SAGINAW BAY WATERSHED

EDUCATOR'S GUIDE

and

RESOURCE DIRECTORY

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Introduction

The Saginaw Bay Watershed is the largest Watershed in Michigan, encompassing all or parts of 22 counties. Nearly 1.6 million people live in the watershed, yet many individuals do not know what a watershed is or how their own personal actions impact water quality in the Saginaw Bay Watershed.

In an effort to promote greater public awareness of the value and challenges facing the Saginaw Bay Watershed the Saginaw Bay National Watershed Initiative is pleased to provide you with the Saginaw Bay Watershed Educator's Guide and Resource Directory. This guide was prepared by Michigan Geographic Alliance and the Initiative, for use by both formal and non-formal educator's located in the Saginaw Bay Watershed who are interested in instructing others about water quality and how various land uses and personal actions impact water quality.

The guide was developed to provide you with both information and idea's to help others understand the importance of water quality. It should, at a minimum, provide you with basic facts, instructional ideas and additional resources necessary to begin your efforts to improve water quality in the Saginaw Bay Watershed. The information and ideas expressed in this guide can also be adapted for use in other watersheds.

The Initiative hopes that you take some time to review the information included in the guide and that you are able to use this information in your quest to educate other individuals in the Saginaw Bay Watershed.

All partners of the Initiative hope that you are able to utilize the information enclosed to begin your efforts, and that you take the time to provide us with feedback as to how this information helped you, as well as how you were able to use this information to expand your efforts. Your feedback will be extremely valuable in assessing this educational effort and in providing additional information to you and others in the future.

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A major challenge that exists in improving water quality in all watersheds is that of gaining a greater public understanding of the role that rivers and streams play in enhancing the daily life of each and every citizen. Thank you for your efforts in instructing others.

The Great Lakes Watershed

If you search the globe for interesting features your eyes will quickly settle on the Great Lakes. They are unique and have been characterized as jewels on the surface of the Earth. Jewels are valuable and the analogy fits the Great Lakes. They are one of North America's most precious resources.

The Great Lakes were formed over the past 2 million years by a special combination of glacial events and geologic structures. The lakes are connected by a series of short rivers to form the largest surface area of freshwater in the world. The largest of the Great Lakes, Superior, is the largest freshwater lake in the world, and the smallest, Ontario, ranks twelfth. About one-fifth of the world's fresh surface water, and 95 percent of the U.S. total, is contained within the Great Lakes. If the water in the Great Lakes were spread evenly across the surface of the 48 contiguous U.S. states, the depth would be about 9.5 feet!

The Great Lakes drain a watershed of over 201, 000 square mile of land. Approximately 35 million people live around the Great Lakes (this is roughly the same land area and population of Spain). Twenty seven million live in the eight Great Lakes states and 8 million in the province of Ontario. This represents 19 percent of the U.S. population and 30 percent of the Canadian. Most of them live near the 10,200 miles of Great Lakes shoreline (Table 1).

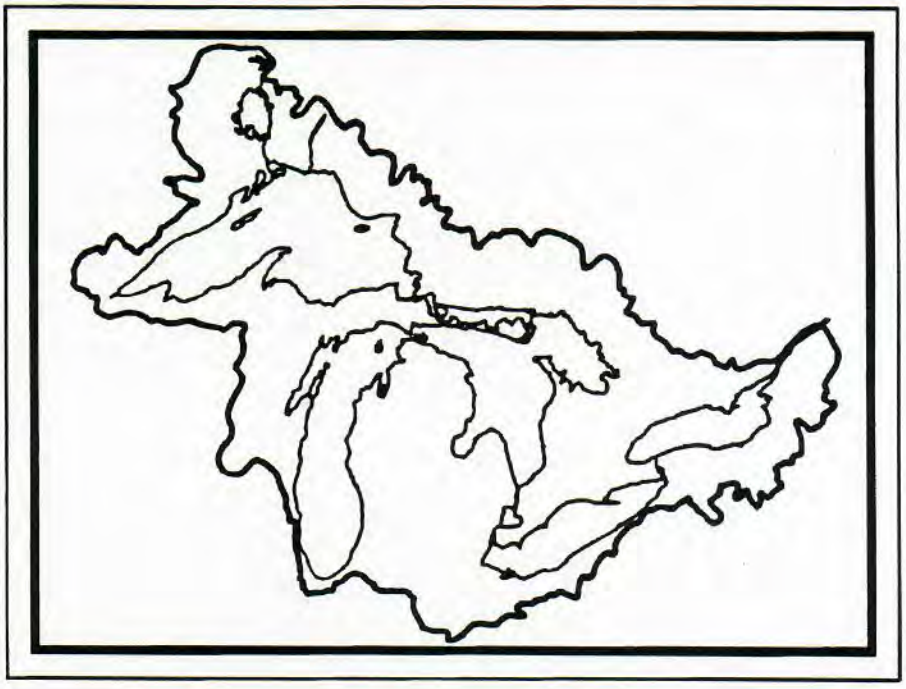


Table 1: Great Lakes Facts

	Superior	Huron	Michigan	Erie	Ontario
Surface Area (square miles)	31,700	23,000	22,300	9,910	7,340
Maximum depth (feet)	1,330	750	923	210	802
Water volume (cubic miles)	2,900	850	1,180	116	393
Shoreline length (miles)	2,726	3,827	1,638	871	712
Retention time* (years)	191	22	99	2.6	6

* Retention time is the number of years on average that the water stays in the lake

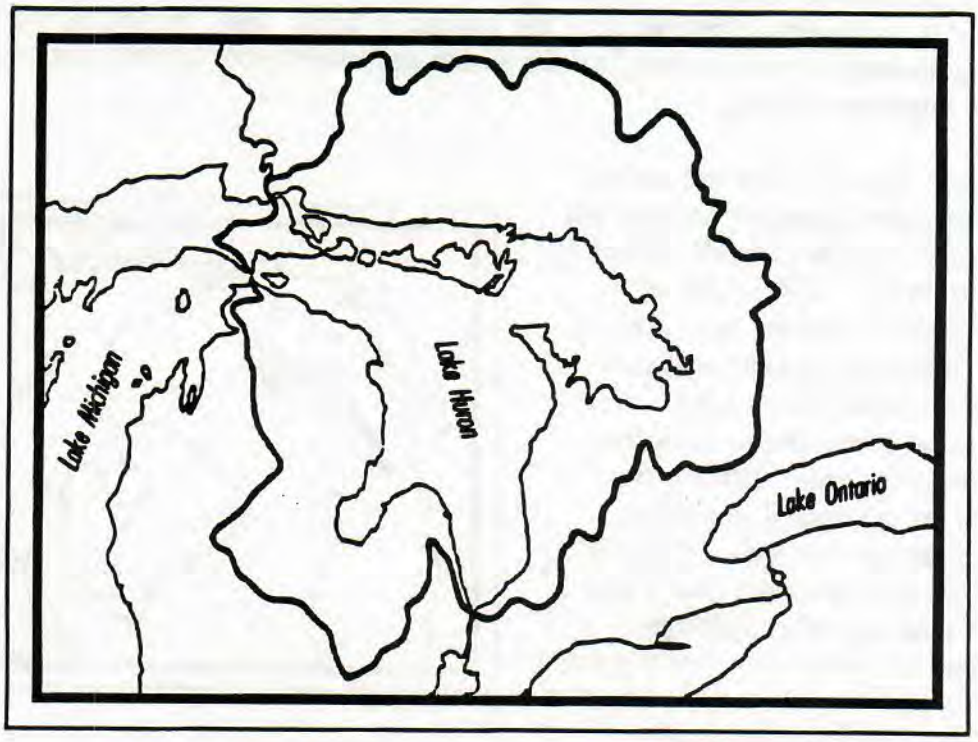
Source: U.S. Environmental Protection Agency and Environment Canada (1988), The Great Lakes: An Environmental Atlas and Resource Book.

The Lake Huron Watershed

Lake Huron is the second largest of the Great Lakes and the third largest freshwater lake in the world. It is connected to Lake Superior by the St. Marys River and to Lake Michigan by the Straits of Mackinac. The water exits through the St. Clair River on its way to Lakes Erie and Ontario. Saginaw Bay and Georgian Bay are the two largest bays on the Great Lakes. Lake Huron was the first of the Great Lakes to be discovered by European explorers.

The land area that drains into Lake Huron is about 51,000 square miles, nearly the same as the entire land area of Michigan. Rivers feed the lake from eastern and northeastern Michigan and western Ontario. Approximately two-thirds of the watershed is forest covered and less than one-third is agricultural and residential. Over 2.5 million people live in the watershed, 1.6 million in Michigan and the remainder in Ontario. Much of the shoreline is lined with cottages, which are used mainly during the summer.

Industrial activities in the watershed center around nickel, uranium, oil and natural gas, chemicals, limestone, and salt. Farmers produce a wide variety of food crops for humans and animals. Commercial and recreational fishing are important in the waters of both Michigan and Ontario. Shipwrecks provide scuba divers with recreational opportunities in five underwater preserves in Michigan and one national park in Ontario.



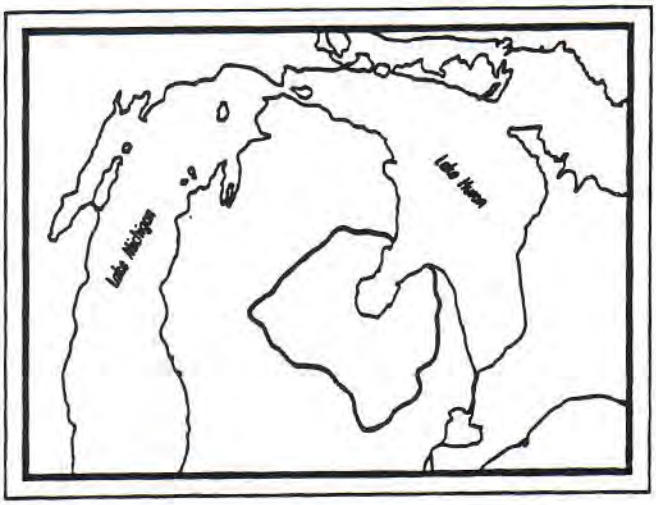
The Saginaw Bay Watershed

The Saginaw Bay Watershed includes more than 8,500 square miles and reaches into 22 counties. It is the largest watershed in Michigan and is made up of seven sub-watershed: the Cass, Flint, Saginaw, Shiawassee, and Tittabawassee Rivers, Coastal East and Coastal West. The Saginaw Watershed is used for a wide variety of human activities. The farmers of the watershed have made it one of the world's major producers of navy beans and an important regional production area of sugarbeets. Bay City, Saginaw, Flint, and Midland are known for their automotive and chemical industries. Nearly 1.6 million people live in the more than 375 villages, townships and cities in the watershed. Many citizens of the watershed have never thought of themselves as belonging to a watershed community. Many do not know what a watershed is nor which sub-watershed they live in. Efforts are underway to identify the environmental issues of each of the seven sub-watersheds and to carry out watershed-wide educational programs.

Saginaw Watershed contains 7,000 miles of streams and 175 lakes. The Bay has 240 miles of shoreline, reaching from Au Sable Point on the northeast to Point Aux Barques on the northeast. The inner bay is shallow, with an average depth of only 15 feet, while the outer bay averages closer to 50 feet. Water naturally recycles by a counterclockwise flow every 186 days.

There are several designated wildlife areas in the watershed, including Shiawassee National Wildlife Refuge, Tobico Marsh, Nayanquing, Fish Point, Wigwam, and Wildfowl Bays. Saginaw Bay is an important resting place for migrating birds. Bald eagles, peregrine falcons, caspian terns, egrets, herons, tundra swans and many other species can be observed during their migratory flights.

The watershed has 138 plant and animal species that are designated as endangered, threatened or of special concern. Many of these depend on the 15,000 acres of coastal wetlands around the bay. This is the largest freshwater coastal wetlands system in the United States, but it is just a fraction of what it was before European settlers came to the area. Efforts are underway in the watershed to protect, enhance and restore wetlands. Acre for acre, wetlands produce more plants and animal life than any other Michigan habitat. They are often the nursery ground for small forage fish. They are a key part of the Saginaw Watershed ecosystem.



Saginaw Bay Initiative

The Saginaw Bay Watershed has been chosen as the Nation's first watershed to be designated under the U.S. Environmental Protection Agency's National Watershed Initiative Program. Designation under this program provided a national focus on the Bay and its watershed to address the interrelated and complex problems facing the area. The Initiative presents an opportunity to take a new approach to local, state, and federal management of this valuable resource. This effort should result in a reclaimed and revitalized Saginaw Bay.

The Saginaw Bay National Watershed Initiative is a process for determining environmental protection and natural resource management priorities. Through the Initiative, local, state and federal agencies, interest groups and citizens are working together to identify short and long term goals for the area. The major tasks of the Initiative include:

- Provide funding and resources to implement pollution control programs and projects within the watershed
- Identify the causes of environmental problems by collecting and analyzing data
- Assess trends of the watershed's water quality, natural resources and land uses

Some of the projects funded include: educational materials development; soil erosion control programs; computerization of soil studies; wetlands education and training programs; water quality monitoring; model on-farm pesticide storage facilities construction; land use zoning study; and an adopt-a-stream program.

Local involvement of public officials, citizens and interest groups is an important concept of the Initiative. One aspect of this program has been the establishment of the Partnership for the Saginaw Bay Watershed. The Partnership promotes cooperative action on water management issues and represents local governments and citizens in the Initiative process. The Partnership's mission is to:

- Improve and enhance the quality of the Saginaw Basin's streams and rivers
- Promote active and coordinated participation in watershed management projects among citizens, government and private groups and citizens
- Serve as an information resource center on watershed and water quality issues

Contact the Initiative office located at Saginaw Valley State University, Pioneer Annex 9A, University Center, MI 48710, phone 517-791-7367, or the Michigan Department of Natural Resources, Office of the Great Lakes, P.O. Box 30028, Lansing, MI 48909, phone: 517-373-3588.

The Partnership for the Saginaw Bay Watershed

The Partnership for the Saginaw Bay Watershed was formed in early 1995 at the urging of both Saginaw Bay Watershed local governments and citizens. The Partnership was established by the merger to two successful watershed-based educational organizations: the Saginaw Bay Watershed Council and the Saginaw Basin Alliance.

The Saginaw Bay Watershed Council was a voluntary association of local governments organized to promote cooperative management on water management issues. Representing the interest of Saginaw Basin communities in water resource matters, Council members jointly developed and promoted watershed activities, gather information, and inform the public about water resource issues. The Council administered several programs and projects, including: the Adopt-A-Stream Program, the School River Monitoring Program, and various educational workshops for both local governments and citizens. The "Council" still exists as a local government caucus of the Partnership.

The Saginaw Basin Alliance was formed in 1988 after the completion of the first Remedial Action Plan for the Saginaw Bay/River Area of Concern. The Alliance promoted restoration, preservation, resource management, planning, and development. Established as a non-profit volunteer organization, members were dedicated to initiating widespread public involvement in the management of the Saginaw Basin's diverse resources.

Together, these agencies formed the Partnership. With the mission of facilitating intergovernmental coordination and public involvement in the wise use of watershed resources, the organization conducts information and education programs and supports watershed enhancement and protection efforts within Michigan's largest watershed. Governed by a 30 member Board of Directors, the Partnership brings together representatives of local government, the citizenry, agribusiness, academia, industry, and environmental organizations into a unified, cohesive voice for water quality protection.

Agriculture

Agriculture has a strong influence on the economy and the ecology of the Saginaw Bay Watershed. Farming methods impact everyone because they can significantly affect our water quality. Nearly 50% of the land in the watershed is used for agriculture.

Wind and water erosion of agricultural land is a major source of sediment in lakes and streams of the Saginaw Bay Watershed. Not only is soil lost from the fields but it also carries pesticides and fertilizers into the rivers and streams. Some drains and channels require expensive dredging to remove these sediments to provide drainage, commercial shipping and recreational boating. Inadequate animal waste management can result in bacterial and nutrient contamination of the water. Excess use and improper handling of pesticides and fertilizers can affect aquatic life, wildlife, and human beings.

Things out of sight can also cause problems throughout the watershed. A leaking underground fuel storage tank, improperly sealed or abandoned wells, and improperly functioning septic systems can contaminate groundwater which may be used as drinking water.

Farmers can help protect and enhance the Saginaw Bay Watershed in many ways. However, not all practices are applicable for every farmer. Each farm needs to be evaluated individually. The following best management practices are only starting points in protecting our watershed resources:

- Use conservation tillage practices
- Apply needed fertilizers after soil is tested and credit is given for legumes and manure application
- Practice Integrated Pest Management to utilize pesticides more effectively
- Mix chemicals on impervious surfaces away from wells
- Plant windbreaks and grassed waterways
- Maintain ground cover and trees along stream banks
- Fence animals out of streams or river corridors
- Properly seal abandoned wells and inspect functioning well casings for cracks
- Monitor underground storage tanks for leaks or preferably remove them
- Construct erosion control structures where needed
- Contact your local conservation agencies for more information

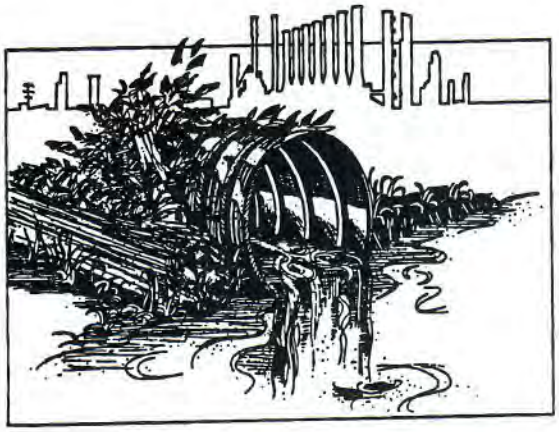
Urbanization

Saginaw Bay is shallow, warm and relatively rich in nutrients and historically supported exceptional fish and wildlife resources. It is naturally productive, but the Bay has been subjected to tremendous quantities of municipal and industrial pollution since the early part of the century.

The first major impact to Saginaw Bay occurred during Michigan's logging era during the late 19th and early 20th centuries. Industrial sawmill wastes, fuels and eroded soils from logging and mill sites went directly into the rivers and the Saginaw Bay. Presently, industrial, municipal and consumer wastes contribute bacteria, nutrients, and toxic contaminants to the water. All kinds of chemical contaminants find their way to the Bay through sewers, street drains and industrial discharges. The natural capacity of the watershed to treat wastes has been overwhelmed and water quality has declined dramatically.

While we have made improvements in preventing toxic chemicals from entering the stream system feeding the Bay, the contaminated sediments remain on the bottom. Removing the contaminated sediments will be expensive and must be done with care to avoid releasing those toxins back to the water. While we struggle to correct these problems, the importance of prevention becomes more evident every day.

The need to reduce toxic chemicals in our waterways is a shared responsibility. Industries, municipalities and consumers must work cooperatively to protect the quality of Saginaw Bay. Pollution control measures involve both mandatory and voluntary actions.



Industries and municipalities

- Reduce the amount of chemicals being used
- Replace chemicals with less toxic alternatives
- Research new methods to clean up existing contaminated sites
- Conduct energy conservation practices which help reduce the water and air pollution associated with producing electricity from fossil fuels
- Develop and enforce zoning ordinances that help protect the environment
- Upgrade sewage systems by:

- building new facilities or connecting with neighboring systems

- improving existing facilities eliminating or treating combined sewage overflows(CSO's) which allow sewage to go directly into surface water during periods of heavy rainfall or snow melt

Small businesses, such as gas stations, repair shops and dry cleaners

- Monitor underground storage tanks or remove them

- Seal floor drains or have wastes drain into holding tanks which are then pumped out and the contents disposed of properly

- Reduce the amount of waste generated

Consumers

- Encourage businesses to provide goods and services that help protect the environment by:

  - patronizing those companies that protect our resources

  - writing to encourage companies to participate in protective measures

  - become active in your own hometown by becoming ''watchdogs'' for a clean, healthy environment

Businesses and manufacturers may call the Office of Waste Reduction Services at 1-800-662-9278 for assistance in reducing pollution.

Wetlands

Wetlands are a key part of Saginaw Bay's ecosystem. Unfortunately, there is much confusion about them. They are called by different names including swamps, marshes and bogs. In the past, they were considered useless areas.

At the turn of the century, wetlands covered nearly two thirds of the Saginaw Bay Watershed. Coastal wetlands occurred naturally along most of the Bay's waterfront. Today, wetlands cover less than one third of the total watershed.

For years, wetlands have been diked and drained to "convert" these areas into agricultural lands. Suburban and urban developments such as parking lots, industrial plants, office buildings, homesites, harbors and marinas have also been constructed on converted wetlands. These land use changes have caused a tremendous loss to the fish, wildlife, plants and water quality of Saginaw Bay. These wetland losses also impacted the economy of the area by affecting tourism and hunting.

Acre for acre, wetlands harbor more plants and animal life than any other Michigan habitat. They provide the nursery grounds for small fish and many kinds of birds. Wetlands also provide benefits not easily noticed. Wetlands filter chemical and nutrient-laden surface waters; minimize erosion; reduce the danger of flooding by acting as a giant sponge; and reduce storm and wave damage on the Bay's waterfront. If we continue to lose remaining wetlands, we also lose the benefits these areas provide.

Anyone who enjoys the rich diversity of fish, wildlife and clean water has a great stake in protecting wetlands. Public and private landowners can have a direct impact by protecting existing wetlands or returning previously drained lands back to more natural conditions.

Local, state and federal ordinances and laws have been passed to help protect wetlands. Filling and draining wetlands over five acres is strictly regulated by state and federal law.

Individual involvement is necessary for protecting wetlands. A beginning step is learning how to recognize them. There are various sources of information such as the local library or the Environmental Protection Agency (EPA) Wetlands Protection Hot line. Call 1-800-832-7828 for current information on the values and functions of wetlands, as well as protection options.

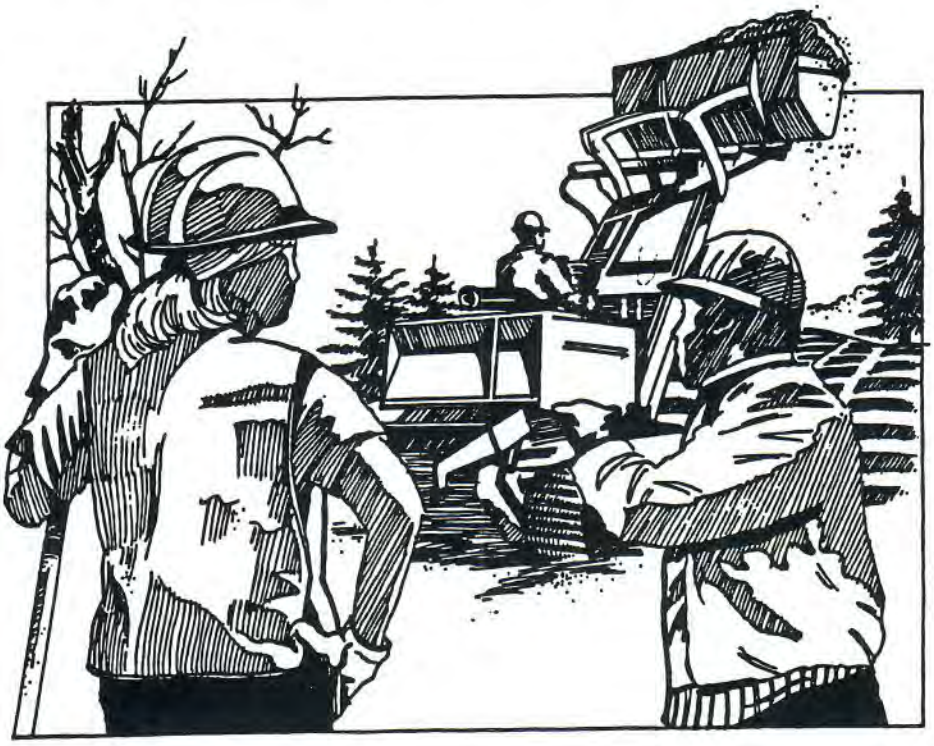
If you are considering any construction on your wetland property contact the DNR for proper permits and guidance and use construction designs which reduce the impact on wetlands.

Get involved locally. Financially support programs that protect or reestablish wetlands. Volunteer with wetland restoration projects. Let your local government know your opinion on wetlands and protection measures. Your involvement will help change attitudes so that wetlands will no longer be seen as unproductive and nuisance areas.

