CHAPTER TWO
ENVIRONMENTAL CONDITIONS

I. Introduction

The complexity of current environmental conditions in the Grand Calumet River basin is evident in the contrasts of the landscape. Four Superfund Sites (National Priority List) and 56 other sites identified as uncontrolled hazardous waste sites for possible remediation through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are located within the Area of Concern. Amongst these sites are remnants of the natural landscape that harbor some of the most diverse native plant and animal communities in the Great Lakes basin. The physical, chemical and biological structure of in-stream habitat in the Grand Calumet River is extremely degraded and results in severely impaired invertebrate and fish communities. Yet, within one mile of the river channel is Clarke and Pine Nature Preserve, which supports the highest concentration of rare and endangered species in the state. Reconciling these extremes into a better integrated landscape is one challenge of the Remedial Action Plan.

Industrial and urban development have caused stress that negatively impacted the integrity of the southern Lake Michigan lakeplain ecosystem through the years. The natural processes that once controlled the ecology of the Area of Concern have been eclipsed by human activity, creating a new set of environmental conditions that will shape the future of the region as much as the natural systems shaped the past. The purpose of the Remedial Action Plan is to balance land use with ecological restoration in order to remove impairments to the beneficial uses, but not to fully restore the landscape to pre-industrial conditions. Considering this, two fundamental issues face the Remedial Action Plan:

- What threats to human health and ecosystem integrity have urban industrial development created, as expressed in the beneficial use impairments? and
- To what extent can these threats be removed and the damage caused to the landscape be repaired?

Ecosystem integrity stems from the health of the biological populations and interactive communities and the ability of the ecosystem to withstand or adapt to stress. An essential concept in ecosystems is that ecological communities are dynamic and exist within ranges of conditions that occur as the result of natural forces. Communities exist in balance with these natural conditions and composition changes throughout various states that tend toward stability and increasingly complex interrelationships. Healthy systems are characterized by their resiliency and their ability to self organize and recover from stress or disruption. The diversity of genetic traits within species and among them supports the ability of ecosystems to survive and prosper even though challenged by changing conditions. Native species and natural communities contain within their genetic makeup the "memory" of thousands of years of conditions that have survived within the Great Lakes Basin. An important measure of the biological integrity of the Area of Concern is its ability to sustain viable populations of native species and community types.

The remnants of the native landscape are snapshots of what was once a beautiful and dynamic natural system. They offer the potential for a new landscape that is rich in biological diversity. Conservation of these natural resources will depend on the recognition of their intrinsic value and protection and restoration of the ecological processes that support them. Restoration of the Area of Concern presents a basic problem: while the remnants of the pre-industrial landscape offer the best opportunities for conservation, restoration and preservation of ecological health to the system; the natural processes that created and kept them dynamic have been changed forever.

The ultimate success of the Remedial Action Plan, restoring the fourteen impaired beneficial uses, depends upon the designation, implementation, and coordination of site-specific remediation and restoration projects that remove impairments to these natural processes. Contamination is generally thought of as the primary cause of environmental degradation in the Area of Concern, and is the one stressor common to all beneficial use impairments. However, simply removing contamination from the system is not sufficient for delisting. Other stressors; physical destruction of habitat, fragmentation, changes in hydrologic regime, introduction of exotic species, shoreline alteration and fire suppression, disrupt the key ecological processes and must be addressed to achieve delisting of all beneficial use impairments. Removing pollutants before they enter the system is just one step toward restoring ecological health. Remediation of the environmental damage caused by historic contamination is more complex.

The combined impact of the stressors has created such extensive environmental degradation that it is imperative to take an ecosystem approach in designing remedial measures that address beneficial use impairments in the Area of Concern. This chapter establishes an ecosystem approach to environmental remediation and restoration. It links ecosystem functions and key ecological processes to the stressors that cause beneficial use impairments in the Area of Concern. Section II describes the lakeplain formation and the key ecological processes and the stresses on the environment. Section III describes how current habitat conditions reflect the impact of industrial development. Finally, sections IV through VI specifically describe the current conditions of the surface water, underlying sediment, groundwater and air.

II. Key Ecological Processes

The post-glacial landscape of the southern Lake Michigan lakeplain is constantly changing. For most of its history, regional physical processes such as climatic conditions, glacial mechanics, and fluctuating lake levels drove this dynamic system. The region's biotic communities have been influenced by the interplay of three major biomes: eastern deciduous forest, tallgrass prairie, and boreal forest. The changing physical terrain and the availability of diverse genetic material created an ecological rhythm that marked time with constantly evolving biotic communities. The ecological processes of natural succession, hydrology (link between the groundwater and surface water, including Lake Michigan), species diversity (interplay of three major biomes), and periodic fire shaped and sustained the natural communities.

A. Lakeplain Formation

The following geologic history of the lakeplain and formation of the Grand Calumet River are summarized from *Geologic History of the Little Calumet and Grand Calumet Rivers* by Steve E. Brown, Indiana Geological Survey, Indiana University, 1996.

Sixteen-thousand years ago the Lake Michigan Lobe of the Wisconsin Glacier covered the southern Lake Michigan area. Over the next 4,000 years the glacier receded and advanced several times. With each successive wave of glaciation, the retreating ice left behind till in the form of moraines. Ancestral Lake Michigan formed as the ice retreated north and the meltwater was trapped between the moraines and the receding ice.

The water level of the lake fluctuated with changes in drainage and precipitation, dropping to its current level. The dynamic history of the lake is recounted by the sand dunes, relict beaches, sandbars and spits of the Southern Lake Michigan lakeplain. These land forms mark three distinct periods of the lake; the Glenwood Beach (13,500 to 12,400 years ago), the Calumet Beach (11,800 to 11,000 years ago) and Toleston Beach (6,300 years ago to present).

Prior to the formation of Toleston Beach, early forms of the Little Calumet River, Salt Creek, and Deep River served as watershed for the area, draining into ancestral Lake Michigan. As Toleston Beach formed, it blocked the rivers' outlets, preventing them from flowing directly into the lake. As the rivers backed up, they formed a large lagoon landward of Toleston Beach. Between 4,500 and 4,000 years ago, Toleston Lagoon emptied into ancestral Lake Michigan near the Indiana-Illinois border, where together they drained southward through the Sag channel. Eventually, the lake level dropped below the Sag Channel outlet transforming the rivers and lagoon into a drainage network that joined the Little Calumet River, Salt Creek, Deep River and Thorn Creek.

As the lake level continued to drop, the Toleston Strandplain formed on the lakeward side of Toleston Beach. Approximately 2,200 years ago, the Little Calumet flowed west landward of Toleston Beach and turned northeast to flow lakeward at a break in the ridge near early Lake Calumet. The lakeward reach became the Grand Calumet River, which emptied into Lake Michigan. During the formation of the strandplain, eastward directed longshore currents forced the mouth of the Grand Calumet River to migrate from west to east along the shoreline. The mouth of the river reached the area now occupied by the Grand Calumet Lagoons about 350 years ago. Figure 1 depicts the formation of the Little and Grand Calumet rivers and the Toleston strandplain (Chrzastowski and Thompson, 1992).

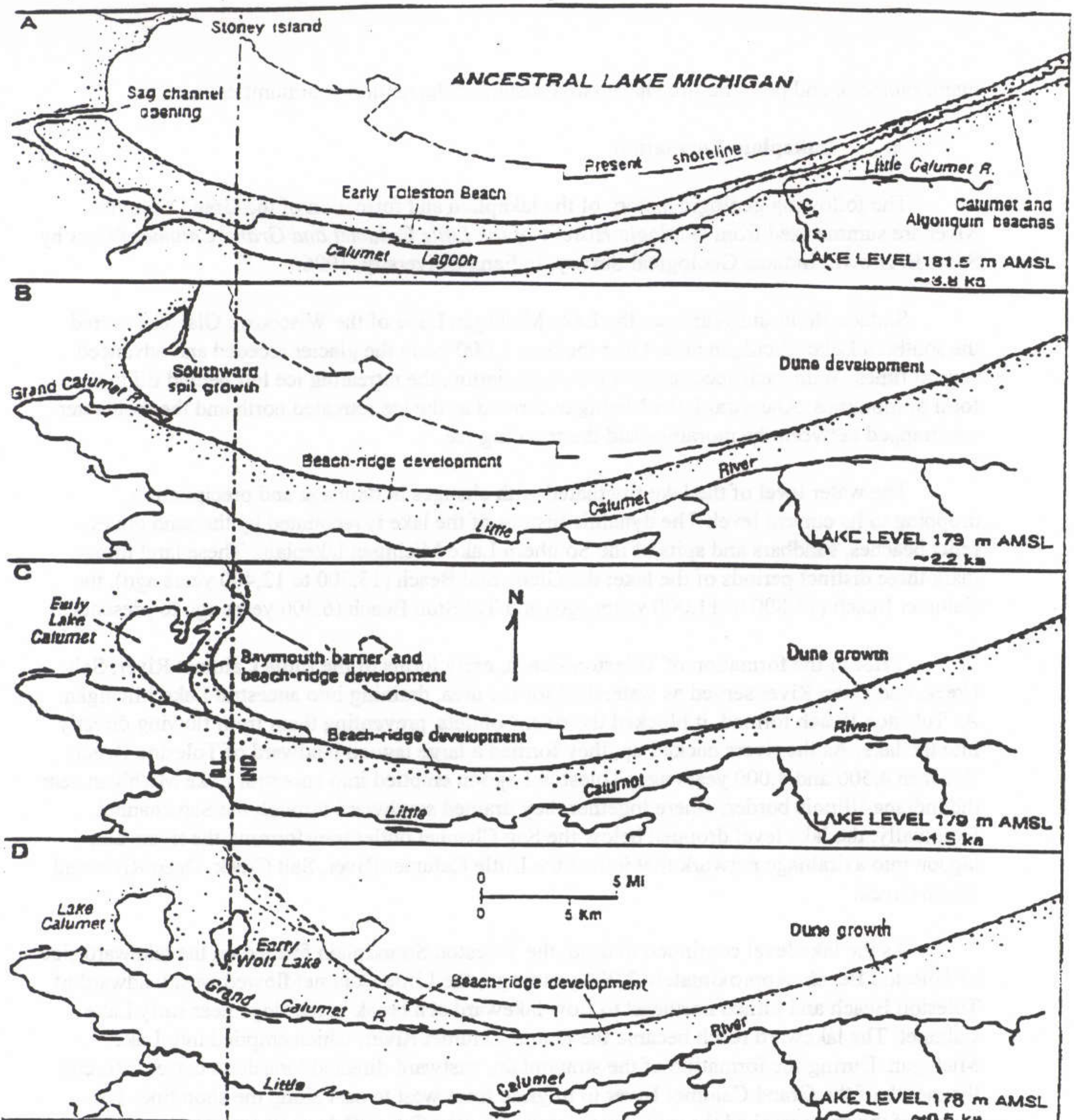


Figure 1. Paleogeographic reconstruction of the shoreline progradation of the Toleston Beach since about 3,800 years ago and the corresponding changes in drainage patterns along the Little and Grand Calumet Rivers (from Chrzastowski and Thompson, 1992).

Toleston Beach, at its east end, begins as a high dune and widens into the Toleston strandplain as it moves west. In the northwest section of the strandplain a series of shallow lakes were captured by spits as the lake receded. To the south and east the surface topography was dominated by a series of ancient linear beach ridges and intervening swales. Near the Indiana-Illinois border there were as many as one hundred of these ridges. Each individual ridge took from tens to hundreds of years to form as the level of Lake Michigan fluctuated. The ridges are built of layers of sand and gravel sediments deposited by shoreline wave activity and are capped with wind blown dune deposits.

Wetlands formed where the swales dip below the groundwater table. The well-drained sandy soils of the ridges grading into the marshy swales created a wide range of moisture conditions that were complicated by the natural fluctuations in the groundwater table including seasonal changes, short term fluctuations of Lake Michigan water level, and the long term retreat of the lake. This is reflected in the variety of natural communities found throughout the dune and swale region. From the dry sand savannas to the interdunal ponds, these communities are interwoven into a fine tapestry of living organisms responding to each temporal or spatial change in the landscape.

The Grand Calumet River formed as a natural land feature along with the dune and swale on the Toleston strandplain. Despite fragmentation, the river corridor and natural-area remnants share a common ecological heritage. The divisions between these areas are artificial impairments to the natural ecological processes. No matter how disturbed the landscape, the remnants are elements of a larger system. Understanding how that system functions and its potential for improvement provides context for habitat restoration projects along the river corridor. The long term viability of the native communities will depend on restoring ecological processes along the river and throughout the watershed.

