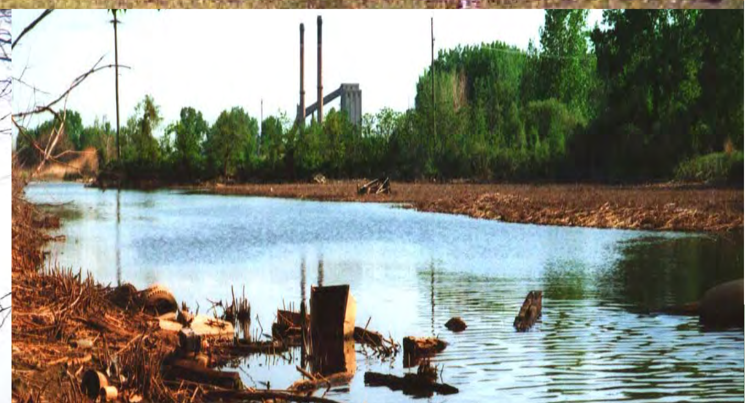
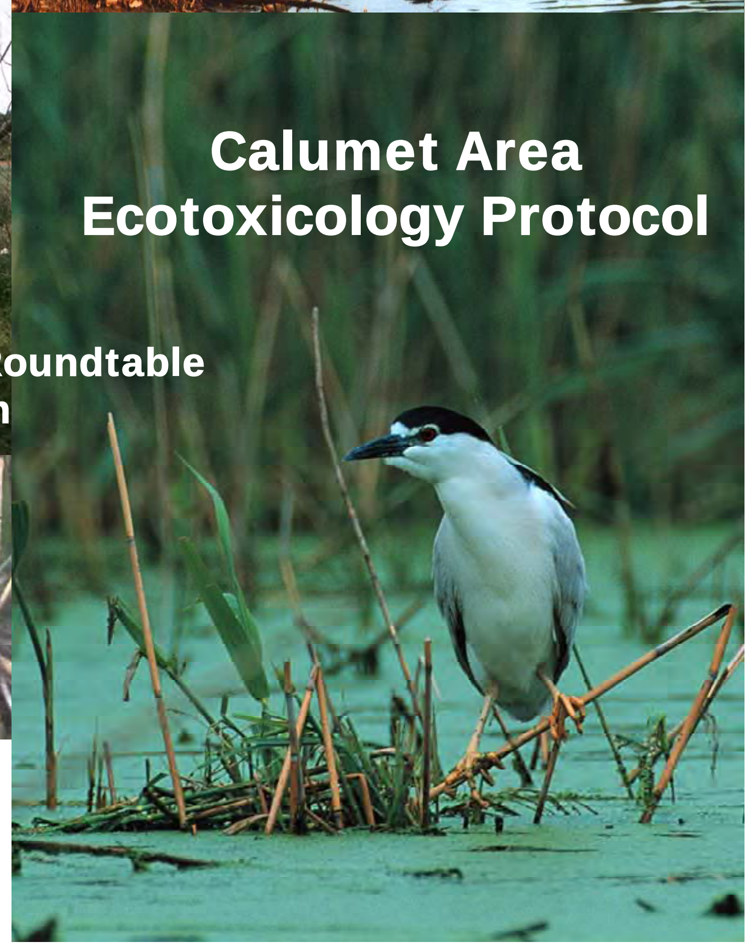
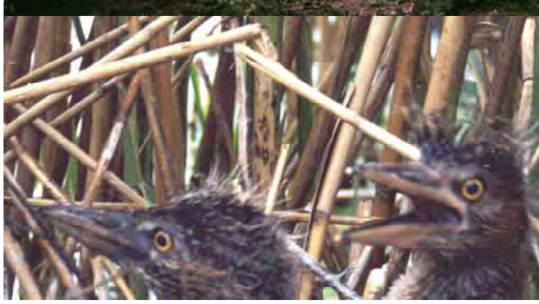




Calumet Area Ecotoxicology Protocol

Prepared by

Calumet Ecotoxicology Roundtable Technical Team



June 2007

This page left intentionally blank

Calumet Ecotoxicology Protocol

Protecting Calumet's Plants and Animals

JUNE 9, 2007

The undersigned operating partner organizations of the Calumet region are committed to facilitating the operation and management of the Calumet Ecotox Protocol in order to achieve consistent ecological health for the Calumet region.

Richard M. Daley

Richard M. Daley, Mayor
City of Chicago

John D. Rogner

John Rogner, Field Supervisor, Chicago Field Office
U.S. Fish and Wildlife Service

Margaret Guerriero, Director of Waste, Pesticides and Toxics
U.S. Environmental Protection Agency, Region V

Douglas P. Scott

Douglas P. Scott, Director
Illinois Environmental Protection Agency

Leslie Sgro, Deputy Director
Illinois Department of Natural Resources

Steven M Bylina Jr

Steven M. Bylina, Jr., General Superintendent
Forest Preserve District of Cook County

Timothy J. Mitchell, General Superintendent
Chicago Park District

This page left intentionally blank

CONTENTS

Section **Page**

Appendix

ACKNOWLEDGEMENTS

The Ecotoxicology Roundtable Technical Team consisted of the following members:

Agency/Stakeholder	Representative
Chicago Department of Environment	Nicole Kamins Annalisa Ahumada David Graham
Chicago Park District	Lee Ann Tomas
Cook County Forest Preserve District	Chris Merenowicz
Illinois Department of Natural Resources	Pat Giordano Beth Whetsell
Illinois Environmental Protection Agency	Thomas Hornshaw Jody Kershaw
Illinois Natural History Survey	David Thomas
U.S. Fish and Wildlife Service	Shawn Cirton Ed Karecki
U.S. Environmental Protection Agency	Barb Mazur David Brauner
Waste Management and Research Center	Marv Piwoni
Baetis Environmental Services, Inc.	David Pott
Parks Consulting Group, LLC	Susan Parks
Tetra Tech EM Inc.	David Homer

Photographs of Adult Black-Crowned Night Heron Provided by Mike Jeffords

This page left intentionally blank

EXECUTIVE SUMMARY

Background

The ecological goal of the Calumet Initiative is to manage roughly 4,800 acres of open space as an Open Space Reserve. The City of Chicago, along with a great number of partners, plans to rehabilitate these open spaces with an eye toward both human and ecological health; contaminant cleanup may be required as part of site rehabilitation. In the end, most properties within this acreage will be transferred to the State and other agencies for ownership, management, and productive use.

Need

Currently, Illinois has no criteria for how to clean up contaminated properties to ensure the health of plants and animals in the final site design. Partners in the Calumet Initiative recognized the need for a guidance protocol to help make design decisions for the Calumet area sites; therefore, they initiated a roundtable to provide the guidance document.

Roundtable

The Calumet Ecotoxicology Roundtable convened in 2003 to develop and implement a consensus framework for investigating ecotoxicological risks within the Calumet area open spaces. Roundtable participants were to define standards for rehabilitation that conscientiously address ecological health. To reach this end, two teams were established—a Management Team and a Technical Team. The Management Team is comprised of key decision makers including involved agencies and potential landowners; its roles include defining current issues and ensuring consensus among the agencies. The Technical Team includes ecotoxicologists, ecologists, hydrologists, and contaminant fate and transport experts; its roles include defining ecotoxicological and other issues in the context of current regulations, analyzing and developing criteria for rehabilitation of chemical contamination acceptable to all interests, and developing a protocol for implementing this framework in the Calumet area. The Ecotoxicology Protocol has resulted from the efforts of both teams.

Scope

The scope of the protocol is to provide guidance for investigating, evaluating, and rehabilitating the Calumet area sites consistent with guidelines identified in the Calumet Area Ecological Management Strategy. The protocol is designed for application to the Calumet area only; however, it could serve as a model for other areas. Authors of the protocol drew heavily on work at the Midewin National Tall Grass Prairie (Joliet/Midewin Ecological Working Group [Midewin] 2000). Extensive collaboration and willingness to give and take were necessary to create a protocol acceptable to regulators and practitioners.

This protocol is not intended to address protection of human health—that is addressed by the Illinois Environmental Protection Agency (IEPA) Tiered Approach to Corrective Action (TACO) Program (Illinois Pollution Control Board [IPCB] 2007).

Objectives

The protocol has three overall objectives:

1. Provide guidance and standardize the approach for site evaluation.
2. Assist stakeholders in prioritizing sites to be rehabilitated.
3. Help stakeholders design the site rehabilitation to address chemical contamination.

Many sites in the Calumet area have been subject to various degrees of evaluation by different entities. The protocol provides a standardized, systematic, state-of-the-art approach to evaluating site data with focus on potential impacts on ecological receptors at the site. This evaluation will also help assess current site conditions and current land uses, and determine overall ecological objectives for the site.

Many sites in the Calumet area have been impacted to varying degrees by releases from different sources. Limited funds are available for rehabilitating these sites, so the decision makers must have assistance in prioritizing sites for rehabilitation. Authors of the protocol sought to provide that assistance by identifying: (1) areas not expected to impact ecological receptors and (2) areas likely to significantly impact receptors. The protocol includes Calumet Open Space Reserve Threshold and Benchmark values for soils, sediment, and surface water that meet these objectives.

The final objective of the protocol is to help the stakeholders design site rehabilitation. The protocol guides stakeholders in developing rehabilitation goals and methods that may address a variety of issues: biological communities and habitats; chemical contamination; recovery potential; community access; and current and final land use. It also provides guidance on developing rehabilitation option arrays and evaluating alternatives.

This page left intentionally blank

1.0 INTRODUCTION

The 20-square mile Calumet area located on Chicago's far southeast side was once one of the largest wetland complexes in lower North America—supporting diverse plant and animal life. To the early inhabitants, the fish and wildlife in its streams, marshes, prairies, and ponds were primary resources. As the area developed, its industries came to be viewed as the primary resource, often at the expense of the ecological resources. During the 1870s and 1880s, pollution from industries in the area, along with straightening the Calumet River, began the 130-year period of habitat destruction that would result from filling and draining marshes, excavating sand, and depositing industrial and municipal waste. The complex natural system of freshwater sloughs and wetlands connected to Lake Michigan was dredged, dammed, and channelized. A growing network of roads and railroads divided and compartmentalized the various habitats. This industrial development was responsible for loss of extensive pre-settlement marsh assemblages once teeming with native flora and fauna. The area has undergone radical change wrought by over a century of intensive industrialization, pollution, and waste disposal.

While many of the wetlands were filled for industrial development, others were left in place. As a result of these contradictory activities, industrialized lands juxtaposing valuable wetland habitats form the defining feature of the current Calumet area. In fact, the remaining Calumet wetlands are among the most ecologically significant in Illinois. Eleven Calumet area wetland sites have been listed in the Illinois Natural Areas Inventory (INAI). In 1980, the U.S. Army Corps of Engineers designated certain wetlands as the highest priority in its Special Areas Management Program (SAMP). The City of Chicago contracted a study that comprehensively inventoried the richness of the bird populations in the area (Environmental Consultants and Planners, Inc 1983).

In June 2000, Chicago Mayor Richard M. Daley and Illinois Governor George H. Ryan announced a new vision for the Calumet area. This agreement covered four key topics: land acquisition, land rehabilitation, industrial development, and green energy. Gaining an understanding of environmental contamination from past activities and its potential impact on ecological receptors are necessary to move forward on the land acquisition and rehabilitation aspects of this agreement.

Moreover, the City of Chicago (City) has an aggressive time schedule for transferring ownership of some parcels of land to the State of Illinois and other potential landowners.

This new vision is reflected in several recent reports. Two reports, the Open Space Reserve (City of Chicago 2001) and the Calumet Area Land Use Plan (City of Chicago 2002), identify the land designated for open space and the primary ecological resource for the area. The Calumet Area Ecological Management Strategy Phase 1 Sites (Calumet EMS) (City of Chicago and others 2002) is the plan for the ecological resources rehabilitation.

The new vision is the first comprehensive effort to strike a balance between the area's economy and its environment—to provide jobs, re-invigorate neighborhoods, and nurture its remaining complex of rare natural areas. A comprehensive strategy for the area has emerged via the City's *Calumet Area Land Use Plan* and the *Calumet EMS* cited in the previous paragraph. These Calumet-focused initiatives involve intensive collaboration between a large number of city, state, and federal government agencies; representatives from industry and universities; environmental group representatives; and local residents.

The *Calumet EMS* has been created as a template for managing ecological sites throughout the Calumet region. It notes the impossibility of returning the Calumet area to pre-settlement conditions after extensive development and resulting disturbances over the years. Instead, it offers three guidelines to serve as a "filter" for management decisions:

- **Preserve** existing plant and animal habitats with high biological value.
- **Improve** existing habitats that will maximize potential for native diversity and ecological health.
- **Create** new habitats, where feasible, that will satisfy the needs of native species and communities.

The anticipated rehabilitation of the Calumet area lands creates an absolutely unique opportunity. The goal of the various rehabilitation projects is to bring roughly 4,800 acres of open space under an ecological management system that allows productive

use. The City of Chicago plans to clean up these open spaces with an eye toward both human and ecological health. In the end, most properties within this acreage would be transferred to the State and other agencies for ownership, management, and productive use. Participating stakeholders recognize the need to establish a consensus framework for addressing ecotoxicology issues in this area.

The *Calumet EMS* states that the goal is not to restore sites to pre-settlement conditions across the region, but to rehabilitate them. It defines rehabilitation as returning sites, wherever possible, to full and sustainable ecological health using pre-settlement conditions as a guide. Understanding that human impact on sites has been so great, that ecological health may come in a new form. Streams and dolomite prairies, for example, might now be able to flourish in former wetlands now filled with slag. The rehabilitation as discussed in this document is consistent with the definition in the *Calumet EMS,* particularly as it relates to chemical contamination.

The Ecotoxicology Roundtable came together to develop and implement a consensus framework for investigating ecotoxicological risks within the Calumet area open spaces. Roundtable participants sought to define standards for rehabilitation that conscientiously address human and ecological health. To reach this end, two teams were established—a management team and a technical team. The Management Team is comprised of key decision-makers representing interested parties including involved agencies and potential landowners; its roles are to define current issues and ensure consensus among the agencies on key decisions where feasible. The Technical Team includes ecotoxicology experts, fate and transport experts, and technical representatives of various stakeholders. Its mission is to define ecotoxicological and other issues in the context of current regulations, analyze and develop criteria for rehabilitation from chemical contamination acceptable to all interests, and develop a protocol for implementing this framework in the Calumet area. The Ecotoxicology Protocol has resulted from the efforts of both teams. Ultimately, future and current landowners and funding agencies will be responsible for implementing the project, and efforts will be made to achieve consensus. Should consensus not be reached, current and future landowners will decide future course of action. A more detailed discussion of this process is in Section 5.4.

1.1 ECOTOXICOLOGY PROTOCOL SCOPE AND OBJECTIVES

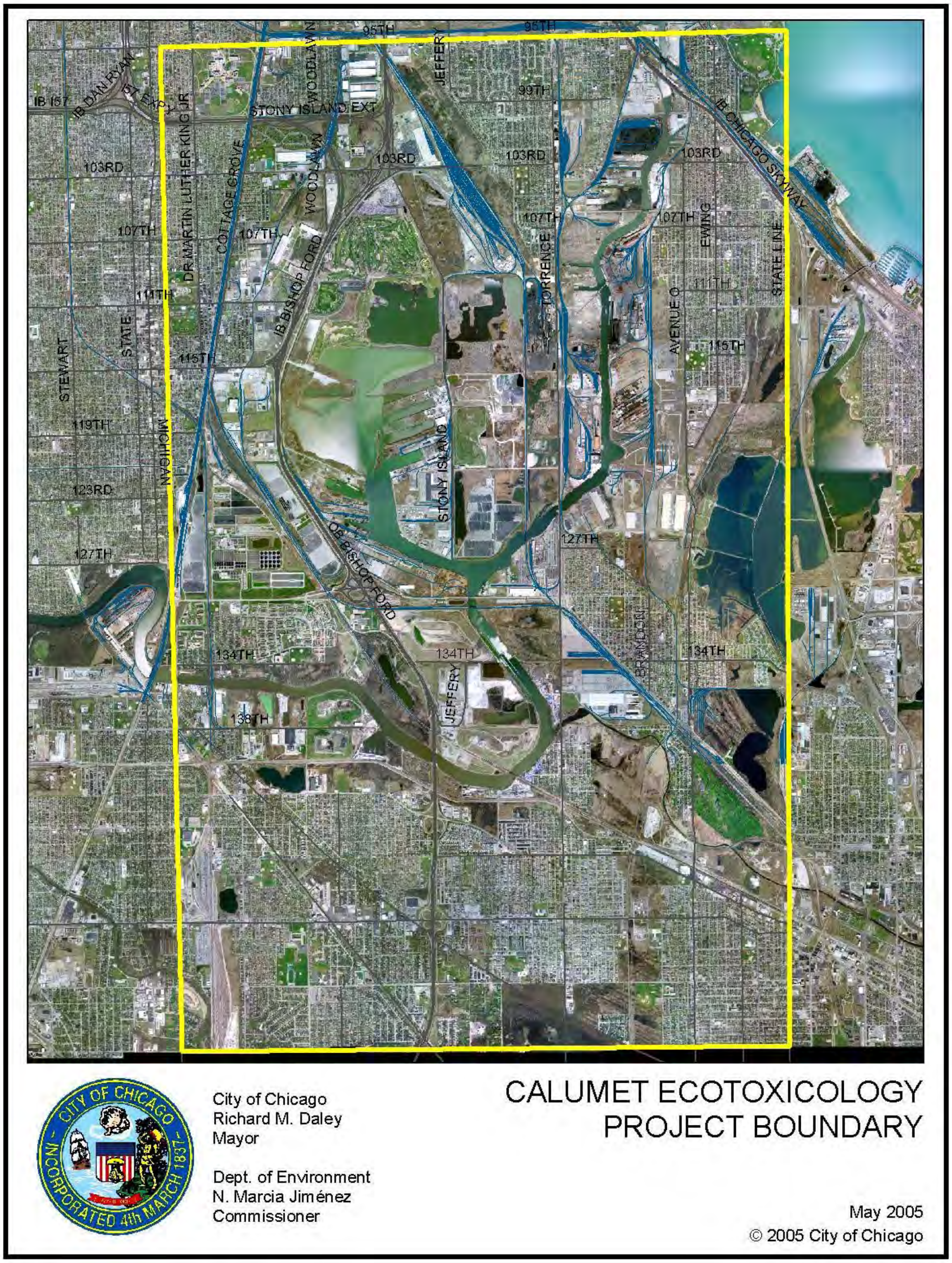
The Calumet area Ecotoxicology Roundtable Technical Team was formed to address potential ecological challenges deriving from contamination in the Calumet area and to provide guidance for rehabilitating selected sites from chemical contamination. The following sections describe the scope of the ecotoxicology protocol and its objectives.

