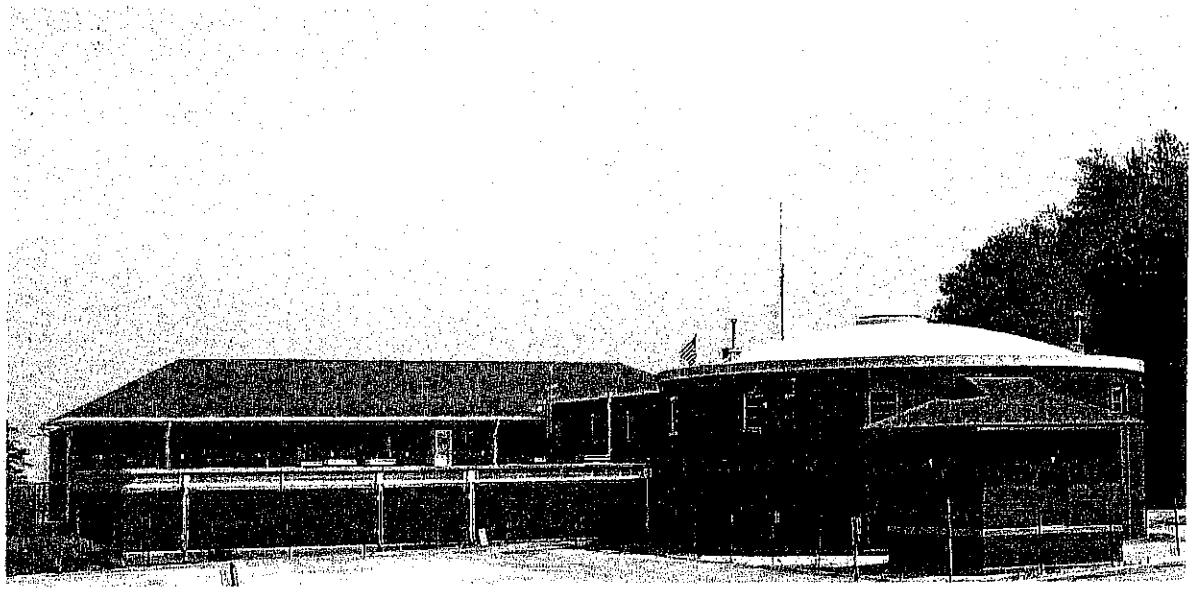
Final Draft

Source Water Assessment Report for the City of South Haven Water Supply June 2003



The City of South Haven, Michigan
Water Treatment Plant

Prepared for:
City of South Haven Water Supply, WSSN 6100

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Michigan Source Water Assessment Report 48

Executive Summary

The purpose of the Source Water Assessment is to analyze the sensitivity and determine susceptibility of a community's source of drinking water to potential sources of contamination.

Sensitivity is determined from the natural setting of the source water (raw water to the water treatment plant), and indicates natural protection afforded the source water. Using procedures established in the Great Lakes Protocol, Michigan Source Water Assessment Program, the offshore intake for the South Haven Water Treatment Plant has a moderate degree of sensitivity to potential contaminants. When the effects of winds, lake currents, and the possible influence of the Black River is considered, the primary South Haven intake in Lake Michigan is categorized as moderately sensitive.

Susceptibility identifies factors within the community's source water area that may pose a risk to the water supply. The susceptibility determination provides information with respect to listed facilities and land areas within the source water area that should be given greater priority and oversight in implementing a source water protection program. The source water area for the South Haven intake includes 80 potential contaminant sources with 92 discharge permits, at least 9 of which discharge directly to Lake Michigan, plus urban and agricultural runoff from the Black River watershed. The potential contaminant sources, in combination with the moderately sensitive intake, indicate that the primary source water for South Haven, Lake Michigan, has moderately high susceptibility to potential contamination.

The primary source of water for South Haven is categorized with moderately high susceptibility, given land uses and potential contaminant sources within the source water area. However, it is noted that historically, the city of South Haven Water Treatment Plant has effectively treated this source water to meet drinking water standards. The city of South Haven has instituted pollution prevention programs, but should be cognizant of additional potential threats to its source of drinking water that are identified in this report. This report explains the background and basis for these determinations.

Using this Assessment

Clean, safe drinking water is fundamental to the viability of any community. Protecting the drinking water **source** is a wise and relatively inexpensive investment in your community's future. The overall intent of this assessment is to provide background information for your community to use in developing a local source water protection program. The assessment benefits your community by providing the following:

- ***A basis for focusing limited resources within the community to protect the drinking water source(s).*** The assessment provides your community with information regarding activities within the **source water area (SWA)** that directly affect your water supply. It is within this SWA that a spill or improper use of **potential contaminants** may cause these contaminants to migrate toward the water **intake**. By examining where the source waters are most susceptible to contaminants, and where potential contaminants are located, the assessment clearly illustrates the potential risks that should be addressed.
- ***A basis for informed decision-making regarding land use within the community.*** The assessment provides your community with a significant amount of information regarding where your drinking water comes from (the source) and what the risks are to the quality of that source. Knowing where the resource is allows your community planning authorities to make informed decisions regarding proposed land uses within the SWA that are compatible with both your drinking water resource and the vision of growth embraced by your community.

- *A basis for dealing with future regulations.*
  The assessment has been designed to functionally meet proposed requirements for surface-water supplies. Information needed to address regulatory needs and requirements has been collected and made available to your community through this report.

This source water assessment also provides the basis for a locally developed, voluntary source water protection program. Communities interested in voluntarily developing source water protection programs should contact the Michigan Department of Environmental Quality (MDEQ) or visit the Department web page at http://www.michigan.gov/deq.

Introduction

In 1996, Congress amended the **Safe Drinking Water Act** and provided resources for state agencies to conduct source water assessments by identifying SWAs, analyzing the **sensitivity** of the source to natural conditions, conducting contaminant source inventories, and determining the **susceptibility** of the source to potential contamination. Delineations, sensitivity analyses, contaminant inventories, and susceptibility determinations comprise a "source water assessment." Assessments will be completed for every public water supply source in Michigan. To support this effort, the MDEQ Water Division established a partnership with the U.S. Geological Survey (USGS) to develop a method for conducting source water assessments for surface water supplies (Sweat and others, 2000; Sweat and others, *in press*).

The requirements for public water supplies in Michigan to meet United States Environmental Protection Agency (USEPA) **maximum contaminant levels (MCLs)** provide some degree of assurance of safe drinking water; however, all systems are vulnerable to potential contamination. One of the best ways to ensure safe drinking water is to develop a local program designed to protect the source of drinking water against potential contamination. Not only does this add a margin of safety, but it also raises the awareness of consumers and/or the community of the risks of drinking water contamination. It is expected that source water assessment results will provide a basis for developing a source water protection program.