Construction Practices

Road building, land developments and clear cutting timber can cause soil erosion and stream sedimentation. This could be kept to a minimum by using adequate planning and best management practices. These same practices won't work at every site. Each construction project must be considered individually, especially since zoning ordinances and other laws may vary in different areas. These regulations often require businesses to conduct impact assessments to help define pollution and erosion prevention measures. The following are actions that can be taken:

- Instead of clearing large areas at one time, smaller areas should be worked on and completed or reseeded and mulched before the next section is started
- Rip-rap and other devices should be installed to slow down the flow of surface runoff and collect sediment before it reaches the waterways
- Streamside filter strips should be left to help slow surface water runoff
- Retention basins should be built in low areas to collect runoff
- Trees and other vegetation should be left on construction sites if possible
- Construction projects should be designed to minimize soil erosion and sedimentation



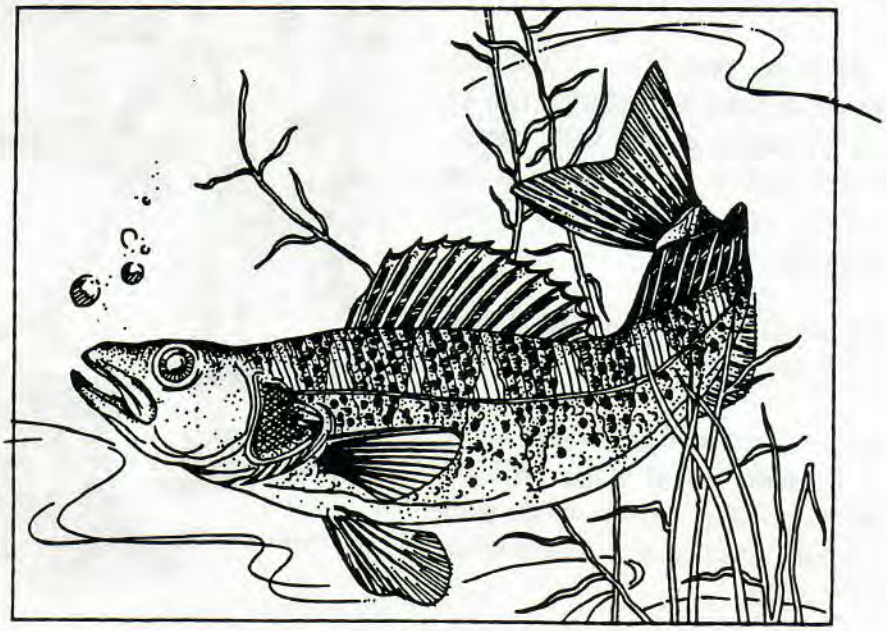
Saginaw Bay Fisheries

Many people ask "What has happened to the Saginaw Bay fishery?" Commercial fishing used to be a big business in the area. In 1902, fishing companies caught around 14 million pounds of fish. However, harvests gradually decreased after that. In 1974, only 1.4 million pounds of commercial fish were caught due to an increase of pollution and overfishing. Hundreds of small commercial fishing operations went out of business.

Although some problems persist, we are seeing progress in restoring the fishery in the Bay. Sport fishing has increased steadily, bringing in tourism dollars which support local businesses. The estimated value of sport fishing in the Bay was approximately $30 million in 1990.

Exotic species also changed the Bay. For example, zebra mussels accidentally introduced into the Bay started impacting the Bay's ecosystem. Help slow the spread of zebra mussels by:

- Inspecting your boat, trailer and vehicle before traveling between different bodies of water
- Removing any plant debris from the boat or trailer
- Checking engine water intake pipes for zebra mussel buildup
- Carefully scraping the hull or trailer or use a high pressure hot water sprayer
- Using extra caution when taking baitfish from one lake to another



Citizen Awareness

Many people are aware of environmental problems in the Saginaw Bay area, but do not know how they can make a difference. The following are actions you can take to help protect the watershed:

- Don't over fertilize your lawn. See your local MSU Extension office to get your soil tested, and follow recommended fertilizer and pesticide application rates.

- Maintain your septic system -- don't pour hazardous chemicals down the drain, pump the tanks on a regular basis, and don't drive or plant trees over the drain fields.

- Compost organic yard and kitchen waste. This extends the life of landfills, and it provides a natural fertilizer and soil conditioner for your lawn.

- Dispose of unwanted toxic items, such as automotive products, home improvement products, pesticides and fertilizers, through a Household Hazardous Waste Collection Program. If your area doesn't have one, help organize a program. Contact your local MSU Extension office for more information.

- Use non-toxic pest controls and safe alternative products in place of hazardous chemicals around the house and yard. Several books have recipes and list commercially available products.

- Recycle as much as possible. Used oil, antifreeze and some types of batteries can be recycled in some areas along with paper, glass, metals and plastics. If recycling is not available in your area, help support and organize a program.

- Plant a natural vegetation strip along stream banks and shorelines.

- Conserve water. Turn off the water while brushing your teeth, install water efficient faucets and toilets, don't over water your lawn, and run full loads in the dishwasher and washing machine.

Day 1. Saginaw Bay Watershed

The graphics on p. 2, "Saginaw Bay Watershed" should be combined with the "What Is A Watershed?" graphic on p. 3. These graphics are helpful in developing the concept of a watershed. They also enable students to begin to make connections between the places and the river systems of the Saginaw Bay Watershed. The "What Is A Watershed?" graphic provides a short and accurate definition of the term and locates Saginaw Bay within the context of the Great Lakes and Lake Huron drainage basins. On the "Saginaw Bay Watershed" graphic the students can identify the counties that are entirely, or partially, within the watershed. They can identify the rivers that form the Saginaw River system and trace their paths to Saginaw Bay. The students can locate where they live and then trace the rivers that come to their community, pass through it, and continue their journey to Saginaw Bay. In doing so, they will learn some basic locational geography of the Saginaw Watershed and understand that they are the recipients of what happened upstream and a contributor to what happens downstream.

They can also get some practice in map reading and applying some mathematics skills. Maps of different scales are presented, but without scale information. The teacher could provide the students with an atlas and a Michigan road map. They could use the graphic scales from these maps to construct graphic scales for the "Saginaw Bay Watershed" and the "What is a Watershed?" maps. With these scales they could then make some distance measurements and some estimates of area.

The "birds eye view" of the bay provides an interesting contrast in orientation and perspective from the other maps. This graphic also demonstrates that maps do not have to be oriented with north at the top of the page.

Selected maps of the Saginaw Bay Watershed produced by the GIS Center, Central Michigan University, are included as Appendix B. Page size maps of the sub-basins and detailed population date for the sub-basins are available upon request from the Partnership for the Saginaw Bay Watershed or the Department of Natural Resources, Office of the Great Lakes. A Saginaw Basin Data Base is included as Appendix C. This data base allows students to make thematic maps of population, agricultural, and industrial variables at the county level of generalization. Appendix D contains lesson suggestions from Jane Moriarty on mapping and graphing activities using the maps and data.

Day 2. Our Toxic River

"Our Toxic River" p. 4, is a map of contaminated sites along the Saginaw River, from its beginning south of Saginaw, through Bay City, to Saginaw Bay. The reader is oriented to the map by highways, streets, and other landmark features. Eight different colored symbols are

used to identify the contaminated sites and the type of contamination. Contaminants include DDT, DDE, DDD, copper, lead, zinc, phosphorus, nitrogen, and PCB. Levels of contamination are given only for PCB's, in parts per billion. A "toxin glossary" is included with the map. There is also a historical perspective of human activities connected to the river from 1820-1993.

The usefulness of this map can be greatly enhanced by bringing the following U.S. Geological Survey Topographic Maps into the classroom: Bay City NE, Essexville, Bay City, and Saginaw at the scale of 1:24,000. They piece together to cover the entire length of the Saginaw River. Topography is portrayed with brown contour lines, water features with blue, wooded areas in green, and cultural features in red and black. These maps can be purchased from the Department of Natural Resources, (517) 334-6943, at $2.75 each plus 6% sales tax and a nominal shipping fee.

The navigational chart of the Saginaw River is another useful information source to accompany the topographic maps and "Our Toxic River." It can be purchased from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, but an easier source is Brennan Marine in Bay City. The cost for the 1:20,000 map is $14.00 plus 6% sales tax.

The topographic maps and the navigational chart provide detailed information about the human activities along the river and tie them to a specific site, which in most cases can be matched with the contaminants identified on "Our Toxic River."

This information can then be the basis for a discussion of what people do along the river, why people do what they do along the river, the consequences of these activities, and the conflicts that arise because of multiple uses of the river. This discussion will probably be most productive if it is carried out in a factual rather than a judgmental context. The following articles could be read as preparation for a discussion: "Past, Future tied to WATER" p. 4, "GM River Plants Handle Toxic Problems Differently," p. 6, "Imperfect City Sewage Plants Flush Their Wastes into River," p. 12.

Day 3. Air Pollution-A Quiet Contributor

This diagram, p. 7, is intended to illustrate that human activities and natural events beyond the boundaries of the Saginaw Bay Watershed affect the air and water quality within the watershed. It is meant to symbolize the fact that pollution comes from a variety of sources, but should not be taken literally. While pollution from forest fires and volcanoes may travel hundreds of miles to the Great Lakes.

Airborne contaminants enter and leave the Saginaw Basin from any point of the compass. The prevailing wind direction is from the west, but on a particular day it can be from any direction. The clockwise circulation of high pressure systems and the counterclockwise circulation around low pressure systems accounts for the daily wind direction. High and low pressure centers migrate through the area on average about every four days.

The prevailing westerlies are a global wind system of the middle latitudes. Airborne particles from Chicago and Grand Rapids are deposited in the Saginaw Basin, but airborne particles from the Saginaw Basin also come to rest in Toronto and Buffalo. They could also be carried in from Detroit and Cleveland, or Sarnia and Sudbury. (If the instructor is insecure about discussing global wind systems an introductory physical geography or meteorology text will provide more than enough background information.)

It is important that students make a connection between local, regional, national, and global events. "Air Pollution" ties the watershed into a global environmental system. Students need to develop global perspectives and to examine topics at different scales of observation. This graphic can serve both purposes if the examples are chosen appropriately. It also provides an opportunity for a multi-disciplinary approach to environmental problem solving. Knowledge from earth science can contribute to the discussion and inject scientific information into a debate that will be decided within a political and economic context.

Two articles in "Cleaning Our Troubled Waters" are appropriate readings for the "Air Pollution" graphic: "Toxins Travel On The Wind," p. 7 and "Businesses Bear Cost of Clean Air and Water," p. 9. These articles focus on air pollution sources in the watershed and make suggestions as to what can be done to improve air quality.

Day 4. Pollution Runoff Effects

This graphic, p. 11, focuses on the surface water runoff within the Saginaw Bay Watershed. Rivers, lakes, and drains are identified by name and their locations are shown with letter and number symbols. Twenty-three lakes/reservoirs and twenty-two rivers/drains are identified. Pollution from surface runoff is emphasized with a particular focus on agriculture. Ground water is not identified specifically in the graphic, but it is implied.

Ten types of problems with the waters in the rivers/drains are identified. The specific problems with each river/drain are indicated. The lakes and reservoirs identified are all eutrophic. The factors that make them eutrophic are listed. A helpful inset compares the level of runoff between cultivated, forest, urban and residential areas.

Stormwater runoff from agricultural areas is a major cause of pollution in the waters of the watershed. A separate diagram illustrates how agricultural activities contribute pollutants to the surface waters. It also contains preventive measures that can protect surface waters. Five factors are identified that greatly affect agricultural runoff. Seven methods for reducing runoff are listed.

This graphic has great potential for a project in cooperative learning. The students can be divided into groups and given the assignment of reading selected articles, answering a series of questions, and reporting their answers and conclusions to the class. The most appropriate articles are the following: "Ag Runoff Fouls Water Even With Improved Practices," p. 9, "Waterways Suffering Under Sediment Deluge," p. 9, "Some Farmers Say 'No Way' to No-Till, Resist Change," p. 10, and "Pesticides Seeping Into Waters" p. 10. Questions the students could address include the following: Which pollutants cause the water quality problems mentioned in the article? Were these pollutants from point or non-point sources, or both? Why do farmers continue to use practices that cause soil erosion? What effects do the pollutants have on ecosystems and/or human health? Why are the pollutants being released? What's being done, or proposed, to solve the problem? What do you think should be done? What would you do to address the problem?

Day 5. Sewage Disposal

This graphic, p.14, illustrates both the functioning of a home septic system and the steps of treating waste water through the Bay City Waste Water Treatment Plant. The value of this graphic is the accuracy of the factual content. The sequential steps of sewage treatment are clearly presented for both systems. Students should have no trouble understanding the processes. It can serve as a means to prepare the students for a field trip to a waste water treatment plant, or for the visit of a treatment plant operator to the classroom.

The text portion of the graphic discusses the problems with selected wastewater treatment plants, and the release of untreated sewage during times of high water. The treatment of sewage is brought to the personal level with a section on 'What You Can Do' if you have a septic system or are part of a city sewage system. The teacher might try to get the class members to make a personal commitment to stop any activities they are doing that are listed in the DO NOT FLUSH and DO NOT POUR statements. They could then begin an educational campaign to try and stop these things from happening at their homes and the school.

This graphic can stand alone as a teaching aid, but the septic system portion of the diagram is slightly flawed. There is nothing wrong with the content. However, the septic tank and leaching field are much closer to the surface than implied in the diagram. The top of the septic tank and the leaching field are just below ground level and both are in a level position. Also, drain field is a more commonly used term than leaching field.

The articles that can be read with this graphic are: "Imperfect City Sewage Plants Flush Their Wastes Into River," p. 12, "Septic-System Use On The Rise," p.12, and "Bad Septics Soiling Waters" p. 13.

Day 6. Tobico Marsh-Our Backyard Wetland

This graphic, p.17, can be used as part of a discussion of wetlands in general or the Tobico Marsh in particular. It can also serve as a basis for discussing wildlife in the Saginaw Basin. A locator map and an annotated aerial photograph are valuable parts of the graphic. These can be enhanced with the addition of the Kawkawlin Quadrangle, 1:24,000. The Tobico Marsh is centered on the quadrangle and its regional setting can be more readily grasped, along with the human activities that occur in the surrounding area. (See "Our Toxic River" if you wish to purchase the quadrangle.) An additional resource that can contribute to an understanding of wetlands is Historical Wetlands of the Saginaw Bay Watershed which was produced for the Saginaw Bay National Watershed Initiative, Office of the Great Lakes, Michigan Department of Natural Resources, Lansing, MI. 48909.

The Hartley and Hartley Landfill is clearly visible on the photography and the topographic map. It is of particular concern since it borders Tobico Marsh and contains large quantities of toxic materials. It ranks as one of Michigan's most polluted spots. These graphics can be used to introduce the topic of landfills and the negative impacts they can have on both surface and ground water. They also provide an opportunity to discuss the problems of solid waste management. The role of recycling could be worked into the discussion at this point.

This graphic is a stand-alone teaching aid, but it would also serve nicely in preparing the students for a field trip to the marsh. If this is not possible, invite a naturalist from the Bay City State Park or the Shiawassee National Wildlife Refuge to the classroom.

The same type of cooperative learning activity that was suggested under "Pollution Runoff Effects," would work here as well. The appropriate articles to read with this graphic are: "County Wildlife Haven Ailing," p. 15, "Hartley Landfill A Threat To Tobico," p. 15, "Bay Not An Aquatic Warehouse," p. 16, "Disappearing Wetlands Vital to Saginaw Bay Ecosystem" p. 2, and "Watershed Pollution Still Threatens Saginaw Bay Area Wildlife" p. 6.

Day 7. Our Poisoned Food

This graphic, p.19, focuses on the impacts of polluted water on the fish in the Saginaw Basin and the dangers to human health if contaminated fish are consumed. It is a stand-alone teaching aid. Students should be made aware of these dangers and take precautions to protect their health. The text contains information on selected water bodies, specific fish species, and the types of contaminants that can be ingested. Information on the commercial fishing industry is a bonus. The 'What You Can Do' section contains helpful suggestions for those planning to eat fish from the Saginaw Basin.

A Public Health Official, a doctor, or the school nurse might be able to elaborate on the dangers to human health that are portrayed on the diagram. School age children may not relate to the dangers of kidney & liver toxicity, reproductive & genetic problems, and nervous system & neurological problems. The students might be asked to keep a record of their food intakes for a few days. These could be tabulated and discussed by the class. The class food consumption patterns could be evaluated by a dietitian or nutritionist and feed back could be given of the consequences of these behaviors. The students might be asked to bring in food labels and research the chemical additives in everyday products. Middle school and high school students are at an age where they take good health for granted and think they are invincible. Anything that makes them more aware of their personal health, the consequences of poor diet, and the preventive measures they can take to protect their health would be worth the effort.

Articles that can be read in conjunction with this graphic are: "State Says Some Fish Should Not Be Eaten," p. 18, "Dangers of The River Invisible to Anglers," p. 18, "Some Believe Advisories Are Overkill And Hurt Sport Fishing," p. 19 and "Scientists Still Angling For Fish Data" p. 20.

Day 8. Cleaning Our Water

The "Cleaning Our Water" graphic, p.23, is a stand-alone teaching aid. Its greatest value is the factual content. "Cleaning Our Water" and "Sewage Disposal" could be used at the same time, or sequentially. Large portions of the population do not know where their water comes from, where it goes, or what happens to it when it leaves their homes. These graphics provide good answers to these questions.

It contains information on private wells, a municipal water system, and the Bay Metropolitan Water Treatment Plant. The sections devoted to private wells and a municipal water system provide an opportunity to discuss ground water.

The discussion of the water treatment plant is clear and concise. It will be new knowledge to many students. They will learn where their water comes from and what must be done to make it potable. The map of water intakes is an important part of the graphic. It should help in developing an appreciation of what is involved in bringing safe water to their homes. The section on 'What's In Our Water' is important information which can be tied into the 'Poisoned Food' graphic. The 'What You Can Do' section brings the matter of safe and good quality water into the students' homes. Many of them will be able to relate to water conditioners because they are in their homes. They are likely to see a reverse-osmosis system in the grocery store where they can fill their gallon jug with treated water.

Various test can be performed to measure some aspect of water quality. Some kits can be purchased at a store that sells supplies for backyard swimming pools. A teacher might want to collaborate with a chemistry teacher to perform tests on different water samples from the

community. Water quality testing kits are readily available from scientific catalogs. The following is a sample of the types of kits that are available: alkalinity, ammonia, calcium, carbon dioxide, chlorine, detergent, dissolved oxygen, total hardness, iron, nitrate, nitrite, phosphate, pH, salinity, silica, and sulfide.

The articles that can be read with this graphic are: "City Water Gets Scrubbed Before It Hits Your Tap" p. 21, and "Some Wishing For Better Water Wells" p. 21.

Day 9. The Initiative

This graphic, p. 25, could be useful as a teaching aid at the high school level. It provides an opportunity to discuss the politics of cleaner water. This would fit the best into a political science class, or possibly an economics class. The students could do a role-playing activity. An array of governmental officials, industrial, agricultural, citizen-action groups, and at-large-citizens could be chosen because they have a stake in issues that concern water. The students could use the entire "Cleaning Our Troubled Waters" reprint as a resource base from which to begin their research on the issues and the different perspectives that may be represented in a community.

A person that deals with some aspect of water management could be brought into the classroom and provide a case study of their responsibilities and the problems they must deal with in serving the community. A county commissioner would have different responsibilities from a city official. A drain commissioner would see things differently from a farmer or a land developer.

Another project that might interest high school students would be an investigation of the impact the school has on water. How does water get to the school? How much water is used in the school? What are the different water uses within the school? What are the impacts of these uses on water quality? What demand does the school places on the sewage treatment system? They could also investigate the impact the school has on surface runoff and infiltration. How much area is devoted to solid surfaces, i.e., roof tops and paved areas? How much area allows water to soak into the ground? What changes could be made in school activities that could reduce the quantity of water that is used and improve the quality of the water that leaves the school? They could also investigate the same questions for their homes.

Mapping The Watershed

Jane Moriarty
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GOALS: To identify and relate the water resources of the earth. Learning incorporates issues from the world view to the local watershed level.

OUTCOMES: Students will investigate, discuss, and evaluate watershed issues. They will become (more) aware of their own behavior as it affects their local watershed and beyond.

GRADE LEVEL: 4 - 8

MATERIALS: Map of the world, map of the U.S., map of Michigan, map of the Saginaw watershed "Major Rivers and Tributaries" (copy for each student), map of local community where school is located

SUGGESTED PROCEDURE:

1. Display variety of maps on board to show world view down to local view.

2. Review some basic water facts:
   70%+ of the Earth's surface is water
   97% of that water is salt water
   Less than 1% of water is fresh water
   20% of the world's fresh water supply is found in the Great Lakes

3. Review concept of a watershed.

4. Locate Saginaw Bay and its watershed on Michigan map.

5. Using the map "Major Rivers and Tributaries," have students locate their community on that map and, using a light marker or colored pencil, trace the flow into the Saginaw Bay (this could be a homework assignment or a group activity).

6. Trace water route from Saginaw Bay to the Atlantic Ocean (good group activity using student atlases).

   L. Huron > St. Clair River > Lake St. Clair > Detroit River > Lake Erie > Niagara River > Lake Ontario > St. Lawrence River > Atlantic Ocean

7. Some issues to discuss:

   - Is it important to save water? Why?
   - Who owns our water?
   - How many ways do we use water? (Keep a chart of daily use, students compare usage.)
   - How does the behavior of others affect our water? Give examples.
   - What are ways in which people have a positive influence on water? A negative influence?
   - Find places in the U.S. (world) that are water poor; places that are water rich. Should anything be done about water rich vs. water poor countries? Explain your ideas.

EVALUATION: Some bases for evaluation might be:

1. On an unlabeled map of the U.S. students can label the Saginaw Bay and trace the route that Saginaw Bay water follows to reach the Atlantic Ocean. (More detailed labeling may be required depending on age of students.)

2. Students can write about/discuss specific water issues using facts to support opinions.

3. Students can, on an unlabeled map of the Saginaw Bay watershed, locate their community and label the river(s) connecting them to the Saginaw Bay.

Graphing Saginaw Bay Watershed Data

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GOALS: To use Saginaw Bay watershed statistics to create graphs and to employ math skills in the study of their local area.

OUTCOMES: Students will identify and use appropriate graphing techniques in the study of Saginaw Bay watershed data. They will use these graphs to help compare, contrast, and assess these data.

GRADE LEVEL: 4 - 8

MATERIALS: Graph paper, data from Saginaw Bay watershed materials. Depending on the experience of the students, sample graphs may be helpful.

SUGGESTED PROCEDURE: A variety of graphs can be made using data in the "Fact Sheets" and the map section of the educator's guide. Some graphing ideas from the simple to more complex are:

1. Population bar graph for the counties in the watershed. Here students consider the implications: How many people share in the use of this water? How might activities in different parts of the watershed affect water quality?

2. Bar graph of Act 307 contamination sites. Graph those in your watershed for a simple graph. Graph all sites for more complex interpretation.

