Chapter 3

LID in Michigan: The Key Determinants

This chapter summarizes Michigan data for the key determinants and variables that are used in LID design. Included with the descriptions of these determinants and variables are resources for obtaining data. The figures, tables, data, etc., included in this chapter are for illustrative purposes only and should not be used for design. Wherever possible, design should be based on site specific information gathered by field investigation or other local data sources. This chapter discusses:

- Michigan climate, including rainfall, snowfall, and soil freezing,
- Geology and soil groups,
- Plant resources, and
- Sensitive areas, including wetlands, wellhead protection areas, and sensitive and impaired waters.

The State of Michigan is a land of contrasts and broad continuums. Driven by climate changes, vast ancient inland seas and mile-high glaciers expanded and contracted over the Michigan landscape. These movements left behind and sculpted geological material overlying mineral deposits across the state and contributed to the emergence of a variety of watersheds with a wide range of characteristics. For example, soils in Michigan range from heavy clay, such as ancient lake sediments on the eastern side of the state, to the very well-draining sands of the northern half of the Lower Peninsula. This may lead practitioners to think that a single development strategy – minimizing hydrologic impacts – would be difficult to implement and standardize. However, LID works across many continuums precisely because the benchmark is always local and calibrated to the local hydrologic conditions.

This manual was prepared for use throughout Michigan. In design, LID is structured to maximize the use of natural features to mimic presettlement hydrology. In application, LID must be site specific. The site specific considerations highlighted in this chapter provide a preview of what to include in a local LID program. The generalized data in this chapter are provided for illustrative purposes. This should be substituted with the best available local data.

Climate

Climate drives site hydrology. Michigan's unique location, bordering four Great Lakes, moderates and exacerbates climate conditions. The lakes can moderate temperature extremes but can also significantly change precipitation patterns. For instance, lake effect precipitation results in the highest annual precipitation totals on the southwestern side of the state. Precipitation in the form of rainfall and snowmelt, and issues relating to freeze/thaw are key determinants that must be considered when using LID techniques.

Rainfall

A common goal in applying LID is to keep as much stormwater on a site as possible. Therefore, design is closely related to rainfall patterns in a particular area. The average annual rainfall in Michigan ranges from less than 28 inches to more than 38 inches per year (Figure 3.1). Annual rainfall varies from the wetter southwest to the drier north and east. But, storm frequency data show some consistency across the state. For example, the two-year frequency, 24-hour duration storm only varies by region from 2.09 to 2.42 inches (Table 3.1). (Storm frequency is based on the statistical probability of a storm occurring in a given year. That is, a 10-year, 24-hour storm has a 10 percent chance of occurring in any single year; a 50-year storm has a two percent chance; and a 100-year storm, a one percent chance).

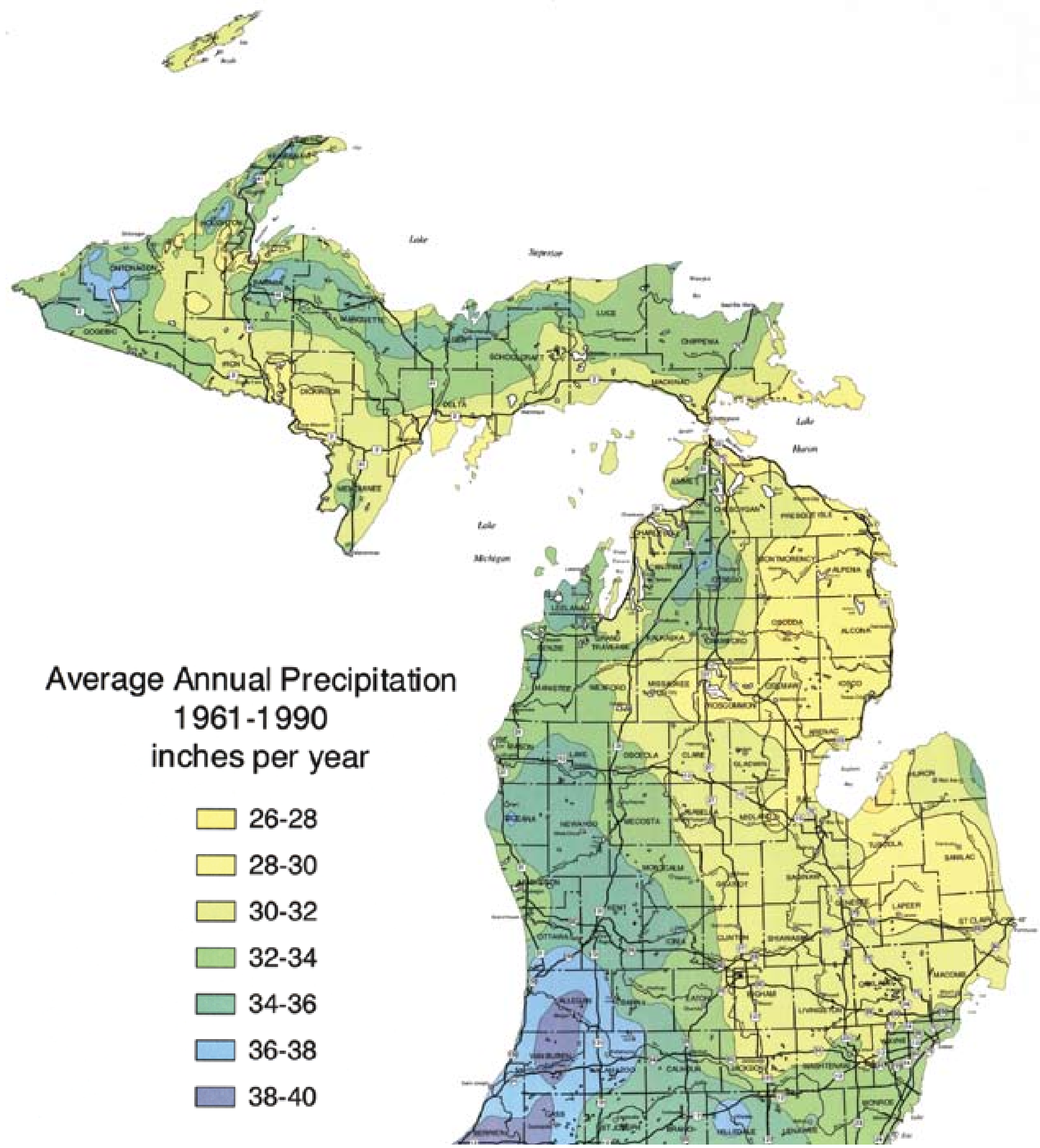
Table 3.1
Rainfall Event Totals of 24-Hour Duration in Michigan

Region of Michigan (numbers refer to the sections of Michigan in Huff and Angel)	1-year Storm (in.)	2-year Storm (in.)	10-year Storm (in.)	50-year Storm (in.)	100-year Storm (in.)
Southwest Lower (8)	1.95	2.37	3.52	5.27	6.15
South-Central Lower (9)	2.03	2.42	3.43	4.63	5.20
Southeast Lower (10)	1.87	2.26	3.13	3.98	4.36
Northwest Lower Peninsula (3)	1.62	2.09	3.21	4.47	5.08
West Upper Peninsula (2)	1.95	2.39	3.48	4.73	5.32

Source: Huff and Angel, 1992. Rainfall Frequency Atlas of the Midwest

Precipitation also varies slightly by season — the wettest seasons being summer (averaging 30 percent of the total annual precipitation) and fall (28.6 percent), followed by spring (24 percent) and winter (17.4 percent). (Huff and Angel, 1992) This seasonal variation is even more dramatic in terms of the largest one-day storms; only 2.3 percent of these large storms occurred in winter, while 44.2 percent fell in fall and 39.5 percent in summer. (Huff and Angel, 1992)

