	High Cost	NA
Overall Utility	Low Utility Highly complex PPA, LERRs and capital financing requirement Large schedule uncertainty ~ 12 years of capacity at high cost	High Utility Low complexity PPA and LERR requirement ~2 years of beneficial use capacity at low cost Average schedule uncertainty	High Utility Modest complexity PPA and LERR requirement ~1 year of beneficial use capacity at low cost Average schedule uncertainty	Medium Utility Low complexity PPA and LERR requirement ~4 years of beneficial use capacity at high cost Low schedule uncertainty	NA

[1] (LEERS) lands, easements, rights-of-way, and relocations

[2] Range in cost per cubic yard reflects alternate material handling operations

[3]Not evaluated due to failure to meet primary screening criteria.

industrial Brownfield sites include 3201 Independence Ave. and/or the General Chemical site located at 5000 Warner Road. These sites would be redeveloped by Ditchman Holdings for use as future office, manufacturing, and warehouse type facilities (Figure 2-2).

A 25-acre parcel currently owned by Zaclon LLC (2981 Independence Road, Figure 7-4) would be used for dredged material dewatering and handling. The conceptual plan prepared by Mr. Ditchman includes design of a mechanical dewatering system and construction of a material handling facility for receipt of hydraulically delivered dredged material at the turning basin docks. Material handling at the site is envisioned to include mechanical dewatering using hydrocyclones, gravity drainage, and treatment of dredged water return flows. Sediment would be loaded onto trucks or railcars for transport offsite. The property has access to I-77 and I-490 rail sidings, and access to the adjacent navigation channel Turning Basin. The 3201 Independence Ave. Brownfield industrial redevelopment site covers approximately 11 acres and is located 1.3 miles from the Zaclon site. The General Chemical Brownfield site is a 54-acre parcel that is 5.2 miles from the Zaclon Site property. The concept provided by Mr. Ditchman includes placement of a minimum of 225,000 CY of dredged material per year for 10 years or more at these and other sites, providing an estimated capacity for managing dredged material greater than 3 million CY. The USACE has not reviewed the engineering feasibility of the dewatering, material handling, and transportation plans proposed by Ditchman Holdings.

Use of dredged material as surface soils at these Brownfield sites will not result in unacceptable risk to humans if the sites are redeveloped for future commercial and industrial use (as determined in the ecological and human health risk evaluation and the tiered pathway analysis contained in previous chapters). Some potential exists for realizing ecological and recreational benefits associated with the General Chemical Brownfield site. Mill Creek runs through Bacci Park near the General Chemical property. Cleveland MetroParks has received grants through the Ohio Scenic Byways Program supporting construction of a recreational trail that will pass through the General Chemical parcel. Since 2006, MetroParks has worked directly with General Chemical and/or third parties to secure an easement through the General Chemical property for the trail. Dredged material used for redevelopment of the site will be suitable for upland habitat restoration surrounding the creek and will not pose unacceptable risk to wildlife. Unacceptable risks to recreational users of a walking trail system are unlikely, but this will need to be reviewed as the land use plans for the project are developed. The contaminants in the dredged material posing the greatest risk to human health may be lower in concentration than the urban background concentrations present in native soils surrounding Mill Creek. Further, engineering controls could potentially be utilized to minimize exposure and risk associated with materials containing contaminants of concern. Placement of more contaminated materials as subsurface layers, which would then be covered with cleaner materials, is one potential applicable control. In addition, use of dredged material to produce quality vegetative cover of low-growing turf grass is achievable and reduces exposure to direct contact as well as reducing soil erosion and contaminant discharges from lesser quality Brownfield soils.

Although the dredged material is expected to meet Federal and State requirements for beneficial use at these Brownfield sites, the Zaclon site redevelopment will require coordination with ongoing RCRA regulatory actions and site remediation under the Ohio VAP program. The 404/401 permitting for the discharge of dredged water to the River may be complicated by potential NPDES permit requirements associated with site remediation. The Zaclon property is zoned for unrestricted industry use, which means virtually any type of heavy constructtion and material transport can occur at the site. Ditchman Holdings currently owns 8 acres of property also adjacent to the turning basin, which is planned for development as an asphalt plant. This industrial activity would be compatible with dredged material processing on the adjacent property.

The use of dredged material is expected to be suitable for structural fill at the Brownfield redevelopment sites; however, site geotechnical engineering should take into consideration the potential variability in grainsize (and other relevant properties) of dredged material used as structural fill.

All three properties (the Zaclon site, General Chemical and 3201 Independence Road) are owned by third parties and execution of the proposed project by Ditchman Holdings will require completion of a series of real estate transfer and/or use agreements. Execution of these real estate agreements in coordination with a public/private project partnership agreement (PPA) between the Cleveland Cuyahoga County Port Authority or other local sponsor and the USACE will create a complex contractual framework for project execution. The complexity of these contractual arrangements will create considerable uncertainty in the schedule for site redevelopment and dredged material processing. The timeframe necessary for construction of the material handling facility is reported by Mr. Ditchman to be 1.5 years following creation of a public/private partnership and project capitalization.

The development of the Zaclon property as a dredged material handling facility by Mr. Ditchman will require a public/private partnership that is able to provide the capital required for site redevelopment. Mr. Ditchman has identified the following requirements:

- *Port of Cleveland or other entity will need to provide financing for the project. Mr. Ditchman has estimated that the capital requirements are approximately $38 to $40 million.*
- *U.S. Army Corps of Engineers/Port of Cleveland will need to provide a minimum volume of 225,000 CY of sediment per year for 10 years, requiring negotiation of terms in a formal agreement.*
- *City of Cleveland will need to secure State funding for environmental restoration of the Zaclon property.*
- *Ohio EPA will need to permit remediation of the Zaclon site under the Ohio EPA VAP.*

It is unlikely that the USACE Buffalo District has the ability to enter into a long-term contractual agreement guaranteeing a fixed annual rate of dredged material production for beneficial use. Dredging operation and maintenance plans and budgets are established by the Federal government on a year-to-year basis based on Congressional appropriations and regional dredging requirements.

However, there is considerable interest at the State, County and local level for redevelopment of the General Chemical Brownfield site. Mr. Ditchman also anticipates that 6-15 jobs will be created on an annual basis from the development of this dredged material dewatering and material handling operation.

This beneficial use plan is attractive because it purports to create more than 3 million CY of dredged material and a timeframe of 10 years of potential capacity for beneficial use of dredged material. However, the unit cost based on 225,000 CY per year is estimated by Mr. Ditchman to be $42 CY. This cost includes receipt of the dredged sediment in a hydraulic slurry at the Zaclon site and all activities and requirements related to dredged material dewatering, water management, material handling, transportation, and final placement of the dredged material at the Independence Ave. and/or General Chemical sites. The total estimated unit cost for dredging operations, material handling, and beneficial use under this proposal is estimated to be $53/CY. Mr. Ditchman has not provided a breakdown of his total unit cost and therefore no verification of the reasonableness of the unit costs has been conducted by the USACE.

Synopsis: Due to the high cost, complexity of a PPA, real estate agreements required, and the anticipated schedule uncertainty in project execution, this beneficial use alternative is considered to have a low overall utility to the USACE for dredged material management relative to the other alternatives.