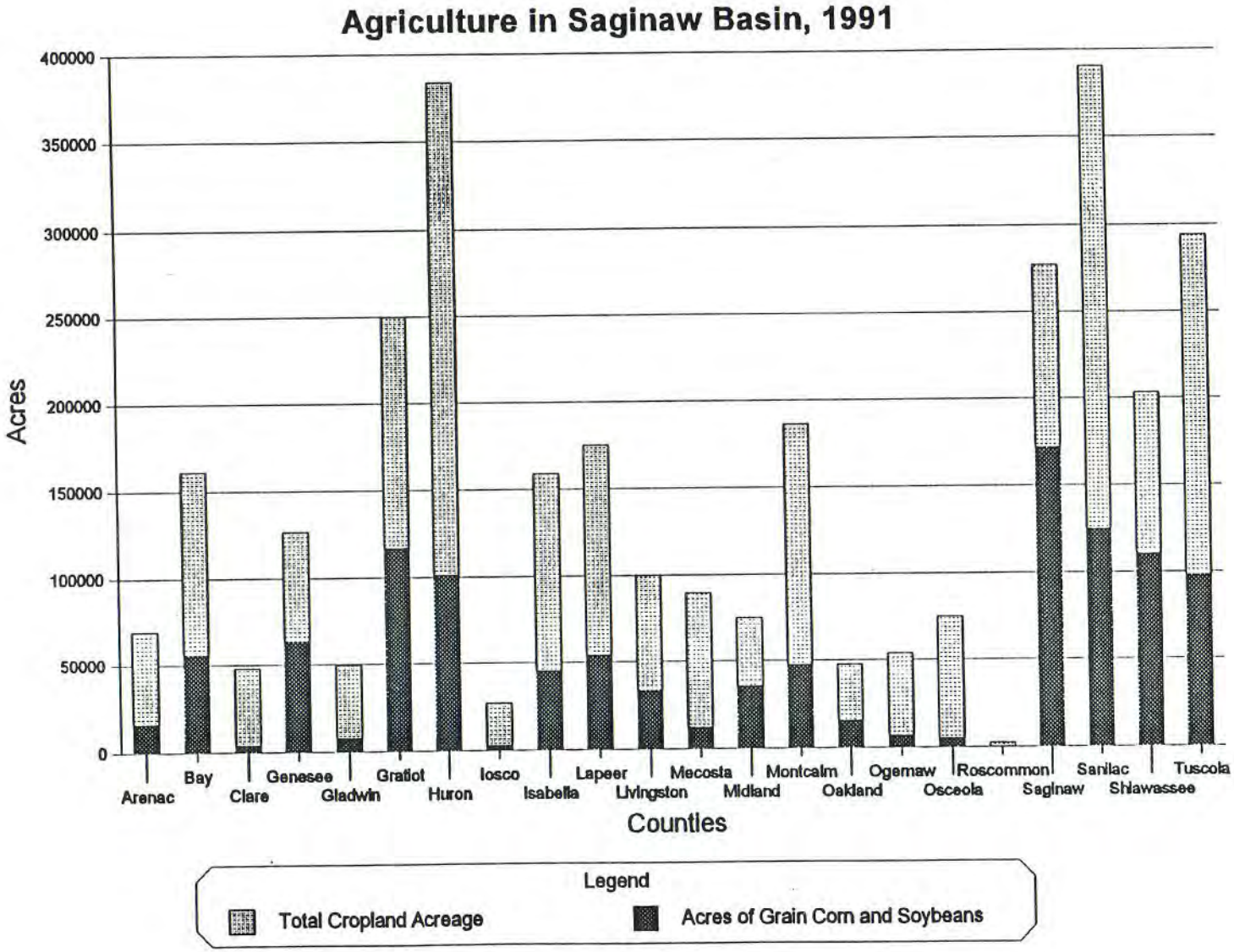
3. Double bar graph comparing two variables (one bar shows the relationship of one variable to the other. A sample is attached showing the amount of total cropland acreage devoted to grain corn and soybeans for each county in the watershed. (Color coding enhances these graphs.) Students can also calculate the percentage of total acreage planted in these grains and map the data to see the patterns of crops within the watershed.

4. Pie graph of different land uses in watershed. Data on different crops or agricultural products or on different industries can be converted to percentages for pie graphs. Again, mapping the data helps reveal regional patterns.

5. If computers are available, explore software data bases that offer information on water and the environment, plus graphing programs that let students create computer-generated graphs.

EVALUATION: Have students gather local data and decide how to graph it. Make sure they can interpret their graph(s). Data may be available from local sources for graphing.

A special thank you is extended to Philip Klein for his editorial suggestions on the Mapping and Graphing activities and the constructing of the activities chart and the agriculture graph.


Agriculture in Saginaw Basin, 1991
Acres
400000
350000
300000
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150000
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Arenac
Bay
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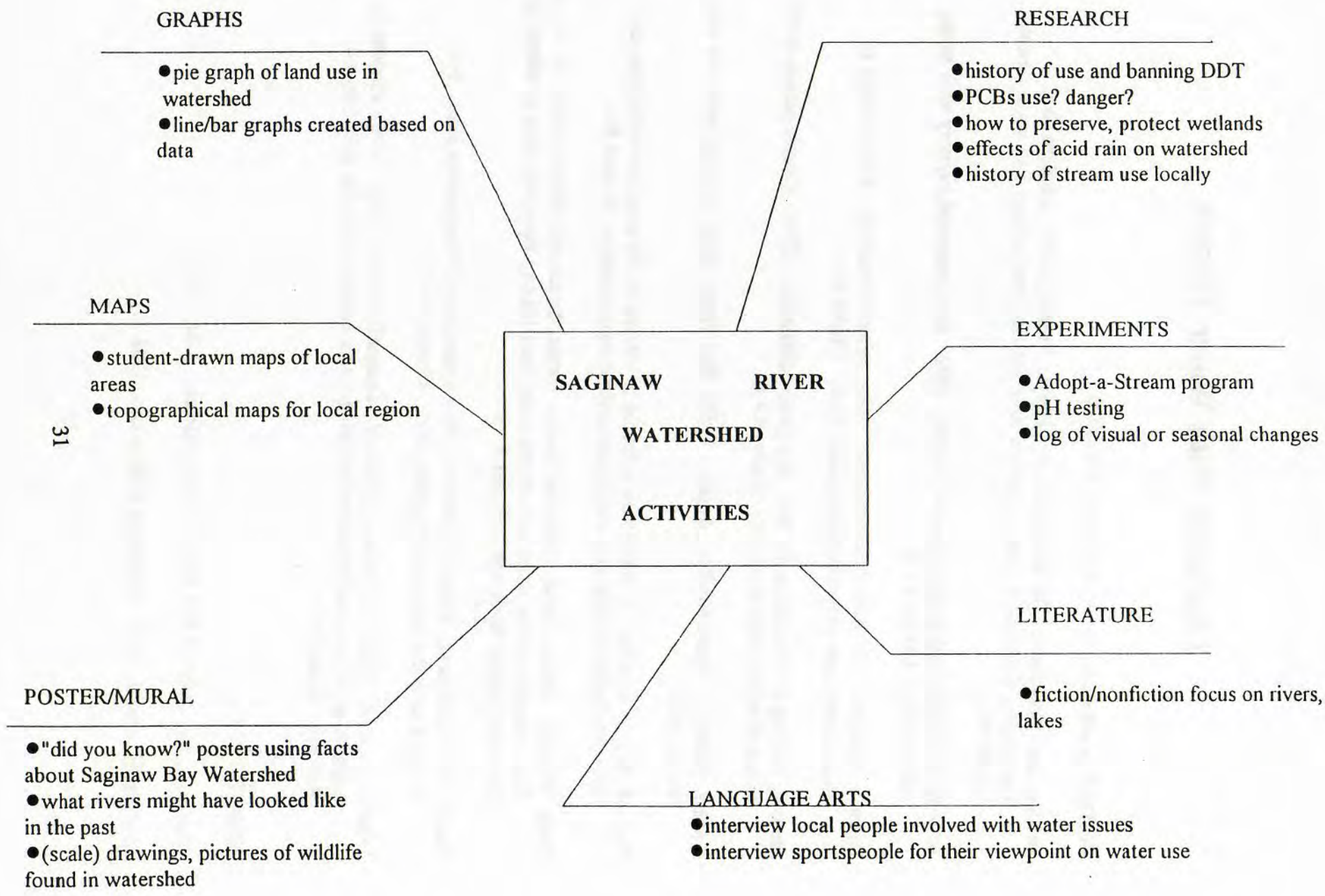
Genesee
Gladwin
Gratiot
Huron
Iosco
Isabella
Lapeer
Livingston
Mecosta
Midland
Montcalm
Oakland
Ogemaw
Osceola
Roscommon
Saginaw
Sanilac
Shiawassee
Tuscola
Counties
Legend
Total Cropland Acreage
Acres of Grain Corn and Soybeans

Some Starting Places For Watershed Projects



Literature With Water Themes

FICTION (a selection, many choices are available)

George, Jean Craighead. *The Talking Earth.* Harper Trophy, 1983. Modern day, Everglades, Seminole Indian girl strives to understand her heritage and environment. Grades 6+.

Who Really Killed Cock Robin? Harper Trophy, 1992. Environmental mystery with strong science base. Grades 4 - 5.

Graham, Kenneth. *The Wind in the Willows.* Many editions available. Classic story of animals and their adventures along their river. Grades 6+.

Holling, Holling C. *Paddle to the Sea.* Houghton Mifflin Co., 1944. Classic picture book; film and lesson plans available. Grades 4 - 6.

Locker, Thomas. *Where the River Begins.* Puffin Pied Piper, 1984. Picture book and story for all ages.

Paulson, Gary. *Hatchet.* A young boy is forced to survive on his own in a wilderness area. Other books by Paulson also emphasize environmental themes. Grades 5+.

Steig. William. *Abel's Island.* Sunburst Books. Farrar, Straus and Giroux, 1976. A mouse finds ways to survive when he is swept away from his city home and onto an island far from his familiar landscape. Grades 4 - 6

Twain, Mark (Clemens, Samuel Langhorn). *The Adventures of Huckleberry Finn.* For younger students, selections might be read. Grades 6 - 8.

Winter, Jeanette. *Follow the Drinking Ground.* Dragonfly Books, 1983. Many versions in addition to this one, of the slaves following rivers northward on the Underground Railroad. Grades 4+.

NON-FICTION

Cherry, Lynn. *A River Ran Wild.* Gulliver/Green. HBJ. 1992.

MacCaulay, David. *Mill.* Houghton Mifflin Co., 1983.

Twain, Mark (Clemens, Samuel Langhorn). *The Adventures of Huckleberry Finn.* For younger students, selections might be read. Grades 6 - 8.

Winter, Jeanette. *Follow the Drinking Ground.* Dragonfly Books, 1983. Many versions in addition to this one, of the slaves following rivers northward on the Underground Railroad. Grades 4+.

NON-FICTION

Cherry, Lynn. *A River Ran Wild.* Gulliver/Green. HBJ. 1992.

MacCaulay, David. *Mill.* Houghton Mifflin Co., 1983.

MacCaulay, David. *Ship.* Houghton Mifflin Co., 1993.

MacCaulay, David. *Underground.* Houghton Mifflin Co., 1976.

Tall tales, legends, fairy tales, and folklore are all rich sources for stories where the importance of water to humans and animal life is emphasized. From the *Gilgamesh* epic to the *Odyssey,* the theme of water is important. Fairy tales like "The Frog Prince" and "The Twelve Dancing Princesses" also reflect the symbolism and "power" of water in the folk tradition. Students can also revisit old favorites such as *Mother Goose, Paul Bunyan, Arabian Nights,* to locate stories involving water as a main theme.

GLOSSARY

AQUIFER

Rock strata and unconsolidated earth materials that can store, transmit, and supply water to springs and wells. Sandstone is the best rock aquifer. Glacially deposited sands and gravels are the predominant aquifers in the Saginaw Basin.

DRAINAGE BASIN

The area of land that contributes surface runoff and groundwater to a specific stream. Drainage basins are separated from one another by divides, along which the waters separate and move into different drainage systems. Drainage basins and watersheds are interchangeable terms. The drainage basin of the Saginaw Bay Watershed is the total land that contributes water to Saginaw Bay.

DRAINAGE SYSTEM

A main river and all its tributaries. The Saginaw River system is the Saginaw River and its major tributaries, such as the Tittabawassee, Shiawassee, and the Cass. It also includes their tributaries, such as the Chippewa and Flint, and their tributaries as well.

DRAINS

Artificially constructed drainage lines. They are dredged into poorly drained areas and connected to the natural drainage lines. Their purpose is to get the excess water out of low-lying areas. The major reason for building drains is to allow the land to be used for agricultural purposes. Underground tile drains are then placed in the fields and connected to the drains.

ECOSYSTEM

Community of organisms interacting with one another and with the natural and human factors making up their environment.

EUTROPHIC

A body of water is considered eutrophic when an increase in mineral and organic nutrients reduces the dissolved oxygen and produces an environment that favors plants over animals. Lakes are more likely to become eutrophic than rivers.

EUTROPHICATION

The physical, chemical, and biological changes that take place in a water body after it receives inputs of plant nutrients, mostly nitrates and phosphates, from surface and sub-surface runoff. The rate at which this natural process develops has been greatly accelerated by human actions.

EXOTIC SPECIES

Plant and animal species that are not native to an area. Human action is always involved in the appearance of an exotic species. Purple loosestrife and zebra mussels are two examples of exotic species in the Saginaw Bay Watershed.

GRAPHIC SCALE

A map scale in which linear distances are delineated along a bar. It is also called a bar scale. The most common units of measurement are miles and kilometers.

GROUND WATER

Water that soaks into soil and percolates downward into an aquifer where all the pore spaces are filled with water. The water moves through the aquifers under the force of gravity and hydrostatic pressure.

HERBICIDES

Chemicals that kill a plant or inhibit its growth.

HIGH PRESSURE SYSTEMS

Anticyclonic air masses in which the air settles to the earth's surface from the upper atmosphere. They circulate in a clockwise manner in the Northern Hemisphere. They generally migrate through the Saginaw Basin on a three or four day cycle. High pressure systems are associated with sunshine and fair weather clouds.

IMPERMEABLE LAYER

Earth materials that will not allow water to penetrate. Clay is the most common impermeable material in the Saginaw Bay Watershed. It causes poor drainage in low-lying areas and causes water to pond at the surface after heavy rainfalls.

LANDFILL

Waste disposal sites in which solid and liquid wastes are buried. Sanitary landfills are located in naturally impermeable materials or lined with impermeable material before disposal begins. The impermeable materials prevent liquids from migrating off site. Liquids from landfills, called leachates, can be forced off site by hydrostatic pressure and thereby contaminate the ground and surface waters of the surrounding area.

LOW PRESSURE SYSTEMS

Cyclonic air masses in which the air rises from the earth's surface. They circulate in a counter-clockwise manner in the Northern Hemisphere. They migrate through the Saginaw Basin on a three or four day cycle. Low pressure systems bring cloudy weather and rain producing clouds.

MARSH

Low-lying areas that are under water at least part of the time, but the water is shallow enough to permit the growth of water-tolerant plants--mostly grasses and sedges. The terms marsh and wetlands are often used interchangeably.

NUTRIENTS

Materials needed for the survival, growth, and reproduction of plants and animals. When excess nutrients, especially nitrates and phosphates, get into the water bodies they speed up the eutrophication process. Runoff from fertilized farm fields, golf courses, and lawns carries large amounts of nutrients into the waters of the Saginaw Basin.

NON-POINT SOURCES OF POLLUTION

Unconfined areas that contribute pollutants into the environment. Farm fields, golf courses, and highways are examples of non-point sources of pollutants.

PESTICIDES

Chemicals that kill or inhibit the growth of an organism that humans consider undesirable.

POINT SOURCES OF POLLUTION

Confined sites that contribute pollutants into the environment. Smoke stacks and waste discharge pipes are the most commonly cited examples.

POLLUTION

Materials that are released into the environment that reduce the capacity of the air, water, and land to support plant and animal life. Pollution has harmful effects on humans, plants, and animals.

POTABLE WATER

Water that is safe for humans to consume.

PREVAILING WESTERLY WINDS

The predominant wind systems that flow from west to east in the latitudes between 30° and 60° in both Hemispheres. The Saginaw Bay Watershed is between 43° and 44° North latitude.

SEDIMENT

Small particles of rock materials and organic debris that are carried, and ultimately deposited, by water, wind, or ice. Fine sediments in rivers and lakes make them appear cloudy or muddy when there is enough turbulence to keep them suspended.

SOIL

The outer portion of the earth's surface occupied by plant roots. It is composed of weathered rock materials, organic matter, living organisms, gasses, and liquids in solution. Almost all of the food supply comes from the soil.

WATERSHED

See definition for drainage basin.

WATER TABLE

The upper limit of groundwater. Wells must be sunk below the water table in order to produce a dependable water supply. Water tables fluctuate in height in rhythm with the rainfall. Wells that pump water faster than it can be recharged cause the water table to drop.

WETLANDS

Lands that stay flooded all or part of the year. The Saginaw Basin has several remaining areas of freshwater wetlands along the Shiawassee and Saginaw Rivers. They are productive ecosystems and important reservoirs for groundwater recharge.

ZONE OF AERATION

The zone between the earth's surface and the water table. Water moves through this zone to reach the water table. Plants draw their water supply from this zone.

ZONE OF SATURATION

The zone below the water table where all the openings in the earth materials are filled with ground water.

The author extends a special thank you to Philip Klein, Burton Nelson, Mark Francek and the students in the Earth Science for Teachers class for their helpful editorial suggestions.

Saginaw Bay National Watershed Initiative Publications Order Form (June 1994)

Publication Number	Title	Check Here
SBWI - 01	Comprehensive Public Participation and Watershed Education Strategy for the Saginaw Bay National Watershed Initiative - August, 1992	_____
SBWI - 02	"New Hope For the Big Bay" - Michigan Natural Resources Magazine, Summer 93	_____
SBWI - 03	Saginaw Bay National Watershed Initiative: A Local, State and Federal Cooperative Effort to Restore and Protect the Saginaw Bay Watershed (Semi-Annual Brochure)	_____
SBWI - 04	Saginaw Bay National Watershed Initiative: A New Approach to Watershed Management (Brochure)	_____
SBWI - 05	Saginaw Bay Watershed Poster (2-sided 21" by 31") Flat (heavier cardstock)	_____
	Folded (8 1/2 by 11)	_____
SBWI - 06	Saginaw Bay National Watershed Initiative Bookmarks:	
	The Saginaw Bay Wetlands	_____
	The Saginaw Bay Watershed	_____

Saginaw Bay National Watershed Initiative Communication Fact Sheets:

SBFS - 01	A Phosphorus Diet for Saginaw Bay	_____
SBFS - 02	Contaminated Sediments in the Saginaw River and Saginaw Bay	_____
SBFS - 03	Saginaw Bay Watershed	_____
SBFS - 04	Saginaw Bay Watershed Wetland Facts	_____
SBFS - 05	Sport Caught Fish Consumption Advisory for the Saginaw Bay Watershed	_____
SBFS - 06	Surface Water Quality Concerns of the Saginaw Bay Watershed	_____
SBFS - 07	Toxic Substances in the Saginaw Bay Watershed	_____
SBFS - 08	Soil Erosion and Sedimentation in the Saginaw Bay Watershed	_____
SBFS - 09	Vegetated Filter Strips (Available June 1995)	_____
SBFS - 10	Animal Access By: Gladwin Soil Conservation District	_____
SBFS - 11	Livestock Manure Management Series By: MSU Extension	_____

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

MDNR - 01	Historical Wetlands of the Saginaw Bay Watershed By: Michigan Natural Features Inventory	_____
MDNR - 02	Saginaw Bay Strategy 1990	_____
MDNR - 03	Saginaw River/Bay Remedial Action Plan Update By: Surface Water Quality Division	_____
MDNR - 04	State of the Great Lakes 1993 Annual Report By: Office of the Great Lakes	_____
MDNR - 05	State of the Great Lakes 1994 Annual Report By: Office of the Great Lakes	_____

PARTNERSHIP FOR THE SAGINAW BAY WATERSHED (Formerly the Saginaw Bay Watershed Council)

PSBW - 01	Adopt-A-Stream Program (Brochure)	_____
PSBW - 02	Adopt-A-Stream Program Binder	_____
PSBW - 03	Physical and Biological Stream Monitoring Manual	_____
PSBW - 04	Project Report - School River Monitoring Program (Yearly)	_____
PSBW - 05	River Rag Newsletter (Quarterly)	_____
PSBW - 06	Saginaw Bay Watershed Council (Brochure)	_____
PSBW - 07	Watershed News & Views (Quarterly)	_____
PSBW - 08	Storm Drain Stenciling (Brochure)	_____
PSBW - 09	Remedial Action Plan for the Saginaw River/Bay Area of Concern (Citizens Guide)	_____

SAGINAW BAY NATIONAL WATERSHED INITIATIVE GRANTEES

SB - 01	Controlling Soil Erosion and Sedimentation Through Local Zoning (Alternative Zoning Methods for Local Governments in Swan Creek Watershed)	By: Saginaw County Metropolitan Planning Commission	_____
SB - 02	Watershed Management and Special Land Uses: Golf Courses in the Swan Creek Watershed	By: Saginaw County Metropolitan Planning Commission	_____
SB - 03	The Swan (Newsletter, The Watershed and You)	By: Saginaw County Metropolitan Planning Commission	_____
SB - 04	Environmental and Economic Concerns in the Saginaw Bay Watershed: Results of a Survey of Environmental Professionals	By: Michigan State University	_____
SB - 05	Non-Formal Education Strategy for the Saginaw Bay National Watershed Initiative	By: Michigan State University Extension	_____
SB - 06	Northern Tittabawassee River Study	By: Saginaw Bay Resource & Development	_____
SB - 07	Northern Tittabawassee River Task Force Brochure	By: Northern Tittabawassee River Task Force	_____
SB - 08	Saginaw Basin Environmental Research Bibliography	By: Saginaw Valley State University	_____
SB - 09	Saginaw Bay Watershed Land Use & Zoning Study	By: Michigan United Conservation Clubs	_____
SB - 10	Soil Erosion Training Handbook	By: East Central Michigan Planning & Development Region	_____
SB - 11	Saginaw Bay Watershed Educators Guide	By: Michigan Geographic Alliance	_____
SB - 12	Turf Grass Maintenance Tips to Preserve Water Quality (Homeowners/Golf Courses)	By: Michigan State University	_____
SB - 13	Wetland Protection in Michigan Handbook for Prosecutors & Law Enforcement Staff	By: Milliken Institute for Community Development	_____
SB - 14	Wetland Restoration Plan for Saginaw Bay	By: Saginaw Valley State University	_____
SB - 15	Wetland Restoration in the Coastal Zone of Saginaw Bay Annual Report 1993	By: Michigan State University	_____
SB - 16	Wetlands Handbook for Local Government Officials	By: Saginaw Valley State University Maritime Research Associates	
SB - 17	Redevelopment Strategies for Environmentally Contaminated Waterfront Sites	By: Public Sector Consultants, Inc.	

ADDITIONAL SUPPORTERS

WAT - 01	A Citizens Guide to the Saginaw River/Saginaw Bay Remedial Action Plan - March, 1990	By: East Central Michigan Planning & Development Region	_____
WAT - 02	"Managing For Them All", Summer 93	By: Michigan Natural Resources Magazine	_____
WAT - 03	Saginaw Bay Watershed Sediment Delivery and Erosion Potential GIS Study	By: U.S. Environmental Protection Agency	_____
WAT - 04	Survey of Farm Operator Attitudes Toward Establishing a Voluntary Soil Conservation Credit Program in the Saginaw Bay Watershed	By: Saginaw Bay RC&D/Michigan State University	_____

VIDEOS/SLIDES (Loan Availability Only)

SBVS - 01	Agriculture in Transition/Video	By: MSU Extension, Huron County	_____
SBVS - 02	Pesticide Storage Facilities (Video/Slides)	By: MSU Extension, Gratiot County	_____
SBVS - 03	Soil Erosion Training Slides	By: East Central Michigan Planning & Development Region	_____
SBVS - 04	Manure - The Renewable Resource of the 90's/Video	By: MSU Extension	_____
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Pioneer Annex 9A, University Center, MI 48710
(517) 791-7367

Description: *The Partnership for the Saginaw Bay Watershed began the Adopt-A-Stream Program in 1992, as an ambitious, grassroots program to help clean and enhance the waterways of the Saginaw Basin. Through monitoring, protecting, and restoring, adopting a stream means that your school becomes primary caretaker of a stretch of stream in the Saginaw Bay Watershed. The Adopt-A-Stream Program can be tailored to fit any school group, depending upon the level of participation they wish to become involved as well as the age of the students. There are four stages the group can participate in; implement streambank clean-ups, conduct streambank surveys, monitor stream insects and gauge water quality, and execute streambank enhancement projects to help control erosion and stabilize streambanks. Teacher training workshops are also held to further educate teachers on the program and what is expected of them once they are involved. To get involved contact the Partnership for the Saginaw Bay Watershed at (517) 791-7367.*

The Storm Drain Stenciling Program is the most recent addition to the Partnership for the Saginaw Bay Watershed's water quality educational programs. Storm Drain Stenciling is a national program to help improve the water quality of our lakes, rivers, and bays by curbing the amount of hazardous materials that enter our storm drains. This program is designed to remind people that anything placed into storm drains will eventually reach the Saginaw Bay by traveling through underground pipes, ditches, wetlands, and rivers. By stenciling "Dump No Waste, Drains to Stream" in front of storm drains, the Partnership hopes people will find safer alternatives for discarding wastes. To get involved contact the Partnership for the Saginaw Bay Watershed at (517) 791-7367.

