1999

Setting a Course for Seneca Lake - The State of the Seneca Lake Watershed 1999

Seneca Lake Area Partners In Five Countries (SLAP-5)

Seneca Lake Pure Waters Association

SETTING A COURSE FOR SENECA LAKE

The State of the Seneca Lake Watershed 1999

Executive Summary

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&
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INTRODUCTION

The Seneca Lake Watershed management planning process began in 1996 with the development of the ***"Seneca Lake Watershed Study: Developing An Understanding of An Important Natural Resource."*** The study called for an in-depth description and analysis to determine watershed health, an education and awareness program to educate local residents about watershed issues and stimulate their interest in protecting Seneca Lake, development of a coalition for cooperation and participation in watershed projects, and development of a plan for the watershed and its residents to achieve the following goal:

"To protect and enhance Seneca Lake and its surrounding watershed through the encouragement of sound management practices and cooperation at the local level to develop a comprehensive approach for improving the quality of life and water in the Seneca Lake Watershed."

Completion of the preliminary watershed study was instrumental in the creation of the Seneca Lake Area Partners in Five Counties (SLAP-5). Comprised of representatives from local, regional, state, and federal agencies as well as concerned citizens, the group serves as the Oversight Committee for the Seneca Lake Watershed Management Planning process. As part of that process, a comprehensive report, ***"Setting A Course for Seneca Lake,"*** was completed in 1999.

Maintaining high water quality in Seneca Lake is a major purpose of watershed planning. This Executive Summary highlights key findings of the Report. It describes the current "state of the watershed" research, outlines potential threats to water quality in the watershed, and summarizes the importance of public and municipal government education and outreach efforts.

Watershed protection necessarily contains a large educational component that provides a connection to peoples' lives and can include a variety of audiences such as various interest-groups, school children, local government, farmers, cottage-owners, developers, businesses, municipal water drinkers, industries, highway superintendents, anglers and boaters. Undertaking an intense public outreach and education program to cement stakeholder participation in the next phases of the planning process is the next step in the Seneca Lake Watershed Project and "Setting A Course for Seneca Lake" forms a solid foundation for the hard work of planning and implementation that lies ahead.

PUBLIC & MUNICIPAL GOVERNMENT STAKEHOLDERS

The cooperation and participation of other the public and municipal government stakeholders in planning, fund-raising and implementing remedial strategies will be critical to the success of the watershed planning process to conserve Seneca Lake resources.

Municipal Participation

Ongoing efforts to involve municipal governments in the watershed project began in 1997 when SLAP-5 began enlistment of municipalities in the Seneca Lake Watershed by signing a "Call for Cooperation" and began the ongoing process to keep them apprised of the status of the project.

The Seneca Lake Watershed encompasses one city and portions of 28 towns and 11 villages with over 300 municipal representatives. Five counties-Chemung, Ontario, Schuyler, Seneca, and Yates–include parts of the watershed. Municipalities include: (see Figure 3.6)

Chemung County: Town of Veteran, Town of Catlin, Town of Horseheads, Village of Millport, Village of Horseheads

Ontario County: City of Geneva, Town of Geneva, Town of Seneca, Town of Phelps, Town of Gorham

Schuyler County: Town of Reading, Town of Tyrone, Town of Orange, Town of Dix, Town of Montour, Town of Catharine, Town of Hector, Town of Cayuta, Village of Montour Falls, Village of Watkins Glen, Village of Burdett, Village of Odessa

Seneca County: Town of Fayette, Town of Varick, Town of Romulus, Town of Ovid, Town of Lodi, Town of Waterloo, Village of Ovid, Village of Lodi

Yates County: Town of Benton, Town of Torrey, Town of Milo, Town of Barrington, Town of Starkey, Town of Jerusalem, Town of Potter, Village of Dundee, Village of Penn Yan, Village of Dresden

Public Participation

Public focus group meetings held during March 1998 gathered public input about the values and benefits of living in this area; environmental concerns about the Seneca Lake Watershed and some possible solutions for the concerns identified in order to make this watershed project a success.

The public's environmental concerns included nonpoint source pollution and other pollutants such as hazardous wastes and agricultural runoff; lake level; nuisance aquatic weeds; littoral zone damage; shoreline erosion; zebra mussels; and ground water contamination. Participants also expressed concerns about unregulated zoning and development; septic system failures; property values and economic issues. Education was viewed as critical to the preservation of the lake along with gathering critical data to assess the current watershed health. The public felt that, to make the watershed project successful, it was necessary to reduce sedimentation and erosion; educate residents, users and regulators; create baseline data on watershed impacting circumstances; upgrade septic systems; and improve and fix roadbanks.

Watershed & Resident Lakeshore Surveys

Watershed resident and lakeshore property owner (Home-A-Syst) surveys provided input from a cross-section of people living in the watershed and along the lakeshore. An important part of the surveys was to gather information on residents' perceptions of water quality and ways to protect the lake, as well as assess environmental and health risks.

The **Seneca Lake Watershed Resident Survey** was conducted in 1998 included 1200 surveys mailed to a selected cross-section of landowners throughout the watershed. 692 responses were received, a 58% response rate.

Since more than half of those surveyed felt that water quality had a major impact on the value of their property, it becomes critical that residents and their municipal government representatives become informed about the contents of the Watershed Report.

The **Lakeshore Property Owners Survey** (Home-A-Syst) includes the results of an environmental risk assessment survey of approximately 1000 lakeshore residents. Information gathered in the survey was used to assess and quantify potential pollution risks from lakefront homes.

While practically all of the homeowners surveyed are fairly knowledgeable about their property, many are not aware of potential environmental and health risks. Most participants were more concerned with those risks directly associated with their health rather than with environmental risks. Although the reported incidence of environmental concerns may be low, this may simply be related to homeowners' lack of knowledge about a potential problem.

WATERSHED DESCRIPTION

A **watershed** is "a geological and geographical area of land that contributes water through its springs, seeps, ditches, pools, culverts, marshes, swamps, and streams to a body of water."

Seneca Lake is the largest and deepest of the eleven Finger Lakes that make up a complex system of lakes and rivers in central New York State known as the Oswego River Basin. The Oswego River Basin has an area of 5,100 square miles and drains into the Oswego River, which flows north into Lake Ontario.