10.1.2 Extend CDF 10B for Burke lakefront Airport

One of the significant features associated with the location of Cleveland's shoreline CDFs is the Burke Lakefront (BKL). The BKL Airport was constructed entirely on fill placed on the Lake Erie bottom. Officially opening in 1947 as the Cleveland Lakefront Municipal Airport, it has been expanded in size over the years by the disposal of dredged material and construction debris. Today the airport is approximately 480 acres in size, has modern airport facilities to land commercial jetliners, and serves as a reliever airport for Cleveland Hopkins International airport. The airport's current primary runway does not meet FAA Runway Safety Area (RSA) requirements and increased separation is required for the two runways. The extension of CDF 10B to the west, creating new land to the northwest of the airport, will provide additional land so that the airport can increase the RSA for the airport (Figure 2-3). The development of runways to the north of the existing runways has been identified as the preferred alternative in the Burke Lakefront Airport Master Plan Update (City of Cleveland Department of Port Control, 2008). The proposed extension for CDF 10B would create approximately 1 million CY of additional storage capacity (Figure 2-4).

Placement of dredged material in an extension of CDF 10B will not result in unacceptable risk to human health or the environment (Chapter 4). The plan would, however, result in loss of submerged aquatic land and habitat for aquatic life in the inner harbor as a trade-off to enhanced regional private and commercial aviation. A project creating additional CDF capacity adjacent to CDF 10B is anticipated to be able to meet Federal and State requirements. Extension of CDF 10B would require NEPA review and a Coastal Zone Management Review by the Ohio DNR.

The beneficial use of extending CDF 10B is to provide additional ground surface for landings and takeoffs at the airport that will provide an additional margin of safety for air traffic. As such, the fill in the CDF would neither be supporting structures nor be required to meet specifications for structural fill. Additional engineering will be required for construction of the CDF dikes or sheet-pile walls, impact on inner harbor currents, and potential changes to sediment transport which are typical engineering design and construction activities conducted by the Corps. A PPA would be required with a local nonfederal sponsor for construction of the CDF extension. The schedule for executing this project is considered to be average in complexity. The project is expected to take approximately 3 years to permit, design, and construct.

Synopsis: The extension of CDF 10B will create approximately 1 million CY and 4 years of additional capacity for management of dredged material at an estimated cost of $55/CY. This alternative is considered to have medium utility to the USACE. The project is anticipated to be more implementable than the Ditchman proposal due to the lower complexity of execution and greater schedule certainty. However, the moderate volume of dredged material that can be managed (1,000,000 CY) is at a relatively high cost ($55/CY).

10.1.3 Industrial Redevelopment of Brook Park Landfill

The Brook Park Landfill is a 28-acre non-operating CD&D landfill located south of Hopkins Airport (Figure 2-5). The landfill does not have a closure plan. The landfill owner, the City of Cleveland, is currently developing plans for capping and landfill closure with the goal of redeveloping the site to accommodate future industrial use. One potential use being considered for the site is a solar collection farm. Regrading of landfill contours will include restoration of Abrams Creek bed and adjacent creek banks.

Use of dredged material as surface soil at an industrial site will not result in unacceptable risk to humans (Chapter 4). The restoration of creek banks using dredged material will not result in unacceptable risk to terrestrial ecological receptors (Chapter 5). Based on the sediment elutriate testing, negative impacts to surface water quality are not expected (Chapter 5). Dredged material may not be suitable for creek bed restoration, depending on the particle size distribution of the creek bed sediments, creek hydrologic characteristics, and relative grain-size of the available dredged material. Additional biological toxicity testing will also be required to confirm the acceptability of using dewatered/dried dredged material for creek bed restoration.

Closure of the landfill, under the draft CD&D landfill closure rules, is currently planned to include installation of an 18-inch recompacted cap and a 6-inch protective soil layer. Suitability of the dredged material for a recompacted cap having a specified permeability and clay content will require review of the material available at the time of construction; however, the inherent variability of the dredged material suggests that meeting material specifications for a recompacted cap would be difficult to assure, and could require additional material processing and blending at significant cost. Analysis of data from sediment samples collected in 2010 indicates, however, that Cuyahoga River sediments should reliably meet the construction criteria for use as CDD landfill cover.

The site is easily accessible for truck transportation and has a capacity for accepting 350,000 to 500,000 yd^3 of dredged material, depending on the final site redevelopment plans. Redevelopment of the site will require a geotechnical survey and engineering analysis of site stability, storm water control requirements, and requirements for protection of the adjacent Abrams Creek. As indicated above, some potential exists for creating ecological benefits associated with riparian restoration of Abrams Creek.

The City intends to conduct environmental and geotechnical assessments in 2011 to confirm the feasibility of redeveloping the site. The site is anticipated to be ready for receiving dredged material as early as 2012. Uncertainty in the ability to complete the necessary engineering and develop plans during 2011 and 2012 creates uncertainty in the schedule. Results from the engineering analysis may modify the final design.

Synopsis: The closure and recontouring of Brook Park Landfill could result in the beneficial use of 350,000 to 500,000 CY of dredged material during the 2013 to 2014 timeframe, at a cost of \$33 to \$35 yd^3, depending upon the selected material handling option. This alternative is considered to be of higher utility to the USACE compared to the extension of CDF 10B and the Ditchman Brownfield proposal, due to substantially lower costs and relative ease of implementation.

10.1.4 Closure of Silver Oak Landfill

Silver Oak Landfill is a 27-acre inactive construction and demolition landfill located on a 49-acre site at 26101 Solon Rd (Figure 2-6). The landfill is licensed to Silver Oak Land Development Inc. and owned by a private party. Negotiations for closure of the landfill under OEPA rules are currently under way between the landfill owner's representative and the Cuyahoga County Board of Health. Closure of the landfill will require recontouring and construction of a cap requiring a minimum of 100,000 CY of suitable imported fill. Due to the current configuration of the landfill and waste present, construction of the final cap and vegetative cover may require a modification to the original landfill design and permit. The site is located adjacent to the Cleveland MetroPark Bedford Reserve, which follows Tinker Creek. This is a high quality recreation area that includes picnic areas, hiking trails, and horseback riding trails. Upstream of the landfill, Tinkers Creek drops 220 feet over a 2-mile reach where a steep, walled gorge is the dominant landform surrounding the Creek. The gorge, declared a National Natural Landmark, is a unique area with numerous tree, shrub, and flower species. Additional dredged material could be used for recontouring and landscaping the closed landfill for use as an upland nature preserve, creating the opportunity to use an additional 200,000 CY of dredged material beneficially.

Analysis of data from sediment samples collected in 2010 indicates that Cuyahoga River sediments will meet the construction criteria for use as CDD landfill cover. Suitability of the dredged material for a recompacted cap having a specified permeability and clay content will require review of the material available at the time of construction; however, as previously noted, meeting material specifications for a recompacted cap will be challenging given the inherent variability of the Cuyahoga River sediments. Additional processing and amendment at additional cost would likely be required.

Use of dredged material as surface soil for a landfill cover will not result in unacceptable risk to humans (Chapter 4). Redevelopment of the site as an upland habitat nature preserve will not result in unacceptable risk to terrestrial ecological receptors (Chapter 5). Based on the sediment elutriate testing, negative impacts to surface water quality in Tinkers Creek is not expected (Chapter 5).

The site is easily accessible for truck transportation and has a capacity for accepting approximately 200,000 CY of dredged material depending on the final landfill closure and site redevelopment plans. Closure of the landfill will require redefining the configuration of the final landfill shape and engineering analysis of site stability and storm water control requirements. As indicated above, some potential exists for creating ecological benefits associated with upland habitat restoration and creation of vernal pools for storm water management.

Resolution of landfill closure and other regulatory compliance requirements with the owner by the Cuyahoga County Board of Health and OPEA is required prior to implementation of this beneficial use alternative. Uncertainty in the timing on resolution of regulatory compliance and legal access to the site creates uncertainty in the schedule to implement this alternative.