The Partnership for the Saginaw Bay Watershed staff will come to any school within the Saginaw Bay Watershed to present various environmental topics related to the Saginaw Bay Watershed. Presentations have included discussion of general water quality, the Saginaw Bay Watershed, exotic species, the Adopt-A-Stream and Storm Drain Stenciling programs, as well as various other topics. To set up a presentation contact the Partnership for the Saginaw Bay Watershed at (517) 791-7367.

The School River Monitoring Program provides schools with the unique opportunity of exposing high school and middle school student to hands-on field experience. The program is designed to encourage involvement from a wide range of students, including those in the language arts, social studies and science. The project is intended to be a year-round endeavor culminating in a River Project "Congress" meeting in the spring. Currently the Partnership has over twenty schools involved in this project. These schools are providing water quality data that is being used at several different levels, from local to federal. This program is periodically expanded depending on the availability of grant funds. For more information contact the Partnership for the Bay Watershed at (517) 791-7367.

Organization: ***East Michigan Environmental Action Council***
Address: **21220 West 14 Mile Road, Bloomfield Township, MI 48301**
(313) 258-5188
Description: *EMEAC was established to research and publish facts and promote responsible action on issues of environmental concern in Southeast Michigan. The Council provides elementary school level programs, presented by volunteers, on recycling, composting and ozone protection. A Great Lakes program is in development.*

Organization: ***Michigan Society of Planning Officials***
Address: **414 Main Street Suite 202, Rochester, MI 48307**
(313) 651-3339
Description: *The Society serves planning professionals and is a source of further information for educators on land use issues.*

Organization: ***East Central Michigan Planning and Development Region***
Address: **3535 State Street, Saginaw, MI 48602**
(517) 797-0800
Description: *Formed to promote intergovernmental cooperation, coordination, and to protect local government by assisting them in their governance. Membership is voluntary and covers the area around the Saginaw Bay. Activities and facilities, including a resource library, are supported by member dues.*

Organization: *Saginaw Bay Resource Conservation and Development Area, Inc.*

Address: **4044 South Three Mile Road, Bay City, MI 48706**
(517) 684-5650

Description: *Sponsored by counties and Soil Conservation Districts and administered by the USDA Soil Conservation Service. Interagency teams work together to improve the social, economic, and environmental conditions of the area.*

Organization: *Groundwater Education in Michigan (GEM) Program*

Address: **Institute of Water Research, 334 Natural Resources Building, Michigan State University, East Lansing, MI 48824**
(517) 353-9775

Description: *The GEM Program promotes protection of groundwater quality by increasing awareness and understanding of groundwater issues. A number of K-12 educational materials have been developed by various GEM projects throughout the state. GEM staff also present effective hands-on workshops and maintain a resource library of groundwater materials.*

Organization: *CIESIN*
Consortium for International Earth Science Information Network

Address: **2250 Pierce Road, University Center, MI 48710**
(517) 797-2700

Description: *The consortium was established to facilitate access to, use and understanding of global change information worldwide. Student visitors will be exposed to a global perspective and the knowledge that their actions are linked to worldwide ecology.*

Organization: *MSU Sea Grant Extension*

Address: **District Office, PO Box 599, Tawas City, MI 48764**
(517) 362-3449

Description: *Sea Grant Extension, like the Land Grant University Extension system, exists to facilitate the transfer and use of university research based information to local communities. Sea Grant Agents are trained in Great Lakes water and coastal resource education methods and provide a number of K-12 classroom programs. They also maintain a water resource library.*

Organization: *The Michigan Geographic*
Address: **292 Dow Science, Central Michigan University,**
Mt. Pleasant, MI 48859
(517) 774-3723

Description: *The Michigan Geographic Alliance is a network of teachers and geographers working to improve the quality of geographic education by providing high-quality, low cost, in-service workshops and products for teachers. Workshops on the geographic and environmental issues of the Saginaw Basin and the Great Lakes, as well as more general workshops on geography and the environment, can be scheduled by calling the Alliance Office. The Michigan Geographic Alliance receives support from the Michigan Department of Education and the National Geographic Society Education Foundation.*

Colleges and Universities

Teachers have ready access to the substantial resources of the Saginaw Bay Watershed's Colleges and Universities. Interaction between K-12 teachers and college faculty can lead to valuable learning experiences for all involved: students, teachers and college faculty. Listed below are nearby institutions teachers will find to be most helpful as they develop watershed studies. College libraries and faculty have been important sources of detailed watershed information. Teachers turn to these institutions when a speaker or expert advisor is needed, when a high school student is looking for advanced studies, and for a myriad of purposes.

Alma College
Department of Biology
614 West Superior Street
Alma, MI 48801
(517) 463-7198

Central Michigan University
Michigan Geographic Alliance
294 Dow Science Building
Mt. Pleasant, MI 48859
(517) 774-3723

Central Michigan University
Geographic Information System Center
276 Dow Science Building
Mt. Pleasant, MI 48859
(517) 774-4995

Delta College
Office F-213, Science Division
University Center, MI 48710
(517) 686-9249

Delta College
Department of Geology G-123
University Center, MI 48710
(517) 686-9249

Kirtland Community College
10775 North St. Helen Road
Roscommon, MI 48653
(517) 275-5121

University of Michigan - Flint
Regional Groundwater Center
Rm. 518 Murchie Science Bldg.
Flint, MI 48502-2186
(313) 766-6608

Michigan State University
Lifelong Education Exchange
East Central Region
2203 Eastman Avenue
Midland, MI 48640-2608
(517) 839-8540

Mid-Michigan Community College
1375 South Clare Avenue
Harrison, MI 48625-9447
(517) 386-6622

Mott Community College
1401 East Court Street
Flint, MI 48503
(810) 762-0200

Saginaw Valley State University
Sponsored Programs
Pioneer Annex
University Center, MI 48710
(517) 790-4295

Saginaw Valley State University
Regional Math/Science Center
Pioneer Annex 10
University Center, MI 48710
(517) 790-4114

Saginaw Valley State University
College of Science, Eng. and Technology
208 Pioneer Hall
University Center, MI 48710
(517) 790-4144

Saginaw Valley State University
Biology Department
155 Science Building
University Center, MI 48710
(517) 790-4484

Michigan State University Extension

Michigan State University Extension offices are located in every watershed county. The primary purpose of these outreach facilities is to extend access to Michigan State University's vast research and information base. Staff members are educators attuned to local issues. Many have developed or are currently developing water resource educational programs suitable for K-12 students. Extension also coordinates most 4-H Youth activities.

Arenac County CES
PO Box 745
Standish, MI 48658-0745
(517) 846-4111

Bay County CES
1220 Washington Avenue
Bay City, MI 48708-5893
(517) 895-4026

Clare County CES
PO Box 439
Harrison, MI 48625-0439
(517) 539-7805

Genesee County CES
G-4215 W Pasadena Avenue
Flint, MI 48504-2376
(810) 732-1470

Gladwin County CES
555 W Cedar Street
Gladwin, MI 48624-2095
(517) 426-7741

Gratiot County CES
204 S Main Street
Ithaca, MI 48847-1465
(517) 875-5233

Huron County CES
250 E. Huron Avenue
Bad Axe, MI 48413-1397
(517) 269-9949

Iosco County CES
PO Box 599
Tawas City, MI 48764-0599
(517) 362-3449

Isabella County CES
200 N Main Street
Mt. Pleasant, MI 48858-2312
(517) 772-0911 Ext. 302

Lapeer County CES
1575 Suncrest Drive
Lapeer, MI 48446-1195
(810) 667-0341

Livingston County CES
820 E Grand River Avenue
Howell, MI 48843-2497
(517) 546-3950

Mescosta County CES
400 Elm Street
Big Rapids, MI 49307-1891
(616) 592-0793

Midland County CES
220 W Ellsworth Street
Midland, MI 48640-5194
(517) 832-6640

Montcalm County CES
617 N State Road
Stanton, MI 48888-0308
(517) 831-5226 Ext. 248

Oakland County CES
1200 N Telegraph Road
Pontiac, MI 48341-0416
(313) 858-0885

Ogemaw County CES
806 West Houghton Avenue
West Branch, MI 48661-1215
(517) 345-0692

Osceola County CES
PO Box 208
Reed City, MI 49677-1149
(616) 832-6139

Roscommon County CES
PO Box 507
Roscommon, MI 48653-0507
(517) 275-5043

Saginaw County CES
705 Adams Street
Saginaw, MI 48602-2192
(517) 799-2233

Sanilac County CES
37 Austin Street
Sandusky, MI 48471-1298
(810) 648-2515

Shiawassee County CES
701 S Norton
Corunna, MI 48817-1298
(517) 743-2251

Tuscola County CES
362 Green Street
Caro, MI 48723-1998
(517) 673-5999 Ext. 228

MSU East Central Region
2203 Eastman Avenue
Midland, MI 48640-2608
(517) 839-8540

Government

This listing of state and federal agencies is intended to facilitate the process of locating the right regional resource person for watershed studies in your area. The offices listed will direct you to the right person, depending upon your need. Some agencies, like the Michigan Department of Natural Resources, publish their own detailed directories. Local, state, and federal government agencies are involved in Saginaw Bay Watershed resource management to varying degrees across the watershed. Local government is a good place to begin when learning about local resource issues. Although local governments are not listed here, local officials often determine zoning and land use patterns which in turn can dramatically effect regional ecosystems. County health officials and drain commissioners play significant roles in water resource management, too.

Michigan Department of Natural Resources
Office of the Great Lakes
P.O. Box 30028
Lansing, MI 48909
(517) 373-3588

Michigan Department of Public Health
PO Box 30195
Lansing, MI 48909
(517) 335-8000

USDA Natural Resource Commission
1405 South Harrison Road
East Lansing, MI 48823
(517) 337-6904

National Oceanic and Atmospheric Administration
Great Lakes Environmental Research Laboratory
2205 Commonwealth Boulevard
Ann Arbor, MI 48105-1593
(313) 741-2285 or 2284

United States Department of Interior
Fish and Wildlife Service
Shiawassee National Wildlife Refuge
6975 Mower Road
Saginaw, MI 48601
(517) 777-5930

US Environmental Protection Agency
Region 5 Public Affairs Division
77 West Jackson Boulevard
Chicago, IL 60604-3590
(312) 353-2147

Guide to Outdoor Education Centers and Nature Preserves

Outdoor Education Centers and Nature Preserves can be found throughout the Saginaw Bay Watershed, which offer students valuable exposure to the out-of-doors. Interpretive trails offer an opportunity to learn about the ecology of the watershed and provide a good backdrop for discussion of current environmental issues.

Facility: *Chippewa Nature Center, Inc.*
Address: **400 Badour, Midland, MI 48640**
(517) 631-0830
Description: *The Chippewa Nature Center offers 17 standard programs for teachers, scout leaders and other youth leaders, in addition to weekend & weekday programs, evening lectures and special events for the general public. The center's programs are enhanced by facilities such as a 14-mile trail network, a wide variety of natural habitats (ponds & other wetlands, deciduous and coniferous woods, two rivers, an Oxbow, open meadows), an 1870's Homestead Farm (including a Log Schoolhouse, Heritage and Herb Gardens, Log Cabin and farm animals) and a Visitor Center (with classrooms, two museums and an auditorium). CNC's youth programs are available for all ages, from pre-school through high school students. Programs available for groups include Aquatic Life, Seasonal Ecology, Winged Wonders, Homestead Holidays, Indian Life, Food, Plant and Water Cycles, Maple Syrup, Homestead Life, Water Quality, Wetlands, and Ready for Winter. A minimum of four weeks is required to reserve a program. Groups may register for programs on weekdays or weekends, (program availability may be limited on weekends). CNC is open year-round (closed Thanksgiving & Christmas Days), and is open to the general public. Trails are open dawn-to-dusk (no bikes, pets or smoking). The Visitor Center is open M-F, 8-5; Saturday, 9-5; Sunday, 1-5.*

Facility: *Fish Point Wildlife Area*
Address: **4139 Miller Avenue, Unionville, MI 48767**
(517) 674-2511
Description: *This area is best known for spring waterfowl viewing. Although there are no facilities for classes, there is a mile-long nature trail and tours are available by appointment. An observation tower is accessible to handicappers.*

Facility: *For-Mar Nature Preserve*
Address: **5360 East Potter Road, Burton, MI 48506**
(810) 789-8548
Description: *A 383 acre nature area that serves Genesee County and visitors from all areas of the country. Naturalists conduct programs for thousands of students every year, also offering Junior Naturalist Day Camps for 4th and 5th graders every summer. Programs for the public are offered on weekends. A handicapper trail (.1 mile) is on site along with 7 miles of walking trails. A new visitor/nature center (7500 square feet) houses an extensive collection of stuffed mounts, nature games, hands-on activities and an observation bee hive; horticulture displays are in the other section of the center. The preserve is open daily from 8 a.m. until sunset; reservations are required for weekday programs. There is no charge for just visiting and walking trails.*

Facility: *Green Point Environmental Learning Center*
Address: **3010 Maple Street, Saginaw, MI 48602**
(517) 759-1669

Description: *The U.S. Fish and Wildlife Service and the City of Saginaw formed a unique partnership to reopen the Center in September 1993. The Center's mission is to provide environmental education opportunities for area school children and educators. There are 2.5 miles of nature trails that wind through bottomland hardwood forests, wetlands, and riparian areas along the river. The interpretive building houses aquariums with native species and a wildlife viewing area. Future programs and exhibits will highlight the Great Lakes ecosystem and migratory birds. The Center is open Monday through Friday.*

Facility: *Hartley Outdoor Education Center*
Address: **12633 Beaver Road, St. Charles, MI 48655**
(517) 865-6295

Description: *Hartley consists of 300 acres of natural habitat featuring wetlands, hardwood forest, creeks, and nature trails. Devoted to environmental education, Hartley's facilities include a Coal Mine Museum, Schroeder Pioneer Cabin, Wildlife observation blinds, forest trails, an Indian Village, and the Fowler One-Room Schoolhouse. The schoolhouse is available by reservation for one-day sessions during the regular school year.*

With a staff of ten individuals, Hartley Outdoor Education Center provides many educational opportunities for all ages. These programs include a 3-day residential program in Outdoor Environmental Education for grade school students; several thousand 4th, 5th and 6th grade students participate in this program each year. Additional programs include Spring and Fall Open Houses featuring nature/wildlife workshops, adult classes, minitrips, and Traveling Naturalist Programs of varying topics. These programs address many facets of environmental and outdoor education including Michigan history, flora, fauna and water use.

Facility: *Huron County Nature Center*
Address: **250 East Huron, Bad Axe, MI 48413**
(517) 738-8667

Description: *Great Lakes topography is one of the special features of this 280 acre wooded site near Port Crescent. Nearly one half of the area is wetland nestled between glacial ridges. Self guided tours may be taken dawn to dusk, and guided tours are available by appointment. There is no permanent staff at the center.*

Facility: *Jennison Nature Center/Saginaw Bay Visitor Center*
Address: **3582 State Park Drive, Bay City, MI 48706**
(517) 667-0717

Description: *The Saginaw Bay Visitor Center (no longer called the Jennison Nature Center) offers a wide array of environmental education programs designed for school groups and other youth groups. Interpretive programs utilize a wide array of hands on activities, labs, live presentations, games and outdoor investigations which focus on the ecology and history of the Saginaw Bay and its watershed. The displays in the renovated Jennison Exhibit Hall depict the natural history of the Saginaw Bay's natural resources and man and how they interact and effect each other. Many of the displays are interactive. Also available in*

1996 is the forty foot traveling Saginaw Bay Watershed trailer which features displays, puppet shows, computer games, video screen, and more.

Facility: *Ligon Outdoor Center*
Address: **5213 East Farrand, Clio, MI 48420**
(810) 387-4270
Description: *The Center provides staffed facilities year-round for general purpose environmental studies. The site includes a three quarter mile bog walk, a wooded area of approximately 300 acres and a 40-acre lake. The 100 person "Stonehouse" classroom, lean-to camping area and picnic pavilion are also available for group use. Teacher in-service training is conducted regularly, and a monthly newsletter describes Ligon's well-rounded programming. Outdoor education curriculum materials are also available.*

Facility: *Seven Ponds Nature Center*
Address: **3854 Crawford Road, Dryden, MI 48428**
(810) 796-3419
Description: *Michigan Audubon Society operates this 240 acre nature center. The full time staff is dedicated to environmental education for youth. As the name suggests, the focus here is pond life. Open every day except Monday, year-around.*

Facility: *Shiawassee National Wildlife Refuge*
Address: **U.S. Department of Interior, Fish and Wildlife Service, 6975 Mower Road, Saginaw, MI 48601**
(517) 777-5930
Description: *This 9,000 acre site includes bottomland hardwood forest, wetlands, riparian area, and crop lands. Two trail systems offer 9 miles for hiking, bicycling, and skiing. An observation tower with a spotting scope, located at the Curtis Road trails, offers an excellent view of waterfowl, bald eagles and other wildlife. A "Backyard Habitat" demonstration area, featuring urban, suburban and rural plots, is near the Headquarters building. The Refuge is open year-round, seven days a week, during daylight hours only.*

Resource Directories and Educational Materials

Resource Directory

Title: "Directory of Great Lakes Education Materials"
Organization: International Joint Commission
Address: Great Lakes Regional Office, PO Box 32869,
Detroit, MI 48232-2869
(313) 226-2170
Cost: Free
Description: This 78 page booklet offers a comprehensive listing of high-quality education materials on various media that deal directly with the Great Lakes and related issues.

Title: "Directory of Water Education Programs in SE Michigan"
Organization: Eastern Michigan University Southeast Regional Center for Groundwater Education in Michigan
Address: Institute for Community and Regional Development, EMU,
34 North Washington, Ypsilanti, MI 48197
(313) 487-4322
Cost: First copy free
Description: A guide to classroom visitation and field trip programs concerning groundwater, surface water, and related environmental topics.

Title: "Resource Guide"
Organization: SVSU Regional Mathematics and Science Center
Address: Saginaw Valley State University, 2250 Pierce Road,
Pioneer Annex #10, University Center, MI 48710
(517) 790-4114
Cost: First copy free
Description: A booklet containing lessons, laboratory modules, and teacher support guides covering various earth science topics. Some of local interest.

Title: "Field Manual for Water Quality Monitoring, An Environmental Education Program for Schools"
Organization: Global River Environmental Education Network (GREEN)
Address: 2050 Delaware Avenue
Ann Arbor, MI 48103
(313) 761-4854
Cost: $10.00
Description: The water monitoring program described in the manual is founded upon the Water Quality Index developed by the National Sanitation Foundation. Students in the monitoring program work together to run nine water quality tests. The results are used to calculate an overall water quality index. The ninth edition also includes emphases on biological monitoring, land use activities, computer networking and local and international models of student action-taking, and partner watershed exchanges internationally.

Title: "Ground Water - Public Information Pamphlet Series"
Organization: American Ground Water Trust
Address: P.O. Box 1796
16 Centre Street
Concord, NH 03301
(603) 228-5444
Cost: $5.00
Description: The American Ground Water Trust Pamphlet Series provides information and explanations about ground water for a non-technical audience. Some water resources issues are complex, and some topics involving ground water science and technology are not easy to understand. The phamplet series is designed to provide basic ground water information building blocks for the public and for high school students.

Educational Materials

Title: "Saginaw Bay Watershed Education K-12"
Organization: Saginaw Bay National Watershed Initiative Office
Address: Saginaw Valley State University, 2250 Pierce Road,
Pioneer Annex 9A, University Center, MI 48710
(517) 791-7367
Cost: Free
Description: A comprehensive survey report containing school and teacher contacts for individual watershed curriculum development efforts. It describes numerous independent efforts at more than 60 schools. It also points out the unavailability of comprehensive, locally oriented, environmental education materials in the watershed.

Title: "Tapping the Source"
Organization: Groundwater Education in Michigan
GEM Program
Address: Institute of Water Research, 334 Natural Resources Bldg.
MSU, East Lansing, MI 48824
(517) 353-3742
Cost: Free
Description: This booklet provides a listing of groundwater education materials available through the Groundwater Education in Michigan program.

Title: "Groundwater Reference Guide"
Organization: Groundwater Education in Michigan
GEM Program
Address: Institute of Water Research, 334 Natural Resources Bldg MSU, East Lansing, MI 48824
(517) 353-3742
Cost: First copy free, additional copies $0.75 each
Description: This easy-to-read, 26 page annotated bibliography format provides information on 16 topics related to groundwater.

Title: "Saginaw Basin Environmental Research Bibliography"
Organization: Saginaw Valley State University
Address: Institute for Environmental Policy and Education
University Center, MI 48710
(517) 790-4496
Cost: Free
Description: References to published and unpublished research documents. Not intended for use directly by students. Computer searchable through CIESIN Information Gateway/GOPHER.

Title: "Project WILD Aquatic Activity Guide"
Organization: Michigan State University
Address: 10 Agriculture Hall
Michigan State University
East Lansing, MI 48824
(517) 355-1712
Cost: $15.00
Description: A workshop with a curriculum supplement which focuses on aquatic wildlife. The status of aquatic habitats and the species that depend on them can serve as indicators of the health of our environment.

Title: "Project Wet"
Organization: The Greening of Detroit
Address: Whittier Towers
415 Burns Drive
Detroit, MI 48214
(313) 821-8733
Cost: $20.00
Description: A workshop designed to promote stewardship of water resources by educating people about water and water resource management. The activities included in the curriculum supplement can be used to teach natural and social sciences, mathematics and the arts.

Title: "Water, Water Everywhere"
Organization: HACH Company World Headquarters
Address: P.O. Box 608
Loveland, CO 80539-0608
(800) 227-4224
Cost: $24.95
Description: This package includes three books: the Teacher's Guide and Experiments, the Student Reading Unit, and the Water Quality Factors Reference Unit. This was prepared for teachers and these materials are recommended for grades 7-12, but may be adapted for lower grades.

APPENDIX A

SAGINAW BAY WATERSHED

FACT SHEETS

SAGINAW BAY NATIONAL WATERSHED INITIATIVE

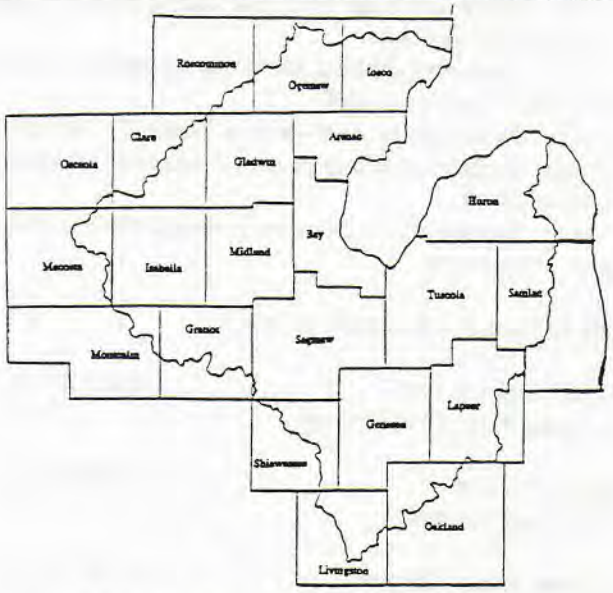
COMMUNICATION FACT SHEET

SURFACE WATER QUALITY CONCERNS OF THE SAGINAW BAY WATERSHED

SAGINAW BAY WATERSHED

A watershed is the area of land that is drained by a river system or by a network of river systems. In the case of Saginaw Bay, the land area that contributes water to the Bay involves a vast network of river systems. Some of these river systems drain directly into the Bay. Most of the watershed is drained by a network of smaller rivers, creeks and streams that make up a series of smaller watersheds. These smaller watersheds converge just south of the city of Saginaw and create the 22-mile long Saginaw River that flows into Saginaw Bay. As amazing as it may seem, the Saginaw Bay Watershed reaches north beyond West Branch, further west than Alma or Clare, eastward past Cass City and south of Howell. The boundaries of the Saginaw Bay Watershed cover all or parts of 22 counties. It is the largest watershed in the state, consisting of 15% of the state's land area.