B. Key Ecological Processes

1. *Natural Succession*

Natural succession, the process where one recognizable biotic community naturally replaces another, takes place over hundreds and thousands of years. As Lake Michigan receded, plants and animals from the surrounding landscape migrated in and colonized the newly formed ridges and swales. The various biotic communities that inhabit these areas mark the stages in the evolution of the lakeplain and reveal the natural succession through which sand and gravel beaches were transformed into living marshes, prairies and savannas. The ridge and swale system closest to the lake (north of the Grand Calumet River) has a higher water table, is more calcareous, and has fewer trees. Prior to logging, white and jack pine dominated the ridges and white cedar was found throughout the swales. The inland ridge and swale system (south of the Grand Calumet River) has a lower pH and is more heavily forested with black and white oaks (Bacone, 1979).

2. *Hydrology*

Ground water flow was crucial to maintaining the moisture regimes in the wetlands, lakes and rivers of the lakeplain. The subsurface of the lakeplain is underlaid with a layer of nearly impermeable clay topped by lacustrine sediments that form the Calumet Aquifer. This formation holds groundwater close to the surface, resulting in poor surface water drainage. Poor drainage and relatively flat topography resulted in marshes, shallow lakes, and sluggish rivers and creeks to form throughout the new landscape. Moisture conditions were complicated by the natural fluctuations in the groundwater table including seasonal changes, short term fluctuations of Lake Michigan water level, and the long term retreat of the lake.

3. *Species Diversity*

Species diversity was enhanced on the southern Lake Michigan lakeplain by successive waves of tundra, boreal, eastern deciduous forest and prairie systems migrating across the region with changes in climate. Boreal and tundra communities were established along the receding edge of the glacier. By the end of the Calumet Beach phase of the lake a forest, dominated by spruce and fir, followed the receding water north. A mild semi-arid period began that spanned several stages of the lake's evolution, allowing deciduous forest to migrate in from the south and east and eventually prairie from the west (Bacone 1979). Elements from these biomes that could survive the changing environmental conditions mixed freely together to form the unique natural communities of the lakeplain.

4. *Fire*

Fire has been an influence on the biotic communities of the lakeplain for at least 4,000 years, creating and maintaining the openness of prairie and savanna communities. During the formation of the Toleston strandplain, human activity began to have a direct influence on the lakeplain landscape. Climatic conditions became more moist and favored the deciduous forest. The forest expanded across the landscape from the south and east pushing the prairie back west. The advance of the forest was checked by Native Americans, who used fire as a hunting tool. Fires swept across the prairies into the edge of the forest, creating openings for prairie species to establish amongst fire tolerant deciduous species (Bacone).

C. Stressors Causing Impairments to Key Ecological Processes

Intensive industrial and urban development have resulted in significant stress on the lakeplain ecosystem and are expressed as beneficial use impairments. Fragmentation and loss of physical habitat, fire suppression, altered hydrology, exotic species, shoreline alterations and contamination are stressors on the biological, chemical and physical structure of the ecosystem. The stressors do not act upon the processes singularly, but in combination, magnifying their influence on the landscape. The following matrix (Table 01) shows the impact of stressors causing beneficial use impairments on the key ecological processes.

Matrix of Stressors Causing Beneficial Use Impairments and Key Ecological Processes

Stressors Causing Beneficial Use Impairments	Key Ecological Processes			
	Succession	Hydrology	Species Diversity	Fire
Pollution and Nutrient Contamination	reduces species & community diversity limits natural community interaction allows for influx of exotics	alters chemical structure of habitat	alters chemical structure of habitat limits species interaction higher rates of extirpation allows for influx of exotics lower recolonization rates	
Loss of Physical Habitat/ Habitat Fragmentation	reduces species & community diversity limits natural community interaction allows for influx of exotics	disrupts surface water flow	alters physical structure of habitat limits species interaction higher rates of extirpation allows for influx of exotics lower recolonization rates	restricts size and range
Altered Hydrology	reduces species & community diversity limits natural community interaction allows for influx of exotics	disrupts groundwater flow disrupts surface water flow	alters physical structure of habitat limits species interaction higher rates of extirpation allows for influx of exotics	
Shoreline Alterations	eliminates early successional communities allows for influx of exotics	disrupts groundwater flow disrupts surface water flow	alters physical structure of habitat limits species interaction higher rates of extirpation allows for influx of exotics	
Exotic Species	replaces native species in succession patterns reduces species and community diversity limits natural community interaction	changes in biological structure can impact surface water patterns	alters biological structure of habitat outcompetes native species limits species interaction	alters fuel loading and composition
Fire Suppression	accelerates succession reduces species and community diversity limits natural community interaction may favor exotic species	changes in biological structure can impact surface water patterns	alters biological structure of habitat limits species interaction higher rates of extirpation may favor exotic species	reduction in frequency increase in intensity of wildfires

1. *Pollution and Nutrient Contamination*

Contamination impacts the chemical structure of habitat, affecting succession and species diversity. Sedimentation can alter the physical structure of aquatic habitat. Contamination can take the form of toxics, pathogens, and nutrients. Contamination alters the chemical environment and creates conditions that cannot support conservative species. Contamination causes greater rates of extinction, reduces available habitat, diminishes species interaction, and creates conditions that favor exotic species.

2. *Loss of Physical Habitat/Habitat Fragmentation*

Fragmentation and physical destruction of habitat destroy the physical structure of the landscape, affecting species diversity, succession, hydrology and fire. Physical changes in habitat conditions along the edges of fragments disrupt biotic communities and allow for the influx of exotic species. Small habitat patches generally have high rates of extinction, low rates of recolonization, and low levels of species diversity. Species that once interacted across the broader landscape are limited to small fragments. As a result, ecological interactions such as succession, pollination and predator/prey relationships are impaired. The ecological niches created by natural and human influences on the landscape go unfilled without the influx of new species. Habitat fragmentation restricts the size and range of fire on the landscape and restricts the ability of fire-sensitive species to recolonize burned areas.

3. *Altered Hydrology*

Altered hydrology impacts the physical and biological structure of the landscape and affects succession, natural hydrology and species diversity. Extensive draining and filling have reduced the total acreage of wetlands in the Area of Concern to about 30 percent of what existed prior to urban industrial development. Precipitation that once recharged the groundwater is now piped away as urban runoff, and rivers and streams have been channelized. These alterations disrupt surface/groundwater interactions, fragment aquatic communities, reduce available aquatic habitats, and allow for the influx of exotic species.

4. *Shoreline Alterations*

Shoreline alterations impact the physical structure of the landscape, affecting succession, hydrology and species diversity. Armoring and filling along the Lake Michigan shoreline impacts succession by inhibiting further dune formation. Two globally rare communities (panne and foredune) have been virtually eliminated from the Area of Concern because they are early successional shoreline communities. Shoreline alterations also reduce available habitat and disrupt surface and groundwater flow.

5. *Exotic Species*

Exotic species alter the biological structure of the landscape and affect succession and species diversity. Introduced species many times have no biological control in the natural system and out compete native species. Introduced species often form large monocultures that destroy and fragment natural habitat. Exotic species can alter succession patterns, limit species interactions, and lower recolonization rates.

6. *Fire Suppression*

Fire suppression alters the biological structure of the landscape, affecting succession and species diversity. Fire suppression also physically affects wildfire behavior by reducing the frequency and increasing the intensity. Areas left unburned build-up heavy combustible fuel loads that, in the event of a wildfire, can be dangerous to people, property, and the natural system. Without fire, savannas and prairies become choked with saplings and brush, shading out herbaceous species. When these areas are shaded out, species diversity is reduced, exotic species are favored, and the biological structure of the natural communities is destroyed.

III. Habitat

The landscape of the Calumet Region has changed dramatically over the past one hundred years. The Grand Calumet River typifies these changes. It was once described as being more like a bayou on Lake Michigan than a river (Moore 1959), but has since been channelized and redirected to flow into the Mississippi river basin. Depending on the level of the lake, the east branch also flows into Lake Michigan. Today roughly 90 percent of the river's water comes from industrial and municipal discharges. The sandy soils of the river bed have been overlain by sediments contaminated with the residue of urban industrial activities. Despite these changes, aspects of the natural systems are still evident along the river corridor and throughout the watershed. Identifying and understanding the significance of the native species and community types is an integral part of assessing the ecological state of the river corridor.

Currently, the most biologically diverse communities along the river corridor are restricted to a series of small tracts that have escaped physical disruption of the natural terrain. These sites include DuPont Dune & Swale, Clark and Pine East, the Grand Calumet Lagoons and Miller Woods unit of the National Lake Shore. There are somewhat disturbed areas, such as the NIPSCO Roxanna Substation, that support degraded native communities. And still others that are extremely degraded in most aspects but maintain specific ecological functions. Roxanna Marsh is the best example of the latter, it bears little resemblance to any native community type, yet it is a crucial stop over point for long range migratory waterfowl.

Migratory birds follow the elongate north-south lakeshore of Lake Michigan toward wintering grounds each fall. These migratory birds ultimately pass through the dune area at the southern tip of the lake. Brock (1986) called this avian convergence in the Area of Concern (and surrounding areas) the funnel effect which resulted in the area becoming a massive portal of migration toward wintering grounds throughout the Midwest. The lake provides rare habitat in the deep lake and beaches of the area. The deep lake attracts numerous diving ducks and the beaches provide the first resting place after long flights over the lake. Even though they are often degraded, remnant habitats in the shoreline area become extremely important areas for migrating birds. The Migrant Trap, Roxanna Pond (Marsh), Lake George Woods, and the Hammond Cinder Flats are exceptional examples of such areas.

A. Natural Heritage Data

This natural heritage information is summarized from *The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities,* by Crispin and Rankin. Seven natural systems have been identified that support biodiversity in the Great Lakes Basin. They are:

open lake, coastal shore, coastal marsh, lakeplain, tributary and connecting channel, inland terrestrial upland and inland wetland. The open lakes, coastal marsh, coastal shore and lakeplain are unique to the basin. Of these, coastal shore and lakeplain support a disproportionate amount of the basin's special biological diversity. Of the sixty-one Great Lakes' dependent, globally significant elements (G1 or G2), 26 percent are supported by coastal shore, while 21 percent are supported by lakeplain systems.

The Southern Lake Michigan region supports both lakeplain and coastal shore systems. The biological diversity of the coastal dunes that stretch along the southeast shoreline from Gary to southwest Michigan is underscored by the fact that the Indiana Dunes National Lakeshore has the third highest plant diversity of all national parks, despite having less than three percent of the total acreage of either of the top two (National Park Service, 1987). Data from the Natural Heritage Network identifies The Greater Calumet Wetlands Site as an area that also supports significant biological diversity on the Southern Lake Michigan lakeplain (Crispin and Rankin).

The Greater Calumet Wetlands Site stretches along the southern shore of Lake Michigan from the southeast side of Chicago to the west side of Gary and extends south to the southern edge of the lakeplain. This area contains several high quality remnants of the native landscape, harboring a wide range of both upland and wetland community types. A number of severely degraded wetlands serve as nesting and foraging habitat for regionally rare birds. There are eighteen natural community types within the site. Inventories include over seven hundred species of native plants, of which eighty-five are globally or state significant; over two hundred species of birds, including eighteen confirmed nesting species that are globally or state significant (The Nature Conservancy).

The Area of Concern is in the northeast section of the Greater Calumet Wetlands Site. It harbors a series of high quality remnants of the dune and swale complex that once covered the Grand Calumet River Watershed. Clark and Pine Nature Preserve, Gibson Woods Nature Preserve, Ivanhoe Dune and Swale Nature Preserve and Toleston Ridges Nature Preserve are examples of islands of biodiversity in the midst of an urban industrial landscape. These sites support a mosaic of interconnected natural communities that at times defy mapping. Seven of the community types are globally rare; panne, wet mesic sand prairie, mesic prairie, dry mesic sand prairie, dry mesic sand savanna, dry sand savanna and sedge meadow. The ridge and swale remnants support the most dense assemblage of rare plants and animals in Indiana with sixty-six state rare and endangered species currently identified at these sites (The Nature Conservancy). Clark and Pine Nature Preserve's forty acres support the highest concentration of rare and endangered species in the state of Indiana.

Several tracts that support significant habitat are adjacent to the Grand Calumet River. DuPont Dune and Swale and Clark and Pine East both include high quality remnants of dune and swale and have riparian wetlands with direct surface water connections to the river channel. The DuPont natural area contains four globally rare communities; wet-mesic sand prairie, dry sand savanna, dry-mesic sand prairie and sedge meadow. Roxanna Marsh and the Calumet Tern Site are both degraded wetlands that are noted as foraging and nesting habitat for regionally rare birds. At the extreme east end of the river are three Natural Heritage sites associated with the Grand Calumet River Lagoons; Miller Beach and Dunes, the U.S. Steel Site and sections of Marquette Park. All are a part of or adjacent to the larger Miller Woods Unit of the Indiana Dunes National Lakeshore, a nine hundred acre remnant of native lakeplain landscape.

Toleston Beach fans out from a single dune ridge in the east to about fifty dune capped beach ridges in the Miller area. The ridges have a linear form that parallels the lakeshore and are capped by moderate size dunes making them higher than those found farther west on the strandplain. Windblown sand has divided sections of the swales into separate ponds. High parabolic dunes occur lakeward of the lagoons (Brown 97). This area was the transition zone between the ridge and swale region to the west and the high dunes to the east. Prior to urban development, Miller Woods graded into the Greater Calumet Wetlands Site, now they are physically separated by the city of Gary.