Synopsis: The closure and recontouring of Silver Oak lLandfill could result in the beneficial use of 200,000 CY of dredged material during the 2014 to 2015 timeframe at a cost of $33 to $35 CY, depending on the selected material handling option. This alternative is considered to be of higher utility to the USACE, and similar to the Brook Park Landfill alternative, as compared to the extension of CDF 10B and the Ditchman Brownfield proposals, due to substantially lower costs and relative ease of implementation .

10.1.5 Beach Nourishment

Analysis of the physical characteristics of sediment samples collected from the navigation channel and Perkins Beach (Figure 2-7) indicate that the dredged material is not suitable for beach nourishment. During some dredging events (e.g. 2010 data), the dredged material will not be suitable even when coarser-gained materials are physically separated from the fines (Chapter 6). Because the dredged material did not meet a primary screening criterion, additional evaluation and analysis of this alternative, including a review of factors affecting implementation and cost, were not conducted.

10.2 Options for Dredged Material Dewatering and Management

Four offloading, dewatering, and material handling operations, at three locations, were considered for the dewatering of sediment for beneficial use at the Silver Oak and Brook Park Landfills. The offloading alternatives and dewatering/material handling sites included:

- Hydraulic and mechanical offloading at the CDFs
- Mechanical offloading at the Upper River Site and the CVIC site

10.2.1 Waterfront CDFs with hydraulic offloading

This option is a low-cost method for material handling estimated to be approximately \$17/CY with a total unit cost estimate for placement at the Silver Oak and Brook Park Landfills of approximately \$33/CY. The risk of relying on this approach is that use of dredged material for raising CDF 12 berms during 2012 will preclude the availability of material that year for beneficial use at Brook Park Landfill, unless an alternate site and material handling plan is developed (e.g. CVIV site) for mechanical offloading and dewatering. Although this approach to dredged material dewatering was demonstrated to be feasible based on the successful beneficial use of dredged material at the CVIC site, significant risk is associated with this plan if the volume of dredged material beneficially used each year equals or exceeds the volume of material produced. Assuming that the berms for Dike 12 are raised, capacity for the current method of hydraulic placement of sediment in the waterfront CDFs exists through 2014. A delay of one year in the beneficial use of dredged material would result in the CDFs reaching their maximum capacity for storage of hydraulically offloaded material within 12 months unless the offloading procedure is modified to accommodate mechanical offloading (which increases cost). Once this storage capacity is reached, dewatered dredged material must be excavated and stockpiled elsewhere on site in order for hydraulic offloading to continue. Any stockpiles that remain on the CDFs from year to year will further reduce the capacity available for dredged material dewatering and drying, in addition to reducing the capacity to manage dredge water produced during hydraulic offloading of barges. Fill management activities under this scenario will need to maintain the freeboard and ponding requirements for dredged water management. Another potential risk is related to the material handling and drying time that may be required for fine-grained sediment that accumulates in the low elevations of the CDFs. During some years the mass of fine-grained dredged material may be relatively small and easy to manage; however, in other years the mass of fine-grained sediment may be much larger. Reworking (active dewatering management, such as use of wick drains, trenching, and tilling) of wet fine-grained sediment may be required to reduce the drying time so that this material can be transported offsite, increasing the costs for material dewatering and handling.

10.2.2 Waterfront CDFs with mechanical offloading

Mechanical offloading of dredged material at the waterfront CDFs was evaluated as a potential method to reduce drying time and ponding, making material more readily available for beneficial uses. This alternative can take full advantage of the nearly 500,000 CY of CDF volume that is necessary for ponded water[9] with the current hydraulic placement method. Use of this substantial volume, in addition to current unoccupied volume in the CDF, permits stockpiling of dredged material from year to year.

Cost of material handling using mechanical offloading at the CDF is estimated to be approximately $21/CY, with a total unit cost estimate including transport to and placement at the Silver Oak and Brook Park Landfills of approximately $35/CY. The additional cost for material handling above the hydraulic offloading option results from the additional capital expenditures required for improvements to the CDFs for mechanical offloading of dredged material and a much higher contingency due to the unfinalized design of the in-water dock and offloading facility. These costs, however, have been expressed on the basis of a 3-year operating period.

This option would potentially eliminate the need for raising Dike 12 berms, saving approximately $3,750,000 used to create approximately 400,000 CY of storage capacity for hydraulic placement of sediment, at a cost of approximately $9/CY. Alternatively, the dikes in CDF12 could be raised to facilitate hydraulic disposal until such time as the mechanical offloading facility is completed (as suggested in Chapter 7), and this would further extend the life of the facility (thus lowering capitalization costs).

[9] Based on assumptions in Hull 2010; a comprehensive capacity and water management analysis will be required, taking into account material bulking during dredging and offloading, subsequent consolidation, and dredge and stormwater production for both mechanical and hydraulic offloading alternatives.

A long-term dredged material management strategy for Cleveland Harbor can be developed when mechanical offloading is used at the waterfront CDFs. This management strategy incurs nearly all of the same capitalization costs with the CDF mechanical offloading alternative for beneficial use. The potential storage volume permitted by mechanical offloading and placement of dredged material in stockpiles is significant. This strategy could offer approximately 2 million CY of additional material handling capacity at the CDFs without additional dike raising, equivalent to an additional 8 years of capacity for dredged material management using the existing CDFs until approximately 2024.The maximum capacity for storage of dredged material in stockpiles at the CDFs is constrained by airspace restrictions imposed by the adjacent Burke Lakefront Airport and the angle of repose of the material. The maximum feasible height of stockpiled dredged material, taking into account both of these constraints, will be approximately 20 to 49 feet above existing CDF berm crests, and approximately 30 to 77 feet below the required FAA airspace envelope (depending on the final design for stockpiling dredged material).

This material handling alternative creates substantial long-term storage capacity for dredged material and is consistent with the requirements for dry, readily transportable bulk soils for beneficial use. The large potential storage capacity eliminates the inherent risk from year-to-year fluctuations in the need for dredged material at beneficial use construction projects. The shared capitalization costs and the combined capability of stockpiling with beneficial use of dredged material to extend CDF life are expected to lead to significantly reduced unit costs in a planning-level cost analysis, far less than the costs for alternatives presented in this study.

A number of engineering aspects for this approach need to be reviewed, however, including geotechnical stability of the berms for supporting the stockpiles, analysis of the structural integrity and strength of storm and combined sewers residing under CDF 10Band Federal Aviation Administration review of flight path transitional surfaces and potential impacts on airport electronic navigation and control systems. In addition, mechanical placement of sediment will require balancing of dredging production rates with rates at which barges are mechanically offloaded. These engineering reviews and approvals create uncertainty in the feasibility of this alternative as well as uncertainty in the schedule for implementation.

Synopsis: This option provides the greatest flexibility and lowest risk for dredged material management that is consistent with the objective of beneficially using dredged material at upland sites. Despite the additional engineering and review required for the mechanical offloading alternative at the existing waterfront CDFs, the combination of this alternative with the long-term stockpiling strategy outlined in Chapter 7 could lead to significantly increased CDF life due to increased storage capacity, increased facility life, and therefore increased opportunity for beneficial use of dredged material. The additional costs associated with dredging and material handling come with substantially reduced risk of running out of storage capacity for dredged material management.

