Dunes Creek Watershed Management Plan

Porter County, Indiana

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Prepared by:
Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Phone 219-879-3937
Fax 219-872-4875
www.savedunes.org

Funding from the Indiana Department of Environmental Management was used to develop this plan.

Executive Summary

The Dunes Creek Watershed Management Plan serves as a framework for achieving the following vision: *A healthy Dunes Creek watershed ecosystem that supports species diversity, protects Lake Michigan water quality, and improves the quality of life in Porter County, while maintaining the important social, economic, and recreational uses of the area.*

High levels of *Escherichia coli* (*E. coli*) in the waters of the creek and surrounding its confluence with Lake Michigan are the primary watershed impairments affecting quality of life in Porter County. The *E. coli* bacteria are used to indicate fecal contamination and the potential presence of other pathogens. Lake Michigan beaches are tested regularly to determine the levels of *E. coli* present. When the amount of *E. coli* exceeds the state standard, beaches must be closed to protect public health. Such closures, which occur regularly at the Indiana Dunes State Park, substantially limit resident and visitor recreation opportunities and adversely affect economic activity in Porter County. This plan addresses the elimination or reduction of the Dunes Creek *E. coli* water quality problem, which will reduce beach closures at the Indiana Dunes State Park and contribute to an improved quality of life for Porter County residents and visitors.

The Dunes Creek Steering Committee includes representatives from the Indiana Dunes National Lakeshore, Indiana Department of Natural Resources, Mittal (formerly International Steel Group), United States Geological Survey, Northwestern Indiana Regional Planning Commission, U.S. Fish and Wildlife Service, and many other entities. The plan was developed by the Steering Committee with regular input from the public and support from Save the Dunes Conservation Fund's watershed coordinator, Christine Livingston.

This plan addresses nonpoint sources of pollution by documenting current water quality and biological integrity and making recommendations for improving water quality. In addition to covering pollution prevention and remediation, the recommendations include restoration activities.

To reduce the identified stressors in the Dunes Creek watershed and address other concerns identified by the Steering Committee and stakeholders, the Steering Committee developed the following goals.

Goal 1: Reduce nutrient and sediment by 20% by 2016.
Goal 2: Reduce pathogen concentrations to meet the state standard by 2016.
Goal 3: Improve stakeholder and public involvement.
Goal 4: Improve biotic communities by 2016 so that they are partially supporting.
Goal 5: Reduce TDS and chloride concentrations to meet Indiana State Standard.

Copies of the Dunes Creek Watershed Management Plan were provided to the distribution list (Appendix A). If you would like a copy of the plan it can be downloaded from www.savedunes.org. For additional information, contact Save the Dunes Conservation Fund at 219-879-3564, cll@savedunes.org, 444 Barker Road, Michigan City, IN 46360.

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1.0 Introduction

The United States has more than 3.5 million miles of rivers and streams that, along with closely associated flood plain and upland areas, comprise corridors of great social, cultural, and environmental value. Increases in human population and industrial, commercial, and residential development place heavy demands on wetlands, streams, rivers, and lakes. These demands result in degradation of water quality, loss of habitat for fish and wildlife, and decreased recreational and aesthetic value.

Watershed management plans are an effective way to manage land use, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land. A watershed is defined as the area of land that drains to a specific wetland, stream, river, or lake. Every body of water has its own watershed that can also include subwatersheds. The boundary of a watershed is defined by the highest elevations surrounding the water body.

In recent years, local, state, and federal agencies, as well as many private organizations and individuals have focused tremendous effort on restoring water quality, floodwater functions, biological integrity, and recreational benefits to rivers and streams within the Calumet Region, including the Dunes Creek watershed. These efforts include work done by Indiana Dunes National Lakeshore, United States Geological Survey, Save the Dunes Council and Conservation Fund, Northwestern Indiana Regional Planning Commission, and many others. The Dunes Creek Watershed Management Plan is the framework for the restoration and management efforts within the Dunes Creek watershed and is consistent with the overall effort underway in the Calumet Region. This plan furthers the overall effort by identifying the priorities as well as restoration and management needs.

In 2003 Save the Dunes Conservation Fund (SDCF) was contracted by Indiana Department of Environmental Management (IDEM) to develop a watershed management plan to address the non-point source pollution problem in Dunes Creek. In 2002 and 2004 IDEM identified Dunes Creek as impaired for biotic communities and excessive *E. coli* concentrations. Using the IDEM designation as a starting point, SDCF created a steering committee to guide the development of a watershed management plan that addresses the issues identified by IDEM and those of watershed residents and stakeholders.

The Dunes Creek Watershed Management Plan is a framework to achieve the vision developed by public participants and Steering Committee members: *A healthy Dunes Creek watershed ecosystem that supports species diversity, protects Lake Michigan water quality, and improves the quality of life in Porter County while maintaining the important social, economic, and recreational uses of the area.*

Steering Committee members and public meeting participants developed the following mission statement: *The Dunes Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershe, and will develop strategies that conserve, protect, and enhance the natural resources of the watershed.*

1.1 Watershed Partnerships

The Steering Committee (Steering Committee/distribution list located in Appendix A) met bimonthly to guide development of the plan, coordinate related efforts, and facilitate public participation. The Steering Committee included representatives from the Indiana Dunes National Lakeshore, Indiana Department of Natural Resources, Indiana Department of Environmental Management, Mittal Steel, United States Geological Survey, Northwestern Indiana Regional Planning Commission, U.S. Fish and Wildlife Service, Coffee Creek Watershed Conservancy, US Environmental Protection Agency Region 5, Save the Dunes Council, and other interested individuals and organizations. These organizations and individuals came together to further the overall mutual goal of improving regional quality of life. They assisted in preparing maps, gave presentations at public meetings, helped gather and interpret existing data and reports, and provided input based on their vast and varied experience and knowledge of the Dunes Creek watershed.

A list of potential stakeholders was compiled early in the development of the plan. Potential stakeholders received direct mailings regarding the progress of the plan to encourage their participation in its development. Quarterly public meetings were held to report progress and solicit input from stakeholders and the general public. The continued efforts of committed stakeholders are needed to implement this plan and ensure its success in achieving their vision for the watershed.

In addition to stakeholder involvement, care was taken to obtain input from as many individuals with professional experience in the watershed as possible. Information was obtained from the Indiana Dunes National Lakeshore, the *E. coli* Task Force, and U.S. Geological Survey on past and current water sampling sites as described in section 3.

1.2 Public Participation

Quarterly meetings for the general public ensured citizen participation in development of the Dunes Creek Watershed Management Plan. During public meetings, mission and vision statements were developed for the group, input on selecting water sampling sites was obtained, a list of concerns was developed and prioritized through group voting, and goals were set for the plan. Draft plans were posted to the Save the Dunes Conservation Fund website and hard copies were provided at public meetings. Public participants provided feedback on the plan’s content.

Outreach to encourage citizen participation was accomplished through the production and distribution of an informative brochure (Appendix B), press release distribution and newspaper articles in local papers (Appendix C), e-mail notification, newsletter articles in various regional newsletters, presentations at various meetings, and web pages at www.savedunes.org.

2.0 Physical Description of the Watershed

2.0.1 Watershed Location

The Dunes Creek watershed is located along Indiana's Lake Michigan shoreline. It extends from the Mittal Steel (formerly Bethlehem and ISG Steel) facility in Portage to the Town of Beverly Shores in Michigan City (Figure 1) and includes the following land uses: residential, business, industrial, agricultural, and recreational. The watershed encompasses nearly all of the Indiana Dunes State Park (see section 2.0.2), parts of Mittal Steel, and a Northern Indiana Public Service Company (NIPSCO) power plant. Residential communities include Dune Acres, portions of the Town of Porter, and a small portion of the west end of Beverly Shores. Large portions of the watershed are within the Indiana Dunes National Lakeshore boundaries, including much of the Great Marsh and prominent natural landmark, Cowles Bog.

The Dunes Creek watershed (Hydrologic Unit Code (HUC)-04040001080020) is a subwatershed of the Little Calumet-Galien watershed (HUC-04040001). It is bordered on the southwest by the Little Calumet River-Burns Ditch outlet (HUC-04040001060040), on the south by the Little Calumet River-Sand/Coffee Creeks (HUC-04040001060030) and Little Calumet River-Kemper Ditch (HUC-04040001060020), and on the east by the Beverly Shores tributary (HUC-04040001080030) (Figure 2).

It is important to note that as part of the construction of Bethlehem Steel during the early 1960s, a storm water collection system was installed. This system collects storm water runoff from primarily all of the facility and directs it to a constructed waterway that discharges to the east arm of the Little Calumet River. Appendix D shows the sewer system that collects the storm water. The installation of this storm sewer system, in addition to ground water pumpage, diverted all storm water runoff from Bethlehem Steel (currently Mittal Steel) from Dunes Creek to the Little Calumet River. **The official delineation of the Dunes Creek watershed still includes this area at the far west end of the watershed that now drains into the adjacent Little Calumet River watershed.**

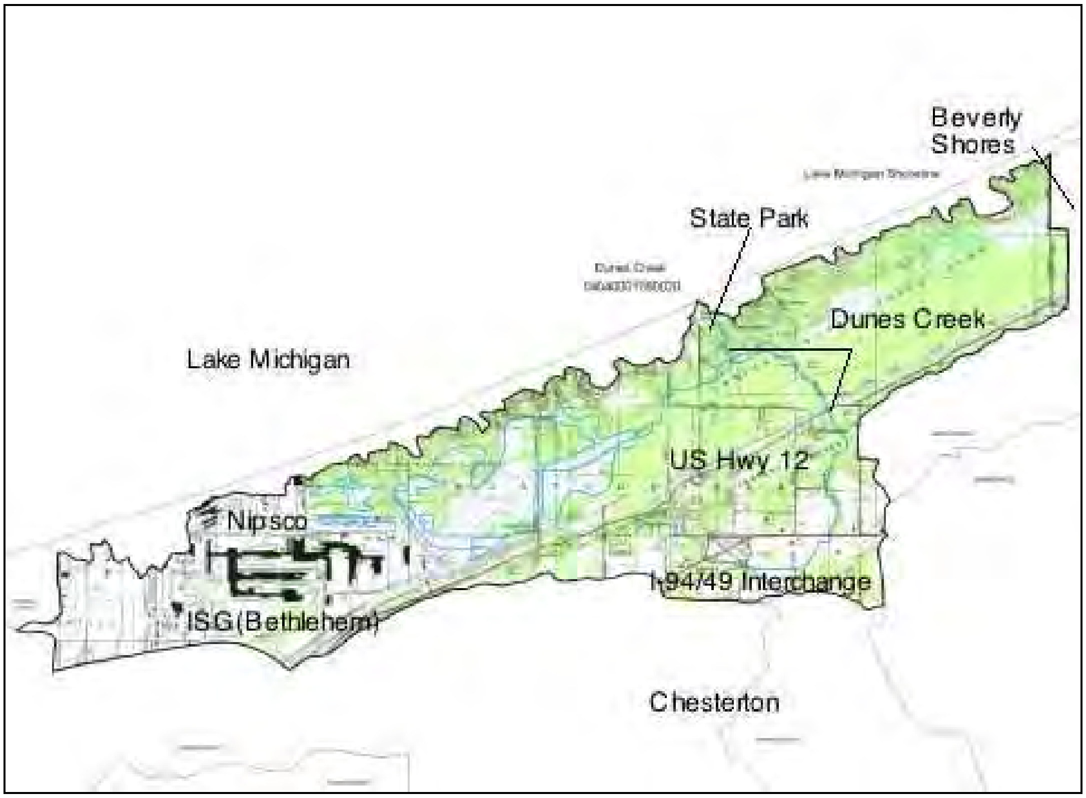


Figure 1. Delineation of Dunes Creek watershed

Map provided by IDEM, 2004.

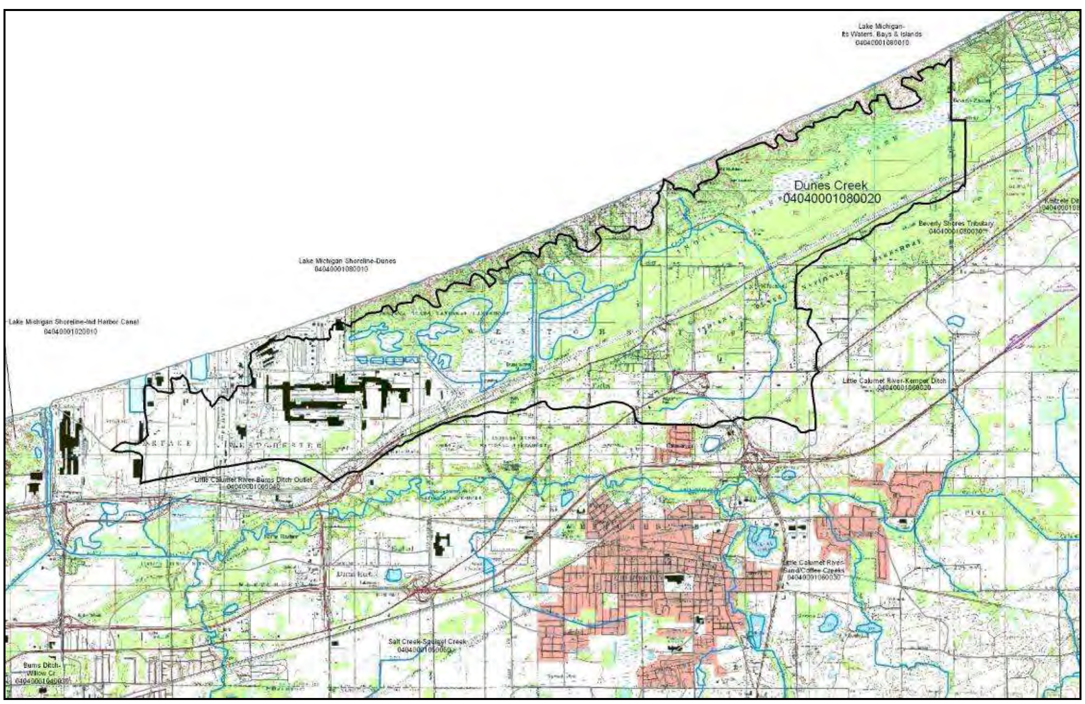


Figure 2. Dunes Creek watershed and surrounding area

Map provided by IDEM, 2004.

2.0.2 Natural History

Within the 7,407-acre (2997-hectare) Dunes Creek watershed are globally rare ecosystems that began to form more than 14,000 years ago as climate warmed and the last of the Ice Age glaciers began to retreat. The resulting biologically rich Indiana Dunes, shaped by wind, waves, and fluctuation in water levels teem with plant and animal life. Portions of these rare ecosystems have been protected by inclusion in national and state parks. This plan takes into account these significant natural areas and the management issues related to them.

Indiana Dunes National Lakeshore - Great Marsh and Cowles Bog Wetland Complex
A large portion of the Dunes Creek watershed is within the Indiana Dunes National Lakeshore boundary, including most of the Great Marsh that formerly extended from Gary to Michigan City. Western portions of the Great Marsh were once part of the Little Calumet Marshes, while Dunes Creek and other creeks to the east drained the marsh area to Lake Michigan (Apfelbaum et al., 1983). In the 1960s the western portion of the marsh was filled in for the construction of the NIPSCO Bailly Power Plant and Mittal Steel. The current southwestern boundary represents more of an interior portion of the Great Marsh than its true southern edge.

These changes over time have affected the biological integrity and water quality of the marsh and Dunes Creek. The macroinvertebrate communities found in the Great Marsh have the structural and functional elements of a community depicting neither a healthy wetland nor a healthy stream. Further investigation into the effects of land use on aquatic communities at different spatial scales will help identify important predictors for watershed health and management (Stewart et al., 2000).

The Cowles Bog Wetland Complex is approximately 197 acres (80 hectares) of various wetland and peatland communities (Reshkin 1981 by Wilcox, et.al. 1986) within the Great Marsh. South of the Town of Dune Acres is a 54 acre (22-hectare) fen within the Cowles Bog Wetland Complex that was designated in 1965 as a National Natural Landmark. The fen is an interdunal wetland located at the western end of the Great Marsh. The bog was purchased by Save the Dunes Council in 1953 at a tax sale and sold in 1973 to the National Lakeshore for inclusion in the park. Much of the bog's southern perimeter is now defined by a constructed berm. On the southern side of the berm are NIPSCO fly-ash ponds (Figure 3). Seepage from the diked ponds, constructed in the early 1970s, increased and stabilized water levels in the bog. The water level changes are presumed to have adversely affected the sedge-grass community and are encouraging the major invasion of Cattails (*Typha* spp.) that increased from 24 acres (9.7 hectares) in 1970 to 92.7 acres (37.5 hectares) in 1982 (Wilcox et al. 1984).

Indiana Dunes State Park
The Dunes Creek watershed includes nearly all of the Indiana Dunes State Park. Along the northern edge of the Dunes Creek Watershed lies the Lake Michigan Shoreline watershed, which is a narrow band that runs the length of Lake Michigan in Indiana. This is the only portion of the Indiana Dunes State Park that technically lies outside of the Dunes Creek Watershed. Inland from the water's edge the base of the dunes meets the beach. Marram Grass (*Ammophila breviligulata*), with its spreading underground root system, begins to establish itself here on the beach.

The foredune area is characterized by a series of hills and swales. Mt. Tom, at 192 feet (58.5 meters) is the highest of these ridge tops. Wind erosion has cut depressions, called blowouts, through these ridges. The three largest of these blowouts, Beach House, Furnessville, and Big Blowout, extend into the interdunal area of hills, pockets, and troughs. Big Blowout has uncovered an area of dead tree trunks known as the Tree Graveyard. Although not as visible as in recent years, this area was once a white pine forest before shifting sands buried it. Because sand is still unstable in the interdunes, vegetation here resembles that found on the foredunes.

The backdune area begins on the leeward slopes of active blowouts or on protected ridges. Tops and upper leeward slopes of the backdunes are forested with nearly pure stands of Black Oak (*Quercus velutina*), mixed with a few White Oaks (*Quercus alba*) and stunted Sassafras (*Sassafras albidum*). Thick stands of Blueberry (*Rubus allegheniensis*), Bracken Fern (*Pteridium aquilinum*), and Greenbrier (*Smilax rotundifolia*) are found in the understory.

South of the dunes is a wetland complex, composed of marsh, shrub swamp, and swamp forest. This large area is drained by Dunes Creek. Between the dunes and this wetland is a strip of sandy flats with greater organic matter. One sheltered cove on these flats has native White Pine (*Pinus strobus*) associated with Oak (*Quercus spp*.), Tulip (*Liriodendron tulipifera*), White Ash (*Fraxinus americana*), and Basswood (*Tilia Americana*). From the wetland, there is a gradual upward slope toward the park's southern boundary. This slope is one of the shorelines of prehistoric Lake Chicago.

Invasive Plants

Invasive plant species occur throughout the Dunes Creek watershed. These species threaten the natural biodiversity of the area and can also impact hydrology. In the upland areas, Garlic Mustard (*Alliaria petiolata*), Dame's Rocket (*Hesperis matronalis*), Multiflora Rose (*Rosa multiflora*), Honeysuckle (*Lonicera* spp.), and Oriental Bittersweet (*Celastrus orbiculatus*) are concerns. Dame's Rocket is just beginning to invade the upper reaches, while Oriental Bittersweet is considered a major concern due to the difficulty of eradicating this species. In wetland areas and along ditches, Phragmites *(Phragmites australis)* and Purple Loosestrife (*Lythrum salicaria*) are problems. Purple Loosestrife is particularly dominant along the Calumet Bike Trail just west of the Interstate 49 overpass. Phragmites occurs in the ditches along Waverly Road. (Noel Pavlovic, USGS Biological Resources Division, pers.comm.)

Figure 3. Cowles Bog Wetland Complex

Center, bordered on southern edge by NIPSCO fly-ash ponds. The NIPSCO Bailly Power Plant is at the top left; lower left is Mittal; center is Cowles Bog. (photo from IDNR, 1999)

2.0.3 Endangered Species

The significant diversity of natural habitats originally present within the Dunes Creek watershed, including Cowles Fen

(Bog), the center of the Great Marsh, the High Dune Complex along the north side of the watershed landward of the Lake Michigan shoreline, and the lower wooded dunes of the Tolleston-Calumet Beach Ridge along the south side of the watershed, supported hundreds of species of wildlife (insects, fish, amphibians, reptiles, birds, mammals, and plants). Many of these species still remain within the Indiana Dunes National Lakeshore and Indiana Dunes State Park, but others have vanished or become rare since European settlement began in the 1830's. The industrial development of the western portion of the watershed has had the most significant impact, but conversion to agricultural and residential development elsewhere, and the associated ditching and drainage, have also altered the habitat and the mix of native species. Lack of fire, a natural component of the native marsh, prairie, and savanna habitats, has also adversely affected the native species diversity. However, both the Indiana Dunes National Lakeshore and the Indiana Dunes State Park have initiated prescribed burning programs to simulate the natural fire regime of the local ecosystem, with the goal of preserving, enhancing, and restoring native habitats and the diversity of species dependent upon them. The National Lakeshore has also initiated restoration work at Cowles Fen and portions of the Great Marsh east of the Dunes Creek watershed.

The Indiana Natural Heritage Data Center, part of the Division of Nature Preserves (DNP), maintains information about federal and state endangered, threatened, rare, and special concern species, high quality natural communities, and significant natural areas in Indiana. This database assists in documenting the presence of special species and significant natural communities and serves as a tool for setting management priorities for these species and habitats. The data for the Dunes Creek watershed comes from numerous sources, including historical studies such as those by Dr. Henry Chandler Cowles 100 years ago and Dr. Charles C. Deam in the1930's; Dr. Gerould S. Wilhelm's reports on the special vegetation of the Indiana Dunes National Lakeshore in the 1980s (1990); the observations of local individuals, including numerous naturalists who used to summer in the dunes before and after the establishment of the Indiana Dunes State Park and the Indiana Dunes National Lakeshore; and through research by scientists studying the Indiana Dunes National Lakeshore and Indiana Dunes State Park. Therefore, the Natural Heritage Database of this area covers approximately the time period between 1890 and 2004. Some of the species in the database have not been reported for many years; they may or may not still be present, and current observers may not have provided their information to the DNP. Because of the wide disparity in the dates of reported occurrences of plant species, we have separated the information into historical (1950 and earlier) and current (1951 to present), which are presented in Appendix E. However, wildlife species lists include both historical and current information because the differences are not as great as for the plants. The lists are for the entire watershed, not specific locations. Therefore, sites where various species were historically present may no longer be extant (*e.g.* now are the Port of Indiana, Mittal, NIPSCO Bailly Generating Station), but the species continue to persist within the watershed at other sites. Alternatively, the Indiana endangered Peregrine Falcon (which no longer has federal listing) nests within these industrial sites and not in the natural areas of the watershed because the industrial facilities provide suitable substitute nesting platforms and a supply of prey.

The federal and Indiana endangered Karner Blue Butterfly (*Lycaeides melissa samuelis*) is not currently extant within the Dunes Creek watershed, although it was present as recently as the 1970s. However, the National Lakeshore has been restoring savanna habitat within the Dune Acres Unit of the park, and restoration of this species to these sites may occur at some time in the future.

2.0.4 Geology and Soils

The Dunes Creek watershed lies within the Calumet Lacustrine Plain, which is primarily abandoned lake bottom of late-glacial and postglacial lakes that occupied the southern Lake Michigan Basin. Three dune-beach complexes were deposited in the Calumet Lacustrine Plain, approximately parallel to the current Lake Michigan shoreline, and are now covered with vegetation. They are primarily eolian sand, but coastal sand and sandy gravel may occur along the northern margins (USDA, 1981). The dune-beach complexes are underlain by 90 to 212 feet (27 to 64.6 meters) of unconsolidated glacial, lacustrine, eolian, and paludal sediments of Pleistocene and Holocene age that were deposited on a bedrock surface modified by pre-Pleistocene erosion. The bedrock is shale and carbonate rocks of Mississippian, Devonian, and Silurian age (Shedlock et al., 1994). Figure 4 shows the Dunes Creek watershed soil types.

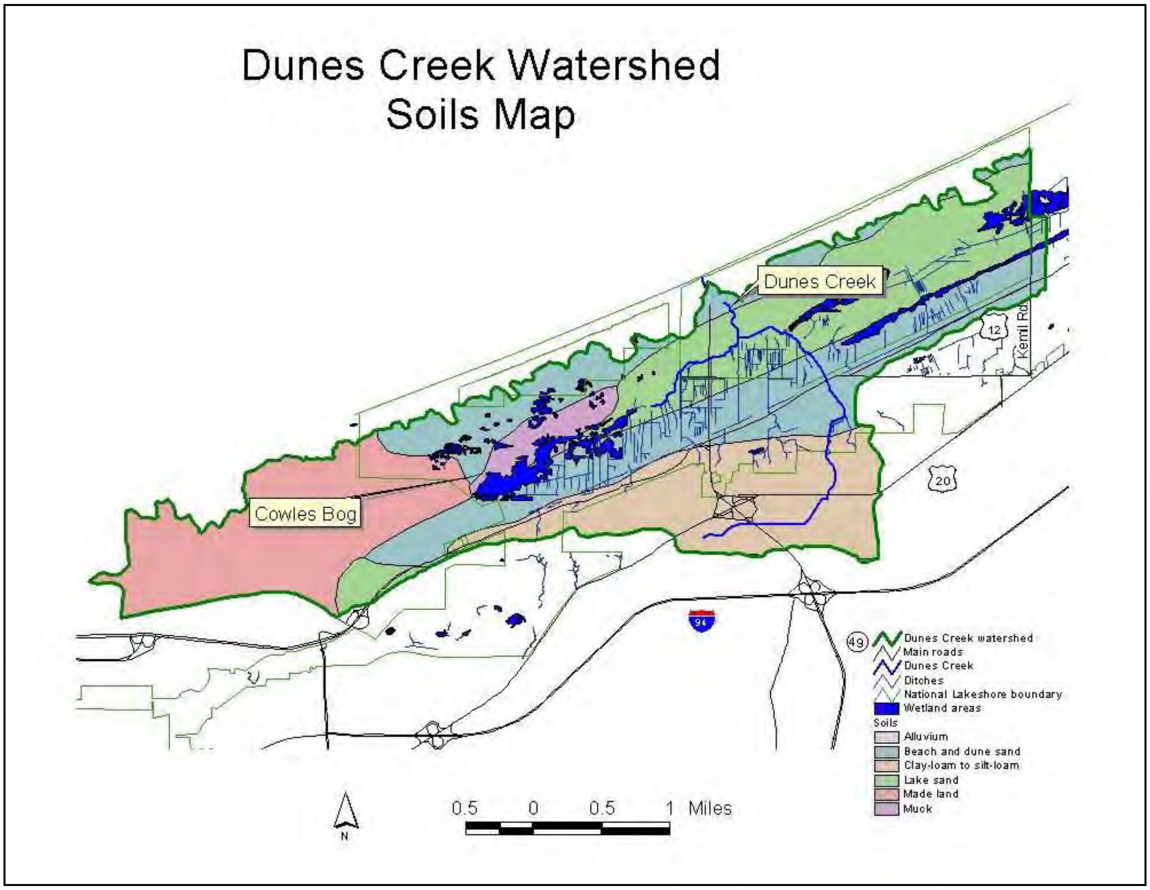


Figure 4. Dunes Creek watershed soils

Map provided by Indiana Dunes National Lakeshore (2004).

2.0.5 Topography

The elevations in the Dunes Creek watershed are relatively low, averaging 624 feet (190 meters) above sea level. The elevation change in the watershed is 182 feet (55.5 meters). The northern boundary of the watershed is dominated by hummocky dunal terrain. The middle section of the watershed is occupied by low-relief bogs and wetlands, and the southern headwater basins are less topographically variable. Figure 5 shows the topography of the Dunes Creek watershed.

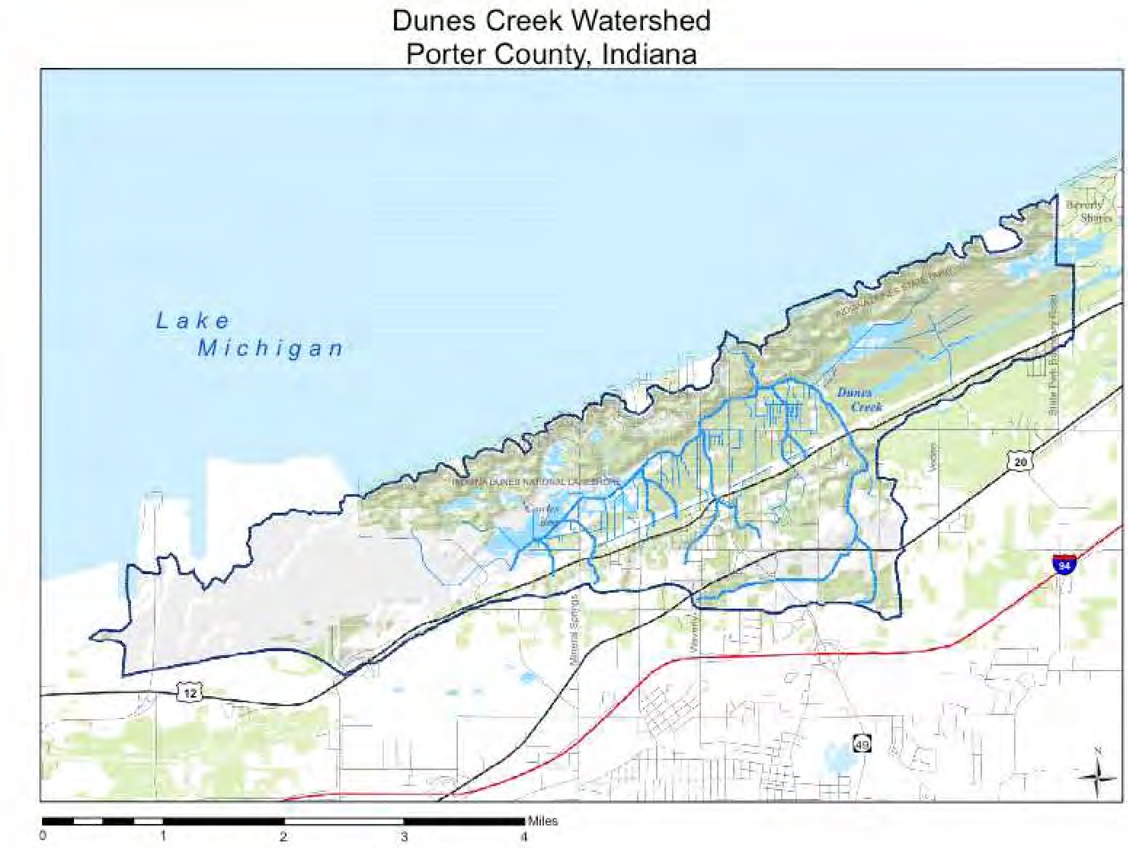


Figure 5. Map showing Dunes Creek watershed with hillshaded topography

Map provided by Indiana Geological Survey (2005).

2.0.6 Hydrology

Historically, Dunes Creek was fed by the Great Marsh (including Cowles Bog) and meandered slowly northward through woodlands and interdunal areas, ultimately flowing into Lake Michigan. Over time, many sections of Dunes Creek have been straightened and dredged and subsequently not maintained. There are over one hundred man-made ditches and drains within the watershed. The creek and many of the ditches and drains that have altered it are shown in Figure 6. The effects of commercial and residential development and agriculture have significantly altered the creek's original character.

According to Stewart in the *Ecological Assessment of Three Creeks Draining the Great Marsh at Indiana Dunes National Lakeshore*, two man-made ditches to the east of the Dunes Creek watershed were cut through the dunes to provide for farming, industrial use, and housing (1997). These ditches divided Dunes Creek and created the new subwatersheds of Kintzele and Derby. Originally, Dunes Creek included much of Michigan City. Today the man-made drainages of Derby Ditch and Kintzele Ditch drain what used to be the east end of Dunes Creek.

Today Dunes Creek begins west of Interstate 49. Its tributaries meander through many ditches. One tributary crosses the South Shore Railroad, two branches cross State Park Road, and one branch crosses Waverly Road and Interstate 49. These branches converge near the Indiana Dunes State Park campground and flow toward the parking lot. Dunes Creek flows through a weir and then a culvert under the parking lot and enters Lake Michigan at the Indiana Dunes State Park swimming beach (Stewart et al., 1997).

As noted earlier in and Appendix D, the installation of a storm sewer system in addition to ground water pumpage diverted all storm water runoff at the Bethlehem Steel site (currently Mittal Steel) from Dunes Creek to the Little Calumet River. **The official delineation of the Dunes Creek watershed still includes this area at the far west end of the watershed that now actually drains into the adjacent Little Calumet River watershed.**

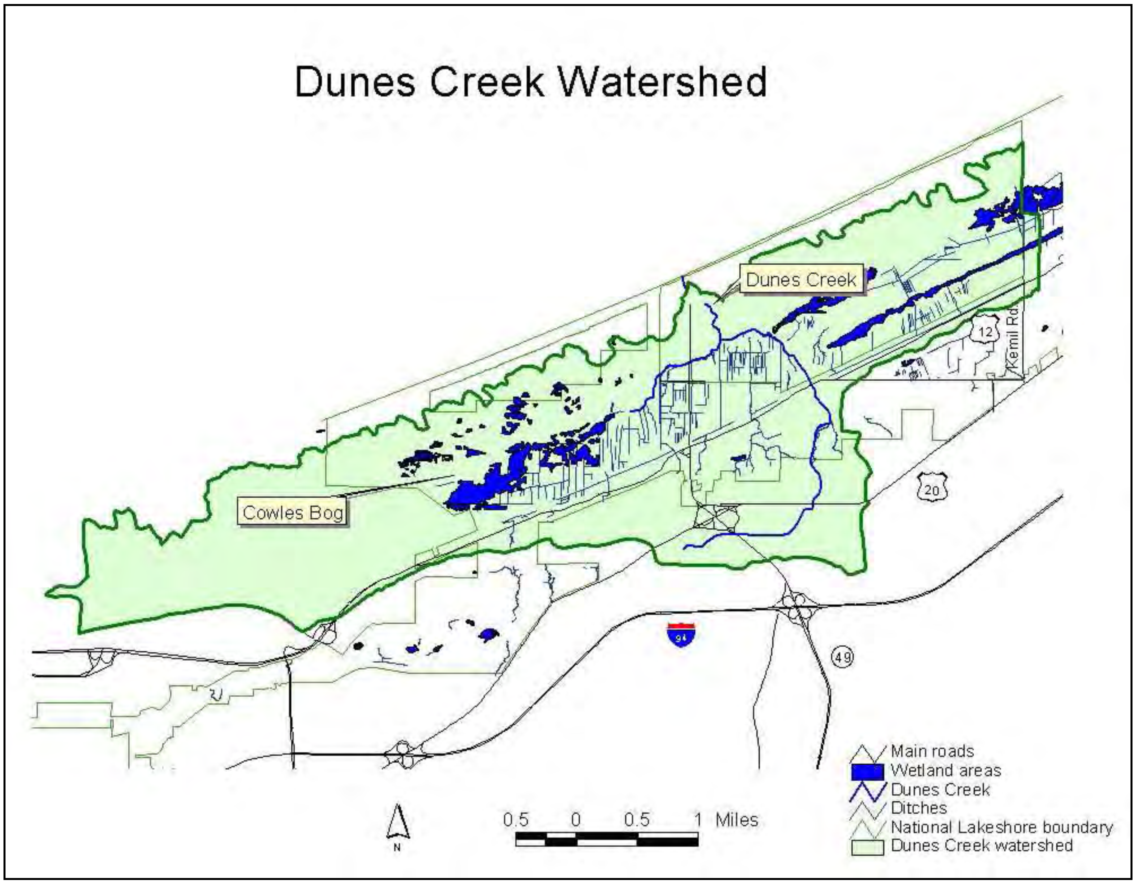


Figure 6. Dunes Creek watershed map depicting hydrology

Map provided by Indiana Dunes National Lakeshore.

2.0.7 Ecoregions

Ecoregions are defined as areas of relative homogeneity in ecological systems and their components. Factors associated with spatial differences in the quality and quantity of ecosystem components, including soils, vegetation, climate, geology, and physiography, are relatively homogeneous within an ecoregion. Ecoregions separate different patterns of human stresses on the environment and different patterns in the existing and attainable quality of environmental resources. They have proven to be an effective aid for inventorying and assessing national and regional environmental resources, for setting resource management goals, and for developing biological criteria and water quality standards.

The approach used to compile ecoregion maps is based on the premise that ecological regions can be identified by analyzing the patterns and composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.

The relative importance of each factor varies from one ecological region to another, regardless of the hierarchical level. To avoid possible confusion with other terms for different levels of ecological regions, a Roman numeral classification scheme has been adopted for this effort. Level I is the coarsest level and divides North America into 15 ecological regions. At level II, the continent is subdivided into 52 classes, and at level III, the continental United States contains 98 ecoregions. Level IV ecological regions are further subdivisions of level III units. The exact number of ecological regions at each hierarchical level is still changing slightly as the framework undergoes development at the international, national, and local levels. The level III ecoregion map (Figure 7) was compiled at a scale of 1:250,000; it depicts revisions and subdivisions of earlier level III ecoregions that were originally compiled at a smaller scale (USEPA 1997; Omernik 1987).

The Dunes Creek watershed is located in Level IV Michigan Lake Plain 56d region that is a subdivision of the Level III Southern Michigan/Northern Indiana Drift Plains (Figure 7). See Appendix F for additional information.

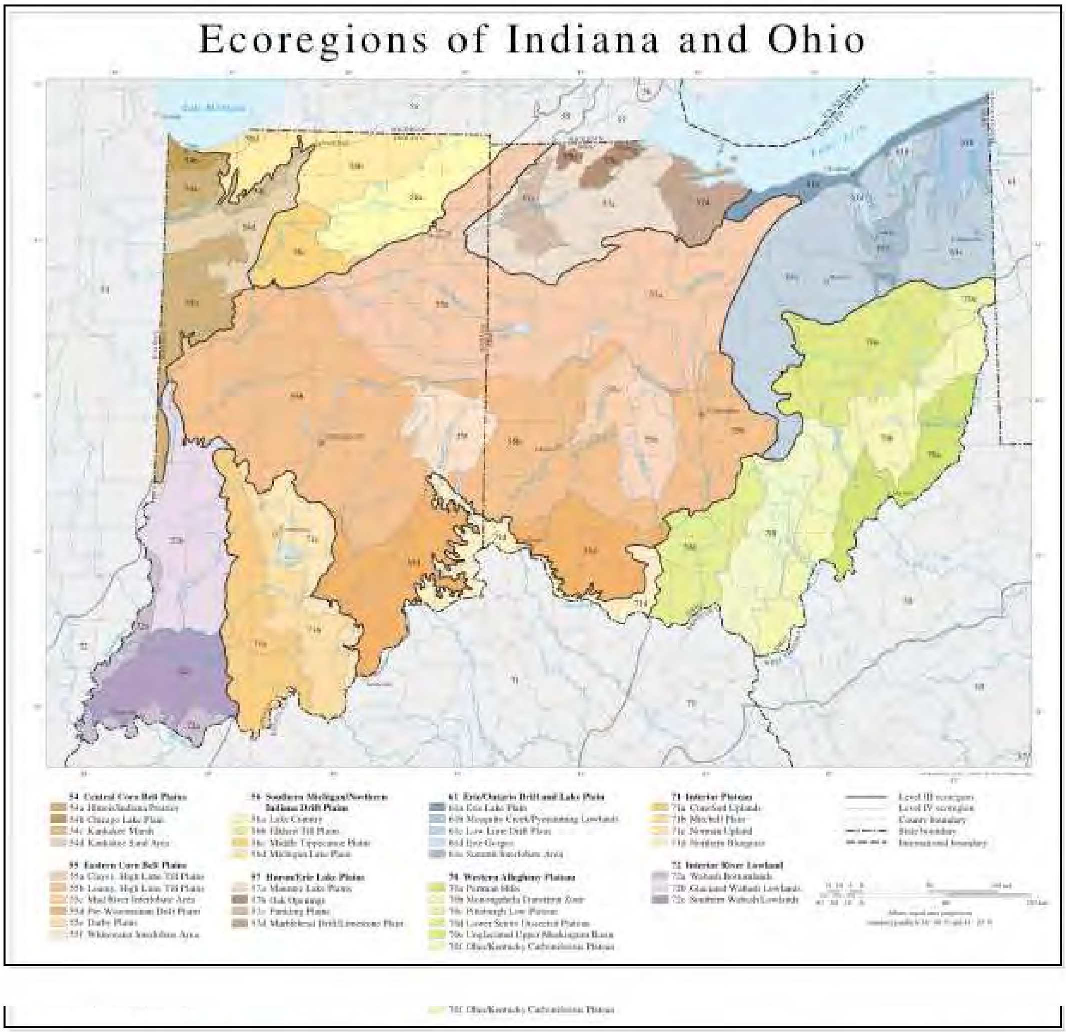


Figure 7. Ecoregions of Indiana and Ohio (USEPA, 2006)

2.1 Land Use Description of the Watershed

Based on the 1990 U.S. Geological Survey (USGS) Land Use and Land Cover data, land use types in the Dunes Creek watershed include 41% forest, 27% wetland, 22% urban/impervious, 6% agriculture, 4% open water, and less than 1% shrubland/woodland. Figure 8 shows these land use types within the watershed as categorized by USGS. The high ratio of land in the watershed that is publicly owned, as shown in Figure 10, has impacted land use in this watershed. Urban/impervious land use appears to be relatively low watershed-wide as a result of federal and state park land being unavailable for development. The watershed areas outside park boundaries continue to be developed and urbanized.

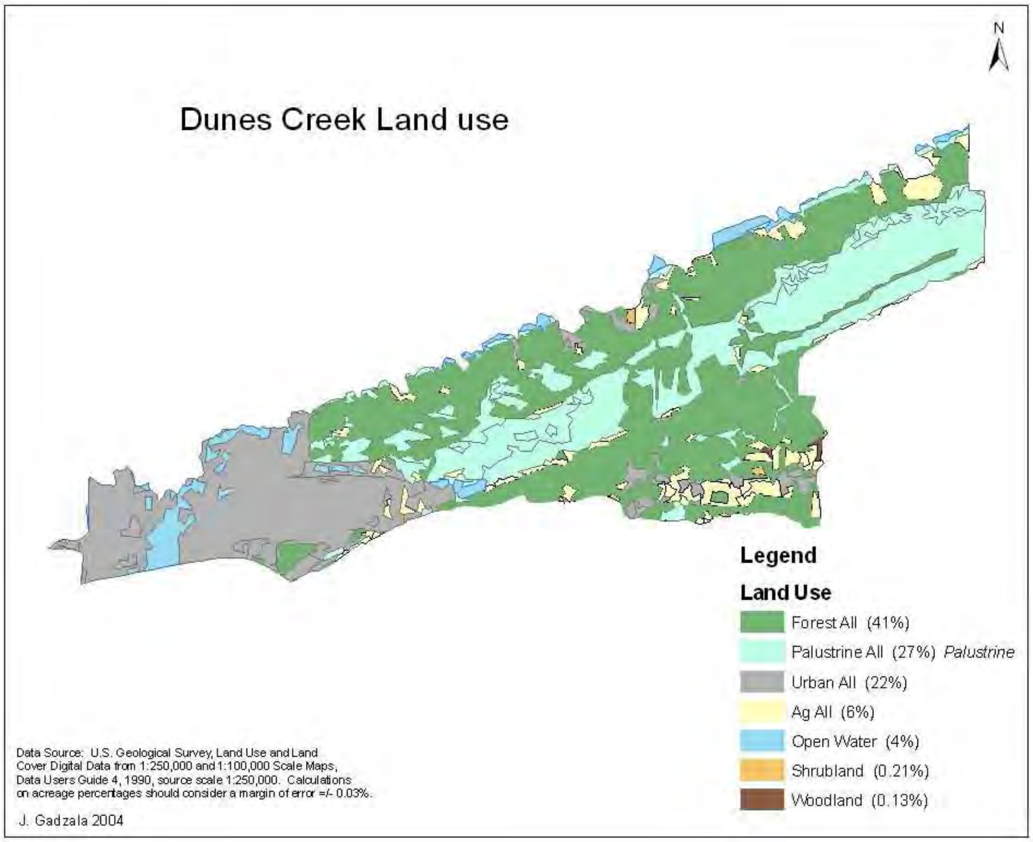


Figure 8. Dunes Creek watershed land use map (based on 1990 USGS land cover data).