1.1.1 SCOPE

Currently, Illinois has no specific criteria for site cleanup based on non-human indicators. The Calumet area initiative has provided a unique opportunity to formulate cleanup guidance amenable to all interests that will serve as a template for ecologically based rehabilitation at the Calumet area sites. The scope of the protocol is to provide guidance for investigating, evaluating, and rehabilitating the Calumet area sites from chemical contamination consistent with guidelines identified in the *Calumet EMS.* The protocol is designed for application to only those sites in the Calumet area that will be publicly managed, not for general application (though it could serve as a model for other areas). The Calumet area is geographically defined in Figure 1-1. The protocol drew heavily on the work done at the Midewin National Tall Grass Prairie (Midewin 2000). Extensive collaboration and willingness to give and take were necessary to create a protocol acceptable to regulators and practitioners.

This protocol is designed as guidance and not as a regulatory framework that must be prescriptively followed. Its intent is to provide a basic framework for use by stakeholders to evaluate whether sites in the Calumet area need rehabilitation

Figure 1-1 Calumet Ecotoxicology Project Boundary



from chemical contamination and to identify rehabilitation options. This guidance does not replace any current laws or regulations; following this guidance does not absolve one from compliance with other applicable regulations.

This protocol is not intended to address evaluation of site contamination or provide rehabilitation guidance for protecting human health. Human health issues are to be evaluated separately following guidance outlined in the Illinois Environmental Protection Agency (IEPA) Tiered Approach to Corrective Action Objectives (TACO) Rules and Regulations (Illinois Pollution Control Board [IPCB] 2007), or other applicable laws and regulations.

There are sites within the Calumet area, such as the Cluster Sites, that are currently managed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This protocol is not designed to apply at those sites. Any remedies at CERCLA-regulated sites may well impact Calumet area sites that may be managed under this protocol. These impacts must be factored into any final rehabilitation decision for the Calumet site.

1.1.2 OBJECTIVES

The protocol has three overall objectives: (1) provide guidance and standardize the approach for site evaluation, (2) assist stakeholders in prioritizing sites to be rehabilitated from chemical contamination, and (3) help stakeholders design the site rehabilitation.

The protocol provides a systematic, risk-based, state-of-the-art, standardized approach to evaluating site data with focus on potential toxicological impacts on ecological receptors at the site. This evaluation will also help assess current site conditions and current land uses, and determine overall ecological objectives for the site.

Many sites in the Calumet area have been impacted to varying degrees by releases from different sources. Limited funds are available for rehabilitating these sites from these releases, so the decision makers must have assistance in prioritizing sites for rehabilitation. One of the protocol's objectives is to provide that assistance by identifying: (1) areas not expected to impact ecological receptors and (2) areas likely to have a significant impact on receptors.

The final objective of the protocol is to assist the stakeholders in designing site rehabilitation of contamination. The protocol guides stakeholders in developing rehabilitation goals and methods that may be based on a variety of issues—

biological communities and habitats; chemical contamination; recovery potential; community access; and current and final land use. It also provides guidance on developing rehabilitation option arrays and evaluating alternatives. This guidance is a living document and will be updated in the future. The Technical Team recognizes the current data have limitations and that data gaps exist. These issues are discussed in Section 5.5.

1.2 AUDIENCE

The protocol is written for multiple stakeholders in the Calumet area and the scientists and engineers supporting them. Stakeholders include current landowners, future landowners, and the public. Current and future landowners will use the protocol to assess ecological conditions of sites, and levels and potential impacts of contamination; they also will reference it for guidance on site rehabilitation. The high level of public interest in the Calumet area suggests that the document will be used to ensure compliance with objectives of the *Calumet EMS*. Finally, the scientists and engineers will use this protocol as a road map to assist the stakeholders.

1.3 REHABILITATION PROCESS

The rehabilitation process will include a variety of stakeholders at each site, and each has an important role to play in the successful site rehabilitation. Figure 1-2 provides an overview of the rehabilitation process, and this protocol provides the general guidance to move sites in the Calumet area through this process. Although the process is presented as linear, several activities may occur at the same time or in an order different than presented. The process is also iterative— as new data become available, reevaluation of assumptions, future actions, and conclusions will occur. Two important teams will oversee the process—the Management Team and the Technical Team. The Management Team is responsible for the overall rehabilitation process; it includes managers from the key state and federal agencies that may own a site, exert regulatory authority over a site, or play an advisory role for protection of ecological resources at the site. The Management Team is responsible for: ensuring that each agency is informed on the project, ensuring that each agency provides needed input

Figure 1-2 Calumet Area Site Rehabilitation Process

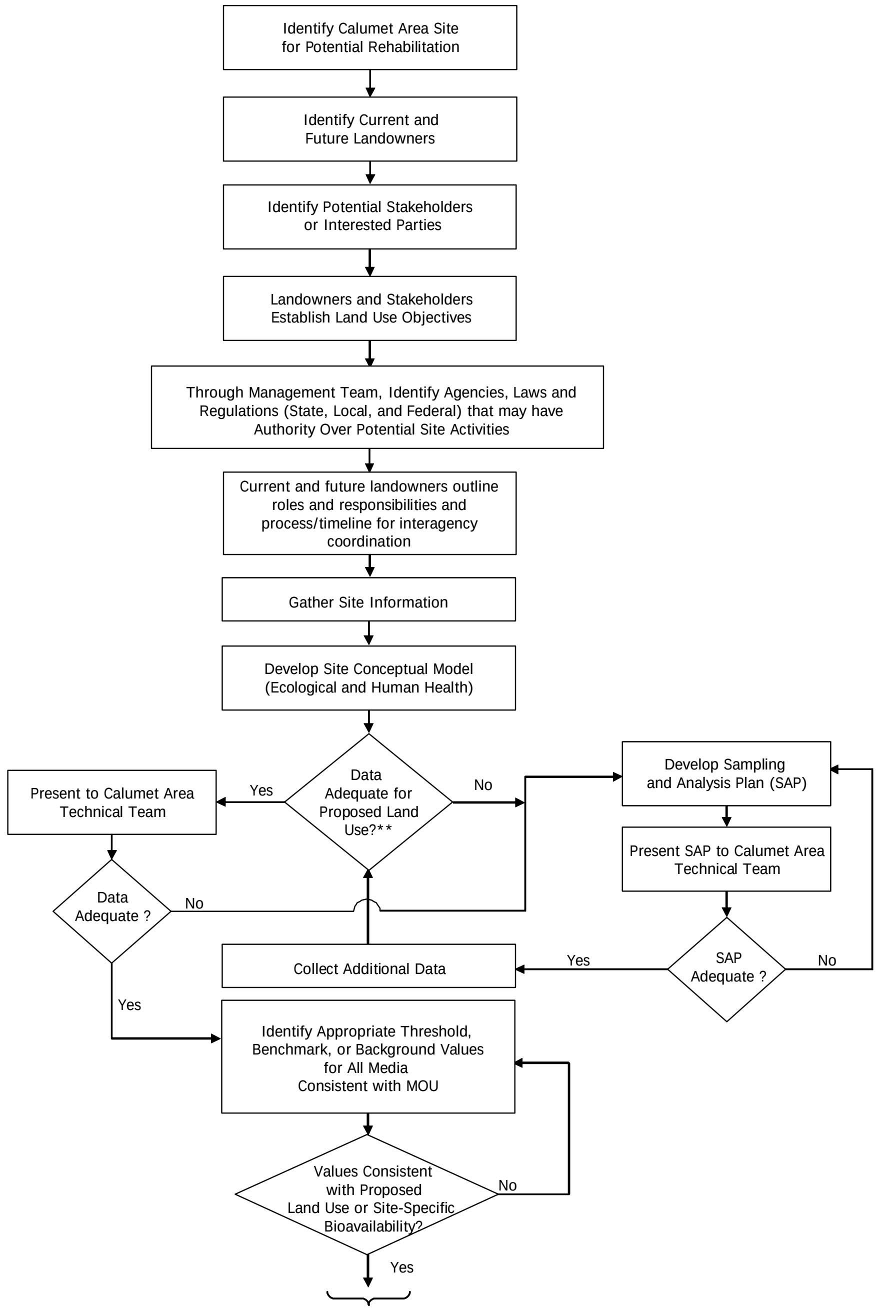
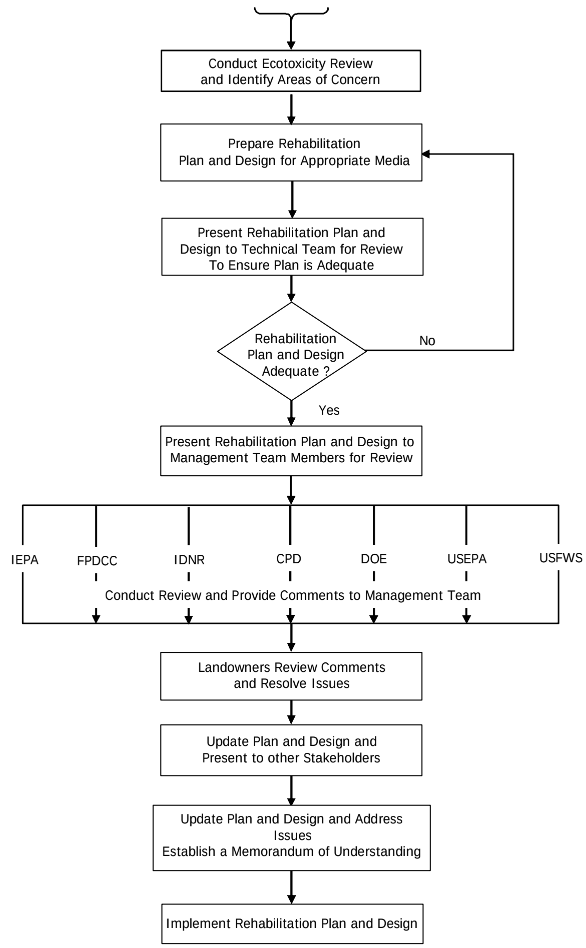


Figure 1-1 Calumet Area Site Rehabilitation Process (continued)



* MOU outlines site description, project objectives, current and future land use, and lines of responsibility for site investigation and rehabilitation from contamination.
** This assumes the responsible agency conducts the first analysis of the data's adequacy before the data are presented to the technical team.

IEPA Illinois Environmental Protection Agency
FPDCC Forest Preserve District of Cook County
IDNR Illinois Department of Natural Resources
USFWS US Fish and Wildlife Service
CPD Chicago Park District
DOE City of Chicago Department of Environment
USEPA US Environmental Protection Agency

concerning legal and jurisdictional issues the project must address, and that each agency communicates with its own management on project status and on critical issues the project must address.

Under direction of the Management Team, the Technical Team (comprised of technical experts) provides technical guidance to the Management Team to ensure achievement of the protocol objective and the *Calumet EMS*. The steps identified in the process flow diagram are described in the protocol.

The remainder of this section briefly describes how a site will move through the rehabilitation process. Once current or future landowners have identified a site for potential rehabilitation, they will identify additional stakeholders and interested parties. The landowners, stakeholders, and interested parties then need to establish overall land-use objectives for the site consistent with the Calumet EMS. When these objectives are defined and indicate possible need for site rehabilitation to meet them, the Management Team comes together to identify agencies, laws, and regulations that may have authority over potential site activities. Once these potential obligations are identified and understood, the current and future landowners identify processes for interagency coordination, and identification of roles and responsibilities. The agency responsible for the site investigation and potential rehabilitation then begins data collection and evaluation, and possibly rehabilitation planning and design. Throughout this process, the Management and Technical Teams receive information from the responsible agency and must reach consensus on investigation methods, data interpretation, and final rehabilitation options. As noted earlier, the current and future landowners have the responsibility to resolve any disputes if consensus is not reached. It is expected that before the rehabilitation is finalized, the current and future landowners will enter into a Memorandum of Understanding (MOU) that will formalize the current and future responsibilities for each agencies.

1.4 DOCUMENT OVERVIEW

The following sections provide guidance on the protocol. Section 2.0 discusses the site status—evaluating the current site data and determining whether additional data are needed. Section 3.0 provides an overview of additional investigation that may be

Funding Sources

Here is a range of funding sources that could support rehabilitation projects in the Calumet area. They include but are not limited to:

Grants

USFWS – North American Wetlands Conservation Grants Program. National Coastal Wetlands Conservation Grants Program

Conservation Fund – Northeast Illinois Wetland Conservation Account

US Army Corps of Engineers – Sections 206 and 1135 of the Water Resources Development Act of 1996

USEPA - Great Lakes National Program Office Grants, Brownfield Program Grants, and Water Grants

IDNR – Open Land Trust Program, Open Space Lands and Acquisition and Development Program, Conservation 2000 Ecosystems Program, Special Wildlife Funds Grants Program

US Forest Service – Various grants

Foundations and Nonprofit Organizations

Supplemental Environmental Projects/ Settlements

Corporate Donations

required. Section 4.0 presents the template to be used for evaluating site data to determine the nature and extent of potential ecotoxicological impacts at the sites. Section 5.0 describes the process that should be followed when rehabilitating a site.

2.0 SITE STATUS

Many sites in the Calumet area have been subject to various degrees of contaminant and ecological investigation. This section describes a systematic approach to evaluating the site conditions—assessing current site data, land use, and legal requirements; formulating overall ecological site objectives; developing a conceptual site model; and identifying data gaps. The aim of this section is to furnish guidelines for documenting the presence of ecological receptors and contamination at a site.

2.1 SITE CONDITIONS

The first step in a scientific site investigation is to describe current site conditions in a manner that can support subsequent efforts to understand the relationship between potential ecological receptors at a site and potential stressors that may be present. This first step primarily focuses on describing conditions at the site, not determining potential effects. Various data will be available, some at higher levels of certainty than others. All can be used to describe the site's status, accompanied by proper documentation of uncertainties. This site description should include current data, land use, and legal requirements.

2.1.1 CURRENT DATA

Data from the sites in the Calumet area are expected to be available; however, the amount and quality of data will vary. This section discusses types of possibly available site data and the data's potential significance to overall understanding of the site's status. Three general categories of data are discussed—physical, chemical, and biological. The overall goal of using these data is to obtain sufficient information to create a conceptual site model (CSM) illustrating the opportunities for contamination to adversely affect organisms, populations, or communities. Section 2.3 discusses the CSM.

One of the first tasks is to collect physical site data to help understand potential movement of contaminants onto the site and from the site. Data on physical conditions at the site include site location, hydrologic and hydrogeologic conditions, topography, and soil types. The location of the site and its relation to adjacent properties are critical for determining whether adjacent sites with potential sources of

contamination could be impacting the site or whether they might provide depositional areas for contaminants leaving the site. General hydrologic and hydrogeologic conditions at the site are also important because movement of water through any landscape and groundwater flow is essential for understanding biological communities or potential contaminant fate and transport. The topography of the site and adjacent properties will indicate whether the site may receive stormwater runon from adjacent properties or may be the source of stormwater runoff. Information regarding local topographic features may assist in understanding groundwater flow, and whether site wetlands are a source of groundwater recharge or point of groundwater discharge. Soil type will help to delineate upland and wetland areas; it may also identify areas that have been subject to borrow or fill activities and other limiting factors. If soil borings have been conducted at the site, the boring logs provide an excellent source of information on subsurface conditions.

Many sites in the Calumet area have received contamination from industries in the region, both directly from point source industrial discharges and indirectly by atmospheric deposition and stormwater runoff. Chemical data that help characterize the type and extent of contamination are essential. Water and sediment quality data are critical for identifying potential impacts on aquatic communities at these sites. Data defining soil contamination can be useful for describing possible impacts on plants and animals that rely on these communities. Chemical data from the three critical media of water, sediment, and soil should include the following contaminant classes:

- Metals
- Polynuclear aromatic hydrocarbons (PAH)
- Polychlorinated biphenyls (PCB)
- Dioxins/furans
- Pesticides and herbicides
- Semi-volatile organic compounds (SVOC)
- Volatile organic compounds (VOC).