Lake Facts

- Almost 50% of the water volume of all the Finger Lakes is stored in Seneca Lake. The Lake contains over 4.2 trillion gallons of water. Spread a foot deep, it would cover 40% of New York State.
- Land area drained: about 457 square miles.
- Dimensions: Seneca Lake is 35.1 miles long and has an average width of 1.9 miles. It has a maximum depth of 651 feet and an average depth of 290 feet. Surface area is 66.3 square miles or about 42,400 acres. Shoreline in Seneca, Ontario, Yates and Schuyler Counties totals about 75 miles.
- Age: 12,500 years.
- pH of Lake water: slightly alkaline (8.0-9.0), varying with season and depth.
- General water clarity: 5 feet in summer to 10 feet in winter (Halfman, 1999).
- Sodium Chloride (salt) concentration in lake water: 150 parts per million (ppm) (Wing et al. 1995).

The sheer volume of water stored in Seneca Lake is one of this resource's most important values, as it:

- Holds and dissipates heat, tempering the local climate and serving as a source for cooling water;
- Provides water for drinking, irrigation, and industrial processes;
- Dilutes and neutralizes pollutants such as sewage effluents, runoff from land, industrial discharges and individual septic systems; and
- Provides various requirements for valuable recreational fisheries.

Geology

During the Paleozoic era, 220,000 - 600 million years ago, the Seneca Lake watershed was part of a vast inland sea. Layers of sand, mud, lime and silt gradually formed on the sea bottom from evaporation, precipitation of dissolved minerals and deposition of silt particles. Eventually, these layers were compressed into rocks with a depth of some 8,000 feet. Their remnants form the sandstones, shales and limestones of today's Hamilton, Genesee, Sonyea, Java, and West Falls formations.

During the great ice age, which began about 2 million years ago, massive glaciers invaded the Finger Lakes region. Repeated glacial advances formed the Seneca Lake valley and carved the famous gorges around the south end of Seneca Lake. Today, these gorges are visited by a million tourists annually.

Soils

As glacial ice retreated 9,000 – 10,000 years ago, it left behind major moraines: great piles of sand and gravel left by the melting face of the glacier. In addition, large deposits of surface debris, called glacial till, mantled the region. In the 10,000 years since, these soils have often been overlaid by and mixed with other material deposited by wind and water and by humus from the forests that covered the area. In 1778, a traveler to the region described the soil's upper layer as composed of 8 to 10 inches of black organic loam. Unfortunately, much of this soil has since been lost due to erosion and oxidation.

The northern portions of Seneca Lake's basin contain moderately coarse-textured soils with calcareous substrata known as Howard, Langford, Valois and Honeoye-Lima soils. To the south, these soils give way to more acid, less well drained types such as Volusia and Mardin-Lordstown. The combination of steep topography and acid, poorly drained soils in the south, compared with better buffered, better drained soils on flatter terrain in the north, is strongly reflected in land use patterns and in the price of farmland. *(Detailed soil mapping prepared as part of this report is available from Yates County Soil and Water Conservation District.)*

Topography

Relatively flat topography at the north end of the Lake changes to rolling hills and steep sided valleys to the south. The main landform features are the Lake itself, with an elevation of about 445 feet above sea level, and the carved rock channel gorges and waterfalls of the Lake's east-west tributaries. The Lake has a smooth, regular shoreline occasionally broken by flat deltas built by tributary streams and wave action. The Lake's bottom drops off steeply, with an average slope of nine percent.

Climate

The Finger Lakes region is characterized by cold, snowy winters and warm, dry summers although major flooding events may occur at any time. At the extreme, flooding has raised the Lake to a maximum level of 450.2 feet. While the central Finger Lakes is one of New York State's driest regions, precipitation is adequate to support most horticulture, especially that of deep rooted plants such as grapes.

Average precipitation for the region is about 34 inches per year, with the smallest amounts falling from December to March. Winter snowmelt commonly occurs in late March or early April. Air temperatures average a maximum of 69 degrees F in July and an average minimum of 24 degrees F in January. Since 1912, ice cover has occurred only in localized, near shore areas.

Vegetation

Before colonial times, the Seneca Lake basin was almost entirely covered by forests. Beginning in the late 18th century, settlers rapidly cleared these forests for farmland. Up to ninety percent of the area had been cleared by the latter half of the 19th century when a trend of farm abandonment began. As a result, much of the cleared land, especially in the basin's southern portion, has reverted back to forest.

Four natural vegetative zones are found in the Finger Lakes region: northern hardwoods, dominated by beech and sugar maple; elm-red maple-northern hardwoods; oak-northern hardwoods; and pine-oak-northern hardwoods. Basswood, white ash and black cherry are found in warmer locations. Hemlock, white pine and white cedar are abundant but unevenly distributed. Alder and larch are found on wet sites and white pine is an early colonizer of abandoned fields. More than ninety percent of the watershed's forests are estimated to contain mixed northern hardwood and oak while eight percent are softwoods. While trees may visually dominate a landscape, smaller understory, groundcover and field plants add vibrant color, unique wildlife habitats and even scent to the natural landscape.

Wildlife

Wildlife in the Seneca Lake basin is abundant and varied. Among the most prominent species are the white-tailed deer; Canada goose; many other kinds of waterfowl, shorebirds and songbirds; beaver; groundhog; skunk; opossum; gray squirrel; Eastern coyote; red fox; ruffed grouse; muskrat; and cottontail rabbit. Other less frequently seen species include bobcat, black bear, otter, red and flying squirrels, and a variety of mice, voles, and bats.

Fisheries

Traditionally, lake trout, smallmouth bass and yellow perch have been the mainstay of Seneca Lake's fishery. Other species such as rainbow trout, brown trout, landlocked Atlantic salmon, northern pike and largemouth bass add diversity. Alewives (sawbellies) and rainbow smelt provide a dependable forage base for trout and salmon. The Lakes 's excellent fishery benefits greatly from annual stockings of lake trout, brown trout and Atlantic salmon. All other fish species are sustained entirely by natural reproduction. An important factor in the recent resurgence of the fishery is NYSDEC's ongoing control of the parasitic sea lamprey. The invasion of other exotic species like zebra mussels and the spiny water flea will no doubt impact the ecology of the lake and may negatively affect the fishery in the future.

Rare & Endangered Species

NYSDEC's Natural Heritage Program has provided a list of Rare and Endangered species found in the Seneca Lake watershed. (These lists may be incomplete and should not be used in place of on site surveys by qualified ecologists.)