The problems and solutions facing the Saginaw Bay Watershed must be approached from both a local and regional perspective. Something that occurs in one area can impact local residents and affect another area miles away. For example, surface runoff contaminants such as gas and oils from the streets in Flint drains into the Bay via the Flint and Saginaw Rivers. It also means that chemicals discharged near Mt. Pleasant may affect numerous people and wildlife as it travels to the Chippewa River which then flows to the Tittabawassee and Saginaw Rivers. Wind or water erosion can deposit top soil and any attached fertilizers from a farmer's field near Sebewaing directly into the Bay or its tributaries. Therefore, even though people in the counties close to the Bay, such as Tuscola, Bay, Huron, Arenac, Iosco, and Saginaw, may be the closest, it is clear that they are but a small part of the Bay's condition.



The area can also be impacted by activities in other countries. Some contaminants have been found in the Great Lakes which have travelled with the air currents and were deposited in this area with rainfall.

WATER QUALITY CONCERNS

In September 1988, the Michigan Department of Natural Resources identified several issues affecting the watershed. These included:

- Restrictions on fish consumption
- Loss of fish and wildlife habitat
- Eutrophication (excessive biological growth)
- Degraded fish populations
- Beach closures
- Restrictions on dredging activity

The highest priority objectives of pollution control activities in the Saginaw River and Saginaw Bay were then determined to be:

- reduction of toxic materials levels to the point where fish consumption advisories are not necessary,
- reduction of toxic material levels in the water to meet Michigan's Water Quality Standards, and
- reduction of the Bay's eutrophication level so that it could support a more desirable biological community.

THE PROBLEMS AND THEIR SOURCES

The Watershed's problems fall into three broad categories - nutrients, sediments and toxics. These materials are deposited in the watershed by numerous sources. **Point** sources discharge materials directly into the environment at an identifiable location. The 127 wastewater treatment plants and 87 industries discharging treated wastewater

Michigan Department of Natural Resources • Office of the Great Lakes (517) 791-7367
Saginaw Valley State University Pioneer Annex 9A, University Center, MI 48710 DNR

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directly to surface waters throughout the Saginaw Bay Watershed are such a source. Materials also arrive in the Bay from **nonpoint sources** such as urban and agricultural runoff, spills, sewage overflows, soil erosion, dredging, landfill seepage and the atmosphere. It is estimated that runoff contributes considerably more materials of concern to the Bay than discharges from municipal and industrial sources.

Excess nutrients causes **cultural eutrophication** to occur when they reach surface waters. This results in abundant plant and algal growth. As the plant material dies and settles to the bottom of the water, it decays and depletes the oxygen needed by fish and other aquatic life. Thick growths of algae also reduces the depth of sunlight penetration into the water column. This inhibits the growth of submerged aquatic plants needed by fish and other animals for food and shelter. Eutrophication has also caused organic debris to be deposited along the Saginaw Bay shoreline, especially near Bay City State Park. This debris is unsightly and its decomposition results in unpleasant odors and limits use of beaches.

One way that nutrients enter the water is through over-application of fertilizers and manure on farm fields. Urban households also contribute to the problem when fertilizers are over-applied to lawns and gardens.

A second major problem in the watershed is **sedimentation.** This occurs when large quantities of soil enter our waterways through wind and water erosion. Some soil erosion occurs naturally, but man's activities have greatly accelerated these processes. Erosion occurs when natural vegetation is removed from the land and the topsoil is left bare. Erosion is usually the result of poorly managed croplands, construction sites, surface mining, urban and rural streambanks and logging roads.

Erosion results in sedimentation that clouds the water, blocks off sunlight from aquatic plants, clogs fish gills, and covers fish eggs and spawning habitat. Soil erosion is also associated with costly dredging of shipping channels to remove the sediment buildup.

Toxic substances are also major pollutants in the Saginaw Bay Watershed. These include PCBs, dioxins, furans, chlorinated organic pesticides and heavy metals such as cadmium, chromium, copper, lead, nickel and zinc.

The primary sources of these contaminants appear to be the atmosphere, sediments, historical municipal and industrial point sources, combined sewer overflows and agricultural practices. The atmosphere has been estimated to contribute 53 kg/year of PCB's to the Saginaw Bay compared to about 4 kg/year for all other known point sources.

Contaminated sediments occur throughout the length of the Saginaw River and in Saginaw Bay's depositional zones. It is estimated that 3.7 metric tons of PCBs remain in the active sediment zone of the inner Saginaw Bay.

WHAT YOU CAN DO!

As a homeowner you can:

✓ Practice proper disposal of household hazardous wastes--don't pour household toxics, paints and cleaners down your drains. Choose nontoxic alternatives.

✓ Plant groundcover, shrubs and trees in your yard to minimize runoff into nearby storm drains or streams.

As a farmer you can:

✓ Work with your conservation district to set up best management practices (BMP's) for water pollution prevention.

As a municipal official you can:

✓ Ensure that your ordinances provide the tools needed to guide growth in your area.

As an industrial company you can:

✓ Help explore and implement best management practices for your wastes.

As a watershed resident you can:

✓ Join others conducting citizen monitoring for local waterways,

✓ Work with your municipal zoning boards to plan and guide development,

✓ Look for pollution problems and report them to the appropriate authorities,

✓ Participate in the Watershed Council's "Adopt-A-Stream" program and help protect a waterway of special concern to you,

✓ Become informed about environmental activities in your local area.

For additional information contact:

DNR, Saginaw Bay National Watershed Initiative	(517) 791-7367
Saginaw Basin Watershed Council	(517) 791-7367
Saginaw Basin Alliance	(517) 791-7341

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SAGINAW BAY WATERSHED

THE WATERSHED

The **Saginaw Bay Watershed** consists of the entire land area and waterways which drain into Saginaw Bay. The word watershed may be interchanged with basin. Thus the terms "Saginaw Bay Watershed" and "Saginaw Bay Basin" refer to the same area.

The Saginaw Bay Watershed is the largest in Michigan. It includes all or portions of 22 counties. The Watershed consists of three major subwatersheds including the Saginaw River Basin, East Coast Basin, and West Coast Basin. Each of these are made up of even smaller subwatersheds.

Saginaw River Basin: the land area whose waterways include the far-reaching Tittabawassee, Cass, Shiawassee and Flint River systems. These rivers converge to create the 22-mile long Saginaw River which accounts for approximately 75% of the water input to the Bay.

East Coastal Basin: predominently consists of the Pigeon, Pinnebog, Sebewaing and Quanicassee Rivers; Bird and Shebeon Creeks; Taft, Columbia and Allen Drains.

West Coastal Basin: includes the Tawas, Au Gres, Rifle, Pine, Pinconning and Kawkawlin Rivers; Big and Saganing Creeks.

STATISTICS

- Saginaw Bay includes all the water inside an imaginary line drawn from Au Sable Point to Point Aux Barques.

- The Bay covers 1,143 square miles with 240 miles of shoreline.

- The Bay is divided into an inner and outer bay based on its natural configuration and depth. The inner bay averages 15 feet deep while the outer bay averages 48 feet. Circulation generally flows counterclockwise with an average flushing time of 186 days.

- The Saginaw Bay Watershed is the largest drainage basin in the state. It covers over 8,700 square miles in 22 counties or about 15% of Michigan.

- The Saginaw Bay Watershed is home to approximately 1.4 million people.

- There are over 175 inland lakes within the watershed and about 7,000 miles of rivers and tributaries.

- Land use in the watershed consists of:

Agriculture	46%	Forest	29%
Open lands	11%	Urban	8%
Wetlands	4%	Water	2%

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FLORA AND FAUNA

The most outstanding habitat feature of the Saginaw Bay Watershed is the expansive coastal wetlands of the Bay itself. They make up the largest remaining freshwater coastal system in the nation, covering approximately 15,000 acres.

Saginaw Bay is an important waterfowl and bird migration resting place. Each year more than 3 million waterfowl migrate through this Great Lakes area. Bald eagles, peregrine falcons, caspian terns, egrets, herons, tundra swans and many other species can be observed during their migratory flights.

In addition, designated wildlife areas occur over much of the basin. These include the Shiawassee National Wildlife Refuge, Tobico Marsh, Nayanquing, Fish Point, Wigwam and Wildfowl Bays. These and other areas contain thousands of acres that provide habitat for bitterns, black terns, ospreys, canada geese, pheasants, muskrats, minks, raccoons, red foxes and white-tailed deer plus numerous insects and amphibians.

The watershed has 138 plant and animal species that have been identified as endangered, threatened or of special concern. Many are associated with the coastal wetlands.

RECREATION

The Saginaw Bay area, particularly the five coastal counties, is a major tourism and water recreation center. The Bay is used extensively for pleasure boating, swimming and water skiing. When it comes to boating, Michigan ranks first in the nation with more than 850,000 registered boats. Over 50% of the boats are within 100 miles of Saginaw Bay!

More than 1 million visitors flock to one of four state parks located on the Bay to camp, swim, hike, bike, picnic, birdwatch and just enjoy the great outdoors each year.

However, the most popular recreational activity around Saginaw Bay is undoubtedly sport fishing. There are over 90 species of fish including walleye, perch, salmon and trout found in the watershed. The Saginaw Bay walleye and perch fisheries have become nationally recognized.

WATER

The Bay is a major water source for a variety of uses. Agriculture, industry and residents rely on the Bay for irrigation, electrical power generation, industrial processes and drinking water.

Other communities and residents of the watershed rely on groundwater for their water supply.

COMMERCE

The regional economy is centered around agriculture, industry, recreation and forestry. The agricultural community produces sugar beets, corn, dry beans, barley, wheat and potatoes. Dairy, hog, poultry, and beef cattle are also raised in the watershed. Industry is dominated by automobile manufacturing and it's related activities. Forestry provides additional economic opportunities with the national and state forests.

The Saginaw River and Bay are important to domestic and international waterborne commerce. Commercial freight traffic in the Saginaw River totalled more than 4.5 million tons during the 1990 shipping season. Bay City and Saginaw serve as the major ports connecting midwestern agricultural and mining industries to other Great Lakes and international ports.

FOR MORE INFORMATION CONTACT:

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SAGINAW BAY WATERSHED WETLAND FACTS

Wetlands can be found throughout the Saginaw Bay Watershed. Historical documents indicate that there were nearly 37,000 acres of emergent marsh around Saginaw Bay before development of the area. Only about 15,000 acres of these coastal areas still remain and make up the largest freshwater coastal system in the nation. More than half of the watershed's original wetlands have been drained, filled, altered or destroyed. Currently, approximately 4% of the watershed consists of wetlands. Many of these wetlands exist on public lands such as national wildlife refuges, game areas, and state parks.

There is no typical wetland. They vary in size, shape and type because of differing climate, vegetation, soils and hydrologic conditions. Wetlands are known by various names including marshes, bogs, swamps, and wet meadows. Wetlands include forested floodplain swamps, cattail-lined marshes, and shallow potholes. They can extend for miles or cover less than an acre.

The value of wetlands and their overall environmental importance have been recognized with the increased awareness of ecological processes. Wetlands benefit the environment and humans in numerous ways. They are used as fish and wildlife habitat, stormwater retention and flood control, water quality improvement, recreational use and aesthetic qualities, and wastewater treatment.

HABITAT

Wetlands offer a diversity of habitats for as many as 600 wildlife species and 5,000 plant species. At least 45 percent of the nation's listed endangered animals and 26 percent of the listed endangered plants survive only in wetlands or rely on them during part of the year. The watershed has 138 animal and plant species that have been identified as being endangered, threatened, or of special concern.

Coastal wetlands provide habitat for spawning and nursery areas for fish such as northern pike, large-mouthed bass, and muskies. These areas help support an annual multimillion dollar commercial and recreational fishing industry.

Many types of creatures depend on wetlands for nesting and feeding areas. White tailed deer, muskrats, minks along with frogs, snakes, turtles, salamanders, and millions of insects make wetlands their home. Food crops grown in wetlands such as wild rice, cranberries and blueberries benefit both wildlife and humans.

A variety of birds including ducks, red-winged blackbirds and a large number of songbirds also feed, nest and raise their young in wetlands. Wading birds, such as herons and egrets, along with hawks, osprey and kingfishers almost exclusively feed in wetlands. Migratory birds such as Canada geese and sandhill cranes utilize wetlands for feeding and resting points during their long journeys.

FLOOD PROTECTION

Wetlands have the ability to store excess water and reduce the damage to adjacent and downstream properties from flood waters. This is done by reducing the amount of water and by reducing the flow rate of surface waters.

WATER QUALITY

One of the most important functions of wetlands is their ability to help maintain and improve the water quality in our lakes, rivers and streams. Wetlands act as a natural filter, slowing water velocity and thus trapping the pollutants that flow through them. Not only do they catch silts and sediments, but they also collect the pesticides and nutrients that are carried with the runoff. Shoreline wetlands also reduce erosion by absorbing some of the wave action.

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RECREATION AND AESTHETICS

Wetlands provide open space and beauty for urban and non-urban areas. They also provide opportunities for fishing, canoeing, hiking, bird watching and sightseeing.

WASTEWATER TREATMENT

Wetlands have been used as part of wastewater treatment systems in various parts of the country. Engineers have utilized natural wetlands and have constructed wetlands in their designs. Wetlands are being considered more often as an alternative treatment system as communities continue to expand.

WETLAND PROTECTION MEASURES

Legislation has been passed to help preserve wetland ecosystems since they provide significant benefits to our society. However, we need to continue replacing wetland areas that we have already destroyed. Wetland restoration and creation are two ways that can slow the loss of wetland acreage.

RESTORING WETLANDS

Wetland restoration is the attempt to return an altered wetland back to its natural state or condition. Restoration may involve discontinuing agricultural practices, eliminating drainage systems or adding a more diverse plant community.

Locating and identifying altered wetlands is the first step of the restoration process. It may be difficult to detect a wetland that has been converted. Your local soil and water conservation district office can provide assistance in identifying wetlands. They have soils information and aerial photographs of your area. It is important to compare photos from several different years since drained wetlands show up differently under various water patterns.

Sometimes it is difficult to determine the original characteristics and the restoration potential of a drained wetland. In these cases, it is necessary to inspect neighboring wetlands and evaluate their type, depth and size. This will help determine what type of wetland restoration that will most likely succeed in your area.

Wetland plans should include varying water depths to provide diverse habitat for wildlife. In areas with no existing wetlands, experts prefer to have both shallow areas with around six inches of water and deep sections with up to three feet or more of water.

CREATING WETLANDS

Wetland creation is the establishment of a wetland where one did not exist before. This usually involves excavation of upland areas, construction of basins, and designing hydrologic features to ensure a saturated condition. Wetland creation efforts are usually more expensive than wetland restoration projects.

Created wetlands are used to protect waterbodies from excess sediment, nutrients and pesticides. Wetlands also are constructed to treat runoff and wastewater from urban areas, mining areas, livestock production facilities, and agricultural lands.

BEFORE BEGINNING YOUR PROJECT

Wetland restoration and creation efforts need to be carefully planned. The end use of the area will guide how the project should be built and managed. Contact your District DNR Land and Water Management Division office or your local soil and water conservation district for information on wetland protection, restoration, and creation.

FOR ADDITIONAL INFORMATION CONTACT:

DNR, Saginaw Bay National Watershed Initiative	(517) 791-7367
Saginaw Basin Watershed Council	(517) 791-7367
Saginaw Basin Alliance	(517) 791-7367

Note: Some of the above information was produced by the Conservation Technology Center.

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A PHOSPHORUS DIET FOR SAGINAW BAY

Shifts in the types and numbers of both aquatic plants and animals occur during a process known as **eutrophication**. This natural process involves an increase of organic and mineral nutrients in our water resources over a long period of time.

Phosphorus is an important nutrient in this process. It is required by living organisms in relatively large quantities and is usually less available than other nutrients required for life. The amount of available phosphorus determines how much plant life can be supported. More plants are produced when more phosphorus is present.

PHOSPHORUS AS A POLLUTANT

Cultural eutrophication is the result of human activities which allows more nutrients to enter the water than desirable. Phosphorus normally attaches itself to soil particles. When erosion occurs, phosphorus is carried into our lakes and rivers along with the sediment. Thus when construction, forestry and agricultural practices do not control surface runoff, more phosphorus is carried into our water. Phosphorus can also get into our groundwater and surface water from septic system overload. In those situations, the soil in the drain fields can no longer hold additional phosphorus and the excess is leached into the water. Municipal and industrial sewage systems may also discharge phosphorus into surface waters.

Excess loadings of phosphorus to the Bay are harmful to most aquatic life. The increase of plant growth lowers the oxygen supply in the water for fish and other aquatic life. Extreme oxygen depletion occurs after blooms of floating algae sink to the lake bottom and begin decaying.

Not only is the biocommunity affected by the excess phosphorus, human use of the water is changed. Water drawn from an eutrophic area may be more difficult to use for public water supplies since the residue of plant life adds to the cost of treatment and may cause a strange water taste. Recreational use of the lakes is also affected. Who wants to swim in weeds? Aesthetic water qualities are affected because the water often changes to a pea green color. Eutrophication also reduces fishing opportunities, especially of species such as lake trout which like oxygen rich waters.

Although the role of phosphorus is well documented, questions remain on the amount of phosphorus entering surface waters that contribute to eutrophication.

Years ago, some scientists believed that once an area had been allowed to become eutrophic, it was not possible to reverse the trend. Recent experience with Saginaw Bay and Lake Erie indicates that reduction in phosphorus loadings can reverse the trend of decreasing water quality.

SAGINAW BAY PROGRAM

In 1970, a six year major Great Lakes water quality study was completed. Nutrient enrichment in Saginaw Bay was identified as a water quality problem. This was believed to be caused by excessive phosphorus loading. The Environmental Protection Agency (EPA) and the Michigan Department of Natural Resources responded by: (1) setting target phosphorus loads to the Bay from the watershed, (2) beginning both phosphorus point and nonpoint source control programs, and (3) calling for additional studies of nutrient related water quality deterioration.

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Michigan set a target load reduction of 225 metric tons of phosphorus for Saginaw Bay. Existing point and nonpoint source phosphorus control programs are leading to this necessary reduction.

REDUCTIONS FROM POINT SOURCES

Municipal discharges over 1 million gallons per day are limited to 1.0 milligram per liter (mg/l) effluent phosphorus concentrations. Additional reductions from industrial and municipal discharges with existing treatment facilities capable of discharging a phosphorus concentration less than 1 mg/l will be required where feasible.

Saginaw Bay Watershed municipalities have invested over 400 million dollars since 1972 to improve waste water treatment facilities. This expenditure has resulted in significant compliance with the effluent requirement. There has been an 80-90 percent reduction in municipal phosphorus loads. Reductions should continue as communities address their Combined Sewer Overflow (CSO) problems.

In 1977, Michigan banned the use of phosphate detergents. This ban significantly reduced the phosphorus loads to municipal wastewater treatment plants and made it easier for municipalities to achieve lower phosphorus concentrations.

REDUCTIONS FROM NONPOINT SOURCES

In the early 1980's it was estimated that nonpoint sources contributed 52% (347.9 metric tons) of the total annual phosphorus load to Saginaw Bay. Most of this came from agricultural lands. Bay, Huron, Saginaw and Tuscola Counties were designated as priority areas for fertilizer and residue management programs. Techniques such as grassed waterways, conservation tillage, permanent vegetative cover, filter strips, and field windbreaks are part of these programs. Proper management and implementation of techniques has resulted in a phosphorus reduction by 180 metric tons through May 1991.

Progress has been made in improving the Saginaw Bay's Watershed ecosystem by controlling phosphorus levels. However, we need to continue our efforts to further restore and protect the area. Additional education and implementation programs are necessary for the entire Saginaw Bay drainage basin. These efforts should focus on fertilizer management, promotion of conservation tillage, and proper management of animal waste.

If you would like additional information regarding the Saginaw Bay Watershed, contact:

DNR, Saginaw Bay National Watershed Initiative	(517) 791-7367
Saginaw Basin Watershed Council	(517) 791-7367
Saginaw Basin Alliance	(517) 791-7341

Note: This information was in part adopted from the Executive Summary of the United States Phosphorus Reduction Task Force Plans for Phosphorus Land Reductions to Lake Erie, Lake Ontario and Saginaw Bay and 1992 Water Quality and Pollution Control in Michigan Report.

SAGINAW BAY NATIONAL WATERSHED INITIATIVE

COMMUNICATION FACT SHEET

TOXIC SUBSTANCES IN THE SAGINAW BAY WATERSHED

Saginaw Bay's health depends on what goes into it. Like all other ecosystems, life in the Saginaw Bay Watershed exists within an intricate web of interacting and interdependent relationships. Parts of the ecosystem suffer or fail to survive when the ecosystem is stressed by toxic substances.

WHAT IS A TOXIC SUBSTANCE?

Toxic substances are best defined by their effects on living organisms. In the 1978 Great Lakes Water Quality Agreement between Canada and the United States, toxic materials were defined as:

"a substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its off-spring, or which can become poisonous after concentration in the food chain or in combination with other substances."

Toxics are often without color or odor. They have varying effects depending on their chemical structure, concentration and passage into the environment. Substances that appear to be harmless may become more dangerous when they are mixed with other chemicals.

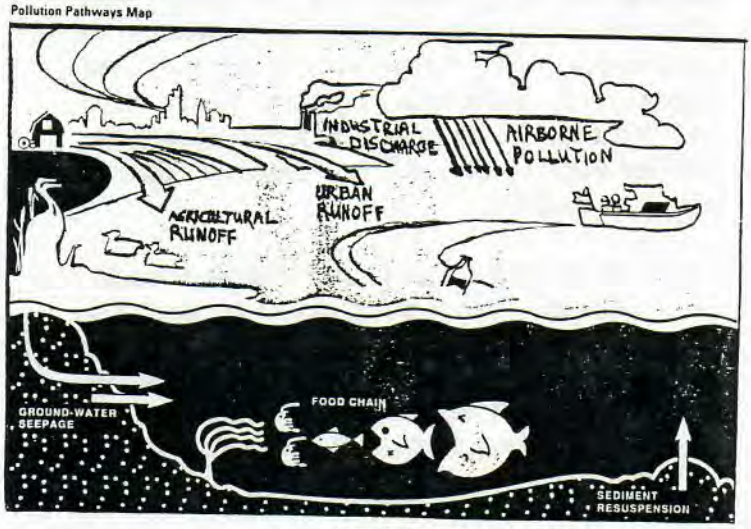
The greatest threat is from those contaminates that do not readily break down and which stay in the environment for a long time. These are referred to as **persistent toxic substances**. They increase the risks of human exposure because they remain in the ecosystem. Over time these chemicals can also mix with other substances and become more potent resulting in damaging human health and large segments of the environment.

WHERE DO TOXICS COME FROM?

Most toxic substances are manufactured by humans and are referred to as being synthetic. Over 70,000 commercial and industrial compounds are now in use. It is estimated that 1,000 new chemicals are introduced each year. These chemicals are found in many products used in our everyday life along with industrial processes. They include pesticides, insulating materials, household cleaners, paints, varnishes and by-products of production mehtods. Some toxics are found naturally and present problems when their concentrations become too high.

Contaminants enter the Saginaw Bay Watershed by several means. **Point sources** include sites which have direct discharges into rivers and streams. Industrial and municipal discharge pipes are two examples. **Nonpoint sources** involve areas where the origin of materials cannot be specifically identified. Surface runoff from agricultural and urban land is an example. Many chemicals also reach the Bay as **airborne pollutants**. Chemicals banned from use in the United States, but used elsewhere, can be found in the Great Lakes region due to travelling here with the wind.

Pollution Pathways Map



Graphic from EPA's Great Minds? Great Lakes!

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WHAT ARE THE CONCERNS?

Some persistent toxic substances become part of the food chain. The contaminates build-up in plant and animal tissue in a process known as **bioaccumulation**. Thus, concentrations of some chemicals can be a million times higher in fish than the water in which it lives. Species at the top of the food chain, such as lake trout and fish-eating birds, suffer adverse effects from these higher concentrations. Humans can also be affected if they consume enough contaminated fish and wildlife.

Between 1969 and 1972 legislation was enacted to restrict or ban the production and use of some of these persistent substances, including dieldrin, heptachlor, DDT, PCBs, lead and mercury. As a result, environmental levels of these contaminants declined significantly and concentrations in fish and fish-eating birds also decreased. Unfortunately, contaminants are still present which can cause human health problems and detrimental environmental impacts. Due to limited space they cannot be listed in this summary but there are various publications where the reader can get more information.

WHAT CAN WE DO?