Data on ecological management parameters should also include the following:

- Dissolved oxygen
- pH
- Hardness
- Total phosphorus
- Specific conductance or total dissolved solids.

Ammonia and cyanide should be measured in water systems and ammonia in sediment. For soil and sediment, organic carbon is important for understanding potential fate and transport and bioavailability.

Biological data are crucial for identifying potential ecological receptors at the site. Knowledge of habitat types at the site is important; these could include open water, wetlands, submerged vegetation, scrub/shrub, prairies, woodlands, and other habitats such as open fields. Previous biological surveys at a site may have included population or community surveys that evaluated the past status of the site according to measures such as standing biomass, species richness, and so on. The survey for biological data need not include population data and could be limited to identifying species present at the site. It is important to document if endangered species are known or suspected to frequent the site. The appropriate state or federal agency should be consulted for information on threatened or endangered species in the area. Documentation of known invasive species present at a site and the extent of their coverage within the site are also important. Even if extensive surveys have not been conducted, information on dominant vegetative species will provide a better understanding of the types of communities that could be present.

Mapping the physical, chemical, and biological data can be useful to establish a picture of the site that may reveal important relationships among these three data types.

2.1.2 LAND USE

Any site status description should include a characterization of the land use—both current and past, if known. Multiple present or former uses of the site are possible.

The description should also include land use on adjacent properties, which could provide insight about sources of potential contamination.

Land use may change in the future as a consequence of site rehabilitation. If foreseen, this information may be included in general or specific formulations of land use goals for a site. An example would be knowledge that a portion of a site will be developed for parkland, and other portions will be returned to native prairie and wetlands. This information can help ensure that data evaluation will proceed assuming the appropriate potentially exposed future populations.

Major laws and treaties that may be applicable:

- Illinois Endangered Species Act
- Federal Endangered Species Act
- Clean Water Act - Sections 401 and 404
- Rivers and Harbors Act – Section 10
- Fish and Wildlife Coordination Act
- International Migratory Bird Treaty
- National Environmental Policy Act

2.1.3 LEGAL REQUIREMENTS

A number of environmental laws and regulations relating to species or habitats present at a site may apply. Presumably, for sites in the Calumet area that would be under the protocols described in this document, the rehabilitation process would not be managed under either the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). However, adjacent properties and their discharge may be regulated or managed under CERCLA or RCRA. If these laws are determined applicable to the site undergoing rehabilitation, any activities for the management of hazardous materials or waste at the site would have to comply with the appropriate CERCLA or RCRA regulations and guidance.

The most common and potentially most significant legal requirements that may apply to these sites are state and federal endangered species laws and regulations. These requirements must be clearly identified, and as early as possible, especially if rehabilitation is expected at a site. Specific data requirements may be in force if these special status species are known or suspected to be present. When specific project goals are identified, the "Consultation Process" under Title 17: Chapter 1: Section 1075.40 Consultation Procedures For Assessing Impacts Of Agency Actions On Endangered And Threatened Species And Natural Areas, must be initiated. The U.S. Fish and Wildlife Service and Illinois Department of Natural Resources must be contacted to determine their exact requirements regarding special status species.

If special status habitats hosting special status species are found, or if habitats specifically regulated (e.g., wetlands) are present, additional specific legal requirements must be met as part of any rehabilitation. For example, the U.S. Army Corps of Engineers has requirements for wetlands under Sections 401 and 404 of the Clean Water Act. These requirements should be identified as early in the investigation as possible to ensure that data are adequate to satisfy them. If federal funds are used in the rehabilitation process, additional National Environmental Policy Act requirements must be met.

2.2 OVERALL SITE OBJECTIVES

As stated earlier, the Calumet area is a focus of both ecological and industrial revitalization. The *Calumet EMS* and *Calumet Area Land Use Plan* have identified a series of overall objectives for the region. It is important that ecological and other objectives for a site under investigation be identified as part of the site status report.

2.2.1 ECOLOGICAL OBJECTIVES

The *Calumet EMS* identified three overall objectives for the sites in the region: preserve, improve, and create. Because many sites are complex mixtures of habitats with varying levels of contamination, distinct objectives for the different habitats within a site may be necessary. For example, a portion of the site may currently have a high-quality wetland habitat; here the objective may be to just preserve that existing habitat. Other portions or media at the site, such as sediments, may be known to contain contaminants at levels harmful to ecological receptors, and the objective may be to improve the quality of the habitat. Still another portion, open fields, may have little ecological value; the objective for this area may be to create a habitat that does not now exist at the site—perhaps a woodland habitat created from an open field to enhance overall biodiversity of the site. Final ecological objectives must be consistent with the *Calumet EMS* and stakeholder interests at the site.

2.2.2 HUMAN USE OBJECTIVES

For some sites, human objectives must be identified because they may impact the ecological objectives. Examples include land use for educational or recreational

purposes. These objectives must be consistent with the *Calumet EMS* and stakeholder interests at the site.

2.3 CONCEPTUAL SITE MODEL

Conceptual Site Model includes source-pathway-receptor diagrams and text.

Defines and describes the following:

(1) Sources of contamination
(2) Media of concern
(3) Fate and transport mechanisms
(4) Contaminant exposure pathways
(5) Potential receptors

The CSM is a written description and visual representation of potential relationships among ecological receptors, the contamination or stressors at a site, and the routes of exposure to receptors. A conceptual model may represent many different relationships among the sources of contamination, migration pathways, and site receptors. The information collected and discussed in the previous sections should be used to construct the conceptual site model. An example of a conceptual site model is provided in Figure 2-1.

The CSM should identify all significant sources of contamination at the site and describe the primary, secondary, and possibly tertiary exposure and migration pathways. These exposure pathways include direct contact with surface water, sediment, or soils; or migration from soils or sediments to surface water or groundwater. Both current and future land uses must be taken into account; this will help to identify appropriate receptors. At a minimum, the model should define the general category of receptors; however, a more detailed food web may also be appropriate.

The initial CSM is developed based on recent information and reflects current understanding of the site. However, the CSM is an iterative document—to be revised and updated as new information is obtained. It may also be used to identify potential fate and transport issues that may influence migration pathways and receptors.

2.4 DATA GAPS

Once completed, the CSM should be reviewed along with the other data obtained from the site to determine if data gaps are present. The focus of the data gap evaluation should be to ensure that sufficient data are available to characterize the nature and extent of contamination at the site. The evaluation should also focus on the description of the ecological community and whether it has been adequately characterized. The data should be reviewed to determine if sufficient data are

available to support any fate and transport analysis or toxicity evaluation. It is important that a technical team with a wide array of expertise (such as biologists, chemists, geologists, and others) assesses the adequacy of the CSM and performs the data gap analysis. This will ensure the site is evaluated from several perspectives—each with its own unique data needs.

FIGURE 2-1

3.0 ADDITIONAL INVESTIGATIONS

Results of the data gap analysis will determine if additional data are required to develop rehabilitation plans for each site. This section presents an overview of the applicable sampling and analysis requirements to support rehabilitation decisions. It also surveys resources available to help plan and complete any additional sampling and analysis. Finally, this section describes the review and approval process for additional sampling and analysis at Calumet area sites.

3.1 DETERMINING SAMPLING AND ANALYSIS REQUIREMENTS

If additional data are required, the following discussions of potential data needs should prove helpful. One of the first steps is to identify data quality objectives (DQO) for the site following current U.S. EPA guidance (EPA 2000). It is important to establish DQOs early, because these provide the context for understanding the purpose of the data collection effort and establish the qualitative and quantitative criteria for assessing the appropriateness of the data set for the intended use. The general data needs should be discussed as three groups—chemical, biological, and physical. Specific data needs would be defined by site-specific DQOs.

Chemical: The main concerns with the chemical data are collecting a sufficient number of samples to adequately describe the nature and extent of contamination at the site, and obtaining sufficient good-quality chemical data to resolve any contaminant fate and transport issues. To determine the nature and extent of contamination, both surficial and depth evaluations should occur. No prescribed number of samples or distance between samples ensures successful characterization of contamination nature and extent. However, collecting a sufficient number of samples is critical to provide a reasonable picture of the overall extent of contamination. Soil samples at the surface (0 to 2 feet) and, if contamination is found in the upper zones, to a depth of at least 6 to 8 feet, should be obtained to assess potential exposures of vegetation and burrowing animals. Creating a map with sample locations and contaminant concentrations will assist in identifying potential sources of contamination and possibly show contaminant migration.

The list of analytes for additional samples should reflect information obtained from the available data, information resulting from past site activities, and known sources

of contamination. The analyte list could be reduced to focus the investigation on constituents known to be present at the site or could require expansion if the original samples were not analyzed for constituents that may be present at the site. Data typically should be obtained for the following general classes of contaminants: metals, VOCs, SVOCs, pesticides, PCBs, and dioxins. Other data that should be obtained for water samples include dissolved oxygen, hardness, pH, ammonia, and specific conductance (total dissolved solids). For soils and sediments, data on total organic carbon content are important for understanding potential fate and transport issues, and a contaminant's bioavailability. Another fate and transport concern is the ability of contaminants to leach from soils. Several tests could be used to assess this potential, including toxicity characteristic leaching procedure and the synthetic precipitation leaching procedure. Whether groundwater is determined a significant source for surface water at the site could impact the types and number of samples required to understand the potential impacts of the groundwater source. Collecting both groundwater and surface water samples during the period of groundwater discharge to the surface water may be necessary to understand the relationship between groundwater and surface water.

The analytical results may include tentatively identified compounds (TIC), compounds whose chromatograms do not allow for positive identification but may provide a possible or tentative identification. Toxicological data available for TICs likely will be limited. However, it may be possible to identify surrogate compounds that may be used to assess potential ecological impacts of the TICs.

It may be reasonable to conduct this sampling and analysis in a phased approach. This may allow some economies in the contaminant definition process.

Biological: A wide variety of biological data may be obtained to characterize a site in the Calumet area—ranging from a delineation of habitats to biological surveys to toxicity studies on specific media of concern.

An essential start to developing sound biological data is a good understanding of the habitats present at a site. Even without definitive knowledge of species present, habitat information will allow characterization of potential or likely species present—

information crucial for completing the conceptual site model and identifying potential receptors. In addition, it is critical to understand the potential impacts from the site stressors on biological receptors at the site. The presence of federal- or state-threatened or endangered species is also a critical piece of information, and can drive potential site rehabilitation efforts.

Biological surveys will provide a more detailed description of potential receptors at the site and hopefully identify any special-status species present. Survey data may also be useful to evaluate the bio-diversity of a site and assess its health and stability. Biological survey methodologies can be used to assess a site, to determine if a habitat is supporting or not supporting a diverse community.

Samples of plants, fish, or invertebrates may be collected for tissue analyses. This data will provide a better understanding of contaminants at the site and, perhaps more importantly, establish current food chain exposure levels—providing a reference baseline for subsequent studies.

Physical Data: Several critical categories of data should be obtained for each site. Hydrologic data are very important for most wetland systems in the Calumet area. This information will aid understanding of availability and movement of water through the ecosystem and can possibly identify off-site sources that may be influencing the site. Important data include available watershed boundaries, surface-water elevations, water-level fluctuations over time, and groundwater flow patterns. The site topography will indicate stormwater runoff and run-on patterns, and possibly groundwater flow patterns. The topography can also be used to identify any input or discharge points from the system. All these data are critical for understanding contaminant movement onto, within, and out of the site or habitat.

3.2 AVAILABLE SAMPLING AND ANALYSIS GUIDANCE

Describing in detail how to conduct additional sampling and analysis at a Calumet area site is not a goal of this protocol. However, the following resources are helpful for that purpose. A suggested outline for the sampling and analysis plan is offered that specifies general topic areas that the plan should address.

SUGGESTED SAMPLING AND ANALYSIS PLAN OUTLINE

I. INTRODUCTION

II. SITE HISTORY AND PROJECT BACKGROUND

A. Site History
B. Project Background
C. Summary of Site Data
1. Soils
2. Sediments
3. Surface Water
4. Groundwater
D. Conceptual Site Model

III. OVERALL PROJECT AND QUALITY ASSURANCE OBJECTIVES

A. Overall Project Objectives
B. QA Objectives

IV. SAMPLING REQUIREMENTS
Provide a table summarizing the sampling program. Discuss number of samples, expected sampling dates, locations, methods; and include information about QC samples and methods of recording data.

V. ANALYTICAL REQUIREMENTS

A. Target Analytes
B. Project-Specific Analytical Methods

VI. OVERALL PROJECT SCHEDULE

VII KEY PROJECT PERSONNEL

Site Investigation/Sampling and Analysis References:

U.S. Environmental Protection Agency (EPA). 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive No. 9355.3-01.

EPA. 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final EPA 540-R-97-006.

EPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.

EPA. 2000. Data Quality Objectives Process for Hazardous Waste Site Investigations, EPA QA/G-4HW. EPA 600/R-00/007.

Swink, F. and G. Wilhelm. No date. "Floristic Quality Assessment" in *Plants of the Chicago Region*. Fourth edition. Indiana Academy of Science. Indianapolis.

U.S. Geological Survey (USGS). 2002. Revised Protocols for Sampling Algal, Invertebrate, and Fish Communities as Part of the National Water-Quality Assessment Program, U.S. Geological Survey Open-File Report 02-150.

USGS. Variously dated. National Field Manual for the Collection of Water-Quality Data (USGS Techniques of Water-Resources Investigations. Book 9, Chapter A1-A9.).

USGS. 1992. Guidelines for Studies of Contaminants in Biological Tissues for the National Water-Quality Assessment Program. USGS Open-File Report 92-494.

USGS. 1995. Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data. USGS Open-File Report 95-398.

3.3 REVIEW AND APPROVAL PROCESS

No specific set of ecological health regulations is available to evaluate and rehabilitate a site in the Calumet area. If no other regulations apply to these sites, no one organization has authority to approve and/or implement additional sampling and analysis plans. Nevertheless, discussion among the Ecotoxicity Roundtable's Management and Technical Teams has led to agreement that the Technical Team will function as the review panel for any additional sampling and analysis planning documents and reports. A proposed additional sampling and analysis plan should be submitted to the Technical Team at least 30 days prior to meeting with the Technical Team to allow for adequate review prior to any proposed sampling activity. The objective of the review is to ensure that the sampling will provide sufficient information to meet the data quality objectives for the site.

4.0 EVALUATION OF SITE DATA

Once all data from the various investigations have been compiled, the data must be evaluated. This section discusses procedures for this that will help stakeholders identify areas of potential concern and determine if rehabilitation is needed.

4.1 IDENTIFICATION OF HABITATS

Identifying the various habitats at a site is one of the most critical steps in the data evaluation process. A map should be created that clearly delineates the extent of each unique habitat. If a site objective is to create a new habitat there, the map should so indicate. Areas that contain special status species should also be included on the map. This spatial representation of habitats will be used along with the chemical analysis data to identify areas of potential concern.

4.2 MEDIA

The site investigations will collect chemical data from various media at a site—soils, sediment, surface water, and possibly groundwater. The first step in evaluating the data is to group the data according to the various media and spatially by unique habitats. The objective of this grouping is to identify potential exposures to the unique receptors found in each habitat, since any rehabilitation decision will refer to specific habitat(s). If data are sufficient, a table should be developed that presents the range of concentrations identified, the maximum and minimum detected concentrations, and if supportable, a statistical analysis of the data identifying the mean value and the 95-percent upper bound value following EPA guidance for identification of exposure concentrations (EPA 2002). (Numbers of samples collected from each habitat at most sites are expected to be too small to support this type of analysis; however, it is encouraged, if possible.)

A map should be created that identifies all sampling locations for each medium. This map should also delineate habitats. The overlay of sampling locations and habitat delineations will help investigators assess the thoroughness of sampling and uncertainty(s) associated with the habitat-specific data.

4.3 REVIEW AND REVISE CONCEPTUAL SITE MODEL

Threshold Values: Chemical concentrations believed protective of ecological receptors in the Calumet area. They are derived from toxicity studies that identified no-observable-adverse-effect levels (NOAEL).

Benchmarks: Concentrations expected to impact ecological receptors in the Calumet area. They are derived from toxicity studies that identified lowest-observable-adverse-effect levels (LOAEL).

Background: Concentrations that represent levels due to ubiquitous releases of contaminants in an urban area and naturally occurring concentrations in the Calumet Area. These are not concentrations that represent pre-1860 conditions.

The conceptual site model is an iterative document—to be revised and updated as new information is obtained. Investigation results from all studies at the site should be reviewed to determine if new data impact any pre-investigative assumptions about developing the conceptual site model (for example, confirming or altering sources of contamination, migration pathways, and receptors). In turn, if the investigation data changes the model assumptions, the conceptual site model should be revised to reflect this new information. Modifying the conceptual site model may be appropriate not only by reference to chemical constituents present, but also by consideration of current and future land use and habitats. The conceptual site model should also identify any special status species present at the site and note any exposure pathways unique to that organism.

4.4 EVALUATION OF CHEMICAL DATA

The next stage in the data evaluation process is to compare the chemical concentrations in the various media and habitats to a series of different chemical concentrations—Calumet Open Space Reserve (COSR) threshold values, background values, and benchmark values. The process of evaluating the chemical data appears in the flow diagram in Figure 4-1. The Technical Team developed these values, defined in the text box, for use in the Calumet area. Appendix A describes in detail how these values were derived.