- **Rare**: Wild Onion, Kentucky Coffee Tree, Marsh Horsetail, False Hop, Handsome Sedge and Rockcress.
- **Endangered**: Leedy's Roseroot and Short-eared Owl.
- **Threatened**: Spreading Globeflower, Northern Wild Comfrey, Green Floater and Bird's-Eye Primrose.
- **Significant but Unprotected**: Slender Pondweed, Straight-Leaf Pondweed, Mare's-Tail, Blue-Hearts, Leiberg's Panic Grass, Cypress-Knee Sedge and Mead's Sedge.
- **Significant but Unprotected Communities**: Perched White Swamp Oak Community, Floodplain Forest, Silver Maple-Ash Swamp and Waterfowl Concentration Area.

Wetlands

Wetlands include such familiar areas as marshes, swamps and bogs where the water table is usually at or near the surface. The wetland area may be covered by shallow water all or part of the year or may not show surface water. There are approximately 4,155 acres of New York State Department of Environmental Conservation regulated freshwater wetlands fairly evenly dispersed throughout the watershed The largest wetland is Queen Catharine Marsh in Schuyler County.

Agriculture

Historically, farming has been a major industry in the watershed due to its relatively mild climate and fertile soils. By 1885, about 85% of the land was under cultivation. However, between the 1950's and the 70's, total agricultural land use declined. This trend only recently reversed with the influx of Mennonite farmers into the area. Similarly, competitive markets for grapes were reduced by the loss of independent wineries in the 1960's and 70's, and many grape-growers ceased production. A resurgence of small, farm-based wineries and developing specialty markets in the 1980's has kept growers in business.

Agriculture has a major impact on the larger economy of the area. Until recently, most of the industries in the watershed were related to agriculture, including canneries, fruit processing, milk processing, cheese making and wine production. The latter also attracts many tourists to the region.

Recreation

Boating is an important recreational use of the Lake. 60,000 boat registrations in the Central New York area that includes the Finger Lakes region indicate a strong demand for boat access to Seneca Lake's waters every year.

Boating is not the Lake's only recreational value. Tourism, much of it generated by lake-related activities, brings many dollars annually into the local economy and the tourism industry is a major employer in the area. Major attractions on Seneca Lake include: Watkins Glen State Park, the Queen Catharine Marsh, Seneca Lake State Park in Geneva, Sampson State Park, Lodi Point Marine Park, Severne Point Boat Launch, Smith Memorial Park in Hector, and Clute Park and Seneca Harbor Park, both in Watkins Glen.

Lake Level Control

The Basin includes three geographic areas which directly affect water flow to and from the Finger Lakes. These include the Appalachian Plateau, Tug Hill, and the Lake Ontario Plain. One additional geographic area – the "Clyde/Seneca River-Oneida Lake Trough – is also significant to the drainage pattern of the Basin. This is the flattest and slowest moving stretch of the Basin into which flows all of the major rivers, including the Seneca, Oswego and Oneida Rivers.

The geography of the basin created flooding and navigational problems and led to many attempts to control lake levels. The first dam on Seneca Lake, built at Waterloo in 1828, was replaced with the present dam and naviga tion lock in 1916. Repeated flooding led to the creation of the NYS Water Storage Committee in 1902 to regulate river flow and to develop hydroelectric power. Today, there is a hydroelectric plant at Waterloo and a second one along the Cayuga-Seneca Canal.

The level of Seneca Lake can be regulated by controls at the outlet at Waterloo or further downstream at Seneca Falls. During the winter, the lake is drawn down to prevent ice and wind damage to shoreline structures and to provide storage for spring runoff. Summer lake levels are stabilized to facilitate priority uses such as boating. Planned winter levels are 445 plus or minus 0.3 feet. Summer levels are planned for 446 plus or minus 0.3 feet. Flood stage is 448. In the 1972 flood, lake levels rose to 450 feet.

Demographic & Socio Economic Profile

Population trends affect the watershed in a number of ways. Population gains drive new development with its associated impacts on the lake and watershed. On the other hand, declining population in municipalities is often accompanied by loss of the tax revenue needed to maintain aging infrastructure and facilities.

The population living year-round in the Seneca Lake Watershed was estimated to be just under 54,000 in 1990, distributed at an average density of about 117 people per square mile. The actual density varies markedly between the more heavily populated areas (e.g., Geneva, Penn Yan, Watkins Glen) and the rest of the watershed. Census data is available only for whole municipalities, though often only a part of a municipality may lie within the watershed. Thus the ability to make demographic statements about "the watershed" is limited.

The total population of the watershed has been relatively stable over the last thirty years and is projected to increase only slightly over the next ten years. However, several municipalities had significant population increases or decreases between 1970 and 1990.

In contrast, in some areas of the watershed, the influx of Mennonites has resulted in a reversal of a long-standing decline in the number of small farms, especially in Yates County. In fact, an increase in farm households will likely be reflected in the new census data when it becomes available in 2002.

LAND USE

The analysis of Land Use for the Seneca Lake Watershed explores how land is used in the watershed and assesses how changes in land use impact water quality.

Comparisons of land use studies conducted in 1971, 1981 and 1995 show that agricultural land has declined, forests and developed areas have increased, and the area of idle land has increased. With development projected to increase, future educational efforts should be focused on communities which have idle acreage ready for development but have only minimal local land use control programs.

The Watershed Report also reviews past land use patterns and potential changes which may influence the rate of contamination, the status of land use laws controlling construction activity, land use type, stormwater runoff, erosion control, landscaping, as well as the protection of floodplains, wetlands and other features of the landscape. (See Figure 4.1)

Agricultural changes

While agricultural land use has increased in some areas, overall agricultural acreage in the watershed has decreased.

Forest increases

Undisturbed forests contribute the least erosion, sedimentation or nutrients to the watershed. However, the increase in forested land has led to increased logging, with its associated localized sedimentation and high runoff problems.

Idle land

Old pastures can grow into excellent wildlife habitat as the initial stages of new forest, but idle land is very likely to be converted to development and thus warrants special attention. The percentage of idle land varies dramatically between individual subwatersheds.