The natural course of the Grand Calumet River was altered to accommodate building the U.S. Steel Steel mill in Gary. The relocation of the river channel isolated the section of the river east of the U.S. Steel facility, as a result, the Grand Calumet Lagoons formed. The area surrounding the lagoons can be separated into two units; north of the lagoons is primarily foredune and dune complex, while south of the lagoons is a savanna complex (Wilhelm, 1990 p.47). Natural Heritage data for Miller Woods and The Grand Calumet Lagoons area is limited. The north unit supports two globally rare communities, panne and foredune. There is no Natural Heritage data available on community classification in the savanna complex to the south of the lagoons.

B. Floristic Quality Assessment

The integrity of a natural area is indicated by its ability to support native species. When natural processes are still intact, the native species dependent on them will continue to thrive. If, on the other hand, those processes are impaired or destroyed those dependent species will vanish. The flora of the Chicago region shows varying degrees of fidelity to specific habitat conditions as well as tolerance for disturbance. The overall health of a natural area is reflected in its diversity of conservative species, those adapted to a specific set of biotic and abiotic conditions (Swink and Wilhelm).

The Floristic Quality Assessment, as described by Swink and Wilhelm (1994) in *Plants of the Chicago Region*, assigns a coefficient of conservatism, C value, to all native plant species in the region. Plants are ranked from zero to ten, with ten being the most conservative species. The C values of plant inventories can be computed for two different floristic assessments. The first is the Native C value, which is the mean C value of plants at a site. The second is the Floristic Quality Index which reflects the richness of conservative species within a natural area. The following is a summary of Native C values and Floristic Quality Index ratings from *Plants of the Chicago Region* .

> Based upon fifteen years of application of this assessment system to all types of land in the Chicago region, certain patterns have emerged. We have found that the mean C values in the preponderance of our open land range from 0 to 2. In light of the fact that 89% of our native flora has a C value of 4 or greater, and a mean C value of 7.3, it is evident that the principle elements of our native systems are uninvolved in the Chicago region landscape today.
>
> The vast majority of land in the region registers *I* values [Floristic Quality Index] of less than 20 and essentially has no significance from a natural area perspective. Areas with *I* values higher than 35 possess sufficient conservatism and richness to be of profound importance from a regional perspective. Areas registering in the 50's and higher are extremely rare and of paramount importance; they represent less than 0.5% of the land area in the Chicago region.

Table 02 summarizes the floristic quality assessments that were done for all the large dune and swale remnants in the Greater Calumet Wetlands Site as part of the Illinois-Indiana Regional Airport Site Selection Report in 1991 (TAMS Technical paper #7). The assessments were updated in 1994. Table 03 summarizes the two units of the Miller Woods site that were surveyed in August of 1978 and August of 1989 (Wilhelm, 1990 p.19).

Table 02. Floristic Quality Assessments for Greater Calumet Wetlands Complex Ridge and Swale Sites

Greater Calumet Wetlands Complex Ridge and Swale Remnant Sites	Native Taxa	Floristic Quality Index	Native C Value
Brunswick Savanna	68	38.81	4.71
Clark & Pine Addition # 1	92	44.00	4.59
Clark & Pine Addition # 2	152	75.03	6.09
Clark & Pine Nature Preserve	277	128	7.7
Clark & Pine East	212	88.58	5.74
Clark Junction	245	101.96	6.51
Clark Junction East	187	76.93	5.63
Cline Ave. Dune & Swale	106	53.52	5.20
DuPont Dune & Swale	226	76.10	5.06
Gibson Woods Nature Preserve	297	103.00	6.0
Ivanhoe Dune & Swale	272	89.62	5.43
Lakeshore Prairie	151	72.02	5.86
Toleston Ridges	261	101.00	6.1
Toleston Woods	93	44.59	4.62

Table 03. Floristic Quality Assessments for Miller Section

Miller Woods and Dunes Sites	Native Taxa	Floristic Quality Index	Native C Value
Unit A Foredune and Dune Complex	210	97.00	6.70
Unit B Savanna Complex	179	78.00	5.81

C. The Grand Calumet River Corridor

The Army Corps of Engineers has identified several reaches of the Grand Calumet River that are associated with specific dredging projects. (Please see the map entitled "Grand Calumet Sediment Remediation Plan: Study Reaches" in the Sediment Clean Up and Restoration Alternatives Project). The land adjacent to four of those reaches supports significant pockets of biodiversity. At the extreme east end of the river, Miller Woods and Dunes surround much of the Lagoons Reach. Clark and Pine East flanks both sides of the river at the west end of the U.S. Steel Reach. DuPont Dune and Swale runs along the north bank of the west half of the DuPont Reach. On the south bank of the river across from DuPont, smaller natural areas support native upland and wetland communities, including the Calumet Tern Site. At the east end of the reach are two small remnants of dune and swale and a large degraded wetland complex on the USS Lead property north of the river. The Roxanna Marsh Reach contains degraded wetlands that are important habitat for migratory waterfowl. The Airport Reach contains significant wetland areas that are important contributors to habitat along the river corridor.

1. *Miller Woods and Dunes*

The remnant natural areas surrounding the lagoons cover over nine hundred acres, including the Miller Woods and Dunes Unit of the Indiana Dunes National Lakeshore, the City of Gary's Marquette Park and private property owned by U.S. Steel Corporation and NIPSCO. The following information on the Miller section of the Indiana Dunes National Lakeshore is summarized in *Special Vegetation of the Indiana Dunes National Lakeshore* by Gerould Wilhelm (Wilhelm 1990). The dune complex north of the lagoons supports panne and foredune communities. The ridge and swale complex to the south of the lagoons is dominated by a savanna and marsh complex. The Miller area has been shown to supply habitat for at least seventy floristic elements considered rare or limited to a unique niche within the Indiana Dunes National Lakeshore.

Foredune communities occupy the windward exposure of the first line of dunes from the lake shore. Characteristic plants of the foredune include: *Ammophila breviligulata, Andropogon scorparius, Artemisia caudata, Calamovilfa longifolia, Cirsium pitcheri, Cornus stolonifera baileyi, Lathyrus japonicus glaber, Populus detoides, Rhus aromatica arenaria* and *Solidago racemosa gillamani.*

Panne communities in the Miller dunes inhabit a series of interdunal depressions that form on the lee sides of the first or second line of dunes. The depressions intersect the ground water table forming calcareous wetlands and ponds. Pannes are unique in floristic composition, containing species that grow nowhere else in the Chicago Region or State of Indiana. Plants of the panne community include: *Aster ptarmicoides, Carex garberi, Carex viridula, Gentiana crinata, Liparis loeselii, Lobelia kalmii, Rynochospora capillacea, Sabatia angularis, Scleria verticillata* and *Utricularia cornuta.*

The ridges and swales south of the lagoons support some of the highest quality black oak savanna in the Chicago Region. The more open sand prairie areas support: *Andropogon scoparius, Arabis lyrata, Asclepias amplexicaulis, Carex mulenburgii, Koelaria cristata, Krigia biflora, Linaria canadensis, Opuntia humifusa, Polygonum tenue* and *Viola pedata lineariloba.* The black oak savannas contain: *Aquilegia canadensis, Aralia nudicaulis, Aster linariifolius, Carex pensylvanica, Diervilla lonicera, Liatris aspera, Lupinus perennis occidentalis, Maiathemum canadense interius, Tephrosia virginiana* and *Vaccinium angustifolium laevifolium.*

Over four hundred and thirty species of native plants have been documented in the Miller Woods and Dune section of the Indiana Dunes National Lakeshore. The area as a whole has a mean C value of 6.84 and a Floristic Quality Index rating of 142, identifying it as a high quality natural area with significant habitat.

2. *Clark and Pine East*

The preserve is not uniform in quality throughout its borders. The entire tract is two hundred and fifty-three acres, which include about fifty acres of remnant ridge and swale. The ridge and swale areas support sand savanna and sand prairie on the upland ridges, and wet prairies, sedge meadows, emergent marsh and shrub swamps in the swales. There are approximately 100 acres of sand mined dune ridges that have revegetated with predominately native plant communities. The remaining acreage includes highly degraded swales, areas filled with fly-ash, and two large borrow pits from a sand mining operation. The Airport Reach contains significant wetland areas that are important contributors to habitat along the river corridor.

The sand mining operation scrapped away the dunes to the water table, creating habitat conditions similar to the natural pannes. Many panne associates are now found growing in these areas including: *Aster ptarmicoides, Carex viridula, Gentiana crinata, Hypericum kalmianum, Liparis loeselii, Potentilla fruticosa, Rynchospora capillacea* and *Sabatia angularis*.

The plant species list for the site contains two hundred and twelve native species and forty adventives, with a Floristic Quality Index of 78.23 and Native C Value of 5.03 with adventives. These numbers indicate Clark and Pine East is of extreme importance, as a natural area, to the Chicago Region.

3. *DuPont Dune and Swale*

There are approximately one hundred and seventy acres of remnant dune and swale included in DuPont's corporate land holdings around its East Chicago plant. Four globally rare communities have been identified at the DuPont natural area; wet-mesic sand prairie, dry-mesic sand prairie, dry sand savanna and sedge meadow.

Approximately fifty acres are a unique formation of dune and swale that have a natural surface water connection with the Grand Calumet River. Marshes along the river curve to the west and grade into linear swales. Near the river the marshes are generally filled with cattails (*Typha* sp.), common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). The swales support high quality wet prairie and sedge meadow communities. Species that are common throughout the swales include *Aster ptarmicoides, Calamagrostis canadensis, Carex stricta, Chelone glabra, Coreopsis tripteris, Eryngium yuccifolium, Eupatorium maculatum, Liatris spicata, Muhlenbergia glomerata, Pycanthemum virginianum, Scirpus pungens,* and *Scirpus validus creber*. Cattails, common reed and purple loosestrife are well established in deeper parts of the swales. These features formed as the result of the mouth of the river migrating to the east as the Toleston strandplain formed, and were once common along the north bank of the river. Now the ones at DuPont are among the few that have not been destroyed.

The plant species list as of 1993 contains two hundred and twenty-six native plant species and thirty-five adventives. It has a Floristic Quality Index rating of 70.8 and Native C value of 4.38 with adventives. These numbers indicate that the DuPont tract is of extreme value as a natural area within the Chicago region.

4. *Airport Sedge Meadow/Wet Prairie Wetlands*

A wetland assessment report for the Gary Regional Airport was completed in 1993; approximately one hundred and sixty-nine acres of jurisdictional wetlands were identified. The wetlands were placed into three general types: emergent marsh/open water; Sedge meadow/wet prairie wetland; and scrub-shrub/forested wetland. The sedge meadow/wet prairie wetlands provide potential habitat for wildlife ranging from cottontail rabbit to coyote and a large and diverse plant community including the States rare Kalms St. Johns-wort (*Hypericum kalmianum*) and over thirty species of sedges, grasses, forbs and small shrubs (Earth-Source, Inc. 1993). Wetlands located west and south of the airport (forty-four and eighty-eight acres, respectively) were considered sufficiently important in functions of habitat and water purification and storage to be included in U.S. EPA (1988) designation as prior identified wetlands unsuitable for filling.

5. *Degraded Habitat Areas*

Although much of the aquatic habitat remaining in the Area of Concern has been degraded, the remaining habitat provides feeding, nesting and resting areas for hundreds of birds each year. Ducks and other aquatic birds (Table 04) utilize open water and wetland habitat associated with the Indiana Harbor Ship Canal (including Lake George Branch), the east and west branches of the Grand Calumet River and various ponded areas (Roxanna Pond, Ralston Street Lagoons, Lake George, Wolf Lake, Bongi Ponds, Georgia Pacific Lagoons, Marquette Park Lagoons, and others) (Brock, 1986; US Fish & Wildlife Service, 1996a and 1996b). Recent records from the Breeding Bird Atlas project (Table 05) indicate that approximately seventy-two species of birds breed in the Area of Concern. At least thrity-six species of mammals have been recorded utilizing various habitats in the area (Table 06) (Whitaker, *et al*., 1994). Numerous endangered, threatened, or of special concern animals also inhabit this area (Table 07).

Roxanna Marsh (Pond) is a 22.4 acre wetland located in the West Branch of the Grand Calumet River near the Hammond Sanitary District plant. The wetland is contiguous to the Grand Calumet River and for the most part is less than one foot in depth, depending on fluctuation of water level in the river. Wetland types include palustrine emergent, aquatic bed and open water. This marsh is extremely important as a feeding area for migrant birds and other wildlife species. Brock (1986) indicates that the area provides the most reliable shorebird habitat in the Dunes Area. Rare species seen at the marsh include: Marbled Godwit, Hudsonian Godwit, American Avocet, Stilt Sandpiper, Long-billed Dowitcher and Red-necked Phalarope (Brock, 1986). Because of the marsh's proximity and connectivity to the Grand Calumet River, the area is considered extremely degraded, having been subjected to excessive levels of contaminants that its primary wetland functions may be significantly impaired. U.S. EPA (1988) found that the functions of absorbing excessive nutrients (nitrogen and phosphorus) and removing particulate matter thus reducing turbidity in this portion of the Grand Calumet River were important enough to designate Roxanna Pond area as a prior identified wetland unsuitable for filling.