The first step in the process is to compare the site chemical concentrations to the COSR threshold values for each medium. The COSR threshold values are chemical concentrations believed protective of ecological receptors in the Calumet area. They are derived from toxicity studies that identified no-observable-adverse-effect levels (NOAEL) for a variety of plants and animals.. The objective of this comparison is to identify media in a specific habitat not expected to exert a significant impact on any receptor. Areas with chemical concentrations below COSR threshold values in all media are not expected to need rehabilitation to protect the habitat's receptors. Therefore, no further action would be needed in these areas.

If media concentrations are found above COSR threshold values, additional analysis is required. The next step is to compare the media concentration to background values if these are available. Currently, background values for only soils are available (sediment and surface water values are under development). As described in Appendix A, soil background values were identified for the Calumet area from several sources. The assumption was that background would not represent conditions before 1860; they would represent constituent concentrations not resulting from direct industrial discharges but from clean locations in the urban and industrial setting of Calumet. Media with concentrations found below background would be assumed not subject to active rehabilitation. However, if a habitat is known to contain a sensitive species, such as a special status species, if concentrations are below background but above the COSR threshold value, those areas may warrant additional investigation or monitoring to determine the magnitude of potential impacts.

The final step is to evaluate those media with concentrations above the COSR threshold and background values. The objective of this step is to identify habitats with media likely to impact sensitive ecological receptors. Benchmark values are defined as chemical concentrations expected to impact ecological receptors in the Calumet area. These are derived from toxicity studies that identified lowest-observable-adverse-effect levels (LOAEL). Therefore, any media with a concentration above the benchmark value should be considered for some type of active rehabilitation or additional monitoring, unless additional site-specific assessments or analysis supports a remediation goal higher than a benchmark value. For example, it may be appropriate to assess a constituent's bioavailability at concentrations above a benchmark value in order to determine an appropriate remediation goal. As noted earlier, the evaluation focus should be habitat based. It is important to note that the values do not take into account potential synergistic, antagonistic, and additive effects of multiple contaminants on receptors.

Because of variability in the development and application of standardized ecotoxocological values, it is possible to develop alternative site-specific COSR sediment values for PAHs and pesticides based on their bio-availability. Site-specific sediment values should be supported by ecological pathway exposure evaluations,

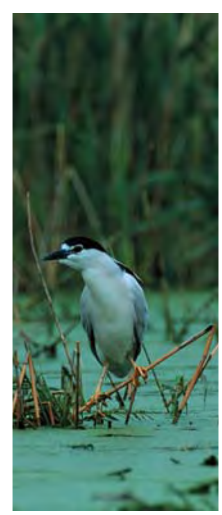
Potential Evaluation of Media-Specific Results

Below Threshold Values—No rehabilitation required.

Above Threshold Values But Below Background—No rehabilitation likely; may need to monitor if special status species present.

Above Threshold and Background Values But Below Benchmark Values—Rehabilitation, monitoring, or additional study required.

Above Benchmark Values—Rehabilitation should be considered.



as well as sediment chemistry, in order to provide a high level of confidence that any contaminants that exceed established benchmark or threshold levels are protective of ecological receptors. If this approach is taken, the Technical Team should be consulted to evaluate the development and use of site-specific sediment values.

Several approaches are useful for comparing media concentration to the COSR threshold, background, and benchmark values. The first approach could be to compare the maximum media concentration within a given habitat to the COSR threshold value. A concentration less than the COSR threshold value implies a very high level of confidence that the concentration does not pose an unacceptable risk. Another approach is to determine the 95-percent upper confidence limit (UCL) value and use that value for comparison. The procedures for calculating the 95 UCL are found in EPA guidance "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (EPA 2002). Whichever statistical test is used, it must be appropriate for the data distribution, normal, non-normal, or neither. If the 95-percent UCL is found below the COSR threshold value, this also indicates a high confidence of an acceptable level of exposure. It can be possible for the highest value to exceed the COSR threshold value but for the 95-percent UCL value to be below the threshold value. This indicates that impacts may be localized but overall impacts may be acceptable. Plotting sample locations above the COSR threshold value on a map showing habitat delineations and special status species locations may indicate whether a special status species may be at risk and additional monitoring may be required. It may also be appropriate to group data for comparison by habitats or exposure areas. This may better highlight areas of concern and areas for rehabilitation.

For soils, the focus of the comparison should be on the upper 2 feet of the profile, which is the most biologically active zone. If contamination is identified in this zone, it is important to evaluate deeper soils, to a depth of 10 feet, to determine if values exceed COSR threshold and benchmark levels. If site knowledge indicates deeper buried material covered by clean fill, these deeper soils should be compared as well.

Sediments samples should be collected as grab samples, or if a core sampler is used, focus should be on the upper 2 feet. However, if a review of the conceptual

site model or other data identify a significant potential receptor that may be exposed to soils deeper than 2 feet, samples below this depth may be warranted.

4.5 REVIEW OF LEGAL REQUIREMENTS

Reviewing the potential legal requirements is important at several points throughout this process. As more data become available, the legal requirements may change. Additional investigation may have identified special status species not previously known to exist at the site. Identifying and mapping habitats may lead to recognition of other legal requirements.

4.6 REPORT FORMAT

To standardize presentation of data collected and evaluated, the following report outline should be followed. The overall objective of the report is to present the data from the site in a manner that can support a decision whether or not to rehabilitate it. The extent of rehabilitation needed is discussed in Section 5.

SUGGESTED SITE STATUS REPORT OUTLINE

I. INTRODUCTION

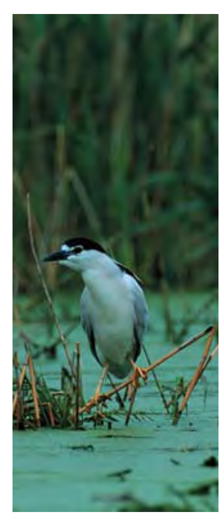
   A. Site Location and History
   B. Site Conditions
   C. Land Use—Current and Future
   D. Overall Site Objectives

II. INVESTIGATION RESULTS

   A. Habitats and Species
   B. Media

      1. Soils
      2. Sediments
      3. Surface Water
      4. Groundwater

   C. Conceptual Site Model



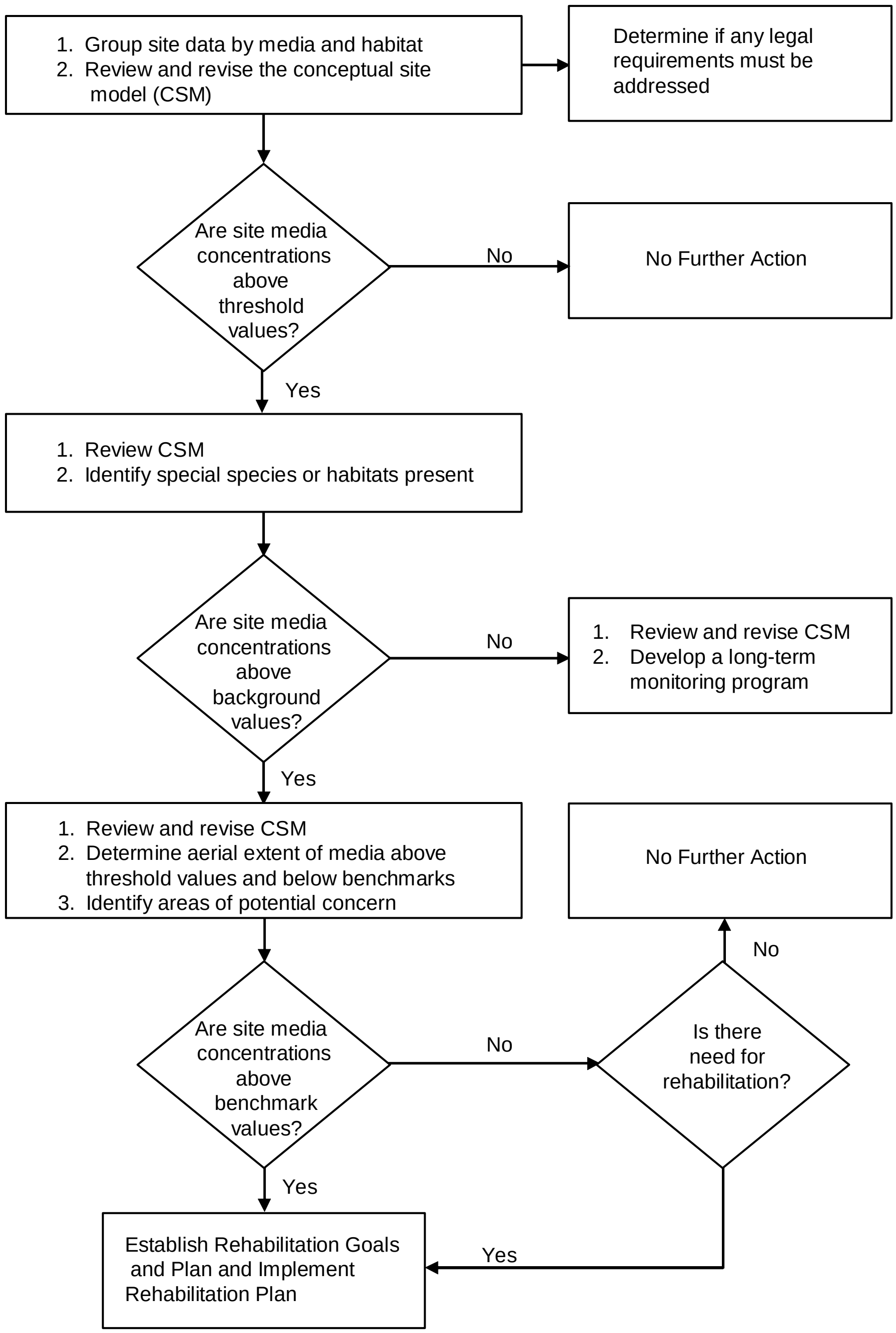
III. EVALUATION OF DATA

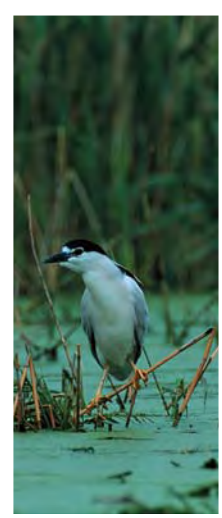
A. Areas Below COSR Threshold Values
B. Areas Above COSR Threshold, Below Background
C. Areas Above COSR Threshold and Background
D. Areas Above COSR Benchmark Values

IV. SUMMARY AND CONCLUSIONS

Figure 4-1

Procedure for Use of COSR Background, Threshold, and Benchmarks Values





5.0 REHABILITATION

The previous sections have discussed data collection, review, and evaluation with an overall objective to determine if sites in the Calumet area need rehabilitation from chemical contamination. This section focuses on sites where rehabilitation is recommended to address chemical contamination and presents the steps that should be followed to move a site through the process. These steps include specifying rehabilitation priorities, developing a rehabilitation options array, evaluating the options, and obtaining approval of the options from the Management Team. The overriding goal of this section is to ensure that any site rehabilitation is consistent with the *Calumet EMS* and acceptable to the site's stakeholders. Moreover, certain rehabilitation activities may be necessary to address ecological needs not related to contamination. These activities must be understood when addressing chemical contamination.

5.1 DEVELOPMENT OF PRIORITIES

Once a site has been identified for rehabilitation, a set of priorities must be developed for the site's rehabilitation. These objectives should take into account a variety of factors—biological, chemical, legal, habitat, recovery potential, land use, and end use. Earlier in the data collection process, the overall site objectives were developed; these should be used as bases for developing the rehabilitation priorities. Using the information collected from the site and the conceptual site model, the stakeholders need to review these objectives and establish rehabilitation priorities for the site. The following subsections discuss how these factors may influence or shape the site's rehabilitation priorities.

5.1.1 BIOLOGICAL

Site rehabilitation may involve multiple biological priorities. The most obvious priority would be protection of a special status species known to either reside at the site or use the site as a foraging location. This situation may influence the rehabilitation in many ways. It could limit the types of possible rehabilitation activities, affect timing of certain activities, and limit areas to rehabilitate.

Several other biological priorities may apply to a Calumet area site. If invasive species are present at the site, removing and replacing them with native species may be a priority. Another priority may be to increase or improve the diversity of the biological communities present at the site. For example, if one or two species dominate the terrestrial plant community, the priority may be to introduce a number of plant species that will improve wildlife habitat at the site.

5.1.2 CHEMICAL

The data evaluation process identifies areas containing chemical concentrations that may impact sensitive biological communities. This process also identifies the specific chemicals of potential concern at these areas. A rehabilitation priority may be to either remove or treat a chemical such that it no longer is present at a concentration that could impact the ecological community at the site. Another possible priority may be to create a barrier that severs exposure pathway to the chemical for the ecological community at the site.

Under either of these priorities, identifying a specific chemical concentration that the rehabilitation should achieve—a rehabilitation goal—is essential. Three different concentration levels could be considered—COSR threshold, background, or benchmark values. Each value provides a different level of certainty or protection for the potential receptors. As described earlier, the threshold concentration is that level known to be protective of sensitive species; this may be the ultimate or final priority for the rehabilitation. However, using background as the priority may be reasonable if it is the only value achievable, given the site location and surrounding land use. The benchmark value may be used as a first-level rehabilitation goal with the final goal being to achieve either a background or threshold value. A site-specific rehabilitation goal may be developed with concurrence of the Calumet Ecotoxicology Technical Team.

Along with developing a chemical-specific rehabilitation goal, specifying means to verify attainment of that goal is necessary. It is also important to develop a level of acceptable uncertainty. The verification sampling should be designed with sufficient number of samples to support a robust statistical analysis—to provide confidence that significant contaminated hot spots are addressed. For example, using the

COSR threshold value as the goal may be appropriate, and if the mean concentration within the medium of concern is below this value, the goal has been achieved. If concern arises that the data are not sufficient to provide a robust statistical evaluation, other options may be used. For example, establishing that no value will be 2 times the COSR benchmark value may ensure no contamination hot spots are present. The DQO process must establish the procedures to determine if specific rehabilitation goals are met. Any identified hot spots must be addressed by applying a variety of methods discussed further in Section 5.2.

The final rehabilitation goal will be site specific. Depending on circumstances at a site, the rehabilitation goal may be the background level, the benchmark value, or the threshold value. The stakeholders and the Management Team will determine the final value with input from the Technical Team.

5.1.3 LEGAL

Remediation efforts must include initial and ongoing identification of the legal requirements and consequences of specific rehabilitation options. Consultation with government agencies is an appropriate first step and should persist throughout this process. Liability issues must be fully resolved before rehabilitation actions proceed.

5.1.4 HABITAT

Identifying the priority habitats for the site rehabilitation is important. These can be wetlands, open water, prairies, savannas, upland forests, and others. The focus of the *Calumet EMS* is to preserve, improve, and create quality ecological habitats in the Calumet area. Rehabilitation priorities for the site's habitats must be consistent with the *Calumet EMS* objectives. The habitats of value must be clearly identified, and accompanied by information on how they will be preserved, improved, or created. If the habitats at the site are special status habitats, requirements appropriate to that status must be part of any rehabilitation activity.

5.1.5 RECOVERY POTENTIAL

Any priority set for the site to be rehabilitated should take into account the site's recovery potential. Recovery potential is defined as the ability of a site to respond

positively and permanently to a rehabilitation activity, and contribute to a corresponding improvement in the ecological community. For example, a site adjacent to lands with contamination sources may not have recovery potential—rehabilitation activity may not achieve *permanent* site rehabilitation because of those adjacent contamination sources.

This analysis may also identify need for a phased approach to the rehabilitation. Identifying a hierarchy of contamination sources to be addressed may be necessary. Certain areas of the site may need to be addressed early in the process to ensure a high probability of success for rehabilitating the entire site.

5.1.6 LAND USE AND FINAL USE

The stakeholders should ensure that anticipated land use is consistent with site data. Levels and locations of contamination may impact final uses of portions of the site. Relocating use areas, trails, support buildings, and parking lots may be necessary to help minimize potential exposures to contamination—for example, locating a parking lot as an exposure barrier in an area of high soil contamination.

5.2 DEVELOPMENT OF REHABILITATION OPTION ARRAY

A multitude of potential options may be applied to rehabilitate a site to meet site-specific rehabilitation priorities. The objective of this phase of the process is to develop an appropriate array of rehabilitation options that will be analyzed more fully later in the process. Each site will have its set of unique challenges, including chemical contamination, invasive species, special status species and habitats, and land use requirements. Each of these challenges may be addressed by application of different options. Several options satisfying the priorities are expected to be identified for each habitat or use area. The goal of this section is to present some of these potential options, keeping in mind that this is not a full list of all potential options. For most site rehabilitations, combinations of several options discussed in

BIOLOGICAL MONITORING GUIDANCE

- Measuring and Monitoring Biological Biodiversity. Standard Methods. Smithsonian Books.
- U.S. Department of Agriculture (USDA). 1993. Basinwide Estimation of Habitat and Fish Populations in Streams. USDA General Technical Report. SE-083.
- Izzak Walton League. 1996. Handbook for Wetlands Conservation and Sustainability. Second Edition.
- EPA. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers. Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. EPA 841-B-99-002.

the following subsections will be appropriate. It is important to note that additional data may be needed before the final rehabilitation option is identified.

5.2.1 NO ACTION

An important part of the evaluation process is to compare all options to a no action option. The no action option serves as a baseline for estimating costs against ecological improvements.