2.1.1 Cultural/Recreational Resources

Indiana Dunes State Park

The Dunes Creek watershed includes nearly all of the Indiana Dunes State Park. The 2,138-acre (865.2 hectare) State Park was designated in 1974 as a National Natural Landmark and is one of the best remaining examples of undeveloped and relatively unspoiled dune landscape along the southern shore of Lake Michigan (National Park Service, 2006). It is a popular recreational destination that attracts over 1 million visitors annually and includes140 campsites in its campground which was reconstructed in 2005. The 1,530-acre (619 hectare) Indiana Dunes State Nature Preserve owned by the Indiana Department of Natural Resources Division of Nature Preserves, comprises the eastern 2/3rds of the Indiana Dunes State Park (Department of Natural Resources, 2006).

Indiana Dunes National Lakeshore

Large portions of the Dunes Creek watershed are within the Indiana Dunes National Lakeshore boundaries, including most of the Great Marsh. The Cowles Bog Wetland Complex consists of various wetland communities within the Great Marsh. Within the Cowles Bog Wetland Complex there is a fen that was designated in 1965 as a National Natural Landmark (National Park Service, 2006).

Calumet Trail

The 9.1-mile (15 kilometer) Calumet Trail path skirts the southern boundaries of Indiana Dunes National Lakeshore and Indiana Dunes State Park. The trail, which accommodates biking, hiking, and skiing, runs through the Dunes Creek watershed parallel to Route 12 and the South Shore Line railroad tracks (Figure 9). The trail occupies land owned by Northern Indiana Public Service Company, but it is managed by the Porter County Park Department. Volunteers from local conservation groups also monitor the trailside vegetation.

Figure 9. Recreational use of the Calumet Bike/Hike Trail (2005)

2.1.2 Land Ownership

As noted earlier, much of the Dunes Creek watershed is under public ownership. The Indiana Dunes National Lakeshore and the Indiana Dunes State Park are federal and state properties. Figure 10 shows the boundaries of public properties within the watershed. The Dunes Creek watershed includes nearly all of the Indiana Dunes State Park. Along the northern edge of the Dunes Creek watershed lays the Lake Michigan Shoreline watershed, which is a narrow band that runs the length of Lake Michigan in Indiana. This is the only portion of the Indiana Dunes State Park that technically lies outside of the Dunes Creek watershed.

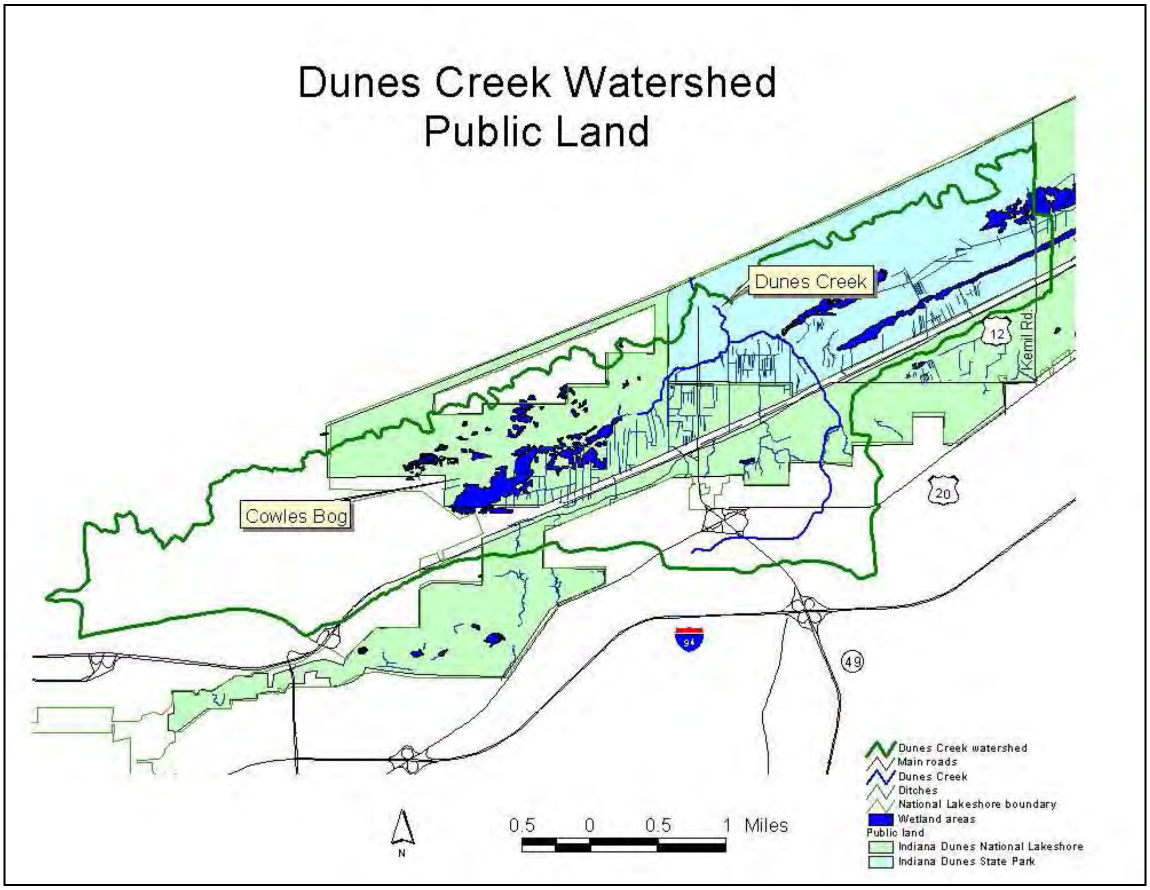


Figure 10. Dunes Creek watershed land ownership

Map provided by Indiana Dunes National Lakeshore (2005).

3.0 Water Quality and Data Collection

Save the Dunes Conservation Fund conducted a literature review of historic water quality and habitat data for Dunes Creek to help document baseline conditions and identify possible problems. In addition to our in-house knowledge of prior studies, Steering Committee members (several of whom have long-term experience working on water quality issues in the watershed) provided relevant articles, reports, and studies.

To obtain current water quality and habitat data, Save the Dunes Conservation Fund contracted for testing physical and chemical water quality parameters at strategic tributary sampling sites. Information was obtained from the Indiana Dunes National Lakeshore and USGS on past and current water sampling sites, shown in Figure 11. Eight new sampling sites were selected based on input from the Steering Committee, public meeting participants, and by utilizing information from the *Ecological Assessment of the Three Creeks Draining the Great Marsh at Indiana Dunes National Lakeshore* (Stewart, 1997). The digital coordinates for the new sampling sites were obtained using a Global Positioning System (GPS) unit (Table 1). The Indiana Dunes National Lakeshore used the coordinates to create a map of the points which is shown in Figure 12. During the course of the sampling program, sampling sites were added to obtain the necessary data in order to better identify critical areas. A map including all of the original sites and the later additions is shown in Figure 13.

Watershed Sampling
Water chemistry, biological community, and physical habitat sampling at each of the eight original stream sites plus three additional sites within the Dunes Creek watershed was conducted by JFNew. Water chemistry samples were collected four times from each of the eight original stream sites, twice following a storm event to capture a runoff event and twice following a period of little precipitation to serve as the “normal” stream condition. Storm sampling occurred on August 5, 2004 following nearly 2 inches of rain in the previous 24-hours and again on July 27, 2005 following more than 1.5 inches of rain in the previous 24-hours. Base flow sampling occurred on September 14, 2004 and June 21, 2005. Each reach’s biological community was assessed once in mid-late summer annually and habitat availability of each reach was assessed once during the sampling period. The three additional sites were only sampled during the 2005 storm event. To ensure comparability to data collected previously by IDEM, contractor JFNew followed similar stream sampling protocols. The stream sampling and the appropriate quality assurance/quality control procedures are referenced in the project’s Quality Assurance Project Plan (QAPP). Appendix G contains the project Quality Assurance Project Plan (QAPP) which was approved by IDEM on September 7, 2004. Appendix H contains the raw data collected during the stream assessments in graphical form and discusses watershed stream results for each parameter. Tables H1 through H3 located in Appendix H contains the raw water chemistry data. Appendix I includes the macroinvertebrate communities present within the Dunes Creek watershed streams and exhibits the habitat assessment Qualitative Habitat Evaluation Index (QHEI) scores attributed to each reach.

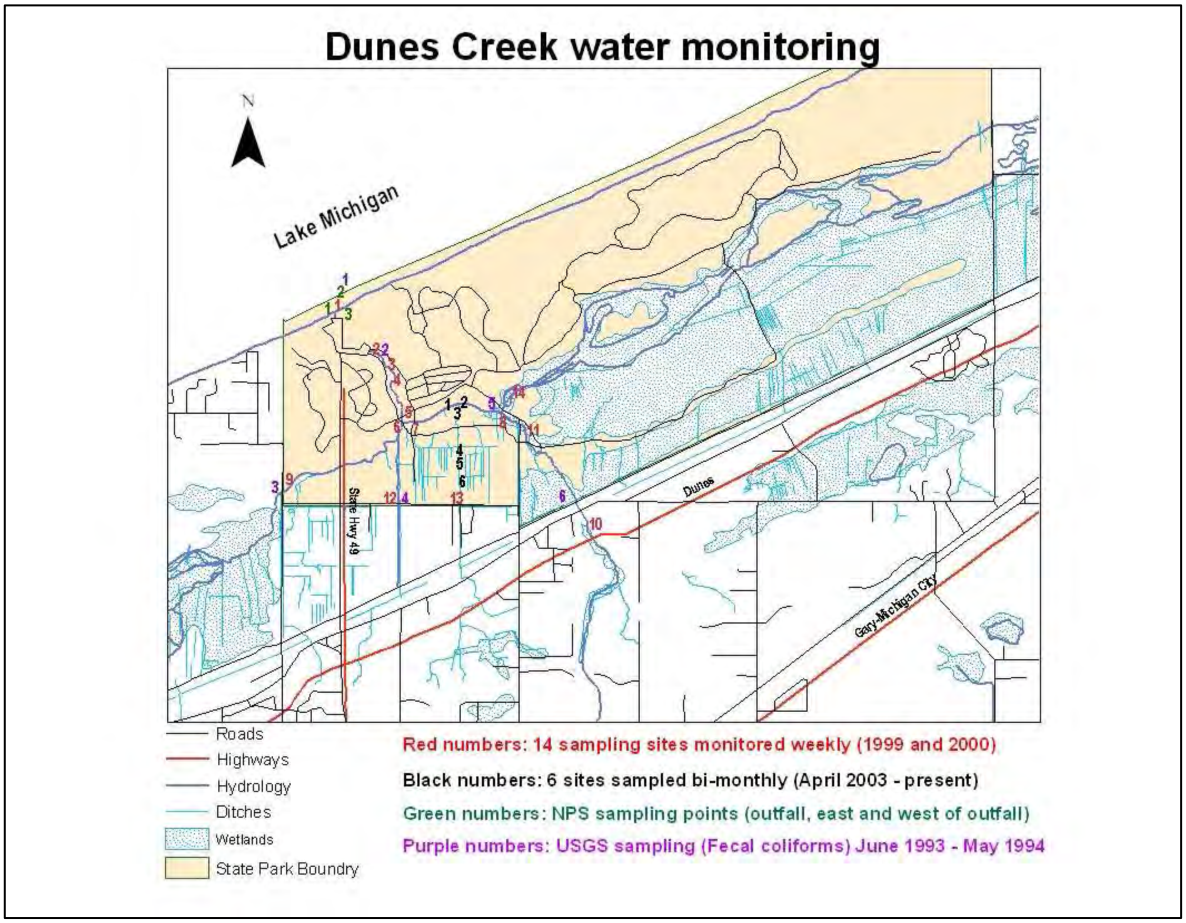


Figure 11. Map of current and past Dunes Creek water monitoring (provided by USGS, 2004).

Table 1. Locations of stream sampling sites

Site No.	Stream Name	Sampling Location	Northing*	Easting*
1**	West Branch of Dunes Creek	downstream of Cowles Bog	494420.100	4611181.256
2	West Branch of Dunes Creek	in state park, upstream of confluence with eastern branch of creek	495182.475	4611622.435
3	Dunes Creek (Culvert)	upstream of the culvert under parking lot	494971.574	4612054.835
4	Dune Creek (Outlet)	outlet of culvert under parking lot	494751.160	4612345.128
5	Great Marsh tributary	near confluence with Dunes Creek	495962.389	4611682.468
6	Dunes Creek	in residential area	496398.614	4610022.772
7	Dunes Creek	downstream of US 20	496419.193	4609515.147
8	Dunes Creek	upstream of US 20	496418.086	4609401.648
e	Dunes Creek	just west of HWY 49	495405.08887	4609074.38755
b	Dunes Creek	east tributary on Rt 12	496410.68244	4611024.56607
a	Dunes Creek	near Munson Ditch on US 20	494535.09764	4608976.20424

* Coordinates are UTM Zone 16 NAD 1983

** During the first sampling event, this site was located at a different location within the bog at 492777.745N, 4610252.782E

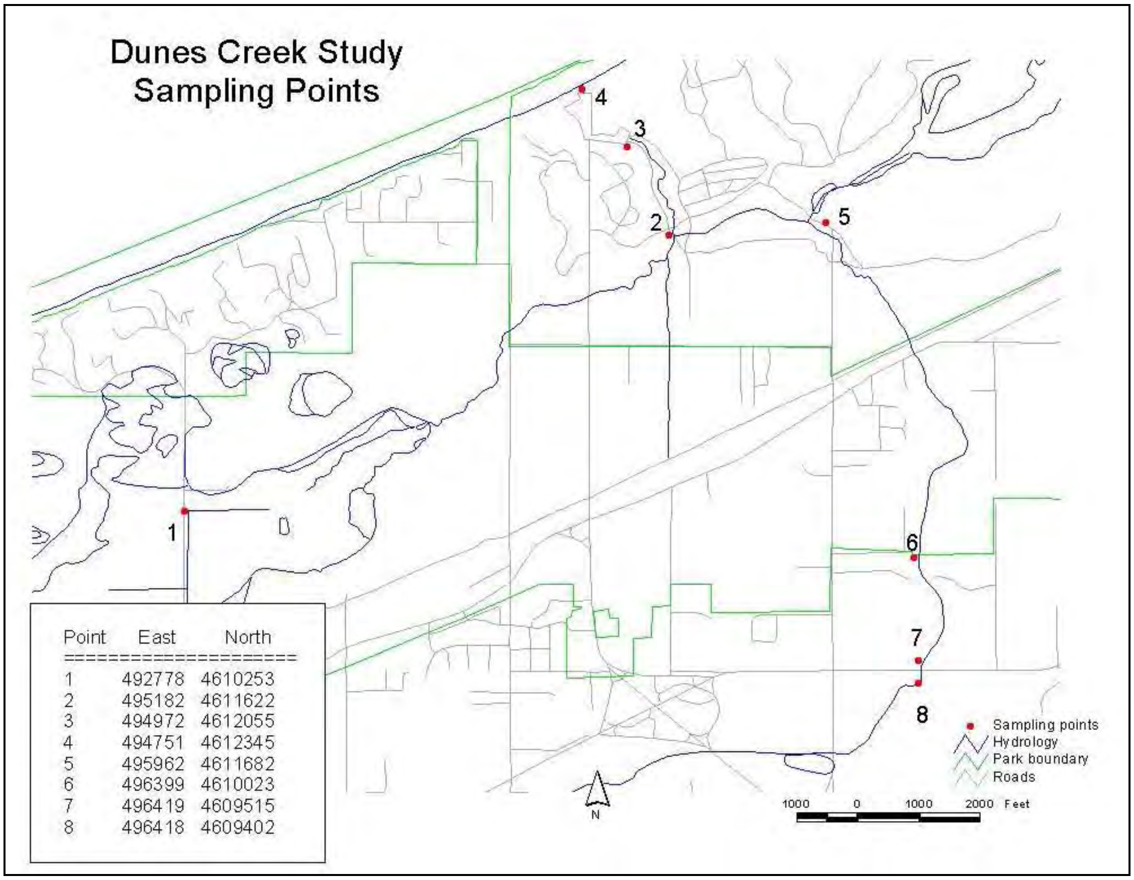


Figure 12. Original 8 sampling sites for the Dunes Creek water quality monitoring program

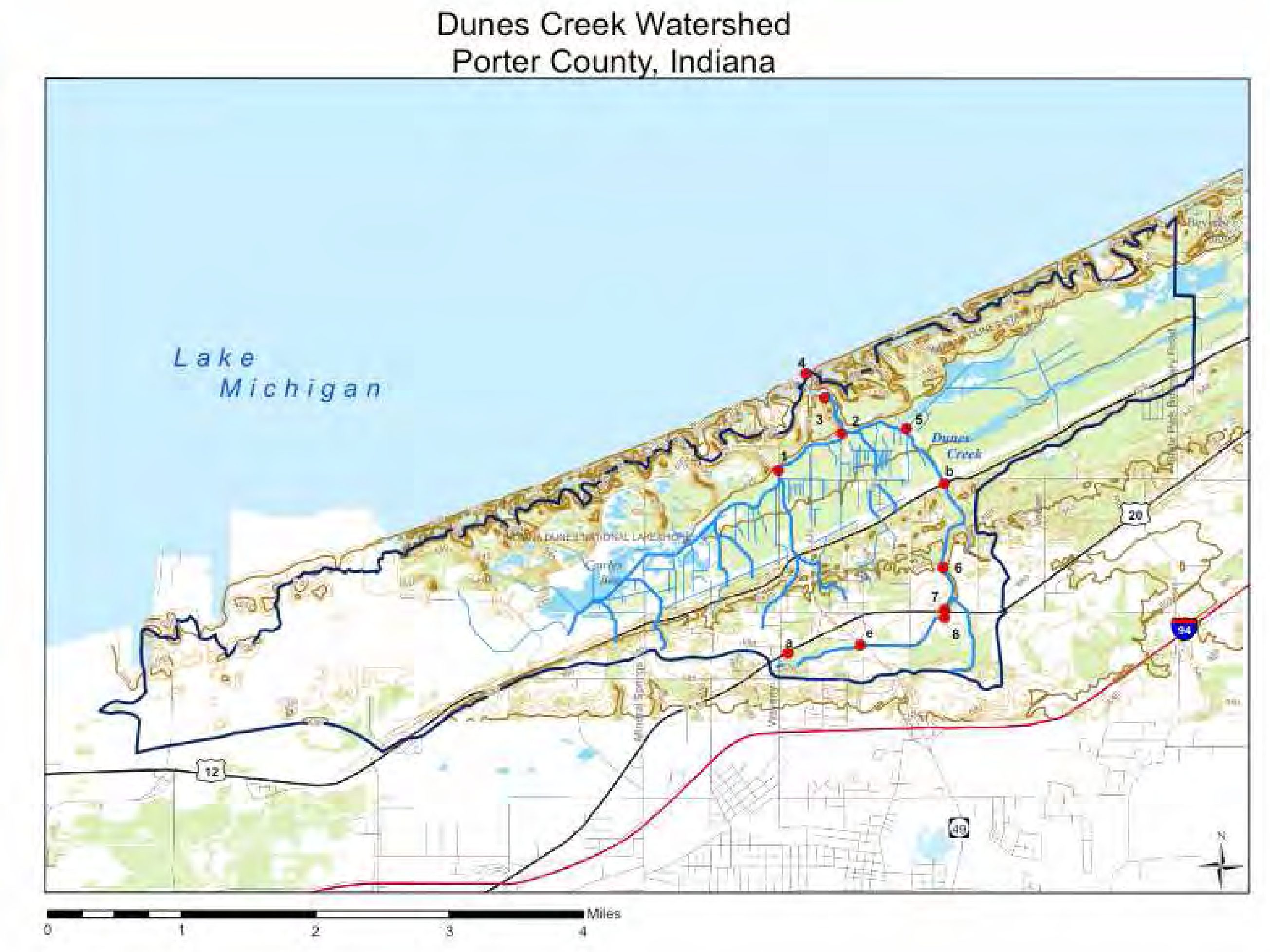


Figure 13. Sampling sites for water quality monitoring program in the Dunes Creek watershed

The following descriptions provide additional detail about each sampling site, why it was selected, and a summary of the data collected. Dunes Creek data are compared to Indiana state water quality standards where available. Otherwise, data were compared to the Ohio standards or recommendations in order to evaluate impairments.

Figure 14. Sampling site 1

(October 17, 2005)

1. Site 1, Cowles Bog Outlet (Figure 14), is located downstream of Cowles Bog east of Mineral Springs Road. The first sample was taken west of Mineral Spring Road. Samples from site 1 reflect water quality in the western tributary to Dune Creek just as it leaves Cowles Bog. Testing the water quality in the western and eastern tributaries allowed comparisons to be made and helped the Steering Committee prioritize areas of concern. The site initially selected was too far west and in stagnant water. The decision was made by Steering Committee members to move the sampling location east. At the new site, conditions are more comparable to remaining sites that have flowing water and a stream type habitat. During the extremely dry conditions of the summer of 2005, many sampling sites became too dry to sample including site 1 shown above in Figure 14.

Water quality at Cowles Bog Outlet (Site 1)

In general, Cowles Bog Outlet water quality was within an acceptable range for streams that receive most of their drainage from wetland complexes. Stagnant or slow-flowing water conditions occurred within this stream during all four sampling events. (The stream was stagnant during two of the four events including the 2004 base flow event and the 2005 storm event.) During both base flow and storm flow conditions, none of the samples violated the Indiana state standards for temperature, pH, conductivity, chloride, nitrate-nitrogen, or ammonia-nitrogen concentrations. However, dissolved oxygen concentrations were well below the state standard during all four sampling events (Appendix H: Figure H2). When the water was flowing, dissolved oxygen concentrations ranged from 0.6 mg/L during the 2004 storm event to 1.15 mg/L during the 2005 base flow event; when the water was stagnant, dissolved oxygen concentrations ranged from 0.3 mg/L (2004 base flow) to 3.35 mg/L (2005 storm event). Overall, dissolved oxygen saturation ranged from 3 to 35% during the four sampling events. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. Low dissolved oxygen concentrations are to be expected in areas downstream of a wetland complex. Decomposition is one of the primary activities that occur within a wetland. The process of decomposition results in bacteria utilizing available oxygen to break down organic materials and chemicals into more soluble forms. As decomposition occurs, oxygen levels are reduced. The slow flow or even stagnant conditions which occur within the Cowles Bog Outlet do not allow for entrainment, or the dissolution of oxygen from the atmosphere into the water, to occur. Likewise, photosynthesis is limited within the water of the Cowles Bog Outlet itself due to a predominance of overhanging vegetation shading out the stream, thereby limiting the production of dissolved oxygen within the water column.

The 2004 and 2005 sampling of the Cowles Bog Outlet highlighted a few areas of concern. First, the stream exhibited *E. coli* concentrations above the Indiana state standard of 235 colony forming units (CFU)/100 mL during three of the four sampling events (2004 base and storm flow and 2005 storm flow). *E. coli* concentrations in excess of the state standard ranged from 560 CFU /100 mL during the 2005 storm event (stagnant) to 1,900 CFU /100 mL during the 2004 base flow event (stagnant), which was the highest *E. coli* concentration measured within the Dunes Creek watershed streams (Appendix H: Figure H12). Also of concern are the Cowles Bog Outlet's orthophosphate and total phosphorus concentrations (Appendix H: Figures H9 and H11, respectively). Indiana does not have a state standard for phosphorus concentrations; however, total phosphorus concentrations during three of the four sampling events (2004 base and storm and 2005 base) were above the concentration recommended by the Ohio EPA to protect aquatic life. (In a study correlating nutrient concentrations to biotic health, the Ohio EPA (1999) recommended keeping total phosphorus concentrations below 0.1 mg/L in most streams to protect aquatic life.) Orthophosphate concentrations were also elevated within the Cowles Bog Outlet accounting for 15 to 80% of the total phosphorus concentration (Appendix H: Figure H10). Additionally, total suspended solids (TSS) concentrations were typically higher in the Cowles Bog Outlet than in any of the other watershed streams (Appendix H: Figure H6). TSS concentrations ranged from 8.5 mg/L during the 2004 base flow sampling event to 430 mg/L during the 2005 base flow event. Suspended and particulate material present within the stream water is not uncommon in streams that receive a majority of their water from wetland complexes. However, the extremely elevated concentration present during the 2005 base flow sampling event is of concern as it exceeds 80 mg/L; Waters (1995)). This concentration is generally considered the threshold value above which impaired biotic communities are likely to occur.

On a more positive note, the Cowles Bog Outlet possessed the lowest nitrate-nitrogen concentration of any of the streams sampled (Appendix H: Figure H7). The concentration is well below the level the Ohio EPA determined necessary for the protection of aquatic biota (0.28 mg/L). Finally, when compared with other streams, the Cowles Bog Outlet exhibited lower pollutant loads relative to other streams during the four sampling events (Appendix H: Figures H13 to H18).

The evaluation of the Cowles Bog Outlet's physical habitat indicated that the stream fell below the threshold at which IDEM typically considers a stream to be "partially supportive" of its aquatic life use designation. Likewise, the biological community assessment indicated that the stream fell short of the threshold level set by IDEM for the ditch's aquatic life use designation. The Cowles Bog Outlet received the second lowest habitat score of any of the streams in the Dunes Creek watershed (Table H6). The stream rated a QHEI score of 41 and was limited by instream cover, poor substrate, low gradient, and lack of pool and riffle complexes. However, as this stream drains a wetland, the gradient score cannot be expected to change over time. Likewise, pool and riffle complexes will never naturally develop in the sand and muck bottom stream. These factors should be taken into account when setting habitat goals within this stream. During 2005 the stream received an mIBI score of 1.0 which ties this site with one other site for the fourth best of the Dunes Creek watershed (Appendix H: Table H5). This score places the stream below the "non-supporting"-"partially supporting" threshold boundary. This score also places the stream in the severely impaired category based on IDEM's criteria. When compared with a reference stream located in the headwaters of Coffee Creek (Site 6 as sampled during the Coffee Creek Watershed Management Plan (JFNew, 2003)) using the Rapid Bioassessment Protocols (RBP) (Plafkin et al., 1989), the stream still rates as severely impaired scoring only 25% of the total possible points compared with the biota present in Coffee Creek (JFNew, 2003).

Figure 15. Sampling site 2

(August 5, 2004)

2. Site 2 (Figure 15) is located in the tributary coming from the west in the Indiana Dunes State Park before it enters the main stem of Dunes Creek. Samples from site 2 reflect water quality in the western tributary after Dunes Creek has passed through residential areas to the east of Cowles Bog. This site is located just before the western tributary enters the main stem of Dunes Creek. The changes in sampling results will reflect the changes in water quality between Cowles Bog and the main stem of Dunes Creek.

Water Quality in East Tributary (Site 2)
For many of the parameters measured, the East Tributary exhibited relatively good water quality. None of the temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, or ammonia-nitrogen measurements violated Indiana state water quality standards. However, dissolved oxygen was low during the four water quality assessment events exhibiting undersaturated conditions ranging from 52 to 78% saturated during the 2005 storm flow event and the 2005 base flow sampling event, respectively (Appendix H: Table H1). When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. As flow through the East Tributary is relatively slow, it is likely that low saturation results from a combination of both of these factors. Additionally, the East Tributary possessed the lowest total phosphorus concentrations of any of the streams during three of the four sampling events (Appendix H: Figure H11). Total phosphorus concentrations exceeded the level determined by the Ohio EPA (1999) to be necessary for the protection of aquatic biota during only the 2005 storm event sampling (0.110 mg/L). Concentrations were generally lower than the level at which streams are rated as eutrophic or highly productive (0.075 mg/L; Dodd et al., 1998). Finally, the East Tributary received the second highest QHEI score (55) and the second highest mIBI scores (2.4 in 2004 and 1.2 in 2005) of any of the sites in the Dunes Creek watershed (Appendix H: Tables A6 and A5, respectively). IDEM considers streams with QHEI scores greater than 51 partially-supportive for their aquatic life use designation. mIBI scores less than 2 are considered non-supportive and scores between 2 and 4 to be partially supportive of their aquatic life designated use. Based on these data, the East Tributary would likely be rated as non-supporting to partially supporting of its aquatic life use designation.

The East Tributary also exhibited a few characteristics of concern. *E. coli* concentrations during all four sampling efforts exceeded the state standard of 235 CFU/100mL (Appendix H: Table H2). *E. coli* concentrations measured during the current assessment ranged from 360 CFU /100 mL during the 2004 base flow assessment to 800 CFU /100 mL during the 2004 storm event (Appendix H: Figure H12). While exceeding the state standard is of concern, the concern should be tempered by the fact that the *E. coli* concentrations observed in the East Tributary during three of the four assessments were below the average *E. coli* concentration typically found in Indiana streams. (In reviewing ten years worth of data from Indiana fixed monitoring stations, White (unpublished) found the average *E. coli* concentration in Indiana streams to be approximately 650 CFU /100 mL.) The East Tributary also possessed the second highest nitrate-nitrogen, ammonia-nitrogen, and total suspended solids loading rates during the 2004 storm event, the second highest *E. coli* loading rate during the 2005 base flow event, and the third highest nitrate-nitrogen, ammonia-nitrogen, and *E. coli* loading rates during the 2004 base flow event (Appendix H: Figures H13 to H18). **This suggests that *E. coli* and nutrient reduction techniques should be the focus when targeting management actions in this subwatershed.**

Figure 16. Sampling site 3

(August 5, 2004)

3. Site 3 (Figure 16) is located just before Dunes Creek enters the culvert that goes under the parking lot in the Indiana Dunes State Park. Samples from site 3 reflect water quality in the main stem of Dunes Creek after the east and west tributaries have converged and the Creek is just about to enter the culvert that goes under the parking lot in the Indiana Dunes State Park.

Figure 17. Sampling site 4

(June 14, 2004)

4. Site 4 (Figure 17) is located just after Dunes Creek leaves the culvert at the Indiana Dunes State Park and enters Lake

Michigan. Samples from site 4 reflect water quality just after Dunes Creek leaves the culvert at the Indiana Dunes State Park and enters Lake Michigan. Any changes in sampling results between site 3 and 4 reflect changes in water quality that take place when the water travels underground in the culvert that could be a result of inflow to the culvert or interaction with the culvert itself.

Water Quality in Dunes Creek mainstem (Sites 3 and 4)
The Dunes Creek mainstem was sampled at two locations during the project. These sites are located within the natural stream corridor upstream of the parking lot and culvert within the Indiana Dunes State Park (Site 3) and downstream of the parking lot and culvert where the stream flows through the beach at its outlet to Lake Michigan (Site 4). During the 2004 storm flow event, samples collected from the Dunes Creek outlet (Site 4) were actually Lake Michigan water as strong wind and wave action pushed Lake Michigan water back into the outlet and culvert within the beach. As such, this data is not representative of Dunes Creek water chemistry and will not be included as part of this water quality discussion. The water chemistry conditions within the two reaches of Dunes Creek are fairly similar. None of the temperature, dissolved oxygen, pH, nitrate-nitrogen, or ammonia-nitrogen measurements taken in Dunes Creek during either of the storm events or under base flow conditions violated Indiana state standards. Concentrations for each parameter were typically similar between the upstream and downstream reaches; no statistically significant difference could be determined for any of the parameters measured within each site during each assessment. Overall, nutrient concentrations were relatively low within the Dunes Creek mainstem. None of the nitrate-nitrogen and only one of the four total phosphorus concentrations (2005 storm event) exceeded the level determined by the Ohio EPA (0.1 mg/L for total phosphorus and 0.26 mg/L for nitrate-nitrogen; 1999) for the protection of aquatic biota (Appendix H: Figures H7 and H10, respectively).

Characteristics of concern within the Dunes Creek mainstem include elevated conductivity and chloride conditions during the 2005 storm event; high *E. coli* concentrations; elevated loading rates during base and storm flows; and poor macroinvertebrate communities. Conductivity and chloride concentrations exceeded the state standard (1000 to 1360 μmhos for conductivity; 230 mg/L for chloride) during the 2005 storm event sample (Appendix H: Figures H3 and H4). Of the samples collected during the 2005 storm event in excess of the state standard, the concentrations present in the Dunes Creek mainstem were the lowest. This suggests that the dissolved solids and chlorides likely originated from upstream reaches and that dissolved solids concentrations were diluted as water moved downstream. Dunes Creek *E. coli* concentrations exceeded the state standard of 235 CFU /100 mL (Appendix H: Figure H12) during three of the four sampling events. The upstream reach (Site 3) possessed *E. coli* concentrations that ranged from 220 CFU /100 mL during the 2005 base flow event to 920 CFU /100 mL during the 2005 storm flow event, while the downstream reach (Site 4) contained *E. coli* concentrations which ranged from 190 CFU /100 mL during the 2004 base flow event to 1,100 CFU /100 mL during the 2005 storm event. *E. coli* concentrations were typically higher in the downstream site (Site 4) than those measured in the site upstream of the culvert (Site 3). Furthermore, the mainstem of Dunes Creek possessed the highest and second highest loading rates for all parameters during all sampling events except for the downstream site during the 2004 storm event (Lake Michigan water) and for ammonia-nitrogen and total suspended solids loading rates during the 2005 storm event (Appendix H: Figures H13 to H18). Typically, the downstream reach (Site 4) possessed higher loading rates for each parameter than those present at the upstream reach (Site 3). When drainage area is normalized, the Dunes Creek mainstem had the highest ammonia-nitrogen areal loading rate during the 2004 base flow event, the highest nitrate-nitrogen areal loading rate and second highest orthophosphorus (tied with Site 3) and total phosphorus loading rates during the 2005 base flow event, at the downstream reach (Site 4) (Areal loading rate is the pollutant-loading rate divided by drainage area. This allows for a comparison of loading rates in different sized drainages. Normally, pollutant-loading rates in larger drainages are expected to be higher than the pollutant loading rates in smaller drainages). The upstream reach (Site 3) possessed the highest ammonia-nitrogen and nitrate-nitrogen areal loading rates during the 2004 storm event, the highest *E. coli* areal loading rate and the second highest total phosphorus and ammonia-nitrogen areal loading rates during the 2004 base flow event, and the second highest nitrate-nitrogen and orthophosphorus (tied with Site 4) areal loading rates during the 2005 base flow event.

Finally, the highest QHEI score (63) of any of the Dunes Creek sites was at the upstream reach (Site 3), while the downstream reach possessed the fourth lowest QHEI score (48) of the Dunes Creek watershed streams (Appendix H: Table H6). IDEM considers streams with QHEI scores greater than 51 to be partially supportive of its aquatic life use designation and scores under 51 to be non-supportive of its aquatic life beneficial use. The downstream reach of Dunes Creek is primarily a highly modified feature (culvert) so its low QHEI score is expected. The biotic communities present within Dunes Creek reflect the limited habitat present at these two sites. The mIBI scores suggest that Dunes Creek's macroinvertebrate community is moderately to severely impaired, scoring a 2.4 at the upstream reach during 2004 and a 1.0 and 2.0 at the upstream and downstream reaches during the 2005 assessment, respectively (Appendix H: Table H5). These scores suggest that the biotic communities present in Dunes Creek's mainstem do not meet their aquatic life use designation.

Figure 18. Sampling site 5

(August 5, 2004)

5. Site 5 (Figure 18) is located in the tributary from the Great Marsh just before the marsh connects with Dunes Creek. Samples from site 5 reflect water quality in the tributary from the Great Marsh just before the marsh connects with Dunes Creek. Initially site 5 was considered as a possible reference site for the watershed. The area remains undisturbed and natural, but it should be noted that flow is low compared to other sites located in the main stem of the stream and the water at this site is draining directly from the wetland complex.

Water quality in the Great Marsh Tributary (Site 5)

Like the Cowles Bog Outlet, water quality within the Great Marsh Tributary was within the expected range for streams that receive most of their drainage from wetland complexes. Stagnant or slow-flowing water conditions occurred within this stream during all four sampling events. (The stream was stagnant during one of the four events, the 2005 storm event.) During both base flow and storm flow conditions, none of the samples violated the Indiana state standards for temperature, pH, conductivity, chloride, nitrate-nitrogen, or ammonia-nitrogen concentrations. However, dissolved oxygen concentrations were well below the state standard during all four sampling events (Appendix H: Table H2). Dissolved oxygen concentrations ranged from 0.7 mg/L during the 2004 base flow event to 4.12 mg/L during the 2005 storm flow event (stagnant water). Overall, dissolved oxygen saturation ranged from 7 to 45% during the four sampling events.

The 2004 and 2005 sampling of the Great Marsh Tributary highlighted a few additional areas of concern. First, the stream exhibited *E. coli* concentrations above the Indiana state standard of 235 CFU /100 mL during two of the four sampling events (2004 and 2005 storm flow; Appendix H: Figure H12). During the 2004 storm event, *E. coli* concentrations in excess of the state standard ranged from 360 CFU /100 mL to 1,500 CFU /100 mL during the 2005 base flow event (stagnant). Also of concern are the Great Marsh Tributary's total phosphorus concentrations, which were above the concentration recommended by the Ohio EPA to protect aquatic life during the two 2005 sampling events (Appendix H: Figure H11). Concentrations also exceeded the level at which Dodd et al. (1998) indicate eutrophic conditions occur during the 2004 storm event. Finally, the Great Marsh Tributary possessed the highest total suspended solids areal loading rate during the 2004 base flow event, the second highest total suspended solids areal loading rate during the 2005 base flow event, and the second highest *E. coli* loading rate during the 2004 base flow event.

The evaluation of the Great Marsh Tributary's physical habitat indicated that the stream was below the threshold at which IDEM typically considers a stream to be "partially supportive" of its aquatic life use designation. Likewise, the biological community assessment indicated that the stream fell short of the threshold level set by IDEM for the stream's aquatic life use designation. The Great Marsh Tributary received the second lowest habitat score of any of the sites in the Dunes Creek watershed (Table H6). The stream rated a QHEI score of 41 and was limited by instream cover, poor substrate, low gradient, and lack of pool and riffle complexes. However, as this stream drains a wetland, the gradient score cannot be expected to change over time. **Likewise, pool and riffle complexes will never naturally develop in this sand and muck bottom stream. These factors should be taken into account when setting habitat goals within this stream.** During 2005, the stream received an mIBI score of 0.8, which is the third lowest score calculated for the Dunes Creek watershed streams (Appendix H: Table H5). This score places the stream below the "non-supporting"-"partially supporting" threshold boundary. This score also places the stream in the severely impaired category based on IDEM's criteria. When compared with a reference stream located in the headwaters of Coffee Creek (Site 6 as sampled during the Coffee Creek Watershed Management Plan (JFNew, 2003)) using the Rapid Bioassessment Protocols (Plafkin et al., 1989), the stream still rates as severely impaired scoring only 25% of the total possible points compared with the biota present in Coffee Creek.

Figure 19. Sampling site 6

(March 4, 2004)

6. Site 6 (Figure 19) is located to the east of a residential area near Hawleywood Road. Samples from site 6 reflect water quality in Dunes Creek as it travels through the residential area near Hawleywood Road. This area has many old homes and some Indiana Dunes National Lakeshore lease back properties. Improperly maintained or outdated septic systems could be contributing to a decrease in water quality.

Figure 20. Sampling site 7

(August 5, 2004)

7. Site 7 (Figure 20) is located just north of U.S. Highway 20 downstream from commercial properties along U.S. Highway 20. Samples from site 7 reflect water quality in the eastern tributary of Dunes Creek north of U.S. Highway 20. This sampling site is downstream from commercial properties along U.S. Highway 20 and captures runoff from the properties that drain into roadside ditches and then into Dunes Creek.

Figure 21. Sampling site 8

(August 5, 2004)

8. Site 8 (Figure 21) is located in the eastern tributary of Dunes Creek just south of U.S. Highway 20. Samples from site 8 reflect water quality upstream of businesses along U.S. Highway 20, but downstream from residential and commercial areas in the Town of Porter. The differences in sampling results from site 7 and site 8 reflect effects on water quality from the ditches that runs in front of businesses along U.S. Highway 20 and flows into the eastern tributary.

Water Quality at Munson Ditch and downstream (Sites 6, 7, 8 above; Site B,below)

The mainstem of Munson Ditch was sampled at three locations during all four assessments (Sites 6 to 8) and once at Site B, where Munson Ditch crosses U.S. Highway 12, during the 2005 storm event. Although temperature, pH, nitrate-nitrogen, and ammonia-nitrogen concentrations measured in the Munson Ditch reaches did not violate any Indiana standards, Munson Ditch exhibited some of the poorest water quality observed in any of the Dunes Creek watershed streams. The ditch possessed, conductivity, chloride, and *E. coli* concentrations that routinely exceeded the state standards. Dissolved oxygen concentrations during the 2004 and 2005 base flow events at Sites 6 to 8 were below the Indiana state standard (Appendix H: Figure H2). Concentrations ranged from 0.06 mg/L in Munson Ditch adjacent to Hawleywood Road (Site 6) during the 2005 base flow event to 2.8 mg/L both upstream and downstream of U.S. Highway 20 (Sites 7 and 8) during the 2005 base flow event. Conductivity concentrations ranged from 1,605 μmhos in Munson Ditch upstream of U.S. Highway 20 (Site 8) during 2004 base flow event (stagnant) to greater than 3,999 μmhos in Munson Ditch downstream of U.S. Highway 20 (Site 7) during the 2004 base flow event (Appendix H: Figure H4). Conductivity concentrations were generally higher in Munson Ditch downstream of U.S. Highway 20 (Site 7) than at any of the other sites. The only exception to this occurred during the 2005 storm event when the reach adjacent to Hawleywood Road (Site 6) possessed the highest conductivity concentration. Chloride concentrations follow a similar pattern with the reach downstream of U.S. Highway 20 (Site 7) possessing the highest chloride concentration of the four reaches (Appendix H: Figure H5) during the 2005 storm flow event. Chloride concentrations ranged from 270 mg/L in Munson Ditch upstream of U.S. Highway 20 during the 2005 base flow (stagnant) to 3,700 mg/L in Munson Ditch downstream of U.S. Highway 20 (Site 7) during the 2005 base flow event. *E. coli* concentrations exceeded the state standard at all three sites during the 2004 storm flow event, at Hawleywood Road (Site 6) and upstream of U.S. Highway 20 (Site 8) during the 2005 base flow event (stagnant), and at Hawleywood Road (Site 6), downstream of U.S. Highway 20 (Site 7), and at the ditch's crossing of U.S. Highway 12 (Site B) during the 2005 storm flow event. (Appendix H: Figure H12).

Phosphorus concentrations were also elevated within Munson Ditch. Phosphorus concentrations exceeded the levels at which Dodd et al. (1998) determined eutrophic or highly productive conditions occur during all four assessments at all three sites and at U.S. Highway 12 (Site B) during the 2005 storm event (Appendix H: Figure H11). Furthermore, total phosphorus concentrations exceeded levels determined by the Ohio EPA (1999) to impair aquatic biota at all sites during all assessments except downstream of U.S. Highway 20 (Site 7) during the 2004 base flow event (stagnant). At all but one site, a majority of the phosphorus measured in the stream was in its soluble form (Appendix H: Figure H10) during all of the assessments. Particulate phosphorus exceeded 50% of the total phosphorus concentration on only one occasion: in Munson Ditch adjacent to Hawleywood Road (Site 6) during the 2005 storm event. Elevated particulate phosphorus levels in streams following storm events are expected and are typically indicative of soil loss via erosion since particulate phosphorus is typically adsorbed to soil particles.

Munson Ditch also possessed elevated loading rates compared with other watershed sites (Appendix H: Figures H13 to H18). During the 2004 base flow event, Munson Ditch downstream of U.S. Highway 20 (Site 7) possessed the second highest orthophosphate and total phosphorus loading rates, while the same sites contained the highest ammonia-nitrogen and total suspended solids and third highest orthophosphate and total phosphorus loading rates during the 2005 base flow event. When normalized for area, Munson Ditch upstream of U.S. Highway 20 (Site 8) possessed the highest orthophosphate, total phosphorus and *E. coli* areal loading rates during the 2004 base flow and the highest nitrate-nitrogen and second highest ammonia-nitrogen and total phosphorus areal loading rates during the 2005 storm event sampling. Munson Ditch downstream of U.S. Highway 20 (Site 7) possessed the highest areal loading rates for ammonia-nitrogen, orthophosphate, total phosphorus, and total suspended solids during the 2005 base flow event, the highest total suspended solids areal loading rate during the 2004 storm event, the second highest *E. coli* areal loading rate during the 2005 base flow event, and the second highest orthophosphate and total phosphorus areal loading rate during the 2004 storm flow event. Munson Ditch at Hawleywood Road (Site 6) also possessed the highest areal loading rates for total suspended solids and *E. coli* during the 2004 storm event and ammonia-nitrogen during the 2005 storm event and the second highest ammonia-nitrogen and nitrate-nitrogen loading rates during the 2004 storm event.