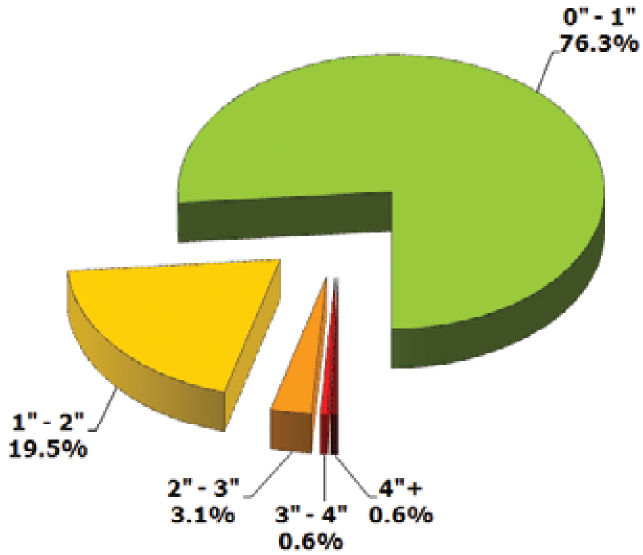
Figure 3.1
Average Annual Precipitation in Michigan



Source: NRCS National Cartography and Geospatial Center

Although large storms are critical in terms of flooding, most rainfall in Michigan actually occurs in relatively small storm events, as indicated in Figure 3.2. Approximately three-quarters of the average annual rainfall throughout the state occurs in storms of one inch or less (76.3 percent calculated for Lansing). About 95 percent of the average annual rainfall occurs in storms of two inches or less, and over 98 percent of average annual rainfall occurs in storms of three inches or less. As discussed above, the two-year frequency rainfall is approximately 2-2.5 inches.

Figure 3.2
Rainfall Distribution by Storm Size for Lansing, Michigan based on Daily Precipitation Values from 1948 to 2007



When stormwater management only addresses large events (two-year storms and greater), much of the actual rainfall and runoff are not properly managed (as much as 95 percent of the annual rainfall). Therefore, managing smaller storms that comprise the vast majority of the annual rainfall in Michigan is critical.

Rainfall frequency data, for application in stormwater calculations, can be found in Chapter 9.

Resources:

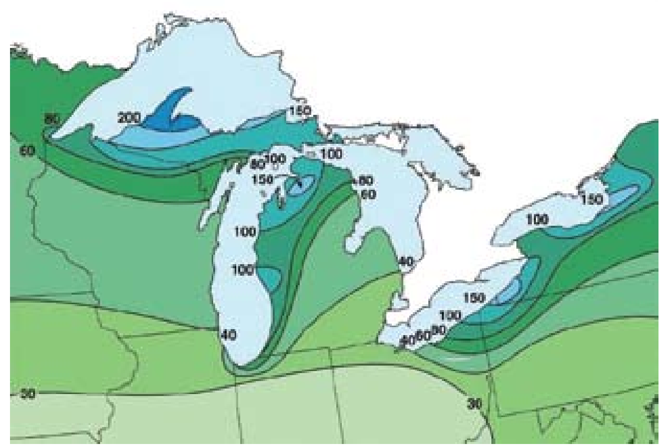
1. The most frequently used rainfall data has been compiled by Huff, F.A. and Angel, J.R. See: Rainfall Frequency Atlas of the Midwest, 1992. Bulletin 71 Midwestern Climate Center and Illinois State Water Survey. MCC Research Report 92-03. Available for free download at: http://www.sws.uiuc.edu/pubdoc/B/ISWSB-71.pdf
2. Long-term daily and monthly precipitation data for about 25 stations throughout Michigan is available free from the United States Historical Climatology Network (USHCN) at: http://cdiac.ornl.gov/epubs/ndp/ushcn/state_MI.html

Snow and soil freezing

Snowfall and soil freezing are both important considerations when applying LID practices in Michigan. This is due to numerous issues including storage of large quantities of snow and the impact of freezing on the functioning of the BMP. (Chapter 7 details these considerations and provides solutions for Michigan). The degree to which these factors drive LID design will vary significantly in different parts of the state.

When selecting and designing a BMP, local information on snowfall is important. Annual snowfall in Michigan increases from southeast to northwest, with an average of 30 inches near Lake Erie, an average of 100-150 inches in the northern Lower Peninsula, and an average of 200 inches in the northern Upper Peninsula (Figure 3.3). In the Lower Peninsula, a lake effect snowbelt extends 10-80 km inland from the shore of Lake Michigan (Thomas 1964, cited in Isard and Schaetzl, 1998).

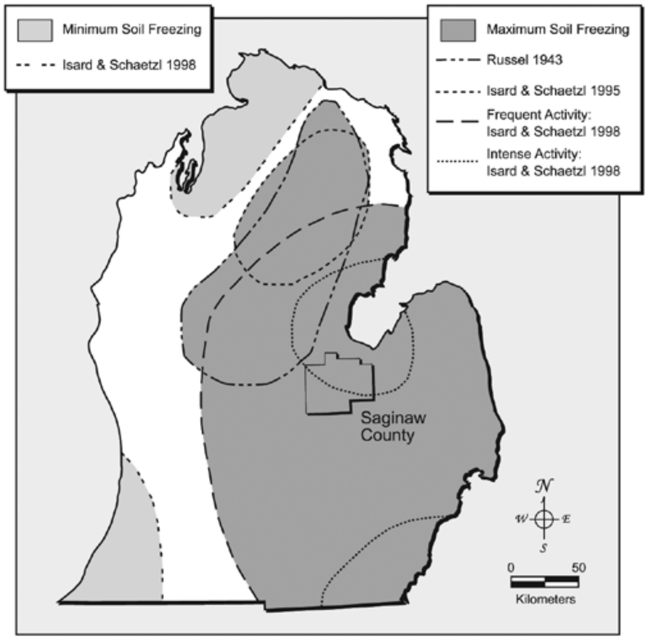
Figure 3.3
Average Annual Snowfall in Inches (1971 – 2000)



Source: Weather Michigan: (http://www.weathermichigan.com)

Local soil freezing information is another important consideration for LID design. This is because ice in soil pores block water infiltration and cause runoff of snowmelt or rain from infiltration BMPs. There are design considerations, such as the use of compost or mulch that insulate infiltration BMP soils (refer to Chapter 7). A thick, persistent snowpack also insulates soil from below-freezing air temperatures. In the snowbelt regions, soil freezing is less frequent, and in some years nonexistent, compared to areas with little or no persistent snow cover throughout the winter (Figure 3.4). On average, the snowbelt regions experience less than two freeze-thaw cycles per year. In contrast, the eastern and southeastern portions of the Lower Peninsula usually

Figure 3.4
Soil Freezing in Lower Michigan



Source: Schaetzl and Tomczak, 2002

experience three to five freeze-thaw cycles per year and the soil may freeze to a depth of five centimeters or more even in warm winters (Isard and Schaetzl, 1998).

Resources:

1. Snowfall and snow cover data are available at: http://www.ncdc.noaa.gov/ussc/.
2. Soil temperature data for the past two months at a limited number of locations can be found at: http://www.agweather.geo.msu.edu/mawn/.

Earth resources

Geology/Soils

Because many LID techniques rely on infiltrating rain water and runoff, it is essential to consider the soil properties and underlying geology that control the balance between infiltration, runoff, and groundwater elevations. Soil type and texture class determine the rate of infiltration, the amount of water stored in the soil pores, and the relative effort required by evaporation or plant roots to draw water back up against gravity.

Depth to groundwater and depth to bedrock are important considerations in BMP design and can constrain design of infiltration BMPs. Although rare in Michigan, karst formations present another potential constraint to infiltration BMPs. Karst is a carbonate-based bedrock, such as limestone or dolomite, that is highly soluble. Increasing infiltration into karst formations can hasten the dissolution of rock and potentially lead to subsurface voids and sinkholes.