5.2.2 MONITORING

Monitoring can play several roles at a site. It may be used to: determine if conditions are changing over time, verify success of a treatment or removal activity, assess changes or improvements in biological populations or diversity, better define baseline conditions, or determine bioavailability of a chemical on site. Both biological and chemical monitoring may be appropriate at a site.

Various types of biological monitoring may be used at a site. If impact on ecological receptors at the site by present contamination is not clear, monitoring the biological community may be a means to resolve this issue. After completion of rehabilitation, monitoring also may determine if the biological component of a habitat improves. This could be accomplished through community surveys of fish, amphibians, or macroinvertebrates in the aquatic environment. In terrestrial environments, plant or animal surveys may be conducted. All these activities can serve to establish the relative health of the community by gathering data allowing a measure of diversity or other biological metrics.

Toxicity tests may also be performed using sediment, surface water, or soils at a site. These data will indicate if a tested medium contains constituents that exhibit toxicity to a particular receptor being tested. Several problems with toxicity tests merit mention. It is also possible that the toxicity may be the result of additive or synergistic effects of multiple contaminants or a constituent that is not measured. The toxicity test alone will not identify constituent(s) causing the toxicity. Chemical analysis of the medium may lead to identification of potential toxic agents. However, occasionally a sample exhibits toxicity not attributable to specific contaminants. In

these cases, toxicity may be due to other factors such as sediment particle size, salt content, or unknown factors.

Biological monitoring that includes bioassays, which evaluate toxicity of a medium to a test organism, could also answer questions about bioavailability and impact of certain contaminants in different media. Another biological monitoring technique would be collection of plant or animal tissue for chemical analysis to assess whether bioaccumulation or bioconcentration is occurring within the habitat. Biological monitoring could be used to track the progress and verify the success of rehabilitation efforts.

Chemical monitoring is a tool applicable at the Calumet area sites. The objective of chemical monitoring could be to trace changes in concentrations at a site. These changes may derive from rehabilitation activities, develop as a function of reduced inputs from various sources, or result from natural attenuation. In addition, chemical monitoring could be useful or necessary for investigating fate and transport concerns at a site—for example, monitoring potential migration of contamination from soils to groundwater via leaching or to surface water via runoff.

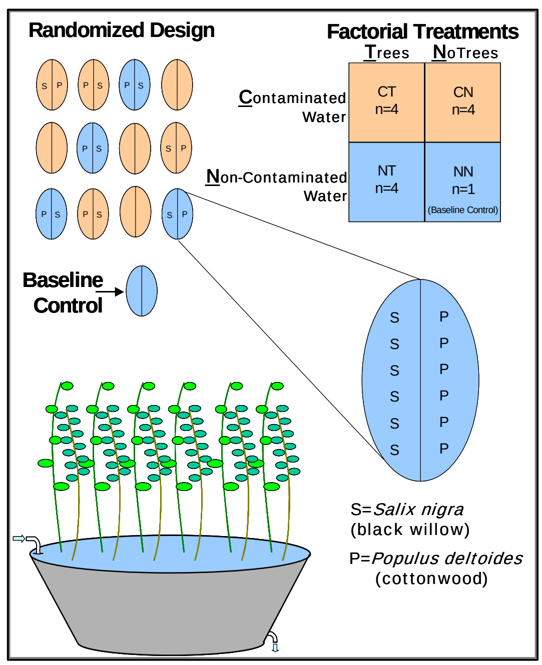
For many sites managed under this protocol, the monitoring data may be used to further refine the rehabilitation options. All rehabilitation decisions must be based on as much site-specific information as is reasonable to collect, and monitoring (chemical or biological) is a means to accomplish this goal.

5.2.3 REMOVAL OF EXPOSURE PATHWAY

A potential ecological receptor is only at risk to contamination present at a site if a pathway for exposure exists. If no exposure occurs, no potential risks exist. Therefore, removing the exposure pathway could provide a level of protection even though the contaminated materials may remain on site. This may be accomplished through a variety of mechanisms. One common option is to place a barrier such as a cap over contaminated materials to limit exposures. Another option could be to consolidate contaminated material from various portions of the site and then place a barrier over that material to limit exposure.

5.2.4 TREATMENT

The overall objective of any treatment process is either to: (1) remove the contaminants or (2) transform them to an unavailable or no longer toxic status. *In situ* treatment in any of several forms may be a viable option at a number of sites. In situ biological treatment, which includes phytoremediation and bioremediation, may be an applicable rehabilitation option. Phytoremediation—using plants to enhance treatment—has successfully dealt with a number of contaminants by translocating contaminants, such as metals, from soils or sediment to plant tissues, which when harvested render the contaminants less available to organisms. Phytoremediation also has improved biodegradation of soil organic contaminants through enhanced biological activity in the plant's root zone. The box at the right depicts a study to determine the potential uptake and remediation of contaminated groundwater by black willow (*Salix nigra*) and cottonwood (*Populus deltoids*) trees. Bioremediation—using microbes to enhance treatment—has been shown to successfully treat a wide range of organic contaminants. One typical treatment option is addition of nutrients into soil or groundwater to increase bacterial population and activity there, and thus increase biodegradation of contaminants.



Chemical and physical treatment may also be appropriate—for example, removing soils and sediments, treating them in a mobile process unit, and then returning the treated soils to the site for final disposal (*ex situ* treatment). A variety of processes that focus on the organic fraction of contaminants include soil vapor stripping, soil extraction, complexation, and fixation.

5.2.5 REMOVAL

Removal of contaminated media from a habitat may be an option for many sites. Removal may involve total removal from the site and disposal in an off-site location.

Another removal option may be removal from one portion of the site or habitat and disposal or consolidation in another portion of the site. Removal may be one of the more simply designed options, but also one of the more costly options—especially if off-site disposal is required.

5.3 EVALUATION OF OPTIONS

Evaluation of various options must proceed consistently and systematically. The evaluation approach described in this section is based on the general approach used in EPA's Superfund program and outlined in EPA's guidance for feasibility studies (EPA 1988). The ensuing discussion covers general evaluation criteria designed to ensure that risks are adequately addressed at the site. To enable the decision makers to identify the options that provide the greatest ecological rehabilitation for the lowest cost, *analysis of cost and ecological benefit must be performed for each option*. Each option will be evaluated to ensure it complies with all applicable environmental regulations.

5.3.1 GENERAL EVALUATION CRITERIA

The National Contingency Plan identifies a series of general criteria that could be applied to all remedial alternatives (rehabilitation options). Although these criteria were developed for the CERCLA program, they are sound scientific and engineering criteria useful for evaluating many different types of projects outside the CERCLA program, including site rehabilitation in the Calumet area. The Technical Team identified six general criteria applicable to the Calumet area and consistent with the Calumet EMS:

- Overall Protection of the Environment
- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume of Toxic Materials
- Short-term Effectiveness
- Implementability
- State and Community Acceptance.

The following is a discussion of each of these criteria and how they should be applied to the rehabilitation options for Calumet area sites.

Overall Protection of the Environment. The focus of this criterion is to ensure that the rehabilitation option meets the *Calumet EMS* objective of habitat preservation, improvement, or creation. One primary means to achieve this objective is to provide protection of the ecological communities in the various habitats at the site from contamination at the site. Accomplishing this could occur variously by removing or treating contamination, removing exposure pathways, or other mechanisms. Each option will be evaluated under this criterion for its ability to protect any special status species and habitats at the site.

Long-term Effectiveness and Permanence. This evaluates potential effectiveness of the rehabilitation option to handle the estimated areas of contamination and meet the rehabilitation goals. It takes into account the volumes of material to be managed, concentrations achieved, and whether acceptable concentrations and habitats can be maintained at the site over a long period of time. The overall emphasis should be on whether the rehabilitation preserves, improves, or creates biological habitat consistent with the *Calumet EMS*.

Reduction of Toxicity, Mobility, or Volume of Toxic Materials. If a site has levels of contamination that must be addressed as part of the rehabilitation, this criterion focuses on the methods used to address the contamination. Under Superfund, the preference is to treat wastes to reduce their toxicity, mobility, or volume; however, this may not be possible at all Calumet area sites due to a number of factors. These reductions in toxicity and mobility may be achieved by means other than treatment—such as removing exposure pathways or placing contaminated material in portions of the site with reduced potential for receptor exposure and contaminant leaching to surrounding environments. Reduction in volume may be accomplished through treatment of materials to reduce the amount of contaminated material, possibly allowing more efficient management of these materials.

Short-term Effectiveness. This evaluation criterion addresses the effects of the proposed option during the construction and implementation phase until the

rehabilitation objectives are met. Under this criterion, options should be evaluated for their short-term effects on the habitat's ecology and with attention to protecting community health during the option's implementation. For example, will implementing the option cause more overall harm to the site's habitats than it will mitigate long-term impacts? The time needed to implement the option should also be evaluated. Impacts on rehabilitation workers should be considered—for instance, whether the workers will be at substantial risk when implementing the option.

Implementability. The implementability criterion addresses the technical and administrative feasibility of implementing a rehabilitation option, and availability of various services and material required during its implementation. The focus needs to be on whether the option is technically feasible. The construction and long-term operational feasibility should be evaluated. If treatment is part of the option—biological, chemical, or physical—the reliability of the treatment process needs evaluation. Also critical is understanding the ease of undertaking the option, whether additional operation and maintenance will be required, and how extensive this will be.

State and Community Acceptance. Acceptance of the rehabilitation options is an important criterion. From development of the *Calumet EMS* through the Ecotoxicology Roundtable, participants have recognized the paramount need for state and community acceptance. The rehabilitation options must be acceptable to the stakeholders and impacted community, which include most federal and state agencies.

5.3.2 COST EFFECTIVENESS AND INCREMENTAL COST ANALYSIS

Cost is a major component of any rehabilitation option and a major consideration in any decision about which option to implement. Various costs are associated with each rehabilitation option. However, not all options will provide the same level of ecological and habitat preservation, improvement, or creation for the same costs. An analysis of cost effectiveness and incremental cost is a means to compare the various options. The U.S. Army Corps of Engineers has developed a procedure for this type of evaluation (U.S. Army Corps of Engineers [USACE] 1995). The cost effectiveness or cost benefit is a measure of the environmental benefit obtained from

the rehabilitation per cost unit (per thousand dollars). Several ways to estimate the environmental benefit are available. USACE (1995) proposes using habitat evaluation procedures as a basis for this estimation. Other approaches, such as developing an ecosystem quality index for the site (Homer, Brunner, and Conforti 2003) could be applied to the site. It is critical to apply a consistent methodology to a specific site to estimate potential benefits from the rehabilitation and to complete the cost benefit analysis.

5.3.3 REVIEW OF LEGAL REQUIREMENTS

Several times throughout the protocol, the legal requirements for the site have been identified and verified. The objective of this criterion is to ensure that all applicable federal, state, and local laws and regulations are addressed as part of the rehabilitation. Refer to Section 2.1.3 for a detailed discussion of the legal requirements.

5.4 REVIEW OF REHABILITATION OPTIONS

The *Calumet EMS* was founded on a consensus approach that has extended to the Ecotoxicology Roundtable and the protocol process. The review of the potential rehabilitation options also aims to reach a consensus with the appropriate stakeholders. As noted earlier, the Roundtable is comprised of a Technical Team and Management Team that includes the various stakeholders for the Calumet area. These teams will be the reviewers for any proposed rehabilitation action for the Calumet area. Each team's role in the review process is described in the following subsections.

5.4.1 TECHNICAL TEAM REVIEW

The Technical Team's role will be to review the proposed rehabilitation options to ensure all information is technically sound, supported by the available data, and consistent with appropriate guidance. The Technical Team may appoint a subcommittee comprised of Technical Team members to review the rehabilitation options. The subcommittee should be comprised of representatives of the current landholders, future landholders, and technical experts as needed. The Technical Team should provide written comments on the recommended options and

specifically identify what additional information is needed or where clarification is required. Once consensus is reached within the Technical Team on the proposed rehabilitation option, this recommendation is forwarded to the Management Team for review and approval.

5.4.2 MANAGEMENT TEAM REVIEW

The Management Team's role will be to review the proposed rehabilitation options to ensure these are consistent with the *Calumet EMS* and acceptable to the major stakeholders at the site. The Management Team's function is to present the rehabilitation options to their respective upper management and identify any issues that must be addressed before the recommended option can be implemented. Each agency that is part of the Management Team has its own internal review process. The Technical Team member from each agency will communicate with the Management Team representative on the issues associated with each site. The Management Team representative will be responsible to ensure that appropriate internal review is occurring. As noted earlier, the Management Team's goal is to reach consensus on the recommended rehabilitation option with all stakeholders. Once consensus is reached with the Management Team, the rehabilitation option should be implemented. Although if consensus is not reached, current and future landowners have the responsibility to resolve the issue before rehabilitation is implemented.

5.5 RECOGNIZED INFORMATION GAPS

During the preparation of this protocol, the Technical Team recognized that important information related to the protocol was not available or immediately forthcoming. Furthermore, the Technical Team understands that as an evolving document, the protocol is subject to change as new information becomes available, and should be updated regularly. The Technical Team recognizes and encourages research that can fill the following information gaps; these additional or updated data would serve to: (1) enhance implementation of the Protocol and/or (2) regularly update the Protocol.

Information Gaps for Protocol Implementation

- General water quality data for the Calumet area to help understand seasonal changes
- Bioavailability of specific contaminants to terrestrial and aquatic species in the Calumet area
- Contaminant movement through the Calumet area ecosystems
- Characterization of long-term environmental impacts of rehabilitation activities
- Development of monitoring strategies
- Ongoing cataloging and evaluation of rehabilitation strategies

Information Gaps for Protocol Update

- Sediment background values
- Threshold and benchmark values for ammonia in sediments
- Acceptable levels of nutrients (nitrogen and phosphorus) in waters
- Toxicity values for plants and potential plant uptakes of metals
- Updates to the threshold and benchmark values in Appendix A

6.0 REFERENCES

City of Chicago Department of Planning and Development. 2001. *Open Space Reserve*. April.

City of Chicago Department of Planning and Development. 2002. *Calumet Area Land Use Plan*. February.

City of Chicago Department of Environment, Chicago's Environmental Fund, Illinois Department of Natural Resources, U.S. Department of Agriculture, V3 Consultants, Ltd. 2002. *The Calumet Area Ecological Management Strategy Phase 1 Sites*. (*Calumet EMS*)

Environmental Consultants and Planners, Inc. 1983. "Final Report: Habitat Evaluation of Lake Calumet Harbor Area, Road and Site Development, Phase II." Prepared for the City of Chicago Department of Public Works. Contract Number 54-379.

Homer, D., J. Brunner, and A Conforti. 2003. "Development Of An Ecosystem Quality Index For Incremental Cost Analysis Of Restoration Alternatives." Proceedings of Society of American Military Engineers Education and Training Conference. Seattle, Washington. May.

Illinois Pollution Control Board (IPCB). 2007. Title 35 of the *Illinois Administrative Code* (IAC), part 742, 'Tiered Approach to Corrective Action Objectives.' February 23. On-line address: http://www.ipcb.state.il.us/documents/dsweb/Get/Document-38408/

Joliet/Midewin Ecological Working Group (Midewin). 2000. Ecological Preliminary Remediation Goals. Prepared for the Joliet Army Ammunition Plant and Midewin National Tallgrass Prairie. Will County, Illinois.

U.S. Army Corps of Engineers [USACE]. 1995. Evaluation of Environmental Investments Procedures Manual. Interim: Cost Effectiveness and Incremental Cost Analysis. Water Resources Support Center, Institute for Water Resources and Waterways Experiment Station, Environmental Laboratory. IWR Report 95-R-1. May

U.S. Environmental Protection Agency (EPA). 1988. Guidance for Conducting Remedial Investigations and feasibility Studies Under CERCLA. Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response.

EPA. 2000. Guidance for Data Quality Objectives Process, EPA QA/G-4. EPA/600/R-96/055. Office of Environmental Information. Washington, D.C.

EPA 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites." OSWER 9285.6-10 on line at www.epa.gov/superfund/programs/risk/ragssa/ucl.pdf

U.S. Geological Survey (USGS). Various dates. U.S. Geological Survey National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapts. A1-A9 available on-line at http://pubs.water.usgs.gov/twri9A

U.S. Water Resources Council. 1983. "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies." March 10.

This page left intentionally blank

APPENDIX A
DEVELOPMENT OF BACKGROUND, THRESHOLD, AND BENCHMARK VALUES FOR THE CALUMET AREA

A1.0 INTRODUCTION

The Calumet Area Ecotoxicity Roundtable Technical Team was formed to address potential ecological challenges deriving from contamination in the Calumet area. One critical issue was to identify chemical concentrations appropriate for assessing possible current or future effects on ecological communities. The Technical Team concluded that three different concentration values should be identified—background, threshold, and benchmark.

The Technical Team recognized that because it represents many state agencies, federal agencies, and stakeholder groups, a consensus on these concentration values would be necessary to satisfy disparate needs of these groups. Of course, the values must be appropriate as well for conditions unique to the Calumet area. The Technical Team presented the values it developed for Calumet area sites to the Calumet Area Ecotoxicity Roundtable Management Team for review.

The Technical Team was not charged to independently develop a set of values, but to apply available information to the Calumet area. In recent years, a number of state and federal agencies have developed lists of chemical concentrations in various media that they believe protective of or adverse to relevant ecological receptors. Not all these lists were developed according to the same ecological assessment endpoint; however, all were based on available toxicity studies.

The lists also differed in objective, media focus, and chemicals of concern. To use the available information, the Technical Team elected to establish a hierarchy of toxicity values sources for the Calumet area.

