Environmental Impacts on the Great Lakes Waters

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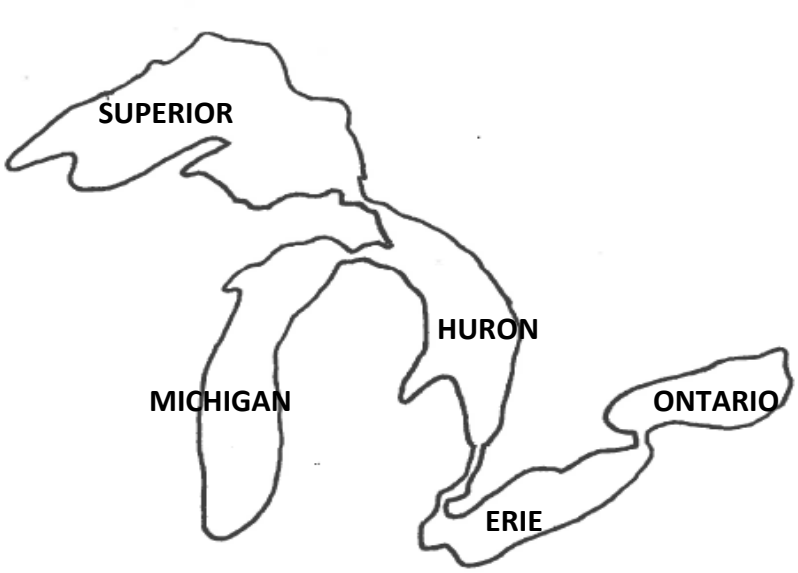
INTRODUCTION

The Great Lakes of North America are located in the northeastern part of the United States on the Canadian border. They form the largest supply of freshwater in the world. The Great Lakes were formed during the last Ice Age, ten thousand years ago, when glaciers sculpted out large quantities of earth and filled them with melting ice water.

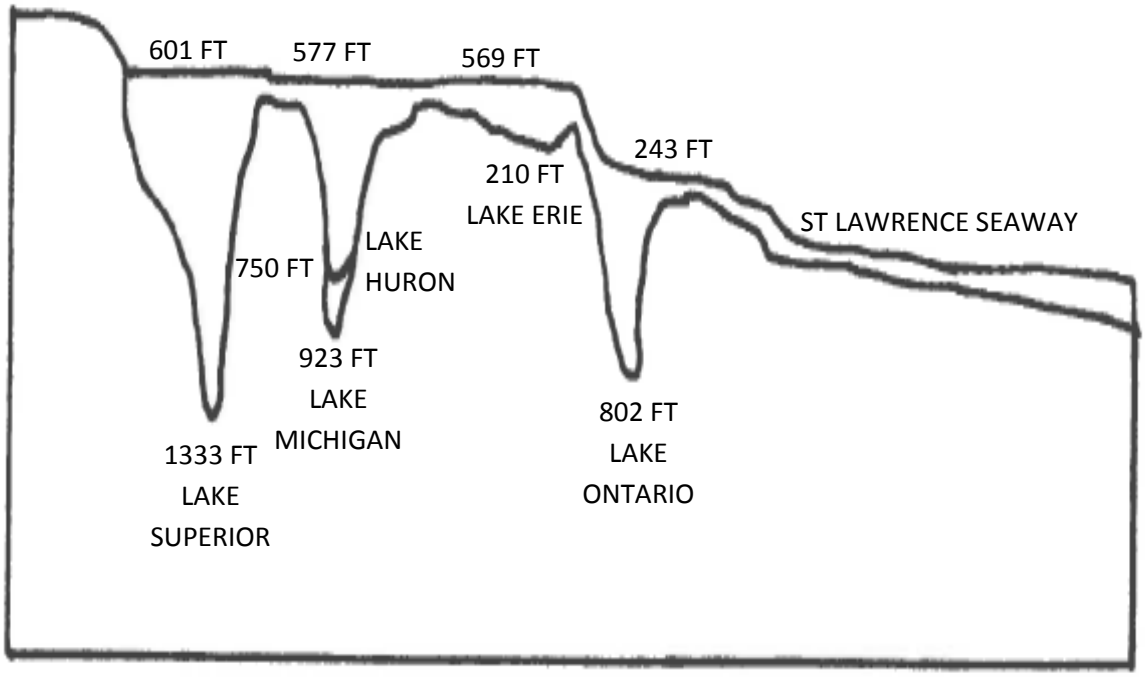
Lake Superior is the largest of the Great Lakes when comparing both surface area and volume of water and also the highest in elevation. Lake Superior flows southeast through the St. Mary's River into Lake Huron which is the second largest Great Lake in surface area. Lake Michigan flows through the Mackinac Strait also into Lake Huron. Lake Michigan is the third largest Great Lake in surface area. Lake Huron flows south through the Detroit River into Lake Erie. Lake Erie is the fourth largest and, by far, the shallowest of all the Great Lakes. Lake Erie flows east through the Niagara River into Lake Ontario. Lake Ontario, the smallest of the Great Lakes, flows through the St. Lawrence Seaway into the Atlantic Ocean. (See Figure 1)

Figure 1: Great Lakes Map



The drop in surface elevation for the first four lakes in the flow line is just 32 feet compared to the drop in elevation from Lake Erie to Lake Ontario which is 326 feet. (The drop in elevation from Lake Erie to Lake Ontario includes the drop down the Niagara Falls. See Figure 2.)

Figure 2: Great Lakes Elevation



The major cities on Lake Superior are: Sault Ste. Marie, Michigan; Marquette, Michigan; Superior, Wisconsin; Duluth, Minnesota; Thunder Bay, Ontario; and Sault Ste. Marie, Ontario.