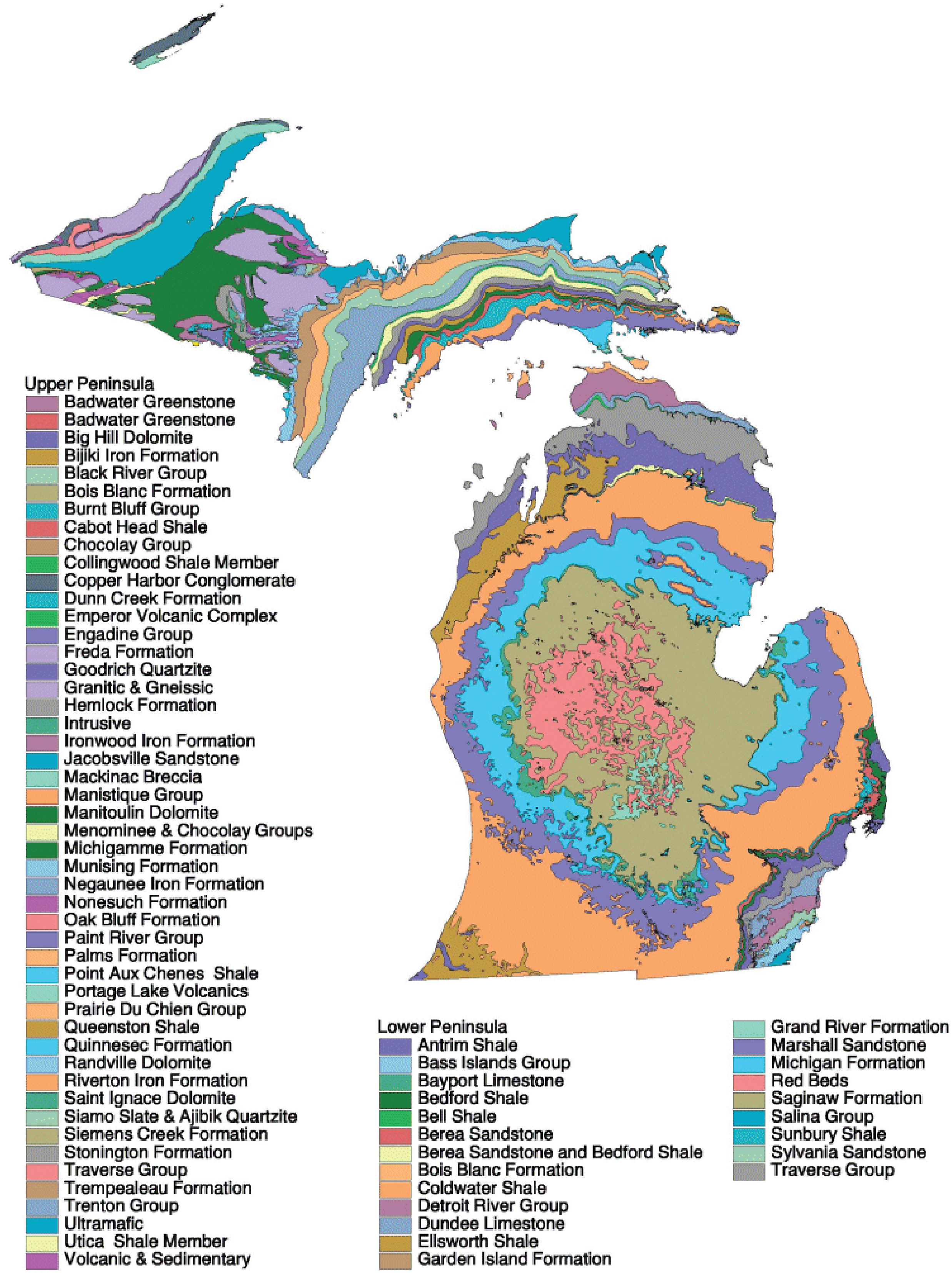
Soils in Michigan are somewhat unique. In most areas of the world, bedrock is weathered to produce soils. However, in Michigan, glacial deposits have buried the bedrock in most areas. This makes the surface geology different in origin and composition than the underlying bedrock geology (Figure 3.5).

In Michigan, ancient bedrock materials are covered with 200-300 feet of glacial deposits, and in some places 1,200 feet of deposits (Kelley, 1960). In general, the surface geology shifts from clay in the southeast Lake Erie region to sands in the north and west (Figure 3.6).

Successfully implementing LID requires balancing the interdependent variables that affect site hydrology. Soils are a key aspect of hydrology that exemplifies this balancing act. Except for a few areas in Michigan where bedrock is exposed in outcrops or erosion of glacial deposits, it is the surface geology that determines soil properties.

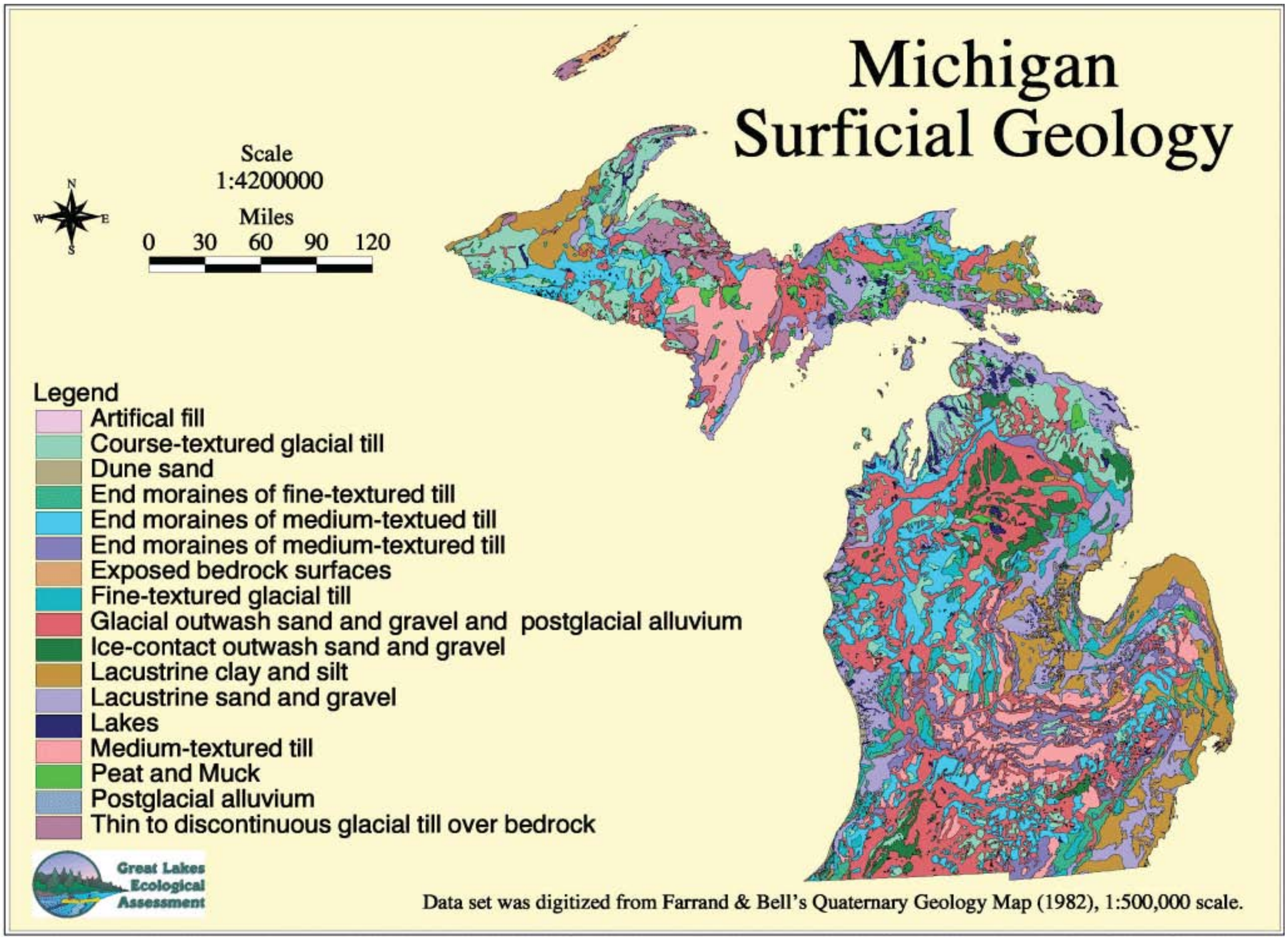
For LID, a soil's infiltration capacity should be understood in relation to the soil's capacity to filter/remove pollutants before reaching groundwater. Clays have very low infiltration rates but tend to have the highest capacity for removing pollutants. On the other hand, sands have high infiltration rates, but tend to have low capacities for removing pollutants. Organic-rich soils tend to have high infiltration rates, but are often found in high groundwater locations. Organic-rich soils also tend to have high capacities for pollutant removal.