The purpose of this appendix is to: (1) document procedures used to identify background, threshold, and benchmark values; (2) provide a template for determining values of additional constituents that may be significant under future conditions; and (3) document procedures used to modify literature-based values to meet the Technical Team's objectives.

It is important to understand that values in this appendix are not static and will be revised as new information becomes available. Use of these values is described in the main body of the guidance document. The values are not appropriate for use independent of the process described there.

A2.0 BACKGROUND VALUES

Over a century of intense industrial activity has degraded water, sediment, land, and air in the Calumet area. The Technical Team decided not to attempt to establish background levels representing predevelopment conditions; rather, the Team sought background levels taking into account over a century of nonspecific source pollution (such as aerial deposition of contaminants) that has impacted the sites and surrounding environment. Assessing how these background levels may impact any rehabilitation that might occur at a site is a vital component of the ecotoxicological assessment process. Moreover, comparing established background values to current contaminant levels should enhance understanding of the significance of the current levels.

After reviewing available data for soils, the Technical Team identified two sources of background data that could be used to reflect background conditions in the Calumet area. The first set of data, for metals, was available from Illinois Environmental Protection Agency (IEPA) Tiered Approach to Corrective Action (TACO) Program (Illinois Pollution Control Board [IPCB] 2007). Under this program, IEPA has established soil background levels for two groups—metropolitan (greater than 100,000 people) and non-metropolitan areas. IEPA collected these data from various investigations at sites around the State, including the Chicago area. IEPA used median values for a specific constituent from all the studies to establish background levels for each metal except arsenic. IEPA conducted additional analysis of the arsenic data and chose to use a 95-percent upper threshold value for this element. The Technical Team chose the IEPA TACO metropolitan area values as background levels for soil metals (Table A-1).

The Technical Team identified a source of background data for polynuclear aromatic hydrocarbons (PAH; also known as PNA) in soils. The City of Chicago (2003) conducted the background study of PAHs in Chicago soils. The purpose of this study was to establish ambient levels of PAHs in the soils in the City of Chicago using the same statistical methodology employed by IEPA to establish metal background values under TACO. IEPA reviewed the data, accepted the 95 upper threshold limits to establish soil background levels for PAHs in Chicago and incorporated these data into TACO as background values for Chicago. The Technical Team chose those values to represent soil PAH background concentrations in the Calumet area (Table A-1) rather than the metropolitan area values.

The Technical Team will continue to search for appropriate data to establish background concentrations for other contaminants of concern for soils.

One study of sediment attempted to establish sediment background values for the Calumet area. Piwoni and others (2006) conducted a study of background sediments from wetlands in the Calumet area. This study provided background values for metals, PAHs, pesticides, and PCBs (Table A-2). The values noted elevated concentrations from many of these constituents. These background values must be reviewed in context with the toxicity based values when evaluating potential impacts and rehabilitation options.

The Technical Team's review of available data identified one study of surface water background values appropriate for the Calumet area, Piwoni and others (2006). This study identified a number of water bodies in the Calumet area that have not received direct discharges from point sources and thus are water bodies impacted through indirect aerial deposition and surface water runoff. This study provided background values for metals (Table A-3). The Technical Team also acknowledged that the Illinois Water Quality Standards are applicable to surface water at these sites regardless of background conditions.

A3.0 THRESHOLD AND BENCHMARK VALUES

The goal of the Calumet Ecological Management System is to preserve, improve, and create habitats that will support healthy ecological communities (City of Chicago 2002). Differentiating areas that may support healthy communities from areas that may pose risk to ecological receptors is critical to achieving that goal. The Technical Team chose to develop threshold and benchmark values for the ecological receptors in the Calumet area to provide a basis for this screening mechanism. The definition of these terms is as follows:

- Calumet Open Space Reserve (COSR) Threshold values: Chemical concentrations believed protective of ecological receptors in the Calumet area. These are derived from toxicity studies that identified no-observable-adverse-effect levels (NOAEL) for a variety of plants and animals.

- COSR Benchmarks: Chemical concentrations expected to impact ecological receptors in the Calumet area. They are derived from toxicity studies that identified lowest-observable-adverse-effect levels (LOAEL).

It should be noted that the definitions of threshold and benchmark values are specific to the Calumet Ecotoxicology process and should not be assumed equivalent to these same terms used in the sources of toxicology data.

A3.1 SOURCES OF COSR THRESHOLD AND BENCHMARK VALUES

The Technical Team reviewed the literature to identify sources of COSR threshold and benchmark values for soil, sediment, and surface water applicable to Calumet area sites. The text below briefly describes the major sources of these values. Following these descriptions is a discussion of the hierarchy of the sources used to identify threshold and benchmark values for the various media. A number of the following descriptions have been modified from the discussion in the Ecological Preliminary Remediation Goals, Joliet Army Ammunition Plant and Midewin National Tallgrass Prairie (Joliet/Midewin Ecological Work Group 2000).

A3.1.1 SOILS

U.S. EPA Ecological Soil Screening Levels (Eco-SSLs)

U.S. EPA developed Eco-SSLs as screening values that can be routinely used to identify contaminants of potential concern in soils requiring further evaluation. These values are concentrations of contaminants in soil that are protective of ecological receptors commonly coming into contact with soil or ingesting biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. These values are presumed to provide adequate protection of terrestrial ecosystems.

Derivation of the Eco-SSLs followed standardized procedures for literature review, toxicity data selection, and data evaluation. Where data were judged adequate, U.S. EPA derived four Eco-SSLs for each contaminant—one each for plants, soil invertebrates, birds, and mammals. Plant and soil invertebrate values were derived from available toxicity test data that measured toxicity related to soil contaminant concentration. The wildlife Eco-SSLs resulted from calculating a soil concentration that would result in a hazard quotient of 1.0, where the quotient is an expected exposure dose divided by a toxicity reference value (TRV). U.S. EPA used a generic food chain model to estimate the concentration in the soil that would result in an acceptable dose for the receptor organism. The TRV used for a contaminant represents a receptor-class-specific estimate of the NOAEL dose for that contaminant.

U.S. EPA has derived Eco-SSLs for aluminum, antimony, arsenic, barium, beryllium, chromium, cadmium, cobalt, iron, lead, vanadium, pentachlorophenol, and dieldrin (EPA 2005). U.S. EPA has announced that levels are being developed for 10 additional chemicals.

Canadian Council of Ministers of the Environment (CCME)

The intent of CCME's national soil quality guidelines (SQG) is to provide equal protection to human health and ecological receptors. These SQGs are general guidance for protection, maintenance, and improvement of specific uses of land and water. Soil values are developed for four land uses with defined exposure scenarios: agricultural, residential/parkland, commercial, and industrial. All values are based on both agricultural/ecological and human protection. SQGs were derived to evaluate the need for further investigation or remediation with respect to a specified land use.

The following description was modified from Friday (1998). The derivation process for SQGs considers adverse effects from direct soil contact and from ingestion of soil and food. Four approaches were used to evaluate contact with soil: (1) weight of evidence, (2) lowest-observable-effects-concentration (LOEC) method, (3) median effects method, and (4) comparison with nutrient and energy cycling.

The weight of evidence method, which is a modification of Long and Morgan (1990), estimates no adverse effects. For agricultural land use, the 25th percentile of the effects and no effects data distribution was chosen as the no potential effects range (NPER). An uncertainty factor was then applied to the NPER to derive the threshold effects concentration (TEC). When the data were inadequate to perform a weight of evidence method, the TEC was derived by extrapolating from the lowest available LOEC divided by an uncertainty factor. Thus, the TEC will lie somewhere below the lowest reported effects concentration.

When LOEC values are unavailable, the TEC is derived using the median effects method. Here, the TEC is obtained by extrapolating from the lowest available effect concentration to 50 percent of the test population (EC_{50})or the lethal concentration to 50 percent of the test population (LC_{50})using an uncertainty factor ranging from 5 to 10.

Once the TEC is calculated, it is compared to nutrient and energy cycling data for selected microbial processes. If the microbial value is less than the TEC, the geometric mean of the microbial and TEC values is selected as the SQG for soil contact. If the TEC is less than the microbial value, the TEC becomes the SQG.

The procedure for deriving SQGs for ingestion of soil and food by grazing livestock and wildlife is used only for agricultural land use. This process is restricted to an herbivorous food chain and considers the bioaccumulation of chemicals in plant tissue. Several steps are required to derive a SQG. First, species considered most at risk from ingesting soil and food are identified, and a daily threshold effects dose is identified based on a minimum of three studies (e.g., two mammals, one avian). Second, the daily threshold effects dose is calculated by dividing the lowest LOAEL by an uncertainty factor. Next, information about the most sensitive species is gathered that includes body weight, rate of soil ingestion, and rate of food ingestion, as well as information on bioavailability and bioconcentration factors specific to the contaminant.

Finally, the lower of the two values (soil contact versus ingestion) is used as the final SQG for agricultural (ecological) use.

Oak Ridge National Laboratory (ORNL)

ORNL has developed separate sets of toxicity benchmarks for plants, earthworms, and soil microbes. The following description was modified from ORNL screening benchmarks reports (Efroymson, Will, and Suter 1997; Efroymson, Will, Suter, and Wooten 1997): The ORNL benchmarks for toxicity to plants from chemical contaminants in soil were initially developed in 1993 because national regulatory criteria for soils that are intended to protect ecological receptors were not available. These thresholds for effects on growth and reproduction were derived from published toxicity studies conducted in soil or solution. The benchmarks are concentrations of chemicals that correspond to the LOEC for the 10^{th} percentile of plant species tested. Statistically significant effects thresholds were used unless a lower concentration tested corresponded with a 20% level of effects.

The ORNL benchmarks for toxicity to invertebrates from chemical contaminants in soil were initially developed in 1994. These benchmarks are thresholds (LOECs) for statistically significant effects on growth, reproduction, or activity. For plant and invertebrate receptors, the method for deriving soil benchmarks was based on the National Oceanic and Atmospheric Administration's (NOAA) method for deriving the effects range low (ER-L) value (Long and Morgan 1990), which has been recommended as a sediment screening benchmark by EPA Region 4.

The toxicity benchmarks were derived by rank-ordering the LOEC values and then selecting a value that approximated the 10^{th} percentile. If 10 or fewer values were available for a chemical, the lowest LOEC was used. If the 10^{th} percentile fell between LOEC values, a value was chosen by interpolation. If a chemical concentration in soil represented a 50% or higher reduction in survivorship of plants, the concentration was divided by 5 to approximate the more sensitive endpoints of growth or production.

Midewin Preliminary Remediation Goals (PRG)

PRGs were selected from the matrix of soil toxicity thresholds calculated for a variety of organisms potentially exposed to soils at Midewin. These were based on toxicity values identified for plants and earthworms, and exposure to higher organisms such as birds, mammals, amphibians, and reptiles. These exposures took into account various exposure models, receptor attributes, and bioaccumulation. These PRGs were also developed using upper and lower toxicity reference values to provide a range of PRGs and relied on some of the same toxicology data sources used in the Calumet process.

The lower thresholds are intended to represent the soil concentration below which toxicity is unlikely to occur. The upper end of the range is intended to represent the concentration above which toxicity is likely to occur. The interval numbers themselves do not represent uncertainties associated with estimating exposure.

These values do take into account the background concentrations for a number of the constituents at Midewin. The lower threshold was set at the mean plus two standard deviations of the background concentration. In several cases, this concentration also exceeded the upper threshold value, and only one PRG value was reported.

U.S. EPA Region 5 Ecological Screening Levels

U.S. EPA Region 5—under the Resource Conservation and Recovery Act, Corrective Action and Permit programs—developed ecological screening levels (ESL) (EPA 2003). According to U.S. EPA, the ESLs represent a protective benchmark for 223 contaminants and four environmental media—air, water, sediments, and soils. The values are to identify contaminants that should be retained for additional ecological risk analysis, and are suitable threshold values for this protocol. A contaminant whose concentration is below the ESL benchmark is assumed to pose no risk to ecological receptors. The ESLs were compiled from a variety of sources, including U.S. EPA Region 4 Supplemental Guidance to Risk Assessment Guidance for Superfund, U.S. EPA National Recommended Water Quality Criteria, U.S. EPA Assessment and Remediation of Contaminated Sediments (ARCS) Program Effects Concentrations, Canadian Environmental Guidelines for all media, Ontario Ministry of Environment (MOE), Dutch Target List, and Washington No-Effects-Levels.

A3.1.2 SEDIMENTS

U.S. EPA Sediment Quality Criteria

U.S. EPA has developed sediment quality criteria for a limited number of constituents—PAHs and pesticides. U.S. EPA used the equilibrium partitioning (EqP) approach to calculate these criteria. The basic procedure used by U.S. EPA to calculate sediment guidelines for nonionic organic compounds is described in detail in DiToro, McGrath, and Hansen (2000). The EqP approach described therein is based on the assumption that a chemical equilibrium is established between the sediment solid phase and the interstitial water (pore-water). This equilibrium is controlled by the organic carbon fraction of the sediment and a chemical's affinity for organic carbon. This affinity is described by a chemical's organic carbon partition coefficient. The chemical concentration in the pore water represents its bioavailable fraction; therefore, sediment quality criteria should be based on the toxicity of the pore water. DiToro, McGrath, and Hansen (2000) proposed using chronic water quality standards for protection of aquatic life as acceptable levels in the pore water to establish sediment guidelines. They stated that the following equation defines this relationship:

$$SQG = f_{oc} x K_{oc} x FCV \qquad \text{(A-1)}$$

where

SQG = Sediment quality guideline
f_{oc} = Fraction organic carbon of the sediment
K_{oc} = Organic carbon partition coefficient
FCV = Final chronic value (chronic ambient water quality criteria or state water quality standard).

For the criteria derived by U.S. EPA, an assumption of 1 percent organic carbon was used. When site-specific data are available, they should be used to calculate the SQG.

Ontario MOE Guidelines for the Protection and Management of Aquatic Sediment Quality

Ontario MOE used the screening level concentration approach to derive two levels of sediment quality guidelines: a lowest effects level and a severe effects level

(Persaud, Jaagumagi, and Hayton 1993). In the screening level concentration approach, field data on the presence or absence of benthic macroinvertebrate species are combined with sediment chemistry data to derive the sediment effects concentration. Ontario MOE used a database from freshwater sediments around the Great Lakes area. The analysis was conducted using species present in at least 20 sites.

For both the lowest effect level and the severe effect level, the contaminant concentrations at all sites where each species is present were first ranked from low to high. The 90th percentile sediment concentration for each species was then taken, and the different 90th percentiles for the different species were then ranked from low to high. The lowest effect concentration was the 5th percentile of these concentrations, and the severe effect level was the 95th percentile (Persaud, Jaagumagi, and Hayton 1993). Ontario MOE sediment quality guidelines are presented as normalized to sediment of 1 percent organic carbon.

Some advantages of this approach are: (1) it is based exclusively on field data and thus avoids issues of extrapolating from the laboratory to the field and (2) consideration is based on long-term exposure of the invertebrate community to the sediment contaminants.

Some disadvantages of this approach are: (1) the approach does not take into account other possible factors besides contaminants (such as habitat or water quality) that may be responsible for species absences at sites, (2) the endpoint considered is species presence or absence, which may be a fairly insensitive endpoint (as opposed to changes in density, for example), and (3) as all sediment benchmark methods, it is based on databases of mixed sediment contamination, and any correlation of contaminants will affect the results.

<u>U.S. EPA ARCS Program Effects Concentrations</u>

In support of U.S. EPA's ARCS program, the U.S. Geological Survey (USGS) collected sediments from nine contaminated sites across the country and conducted laboratory toxicity tests on the sediments (Ingersoll and others 1996; EPA 1996). The sites included seven freshwater sites and two estuarine sites. The laboratory tests conducted on the sediments were 14-day tests using the amphipod *Hyallela azteca* and larvae of the midge *Chironomus riparius*, and 21-day tests using *H. azteca*. Endpoints measured in the tests were survival, growth, and maturation. Results from contaminated sites were statistically compared to results from control sediment to determine whether statistically significant differences from control sites occurred in each of the contaminated sediment samples. For each contaminant, four different effects concentrations for each test endpoint were derived from the data:

- Effects Range-Low (ER-L), which is the 15th percentile of effects concentrations
- Effects Range-Median (ER-M), which is the 50th percentile of effects concentrations
- Threshold Effects Level (TEL), which is the geometric mean of the 15th percentile of effects concentrations and the 50th percentile of no effects concentrations
- Probable Effects Level (PEL), which is the geometric mean of the 50th percentile of effects concentrations and the 85th percentile of no effects concentrations.

Some potential advantages of this approach are: (1) it is based on controlled laboratory toxicity tests that demonstrate statistically significant toxic effects on common and relatively sensitive freshwater invertebrate species, and (2) the TEL and PEL incorporate both effects data and no effects data.

Some potential disadvantages of this approach are: (1) extrapolating results of laboratory toxicity tests to field conditions is uncertain; (2) tests were run on sediments containing complex mixtures of contaminants, and no causality of toxicity was determined; and (3) the number of sediments examined was limited, which limited the robustness of the statistical analysis.