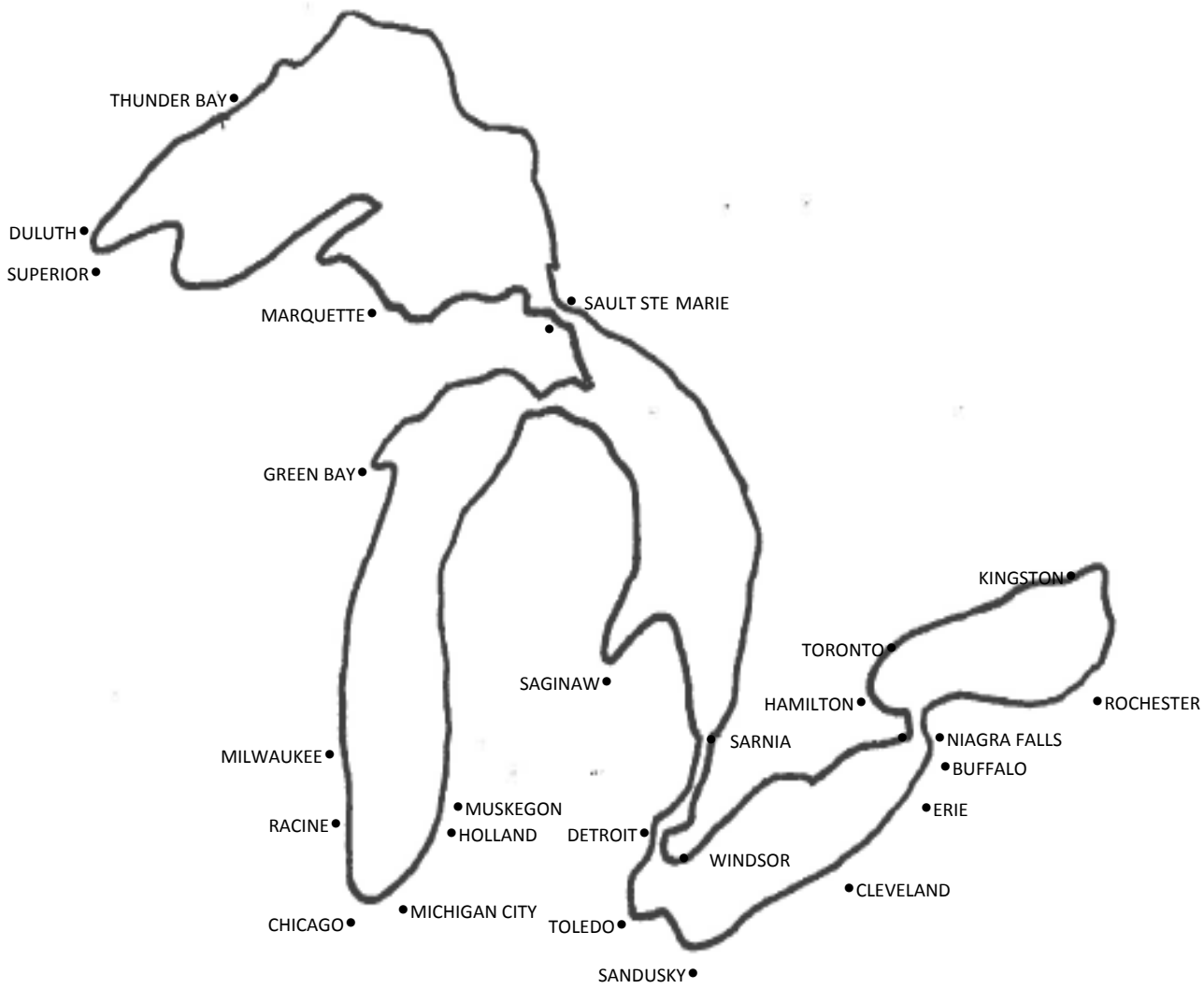
The major cities on Lake Michigan are: Muskegon, Michigan; Holland, Michigan; Michigan City, Indiana; Chicago, Illinois; Racine, Wisconsin; Milwaukee, Wisconsin; and Green Bay, Wisconsin.

The major cities on Lake Huron are: Saginaw, Michigan; and Sarnia, Ontario.

The major cities on Lake Erie are Detroit, Michigan; Toledo, Ohio; Sandusky, Ohio; Cleveland, Ohio; Erie, Pennsylvania; Buffalo, New York; Rochester, New York; Windsor, Ontario.

The major cities on Lake Ontario are: Niagara Falls, New York; Rochester, New York; Niagara Falls, Ontario; Hamilton, Ontario; Toronto, Ontario; and Kingston, Ontario. (See Figure 3)

Figure 3: Great Lakes Cities



GREAT LAKES WATER

The Great Lakes basin provides water for domestic and industrial needs, transportation, recreation, and a variety of other uses to one-tenth the population of the United States and to one-quarter the population of Canada.

Although the Great Lakes are the largest source of fresh water on earth, they are not without being susceptible to the problems associated with environmental pollution. The pollution can come from waste water emission from municipal and industrial sources and the various other land born pollutants in the streams and rivers feeding the lakes. Another source of pollution comes from the atmosphere as particle fallout through direct deposition from falling rain or snow on the large surface area of the Lakes as well as on their watersheds (The land being drained by the streams and rivers feeding the lakes). Invasive species (fish and other aquatic animals and plants) have invaded the Great Lakes from foreign bodies of water. In many locations, environmental pollution of the Great Lakes has upset the delicate balance that nature has provided between water and its aquatic flora and fauna.

An extreme amount of time and money has been spent on Great Lakes cleanup that has helped, but there is still an extensive amount of work that has to be accomplished. The balance must be maintained if the lakes are to survive as we know them today.