Background

The city of South Haven is located in Van Buren County on the east shore of Lake Michigan, about 45 miles (mi) north of Indiana, and about 45 mi southwest of Grand Rapids (fig. 1). The South Haven water treatment plant (WTP) was originally constructed in 1928, and a replacement intake was installed in 1951. It consists of a 10-foot (ft) diameter cone connected to a 24-inch diameter concrete intake pipe. The top of the intake is under about 34 ft of water, and is about 5,650 ft from shore. A zebra mussel control system, consisting of 1.5-inch diameter polyethylene tubing was installed in the summer of 1992. The current treatment capacity of the South Haven WTP is 4.2 million gallons per day (MGD).

Lake Michigan – City of South Haven Source Water

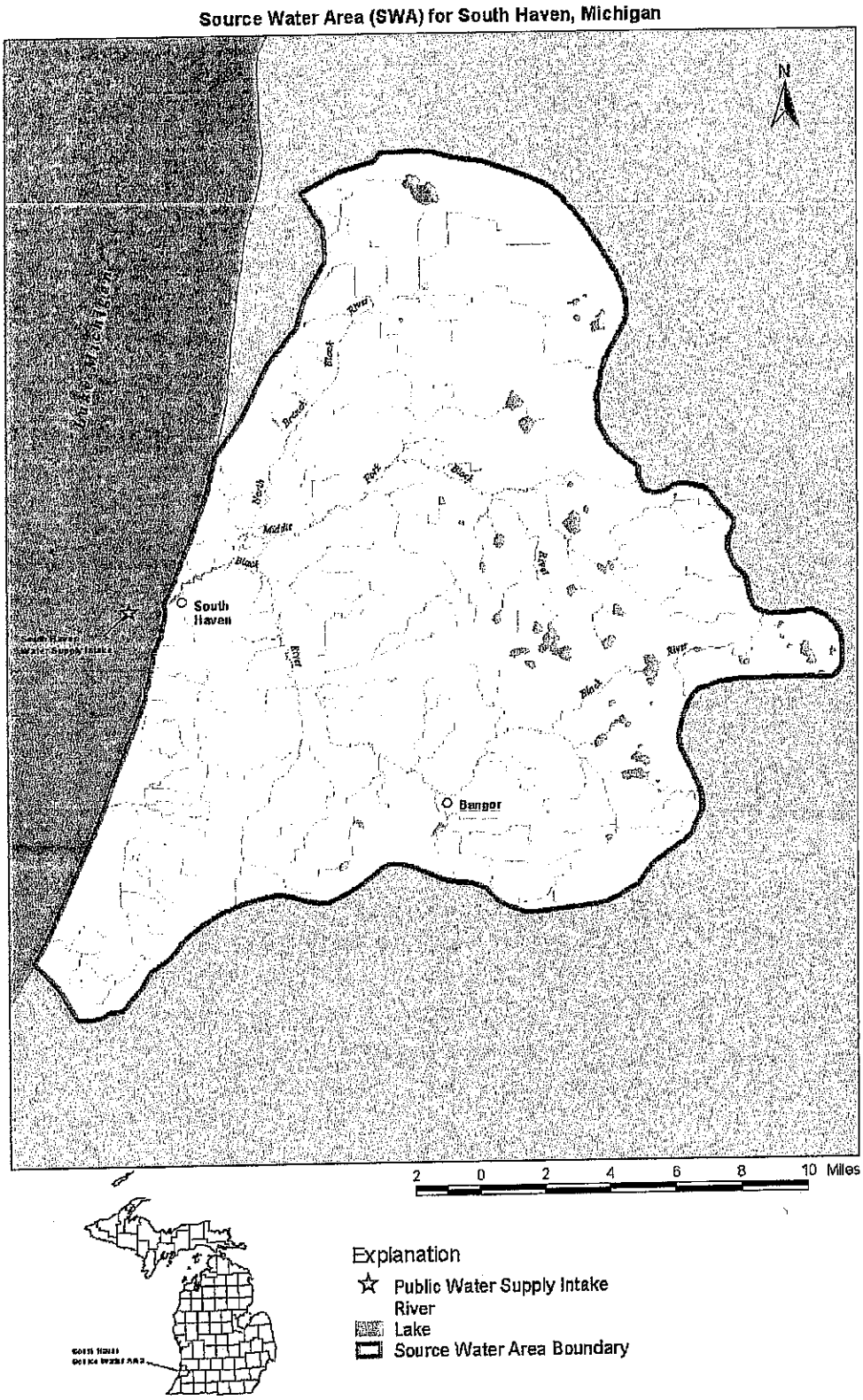


Figure 1. Source water area (SWA) for the evaluation of the South Haven water supply, South Haven, Michigan.

An emergency intake is located in the Black River, and consists of an 18-inch diameter pipe in a concrete superstructure that is submerged between 0 and 2 ft, depending on stage of the Black River. This intake has never been used according to WTP personnel and was capped in 1995.

The WTP is rated at 4.2 MGD and has two in-ground reservoirs on site with a total capacity of 1.23 million gallons (MG). There are 2 reservoirs located on the distribution system with 2.5 MG total capacity. Total system storage capacity is 3.73 MG, which is about 120 percent of the five year, maximum day demand (Greiner and Howard, 1993). The South Haven WTP serves approximately 6,200 people in the city and Casco, Covert, and South Haven Townships.

Water treatment plants are periodically inspected to identify construction, maintenance, and operational or source defects that could make them vulnerable to contamination, particularly from contaminants that are microbial in nature, such as fecal coliforms. Water suppliers are provided a sanitary survey report that notes any deficiencies in the system, and the State may direct the system to make necessary corrections. The sanitary survey is an important part of a safe drinking water program. The most recent sanitary survey of the South Haven WTP was completed in February 2003.

Climate

The South Haven water supply is located in the Southern Lower Peninsula hydrologic province (Rheaume, 1991). The region experiences temperate summers with moderate winters. The South Haven weather station reports long-term average annual precipitation for the period 1894-1999 was about 36 inches, with about 31 percent of that as snowfall between November and March. Average annual precipitation from 1995-1999 was about 29 inches (NOAA, 1999). Annual average runoff for the South Haven SWA is about 15 inches (Blumer and others, 2001, p. 94), with higher runoff values closer to Lake Michigan (Miller and Twenter, 1986, p. 279).

Source Water Area Geology and Hydrology

The study area for evaluating the South Haven WTP SWA includes the Black River and miscellaneous creek watersheds, in addition to Lake Michigan (fig. 1). The SWA consists of lakebed, outwash, and dune deposits. These landforms are underlain by Coldwater Shale (Martin, 1955; Milstein, 1987). Soils in the South Haven SWA are primarily from the Metea complex. They include sands, sandy peat, loamy sands, sandy loams, loam, muck, and loamy fine sands (U.S. Department of Agriculture, 1980; 1987; BASINS, 1998).

Soil permeability is based on the calculated time of travel, in inches per hour (in/hr), for water to move vertically through a saturated soil zone. Soil thickness and permeability values are available in soil survey reports published by the National Cooperative Soil Survey and U.S. Department of Agriculture (1987). Permeability ranges from less than 0.06 in/hr, rated as very slow, to more than 20 in/hr, rated as very rapid.

