Chapter Two: Understanding Watersheds

Photo 2–1: Good water quality supports a diverse and abundant wildlife population, such as these Redheads at the Saginaw Bay.

A watershed is an area of land in which all surface waters drain to a common outlet, similar to a household funnel (See Figure 2–1). All of Michigan's watersheds drain into the Great Lakes surrounding the state. Watersheds vary in size, depending upon the terrain, and whether one is working with sub-watersheds within larger watersheds.

WATERSHED DEFINITION

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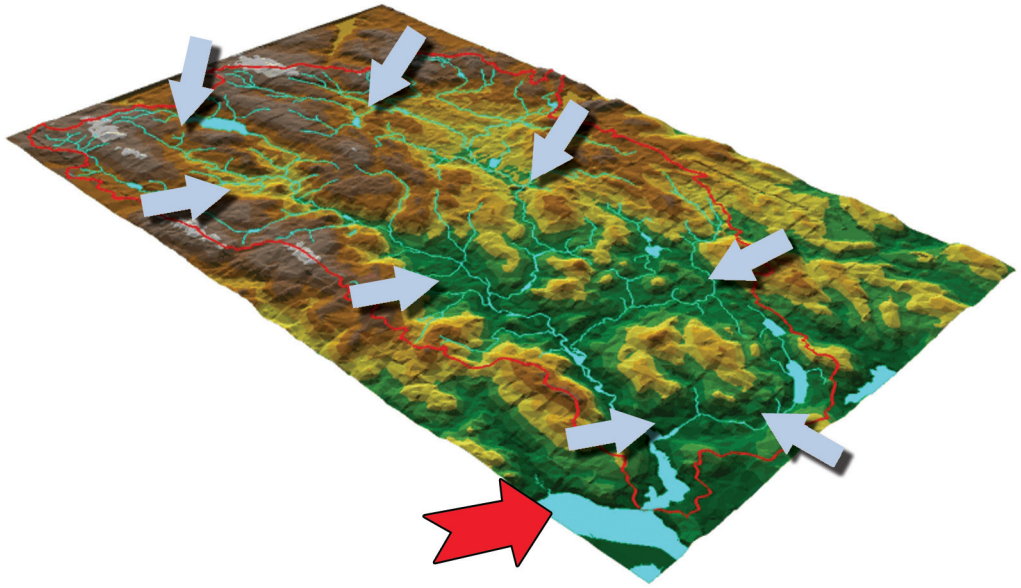
It is important to understand the configuration and functions of local sub-watersheds when thinking about water quality. This is because as water flows across the land of a watershed and the buildings, streets and parking lots we build there, it picks up and carries contaminants, and concentrates them at the point of outflow, often at high and unhealthy levels.