10.2.3 Upper River site with mechanical offloading

The 25-acre parcel for the Upper River site does not provide adequate capacity to accommodate the anticipated annual production of dredged material. The maximum volume of dredged material that can be managed at the site in one year is approximately 80,000 CY, or less than half of the material that may be generated during the spring dredging events. The use of this site would require a second site (e.g. the CVIC site) or use of the existing CDFs, for placement of the excess dredged material. Significant risk is associated with this material handling operation at this location due to the limited capacity to store dredged material, and the potential for disparity in schedules for placement at the beneficial use site and navigation channel maintenance. If alternate storage capacity is not available at another site, then dredging operations will not be possible (or at least the volume that can be dredged will be significantly reduced from that which is required). Additional uncertainty exists with respect to land acquisition, and represents potential risk to project implementation and schedule. The cost for dredging, material handling, transportation and placement at the landfill sites is approximately $33/CY assuming 650,000 CY of dredged material can pass through the facility in three years. Modification of the screening- level cost analysis provided to pass 160,000 CY/yr through the facility over three years resulted in an estimated cost of $35.5/CY (Chapter 9).

Synopsis: Because of the limited capacity for dredged material storage and potential for limiting dredging operations, mechanical offloading at the upper river site is considered to have low feasibility.

10.2.4 CVIC Site with mechanical offloading

The CVIC site material handling alternative, on its own, also does not provide sufficient capacity for managing the annual production of dredged material each year. As for the Upper River site, significant risk exists for this alternative due to the limited capacity to store dredged material; the maximum volume of dredged material that can be managed at the site in one year is approximately 150,000 CY (based on estimates provided by Hull and Associates). Risk associated with development of Morgana Run as a dredged material handling facility requires the long-term coordination of the bulk movement of dredged materials with other industrial activities planned for the site. The objective of the Greater Cleveland Community Improvement Corporation is to redevelop the CVIC site to promote industrial manufacturing and jobs within the city of Cleveland. If material handling operations at the CVIC site prevent industrial development at the site, another material handling location would need to be identified. The cost for dredging, material handling, transportation and placement at the landfill sites is approximately $35/CY, with uncertainty surrounding some facets of the cost estimate (e.g., amortization period and contingency).

Synopsis: Because of the limited capacity for dredged material storage and associated potential for limiting dredging operations, mechanical offloading at the CVIC site is considered to have low feasibility.

10.3 Recommendations

Beneficial use of dredged material for the closure and redevelopment of the Silver Oak and Brook Park Landfills is the most feasible and lowest-cost short-erm option. These two beneficial use alternatives provide the lowest cost means for managing approximately 550,000 to 700,000 CY of dredged material over a 3-year period. With mechanical offloading of sediment at the existing CDFs, the cost is estimated to be approximate $35/CY. The unique aspect of this material handling option is that it can take full advantage of all available CDF volume and it is compatible with and shares significant capitalization costs with a long-term dredged material management strategy. This management strategy can significantly extend the life of the CDF (estimated in Chapter 7 from 2022 to 2028) without removal of material for beneficial use or further expansion of the facility footprint. The combination of beneficial use of dredged material and the long-term material management strategy could lead to significantly increased CDF life due to increased storage capacity, increased facility life, and therefore increased opportunities for beneficial uses of the dredged material. The capital improvement costs for mechanical unloading and material handling can be amortized over a 10- to 15-year period, perhaps longer depending on demand for the dredged material. This is expected to significantly lower the beneficial use cost per yard in a planning-level cost analysis, making it far less than the cost estimates developed in this study that are either comparable, given the uncertainties involved, or notably higher (Chapter 9).

11 Long-term Strategies for beneficial use

11.1 Leadership & Local Responsibility

Long-term management of dredged material from the Cuyahoga River navigation channel will require a strategic plan developed by the local community, City of Cleveland, Cuyahoga County, Ohio Department of Natural Resources, and Ohio Environmental Protection Agency. Through appropriations from Congress, the US Army Corps of Engineers maintains harbor navigation channels, pier heads, and breakwater structures. The Federal investment in the maintenance and capital improvements to Cleveland Harbor is based on the benefits returned to the public and the local cost sharing as required by Federal laws.

Management of dredged material is a shared responsibility when open lake disposal is not possible. This report and the information provided to local stakeholders represents the Federal government's contribution to identify a long-term strategy and build consensus for a cost-effective solution for managing Cleveland Harbor's dredged material.

A long-term, sustainable strategy for cost-effective management of dredged material must achieve the following objectives:

- Technical feasibility – consistent with sound engineering practices and producing desired benefits
- Compliance with regulations - meets all legal/regulatory requirements with no unacceptable environmental or human health effects
- Economic feasibility - cost achievable for the City, County, and State governments and within Federal Authorizations
- Stakeholder consensus/public support

The scope of dredging operations and material management for the Cleveland Harbor is significant. Currently to maintain critical channel depths until a DMMP can be completed and implemented, a minimum volume of approximately 225,000 CY of sediment is removed from the navigation channel each year at a cost of over $10 million. The resulting long-term financial commitment for dredging and dredged material management is large. Local leadership is required to develop and execute a sustainable plan that has the support of the City of Cleveland, Cuyahoga

County, and State agencies. Simply stated, the role of local, city, county, and state agencies is not solely to regulate dredging and dredged material management, it is to support the development and execution of a publically acceptable long-term solution. Regulatory and policy barriers that limit the ability to achieve sustainable management of dredged material require review and public discourse. The scope of the problem and financial implications to the local community make this imperative. A sustainable solution for the maintenance of Cleveland Harbor must be created by a multi-agency/community partnership with a local sponsor taking a leadership role for achieving the management objectives.

11.2 Developing a Long-term Strategic Plan

Maintenance of Cleveland Harbor requires incorporation of a strategic plan for dredged material management into the USACE Dredged Material Management Plan (DMMP). The Great Lakes Dredging Team recently released a strategic plan for the Great Lakes harbors, which can provide guidance to Cleveland (GLDT 2011). The plan indentifies five basic strategies to achieve sustainable dredged material management:

1. Extend CDF life through fill management
2. Preserve existing CDF capacity through beneficial use and reuse
3. Decrease the amount of material entering rivers and harbors
4. Engage local and state agencies in solutions
5. Foster partnership with USEPA to leverage funding for projects supporting both environmental goals and navigation benefits

It is important to note that the strategic plan does not include the construction of new CDFs. CDFs are considered too costly and too often are used for disposal of dredged material that meets the Federal Standard for open water placement or that may be suitable for beneficial use. Based on available data, Cleveland Harbor dredged material may not meet the Federal Standard for open water placement in the future and beneficial use alternatives appear to provide a lower cost option than construction of a new CDF (USACE 2010).

11.3 Extending CDF life through fill management

The recommended short-term beneficial use alternatives rely on modifying the fill management approach used at the waterfront CDFs. Mechanical offloading of sediment, dewatering, and stockpiling (by stacking within the CDF cells) could provide capacity for managing dredged material until approximately 2024. The engineering analysis to confirm the feasibility of this fill management activity should be a high priority. Establishing a long-term fill management plan incorporating mechanical off-loading and stockpiling is consistent with the needs for future beneficial use at upland sites.

11.4 Preserve existing CDF capacity through beneficial use and reuse

Low-cost, near-term projects have been identified in this report that are capable of using 500,000 to 650,000 CY of dredged material beneficially, which is equivalent to approximately 2 years of channel maintenance. The proposed beneficial uses, closure, and redevelopment of two landfills in Cuyahoga County provide real and tangible benefits to the community. The greatest limiting factor to executing these and other similar projects will be the management resources required to coordinate public agencies, execute contracts for project execution, regulatory review and permitting, and development of financial resources required by non-Federal partners.