Increasing Development

Development is the land use category that has experienced the most dramatic changes in the Seneca Lake Watershed. Lot and house sizes have been steadily on the increase since World War II and second homes are on the rise. This expansion into rural areas brings potential conflict with farmers, long time residents, wildlife, and the visual quality of the landscape. In addition there are physical impacts on water quality due to runoff from new construction, long term use of lawn care products, demand for deicing salts, alteration of drainage patterns and the loss of wetlands.

Other threats come from leaching landfills, junkyards and septic disposal systems. Future developments, if not carefully controlled, bring with them additional problems.

Implications of Land Use for Water Quality

Without positively changing the way that people use land and without changes in government policies toward land use, the watershed is likely to continue to lose farmland, gain forests, and see the conversion of idle land to forest or development. How will these trends impact water quality?

The areas which drain into the lake also present problems, both with the quality and quantity of water that is discharge to the lake. Silt, a major threat to Seneca Lake, discolors the water, covers spawning beds and provides a rooting bed for weeds and other plant growth. Construction of more impervious surfaces such as hard-surfaced roofs and blacktop send increasing volumes of water into the streams that feed the lake. Straightened ditches and culverts compound siltation problems by increasing stormwater flow rates.

Several programs such as Agricultural Environmental Management (AEM) planning , the adoption of county farmland protection plans, and private efforts to acquire farmland protection easements could be marshaled to slow the loss of farmland while preventing farm-related water pollution.

A secondary effect is that cheap logged land is available for development. Logging registration laws and good forest management practices can prevent water problems associated with logging, while sound land use and subdivision laws can minimize development problems.

This poses the question of whether local communities, especially those with large amounts of idle land, are prepared to deal with the conversion of such land to more intensive uses?

Active purchase of development easements by open space preservation groups such as the Finger Lakes Land Trust and the adoption of land use laws by local communities can direct development to appropriate locations and control water quality impacts without adversely curtailing the development market.

LIMNOLOGY of SENECA LAKE

Seneca Lake is believed to be relatively pollution free – but not worry free. A number of recent concerns at neighboring lakes suggest a growing need to continue monitoring the health of Seneca Lake.

Our current understanding of the limnology and water quality of Seneca Lake is based on ongoing monitoring by Hobart and William Smith Colleges (HWS) in conjunction with Seneca Lake Pure Waters Association, Inc., the watershed's local, citizen-based advocacy group.

Water quality evaluation includes the following questions:

- What is the water quality of the lake, especially with regard to chloride, hardness and selected pollutants?
- What is the trophic status (i.e., nutrient loading) of the lake?
- Does the water quality and/or trophic status change in different parts of the lake?
- Does the water quality and/or trophic status of the lake change over time? For example, have zebra mussels and/or other factors influenced the lake?

Lake Biology – Fundamentals

The littoral zone is a unique area where waters are shallow enough to let large amounts of sunlight reach the bottom, supporting both plant and animal life at the bottom of the food chain. Seneca Lake, with its steep shores and great depth, has an unusually low proportion of its total water volume in its littoral zone. This littoral zone needs protection against pollutants, against structures which shade the sunlight, and against activities which disturb the plant and animal life.

The biology of any lake is primarily made up of **plankton** – microscopic floating life forms that are divided into three major groups: phytoplankton, zooplankton, and bacterioplankton. Other organisms are less important in terms of their total biomass but are more familiar to the average person. They include fish, shallow-water weeds, and zebra mussels.

In Seneca Lake, the dominant **phytoplankton** are various forms of diatoms, which are phytoplankton that secrete siliceous shells. Asterionella dominates in the spring and Fragillaria dominates in the fall. Certaium, a green algae, may dominate in the summer months with occasional but brief blooms of blue green algae (*Anabaena*) and microscopic plants (*Ecballocystis*). The difference reflects the availability of specific nutrients, sunlight, and predation pressures.

The dominant zooplankton are copepods, a class of organisms belonging to the phylum Crustacea that look like a miniature lobster. Along with freshwater shrimp, rotifers and daphnia, copepods are the first-order consumers. The latter are an important source of food for young lake trout, while the former are eaten by forage fish which, in turn, are eaten by older lake trout.

Near shore, attached plants and other organisms, include ing Eurasian water milfoil and zebra mussels, impact the lake's ecosystem. Milfoil provides a habitat for various species of fish but is a nuisance for boaters and swimmers. Zebra mussels, an exotic species first observed in 1992, feed on plankton and have now colonized almost every suitable shallow-water habitat.

Seneca Lake as A Source of Drinking Water

Water is one of our most precious natural resources since it is fundamental for survival. Seneca Lake is the drinking water source for over 70,000 people in central New York State. It provides Class "AA" water, which is the best possible potable water classification. Briefly, Class "AA" and "A" water supplies are used for drinking water and only require disinfection and filtration treatments. Class "B" water can be used for swimming but not drinking. Class "C" and "D" water have greater restrictions.

Chloride Concentrations

Chloride is typically the most abundant chemical dissolved in natural waters because it is rarely removed by biological and chemical processes within the lake. Too much chloride in drinking water is a health risk. Seneca Lake has chloride concentrations of 150 mg/L, which doesn't pose an immediate health risk to the majority of the population but is of concern however, because it is 2 to 10 times higher than the chloride concentration of the other Finger Lakes.

Seneca Lake is saltier than the other Finger Lakes because its basin intersects the Silurian beds of salt 450 to 600 meters below the ground surface. Percolating groundwater brings saline water into the lake from below. Calculations indicate that, in addition to surface runoff, an extra 375 million pounds of salt must be added to Seneca Lake this way each year to produce the measured concentration in the lake. This significantly exceeds the amount discharged into the lake by salt mines, road salting and wastewater treatment plants.

Acidification of Seneca Lake

The burning of fossil fuels releases sulfur and nitrogen oxides into the atmosphere, which convert to strong acids when mixed with water in the air or on the ground. The pH of Seneca Lake varies from 8 to 9, indicating that acid rain has had minimal impact on the acidity of the lake. Seneca Lake's higher capacity to neutralize acids is due to the limestone found in the glacial tills and bedrock the watershed. The lake itself is rich in dissolved carbonate, bicarbonate and other acid buffering ions which neutralizes acid precipitation before it impacts the Lake.