Very slowly permeable soils significantly reduce the movement of water through the soil zone and, as a result, allow greater time for natural degradation of contaminants. However, such soils also provide for rapid overland transport of contaminants directly to receiving waters, which in turn may affect the water supply intake. In contrast, very rapidly permeable soils allow for rapid infiltration and passage through the soil zone from the surface. Such soils potentially allow rapid transport of contaminants with minimal contact-time available for contaminant breakdown. Erosion and transport of soils by surface waters can cause an increase in turbidity.

Mean, area-weighted, depth-integrated permeabilities for the South Haven SWA range from 0.47 in/hr to as much as 12.8 in/hr. The mean permeability is 7.16 in/hr (Schneider and Erickson, undated, series of 5 maps; BASINS, 1998). Soils are generally rapidly permeable to very rapidly permeable throughout the SWA (fig. 2; U.S. Department of Agriculture, 1980; 1987; BASINS, 1998), with some small areas of moderately slow permeability and moderate permeability in the north, south, and east-central parts of the SWA. Soils with very rapid permeability are closest to the Black River and Lake Michigan (Lusch and others, 1992; BASINS, 1998).

The South Haven SWA contains an area of about 330 square miles (mi^2) and is directly connected to Lake Michigan. The most significant tributary to Lake Michigan from the SWA is the Black River, with a drainage area of about 244 mi^2. Two gauges are operated in the SWA by the USGS (Blumer and others, 2001, p. xii). Annual mean discharge at the Black River near the South Haven gauging station was 92.1 cubic feet per second (cfs) between 1994 and 2000, and ranged from 63.0 to 145 cfs. In the Grand River watershed, north of the SWA, 10 gauges are currently in operation, and in the Kalamazoo River watershed, south of the SWA, 13 gauges are currently in operation.

Under ambient conditions, currents in Lake Michigan are, typically, from the south-southwest and pass over the South Haven WTP intakes. Water from the Black River flows west and north from its mouth, toward the intakes, and may occasionally influence water quality and chemistry at the intake. In addition, sustained strong winds from the west often affect lake currents, causing increases in near shore turbidity, and, possibly, increases in coliform concentrations.

History of Raw Water Quality at the Source

Public water supplies are required to routinely monitor raw water quality for selected parameters to optimize treatment, and to monitor treated water quality for a list of contaminants that is determined by MDEQ and the Safe Drinking Water Act. A detection of any contaminant may indicate that a pathway exists for contaminants to reach the intake. It is important to realize that the results from a given sample only provide information regarding the water quality at the time the sample was collected. Water quality can change with time for a number of reasons. The fact that a water sample does not contain contaminants is no guarantee that contamination will not occur in the future. Conversely, the detection of a contaminant in the past does not indicate that it will occur in the future.

The South Haven WTP records show that water use between 1998 and 2002 fluctuated between 0.705 and 2.897 MGD, with an average annual use of about 431 million gallons. Water quality and meteorological conditions have been monitored since about the 1890's. An analysis of wind direction, water and air temperature, precipitation, discharge from the Black River, and source water chemistry indicates that there may be an indirect correlation between wind direction and turbidity, and perhaps wind direction and total coliform bacteria. Regression analysis of these data indicated that when the wind is from the north-northwest through north-northeast (330-30°) for more than 24 to 36 hours, there is a quantifiable increase in turbidity of the source water after 3 to 4 days, and possibly an increase in total coliforms after 2 to 3 days. This occurs because these sustained winds shift the circulation pattern in the Lake near the intakes, and may cause water from the Black River to pass over the intake. This increase in turbidity and total coliforms requires modifications to the treatment process. Monthly operation report summaries for 1998 through 2002 indicated raw water quality ranges of 0.42 to 72 NTU for turbidity, 7.6 to 8.9 for pH, 102 to 170 mg/l for hardness and 166 to 160 mg/l for alkalinity.

Data indicate that sustained winds from the south through southwest (180-225°) can cause an increase in turbidity. These changes are most likely associated with changes to circulation patterns in Lake Michigan, which can cause sediments near the intake to be suspended in the water column due to wave action. While not regulated, esthetic parameters such as taste and odors associated with algae blooms are also a source water concern for the South Haven WTP.

Thermal inversions in Lake Michigan can also cause treatment problems for the plant. Thermal inversions are typically associated with heating of the surface of the lake in spring, and cooling of the surface of the lake in fall or early winter. Both events cause density differences in the lake that cause the water to turnover and mix, often stirring up bottom sediments and detritus. These materials enter the WTP through the intake and may cause treatment difficulties. In addition, rapidly fluctuating lake temperatures and very cold water can upset the treatment process at the plant.

The South Haven WTP periodically tested both raw water for the presence of total coliform bacteria before 1992. In 1992, the WTP began applying chlorine at its intake to control zebra mussels. Before chlorine application at intake, coliform bacteria were routinely detected in raw water. Treated water continues to be tested for the presence of coliform bacteria, with the results indicating that total coliform bacteria are not present in the treated water.

Source Water Assessment Methodology

Technical guidelines for completing source water assessments are contained in the Michigan **Source Water Assessment Program**, Assessment Protocol for Great Lakes Sources (Protocol) (MDEQ, 1999, Appendix L) available at http://www.deq.state.mi.us/dwr. In general, an assessment is a process for evaluating a drinking water supply and the potential for its treated water to exceed an MCL due to raw water contamination. A source water assessment considers the SWA, potential sources of contamination within the SWA, conditions of the water supply

Figure 2. Source water (SWA) permeability map for the South Haven water supply, South Haven, Michigan.

intake, and susceptibility to contaminants in order to identify potential risks to drinking water quality. Although the Protocol provides the minimum requirements and instructions on how to conduct an assessment, each water supply is unique with respect to how the process is carried out, due to local conditions and information. Sweat and others (2000, *in press*) have developed and documented the methodology used in the preparation of this assessment.

Delineating Source Water Areas

Delineation of the SWA is accomplished by using **geographic information system** (GIS) software to map the watershed(s) that have the potential to affect source water at the intake. Using information from the water supply, a **critical assessment zone** (CAZ) is defined for the intake (MDEQ, 1999, Appendix L). A buffer is then created along any shoreline intersected by the CAZ, and from the edge of the CAZ to the mouth of any river(s) that might influence the intake. Finally, the buffer is extended along the shoreline of any river(s) that might influence the intake, from the mouth of the river to its headwaters. The area defined by the CAZ, river and shoreline buffers is termed the **susceptible area.** The susceptible area within the SWA defines locations where a water supply should focus its management strategies and resources to benefit the drinking water resources.

Using the Great Lakes Protocol and the South Haven water supply information:

- The CAZ for the Lake Michigan intake for South Haven is calculated as:

  5,650 (the length of the intake in ft.) x 34 (the depth of the intake in ft.) = 192,100 (unitless)
  This results in a CAZ of 1,000 ft, and a SWA rating of moderately sensitive (MDEQ, 1999, Appendix L; fig. 3).