A number of beneficial use opportunities have been identified in this report for which initial screening information is currently inadequate. Several of these beneficial use opportunities may have the potential for using a significant volume of dredged material. To be successful, the management team developed by local sponsors must begin gathering information to evaluate the feasibility of these long-term alternatives. Several options require significant technology evaluation, engineering design work, or a pilot-scale demonstration project to adequately evaluate their feasibility. Sources of funding from Federal, State and Local agencies must be identified to support evaluation of the most promising alternatives and any required laboratory testing, economic and engineering analysis, or field pilot demonstration projects. The manufacturing of lightweight construction aggregate and insitu harvesting of coarse-grained sediment for construction or beach nourishment fall into this category. Other significant opportunities for beneficial use of dredged material include redevelopment of industrial/urban properties in Cuyahoga County and the restoration of wetland and upland habitat in the Cuyahoga River AOC.

11.5 Redevelopment of Industrial and Urban Property

A number of opportunities exist for redevelopment of urban and industrial properties in Cuyahoga County. There is considerable local interest in redevelopment of the General Chemical site on Warner Road. The proposal provided by Ditchman Holdings provided a [high cost] option that included material handling at the Zaclon site; the opportunity to redevelop the General Chemical Brownfield site using dredged material dewatered at the CDFs should also be reviewed.

Likewise, the ODOT Innerbelt and Lakefront West projects will have significant requirements for sub-soil and topsoil. Although the design for the new bridge has not been finalized, 80,000 CY of topsoil is estimated to be required in 2015, near the end of bridge construction. Landscaping associated with the Lakefront West project is anticipated to require additional large quantities of topsoil. The availability, suitability, and costs associated with using dredged material as subsoil and topsoil needs to be conveyed to the general contractor and the ODOT. State and local sponsors should consider incentives to encourage the use of dredged material as topsoil on these projects. As a design-construct bid project, the general contractor may have flexibility to use dredged material for subsoil where meeting ODOT structural fill specifications is not required. Local leadership and active ODOT support are required to develop this opportunity.

The screening level evaluations of potential risk to human health demonstrated that dredged material will exceed OEPA's acceptable risk levels for use as surface soils in residential settings. However, when considered in the context of restoring vacant and abandoned properties in Cleveland's urban core, the use of dredged material as topsoil is expected to actually reduce exposure to contaminants and reduce human health risk. The available information indicates that the navigation channel sediment is likely to exhibit half the risk to human health compared to some residential neighborhood surface soils. The primary source of PAH contaminants impacting human health in the Cuyahoga River sediment is the watershed's urban soils. It is also important to note as a counterpoint that the concentration of PAHs in dredged material that result in risk to human health fall within the range considered typical for uncontaminated rural soils in New York State. A review of OEPA policy regarding risk limits and the procedures used to calculate risk should be conducted. The real health risks to urban communities and individuals associated with abandoned properties far outweigh the theoretical risk of trace level contaminants present in dredged material. Over the last several years, an average of 1,000 residential properties have been demolished per year, requiring approximately 185 CY yards of fill for each foundation and property restoration. At this rate, 75% of the average annual production of dredged material could be used for vacant property rehabilitation. The reconsideration of OEPA's current policy and the regulatory framework used for assessing human health risk, and the suitability of dredged material for restoration of soils at vacant properties is warranted.

11.6 Wetland Habitat Restoration

The federal interest in conducting a Section 204 Regional Sediment Management study for restoration of the near-shore wetland at Voinovich Park, and wetland habitat construction at Whisky Island Park (Figure 11-1), has recently been reviewed . These two beneficial use projects could potentially utilize over 800,000 CY of dredged material and result in the creation of nearly 10 acres of wetland habitat in Cleveland's urban core. The limiting factor will be the environmental acceptability of dredged material for use in these projects. Additional testing will be required, comparing dredged material quality to the sediment quality at these two sites. Given the results of this beneficial use study showing that some dredged material may be suitable for wetland habitat restoration projects (while other material may not be suitable), the USACE should be prepared to conduct a Tier IV risk assessment as part of its evaluation of the feasibility of these two wetland restoration projects.

Figure 11-1. Long-term planning for habitat restoration at Voinovich and Whisky Island Parks

These Tier IV risk evaluations should be considered the stepping stone for consideration of a larger scale wetland restoration project (and perhaps also a basis for regulatory revision taking into account real, rather than theoretical, risk posed by the beneficial use of Cuyahoga River sediments). Historical development of Cleveland's industry and urban core along the Lake waterfront and Cuyahoga River has resulted in the loss of the natural estuary. A long-term, larger scale plan should be considered that begins to recreate this estuary using dredged material and existing breakwaters protecting the inner harbor. Development of emergent wetlands could be used to promote vegetative uptake of nutrients, as well as provide habitat for fish, shorebirds, and additional storm protection for the urban waterfront. A Tier IV risk analysis will need to consider the natural attenuation of trace level contaminants in the dredged material over time and the relative risk to aquatic and wildlife populations that will result from creating new habitat in an urban waterfront. A properly designed manmade wetland/barrier island would not require confinement of dredged material if risks of contaminant and material transport are determined to be low.

11.7 Decrease amount of material entering rivers and harbors

The Cuyahoga County Soil and Water Conservation District and the USDA-NRCS are responsible for reducing soil erosion in the watershed, and the USEPA and OEPA have regulatory responsibilities to reduce contaminant loading into the Cuyahoga River Area of Concern (AOC). The USDA-NRCS provides funding for implementing voluntary programs directed towards improving water quality in the Cuyahoga River watershed and supports studies to evaluate impacts of non-point discharges of soil from rural and urban land uses and riparian areas. The Cuyahoga Soil & Water Conservation District Watershed Program works at a local level to foster community-based watershed stewardship efforts involving elected officials, citizens and watershed groups. Including these organizations in the monitoring programs evaluating sediment quality will keep them informed on which watershed management efforts are likely to have a tangible effect on increasing the dredged material quality, so that it can become an unrestricted soil resource.

11.8 Engage local and state agencies in solutions

The OEPA and USEPA should establish an AOC monitoring program to identify ongoing and intermittent releases of contaminants to the river, given the costs incurred for dredged material management. This would support enforcement actions for violations of the CWA and provide baseline data necessary for evaluation of the current status of sediment quality and its suitability for beneficial uses. Requiring a full testing and evaluation program for each beneficial use project will take months to a year, which limits timely decision-making and results in lost opportunities for beneficial use of dredged material. A full testing program conducted every five years should be sufficient to make decisions on suitability of beneficial uses, assuming water and sediment quality are monitored more frequently, and enforcement/remedial actions by Ohio EPA occur when violations are identified.

11.9 Foster partnership with USEPA to leverage funding for projects supporting both environmental goals and navigation benefits

There is potential for symbiotic benefits through partnering with USEPA to leverage maintenance dredging activities with cleanup/restoration initiatives. Under the Great Lakes Restoration Initiative, the benefit of using dredged material for beneficial use projects in Minnesota and Michigan is being evaluated. Other USEPA efforts have provided removal of contaminated sediments that contribute to COCs in navigation sediments, such as the Kinnickinnic River in Milwaukee, WI, in partnership with USACE's maintenance dredging projects. Other partnering efforts include evaluation of potential AOC delisting. A project that should be initiated for the Cleveland Harbor is the development of a data management system for tracking sediment quality data that would incorporate results from annual monitoring and more comprehensive 5-year reviews of sediment quality. Sediment in the Cuyahoga navigation channel can provide a litmus test for determining the health of the Cuyahoga watershed, and the suitability of dredged material for multiple beneficial uses can be used as one metric for delisting the Cuyahoga AOC.