THE WATERSHED IS A SYSTEM

Hydrologic Cycle

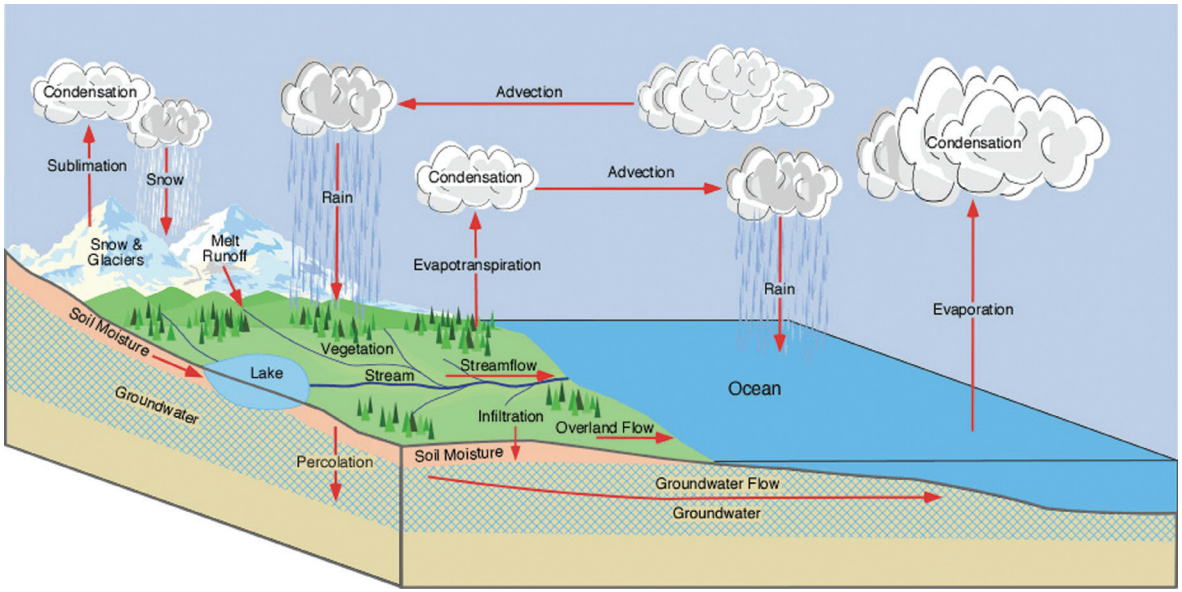
The continuous flow of water, from the sky to earth and vice versa is called the hydrologic cycle (See Figure 2–2). Water rises into the clouds when it evaporates from oceans, from lakes, and from plant leaves, parking lots, and building surfaces on warm or windy days. Rain falls when water vapor in the clouds cools, collecting into drops that are heavy enough to fall to the ground. Rain and melted snow seeps into the ground or flows across the surface. Some of the water that seeps into the ground is absorbed by plant roots, while the remainder moves deeper in the ground. Water that flows across the ground, and into rivers and lakes, and eventually on to the ocean is surface water. The water that seeps into the ground moves downward through the soil due to gravity and the suction of the tiny pores of the soil. It becomes groundwater.

Figure 2-1: Diagram of a Watershed, Draining to a Single Outlet



Source: Nonpoint Education for Municipal Officials (NEMO) Program, University of Connecticut.

Figure 2-2: The Hydrologic Cycle



Source: The Encyclopedia of Earth.

The amount of water that seeps into the ground depends upon how much pore space is in the soil, and how connected the pores are to allow the water in. Sandy soil is more porous than clay soil for example, and water can move more quickly through a sandy soil. However, a clay soil may hold water for a longer period, giving the soil more opportunity to filter out pollutants. In the upper layer of soil, some of the pores contain water, and some contain air. Deeper in the ground all the soil pores may fill with water, creating a zone of groundwater from which we can get well water. When there is enough water to supply a well, the zone of groundwater is called an aquifer. The top of the groundwater is called the water table. The water table may be near the surface, or it may be hundreds of feet underground. If you stand on a long sloping hill, groundwater may be below you in a zone that is roughly parallel to the slope on which you are standing. It is likely flowing slowly downhill through pores in the soil or through cracks in rock. It may seep out of the ground many months or years later at some lower point, such as a spring, stream, or lake. The groundwater may be under pressure from the weight of the rocks and earth above it. If a well is dug into such an aquifer, an artesian well results, with the water flowing out, because it is under pressure.

Now imagine looking at the heavy rain falling on a road. If it is raining hard enough, there can be a layer of water flowing across the surface, perhaps as much as an inch deep. This surface flow is called stormwater runoff. Runoff finds the most direct path downhill. The most direct path may be over pavement and into a drain, or it may be across a lawn or a field. On bare ground, the water may concentrate in a depression, where it starts cutting a gully that finds a path into a stream. Nearly all the rain that falls on pavement collects on the surface, and then runs off. This is because it is an impermeable surface. Much less water is running off a lawn, because as much as half is soaking into the ground. Now look into the woods. Almost no water is flowing on the surface, because nearly all of it is soaking into the ground. In the woods, tree roots and an undisturbed and uncompacted soil allow more water to infiltrate. The more water infiltrates the less there will be surface runoff. The less surface runoff, the less flooding and pollution of lakes and streams will occur.

Water Storage

Water is stored in the watershed. Some of it is released slowly, such as groundwater that continues to flow long after a rain has soaked the ground, replenishing streams and lakes through much of the year. Snow is a form of storage, but the water is released over a short period of time when it melts in the spring, filling streams and lakes to overflowing, and flooding low areas. Streams, rivers and lakes also store water. Water remains in lakes and streams in

the watershed depending upon how fast the water flows through them. The water in a lake may flow in as surface runoff and groundwater flow, but have no streams through which it flows out again. Water would only leave through evaporation and groundwater flow, and it would take several years for the water in the lake to change completely. If the lake has several large streams flowing both in and out then the water could change in less than a year.