As the CAZ for the intake does not intersect the shoreline, there is no shoreline susceptible area. A susceptible area of 300 ft from each bank of the Black River and its tributaries is used instead (fig. 3).

Contaminant Source Inventory

Past, current, and potential future sources of contaminants were inventoried to identify several categories of potential sources of contaminants including microorganisms (bacteria, oocysts, and viruses), inorganic compounds (nitrates and metals), organic compounds (solvents, petroleum compounds, pesticides), and disinfection by-product precursors (trihalomethanes, haloacetic acids).

It is important to remember that sites and areas identified by this process are only **potential contaminant sources** (PCS) to the drinking water. Environmental contamination is not likely to occur when potential contaminants are used and managed properly. In addition, assumptions were made about particular types of land uses and risks associated with those land uses. Assumptions are discussed further in the results portion of this report.

The process for completing the inventory included several steps, which are summarized as follows:

1. Reviewed readily available land use maps and historical/current aerial photographs.
2. Plotted relevant information from applicable state and federal regulatory databases including the following lists:
   - MDEQ leaking underground storage tank (LUST) sites;
   - MDEQ registered underground storage tank (UST) sites;
   - MDEQ Environmental Cleanup Site Information System (ECSI) sites;
   - MDEQ Source Information System (for water discharge permit sites including National Pollutant Discharge Elimination System (NPDES) permits, Water Pollution Control Facility (WPCF) permits, storm water discharge permits, and on-site sewage (septic) system permits);
   - MDEQ Underground Injection Control (UIC) database;
   - MDEQ Active Solid Waste Disposal Permits list;
   - Michigan Department of Transportation (MDOT) - Hazardous Materials database;
   - State Fire Marshall registry of above-ground fuel storage tank sites;

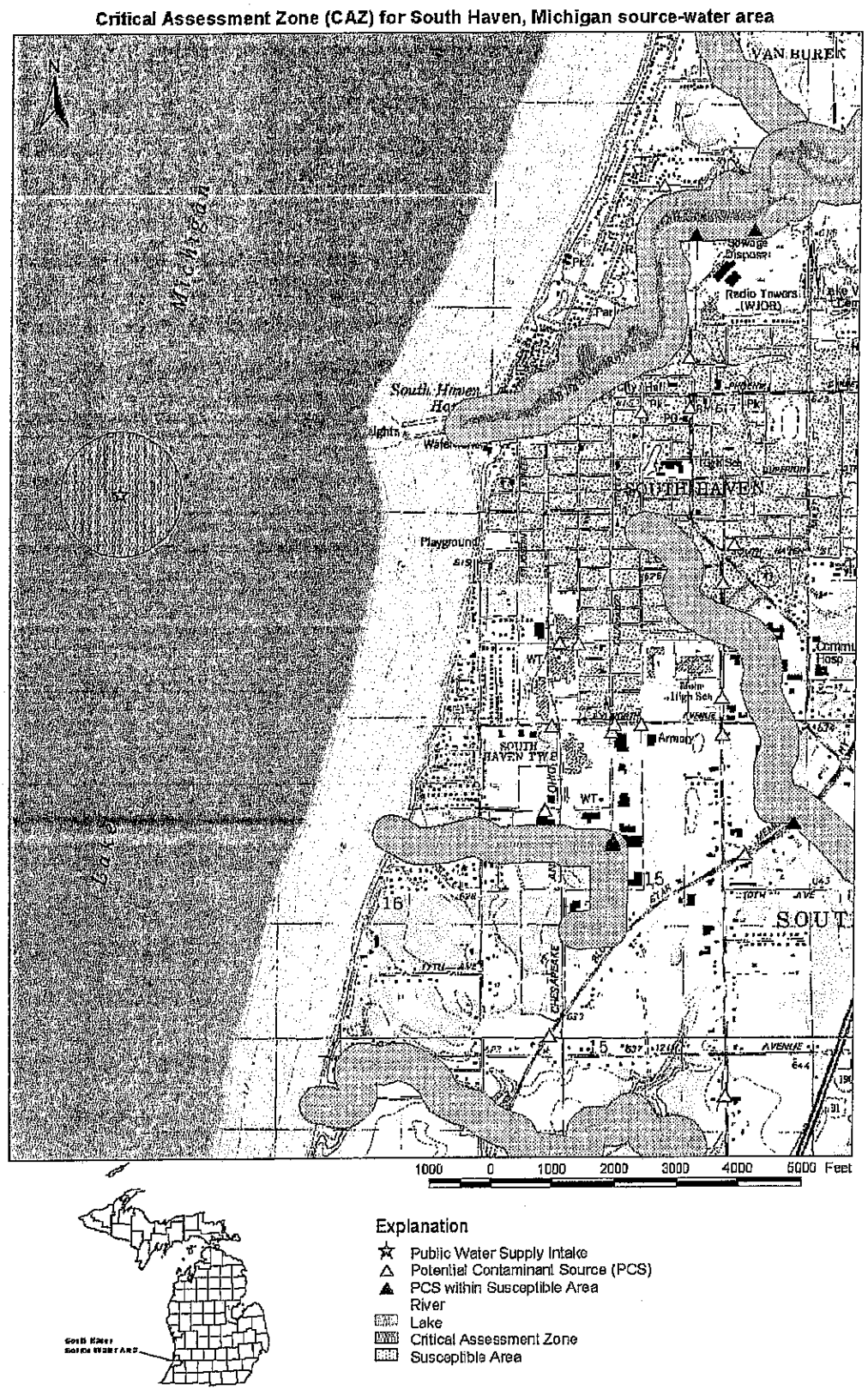


Figure 3. Critical assessment zone (CAZ) and Susceptible Area for the South Haven water supply, South Haven, Michigan

- State Fire Marshall Hazardous Material Handlers and Hazardous Material Incidents (HAZMAT) sites; U.S. EPA BASINS software, version 2.01.
- U.S. EPA Envirofacts database;
- U.S. EPA Resource Conservation Recovery Act (RCRA) generators or notifiers list;
- U.S. EPA RCRA Treatment, Storage, and Disposal Facility (TSDF) Permits list;
- U.S. EPA National Priorities List (NPL);
- U.S. EPA Comprehensive Environmental Response, Compensation and Liability Information System (CERCLA) List;
- U.S. EPA RCRA Corrective Action Activity List (CORRACTS);
- U.S. Department of Transportation (DOT) Hazardous Materials Information Reporting System (HMIRS);
- U.S. EPA Toxic Chemical Release Inventory System (TRIS); and
- U.S. EPA Oil Pollution Act of 1990 Spill Response Atlas.