Table 04. Bird Species Known From the Indiana Harbor, Indiana Harbor Ship Canal, Lake George Branch, and Grand Calumet River Area, including the ECI Site. This includes migrants, wintering species, and nesting species. (Adopted from U.S. FWS 1996b).

Double-crested cormorant	*Phalacrocorax auritus*
Horned grebe	*Podiceps auritus*
Pied-billed grebe	*Podilymbus podiceps*
White pelican	*Pelecanus erythrorhynchos*
Mute swan	*Cygnus olor*
Canada goose	*Branta canadensis*
Mallard*	*Anas platyrhynchos*
Blue-winged teal*	*A. discors*
Redhead	*Aythya americana*
Canvasback	*A. valisineria*
Greater scaup	*A. marila*
Lesser scaup	*A. affinis*
Ring-necked duck	*A. collaris*
Bufflehead	*Bucephala albeola*
Common goldeneye	*B. clangula*
White-winged scoter	*Melanitta deglandi*
Oldsquaw	*Clangula hyemalis*
Common merganser	*Mergus merganser*
Red-breasted merganser	*M. serrator*
Hooded merganser	*Lophodytes cucullatus*
Short-eared owl	*Asio flammeus*
Turkey vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
Sharp-shinned hawk	*Accipiter striatus*
Red-tailed hawk*	*Buteo jamaicensis*
Red-shouldered hawk	*B. lineatus*
Rough-legged hawk	*B. lagopus*
Broad-winged hawk	*B. platypterus*
Peregrine falcon*	*Falco peregrinus*
Kestrel*	*F. sparverius*
Ring-necked pheasant*	*Phasianus colchicus*
Common egret	*Casmerodius albus*
Great blue heron	*Ardea herodias*
Green-backed heron*	*Butorides virescens*
Little blue heron	*Florida caerulea*
Black-crowned night heron*	*Nycticorax nycticorax*
Least bittern*	*Ixobrychus exilis*
American coot*	*Fulica americana*
Common moorhen*	*Gallinula chloropus*
Sora	*Porzana carolina*
Black-bellied plover	*Pluvialis squatarola*
Killdeer*	*Charadrius vociferus*
Semipalmated plover	*C. semipalmatus*
Solitary sandpiper	*Tringa solitaria*

Greater yellowlegs	*T. melanoleuca*
Lesser yellowlegs	*T. flavipes*
American avocet	*Recurvirostra americana*
Spotted sandpiper	*Actitis macularia*
Hudsonian godwit	*Limosa haemastica*
Marbled godwit	*L. fedoa*
Western sandpiper	*Calidris mauri*
Least sandpiper	*C. minutilla*
White-rumped sandpiper	*C. fuscicollis*
Pectoral sandpiper	*C. melaanotos*
Dunlin	*C. alpina*
Stilt sandpiper	*C. himantopus*
Short-billed dowitcher	*Limnodromus griseus*
Long-billed dowitcher	*L. scolopaceus*
Common snipe	*Gallinago gallinago*
American woodcock*	*Scolopax minor*
Wilson's phalarope	*Phalaropus tricolor*
Red-necked phalarope	*P. lobatus*
Ring-billed gull*	*Larus delawarensis*
Herring gull*	*L. argentatus*
Caspian tern	*Hydroprogne caspia*
Black tern*	*Chlidonias niger*
Rock dove*	*Columba livia*
Mourning dove*	*Zenaidura macroura*
Nighthawk*	*Chordeiles minor*
Whip-poor-will	*Caprimulgus vociferus*
Chimney swift*	*Chaetura pelagica*
Belted kingfisher*	*Megaceryle alcyon*
Flicker*	*Colaptes auratus*
Red-headed woodpecker	*Malanerpes erythrocephalus*
Eastern kingbird*	*Tyrannus tyrannus*
Willow flycatcher*	*Empidonax traillii*
Barn swallow*	*Hirundo rustica*
Tree swallow*	*Iridoprocne bicolor*
Bank swallow*	*Riparia riparia*
Rough-winged swallow	*Stelgidopterix serripennis*
Blue jay*	*Cyanocitta cristata*
Crow*	*Corvus brachyrhynchos*
Black-capped chickadee*	*Parus atricapillus*
Tufted titmouse*	*P. bicolor*
Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia familiaris*
Marsh wren*	*Cistothorus palustris*
House wren*	*Trogolodytes aedon*
Brown thrasher*	*Toxostoma rufum*
Catbird*	*Dumetella carolinensis*
Mockingbird	*Mimus polyglottos*
Robin*	*Turdus migratorius*

Eastern bluebird	*Sialia sialis*
Hermit thrush	*Hylocichla guttata*
Swainson's thrush	*H. ustulata*
Golden-crowned kinglet	*Regulus satropa*
Ruby-crowned kinglet	*R. calendula*
Yellow warbler*	*Dendroica petechia*
Black-throated green warbler	*D. virens*
Yellow-rumped warbler	*D. coronata*
Yellowthroat*	*Geothlypis trichas*
Warbling vireo*	*Vireo gilvus*
White-eyed vireo	*V. griseus*
Red-eyed vireo*	*V. olivaceua*
Starling*	*Sturnus vulgaris*
House sparrow*	*Passer domesticus*
Eastern meadowlark*	*Sturnella magna*
Red-winged blackbird*	*Agelaius phoeniceus*
Yellow-headed blackbird*	*Xanthocephalus xanthocephalus*
Grackle*	*Quiscalus quiscula*
Brown-headed cowbird*	*Molothrus ater*
Northern oriole*	*Icterus galbula*
Indigo bunting*	*Passerina cyanea*
House finch*	*Carpodacus mexicanus*
Cardinal*	*Richmondena cardinalis*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
American goldfinch*	*Spinus tristis*
Rufous-sided towhee*	*Pipilo erythrophthalmus*
Junco	*Junco hyemalis*
Field sparrow*	*Spizella pusilla*
Chipping sparrow	*S. passerina*
White-throated sparrow	*Zonotrichia albicollis*
Song sparrow*	*Melospiza melodia*
Swamp sparrow*	*M. georgiana*

*Known to nest

Based on sightings reported in the Peregrine Falcon Journal (1990-1995), personal observations by U.S. FWS biologists, Brock (1986), and Sabuco (1994).

Table 05. Breeding Bird Atlas records for priority breeding blocks (west-central 1/6 of topographic map) in or near the Grand Calumet River Indiana Harbor Ship Canal Near Shore Lake Michigan Area of Concern.

Topo Map/County	Portage/Porter	Gary/Lake	Highland/Lake	Whiting/Lake
Atlas Block No.	**830**	**831**	**832**	**859**
Priority Block No.	**3**	**3**	**3**	**3**
SPECIES				
Pied-billed Grebe		1		
Green Heron	3	2		
Mute Swan				1
Canada Goose		2	1	2
Wood Duck	2	1	1	
Mallard	1	1	1	1
Blue-winged Teal			1	
Red-tailed Hawk	3	2		
American Kestrel		1		
Ring-necked Pheasant	2			
Northern Bobwhite	1			
Common Moorhen		1		
American Coot				2
Killdeer	2	1	1	1
Spotted Sandpiper		2		
Rock Dove	2	2	2	2
Mourning Dove	2	1	1	2
Eastern Screech-Owl		3		
Common Nighthawk	2	3		2
Chimeny Swift	2	3	3	2
Ruby-throated Hummingbird		3		
Belted Kingfisher	2		2	2
Red-headed Woodpecker	2	2	2	
Red-bellied Woodpecker	2			
Downy Woodpecker	2	1	1	1
Hairy Woodpecker	2	2		

Topo Map/County	Portage/Porter	Gary/Lake	Highland/Lake	Whiting/Lake
Atlas Block No.	830	831	832	859
Priority Block No.	3	3	3	3
SPECIES				
Northern Flicker	2	2	1	2
Eastern Wood-Pewee	2			
Alder Flycatcher				3
Willow Flycatcher	2	2		
Great Crested Flycatcher	2		2	2
Eastern Kingbird	2	1	1	
Purple Martin	3	1		1
Tree Swallow		1	3	1
N. Rough-winged Swallow		1		
Bank Swallow	3		1	
Barn Swallow	1	1	1	3
Blue Jay	1	1	2	1
American Crow	1	1		2
Black-capped Chickadee	2	3	1	
Tufted Titmouse	2	3		
White-breasted Nuthatch	2		2	
Carolina Wren	2			
House Wren	2	1	1	
Marsh Wren				2
Blue-gray Gnatcatcher			2	
Eastern Bluebird	1			
Veery	3			
Wood Thrush	2	2		
American Robin	1	1	1	1
Gray Catbird	2	2	1	2
Brown Thrasher	2			
Cedar Waxwing	2	2	2	
European Starling	1	1		1

Topo Map/County	Portage/Porter	Gary/Lake	Highland/Lake	Whiting/Lake
Atlas Block No.	**830**	**831**	**832**	**859**
Priority Block No.	**3**	**3**	**3**	**3**
SPECIES				
Yellow-throated Vireo		3		3
Warbling Vireo	3	2	2	3
Red-eyed Vireo	2	2	2	
Yellow Warbler	2	2		3
Chestnut-sided Warbler			3	
Prothonotary Warbler			3	
Common Yellowthroat	2	2	2	3
Scarlet Tanager	2	3		
Northern Cardinal	2	1	1	1
Rose-breasted Grosbeak	2	3		
Indigo Bunting	1	1	1	3
Rufous-sided Towhee	2	2		3
Chipping Sparrow	1	1	1	2
Field Sparrow	3		1	
Lark Sparrow		1		
Song Sparrow	2	1	1	2
Swamp Sparrow		1		
Red-winged Blackbird	2	1	2	1
Eastern Meadowlark	2	3		
Common Grackle	1	1	2	1
Brown-headed Cowbird	1	1	1	2
Orchard Oriole			2	
Northern Oriole	2	1	2	
House Finch	1	2		
American Goldfinch	2	1		1
House Sparrow	2	1	1	1

* Breeding Codes: (1) confirmed, (2) probable, (3) possible.

Table 06. Mammals reported from Indiana Dunes National Lakeshore (modified from Whitaker, et al., 1994).

Virginia opossum	*Didelphis virginiana*
Least shrew	*Cryptotis parva*
Masked shrew	*Sorex cinereus*
Northern short-tailed shrew	*Blarina brevicauda*
Eastern mole	*Scalopus aquaticus*
Little brown myotis	*Myotis lucifugus*
Eastern red bat	*Lasiurus borealis*
Silver-haired bat	*Lasionycteris noctivagans*
Big brown bat	*Eptesicus fuscus*
Eastern cottontail	*Sylvilagus floridanus*
Eastern chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*
Franklin's ground squirrel	*Spermophilus franklinii*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Eastern gray squirrel	*Sciurus carolinensis*
Eastern fox squirrel	*Sciurus niger*
Red squirrel	*Tamiasciurus hudsonicus*
Southern flying squirrel	*Glaucomys volans*
American beaver	*Castor canadensis*
White-footed mouse	*Peromyscus leucopus*
Prairie deer mouse	*Peromyscus maniculatus bairdii*
Norway rat	*Ratus norvegicus*
House mouse	*Mus musculus*
Prairie vole	*Microtus ochrogaster*
Meadow vole	*Microtus pennsylvanicus*
Woodland vole	*Microtus pinetorum*
Common muskrat	*Ondatra zibethicus*
Southern bog lemming	*Synaptomys cooperi*
Meadow jumping mouse	*Zapus hudsonius*
Red fox	*Vuples vulpes*
Common raccoon	*Procyon lotor*
Long-tailed weasel	*Mustela nivalis*
Mink	*Mustela vison*
American badger	*Taxidea taxus*
Striped skunk	*Mephitis mephitis*
White-tailed deer	*Odocoileus virginianus*

Table 07. Animals recorded in the Grand Calumet River, Indiana Ship Harbor Canal and Near Shore Lake Michigan Area of Concern that are listed as endangered, threatened or of special concern. Animals on watch lists have also been included. (Data from Indiana Department of Natural Resources)