In the 1970s, large investments were made in improving waste water treatment plants. Improvements were and are still being made in agriculture practices to reduce the amount of waterborne pollution such as fertilizers, pesticides, and suspended soil from entering the lakes through the many streams and rivers that compromise the lakes' drainage basin. Efforts are being made to extinguish the number of invasive species that have infiltrated the Great Lakes. The improvements made have helped; however, there is a vast amount of work that has to be completed if the lakes are to survive in their natural state.

WATER POLLUTANTS

Most water pollutants can generally be classified as follows:

Soil: Soil is one of the more recent major causes of pollution in our waters. Most of the soil comes from fields or large tracts of land where trees, shrubs, weeds, and grass have been removed for farming, mining, logging, or construction leaving the earth exposed to be washed away during periods of heavy rainfall. The fast moving streams that are created wash away banks and bottoms adding to the concentration of soil in the water. The muddy water flows into rivers and lakes killing fish by clogging their gills and killing aquatic plants by blocking out sunlight.

The solution is to disturb the land as little as possible and not leave large tracts of barren land unprotected. Where loose soil has been exposed, vegetation should be left standing or planted all around the entire site to filter rain water or use special low-lying type shielding fences to contain loose soil inside sites where the ground has been broken.

Bacteria: Bacteria are single celled organisms (living matter) that are present in all living creatures. Bacteria are necessary for decomposition and digestion of food in human beings. Helpful bacteria are called antigenic while harmful disease causing bacteria are called pathogenic. Pathogenic bacteria can cause cholera, dysentery, shigellosis, and typhoid fever. (Shigellosis is an infectious disease that can cause fever, stomach cramps, and diarrhea, in humans.) The main source of harmful bacteria in our waters is from sewage treatment plants overflowing during heavy rainfalls. Interconnecting sanitary sewer and storm sewer piping systems are one reason treatment plants overflow during heavy rainfalls. Also, animal wastes (manure) and dog droppings can be washed into storm sewer systems causing harmful bacteria to enter our streams, rivers, and lakes. Government mandated high efficient, high capacity treatment plants and control of animal wastes has helped to reduce the amount of bacteria entering our waterways. Also, separating sanitary and storm sewer plimbing systems reduces the chance of sewage treatment plants overflowing during heavy rainfalls.

Nutrients: Nutrients are a high cause of the pollution of our waterways. The two most common nutrients are phosphorus and nitrogen; both found in abundant quantities in farmland crop fertilizer. Nutrients cause algae to grow and turn water green. The darkened water shades sunlight from aquatic plants killing them. When algae die, they remove oxygen from the water. Oxygen is a necessary ingredient for the survival of fish and aquatic plants. Farmers are finding new ways to minimally apply and prevent fertilizer runoff such as explained above for soil runoff; however, the problem persists and much more work has to be done.

Polychlorinated biphenyls: (PCBs) are a group of organic (carbon containing) chemicals which can be odorless solids or oily liquids. PCB's were formally used in the United States as hydraulic fluid, adhesives, fire retardants, pesticides, lubricants, and other related items. Some people who drink water containing PCBs suffer serious illnesses including cancer. PCBs get into drinking water from landfill runoff and the unlawful discharge of waste chemicals. In 1974, Congress passed the Safe Drinking Water Act which directed the Environmental Protection Agency (EPA) to determine maximum contaminant levels (MCLs) to be allowed in drinking water. Because PCBs are such a great danger to human health the MCL for the chemical was set at the extremely low concentration of 0.0005 mg/l (milligrams per liter) for municipal plants to meet in treated drinking water.

Mercury is an extremely rare element that is the only metal found in liquid form at standard temperature and pressure. Mercury occurs in deposits in the ground throughout the world. Mercury is used in many devices such as switches, thermometers, and bulbs. Because of its toxicity, the use of mercury is now being restricted to scientific research.

Mercury enters the atmosphere from the burning of fossil fuels, mainly coal in utility and industrial boilers, and from natural sources such as volcanoes and the weathering of ordinary rocks. Mercury in the air settles in water bodies affecting water quality. Mercury in the air can also fall on the ground where it ends up in streams, rivers, and lakes. Mercury accumulates in fish causing tumors and animals that eat fish causing health problems and even premature mortality. Children of mothers exposed to mercury by eating fish or shellfish have been

found to have impaired neurological development. Mercury breathed through the lungs can cause health problems for humans. High doses cause a large number of mental and physical disorders including death. Very strict controls have been put on the coal burning industry by the government to reduce smokestack mercury emissions which have resulted in the closing of many such plants.

Lead is a chemical element that is a soft and malleable metal. Lead is used, among other things, in batteries, solders, pipes, and radiation shields. Lead is rarely found in treatment plant water, but enters the body because of its use in household and municipal plumbing systems. If taken into the body by either eating or breathing, lead is poisonous to both children and adults. Like mercury, it attacks the nervous system and accumulates in the body causing a complication of illnesses. The use of lead in paint, plumbing, and other products has been severely restricted around the world because of its high toxicity.

Sea Lamprey: Large numbers of a variety of different invasive (non-native) species originating from the ballast waters of ocean-going vehicles traveling through the Saint Lawrence Seaway have entered the Great Lakes waters greatly upsetting the delicate balance that nature has provided for the entire ecosystem. It is proving extremely difficult to eradicate or even control their spread. The invasion of foreign species into the Great Lakes has led to strict controls on sealing ship's ballast tanks and dumping ballast water into the Great Lakes.