3. Met with public water supply and community officials on May 29, 2002 to identify potential sources not listed elsewhere in databases or on maps and completed a preliminary inventory form to be used in completing the SWA base map. Subsequent contacts by email and telephone on numerous occasions to request additional data, clarify data, and discuss results.
4. Land use and/or ownership (for example, residential/municipal; commercial/industrial; agricultural/forest; and other land uses) was mapped and evaluated in relation to PCS, soil characteristics, and proximity to the intakes.
5. Conducted an informal field inventory to locate additional PCS.
6. Completed final inventory form of PCS and plotted locations of PCS on the base map.

The purpose of the inventory is three fold: first, to provide information on the location of PCS, especially those within the susceptible area; second, to provide an effective means of educating the public about PCS; and third, to provide a reliable basis for developing a management plan to reduce potential contaminant risks to the South Haven water supply.

The inventory process attempts to identify potential point-source contaminants within the SWA. It does not include an attempt to identify specific potential contamination problems at specific sites, such as facilities that do not safely store potentially hazardous materials. However, assumptions were made about particular types of land use. For example, it is assumed that rural residences associated with farming operations have specific potential contamination sources such as fuel storage, chemical storage and mixing areas, and machinery repair shops. It should also be noted that although the inventory depicts existing agricultural uses (crops grown), these are likely to undergo continual change due to normal crop rotation practices. What is irrigated farmland now may be non-irrigated farmland next year, or vice versa.

The results of the inventory were analyzed in terms of current, past, and future land uses and their relationship to the susceptible area and the supply intake. In general, land uses and PCS that are closest to the supply intake pose the greatest threat to a safe drinking water supply. Inventory results are summarized in tables 1 and 2 and are shown on figure 4.

Table 1. Potential contaminant sources in the South Haven source-water area, Michigan.

Type of potential contaminant source	Number of potential contaminant sources	Number of potential contaminant sources with permitted discharges to Lake Michigan
Hazardous or Solid Waste Site	53	7
Industrial Facilities Discharge Site	18	7
National Priority List Sites	0	0
Permit Compliance System	15	6
Toxic Release Inventory	6	1

Many PCS are readily identifiable because they have a single discharge point, and often a permit is required for these discharges. Other PCS have diffused, poorly defined discharge locations. These are known as non-point discharges because they occur over large areas and may not be quantifiable by readily accepted methods. These non-point source discharges are difficult to identify and control, and consequently to quantify, yet they are a major source of water pollution (Carpenter and others, 1998). Non-point sources also include atmospheric deposition over water and land, and include urban, rural, and agricultural runoff from areas such as lawns, golf courses, farm fields, pastures, parking lots, and roadways. Runoff from these areas can contain many types of pollutants including sediments, metals, organic and inorganic chemicals, viral and bacterial pathogens, pharmaceuticals, and animal wastes. Storm sewers and combined sewer overflows also present a potential contaminant threat.

Table 2. Potential-contaminant source-inventory results, South Haven source-water area, Michigan

Site Name	ID Number	Reason for Permit	Reason for Listing as Potential Contaminant Source
Controlled Rubber Products Inc [A]	MID005426671	Runoff or airborne particulates	Hazardous or solid waste site
Four Star Corp	MID074323585		
MIDOT Maint Div	MID981795867		
Pullman Ind Inc	MID985574029		
South Haven City Of St Dept	MID985579432		
Village Coin Laundry And Dry Cleaners	MID985654979		
Wyckoff Chemical Co Inc [B]	MID080361454		
Bangor WWSL [C]	MI0022055	Process, treatment, and waste water	Industrial facilities discharge site
Bohn Aluminum-South Haven [D]	MI0003131		
Controlled Rubber Products Inc [A]	MI0036617		
Fennville WWSL	MI0021211		
South Haven Rubber Co [E]	MI0029513		
South Haven WWTP [F]	MI0020320		
Textron-Cwc Castings-S Haven	MI0003115		
Bangor WWSL [C]	MI0022055	Waste water, dust, and process water	Permit compliance system
Bohn Aluminum-South Haven [D]	MI0003131		
Mt Pleasant Association WWSL	MI0045021		
South Haven Twp WWTP	MI0052515		
South Haven WWTP [F]	MI0020320		
Yale-South Haven Inc-S Haven [E]	MI0029513		
Wyckoff Chemical Co. Inc. [B]	MID080361454	Release or manufacture of toxic compounds	Toxic release inventory

[A] Superscript denotes multiple permits at same location

Transportation also represents a non-point source of contamination. Trucking, railroads, and shipping all transport potential contaminants through the SWA. An accident causing a spill could lead to potential contaminants entering a storm sewer, or in the case of shipping, directly discharge to Lake Michigan, possibly near the water intake. Non-point sources of concern to the South Haven water supply are primarily from agriculture and livestock in the South Haven