Because groundwater moves so slowly, it chemically interacts with the minerals or other substances in the ground. This changes the composition of the water, and will affect its chemical content and taste. Surface water runoff can carry impurities in the form of sediments, oils, grease, gasoline, pesticides, herbicides, and other pollutants.

Groundwater and surface (streams and lakes) water are interconnected. Lake levels are often nearly the same as the level of the water table in the surrounding land. When a gravel pit is excavated in an area with a high water table, the pit quickly fills with water. When there has been little rain, groundwater keeps a stream flowing until the water table drops below the bed of the stream. When this happens, lake levels can also drop, and shallow wells can start to go dry.

An isolated lake is fed by only runoff and groundwater. It is affected entirely by how the land is used in the immediate watershed.

A riverine lake has tributary streams or rivers supplying it with water, and one or more rivers or streams flowing out. Nutrients and other chemicals that enter a river system will eventually be carried into the lakes down the system, affecting water quality.

The formation of lakes and streams by glaciers, and the action of subsequent erosion provides large shallow areas in lakes and floodplains along rivers. Plants adapted to grow above the water, but with their roots in the water or wet soil establish in these places, called wetlands. Wetlands are found along lakeshores, along rivers and streams, in former lake and stream beds, and in valley bottoms. There may also be wetlands in land depressions. They play an important role in the hydrologic cycle of the watershed, because they moderate the effect of floods, filter sediments, and provide wildlife habitat.

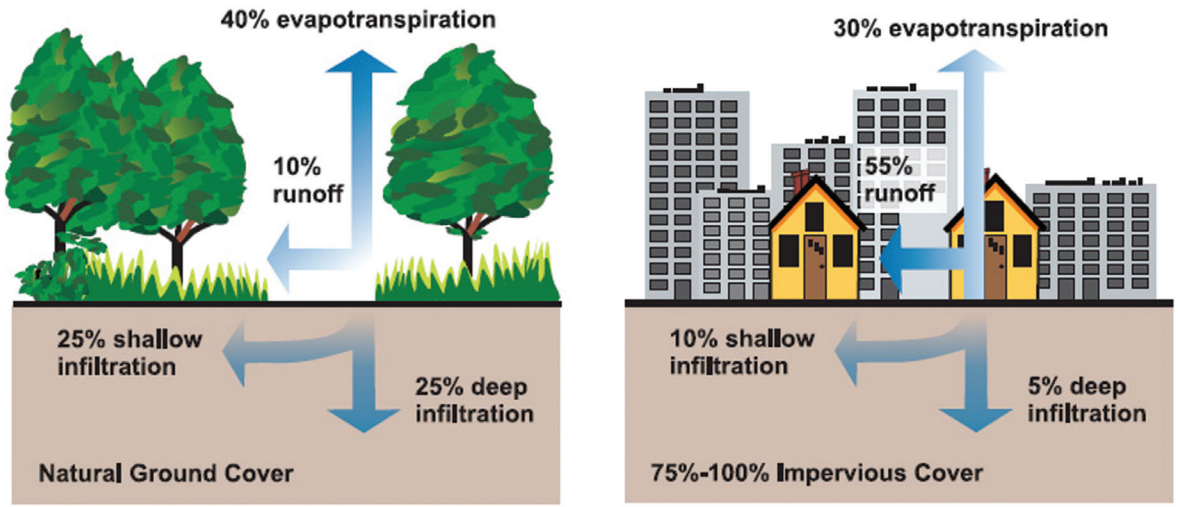
IMPERVIOUSNESS

Variable Imperviousness of Different Land Cover Types

When rain falls on the land, or when snow melts, part of the water soaks (infiltrates) into the ground, part evaporates, and part runs off into drains, streams, and lakes. The relative amount of water that runs off, soaks in, or evaporates depends on what is covering the ground and other factors, such as temperature, humidity, and wind. The more the land cover is impervious to infiltration, the more water that is likely to run off and the less is likely to soak in (See Figure 2–3). Evaporation is largely dependent on how much of the water is subject to wind and sunshine and the growth processes of plants. If there are a lot of plants on the landscape, especially trees, large amounts of water are likely to evaporate from leaf surfaces. Also, plants transpire water vapor, which moves water from the ground, through the plant roots, stems and leaves into the air. Paved surfaces and building rooftops (impervious surfaces) generally prevent water from soaking into the ground, and force it to run off (See Photo 2–2). The larger the amount of impervious surface, the more water runs off, and the larger the drainage system needs to be to handle larger volumes and speeds of runoff. There is a measure of how much water runs off a landscape compared to soaking in; it is called the coefficient of runoff. Engineers use