MAMMALS		
Franklin's ground squirrel	*Spermophilus franklinii*	E*
Star-nosed mole	*Condylura cristata*	SC
Least weasel	*Mustela nivalis*	SC
BIRDS		
American bittern	*Botaurus lentiginosus*	E
Great egret	*Casmerodius albus*	E
Black-crowned night-heron	*Nycticorax nycticorax*	E
Yellow-crowned night-heron	*Nyctanassa violaceus*	E
Peregrine falcon	*Falco peregrinus*	E-F
King rail	*Rallus elegans*	E
Piping plover	*Charadrius melodus*	E-F
Black tern	*Chlidonias niger*	E
Least bittern	*Ixobrychus exilis*	SC
Red-shouldered hawk	*Buteo lineatus*	SC
Virginia rail	*Rallus limicola*	SC
Marsh wren	*Cistothorus palustris*	SC
Yellow-headed blackkbird	*Xanthocephalus xanthocephalus*	T?
Cooper's hawk	*Accipiter cooperii*	WL
Sedge wren	*Cistothorus platensis*	T
Brown creeper	*Certhia americana*	WL
Least flycatcher	*Empidonax minimus*	SC
Golden winged warbler	*vermivo chrysoptera*	*E*
REPTILES		
Spotted turtle	*Clemmys guttata*	T
Western smooth green snake	*Opheodrys vernalis*	T
Blanding's turtle	*Emydoidea blandingi*	SC
Western ribbon snake	*Thamnophis proximus*	SC
Eastern massasauga	*Sistrurus catenatus*	T
Slender glass lizard	*Ophisaurus attenuatus*	?
AMPHIBIANS		
Mudpuppy	*Necturus maculosus*	SC
Blue-spotted salamander	*Ambystoma laterale*	SC
Northern leopard frog	*Rana pipiens*	SC

Table 07. (Continued)

FISH		
Lake sturgeon	*Acipenser fulvescens*	E
Popeye shiner	*Notropis ariommus*	E
BUTTERFLIES		
Ottoe skipper	*Hesperia ottoe*	E
Karner blue	*Lycaeidus melissa samuelis*	E-F
Dusted skipper	*Atrytonopsis hianna*	E
Olympia marblewing	*Glaucopsyche lygdamus couperi*	E
Byssus (Bunchgrass) skipper	*Problema byssus*	SC
Columbine borer	*Papaipema leucostigma*	WL
Bracken borer moth	Papaipema pterisii	WL

* E = State Endangered; E-F = State/Federal Endangered; T = State Threatened; SC = Special Concern; WL = Watch List

IV. Surface Water in the Grand Calumet River and the Indiana Harbor Ship Canal

A. Water Quality Monitoring

According to the Indiana 305(b) Report 1992-93 (IDEM, 1994), the waters of the Grand Calumet River and the Indiana Harbor Ship Canal continue to have persistent water quality problems. The sampling data indicate that concentrations of cyanide and *E. coli* continue to be of concern throughout much of the system.

> Cyanide concentrations exceeded the acute criterion for this substance at three (3) of seven sampling stations from seventeen to thirty-three percent (17-33%) of the time. Two D.O. (dissolved oxygen) violations were found at the Grand Calumet River/Indiana Harbor Canal stations and a 1990 fish community sampling assessment indicates that D.O. levels may be of concern. Un-ionized ammonia criteria were not violated at any station at the acute level. The *E. coli* bacteriological criterion was exceeded up to eighty-six percent (86%) of the time at each of the monitoring stations.

Monitoring results for the period 1994-95 showed similar water quality violations for cyanide and *E. coli*. Un-ionized ammonia did not meet the chronic criteria in 28 percent of surface water samples collected (IDEM, 1996). The status of designated use support lists both the East and West branches of the Grand Calumet River, and the Indiana Harbor Ship Canal as nonsupporting for both aquatic life and recreational use. Probable causes include oil and grease, lead, PCB, pesticides, mercury, ammonia, and combined sewer overflows (IDEM, 1994 and IDEM, 1996). While problems in the Grand Calumet River have existed for many years, some past pollutant problems have been resolved, and the concentrations of many substances have been reduced even though water quality standards violations still occur. Water quality of Lake Michigan does vary (in the Indiana portion). Concentrations of substances in the near shore zone reflect the effects of wastewater and tributary contributions from the watershed and are nearly always higher near shore than in the "open water" lake samples (IDEM, 1996).

B. Sediment Monitoring and Characterization

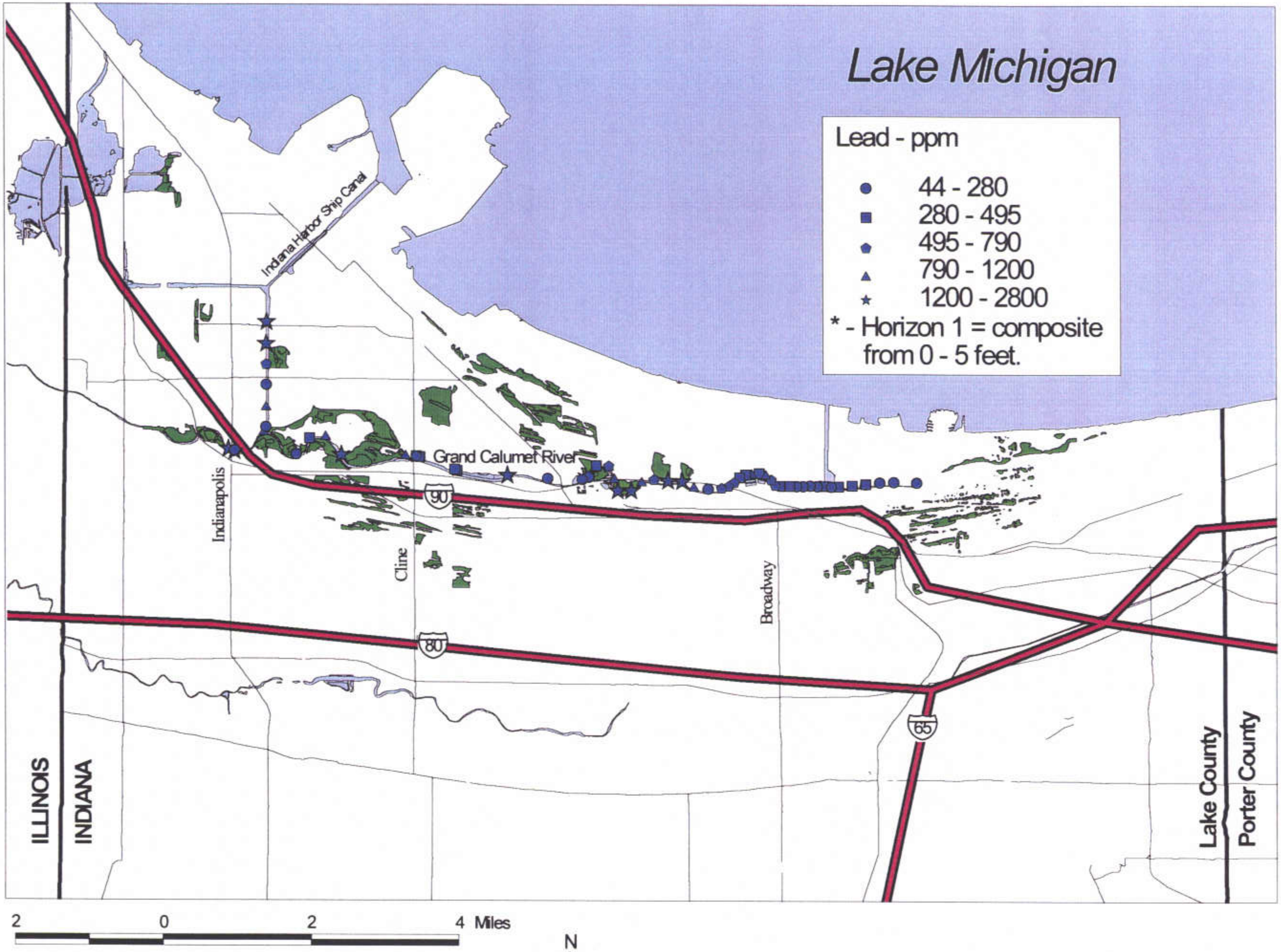
Sediment in the bottom of a river or lake provides a habitat for numerous aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into surface waters. In the aquatic environment, most man-made chemicals and waste materials, including toxic organic and inorganic chemicals, eventually accumulate in the sediment (Sobiech *et al.*, 1994). Mounting evidence of environmental degradation exists in areas where U.S. EPA Water Quality Criteria (WQC; Stephan *et al.,* 1985) are not exceeded, yet organisms in or near sediments are adversely affected (Chapman, 1989). Concentrations of contaminants in the sediment may be several orders of magnitude higher than in the overlying water; however, bulk sediment concentrations have not been strongly correlated to bioavailability (Burton, 1991). The biological viability of the Grand Calumet River and Indiana Harbor Ship Canal has been severely degraded due in part to numerous spills, municipal and industrial waste-water discharges, and combined sewer overflows (Sobiech *et al.,* 1994). These actions have caused a dramatic deterioration of the water quality and significantly impaired the sediments of this aquatic ecosystem.

Sediment characterization studies have detected a wide array of chemical compounds that include: conventional pollutants, metals, and organic chemicals such as PCBs. The concentration of any one of the following contaminants could cause adverse ecological effects. Characterization of Grand Calumet River and Indiana Harbor Ship Canal sediments, conducted by Hoke *et al.* (1993), analyzed for one hundred and four organic chemicals and detected sixty-three compounds. Concentrations of the various compounds present in the sediments varied greatly. Chemicals such as m-chlorophenol, 2,6-dichlorophenol, 2,4,6-trichlorophenol, 2,3,5,6-tetrachlorophenol, 3,4-dichloroaniline, 3,3-dichlorobenzidine, *p,p*'-DDD, tetrachloroethylene, 1,2,3-trichlorobenzene, 1,1,1-trichloroethane, di-*n*-butyl phthalate, 1-chloro-2-nitrobenzene, and 2,4-dinitrotoluene were generally present in low ug/kg (part per billion) range. Compounds exhibiting the greatest sediment concentrations were the various polycyclic aromatic hydrocarbons (PAHs), total polychlorinated biphenyls (PCBs, such as Aroclor 1248), *p,p*'-DDE, toxaphene, *p*-chlorotoluene, ethylbenzene, and *p*-dichlorobenzene. These compounds were generally present in the 2-20 mg/kg (ppm) range although several of the PAHs were present at concentrations as great as 100 mg/kg.

Detectable concentrations of most metals analyzed were present in all study sites' sediments. Iron, magnesium, and manganese were generally present in high mg/kg to low gm/kg (grams per kilogram) (or parts per thousand) concentrations in solid phase sediments. Of the metals of toxicological concern in aquatic systems, zinc, lead, and chromium were present at concentrations as great as 5.23, 3.94, and 1.22 gm/kg (or parts per thousand), respectively. Copper, nickel, and cadmium concentrations were generally below 500 mg/kg (or parts per million). Compounds detected at concentrations present have the potential of causing adverse ecological effects.

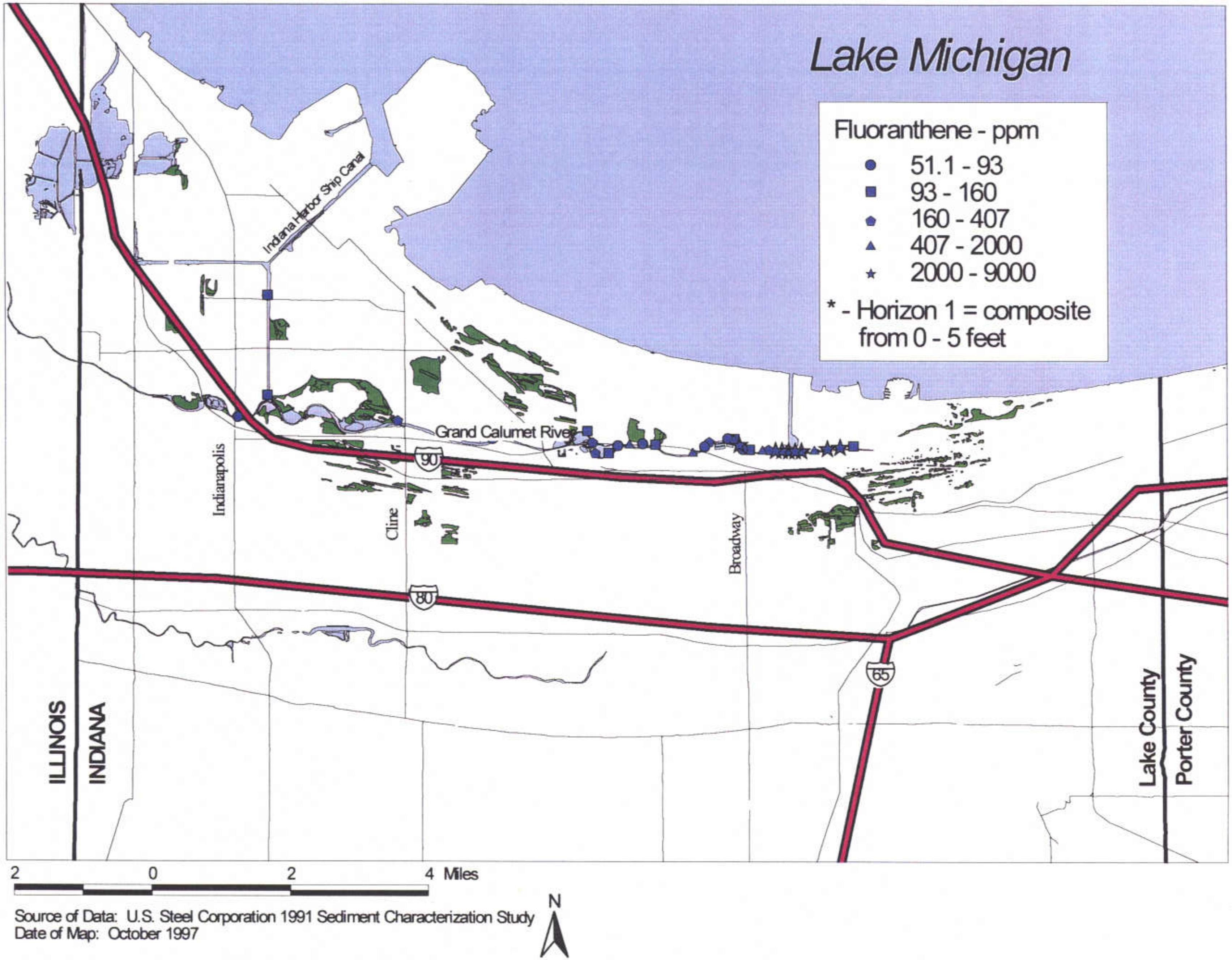
Results from the U.S. Steel Corporation 1991 Sediment Characterization Study showed similar results. A wide variety of organics and metals were detected. Due to the wide assortment of contaminants detected, five contaminants were selected from this study in an attempt to illustrate the level of contamination detected. These contaminants are displayed with their corresponding levels and spatial distributions (Figures i - v).