Finally, the biological and physical habitat assessments indicated impairment of these components of the ecosystem along the length of Munson Ditch. Munson Ditch upstream (Site 8) and downstream (Site 7) of U.S. Highway 20 received the lowest QHEI scores of any of the watershed streams (41 and 26 points, respectively; (Appendix H: Table H6). Poor substrate, limited instream cover, a lack of channel development, limited riparian vegetation and cover, and poor pool and riffle complex development limited habitat available at these sites. Conversely, Munson Ditch adjacent to

Hawleywood Road (Site 6) possessed the third highest QHEI score (51). This site possessed better substrate components, higher quality channel development, better riparian cover, and deeper pools than those present upstream. Scores from all three sites suggest that Munson Ditch is non-supporting of its aquatic life use designation based on habitat scores. All of the mIBI scores for the macroinvertebrate communities present in the three reaches of Munson Ditch during the 2005 assessment indicate that the biotic communities within the overall reach are severely impaired (Appendix H: Table H5). All of these scores suggest that the stream is non-supporting of its aquatic life use designation.

Figure 22. Sampling site A

4 volunteers and JFNew (June 21, 2005)

Sampling site A (Figure 22) is located along U.S. Highway 20 west of Interstate 49 and just north of Munson Ditch. This site was added because of the possibility that the waterpark located within the watershed is discharging into ditches that flow into Dunes Creek. Local residents have complained of a strong chlorine smell. The site was added in 2005 to help the Steering Committee further identify critical areas.

Figure 23. Sampling site B

(October 17, 2005)

B. Sampling Site B (Figure 23) is located in the eastern tributary as it crosses US 12. This site was added to aid Steering Committee members in further understanding what could be causing high levels of *E. coli* at site 6 behind the residential areas. Sampling data from this site reflect any problematic septic systems north of site 6. This information helped the Steering Committee focus implementation efforts in the appropriate area.

Figure 24. Sampling site E

(February 10, 2005)

E. Sampling site E (Figure 24) is located along Interstate 49 in a regulated drain called Munson Ditch located in the headwaters of Dunes Creek upstream from site 8. This site was added to help identify problem areas downstream from site A and establish baseline information for the Porter County Visitor Center site (just behind the stand of trees in the above photo). The Creek runs through the southern corner of the site.

Munson Ditch Headwaters (Sites A and E)

The headwaters of Munson Ditch were sampled at two locations including the ditch crossing at U.S. Highway 12 and at Interstate 49 during the 2005 storm event. Sampling results from these locations indicate several impairment issues within the headwaters of Munson Ditch. Conductivity and chloride concentrations exceeded the Indiana state standards at both locations (Appendix H: Table H1). Conductivity concentrations ranged from 1,330 µmhos at U.S. Highway 12 to 1,950 µmhos at Interstate 49, while chloride concentrations ranged from 340 mg/L at U.S. Highway 12 to 460 mg/L at Interstate 49. Dissolved oxygen concentrations were also low within the headwaters of Munson Ditch; however, they were below the Indiana state standard at only one site, which is located east of the ditch's intersection with Waverly Road. Total phosphorus concentrations exceeded the level at which the Ohio EPA indicates that biotic impairment occurs (Appendix H: Table H2). Orthophosphate concentrations were also elevated at the Interstate 49 stream crossing accounting for more than half of the total phosphorus present within the Munson Ditch headwaters at this location. *E. coli* concentrations exceeded the Indiana state standard at all three sites during this assessment; however, the concentrations were below the median concentration found in Indiana streams (650 CFU /100 mL).

When compared with other sites in the watershed, the Munson Ditch headwaters do not possess elevated loading rates; however, when the loading rates are normalized for watershed area, these stream reaches possess some of the highest areal loading rates. Munson Ditch at Interstate 49 (Site E) possesses the highest orthophosphate and total phosphorus and *E. coli* areal loading rates and the second highest nitrate-nitrogen areal loading rate during the 2005 storm flow assessment. Munson Ditch east of Waverly Road (Site A) possessed the highest total suspended solids areal loading rate and the second highest total phosphorus and *E. coli* areal loading rates during the 2005 storm event. **This suggests that controlling sediment and nutrient loading within this portion of the Dunes Creek watershed will likely improve water quality in downstream reaches.**

4.0 Water Quality Causes/Stressors and Sources

Below is a list of problem causes/stressors and sources in the Dunes Creek watershed identified and prioritized by the stakeholders, public meeting participants, and Steering Committee members using available data. Goals related to causes/stressors are listed in the tables located in section 5.

Table 2. Dunes Creek water quality impairment causes/stressors, sources, and basis for concern

Cause/ Stressor	Potential Source	Goal (see section 6)	Activity	Approach	Basis/Evidence
Pathogens	Wastewater disposal: onsite wastewater systems and inappropriate waste disposal. *Human sewage from sources such as individual septic system seepage and disposal from trains.*	2,3	Remediate failing on-site sewage disposal systems, Improve O&M	Education, capacity building	Suspected failing septic systems indicated by high *E. coli* levels (303d impairment). Research (Hardy 1984) confirms that this is a concern. Confirmed by water quality data.
Pathogens	Agriculture: Livestock. *Animal waste from agricultural areas in storm water runoff.*	2	Reduce ag. sources of *E.coli*	Promote new technologies for watering; manure management alternatives, and livestock exclusion	Suspected runoff from animal farms indicated by high *E. coli* levels (303d impairment) and visual inspection.
Pathogens	Natural Sources. *Wild animal waste in storm water runoff.*	3	Educate the decision maker & public on the importance of not feeding wildlife	Education	Suspected runoff of wild animal waste indicated by high *E. coli* levels (303d impairment).
Pathogens	Urban runoff: *Domestic animal waste in storm water runoff.*	3	Promote proper management of pet waste	Media campaign	Suspected runoff of pet animal waste indicated by high *E. coli* levels (303d impairment).
Pathogens/ point source	Urban runoff: Illicit connections/illegal hook-ups/dry weather flows. *Straight pipe sewage discharges and State Park sewage treatment facility discharge.*	Coordinate w/existing regulatory programs	Promote compliance	While not specific goal, watershed mngmt. plan assumes NPDES Permits will be complied with	Visual inspection of State Park sewage treatment facility revealed damaged tiles in leach field. No evidence found of straight pipe discharge.

Siltation	Urban runoff: channel erosion and sedimentation. *Increased volume and flow due to altered hydrology (ditches and regulated drains, filled wetlands, and impervious surfaces).*	1,3,4	Treat storm water, implement BMPs, reduce stormwater source areas, reduce construction impacts, etc.		Suspected erosion along Dunes Creek confirmed by visual inspection (Figure 26).
Siltation	Construction: highway, road, bridge, and land development. *Sediment from existing and new residential developments.*	3, Coordinate w/ existing regulatory programs	Promote compliance	While not specific goal, the watershed management plan assumes all NPDES Permits will be complied with	Suspected high levels of sediment directly downstream from development sites, confirmed by visual inspection (Figures 27 and 28).
Salinity/TDS/ Chlorides	Salt storage site and urban runoff. *Runoff from INDOT facility, roadways, parking lots, and railroads*.	3		CZARA	Suspected high levels of road salt from INDOT facility and roadways. High conductivity and chlorides confirmed by water sampling.
Salinity/TDS/ Chlorides-point source	Chlorine discharge from water park	5, Coordinate w/existing regulatory programs	Promote compliance	NPDES Permits will be complied with	Confirmed by IDEM inspection. Water park found in violation. High conductivity and chlorides confirmed by water sampling.
Oil and Grease	Urban runoff. *Runoff from roadways, parking lots, and railroads.*	1			Concern raised by participant at public meeting.
Pesticides	Agriculture: crop-related sources. *Pesticide contaminants from agricultural areas.*	1		Promote CORE4	Concern raised by participant at public meeting. Additional sampling necessary to confirm.
Pesticides	Urban runoff: other urban runoff. *Pesticide contaminants from residential areas.*	3			Concern raised by participant at public meeting. Additional sampling necessary to confirm.
Nutrients	Agriculture: crop-related sources. *Fertilizer and contaminants from agricultural areas.*	1		Promote CORE4	Visual inspection indicates that increased nutrient levels could be coming from agricultural operation (Figure 30).
Nutrients	Urban runoff:	1, 3			Concern raised by participant at public meeting. High total phosphorus confirmed by water sampling.

Flow Alteration	Hydromodification: channelization. *Ditches, regulated drains, and segment of Dunes Creek channeled under IDSP parking lot.*	4			Suspected increase in *E coli*, sediment, and other pollutant loads related to ditches, drains, and channelization; extent of ditching confirmed by R. Whitman.
Flow Alteration	Hydromodification: flow regulation/modification. *Filled or drained wetlands, including NIPSCO dike.*	4			Suspected increase in *E coli*, sediment, and other pollutant loads related to wetland loss throughout the watershed.
Habitat Alteration	Habitat modification: removal of riparian vegetation and bank modification/ destabilization. *Segment of Dunes Creek channeled under IDSP parking lot and regulated drains/ditches.*	1, 3, 4			Confirmed by visual inspection and impaired biotic communities designation (Figures 33 and 34).
Cause Unknown	Urban runoff: other urban runoff. *Industrial contaminants in the surface soil on heavy industrial properties at west end of watershed and light industry on the east end.*	Coordinate w/existing regulatory programs	Promote compliance	NPDES Permits will be complied with	Suspected contamination from light industry, indicated by high conductivity levels directly downstream and visual inspection (Figure 29).
Air emissions	Atmospheric deposition of nitrogen emissions from nearby industry.	Coordinate w/existing regulatory programs	Promote compliance		Airborne particulates from nearby industry wash into the watershed. Additional sampling necessary to confirm.

4.1 Pathogens

Both Dunes Creek and Muson Ditch are listed on Indiana's draft 2006 list of impaired waterbodies for *E. coli*. These streams are listed due to exceedance of the Indiana state single day (235 CFU /100 mL) or the geometric mean standard (125 CFU /100 mL), which is calculated from five samples measured during a 30-day period. Dunes Creek was initially assessed for inclusion on the impaired waterbodies list in 2002 and found to be not supporting of its recreational use designation. This assessment was based on 1998 *E. coli* data collected by the *E. coli* Task Force through the Department of the Interior (USGS). Applying IDEM's current criteria, the waterbody is still impaired. This is based on 68% of the samples exceeding the single day standard and 44% exceeded 576 CFU/100mL (Jody Arther, personal communication). Munson Ditch's *E. coli* listing is similar to that for Dunes Creek. Munson Ditch was first added to Indiana's list of impaired waterbodies in 1998 based on data collected during previous years' assessments.

Current sampling results indicate that Dunes Creek and Munson Ditch remain impaired for recreational usage. Applying IDEM's current criteria, 71% of the samples exceeded the single day standard (Appendix H: Table H2). Sampling completed by IDEM during 2005 indicates that the impairment is still present in these streams as well.

4.1.1 Failing Septic Systems

<u>Problem statement:</u> Failing or antiquated septic systems throughout the watershed could be degrading water quality in Dunes Creek by contributing to *E. coli* levels.

Several Dunes Creek watershed water quality studies have been conducted in the Dunes Creek watershed in the past few decades. During the period from 1978 – 1980, several sites on Munson Ditch north of US 12 were sampled during both high flow and low flow conditions (Hardy, 1984). During high flow in November 1978, dissolved solids concentrations were high at the site just north of US12 "…primarily because of high concentrations of sodium and chloride. Seepage from residential septic systems and runoff from a road salt storage area were probably the sources of sodium and chloride." Also, high concentrations of nitrite plus nitrate at that site "…suggest that the seepage from non-point sources such as septic systems and fertilized lawns in the upstream residential areas significantly increase nitrite in Dunes Creek."

Between June 1993 and May 1994 three creeks draining the Great Marsh were sampled for water quality and aquatic life, including diatoms and macroinvertebrates (Stewart et al. 1997). The purpose of the research was to provide biological and chemical information on the three creeks and document land use effects on water quality, bacteria densities, and the ecology of the streams. The sample site on Munson Ditch was just north of US 12 where the Calumet bike trail crosses the stream. The site had high pH, turbidity, phosphates, specific conductance, total hardness, chloride, and nitrate. It had the highest readings of all sites sampled in all three creeks for nitrate and the second highest for chloride. **The report stated that " …the high nitrate concentrations at site DC6 were probably due to non-point pollution sources in the surrounding residential areas such as septic systems and fertilized lawns."**

The sandy soils that predominate in the Dunes Creek watershed are not optimal for septic system absorption fields. There are several residential areas located throughout the Dunes Creek watershed that are using septic systems that were installed many decades ago. Mound systems are one way to overcome soil suitability limitations and have been installed in areas of Dunes Creek, although some sites simply are not suitable for any septic system. Figure 25 shows a map of soil suitability for septic systems in the Dunes Creek watershed.

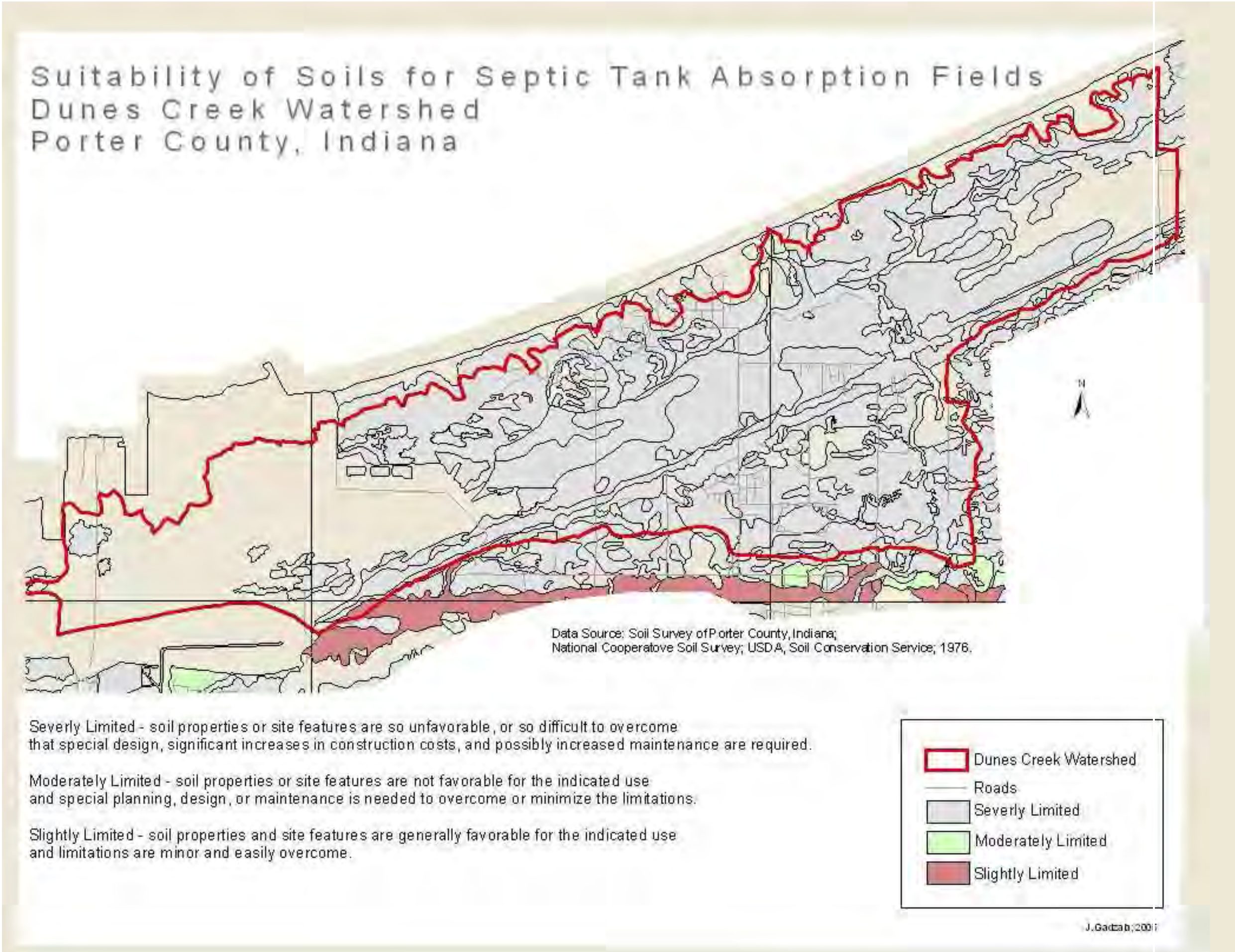


Figure 25. Suitability of soils for septic tank absorption fields

(data source: Soil Survey of Porter County, 1976)

4.1.2 Agricultural Livestock Runoff

Problem statement: Runoff from livestock pastures could be degrading water quality in Dunes Creek by contributing to *E. coli* levels.

Only 6% of the watershed is agricultural. There is an opportunity to work with the small number of agricultural landowners within the watershed to minimize the effect of runoff from livestock pastures by installing riparian buffer strips.

4.1.3 Wildlife

Problem statement: Wildlife overpopulation could be degrading water quality in Dunes Creek by contributing to high *E. coli* levels.

Wildlife is a known source of *E. coli* impairments in the Dunes Creek watershed. Many animals spend time in or around water bodies within Dunes Creek. Deer, geese, seagulls, ducks, raccoons and other mammals all create potential sources of *E. coli*. Wildlife contributes to the impact of contaminated runoff from animal habitats, such as forest and cropland. This plan recognizes wildlife as an uncontrollable source of *E.coli* and will be addressed only through public education related to feeding wildlife.

4.2 Siltation

Problem statement: Wetland loss, ditching, and increases in impervious surfaces could be causing erosion of the stream banks and degrading water quality in Dunes Creek by causing siltation.

Based on visual inspection the flow of water through the watershed is accelerated due to wetland loss, ditching, and ever-increasing impervious surfaces. The increase in flow causes erosion of the stream banks. Such erosion has occurred within the Indiana Dunes National Lakeshore to the east of Tremont Road between U.S. Highway 12 and U.S. Highway 20.

Figure 26. Dunes Creek channel erosion (2005)

Sedimentation and channel erosion in Dunes Creek east of Tremont Road between U.S. Highway 12 and U.S. Highway 20 are shown in Figure 26. Installing appropriate best management practices (BMPs) and restoring natural hydrology upstream could minimize impacts to stream channels (Goals 1 and 4, Section 6).

Figure 27. New development site in Dunes Creek watershed (2004)

Figure 28. Sediment from new development site enters Dunes Creek (2004)

High levels of sediment shown in Figures 27 and 28 wash into Dunes Creek from development site located on Wagner Road. Proper installation of appropriate BMPs for construction sites could minimize impact of development on water quality (Goals 1 and 3, Section 6)

Figure 29. Sediment from light industry (2004)

Sediment from light industrial operation and a parking lot is carried onto U.S. Highway 20 by truck and car traffic. Sediment is then carried into roadside ditches that connect to Dunes Creek. Proper installation of appropriate BMPs could minimize impact of development on water quality (Goals 1 and 3, Section 6)

4.3 Salinity/TSS/Chlorides

Problem statement: Runoff from roads that carry road salt could be degrading water quality in Dunes Creek by contributing to elevated levels of chloride and high conductivity.

Road salts are common constituents in stormwater runoff during the winter throughout the Midwest, since various forms of salt are applied to roads for controlling icy, slippery road conditions. In the Dunes Creek watershed, high levels of road salt were noted in water near the roadways and around the Indiana Department of Transportation facility where road salt is stored.

4.4 Nutrients

Problem statement: Runoff from farm fields and lawns could be degrading water quality in Dunes Creek by contributing to elevated levels of nutrients.

Figure 30. Agricultural operation (2004)

High levels of nutrients could be coming from the agricultural operations within the watershed. Impact of the agricultural operations could be lessened by installation of riparian buffer strips (Goals 1 and 3, Section 6).

4.5 Flow and Habitat Alteration

Problem statement: Altered hydrology and habitat are contributing to the impairment of the biotic community and water quality degradation in Dunes Creek by causing water to move too quickly, elevating its temperature, and hindering the natural filtering process provided by wetlands.

Altered hydrology as a result of wetland loss, impervious surfaces, and ditching throughout the watershed contributes to pollutant loads. Extensive man-made alterations to natural hydrology exist throughout the watershed and cause water to move too quickly into Dunes Creek and subsequently into Lake Michigan. The extent of ditching is confirmed by research provided by R. Whitman. The natural filtering process provided by wetlands is limited and water quality is compromised. "…ditching of the stream, increased drainage, and subsequent loss of wetlands may account for the chronically high *E. coli* levels observed." (Whitman et al., 1999-2000 data).

Man-made alterations exist watershed-wide. Dunes Creek was once part of the larger marsh ecosystem adjacent to the Lake Michigan shoreline. The Great Marsh was drained and ditched for development in the early 20th century. Dunes Creek has been drastically channelized and modified from its natural state. For example, it currently enters a culvert and travels underground through the Indiana Dunes State Park's parking lot (Figure 34) and flows into Lake Michigan through a culvert (Figure 33). Another example is the dike along the west end of Cowles Bog constructed by NIPSCO (Figure 3).

4.6 Causes Unknown

Problem statement: Storm water runoff and airborne particulates from industry within or immediately adjacent to the watershed could contain pollutants that wash into Dunes Creek and degrade water quality. There are industrial areas located at the west and east ends of the watershed that could be impacting water quality (e.g., power plant, recycling and trucking businesses, and steel mills).

Dunes Creek and Munson Ditch are both on Indiana's list of impaired waterbodies for impaired biotic communities. The 1986-1987 305(b) report details Dunes Creek as fully supporting but threatened for aquatic life use (IDEM, 1988). The report indicates that this is an evaluated assessment, meaning that it was based on data collected in other streams similar to Dunes Creek that possesses stressors similar to those present in Dunes Creek at the time rather than data from Dunes Creek itself. The 1990-1991 305(b) report indicates that a monitoring assessment was completed at Dunes Creek; however, IDEM's database does not contain any biological data for this or any other assessment (Jody Arthur, personal communication).

Based on current macroinvertebrate community data and information from IDEM, the waterbodies within Dunes Creek's watershed are non-supporting for their aquatic life use designation. The impairment of this community could be caused by a number of parameters within the watershed including, but not limited to, the intermittent nature of many of the watershed's waterbodies; limited in-stream habitat (as evidenced by the QHEI scores); elevated nutrient, sediment, and pathogen concentrations; low dissolved oxygen concentrations; or elevated conductivity and chloride concentrations.

Goals 1 and 2 address pathogen, nutrient, and sediment impairments. Goal 4 stresses the importance of improving the biological communities present within Dunes Creek and Munson Ditch through habitat and riparian cover improvement. All of these should play an important part in improving biological integrity within the Dunes Creek watershed waterbodies.

Figure 31. Recycling operation (2005)

Stormwater runoff from sources within the watershed such as the recycling operation shown in Figure 31 could be minimized by working with agricultural interests, industry, and residents to identify sources and implement management measures to protect water quality (Goals 1 and 3, Section 6).

5.0 Goals, Objectives, and Implementation Priorities

The watershed management goal is to improve the water quality and habitat of Dunes Creek by reducing and preventing pollutant loads in the watershed such that, at a minimum, the creek meets Indiana water quality standards. This plan provides specific recommendations for actions (including BMPs) and educational programs to address the water quality issues impacting Dunes Creek. The implementation of these BMPs combined with the educational programs and outreach about water quality and land use will lead to lower pollutant loads. Table 3 provides a schedule of goals and objectives, including action steps, responsibility, and indicators. Implementation priorities are highlighted in blue.

Dunes Creek Watershed Model Summary

The Save the Dunes Conservation Fund contracted the Indiana Geological Survey to provide modeling support for the Dunes Creek Watershed Management Plan development process. The objectives of the modeling were to:

1. represent the hydrology, sediment, and bacterial characteristics in the drainage network, and
2. simulate how land-use and land-management changes (e.g., filling or plugging ditches) might achieve reduction of *E. coli* or other contaminants in Dunes Creek.

For this investigation, the primary constituents were water, sediment, bacteria, nitrate, nitrite, ammonia, and phosphate. The model evaluated the watershed as one drainage basin, by reach, and spatially during both base flow and storm flow conditions. Much of the modeling work was focused on the realistic representation of the conditions in the watershed, particularly the distribution of soils and land use across the watershed. Model inputs were based on data collected at long-term monitoring stations (weather inputs and basic stream discharge characterization), as well as more sporadic point measurements of stream discharge and pollutant loads during both base flows and storm flows.

The final Indiana Geological Survey report documents that during storm flow most water-quality constituents evaluated could be improved by filling ditches and/or restoring wetlands. Specifically, the model results suggest the following:

- ***E. coli*** **levels might be reduced by filling ditches and/or restoring wetlands on the east branch of Dunes Creek and/or along the west branch of Dunes Creek nearest the outlet.**
- **nitrate loading might be reduced by filling ditches and/or restoring wetlands on the west branch of Dunes Creek, or filling some of the ditches on the extreme eastern portion of the watershed.**

For more the details of the modeling effort, please see; “Final Report for Dunes Creek Watershed Model Porter County, Indiana” by Sally Letsinger, Center for Geological Data Analysis, Indiana University, Indiana Geological Survey, Bloomington, IN 47405-2208. http://igs.indiana.edu

Table 3. Dunes Creek goals and objectives schedule.

Items **highlighted in blue** are priorities for implementation.

Goal 1: Reduce nutrient and sediment loading by 20% by 2016.					
Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
Reduce storm water-related impact, particularly associated with *E. coli*, nutrient and sediment.	1. Manage stormwater runoff.	Design/conduct targeted wetland restorations. Consider impacts on infrastructure and residences. Coordinate with government agencies on wetland restoration efforts.	SDCF, INDU, USFW, property owners	1-5 years	Volume of water treated; Water quality: *E. coli*, and/or embeddedness.
	2. Implement stormwater best management practices.	Within critical areas: identify BMPs sites and willing partners. BMPs could include but are not limited to; vegetated swales, pervious paving/building materials, and bioretention islands.	SDCF, property owners	1-5 years	Number and length of buffers installed; *E. coli*, conductivity, Suspended Sediment Concentration (SSC), and/or embeddedness, water quality data.
	3. Restore natural hydrology.	Daylight the segment of Dunes Creek under the IDSP parking lot, plug ditches, restore wetlands, control exotic species , and promote 2-stage ditches.	IDNR, INDU, property owners, Drainage Board	1-5 years	Water quality and habitat improvements.

Goal 1 Continued: Reduce nutrient and sediment loading by 20% by 2016.					
Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
	4. Reduce agricultural sources of nutrient and sediment.	Work with ag. community to promote educational/incentive programs for conservation tillage, stream bank stabilization, nutrient management practices, new technologies for watering, manure management alternatives, and livestock exclusion. Promote CORE 4.	NRCS, SDCF, ISDA, SWCD, IDNR, IDEM, CTIC	1-5 years	Number of practices installed, number of conserv. plans written.
Prevent NPS pollution to the extent practicable.	5. Reduce NPS pollution at the source.	Work with agricultural interests, industry, and residents to identify sources and implement management measures.	SWCD, CTIC, NRCS, IDEM, Farmers	1-5 years	Acres with pollution prevention plans.

Goal 2: Reduce pathogen concentrations to meet the state standard by 2016.

Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
Reduce *E. coli* levels.	1. Remediate failing on-site sewage disposal systems (OSDSs). Improve O&M of non-failing OSDS's.	Identify specific sources, address violations, and pursue alternatives to OSDSs.	SDCF, health departments, INDU, property owners	1-5 years	Number of property owners engaged, systems remediated/replaced; *E. coli* water quality data.
	2. Educate and work with residents to prevent future problems related to OSDSs.	Generate media coverage, host public meetings, and communicate one on one with property owners.	SDCF, health departments, INDU, property owners	1-5 years	Number of property owners engaged; *E. coli* water quality data.
	3. Reduce agricultural sources of *E. coli*.	Work with ag community to promote new technologies for watering, manure management alternatives, and livestock exclusion.	NRCS, IDEM, SWCD, property owners	5-10 years	*E. coli* water quality data, number of practices installed.
	4. Improve waste water treatment at state park treatment facility.	Work w/ IDNR to identify feasible solutions to improving treatment facility.	IDNR	5-10	Waste water treatment facility improvements or replacement.

Goal 3: Improve stakeholder and public involvement.

Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
Encourage builders, developers, contractors, and other onsite workers to reduce construction impacts.	1. Promote best management practices during construction.	Build contacts, increase awareness, conduct workshops.	IDNR, and NIRPC watershed coordinators, IDEM, Planning w/Power	1-5 years	Number of construction sites implementing BMPs, # of violations.
	2. Promote low-impact development principles and practices.	Build contacts and increase awareness, conduct workshops.	IDEM, USEPA, IDNR, SDCF, NIRPC	1-5 years	Number of developers who implement low impact practices.
Build public awareness and stewardship ethic.	3. Encourage proper lawn chemical management.	Conduct workshop(s). Work w/Purdue Extension Service (Brad Lee and Extension Agents).	Purdue	5-10 years	Number of participants (from DC watershed) who install best practices.
	4. Educate decision makers & public on issue of feeding wildlife	Work with organizations, and land trusts to discourage wildlife feeding.	INDU, IDNR, CCWC, SHLT	5-10 years	Number of signs posted.
	5. Encourage native landscaping.	Work with organizations, nurseries, land trusts and Purdue Extension.	USEPA, Purdue	1-10 years	Number of projects w/native landscaping, number of nurseries offering native landscaping services.
	6. Promote water conservation.	Promote water resource toolkits, and proper household water management.	NIRPC	1-5 years	Number of participants who install best practices.
	7. Promote proper management of pet waste.	Work with other organizations and land trusts to encourage proper management of pet waste.	CCWC, SHLT	5-10 years	Number of participants who install best practices.

Encourage public policy for watershed protection.	8. Promote impervious surface alternatives.	Work with Planning Departments, Drainage Commissions, and storm water boards. Pursue demonstration project(s).	SDCF, USEPA, NIRPC, IDEM	1-5 years	Ordinance code changes, number of demonstration projects.
	9. Encourage planning and zoning to incorporate buffer corridors and green space.	Engage in planning processes with public officials. Coordinate w/ ICRAT Coastal Land Management project.	SDCF, USEPA, Planning with Power, IDNR	1-5 years	Ordinance code changes.
Encourage departments of transportation to reduce transportation-related impacts.	10. Promote efficient and effective use of road salt and its alternatives.	Build contacts and increase awareness.	INDOT, IDNR	10-15 years	Number of new management practices implemented.
	11. Encourage native landscaping and promote management practices that control exotics.	Conduct workshop(s). ICRAT/INDU native plant sales/ workshops. Build contacts and foster interest.	TNC, INDOT, Utility Co, SDCF, FRIENDS	5-10 years	Number of rights-of-way converted to native plants, Number of participants committed to best practices.
	12. Promote best available technology for road improvements (e.g., elevate as necessary on piling/pervious surface).	Build contacts and increase awareness.	LTAP (Local Technical Assistance Program), INDU	5-10 years	Number of road improvement projects undertaken.

Goal 4: Improve biotic communities by 2016 so that they are partially supporting.

Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
1. Eliminate/reduce erosion problems.	Restore and manage stream bank habitat.	Design/conduct targeted stream bank restoration projects. Promote riparian corridor protection and 2-stage ditches.	Homeowners, Drainage Board, SDCF, ACOE, IDNR	5-10 years	SSC and/or linear feet installed/stabilized.
2. Restore natural hydrology.	Improve flow dynamics.	Design and conduct environmentally sensitive drainage projects (include workshop). Restore wetlands.	USEPA, SWCD, CTIC	1-10 years	Water quality, biological communities, workshop participants.

Goal 5: Reduce TDS and chloride concentrations to meet Indiana State Standard.

Objective	Activity	Action Steps	Responsibility	Schedule	Indicators
1. Investigate source of elevated chloride concentration and high conductivity.	Work with IDEM, USGS, and INDOT to determine source of contamination.	To be determined	IDEM, INDOT, business owners	5-10 years	Chloride, and TDS back within permissible limits.

6.0 Management Measures and Resources

The Dunes Creek goals and objectives action register (Table 4) describes the systematic process to address the goals. It identifies resources and funding sources, and provides general cost estimates.

Table 4. Dunes Creek goals and objectives action register.

Items **highlighted in blue** are priorities for implementation.

Goal 1: Reduce nutrient and sediment loading by 20% by 2016.					
Activity	Action Steps	Technical Resources	Cost Estimate (Estimates are approximate. Cost will vary with number, area, and size of practice.)	Potential Funding Sources	Potential Financial Partners
1. Manage stormwater runoff.	Design/conduct targeted wetland restorations. Consider impacts on infrastructure/residences. Coordinate with government agencies on wetland restoration efforts.	USFWS, IDEM, IDNR	Greater than $100,000	IDEM 319, Municipal MS4 fees, IDNR 6217 funding	NIRPC, Coffee Creek Watershed Conservancy, Porter County Tourism, IDNR, INDU , IDEM
2. Implement stormwater best management practices.	Within critical areas: identify BMP sites and willing partners. BMP's could include but are not limited to; vegetated swales, pervious paving/building materials, and bioretention islands.	NRCS, SWCD, IDEM	Greater than $100,000	IDEM 319, IDNR 6217	

3. Restore natural hydrology.	Daylight the segment of Dunes Creek under the IDSP parking lot; plug ditches, restore wetlands; promote 2-stage ditches.	IDNR, INDU, IDEM, Drainage Board, USEPA	Greater than $100,000	NOAA, LARE, IDEM 319	IDNR, IDEM, CTIC
4. Reduce agricultural sources of sediment and nutrient.	Work with ag. community to promote educational/incentive programs for conservation tillage, stream bank stabilization, nutrient management practices, new technologies for watering, manure management alternatives, and livestock exclusion. Promote CORE 4.	NRCS, SWCD, Indiana Conservation Tillage Initiative, Farm Bureau, ISDA, CTIC	$25,000-$100,000	NRCS, SWCD, Purdue Extension	NIRPC, SWCD, NRCS, IDNR, CTIC
5. Reduce NPS pollution from commercial sources.	Work with commercial interests to identify sources and implement management measures.	IDEM, EPA	$25,000-$100,000	IDEM 319, IDNR 6217	Commercial interests

Goal 2: Reduce pathogen concentrations to meet the state standard by 2016.					
Activity	Action Steps	Technical Resources	Cost Estimate (Estimates are approximate. Cost will vary with number, area, and size of practice.)	Potential Funding Sources	Potential Financial Partners
1. Remediate failing on-site sewage disposal systems (OSDSs).	Isolate and address violations and pursue alternatives to OSDSs.	Local and state health departments, INDU	$25,000-$100,000	State Revolving Fund, IDEM 319	Health departments, IDEM
2. Educate and work with residents to prevent future problems related to OSDSs.	Generate media coverage, host public meetings, and communicate one on one with property owners.	Local and state health departments	$25,000-$100,000	USDA Rural Housing Service	Health departments, IDEM
3. Reduce agricultural sources of *E. coli*.	Work with ag. community to promote new technologies for watering, manure management alternatives, and livestock exclusion.	NRCS, SWCD, Indiana Conservation Tillage Initiative, Farm Bureau, ISDA, CTIC	$25,000-$100,000	NRCS, SWCD, Purdue Extension	NRCS
4. Improve waste water treatment facility at state park.	Work w/IDNR to identify feasible solutions to improving treatment facility.	IDNR	Greater than $100,000	IDNR	IDNR

Goal 3: Improve stakeholder and public involvement.					
Activity	Action Steps	Technical Resources	Cost Estimate (Estimates are approximate. Cost will vary with number, area, and size of practice.)	Potential Funding Sources	Potential Financial Partners
1. Promote best management practices during construction.	Build contacts, foster interest/increase awareness, conduct workshops.	USEPA, Tetra Tech	$25,000-$100,000	USEPA, IDNR, IDEM	USEPA, IDNR, IDEM, NIRPC, QLC
2. Promote low-impact development principles and practices.	Build contacts, foster interest/increase awareness, conduct workshops.	USEPA	$25,000-$100,000		
3. Encourage proper lawn chemical management.	Conduct workshop(s).	USEPA, Purdue University	Less than $25,000	LMCP, USEPA, GLAHNF, IDEM 319	IDEM
4. Educate decision makers & public on the issue of feeding wildlife.	Post signs. Work with organizations and land trusts to discourage wildlife feeding.	INDU, IDNR	Less than $25,000		IDEM, IDNR
5. Encourage native landscaping.	Work with organizations nurseries, land trusts and Purdue Extension.	USEPA, Purdue	$25,000-$100,000		IDEM
6. Promote water conservation.	Promote NIRPC toolkits, and proper household water management.	To be determined	Less than $25,000		IDEM

7. Promote proper management of pet waste.	Conduct media campaign.	To be determined	Less than $25,000		IDEM
8. Promote alternatives to impervious surfaces.	Work with Planning Departments, Drainage Board, storm water boards. Pursue demonstration project(s).	USEPA, local government	$25,000-$100,000	IDNR, IDEM, USEPA	IDEM 319, USEPA, IDNR
9. Encourage planning and zoning to incorporate provisions for buffer corridors and green space.	Engage in planning processes with public officials.	Local planning departments/commissions, USEPA, Planning with Power	$25,000-$100,000	USEPA	IDEM 319, USEPA
10. Promote effective and efficient use of road salt and its alternatives.	Build contacts and increase awareness.	Local, state, and federal departments of transportation	$25,000-$100,000	IDNR	INDOT, IDNR
11. Encourage native landscaping and promote management practices that control exotics.	Build contacts, increase awareness, conduct workshops.	Residents, nurseries and garden centers, departments of transportation	$25,000-$100,000	USEPA, IDNR	ICRAT
12. Promote best available technology for road improvements (e.g., elevate as necessary on piling/pervious surface).	Build contacts and increase awareness.	Local, state, and federal departments of transportation	Greater than $100,000	IDNR	To be determined

Goal 4: Improve biotic communities by 2016 so that they are partially supporting.

Activity	Action Steps	Technical Resources	Cost Estimate (Estimates are approximate. Cost will vary with number, area, and size of practice.)	Potential Funding Sources	Potential Financial Partners
1. Restore and manage streambank habitat.	Design/conduct targeted stream bank restoration project(s). Promote riparian corridor protection.	USFW, INDU	Greater than $100,000	IDEM 319, IDNR 6217	Land owners
2. Improve flow dynamics.	Design and conduct environmentally sensitive drainage projects (include workshop). Restore wetlands.	USEPA, CTIC, Drainage Board	Greater than $100,000	IDEM 319, IDNR 6217	IDEM, IDNR

Goal 5: Reduce TDS and chloride concentrations to meet Indiana State Standard.					
Activity	Action Steps	Technical Resources	Cost Estimate (Estimates are approximate. Cost will vary with number, area, and size of practice.)	Potential Funding Sources	Potential Financial Partners
Work with IDEM, USGS, and INDOT to determine source of contamination.	To be determined	USEPA	Greater than $100,000	IDEM 319, USEPA	IDEM, USEPA

Goal 1: Reduce nutrient and sediment loading by 20% by 2016

Total Phosphorus Goal: 50% of the stream sites assessed achieving total phosphorus concentrations (0.08 mg/L for wadeable streams; 0.10 mg/L for headwater streams) within 10 years. Based on data listed below, most implementation projects targeting a reduction in total phosphorus loading should occur within the headwaters portion of the watershed. If all of the streams meet their target, then the resulting loads will result in 1259 lbs (571 kg) less phosphorus loading from Dunes Creek to Lake Michigan per year.

As stated previously, the State of Indiana maintains water quality standards for many pollutants. However, the state has not yet established a water quality standard for total phosphorus. The draft 2006 list of impaired waterbodies (303(d) list) details methodology for determining the impairment of Indiana streams based on total phosphorus concentration (Indiana Register, October 2005). As described, the total phosphorus concentration cannot exceed 0.3 mg/L in concert with other nutrient or physical exceedances (nitrate-nitrogen, dissolved oxygen, pH, or algal condition). As the Dunes Creek watershed streams already possess total phosphorus concentrations below this level, it was determined that the target would be the levels recommended by the Ohio EPA (OHIO EPA,1999) for modified warmwater habitat headwater (0.10 mg/L) and wadeable (0.08 mg/L)streams. Required load reductions were calculated based on median stream flows and targeted concentrations. The targeted reductions are listed in Table 5.

Table 5. Comparison of total phosphorus (P) concentrations to target values in Dunes Creek

by sampling site drainage area

Sampling Station	Watershed Size in Acres (Hectares)	Target (mg/l)	Average[1] (mg/l)	Current Average Load (kg/yr) (lbs/yr)	% Reduction Needed to Meet Target	Comments
3	7407 (2997.5)	0.08	0.046	88.9 (196.0)	0%	Wadeable
2	3985 (1612.7)	0.08	0.070	13.2 (29.1)	0%	Wadeable
B	840 (339.9)	0.10	0.167	32.2 (71.0)	40%	Headwaters
7	487 (197.1)	0.10	0.160	29.3 (64.6)	37.5%	Headwaters

Total Suspended Solids Interim Goal: 50% of the streams obtaining total suspended solids concentration less than 5 mg/L within 5 years. This reduction will result in 357 pounds (162 kg) less sediment loading to Lake Michigan from Dunes Creek annually.

Like total phosphorus, the state does not currently have a water quality standard for total suspended solids. Furthermore, the draft 2006 list of impaired waterbodies (303(d) list) does not detail methodology for determining the impairment of Indiana streams based on total suspended solids concentration (Indiana Register, October 2005). However, information listed on the IDEM TMDL website indicates that streams may be listed for sediment impairment if the total suspended solids concentration exceeds 30 mg/L. As concentrations at all sample sites within the Dunes Creek watershed are less than the standard identified by IDEM, a lower concentration was utilized as the interim goal. As a result, the total suspended solids reduction necessary to improve water quality within Dunes Creek is based on achieving instream concentrations less than the median concentration currently present at Dunes Creek sampling sites. Again, work should be targeted at the headwaters portion of the watershed. Required reductions are listed in Table 6.

Table 6. Comparison of total suspended solids concentrations to target values in Dunes Creek by sampling site drainage area

Sampling Station	Watershed Size in Acres (Hectares)	Target (mg/l)	Average [1] (mg/l)	Current Average Load in kg/yr (lbs/yr)	% Reduction Needed to Meet Target
3	7407 (2997.5)	5	4.4	5603.9 (12354.5)	0%
2	3985 (1612.7)	5	2.3	668.6 (1474.0)	0%
B	840 (339.9)	5	14.0	2715.2 (5986.0)	64%
7	487 (197.1)	5	13.0	2390.4 (5269.9)	61%

Activity 1. Manage stormwater runoff.

Shallow water areas, including ponds and wetlands, within or near farmland provide cover and a water source for wildlife while also acting as a filter. Embankments and berms that pond water increase the land's water storage capacity helping to reduce volumes and flow rates of runoff. Constructed wetlands contribute to water quality improvement by: 1) reducing coliform bacteria by up to 90% (Reed and Brown, 1992); 2) fostering growth of microbes that recycle and retain nutrients (Wetzel, 1993); 3) providing additional adsorption sites for nutrients through the decomposition of organic matter (Kenimer et al., 1997); 4) providing anaerobic areas where denitrification processes can release nitrogen to the atmosphere; 5) degrading organic materials thereby decreasing biological oxygen demand (BOD); 6) offering sedimentation and filtration processes which remove suspended solids and adsorbed nutrients; and 7) providing flood water storage to attenuate peak flood flows.

Within the Dunes Creek watershed, wetland restoration sites will be identified. Landowners will be contacted in regards to their interest in wetland restoration. SDCF will work with landowners and coordinate with government agencies to restore wetlands and/or plug ditches.