Each of us enjoys the benefits that modern society provides by using products that are created with chemicals--from colored paper to televisions to automobiles. Yet many of these products and byproducts can be harmful to the environment and to us. What can we do to stop toxic substances from entering Saginaw Bay and its Watershed? Several things are possible.

- Support federal, state, and local governments that are: implementing control measures and programs that clean up contaminated areas; identifying and eliminating sources of persistent toxic substances; and preventing further contamination of the environment.
- Work with citizen organizations that protect our natural resources.
- Reduce your use and consumption of products that are toxic or result in toxic substances being created. By making wise purchases we can make a difference!
- Encourage industries to continue their voluntary pollution prevention efforts by writing to them and purchasing goods from companies that incorporate environmental protection measures. Industries can substitute less hazardous materials for highly toxic and persistent substances, stop production of certain products, and utilize proper disposal methods.

Learn more about the issues facing Saginaw Bay and its watershed. These issues affect your home and health.

FOR MORE INFORMATION:

Contact your local Health Department, MSU Extension Office and library for additional information about household hazardous wastes and other toxic materials.

If you would like additional information regarding the Saginaw Bay Watershed, contact:

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SAGINAW BAY NATIONAL WATERSHED INITIATIVE

COMMUNICATION FACT SHEET

CONTAMINATED SEDIMENTS IN THE SAGINAW RIVER AND SAGINAW BAY

Bottom sediments in portions of the Saginaw River and Saginaw Bay are contaminated with toxic organic and metal compounds. These contaminated sediments are a suspected source of toxic materials to the aquatic life in the area and may have contributed to the issuance of fish consumption health advisories in Saginaw River and Saginaw Bay. The general locations of the most contaminated sediments are known. However, the areal extent and volume of material has only been approximated.

To address the sediment problems in the Saginaw River and Saginaw Bay and other highly contaminated sites within the Great Lakes Basin, the U.S. Environmental Protection Agency has undertaken an intensive study. This program is known as the **Assessment and Remediation of Contaminated Sediments** or **ARCS**. The ARCS program is developing and testing assessment and clean-up alternatives for contaminated sites.

WHERE DID ARCS COME FROM?

The 1987 amendments to the Clean Water Act authorized the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO) to conduct a 5-year study and demonstration project on the treatment of toxic pollutants in bottom sediments of highly contaminated sites on the Great Lakes. In response, GLNPO launched the ARCS program.

Five priority areas were selected for demonstration projects:

1) Saginaw Bay, Michigan
2) Sheboygan Harbor, Wisconsin
3) Grand Calumet River, Indiana
4) Ashtabula River, Ohio
5) Buffalo River, New York

THE SAGINAW RIVER/BAY ARCS PROJECT

The Saginaw River/Bay project will try to:

- assess the nature and extent of bottom sediment contamination,
- evaluate and demonstrate advanced treatment technologies, and
- provide guidance to determine the extent of the problem and identify cleanup alternatives.

Many complicated questions need to be addressed to assure cleanup of the River and Bay. These include:

- Are the sediments contaminated with substances that are harmful to plants, animals and humans?
- Are the environmental problems so great that some action is urgently needed?
- What cleanup alternatives are available? What are their limitations? How effective are they likely to be?
- What are the possible adverse impacts and costs of the cleanup itself?

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ARCS is NOT a cleanup program and will not solve the contaminated sediment problems at the five priority areas mentioned. However, the program will provide valuable information that can be used by other programs to actually solve the identified problems.

TECHNOLOGY USED

The Saginaw River and Bay demonstration is using a hydrocyclone particle separation process developed by Bergmann USA. Hydrocyclones are commonly used in mining and mineral processing industries to separate slurries into sets of different sized particles. In this demonstration, a series of hydrocyclones will be used to separate the sediments into two major fractions: sand and fine-grained particles.

The separation process can greatly reduce the volume of contaminated material. Sediment contaminants have been known to "stick" to the fine-grained particles (silts and clays). Therefore, if the sediments are separated, the fine-grained material will contain most of the contaminants and the sand will be relatively clean.

The Saginaw River and Bay sediments are mostly made up of sand with small amounts of silts and clays. The hydrocyclone process may be able to reduce the amount of contaminated material needing treatment and disposal. For example, if 100,000 cubic yards of sediment that is 90% sand and 10% silts and clays is separated, we would end up with 10,000 cubic yards of contaminated sediment after the process.

An additional benefit of the reduction in the amount of contaminated material is that we have the potential to produce large amounts of clean sand that can be used for a number of beneficial purposes such as beach nourishment, construction fill, and other uses.

DEMONSTRATION PROJECT

Around 300,000 cubic yards of sediment has been dredged from the Saginaw River and transported to the Saginaw Bay Confined Disposal Facility (CDF). These sediments were fed into the treatment process. As the sands and fine-grained particles separated, they were collected in different areas of the CDF.

Samples were collected from the hydrocyclone throughout the treatment process. They are now being analyzed to see if the particles are being separated by size, and if the contaminants stayed with the silts and clays.

The end goal of the ARCS program is to develop guidelines that can be used by environmental managers throughout the Great Lakes to make cost effective, environmentally sound decisions about how to deal with contaminated sediments.

A final report on the Saginaw River/Bay demonstration is expected the summer of 1993. For more information on the ARCS program, contact EPA Region 5, Office of Public Affairs at (312) 886-7478 or GLNPO at (312) 353-0117.

IF YOU WOULD LIKE ADDITIONAL INFORMATION REGARDING THE SAGINAW BAY WATERSHED, CONTACT:

DNR, Saginaw Bay National Watershed Initiative	(517) 791-7367
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SAGINAW BAY NATIONAL WATERSHED INITIATIVE

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SOIL EROSION AND SEDIMENTATION IN THE SAGINAW BAY WATERSHED

Soil erosion and sedimentation are major issues in the Saginaw Bay Watershed. These concerns originate in both rural and urban areas and their impacts are widespread.

Sedimentation occurs when excessive quantities of eroded soil enter our waterways through wind and water erosion. Erosion occurs naturally, but human activities have greatly accelerated soil erosion. Erosion occurs whenever we remove natural vegetation from the land leaving the topsoil bare. Soil erosion can occur from different land uses. These include:

Agricultural Erosion refers to soil lost from fields, pastures. The runoff from these lands can carry fertilizers, pesticides and sediment into rivers, streams and lakes. The monetary value of nitrogen, phosphorous and potassium that is lost with soil erosion was estimated between $3.00 - $6.00 per ton of soil. Reduced productivity can range from 10-20% reduction in yield, with severe erosion, dependent on the soil properties.

Urban/Transportation Erosion, on per unit basis is extremely significant. Up to 90% of the urban soil erosion is attributable to the lands under development, for example, construction and roads. Without proper planning construction sites can erode at a rate of 200 times greater than erosion from cropland and 2000 times greater than erosion from woodland. The replacement of relatively permeable land area with large impervious surfaces and lined drainage channels or storm sewers has led to increased water runoff and soil erosion, and decreased infiltration and groundwater recharge. The large volumes of water from urban runoff have caused flooding, soil erosion, and siltation problems.

Watercourses includes hydrologic modifications such as: dredging, channelization and impoundments can significantly add to the volume of erosion. Streambank erosion occurs naturally from impacts of wave action and increased streamflows. Bridge construction, recreational traffic, timber harvesting, and grazing also cause steambank erosion.

Forestland Erosion is accelerated by recreational vehicle use, access road construction and by some timber harvesting operations. As in agriculture, a small percentage of the forestlands are contributing the majority of the soil erosion. By implementing forest management practices, soil erosion, runoff and flood potential can be reduced.

Soil generally erodes from construction sites faster than from farmlands, woodlands, or streambanks.

RISK FACTORS

We're all at risk when the quality of our water and the productivity of our land are compromised by excessive soil erosion. For example, if you are a farmer, soil erosion can wash away valuable topsoil and nutrients. If you are a shoreline property owner, erosion can cause property damage, flooding expenses and costly drainage system problems.

Our entire ecosystem is at risk because:

- Eroded soil can carry nutrients, such as phosphorus, to surface waters. Eutrophication can result if fertilizer runoff is excessive. This process can lead to stages of: excessive weed growth, thereby lowering oxygen content, and finally, killing fish.

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• Fish habitat is destroyed when sediment fills spaces between rocks and gravel in the streambed, smothering fish eggs and other aquatic animals.

• Water quality is degraded by increased levels of sediments and nutrients that drain into Saginaw Bay.

• Toxic contamination can occur when sediment transports chemicals, such as herbicides, oils and greases from farmland and streets into our rivers and lakes.

• Streambank vegetation is uprooted and the banks collapse when runoff increases in volume and velocity.

ECONOMIC IMPACTS

A multi-million dollar sport and commercial fishing industry is impacted by the effects of soil erosion and sedimentation.

Agricultural productivity, in the Saginaw Bay Watershed, is reduced as over 8,000,000 metric tons of topsoil erode from cropland each year.

Dredging of sediment from recreational and commercial harbors of the Saginaw Bay costs the public tens of millions of dollars annually. Disposal of the spoils is another huge expense.

Flooding costs increase when erosion impacts reduce the capacity of the watershed to absorb precipitation, and when drainage ways are plugged with sediment.

Maintenance costs increase for drainage systems, ditch and road operations that are impaired by the effects of sedimentation.

Recreational opportunities are impaired by increased sediment and nutrient loadings that often cause nuisance weed growth and high bacteria counts.

TAKING ACTION

Partnerships are emerging throughout the Saginaw Bay Watershed to solve land and water resource problems. Federal agencies such as the USDA Natural Resources Conservation Service (NRCS) and the Consolidated Farm Service Agency (FSA) are working with local land owners to reduce soil erosion. NRCS provides technical assistance while FSA provides financial support.

Michigan's Department of Natural Resources is responsible for the Nonpoint Source Control Program, and Public Act 347 Construction Site Soil Erosion & Sedimentation Control Program.

At the local level, Soil and Water Conservation Districts and USDA's Resource Conservation & Development (RC&D) Areas provide assistance to land owners. These organizations help control soil erosion by coordinating projects in the field.

WHAT YOU CAN DO

• If you are a farmer, contact your local conservation agency for information on soil erosion, sedimentation and water quality protection programs available in your area.

• If you are a developer, make sure proper measures are taken to prevent construction site erosion and off-site sedimentation.

• If you are a local official, ensure that local zoning and construction site erosion ordinances are adequate.

• Watershed residents should consider the impact of their actions to ensure that soil erosion is kept to a minimum.

For additional information contact:

DNR, Saginaw Bay National Watershed Initiative (517) 791-7367

SAGINAW BAY NATIONAL WATERSHED INITIATIVE

COMMUNICATION FACT SHEET

ANIMAL ACCESS

THE PROBLEM

Many livestock producers allow their stock unlimited access to water channels. This can cause many pollution and erosion problems including sedimentation of the river bottom and increased nutrient loading in downstream lakes and reservoirs. Here is a list of several common perceptions about livestock access to stream and some factual answers as to why these perceptions may not be sound.

PERCEPTION - My cattle don't damage the streambank and cause erosion. It is just a natural process.

FACT - The hoof action from cattle traffic can cause sever erosion. A bank recession rate of only one inch per year on 1/4 mile of average stream bank amounts to 30 tons of soil per year. This amount of soil also puts 198 pounds of phosphorus and 399 pounds of nitrogen in the stream per year.

PERCEPTION - The stream bank through my property looks much neater with the brush grazed off.

FACT - Vegetation on the streambank helps to hold the soil in place and to filter out nutrients that may wash in from the bank. The presence of brush and trees shades the water to keep it cooler which promotes the presence of more desirable species of game fish.

PERCEPTION - What little manure my cattle deposit in the stream damages nothing. After all, fish, deer, and all manner of wildlife deposit waste in the water.

FACT - A typical cow will produce between 60-70 pounds of manure and urine in a day. A cow deposits most of his/her waste matter when he/she is up and active. (i.e., drinking from the creek, walking across the creek to the barn). This amount of waste can usually contain about 0.5 pounds of phosphorus and 2 pounds of nitrogen.

PERCEPTION - This my land and I will do what I want with the water flowing through it.

FACT - The water in the stream is just passing through and it is your moral, ethical and legal responsibility to do what you can to protect it. It is your right to a reasonable use of the water for livestock or crops but it is also your responsibility to have it leave your property in at least as good a condition as it entered. Most people would agree that a high sediment load or large amount of fecal material in the water would impair its use and enjoyment by downstream residents.

Michigan Department of Natural Resources • Office of the Great Lakes (517) 791-7367
Saginaw Valley State University Pioneer Annex 9A, University Center, MI 48710 DNR

PR 0950 (4/93)

APPENDIX B

MAPS AND TABLES

FOR

SAGINAW BAY WATERSHED

Dr. Robert S. Yuill
Department of Geography
Central Michigan University
Mt. Pleasant, MI. 48859

MAPS AND TABLES FOR THE SAGINAW BAY WATERSHED

MAP - Saginaw Bay Watershed:

This is a base map for teachers and students to plot their own data. It contains the following: major rivers and streams of the watershed, the watershed boundary, county boundaries (darker lines), township boundaries, and settlements (cities, villages, and some Census Designated Places)

MAP - Major Rivers and Tributaries:

This map identifies the major rivers of the watershed and the counties in which they are located. Townships and settlements are not shown so the river system can be more clearly seen.

MAP- Drainage Basins of the Saginaw Bay Watershed:

The watershed is divided into seven drainage basins (West Coastal, Tittabawassee, Shiawassee, Flint, Cass, East Coastal, and Saginaw) Settlements and townships are shown so that it can be seen exactly in what drainage basin each is located. This can be used in conjunction with the "1990 Population Distribution in Settlements and Townships" data set.

MAP - Populations of Villages, Towns, Cities, and Townships:

This is a visual representation of the population distribution. Since both surface and groundwater are affected by human activities, this can be used to quickly identify higher impact areas. This also can be used with the 1990 population data set.

MAP - Settlements in the Saginaw Bay Watershed:

This map emphasizes the map view of settlements. They are shown in correct size and shape. One possible use is to examine which settlements affect rivers in a drainage basin. (It can be used in conjunction with Drainage Basin Map and 1990 population data set.)

MAP - Sources of Municipal Water*:

A major concern in any drainage basin or watershed is fresh water for drinking, cleaning, and industrial use. This is obtained from either surface or groundwater. The map shows water sources for selected places. It can be used in conjunction with the agriculture & environmental contamination maps to look at potential vulnerability of water supplies.

*(Although Alma is officially classified as getting water from the Pine River, this really means that the city has a shallow well near the river that can be affected by water from the river.)

MAP - Locations and Capacities of Municipal Sewer Systems:
When sewage is treated in a municipal sewer system, the leftover water often is often discharged into streams or lakes. Although we try to remove as much material as possible, some extra nutrients are included in the leftover water. This map could be used to look at the potential impact on surface water

MAP - Agricultural Land Use:
Another way that humans affect the water is through activities covering large areas (non-point source pollution) such as agriculture. Many farmers have found that some crops may require more water than provided by precipitation, and use well or use surface water. for irrigation. This increases the competition for surface and groundwater. Plowed cropland also contributes sediment in surface waters. In addition, by using agricultural chemicals on large areas some water sources may be contaminated. (This can be used with the "County Data Table.")

MAP - Sites of Environmental Contamination, 1994:
These are Act 307 contamination sites listed in the MDNR April report. Some chemical or substance has been released or spilled on or in the ground. This map can be used to identify high impact areas in the watershed.

MAP - Flint River Subwatershed and its Principal Tributaries.
Settlements of the Flint River; Number of Environmental Contamination Sites in Flint River Basin and Detailed Population Figures for Flint River Subwatershed. This information is enclosed as a example of maps and tables available for all seven subwatersheds of the Saginaw Bay Watershed. Other subwatershed data is available upon request for the following subwatersheds: Tittabawassee River, West Coastal, East Coastal, Cass River, Shiawassee River.

In addition to the maps and tables provided in this directory the following maps and tables are available by request from the Partnership for the Saginaw Bay Watershed, Michigan Geographic Alliance or the Department of Natural Resources, Office of the Great Lakes:

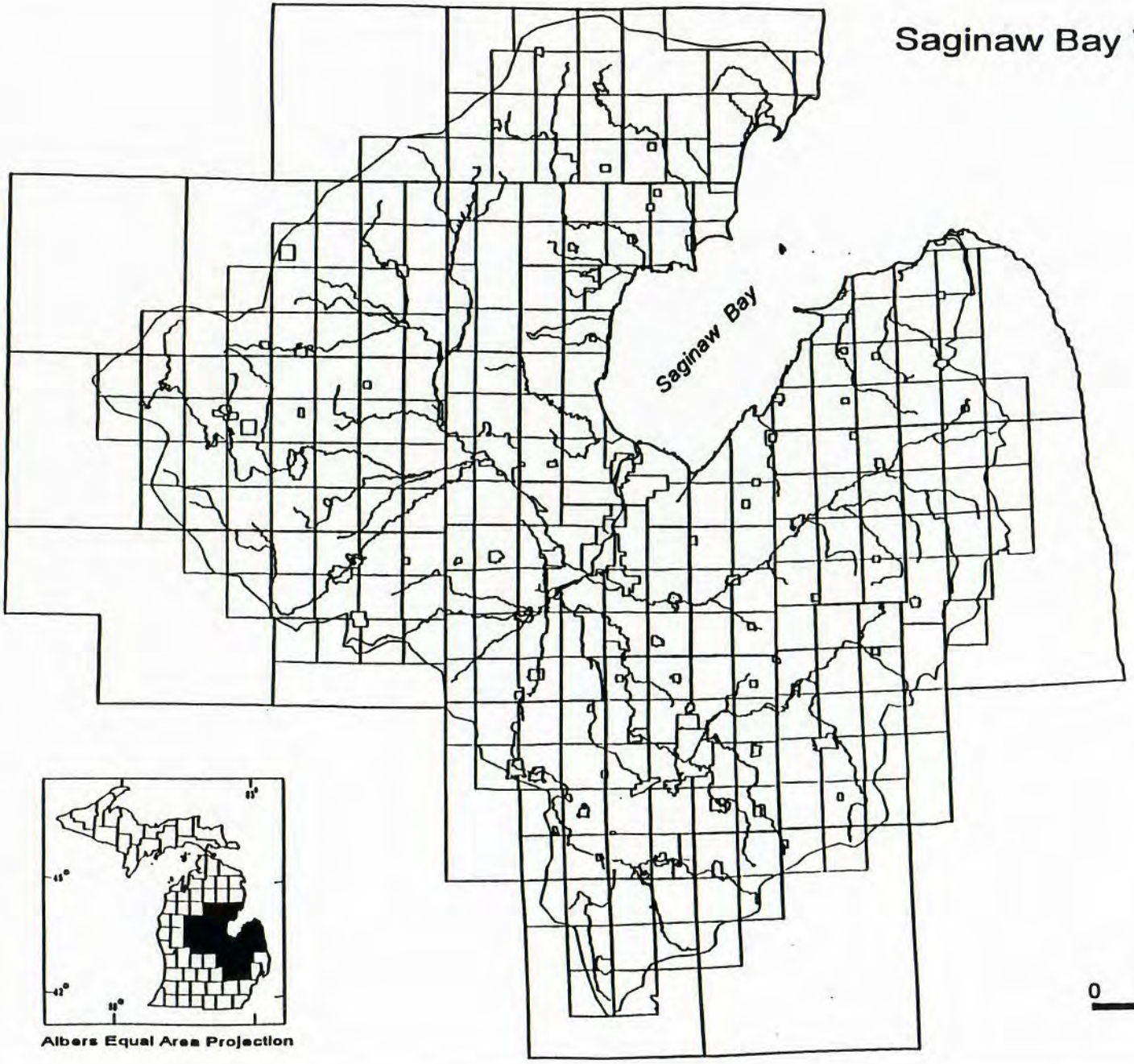
MAP - Use of Insecticides and Herbicides on Agricultural Land:
These agricultural chemicals may wash into streams and rivers and potentially cause problems downstream. This could be used with "County Data Table" to look at concept of non-point source pollution.

MAP - Leaking Underground Storage Tank Sites:
Underground storage of petroleum products is a standard practice. As tanks have aged, many have deteriorated and leaked some of their contents. Since these tanks are underground, detection is more difficult. In some cases a contaminated well has been the first sign.

MAP - Streams for which a Public Health Fish Consumption Advisory was issued in 1991
This is a good example of contamination in one area or at one place affecting another part of the ecosystem - downstream. Not only is the ecosystem affected, but other human activities such as fishing and swimming are affected.

DATA SET - 1990 Population Distribution in Settlements and Townships
This gives the population (1990 census data) for the settlements and townships in each of the 22 counties of the watershed, and the specific drainage basin in which each is located. For townships on the watershed boundary, the portion of that township within the watershed is indicated. For townships or settlements on drainage basin boundaries, the proportion in each basin is shown.