Photo 2–2: Water flowing off paved surfaces can carry oils, chemicals, bacteria, and sediment.

Figure 2-3: Variable Rates of Infiltration Depending on Impervious Cover



Source: U.S. EPA, "Protecting Water Quality from Urban Runoff," Doc # EPA 841-F-03-003. Imperviousness and Water Quality.

this coefficient to calculate the size of drains, stormwater pipes, and catchment basins needed to manage stormwater runoff.

Imperviousness and Water Quality

The quality of water in streams and lakes is affected by the amount and type of impervious surfaces in the watershed. Where there is a larger proportion of impervious surface than vegetated surface, stormwater that flows into streams and lakes tends to be much warmer, have a greater velocity, and to carry sediment and chemical pollutants. Warmed stormwater changes the temperature of streams and lakes, with a resulting change in the plants and animals that can live there. Streams experiencing the high velocities of stormwater are called "flashy." This means that the stream beds and banks tend to erode, and the amount of water in the stream has extremes of high and low levels. The chemicals that originate from impervious surfaces can include oils, pesticides, herbicides, and nutrients. Some chemicals and the nutrient Phosphorus attach to soil particles, and travel with eroded soil or dust that collects on roads and rooftops, where they then can be carried into streams and lakes by stormwater runoff (See Figure 2–4). Stream, river, and lake water quality has been shown to change in its visual character and capacity to sustain plant and fish species that exist there when imperviousness reaches as little as 15 percent of the watershed and to suffer major degradation and a significant change of fish and other organisms living in them when imperviousness reaches as little as 25 percent of the watershed (See Figure 2–4).

VALUE OF WATERSHEDS

Understanding of Ecosystem, Human, and Economic Health Relationship

Quality-of-Life Assets

The quality of water in streams, rivers, and lakes affects both the perception of quality of life for people living in, or visiting those regions, and quality of life in real terms.