One of the oldest invasive species to populate the Great Lakes is the sea lamprey (lamprey eel). The lamprey eel is a jawless fish that is native to the Atlantic Ocean. One species of the lamprey attaches itself to the side of a larger fish and feeds on its blood and body fluids. This species was first found in the Great Lakes in Lake Ontario in 1835 and in all five Great Lakes by 1946, the last lake being Lake Superior. The largest collection of Great Lakes lamprey eels is now found in the St. Mary's River which connects Lake Superior to Lake Huron. There they have spread heavily into Lake Huron and northern Lake Michigan where they have decimated the populations of lake trout and whitefish. They have been the major cause of the collapse of lake trout, whitefish, and chub populations in all the Great Lakes during the 1940's and 1950's.

Lamprey larvae live for two years burrowed in the bottom sediments of river bottoms. Aircraft are now used to release chemicals into river waters killing the young larvae before they become adults and populate Great Lakes waters; however, more work has to be done before the entire population can be considered to be under control.

Zebra Mussel: Zebra mussels were originally native to lakes in southern Russia. They have become invasive species to many different countries worldwide. In 1988, they were inadvertently introduced into Lake St. Clair which is located between Lakes Huron and Erie and they quickly spread throughout the Great Lakes. They are a small, 1/2 to 2 inches, clam-like shelled aquatic bottom dweller that feeds by ingesting water, filtering out food particles, depositing non-food particles on the lake floor, and then passing clearer water back into the lake. One zebra mussels can feed on one gallon of water per day. Since zebra mussels became abundant in Lake Erie, water clarity has increased from 6 inches to up to 3 feet in some areas. The increased clarity allows sunlight to penetrate deeper allowing excessive growth and spread of aquatic plants which, when dying, use up valuable oxygen in the water and produce bacteria which washes up on shorelines polluting beaches. Zebra mussels have also been known to plug municipal water treatment plant intake screens.

Round Goby: The round goby is a small soft bodied boneless fish that is a bottom feeder and is native to Eurasia including the Black Sea and the Caspian Sea. It was introduced into the Great Lakes from ocean ship ballast water. It was first discovered in the St. Clair River in 1990. The St. Clair River connects Lake St. Clair to Lake Huron. Since then, it has rapidly spread to many areas of the Great Lakes. The round goby, although declared an invasive species, is somewhat of a paradox when considering its effect on the ecology of the Great Lakes. It competes with native species in the food chain; however, native fish have come to prey on the round goby for their own sustenance. The round goby also consumes other invasive species such as the zebra mussel; and, has itself become a source of food for the Great Lakes watersnake which once was on the endangered species list.

Asian Carp are a very large species that have become veracious eaters of the same food that native Great Lakes fish feed on; and therefore, present a great danger to the survival of all Great Lakes fish.

Asian carp were introduced into the United States in the 1970s to fish farms in Arkansas. Flooding allowed them to escape and establish habitats in the wild by the 1980s. Recently they have been found in the Illinois River which connects the Mississippi River to the Great Lakes. Three electric barriers have been installed to prevent Asian carp from entering the Great Lakes but there are signs indicating that they may be penetrable. Many studies are presently being conducted to determine ways to prevent Asian carp from entering the Great Lakes.

Invasive plants such as the common reed, reed canary grass, curly pondweed, and non-native cattails are rapidly spreading throughout the Great Lakes. They spread rapidly displacing native aquatic plant populations and hindering swimmers and boaters.

WASTE WATER TREATMENT PLANTS

One of the biggest reasons for the clean-up of the Great Lakes is the more efficient use of sanitary sewage treatment plants. Today's sanitary sewage treatment plants are truly a miracle of modern technology. Water, contaminated by almost every conceivable waste product generated by man, can be cleansed, purified and returned to nature in its natural state.

There are approximately 16,000 municipal sanitary sewage treatment plants operating in the United States. Over 75 percent of the population's wastes are treated by centralized sanitary sewage plants. Others use septic or other onsite systems

There are three phases involved in the purification of waste water in treatment plants: primary, secondary, and tertiary. The Clean Water Act 0f 1972 provided federal money to "restore and maintain the chemical, physical, and biological integrity of the nation's waters". It requires that all municipal waste water

treatment plant discharges meet a minimum of “secondary” treatment. Over 30 percent of today’s waste water treatment plants produce discharges that are even cleaner than secondary treatment.

Preliminary Treatment: The first stage in the domestic wastewater treatment process is called “primary treatment”. Primary treatment involves holding the sewage undisturbed in a tank where the heavy solids fall to the bottom and the lighter solids float on top. Both are removed and the remaining sewage is passed on for secondary treatment.

Secondary Treatment: Secondary treatment involves removing dissolved and suspended biological (from living) matter that was not removed during primary treatment. This is done by allowing microorganisms (small living) to grow and react with and allow the removal of the unwanted matter.

Tertiary: (Advanced Treatment): Tertiary treatment involves any treatment following secondary treatment that is required to discharge effluent (treated outflow) that will not harm highly sensitive ecological areas. Disinfection of treated effluent with chlorine is one of the common methods used.

Wastewater Byproducts: The byproducts recovered from wastewater treatment plants have to be dealt with in a safe and effective way as prescribed by Federal law. More than half of these substances are declared safe for use as soil conditioners or fertilizers. The remaining are incinerated or taken to landfills. Ocean disposal of these substances is not allowed.

Microplastics: Recently a great lakes organization that represents more than 100 cities in the United States and Canada asked federal and industry leaders to take action on the recently discovered problem of “microplastics”. Over the past two years, microscopic bits of plastic have been found in Great Lakes water. Microplastics are too small to be filtered out during sewerage treatment and too inert to be chemically removed. It is believed they come from personal products such as facial and body washes, deodorants, and toothpaste. Large personal care companies have been notified of the problem and have been asked to eliminate the use of microplastics in their products. Several of the largest companies have

agreed to stop using microplastics and replace them with more friendly environmental alternatives. It is expected that the remaining companies will soon follow the lead of these larger companies.