Saginaw Bay Watershed



Albers Equal Area Projection

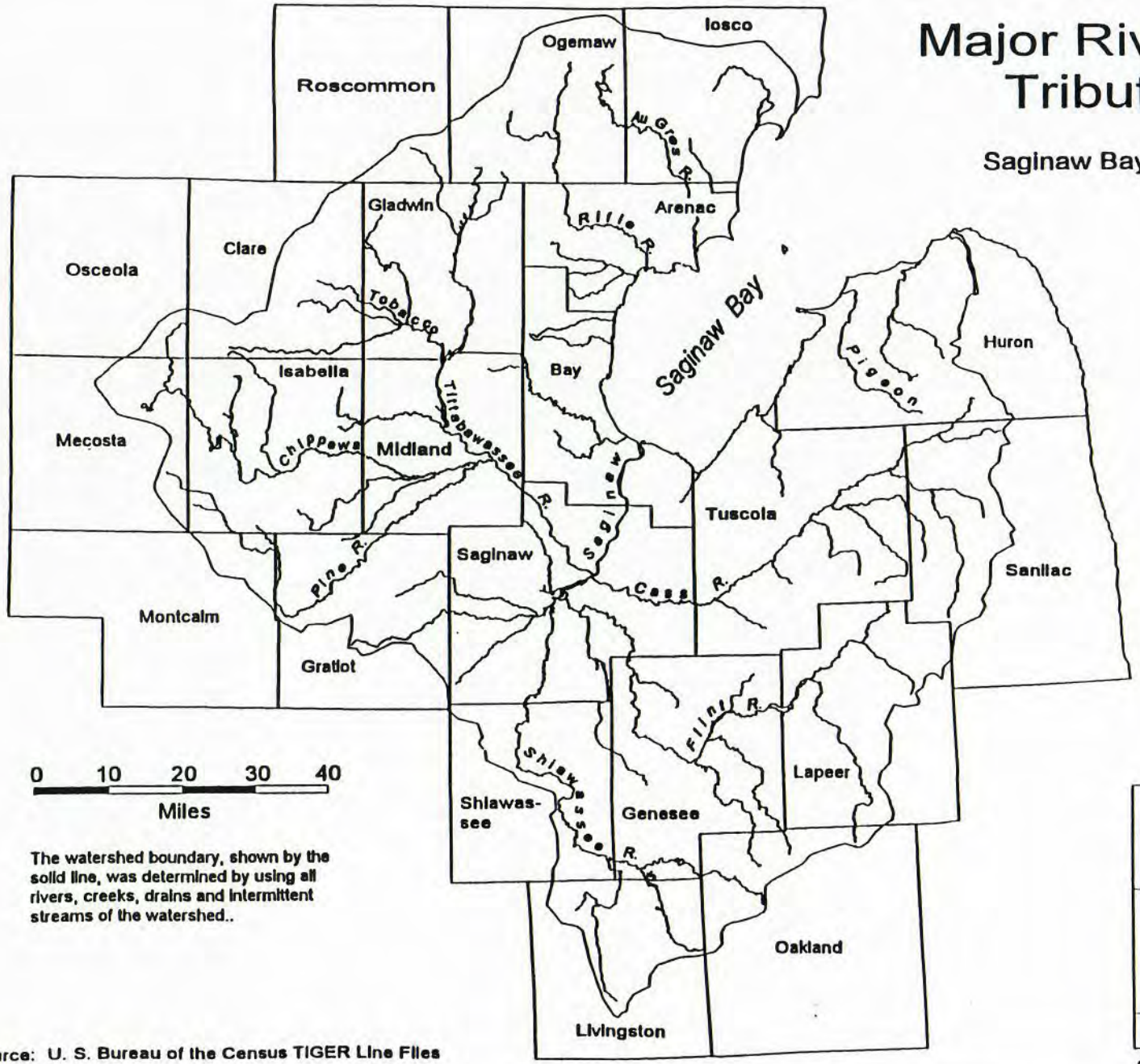
0 10 20 30 40

Miles

Central Michigan University GIS Center

Major Rivers and Tributaries

Saginaw Bay Watershed

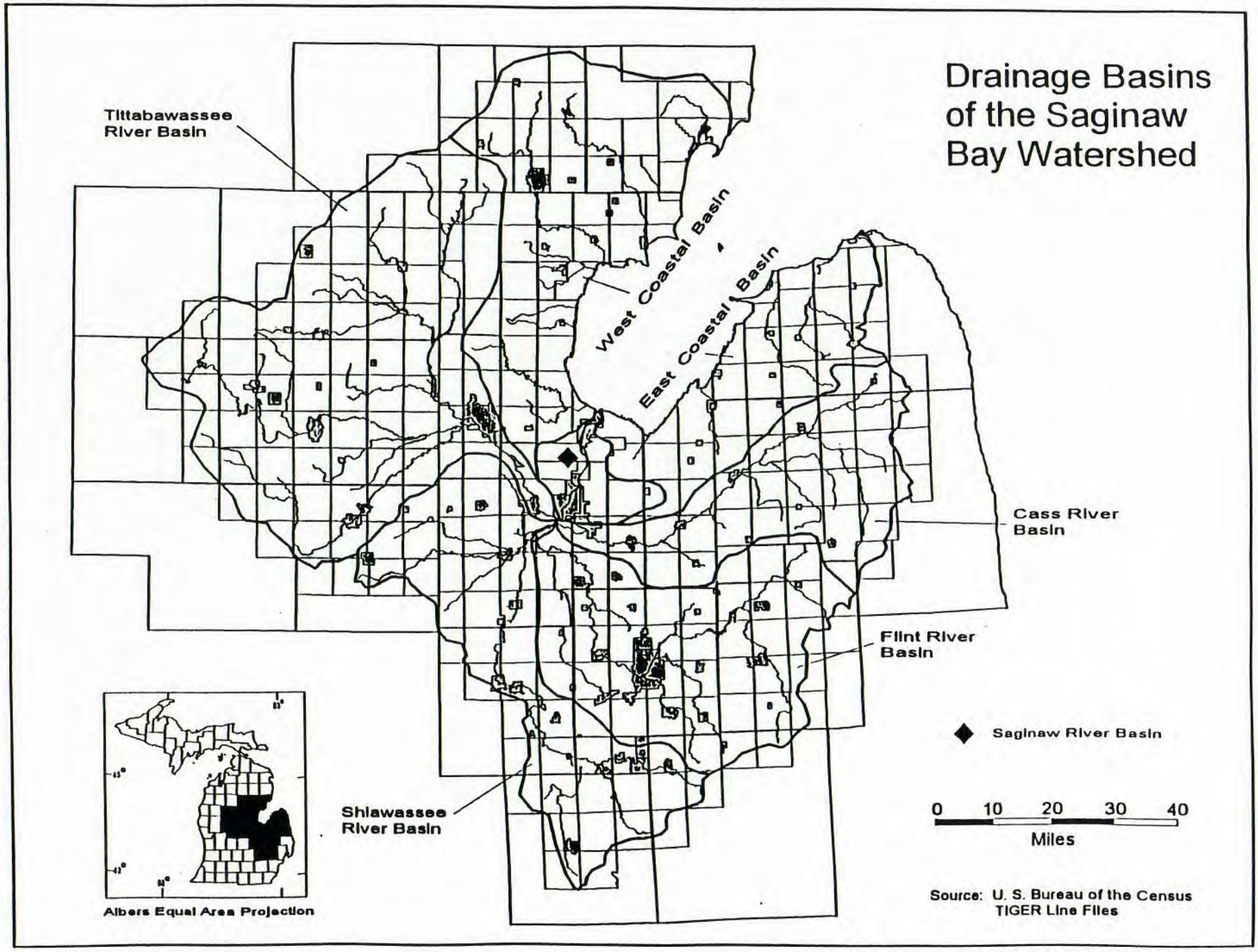


The watershed boundary, shown by the solid line, was determined by using all rivers, creeks, drains and intermittent streams of the watershed..

Albers Equal Area Projection

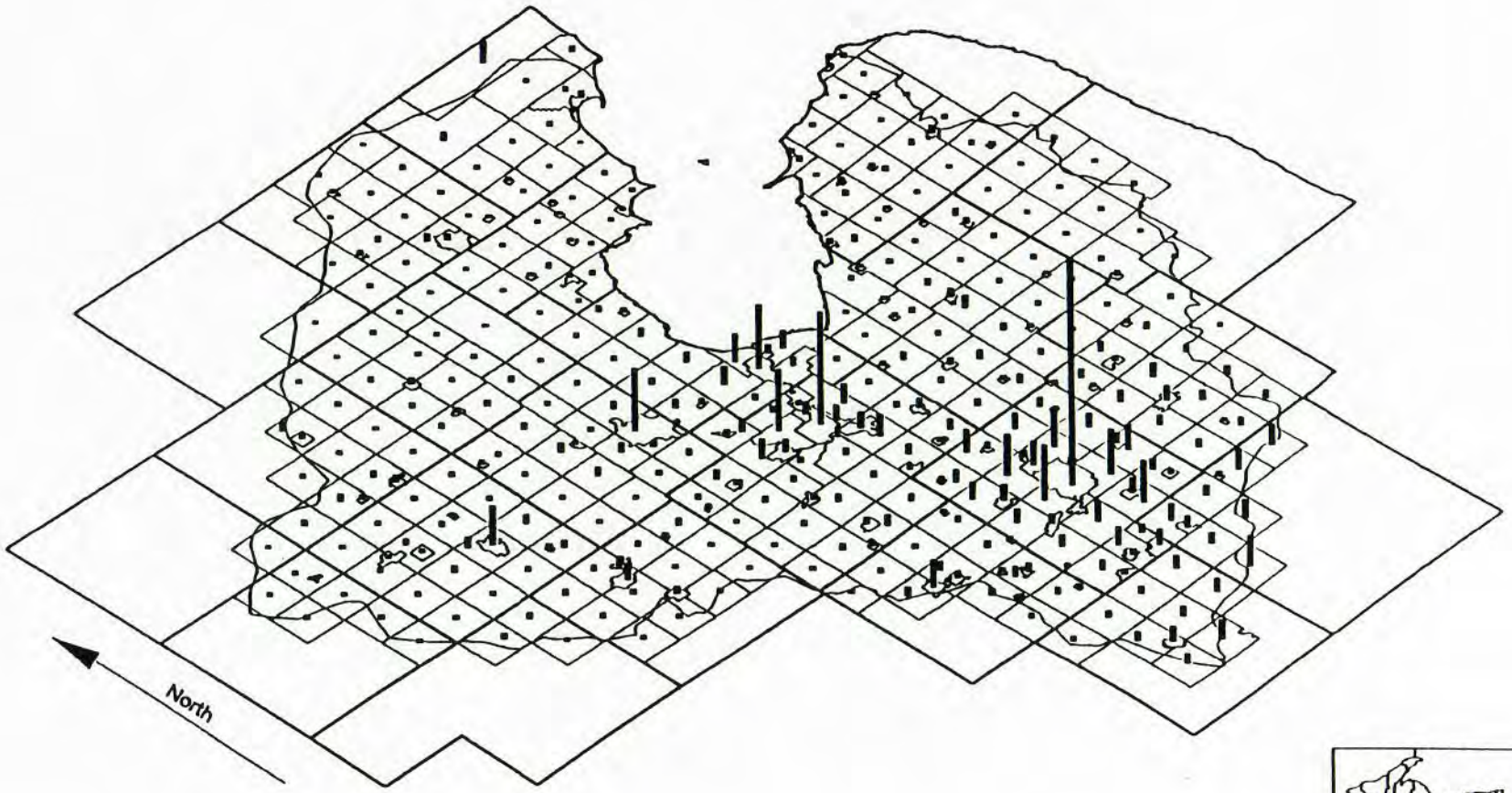
Source: U. S. Bureau of the Census TIGER Line Files

Central Michigan University GIS Center


Drainage Basins of the Saginaw Bay Watershed
Tittabawassee River Basin
West Coastal Basin
East Coastal Basin
Cass River Basin
Flint River Basin
Shiawassee River Basin
Saginaw River Basin
0 10 20 30 40
Miles
Source: U. S. Bureau of the Census TIGER Line Files
Albers Equal Area Projection
Central Michigan University GIS Center

Populations of Villages, Towns, Cities, and Townships

Saginaw Bay Watershed



Scale: The height of each bar is proportional to the population of the area at its base. One half inch equals approximately 50,000 people.

Source: U. S. Census of Population, 1990 STF3A Files

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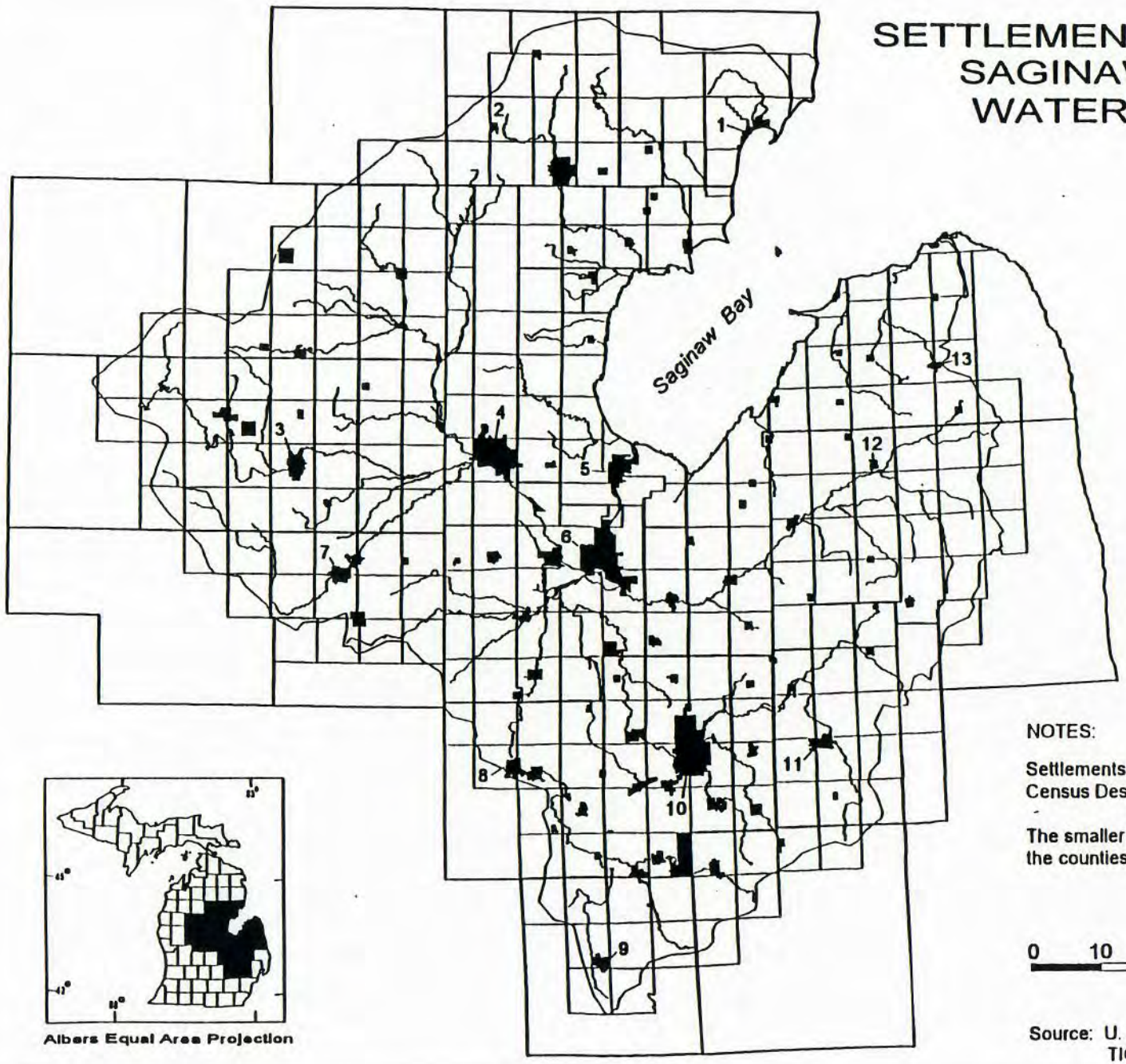
SETTLEMENTS IN THE SAGINAW BAY WATERSHED



CITY KEY

1. Tawas City
2. West Branch
3. Mt. Pleasant
4. Midland
5. Bay City
6. Saginaw
7. Alma
8. Owosso
9. Howell
10. Flint
11. Lapeer
12. Cass City
13. Bad Axe

NOTES:

Settlements include, cities, villages, and Census Designated Places.

The smaller areal divisions within the counties are townships.

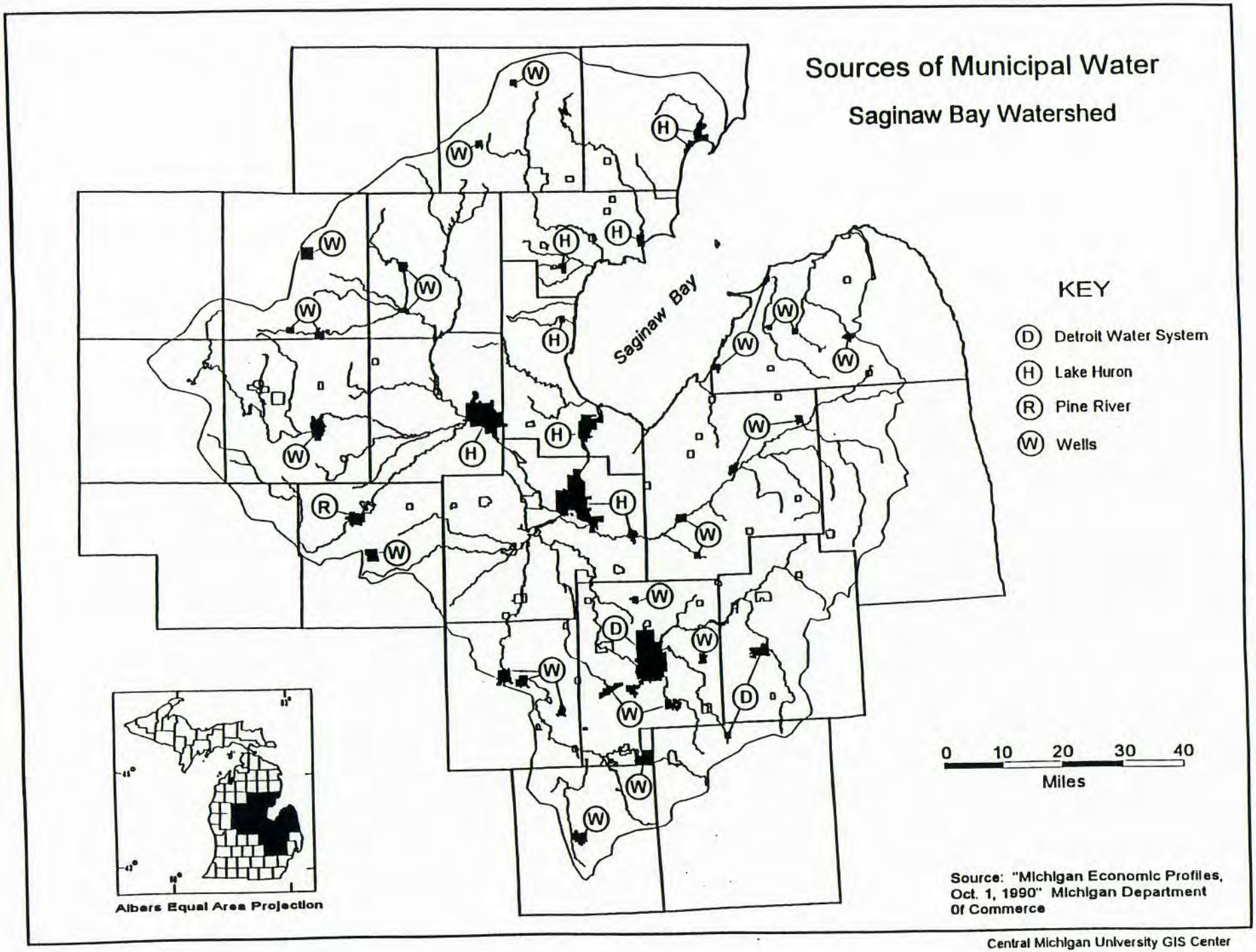
Albers Equal Area Projection

0 10 20 30 40

Miles

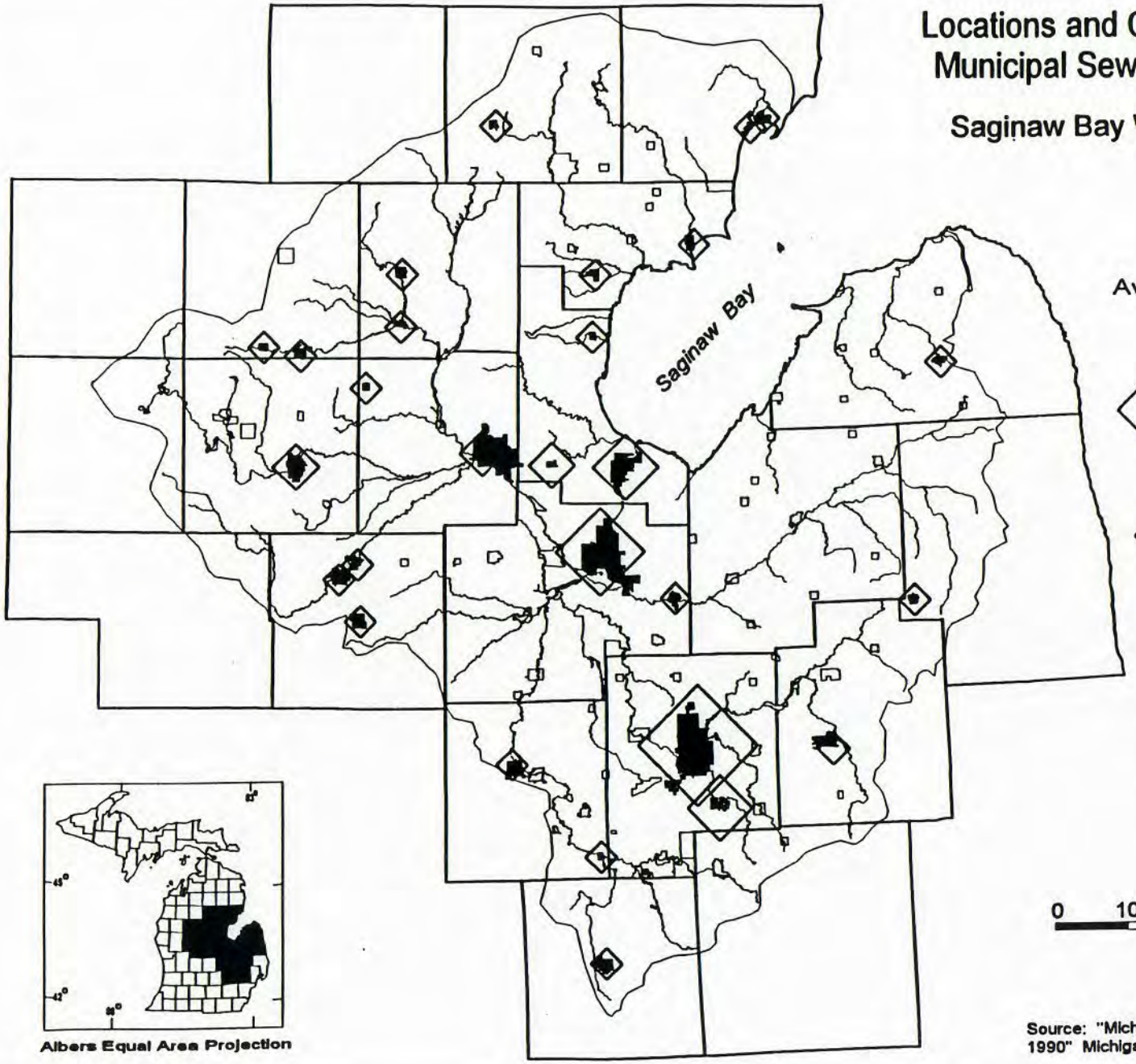
Source: U. S. Bureau of the Census
TIGER Line Files

Central Michigan University GIS Center


Sources of Municipal Water
Saginaw Bay Watershed
Saginaw Bay
KEY
D Detroit Water System
H Lake Huron
R Pine River
W Wells
0 10 20 30 40
Miles
Albers Equal Area Projection
Source: "Michigan Economic Profiles, Oct. 1, 1990" Michigan Department Of Commerce
Central Michigan University GIS Center

Locations and Capacities of Municipal Sewer Systems

Saginaw Bay Watershed



Source: "Michigan Economic Profiles, Oct. 1, 1990" Michigan Department of Commerce