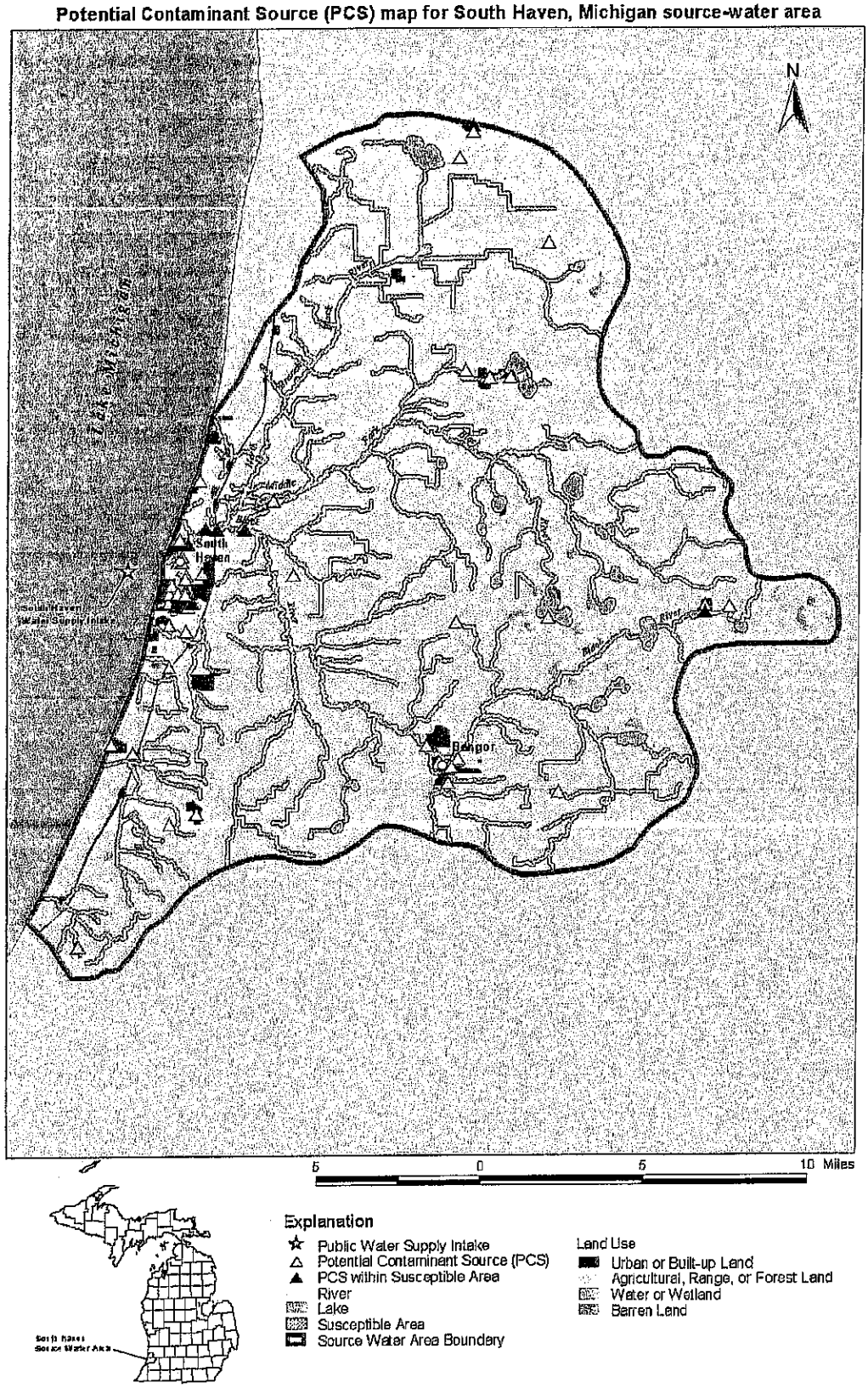
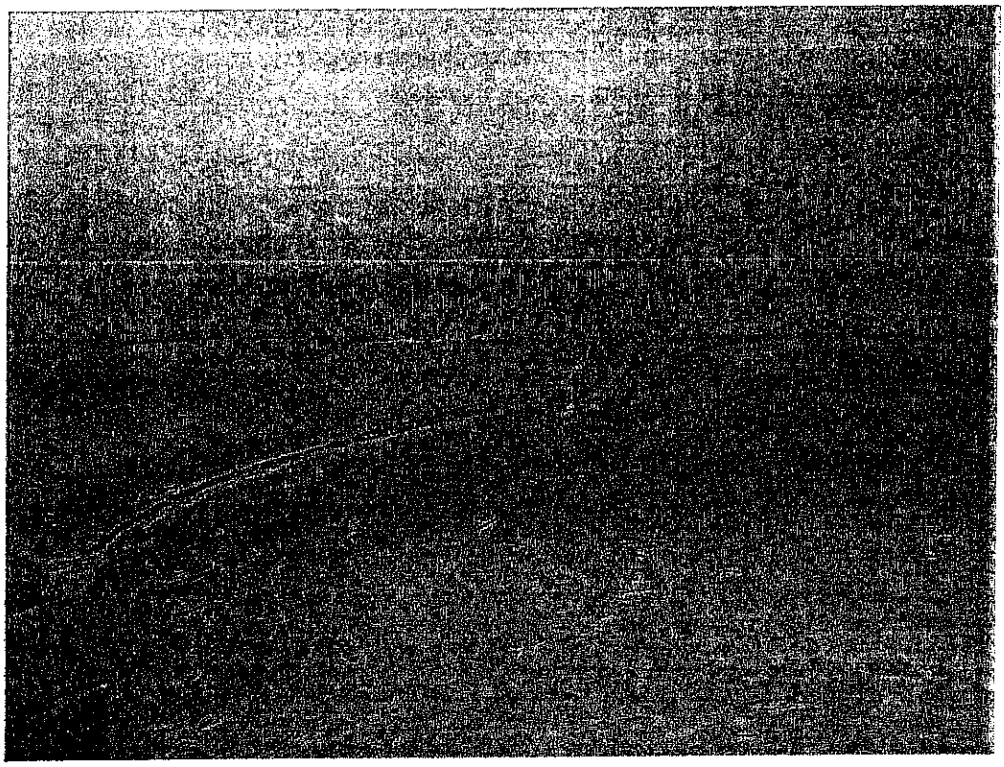


Figure 4. Contaminant Source Inventory for the South Haven water supply, South Haven, Michigan.

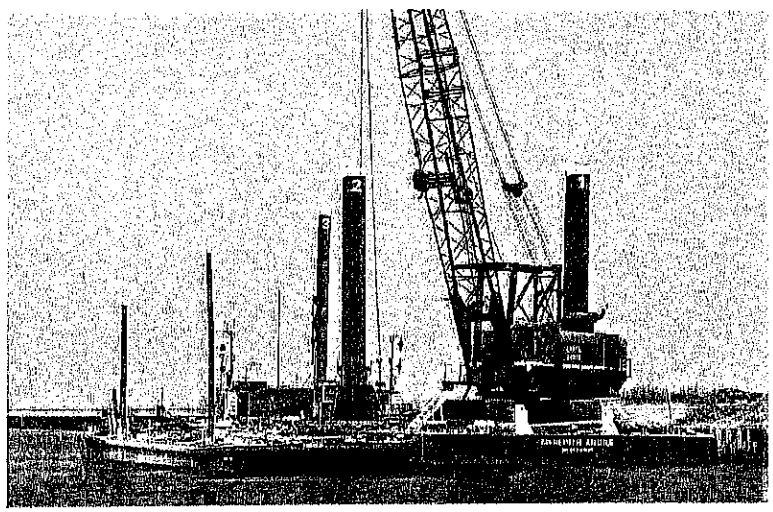


Storm Sewer Drainage to Lake Michigan Poses Potential Contaminant Source

SWA, and from industrial, commercial, and residential sources in South Haven and surrounding communities, and from the transport of fuel, coal, salt, and cement on Lake Michigan. The Michigan Department of Agriculture has identified at least 1 concentrated animal feedlots (greater than 1000 animal units) in the Black River watershed.

The U.S. Environmental Protection Agency (USEPA) has identified 2 **impaired water bodies** in the South Haven SWA on its Clean Water Act 303(d) list. The parameters of concern listed for the river and its tributaries are nutrient enrichment and nuisance plant growth (MDEQ, 2001). In addition, nearby watersheds have been identified as contributors of chemicals of concern by the USEPA (2001). The Kalamazoo and Muskegon rivers have been identified as minor contributors of *trans*-Nonachlor loading to Lake Michigan, while the Grand River is listed as a major contributor of *trans*-Nonachlor (USEPA, 2001). The Grand River is a significant contributor of mercury to Lake Michigan, and the Kalamazoo and Muskegon rivers contribute minor amounts of mercury. The Kalamazoo, Muskegon, and Grand Rivers were identified as minor contributors of PCBs. Results for atrazine have not yet been released.

In general, PCS within the susceptible area pose greater risks than those outside the susceptible area. The presence of PCS within the SWA indicates potential sources of chemicals that could, if improperly managed or released, affect the water quality at the intake. A small quantity of these chemicals, in some cases a gallon or less, can significantly affect the supply. Also of concern is the location and distribution of these sources with respect to highly permeable soils. Overlaying the PCS locations and the soil permeability map for the South Haven SWA indicates that more than 83 of the located PCS are located on or very near to areas with rapidly permeable to very rapidly permeable soils (fig. 2).