Figure 3.5
Michigan Bedrock Geology



Source: US Forest Service, Great Lakes Ecological Assessment, (http://www.ncrs.fs.fed.us/gla/)

Figure 3.6
Michigan Surficial Geology



Source: US Forest Service, Great Lakes Ecological Assessment, (http://www.ncrs.fs.fed.us/gla/)

Soil groups

Soils can be grouped and classified in a number of ways, including by:

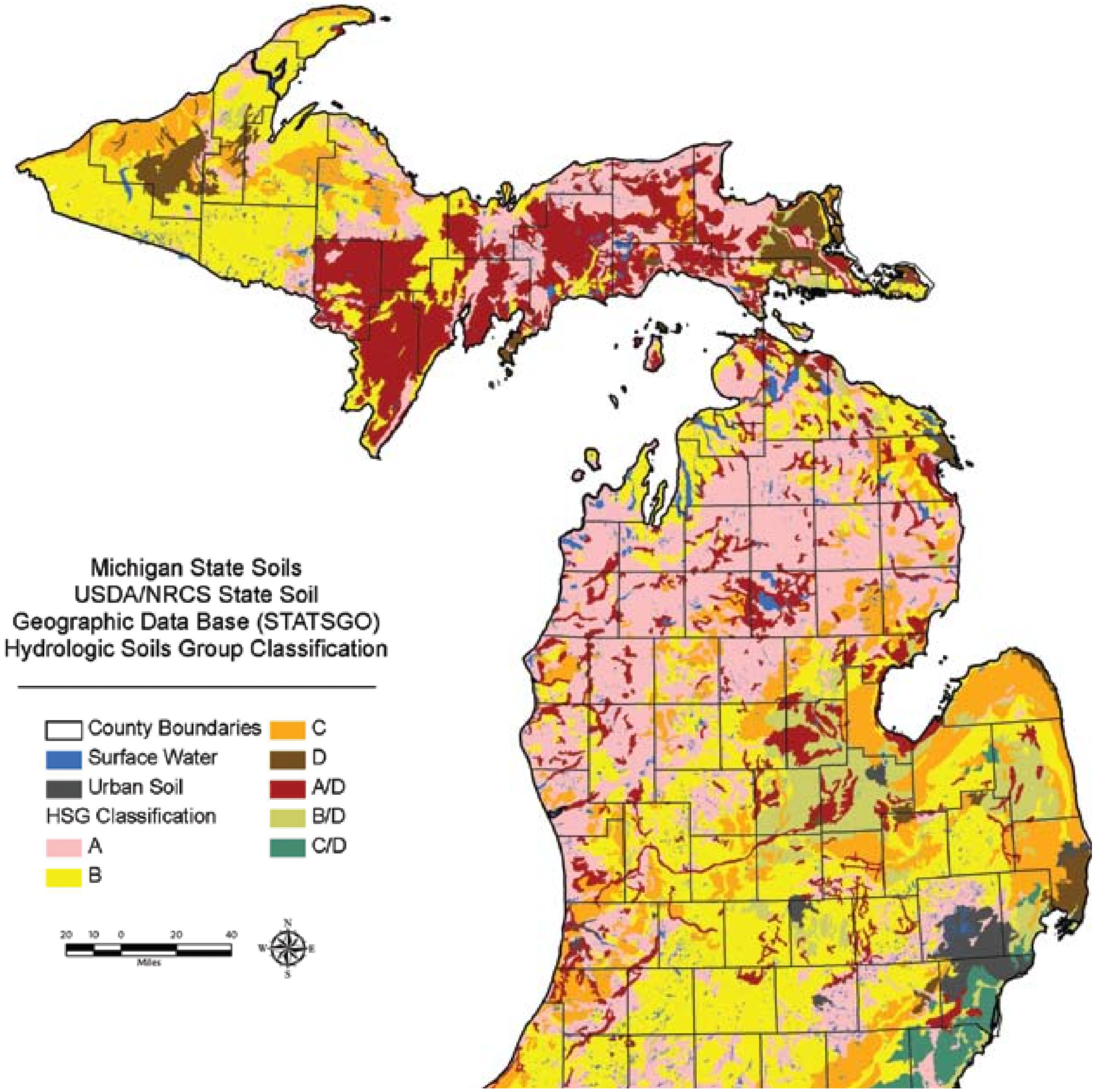
- Soil orders (soil origin and properties),
- Texture class (silt, clay, loam, etc.),
- Engineering properties (bearing strength, internal cohesion, angle or repose, etc.),
- Chemical properties (acidity, cation exchange capacity), and
- Hydrologic properties (well-drained, poorly drained).

The Natural Resources Conservation Service (NRCS) has developed electronic maps of almost all soils in Michigan (refer to: http://websoilsurvey.nrcs.usda.gov/app/). NRCS delineates soils by series; these soils series and names are locally specific. NRCS has associated the series names and soil properties in this spatial, electronic database.

Although soil series names are different in counties across the state, many soil series are quite similar with respect to drainage. Soil series are assigned a Hydrologic Soil Group (HSG) rating, A-D, which describes the physical drainage and textural properties of each soil type and is useful for stormwater, wastewater, and other applications (Figure 3.7). This HSG rating usually is based on a range of permeability, as well as certain physical constraints such as soil texture, depth to bedrock, and seasonal high water table (SHWT) and are defined in Table 3.2.

All soils are permeable and drain to some degree unless they are saturated by hydrologic conditions, such as hydric soils in a wetland. The wetter D soils have little or no infiltration potential during rainfall and produce much greater surface runoff with seasonal variability.

Figure 3.7
Hydrologic Soils Group Classification



Source: United States Department of Agriculture, Natural Resources Conservation Service

Table 3.2
Hydrologic Soil Groups

Soil Group	Soil Type	Drainage Capacity
A	sand, loamy sand, sandy loam	very well drained and highly permeable
B	silt loam, loam	good
C	sandy clay loam	fair
D	clay loam, silty clay loam, sandy clay, silty clay, clay	poorly drained and generally situated in a valley bottom or floodplain

Most soils in Michigan are classified with a HSG rating of A or B, both usually being very good for applying many stormwater management systems, as well as onsite septic systems and other infiltration applications. State Soil Geographic Database (STATSGO) data for Michigan indicates that:

- 29 percent of soils are classified as A,
- 32 percent as B,
- 13 percent as C, and
- Three percent as D, along with some mixed (A/D, B/D) classifications (Figure 3.8).

It should be noted that the permeability ranges listed for the HSG ratings are based on the minimum rate of infiltration obtained for bare soil after prolonged wetting (USDA SCS,1986). Vegetative cover increases these rates three to seven times (Lindsey et. al., 1992).

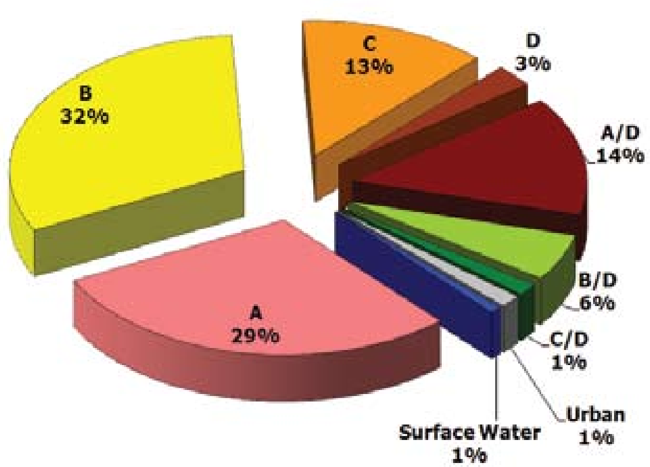
It is important to also understand the infiltration capacity of soils below the near-surface (approximately top 12 inches) to adequately characterize a soil's infiltration capacity because deeper soils may be more limiting to infiltration than surface soils.

County soil surveys may be used as a preliminary source for soil column characterization. However, it is recommended that site specific soil testing be done before final design and implementation of LID projects in order to confirm soil characterization and infiltration capacity (Appendix E).