Figure i: Lead Horizon 1*



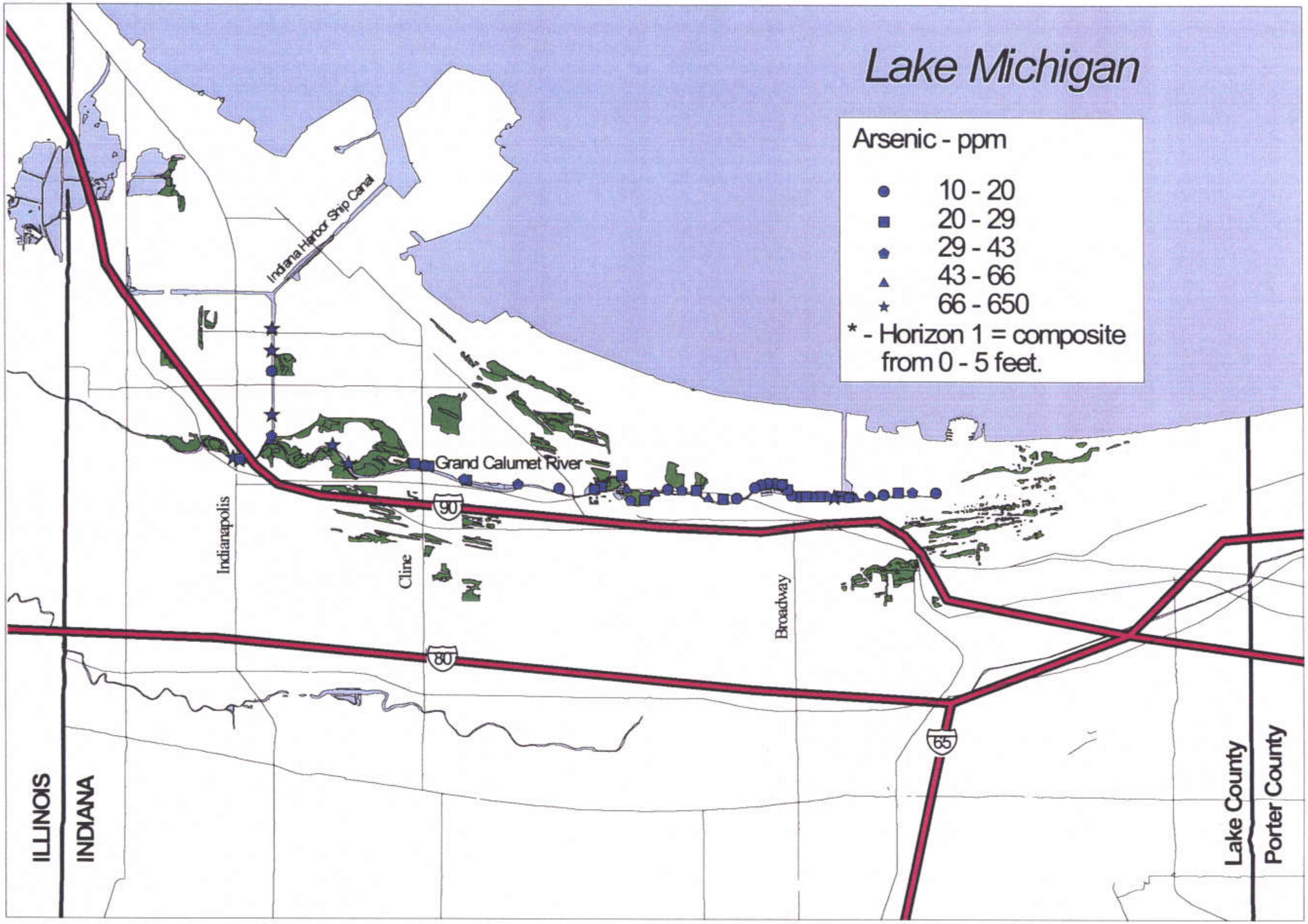
Source of Data: U.S. Steel Corporation 1991 Sediment Characterization Study
Map Date: October 1997

Figure ii: Flouranthene Horizon 1*



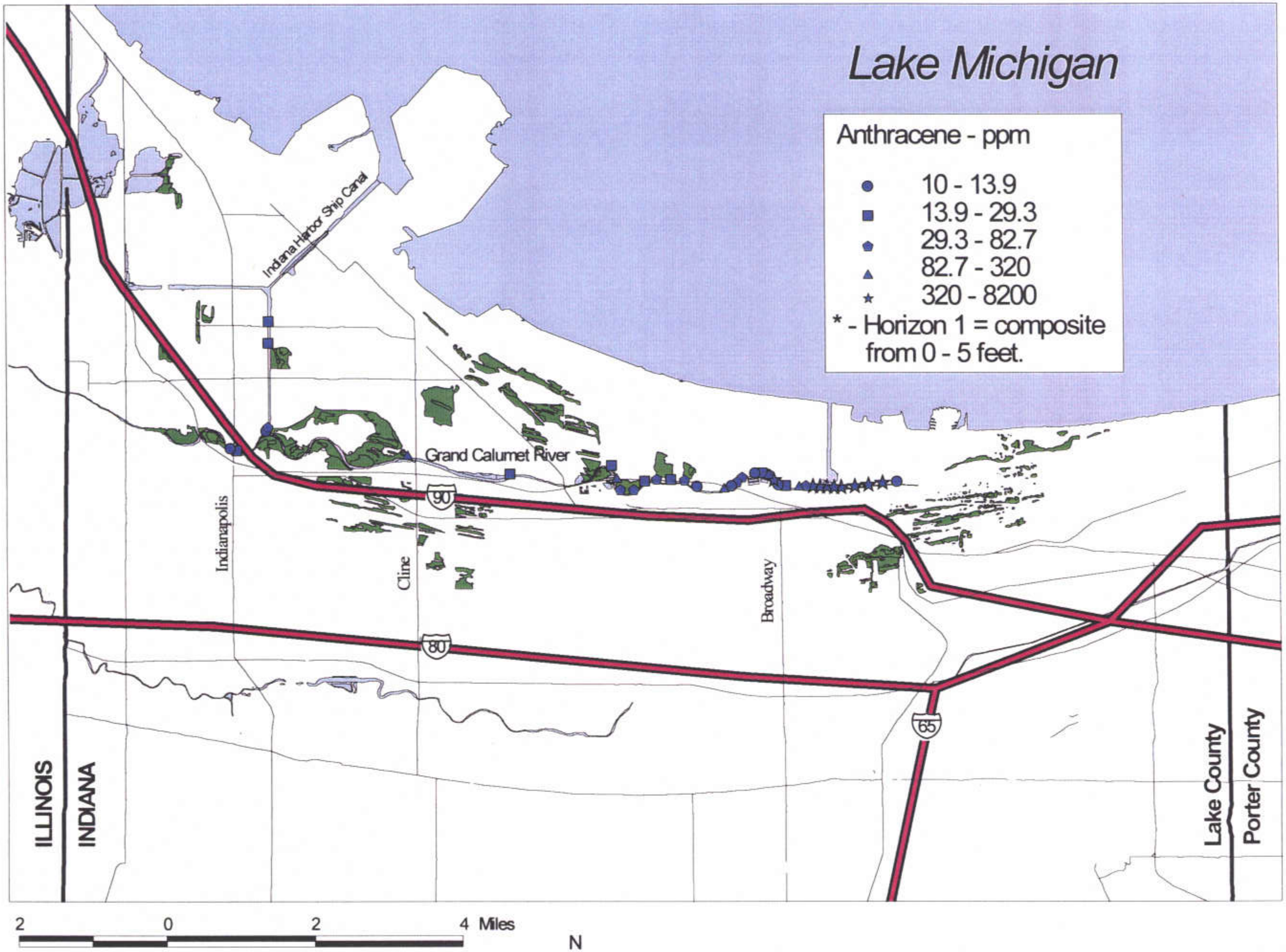
Source of Data: U.S. Steel Corporation 1991 Sediment Characterization Study
Date of Map: October 1997

Figure iii: Arsenic Horizon 1*



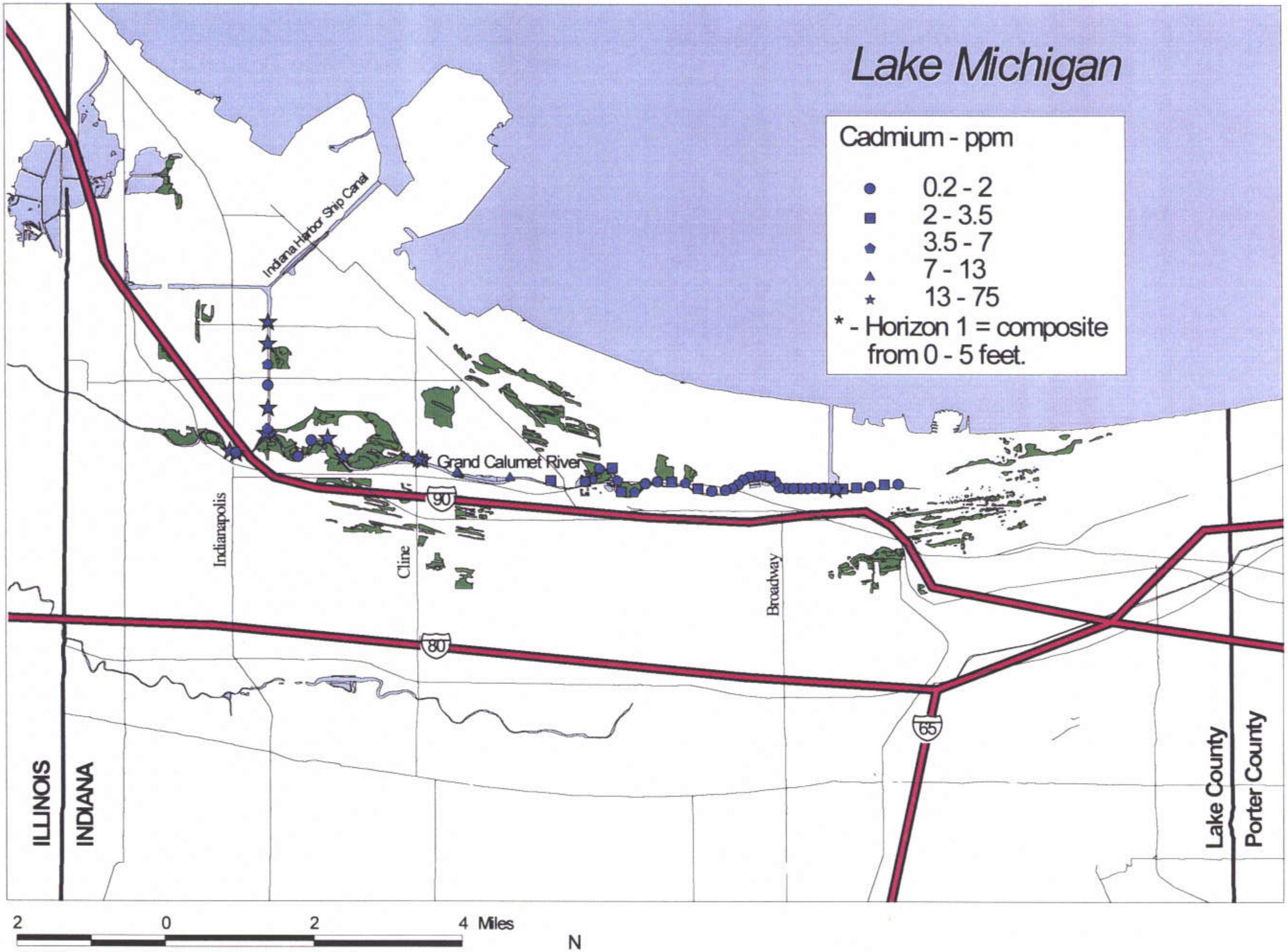
Source of Data: U.S. Steel Corporation 1991 Sediment Characterization Study
Map Date: October 1997