11.10 Summary

A Long-Term Strategic Plan must anticipate future needs as well as changes in Federal and stakeholder budgets and funding authorizations. Planning for beneficial use of dredged material requires that decisions on suitability be determined in advance of beneficial use opportunities. A 5-year sampling and evaluation plan to reassess beneficial use suitability is recommended. This would reasonably ensure that sediment quality in the Federal navigation channel hasn't significantly changed over time and would permit beneficial use planning that is responsive to the natural changes in the amount and type of sediment accumulating in the navigation channel. Based on the 5-year plan, sediment should be classified as suitable for 1) open water or unconfined littoral placement, 2) use as unrestricted soil, 3) use as restricted soil or fill, or 4) impaired with no beneficial use. Impaired designation requires disposal in a CDF regulated under the CWA, or in a solid waste landfill regulated under RCRA. Dredged material is determined suitable for open-water beneficial use if it meets the requirements of Sec 404 of the CWA, and meets USEPA approved state standards for protection of water quality. The beneficial use of dredged material meeting open-water placement standards should be included as part of a comprehensive, long-term strategy to restore aquatic habitat under the Cuyahoga AOC Remedial Action Plan. Dredged material classed as suitable for unrestricted soil is not likely achievable in the immediate future based on the concentrations of background urban contamination, but restricted soil uses are feasible for industrial fill as well as restoration of Brownfield properties. Suitability for habitat creation and recreational opportunities is likely, as long as sufficient site-specific impacts are evaluated and risk management is an integral part of the project planning and implementation. This study recognizes that risks associated with specific beneficial use projects may require site-specific, use-specific, and exposure-specific evaluation analysis and controls, and does not endorse beneficial uses that have not been sufficiently evaluated. What this study proposes is consideration of a benefit/risk-based approach for dredged material management that maximizes use of this resource where practical, safe, and cost- effective, and takes into account indigenous risks associated with the aquatic and upland environments where beneficial use projects are proposed.

12 Summary and Recommendations

During 2010, 16 opportunities for potential beneficial use of dredged material were identified. From this list, five alternatives that could potentially be implemented prior to 2015 were identified. Each alternative could utilize more than 50,000 CY of dredged material. These alternatives were also determined to have adequate information for a preliminary evaluation of project feasibility and were consistent with Federal, State, and local laws and ordinances. These alternatives included:

- Beach nourishment using coarse-grained sediments from the head of navigation
- Closure and redevelopment of Brook Park Landfill for future industrial use
- Closure of Silver Oak Landfill and site redevelopment for potential recreational use
- Implementation of the Ditchman Brownfield Proposal for redevelopment of industrial Brownfield sites
- Extension of CDF 10B to expand Burke Airport

Collection of additional sediment quality data during 2010 for both Perkins Beach (a potential littoral nourishment site) and the upper reach of the Federal navigation channel (DMMU-1) confirmed earlier conclusions that the Cuyahoga River dredged material is not suitable for beach nourishment. The grain-size distribution for sediment samples collected in DMMU-1 were markedly different than the grain size distribution of sediment samples collected from Perkins Beach, and further processing to recover a sufficient coarse fraction for this beneficial use does not appear to be feasible.

From the remaining list of alternatives, the closure and redevelopment of Brook Park and Silver Oak Landfills were selected as the lowest cost alternatives that were most implementable. The closure and recontouring of Silver Oak landfill could result in the beneficial use of 200,000 CY of dredged material during the 2014 to 2015 timeframe at a cost of approximately $35/CY. The resolution of regulatory compliance and legal access to the site creates uncertainty in the schedule to implement this alternative, however, this alternative is considered to be of higher utility to the USACE as compared to the extension of CDF 10B and the Ditchman

Brownfield proposals, due to substantially lower costs and relative ease of implementation. The closure and recontouring of Brook Park Landfill could result in the beneficial use of 350,000 to 500,000 CY of dredged material during the 2013 to 2014 timeframe, at a cost of approximately $35/CY. Redevelopment of the site will require environmental and geotechnical assessments in 2011 and 2012 to confirm the feasibility of this project. The city anticipates the site to be ready for receiving dredged material in 2012. However, uncertainty in the ability to complete the necessary engineering and plan development during 2011 and spring 2012 suggests that construction beginning during the summer of 2012 may be unlikely. For planning purposes, construction beginning either late in 2012 or in 2013 is more likely. This alternative is also considered to be of higher utility to the USACE as compared to the extension of CDF 10B and the Ditchman Brownfield proposal due to substantially lower costs and relative ease of implementation.

12.1 Criteria Evaluated for Selection of Alternatives

12.1.1 Protection of Human Health and the Environment

Beneficial use alternatives considered in this effort underwent a screening level analysis of the potential risk to human health and ecological risks. The placement of dredged material as surface soil and fill at commercial and industrial sites was determined to have low risk and this beneficial use would be protective of human health. The potential risk to human health varies when dredged material is used for development of recreational sites based on the recreational activity and thus the acceptability of using dredged material for development of recreational land uses needs to be reviewed on a case-by-case basis. Engineering controls and site construction methods during redevelopment projects can also be used to eliminate the potential for future exposure and reduce human health risk to acceptable levels. Dredged material was found to be unsuitable as surface soils in residential settings based on OEPA guidance for conducting screening level human health risk assessments. However, the contaminants present in the dredged material fall within concentration ranges considered typical for rural and urban soils. This inconsistency suggests that Ohio policy and guidance for evaluating human health risks associated with dredged material management should be reevaluated. The approval of using dredged materials as surface soils for residential and other land uses should be sought from OEPA based on a threshold concentration that is considered to be background for urban environments. The screening level analysis of potential risk to terrestrial organisms showed that there is no significant risk associated with exposure to contaminants in dredged sediment placed at upland sites. In addition, laboratory testing indicated that no risk to aquatic life is expected when dredged material from the upper reach of the navigation channel (study area DMMU-1) is used for wetland restoration projects. However, toxicity was observed when aquatic macroinvertebrates were exposed to sediment collected further downstream (study area DMMU-2). The potential for bioaccumulation of persistent toxic chlorinated chemicals such as DDT, dieldrin and PCBs into fish, birds and wildlife was not considered significant. The uptake of these chemicals by soil and aquatic macroinvertebrates would not result in toxicity to fish, birds or wildlife nor would it result in fish having tissue concentrations exceeding U.S. Food and Drug Administration (FDA) limits for human consumption. The placement of dredged material in aquatic environments for beneficial use projects is not expected to have a significant impact on water quality or toxicity to aquatic life. Low levels of toxicity were observed when Fathead Minnows were exposed to elutriate samples prepared from DMMU-2. However, the source of toxicity appears to be the concentration of unionized ammonia that is not expected under field conditions due to the potential for rapid dilution following placement, and differences in the receiving water pH and temperature. Analysis of the dredged material placement operations that are specific to the habitat restoration site and modeling of water quality will be required to confirm that State and Federal water quality standards are not violated and to ascertain that toxicity to aquatic life will not occur at the mixing zone boundary. Given the results of this beneficial use study, which showed that some dredged material may be suitable for wetland habitat restoration projects (while other material may not be suitable), the USACE should be prepared to conduct a Tier IV risk assessment as part of its evaluation of the feasibility of using dredged material for wetland restoration projects.

Based on simple predictive models, the potential for trace level contaminants to leach and impact groundwater quality is very low. These simple screening models provided very conservative estimates of risk since they did not take into account potential geochemical loss mechanisms (e.g., adsorption, precipitation, volatilization, biodegradation, cation exchange, hydrolysis and plant uptake) that would be expected to occur. The beneficial use of dredged material is not expected to impact drinking water aquifers when 5 feet of native soil resides between the aquifer and the dredged material. A more rigorous analysis of the fate and transport of trace level contaminants may determine that less than 5 feet of material is required when site-specific data on soil and aquifer characteristics are used.