<u>Estimated load reduction</u>: While many of the implementation tasks will result in a reduction in pollutant loads, the primary focus of this activity is education. Pollutant load reduction can be used as an indicator of progress. The volume of pollutant loading reduction that will be observed will depend upon the type of water quality improvement project implemented. The following information sources provide a range of pollutant load reduction values. Current research suggests that wetland restoration may remove more than 80% of the sediment and approximately 45% of the nutrients (Winer, 2000; Claytor and Schueler, 1996; Metropolitan Washington Council of Governments, 1992). Nutrient removal efficiencies differ depending upon the form of the nutrient measured. For example, total phosphorus removal efficiencies are often greater than ammonia-nitrogen removal efficiencies. Based on the wetland sizes utilized by the above mentioned references and the targeted reduction for the Dunes Creek watershed, it is anticipated that a minimum of 8 acres of wetland need to be restored to provide a 20% reduction in total phosphorus, while only 2 acres need to be restored to result in a similar percent reduction for total suspended solids.

Activity 2. Implement stormwater best management practices.

SDCF will identify potential partners and work with them to increase their awareness of stormwater best management practices and identify the most appropriate practices for each site. Implementation of stormwater best management practices will contribute to achieving goals 2 and 4.

The new Porter County Visitor Center will be located at the corner of Interstate 49 and U.S. Highway 20 in Porter and was chosen because of its high visibility and easy access. It will serve as a Visitor Center for Porter County, as well as the Indiana Dunes National Lakeshore. The long-term plan for this tract of land includes additional commercial development. The Visitor Center will be the first structure people visiting this commercial development encounter.

The new Visitor Center site for the Porter County Convention Recreation and Visitor Commission (PCCRVC) has been identified as an ideal site for demonstrating several stormwater BMPs. Through the watershed management plan development process, SDCF has identified an opportunity to work with the Porter County Visitor Center design team, the Indiana Dunes National Lakeshore, US Environmental Protection Agency Region 5, and the Indiana Department of Natural Resources (IDNR) on site design options that would reduce the impact of the new development on the Dunes Creek watershed through the implementation of BMPs.

In addition to the visitor center, SDCF will attempt to work with future developers of the remaining tract of land to highlight the value of LID/CD. The value of implementation projects at this site is enhanced because of the site's location and the large number and diverse nature of the people who will visit the center. This is an extraordinary opportunity to educate the public on water quality issues at this location.

PCCRVC board members have authorized the partnership with SDCF to incorporate additional BMPs into the site design. The Indiana Dunes National Lakeshore, EPA Region 5, and the Lake Michigan Coastal Program will assist SDCF in this aspect of the project. The IDNR has committed additional funds to spend at this site.

The following recommendations are specific to the visitor center. Other demonstration projects will be implemented over the next 5 years. Timeframe is 2006-2011.
1. Identify appropriate BMPs for the site (year 1).
2. Design and construct BMPs (year 1).
3. Design and construct interpretive signage (year 1).

Estimated load reduction: A variety of stormwater BMPs are planned for the Visitor Center. However, the specifics have not yet been determined. Based on the following references, it is estimated that installed practices should reduce total phosphorus loading by 25 to 90%, while total suspended solids reductions could total 40 to 90% (Schueler, 1987). The exact size and specifications of practices to be installed at this site will be determined during project design. Once those calculations are completed, the resulting information will be used to update the total number and size of other practices to be implemented within the watershed to achieve the appropriate reduction will be recalculated.

Activity 3. Restore natural hydrology.

The Indiana Department of Natural Resources has recently completed the process of daylighting Dunes Creek. Best available technologies were used to stabilize the sand dunes neighboring the stretch of Dunes Creek that was restored. This project consisted of the implementation of a stabilization structure and development of a restoration plan for the creek. The restoration involved re-meandering the creek channel. Exposure of the creek to sunlight, air, and soil will allow growth of aquatic and riparian vegetation that can improve water quality by taking up organic and inorganic pollutants. A minimum of 10% flow reduction is assumed. This should result in an almost 10% reduction in total phosphorus and total suspended solids.

Goal 2: Reduce pathogen concentrations 72% to meet the state standard by 2016

E. coli Interim Goal: 50% of stream sites obtaining *E. coli* concentrations that meet the state standard (235 CFU /100 mL) within 10 years.

> *Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of designated uses and corresponding numeric criteria. Designated uses reflect how the water can potentially be used by humans and how well it supports a biological community. Examples of designated uses include aquatic life support, drinking water supply, and recreation. Criteria express the condition of the water that is necessary to support the designated uses. Numeric criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody.*

All water bodies in Indiana are designated for recreational use. The numeric criteria associated with protecting the *recreational use are described below:*

> "This subsection establishes bacteriological quality for recreational uses. In addition to subsection (a), the criteria in this subsection are to be used to evaluate waters for full body contact recreational uses, to establish wastewater treatment requirements, and to establish effluent limits during the recreational season, which is defined as the months of April through October, inclusive. *E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period." [Source: Indiana Administrative Code Title 327 Water Pollution Control Board. Article 2. Section 1-6(a). Last updated November 1, 2003.]

The part of the standard that states that no samples shall exceed 235 CFU/100 mL is typically referred to as the "not-to-exceed" standard whereas the other part of the standard is referred to as the geometric mean standard.

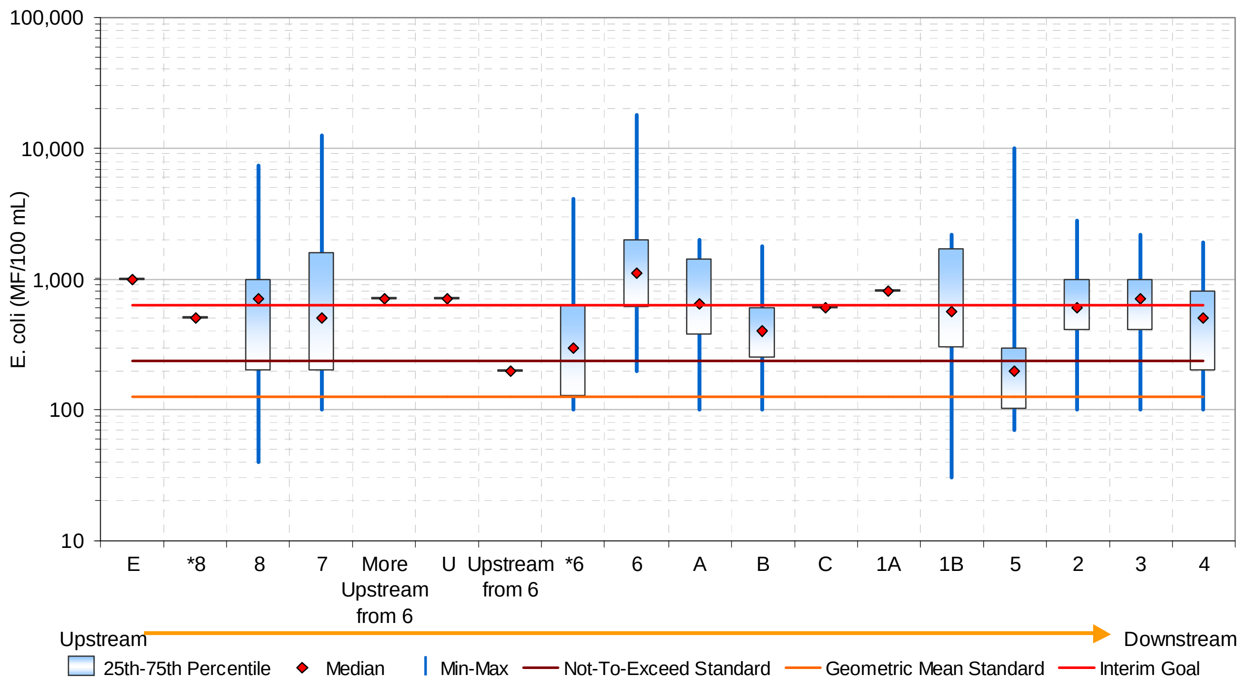


Figure 32. *E. coli* data box plots for all datasets

Table 7. Comparison of *E. coli* values to target values in Dunes Creek by sampling site drainage area

Sampling station	Watershed size (acres)	Target (CFU/100 ml)	Average Value[1] (CFU/100 ml)	% Reduction Needed to Meet Target
3	7407	235	826	61%
2	3985	235	800	59%
b	840	235	559	42%
7	487	235	1254	74%

1: based upon combined data set (Figure A)

Activities 1 and 2. Remediate failing on-site sewage disposal systems (OSDSs). Educate and work with residents to prevent future problems related to OSDSs.

SDCF, working with the Porter County and State of Indiana Health Departments, will coordinate a septic remediation program for problem areas in the watershed. The program will focus on critical areas that have been identified by using water quality data and other information in areas in which septics have been identified as a problem, such as the Hawleywood Road neighborhood. SDCF will contact property owners and educate them in maintaining and remediating on-site systems. SDCF will implement and build on the recommendations of the Dunes Creek Watershed Management Plan (DCWMP) to promote the most appropriate alternatives to the existing on-site systems, including identifying and pursuing funding sources and cost share programs for long term management. SDCF will continue to work with the state and county health departments and the National Lakeshore to identify problem areas, develop solutions, and implement remediation measures. SDCF will coordinate with Indiana Onsite Wastewater Professional's Association (IOWPA) to offer routine maintenance assistance to homeowners. As part of the IOWPA effort septic system inspections will be offered. SDCF will then coordinate with homeowners and the Porter County Health Department if any improvements need to be made.

The following recommendations will be implemented over the next 5 years. The timeframe is 2006-2011.
1. Identify additional critical areas that will be the focus of septic remediation program (year 1).
2. Develop outreach material to be distributed to homeowners during program that includes cost share information (year 1).
3. Coordinate door-to-door campaigns in critical areas (years 2-5).
4. GPS each addressed septic system location (years 2-5).
5. Work with health departments and homeowners to resolve failing septic systems in violation or likely contributing to high *E. coli* levels (year 2-5).
6. Porter County and State of Indiana Health Departments have committed to provide the following:
   - Send letters to homeowners that are not in violation but indications are that their septic systems are contributing to elevated levels of *E coli* in ground water or surface water.
   - Provide alternative system options for use with homeowners.
   - Follow up with enforcement action if necessary on any septic systems found in violation of county ordinances.
   - Provide technical expertise necessary to identify critical areas and assist in prioritizing work areas
   - Perform soil borings at each homeowner site that is inspected.
   - Provide boring data and analysis to identify critical areas and assist in prioritizing work areas in years 2-5.

<u>Estimated load reduction</u>: The expected reduction that will occur with each remediation will be calculated based on the site specific factors for that failing system. The goal is to identify as many failing systems as possible in the critical areas, then correct as many of those as is feasible. Reduction calculations will be determined at the time of remediation utilizing the Ohio EPA formula for estimating load reduction associated with septic system remediation.

Goal 3: Improve stakeholder and public involvement.

Activity1. Promote best management practices during construction.

SDCF will partner with Tetra Tech Inc., and Conservation Technology Information Center (CTIC) to conduct a workshop for excavation contractors, developers, equipment operators, road departments, public works employees, staff involved in the stormwater program, code enforcement officers, and anyone else involved in construction projects that include earthwork or excavation. The workshop will include information on controlling sediment, preventing erosion, protecting riparian areas, staging/phasing construction activities, and preserving existing vegetation where possible. Additional workshops will be conducted as necessary.

Activity 2. Promote low-impact development principles and practices.

Low Impact Development (LID) is focused on sound management of storm water. LID techniques are intended to help maintain or restore the natural hydrologic functions of a site to protect natural resources. LID employs a variety of natural and built features that reduce the rate of runoff, filter out pollutants, and facilitate the infiltration of water into the ground. By reducing water pollution and increasing groundwater recharge, LID helps to improve the quality of receiving surface waters and stabilize the flow rates of nearby streams. LID incorporates a set of overall site design strategies as well as highly localized, small-scale source control techniques. Rather than collecting runoff in piped or channelized networks and controlling the flow downstream in a large storm water management facility, LID takes a decentralized approach that disperses flows and manages runoff closer to where it originates.

While Conservation Design (CD) and LID are proven approaches, their use is still in early stages. Developers are often reluctant to plan for Conservation Design or LID features. SDCF will continue to work in partnership with the USEPA, IDNR, IDEM, and the Northwestern Indiana Regional Planning Commission to provide forums that address the factors identified above which discourage or inhibit Conservation Design/LID design features and best management practices.

SDCF has conducted one workshop. SDCF gathered and organized relevant information, met with key stakeholder groups, conducted preliminary analyses, and then convened a focused workshop for developers, builders, planners, and local officials that addressed the benefits of, and barriers to, Conservation Design/LID practices. Follow up meetings with planners, builders and developers have taken place. Follow up workshops that build on this effort will be conducted to accelerate the adoption of LID/CD approaches in the Dunes Creek watershed.

Goal 4: Improve biotic communities by 2016 so that they are partially supporting.

Macroinvertebrate Goal: 50% of stream sites considered to be partially supporting for aquatic life use (mIBI score exceeds 2) within 10 years.

As determined by the IDEM Assessment Branch and based on sampling completed in 2004 and 2005, Dunes Creek's biotic community is impaired. On average all sites sampled in 2004 and 2005 are classified as non-supporting for aquatic life use. This impairment is based both on poor water chemistry and limited habitat availability. Because of the poor quality and habitat constraints associated with the macroinvertebrate communities in Dunes Creek, it is unlikely that these communities will be rated as fully supporting, or even partially supporting, within the near future even with substantial work occurring within the watershed. Based upon these constraints, watershed stakeholders set interim goals that are attainable within the foreseeable future. This goal will focus on both water quality and habitat improvements and will be measured via water chemistry, habitat, and macroinvertebrate assessments conducted at a minimum of four sites on a two-year cycle. The cycle will begin in 2005 and continue through 2015 (10 years). The aquatic life support (ALUS) assessment will be based on macroinvertebrate community collection. Samples will be collected using methodologies identified in the QAPP developed during completion of this watershed management plan.

Habitat Goal: 50% of stream sites obtaining QHEI metric target scores within 5 years.

As noted above, poor habitat is one of the factors that lead to the impaired biotic communities in Dunes Creek. QHEI scores are determined through the measurement of six metrics: substrate type and quality; channel morphology; riparian quality; instream cover; pool, riffle, run development; and stream gradient. Some of these metrics will never score very high, which will ultimately limit the habitat within the stream as scored by the QHEI. For example, as sand-bottom streams, streams within the Dunes Creek watershed will likely never develop stable pool-riffle sequences. Likewise, the stream's gradient will not change over time; therefore, the 4 to 6 points lost at each of the stream reaches cannot be gained through watershed work. For these reasons, three metrics were chosen to use as guidance for improvements in habitat within the Dunes Creek watershed. These metrics are: substrate type and quality, channel morphology, and riparian quality. The target scores are as follows:

Substrate type and quality ≥ 15 of 20 possible points
Channel morphology ≥ 15 of 20 possible points
Riparian quality ≥ 8 of 10 possible points

1. Restore and manage stream bank habitat.

This activity consists of two components: riparian management and restoring hydrology.

Riparian management consists of protecting and enhancing existing natural areas adjacent to the stream network/drainage network and implementing a program to re-establish areas where the native riparian vegetation has been removed or degraded. Channel management focuses on establishing where two–stage ditches are physically feasible for managed drainage ditches and adopting ecologically based approaches for necessary ditch maintenance activities.

Properly managed riparian zones provide numerous benefits, including reduced watershed imperviousness, space for streams to naturally move laterally over time, protection against stream bank erosion, increased pollutant removal through filtration and absorption, and wildlife habitat.

Riparian management is done by first delineating a riparian zone and inventorying the areas to identify protection, enhancement, and restoration sites. The limitations of the model used in the broad-scaled modeling effort prevented the identification of these sites and must be done manually. The width and uses of the riparian zone will depend on two factors; 1) quality of the downstream network and 2) location within the network and adjacent slopes. Restored and enhanced sites will be used to treat runoff from the adjacent landscape. The headwater streams and existing natural areas are the highest priority for protection and enhancement action.

The following recommendations will be implemented over the next 15 years. The timeframe is 2005 to 2020.

1) Delineate and inventory riparian zone (year 1).
2) Develop site eligibility criteria for available funding (year 2).
3) Design guidelines for restoration and enhancement sites (year1).
4) Institutionalize plan reviews and inspection procedures (year 2).
5) Long-term maintenance plan to ensure riparian zone provides expected benefits (year 1 –2).
6) Identify appropriate units of government to work with on modifying master plans/zoning ordinances, etc. (ongoing).
7) Restore and enhance identified riparian areas (20% addressed in year 1-5).
8) Implement long-term volunteer stream monitoring program to provide management feedback and serve as a screening effort for enforcement programs (ongoing).

Channel management will focus on demonstration efforts and modifying existing approaches to management of legal drains. Traditional approaches to maintaining drainage ditches have adverse effects on the environment due to removal of streamside and channel vegetation, dredging of the drains, and increased stress on downstream hydraulics. In watersheds with impervious cover in the range of 11-25 percent and where traditional drainage maintenance is practiced, the issue of unstable channels is more pronounced since both conditions individually are associated with unstable channel conditions.

The following recommendations will be implemented over the next 15 years. The timeframe is 2005 to 2020.

1) Inventory existing drainage ditch maintenance schedule and activities (years 1-2).
2) Develop ecologically sensitive maintenance approach, based upon available funding (years 1-2).
3) Identify appropriate units of government to work with on modifying existing approaches (ongoing).
4) Conduct a workshop on 2-stage drainage ditch technique (year 1).
5) If feasible, develop a demonstration for a 2-stage drainage ditch project (years 1- 2).
6) Implement long-term volunteer monitoring program to provide management feedback on ecologically sensitive maintenance approach.

Goal 5: Reduce TDS and chloride concentrations to meet Indiana State Standard.

The investigation of possible sources of chlorides is a long-term activity and will not be pursued during Phase 1 (years 1-5) unless an opportunity becomes available. The 2010 revision to the Dunes Creek Watershed Management Plan will address this goal based upon additional information and available funding. Instream monitoring will continue to further refine the issues associated with TDS and chloride concentration.

7.0 Existing/On-going Activities

Porter County Visitor Center

The new Visitor Center site for the Porter County Convention Recreation and Visitor Commission (PCCRVC) has been identified as an ideal site for implementation projects for Dunes Creek that address several of the objectives in Table 3. As part of developing the watershed management plan and identifying opportunities for implementation, SDCF has met with the Porter County Visitor Center design team, the Indiana Dunes National Lakeshore, US Environmental Protection Agency Region 5, and the Indiana Department of Natural Resources to reduce the impact of the new development on the Dunes Creek watershed. Utilizing a LID/CD approach, SDCF has identified and is working with the design team to include native landscaping, wetland restoration, rain gardens, vegetated swales, and pervious surface alternatives such as paving bricks or grass pave in the site design. Budget constraints and site limitations are the primary obstacle to inclusion of the BMPs into the design. Those practices that are more dependent on the initial construction of the center will be used as demonstration projects. Others will wait for the implementation phase of the Dunes Creek watershed project.

The new Visitor Center will be located at the corner of Interstate 49 and U.S. Highway 20 in Porter and was chosen as the primary demonstration project for LID/CD concepts because of its high visibility and easy access. It will serve as a Visitor Center for Porter County, as well as the Indiana Dunes National Lakeshore. The long-term plan for this tract of land includes additional commercial development. The Visitor Center will be the first structure people visiting this commercial development encounter. Based upon the success of the initial projects, there will be future opportunities to work with the future development of this tract. The value of demonstration and implementation projects at this site is enhanced because of the site’s location and the large number and diverse nature of the people who will visit the center. This provides an extraordinary opportunity to educate the public and special interest groups on water quality issues and approaches that will protect water quality.

Water Park Violation

Following an inspection in May of 2004, a water park located in the Dunes Creek watershed was found in violation of 327 IAC 5-2-2, IC 13-18-4-5, IC 13-30-2-1, and 317 IAC 2-6.1-7 for discharges of chlorinated waters without a National Pollutant Discharge Elimination System permit. The discharges occurred to ditches along US 20 and Waverly Road. The watershed Steering Committee is waiting for resolution of the IDEM enforcement action against the water park to ascertain its impact on the Dunes Creek efforts.

Indiana Department of Natural Resources / Indiana Dunes State Park

There are a number of ongoing and planned activities that will impact Dunes Creek and are incorporated into the Dunes Creek Watershed Management Plan.

Daylighting

Daylighting Dunes Creek is an important component in the overall effort to improve water quality and is included in the goals section of this plan. The Indiana Department of Natural Resources used best available technologies to stabilize the dunes neighboring a stretch of Dunes Creek. This project consisted of implementation of a stabilization structure and development of a restoration plan for the creek. The restoration component involved re-meandering the creek channel and creation of a wetland for water quality improvement. Exposure of the creek to sunlight, air, and soil will allow growth of aquatic and riparian vegetation and result in improved water quality by removal of organic and inorganic pollutants. Remeandering of the creek will slow and infiltrate runoff. Sites 3 and 4 will generate data that will be used to evaluate the impact of the daylighting project.

In addition the Indiana Department of Natural Resources will redevelop the Indiana Dunes State Park campground. The goal of the campground project is to reduce the recreational use impacts on the dune and swale ecosystem. The campground project will reduce stormwater volumes and preserve native plant and animal species.

Figure 33. Daylighting in Dunes Creek (2005)

Figure 34. Daylighting in Dunes Creek (2005)

Dunes Creek is shown in Figure 33 entering a culvert that runs under a parking lot shown in Figure 34 at the Indiana Dunes State Park. Restoring natural hydrology by daylighting this section of the Creek and restoring the stream bank could improve water quality (Goals 1 and 4, Section 6).

New Entrance
Indiana Dunes State Park constructed a new entrance to the park in the auxiliary lot on the south side of the main entrance road. The project has been completed.

Natural Resources Management Plan
Indiana Department of Natural Resources is in the process of completing the Natural Resource Management Plan. The draft was completed September 2005.

Wetland Restoration
The Indiana Department of Natural Resources received a grant through the Lake Michigan Coastal Program for riparian restoration and wetland remediation for reduction of *E. coli* in Dunes Creek. This project investigated the efficacy of wetland restoration in the Dunes Creek watershed as a mechanism to reduce loadings of *E. coli* to the beaches at Indiana Dunes State Park. The pilot wetland restoration project was designed, conducted, and monitored for water quality improvements. The results from this effort will be utilized to define future wetland restoration efforts.

Indiana Dunes National Lakeshore Potential Projects within the Dunes Creek Watershed
The Dunes Creek watershed is home to some of the most unique natural communities within the Indiana Dunes National Lakeshore, including the Cowles Bog Wetland Complex, the Little Lake Wetland, remnants of the Goose Lake wetlands, and Howes Prairie. These areas include some of the Indiana Dunes National Lakeshore's top biological diversity "hotspots."

Cowles Bog Wetland Complex
The Cowles Bog Wetland Complex (CBWC) represents 198 acres (80 hectares) of the western terminus of the largest interdunal wetland (the Great Marsh) present on the Lake Michigan shoreline. Inventory work conducted from 2002 to 2004 demonstrated that the complex is an exceptional composition of bog, fen, hydromesophyic swamp forest, sedge-meadow, wet-prairie, shallow-marsh, and a vegetated floating mat all intertwined in a relatively small area. In 1976, the federal endangered Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*) was observed in the CBWC. As recently as 1990, 15 state listed plant species and 41 special floristic elements were present. The inventory work indicated that invasive species (Hybrid Cattail and Common Reed) are present in over 90 percent of the CBWC; however, there remain areas with exceptional floristic vestiges. Action now will save much of the diverse native vegetation and provide much needed habitat for native insects and other wildlife. Indiana Dunes National Lakeshore is seeking NPS funding to initiate restoring this nationally significant wetland. However, additional resources will be required to complete the restoration of this area.

Great Marsh: Western Dunes Creek Study Area
In the Dunes Creek watershed west of the Indiana Dunes State Park, there are approximately 15 miles (24 kilometer) of small drainage ditches within a 750-acre (304 hectare) area of the Great Marsh located within the Indiana Dunes National Lakeshore. There may be the potential to restore a more natural hydrological regime to a portion of this area without impacting roads or other developments. Clearly restoring the areas hydrology would benefit the Dunes Creek system by reducing the rate and volume of runoff into the creek. Studies are needed to determine sub-watershed characteristics that can be used to develop a hydrological restoration plan for this area. This information would include ditch location and elevation information, surface water depths, water flow direction, shallow ground water table information (height and flow directions), and information on infrastructure elevations.

Interdunal Wetland Restoration
Several interdunal wetlands occur in westernmost portions of the Dunes Creek watershed outside of the Great Marsh. These wetlands include "Little Lake," several unnamed smaller wetlands, and the remnants of the large shallow lake called "Goose Lake." Although these wetlands have been degraded through a variety of impacts ranging from draining to create a golf course (ca. 1920s) to inundation from discharge from the NIPSCO settling

ponds (ca. 1966-1977), what remains continues to support a great diversity of plant life. Little Lake was home to over 80 native plant species as recently the early 1990s. Furthermore, while Goose Lake was entirely lost when industrial development replaced the great central dunes, what remains of the former Goose Lake wetlands continue to support a number of rare plant species. These interdunal wetlands are all being degraded by invasive plant species, including Common Reed, and the rapid expansion of woody growth. Work is needed to address these significant threats to the exceptional biological diversity of these wetlands.

Howes Prairie Invasive Plant Control
Forty species found at Howes Prairie are listed as special vegetation floristic elements, meaning they are rare in the Chicago Region, or endangered or threatened in Indiana. More than 700 of 1,550 native vascular plant taxa in the Chicago region have been documented in the 1,000-acre(405 hectare) area that includes Howes Prairie. A 2003 survey for non-native plant populations revealed Howes Prairie and the surrounding areas are impacted by several invasive species. The National Lakeshore has initiated work to map and control invasive plants in Howes Prairie. However, significant additional work will be needed to maintain the biological richness of this area.

Rehabilitation of the East State Park Road, Beverly Drive Intersection
The Indiana Dunes National Lakeshore in partnership with the Federal Highway Administration has begun the environmental assessment process for the rehabilitation of the intersection of East State Park Road and Beverly Drive. This intersection, which frequently floods, is located near the eastern boundary of the Dunes Creek watershed. The flooding results in poor driving conditions and creates the potential for contaminants from vehicles to be washed into the adjoining wetlands. Several alternatives are being considered and evaluated. SDCF will work with the Indiana Dunes National Lakeshore and the Federal Highway Administration on possible LID/CD opportunities associated with this effort.

Removal of Unoccupied Structures
The National Lakeshore will continue to remove structures on park property as they become vacant. There are approximately 17 residential structures within the Dunes Creek watershed on National Lakeshore property. As the terms of use for these properties expire (2006 - 2010) and as resources allow they will be removed. Removing structures should reduce the potential for impacts to the Dunes Creek watershed from septic systems and other potential sources of contamination (e.g., lawn chemicals, pets, etc.)

8.0 Measuring Progress and Plan Evaluation

The first measure of success will be the completion of the Dunes Creek Watershed Management Plan in compliance with IDEM's checklist guidelines. The overall success of the plan is dependent upon implementation of action items for improving water quality to attain *E. coli* and biotic water quality standards. The implementation of the Dunes Creek Watershed Management Plan will be tracked through a system of adminsitrative, social, and environmental indicators. For example, environmental indicators will include the number of wetland acres restored and the length of buffers installed; and administrative the number and type of best management practices (BMPs) implemented once the implementation phase is underway. Water quality monitoring results will help document the impact of implementation projects. Social or behavioral indicators will focus on documenting involvement, such as the number of property owner responses, the number of volunteer hours logged, the number of stakeholders recruited and involved in the Steering Committee and public meetings, the number of partners providing project support, and the amount of match received. Community indicators of social change such as public policy/ordinance changes will also be used.

As new information about the health of the watershed becomes available it will be incorporated into the watershed management plan by using an adaptive management process. Adaptive management is a blend of implementation, monitoring, and evaluating practical management that allows for experimentation and provides the opportunity to "learn by doing". It is a necessary and useful process because of the uncertainty about landowner participation, how ecosystems function, and how management affects ecosystems.

The following section describes concrete milestones for stakeholders to reach and tangible deliverables produced while they work toward each goal. Because several of the goals are long-term goals (i.e. it will take more than 5 years to attain), adaptive management is essential to ensure the actions stakeholders take are helping achieve those goals. Adaptive management provides stakeholders a framework to make timely adjustments to their implementation efforts if the monitoring results indicate such adjustments are needed.

Goal 1: Reduce nutrient and sediment loading by 20% by 2016.

Milestones: (Except for annual or continuous tasks, this goal should be reached by 2016.)

- Number of wetlands identified for enhancement/restoration potential.
- Number of meetings held with residents owning potentially restorable wetlands.
- Number of meetings held with governmental agencies in regard to wetland restoration.
- Number of BMP sites identified.
- Number of BMPs implemented.
- Daylighting project completed.
- Number of ditches identified for plugging.
- Number of locationsidentified as suitable for 2-stage ditch implementation.
- Number of properties managed as 2-stage ditches.
- Number of ditches plugged.
- Exotics control areas identified.
- Area of exotics control completed.
- Number of agricultural, industrial, and residential BMPs identified.
- Number of individuals attending BMP meetings.
- Number of BMPs implemented.

Goal Attainment: The goal is attained when the sediment and nutrient loads in the Dunes Creek watershed are only 20% of the current loads. This will be measured using total suspended solids (TSS) and total phosphorus (TP).
Indicator to be monitored: Total suspended solids and phosphorus loading at each of the four watershed sites (see interim goal below).
Parameter assessed: Flow (estimated) total suspended solids and total phosphorus
Frequency of monitoring: Samples will be collected from four sites, which correspond with Sites 3, 2, B, and 7, at least once annually during base flow and once annually during a storm flow event.
Location of monitoring: Sites 3, 2, B, and 7.
Length of monitoring: The monitoring will be conducted for 10 years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project.
Monitoring equipment: Samples will be collected in bottles provided by the contracted laboratory.
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter TSS, TP, and flow measurements in an electronic database.
Data evaluation: At the end of the implementation project, all data will be evaluated and compared with data collected during the current assessment (baseline data). This data will be included in the final report for the project.

Goal 2: Reduce pathogen concentrations to attain the state standard by 2016.

Milestones: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2016.)

- Number of failing septic systems identified.
- Number of individual meetings held regarding failing septic systems.
- Number of individuals attending public meetings regarding failing septic systems.
- Number of media outlets contacted and materials published regarding failing septic systems.
- Number of agricultural areas identified for manure management and/or livestock exclusion practices.
- Number of meetings held with individuals regarding manure management or livestock exclusion practices.
- Meetings held with IDNR regarding failing wastewater treatment plant at state park.
- Plans developed for wastewater treatment plant facility update.

Goal attainment: The goal is attained when the *E. coli* concentration in each watershed waterbody meets the state standard (235 CFU /100 mL).
Indicator to be monitored: *E. coli* concentration less than 235 CFU /100 mL for the Dunes Creek watershed.
Parameter assessed: *E. coli* concentration.
Frequency of monitoring: Samples will be collected from four sites, which correspond with Sites 3, 2, B, and 7, monthly during the growing season; weekly for five consecutive weeks (July-August); once during base and once during storm flow.
Location of monitoring: Sites 3, 2, B, and 7 as indicated.
Length of monitoring: The monitoring will be conducted for 10 years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project.
Monitoring equipment: Samples will be collected in bottles provided by the contracted laboratory.
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter *E. coli* and flow measurements in an electronic database.
Data evaluation: At the end of the implementation project, all data will be evaluated and compared with data collected during the current assessment (baseline data). This data will be included in the final report for the project.

Goal 3: Improve stakeholder and public involvement.

Milestones: (Except for annual/continuous tasks milestones should be reached by the end of 2021.)

- Number of builders/developers contacted regarding construction site BMPs.
- Number of construction site BMPs implemented.
- Number of low impact development principles implemented.
- Number of individuals attending lawn chemical workshop.
- Number of individuals switching to a non-phosphorus based fertilizer.
- Number of individuals contacted in regards to wildlife feeding.
- Number of wildlife foodplots no longer in use.
- Number of nurseries contacted in regards to the use of native plants for landscaping.
- Number of native plants purchased from local nurseries.
- Number of water resource toolkits distributed.
- Number of individuals contacted in regards to pet waste management.
- Area of impervious surface alternatives installed.
- Number of meetings attended with local personnel.
- Number of individuals contacted in regards to the usage of road salt and its alternatives.
- Amount of alternatives employed versus traditional road salt.
- Number of individuals attending native landscaping workshops.
- Watershed group meetings held.
- Watershed group meeting minutes published.
- Watershed group newsletter published.
- Watershed group website developed.
- Website updates noting new members and participants.
- Hoosier Riverwatch volunteer training attended.
- Hoosier Riverwatch data collected and submitted.

Goal Attainment: This goal lacks a specific water quality target similar to that which the other goals possess. Rather than being attained this goal will be a continual effort by watershed stakeholders.

Goal 4: Improve biotic communities by 2016 so that they are partially supporting.
Combination of actions from goals 1 & 2
Goal attainment: The goal is attained when the modified QHEI value meets the project's criteria.
Indicator to be monitored: Biological community
Parameter assessed: Need to list the factors going into your modified QHEI for the Dunes Creek watershed.

Frequency of monitoring: Samples will be collected from four sites, which correspond with Sites 3, 2, B, and 7, twice a year during the growing season.
Location of monitoring: Sites 3, 2, B, and 7 as indicated.
Length of monitoring: The monitoring will be conducted for 10 years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project.
Monitoring equipment: Samples will be collected in containers provided by the contractor.
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter factors/variable measurements in an electronic database.
Data evaluation: At the end of the implementation project, all data will be evaluated and compared with data collected during the current assessment. This data will be included in the final report for the project.

Goal 5: Reduce TDS and chloride concentrations to meet Indiana State Standard.
Need to add practices/actions

Goal Attainment: The goal is attained when the TDS and chloride concentrations attain water quality standards.
Indicator to be monitored: TDS and chloride concentrations (see interim goal below).
Parameter assessed: Flow (estimated), TDS, and chloride.
Frequency of monitoring: Samples will be collected from four sites, which correspond with Sites 3, 2, B, and 7, at least once annually during base flow and once annually during a storm flow event.
Location of monitoring: Sites 3, 2, B, and 7.
Length of monitoring: The monitoring will be conducted for 10 years.
Protocol: Monitoring will be conducted according to the protocol identified in the QAPP for this project.
Monitoring equipment: Samples will be collected in bottles provided by the contracted laboratory.
Data entry: The monitor will maintain data forms in a three-ring binder and share the information with the watershed group during meetings. The monitor will also enter data flow measurements in an electronic database.
Data evaluation: At the end of the implementation project, all data will be evaluated and compared with data collected during the current assessment (baseline data). This data will be included in the final report for the project.

9.0 Future Considerations

There are several considerations stakeholders should keep in mind as they implement the Dunes Creek Watershed Management Plan. Many of these considerations are noted in the proceeding sections of this text, but due to their importance, they warrant reiteration.

Permits, Easements, and Agreements

Operation and Maintenance

Wetland Restoration: Wetland restoration projects were identified in the watershed. In the long term, these areas will provide water quality benefits while requiring little maintenance. In the short term, certain management activities may be employed to help these areas recover faster than they would if they were left alone. Such activities include prescribed burns, spot herbicide treatments, and supplemental plantings. These maintenance activities, which are designed to increase the plant diversity of the wetland, will also increase functionality of the wetland. They also increase the pace of wetland restoration. Additional burns, herbicide spot treatments, and plantings may further increase the wetland's recovery. As wetland recovery progresses, additional maintenance activities may be deemed necessary in the future.

Vegetated Swale: The need for a vegetated strip to filter runoff from the Porter County Visitors Center was identified as a need in the watershed. Any filtration area built to treat erosion and prevent sediment loading to Munson Ditch will require periodic maintenance. This maintenance simply involves removing any sediment accumulated that prevents proper filtration of the stormwater directed to the area. Sediment accumulation should be checked on an annual basis.

Monitoring

Monitoring is an important component of this watershed management plan. Without monitoring, stakeholders will not know when or whether they have achieved their goals; or worse, they will not make timely refinements to their actions to ensure the actions they are taking will achieve their goals. The previous section details how stakeholders will monitor their progress toward achieving the goals set in this watershed management plan.

Plan Revisions

This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as other stakeholders become more active in implementing the plan.

10.0 Implementation

SDCF will be the lead entity promoting the implementation of the Dunes Creek Watershed Management Plan. Expanding upon the partnerships developed during the plan development phase, SDCF will solicit additional partners to support the implementation plan. Once approved, SDCF will coordinate the funding, implementation, and evaluation of the Dunes Creek Watershed Management Plan. Annual updates will be posted on www.savedunes.org. Upcoming events can also be found at www.savedunes.org.

Appendices

Appendix A **Watershed Plan Distribution List and Steering Committee Members**

Chesterton Town Council
Mike Bannon
726 Broadway
Chesterton, IN 46304

Chesterton Utility Environmental Control Facility
Steve Yagelski
300 League Lane
Porter, IN 46304

Coffee Creek Watershed Conservancy
Steve Barker
219 S. Calumet
Chesterton, IN 46304

Great Lakes Research and Education Center
Joy Marburger
1100 Mineral Springs Road
Porter, IN 46304

Indiana Department of Environmental Management
Watershed Management Section
Betty Ratcliff, Quality Assurance Manager
100 North Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015

Indiana Department of Environmental Management
Watershed Management Section
Sky Schelle, Project Manager
100 North Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015

Indiana Department of Natural Resources
Indiana Dunes State Park
Brandt Baughman
1600 N 25 East
Chesterton, IN 46304

Indiana Department of Natural Resources
Lake Michigan Coastal Program
Jenny Orsburn
Indiana Dunes State Park
1600 North 25 East
Chesterton, IN 46304

Indiana Department of Natural Resources
Lake Michigan Coastal Program
Joe Exl
Indiana Dunes State Park
1600 North 25 East
Chesterton, IN 46304

Indiana Department of Natural Resources
Lake Michigan Coastal Program
Mike Molnar
402 W Washington St. Rm W265
Indianapolis, IN 46204

Indiana Dunes National Lakeshore
Dale Engquist, Superintendent
1100 Mineral Springs Road
Porter, IN 46304

Indiana Dunes National Lakeshore
Dan Mason
1100 Mineral Springs Road
Porter, IN 46304

Indiana Dunes National Lakeshore
Scott Hicks, Assistant Chief of Resource Management
1100 Mineral Springs Road
Porter, IN 46304

Indiana Capacity Center for Management of Onsite/Decentralized Systems
Richard Wise, President
PO Box 88754
Indianapolis, IN 46208

Kathy Luther
308 Green Acres
Valparaiso, IN 46383

Lake Michigan Ecological Research Station
Richard Whitman
1100 N. Mineral Springs Road
Porter, IN 46304

Lionel Bolin
P. O. Box 126
Beverly Shores, IN 46301

Mittal Steel
Doug Bley
250 West US Hwy. 12
Burns Harbor, IN 46304

NiSource
Kevin Hoge
801 East 86th Avenue
Merrillville, IN 46410

Northwestern Indiana Regional Planning Commission
Reggie Korthals
6100 Southport Road
Portage, IN 46368

Porter County Plan Commission
Robert Thompson
Porter County Administration Building
155 Indiana Avenue, Suite 304
Valparaiso, IN 46383

Porter County Convention Recreation and Visitor Commission
Lorelei Y. Weimer
800 Indian Boundary Road
Chesterton, IN 46304

Porter County Commissioner
John Evans
155 Indiana Room 205
Valparaiso, Indiana 46383

Porter County Commissioner
Robert Harper
155 Indiana Room 205
Valparaiso, Indiana 46383

Porter County Commissioner
Carol Knoblock
155 Indiana Room 205
Valparaiso, Indiana 46383

Porter County Surveyor
Kevin Breitzke
155 Indiana Avenue
Valparaiso, IN 46383

Town of Porter Public Works Department
Bauer, Karl
550 Beam Street
Porter, IN 46304

Porter Town Council
Sandi Snyder
303 Franklin Street

Porter, Indiana 46304

Save the Dunes Conservation Fund
Christine Livingston
444 Barker Rd.
Michigan City, IN 46360

Save the Dunes Conservation Fund
Tom Anderson, Director
444 Barker Road
Michigan City, IN 46360

Save the Dunes Council
Charlotte Read, Assistant Director
444 Barker Road
Michigan City, IN 46360

Splash Down Dunes

Town of Chesterton
Jennifer Gadzala
6100 Southport Road
Portage, IN 46368

United States Environmental Protection Agency
Thomas Davenport
77 West Jackson Boulevard
Chicago, IL 60604

United States Fish and Wildlife Service
Elizabeth McCloskey, Fish and Wildlife Biologist
1000 West Oakhill Road
Porter, IN 46304

United States Geological Survey
Doug Wilcox
1451 Green Road
Ann Arbor, MI 46105

Westchester Library
200 West Indiana Avenue
Chesterton, IN 46304

Appendix B Outreach Brochure

The Dunes Creek Watershed Project

Save the Dunes Conservation Fund (SDCF) has been funded by the Indiana Department of Environmental Management (IDEM) to develop a watershed management plan for the Dunes Creek watershed. Dunes Creek begins west of State Route 49, flows through the Indiana Dunes State Park, and enters Lake Michigan through a pipe at the State Park. Its 7,407 acre watershed encompasses all of the Indiana Dunes State Park and Cowles Bog and a large portion of the Great Marsh in the Indiana Dunes National Lakeshore.

The Dunes Creek Watershed Management Plan will address nonpoint sources of pollution that cause *E. coli* exceedances and contribute to impaired biotic communities. The exceedances frequently require closing the beach to swimming at the Indiana Dunes State Park. Dunes Creek has been identified in IDEM's *Impaired Waters Lists* for 1998 and 2002, and is on the draft list for 2004.

The Dunes Creek Watershed Management Plan will assess current water quality and biological integrity using existing data and new data as necessary. The final plan will make recommendations for improving water quality in the Dunes Creek watershed and will continue engaging the public in this process.

Mission Statement

The Dunes Creek watershed stakeholders will foster improved communication, collaboration, education, and scientific understanding of the watershed, and will develop strategies that conserve, protect, and enhance the natural resources of the watershed.

What Can We Do?

If you drink water from Lake Michigan, enjoy the beach, own property within the Dunes Creek watershed, or have concern for the protection of our natural resources, you have a vested interest in the success of this project.

Please attend the Dunes Creek Watershed Management Plan public meetings that are held quarterly (schedule below). Broad-based participation in the development of the Dunes Creek Watershed Management Plan will ensure that everyone's interests are represented. You can help provide information and insight based on your experiences, knowledge, and background. We want your input!

The group's vision is a healthy Dunes Creek watershed ecosystem that supports species diversity, protects Lake Michigan water quality, and improves quality of life in northwest Indiana while maintaining the important social, economic, and recreational uses of the area.

In addition to collecting public input, and fully utilizing available research and local expertise, SDCF established a Technical Steering Committee. SDCF will rely on public input and the steering committee to guide the two-year process of developing the Dunes Creek Watershed Management Plan.

Public Meeting Schedule

Where: Indiana Dunes State Park Nature Center
When: On the following Thursdays at 7:00 P.M.

April 1, 2004	January 6, 2005
July 1, 2004	April 7, 2005
October 7, 2004	July 7, 2005
	October 6, 2005

Note - *Meeting dates are subject to change. For additional information or to verify dates, contact*
Christine Livingston, Project Manager
at 219-879-3937 or cll@savedunes.org

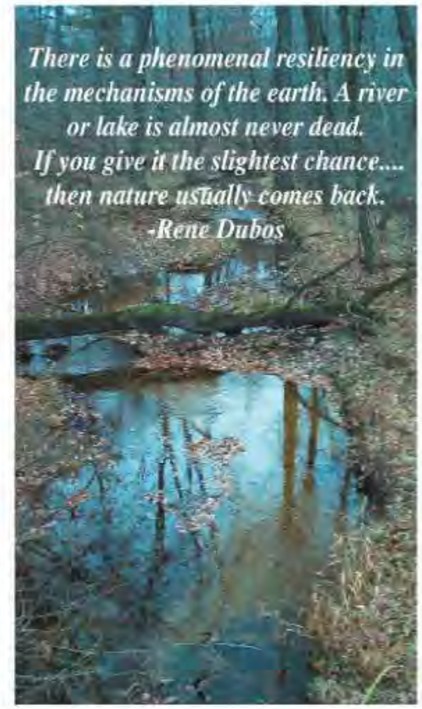
Dunes Creek Watershed

Why Develop A Watershed Management Plan?

The United States has more than 3.5 million miles of rivers and streams that, along with closely associated flood plain and upland areas, comprise corridors of great social, cultural, and environmental value. Increases in human population and industrial, commercial, and residential development place heavy demands on streams, rivers, and lakes. This is especially true along Indiana's Lake Michigan basin. These demands result in degradation of water quality, loss of habitat for fish and wildlife, and decreased recreational and aesthetic value.