Resources:

1. Soil survey data are available online from NRCS Soil Surveys at: http://websoilsurvey.nrcs.usda.gov/app/.

Figure 3.8
Distribution of Hydrologic Soil Groupings (HSGs) in Michigan



Pollutant removal by soils
Many factors influence a soil's pollutant removal capacity. Factors that influence pollutant removal include infiltrated water quality, and soil characteristics such as age, pH, particle size, mineral content, organic matter content, oxidation-reduction potential (redox), as well as the soil flora and fauna at the surface and in the subsurface. To simplify, this manual limits discussion to a few key factors that are reasonable surrogates for estimating pollutant removal through soils — soil organic matter content and cation exchange capacity (CEC).

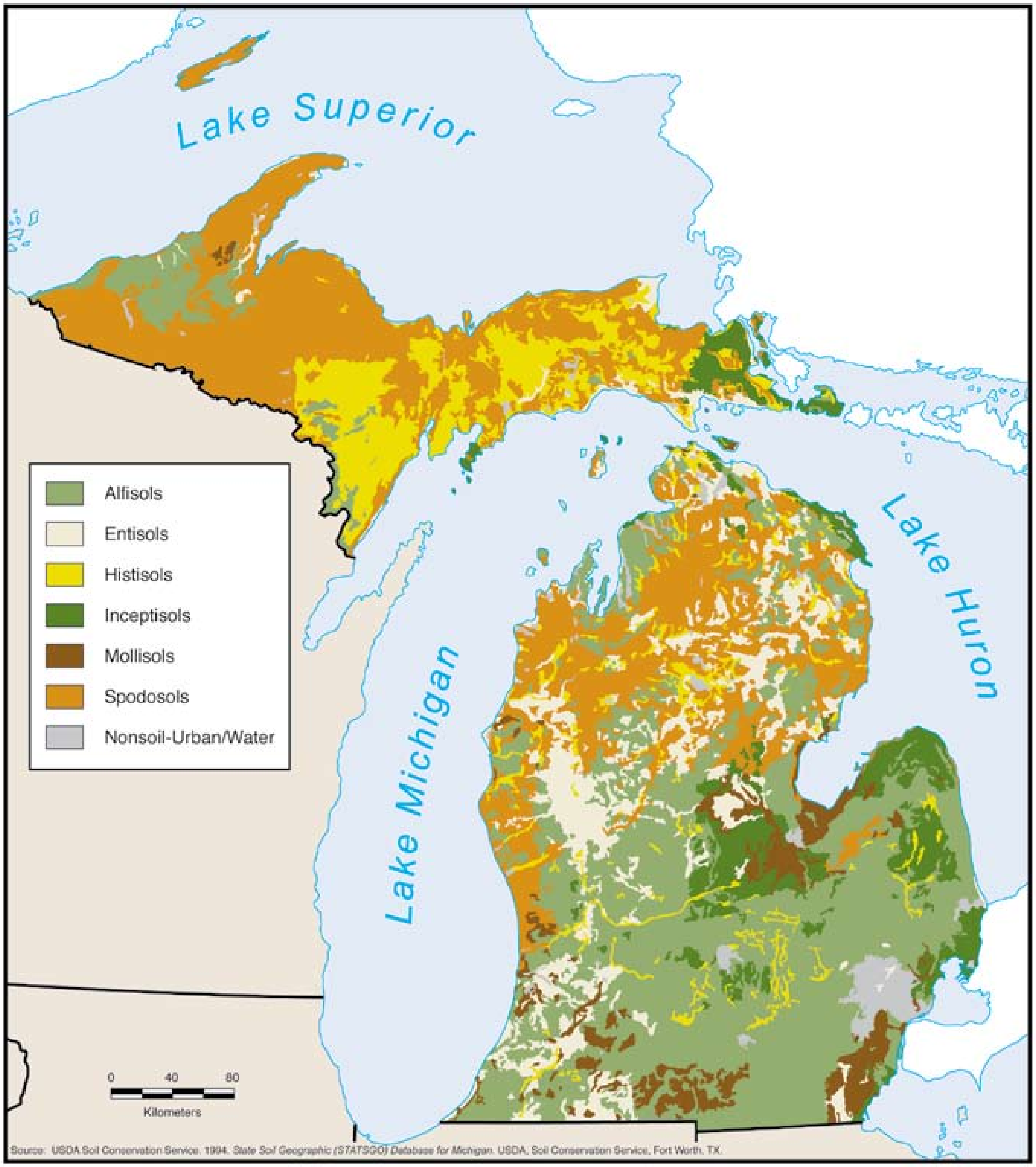
Soil provides the medium for decomposition of all organic material generated on the land surface. Soil is the habitat for a vast spectrum of micro- and macro-organisms that form a natural recycling system. The rhizosphere (the rooting zone) includes: roots, viruses, bacteria, fungi, algae, protozoa, mites, nematodes, worms, ants, maggots, other insects and insect larvae (grubs), earthworms, and rodents.

Processed nutrients in the rhizosphere are, in turn, used by the vegetative systems that develop on the soil mantle. When precipitation is infiltrated, it transports pollutants from the surface into this soil treatment system, which effectively and efficiently breaks down most nonpoint source pollutants (biologically), removes them from the stormwater by cation exchange (chemically), and/or physically filters them through soil particles.

One important measure of chemical pollutant removal potential is the CEC which is closely related to the organic content in the soil. Soils with a CEC of 10 milliequivalents per 100 grams of soil are very efficient as a treatment medium, and offer the best opportunity to reduce or completely remove most common pollutants, such as phosphorus, metals, and hydrocarbons. Pollutants that are dissolved in stormwater, such as nitrate, are the exception. Nitrates typically move with the infiltrating rainfall and do not undergo significant reduction or transformation, unless an anaerobic environment with the right class of microganisms is encountered.

There are seven soil orders in Michigan with varying CECs (Figure 3.9). The typical CEC ranges of these soil orders are summarized in Table 3.3. Two soil orders that have relatively high CECs in Michigan are Mollisols and Histosols. Mollisols are young soils formed in grassland regions, and have high organic content derived from long-term additions from plant roots. Mollisols are common in the southeastern portion of the Lower Peninsula and sporadic throughout the remainder of the Lower Peninsula. Histosols, or peat-derived soils, have very high organic matter content and also have high CEC. Histosols are common in the eastern Upper Peninsula, and present sporadically in the Lower Peninsula.

Figure 3.9
Dominant Soil Orders of Michigan



Source Michigan State University Center for Remote Sensing and Geographic Sciences (http://www.rsgis.msu.edu)

Table 3.3
Representative Cation Exchange Capacities in Surface Soils

Soil Order	CEC $mol_c\ kg^{-1}$
Alfisols	0.12 ± 0.08
Aridisols	0.16 ± 0.05
Entisols	1.4 ± 0.3
Inceptisols	0.19 ± 0.17
Mollisols	0.22 ± 0.10
Oxisols	0.05 ± 0.03
Spodosols	0.11 ± 0.05
Ultisols	0.06 ± 0.06
Vertisols	0.37 ± 0.08

Source: Sposito, 1989. *The Chemistry of Soils*.