Black River Channel Dredging Potentially Threatens Source Water

The SWA consists of primarily agricultural, forested, and urban land (fig. 4). The results of the PCS inventory performed for the South Haven water supply are shown on figure 4 and are summarized as a function of PCS locations within the SWA relative to land use. Inventory results indicate that there are 80 PCS, holding 92 discharge permits, within the SWA, at least of 9 of which discharge directly to Lake Michigan (tables 1, 2).

Storm Sewer Outfall to Lake Michigan

Sensitivity Analysis

Sensitivity is the natural ability of a SWA to provide protection against the contamination of the water supply intake, and includes physical attributes of lakes, rivers, and soils. The sensitivity analysis requires consideration of several different variables related to the natural environment, for example:

- Water quality history of the source.
- Distribution of rapidly to very rapidly permeable soils.
- Amount of available water from precipitation or runoff.
- Potential for runoff to affect the intake.
- Nature of the intake, including: depth, distance from shore, age, and materials used.
- Surface water flow patterns in vicinity of intake.

To perform this analysis, USGS, MDEQ, and the operator of the South Haven WTP collected, researched, and analyzed information from the WTP, monthly operator reports, sanitary surveys, soil maps, published reports, and historical plant operation and raw water quality data. The Michigan SWAP has three categories of sensitivity for surface water sources ranging from moderately sensitive to very highly sensitive. Analysis of this information, using guidelines provided in Brogren (1999) and Sweat and others (2000, 2002), indicates that the South Haven intake is moderately sensitive (fig. 5). This means that the natural environment offers some limited protection against contamination of the water supply intake.

Susceptibility Determination

Susceptibility is the relative potential for contamination to reach the public water supply intake used for drinking water purposes. Whereas the sensitivity of a water supply is the natural ability of the area to protect the intake against contamination, the susceptibility determination also takes into account other factors that will affect whether a contaminant reaches the intake. Whether or not a particular drinking water source becomes contaminated depends on three factors:

(1) The distribution of PCS;
(2) The source water area; and
(3) The natural protection, or sensitivity, of the source.

In conducting a susceptibility determination, the part of the SWA that yields water to the water supply-system intake is identified by establishment of the susceptible area within the source water area. PCS within the susceptible area are then located. Based on the distribution of PCS within the susceptible area, the type of PCS, and the nature of the chemicals they use or store, PCS are analyzed for the risk they may represent to the water supply intake. Along with the presence and distribution of PCS, the sensitivity analysis is then used to determine the susceptibility of the water supply (fig. 5). This leads to a determination of whether the drinking water source is moderately susceptible, highly

susceptible, or very highly susceptible to contamination (Sweat and others, *in press*). It is important to understand that a system can have low sensitivity relative to some conditions (for example, intake construction and location), and high susceptibility because of other conditions (for example, the type of PCS). In Michigan, surface water sources of drinking water range from moderately low to very-high susceptibility.

When a public water supply is determined to have a moderate, high, or very high susceptibility because of a particular condition or set of conditions, there is a significant risk of contamination of the drinking water source because of that condition or set of conditions. Although the susceptibility determination does not predict when or if contamination will actually occur, it does recognize conditions that are highly favorable for contamination of the supply. In the event of a contaminant release to soils or surface water within the susceptible area, it is very likely that contamination at the intake would occur without completion of remedial actions.

If a public water supply's drinking water source is determined to be highly susceptible, it is recommended that the system identify the condition(s) that lead to the high susceptibility. Immediate steps should be taken to protect the source, and action should be considered to remedy the condition (for example, repairing or replacing faulty intake construction, working directly with facility operators to implement sound management practices, etc.).

All water supplies, regardless of their susceptibility, should consider identified factors that could lead to higher susceptibility in the future, and should prepare a strategy to protect the water supply source. Raising public awareness through signs and other education programs, encouraging proper intake construction and the use of best management practices in existing facilities are good ways of ensuring that a surface water source maintains its moderate susceptibility rating.

The South Haven WTP primary intake is located far enough from shore and in deep enough water that the CAZ is 1,000. The CAZ does not intersect the shoreline, so there is no shoreline susceptible area (figs. 3, 4). The South Haven WTP intake is considered to have moderately high susceptibility (fig. 5).

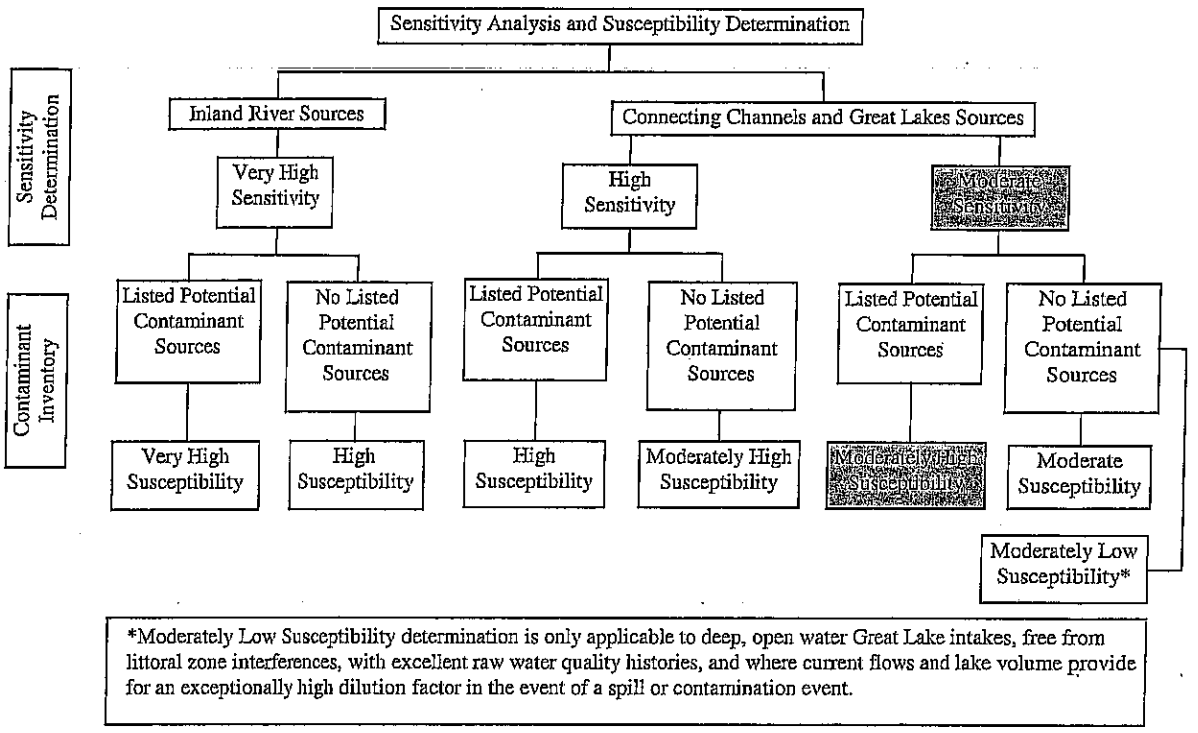


Figure 5. Surface-water source sensitivity analyses and susceptibility determination, South Haven water treatment plant source-water area, South Haven, Michigan.