There is a critical need for us to improve the quality of our water. A well developed watershed management plan is one of the first steps in this process. The Dunes Creek Watershed Management Plan will guide the process of improving the water quality in the Dunes Creek watershed while accommodating important economic, social, and recreational uses.

This project has been funded in part by the United States Environmental Protection Agency under assistance agreement A305-3-750 to the Indiana Department of Environmental Management. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.



Dunes Creek in the Indiana Dunes State Park.

Appendix C Press Releases
Monday, December 1, 2003

Contact: Christine Livingston, Project Manager
Office: 219-879-3937 Email: cll@savedunes.org

Improving Water Quality

Save the Dunes Conservation Fund is embarking on an exciting new project - development of a watershed management plan for the Dunes Creek watershed. Dunes Creek begins west of State Route 49, runs through the Indiana Dunes State Park, and flows into Lake Michigan through a pipe at the State Park. Its 7407 acre watershed encompasses all of the Indiana Dunes State Park, Cowles Bog and much of the Great Marsh.

The Dunes Creek Watershed Management Plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities. The exceedances frequently require closing the beach to swimming at the Indiana Dunes State Park. Dunes Creek has been identified in the Indiana Department of Environmental Management's *Impaired Waters List* for 1998, and is on the draft list for both 2002 and 2004.

The Watershed Plan will assess current water quality and biological integrity using existing data and acquiring new data as necessary. The final plan will make recommendations for improving water quality in the Dunes Creek watershed and will begin engaging the public in this process. Citizen input will be encouraged at quarterly public meetings. The first public meeting will be held on January 8, 2004 at 7:00 at the Indiana Dunes State Park Nature Center.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Thursday, January 6, 2004

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3937 Email: cll@savedunes.org

Watershed Management Plan Public Meeting

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the development of the Dunes Creek Watershed Management Plan at 7:00 p.m.– 8:30 p.m. on Thursday, January 6, 2005. The meeting will be held at the Westchester Public Library 200 W. Indiana Avenue, Chesterton, Indiana. Joy Marburger from Indiana Dunes National Lakeshore's Great Lakes Research and Education Center will present information from her restorations work in the watershed.

Watershed management plans are becoming increasingly popular as an effective way to manage land use, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land.

A watershed is defined as the area of land that drains to a specific stream, river, lake or ocean. The boundary of a watershed is defined by the highest elevations surrounding the water body. Any water that falls outside of the boundary will drain to the adjacent watershed. Every body of water has its own watershed that can also include subwatersheds. All lands drain to one body of water or another.

Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management's 319 Grant Program to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities in Dunes Creek. The Indiana Department of Environmental Management's Impaired Waters List for 2002 and draft List for 2004 identify Dunes Creek as impaired for biotic communities and *E. coli*.

The final plan will make recommendations for improving water quality in Dunes Creek. Christine Livingston, watershed coordinator explains, "We strongly encourage the public to get involved in the development of this plan. Community support is essential for the watershed plan to be a success". Citizen input will continue to be encouraged at quarterly public meetings.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Thursday, March 25, 2004

Contact: Christine Livingston, Project Manager
Office: 219-879-3937 Email: cll@savedunes.org

Watershed Management Plan to Improve Water Quality

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the development of the Dunes Creek Watershed Management Plan at 7:00 p.m. on April 1, 2004 at the Indiana Dunes National Lakeshore's Ranger Station located at 1100 Mineral Springs Road in Chesterton. Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management (IDEM) using 319 money to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities in Dunes Creek. The Indiana Department of Environmental Management's Impaired Waters List for 2002 and draft List for 2004 identify Dunes Creek as impaired for biotic communities and E. coli.

The Dunes Creek watershed encompasses all of the Indiana Dunes State Park, designated in 1974 as a National Natural Landmark and one of the best remaining examples of undeveloped and relatively unspoiled dune landscape along the southern shore of Lake Michigan -www.nature.nps.gov/nnl/Registry/USA_Map/States/Indiana/NNL/DNP/.
The Park contains Ancient Pines Nature Area, a prehistoric forest now exposed by dune blowouts. It is also a popular recreational park that attracts over 2 million visitors annually.

High E. coli levels and consequent swimming advisories have been a chronic problem at the park. Concerns over these closures have prompted land managers and regulatory officials to seek the sources of excessive E. coli. The public meeting will include a presentation by guest speaker, Sandra Wilmore, on the development of a beach monitoring and notification plan for Indiana's portion of the Lake Michigan shoreline under the Beaches Environmental Assessment and Coastal Health (BEACH) Act - http://swann2.ansc.purdue.edu/nwibeach/.

Other human-related sources and activities potentially affecting the watershed include an abundance of on-site sewage disposal systems, railroad and trucking facilities, hydromodification to support industrial and residential developments, a road salt storage facility, and other light and heavy industry. "We strongly encourage public participation in the development of this plan. The more involvement we have, the better the final watershed plan will be," says Christine Livingston, Project Manager. The final plan will make recommendations for improving water quality in the Dunes Creek. Citizen input will continue to be encouraged at quarterly public meetings.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Thursday, June 24, 2004

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Contact: Christine Livingston, Project Manager
Office: 219-879-3923 Email: cll@savedunes.org

Watershed Management Plan to Improve Water Quality

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the development of the Dunes Creek Watershed Management Plan at 6:30 p.m. on Thursday, July 1, 2004 at the Nature Center at the Indiana Dunes State Park in Chesterton.

Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management's 319 Grant Program to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities in Dunes Creek. The Indiana Department of Environmental Management's Impaired Waters List for 2002 and draft List for 2004 identify Dunes Creek as impaired for biotic communities and E. coli.

The Dunes Creek watershed encompasses all of the Indiana Dunes State Park, designated in 1974 as a National Natural Landmark and one of the best remaining examples of undeveloped and relatively unspoiled dune landscape along the southern shore of Lake Michigan -www.nature.nps.gov/nnl/Registry/USA_Map/States/Indiana/NNL/DNP/.
The Park contains Ancient Pines Nature Area, a prehistoric forest now exposed by dune blowouts. It is also a popular recreational park that attracts over 2 million visitors annually. High E. coli levels and consequent swimming advisories have been a chronic problem at the park. Concerns over these closures have prompted land managers and regulatory officials to seek the sources of excessive E. coli.

The public meeting will begin with a tour of a wetland creation project site, a separate but related project funded by the Department of Natural Resources currently taking place within the watershed. Wear appropriate foot gear and clothes for the tour and meet at the Nature Center at 6:30. The meeting will be conducted immediately following the tour.

Other human-related sources and activities potentially affecting the watershed include an abundance of on-site sewage disposal systems, railroad and trucking facilities, hydromodification to support industrial and residential developments, a road salt storage facility, and other light and heavy industry. "We strongly encourage public participation in the development of this plan. The more involvement we have, the better the final watershed plan will be," says Christine Livingston, Project Manager. The final plan will make recommendations for improving water quality in the Dunes Creek. Citizen input will continue to be encouraged at quarterly public meetings.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Thursday, October 7, 2004

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3937 Email: cll@savedunes.org

Watershed Management Plan Public Meeting and Tour

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the development of the Dunes Creek Watershed Management Plan at 7:00 p.m. on Thursday, October 4, 2004. The meeting will be held at the Nature Center at the Indiana Dunes State Park in Chesterton. An optional tour of a Cowles Bog Wetland Complex restoration site led by Daniel Mason, Indiana Dunes National Lakeshore botanist will precede the public meeting beginning at 4:45 p.m.

Watershed management plans are becoming increasingly popular as an effective way to manage land use, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land.

A watershed is defined as the area of land that drains to a specific stream, river, lake or ocean. The boundary of a watershed is defined by the highest elevations surrounding the water body. Any water that falls outside of the boundary will drain to the adjacent watershed. Every body of water has its own watershed that can also include subwatersheds. All lands drain to one body of water or another.

Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management's 319 Grant Program to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities in Dunes Creek. The Indiana Department of Environmental Management's Impaired Waters List for 2002 and draft List for 2004 identify Dunes Creek as impaired for biotic communities and *E. coli*.

The final plan will make recommendations for improving water quality in Dunes Creek. Christine Livingston, watershed coordinator explains, "We strongly encourage the public to get involved in the development of this plan. Community support is essential for the watershed plan to be a success". Citizen input will continue to be encouraged at quarterly public meetings.

The Cowles Bog Wetland Complex to be toured represents the westernmost extent of the Great Marsh and the northwestern portion of the Dunes Creek watershed. This wetland complex is of historic, spiritual and floristic importance to Indiana Dunes National Lakeshore. Due to a variety of stressors, Hybrid Cattail, Common Reed and shrubs have replaced the unusual plant communities present during the early twentieth century. Daniel Mason will present a summary of inventory and experimentation initiated in 2002. A restoration plan for the wetland complex is scheduled for release in late 2005.

Portions of the tour will be very rugged and muddy, so please wear appropriate footgear and clothing. The tour will leave at 5:00 p.m. sharp from the Calumet Bike Trail parking lot on the west side of Mineral Springs Road just north of U.S. Highway 20. After the tour the group will move to the Nature Center for a presentation by Daniel Mason and the public meeting.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Thursday, March 31, 2005

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3564 Email: cll@savedunes.org

Get Your Feet Wet!
Learn More at Dunes Creek Watershed Management Plan Public Meeting

Watershed management plans are becoming increasingly popular as an effective way to manage land use, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land. Save the Dunes Conservation Fund watershed coordinator, Christine Livingston, is encouraging the public to get involved in the development of a plan for the management of the 7407-acre Dunes Creek watershed in northern Porter County. She explains, “This Watershed Plan is being developed for the citizens. We want to encourage the public to get involved to be sure that the plan meets the needs of the community”.

Over the past few months watershed group members prioritized concerns at public and steering committee meetings. To assist the watershed group in identifying critical areas, the water-monitoring program is being expanded to include more sites and additional sampling events. As part of this expansion, Livingston is working on developing a volunteer monitoring program. This program will help the group get the most comprehensive assessment of the watershed possible as they near the implementation phase of the project.

Save the Dunes Conservation fun needs volunteers to collect water quality data that will aid in identifying pollution sources and identify critical areas. The volunteer program is a great way to get more involved in protecting the natural areas that make Porter County such a great place to live. Livingston is working with the Hoosier Riverwatch program coordinators to provide training to volunteers.

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the Dunes Creek Watershed Management Plan, and explain volunteer opportunities at 7:00 p.m.– 8:30 p.m. on Thursday, April 7, 2005. The meeting will be held at the Westchester Public Library 200 W. Indiana Avenue, Chesterton, Indiana.

Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management’s 319 Grant Program to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause *E. coli* exceedances and contribute to impaired biotic communities in Dunes Creek. The final plan will make recommendations for improving water quality in Dunes Creek.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3564 / Fx. 219-872-4875

Thursday, June 30, 2005

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3937 Email: cll@savedunes.org

Watershed Management Plan Public Meeting

Save the Dunes Conservation Fund will hold a public meeting to obtain input and update the public on the development of the Dunes Creek Watershed Management Plan at 7:00 p.m.– 8:30 p.m. on Thursday, July 7, 2005. The meeting will be held at the Westchester Public Library 200 W. Indiana Avenue, Chesterton, Indiana.

Watershed management plans are becoming increasingly popular as an effective way to manage land use, increase public understanding and awareness about water quality issues, and promote better stewardship of private and public land.

A watershed is defined as the area of land that drains to a specific stream, river, or lake. The boundary of a watershed is defined by the highest elevations surrounding the water body. Any water that falls outside of the boundary will drain to the adjacent watershed. Every body of water has its own watershed that can also include subwatersheds. All lands drain to one body of water or another.

Save the Dunes Conservation Fund has been funded by the Indiana Department of Environmental Management's 319 Grant Program to develop the Dunes Creek Watershed Management Plan. The plan will address nonpoint sources of pollution that cause E. coli exceedances and contribute to impaired biotic communities in Dunes Creek. The Indiana Department of Environmental Management's Impaired Waters List for 2002 and draft List for 2004 identify Dunes Creek as impaired for biotic communities and *E. coli*.

The final plan will make recommendations for improving water quality in Dunes Creek. Christine Livingston, watershed coordinator explains, "We strongly encourage the public to get involved in the development of this plan. Community support is essential for the watershed plan to be a success". Citizen input will continue to be encouraged at quarterly public meetings.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3937 / Fx. 219-872-4875

Tuesday, January 24, 2006

Contact: Christine Livingston, Watershed Coordinator
Office: 219-879-3564 Email: cll@savedunes.org

Watershed Management to Protect Water Quality!
The Dunes Creek Watershed Management Plan Moves to Action.
Thursday, January 26, 2006, 4:00 p.m.
Chesterton Library, Bertha Wood Room 2nd Floor

Save the Dunes Conservation Fund (SDCF) is leading an effort to develop and implement a plan for the management of the 7407-acre Dunes Creek watershed in northern Porter County. Many issues and concerns have been identified and the watershed group is moving into action. Involved citizens want the Dunes Creek Watershed Management Plan to promote better stewardship of private and public land, identify and implement ways to improve land use management, and increase public understanding and awareness about water quality issues.

The Dunes Creek Watershed Management Plan provides a framework for achieving a healthy Dunes Creek watershed and describes upcoming projects aimed at protecting water quality. The draft watershed plan is now available for public comment. Save the Dunes Conservation Fund will hold a public meeting to update the public on the development and implementation of the Dunes Creek Watershed Management Plan from 4:00 p.m.– 5:30 p.m. on Thursday, January 26, 2006. The meeting will be held at the Westchester Public Library, 200 W. Indiana Avenue. Sections of the plan will be distributed at Thursday's meeting and it is available on the web at www.savedunes.org.

Site enhancements to the new visitor center located at Interstate 49 and Rt. 20 for the Porter County Convention, Recreation and Visitor Commission (PCCRVC) that include low impact design techniques are among the implementation projects that are underway. The willingness of the PCCRVC design team, and visitor center tenant Indiana Dunes National Lakeshore to implement low impact design techniques at the new visitor center site and the Indiana Department of Environmental Management's (IDEM) willingness to provide financial support will enable this project to be a demonstration site for all of northwest Indiana.

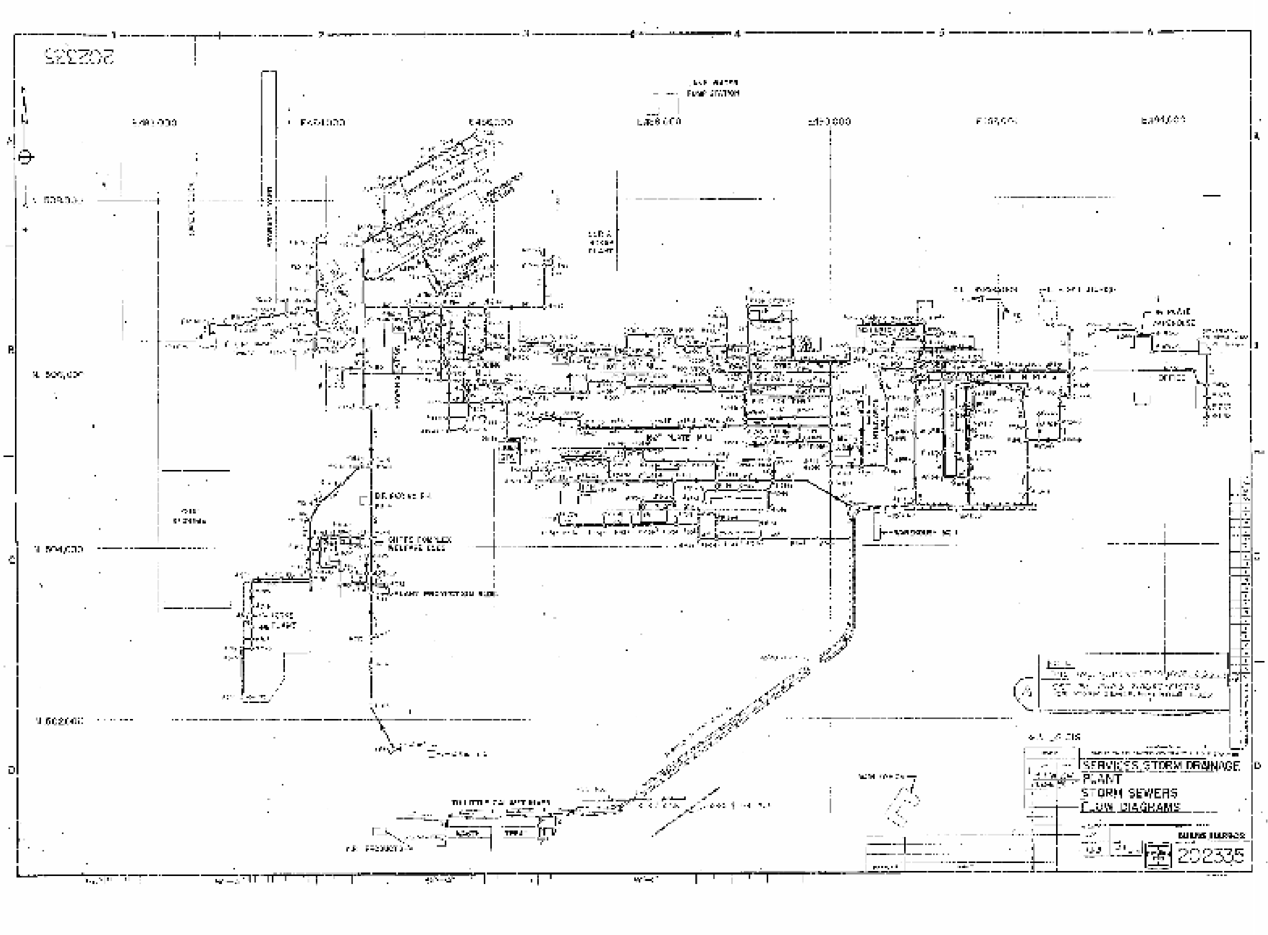
The techniques being installed at this site will be described at Thursday's meeting and the PCCRVC Director Lorelei Weimer will explain the why PCCRVC supports the enhancements. Save the Dunes Conservation Fund watershed coordinator, Christine Livingston, explains that there is a lot of interest in utilizing low impact development techniques. "One of the goals of the Dunes Creek Watershed Management Plan is to work with developers and property owners to demonstrate how effective these techniques are at minimizing environmental impact."

The Visitor Center is just one of many planned projects within the Dunes Creek Watershed. SDCF will also be restoring wetland areas and working with property owners that have individual septic systems that may be contributing to high levels of E. coli in Dunes Creek.

Save the Dunes Conservation Fund has been funded in part by IDEM's 319 Grant Program to develop the Dunes Creek Watershed Management Plan.

Save the Dunes Conservation Fund
444 Barker Road
Michigan City, IN 46360
Ph. 219-879-3564 / Fx. 219-872-4875

<u>Appendix D</u> Mittal Steel



<u>Appendix E</u> <u>Endangered, Threatened, and Rare Species</u>
High Quality Natural Communities, and Significant Natural Areas Documented in the Dunes Creek Watershed

ENDANGERED, THREATENED, AND RARE SPECIES
AMPHIBIANS AND REPTILES
ALL RECORDS

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Ambystoma laterale	Blue-spotted salamander	SC	**
Clemmys guttata	Spotted turtle	SE	**
Clonophis kirtlandii	Kirtland's snake	SE	**
Emydoidea blandingii	Blandings turtle	SE	**
Hemidactylium scutatum	Four-toed salamander	SE	**
Liochlorophis vernalis	Smooth green snake	SE	**
Ophisaurus attenuatus	Slender glass lizard	**	**
Rana pipiens	Northern leopard frog	SC	**
Sistrurus catenatus catenatus	Eastern massasauga rattlesnake	CA	**
Thamnophis proximus	Western ribbon snake	SC	**

Table E 1. Endangered, threatened, and rare amphibians and reptiles.

ENDANGERED, THREATENED, AND RARE SPECIES
INSECTS
ALL RECORDS

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Callophrys irus	Frosted elfin butterfly	SR	**
Euchloe Olympia	Olympia marblewing	ST	**
Lycaeides Melissa samuelis	Karner blue butterfly	SE	LE
Poanes viator viator	Big broad-winged skipper	SR	**
Problema byssus	Bunchgrass skipper	SR	**

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

Table E 2. Endangered threatened and rare insects

ENDANGERED, THREATENED, AND RARE SPECIES
VASCULAR PLANTS
CURRENT RECORDS – 1951 TO PRESENT

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Actaea rubra	Red baneberry	SR	**
Arctostaphylos uva-ursi	Bearberry	SR	**
Aristida tuberculosa	Seabeach needlegrass	SR	**
Aster borealis	Rushlike aster	SR	**
Aster sericeus	Western silvery aster	SR	**
Botrychium matricariifolium	Chamomile grape-fern	ST	**
Buchnera Americana	Bluehearts	SE	**
Carex atherodes	Awned sedge	SE	**
Carex conoidea	Prairie gray sedge	SE	**
Carex debilis rudgei	White-edge sedge	ST	**
Carex flava	Yellow sedge	ST	**
Carex folliculata	Long sedge	ST	**
Carex leptonervia	Finely-nerved sedge	SE	**
Carex limosa	Mud sedge	SE	**
Carex seorsa	Weak stellate sedge	SR	**
Chimaphila umbellate	Pipsissewa	ST	**
Chrysosplenium americanum	American golden-saxifrage	ST	**
Clintonia borealis	Clinton (blue-bead) lily	SE	**
Cornus Canadensis	Bunchberry dogwood	SE	**
Cypripedium calceolus	Small yellow lady's-slipper	SR	**
Cypripedium candidum	Small white lady's-slipper	SR	**
Drosera intermedia	Spoon-leaved sundew	SR	**
Eleocharis melanocarpa	Black-fruited spike-rush	ST	**
Epigaea repens	Trailing arbutus	**	**
Fimbristylis puberula	Carolina fimbry	SE	**
Fuirena pumila	Dwarf umbrella-sedge	ST	**
Gentiana alba	Yellow gentian	SR	**
Geranium bicknellii	Bicknell northern crane's-bill	SE	**
Hudsonia tomentosa	Sand-heather	ST	**
Juncus articulatus	Jointed rush	SE	**
Juncus balticus littoralis	Baltic rush	SR	**
Juncus militaris	Bayonet rush	SE	**
Juncus pelocarpus	Brown-fruited rush	ST	**
Juncus scirpoides	Scirpus-like rush	ST	**
Lechea stricta	Upright pinweed	SX	**
Linum striatum	Ridged yellow flax	**	**
Ludwigia sphaerocarpa	Globe-fruited false-loosestrife	SE	**
Lycopodiella inundata	Northern bog clubmoss	SE	**
Lycopodium tristachyum	Deep-root clubmoss	ST	**
Melampyrum lineare	American cow-wheat	SR	**
Milium effusum	Tall millet-grass	SR	**
Myosotis laxa	Smaller forget-me-not	SE	**
Oryzopsis asperifolia	White-grained mountain-Ricegrass	SE	**

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Panax quinquefolia	American ginseng	**	**
Panax trifolius	Dwarf ginseng	**	**
Panicum boreale	Northern witchgrass	SR	**
Panicum verrucosum	Warty panic-grass	ST	**
Pinus banksiana	Jack pine	SR	**
Pinus stobus	Eastern white pine	SR	**
Platanthera hookeri	Hooker orchid	SX	**
Platanthera hyperborean	Leafy northern green orchid	ST	**
Platanthera psycodes	Small purple-fringed orchid	SR	**
Poa alsodes	Grove meadow grass	SR	**
Poa paludigena	Bog bluegrass	WL	**
Polygala paucifolia	Gay-wing milkwort	SE	**
Polygonella articulata	Eastern jointweed	SR	**
Polygonum hydropiperoides	Northeastern smartweed	ST	**
Potentilla anserine	Silverweed	ST	**
Prunus pensylvanica	Fire cherry	SR	**
Psilocarya scirpoides	Long-beaked baldrush	ST	**
Pyrola rotundifolia	American wintergreen	SR	**
Rhus aromatica arenaria	Beach (fragrant) sumac	ST	**
Rhynchospora macrostachya	Tall beaked-rush	SR	**
Rhynchospora recognita	Globe beaked-rush	SE	**
Scirpus expansus	A bulrush	SE	**
Scirpus hallii	Hall's bulrush	SE	**
Scirpus purshianus	Weakstalk bulrush	SR	**
Scirpus smithii	Smith's bulrush	SE	**
Scleria reticularis	Reticulated nutrush	ST	**
Solidago simplex gillmanii	Sticky goldenrod	ST	**
Sparganium androcladum	Branching bur-reed	ST	**
Stipa avenacea	Blackseed needlegrass	ST	**
Thuja occidentalis	Northern white cedar	SE	**
Viola primulifolia	Primrose-leaf violet	SR	**
Woodwardia areolata	Netted chainfern	SR	**

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

Table E 3. Endangered, threatened, and rare vascular plants (1951-present).

ENDANGERED, THREATENED, AND RARE SPECIES
VASCULAR PLANTS
HISTORICAL RECORDS – 1950 and EARLIER

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Aralia hispida	Bristly sarsaparilla	SE	**
Arenaria stricta	Michaux's stitchwort	SR	**
Aster furcatus	Forked aster	SR	**
Botrychium multifidum	Leathery grape-fern	SX	**
Carex atlantica capillacea	Howe sedge	SE	**
Carex garberi	Elk sedge	*ST*	**
Cornus rugosa	Roundleaf dogwood	SR	**
Dryopteris clintoniana	Clinton woodfern	SX	**
Eleocharis robbinsii	Robbins spikerush	SR	**
Eriocaulon aquaticum	Pipewort	SE	**
Eriophorum angustifolium	Narrow-leaved cotton-grass	SR	**
Hypericum adpressum	Creeping St. John's-wort	SE	**
Juniperus communis	Ground juniper	SR	**
Lathyrus ochroleucus	Pale vetchling peavine	SE	**
Linnaea borealis	Twinflower	SX	**
Orobanche fasciculate	Clustered broomrape	SE	**
Oryzopsis pungens	Slender mountain-ricegrass	SX	**
Panicum mattamuskeetense	A panic-grass	SX	**
Plantanthera ciliaris	Yellow-fringed orchid	SE	**
Polygonum careyi	Carey's smartweed	ST	**
Populus balsamifera	Balsam poplar	SX	**
Psilocarya nitens	Short-beaked bald-rush	SX	**
Pyrola secunda	One-sided wintergreen	SX	**
Salix cordata	Heartleaf willow	ST	**
Scirpus torreyi	Torrey's bulrush	SE	**
Selaginella rupestris	Ledge spike-moss	ST	**
Sisyrinchium montanum	Strict blue-eyed-grass	SE	**
Thalictrum pubescens	Tall meadow-rue	ST	**
Trichostema dichotomum	Forked bluecurl	SR	**
Utricularia minor	Lesser bladderwort	SE	**
Xyris difformis	Carolina yellow-eyed grass	ST	**

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

Table E 4. Endangered, threatened, and rare vascular plants (1950 and earlier).

ENDANGERED, THREATENED, AND RARE SPECIES
MAMMALS AND BIRDS
ALL RECORDS

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS
Taxidea taxus	American badger	SE	**
Ammodramus henslowii	Henslow's sparrow	SE	SC
Asio otus	Long-eared owl	**	**
Botaurus lentiginosus	American bittern	SE	**
Buteo lineatus	Red-shouldered hawk	SC	**
Buteo platypterus	Broad-winged hawk	SC	**
Circus cyaneus	Northern harrier	SE	**
Cistothorus palustris	Marsh wren	SE	**
Cistothorus platensis	Sedge wren	SE	**
Dendroica cerulean	Cerulean warbler	SC	SC
Dendroica virens	Black-throated green warbler	**	**
Falco peregrinus	Peregrine falcon	SE	**
Ixobrychus exilis	Least bittern	SE	**
Lanius ludovicianus	Loggerhead shrike	SE	SC
Mniotilta varia	Black-and-white warbler	SC	**
Nycticorax nycticorax	Black-crowned night heron	SE	**
Rallus elegans	King rail	SE	**
Rallus limicola	Virginia rail	SE	**
Vermivora chrysoptera	Golden-winged warbler	SE	**
Wilsonia canadensis	Canada warbler	**	**
Wilsonia citrine	Hooded warbler	SC	**

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate SC – Species of concern ** - Not listed

Table E 5. Endangered, threatened, and rare mammals and birds.

<u>Appendix F</u> Dunes Creek Ecoregion

Physiography
The southern shoreline of Lake Michigan is described as a sandy coastal strip with beaches, high dunes, mucky interdunal depressions, sandy beach ridges, and swales. These features are attributed to the glaciated state this area was in thousands of years ago.

Geology
The Michigan Lake Plain ecoregion contains quaternary beach deposits, dunes sand, lacustrine material, and clayey glacial till. In addition, made land (fill) and scattered organic material occur also. Such deposits overlie Silurian and Devonian shale, dolomite, and limestone.

Soil
There is a variety of soil orders (great groups) found in the watershed. **Mollisols** (Endoaquolls and Argiaquolls) are typically found in grasslands and have a high organic matter content and base saturation. This type of soil is common in midwestern agricultural regions. **Entisols** (Udipsamments) are very recent soils with little profile development and found where parent material is young or resistant to weathering. **Alfisols** (Hapludalfs and Epiaqualfs) have a high to medium base saturation and found on somewhat old landscapes and in mesic climates conducive to some leaching. **Histosols** (Medisaprists) are also found scattered in the peatlands and bogs.
In addition, there are nine common series of soils found which include Oakville, Maumee, Brems, Houghton, Adrian, Palms, Morley, Blout, and Pewamo. These soils are described as having a Mesic temperature regime and Aquic and Udic moisture regimes.

Climate
The mean annual precipitation is 36-42 inches. The mean number of frost-free days in a year is 165-190 with the maximum number of days occurring near Lake Michigan. The mean temperatures (min/max) in January are 19/35 ^{o}F. Mean temperatures in July are 63/86 ^{o}F.

Potential Natural Vegetation
There is an incredible amount of plant diversity found in the Dunes Creek watershed. The native vegetative communities encountered are oak-hickory forest and prairie with beach, dune, oak savanna (with some conifers), and fens.

Land Use and Land Cover
A large portion of land in the area is used for urban-industrial development. Agricultural use is also a major factor including fruit and vegetable farming. Woodlands on the lee side of the dunes and in some poorly-drained areas provide land cover for Dunes Creek.

Appendix G Quality Assurance Project Plan

Quality Assurance Project Plan
for
Dunes Creek Watershed Management Plan
ARN # A305-3-750
Prepared by:
Christine Livingston
Project Manager
Save the Dunes Conservation Fund

Prepared for:
Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

June 22, 2004

Approved By:

Project Manager:	Christine Livingston	8/5/04 Date
WMS QA Manager:	Betty Ratcliff	8/13/04 Date
WMS Section Chief:	Linda Schmidt	8/17/04 Date
Planning Branch Chief:	Martha Clark Mettler	8/18/04 Date

<u>Appendix H</u> Water Quality Parameters and Discussion by Stream Reach

Watershed Sampling

To supplement the base of existing data, JFNew collected water chemistry, biological community, and physical habitat data from each of the eight original stream sites plus three additional sites within the Dunes Creek watershed. Water chemistry samples were collected four times from each of the eight original stream sites, twice following a storm event to capture a runoff event and twice following a period of little precipitation to serve as the “normal” stream condition. Storm sampling occurred on August 5, 2004 following nearly 2 inches of rain in the previous 24-hours and again on July 27, 2005 following more than 1.5 inches of rain in the previous 24-hours. Base flow sampling occurred on September 14, 2004 and June 21, 2005. Each reach’s biological community was assessed once in mid-late summer annually and habitat availability of each reach was assessed once during the sampling period. The three additional sites were only sampled during the 2005 storm event. To ensure comparability to data collected previously by IDEM, JFNew followed similar stream sampling protocols. The stream sampling and the appropriate quality assurance/quality control procedures are referenced in the project’s Quality Assurance Project Plan (QAPP). Appendix G contains the project Quality Assurance Project Plan (QAPP) which was approved by IDEM on September 7, 2004.

Chemical and bacterial concentration, loading, and areal loading data for the Dunes Creek watershed streams are listed in Tables H1 to H4.

Table H 1. Physical parameter data collected during base and storm flow sampling events

in the Dunes Creek watershed waterbodies on August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Site	Stream Name	Date	Event	Flow (cfs)	Temp (deg C)	DO (mg/L)	% Sat	pH	Cond (µmohs/cm)	Cl- (mg/L)	TSS (mg/L)
1A	Cowles Bog outlet at Waverly Road	8/5/04	storm	0.066	18.6	0.6	6.3	7.1	555	17	8.5
		9/14/04	base	**	18.2	0.3	3.2	7.1	320	15	74.0
		6/21/05	base	0.001	18.7	1.15	12	6.8	275	25	430.0
		7/27/05	storm	**	21.9	3.35	35.3	6.9	504	34	23.0
2	West Tributary at Trail 2	8/5/04	storm	0.764	18.1	6.0	63.4	7.8	351	97	11.0
		9/14/04	base	0.200	18.2	6.4	69	7.8	605	110	2.1
		6/21/05	base	0.193	16.7	7.56	78.1	8.0	680	150	1.9
		7/27/05	storm	0.120	19.9	5.6	62.4	7.6	689	150	2.6
3	Dunes Creek (pre-culvert)	8/5/04	storm	3.311	18.7	7.0	78.1	7.8	648	98	5.6
		9/14/04	base	1.010	19.3	6.15	67.1	7.0	448	56	1.9
		6/21/05	base	0.351	18.4	6.7	71.6	7.8	512	76	3.2
		7/27/05	storm	1.035	20.1	6.16	67.8	7.7	1310	300	7.1
4	Dunes Creek Outlet at Lake Michigan	8/5/04	storm*	*	19.2	7.4	78.8	8.4	485	64	21.0
		9/14/04	base	1.070	19.2	7.07	76.5	8.0	449	55	2.0
		6/21/05	base	0.384	18.5	8.64	93.7	7.9	719	73	1.9
		7/27/05	storm	1.250	20.2	6.23	69.1	7.7	1340	320	8.0
5	Great Marsh Tributary	8/5/04	storm	0.859	19.3	0.8	6.6	6.9	145	22	9.2
		9/14/04	base	0.327	20.3	0.7	8	7.1	368	30	8.4
		6/21/05	base	0.026	19.4	2.02	22	6.8	442	52	49.0
		7/27/05	storm	**	20.6	4.12	45.9	7.4	159	1.3	6.2
6	Munson Ditch at Hawleywood Road	8/5/04	storm	0.308	18.7	6.4	69.3	7.8	1723	420	8.4
		9/14/04	base	**	18.7	0.82	9	7.5	1700	360	27.0
		6/21/05	base	**	17.5	0.057	6.2	7.8	3825	1200	5.2
		7/27/05	storm	0.311	20.7	5.53	61.2	7.9	2710	620	5.8
7	Munson Ditch downstream of US20	8/5/04	storm	0.280	18.9	6.9	70.1	7.6	1760	450	17.0
		9/14/04	base	**	19.3	1.7	18	7.8	3270	890	30.0
		6/21/05	base	0.120	17.8	2.87	21.8	8.2	>3999	3700	11.0
		7/27/05	storm	0.252	20.9	5.17	58.1	7.8	1800	370	7.0

Site	Stream Name	Date	Event	Flow (cfs)	Temp (deg C)	DO (mg/L)	% Sat	pH	Cond (µmohs/cm)	Cl- (mg/L)	TSS (mg/L)
8	Munson Ditch upstream of US20	8/5/04	storm	0.226	18.9	5.4	57.7	7.5	1664	440	5.2
		9/14/04	base	**	18.7	1.5	15.5	7.8	1605	270	10.0
		6/21/05	base	**	18.3	2.81	28.9	8.1	1820	370	20.0
		7/27/05	storm	0.231	24.7	5.18	57.1	7.7	2170	430	<1.9
A	Munson Ditch at Waverly	7/27/05	storm	0.025	24.7	3.83	47.9	7.8	1910	460	66.0
B	Munson Ditch at US 12	7/27/05	storm	0.206	19.1	7.01	75.6	7.8	1440	340	13.0
E	Munson Ditch at Interstate 49	7/27/05	storm	0.210	21.1	5.02	58.7	7.6	1950	460	<1.9
AA	Across from Splashdown Dunes	6/21/05	base	0.033	24.6	3.88	46.6	7.5	2156	--	--

*Backwash from Lake Michigan.
**Stagnant water-no flow measured; no loading calculated

Table H 2. Chemical and bacterial characteristics of the Dunes Creek watershed waterbodies as sampled on August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Site	Stream Name	Date	Event	Ammonia-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Ortho-Phosphate (mg/L)	Total Phosphorus (mg/L)	*E. coli* (col/100 mL)
1A	Cowles Bog outlet at Waverly Road	8/5/04	storm	0.047	0.030	0.096	0.120	800
		9/14/04	base	0.300	0.030	0.073	0.240	1900
		6/21/05	base	0.170	<0.10	0.220	0.350	30
		7/27/05	storm	0.150	<0.10	0.010	0.090	560
2	West Tributary at Trail 2	8/5/04	storm	0.082	0.170	0.052	0.039	680
		9/14/04	base	0.052	0.290	0.020	0.006	360
		6/21/05	base	0.140	0.210	0.050	0.030	700
		7/27/05	storm	0.150	0.220	0.040	0.110	550
3	Dunes Creek (pre-culvert)	8/5/04	storm	0.079	0.150	0.057	0.068	600
		9/14/04	base	0.044	0.150	0.026	0.021	500
		6/21/05	base	0.080	0.260	0.080	0.050	220

Site	Stream Name	Date	Event	Ammonia-Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	Ortho-Phosphate (mg/L)	Total Phosphorus (mg/L)	*E. coli* (col/100 mL)
		7/27/05	storm	0.330	0.290	0.050	0.140	920
4	Dunes Creek Outlet at Lake Michigan	8/5/04	storm*	0.055	0.220	0.038	0.051	1600
		9/14/04	base	0.047	0.160	0.026	0.012	190
		6/21/05	base	0.070	0.250	0.070	0.050	800
		7/27/05	storm	0.160	0.330	0.060	0.170	1100
5	Great Marsh Tributary	8/5/04	storm	0.011	0.030	0.043	0.096	360
		9/14/04	base	0.015	0.030	0.037	0.045	220
		6/21/05	base	0.130	<0.10	0.110	0.190	70
		7/27/05	storm	0.260	0.530	0.030	0.180	1500
6	Munson Ditch at Hawleywood Road	8/5/04	storm	0.062	0.090	0.150	0.180	1800
		9/14/04	base	0.361	0.050	0.290	0.370	310
		6/21/05	base	3.500	<0.10	0.820	0.780	9200
		7/27/05	storm	0.300	0.290	0.070	0.190	1500
7	Munson Ditch downstream of US20	8/5/04	storm	0.042	0.050	0.200	0.240	900
		9/14/04	base	0.033	0.030	0.063	0.097	100
		6/21/05	base	1.000	<0.10	0.130	0.130	110
		7/27/05	storm	0.090	0.150	0.110	0.200	1600
8	Munson Ditch upstream of US20	8/5/04	storm	0.044	0.050	0.210	0.230	930
		9/14/04	base	0.010	0.030	0.180	0.240	40
		6/21/05	base	0.431	<0.10	0.380	0.380	1600
		7/27/05	storm	0.100	0.540	0.140	0.230	80
A	Munson Ditch at Waverly	7/27/05	storm	0.090	0.450	0.070	0.230	1500
B	Munson Ditch at US 12	7/27/05	storm	0.080	0.510	0.040	0.160	1600
E	Munson Ditch at Interstate 49	7/27/05	storm	<0.02	0.360	0.170	0.290	1000

*Backwash from Lake Michigan.

Table H 3. Chemical loading data for the Dunes Creek watershed waterbodies as sampled on August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Site	Stream Name	Date	Event	Ammonia-Nitrogen Load (lb/d)	Nitrate-Nitrogen Load (lb/d)	Ortho-Phosphate Load (lb/d)	Total Phosphorus Load (lb/d)	TSS Load (lb/d)	*E. coli* Load (mil col/d)
1A	Cowles Bog outlet at Waverly Road	8/5/04	storm	0.017	0.011	0.034	0.043	3.024	1.29
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	0.001	bdl	0.001	0.002	2.318	0.0007
		7/27/05	storm	--	--	--	--	--	--
2	West Tributary at Trail 2	8/5/04	storm	0.338	0.700	0.214	0.161	45.302	12.70
		9/14/04	base	0.056	0.313	0.022	0.006	2.264	1.76
		6/21/05	base	0.146	0.218	0.052	0.031	1.977	3.30
		7/27/05	storm	0.097	0.142	0.026	0.071	1.682	1.61
3	Dunes Creek (pre-culvert)	8/5/04	storm	1.410	2.677	1.017	1.214	99.948	48.57
		9/14/04	base	0.240	0.817	0.142	0.114	10.344	12.35
		6/21/05	base	0.151	0.492	0.151	0.095	6.055	1.89
		7/27/05	storm	1.841	1.618	0.279	0.781	39.612	23.28
4	Dunes Creek Outlet at Lake Michigan	8/5/04	storm*	--	--	--	--	--	--
		9/14/04	base	0.271	0.923	0.150	0.069	11.536	4.97
		6/21/05	base	0.145	0.517	0.145	0.103	3.933	7.51
		7/27/05	storm	1.078	2.224	0.404	1.145	53.905	33.62
5	Great Marsh Tributary	8/5/04	storm	0.051	0.139	0.199	0.445	42.600	7.56
		9/14/04	base	0.026	0.053	0.065	0.079	14.807	1.76
		6/21/05	base	0.018	bdl	0.015	0.027	6.867	0.04
		7/27/05	storm	--	--	--	--	--	--
6	Munson Ditch at Hawleywood Road	8/5/04	storm	0.103	0.149	0.249	0.299	13.946	13.56
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	--	--	--	--	--	--
		7/27/05	storm	0.503	0.486	0.117	0.319	9.723	11.41
7	Munson Ditch downstream of US20	8/5/04	storm	0.063	0.075	0.302	0.362	25.659	6.16
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	0.647	bdl	0.084	0.084	7.115	0.32
		7/27/05	storm	0.122	0.204	0.149	0.272	9.509	9.86

Site	Stream Name	Date	Event	Ammonia-Nitrogen Load (lb/d)	Nitrate-Nitrogen Load (lb/d)	Ortho-Phosphate Load (lb/d)	Total Phosphorus Load (lb/d)	TSS Load (lb/d)	*E. coli* Load (mil col/d)
8	Munson Ditch upstream of US20	8/5/04	storm	0.054	0.061	0.256	0.280	6.335	5.14
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	--	--	--	--	--	--
		7/27/05	storm	0.125	0.672	0.174	0.286	bdl	0.45
A	Munson Ditch at Waverly	7/27/05	storm	0.012	0.061	0.009	0.031	8.894	0.92
B	Munson Ditch at US 12	7/27/05	storm	0.089	0.566	0.044	0.178	14.436	8.06
E	Munson Ditch at Interstate 49	7/27/05	storm	--	0.408	0.192	0.328	--	5.13

bdl=Below detection level
*Backwash from Lake Michigan.