<u>NOAA Effects Ranges</u>

NOAA summarized sediment toxicity and contamination data from its National Status and Trends sediment-monitoring program into sediment effects ranges (Buchman 1999). Data from sediment monitoring locations across the country were combined into a single database, with most data coming from saltwater sites. The type of sediment effects data varied from site to site, and included results of laboratory toxicity tests of field-collected sediments, spiked sediment bioassays, and field benthic macroinvertebrate community sampling. The sites were split into those for which adverse effects were observed and those for which no adverse effects were observed. After a screening of the data based on professional judgment, concentrations of each contaminant at effects sites were ranked from low to high. Two effects concentrations were then derived: the ER-L is the 10^{th} percentile of the effects concentrations; and the ER-M is the 50^{th} percentile of the effects concentrations.

Some advantages of this approach are: (1) it is based on an extensive database of contaminated sediment effects from sites across the country, and (2) the effects concentrations have been shown effective at predicting no toxicity (concentrations below the ER-L) and toxicity (concentrations above the ER-M) at sites not used to derive the effects concentrations.

Some disadvantages of this approach are: (1) it uses only effects data and ignores data from sediment samples where no effects were observed; (2) it is based primarily on data from saltwater sites, which may make the effects concentrations less applicable to the Calumet area; and (3) tests were run on sediments containing complex mixtures of contaminants, and no causality of toxicity was determined.

NOAA also reported freshwater sediment values based on the ARCS programs TELs and PELs, previously described.

Canadian Sediment Quality Guidelines for the Protection of Aquatic Life

Sediment quality guidelines for freshwater sediments were developed by Canada (Smith and others 1996). These guidelines are based on a combined dataset that includes data used by the Ontario MOE, the U.S. EPA ARCS program, NOAA, and other published data. Two threshold effects levels were developed, a TEL and PEL, using the same approach and methods used for the EPA ARCS benchmarks. Effects concentrations were developed for 8 metals and 13 organic contaminants. Because these guidelines are based on the same data used by the Ontario MOE, U.S. EPA ARCS, and NOAA, these guidelines have advantages and disadvantages similar to the other benchmarks that stem from the underlying data, and are similar to the U.S. EPA ARCS TEL and PEL effects concentrations that stem from the method.

Oak Ridge National Laboratory

ORNL's "Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment—Associated Effects Biota" derived sediment effect concentrations from the ARCS database of toxicity test results using two different invertebrate species and two different test durations (Jones, Suter, and Hull 1997). For each contaminant, ORNL determined which of the various effects concentrations reported by ARCS were most accurate at predicting absence of toxicity (ER-Ls or TELs for the different species and test durations) or presence of toxicity (ER-Ms or PELs for the different species and test durations). The best lower concentration threshold was termed the Threshold Effect Concentration (TEC), and the best upper effect level was termed the Probable Effect Concentration (PEC). Thus, although the ORNL effects concentrations are not based on original data, they do provide a reasonable approach for selecting specific effects concentrations from the array of effects concentrations presented by U.S. EPA ARCS.

Consensus Sediment Guidelines

MacDonald, Ingersoll, and Berger (2000) developed consensus-based sediment quality guidelines (SQG) for freshwater ecosystems. They compiled sediment standards, criteria, and guidelines from a variety of sources and developed by a variety of approaches. They developed two SQGs from this data—a TEC and a PEC. MacDonald, Ingersoll, and Berger (2000) defined TECs as values intended to identify concentrations of sediment-associated contaminants below which adverse effects on sediment dwelling organisms are not expected to occur. They defined PECs as values intended to define the concentration of sediment-associated contaminants above which adverse effects on sediment-dwelling organisms are likely to occur. It should be noted that no toxicity-based guidelines for barium, manganese, potassium, and cyanide were identified.

A Compendium of Environmental Quality Benchmarks

MacDonald and others (1999), in support of the Georgia Basin Ecosystem Initiative, compiled environmental quality criteria, guidelines, objectives, and standards worldwide. They focused on values that would be protective of ecological receptors in surface water and sediments in freshwater, estuarine, and marine environments. Government agencies that support regulatory and enforcement programs established these values. Only benchmarks meeting the following criteria were included:

- Methods used to derive the benchmarks were readily apparent.
- The source of the original benchmarks was readily apparent.
- The benchmarks were effects-based (for example, the benchmarks were based on effect or lack of effects on the uses of designated water, sediment, and biological tissues).

U.S. EPA Region 5 Ecological Screening Values

See description in Section 3.1.1, above.

Illinois Sediment Screening Values

These values are classification values used by IEPA to determine whether contaminant levels in sediments in either lakes or streams are low, normal, elevated, or highly elevated. They are based on over 550 samples from various parts of the State and are not representative of biologically active concentrations of various components. These values are not intended as standards and should not be used as such. IEPA states that these are to be used to compare and classify lake and stream sediments; these may be useful in attempting to define background concentrations of some contaminants.

A3.1.3 SURFACE WATER

Illinois Water Quality Standards or Criteria

The State of Illinois has established through regulations water quality standards and criteria for protection of aquatic life. Two sets of water quality standards have been promulgated—a general standard and specific standards for the Lake Michigan Basin. A limited number of constituents have standards specific to the Lake Michigan Basin. Since the Calumet area is part of this basin, these values are the most appropriate. The criteria values are derived from the U.S. EPA Ambient Water Quality Criteria.

A Compendium of Environmental Quality Benchmarks

See description in Section 3.1.1, above.

U.S. EPA Region 5 Ecological Screening Values

See description in Section 3.1.1, above.

DiToro, McGrath, and Hansen

DiToro, McGrath, and Hansen (2000) found through analysis of toxicity data that the critical body burden associated with acute toxicity is 35.3 micromoles per gram (μmol/g) octanol (with octanol serving as a surrogate for lipids) for the 5th percentile of the species sensitivity distribution. This is approximately equivalent to the 95-percent level of protection used by EPA in developing its water quality criteria, both acute and chronic. The equation that describes this relationship is as follows:

$$\log (35.3\ \mu mol/g\ octanol) = \log (LC50) + 0.945 \log (K_{ow}) \quad \text{(A-2)}$$

DiToro, McGrath, and Hansen (2000) also found that different classes of narcotic compounds had slightly different potencies; in particular, polynuclear aromatic hydrocarbons (PAH) and chlorinated hydrocarbons had slightly higher toxicities than most other narcotics. Therefore, a class correction of 0.546 for PAHs and 0.57 is applied. Also, the differences between acute and chronic toxicity benchmarks needed to be accounted for. DiToro, McGrath, and Hansen (2000) suggested 5.09 as the acute to chronic ratio; dividing the acute value (lethal concentration to 50 percent of the test population [LC50]) by this ratio yields an equivalent of the final chronic value (FCV) used to establish water quality criteria protective of chronic effects. Therefore, the following equations were used to estimate the FCV for the remaining organic compounds:

$$\log(\text{FCV for PAHs}) = \log (35.3{*}0.546\ \mu mol/g\ octanol) - 0.945 \log (K_{ow}) - \log (5.09) \quad \text{(A-3)}$$

$$\text{halogenated hydrocarbons} = \log (35.3{*}0.57\ \mu mol/g\ octanol) - 0.945 \log (K_{ow}) - \log (5.09) \quad \text{(A-4)}$$

$$\log(\text{FCV for dibenzofuran and other phthalate compounds}) = \log (35.3\ \mu mol/g\ octanol) - 0.945 \log (K_{ow}) - \log (5.09) \quad \text{(A-5)}$$

A3.2 DEVELOPMENT OF CALUMET OPEN SPACE RESERVE THRESHOLD VALUES

As stated earlier, the COSR threshold values are equivalent to NOAELs and are to be set at a concentration expected to be protective of ecological receptors anticipated at the Calumet area sites. The various sources described above were used to identify the threshold values for soils, sediments, and surface water. The following subsections describe the hierarchy applied to the various source documents used to identify the appropriate values.

A3.2.1 SOILS

The primary sources for soil threshold values are listed below in priority. In other words, if a contaminant threshold value was not available in the first reference, then the second reference is consulted and so forth. In addition, comments are included to document further how the values were identified. The COSR threshold values for soils are presented in Table A-1.

1) U.S. EPA Eco-SSLs are available for a limited number of constituents—aluminum, antimony, barium, beryllium, cadmium, cobalt, iron, lead, and dieldrin. As noted earlier, these values are based on the concentration that will be protective of the most sensitive organism within the following groups: plants, soil invertebrates, birds, and mammals. These are the most thoroughly researched values and have the highest degree of confidence associated with them.

2) Midewin Lower End Preliminary Remediation Goals (PRG) was the second source used to identify threshold values. The Technical Team modified the Midewin lower end PRGs values to exclude values that would be protective for wetland invertebrates; these groups of organisms are addressed via sediment threshold values. These values were developed for habitats similar to those in the Calumet area, and the Medwin site is near the Calumet area.

3) CCEM – As noted in the description, the guideline for agricultural use was used for the threshold value for soils. These values focused on toxicity data; they resulted from a thorough review of the literature and were based on LOEC.

4) ORNL – If a contaminant did not have a value in any of the previous documents, the lowest value protective of plants, soil invertebrates, or microorganisms was used as the threshold value. These values are also based on a literature review, and not all organisms used to

establish these values are present in the Calumet area; moreover, the ORNL benchmarks are based on an older data set. Each value is based on the 10th percentile of the LOEC.

A3.2.2 SEDIMENT

The primary sources for sediment threshold values are listed below in priority of their use. Additional comments further document how the values were identified. The threshold values for sediments are presented in Table A-2.

1) U.S. EPA Sediment Quality Criteria – EPA has developed criteria for a limited number of contaminants found in the Calumet area: acenaphthene, fluoroanthene, fluorene, and phenanthrene. The Technical Team used the sediment quality criteria for these compounds as threshold values. These values have been thoroughly researched and are supported by U.S. EPA.

2) Consensus Sediment Guidelines – The threshold effects concentrations developed by MacDonald, Ingersoll, and Berger (2000) for metals, PAHs, and pesticides were used as threshold values. These values derive from an evaluation of literature-based values from a variety of sources.

3) A Compendium of Environmental Quality Benchmarks – This document contains a wide array of environmental standards criteria and guidelines for sediments. Selection of threshold values from this compendium was based on freshwater toxicity data; lowest effect levels; and either a standard, criteria, or guideline in that order of preference. These benchmarks were chosen to be used next, because they provided a wide array of regulatory based values.

4) U.S. EPA Region 5 Ecological Screening Values – Values taken from this source for Calumet area threshold values were used with no modifications. Many of these values are based on calculated or estimated toxicities, not site-specific or laboratory studies.

5) Ontario Ministry of Environment – The Ontario MOE has developed several guidelines for sediments. The Technical Team identified the lowest effect concentrations as the Calumet area threshold values. These values were used next because they are older and based a variety of sources.

6) Literature Values – If no value was available from the various guidelines or criteria, the Technical Team reviewed the sediment toxicity literature to identify studies that would provide NOAELs useful for threshold values. These are cited in the table. Because these values are not regulatory based, a higher level of uncertainty is associated with these values.

A3.2.3 SURFACE WATER

The primary sources for surface-water threshold values are listed below in priority of use. Comments are included to further document how the values were identified. The threshold values for surface water are presented in Table A-3.

1) Illinois Water Quality Standards or Criteria – The Illinois chronic water quality standards for the Lake Michigan Basin furnished the first priority value. The next value to use was the general state chronic water quality standard. If no standards were available, the Illinois water quality criteria for chronic exposure were used. Since these values are enforceable, they were viewed with the highest confidence.

2) U.S. EPA Ambient Water Quality Criteria (AWQC) – If Illinois had not adopted a standard or criteria for a contaminant, the next source used was the chronic AWQC. These values are also of a high quality but are only criteria, not standards.

3) A Compendium of Environmental Quality Benchmarks – This document contains a wide array of environmental standards, criteria, and guidelines for surface water. Selection of threshold values from this compendium was based on freshwater toxicity data, lowest effect levels, and either standards criteria or guidelines in that order of preference. These values were chosen next because they are supported by regulations or guidance from other regulatory bodies.

4) U.S. EPA Region 5 Ecological Screening Values was the next source for Calumet area threshold values. These values were used with no modifications. The limited values used from this source were based on limited literature values and have a higher level of uncertainty than those above.

5) DiToro, McGrath, and Hansen (2000) – If no value was available from the above sources, a FCV was calculated using procedures outlined in this source. This calculated value was used as the threshold value for the Calumet area. But calculated values have a higher level of uncertainty.

A3.3 DEVELOPMENT OF CALUMET OPEN SPACE RESERVE BENCHMARK VALUES

As stated earlier, benchmark values are to be set at concentrations expected to impact ecological receptors anticipated at the Calumet area sites. The various sources described in Section 3.1.1 were referenced to identify benchmark values for Calumet soils, sediments, and surface water. The approach to selecting values paralleled the process used for COSR threshold values. The following subsections describe the hierarchy used to identify the appropriate values.

A3.3.1 SOILS

The primary sources for COSR soil benchmark values are listed below in priority of their use. Comments are included to further document how the values were identified. The COSR benchmark values for soils are presented in Table A-1.

1) US EPA Eco SSLs are available for a limited number of constituents—aluminum, antimony, barium, beryllium, cadmium, cobalt, iron, lead, and dieldrin. As noted earlier, these values are based on identifying the concentration that will be protective of the most sensitive organism within the following groups: plants, soil invertebrates, birds, and mammals. The Technical Team reviewed the supporting data provided for each of these constituents and modified the Eco-SSL using the identified LOAEL data for these compounds. The modification followed the procedures U.S. EPA used to identify threshold values based on NOAELs. The Technical Team calculated the geometric mean of the LOAEL values for the most sensitive receptor group. For cases in which LOAEL data were not available (most often with plants), the highest effects concentration for 20 percent of the test population from the studies accepted by U.S. EPA was used to modify the Eco-SSL. The modified Eco-SSLs were used as benchmark values for the Calumet area. These are the most thoroughly researched values and have the highest degree of confidence associated with them.

2) Midewin High-End Preliminary Remediation Goals (PRG) was the next source used to identify benchmark values. The Technical Team modified the Midewin high-end PRGs values to exclude values that would be protective for wetland invertebrates; these groups of organisms are addressed via sediment benchmark values. These values were developed for habitats similar to those in the Calumet area, and the Medwin site is near the Calumet area.

3) If no value was available from the above sources, the Technical Team obtained a benchmark value by multiplying the threshold value by an adjustment factor of 10. This adjustment factor represents a general relationship between chronic and acute toxicity values. It is commonly used as an uncertainty factor when only acute toxicity data are available and a toxicity value for chronic exposure must be determined. This value has a higher level of uncertainty than those previously identified.

A3.3.2 SEDIMENT

The primary sources for COSR sediment benchmark values are listed below in priority of use. Comments are included to further document how the values were identified. The benchmark values for sediments are presented in Table A-2.

1) Consensus Sediment Guidelines – The probable effects concentrations developed by MacDonald, Ingersoll, and Berger (2000) for metals, PAH, and pesticides were used as benchmark values.

2) A Compendium of Environmental Quality Benchmarks contains a wide array of environmental standards criteria and guidelines for sediments. Selection of benchmark values from this compendium was based on freshwater toxicity data, probable effect levels, and either standards criteria or guidelines in that order of preference. These benchmarks were chosen to be used next, because they provided a wide array of regulatory based values.

3) Ontario Ministry of Environment – The Ontario MOE has developed several guidelines for sediments. The Technical Team identified the probable effect concentration as the COSR benchmark values. These values were used next because they are older and based a variety of sources.

4) U.S. EPA Region 5 Ecological Screening Values was the next source for COSR benchmark values. The Technical Team adjusted the threshold values in this source by multiplying the value by an adjustment factor of 10 to obtain a benchmark value. This adjustment factor represents a general relationship between chronic and acute toxicity values. It is commonly used as an uncertainty factor when only acute toxicity data are available and a toxicity value for chronic exposure must be determined. These were used next because the original values were reviewed by EPA, and the modification adds uncertainty to the process.

5) Literature Values – If no value was available from the various guidelines or criteria, the Technical Team reviewed the sediment toxicity literature to identify studies that could provide LOAELs useful for benchmark values. These are referenced in Table A-2. Because these values are not regulatory based, a higher level of uncertainty is associated with these values.

A3.3.3 SURFACE WATER

The primary sources for surface-water COSR benchmark values are listed below in priority of use. Comments are included to further document how the values were identified. The COSR benchmark values for surface water are presented in Table A-3.

1) Illinois Water Quality Standards or Criteria – The Illinois acute water quality standards for the Lake Michigan Basin furnished the first priority value. The next value to use was the general state acute water quality standard. If no standards were available, the Illinois water quality criteria for acute exposure were used. Since these values are enforceable, they were viewed with the highest confidence.

2) U.S. EPA AWQC – If Illinois had not adopted a standard or criteria for a specific contaminant; the next source used was the acute AWQC. These values are also of a high quality but are only criteria, not standards.

3) A Compendium of Environmental Quality Benchmarks contains a wide array of environmental standards criteria and guidelines for surface water. Selection of benchmark values from this compendium was based on freshwater toxicity data, probable effect levels, and either standards criteria or guidelines in that order of preference. These values were chosen next because these are supported by regulations or guidance from other regulatory bodies.

4) DiToro, McGrath, and Hansen (2000) – If no value was available from the above sources, a final acute value was calculated using the procedures outlined in this source. This calculated value was adopted as the benchmark value for the Calumet area. These are calculated values and have a higher level of uncertainty.

5) If no value was available from the above sources, the Technical Team obtained a benchmark value by multiplying the threshold value by an adjustment factor of 10. This adjustment factor represents a general relationship between chronic and acute toxicity values. It is commonly used as an uncertainty factor when only acute toxicity data are available and a toxicity value for chronic exposure must be determined. Of all values identified, this value has the highest uncertainty associated with it.