Summary and Recommendations

The actual susceptibility of the drinking water source of a water supply depends on a number of contributing factors, some of which are only slightly related. Sensitivity is determined from the natural setting of the source and identifies the natural protection afforded to the source water. Susceptibility is determined by identifying those factors within the community's SWA that may pose a risk to the source water. The susceptibility determination provides information with respect to facilities within the SWA or land areas within the SWA that should be given greater priority and oversight in the implementation of a drinking water protection program.

Sensitivity Analysis: Based on criteria adopted in the Great Lakes Protocol of the Michigan Source Water Assessment Program, the offshore intake for the South Haven Water Treatment Plant has a moderate degree of sensitivity to potential contaminants. When considering off shore winds and influences from the Black River, the South Haven intake is categorized as moderately sensitive.

Susceptibility Determination: The SWA for the South Haven intake includes 80 listed potential contaminant sources, holding 92 discharge permits, plus agricultural, urban, and industrial runoff from the South Haven SWA. However, the intake is far enough from shore that the susceptible area likely doesn't influence it. The moderately sensitive intake for the South Haven WTP has a moderately high susceptibility determination (fig. 5).

Effective Treatment: While it has been determined the South Haven source water has moderately high susceptibility to potential contamination, it is also noted the city of South Haven Water Treatment Plant has, historically, effectively treated this source water to meet drinking water standards with minimal complaints from the public. This assessment provides the WTP with a basis to institute a source water protection program as another tool to assure the continued safety of its water supply.

The results of this assessment and the recommendations based on these results are summarized as follows:

- *Intake* - The South Haven Water Supply was originally constructed in 1928. The current surface-water intake was installed in 1951, and draws water 5,650 ft from shore, under about 34 ft of water (1935 datum), making it a moderately sensitive intake.
- *Soils* – Using a mean, area-weighted, depth-integrated permeability estimation, the soil and subsoil material in the SWA range from 0.47 in/hr to as much as 12.8 in/hr. The mean permeability is 7.16 in/hr (Schneider and Erickson, undated, series of 5 maps; BASINS, 1998). Most of the soils in the South Haven SWA are rapidly and very rapidly permeable. More than 80 PCS are located on these soils. These factors combine to make the SWA, and thus the intake, moderately sensitive. The community should take steps to evaluate current and future land use in areas of highly permeable soils, particularly those occurring within the susceptible area. Those PCS that have been identified either on or in close proximity to these soils should be informed of the sensitive nature of the area and encouraged to adopt best management practices designed to minimize the risk of a ground release. Residential areas that have been developed on these soils should be targeted for educational programs identifying steps that residents can take to protect the water supply.
- *Historical Contaminant Detections* - There have been no detections of synthetic or volatile organic contaminants in the systems raw water. Inorganic contaminants are typically at lake background levels. Nitrate concentrations are routinely below the detection limit. Positive coliform bacteria detections have occurred often associated with snowmelt, spring runoff, and discharge from the Black River above median flow. The periodic presence of coliform bacteria before chlorination at the intake is indicative of a relationship between runoff and soil conditions, causing the occasional presence of bacteria at detectable levels in the source water. These factors indicate that the SWA, and thus the intake, is moderately highly susceptible.
- *Sanitary Survey* - The most recent sanitary survey (Greiner and Howard, 1993) revealed only minor defects. Those requiring repair either have been corrected or are scheduled for repair. It is important that the water supply continue to follow good management practices.
- *Potential Contaminant Sources* - A review of the PCS inventory and the rapidly permeable and very rapidly permeable soil distribution indicates that the South Haven SWA has more than 80 PCS located on these soils. It is recommended that the community focus initially on PCS that are located on rapidly permeable and very rapidly permeable soils and nearest any water bodies, as they pose the greatest potential threat to the water supply. These facilities should be made aware of free technical assistance that is available through MDEQ's pollution prevention programs. Through chemical inventory, waste reduction, and by increasing

awareness of best management practices, the risk these facilities pose to source waters can be reduced. The PCS inventory indicates that the source has moderately high susceptibility.

- *Source Water Assessment* - The South Haven source water assessment of moderately high susceptibility is based on these site-specific parameters:
  1. Definition of a Critical Assessment Zone around the primary and emergency intakes for a source with moderate sensitivity;
  2. Definition of a SWA for the Black River and the shoreline near the intake;
  3. Wind and current patterns in Lake Michigan near the South Haven WTP intakes and their effects on source water quality; and
  4. Listed and nonlisted potential contaminant sources.
- *Source Water Protection* – The City has initiated source water protection activities with an Industrial Pretreatment Program incorporating management plans, chemical containment, and spill response, spill response training, and a street cleaning program.

The South Haven WTP and/or the community should assemble a team to assist in the development and implementation of a source water protection program that uses this assessment to further protect the South Haven source water area.

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GLOSSARY

Critical Assessment Zone (CAZ) – the area from the intake structure to the shoreline and inland, including a triangular water surface and a land area encompassed by an arc from the endpoint of the shoreline distance on either side of the on shore intake pipe location

Geographic Information System (GIS) – a system to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information

Impaired water bodies – As defined by USEPA and Clean Water Act 303(d) list

Intake – the point at which source (raw) water is drawn into a pipe to be delivered to a water treatment plant

Lignins – an amorphous, cellulose-like, organic substance that acts as a binder for the cellulose fibers in wood and adds strength and stiffness to cell walls

Maximum Contaminant Level (MCL) – the maximum permissible level of a contaminant in water that is delivered to any user of a public water system

Potential Contaminant Sources (PCS) – listed and non-listed agricultural sites, businesses, and industries that have the potential to cause contaminants to be introduced into source water

Sensitivity – a measure of the physical attributes of the source area and how readily they protect the intake from contaminants

Source – the water body from which a water supplier gets its water

Source Water Area (SWA) – the land and water area upstream of an intake that has the potential to directly influence the quality of the water at the intake

Source Water Assessment Program (SWAP)– in Michigan, the process defined by the state Department of Environmental Quality to complete assessments of all the state's public water supplies

Susceptibility – the Susceptibility identifies factors that may pose a risk within the community's source water area

Susceptible Area – the area defined by the critical assessment zone and a buffer on either side of any drainages that contribute water to an intake

Synthetic Organic Contaminants (SOC) – Manmade organic chemical compounds such as pesticides, etc.

Tannins – naturally occurring phenolic compounds that precipitate proteins, alkaloids, and glucosides from solution that has a yellowish appearance

Volatile Organic Contaminants (VOC) – Unnatural, volatile organic chemical compounds such as gasoline components, solvents, degreasers, etc.