Flow Schematic: Figure 4 has a fluid flow schematic for a small town state-of-the-art sewerage treatment plant designed to treat 2.0 million gallons of influent per day as follows:

- Wastewater is delivered to the plant through a 16-inch diameter pipe to a receiving tank shown on the upper left of the sketch. Notice there is an optional storage tank connected to the receiving tank to assist the receiving tank in containing inflow during plant maintenance and/or heavy rains. This prevents the plant from being overfilled and having to dump raw sewerage into the environment.

- The incoming wastewater is passed through a manually cleaned bar screen. This screen has 2½ feet wide parallel bars that remove large objects from the incoming sewerage.

- The wastewater then flows through a comminutor. The comminutor catches and shreds smaller sized solid matter and discharges the effluent into a grit tank.

- The aerated grit tank permits the settling out of heavy solid mater, while the lighter organic solids pass through.

- Grit-free wastewater from the grit tank then flows to two primary clarifier sedimentation tanks through a 24-inch pipe.

- The two primary clarifier sedimentation tanks remove the lighter organic solids and a smaller fraction of the biochemical energy demand from the waste water. (Many pollutants absorb dissolved oxygen in waste water. Dissolved oxygen is needed in open waters to support fish and aquatic plant life. Biochemical oxygen demand or BOD is used to determine the ability of the effluent to support aquatic life as it passes through a sewerage treatment plant.) The solids separated in these

tanks are removed as sludge and skimming material. The primary sludge is pumped to the primary digester. The settling tank outflow (primary effluent) is discharged to the ten rotating biological contactors.

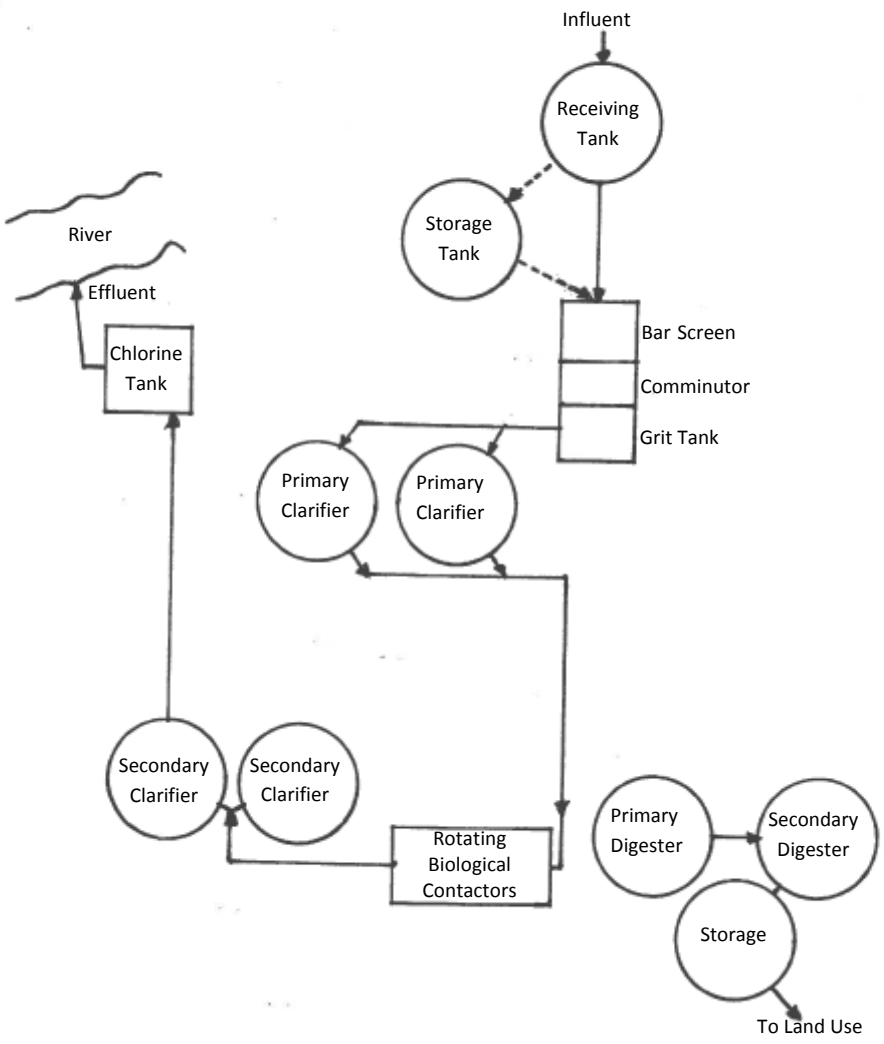
- The biological contactors employ ten spaced plastic discs that rotate around a horizontal shaft. The discs move alternately through the wastewater and out developing a biological growth on their surfaces that removes oxygen-demanding materials in the wastewater as food and take on oxygen from the air for respiration. As the process continues, some oxygen-bearing bacteria dislodge from the contactors and fall into the purified wastewater adding oxygen.

- This mixture of bacterial solids and wastewater flows from the biological contactors through 24 inch diameter pipes to two secondary clarifiers where solids are separated and accumulate as sludge at the bottom of the tanks.

- This secondary sludge is then pumped, along with the primary sludge, to the primary digester. The sludge is processed in the primary and secondary anaerobic (without air) digesters where it is stabilized and reduced in volume. Stabilized sludge from the digesters is disposed by land application (fertilizer or soil conditioning).

- Treated effluent from the secondary clarifier tanks is delivered to the chlorine contact tank where it is diffused with chlorine solution and detained for an adequate disinfection period before discharge to the environment. Excess chlorine is removed by adding sodium bisulfite. The plant also has provisions for introducing alum and polymer to the wastewater to both the primary and secondary sedimentation tanks for phosphorus removal and improved clarification.