12.1.2 Physical Characterization, Engineering Properties, and Volume.

Physical data collected during November 2010, data from past sediment sampling, and other project survey data were used to estimate the volume-weighted grain-size distributions of navigation channel sediments. These data have then been applied to engineering and construction material specifications to evaluate the suitability and available volume of dredged material for various beneficial uses.

Dredged material from the navigation channel tends to be dominated by fine-grained sediments consisting predominately of clay, silt and fine sand with the composition and volume of each grain-size class varying from year to year. The percent of dredged material that is represented by sand varies from 8 to 44 percent depending on dredging location and year. The majority of this sand fraction consists of material considered to be fine sand, which is generally not suitable for construction aggregate. For the years with available data, the maximum volume of sand removed from the navigation channel was approximately 25,000 CY. This was less than 10% of the total volume dredged in that year (295,000 CY total in 2002). Of the 25,000 CY of sand removed as a component of the sediment dredged in 2002, only 5,000 CY consisted of material having a grain-size coarser than fine sand (i.e. medium sand and coarser).

The characterization of dredged material present in CDF 10B that was conducted prior to the excavation and reuse of dredged material for fill at the CVIC site showed higher percentages of coarse-grained sediment in some locations within the CDF. Anecdotal observations from annual dredging operations, including dredging that occurred during spring 2011, also suggest that coarser-grained dredged material may be produced in some years than the material identified in the 2002, 2007 and 2010 data sets. However, the higher percent sand observed for some locations in CDF 10B incorporates the natural separation of coarse-grained from fine-grained dredged material following hydraulic placement. The CDF 10B grain size data do not represent characteristics of insitu sediments.

12.1.2.1 *Suitability for Landfill Cover*

Dredged material would be suitable for construction and demolition debris (CDD) landfill covers but may not meet the clay content and permeability requirements for recompacted landfill caps. Fine-grained sediment taken from some locations of the navigation channel may be capable of meeting the requirements for landfill caps. However, the year-to-year and location-to-location variability makes the feasibility of using dredged material for recompacted landfill caps unlikely. Landfill closures also require placement of a 30- to 36-inch soil protective layer above the recompacted cap that is capable of supporting vegetative cover. The DMMU-1 and DMMU-2 physical and chemical data demonstrate that the dredged materials will be highly suitable for a landfill protective layer that supports the required vegetative cover.

12.1.2.2 *Suitability for Fine Aggregate, Sand Cover, Pipe Bedding and Backfill*

Dredged material from the navigation channel tends to be fine-grained and will not meet the ODOT specifications for fine construction aggregate, sand cover, and pipe bedding and backfill. The feasibility of separating coarse- grained materials for producing fine construction aggregate and other construction materials meeting ODOT construction specifications is low due to the small percentage of medium and coarser-grained sand in the dredged material. Given the large material handling requirements and likely small volume of material that can be produced that will meet ODOT specifications, beneficial use of dredged material for construction aggregate is not considered feasible. One exception to this may be the low energy, in situ collection of coarse-grained sediment using the Streamside Systems technology. The design requirements and feasibility for this approach, however, have not been fully developed. Additional engineering and a pilot scale project have been proposed by the vendors.

12.1.2.3 *Suitability for Construction of Embankments*

The dredged material is not expected to be suitable for construction of embankments without amendments or physical separation of finer grained materials. The ODOT soil specifications require that soils must have a liquid limit less than 65. The 2010 DMMU-1 and -2 sediment samples were determined to have high liquid limits (75 and 60, respectively).

12.1.2.4 Suitability for Compacted Fill

The USCS classification of 2010 sediment samples was MH or OH, which is considered undesirable as compacted fill. No soil classification data are available for 2002 and 2007 sediment sampling events. However, dredged materials mined from Cleveland Harbor CDFs have been selectively removed from the CDF or successfully mixed with coarser-grained materials to produce material suitable as structural fill. An analysis of the suitability of material harvested from CDF 10B for use as compacted fill indicates that approximately 50 to 60% of the material in CDF 10B was suitable for this use.

12.1.2.5 Suitability for Upland and Wetland Habitat Restoration

The physical characteristics of navigation channel sediment are suitable for land creation, restoration of urban soils, wildlife habitats, fisheries improvement and wetland restoration. The relative percent of fine- to coarse-grained sediment required for specific applications and beneficial use sites will vary. However, the navigation channel dredged material will typically produce silt to sandy loam soils with sufficient organic matter and nutrient content to be considered suitable for establishing upland and wetland vegetation and restoring the fertility of degraded urban soils.

12.1.2.6 Suitability for Beach Nourishment

Sediment samples collected from the navigation channel in spring 2002, summer 2007 and fall 2010 are not suitable for beach nourishment. Material considered suitable for beach nourishment has grain sizes predominantly in the fine to very coarse sand size range, with percentages of very fine sand, silt, and clay not exceeding 10%. Comparison of the median grain size for the sand fraction at Perkins Beach to the 2002, 2007 and 2010 navigation channel samples demonstrated that dredged material will not fall within the grain size envelope considered suitable for placement at Perkins beach. Thus, it appears that any use of dredged material for beach nourishment will require separation of fine- and coarse-grained material. However, the medium sand and coarser grain-size content of the dredged material is small. Only a small fraction (12.1 %) of the spring 2002 dredged material could have been beneficially used for beach nourishment. Dredged material produced during fall 2010 would not be suitable for beach nourishment even if coarse-grained particle separation had been performed.

12.2 Dredged Material Handling Requirements and Alternatives

Dredged material dewatering and material handling operations are a significant component for the beneficial use of dredged material in upland environments. Material handling operations require scow unloading, material dewatering, stockpiling, and return flow water management. Five material handling operations at four locations were considered. These alternatives included material handling at:

1. Waterfront CDFs with hydraulic offloading and operational modifications
2. Waterfront CDFs with mechanical offloading
3. Upper River site with mechanical offloading
4. CVIC Site with mechanical offloading (Hull Associate concept)
5. Zaclon site with hydraulic offloading (Ditchman proposal)

Material handling at the Waterfront CDFs with hydraulic offloading, Upper River site, and CVIC Site were determined to be feasible but resulted in unacceptable operational risk when considered individually. Significant risk is associated with these plans if the annual rate of beneficially used dredged material does equal or exceed the annual volume of material produced. Storage capacity associated with these material handling approaches is limited. If the annual beneficial use of dredged material does not keep up with the annual production of dredged material, dredging operations would be impacted. Although these risks were not identified with material handling at the Zaclon site, this alternative included other risks and a high estimated cost for material handling and beneficial use of dredged material.

Mechanical offloading of dredged material at the waterfront CDFs was determined to be the most feasible and lowest cost material handling option for dewatering dredged material. This alternative eliminates the need for nearly 500,000 CY of CDF storage capacity for managing dredge water and permits stockpiling of dredged material from year to year. The possibility of stockpiling dried dredged material at a gradual grade above the crest of the CDF dikes was also investigated as a means of increasing storage capacity with the mechanical offloading option. The potential storage volume permitted by using this approach is significant. Dredged material may be stockpiled using the existing CDFs, potentially creating more than 2 million CY of total storage capacity without additional dike raising and providing capacity for dredged material management until approximately 2024. A number of engineering aspects for this approach need to be reviewed: 1) analysis of the geotechnical stability of the berms for supporting the stockpiles, 2) stability of the dredged material itself and a maximum angle of repose, 3) analysis of the structural integrity and strength of storm and combined sewers residing under CDF 10B, and 4) Federal Aviation Administration review of flight path transitional surfaces and potential impacts on electronic navigation and control systems. These engineering reviews and approvals create uncertainty in the feasibility of this alternative as well as uncertainty in the schedule for implementation.