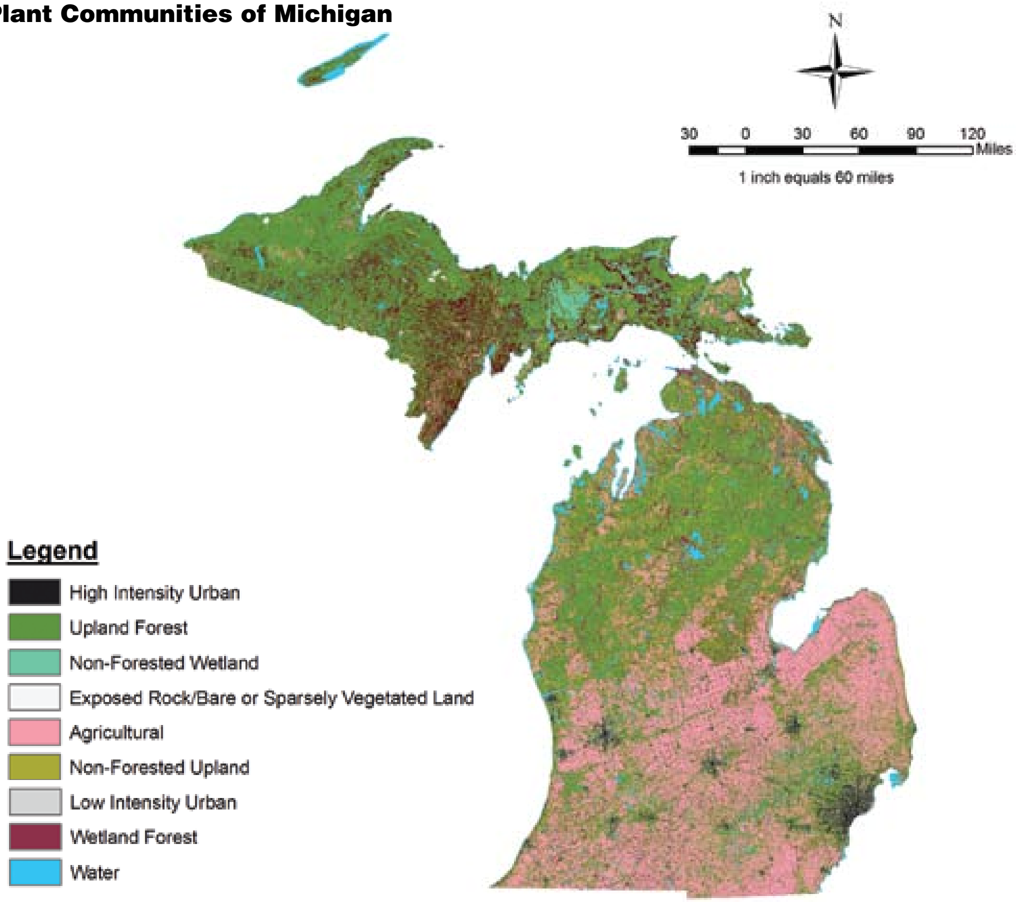
Biotic resources

The biotic resources of Michigan span a vast array of flora and fauna. These organisms impact the effectiveness of stormwater management programs and are impacted by the programs set in place. LID involves capitalizing on the unique opportunities afforded by natural systems to a more significant extent than conventional stormwater management. In turn, LID attempts to reduce impacts on natural systems beyond the capacities of conventional development.

Successfully applying LID involves shifting our approach from design by reshaping the environment to design by developing land in ways that take advantage of natural processes. Clearly, minimizing impervious surfaces, a key LID nonstructural BMP (Chapter 6), maximizes the preservation of natural features. On developed land, many LID BMPs emulate the process of natural soils, flora, and fauna. The entire plant sphere, from the tree canopy to the understory, shrubs and herbaceous shoots, plant litter, and the rhizosphere is actively engaged in water recycling. Along each step of the way, plants work to capture, store, and reuse precipitation. LID BMPs capitalize on this natural water conservation and reuse cycle.

In addition to the stormwater management benefits, plant communities provide food, shelter, and habitat for wildlife species in Michigan, including mammals, birds, reptiles, amphibians, and insects.

Figure 3.10
Current Plant Communities of Michigan



Preserving natural communities

A key concept of LID is preserving natural areas through various land design options (Chapter 6, Nonstructural BMPs). During site design, it is critical to systematically consider the present land cover, as well as the quality of the existing ecological and plant communities in order to determine if and how these communities should be preserved through LID.

The Floristic Quality Assessment (MI DNR, 2001) is a method for evaluating the quality of existing ecological and plant communities. The FQA provides a consistent and repeatable method for evaluating plant quality and biodiversity. Floristic quality is assumed to be an implicit indicator of biological health and natural feature significance. High floristic quality scores indicate that local conditions, including hydrology and water quality, are still functioning in a range that supports native vegetation. Figure 3.10 provides a graphic summary of current plant communities throughout Michigan.

Using native plants for revegetation

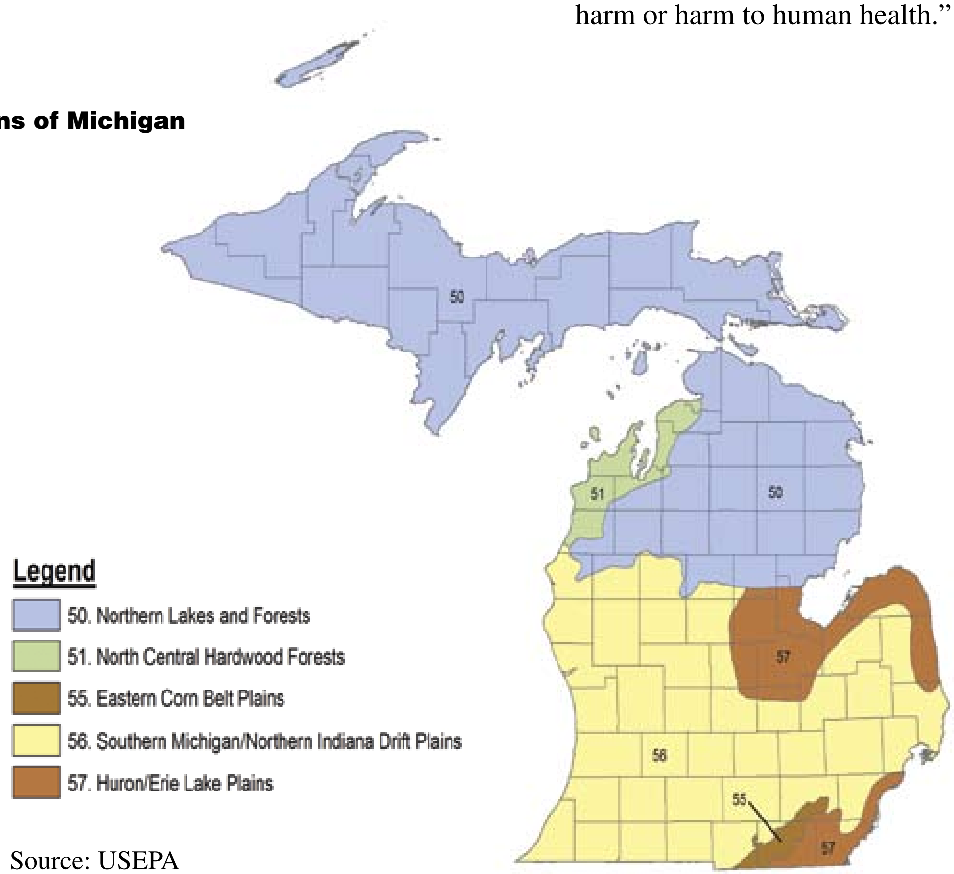
LID BMPs usually include using native plants because of the multiple benefits they provide. (For the purposes of this manual, native plants are defined as those occurring in a given ecoregion prior to European settlement). Native plants offer many advantages over non-natives, while still providing beneficial services such as increased infiltration rates, nutrient removal from stormwater, and carbon sequestration in their roots. Native plants are typically drought and disease tolerant, require little maintenance once established, and help restore plant diversity and soil stability. Native plants also attract a diverse abundance of wildlife including butterflies, songbirds, and beneficial insects, such as honey bees.

Native plants help create a self-sustaining natural habitat. Plant selection criteria should be based on an ecoregion (Figure 3.11) to ensure that plants can survive and flourish in specific climatic and environmental conditions. Recommended commercially available native plant lists by ecoregion and by BMP are provided in Appendix C (Recommended BMP Plant Lists).

Exotic and invasive plant species

In addition to native species, approximately 800 non-native plants have been introduced into the wild flora of Michigan. Of these introduced species, a small percentage has become invasive. The Michigan Invasive Plant Council (MIPC, www.invasiveplantsmi.org) defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."

Figure 3.11
Ecoregions of Michigan



Source: USEPA

There is currently no single broadly accepted list of invasive species in Michigan. However, MIPC is currently evaluating species based on several scientific criteria in order to produce a recommended list of species identified as invasive. The Michigan Natural Features Inventory also has produced a series of fact sheets on selected invasive species (see *Resources*). Species that are generally accepted as invasive typically include:

- Spotted knapweed (*Centaurea maculosa*),
- Purple loosestrife (*Lythrum salicaria*),
- Common reed (*Phragmities australis*),
- Garlic mustard (*Alliaria petiolata*), and
- Honeysuckle species (*Lonicera spp.*).