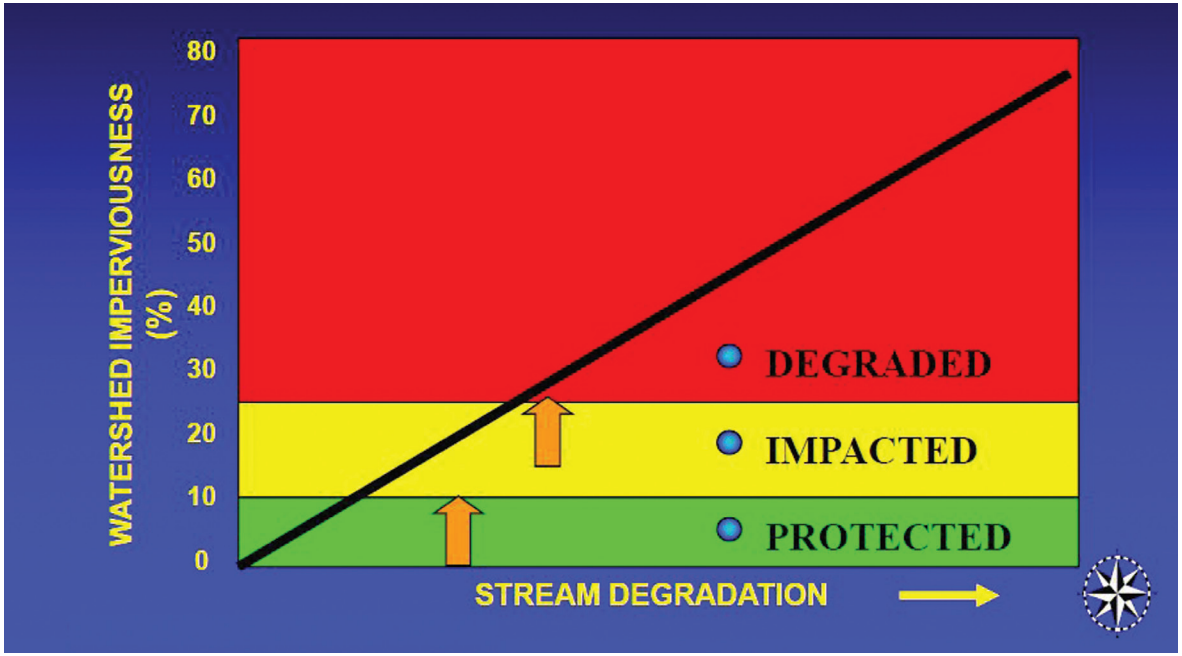
Water Purity is Important

Water purity affects both the human health and economic health of communities. Water with contaminates, such as bacteria or nitrates, can be a health hazard to people. The more contaminants in water, the more expensive it is to make it safe for people and livestock to drink or to swim in.

Water as Scenic Amenity

Streams, rivers, and lakes that are clear, and with natural shorelines tend to be considered more attractive than those with murky water or seawalls on the banks.

Figure 2-4: Waterway Health and Imperviousness



Note: This figure shows the correlation between an increase in water quality degradation and the percentage of imperviousness. It also illustrates that once the imperviousness is greater than 10 percent, water quality is impacted and at more than 25 percent imperviousness, water quality is degraded.
Source: Adapted from Schueler et al., 1992.

Wildlife Habitat

A greater number of species of fish, birds, other animals, and the organisms they feed on can live in clean water. A rich variety of species tends to have enough predators and prey to keep a relative balance.

Nearby Recreation

People who have water resources they can utilize for swimming, fishing, boating, bird watching, and other forms of water-related recreation enjoy a greater quality of life, and greater attachment to their communities. This often contributes to greater efforts to protect these resources.

Economic Assets

Scenic Attraction

Scenery is an economic asset, and water is one of the most powerful visual attractions. Communities with cleaner water are more likely to have sustained prosperity.

Active and Passive Recreation and Eco-Tourism

Clean water is important to the recreational desires of residents, and a reputation for clean water and diverse water-related wildlife boosts the opportunities for economic development around tourists interested in exploring diverse and productive ecosystems.

Water for Residential, Commercial and Industrial Use

Residential, commercial, and industrial land uses require water, with some uses requiring large amounts. Clean water is less expensive to treat for such uses, especially for residential use. Keeping it clean ensures a sustainable supply.

CASE STUDY: THE SAGINAW BAY WATERSHED AND SUB-WATERSHEDS

The Great Lakes form a portion of the international boundary between the United States and Canada, and both countries have jurisdiction over their protection and restoration. The Great

Photo 2–3: Good quality water nearby provides more chances for the young to learn to appreciate our natural resources.

Lakes Water Quality Agreement (GLWQA) between the United States and Canada was developed in 1972, and established objectives and criteria for the protection, restoration, and enhancement of water quality in the Great Lakes system. A revised GLWQA was signed in 1978, recognizing the need to understand and effectively reduce toxic substance loads to the Great Lakes. The newest agreement was signed in 2012. New provisions address the nearshore environment, aquatic invasive species, habitat degradation, and the effects of climate change. It also supports continued work on existing threats to people's health and the environment in the Great Lakes basin, such as harmful algae, toxic chemicals, and discharges from vessels (EPA, 2012[1]).

The 1978 Great Lakes Water Quality Agreement adopted general and specific objectives and outlined programs and practices necessary to reduce pollutant discharges to the Great Lakes system. Under Annex 2 of the 1987 Protocol Amending the 1978 GLWQA, the United States and Canadian governments identified 43 areas on the Great Lakes that had serious water quality problems known to cause beneficial use impairment of the shared aquatic resources. These areas have been formally designated by the two governments as Areas of Concern. Michigan has 14 Areas of Concern (AOCs) (See Figure 1–1 in Chapter 1). Water quality impairments are linked to activities in the watershed, with Figure 2–5 showing the Saginaw Bay watershed, and Figure 2–6 a close-up view.