Water Hardness

Seneca Lake's water is moderately hard, with total concentrations of 140 - 150 mg/L, though the lake water is not as hard as the local groundwater. High concentrations of calcium, coupled with high alkalinity concentrations in Seneca Lake, result in the occasional precipitation of calcium carbonate from the water during warm, biologically productive summer months. Precipitation events are occasionally observed as a white coating on stems and leaves of near-shore submerged plants. Dissolved calcium and carbonate ions are also required for the calcium carbonate shells for zebra mussels, clams, snails and other shelled animals. Preliminary calculations suggest that zebra mussels remove approximately 30% of the calcium precipitated on the lake floor.

Herbicides, Pesticides and Other Pollutants

The US Geological Survey (USGS) Water Resources Division has analyzed water from the Finger Lakes for the occurrence of various herbicides. The results show concentrations for atrazine and other herbicides that either exceed or fall just below the EPA's minimum threshold for safe drinking water. Cayuga Lake has the highest concentration of the Finger Lakes, perhaps due to its larger watershed and higher density of agricultural land with Seneca Lake and other lakes a close second.

Hobart and William Smith Colleges is investigating atrazine levels in Seneca Lake. Atrazine, a common herbicide used to control broadleaf weeds in corn and other common crops, is susceptible to surface runoff after application to the fields. Preliminary results indicate that atrazine concentrations in the lake are below the maximum contaminant levels (MCLs) of 3.0 ppb established by the EPA. Stream samples reveal that the major source for atrazine is from surface runoff of agricultural land with the remainder from groundwater and atmospheric sources.

Fish health advisories related to elevated levels of PCB's in lake trout from Canadice and Canandaigua Lakes, DDT in lake trout from Keuka Lake, along with isolated heavy metal contamination of sediments, is under study by NYSDEC. Unfortunately, data are not available to exclude the full range of potential pollutants in the Seneca Lake Watershed or detail changes in these water quality parameters over time.

Water Temperature

Water temperature decreases with water depth for typical lakes in North America. Seneca Lake's deep water is always cold. Surface water temperature varies season ally, rising to over 20°C (70°F) during the summer falling to near 0°C (32°F) during the winter. Winter water temperatures are colder at the surface (near 0°C) than at the bottom (near 4°C) of the lake.

The seasonal change in temperature at the surface and constant temperatures at the lake floor is related to the seasonal cycle of the sun. The solar cycle produces warm surface water in the summer and cold surface water in the winter. The density of water varies with temperature, but – unlike most liquids – water is most dense at 4°C and becomes less dense at both warmer and colder temperatures.

The seasonal change in water temperature, and thus water density, is critical because less dense liquids "float" on more dense liquids. During the summertime, warm surface water "floats" on the colder, denser bottom water. These layers are separated by the **thermocline**, the zone of rapidly changing temperatures in the water column. During the fall, solar heating decreases, energy is lost from the lake, and the upper layer cools. By late fall or early winter, the entire water column is at the same temperature and the lake may overturn, mixing bottom and surface waters. As the surface water cools below 4° C, the colder surface water becomes less dense and "floats" on the warmer, bottom water, which is still at 4 degrees C, restricting mixing. Increased solar energy in the spring warms the surface water to 4°C, once again allowing the lake to mix.

In Seneca Lake, the seasonal cycle of surface water temperatures is from ~4 to ~25 degrees C. The annual thermal cycle and seasonal stratification of the water column is critical because it defines seasons when the water column can mix and when the water column is stratified and isolates the bottom water of the lake. This cycle influences the distribution and concentration of dissolved gases, ions, nutrients and other items essential for life. The temperature of the water also governs the rate of chemical, biochemical and physiological reactions. Biochemical and physiological reactions are exponentially faster in warmer than colder water. For example, bacterial respiration increases 1.5 to 4 times for every 10 degrees C increase in water temperature.

Not only does the depth of the thermocline vary seasonally, it also migrates upward and downward in response to wind and current induced internal waves. Strong north or south winds push the water's upper layer towards the downwind end of the lake. The upper layer thickens by 15 or more meters at the downwind end and thins by the same amount at the upwind end. When the wind stops, the water sloshes back and forth in the lake like a standing wave in a bathtub, forcing both the surface of the lake and the thermocline to oscillate upward and downward. As water temperatures at a given location change from day to day and season to season, their influence on the structure, biology and chemistry of the lake changes as well. Lakes are dynamic and impossible to quantify with isolated samples.

Trophic Status of Seneca Lake and Recent Changes

The trophic status of any lake is determined by the concentration of dissolved oxygen, soluble nutrients and the biological productivity that results. Trophic states range from oligotrophic to eutrophic lakes. Oligotrophic lakes are biologically sparse, transparent, nutrient poor, and not very productive in fish. Eutrophic lakes are more productive, turbid, green, nutrient rich, and fertile in fish. Dissolved oxygen concentrations, water clarity, and nutrient and chlorophyll concentrations are used to determine the trophic status. Seneca Lake is oligotrophic/ mesotrophic (i.e., somewhere between eutrophic and oligotrophic).

Dissolved Oxygen

The concentration of dissolved oxygen (DO) in lakes is influenced by water temperature, diffusion into the water column from the atmosphere, and biological reactions such as photosynthesis and respiration. Even though oxygen is abundant in the atmosphere, its low solubility and slow diffusion into water produces low DO concentrations in the water column. Colder water can dissolve more gas than warmer water. (For example, cold soda has more dissolved CO_2 than warm soda.) Maximum DO concentrations are approximately 13 mg/L at 4°C and 8 mg/L at 25°C. However, biological photosynthesis and respiration alter these DO levels.

Photosynthesis releases oxygen, primarily to Seneca Lake's upper layer and respiration consumes oxygen, primarily from the lower layer. Both biological processes occur at rates faster than oxygen diffuses into the lake from the atmosphere. Thus, eutrophic lakes with their high rates of photosynthesis and respiration can supersaturate near surface waters with oxygen while depleting oxygen from deep water. In contrast, DO concentrations are only slightly modified by biological activity in oligotrophic lakes and are primarily influenced by water temperature. Thus, DO concentration should increase with water depth during the summer in oligotrophic lakes.

In Seneca Lake, DO concentrations are at or near saturation throughout the water column during the entire year, indicating that DO concentrations are dictated by water temperature and are not affected by substantial biological activity.

Secchi Disc Depths

The Secchi disc is a simple but accurate method to measure water transparency. Secchi depths reflect plankton concentrations and trophic status in Seneca Lake. The typical depths suggest that Seneca Lake is an oligotrophic /mesotrophic lake.