12.3 Permitting and Legal

The beneficial use of dredged materials at the Brook Park and Silver Oaks Landfills has the potential to comply with all Federal requirements. Site designs, engineering plans, and specifications need to be developed that conform to State and Local laws and ordinances. Dredging and material handling activities must comply with Sections 404/401 of the Clean Water Act and must also comply with the applicable requirements of the National Environmental Policy Act (NEPA) and its implementing regulations. A NEPA Environmental Assessment will be required to establish whether an Environmental Impact Statement (EIS) is required for these beneficial use projects. The State of Ohio authorizes the transportation of dredged materials from lakeshore CDFs or other material handling facilities for use at upland placement sites through the issuance of a Material Management Plan (MMP).

State permit requirements may include the following:

- Material Management Plan (MMP)
- National Pollutant Discharge Elimination System (NPDES) general permit
- Section 401 Water Quality Certification
- Coastal Zone Consistency Review
- Shore Structure Permits

12.4 Long-term Strategies for Beneficial Use

1. A sustainable solution for the maintenance of Cleveland Harbor must be created by a multi-agency/community partnership with a local sponsor taking a leadership role for achieving the management objectives. Long-term management of dredged material requires a strategic plan developed by the local community, City of Cleveland, Cuyahoga County, Ohio

Department of Natural Resources, Environmental Protection Agency, and Department of Transportation. The role of city, county, and state agencies is not solely to regulate aspects of dredging and dredged material management. It is to support the development and execution of a publically acceptable long-term solution that has a large financial impact on the local community and regional economy. Local leadership is required to develop and execute this plan.

2. The recommended short-term beneficial use alternatives include modifying the fill management approach used at the waterfront CDFs through mechanical offloading of sediment, dewatering, and stockpiling. This approach could provide capacity for managing dredged material until approximately 2024. The engineering analysis to confirm the feasibility of this fill management activity should be a high priority. Establishing such a long-term fill management plan incorporating mechanical offloading and stockpiling is consistent with the needs for future beneficial use at upland sites.
3. The development of long-term alternatives will require further and more detailed evaluation than provided in this report. Several potential long-term beneficial use concepts identified require additional technology evaluation, engineering design work, or a pilot-scale demonstration project prior to evaluating their feasibility. The manufacturing of lightweight construction aggregate and insitu harvesting of coarse-grained sediment for construction or beach nourishment fall into this category. Sources of funding from Federal, State and Local agencies must be indentified for the additional engineering and economic analysis that may be required to effectively evaluate the feasibility of these options. A number of opportunities exist for redevelopment of urban and industrial properties in Cuyahoga County. For example, there is considerable local interest in redevelopment of the General Chemical site on Warner Road. Although the unsolicited proposal provided by Ditchman Holdings provided a high cost option that included material handling at the Zaclon site, the opportunity to redevelop the General Chemical Brownfield and other sites using dredged material dewatered at the CDFs should be reviewed. This proposal contemplated the beneficial use of over 3 million CY of dredged material over a 10-year period.
4. The ODOT Innerbelt and Lakefront West projects will have significant requirements for sub-soil and topsoil. Although the design for the new bridge has not been finalized, 80,000 CY of topsoil is estimated to be required in 2015 near the end of bridge construction. Landscaping associated with the Lakefront West project is anticipated to require

additional large quantities of topsoil. The availability, suitability, and costs associated with using dredged material as sub-soil and topsoil needs to be conveyed to the general contractor and the ODOT. State and local sponsors should consider incentives to encourage the use of dredged material as topsoil for these projects. Local leadership and active ODOT support are required to develop this opportunity.

5. Over the last several years, an average of 1,000 residential properties in Cleveland have been demolished per year. These properties require approximately 185 CY of fill for each foundation and property restoration. At this rate, 75% of the average annual production of dredged material could be used for vacant property rehabilitation. However, the screening level assessment of potential risk to human health demonstrated that dredged material will exceed OEPA's acceptable risk levels for use as surface soils in residential settings. This analysis, however, ignores the actual benefits of using dredged material to improve the environmental quality of Cleveland's urban core. When considered in the context of restoring vacant and abandoned properties, the use of dredged material as topsoil is expected to actually reduce exposure to contaminants and the everyday risks faced by Cleveland's urban communities. The available information indicates that the navigation channel sediment is likely to exhibit half the risk to human health compared to some neighborhood surface soils. A review of OEPA policy regarding risk limits and the procedures used to define acceptable levels of risk in urban environments should be conducted. The acceptability of using dredged material for rehabilitation of urban soils and restoration of vacant properties should be based in part on the typical background concentration of contaminants considered normal for Cleveland and surrounding urban communities.
6. A Section 204 Regional Sediment Management study was conducted in 2010 that evaluated the Federal interest in the nearshore wetland restoration at Voinovich Park and Wetland habitat construction at Whisky Island Park. These two beneficial use projects could potentially result in the beneficial use of over 800,000 CY of dredged material and the creation of nearly 10 acres of wetland habitat in Cleveland's urban core. Given the results showing that some dredged material may be suitable for wetland habitat restoration projects (while other material may not be suitable), the USACE should be prepared to conduct a Tier IV risk assessment as part of its evaluation of the feasibility for these two wetland restoration projects. This Tier IV risk assessment should be considered the stepping stone for consideration of a larger scale wetland restoration project that incorporates existing breakwaters protecting the inner harbor.

Development of emergent wetlands could be used to promote vegetative uptake of nutrients from the dredged material, as well as provide habitat for fish, shorebirds, and additional storm protection for the urban waterfront. A Tier IV risk analysis will need to consider the relative benefits to aquatic and wildlife populations that result from creating new habitat in Cleveland's urban waterfront compared to the low levels of potential risk from trace level urban contaminants in the dredged material. An engineered wetland/barrier island would not require confinement of dredged material to reduce exposure to contaminants in the dredged material if the risks associated with this use are determined to be low.

7. The Cuyahoga County Soil and Water Conservation District and the USDA-NRCS are responsible for reducing soil erosion in the watershed and the USEPA and OEPA have regulatory responsibilities to reduce contaminant loading into the Cuyahoga River Area of Concern (AOC). Including these organizations into the monitoring programs evaluating sediment quality will keep them informed on which watershed management efforts are likely to have a tangible effect on increasing the dredged material quality so that it can become an unrestricted soil resource.
8. An AOC monitoring program to identify ongoing and intermittent releases of contaminants to the river is needed to support enforcement actions for violations of the CWA. Such a monitoring program would provide baseline data necessary for determining the current status of sediment quality and suitability for beneficial uses. Engagement and support for such a program should be sought from OEPA and USEPA. A full testing program conducted every five years by the USACE should be sufficient to make decisions on suitability of beneficial uses with periodic confirmatory sediment quality monitoring overseen by OEPA . When CWA violations are identified, more frequent water and sediment quality monitoring may be required with enforcement by Ohio EPA.
9. A project should be initiated with the USEPAto develop an environmental data management system that can be used to track annual and more detailed 5-year monitoring of reviews of sediment quality data. These sediment quality data will be used to assess the suitability of dredged material for multiple beneficial uses and can also be used as one metric for delisting the beneficial use impairments associated with the Cuyahoga AOC.

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