When designing a LID technique, it's imperative to use plants that are not invasive, preferably using plants that are native to Michigan. That's because invasive species can affect the LID practice by altering the natural community's hydrologic processes. By affecting soil and vegetative structure, invasive species have the ability to increase erosion, decrease infiltration, and decrease water filtration. For instance, garlic mustard, a biennial herb, will often inhibit tree regeneration along woodland edges. Fewer trees will lead to less rainfall interception and lower amounts of organic matter in the forest soil, thus reducing a soil's ability to infiltrate and treat stormwater.

In addition, many of the nonstructural BMPs include preservation of natural areas. It's important to note that the quality of the natural area (not just quantity of the natural area) also should be assessed. For example, in preserving a riparian area, an inventory of potential invasive species and a management program should be put in place.

Resources:

1. Michigan Natural Features Inventory fact sheets can be found online at: http://web4.msue.msu.edu/mnfi/education/factsheets.cfm
2. Michigan Department of Natural Resources Floristic Quality Assessment. Refer to http://www.michigandnr.com/publications/pdfs/HuntingWildlifeHabitat/FQA_text.pdf

Sensitive areas

When implementing LID in Michigan, it is vitally important to understand the connection of the site to such sensitive areas as wetlands, high quality waters, wellhead protection areas, and impaired waterways. Each one of these sensitive areas may require adjustment in the LID design to ensure protection of these resources. Additional information on some of these topics can be found in Chapter 8, Implementing LID in Special Areas.

Wetlands

In Michigan, approximately 3-5 million of the original 11 million acres of wetlands remain; the 100,000 acres of coastal wetlands that remain represent only one-quarter of presettlement cover (Mitsch and Gosselink, 1993). Wetlands are delineated based on soil properties, hydrologic regime, and vegetation. LID provides an opportunity in Michigan to help sustain hydrology and water quality in wetlands. For instance, floristic quality and ecological function are largely driven by water quality and the amount of time the species is saturated with water.

Before changes in land use occurred, many wetlands were fed mostly by groundwater. With land development and artificial drainage, additional surface runoff is channeled to wetlands. The additional surface runoff can have adverse impacts such as raising inundation depths, duration of high water, and degrading water quality. Higher water depths maintained for longer periods of time, either in combination with degraded water quality or alone, can significantly alter native wetland plant populations. This is a problem that has transformed many of Michigan's emergent wetlands from areas of diverse vegetation with a high level of habitat value to flow-through cattail or phragmites ponds.

Wetlands provide important value and service, including water storage, water quality improvement, and habitat for aquatic fauna and birds. Wetlands produce more wildlife and plants than any other Michigan habitat type on an area basis (MDNR - Wetlands). For these reasons most wetland systems should not be subjected to significant hydrologic or water quality alterations. Restoring historically lost wetlands and creating new wetlands where they never existed are better alternatives to address stormwater volume and control. The Department of Environemental Quality has developed a GIS-based Landscape Level Wetland Functional Assessment tool identifying prime areas for re-establishing historically lost wetlands. Highly degraded wetlands such as those dominated by invasive species may offer additional alternatives. (see "Utilizing Wetland Restoration and Creation BMPs for Stormwater Volume Control" p. 31).

The State of Michigan assumes responsibility for administering Section 404 of the Clean Water Act by regulating most inland wetlands within the state. The Department of Environmental Quality regulates wetlands under state law provided in Part 303 of the Natural Resources and Environmental Protection Act 1994 PA 451. The state and the U.S. Army Corp of Engineers together regulate wetlands adjacent to the Great lakes and connecting channels. In general, wetlands are regulated by the state if they have a direct surface water connection or are within 500 feet of a lake, pond, river, or stream; if they have a total area greater than 5 acres; or if the state determines that the protection of the wetland is essential to the preservation of the natural resources of the state.

Michigan encourages municipalities to regulate wetlands not falling under the state program. State law (Part 303) authorizes municipalities to regulate smaller wetlands, provided municipalities use the same wetlands definition, regulatory standards, and application process used by MDEQ. Some Michigan municipalities (e.g., Ann Arbor Township) have addressed the value of wetlands in their master plan, developed wetlands inventories, and enacted wetlands ordinances, consistent with this state guidance.

Based on three major attributes (soil properties, hydrologic regime, and vegetation), Michigan's wetlands can be divided into several major categories. Among these classifications are:

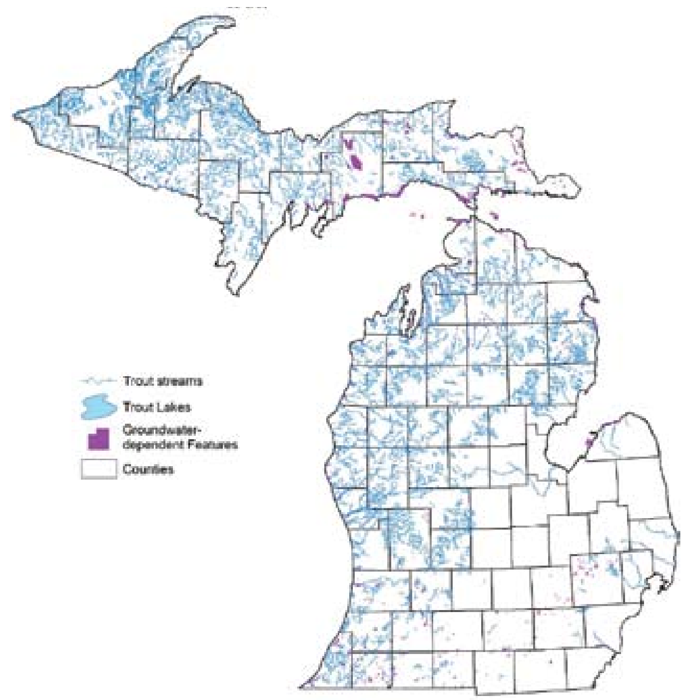
- Bogs,
- Fens,
- Forested wetlands,
- Marshes,
- Shrub carr/thickets, and
- Wet prairies.

Detailed descriptions of Michigan's wetland types were developed by the Michigan Natural Features Inventory. The Michigan Department of Environmental Quality has created county maps that overlay the National Weland Inventory (NWI) data with soils data and MDNR's Michigan Resource Inventory System land cover data. In Southeast Michigan, SEMCOG created maps that overlay NWI data, soils data, and the SEMCOG 2000 land use/land cover map for their seven-county planning region. Although these resources can be used as an overview, onsite wetland delineations must be performed in accordance with Part 303 for jurisdictional determination.

Resources:

1. Detailed description of wetland types from the Michigan Natural Features Inventory can be found at http://web4.msue.msu.edu/mnfi/communities/index.cfm
2. MDEQ wetland maps can be viewed at http://www.michigan.gov/cgi/0,1607,7-158-12540_13817_22351-58858--,00.html.
3. SEMCOG's Wetland Indicator Maps are available at http://www.semcog.org

Figure 3.12
Designated Trout Streams and Lakes



Source: Michigan Groundwater Inventory and Mapping Project, 2005 http://www.egr.msu.edu/igw/GWIM%20Figure%20Webpage/index.htm

Wellhead protection areas/ public water supply

Wellhead protection areas and public water supply areas are sensitive areas due to the fact that residents rely on groundwater for their drinking water. Therefore, certain LID practices, specifically infiltration practices, need to be assessed carefully in these areas (e.g., during the site plan review process). Typically, appropriately sized infiltration BMPs with a reasonable depth of topsoil (18-24 inches) should provide a high degree of filtering of runoff. However, there may be some combination of site constraints, including high groundwater in a public supply area with rapidly infiltrating soils that may necessitate a higher degree of water quality analysis and design redundancy than typical infiltration BMP designs. Please see Chapter 8 for additional information on the use of infiltration BMPs in public water supply areas.

Figure 3.13
Designated Natural Rivers

Source: MDNR, Michigan's Natural Rivers Program

Well data, wellhead protection areas, and other information can be found at http://www.michigan.gov/deqwhp

Sensitive waters

Michigan has numerous designations highlighting high quality waters. These include: trout streams and lakes (Figure 3.12), natural rivers, federal wild and scenic rivers, and outstanding state resource waters. In addition, waters that are currently designated with water impairments may need special consideration as well.