The Guidance for Delisting Michigan's Areas of Concern (Guidance) identifies the criteria used to determine when a Beneficial Use Impairment (BUI) is restored. The Michigan Department of Natural Resources and Environment, working with the local Public Advisory Councils (PACs) use this Guidance to remove BUIs that will lead to AOC delisting. The PAC serving the Saginaw Basin is the Partnership for the Saginaw Bay Watershed. The Guidance provides statewide criteria for 12 of 14 potential BUIs. Local PAC's could either accept the statewide criteria or develop local BUI removal targets. Locally developed targets, at a minimum, must be functionally equivalent to or exceed the criteria in the Guidance. The loss of fish and wildlife habitat, and the degradation of fish and wildlife populations BUIs tend to be highly site-specific. Because statewide criteria for these BUIs were not appropriate, the Guidance provided a criteria setting process developed in partnership with agency resource managers, locals, and PAC members that resulted in AOC-specific local restoration goals needed to remove these BUIs.

The 2010 Strategy for Delisting Michigan's Areas of Concern (Strategy) identifies actions needed to remove BUIs and delist AOCs, establishes Area of Concern Program priorities, and sets resource allocations in the AOC Program. The strategy addresses all identified BUIs within each AOC. This Strategy is a companion document to the Guidance. The AOC BUIs, and restoration actions needed, are compiled in a table provided in the "*Saginaw Bay Watershed and Area of Concern*," March 2012, prepared by Public Sector Consultants, as part of the same Great Lakes Restoration Initiative grant that supported this guidebook. Copies are available from the Planning & Zoning Center at MSU, from Public Sector Consultants, or may be downloaded at:

http://www.landpolicy.msu.edu/modules.php?name=Documents&op=viewlive&sp_id=2082.

Public Involvement

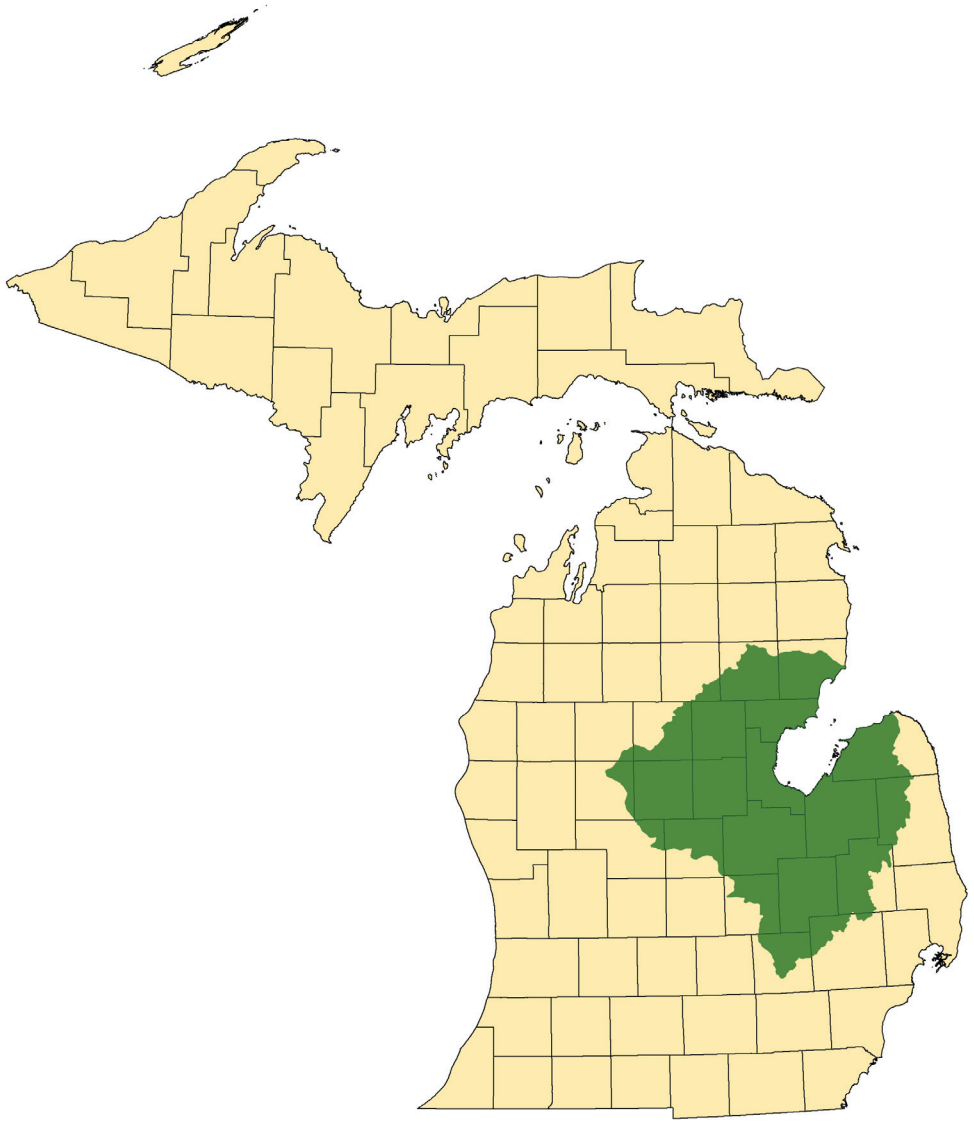
Public involvement is a key component of the Area of Concern Program in Michigan. Each Remedial Action Plan has had significant input from a Public Advisory Council, a group of stakeholders that participates in the Area of Concern activities. The Statewide Public Advisory Council consisting of members from each of Michigan's 14 Area's of Concern, also supports the Area of Concern Program. The Statewide Public Advisory Council promotes sharing of ideas across the state's AOCs. The Public Advisory Councils and Statewide Public Advisory Council provide local stakeholder perspective related to goals and objectives within AOCs. This relationship is integral to the implementation of the Area of Concern program.