How far sunlight can penetrate the water column determines both the thickness of water that is warmed by the sun and the maximum depth that sunlight is available for photosynthesis. Measurements are taken by attaching the Secchi disc to a rope that is slowly lowered through the water column until it disappears from view. Since plankton and suspended mud particles are the major contributors to water turbidity, shallow Secchi depths indicate higher plankton and/or suspended sediment concentrations.

Secchi depths are shallower during the summer months than early spring and late fall and this seasonal variation parallels the expected rise and fall of plankton concentrations, with the largest plankton concentrations in the summer months when sunlight is most abundant and nutrients are still available. On any given day, Secchi disc depths from across the lake are within 1 meter of each other and the differences are consistent with expected patchy concentrations of plankton.

Nutrient Concentrations

Nutrient concentrations are a good indicator of trophic status. Higher concentrations allow for more biological growth and are more typical of eutrophic lakes, whereas lower concentrations restrict growth and are more typical of oligotrophic lakes. Lately, many lakes are becoming increasingly eutrophic due to human activities which increase nutrient loading.

The nitrate and phosphate data indicate that Seneca Lake is either oligotrophic, mesotrophic or somewhere in between, depending on which nutrient is used to determine the ranking. Algae require a fixed ratio of 1:7 of nitrogen and phosphorous. In Seneca Lake, the P:N ratio is significantly smaller, indicating that Seneca Lake is severely "phosphorous limited" which in practical terms, this means that excess loading of phosphorous from sewage treatment facilities, septic systems and elsewhere could result in algal blooms and possible eutrophication of the lake.

Nitrates are introduced by nonpoint source pollutants such as acid rain. Loss of vegetation through fires, flooding or clearing in the watershed reduces nitrogen uptake and results in greater runoff. Also human-induced sources of nitrates enter the lake in the form of runoff from agricultural land, especially after the application of fertilizer, runoff from farm animal feed lots, and discharge from improperly treated sewage, especially private septic systems.

Phosphates, the usable form of phosphorous, are naturally eroded from bedrock and soils but at very slow rates. However, domestic, agricultural and some industrial wastes are major sources of phosphates in lakes, especially from use of phosphate-rich soaps and improperly treated sewage within the watershed.

Diatoms also require dissolved silica to secrete their shells. These nutrients are very scarce in lakes and limits plant growth during the non-winter seasons which in turn, limits the amount of food for organisms higher in the food chain.

In general, nutrient concentrations vary during the year and with water depth. Photosynthetically active algae are restricted to the upper layer, where sunlight is available and deplete nutrients from the top layer during the non-winter seasons. When algae die and sink to the lake floor, bacteria decompose the organic matter and excrete nutrients into the water. Nutrients that reach the sunlit upper layer are recycled into the next generation of algae; nutrients released to the lower layer accumulate there because bottom waters are too dark for photosynthesis. Thus, nutrients build up in the lake's depths during the spring, summer and fall of the year, eventually returning to the lake's surface when the lake overturns during the late fall and early spring.

Chlorophyll-a

Chlorophyll-a is the most common pigment used to capture sunlight for photosynthesis and its concentration is typically proportional to the total algal biomass and trophic status of the lake. Concentrations change with water depth seasonally and the largest chlorophyll concentrations during the summer months parallels the summer rise in algal populations. Algal blooms may occur locally in a patchy distribution if nutrients are added to the lake's upper layer from intense storm runoff events, sewage spills, runoff of agricultural fertilizers or the upwelling of nutrient-rich bottom waters.

In Seneca Lake, chlorophyll-a concentrations range from

below the detection limit to slightly greater than 10 μg/L again indicating that Seneca Lake is borderline oligotrophic–mesotrophic.

Long Term Changes in the Limnology of Seneca Lake

Very little data is available to investigate changes before 1990. Secchi disc records reveal a progression from more transparent to more turbid waters during the middle part of the century that may correspond to a human-induced increase in nutrient loading contributing to lake eutrophication. The noted decrease in turbidity from 1970 to 1990 may also reflect better sewage treatment systems and better farming practices, although other limnological and land use data are unavailable to confirm these suspicions.

Over the past decade, biological parameters in Seneca Lake show a marked reversal after 1998. Deeper Secchi depths and less chlorophyll-a in the lake from 1990 to 1998 suggest fewer plankton and significantly clearer water over time. The trends may reflect a continued reversal of the lake's eutrophication although this hypothesis is not consistent with the constant nitrate and phosphate concentrations or higher concentrations of dissolved silica over this time frame.

The trends from 1990 to 1998 also may reflect the observed rise in zebra mussel populations in Seneca Lake substantiated by the apparent increase in dissolved silica from the early 1990's to 1997 resulting from the selective consumption of plankton by zebra mussels. Since plankton are primarily diatoms, reducing their population removes the primary consumer of dissolved silica from the lake.

The decrease of phytoplankton populations from 1992 to 1998 should result in the consumption of less and less dissolved nutrients over the same time period. Yet phosphate and nitrate concentrations have remained relatively constant over this time period, and are perhaps being removed by another species of plant in the lake. Alternatively, these nutrients may be removed by the accumulating biomass of zebra mussels.

The drastic reduction in the phytoplankton biomass over the past decade must impact the lake's ecology. Continuously, less food was available from the early 1990s to 1997 to feed organisms higher up the food chain. This scarcity most likely reduced their populations, although no systematic sampling has been performed to confirm this result. Nevertheless, this scenario is consistent with numerous but unofficial reports of fewer and smaller fish catches by local fishermen.

The 1998 mid-summer increase in nutrient concentrations and chlorophyll-a, and a decrease in Secchi disc depths, suggest an influx of nutrients to the lake that triggered an increase in algal productivity and more turbid water, especially during that summer.

Pinpointing the exact source of these additional nutrients is difficult because data are insufficient. While a number of possible explanations have been suggested, the most likely hypothesis seems to be that the decomposition of zebra mussels may have provided a previously unavailable source of nutrients to the upper layer of the lake in the summer of 1998, so the decomposition of dead zebra mussels and the associated recycling of the nutrients in their biomass probably would not impact the lake until 1997 or 1998. This delay could explain the increased release of nitrates and phosphates to the lake during 1998 and 1999.