Table H 4. Chemical areal loading data for the Dunes Creek watershed waterbodies as sampled on August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Site	Stream Name	Date	Event	Ammonia Areal Load (lb/ac-d)	Nitrate Areal Load (lb/ac-d)	OP Areal Load (lb/ac-d)	TP Areal Load (lb/ac-d)	TSS Areal Load (lb/ac-d)	*E. coli* Areal Load (mil col/ ac-d)
1A	Cowles Bog outlet at Waverly Road	8/5/04	storm	0.00000	0.00000	0.00001	0.00001	0.00072	0.00031
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	0.0000002	--	0.0000003	0.0000004	0.0005520	0.0000002
		7/27/05	storm	--	--	--	--	--	--
2	West Tributary at Trail 2	8/5/04	storm	0.00026	0.00054	0.00016	0.00012	0.03471	0.00973
		9/14/04	base	0.000043	0.00024	0.000017	0.000005	0.00173	0.00135
		6/21/05	base	0.00011	0.00017	0.00004	0.00002	0.00151	0.00253
		7/27/05	storm	0.00007	0.00011	0.00002	0.00005	0.00129	0.00124
3	Dunes Creek	8/5/04	storm	0.00019	0.00036	0.00014	0.00016	0.01349	0.00656

Site	Stream Name	Date	Event	Ammonia Areal Load (lb/ac-d)	Nitrate Areal Load (lb/ac-d)	OP Areal Load (lb/ac-d)	TP Areal Load (lb/ac-d)	TSS Areal Load (lb/ac-d)	*E. coli* Areal Load (mil col/ ac-d)
	(pre-culvert)	9/14/04	base	0.000032	0.00011	0.000019	0.00002	0.00140	0.00167
		6/21/05	base	0.000020	0.000066	0.000020	0.000013	0.00082	0.00025
		7/27/05	storm	0.00025	0.00022	0.00004	0.00011	0.00535	0.00314
4	Dunes Creek Outlet at Lake Michigan	8/5/04	storm*	--	--	--	--	--	--
		9/14/04	base	0.000037	0.00012	0.000020	0.00001	0.00156	0.00067
		6/21/05	base	0.000020	0.000070	0.000020	0.000014	0.00053	0.00101
		7/27/05	storm	0.00015	0.00030	0.00005	0.00015	0.00728	0.00454
5	Great Marsh Tributary	8/5/04	storm	0.00002	0.00006	0.00008	0.00018	0.01773	0.00315
		9/14/04	base	0.000011	0.00002	0.000027	0.00003	0.00616	0.00073
		6/21/05	base	0.00001	--	0.000006	0.000011	0.00286	0.00002
		7/27/05	storm	--	--	--	--	--	--
6	Munson Ditch at Hawleywood Road	8/5/04	storm	0.00017	0.00025	0.00041	0.00049	0.02298	0.02233
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	--	--	--	--	--	--
		7/27/05	storm	0.00083	0.00080	0.00019	0.00052	0.01602	0.01879
7	Munson Ditch downstream of US20	8/5/04	storm	0.00013	0.00015	0.00062	0.00074	0.05269	0.01265
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	0.00133	--	0.00017	0.00017	0.01461	0.00066
		7/27/05	storm	0.00025	0.00042	0.00031	0.00056	0.01953	0.02024
8	Munson Ditch upstream of US20	8/5/04	storm	0.00015	0.00017	0.00072	0.00079	0.01784	0.01448
		9/14/04	base	--	--	--	--	--	--
		6/21/05	base	--	--	--	--	--	--
		7/27/05	storm	0.00035	0.00189	0.00049	0.00081	--	0.00127
A	Munson Ditch at Waverly	7/27/05	storm	0.00034	0.00168	0.00026	0.00086	0.24706	0.02547
B	Munson Ditch at US 12	7/27/05	storm	0.00011	0.00067	0.00005	0.00021	0.01719	0.00959

Site	Stream Name	Date	Event	Ammonia Areal Load (lb/ac-d)	Nitrate Areal Load (lb/ac-d)	OP Areal Load (lb/ac-d)	TP Areal Load (lb/ac-d)	TSS Areal Load (lb/ac-d)	*E. coli* Areal Load (mil col/ ac-d)
E	Munson Ditch at SR 49	7/27/05	storm		0.00261	0.00123	0.00210		0.03292

*Backwash from Lake Michigan.

Temperature

Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Water temperature also governs species composition and activity of aquatic biological communities. Since essentially all aquatic organisms are 'cold-blooded', the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana streams according to the time of year. For example, temperatures during the summer and fall months (June through September) should not exceed 32.2 °C (90 °F).

Water temperatures in the Dunes Creek watershed streams varied over time. (Table H1 lists the temperatures collected at each site while Figure H1 displays temperature variations at the eight main sites over the four collection events.) As expected, stream temperatures in August 2004, September 2004, and June 2005 were lower than stream temperatures in July 2005 during storm flow conditions. Temperatures were generally higher in reaches that lacked overhanging vegetation, such as Munson Ditch or those that drained wetlands, like the Great Marsh Tributary. Streamside vegetation provides shading to the water and typically prevents heat gain. Additionally, those streams with cooler temperatures likely had a greater proportion of groundwater flowing in them. The higher temperatures measured in these sites are likely due to the lack of riparian and overhanging vegetation, lack of tree canopy, lower proportion of groundwater inputs, and/or higher proportions of surface water inputs.

Water temperatures were generally lower in those stream reaches that were shaded by overhanging vegetation, like the West Tributary which is located within the Indiana Dunes State Park. Water temperatures during the 2005 storm flow ranged from 19.9 °C in the West Tributary (Site 2) to 24.7 °C (76.5 °F) in Munson Ditch immediately upstream of U.S. Highway 20 (Site 8) and east of Waverly Road (Site A). Greater variation was observed during the other three events when stream temperatures ranged from 18.1 °C (64.6 °F) at the West Tributary (Site 2) to 19.3 °C (66.7 °F) at the Great Marsh Tributary (Site 5) during the 2004 storm event, from 18.2 °C (64.8 °F) at the Cowles Bog outlet (Site 1) and the West Tributary (Site 2) to 20.3 °C (68.5°F) iat the Great Marsh tributary during the 2004 base flow event, and from 16.7 °C (62.1 °F) at the West Tributary (Site 2) to 19.4 °C (66.9 °F) in the Great Marsh Tributary (Site 5) during the 2005 base flow event. None of the observed water temperatures exceeded the IAC standard for the protection of aquatic life.

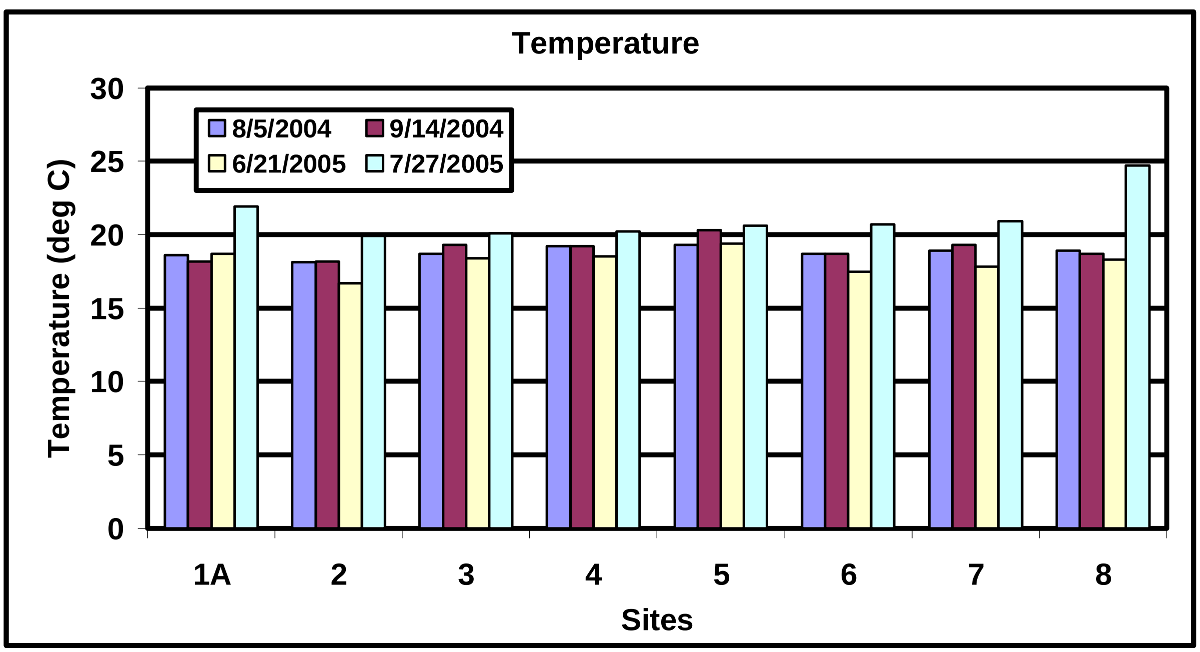


Figure H 1. Temperature levels in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005. Dunes Creek watershed and surrounding area.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3-5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC sets the minimum DO concentration at 4 mg/L, but all waters must have a daily average of 5 mg/L. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Conversely, dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Dissolved oxygen concentrations were generally low throughout the watershed. (Table H1 lists the dissolved oxygen concentrations collected at each site while Figure H2 displays dissolved oxygen concentration variations at the eight main sites over the four collection events.) Dissolved oxygen concentrations were typically lower in reaches downstream of large wetland complexes like Cowles Bog and the Great Marsh, Sites 1 and 5, respectively, and in reaches with stagnant or very slow flowing water, like Munson Ditch (Sites 6 to 8). During all four sampling events, dissolved oxygen levels at the Cowles Bog outlet (Site 1) and at the Great Marsh Tributary (Site 5) were below the Indiana state standard (5 mg/L). Concentrations in the Cowles Bog outlet ranged from 0.3 mg/L during the 2004 base flow event to 3.4 mg/L during the 2005 storm event, while concentrations in the Great Marsh Tributary ranged from 0.7 mg/L during the 2004 base flow event to 4.1 mg/L during the 2005 storm event. Concentrations in Munson Ditch at Hawleywood Road (Site 6), downstream of U.S. Highway 20 (Site 7), and upstream of U.S. Highway 20 (Site 8) during both the 2004 and 2005 base flow events were also below the state standard. The stream was stagnant at these three reaches during both events except for the reach associated with Site 7 during the 2005 base flow event.

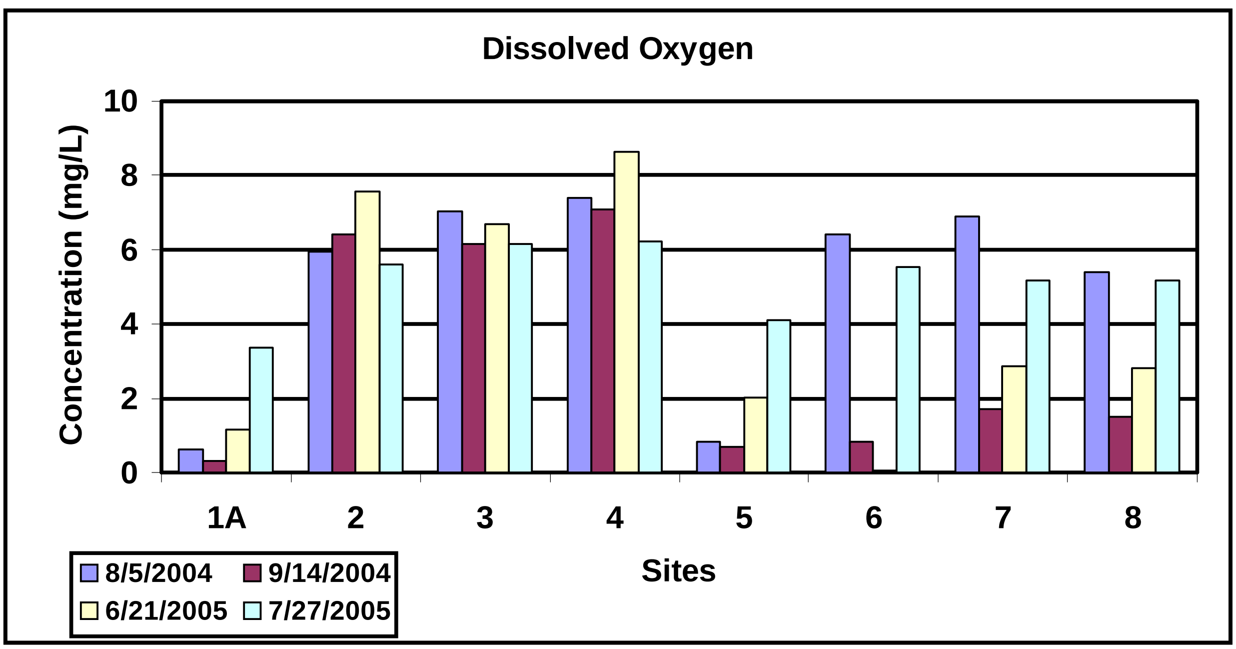


Figure H 2. Dissolved oxygen concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Because DO varies with temperature (cold water can contain more oxygen than warm water), it is relevant to examine DO saturation values. DO saturation refers to the amount of oxygen dissolved in water compared to the total amount possible when equilibrium between the stream water and the atmosphere is maximized. When a stream is less than 100% saturated with oxygen, decomposition processes within the stream may be consuming oxygen more quickly than it can be replaced and/or flow in the stream is not turbulent enough to entrain sufficient oxygen. All of the Dunes Creek watershed stream reaches were undersaturated during the sampling events. Saturation levels varied from 3.2% in the Cowles Bog outlet (Site 1) during the 2004 base flow event to 93.7% in the Dunes Creek outlet (Site 4) during the 2005 base flow event. Low saturation is likely attributed to slow stream flow, lack of dissolved oxygen entrainment from the atmosphere, and elevated stream temperatures at some sites.

Conductivity

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1998). During low discharge, conductivity is typically higher during base flow than during high discharge, because the water moves more slowly across or through ion containing soils and substrates. Carbonates and other charged particles (ions) dissolve into the slow-moving water, thereby increasing conductivity measurements.

Rather than setting a conductivity standard, the IAC sets a standard for dissolved solids (750 mg/L). Multiplying a dissolved solids concentration by a conversion factor of 0.55 to 0.75 µmhos per mg/L of dissolved solids roughly converts a dissolved solids concentration to specific conductance (Allan, 1995). Thus, converting the IAC dissolved solids concentration standard to specific conductance by multiplying 750 mg/L by 0.55 to 0.75 µmhos per mg/L yields a specific conductance range of approximately 1000 to 1360 µmhos. This report presents conductivity measurements at each site in µmhos.

Conductivity levels were relatively normal for Indiana streams in the mainstem of Dunes Creek, the Western Tributary, Cowles Bog outlet, and Great Marsh Tributary during most assessments; however, concentrations were elevated in Munson Ditch and the mainstem of Dunes Creek during the 2005 storm event. (Table H1 lists the conductivity collected at each site while Figure H3 displays conductivity variations at the eight main sites over the four collection events.) Conductivity concentrations were within normal ranges for Indiana streams during the all four sampling events for the Cowles Bog outlet (Site 1), the West Tributary (Site 2), the mainstem of Dunes Creek upstream and downstream of the culvert (Sites 3 and 4, respectively), and the Great Marsh Tributary (Site 5). However, conductivity readings approached but did not exceed the Indiana state standard (1360 µmhos) within the Dunes Creek mainstem upstream and downstream of the culvert (Sites 3 and 4, respectively) during the 2005 storm event. Concentrations ranged from 1310 µmhos upstream of the culvert to 1340 µmhos downstream of the culvert.

Conductivity readings exceeded the Indiana state standard in Munson Ditch during all four of the sampling events. Concentrations ranged from 1605 µmhos upstream of U.S. Highway 20 (Site 8) during the 2004 base flow event to >3,999 µmhos downstream of U.S. Highway 20 (Site 7) during the 2005 base flow event. Concentrations were generally highest in Munson Ditch downstream of U.S. Highway 20 (Site 7) during all four sampling events. During both base flow events, conductivity measurements downstream of U.S. Highway 20 (Site 7) were nearly double those measured at the upstream sampling location (Site 8).

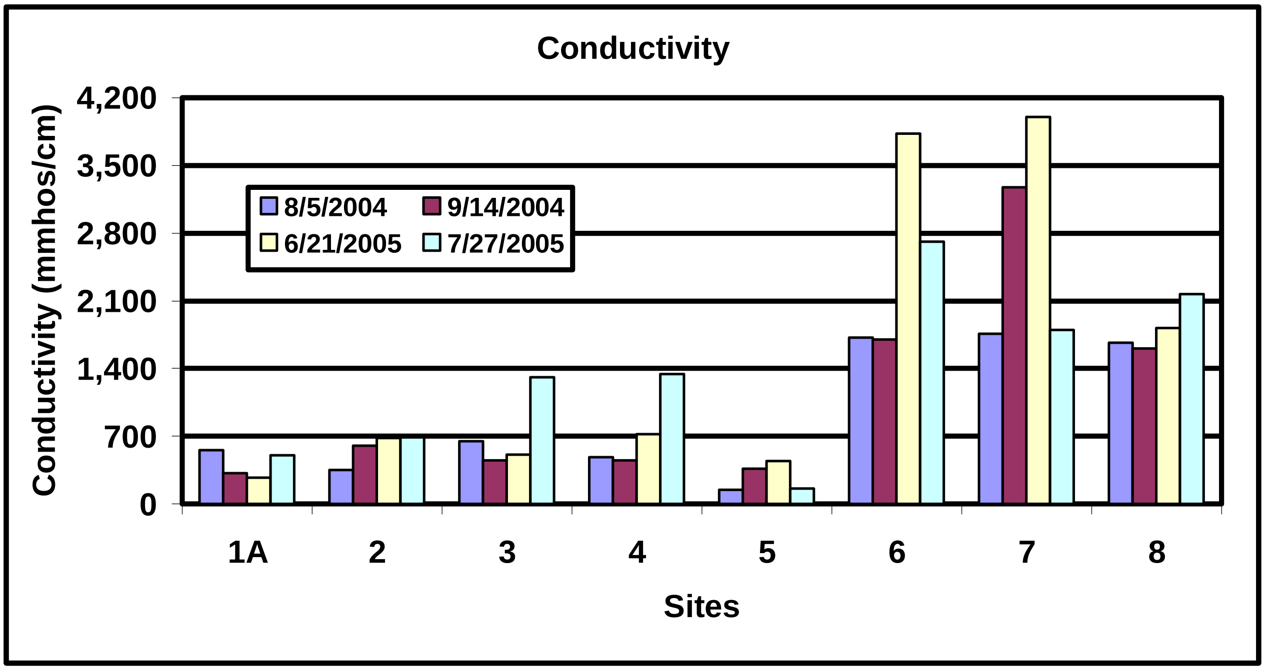


Figure H 3. Conductivity concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Historical studies indicate that elevated conductivity measurements have long been an issue in the Dunes Creek watershed streams. Arihood (1974) indicated that conductivity levels were higher in Dunes Creek watershed streams than most streams in the region; however, conductivity measurements did not exceed the Indiana state standard. Hardy (1984) found highly variable specific conductance levels and dissolved solids concentrations in Dunes Creek. Furthermore, Hardy reported that the high levels reflected elevated levels of sodium and chloride during high flow periods. Based on the location of the sampling sites, Hardy attributed these levels to seepage from residential septic systems and runoff from the road salt storage facility located on U.S. Highway 20 just east of Interstate 49. Hardy (1984) also suggested that the two north tributaries of Markowitz Ditch (not sampled during the current study) contribute high dissolved solids concentrations in Dunes Creek.

Chlorides

The chloride ion (Cl^-) is one component of common salts applied to roads, sidewalks, and parking lots to remove snow and ice from these hard surfaces. Pitt (1985) suggests that almost all of salt applied to roads ends up in nearby creeks and streams due to the high solubility of salt in water. At high levels, salts can increase the salinity of freshwater streams to the point of toxicity for many freshwater biota (Schueler, 1987). The IAC sets a maximum concentration for chlorides at 230 mg/L to protect aquatic life.

Like conductivity levels, chloride concentrations were relatively normal in the mainstem of Dunes Creek, the Western Tributary, Cowles Bog outlet, and Great Marsh Tributary during most assessments; however, concentrations were elevated in Munson Ditch during all four assessments. (Table H1 lists the chloride concentrations measured at each site while Figure H4 displays conductivity variations at the eight main sites over the four collection events.) Chloride concentrations were within normal ranges for Indiana streams during all four sampling events for the Cowles Bog outlet (Site 1), the West Tributary (Site 2), the mainstem of Dunes Creek upstream and downstream of the culvert (Sites 3 and 4, respectively), and the Great Marsh Tributary (Site 5). However, conductivity readings exceeded the Indiana state standard (230 mg/L) within the Dunes Creek mainstem upstream and downstream of the culvert (Sites 3 and 4, respectively) during the 2005 storm event. Concentrations ranged from 300 mg/L upstream of the culvert to 320 mg/L downstream of the culvert.

Chloride concentrations exceeded the Indiana state standard in the three reaches of Munson Ditch during all four of the sampling events. Concentrations ranged from 270 mg/L upstream of U.S. Highway 20 (Site 8) during the 2004 base flow event to 3700 mg/L downstream of U.S. Highway 20 (Site 7) during the 2005 base flow event. Like conductivity measurements, chloride concentrations were generally highest in Munson Ditch downstream of U.S. Highway 20 (Site 7) during all four sampling events.

High levels of sodium and chloride in Dunes Creek during high flow periods have historically been attributed to seepage from residential septic systems and runoff from the road salt storage facility located on U.S. Highway 20 just east of Interstate 49 (Hardy, 1984). Arihood (1974) also reported elevated groundwater chloride concentrations ranging from 3.5 to 240 mg/L. Hardy (1984) suggested that the two north tributaries of Markowitz Ditch (not sampled during the current study) contribute high dissolved solids concentrations. Watson et al. (2002) reported that the principal source of elevated chloride and sodium levels in ground water in parts of the Dunes Creek watershed were from highway deicer. They found chloride concentrations exceeding the USEPA secondary maximum contaminant level of 250 mg/L for drinking water in seven wells during late winter, spring, and summer samplings. The sample sites were located down-gradient from US Highway 12 and east of Kemil Road in the southeast corner of the Dunes Creek watershed. Sodium levels also periodically exceeded the USEPA drinking-water equivalency level of 20 mg/L (Watson et al. 2002).

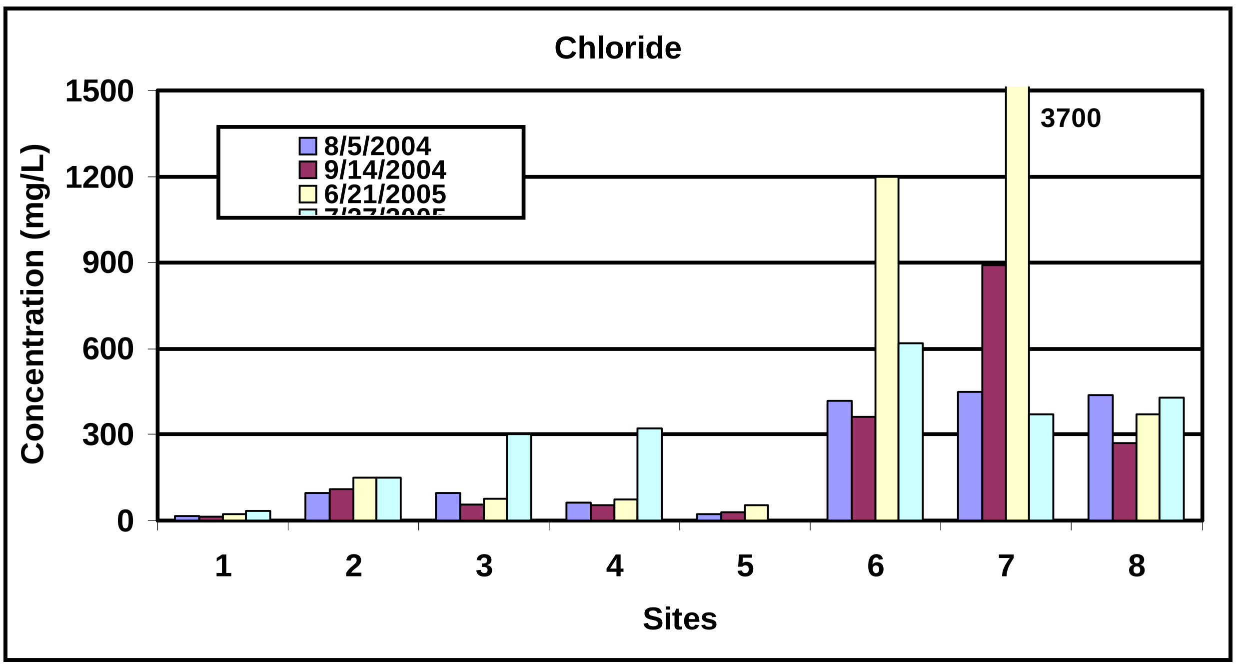


Figure H 4. Chloride concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

pH

The pH of water describes the concentration of acidic ions (specifically H+) present in water. Water's pH determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6 to 9 pH units for the protection of aquatic life. pH concentrations in excess of 9 are considered acceptable when the concentration occurs as daily fluctuations associated with photosynthetic activity. (Table H1 lists the pH levels recorded at each site while Figure H5 displays pH variations at the eight main sites over the four collection events.)

pH values fell within acceptable ranges for all four sampling events at all eight sites. pH values in Dunes Creek and its tributaries ranged from 7.0 in Dunes Creek upstream of the culvert (Site 3) to 8.2 in Munson Ditch downstream of U.S. Highway 20 (Site 7) during the 2005 base flow event. (Dunes Creek at Lake Michigan (Site 4) during the 2004 storm flow event actually possessed the highest measured pH. However, this was Lake Michigan water, not Dunes Creek water, as lake water was being blown into the mouth of the stream by strong winds on the day of sample collection.) All pH values measured were within the range of 6 to 9 units established as acceptable by the IAC for the protection of aquatic life.

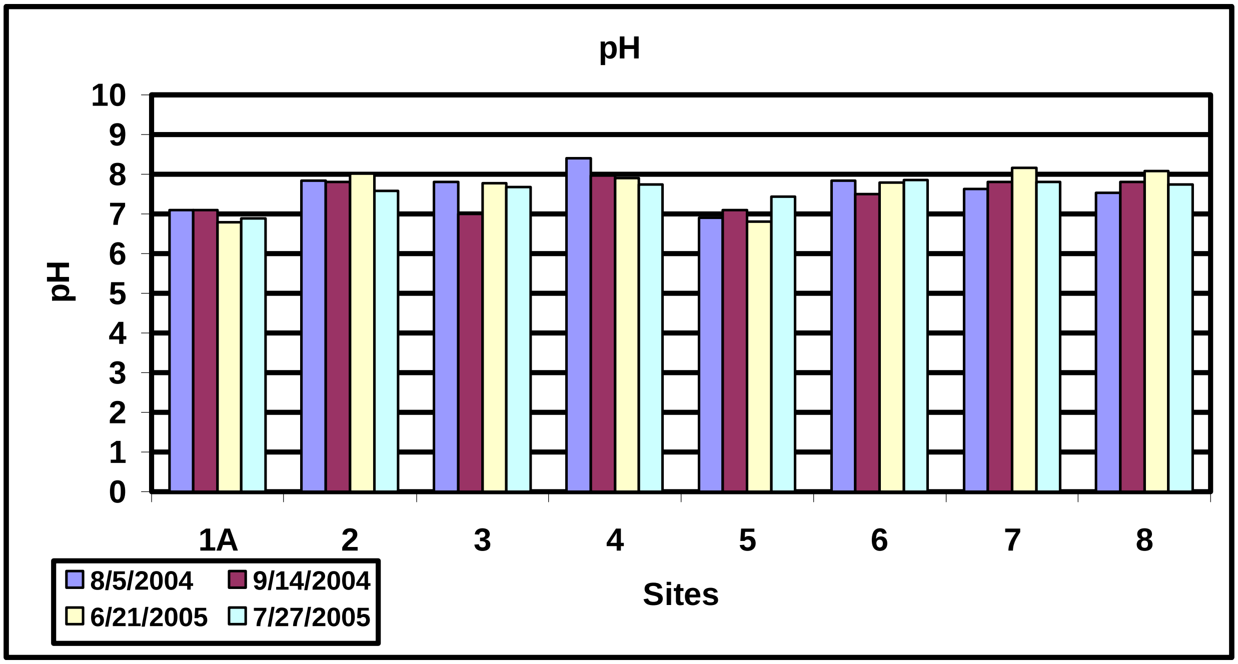


Figure H 5. pH concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Total Suspended Solids (TSS)

A TSS measurement quantifies all particles suspended in water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in water.

Suspended solids impact streams and lakes in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek or lake bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. Few people are enthusiastic about having a picnic near a muddy creek or lake. Pollutants attached to sediment also degrade water quality. In general, TSS concentrations greater than 80 mg/L have been found to be deleterious to aquatic life (Waters, 1995).

The concentration of suspended solids is generally greater in streams during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream. The sediment in water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks and poorly managed farm fields.

Total suspended solids concentrations measured during storm flow events typically exceed concentrations measured during base flow conditions within streams; however, this does not occur within the Dunes Creek watershed streams. (Table H1 lists the total suspended solids concentrations measured at each site while Figure H6 displays total suspended solids concentration variations at the eight main sites over the four collection events.) High overland flow velocities typically result in an increase in sediment particles in runoff. Additionally, greater streambank and streambed erosion typically occurs during high flow. Therefore, higher concentrations of suspended solids are typically measured in storm flow samples. In the Dunes Creek watershed, the typical version of total suspended solids concentrations being higher during storm flow conditions occurs only within the mainstem of Dunes Creek; at all other sites, TSS concentrations measured during storm flow are not always greater than TSS concentrations measured during base flow events. Total suspended solids concentrations ranged from 1.9 mg/L to 3.3 mg/L in the mainstem of Dunes Creek upstream and downstream of the culvert during base flow and ranged from 5.6 mg/L to 21 mg/L in these same sites during storm flow sampling. However, the highest total suspended solids concentrations (430 mg/L and 74 mg/L) were measured in the Cowles Bog outlet during the 2005 base flow sampling and the 2004 base flow sampling, respectively. Flocculent, organic material flowing through this stream was collected within the total suspended solids sample. This material is common in streams that drain large wetland complexes. None of the other stream samples possessed total suspended solids concentrations that exceed the concentration found to be deleterious to aquatic life (Waters, 1995).

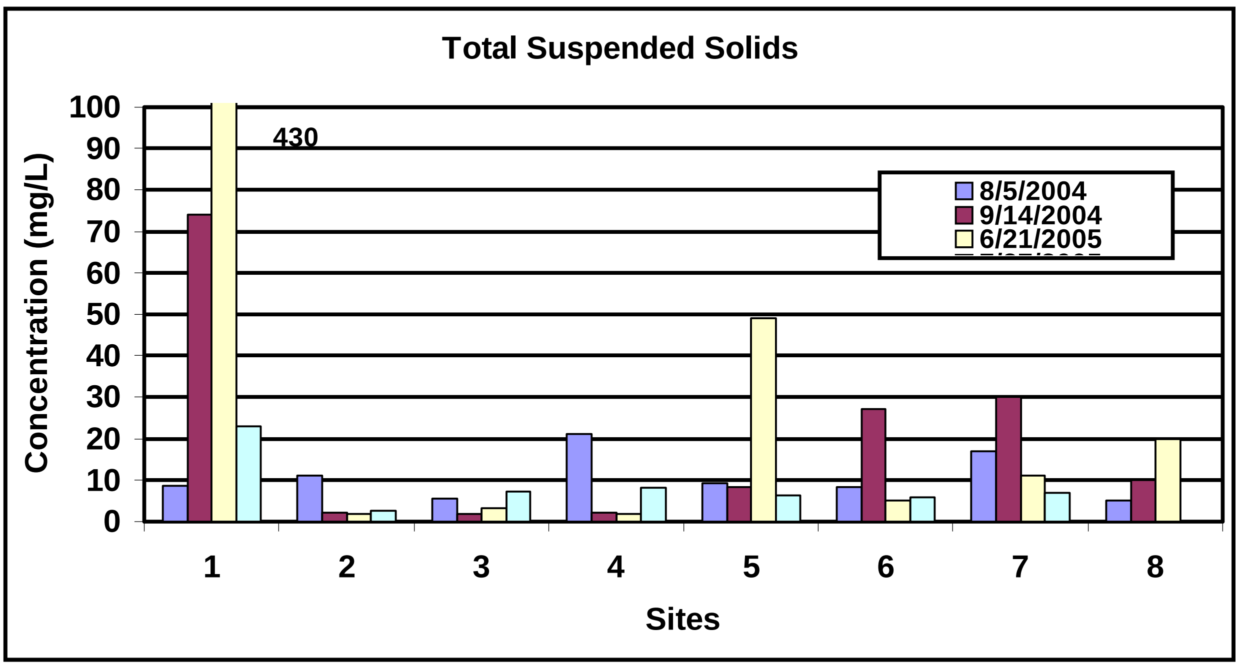


Figure H 6. Total suspended solids concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Nutrients

Limnologists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a lake or stream. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy lake or stream. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a lake or stream. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a lake or stream. Limnologists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

Nutrients themselves, as well as the primary producers (algae and plants) they feed, can also affect the composition of secondary producer communities such as macroinvertebrates and fish. Changes in secondary producer communities can, in turn, impact the way chemical constituents in the water are processed. This is an additional reason for examining nutrient levels in an aquatic ecosystem.

Like terrestrial plants, algae and rooted aquatic plants rely primarily on phosphorus and nitrogen for growth. Aquatic plants receive these nutrients from fertilizers, human and animal waste, atmospheric deposition in rainwater, and yard waste or other organic material that reaches the lake or stream. Nitrogen can also diffuse from the air into the water. This nitrogen is then “fixed” by certain algae species into a usable, “edible” form of nitrogen. Because of this readily available source of nitrogen (the air), phosphorus is usually the “limiting nutrient” in aquatic ecosystems. This means that it is actually the amount of phosphorus that controls plant growth in a lake or stream.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are **orthophosphate (OP)** and **total phosphorus (TP)**. OP is the dissolved form of phosphorus. It is the form that is “usable” by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are **nitrate-nitrogen (NO_3)** and **ammonium-nitrogen (NH_4^+)**. Nitrate is a dissolved form of nitrogen that is commonly found in the upper layers of a lake or anywhere that oxygen is readily available. Because oxygen should be readily available in stream systems, nitrate-nitrogen is often the dominant dissolved form of nitrogen in stream systems. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like OP, ammonium is a dissolved form of nitrogen and the one utilized by algae for growth.

While the United States Environmental Protection Agency (USEPA) has established some nutrient standards for drinking water safety, it has not established similar nutrient standards for protecting the biological integrity of a stream. (The USEPA, in conjunction with the States, is currently working on developing these standards.) The USEPA has issued recommendations for numeric nutrient criteria for streams (USEPA, 2000). While these are not part of the Indiana Administrative Code, they serve as potential target conditions for which watershed managers might aim. The Ohio EPA has also made recommendations for numeric nutrient criteria in streams based on research on Ohio streams (Ohio EPA, 1999). These, too, serve as potential target conditions for those who manage Indiana streams. Other researchers have suggested thresholds for several nutrients in aquatic ecosystems as well (Dodd et al., 1998). Lastly, the IAC requires that all waters of the state have a nitrate concentration of less than 10 mg/L, which is the drinking water standard for the state.

Researchers have recommended various thresholds and criteria for nutrients in streams. The USEPA’s recommended targets for nutrient levels in streams are fairly low. The agency recommends a target total phosphorus concentration of 0.033 mg/L in streams (USEPA, 2000). Dodd et al. (1998) suggest the dividing line between moderately (mesotrophic) and highly (eutrophic) productive streams is a total phosphorus concentration of 0.07 mg/L. The Ohio EPA recommended a total phosphorus concentration of 0.08 mg/L in headwater streams and 0.1 mg/L in wadeable streams to protect the streams’ aquatic biotic integrity (OHIO EPA, 1999). (These criteria are for streams classified as Warmwater Habitat, or WWH, meaning the stream is capable of supporting a healthy, diverse warmwater fauna. Streams that cannot support a healthy, diverse community of warmwater fauna due to “irretrievable, extensive, man-induced modification” are classified as Modified Warmwater Habitat (MWH) streams.) For planning purposes the WWH definition, 0.08 – 0.1 mg/L is being used as a goal for Dunes Creek.

The USEPA sets aggressive nitrogen criteria recommendations for streams compared to the Ohio EPA. The USEPA’s recommended criterion for nitrate-nitrogen concentration in streams in Aggregate Nutrient Ecoregion VII is 0.30 mg/L (USEPA, 2000). In contrast, the Ohio EPA suggests using nitrate-nitrogen criteria of 1.0 mg/L in headwater streams to protect aquatic life. Dodd et al. (1998) suggests the dividing line between moderately and highly productive streams using nitrate-nitrogen concentrations is approximately 1.5 mg/L.

It is important to remember that the nutrient threshold or recommended concentrations listed above are not state standards for water quality. They are presented here to provide a frame of reference for the concentrations found in

Dunes Creek and its tributaries. The IAC sets only nitrate-nitrogen and ammonia-nitrogen standards for waterbodies in Indiana. The IAC requires that all waters of the state have a nitrate-nitrogen concentration of less than 10 mg/L, which is the drinking water standard for the state. The IAC standard for ammonia-nitrogen depends upon the water's pH and temperature, since both can affect ammonia-nitrogen's toxicity. None of the samples collected from Dunes Creek violated the state standard for either nitrate-nitrogen or ammonia-nitrogen.

Nitrate-nitrogen

Nitrate-nitrogen concentrations during all four sampling events were extremely low at all sites. (Table H2 lists the nitrate-nitrogen concentrations measured at each site while Figure H7 displays nitrate-nitrogen concentration variations at the eight main sites over the four collection events.) Nitrate-nitrogen concentrations did not display any relationship between storm flow and base flow concentrations. Base flow concentrations ranged from 0.03 mg/L in the Cowles Bog outlet, the Great Marsh Tributary, and Munson Ditch upstream and downstream of U.S. Highway 20 during the 2004 base flow to 0.29 mg/L in the West Tributary during the 2004 base flow sampling event. During storm flow, concentrations ranged from 0.03 mg/L in the Cowles Bog outlet and the Great Marsh Tributary during the 2004 storm event to 0.54 mg/L in Munson Ditch upstream of U.S. Highway 20 during the 2005 storm event. Typically, nitrate-nitrogen concentrations were higher in Munson Ditch (Sites 6 through 8) than those concentrations measured in the mainstem of Dunes Creek, the West Tributary, or the Cowles Bog and Great Marsh outlets. All sites except the Dunes Creek mainstem (Sites 3 and 4) and Munson Ditch headwaters (Sites 8, A, B, and E) during the 2005 storm event were below the USEPA recommended criterion for nitrate-nitrogen of 0.3 mg/L for streams in the ecoregion, which includes the Dunes Creek watershed (USEPA, 2000). Additionally, all nitrate-nitrogen concentrations were below the concentration observed in Ohio streams (1.0 mg/L) known to support healthy warmwater fauna (OHIO EPA, 1999). Furthermore, concentrations at all stream sites were below the 10 mg/L concentration set by the IAC for safe drinking water.

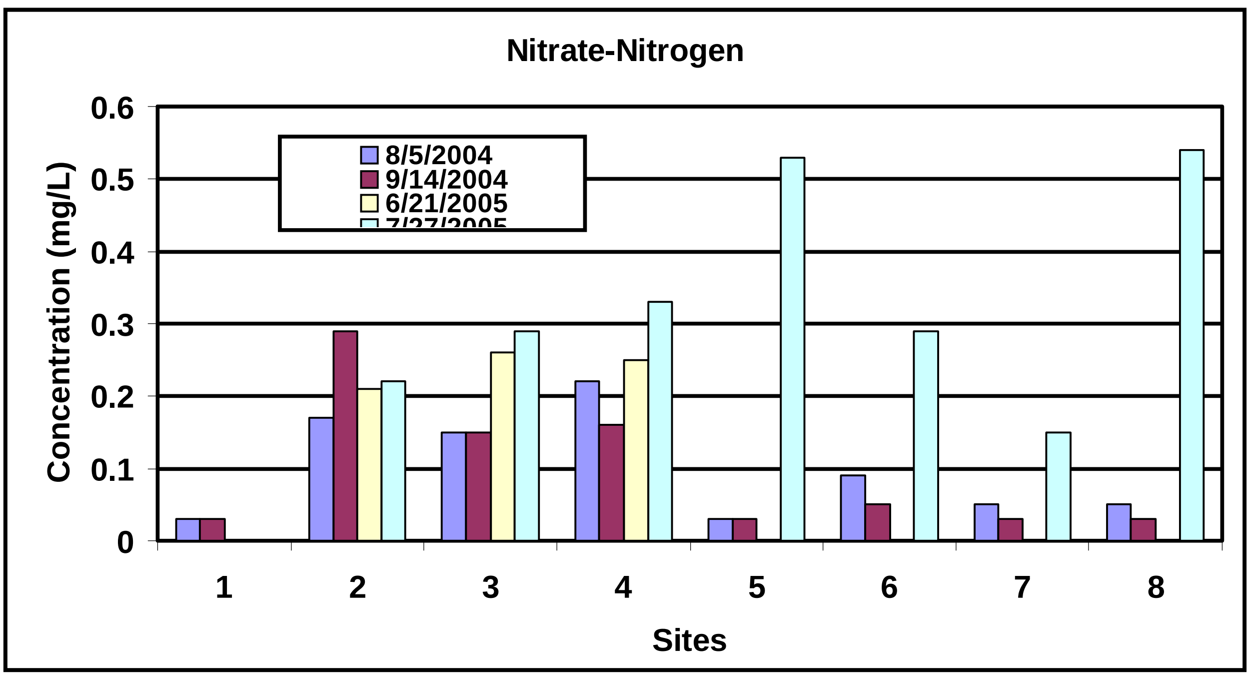


Figure H 7. Nitrate-nitrogen concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Ammonia-nitrogen

Like the nitrate-nitrogen concentrations, ammonia-nitrogen concentrations were relatively low at all sites during the four sampling events. (Table H2 lists the ammonia-nitrogen concentrations measured at each site while Figure H8 displays ammonia-nitrogen concentration variations at the eight main sites over the four collection events.) Under base flow conditions, Munson Ditch at Hawleywood Road (Site 6) during the 2005 base flow event exhibited the highest ammonia-nitrogen concentration (3.5 mg/L), while Munson Ditch downstream of U.S. Highway 20 (Site 7) during the same event was also elevated (1.0 mg/L). (Both sites were stagnant and contained extremely low dissolved oxygen concentrations during this sampling event. This suggests that decomposition may be occurring at these sites during stagnant water conditions.) Ammonia-nitrogen concentrations during storm flow conditions ranged from 0.011 mg/L in the Great Marsh Tributary (Site 5) during the 2004 storm event to 0.33 mg/L in Dunes Creek upstream of the culvert (Site 3) during the 2005 storm event. None of the samples collected during base or storm flow exceeded the IAC ammonia-nitrogen standard for the protection of aquatic life. Finally, it should be noted that all of the ammonia-nitrogen concentrations are flagged by Severn Trent Laboratiories for exceeding the laboratory's relative percent difference Quality Check (QC) during the 2004 base flow sampling. This is of concern, as data are reported that do not meet the laboratory's QC. However, ammonia-nitrogen concentrations are relatively low, so this is not of great concern.

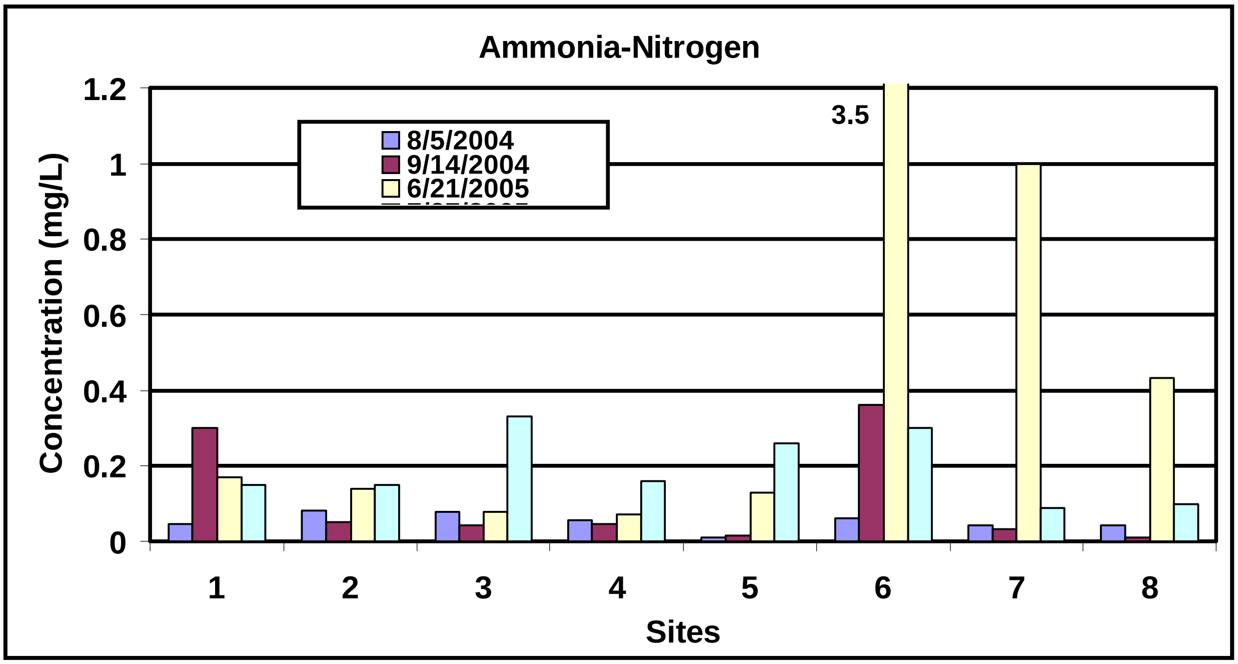


Figure H 8. Ammonia-nitrogen concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Orthophosphate

Orthophosphate, or dissolved phosphorus, concentrations within the Dunes Creek watershed streams were generally low. (Table H2 lists the orthophosphate concentrations measured at each site while Figure H9 displays orthophosphate concentration variations at the eight main sites over the four collection events.) Orthophosphate concentrations measured in Munson Ditch (Sites 6 to 8) exceeded concentrations measured throughout the rest of the watershed. Although there are no recommended criteria for orthophosphate concentrations, a comparison with total phosphorus concentration recommendations indicates that most of the Dunes Creek watershed sampling sites possess orthophosphate concentrations greater than those recommended for total phosphorus by the USEPA (0.033 mg/L) during all sampling events. Furthermore, Dunes Creek (Site 3) during the 2005 base flow event, the Cowles Bog Outlet (Site 1) during the 2004 storm flow and the 2005 base flow events, Great Marsh Tributary (Site 5) during the 2005 storm event, and the Munson Ditch sites (Sites 6 to 8) during three of the four sampling events contained orthophosphate concentrations that exceeded the mesotrophic-eutrophic boundary level identified by Dodd et al. (1998) and the level at which the Ohio EPA indicates that biotic impairment can occur (0.1 mg/L).