Figure 4 : Treatment Plant Flow Schematic



LAKE SUPERIOR

Lake Superior has the largest surface area, the largest water volume, and the largest watershed (drainage area of the lake and all connecting streams and rivers) of all the Great Lakes. It is generally considered to be the largest fresh water lake in the world as measured by surface area. It is the world's third largest lake by volume and the largest lake in North America. It has more water than all the other Great Lakes combined. It has enough water to cover the entire land area of North and South America with one foot of water.

Lake Superior was named by the French "le lac superieieur" or "the upper lake" (above Lake Huron). The British changed it to "Lake Superior" because of its existence as the largest lake on the continent. Lake Superior borders the U.S. states of Wisconsin and Minnesota and the province of Ontario, Canada.

Because a large portion of the drainage basin is forested, lightly farmed, and sparsely populated, Lake Superior has the cleanest and clearest water of all the Great Lakes; nevertheless, there are regions that are areas of concern.

Saint Louis River: The Saint Louis River (named after St. Louis County, Minnesota) is the largest river that flows into Lake Superior. It starts in the far northeast corner of the State of Minnesota and runs for 179 miles. It flows in a southwesterly direction for about half its length, makes a 90 degree bend, and then flows southeast emptying into the southwestern most tip of Lake Superior between the cities of Duluth, Minnesota and Superior, Wisconsin. It drains an area of 3,634 square miles in northern Minnesota and Wisconsin

The upper 140 miles of the river pass through heavily forested and, to a lesser extent, agricultural areas, and is not as much of a concern as the lower 39 miles. The lower 39 mile stretch includes Duluth, Minnesota and Superior, Wisconsin where there is heavy industrial activity. Some of the industrial activity includes steel making, oil refining, paper production, and wood product manufacturing. As early as 1941, the lower part of the river had become one of the most heavily polluted waterways in the state of Wisconsin as touched on briefly in the book "Paddle-to-the-Sea" written by Holling Clancy Holling.

There were a number of significant steps taken from 1971 to 1989 by the United States and Canada over the lower Saint Louis River pollution problem. In 1987, a United States-Canadian commission was established to define Areas of Concern (AOCs) in the Great Lakes region that fail to meet specific objectives where failure will cause impairment of the area's ability to support aquatic life. Some of the impairments were described as follows:

- restrictions on fish and wildlife consumption
- degradation of fish and wildlife populations
- bird or animal deformities or reproduction problems
- restrictions on dredging dumping
- spreading of undesirable algae
- drinking water restrictions, taste, or odor problems
- beach closings

There were a total of 43 such locations declared AOCs, 26 in the United States and 17 in Canada with 5 of the 43 shared by both countries. The Saint Louis River was one of the 43 AOCs.

In 1989, a joint effort between the states of Minnesota and Wisconsin focused on the heavily industrialized last 39 miles of the Saint Louis River below the city of Cloquet, Minnesota. Also included was the entire Nemadji River 360 square mile watershed which flows between Minnesota and Wisconsin and empties into Lake Superior near the mouth of the Saint Louis River. It was estimated that the Nemadji River poured 33,000 tons of red clay sediment per year into Lake Superior. Because of action taken by various governmental agencies on both sides of the border, water pollution and fish population in the lower Saint Louis and Nemadji Rivers have been significantly improved. Industrial spillage has been eliminated. Wastewater collection and sewage treatment systems have been upgraded to provide the latest in water purification and rivers have been dredged cleaning up contaminated bottom sediments. According to a U.S./Canadian report

dated 2009, the Lake Superior ecosystem (living things and their environment) has improved. Birds and land animals are recovering and fisheries are in good to excellent condition.

LAKE MICHIGAN

Lake Michigan is the second largest of the five Great Lakes and the only one to lie entirely within the United States. (The other four Great Lakes are shared by the U.S. and Canada.) Lake Michigan is bounded, from west to east, by the states of Wisconsin, Illinois, Indiana, and Michigan. Lake Michigan and Lake Superior both flow into Lake Huron. Lake Michigan flows into Lake Huron through the wide Straits of Mackinac. The two are at the same surface elevation; and, technically speaking, are one lake; and, if so, are the largest lake in the world.

Lake Michigan has one of the longest shorelines of any body of water in the United States. Bathers from four different states have come to enjoy the beaches. Unfortunately, the problem exists where raw sewage has been dumped into the lake causing polluted areas of concern. Because of water quality being such a danger to human health, many of the beaches have had frequent closings causing the loss of millions of dollars to local business and community economies.

Chicago River: The pollution problems of Lake Michigan started early. The city of Chicago lies on the southern tip of Lake Michigan. In 1854, an epidemic of cholera hit Chicago because of drawing drinking water from the Chicago River which was also used by the city to dump raw sewage. Years later, to get cleaner drinking water, the treatment plant intake pipe was moved two miles out into Lake Michigan away from shore pollution caused by Chicago River outflow. The river however, flowing into Lake Michigan, still caused a major pollution problem to the lake.

In 1900, to alleviate polluting Lake Michigan, in one of the greatest engineering feats of the time, the flow of the Chicago River was reversed. Water was made to flow from Lake Michigan to the Mississippi River.

In 2011, the Federal Government ordered Chicago to further clean up the Chicago River and its tributaries including heavily polluted tributary Bubble Creek which many meatpacking industry slaughter houses used as a dumping place for animal waste. Chicago was the only major U.S. city not to disinfect effluent (remove harmful bacteria) from its waste water treatment plants. Disinfection of outflow from treatment plants is necessary to make waterways and beaches safe for public bathing, fishing, and boating.