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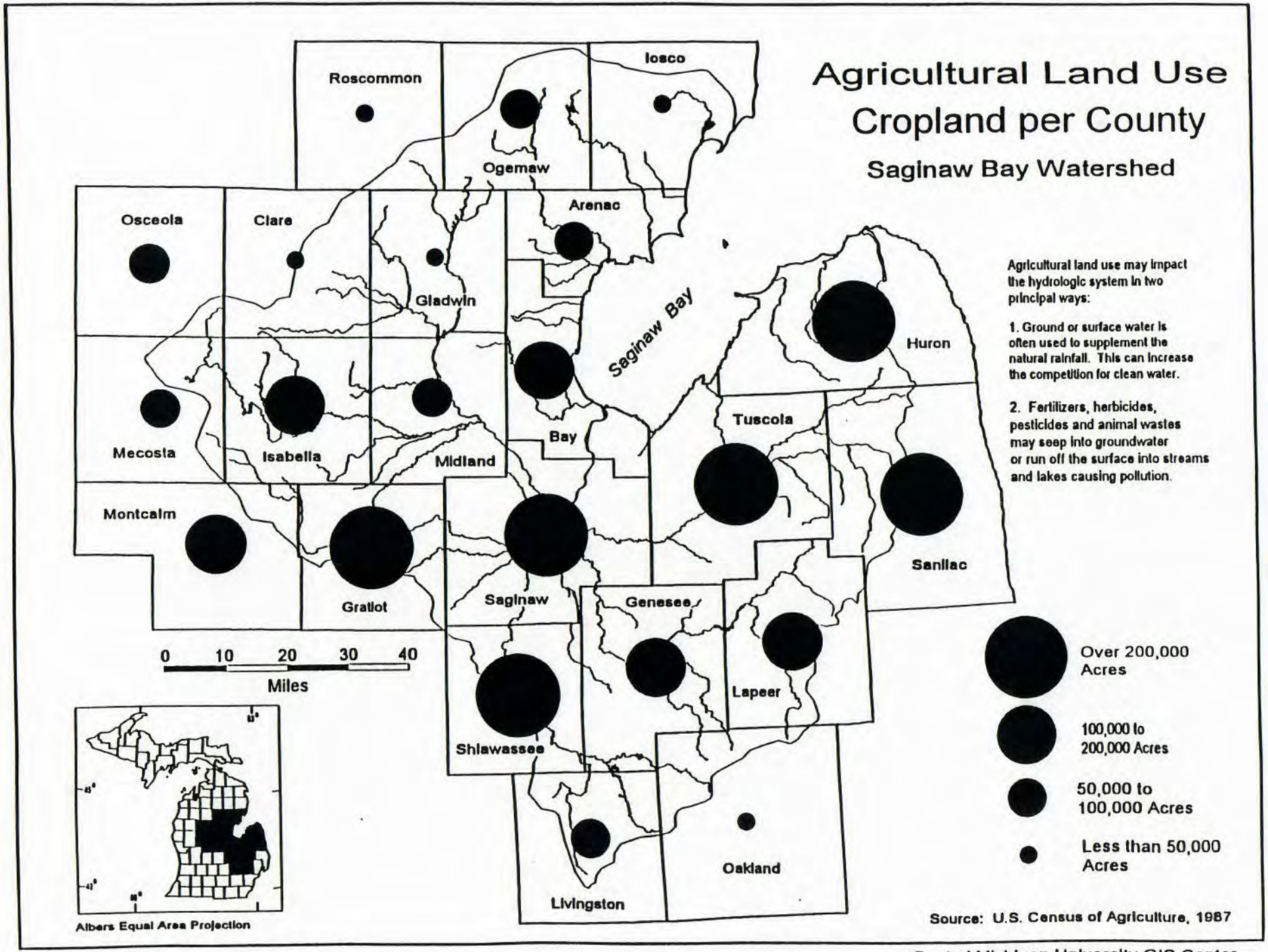
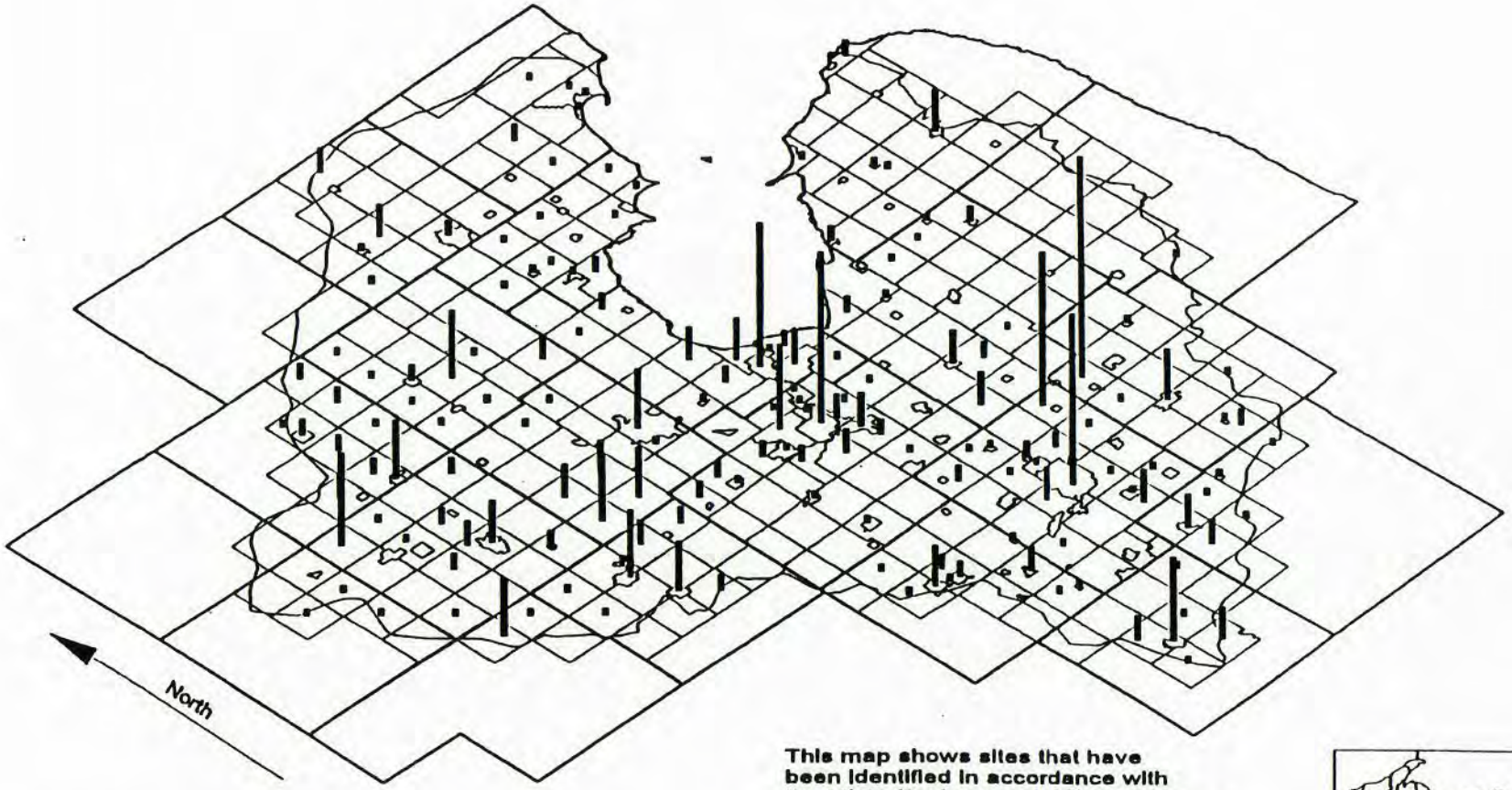

Agricultural Land Use
Cropland per County
Saginaw Bay Watershed
Roscommon
Iosco
Ogemaw
Osceola
Clare
Arenac
Gladwin
Saginaw Bay
Huron
Mecosta
Isabella
Midland
Bay
Tuscola
Montcalm
Gratiot
Saginaw
Genesee
Sanilac
Lapeer
Shiawassee
Oakland
Livingston
0 10 20 30 40
Miles
Albers Equal Area Projection
Agricultural land use may impact the hydrologic system in two principal ways:
1. Ground or surface water is often used to supplement the natural rainfall. This can increase the competition for clean water.
2. Fertilizers, herbicides, pesticides and animal wastes may seep into groundwater or run off the surface into streams and lakes causing pollution.
Over 200,000 Acres
100,000 to 200,000 Acres
50,000 to 100,000 Acres
Less than 50,000 Acres
Source: U.S. Census of Agriculture, 1987
Central Michigan University GIS Center

Sites of Environmental Contamination, 1994

Saginaw Bay Watershed



This map shows sites that have been identified in accordance with the Mich. Environmental Response Act of 1982. (Act 307) Included are the following:

Sites that have been identified but where no action has been taken

Sites that are being evaluated

Sites where cleanup actions have been taken or are in progress

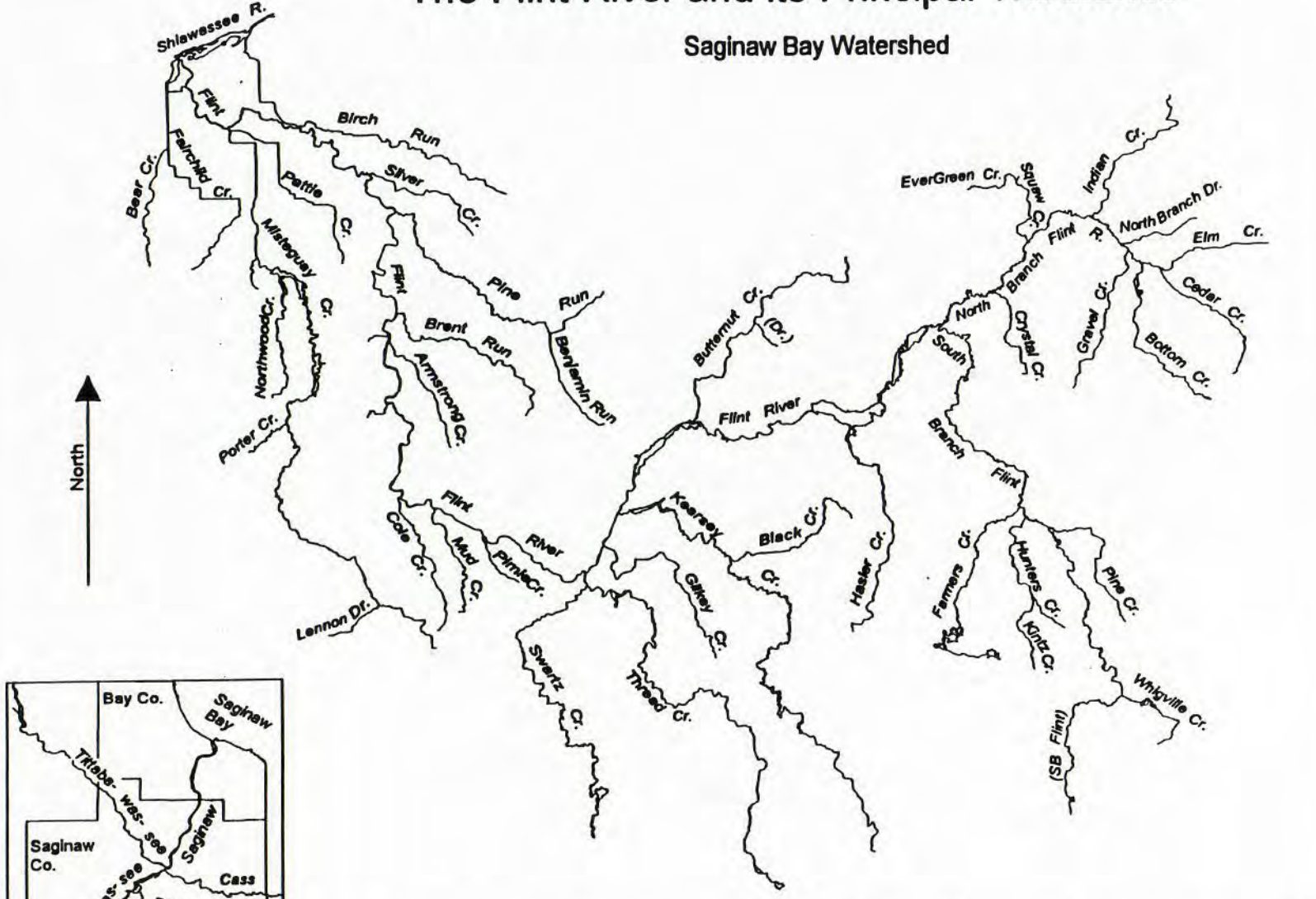
Vertical Scale: The Height of each bar is proportional to the number of 307 sites for the area represented by the bar.
1/20 inch = 1 site.
1 inch represents 20 sites.

Source: "Michigan Sites of Environmental Contamination" Michigan Department of Natural Resources, April 1994

Central Michigan University GIS Center

The Flint River and its Principal Tributaries

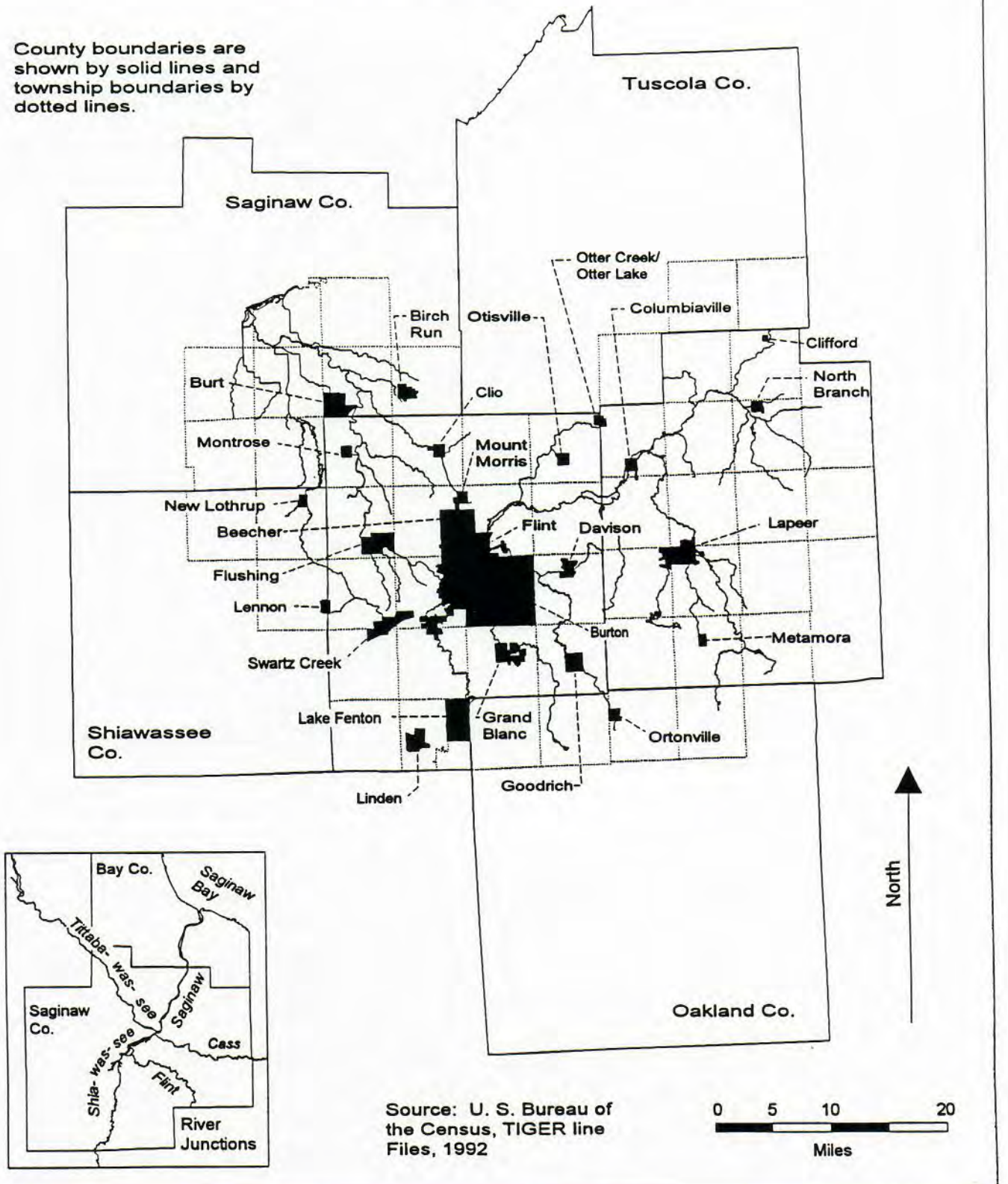
Saginaw Bay Watershed



Central Michigan University GIS Center

Settlements of the Flint River Basin

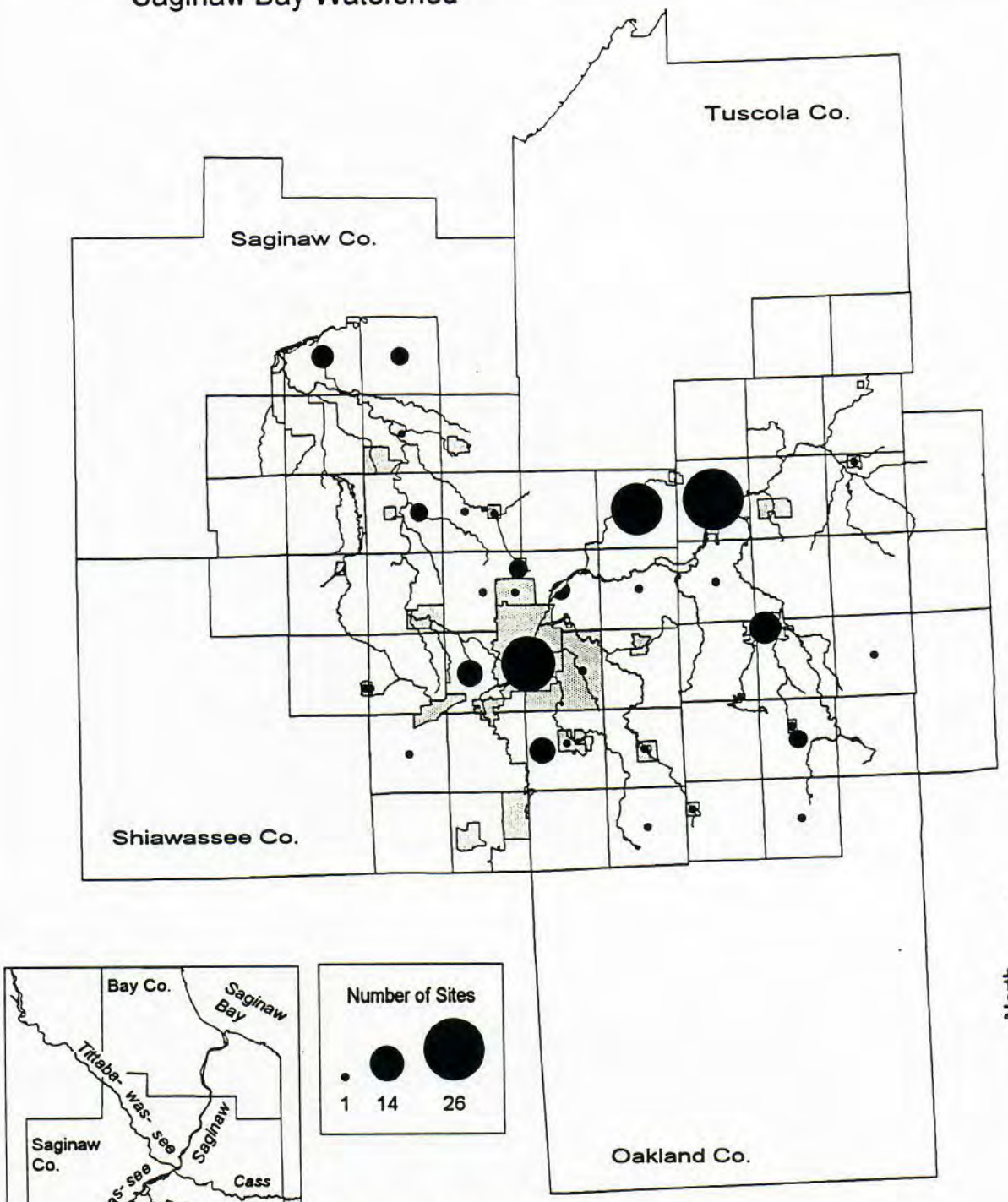
Saginaw Bay Watershed



Central Michigan University GIS Center

Number of Environmental Contamination Sites in Flint River Basin Settlements and Townships

Saginaw Bay Watershed



Source: "Michigan Sites of Environmental Contamination," Michigan Department of Natural Resources, Environmental Response Division, April, 1994.

Central Michigan University GIS Center

APPENDIX C

SAGINAW BASIN

DATA BASE

Dr. Wayne E. Kiefer
Department of Geography
Central Michigan University
Mt. Pleasant, MI. 48859

THE SAGINAW BASIN DATA BASE

COUNTIES	Area Square Mile[1]	Area Square Kilo.[1]	Total Population[1]	Density	
				Per Sq. Mile[1]	Per Sq. Kilo[1]
Arenac	366.9	950.2	14,931	40.7	15.7
Bay	444.3	1,150.6	111,723	251.5	97.1
Clare	566.9	1,468.2	24,952	44.0	17.0
Genesee	639.7	1,656.7	430,459	672.9	259.8
Gladwin	506.8	1,312.7	21,896	43.2	16.7
Gratiot	570.2	1,476.7	38,982	68.4	26.4
Huron	836.6	2,166.8	34,951	41.8	16.1
Iosco	549.1	1,422.3	30,209	55.0	21.2
Isabella	574.3	1,487.5	54,624	95.1	36.7
Lapeer	654.3	1,694.7	74,768	114.3	44.1
Livingston	568.4	1,472.2	115,645	203.5	78.6
Mecosta	555.8	1,439.5	37,308	67.1	25.9
Midland	521.2	1,350.0	75,651	145.1	56.0
Montcalm	708.1	1,833.9	53,059	74.9	28.9
Oakland	872.7	2,260.3	1,083,592	1,241.7	479.4
Ogemaw	564.4	1,461.7	18,671	33.1	12.5
Osceola	566.1	1,466.2	20,146	35.6	13.7
Roscommon	521.4	1,350.5	19,776	37.9	14.6
Saginaw	809.0	2,095.2	211,946	262.0	101.2
Sanilac	963.9	2,496.4	39,928	41.4	16.0
Shiawasee	538.8	1,395.6	69,770	129.5	50.0
Tuscola	812.6	2,104.6	55,498	68.3	26.4
Total	13,711.5	35,514.5	2,638,485	192.4	74.3

[1]1990 Census of Population and Housing, Table 15.

COUNTIES	POPULATION, 1990[2]			
	Total	Urban	Rural Non-Farm	Rural Fram
Arenac	14,931	--	14,322	609
Bay	111,723	74,139	35,450	2,134
Clare	24,952	3,013	21,444	495
Genesee	430,459	338,987	89,622	1,850
Gladwin	21,896	2,682	18,515	699
Gratiot	38,982	15,871	19,501	3,610
Huron	34,951	3,484	27,860	3,607
Iosco	30,209	7,967	21,913	329
Isabella	54,624	23,289	29,656	1,679
Lapeer	74,768	10,680	60,771	3,317
Livingston	115,645	18,143	95,937	1,565
Mecosta	37,308	12,603	23,606	1,099
Midland	75,651	37,819	36,566	1,266
Montcalm	53,059	8,101	43,280	1,678
Oakland	1,083,592	969,743	112,906	943
Ogemaw	18,671	2,569	15,784	328
Osceola	20,146	--	19,239	907
Roscommon	19,776	3,353	16,400	23
Saginaw	211,946	147,047	60,316	4,583
Sanilac	39,928	--	36,766	3,162
Shiawasee	69,770	23,696	42,403	3,671
Tuscola	55,498	6,613	44,971	3,914
Total	2,638,485	1,709,799	887,228	41,468

[2]1990 Census of Population and Housing Summary, Tape File 3C.

COUNTIES	AGRICULTURE, 1991[3]					
	Cropland Acreage	Grain Corn Acreage	Soybean Acreage	Acreage in Orchards	Cattle & Calves (Total)	Hogs & Pigs (Total)
Arenac	69,511	11,538	4,476	75	7,621	5,661
Bay	161,157	35,358	20,318	81	4,683	1,843
Clare	47,994	3,639	81	20	10,628	7,479
Genesee	126,584	36,725	26,676	627	14,423	14,203
Gladwin	49,499	6,303	1,433	D	8,922	2,709
Gratiot	249,668	61,687	54,987	172	29,895	21,543
Huron	383,583	95,978	5,097	35	74,370	44,207
Iosco	26,892	2,641	135	37	8,937	1,423
Isabella	158,954	33,545	11,526	96	31,312	18,774
Lapeer	175,050	46,631	7,665	757	30,285	9,591
Livingston	99,835	28,864	4,428	553	18,903	5,553
Mecosta	89,564	11,825	125	356	17,567	8,959
Midland	74,957	19,602	15,769	28	6,910	5,777
Montcalm	186,322	41,000	6,639	1,119	22,355	10,716
Oakland	47,708	14,268	1,277	523	5,119	1,870
Ogemaw	53,732	6,848	D	31	14,074	1,362
Osceola	75,019	4,509	260	10	18,264	2,904
Roscommon	2,362	--	--	--	326	D
Saginaw	277,062	61,461	110,340	147	14,622	7,252
Sanilac	390,529	85,554	38,961	329	65,275	17,321
Shiawassee	203,050	41,765	68,441	127	20,691	14,626
Tuscola	294,089	75,513	22,526	372	19,906	17,979
Total	3,243,121	725,254	401,160	5,495	445,088	221,752

[3]1987 Census of Agriculture, Volume 1, Geographic Area Series: Michigan - Tables 5, 11, 12, 15, 28

COUNTIES	NUMBER OF INDUSTRIES, 1987[4]						
	Primary Metal	Fabricated Metal	Industrial Machinery & Equipment	Chemicals & Allied Products	Transportation Equipment	Lumber & Wood Products	Paper & Allied Products
Arenac	1	5	9	--	1	3	--
Bay	5	19	31	3	6	7	3
Clare	--	5	7	--	--	2	--
Genesee	4	54	63	12	18	8	8
Gladwin	--	2	10	--	--	2	--
Gratiot	3	5	8	--	6	4	1
Huron	4	9	20	3	4	1	--
Iosco	--	6	8	--	3	8	--
Isabella	--	2	11	--	--	5	3
Lapeer	1	19	24	2	11	6	1
Livingston	5	33	54	11	7	6	2
Mecosta	--	5	14	--	--	10	--
Midland	3	1	4	6	--	5	--
Montcalm	--	10	12	2	4	9	2
Oakland	57	370	791	58	89	53	14
Ogemaw	1	8	11	--	--	14	--
Osceola	--	5	4	--	2	9	1
Roscommon	--	4	5	--	2	8	--
Saginaw	10	20	60	4	6	13	3
Sanilac	--	16	12	2	3	5	--
Shiawassee	--	6	20	--	8	5	2
Tuscola	4	7	13	1	4	6	--
Total	98	611	1,191	104	174	189	40

[4]1987 Census of Manufacturers: Geographic Area Series, Table 9. Distribution of Establishments by Employment Group for the State and Counties: 1987.