Surface water temperatures were much warmer and the depth to the thermocline was much deeper in 1998 than in the recent past. This would have contributed to faster and more complete decomposition of dead zebra mussels in 1998. The decomposition would be fastest during the warm mid-summer season. This scenario conveniently explains the increase in trophic status of the lake during 1998. However, it provides many more questions than answers. To what extent was the change in 1998 the result of warmer water, zebra mussel life cycles, or an alternative hypothesis? This is a tough question to answer. Interestingly, data in 1999 are very similar to the 1998 results, and suggests the same scenario is continuing. More importantly, 1999 marks the first year for significant accumulations of dead zebra mussels along the shoreline and littering the lake floor. The occurrence is consistent with our nutrient recycling hypothesis.

Stream Water Quality in the Seneca Lake Watershed

Surface runoff carried by streams is the major non-point source of pollutants and contaminants to Seneca Lake. Stream hydrology and water chemistry data are crucial to understanding and managing Seneca Lake. However, information about the hydrology and water quality of the streams that empty into Seneca Lake is still limited.

Seneca Lake's watershed is drained by a number of streams and overland runoff known as "direct drainage areas" to the Lake. These are divided among twenty-nine sub-watersheds and direct drainages. (See Figure 3.5)

Current stream information is based on measurements taken by Hobart and William Smith Colleges in conjunction with Seneca Lake Pure Waters Association, a local, citizen-based, advocacy group. Additional data was obtained from NYSDEC. The current monitoring program collects and analyzes stream hydrochemical data from seven of the approximately 130 streams and tributaries within the watershed. Selected streams include Wilson, Kashong, Keuka Outlet, Plum Point, Big Stream, Reeder and Kendig, all specifically selected to assess the impact of agricultural land use and basin areas on stream hydro chemistry. While providing a diverse cross section of major parameters within the watershed, basin areas and agricultural land use are not the only sources of potential impact.

At each site, stream discharge was measured and water samples analyzed for dissolved oxygen, pH, chloride, alkalinity, hardness, nutrients (e.g. nitrates, phosphates, silica), total suspended solids and specific conductivity. Water samples in 1999 were also analyzed for atrazine, a common herbicide. However, sampling was not carried out on a regular schedule and no systematic effort was made to sample major hydrologic events like heavy rainstorms or spring snowmelt. Information on additional parameters like heavy metals, polychlorinated organics and other pollutants are not available at the present time.

Water Discharge

Spring snowmelt, major precipitation events, and longer-term climatic cycles clearly influence discharge to the lake. Most of these streams are high during snowmelt and run lower to dry by the middle or end of summer. Discharge in the Keuka Outlet is significantly influenced by the dam at Penn Yan.

Chemical loads were not calculated because not enough data is available from major hydrologic events like the spring snowmelt and heavy rainstorms, when the majority of chemicals are probably flushed into the lake. If the watershed is at equilibrium, stream and lake concentrations should be similar. However, higher concentrations of a chemical in the lake indicates the presence of additional sources of that chemical. Conversely, higher stream concentrations indicate that some mechanism is removing the chemical from the land.

Chloride, Hardness, and Atrazine Concentrations

No relationship was observed between chloride concentrations and subwatershed size or agricultural land use for the seven selected streams. Chloride concentrations in the streams are much lower than in the lake and the difference suggests that chloride may also enter the lake as runoff from road salt application and from salt deposits beneath the lake. Calcium concentrations or hardness values are found in streams with underlying calcium rich soils, glacial tills and limestone bedrock.

These are more prevalent in the northern part of the watershed. Calcium concentrations in all these streams are higher than the average lake concentration. The difference probably reflects the amount of calcium removed from lake water by precipitation and the incorporation of calcium into the shells of zebra mussels. HWS estimates that over 4,000 metric tons of calcium are deposited on the lake floor each year by these two processes.

Atrazine is a common herbicide used to control weeds in corn and other crops. Mean atrazine concentrations for the selected streams average 0.17 ppb and range from a low of 0.06 to a high of 0.29 ppb. Concentrations are significantly below the maximum contaminant levels of 3.0 ppb established by the EPA. Except for Kashong Creek and Big Stream, atrazine concentrations are proportional to agricultural land. Concentrations increase significantly during mid-summer months after the application of the herbicide, indicating a clear link between agricultural runoff and the presence of atrazine in the lake.

Nutrient Concentrations

Nutrient runoff significantly impacts the water quality of the streams in the Seneca Lake Watershed. Nutrient concentrations of mean nitrate, soluble reactive phosphate and soluble reactive silica concentrations from the selected streams increase during extreme hydrologic events, especially snowmelt, and after the application of fertilizer on agricultural areas. No relationship was observed between nutrient concentrations and subwatershed size. Surprisingly little connection was observed between agricultural land use and nutrient concentrations. Perhaps a more consistent linkage will be found when detailed sampling of hydrologic events is incorporated in the analysis. Other factors, such as the quantity and quality of wastewater treatment facilities and septic systems or wetlands in the subwatershed, may also affect the concentration of nutrients in streams.

Nutrient concentrations are higher in the streams than in the lake, underscoring the importance of managing nutrient loads to the lake since increased nutrient levels result in increased biological growth and lake eutrophication.

Other Parameters

Mean total suspended sediment concentrations, dissolved oxygen (DO) concentrations and specific conductance data from the selected streams reveal basin area or land use correlations. Larger sediment and conductance values occur during significant hydrologic events. The dissolved oxygen values are saturated or nearly saturated, suggesting that oxygen demand from bacteria and other life forms is minimal in these streams. Another possibility is that these streams are shallow or turbid enough to promote rapid transfer of oxygen from the atmosphere to the water.

Other Information

The 1996 Priorities Waterbodies List (PWL) indicates that segments of Catharine Creek, Upper Dam Lake, Punch Bowl Lake, Kashong Creek, the Keuka Lake Outlet and Hector Falls Creek are stressed or threatened by agricultural activities, gravel removal, failing septic systems, stream bank erosion, roadbank erosion, urban runoff, landfills, onsite systems, and industrial wastes. However, minimal documentation exists to confirm these findings.

SOURCES OF POLLUTION:

New York State has a long history of addressing water pollution through the inventory and control of point sources. With point sources under strict regulation by the state, water contamination from diffuse sources is now the primary concern for water quality managers. However, cleaning up or preventing non-point source contamination is difficult. Instead of simply issuing regulatory directives to a relatively small number of facilities owners, controlling diffuse source pollution involves communicating with thousands of landowners to secure their cooperation in preventing and controlling water quality problems.