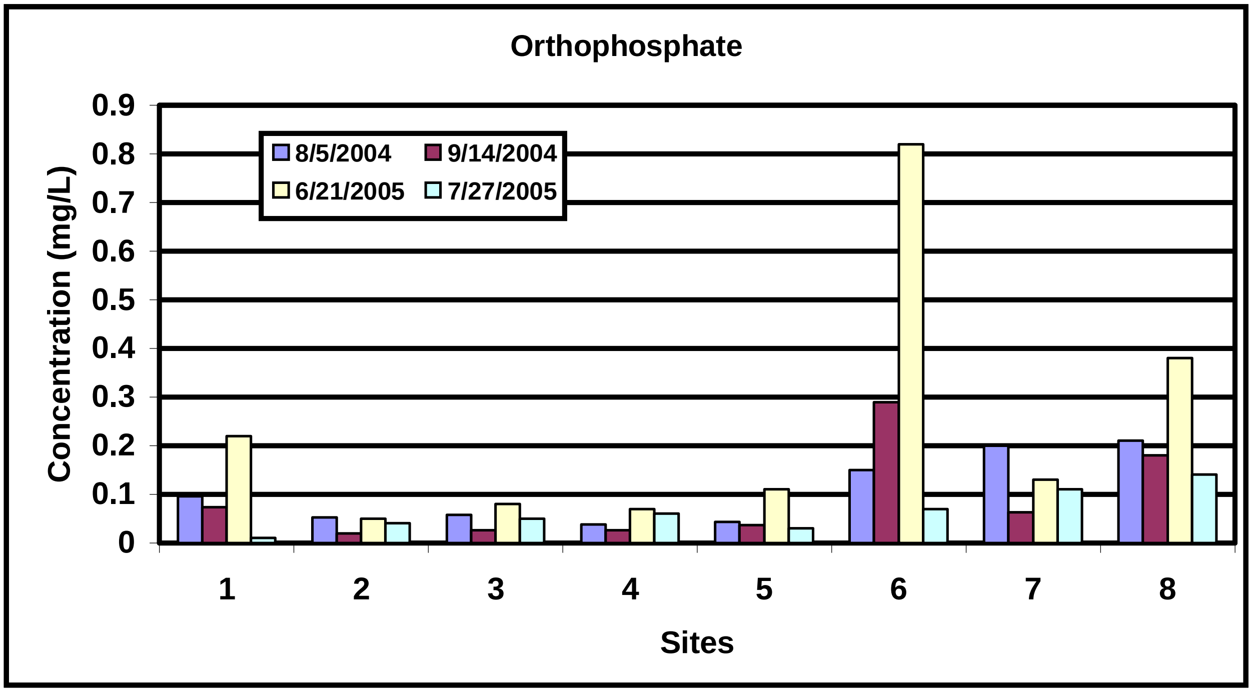


Figure H 9. Orthophosphate concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Samples from most streams revealed that the orthophosphate fraction was greater than half of the total phosphorus concentration suggesting that most phosphorus loading was dissolved, available phosphorus not particulate soil-associated phosphorus (Figure H10). The West Tributary during three of the four sampling events and Dunes Creek upstream and downstream of the culvert during the 2004 base flow and 2005 storm flow events possessed orthophosphate concentrations that exceeded the respective total phosphorus concentrations. This is likely a result of limitations involved with laboratory sample analysis procedures. It should be noted that all of the total and orthophosphate concentrations were flagged for the 2004 base flow sampling as they were below the laboratory's reporting limit but exceeded the laboratory's QC detection limit. The subsequent sampling events also possessed some QC flags. These include soluble and total phosphorus concentrations below the laboratory's reporting limit but above their detection limit. In the case of phosphorus, Save the Dunes requested that Severn Trent Laboratiories report data at a level that the laboratory is not completely comfortable with reporting (below their reporting level) and in doing so, some of the data become questionable. However, these data meet minimum criteria based on the number of significant figures (3) that Severn Trent Laboratiories reported and the relatively similar concentrations of soluble and total phosphorus. Essentially, as noted above, the majority of total phosphorus is almost entirely composed of orthophosphate which accounts for a large amount of the data variability. For the remaining sites, the results suggest that nearly all of the total phosphorous measured in the Dunes Creek watershed streams consist of dissolved phosphorus. All sites exhibited higher particulate phosphorus levels during the 2005 storm event than those present during the other three sampling events. Elevated particulate phosphorus levels in streams following storm events are indicative of soil loss via erosion since particulate phosphorus is typically adsorbed to soil particles.

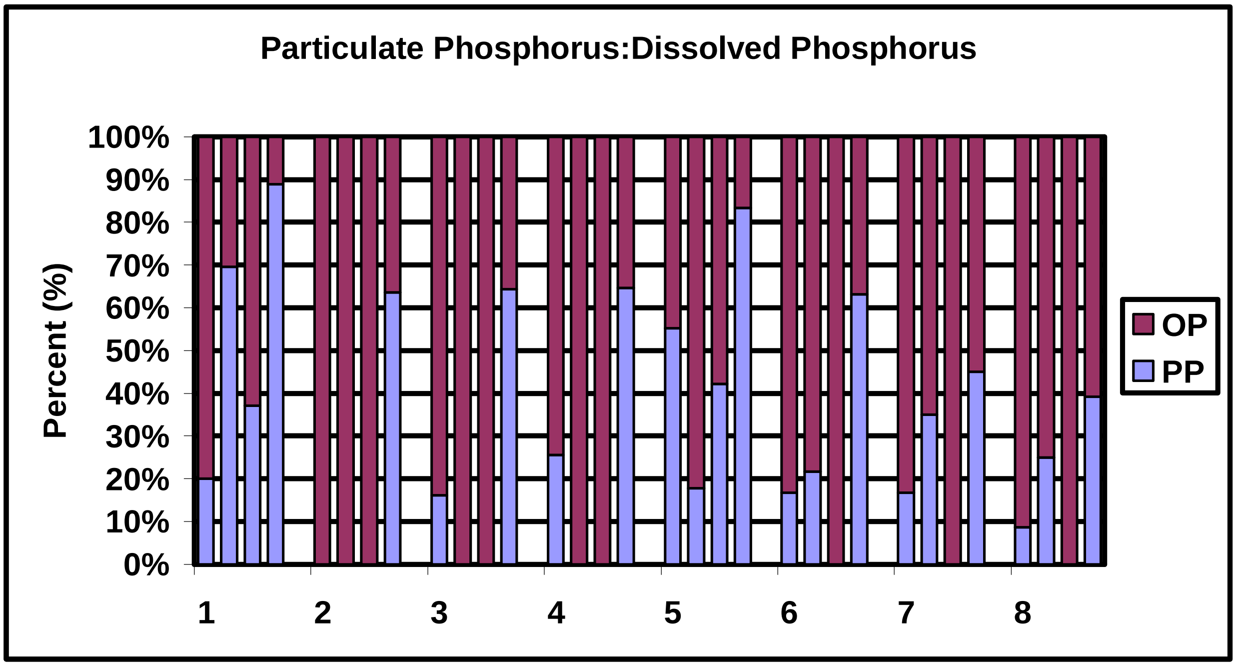


Figure H 10. Orthophosphate percentage of total phosphorus concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

(Each stream possesses four bars, which represent each of the sampling events: 2004 storm, 2004 base, 2005 base, 2005 storm, respectively.) TP concentration minus OP concentration yields an estimation of particulate phosphorus.

Total Phosphorus

Generally, total phosphorus concentrations measured in the mainstem of Dunes Creek and other tributaries located within the Indiana Dunes State Park were lower than those measured in Munson Ditch. (Table H2 lists the total phosphorus concentrations measured at each site while Figure H8 displays total phosphorus concentration variations at the eight main sites over the four collection events.) All sites during the 2005 storm flow event and the Cowles Bog Outlet (Site 1) and the Munson Ditch sites (Sites 6 to 8) during all of the sampling events possessed total phosphorus concentrations that meet or exceed the USEPA recommended criterion (0.033 mg/l) for the ecoregion (USEPA, 2000). The Munson Ditch sites (Sites 6 to 8) generally possessed the highest total phosphorus concentrations; however, the Cowles Bog Outlet (Site 1) also possessed elevated total phosphorus concentrations. All concentrations measured at these four sites exceeded the level at which Dodd et al. (1998) indicates that eutrophic or highly productive conditions exist. Likewise, all of the sites during the 2005 storm flow event and Sites 1, 6, 7, and 8 during all of the events possessed total phosphorus concentrations greater than the median level (0.10 mg/l) measured in streams classified as warmwater habitat (OHIO EPA, 1999). The Ohio EPA uses this level (0.10 mg/L) as the maximum total phosphorus concentrations to avoid impairment of aquatic life in warmwater and modified warmwater habitat streams, respectively. The elevated total phosphorus concentrations and resultant productivity within the Cowles Bog Outlet (Site 1) and in Munson Ditch (Sites 6 to 8) may be altering the biotic community structure and impairing aquatic life in these streams.

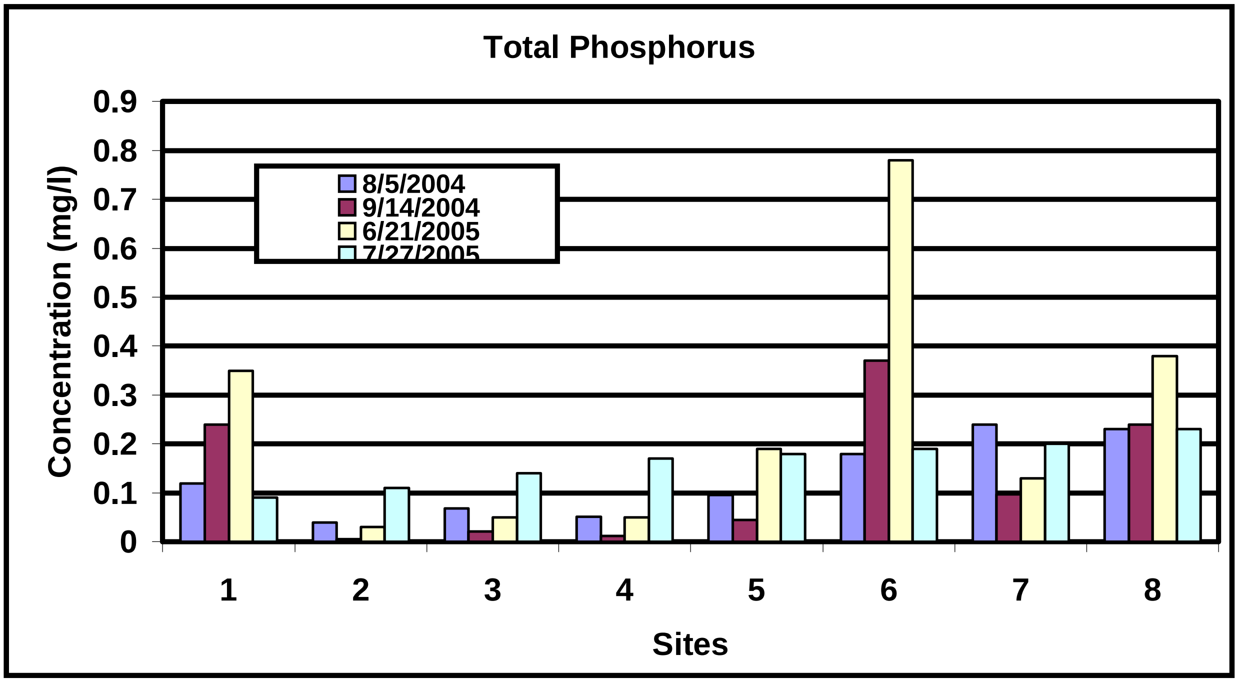


Figure H 11. Total phosphorus concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Historic evidence indicates that elevated total phosphorus concentrations have long been an issue in the Dunes Creek watershed. Arihood (1974) reported high total phosphorus concentrations (0.71 mg/L) downstream of Cowles Bog. (This would roughly correspond with sample site 1 during the current assessment). Data collected by Stewart et al. (1997) indicates that elevated total phosphorus concentrations are typical of Dunes Creek watershed streams. The median value (0.19 mg/L) for total phosphorus samples collected by Stewart et al. (1997) exceeds the level at which the Ohio EPA indicates biotic impairment can occur.

E. coli

E. coli is one member of a group of bacteria that comprise the fecal coliform bacteria and is used as an indicator organism of the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum concentration of *E. coli* at 235 CFU /100 mL in any one sample within a 30-day period or a geometric mean of 125 colonies per 100 mL for five samples collected in any 30-day period.

E. coli concentrations exceeded the Indiana state standard (235 CFU /100 mL) at most of the Dunes Creek sampling reaches during the four sampling events. (Table H2 lists the *E. coli* concentrations measured at each site while Figure H12 displays *E. coli* concentration variations at the eight main sites over the four collection events.) During the two storm flow events, all *E. coli* concentrations measured in the Dunes Creek watershed streams exceeded the Indiana state standard. Storm flow concentrations ranged from 1.1 to 4 times the state standard. During base flow, all of the sites except the West Tributary (Site 5) and Munson Ditch downstream of U.S. Highway 20 (Site 7) exceeded the state standard on at least one occasion. Concentrations in excess of the standard ranged from 1.1 to 28 times the standard. High *E. coli* concentrations suggest the presence of other pathogens. These pathogens may impair the biota in Dunes Creek watershed streams and limit human use of the streams. The sources of *E. coli* in the Dunes Creek watershed have not been identified; however, wildlife, livestock, and/or domestic animal defecation; manure fertilizers; previously contaminated sediments; and failing or improperly sited septic systems are common sources of the bacteria.

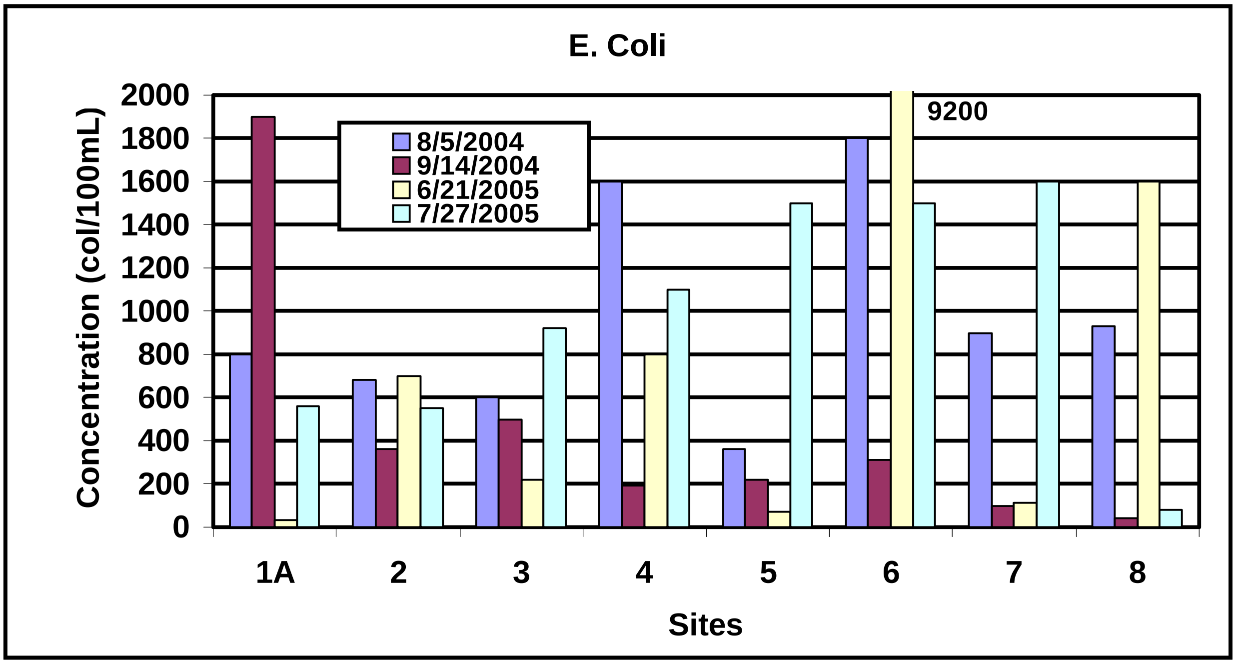


Figure H 12. *E. coli* concentrations in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Both fecal coliform and *E. coli* samples collected from Dunes Creek watershed streams over the past 30 years indicate some level of pathogenic contamination is occurring within the Dunes Creek watershed. None of the fecal coliform samples collected by Stewart et al. (1997) exceed the Indiana state standard (4,000 CFU /100 mL); however, five of the seven samples were in excess of the Illinois state standard (400 CFU /100 mL). (Indiana's fecal coliform standard is nearly 10 times the Illinois standard, which is likely set at a more appropriate level for protecting both human and biotic health.) Data collected by Whitman et al. (1999-2000data) ranged from 50 CFU /100 mL to 20,130 CFU /100 mL in samples collected from the mainstem of Dunes Creek, from 1 colony/100 mL to 2000 CFU /100 mL in the eastern branch of Dunes Creek, and from 1 colony/100 mL to 2346 CFU /100 mL in the western branch of Dunes Creek. Whitman et al. (no date-data collected in 1999-2000) indicate that *E. coli* were primarily found in submerged sediments and margin sands adjacent to Dunes Creek watershed streams and that they were sporadically found in forest soils, seeps, springs, and standing and running water. Whitman et al. (1999-2000 data) indicated that *E. coli* concentrations within the watershed streams were relatively high throughout the year; however, concentrations present in wetlands and unditched drainages, such as the mainstem of Dunes Creek, were much lower than concentrations found in ditched drainages, like Markowitz or Munson ditches.

E. coli data collected by volunteers from June to August 2005 also support the elevated *E. coli* concentrations measured by JFNew and others (Whitman (1999-2000 data), Stewart et al. (1997)). Concentrations ranged from no colonies observed at Sites 2, 5, 1B, 6*, 7, 8, and A to 18,000 CFU /100 mL at Site 6 on June 22, 2005 (Table H5). Geometric means calculated for all sites except Site 5 exceed the Indiana state standard (125 CFU /100 mL). Only Sites 2, 3, 6, and 8 possessed median *E. coli* concentrations in excess of the average concentration measured for Indiana streams (650 CFU /100 mL). Table H6 and Figure H13 illustrate the Indiana state standard (235 CFU /100 mL), the geometric mean standard (125 CFU /100 mL), and the average concentration in Indiana streams (650 CFU /100 mL).

Table H 5. Volunteer *E. coli* data collected during the summer of 2005 (CFU/100mL).

Date	Site 4	Site 3	Site 2	Site 5	Site 1B	Site B	Site 6	Site *6	Site 7	Site 8	Site A
06/22/05	200	400	0	100	0	300	18000	--	0	400	--
06/23/05	700	600	600	400	0	100	16000	--	100	500	--
06/24/05	800	100	400	100	400	100	4500	4100	200	1200	1800
06/25/05	200	700	900	100	0	1800	2200	--	0	2000	200
06/26/05	200	500	800	100	0	200	800	--	300	1000	0
06/27/05	100	300	400	100	100	800	1400	400	200	1000	0
06/28/05	300	1000	1800	200	100	1000	600	200	2300	1100	100
06/29/05	1200	900	600	0	1500	200	600	0	400	100	0
06/30/05	300	1000	1000	300	400	200	600	1000	1200	200	500
07/01/05	1200	700	2100	200	1600	600	1700	700	100	700	0
07/02/05	500	700	600	100	400	300	200	0	300	100	0
07/03/05	700	1600	1100	100	400	600	2300	--	100	100	0
07/04/05	500	1700	1300	0	2100	600	800	400	1500	0	0
07/05/05	1400	1800	300	0	1000	600	700	100	2000	7400	2000
07/06/05	1900	1700	700	300	800	300	500	100	900	800	100
07/07/05	800	200	2800	0	700	200	1800	100	2900	500	0
08/06/05	200	100	500	--	2200	600		--	12500	--	0
08/14/05	200	2200	400	--	200	400	700	--	400	1000	0
08/19/05	200	600	1200	--	0	100	400	--	600	--	0
median	500	700	700	100	400	300	800	200	400	700	0
geomean	440.7	645.5	802.3	151.3	562.6	347.9	1272.1	356.0	579.4	590.5	391.5
max	1900	2200	2800	400	2200	1800	18000	4100	12500	7400	2000
min	100	100	0	0	0	100	200	0	0	0	0

Table H 6. *E. coli* violations for all datasets.

Station ID	**Location**	**Not-To-Exceed Violations**	**Percent Not-To-Exceed Violations**	**Geometric Mean Evaluations**	**Geometric Mean Violations**	**Percent Geometric Mean Violations**	**Interim Goal Violations**	**Percent Interim Goal Violations**
A	Across from Splash Down Dunes	11	50.00%	0	0	0%	7	32%
E	Munson Ditch at Interstate 49	1	50.00%	0	0	0%	1	50%
*8		1	100.00%	0	0	0%	0	0%
8	East Tributary (upstream of US20)	14	53.85%	0	0	0%	11	42%
7	East Tributary (downstream of US20)	14	50.00%	5	5	100%	9	32%
More Upstream from 6	Upstream from 6	1	100.00%	5	5	100%	1	100%
U		1	100.00%	5	5	100%	1	100%
Upstream from 6	Upstream from 6	0	0.00%	0	0	0%	0	0%
*6		5	35.71%	18	18	100%	3	21%
6	East Tributary (Hawleywood Road)	22	84.62%	0	0	0%	15	58%
B	Munson Ditch at US 12	17	31.48%	0	0	0%	4	7%
C		1	100.00%	0	0	0%	0	0%
1A	Cowles Bog (culvert)	1	100.00%	0	0	0%	1	100%
1B	Cowles Bog oulet at Waverly	14	53.85%	8	8	100%	9	35%
5	Great Marsh Tributary	6	25.00%	0	0	0%	2	8%
2	West Tributary	22	73.33%	0	0	0%	13	43%
3	Dunes Creek (pre-	20	68.97%	0	0	0%	13	45%

	culvert)							
4	Dunes Creek Outlet	16	55.17%	0	0	0%	11	38%

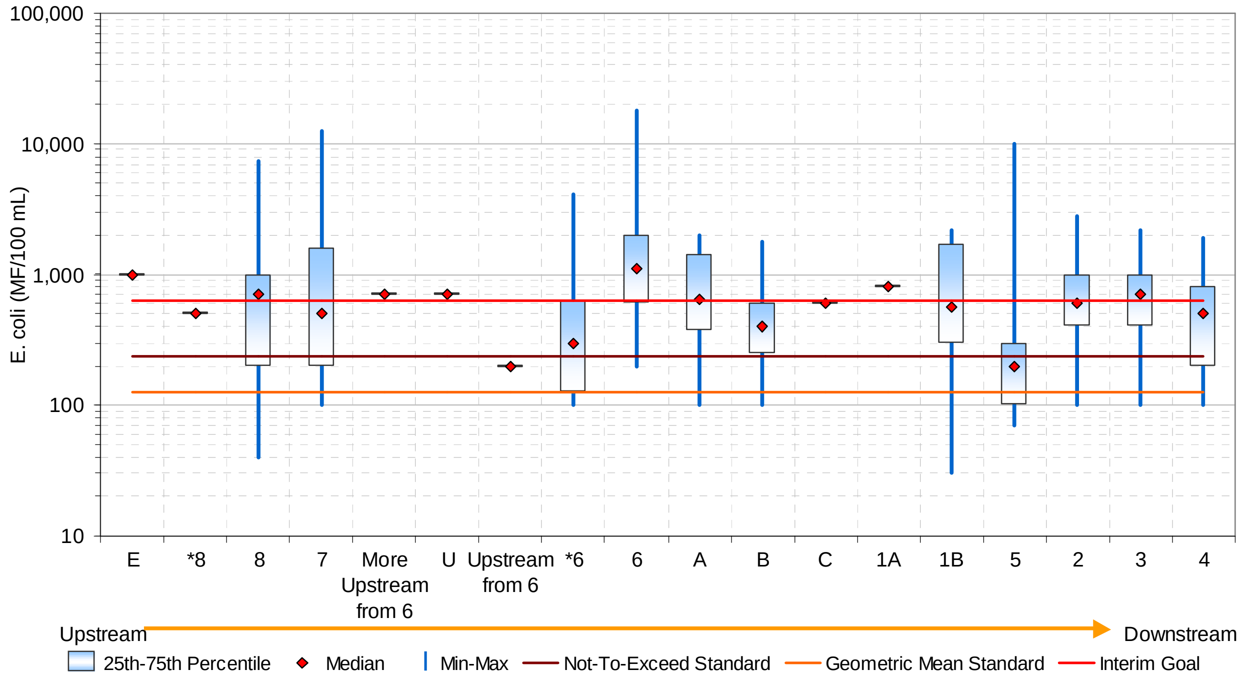


Figure H 13. ***E. coli*** **data box plots for all datasets.**

Loading

Loading rates were difficult to calculate for Dunes Creek watershed streams. Multiple streams were sampled during stagnant conditions, such as the Cowles Bog Outlet (Site 1) during the 2004 base flow and 2005 storm flow events, Munson Ditch at Hawleywood Road (Site 6) during the 2004 and 2005 base flow events, Munson Ditch upstream of U.S. Highway 20 (Site 8) during the 2004 and 2005 base flow events, and the Great Marsh Tributary (Site 5) during the 2005 storm event. Furthermore, sampling during the 2004 storm event occurred at the Dunes Creek outlet (Site 4) when Lake Michigan water was pushed back into the channel by wind and wave action. For these events, loading rates could not be calculated. Still for other parameters, concentrations were below the detection level, thereby limiting the calculation of loading rates as specific sites for specific parameters. For these reasons, loading rates were calculated for those sites which possessed flowing water and concentrations above the laboratory's detection limit. This limits the determination of which stream possesses higher loading rates; however, some conclusions can be drawn from the limited information calculated for these streams.

As expected, the mainstem of Dunes Creek (Sites 3 and 4) possessed the greatest pollutant loads for most parameters during the four sampling events. (Table H3 and Figures H14 to H19 detail the loading rates for the Dunes Creek watershed streams during the four sampling events.) Pollutant loads in Dunes Creek upstream of the culvert (Site 3) were the highest for all parameters during the 2004 storm event. This reach possessed the highest *E. coli* and total phosphorus loading rates during the 2004 base flow event and the highest ammonia-nitrogen and total suspended solids loading rates during the 2005 base and storm flow events. (Site 4 was back-flowing and full of Lake Michigan water due to heavy winds and wave action during the 2004 storm flow sampling.) The Dunes Creek Outlet (Site 4) possessed the highest ammonia-nitrogen, nitrate-nitrogen, orthophosphate, and total suspended solids loading rates during the 2004 base flow event, the highest nitrate-nitrogen, total phosphorus, and *E. coli* loading rates during the 2005 base flow event, and the highest nitrate-nitrogen, orthophosphate, total phosphorus, and *E. coli* loading rates during the 2005 storm flow event. The only exception to the most downstream sites possessing the highest loading rates occurred in Munson Ditch downstream of U.S. Highway 20 (Site 7) during the 2005 base flow event where this stream contained the highest ammonia-nitrogen and total phosphorus loading rates.

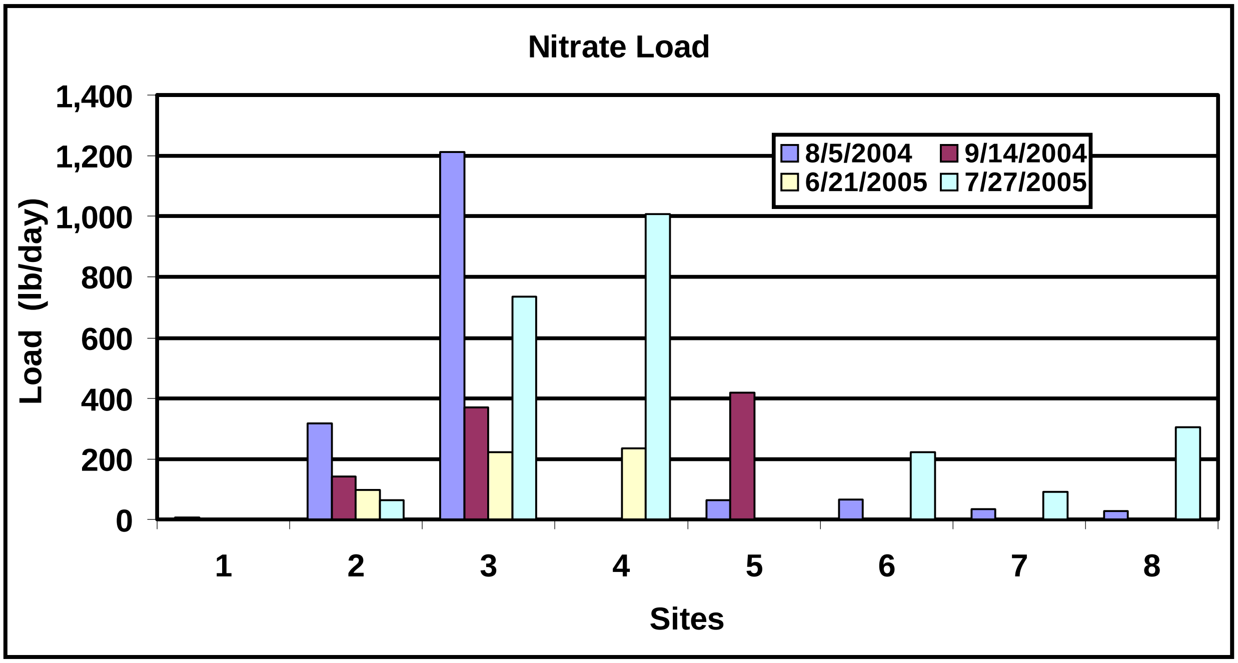


Figure H 14. Nitrate-nitrogen loading in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

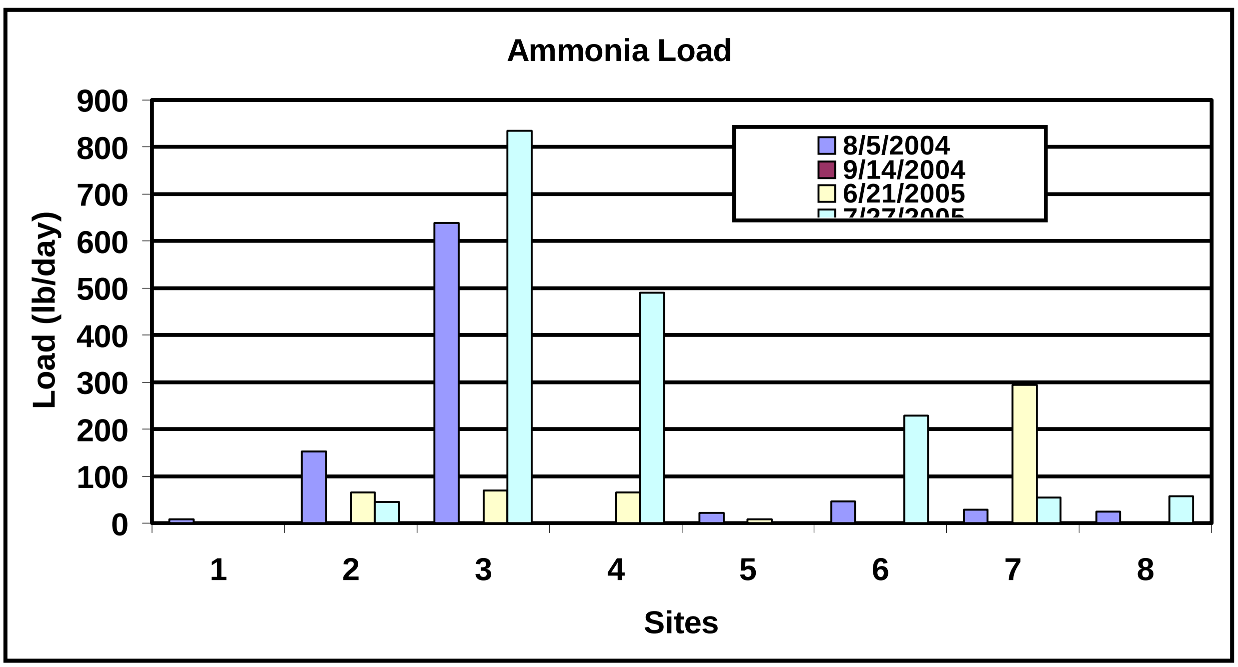


Figure H 15. Ammonia-nitrogen loading in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

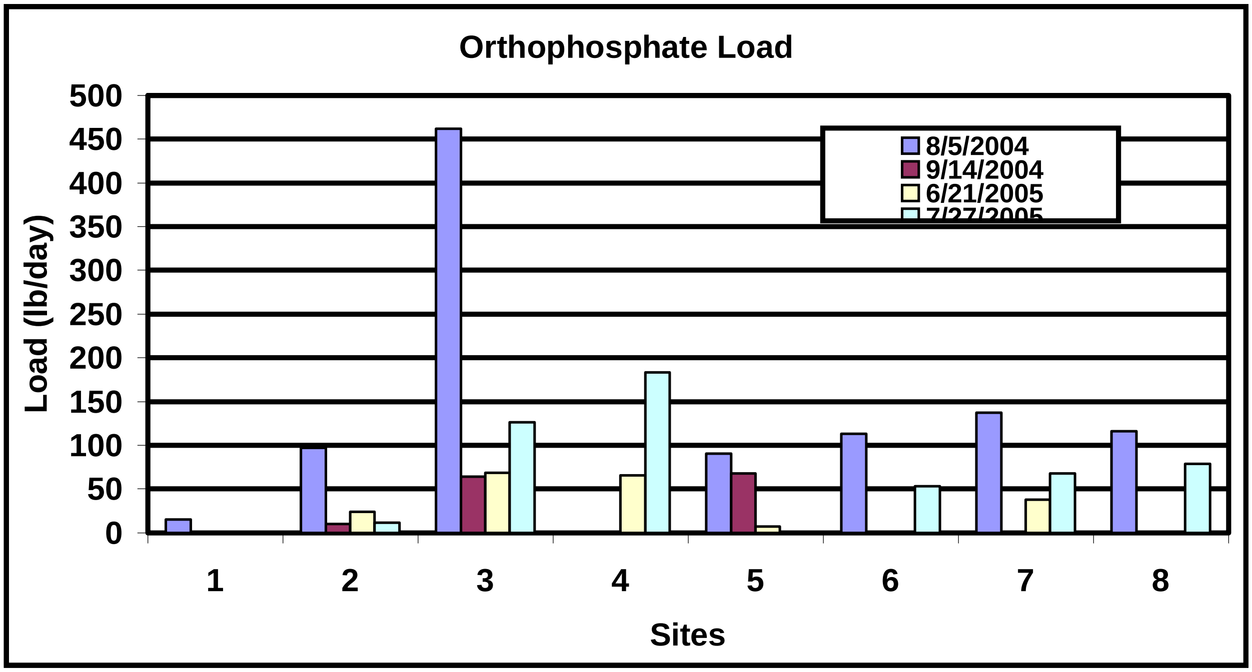


Figure H 16. Soluble reactive phosphorus loading in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

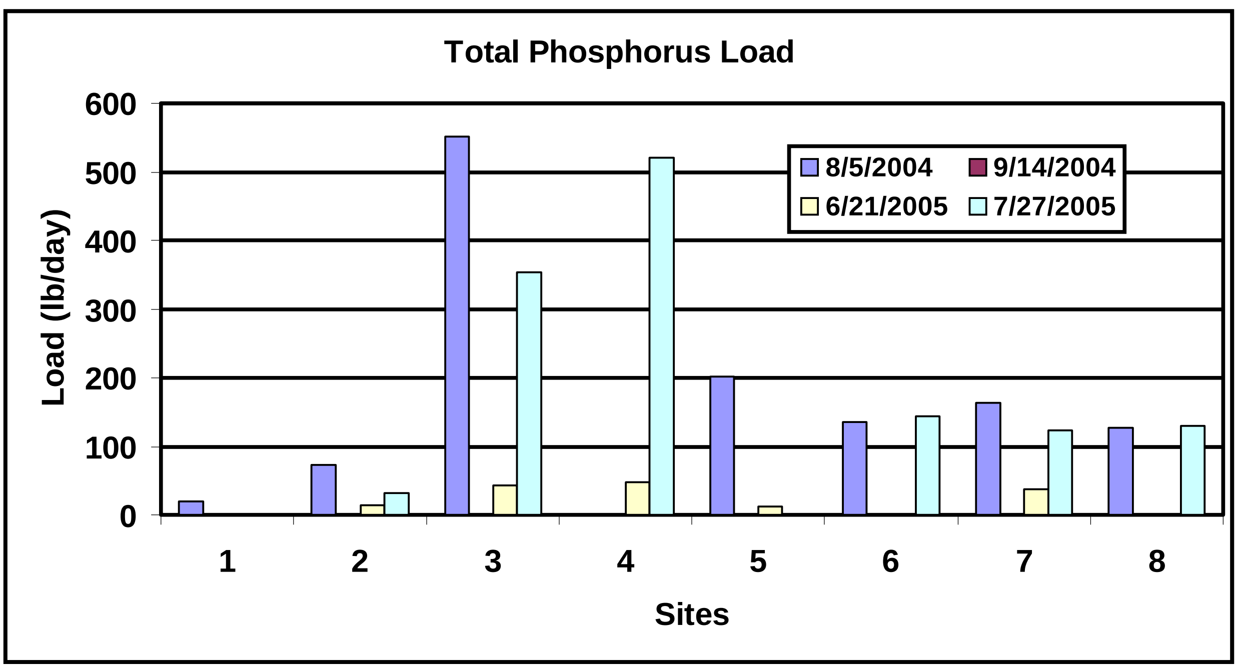


Figure H 17. Total phosphorus loading in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

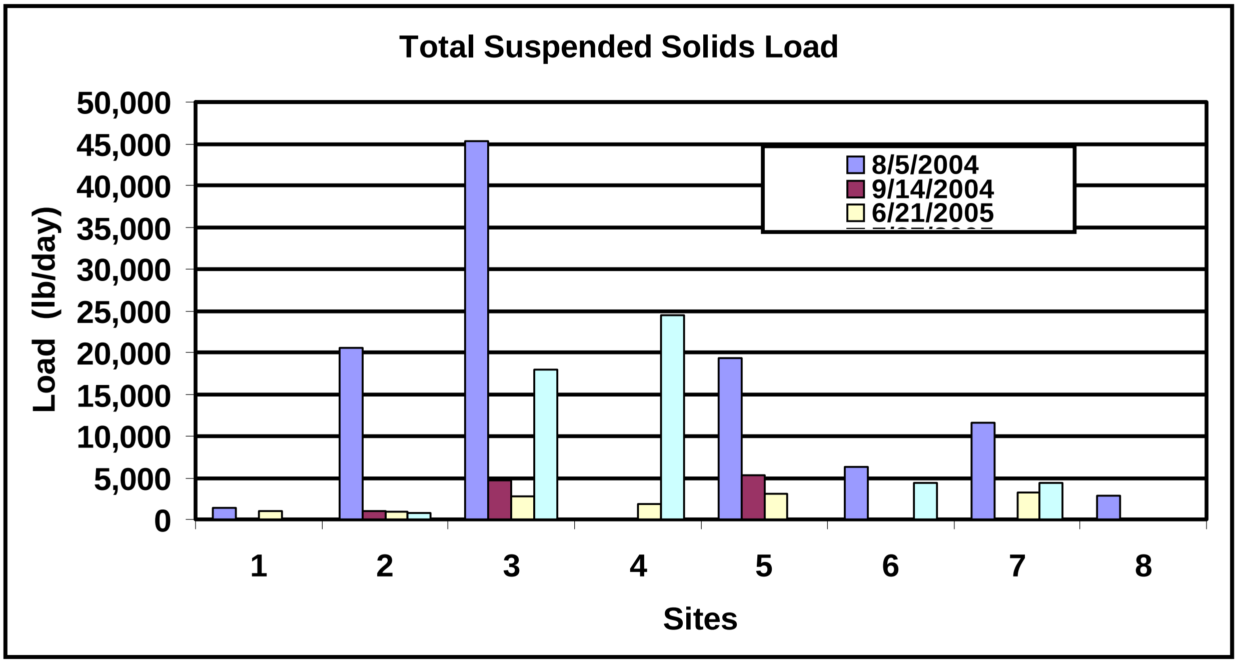


Figure H 18. Total suspended solids loading in Dunes Creek watershed streams as sampled August 5, 2004, September 14, 2004, June 21, 2005, and July 27, 2005.

Areal Loading

In an effort to normalize the nutrient and sediment loading rates, the rates were divided by subwatershed size above each sampling site. This means that mainstem Dunes Creek subwatershed acreages, such as Site 3, combine the entire portion of the Dunes Creek watershed that drains through the respective sampling sites. For instance, the Dunes Creek watershed upstream of the culvert (Site 3) receives water from both the West Tributary (Site 2) and from the Cowles Bog Outlet (Site 1); therefore, the acreage used to calculate areal loading was the combination of these subwatersheds.

During base flow events, when most of the upper watershed streams were dry or stagnant, the West Tributary (Site 2) and the Great Marsh Tributary (Site 5) possessed the highest areal loading rates for many parameters. During at least one of the two base flow events, the West Tributaries possessed the highest ammonia-nitrogen, nitrate-nitrogen, and *E. coli* areal loading rates and the second highest total suspended solids, orthophosphate, and total phosphorus areal loading rates. Likewise, the Great Marsh Tributary possessed the highest areal loading rates for ammonia-nitrogen, orthophosphate, total phosphorus, and total suspended solids and the second highest areal loading rates for *E. coli.* During the 2004 storm flow event, the West Tributary (Site 2) also possessed elevated ammonia-nitrogen and nitrate-nitrogen areal loading rates. However, Munson Ditch reaches (Sites 8 and 6) possessed the highest orthophosphate, total phosphorus, and *E. coli* areal loading rates and the second highest total suspended solids and *E. coli* areal loading rates, respectively. During the 2005 storm event, Munson Ditch sites possessed the highest and second highest areal loading rates for all parameters. Site E contained the highest areal loading rate for orthophosphate, total phosphorus, and *E. coli*, while Site A possessed the greatest total suspended solids and second highest total phosphorus areal loading rates, and Sites 6 and 8 possessed the highest ammonia-nitrogen and nitrate-nitrogen, respectively.