According to the U.S./Canadian 2009 report, because of clean-up activities in all areas, Lake Michigan remains a good source of drinking water for its 12 million residents. There are a decreasing number of beach advisory days and there is a notable return in bird, mammal, and fish population although advisories are still necessary.

More recently, Lake Michigan and the other Great Lakes are experiencing a declining population of “diporeia”; a shrimplike crustacean (shell fish) that is a food for most fish and an increase in the invasive quagga mussel which is believed to lead to increased algae growth.

LAKE HURON

Lake Huron is named after the Huron tribe of Native American who inhabited the area before the arrival of the Europeans. In surface area, it is the second largest of the Great Lakes behind Lake Superior. In water volume, it is the third largest of the Great Lakes behind Lake Superior and Lake Michigan. As mentioned, since Lake Huron and Lake Michigan are connected by the Straits of Mackinac, and the surfaces of the two are at the same level, together they could be considered one entity making it the largest fresh water lake in the world. Lake Huron is bounded by the state of Michigan and the province of Ontario, Canada.

Because of its large surface area and central location in a large industrial state, the deposition of airborne pollution on the surface of Lake Huron and its watershed is the highest of all the Great Lakes. Airborne emissions come from smokestacks, automobile exhausts, and wind born particulate matter. Curbs have

been put on smokestack and automobile emissions while other airborne pollution has been dealt with by eliminating the exposure of land source particulate matter to the atmosphere.

The Lake Huron pollution problem stemming from land born sources is not as severe as the other two lower Great Lakes; however, ongoing efforts are working to maintain recreational water quality. Land born contaminants in Lake Huron come from sources similar to the other Great Lakes such as industrial and municipal wastewater and agricultural runoff. Lake Huron has six locations that have been designated as AOCs (Areas of Concern). Of these, five are located in Canada which are being dealt with by the Canadian Government. The one located in the United States is the Saginaw River.

Saginaw River: The Saginaw River is a 22 mile long navigable stretch of water located in mid-Michigan flowing north into Saginaw Bay on into Lake Huron. The river and its watershed have been polluted by various wastes discharged into it from the effluent of several cities and industrial sites. The Saginaw River has Michigan's largest watershed, 709 square miles. The area is diverse with farming, manufacturing, tourism, and outdoor recreation. It has been designated as an "Area of Concern" because of contaminated fish, loss of fish, polluted sediments, and loss of a major recreational area.

There has been much government involvement in improving Saginaw River and Bay water quality. Municipal and industrial discharge has been cleaned up by government mandated secondary level sewage treatment plants. Other priorities include reducing soil runoff, removing contaminated sediments, and restoring fish population.

Detroit River: The Detroit River may be more correctly defined as a strait or connecting channel. It is a 28 mile long by .5 to 2.5 mile wide waterway that funnels the waters of Lake Huron and the two other upper Great Lakes - Superior and Michigan, into the lower Great Lakes - Erie and Ontario.

The Detroit River passes adjacent to the city of Detroit and serves as a part of the boundary between the United States and Canada. It is a very busy waterway as it

connects the upper Great Lakes to the Atlantic Ocean via the St. Lawrence Seaway.

In the early 1900s, heavy industrialization took place around Detroit and the surrounding area due to the expansive development of the automotive industry. This led to the Detroit River and its tributaries which include the Rouge River becoming heavily polluted and named as an Area of Concern.

Numerous efforts by the U.S., Canada, Michigan, and Detroit governments have led to the cleaning up of the Detroit River and its tributaries. Municipal and industrial discharge is being brought under control and the river bottom has been dredged for contaminants. The various species of fish and birds are beginning to return; however, the work is not done until all pre-established conditions of a complete clean-up are met as defined in the definition of an Area of Concern.

LAKE ERIE

Lake Erie is the fourth largest of the five Great Lakes measured by surface area. It is bounded by the states of Ohio, Pennsylvania, and New York of the United States, and the province of Ontario, Canada. It is the southernmost, shallowest, and contains the least amount of water of all the Great Lakes making it the most prone to the adverse effects of pollution. It is named after the Erie tribe of Native Americans who lived along its southern shore. The upper three Great Lakes flow into Lake Erie by way of the Detroit River making the quality of the waters of Lake Erie (and Lake Ontario) highly dependent on the quality of the water fed into it by the upper three Great Lakes.

According to the U.S./Canadian 2009 report, after some of all the planned conservation measures have been taken, the smaller fish (yellow perch) in Lake Erie are recovering; however, the larger predator fish (walleye) are struggling. Contaminant levels of PCBs and mercury continue to affect fish consumption. Invasive species such as zebra and quagga muscles, round gobies (small bottom dwelling fish), and zoo plankton (small boneless floating animals) are affecting the food chain.

Recently, large algae blooms have been appearing in the western end of Lake Erie due to increasing amounts of phosphorus contaminating the water. Large algae blooms can excrete toxins that can sicken people, kill pets, and threaten fish and wildlife.

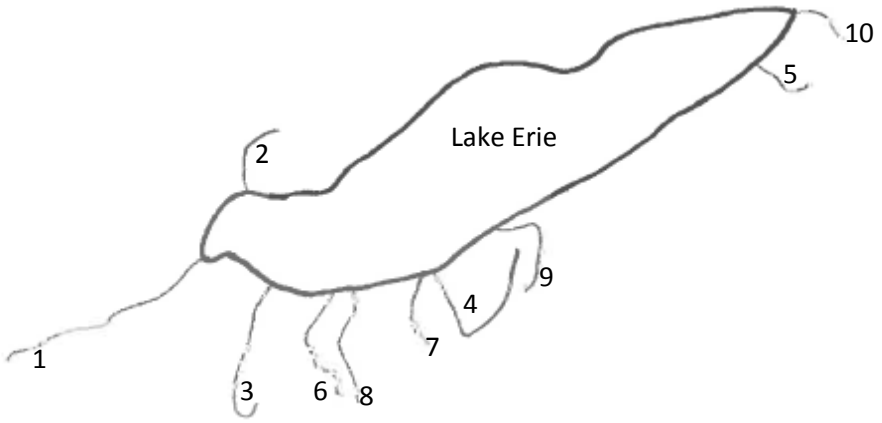
Figure 5 has a chart which estimates the amount of phosphorus entering Lake Erie from major streams and rivers along the U.S. south shore for the year 2009. (It should be noticed that the amount of phosphorus estimated for the Detroit River does not include that entering from Canada and the upper Great Lakes.) The greatest amount of estimated phosphorus discharge into Lake Erie for the year 2009 as shown by the chart is from the Maumee River which enters Lake Erie's western tip at Toledo, Ohio.