Measuring Progress

Significant progress within each Area of Concern has occurred since the inception of Michigan's program and has been documented in the various Remedial Action Plans and

1. "Great Lakes Water Quality Agreement," U.S. Environmental Protection Agency: **http://www.epa.gov/glnpo/glwqa/**.

Figure 2-5: Watershed Draining into the Saginaw Bay



Source: Michigan Geographic Data Library, Michigan Department of Technology, Management & Budget.

Remedial Action Plan Updates. In 2006, in an effort to assess the status of individual Beneficial Use Impairments, direct restoration efforts, and develop benchmarks for measuring their success, the Michigan Department of Natural Resources and Environment developed the Guidance for Delisting Michigan's Areas of Concern. The purpose of this document is to: 1) provide guidance to AOC communities about the state's process for removing BUIs and delisting Areas of Concern; 2) identify specific quantitative or qualitative criteria, which the State will use to determine when BUIs have been removed.

Of the 14 Impairments criteria, the Saginaw River/Bay includes 10:

1. Restriction on fish and wildlife consumption.
2. Eutrophication or undesirable algae.
3. Degradation of fish and wildlife populations.
4. Beach closings.
5. Degradation of aesthetics.
6. Bird or animal deformities or reproduction problems.
7. Degradation of benthos lakebed ecosystem.
8. Degradation of phytoplankton and zooplankton populations.

Figure 2-6: Watershed Draining into the Saginaw Bay (Close Up)

Source: Michigan Geographic Data Library, Michigan Department of Technology, Management & Budget.

9. Restriction of dredging activities.
10. Loss of fish and wildlife habitat.

Many different local, State, and federal resources are being applied to tackle the problems in the Saginaw Bay Area of Concern. These include government agencies, universities, nonprofit groups, and individuals. Some of these actions have been going on for a number of years. One of the important actions has been continual monitoring, especially the sanitary conditions at public beaches. Several Health Departments around the Saginaw Bay have continued E-Coli bacteria testing that has led to the closing of several beaches to protect public health.

As of 2011, assessment of progress was taking place on sources of bacteria that led to beach closings by Michigan State University scientists, and on bird and animal deformities. The Partnership for the Saginaw Bay Watershed provided a grant to support a Public Advisory Council to help determine strategies to de-list many of the BUIs.

Of note, the use impairment concerning "tainting of fish and wildlife flavor" was removed in 2008. However, in 2011, there were news reports of tainted drinking water flavor in the region.

For information on the status of efforts to improve water quality in the other 13 Areas of Concern, visit:

http://www.michigan.gov/deq/0,4561,7-135-3313_3677_15430---,00.html.