Macroinvertebrates

Save the Dunes Conservation Fund contracted with JFNew to collect samples from the benthic macroinvertebrate communities within the Dunes Creek watershed using a multi-habitat approach. Biological samples were analyzed using IDEM's Macroinvertebrate Index of Biotic Integrity (mIBI). Comparison between the samples collected in Dunes Creek and at a reference site located within the headwaters of Coffee Creek was also conducted using the Rapid

Bioassessment Protocol (Plafkin et. al., 1989). One sample was collected annually at the mouths of the major tributaries (West Tributary (Site 2) and East Tributary) and along the mainstem of Dunes Creek upstream of the culvert (Site 3). Additionally, the macroinvertebrate communities at each of the water chemistry sampling sites were assessed during the 2005 sampling event. Both assessments occurred under base flow conditions during the summer as detailed by the project Quality Assurance Project Plan (Appendix G). Organisms were identified to the family level. (Macroinvertebrate communities collected at each of the sampling sites are listed in Appendix I.)

Macroinvertebrate samples from the Dunes Creek watershed streams were used to calculate an index of biotic integrity. Aquatic macroinvertebrates are important indicators of environmental change. The insect community composition can reflect water quality; research shows that different macroinvertebrate orders and families react differently to pollution sources. Indices of biotic integrity are valuable because aquatic biota integrate cumulative effects of sediment and nutrient pollution (OHIO EPA, 1995).

The benthic community at each sample site was evaluated using IDEM's macroinvertebrate Index of Biotic Integrity (mIBI). The mIBI is a multi-metric index designed to provide a complete assessment of a creek's biological integrity. The mIBI consists of ten metrics (Table H7) which measure the species richness, evenness, composition, and density of the benthic community at a given site. The metrics include family-level HBI (Hilsenhoff's FBI), number of taxa, number of individuals, percent dominant taxa, EPT Index, EPT count, EPT count to total number of individuals, EPT count to chironomid count, chironomid count, and total number of individuals to number of squares sorted. (EPT stands for the *Ephemeroptera*, *Plecoptera*, and *Trichoptera* orders.) A classification score of 0, 2, 4, 6, or 8 is assigned to specific ranges for metric values. For example, if the benthic community being assessed supports nine different families, that community would receive a classification score of 2 for the "Number of Taxa" metric. The mIBI is calculated by averaging the classification scores for the ten metrics. mIBI scores of 0-2 indicate the sampling site is severely impaired; scores of 2-4 indicate the site is moderately impaired; scores of 4-6 indicate the site is slightly impaired; and scores of 6-8 indicate that the site is non-impaired.

Table H 7. Benthic macroinvertebrate scoring criteria used by IDEM in the evaluation of pool-riffle streams in Indiana.

	SCORING CRITERIA FOR THE FAMILY LEVEL MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (mIBI) USING PENTASECTION AND CENTRAL TENDENCY ON THE LOGARITHMIC TRANSFORMED DATA DISTRIBUTIONS OF THE 1990-1995 RIFFLE KICK SAMPLES				
	CLASSIFICATION SCORE				
	0	**2**	**4**	**6**	**8**
Family Level HBI	≥5.63	5.62- 5.06	5.05-4.55	4.54-4.09	≤4.08
Number of taxa	≤7	8-10	11-14	15-17	≥18
Number of individuals	≤79	129-80	212-130	349-213	≥350
Percent dominant taxa	≥61.6	61.5-43.9	43.8-31.2	31.1-22.2	<22.1
EPT index	≤2	3	4-5	6-7	≥8
EPT count	≤19	20-42	43-91	92-194	≥195
EPT count to total number of individuals	≤0.13	0.14-0.29	0.30-0.46	0.47-0.68	≥0.69
EPT count to chironomid count	≤0.88	0.89-2.55	2.56-5.70	5.71-11.65	≥11.66
Chironomid count	≥147	146-55	54-20	19-7	≤6
Total number of individuals to number of squares sorted	≤‖↓	30-71	72-171	172-409	≥410

Where: 0-2 = Severely Impaired, 2-4 = Moderately Impaired, 4-6 = Slightly Impaired, 6-8 = Non-impaired

In general, the macroinvertebrate communities present within the Dunes Creek watershed streams were dominated by pollution tolerant species. (Appendix I details macroinvertebrate community data collected from the Dunes Creek watershed streams.) During the 2004 assessment, the East Tributary and the West Tributary possessed much higher taxa richness (number of taxa) than the community present along the mainstem of Dunes Creek. (The East Tributary contained 20 taxa and the West Tributary contained 17 taxa, while the mainstem contained only 9 taxa.) Pollution tolerant species composed the communities at all three sites. Members of the pollution tolerant family *Asellidae* dominated the community present within each of the three streams. Limited numbers of the pollution intolerant orders of Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa) were present within the three streams. The West Tributary possessed the lowest density (12 individuals) of EPT taxa but contained the highest diversity (4 families), while the East Tributary and the mainstem each possessed three EPT families and contained 19 (East) to 23 (mainstem) individuals representing these orders. The community present in the East Tributary rated the best mIBI score (3.4) garnering a moderately impaired rating, while the West Tributary (2.4) and the mainstem (2.4) possessed poorer macroinvertebrate communities which also rated as moderately impaired.

When compared with a reference stream located in the headwaters of Coffee Creek (Site 6 as assessed during the development of the Coffee Creek Watershed Management Plan (JFNew, 2003)) using the rapid bioassessment protocol (RPB) (Plafkin et al., 1989), the streams rate slightly better than the results obtained from the mIBI scoring. Both the West Tributary and the mainstem rated as moderately impaired using the RPB receiving 75% of 62.5% of the total points possible, respectively, when compared with the biota present in Coffee Creek during 2002. The East Tributary's biotic community was of higher quality than the community present within the other two sites based on the RPB. The East Tributary scored 87.5% of the total points possible when compared with Coffee Creek biota collected in 2002.

The 2005 assessment of Dunes Creek watershed macroinvertebrate communities yields similar but poorer results than those observed during the 2004 assessment. Each of the sample sites possessed low taxa richness; only 5 (Sites 1 and 5) to 9 (Site 3) taxa were observed at each site. Most of the streams possessed 6 (East Tributary and Site 8) to 8 (Sites 2, 4, 6, and 7) taxa. These diversity numbers are lower than those observed during the 2004 assessment. Densities were also lower during the 2005 assessment than those observed during 2004. Less than 25 individuals were collected within the Munson Ditch sites (Sites 7 and 8), while only 52 and 82 individuals were collected from Munson Ditch at Hawleywood Road (Site 6) and the Dunes Creek outlet (Site 4), respectively. Densities observed at the East Tributary, West Tributary, and mainstem in 2005 were similar to densities present during the 2004 assessment. However, pollution intolerant species were collected at only two sites, the Dunes Creek outlet (Site 4) and the West Tributary (Site 2). In general, the macroinvertebrate communities present within the Dunes Creek watershed streams were dominated by the pollution tolerant families *Chironomidae* and *Asellidae*. The only exception to this occurred at the Dunes Creek outlet (Site 4) where members of the pollution intolerant stonefly family *Perlidae* were co-dominant with *Chironomidae*. Low water levels and limited flow conditions throughout the Dunes Creek watershed likely limited the density and diversity of macroinvertebrates within the streams. Only the outlet contained pollution intolerant species. However, all of the macroinvertebrate communities present within the streams rated as severely impaired during the 2005 assessment.

When compared with biota present in the headwaters of Coffee Creek (Site 6 as assessed during development of the Coffee Creek Watershed Management Plan (JFNew, 2003)), the Dunes Creek macroinvertebrate communities present during the 2005 assessment rate as moderately to severely impaired. The Dunes Creek outlet (Site 4) possessed the most similar community but scored only 62.5% of the total possible points. Munson Ditch downstream of U.S. Highway 20 (Site 7) scored 50% of the total points, while the West Tributary (Site 2), the mainstem of Dunes Creek upstream of the culvert (Site 3), and Munson Ditch adjacent to Hawleywood Road (Site 6) each scored 37.5% of the total points. All these streams rate as moderated impaired based on the RBP. The East Tributary, Cowles Bog Outlet (Site 1), and Great Marsh Tributary (Site 5) each scored 25% of the total points, while Munson Ditch upstream of U.S. Highway 20 (Site 8) scored the lowest receiving only 16.7% of the total points. These streams rated as severely impaired based on the RBP.

The mIBI scores highlight the difference between the macroinvertebrate communities found in the Dunes Creek watershed streams in 2004 and 2005. In general, the biotic integrity of the macroinvertebrate communities as assessed in 2004 indicate that the streams were less impaired during the 2004 assessment than during the 2005 assessment. The results of the macroinvertebrate survey clearly demonstrate the difference (Figure H20 and Table H8). The variation in biotic integrity is likely a result of climatic conditions. mIBI scores for both years suggest that the macroinvertebrate communities in the Dunes Creek watershed streams are moderately to severely impaired. Most indices of biotic integrity are developed to ensure that there is a statistically significant difference between impairment categories (Karr and Chu, 1999). As such, the macroinvertebrate survey results suggest there is a significant difference between the biological integrity of the macroinvertebrate communities observed in 2004 and 2005 with the 2005 community rating as poorer. However, there appears to be no significant difference between the macroinvertebrate communities present in the headwaters of Munson Ditch (Sites 6 to 8), the Great Marsh Tributary (Site 5), the Cowles Bog Outlet (Site 1), or along the mainstem of Dunes Creek (Sites 3 and 4) during the 2005 assessment. Reassessing these streams' macroinvertebrate communities under more normal climatic conditions may allow for a better determination of water quality characteristics.

Table H 8. Metric classification scores and mIBI scores for the Dunes Creek watershed sampling sites as sampled in 2004 and 2005.

Metric	HBI	# of Taxa	# of Indiv.	% Dom Taxa	EPT Ind.	EPT Count	EPT: Total	EPT Abund	# Indiv./ Square	Chir. Count	mIBI Score
2004 Sampling											
East	0	8	2	8	2	0	2	4	0	8	3.4
West (S2)	0	6	2	4	4	0	0	2	0	6	2.4
Mainstem (S3)	0	2	**2**	0	2	2	2	6	0	8	2.4
2005 Sampling											
East	0	0	2	2	0	0	0	0	0	4	0.8
West (S2)	0	2	2	4	0	0	0	0	0	4	1.2
Mainstem (S3)	0	2	2	0	0	0	0	0	0	6	1.0
Site 1	0	0	2	0	0	0	0	0	0	2	0.4
Site 4	4	2	2	4	0	2	0	2	0	4	2.0
Site 5	0	0	2	2	0	0	0	0	0	4	0.8
Site 6	0	2	0	0	0	0	0	0	0	4	0.6
Site 7	0	2	0	4	0	0	0	0	0	6	1.2
Site 8	0	0	0	2	0	0	0	0	0	8	1.0

Where: 0-2 = Severely Impaired, 2-4 = Moderately Impaired, 4-6 = Slightly Impaired, 6-8 = Non-impaired

Although these criteria are not part of the IAC, IDEM hints that it may be using mIBI scores to determine whether a waterbody is meeting its aquatic life use designation. (Under state law, all waters of the state, except for those noted as Limited Use in the IAC, must be capable of supporting recreational and aquatic life uses.) In the 2000 305(b) report, IDEM suggests that those waterbodies with mIBI scores less than 2 are considered non-supporting for aquatic life use. Similarly, waterbodies with mIBI scores between 2 and 4 are considered to be partially supporting for aquatic life use. Under federal law, waters that do not meet their designated uses must be placed on the 303(d) list and remediation/restoration plans (Total Maximum Daily Load plans) must be developed for these waters. Dunes Creek is already listed on the 303(d) list for impaired biotic communities. As detailed in Figure H20, the macroinvertebrate community data collected during the development of this watershed management plan supports the listing of these streams for impaired biotic communities. Figure H20 displays the Dunes Creek watershed mIBI scores based on the macroinvertebrate sampling effort with respect to the suggested IDEM criteria. The mIBI scores suggest that during normal climatic conditions, the Dunes Creek watershed streams within the Indiana Dunes State Park are at least partially supporting of aquatic life use. However, during conditions which results in lower than normal precipitation, all of the streams' mIBI scores suggest that the streams will rate as non-supporting for their aquatic life use designation.

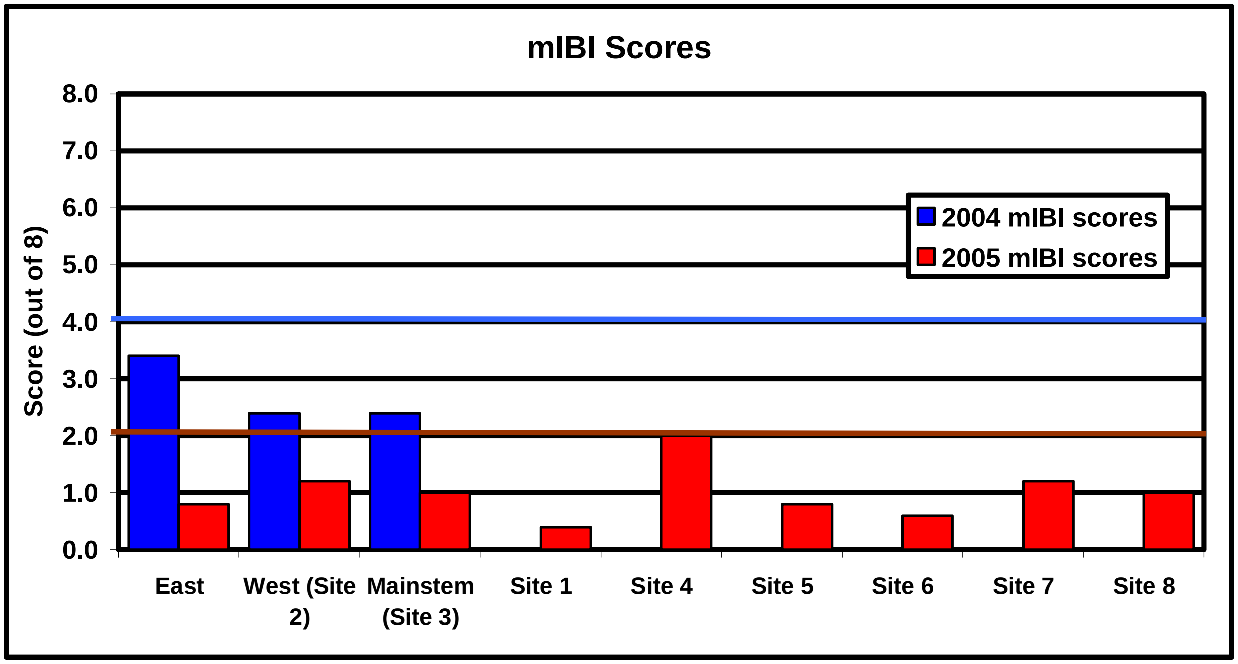


Figure H 19. Aquatic life use support (ALUS) assessment based on macroinvertebrate community collection. Note: IDEM suggests that scores below two rate as non-supporting for their aquatic life use designation, while scores from two to four rate as partially supporting for their aquatic life use designation.

Stewart et al. (1997) reported that the Dunes Creek macroinvertebrate community was representative of neither a healthy wetland nor stream system. Still, relative to the other sites sampled in the study (in the Derby Ditch and Kintzele Ditch watersheds just east of Dunes Creek), Dunes Creek had the highest riparian, channel, and environmental (RCE) value (336) and lowest HBI score. Ironically, one Dunes Creek site was considered the least impacted wetland habitat sampled in the Great Marsh, but had the poorest stream habitat with reference to macroinvertebrate communities. This site drained a large wetland and was dominated by tolerant organisms able to thrive in low dissolved oxygen conditions with highly organic substrate (Stewart et al., 1997).

Stewart et al. (1997) correlated several water chemistry variables to land use. Chloride, specific conductance, total hardness, and turbidity were all positively correlated to development-related land use. Temperature, specific conductance, total hardness, and turbidity were negatively correlated with percent natural area. Percent wetland was negatively correlated with pH levels and positively correlated with iron. Percent commercial, residential, industrial, and heavy land use was positively correlated with ion measurements. Overall, Stewart et al. (1997) found that local conditions were more influential than watershed-scale factors in determining macroinvertebrate community structure and function.

Habitat

Substrate type(s) and quality are important factors of habitat quality and the QHEI score is partially based on these characteristics. Sites that have greater substrate diversity receive higher scores as they can provide greater habitat diversity for benthic organisms. The quality of substrate refers to the embeddedness of the benthic zone. Because the rocks (gravel, cobble, boulder) that comprise a stream's substrate do not fit together perfectly like pieces in a jigsaw puzzle, small pores and crevices exist between the rocks in the stream's substrate. Many stream organisms can colonize these pores and crevices, or microhabitats. In streams that carry high silt loads, the pores and crevices between substrate rocks become clogged over time. This clogging, or "embedding", of the stream's substrate eliminates habitat for the stream's biota. Thus, sites with heavy embeddedness and siltation receive lower QHEI scores for the substrate metric.

In-stream cover, another metric of the QHEI, refers to the type(s) and quantity of habitat provided within the stream itself. Examples of in-stream cover include woody logs and debris, aquatic and overhanging vegetation, and root wads extending from the stream banks. The channel morphology metric evaluates the stream's physical development with respect to habitat diversity. Pool and riffle development within the stream reach, the channel sinuosity, and other factors that represent the stability and direct modification of the site comprise this metric score.

A stream's buffer, which includes the riparian zone and floodplain zone, is a vital functional component of riverine ecosystems. It is instrumental in the detention, removal, and assimilation of nutrients. Riparian zones govern the quality of goods and services provided by riverine ecosystems (OHIO EPA, 1999). Riparian zone (the area immediately adjacent to the stream), floodplain zone (the area beyond the riparian zone that may influence the stream though runoff), and bank erosion were examined at each site to evaluate the quality of the buffer zone of the stream, the land use within the floodplain that affects inputs to the waterway, and the extent of erosion in the stream, which can reflect insufficient vegetative stabilization of the stream banks. For the purposes of the QHEI, a riparian zone consists only of forest, shrub, swamp, or woody old field vegetation. Typically, weedy, herbaceous vegetation has higher runoff potential than woody components and does not represent an acceptable riparian zone type for the QHEI (OHIO EPA, 1989). Streams with grass or other herbaceous vegetation growing in the riparian zone receive low QHEI scores for this metric.

Metric 5 of the QHEI evaluates the quality of pool/glide and riffle/run habitats in the stream. These zones in a stream, when present, provide diverse habitat and, in turn, can increase habitat quality. The depth of pools within a reach and the stability of riffle substrate are some factors that affect the QHEI score in this metric.

The final QHEI metric evaluates the topographic gradient in a stream reach. This is calculated using topographic data. The score for this metric is based on the premise that both very low and very high gradient streams will have negative effects on habitat quality. Moderate gradient streams receive the highest score, 10, for this metric. The gradient ranges for scoring take into account the varying influence of gradient with stream size.

The QHEI evaluates the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (OHIO EPA, 1999). IDEM indicates that QHEI scores above 64 suggest the habitat is capable of supporting a balanced warmwater community; scores between 51 and 64 are only partially supportive of a stream's aquatic life use designation (IDEM, 2000).

Table H9 lists the QHEI scores for the Dunes Creek watershed streams. (Detailed QHEI datasheets are contained in Appendix C.) The mainstem of Dunes Creek upstream of the culvert (Site 3) received the highest score, 63. Stable substrate, well developed channel morphology, available instream and canopy cover, and moderately well developed pools and riffles characterize this reach. The West Tributary (Site 3) and the East Tributary received the next highest scores rating 55 and 53 points, respectively. Scoring differences between the mainstem and the two tributaries relate mostly to gradient. Both tributaries scored 4 points less than the mainstem in regards to gradient. Additionally, the mainstem possesses limited riffle development which both tributaries lack. As these streams are sand bottom streams, it is unlikely that any additional natural riffles will form within the streams; therefore, variations in gradient and riffle score are noted, but are unlikely to change in the future. Munson Ditch downstream of U.S. Highway 20 (Site 7) received the lowest score, 26 of a possible 100. Poor instream and canopy cover, lack of well developed pools and riffles, and poor substrate limited the available habitat at this reach. The low QHEI scores suggest that the upper portion of Munson Ditch may not be capable of supporting healthy aquatic communities.

Table H 9. QHEI scores for Dunes Creek watershed sampling sites.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	**20**	**20**	**20**	**10**	**12**	**8**	**10**	**100**
East Tributary	10	14	10	10	3	0	6	**53**
West Tributary (Site 2)	14	12	10	10	3	0	6	**55**
Mainstem (Site 3)	14	13	10	10	4	2	10	**63**
Cowles Bog Outlet (Site 1)	5	14	13	10	0	0	6	**48**
Dunes Creek Outlet (Site 4)	12	2	11	8	0	2	6	**41**
Great Marsh Tributary (Site 5)	10	7	14	10	0	0	6	**47**
Munson Ditch (Site 6) Hawleywood Rd.	13	5	15	10	4	0	4	**51**
Munson Ditch (Site 7) Downstream U.S. Hwy 20	1	5	8	4	0	0	8	**26**
Munson Ditch (Site 8) Upstream U.S. Hwy 20	9	5	10	7	2	0	8	**41**

Appendix I Macroinvertebrate Results

Macroinvertebrate results from 2004 and 2005 assessments within the Dunes Creek watershed streams.

Table I 1. Macroinvertebrates collected from the Dunes Creek watershed streams during the September 14, 2004 assessments.

Scientific Name	West	Mainstem	East
Odonata			
Calopterygidae	4	1	8
Corduliidae	1	1	
Hemiptera			
Corixidae	1		11
Trichoptera			
Hydropsychidae	2	17	6
Limnephilidae	2		
Phyganeidae	2		1
Ephemeroptera			
Caenidae		1	
Heptageniidae	7	5	12
Coleoptera			
Dytiscidae			1
Elmidae			1
Diptera			
Ceratopogonidae	1		1
Chironomidae	3	2	4
Chironomidae (blood red)	5		
Culicidae	1	1	2
Tabanidae	1		1
Other Arthropoda			
Asellidae	41	72	17
Gammaridae	21	12	4
Gastropoda			
Lymnaeidae			5
Physidae	4		6
Planorbidae			2
Bivalvia			
Sphaeriidae			6
Platyhelminthes			
Oligochaeta	3		2
Annelida			7
Hirudinea	1		7
Total Number of Individuals	**100**	**112**	**104**

Table I 2. East Tributary multi-habitat macroinvertebrate results, September 14, 2004.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Arthropoda					
Asellidae	17		8	136	16.35
Gammaridae	4		4	16	3.85
Bivalvia					
Sphaeriidae	6		8	48	5.77
Coleoptera					
Dytiscidae	1				0.96
Elmidae	1		4	4	0.96
Diptera					
Ceratopogonidae	1		6	6	0.96
Chironomidae	4		6	24	3.85
Culicidae	2				1.92
Tabanidae	1		6	6	0.96
Ephemeroptera					
Heptageniidae	12	12	4	48	11.54
Gastropoda					
Lymnaeidae	5		6	30	4.81
Physidae	6		8	48	5.77
Planorbidae	2		7	14	1.92
Hempitera					
Corixidae	11		10	110	10.58
Odonata					
Calopterygidae	8		5	40	7.69
Oligochaeta	2				1.92
Platyhelminthes					
Annelida	7				6.73
Hirudinea	7				6.73
Trichoptera					
Hydropsychidae	6	6	4	24	5.77
Phyganeidae	1	1	4	4	0.96
	104	**19**		**6.56**	
				HBI	

Table I 3. East Tributary mIBI metrics, September 14, 2004.

		Metric Score
HBI	6.56	0
Number of Taxa (family)	20	8
Number of Individuals	104	2
% Dominant Taxa	16.3	8
EPT Index	3	2
EPT Count	19	0
EPT Count/Total Count	0.18	2
EPT Abundance/Chironomid Abundance	4.75	4
Number of Individuals Per Square	4.95	0
Chironomid Count	4.00	8
mIBI Score		**3.4**

Table I 4. West Tributary (Site 3) multi-habitat macroinvertebrate results, September 14, 2004.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Arthropoda					
Asellidae	41		8	328	41.00
Gammaridae	21		4	84	21.00
Diptera					
Ceratopogonidae	1		6	6	1.00
Chironomidae	3		6	18	3.00
Chironomidae (blood red)	5		8	40	5.00
Culicidae	1				1.00
Tabanidae	1		6	6	1.00
Ephemeroptera					
Heptageniidae	7	7	4	28	7.00
Gastropoda					
Physidae	4		8	32	4.00
Hempitera					
Corixidae	1		10	10	1.00
Odonata					
Calopterygidae	4		5	20	4.00
Corduliidae	1		3	3	1.00
Oligochaeta	3				3.00
Platyhelminthes					
Hirudinea	1				1.00
Trichoptera					
Hydropsychidae	2	2	4	8	2.00
Limnephilidae	2	2	4	8	2.00
Phyganeidae	2	2	4	8	2.00
	100	**13**		**6.3**	
				HBI	

Table I 5. West Tributary (Site 2) mIBI metrics, September 14, 2004.

		Metric Score
HBI	6.31	0
Number of Taxa (family)	17	6
Number of Individuals	100	2
% Dominant Taxa	41.0	4
EPT Index	4	4
EPT Count	13	0
EPT Count/Total Count	0.13	0
EPT Abundance/Chironomid Abundance	1.63	2
Number of Individuals Per Square	2.22	0
Chironomid Count	8.00	6
mIBI Score		**2.4**

Table I 6. Mainstem (Site 3) multi-habitat macroinvertebrate results, September 14, 2004.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Arthropoda					
Asellidae	72		8	576	64.29
Gammaridae	12		4	48	10.71
Diptera					
Chironomidae	2		6	12	1.79
Culicidae	1				0.89
Ephemeroptera					
Caenidae	1	1	7	7	0.89
Heptageniidae	5	5	4	20	4.46
Odonata					
Calopterygidae	1		5	5	0.89
Oligochaeta	1				0.89
Trichoptera					
Hydropsychidae	17	17	4	68	15.18
	112	**23**		**6.7**	
				HBI	

Table I 7. Mainstem (Site 3) mIBI metrics, September 14, 2004.

		Metric Score
HBI	6.69	0
Number of Taxa (family)	9	2
Number of Individuals	112	**2**
% Dominant Taxa	64.3	0
EPT Index	3	2
EPT Count	23	2
EPT Count/Total Count	0.21	2
EPT Abundance/Chironomid Abundance	11.50	6
Number of Individuals Per Square	9.33	0
Chironomid Count	2.00	8
mIBI Score		**2.4**

Table I 8. Macroinvertebrates collected from the Dunes Creek watershed streams during the June 21, 2005 assessment.

Scientific Name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	East
Odonata									
Aeshnidae		2				1	1		
Plecoptera									
Perlidae				25					
Hemiptera									
Corixidae			2	1		2	2	7	
Gerridae			1						
Nepidae				1					
Notonectidae			1			1			
Trichoptera									
Limnephilidae		1							
Coleoptera									
Dytiscidae		1		1					
Elmidae			1						
Diptera									
Chironomidae	93	25	2	26	54	42	8	1	2
Chironomidae (blood red)			5				1		32
Culicidae					2		1	1	
Ephydridae							1		
Tabanidae		1				1			
Collembola									
Poduridae	1								
Other Arthropoda									
Asellidae		38	73	5	4				49
Cambaridae						3		1	
Gammaridae		29	24	7					11
Talitridae								1	
Gastropoda									
Lymnaeidae						1			
Physidae	6	3	4	16			1		
Planorbidae	11								
Pelecypoda									
Sphaeriidae	3				6	1			
Platyhelminthes									
Hirudinea									2
Nematoda					41		8		12
Oligochaeta								4	
Total Number of Individuals	**114**	**100**	**113**	**82**	**107**	**52**	**23**	**15**	**108**

Table I 9. East Tributary multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Diptera					
Chironomidae	2		6	12	1.9%
Chironomidae (blood red)	32		8	256	29.6%
Other Arthropoda					
Asellidae	49		8	392	45.4%
Gammaridae	11		4	44	10.2%
Platyhelminthes					
Hirudinea	2				1.9%
Nematoda	12				11.1%
	108	**0**		**7.49**	
				HBI	

Table I 10. East Tributary mIBI metrics, June 21, 2005.

		Metric Score
HBI	7.49	0
Number of Taxa (family)	6.00	0
Number of Individuals	108.00	2
% Dominant Taxa	45	2
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	8.31	0
Chironomid Count	34.00	4
mIBI Score		**0.8**

Table I 11. West Tributary (Site 2) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Odonata					
Aeshnidae	2		3	6	2.0%
Trichoptera					
Limnephilidae	1	1	4	4	1.0%
Coleoptera					
Dytiscidae	1				1.0%
Diptera					
Chironomidae	25		6	150	25.0%
Tabanidae	1		6	6	1.0%
Other Arthropoda					
Asellidae	38		8	304	38.0%
Gammaridae	29		4	116	29.0%
Gastropoda					
Physidae	3		8	24	3.0%
	100	**1**		**6.10**	
				HBI	

Table I 12. West Tributary (Site 2) mIBI metrics, June 21, 2005.

		Metric Score
HBI	6.16	0
Number of Taxa (family)	8.00	2
Number of Individuals	100.00	2
% Dominant Taxa	38	4
EPT Index	1.00	0
EPT Count	1.00	0
EPT Count/Total Count	0.01	0
EPT Abundance/Chironomid Abundance	0.04	0
Number of Individuals Per Square	9.09	0
Chironomid Count	25.00	4
mIBI Score		**1.2**

Table I 13. Mainstem (Site 3) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Hemiptera					
Corixidae	2		10	20	1.8%
Gerridae	1		5	5	0.9%
Notonectidae	1				0.9%
Coleoptera					
Elmidae	1		4	4	0.9%
Diptera					
Chironomidae	2		6	12	1.8%
Chironomidae (blood red)	5		8	40	4.4%
Other Arthropoda					
Asellidae	73		8	584	64.6%
Gammaridae	24		4	96	21.2%
Gastropoda					
Physidae	4		8	32	3.5%
	113	**0**		**7.02**	
				HBI	

Table I 14. Mainstem (Site 3) mIBI metrics, June 21, 2005.

		Metric Score
HBI	7.08	0
Number of Taxa (family)	9.00	2
Number of Individuals	113.00	2
% Dominant Taxa	65	0
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	18.83	0
Chironomid Count	7.00	6
mIBI Score		**1**

Table I 15. Cowles Bog Outlet (Site 1) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	**#**	**EPT**	**Tolerance (t)**	**# x t**	**%**
Diptera					
Chironomidae	93		6	558	81.6%
Collembola					
Poduridae	1				0.9%
Gastropoda					
Physidae	6		8	48	5.3%
Planorbidae	11		7	77	9.6%
Pelecypoda					
Sphaeriidae	3		8	24	2.6%
	114	**0**		**6.26**	
				HBI	

Table I 16. Cowles Bog Outlet (Site 1) mIBI metrics, June 21, 2005.

		Metric Score
HBI	6.26	0
Number of Taxa (family)	5.00	0
Number of Individuals	114.00	2
% Dominant Taxa	82	0
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	4.22	0
Chironomid Count	93.00	2
mIBI Score		**0.4**

Table I 17. Dunes Creek outlet (Site 4) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Plecoptera					
Perlidae	25	25	1	25	30.5%
Hemiptera					
Corixidae	1		10	10	1.2%
Nepidae	1				1.2%
Coleoptera					
Dytiscidae	1				1.2%
Diptera					
Chironomidae	26		6	156	31.7%
Other Arthropoda					
Asellidae	5		8	40	6.1%
Gammaridae	7		4	28	8.5%
Gastropoda					
Physidae	16		8	128	19.5%
	82	**25**		**4.84**	
				HBI	

Table I 18. Dunes Creek outlet (Site 4) mIBI metrics, June 21, 2005.

		Metric Score
HBI	4.84	4
Number of Taxa (family)	8.00	2
Number of Individuals	82.00	2
% Dominant Taxa	32	4
EPT Index	1.00	0
EPT Count	25.00	2
EPT Count/Total Count	0.01	0
EPT Abundance/Chironomid Abundance	0.96	2
Number of Individuals Per Square	1.06	0
Chironomid Count	26.00	4
mIBI Score		**2**

Table I 19. Great Marsh Tributary (Site 5) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Diptera					
Chironomidae	54		6	324	50.5%
Culicidae	2				1.9%
Other Arthropoda					
Asellidae	4		8	32	3.7%
Pelecypoda					
Sphaeriidae	6		8	48	5.6%
Platyhelminthes					
Nematoda	41				38.3%
	107	**0**		**6.31**	
				HBI	

Table I 20. Great Marsh Tributary (Site 5) mIBI metrics, June 21, 2005.

		Metric Score
HBI	6.31	0
Number of Taxa (family)	5.00	0
Number of Individuals	107.00	2
% Dominant Taxa	50	2
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	5.35	0
Chironomid Count	54.00	4
mIBI Score		**0.8**

Table I 21. Munson Ditch at Hawleywood Road (Site 6) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Odonata					
Aeshnidae	1		3	3	1.9%
Hemiptera					
Corixidae	2		10	20	3.8%
Notonectidae	1				1.9%
Diptera					
Chironomidae	42		6	252	80.8%
Tabanidae	1		6	6	1.9%
Other Arthropoda					
Cambaridae	3				5.8%
Gastropoda					
Lymnaeidae	1		6	6	1.9%
Pelecypoda					
Sphaeriidae	1		8	8	1.9%
	52	**0**		**6.15**	
				HBI	

Table I 22. Munson Ditch at Hawleywood Road (Site 6) mIBI metrics, June 21, 2005.

		Metric Score
HBI	6.15	0
Number of Taxa (family)	8.00	2
Number of Individuals	52.00	0
% Dominant Taxa	81	0
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	0.68	0
Chironomid Count	42.00	4
mIBI Score		**0.6**

Table I 23. Munson Ditch downstream of U.S. Highway 20 (Site 7) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Odonata					
Aeshnidae	1		3	3	4.3%
Hemiptera					
Corixidae	2		10	20	8.7%
Diptera					
Chironomidae	8		6	48	34.8%
Chironomidae (blood red)	1		8	8	4.3%
Culicidae	1				4.3%
Ephydridae	1		6	6	4.3%
Gastropoda					
Physidae	1		8	8	4.3%
Platyhelminthes					
Nematoda	8				34.8%
	23	**0**		**6.64**	
				HBI	

Table I 24. Munson Ditch downstream of U.S. Highway 20 (Site 7) mIBI metrics, June 21, 2005.

		Metric Score
HBI	6.64	0
Number of Taxa (family)	8.00	2
Number of Individuals	23.00	0
% Dominant Taxa	35	4
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	0.30	0
Chironomid Count	9.00	6
mIBI Score		**1.2**

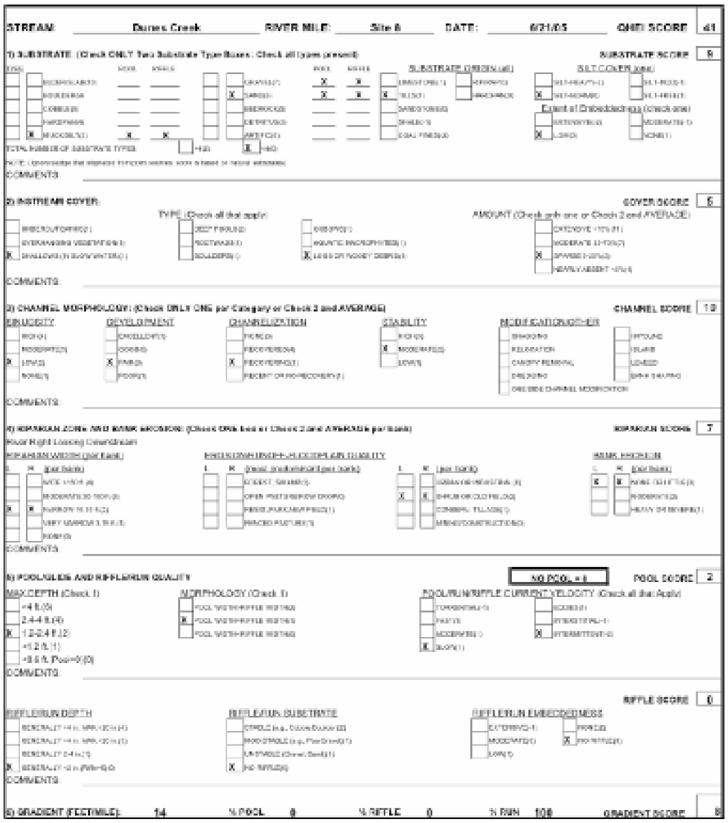
Table I 25. Munson Ditch upstream of U.S. Highway 20 (Site 8) multi-habitat macroinvertebrate results, June 21, 2005.

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Ephemeroptera					
Hemiptera					
Corixidae	7		10	70	46.7%
Diptera					
Chironomidae	1		6	6	6.7%
Culicidae	1				6.7%
Other Arthropoda					
Cambaridae	1				6.7%
Talitridae	1		8	8	6.7%
Platyhelminthes					
Oligochaeta	4				26.7%
	15	**0**		**7.64**	
				HBI	

Table I 26. Munson Ditch upstream of U.S. Highway 20 (Site 8) mIBI metrics, June 21, 2005.

		Metric Score
HBI	9.33	0
Number of Taxa (family)	6.00	0
Number of Individuals	15.00	0
% Dominant Taxa	47	2
EPT Index	0.00	0
EPT Count	0.00	0
EPT Count/Total Count	0.00	0
EPT Abundance/Chironomid Abundance	0.00	0
Number of Individuals Per Square	0.19	0
Chironomid Count	1.00	8
mIBI Score		**1**

Macro worksheets



STREAM: Dunes Creek RIVER MILE: Site 8 DATE: 6/21/05 QHEI SCORE 41

1) SUBSTRATE (Check ONLY Two Substrate Type Boxes; Check all types present) SUBSTRATE SCORE 9

TOTAL NUMBER OF SUBSTRATE TYPES

COMMENTS:

2) INSTREAM COVER: COVER SCORE 5

TYPE (Check all that apply)

AMOUNT (Check only one or Check 2 and AVERAGE)

COMMENTS:

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) CHANNEL SCORE 10

SINUOSITY DEVELOPMENT CHANNELIZATION STABILITY MODIFICATIONS/OTHER

COMMENTS:

4) RIPARIAN ZONE AND BANK EROSION (Check ONE box or Check 2 and AVERAGE per bank) RIPARIAN SCORE 7

RIPARIAN WIDTH (per bank) BANK EROSION

COMMENTS:

5) POOL/GLIDE AND RIFFLE/RUN QUALITY NO POOL = 0 POOL SCORE 2

MAX.DEPTH (Check 1) MORPHOLOGY (Check 1) POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

2.4-4 ft.(4)

1.2-2.4 ft.(2)

<1.2 ft.(1)

COMMENTS:

RIFFLE SCORE 0

RIFFLE/RUN DEPTH RIFFLE/RUN SUBSTRATE RIFFLE/RUN EMBEDDEDNESS

COMMENTS:

6) GRADIENT (FEET/MILE): 14 % POOL 0 % RIFFLE 0 % RUN 100 GRADIENT SCORE 8

Conducted by: JFNew
Project Number: 04-04-17

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Acronyms

ACOE	Army Corps of Engineers
BMP	Best Management Practice
BOD	Biological (or Biochemical) Oxygen Demand
CCWC	Coffee Creek Watershed Conservancy
CD	Conservation Design
CFU	Colony Forming Units
CRP	Conservation Reserve Program
CTIC	Conservation Technology Information Center
CWA	Clean Water Act
CWP	Center for Watershed Protection
USEPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FRIENDS	Friends of the Indiana Dunes
GAP	Gap Analysis Program
GIS	Geographic Information System
GLAHNF	Great Lakes Aquatic Habitat Network and Fund
GPS	Global Positioning System
HUC	Hydrologic Unit Code
INDOT	Indiana Department of Transportation
INDU	Indiana Dunes National Lakeshore
IAC	Indiana Administrative Code
ICRAT	Indiana Coastal Restoration Action Team
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ISDA	Indiana State Department of Agriculture
ISS	Individual Septic System
LARE	Lake and River Enhancement
NIRPC	Northwestern Indiana Regional Planning Commission
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
OSDS	On-site sewage disposal systems
QHEI	Qualitative Habitat Evaluation Index

RPB	Rapid Bioassessment Protocol
SDCF	Save the Dunes Conservation Fund
SHLT	Shirley Heinze Land Trust
SSC	Suspended Sediment Concentration
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFW	United States Fish and Wildlife
USGS	United States Geological Survey
UWA	Unified Watershed Assessment
WHIP	Wildlife Habitat Incentives Program

Glossary of Terms

303(d) List – a list identifying waterbodies that are impaired by one or more water quality elements thereby limiting the performance of designated beneficial uses.

Aquifer – any geologic formation containing water, especially one that supplies water for wells, springs, etc.

Best Management Practices (BMPs) – practices implemented to control or reduce nonpoint source pollution.

Canopy Cover – the overhanging vegetation over a given area.

Channelization – straightening of a stream; often the result of human activity.

Coliform – intestinal waterborne bacteria that indicate fecal contamination. Exposure may lead to human health risks.

Conservation Design (CD) – a development approach that seeks to protect natual resources from development impacts by taking existing landscape, drainage, and natural features into consideration.

Designated Uses – state-established uses that waters should support (e.g. fishing, swimming, aquatic life).

Detention Pond – a basin designed to slow the rate of stormwater run-off by temporarily storing the run-off and releasing it at a specific rate.

Dissolved Oxygen (DO) – oxygen dissolved in water that is available for aquatic organisms.

Easement – a right, such as a right of way, afforded an entity to make limited use of another's real property.

Ecoregion – a geographic area characterized by climate, soils, geology, and vegetation.

Ecosystem – a community of living organisms and their interrelated physical and chemical environment.

Erosion – the removal of soil particles by the action of water, wind, ice, or other agent.

Escherichia coli (E.coli) – a type of coliform bacteria found in the intestines of warm-blooded organisms, including humans.

Exotic species – an introduced species not native or endemic to the area in question.

Gradient – measure of a degree of incline; the steepness of a slope.

Groundwater – water that flows or seeps downward and saturates soil or rock.

Headwater – the origins of a stream.

Hydrologic Unit Code (HUC) – unique numerical code created by the U.S. Geological Survey to indicate the size and location of a watershed within the United States.

Impervious Surface – any material covering the ground that does not allow water to pass through or infiltrate (e.g. roads, driveways, roofs).

Infiltration – downward movement of water through the uppermost layer of soil.

Low Impact Development (LID) - a development approach that utilizes a variety of natural or built features to promote sound management of stormwater.

Macroinvertebrates – animals lacking a backbone that are large enough to see without a microscope.

National Pollutant Discharge Elimination System (NPDES) – national program in which pollutant dischargers such as factories and treatment plants are given permits with set limits of discharge allowable.

Nonpoint Source Pollution (NPS) – pollution generated from large areas with no identifiable source (e.g., stormwater run-off from streets, development, commercial and residential areas).

Permeable – capable of conveying water (e.g., soil, porous materials).

Point Source Pollution – pollution originating from a "point," such as a pipe, vent, or culvert.

Pollutant – as defined by the Clean Water Act (Section 502(6)): "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

Pool – an area of relatively deep, slow-moving water in a stream.

Retention Pond – A basin designed to retain stormwater run-off so that a permanent pool is established.

Riffle – an area of shallow, swift moving water in a stream.

Riparian Zone – an area, adjacent to a waterbody, which is often vegetated and constitutes a buffer zone between the nearby land and water.

Run-off – water from precipitation, snowmelt, or irrigation that flows over the ground to a waterbody. Run-off can pick up pollutants from the air or land and carry them into streams, lakes, and rivers.

Sediment – soil, sand, and minerals washed from the land into a waterbody.

Sedimentation – the process by which soil particles (sediment) enter, accumulate, and settle to the bottom of a waterbody.

Storm Drain – constructed opening in a road system through which run-off from the road surface flows on its way to a waterbody.

Stormwater – the surface water run-off resulting from precipitation falling within a watershed.

Substrate – the material that makes up the bottom layer of a stream.

Topographic Map – map that marks variations in elevation across a landscape.

Total Maximum Daily Load (TMDL) – calculation of the maximum amount of a pollutant that a waterbody can receive before becoming unsafe and a plan to lower pollution to that identified safe level.

Tributary – a stream that contributes its water to another stream or waterbody.

Turbidity – presence of sediment or other particles in water, making it unclear, murky, or opaque.

Water Quality – the condition of water with regard to the presence or absence of pollution.

Water Quality Standard – recommended or enforceable maximum contaminant levels of chemicals or materials in water.

Watershed – the area of land that water flows over or under on its way to a common waterbody.

Wetlands – lands where water saturation is the dominant factor in determining the nature of soil development and the types of plant and animal communities.