Maumee River: The Maumee River begins in Ft. Wayne, Indiana and runs for more than 130 miles before emptying into Lake Erie in Ohio. The Maumee River has the largest drainage area of any Great Lake river with 3,942 miles of tributaries. It is also one of the Great Lakes forty-three "Areas of Concern" (AOC).

When the AOC was first designated, the focus was on agriculture runoff; however, upon further investigation, more problems were found such as old dumps, contaminated industrial sites, combined storm and sanitary sewage system overflows, and disposal of dredged polluted materials.

Much work is being accomplished by both public and private instructions on the clean-up of the Maumee River and its watershed. Recently the focus of the work has been the reduction of phosphorus entering the river from farmland runoff. Voluntary action from the agriculture industry has been strongly requested but, if not successful, more government mandated programs will be enacted. Already, some government agencies have asked the agriculture industry to do what is necessary to reduce phosphorous runoff into the Great Lakes by 40%.

Figure 5: Tracking Phosphorus (2009)



Waterway	Sq Miles	Phosphorus	Sewage	St. Sewer	Fertilizer	Manure	Forests
1 – Maumee River	6544	1822 Tons	26%	9%	37%	26%	2%
2 – Detroit River	466	1108	76	12	6	4	2
3 – Sandusky River	1337	404	9	8	56	25	2
4 – Cuyahoga River	807	295	71	19	3	3	4
5 – Cattaraugus Cr.	559	162	5	8	14	46	27
6 – Huron River	416	127	12	6	60	18	4
7 – Rocky River	292	108	48	24	10	8	10
8 – Vermilion River	262	107	9	4	53	26	8
9 – Grand River	710	104	4	12	32	27	25
10 – Buffalo Creek	451	93	28	14	12	33	13
Average	1184	433	29%	12%	28%	22%	9%

Cuyahoga River: The Cuyahoga River, another one of the forty-three "Areas of Concern", is located in northeastern Ohio. It is a 100 mile long U-shaped river that starts near Hambden, Ohio. From Hambden, it runs southwest for about 50 miles to near Akron, Ohio. From Akron it turns north to Cleveland where it empties into Lake Erie. It has a drainage area of 807 square miles compared to 6544 square miles for the Lake Erie Maumee River mentioned above; however, it has become notorious for having caught fire on a number of occasions from oily substances floating on its surface. The last fire, occurring in 1969, drew national attention and the formation of the "Clean Water Act" and the federal and state "Environment Protection Agencies". At the time, the Cuyahoga River was considered "dead" (devoid of fish) because of containing excessive amounts of highly toxic substances due to municipal and industrial sewage, bank erosion, commercial/residential development, atmospheric deposition, hazardous waste disposal sites, urban storm water runoff, combined sewer overflows and wastewater treatment plant bypasses.

The Remedial Action Plan (RAP) began in 1988 under the auspices of the Ohio EPA. Several of the items have shown improvement especially fish and wildlife populations. The establishment of bald eagles as an "area of concern" was a major achievement in the remedial action process.

Water quality of the Cuyahoga has improved and, partially in recognition of this feat, in 1988, the Cuyahoga River was designated as one of the 14 American Heritage Rivers. Nevertheless, pollution continues to exist in the Cuyahoga River due to sources such as urban runoff, nonpoint source problems, and combined sewer overflows. However, the most polluted portions of the river now generally meet established aquatic life water quality standards. Sections of the river, once devoid of fish, now support 44 species. Recreation water quality standards using bacteria as indicators are generally met during dry weather conditions, but are sometimes exceeded during heavy rain downpours due to nonpoint sources and combined sewer overflows.

LAKE ONTARIO

Lake Ontario is bounded on the north by the Canadian Province of Ontario and on the south by the U.S. State of New York. It is the only one of the five Great Lakes that does not touch the State of Michigan. Lake Ontario receives its water from Lake Erie and is the last in the drainage chain of the five Great Lakes, delivering its waters to the Atlantic Ocean via the St. Lawrence Seaway. What the other four Great Lakes don't clean out of their water, Lake Ontario receives; thereby contributing to the polluted state of affairs that has been experienced. Lake Ontario's fishing has been negatively affected by over fishing, water pollution, and invasive species. Water pollution has come from industrial chemicals, agricultural fertilizers, and untreated sewage.

Oswego River: New York's Oswego River drains into the far southeastern shore of Lake Ontario. Pollution was such a problem that it was included in the original 43 Areas of Concern in The Great Lakes Water Quality Agreement between the United States and Canada.

Since then, the Syracuse city waste water sewage plant was upgraded to tertiary level while industrial waste pollution has been eliminated. Contaminated river sediments have been dredged and hazardous waste sites have been capped. Programs have been progressing on the control of barren land runoff to reduce soil and phosphorus pollutants. All the activities have achieved their purpose; and, on July 21, 2006, the Oswego River became the first United States Area of Concern to be delisted.