When incorporating LID practices, special consideration may need to be given to developments that drain to these sensitive water resources. Chapter 8 provides more details on LID implementation in these kinds of areas.

The Michigan Department of Natural Resources has identified trout streams and lakes and classifies them into several categories based on various fishing regulations. These waterbodies are of high quality and LID designs near these areas should be carefully considered to avoid adversely impacting water quality or water temperature.

Resources:

1. Michigan Inland Trout and Salmon Guide: http://www.michigan.gov/dnr/0,1607,7-153-10371_14724-137192--,00.html

The Michigan Natural Rivers Program began with the Natural Rivers Act (1970). This program creates simple zoning criteria that local communities use to design a river protection plan. The purpose and goals of the Natural Rivers Program are consistent with the goals of LID. The Natural Rivers Act aims to minimize direct impacts to the river, banks, and riparian corridor. The communities in the watershed of a designated river work together, across municipal and township boundaries, to create a consistent plan for their waterbody. The program stresses use of natural vegetative buffers in the riparian area, as well as minimum lot widths and setback distances to avoid overcrowding of development on the riverbank (MDNR – Natural Rivers Webpage). Currently, 2,091 miles of river are designated state Natural Rivers in Michigan (Figure 3.13).

The Wild and Scenic Rivers Program is a federal program that designates stream segments on public land or otherwise protected open land as Wild and Scenic Rivers based on scenic, recreational, geologic, fish and wildlife, historic, cultural, and other similar values. The program protects these stream segments by prohibiting dams or other projects that would adversely affect the river values, protecting outstanding natural, cultural, or recreational values; ensuring that water quality is maintained; and requiring creation of a comprehensive river management plan. Where development occurs in the watersheds of Wild and Scenic Rivers, LID would be the building practice most consistent with the goals of the Wild and Scenic Rivers Program. In Michigan, 16 stretches of rivers, comprising 625 miles, including sections of the Pere Marquette, Au Sable, Tahquamenon and Presque Isle Rivers, have been designated under the Wild and Scenic Rivers Program.

Outstanding state resource waters

Where water quality of existing water bodies meets the standards for its designated uses, the water is considered to be high quality. The quality of these waters must be maintained and protected unless relaxing the standards is necessary to accommodate important economic or social development in the area. No lowering of water quality is allowed in waters that are designated Outstanding State Resource Waters (OSRWs). In most cases, LID would be the development practice most consistent with protecting OSRW water quality. However, special provisions for water quality treatment of runoff should be made in areas of highly permeable soils such as sand.

OSRWs include parts of the Carp, Ontonagon, Sturgeon, Tahquamenon, Yellow Dog, and Two-Hearted Rivers; all water bodies in Sleeping Bear Dunes National Lakeshore, Pictured Rocks National Lakeshore and the Isle Royale National Park; and all surface waters of the Lake Superior basin.

Resources:

1. A more complete list of OSRWs can be found in MDEQ's Water Quality Rules. Refer to: http://www.deq.state.mi.us/documents/deq-wb-swas-rules-part4.pdf

Impaired waters

Section 303(d) of the Clean Water Act requires that states assess the quality of their waters and prepare a list of waters that do not meet their designated uses or water quality standards. In Michigan, all waterbodies are required to meet the criteria for the following eight designated uses:

- Agriculture,
- Navigation,
- Warm-Water Fishery,
- Indigenous Aquatic Life and Other Wildlife,
- Partial Body Contact Recreation,
- Total Body Contact Recreation (between May 1 and October 31),
- Public Water Supply, and
- Industrial Water Supply.

There are some waterbodies designated for other uses, such as cold-water fishery. MDEQ publishes the 303(d) list every two years.

Reasons for impairment can include:

- Sediment,
- Nitrogen/ammonia,
- Nuisance plant growth/phosphorus,
- Organic enrichment/low dissolved oxygen,
- Pathogens,
- Mercury,
- Priority organic compounds,
- Flow alterations, and
- Habitat alterations.

Table 3.4
Michigan Rivers and Stream Miles not Supporting Designated Uses Listed by Cause of the Impairment

Cause	Total Miles
Toxic organics	
PCBs in water column	34,754
PCBs in fish tissue	14,844
Dioxin	3,124
PBBs	144
Petroleum hydrocarbons	13
Metals	
Mercury in water column	7,179
Mercury in fish tissue	6,884
Copper	34
Lead	13
Chromium	13
Flow alterations	7,632
Habitat alterations	7,028
Pathogens	1,963
Sedimentation/siltation	1,529
Oxygen depletion	1,136
Nutrients	632
Organic enrichment (sewage)	187
Pesticides	
Chlordane	149
DDT	144
Excess algal growth	106
Impairment unknown	63
Thermal impacts	57
Total suspended solids	47
Oil and grease	37
Unionized ammonia	31
Total dissolved solids	19
Aquatic plants	19
Solids (suspended/bedload)	13

Source: MDEQ, 2008.

Once placed on the 303(d) list, a timeline is put in place for developing a Total Maximum Daily Load (TMDL) for the waterbody. The TMDL rations allowable pollutant load amongst watershed sources. LID practices are an opportunity to help watershed sources achieve TMDLs in impaired waters, both from the perspective of filtering and transforming pollutants, as well as for conserving or restoring (in the case of retrofits) presettlement hydrology.

Resources:

1. The Michigan 303(d) list can be found in the Integrated Water Quality Report, online at http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-12711--,00.html

Utilizing Wetland Restoration and Creation BMPs for Stormwater Volume Control

Wetlands improve water quality by filtering out and trapping pollutants like sediments and nutrients in stormwater runoff. Wetlands also store large quantities of water during spring melt and after large rain events reducing the frequency and extent of flooding. This stored water is then released slowly over time to maintain flow in streams and reduce flashiness. Some wetlands are also important for recharging groundwater. Wetlands provide habitat for many species of fish and wildlife while also providing open space and natural beauty. Protection of high quality wetlands involves avoiding the filling of wetlands and minimizing changes to hydrology that will affect wetland quality and function. Re-establishing wetlands where they historically existed, (but don't presently exist), or creating new wetlands (where they never existed) provides an opportunity to provide stormwater quantity control while also increasing wetlands acreage and functions. In rare cases, existing highly degraded wetlands may be used to provide stormwater volume control if the project will also improve other wetland functions. To illustrate this concept, below is suggested language for a city's engineering design manual.

The City discourages the use of existing wetlands for the purposes of providing stormwater quantity control. The City encourages the re-establishment of wetlands where they historically existed, but don't presently exist, or the creation of new wetlands to provide stormwater quantity control and the related functions wetlands provide. The City will only consider approval of use of an existing wetland for stormwater quantity control if all of the following are requirements are satisfied:

A. The wetland must already be highly altered by watershed development and meet certain benchmarks for isolation, high water level fluctuation, low wetland plant richness, dominance of invasive or aggressive plants and altered hydrology.

B. It must be shown that the wetland site does not contain any unique wetland features.

C. An analysis of the pre-developed and post developed water balance for the wetland shows no negative impacts to the existing wetland or adjacent properties. The designer is required to provide the water balance documentation for review. The water balance should include runoff from irrigation.

D. A stormwater management easement shall be provided for the entire wetland. Where portions of the wetland are located on adjacent properties, the developer shall secure all of the required easements.

E. Sufficient pretreatment of the stormwater is provided prior to its discharge to the wetland.

F. A wetland enhancement plan shall be provided. The enhancement plan may include some or all of the following: removal of all or some of the invasive species and restoration with native species; planting of additional trees and shrubs; the creation of open water areas.

G. For wetlands regulated by the Michigan Department of Environmental Quality, a permit from the MDEQ has been obtained for use of the existing wetland for stormwater quantity control.

H. For wetlands regulated by the City, a permit from the City has been obtained for all proposed stormwater discharges and use of the existing wetland for stormwater quantity control.

Source: Environmental Consulting and Technology and the MDEQ Land and Water Management Division.

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*Note: Not all of the above references are cited in this chapter, but are included here for informational purposes.