Figure iv: Anthracene Horizon 1*



Source of Data: U.S. Steel Corporation 1991 Sediment Characterization Study
Map Date: October 1997

Figure v: Cadmium Horizon 1*



Source of Data: U.S. Steel Corporation 1991 Sediment Characterization Study
Map Date: October 1997

The most recent sediment contaminant monitoring results (1994) on the Grand Calumet River and Indiana Harbor Ship Canal by IDEM Office of Water Management also exhibited a variety of PAHs, PCB as Aroclor 1248, and metals. Regular collections of surficial aquatic sediment from the channel have occurred at Bridge Street, Cline Avenue, Kennedy Avenue, Indianapolis Boulevard, and at Dickey Road on the Indiana Harbor Ship Canal. The PAHs of highest concentration in the surficial sediment samples were chrysene, pyrene, fluoranthene, phenanthrene, and benzo (*a*) pyrene. Metals of concern had the following concentration ranges (mg/kg dry weight):

	Low		High	State mean	95th percentile
cadmium	3.0	to	29.2	0.37	7.09
copper	105	to	879	20.2	120
lead	230	to	4350	24.1	197
mercury	0.220	to	12.4	0.057	0.34
nickel	1.7	to	418	13.2	64.7
zinc	1080	to	4860	84.0	460
arsenic	20.5	to	101	6.43	22.2
chromium	185	to	696	16.1	97.9

(Wente, 1994).

These concentration ranges are generally on the order of ten times higher than the mean sediment concentration for Indiana assuming no spatial variability with high ranges ranking well above the ninety-fifth percentile.

C. Sediment Toxicity Analysis

Sediment toxicity was also analyzed in the 1994 U.S. FWS study (Pre-Remedial Biological and Water Quality Assessment of the East Branch Grand Calumet River Gary, Indiana). Sediment toxicity is determined by exposing test organisms that are commonly found in sediments (i.e. *Hyalella azteca*, *Chiromonus riparius* and *Chironomus tentans*) to sediment collected from the test area indicating whether pollutants exist in toxic amounts or toxic conditions exist. Sediment samples for toxicity testing were collected from various locations along the East Branch of the Grand Calumet River. Additionally, sediments were collected from Long Lake, Indiana Dunes National Lakeshore (IDNL), to serve as a reference location. Results from the sediment toxicity testing revealed that statistically significant *H. azteca* mortality occurred in all East Branch sediments, relative to the reference sample collected from IDNL (Table 08).

Percent mortality observed for each sediment sample at the termination of the 10-day static renewal acute toxicity tests with Hyalella azteca.

Sediment I.D.	Percent Mortality				
	Rep A	Rep B	Rep C	Rep D	Rep E
Test Dates: July 6-16, 1994					
GCR-28	95	100	100	100	100
GCR-32	100	100	100	100	100
GCR-34	80	85	80	85	90
GCR-35	100	100	100	100	100
GCR-36	100	100	100	100	100
IDNL	0	5	0	10	0
Test Dates: July 8-18, 1994					
GCR-06	100	100	100	100	100
GCR-11	65	75	90	60	72
GCR-18	100	100	80	100	100
GCR-21	45	50	50	45	70
GCR-24	100	100	100	100	100
IDNL	0	0	0	5	0

a - Statistically different as compared to the reference control (IDNL. test dates July 6-16, 1994).
b - Statistically different as compared to the reference control (IDNL. test dates July 8-18, 1994).

(reproduced from Springborn Laboratories. Inc. 1994. Toxicity evaluation of the sediment collected from the East Branch of the Grand Calumet River in Gary, Indiana.)

Table 08.

Sediment toxicity was also confirmed from a study conducted with *Chironomus tentans*, (Hoke *et al*., 1993), which analyzed sediment collected from ten locations along the Grand Calumet River [spanning from the East Branch to the Indiana/Illinois border] and three locations in the Indiana Harbor Ship Canal. In this study, toxicity is demonstrated by an inhibition in weight gain of the test species (*C. tentans*) exposed to the sediment. The results of this study demonstrated an average inhibition in growth of 91.9 percent. Compared to a control, this indicates a significant increase in toxicity.

D. Biological Community Monitoring

Numerous studies have characterized the quality (or biological integrity) of the fish communities as well as aquatic insect communities of the Grand Calumet River and Indiana Harbor Ship Canal (U.S. EPA, 1985; Simon *et al.*, 1988; Bright, 1988; Sobiech *et al.*, 1994). Fish and insect community monitoring gives a collective measurement of all stresses imposed on the ecological integrity of the system. The biological community imprints into its compositional, structural, and functional organization all stresses, not only reflecting the stresses at the immediate site sampled but the collective ecological stresses of all aspects of the system upstream. An Index of Biotic Integrity (IBI) is used to assess the ecological integrity of the fish community. It is based on scored attributes of the community including its compositional, structural, and functional makeup. The IBI is compared to a calibrated reference on best attainable conditions. Changes in the biological community will be reflected in the indicators and monitoring strategies developed. See Chapter Seven.

IDEM, along with U.S. EPA Region V, conducted fish community surveys during the mid 1980s. Fish sampling locations for Grand Calumet River and Indiana Harbor Ship Canal consisted of five hundred meter river reaches sampled along the near-shore margins of both banks. All fish netted were identified to species, measured for length range, weighed, and enumerated in the field. Simon *et al.* (1988) showed that water quality in the Grand Calumet River had improved from 1985 to 1988. Forty-three fish collections were made in the basin from 1985 to 1988, resulting in a cumulative total of twenty-one fish species documented. The east branch and the Indiana Harbor Ship Canal had IBI ratings of "very poor" to "poor" during the period. The IBI ratings for the west branch were "very poor" with no fish being collected in same areas during 1987 and 1988. A "very poor" rating in an IBI describes the community as having few fish present, mostly introduced or tolerant forms; hybrids common; diseases, parasites, fin damage, and other anomalies regular. A "poor" rating describes the community as dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present (Simon *et al.*, 1991; Sobiech *et al.*, 1994). The high proportion of omnivorous fish in the Grand Calumet River is symptomatic of declining environmental quality (Simon, 1991).

Golden shiner, goldfish, and common carp generally dominate the fish community of the Grand Calumet River and Indiana Harbor Ship Canal making up over 80 percent of the community (Simon *et al.*, 1988). All three of these species are considered very tolerant of stressed conditions (Simon, 1991). Goldfish and common carp are not species native to the river. The overall quality of the Grand Calumet River is "very poor" even though a high proportion of cattail marsh wetland lies along the basin margins (Simon, 1991). Simon (1991) states that:

> Overall, habitat is not the limiting factor in the improvement of this basin since enough refuges exist

to facilitate the colonization of impacted areas after the perturbations have been removed. The high degree of industrialization along the River's banks is the principal cause of toxic influence impacting the aquatic community.

The most recent fish community study, by Sobiech *et al.* (1994) focused on the East Branch of the Grand Calumet River. In this study, all sites sampled had an IBI rating of "very poor." Again a high proportion of omnivorous fish were observed. There was also a lack of simple lithophilic spawners demonstrating the absence of clean gravel or cobble substrate necessary for reproduction. Hybrids were common and DELT (deformities, eroded fins, lesions, and tumors) anomalies were frequent (Sobiech *et al.*, 1994). Simon (1991) observed DELT anomalies from 3.4 to 12.5 percent of the total fish community. Normal DELT anomaly occurrence would be expected to be no more than 1-2 percent of the community.

IDEM has conducted biennial sampling for aquatic macroinvertebrates in the Indiana Harbor Ship Canal at the Dickey Road bridge for a number of years. IDEM also conducted several studies on the Grand Calumet River in the mid-to-late 1980s. Aquatic macroinvertebrates are sampled using artificial substrate samplers suspended into the water column from a bridge (Fullner, R.S., 1971). The sampler is retrieved after six to eight weeks and all organisms preserved. The insects, snails, worms, etc. are then identified, enumerated, and the community integrity assessed. Bright evaluated collections from the east and west branches of the Grand Calumet River, Indiana Harbor Ship Canal, and the Lake George Canal. "No intolerant species were present at any of the sites." However, he noted that the presence of many facultative organisms (esp. dragonflies, certain midges, and snails) indicated that severe oxygen depletions do not occur, but that the benthic fauna were stressed by toxic chemicals. Bright also noted the absence or rarity of groups generally tolerant of mild organic pollution that are quite sensitive to toxic chemicals. Bright also saw an association between the amounts of cyanide and PAHs (polycyclic aromatic hydrocarbons) in the sediments and the amount of biological community depression. The most biologically depressed site in this study was at Bridge Street in the East Branch.

The study by Sobiech *et al.* (1994), also included the assessment of aquatic macroinvertebrate communities using artificial substrate samplers. They used an Invertebrate Community Index (ICI) score which is similar to an IBI and is based on observed attributes of the macroinvertebrate community (Ohio EPA, 1989). A Family Biotic Index (FBI; Hilsenhoff, 1988), which provides a measure of the effects of organic degradation on an invertebrate community based on the pollution tolerance of the invertebrates collected, was also calculated for each sampling location.

The Sobiech *et al.* (1994) study concluded that the overall invertebrate taxa composition of the East Branch was poor. Low numbers of individuals, low organism density, and low taxa diversity were observed at all sites during the survey. No sensitive taxon of invertebrates were collected from the East Branch. The East Branch's invertebrate community was dominated by tolerant individuals (95.5 percent). The FBI score for the sites reflects the presence of fairly poor to very poor pollution-tolerant invertebrate communities and indicate those pollutional degree ranges from substantial to severe in the East Branch. The poor taxa composition of the East Branch is reflective of the degraded environmental conditions. Degraded environmental conditions resulting from continual toxic loading to the East Branch have adversely affected its invertebrate trophic composition.

Additionally, the Assessment and Remediation of Contaminated Sediments (ARCS) Program conducted a study of the Indiana Harbor Ship Canal. The results from this indicated a very stunted benthic invertebrate community. The invertebrate community, dominated by the Oligochaeta family Tubificidae (worms), is indicative of a benthic invertebrate community subjected to heavy organic pollution (Brinkhurst *et al.*, 1972; Brinkhurst and Cook, 1974; Cook and Johnson, 1974; Burt *et al.*, 1991). All of the Tubificidae genera present in the Indiana Harbor are known to be very tolerant of organic pollutants (Kennedy, 1965; Brinkhurst *et al.*, 1972). *Limnodrilus hoffmeisteri*, one of the most pollution tolerant Oligochaeta species, was the most abundant species at all stations sampled (ARCS, 1993).

E. Fish Tissue (and other biological matrices) Monitoring

Fish tissue monitoring is a widely used method of monitoring and assessing environmental contaminants and their bioavailability. It is known that concentrations of some contaminants may be greater in tissues than in water because of bioconcentration, bioaccumulation, and/or biomagnification. Tissue contaminant monitoring is a tool that measures contaminants that can not be otherwise measured in water or air. Tissue contaminant monitoring, when part of an integrated multimedia monitoring program, gives insight into exposure levels and allows IDEM to better develop its understanding into the complexities of contaminant distribution, fate, and effects.

The Biological Studies Section of the Office of Water Management at IDEM has been collecting fish tissue from the Grand Calumet River and Indiana Harbor Ship Canal since 1986. The IDEM collected fish tissue from both the Grand Calumet River and Indiana Harbor Ship Canal prior to 1986. The most recent fish tissue contaminant results are from 1994. Lake Michigan open waters fish are also regularly collected and analyzed for contaminants. Both salmonid and non-salmonid Lake Michigan samples are analyzed. The Lake Michigan samples are collected by IDNR's Division of Fish and Wildlife personnel, and processed by IDEM Biological Studies personnel and analyzed by a contract laboratory. Some samples are sent to the U.S. Food and Drug Administration Lab in Minneapolis, Minnesota for analysis. All resulting data (to various degrees) are used to support the issuance of fish consumption advisories for both the Grand Calumet River and Indiana Harbor Ship Canal and lakewide interstate fish consumption advisories.