REFERENCES

Buchman, M.F., 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1. Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration. Seattle, Washington. 12 Pages.

Canadian Council of Ministers of the Environment (CCME). 2002. Summary of Existing Canadian Environmental Quality Guidelines.

City of Chicago Department of Planning and Development. 2002. *Calumet Area Land Use Plan*. February.

City of Chicago. 2003. Polynuclear Aromatic Hydrocarbon Background Study. February 24.

DiToro, D.M, J.A. McGrath, and D.J. Hansen. 2000. "Technical basis for narcotic chemicals and PAH criteria. I. Water and tissue." *Environ. Toxicol. Chem.* 19:1951-1970.

Efroymson, R.A., M.E. Will, and G. W. Suter. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soils and Litter Invertebrates and Heterotrophic Processes: 1997 Revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee. ES/ER/TM-126/R2.

Efroymson, R.A., M.E. Will, G. W. Suter and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory. Oak Ridge, Tennessee. ES/ER/TM-85/R3.

Friday,G. 1998. Ecological Screening Values For Surface Water, Sediment, and Soil. Westinghouse Savannah River Company. WSRC-TR-98-00110

Illinois Pollution Control Board (IPCB). 2007. Title 35 of the *Illinois Administrative Code* (IAC), part 742, 'Tiered Approach to Corrective Action Objectives.' February 23. On-line address: http://www.ipcb.state.il.us/documents/dsweb/Get/Document-38408/.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, CE, Hanke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. "Calculation and Evaluation of Sediment Effect Concentrations for the Amphipoid *Hyalella axteca* and the Midge *Chironomus riparius*." *Journal of Great Lakes Research*. 22:602-623.

Joliet/Midewin Ecological Working Group (Midewin). 2000. Ecological Preliminary Remediation Goals. Prepared for the Joliet Army Ammunition Plant and Midewin National Tallgrass Prairie. Will County, Illinois.

Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-95/R4.

Long, E.R. and LG. Morgan. 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum. NOS OMA 52.

MacDonald, D.D., T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J. MacDonald, S.L. Smith, and D.P. Shaw. 1999. A Compendium of Environmental Quality Benchmarks. Prepared for Environment Canada. Vancouver, British Columbia.

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

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A Preliminary Evaluation of Sediment Quality Assessment Values for Freshwater Ecosystems. Journal of Great Lakes Research. 22 (3):624-638

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Water Resources Branch. Ontario Ministry of the Environment. Toronto.

Piwoni, M., T. Chow, G. Bordson, J. Talbott, L. Wiededmann, M. Wilcoxon, and W. Bogner. 2006. "Chicago Area Background Contaminants in Wetland Sediments and Surface Waters: Supporting the Calumet Wetlands Ecotoxicological Assessment. Illinois Waste Management and Research Center and Illinois State Water Survey. Draft. September.

U.S. Environmental Protection Agency (EPA). 1993. Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning. Office of Water. EPA-822-R-93-011.

EPA. 1996. Calculation and Evaluation of Sediment Effect Concentrations of the Amphipoid *Hyalella axteca* and the Midge *Chironomus riparius*. EPA 905-R96-008. Great Lakes National Program Office. Chicago, Illinois.

EPA. 2003. U.S. EPA Region 5 Ecological Screening Levels. On-line at www.epa.gov/reg5rcra/ca/edql.html/

EPA. 2005. Ecological Soil Screening Levels (Eco-SSL) Guidance and Documents. Office of Solid Waste and Emergency Response. March. On-line at www.epa.gov/oswer/ecorisk/ecossl/

TABLES

TABLE A-1

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SOIL

Constituents	Soil Background[1] (mg/kg)	Source	Soils[2] Threshold (mg/kg)	Source	Soils[3] Benchmark (mg/kg)	Source
Metals						
Aluminum	9,500	a	NA		NA	
Antimony	4	a	0.3	a	65	a
Arsenic	13	a	18	a	31	e
Barium	110	a	330	a	585	a
Beryllium	0.59	a	21	a	48	a
Cadmium	0.6	a	0.4	a	3.37	a
Chromium	16.2	a	26	a	131	
Chromium - 3+	NA		26	a	131	b
Chromium - 6+	NA		0.4	b	21.3	b
Cobalt	8.9	a	13	a	102	a
Copper	19.6	a	54	a	190	b
Cyanide	0.51	a	0.9	c	9	d
Iron	15,900	a	NA		NA	
Lead	36	a	16	a	430	a
Manganese	636	a	152	a	500	b
Mercury	0.06	a	0.07	b	1.3	b
Nickel	18	a	44	b	210	b
Selenium	0.48	a	0.8	b	1	b
Silver	0.55	a	0.4	b	2	b
Thallium	0.32	a	0.86	b	1.3	b
Vanadium	25.2	a	8	a	43	b
Zinc	95	a	113	b	250	b
Polynuclear Aromatic Hydrocarbons (PAHs)						
Acenaphthene	0.09	b	4	b	20	b
Acenaphthylene	0.03	b	NA		NA	
Anthracene	0.25	b	11,400	b	51,000	b
Benzo(a) anthracene	1.1	b	NA		NA	
Benzo(b) fluoranthene	1.5	b	1	c	10	d
Benzo(k) fluoranthene	0.99	b	1	c	10	d
Benzo(g,h,I)perylene	0.68	b	NA		NA	
Benzo(a)pyrene	1.3	b	11.3	b	113	b
Chrysene	1.2	b	NA		NA	
Dibenzo(a,h) anthracene	0.2	b	NA		NA	
Fluoranthene	2.7	b	1,380	b	2,750	b
Fluorene	0.1	b	6	b	30	b
Ideno(1,2,3-cd) pyrene	0.86	b	1	c	10	d

TABLE A-1

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SOIL

Constituents	Soil Background[1] (mg/kg)	Source	Soils[2] Threshold (mg/kg)	Source	Soils[3] Benchmark (mg/kg)	Source
Naphthalene	0.04	b	852	b	1,700	b
Phenanthrene	1.3	b	5	d	50	d
Pyrene	1.9	b	83	b	1,350	b
Pesticides/PCBs/Dioxins						
Chlordane	NA		0.035	b	12.6	b
DDD	NA		0.004	b	0.04	b
DDE	NA		0.004	b	0.04	b
DDT	NA		0.004	b	0.04	b
Dieldrin	NA		0.002	a	0.54	b
Endrin	NA		0.014	b	0.14	b
Heptachlor	NA		0.268	b	3.36	b
Heptachlor epoxide	NA		0.008	b	0.042	b
Polychlorinated biphenyls	NA		1.3	c	13	d
Dioxin (2,3,7,8-TCDD) TEQ	NA		4 ng/kg	c	40 ng/kg	d

Notes:

Information good as of 2/23/07.

1 Background values for metals taken from (a) Illinois Environmental Protection Agency's (IEPA) value for metropolitan area soils. (b) Background values for polynuclear aromatic hydrocarbons are from IEPA;s value for Chicago.

2 Soil values were obtained from the following sources: (a) EPA 2005, (b) Midewin (2000) (did not include values for wetland invertebrates), (c) Canadian Council of Ministers of the Environment (CCME) 2002, and (d) Oak Ridge National Laboratory 1997a, b.

3 Soil values were obtained from the following sources: (a) Modified from EPA 2003, (b) Midewin (did not include values for wetland invertebrates), (c) Canadian Council of Ministers of the Environment (CCME) 2002, (d) threshold value X 10, and (e) value same as threshold value due to the Midewin value being lower than the EPA threshold value.

*	Based on total DDT (DDT and all isomers).
NA	Value currently not available or under development
mg/kg	Milligrams per kilogram
ng/kg	Nanograms per kilogram
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
TCDD	Trichlorodibenzo-p-dioxin
TEQ	Toxicity equivalent

TABLE A-2

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SEDIMENT

Constituents	Sediment Background[1] (mg/kg)	Source	Sediment Threshold[2] (mg/kg)	Source	Sediment Benchmark[3] (mg/kg)	Source
Metals						
Aluminum	15,000	a	NA		NA	
Antimony	0.80	a	3.2	c	70	b
Arsenic	26.4	a	9.79	b	33	a
Barium	213	a	NA		NA	
Beryllium	1.5	a	NA		NA	
Cadmium	3.7	a	0.99	b	4.98	a
Chromium	69.9	a	43.4	b	111	a
Chromium - 3+	NA		NA		NA	
Chromium - 6+	NA		NA		NA	
Cobalt	17.2		NA		NA	
Copper	99.9	a	31.6	b	149	a
Cyanide	NA	a	0.1	d	NA	
Iron	41,600	a	21200	c	43766	c
Lead	538	a	35.8	b	128	a
Manganese	1,810	a	460	e	1100	d
Mercury	0.47	a	0.18	b	1.06	a
Nickel	49.2	a	22.7	b	48.6	a
Selenium	5.03	a	4	f	4	e
Silver	0.64	a	1	c	3.7	b
Thallium	1.10	a	NA		NA	
Vanadium	56.3	a	NA		NA	
Zinc	761	a	121	b	459	a
Polynuclear Aromatic Hydrocarbons (PAHs)						
Acenaphthene	0.12	a	1.3	a	1.30	f
Acenaphthylene	0.1	a	0.01	c	0.13	b
Anthracene	1.06	a	0.06	b	0.85	a
Benzo(a) anthracene	2.91	a	0.11	b	1.05	a
Benzo(b) fluoranthene	2.69	a	10	d	NA	
Benzo(k) fluoranthene	2.70	a	0.24	e	13.4	d
Benzo(g,h,I)perylene	2.2	a	0.17	e	3.2	d
Benzo(a)pyrene	2.99	a	0.15	b	1.45	a
Chrysene	3.76	a	0.17	b	1.29	a
Dibenzo(a,h) anthracene	0.691	a	0.03	b	0.14	b
Fluoranthene	9.07	a	6.2	a	6.2	f

TABLE A-2

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SEDIMENT

Constituents	Sediment Background[1] (mg/kg)	Source	Sediment Threshold[2] (mg/kg)	Source	Sediment Benchmark[3] (mg/kg)	Source
Fluorene	0.429	a	0.54	a	0.54	a
Ideno(1,2,3-cd) pyrene	3.480	a	0.2	e	2	d
Naphthalene	0.2	a	0.47	a	0.56	a
Phenanthrene	3.7	a	1.8	a	1.8	f
Pyrene	7.77	a	0.20	b	1.52	a
Pesticides/PCBs/Dioxins						
Chlordane	0.004	a	0.003	b	0.02	a
DDD	1.250	a	0.005	b	0.06	a
DDE	0.14	a	0.003	b	0.03	a
DDT	0.75	a	0.004	b	0.03	a
Dieldrin	NA	a	0.002	b	0.06	a
Endrin	NA	a	0.002	b	0.02	a
Heptachlor	0.00001	a	0.002	b	0.02	a
Heptachlor epoxide	NA	a	0.002	b	0.02	a
Polychlorinated biphenyls	0.134	a	0.06	b	0.68	a
Dioxin (2,3,7,8-TCDD) TEQ	NA	a	0.85 ng/kg	c	21.5 ng/kg	c

Notes:
Information good as of 10/1/06.

1 Background values were obtained from: (a) Piwoni and others (2006) "Chicago Area Background Contaminants in Wetland Sediments and Surface Waters: Supporting the Calumet Wetlands Ecotoxicological Assessment."

2 Sediment values were obtained from the following sources: (a) U.S. EPA 1993 Technical Basis for Deriving Sediment Quality Criteria for the Protection of Benthic Organisms, (b) MacDonald and others 2000, (c) A Compendium of Environmental Quality Benchmarks - Georgia Basin (MacDonald and others 1999), (d) U.S. EPA Region 5 ESLs, (e) Ontario Ministry of Environment, and (f) Venderveer and Canton, Env. Tox. and Chemistry, Vol. 16, pages 1260-1267.

3 Sediment values were obtained from the following sources: (a) MacDonald and others 2000, (b) A Compendium of Environmental Quality Benchmarks – Georgia Basin (MacDonald and others 1999), (c) Ontario Ministry of Environment, (d) U.S. EPA Region 5 ESLs X 10, (e) Venderveer and Canton, Env. Tox. and Chemistry, Vol. 16, pages 1260-1267, and (f) benchmark value set equal to threshold value since other values from non-EPA sources lower than threshold values.

Blanks indicate no value available.

*	Based on total DDT (DDT and all isomers)
NA	Value currently not available or under development
mg/kg	Milligrams per kilogram
ng/kg	Nanograms per kilogram

DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
TCDD	Trichlorodibenzo-p-dioxin
TEQ	Toxicity equivalent

TABLE A-3

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SURFACE WATER

Constituents		Surface Water Background[1] (µg/L)	Surface Water Threshold[2] (µg/L)	Source	Surface Water Benchmark[3] (µg/L)	Source
Metals						
Aluminum		140	NA		NA	
Antimony		<8	30	c	88	c
Arsenic		2.5	48	a	340	a
Barium		50	5,000	a	5,000	a
Beryllium		<4	NA		NA	
Cadmium[5]		<2	5.1	a	14.3	a
Chromium		<8	NA		NA	
Chromium - 3+[5]		NA	184.7	a	1,420.2	a
Chromium - 6+		NA	11	a	16	a
Cobalt		<4	24	d	110	d
Copper[5]		5.1	23.2	a	36.4	a
Cyanide		<2	5.2	a	22	a
Iron		710	1,000	a	1,000	a
Lead[5]		<2	16.7	a	318.2	a
Manganese		42	1,000	a	1,000	a
Mercury		0.017	0.9	a	1.7	a
Nickel[5]		<20	133.6	a	1,202.8	a
Selenium		<2	5	a	10	a
Silver		<2	5	a	5	a
Thallium		<2	10	e	20	d
Vanadium		<2	12	e	190	d
Zinc[5]		12	303.9	a	301.4	a
Polynuclear Aromatic Hydrocarbons (PAHs)						
Acenaphthene		NA	62	b	120	b
Acenaphthylene		NA	15	b	190	b
Anthracene		NA	4	d	35	d
Benzo(a) anthracene		NA	0.03	e	0.2	d
Benzo(b) fluoranthene		NA	9.1	e	5.7	e
Benzo(k) fluoranthene		NA	1.3	f	90.7	f
Benzo(g,h,I)perylene		NA	7.6	e	13.2	f
Benzo(a)pyrene		NA	0.02	d	8.1	e
Chrysene		NA	3.6	f	17.6	e
Dibenzo(a,h) anthracene		NA	0.5	f	2.5	e
Fluoranthene		NA	4.4	d	199	d
Fluorene		NA	19	e	336.8	e
Ideno(1,2,3-cd) pyrene		NA	4.3	e	5	f

TABLE A-3

Calumet Open Space Reserve
Background, Threshold, and Benchmark Values

SURFACE WATER

Constituents		Surface Water Background[1] (µg/L)	Surface Water Threshold[2] (µg/L)	Source	Surface Water Benchmark[3] (µg/L)	Source
Naphthalene		NA	68	b	510	b
Phenanthrene		NA	3.7	b	46	b
Pyrene		NA	0.3	e	87.6	e
Pesticides/PCBs/Dioxins						
Chlordane		NA	0.0043	b	2.4	b
DDD		NA	NA		NA	
DDE		NA	NA		NA	
DDT		NA	0.001* ng/L	b	1.1 ng/L*	b
Dieldrin		NA	0.06	c	0.24	a
Endrin		NA	0.03	b	0.16	b
Heptachlor		NA	0.004	b	0.52	b
Heptachlor epoxide		NA	0.004	b	0.52	b
Polychlorinated biphenyls		NA	0.014	c	0.14	f
Dioxin (2,3,7,8-TCDD) TEQ		NA	0.00001	c	0.0001	f
Ammonia		NA	25		140	
Nitrogen		NA	10 mg/L		NA	
Phosphorus		NA	7		NA	

Notes:
Information good as of 10/1/06.

1 Background values were obtained from Piwoni and others (2006) "Chicago Area Background Contaminants in Wetland Sediments and Surface Waters: Supporting the Calumet Wetlands Ecotoxicological Assessment."

2 Surface water values were obtained from the following sources: (a) Illinois Water Quality Standards for Lake Michigan Basin or general state standards for chronic exposure, (b) Illinois Water Quality Criteria, (c) U.S. EPA Water Quality Criteria, (d) Georgia Basin (MacDonald and others 1999), (e) U.S. EPA Region 5 EDQLs, and (f) DiToro and others 2000.

3 Surface water values were obtained from the following sources: (a) Illinois Water Quality Standards for Lake Michigan Basin or general state standards for acute exposure, (b) Illinois Water Quality Criteria, (c) U.S. EPA Water Quality Criteria, (d) Georgia Basin (MacDonald and others 1999), (e) DiToro and others 2000, and (f) threshold value X 10.

4 Values based on a water hardness of 305 mg/L as $CaCO_3$ based on data from Indian Ridge Marsh—can adjust for site-specific hardness using equations provided in the Illinois Water Quality Standards.

*	Based on total DDT (DDT and all isomers).
mg/L	Milligrams per liter
µg/L	Micrograms per liter
NA	Value currently not available or under development
ng/L	Nanograms per liter
DDD	Dichlorodiphenyldichloroethane

DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
TCDD	Trichlorodibenzo-p-dioxin
TEQ	Toxicity equivalent