Of the fish tissue samples analyzed from the Grand Calumet River and Indiana Harbor Ship Canal in 1994, 95 percent had total PCB concentrations that exceeded 2.0 parts per million (ppm). In fact common carp total PCB levels averaged 10.3 ppm on a whole fish basis ranging from 0.8 to 27 ppm. All fish tissue samples collected from four locations in the Grand Calumet River showed a continued high level of contamination (IDEM, 1994; IDEM, 1996). Historically, most samples analyzed by IDEM have had total PCB concentrations in excess of 2.0 ppm. Contaminant analyses in crayfish as well as snapping turtle tissue have historically found PCB at levels ranging from 0.13-1.2 ppm (IDEM, unpublished data. However, this data has undergone quality assurance and quality control and is public data). The Grand Calumet River and Indiana Harbor Ship Canal has long been known for its PCB contaminated sediments.

The Grand Calumet River and Indiana Harbor Ship Canal fish still rank as the most contaminated fish in the state of Indiana. More kinds of contaminants are detected in Grand Calumet River and Indiana Harbor Ship Canal fish tissue than anywhere else in the state. Other contaminants of concern detected include the organochlorine-based pesticides aldrin, total DDT, chlordane, lindane, dieldrin, and hexachlorobenzene. A number of polycyclic aromatic hydrocarbons including 1-methyl naphthalene, 2-methyl naphthalene, acenaphthene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, and indeno (1,2,3-c,d) pyrene, are detected in fish tissue (IDEM unpublished data). Other semivolatile and volatile organic compounds detected in fish tissue samples have been benzene, dibenzofuran, tetrachloroethylene, trichloroethylene, di-n-butylphthalate, 1,1,1-trichloroethane, and trichloromethane.

F. Fish Consumption Advisory

In 1995 a risk-based approach was adopted by Indiana State Department of Health (ISDH) for evaluating PCB contamination in fish tissue. This approach was based on the protocols developed by the Great Lakes Sport Fish Consumption Advisory Task Force (Anderson *et al.*, 1993). In 1986 this Task Force was created and ultimately charged with developing a uniform sport fish consumption advisory protocol applicable to all Great Lakes and their immediate tributaries. The advisory goals were to: 1) maintain the health benefit of fish consumption; 2) minimize the potential for angler toxic chemical exposure; 3) use credible and understandable science; and 4) present the information in a manner conducive to maximal voluntary compliance.

The Task Force spent considerable time reviewing and discussing the risk of adverse health effects from consumption of contaminated sport fish. They chose to focus initial advisory protocol on PCB, the chemical contaminant most frequently encountered in Great Lakes fish which necessitated a fish consumption advisory. Their advisory approach utilizes a weight-of-evidence derived individual health protection value (HPV) of 0.05ug/kg/day for PCB residue ingested from fish tissue. The HPV is intended to encompass acceptable reproductive and developmental risks as well as cancer. Mercury contamination in fish tissue has also been evaluated using a similar type reference dose value (RDV) to encompass acceptable reproductive and developmental risks (ISDH *et al.*, 1996). Mercury is detected ubiquitously in fish tissue samples from Indiana waters. Mercury based fish consumption advisories using this new approach were included in the 1996 Indiana Fish Consumption Advisory.

The fish consumption advisory for Lake Michigan and its immediate tributaries is the result of effort from all of the Great Lakes states for a consistent and uniform fish consumption advisory as well as additional data collected by IDEM. The Indiana Lake Michigan advisory extends for two hundred and forty-one square miles which is the southern most waters of the lake. The current fish consumption advisory for Lake Michigan and its tributaries is included in Table 09.

Table 09. Fish Consumption Advisory for Lake Michigan and Tributaries (ISDH *et al.*, 1997).

Location	Species	Fish size	Group
Grand Calumet River and Indiana Harbor Ship Canal in Lake County	**All**	**All**	**5*@**
Lake County	**Goldfish**	**4+**	**5***
	Golden Shiner	**3-6**	**5***
Lake, LaPorte, & Porter counties	Black Crappie	7-8"	3*
		8+"	4*
	Brook Trout	All	3*
	Brown Trout	up to 18"	3*
		18-27"	4*
		27+"	5*
	Common Carp	**All**	**5*@**
	Catfish	**All**	**5***
	Chinook Salmon	up to 26"	3*
		26"+	4*
	Coho Salmon	17-28"	3*
		28"+	4*
	Lake Trout	up to 21"	3*
		21-26"	4*
		26"+	**5***
	Largemouth Bass	4-7"	3*
		7+"	4*
	Longnose Sucker	14-23"	4*@
		23"+	**5***
	Northern Pike	10-14"	3*
		14+"	4*
	Pink Salmon	All	3*
	Rainbow Trout	up to 22"	3*
		22"+	4*
	Walleye	17-26"	3*
		26"+	4*
	Whitefish	up to 23"	3*
		23"+	4*
	White Sucker	14-23"	3*
		23"+	4*

* = Advisory driven by PCB contamination.; @= Advisory driven also by mercury contamination.

The new advisory approach divides restrictions into five consumption advisory groupings: Group 1- unrestricted consumption (one meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15), Group 2- one meal per week (**one meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15**), Group 3- one meal per month (**women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat**), Group 4-one meal per two months (**women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15 do not eat**), Group **5-NO CONSUMPTION (DO NOT EAT).** It is very important that pregnant women, nursing mothers, women who may become pregnant in the next several years, and all children under the age of 15 follow the recommendations in this advisory. Spacing fish meals out for the recommended groupings prevents the contaminants from building up to harmful levels in the body.

V. Ground Water Flows and Data

The Area of Concern is characterized by a complex and shallow ground water flow that is intrinsically connected to the surface water. Contaminants can enter the ground water through soil and surface water interactions with the ground water. The uppermost bedrock area has been disrupted by numerous excavations for water reclamation and storm drainage tunnels. Based on ground water data analysis, small amounts of contamination detected in the uppermost bedrock aquifer could be attributed to leakage from surface or shallow ground water from improperly sealed wells or borings and not due to transport through geologic material (Kay *et al.*, 1996).

A study done by the USGS in 1988-89 (Fenelon and Watson, 1993) described the ground water quality as being poorest at the steel and petrochemical facilities, moderate near light industrial and commercial areas, and best in residential and park areas. One study estimated that ground water may contribute to more than ten percent of the total chemical load of ammonia, chromium, and cyanide to the Grand Calumet River (Kay *et al.*, 1996). For a more complete discussion of ground water quality in the Area of Concern, see appendix A of the Sediment Cleanup and Restoration Alternatives Project, 1997.

The disposal of large quantities of municipal and industrial wastes affects ground water quality at several industrial and waste disposal sites. This decreases the viability of the lakes and wetlands. In addition, crushed and hot poured slag has also been used as fill to create large areas of "made" land along the shores of Lake Michigan, Wolf Lake, and Lake George (Kay *et al.*, 1996). A study of the location and effects of the slag and other anthropogenic fill sites in the Area of Concern has been made by the USGS and U.S. EPA. These two agencies released this document entitled, "Characterization of Fill Deposits in the Calumet Region of Northwest Indiana and Northeast Illinois".

Geotechnical and environmental investigations at specific industrial and waste disposal sites have been completed. Results indicate environmental problems at several sites, many of which are adjacent. These site-specific investigations generally provide a detailed understanding of the geohydrology at a specific site, but not of the hydrogeologic relation between adjacent sites and between a site and the area as a whole (Kay *et al.*, 1996).

VI. Air Quality

The relationship between air emissions and impaired uses is not clearly established because air quality has historically not been evaluated using biological indicators but rather measurements of ambient air concentrations of pollutants. Ambient air monitoring data indicate Lake and Porter counties have the most severely polluted air in Indiana. While the relationship between air emissions and the impaired uses is not clearly established, many pollutants affecting the Area of Concern, especially bioaccumulative heavy metals such as mercury, originate from air emissions. Also, because air pollutants can be transported over long-distances, a significant portion of the air quality impact on this area may originate outside the Area of Concern.

IDEM does not currently use biomonitoring to assess the effects of air pollutants on biological organisms. However, certain plant and animal species are highly susceptible to pollutants introduced to the ecosystem through air emissions. Biomonitoring is recognized as a possible method by which to better assess the effects of air deposition in the Area of Concern.

The Wisconsin Department of Natural Resources has conducted studies on the effects of tropospheric ozone on the growth of Trembling Aspen (Populus tremoloides) and has found it to be an excellent bioindicator. Aspen trees in areas with high ambient ozone levels grew more slowly than trees in areas with lower ozone levels. Milkweed is another plant commonly used as a bioindicator. Studies in Wisconsin indicate an increase in visible foliar injury (stems and leaves) to milkweed plants in areas with higher ozone levels.

Lichens have the capacity to accumulate mercury in their tissues up to several thousand times ambient mercury levels. Because of that capability, they are another type of organism that serve as an ideal bioindicator. Wisconsin has conducted several lichen distribution studies since the early 1990s.

Great Lakes studies cited in Stage I have found deformities in migratory birds. The Area of Concern has many migratory species, although it is not known if these birds were contaminated in this area. Additionally, wildlife has greatly diminished during this century. The U.S. FWS plans to conduct more research on the subject of wildlife in the Area of Concern in the near future.

VII. Conclusion

The ecological resources of the area include eighteen natural community types, over seven hundred species of plants, and over two hundred species of birds. Seven of the community types, eighty-five of the plant species and eighteen of the nesting bird species are globally or state significant. Important natural processes which contributed to the development of the region's diversity have been altered by human development. Ecological succession and hydrologic interconnections have been disrupted by stressors such as habitat fragmentation, fire suppression, hydrologic modification, exotic species, shoreline alteration and environmental contamination. As a result of these stressors, critical habitat areas exist in varying states of degradation, from minimally disturbed to severely degraded. Some of these critical habitat areas include the Miller Woods and Dunes area, the Clark and Pine East preserve, the DuPont Dune and Swale area, the Gary Airport Sedge Meadow area, and Roxanna Marsh.

Water quality in the Grand Calumet River and Indiana Harbor Ship Canal system continues to be of concern. Concentrations of many contaminants in the water system have been reduced, however there are still water quality violations. Cyanide, unionized ammonia, and *E. coli.* levels are most frequently found to exceed water quality standards. Other water quality problems include oil and grease, lead, PCBs, pesticides, and mercury. Contaminated sediments throughout the Grand Calumet River and Indiana Harbor Ship Canal system are significant contributors to the degradation of both water quality and aquatic habitat. Sediments are heavily contaminated with organic chemicals including pesticides, PAHs, PCBs and with heavy metals. Tests have shown these sediments to be toxic to aquatic organisms. Ground water in the area is also contaminated. Highest contamination levels are found in the metal and petroleum industrial areas. Because ground and surface water in the Area of Concern are hydrologically linked, ground water contamination and surface water quality problems are closely related. Further, air quality in the Area of Concern contributes to water quality problems. Some bioaccumulative pollutants, such as mercury, are primarily delivered to water through air deposition.

Aquatic species and macroinvertebrate communities in the system show low biodiversity. Species composition is typical of degraded environmental conditions with only pollution tolerant species present. Species which are present have multiple indications of exposure to contaminants, including higher incidence of disease and low growth rates. Studies indicate that toxic contamination, rather than habitat loss, is most likely the limiting factor contributing to these degraded communities. Many of the contaminants prevalent in the system are bioaccumulating. The high concentrations of toxic chemicals such as PCBs and mercury in fish tissues have resulted in IDNR recommendations that no fish from the Grand Calumet River and Indiana Harbor Ship Canal system areis safe for human consumption.

Environmental conditions in the Area of Concern exist in a wide range of extremes. There are multiple heavily contaminated National Priorities List sites side by side with natural areas of significant biological diversity. The Area of Concern contains ecological resources of global significance which are threatened by the concurrent environmental degradation. Water quality fails to meet its designated standards and is a problem which is contributed to by contaminated sediments, contaminated groundwater, and air deposition. Diverse terrestrial and wetland communities contrast with degraded aquatic communities. Fish able to survive in the system are so heavily contaminated that they are unfit for human consumption.

The significant amount of stress in the Area of Concern has caused much of the degradation of the ecosystem, resulting in the loss of habitat, increased sedimentation, lack of or excessive nutrient loadings, etc. The stress can occur from either biological, physical, or chemical factors. The six leading contributors to the high level of stress are almost all derived from human activity.

Contamination is related to all fourteen of the beneficial uses of the Area of Concern. It seriously alters fish and wildlife populations, drinking water standards, aesthetics, deformities, agricultural and industrial work, etc. Contamination contains a variety of factors which affect the environment. Contaminated sediment from municipal and industrial point discharge, combined sewer overflow, and urban runoff all contribute to the decreasing efficiency of the ecosystem. Also, non-point source pollution, land development, erosion, runoff, and air emissions (directed at the National Ambient Air Quality Standards ---NAAQS) limit the beneficial uses in the Area of Concern. Other major stressors include fragmentation and loss of physical habitat, altered hydrology, shoreline alterations, introduction of exotic species, and fire suppression. All of these inducers of stress add to the reduction of the fourteen beneficial uses and the increased degradation of the environment.