AGRICULTURE

The Seneca Lake watershed supports a diverse agricultural base that includes vineyards, dairy and livestock farms, orchards, vegetable crops, cash crops and a few specialty crops. Agriculture represents 114,407 acres or 39% of the land base for the watershed.

Agriculture and related industry, such as vineyards and wineries, provide tremendous benefits to the watershed community. They are vital to providing community livelihoods, a tax base and tourism revenue. As a land use, agriculture preserves open space, protects water quality and creates the unique rural ambiance that appeals to visitors and local residents. More importantly, diverse localized farming provides and maintains a regionally available food supply for the consumer.

To determine to what extent agriculture is a potential non-point pollution source in the watershed, a comprehensive farm survey was used in conjunction with a computer modeling program developed at Cornell University. The Agricultural Survey was used to collect data on general farm operations including animal units, cropping and various management practices in the watershed. The computer modeling program provided a second method for analyzing potential erosion based on land use.

The results identify areas of potential concern based on agricultural activity and point to the need for implementing agricultural best management practices to protect the quality of the watershed. Combining the two evaluation methods developed a clearer picture of the pollution potential created by agricultural activity in the watershed.

Farm Inventory Data

Of 563 identified agricultural operations in the Seneca Lake watershed, 343 active farms owning 61,624 acres returned surveys. The most common crop grown in the watershed is hay followed by corn. Grapes comprised 1992 acres in the survey. The Keuka Lake Outlet , Kashong Creek and Catharine Creek subwatersheds have the largest crop acres for the Seneca Lake watershed.

Livestock Numbers and Operations

Based on survey responses, livestock are present on 198 (58%) of the farms. Poultry make up the greatest number of livestock, with the majority located in Schuyler County. Dairy cattle and "other" comprise the next largest numbers of animals in the Seneca Lake watershed. Catharine Creek has the largest concentration of dairy cattle. Overall, the Catharine Creek, Keuka Lake Outlet and Kashong Creek subwatersheds have the largest numbers of animals.

About half the operators (175) indicated they spread manure, with 65% spreading seasonally, 22% spreading monthly, 4% weekly and 10% daily. One hundred forty-three respondents indicated having no manure storage.

Based on the 342 survey responses, silage is stored on 116 farms (34%). Of those, 28% utilize upright storage, 8% use horizontal storage and 4% use other forms of storage such as "ag bags."

The survey indicated that 45% of the farms with livestock have dairy herds. The most common form for disposing of milking center wash water is field tile, with 39% of dairy farms using this method. Twenty percent (20%) of the farms discharge milkwash onto the soil surface, 17% use a dry well, 17% use a septic system and 7% use lagoons.

Eighty one percent (81%) of the farms with livestock have some holding area for livestock. Pasture is present on 95% of the farms having livestock. Only 51% of farms having pasture use rotational grazing. Of those farms with pastured livestock, 65% use water tanks as a source of drinking water, 26% use streams, 35% use ponds and 12% use other methods for watering.

Crop Tillage Practices

Fifty-five percent of the survey returns indicated that cash crops, field crops, fruits and vegetables were grown during 1996 and 1997. The most common tillage practice used is spring moldboard plowing.

Highly Erodible Land

Just over a third (36%) of farms reported having Highly Erodible Land (HEL) as defined by the USDA.

Fertilizer Usage

Based on survey responses, 70% of farms used fertilizer. Thirty eight percent (38%) do not use soil tests to determine manure or fertilizer rates and 29% do not test to determine soil pH. Petiole sampling is done on 83% of the vineyards.

Herbicide/Pesticide Use

Eighty nine percent of the respondents use herbicides or pesticides. Chemical application is the most common method for controlling weed growth, followed by cultivation, crop type or crop rotations. Most survey responses indicated using a combination of weed control methods: 65% use chemicals, 54% use cultivation and 46% use crops and crop rotation

Sixty-four percent of the respondents apply pesticides. Insecticides, fungicides and rodenticides were applied by 60%, 35% and 9% of the respondents respectively. Survey responses also indicated that combinations of more than one type of pesticide are used for controlling pests.

Respondents use a number of methods to determine when to use pesticides and how much to use. Field scouting is the most common method (60%) used to identify problems before applying pesticides.

Eighty-four percent of the respondents indicated that they read the labels to determine how much pesticide to use. Forty-one percent rely on personal knowledge, 36% use Cooperative Extension, 29 % use the pesticide salesman, 24% use IPM for deciding how much pesticide to use. Twenty nine percent of respondents indicated that unused pesticides are stored on the farm. One quarter of these would like assistance with proper disposal. Most indicated they would use stored pesticides the following year. The survey did not identify the types of chemicals that need disposal.

Petroleum

Seventy percent of survey respondents indicated that petroleum is stored on the farm. It is not known how many petroleum tanks have secondary containment barriers.

Computer Modeling

Sediment loading estimates are an important component of nonpoint source pollution studies. Sediment is a major water pollutant, transporting chemicals including nutrients, pesticides and metals. The Generalized Watershed Loading Functions Model (GWLF) developed by Mr. Doug Haith, Cornell University Department of Agricultural and Biological Engineering, was used to determine sediment yields. This model simulates sediment and nutrient loading based on land use, soils and agronomic practices. Its is the same model used in both the Canandaigua and Keuka Lake watershed projects.

With Dr. Haith's assistance, the model was modified to accommodate unique crop rotations and soil nutrient data specific to the Seneca Lake watershed. Representative agricultural soil samples were collected within the watershed. Thirty-one active agricultural soils were determined in consultation with area soils experts to calibrate the computer model to local soil conditions. Twenty-four major field and vegetable crop soils and seven vineyard soils were identified. The collected representative soil samples in association with the developed comprehensive soils database for the watershed were used to calibrate the computer model for local soil conditions, and estimate nonpoint source pollution loading potential.

Agricultural Ranking of Subwatersheds

Using the values for the twelve agricultural factors, pollution potential was determined for each Seneca Lake subwatershed and direct drainage areas. Agricultural pollution potential for each factor and the overall pollution loading potential for each subwatershed were given a ranking of "low", "medium" or "high".

The two evaluation methods were useful for developing a clearer picture of agricultural activity in the watershed. Pollution potential was identified in both methods. The highest three subwatersheds for pollution potential were the same in both methods.

(See Figure 7A.5)

CHEMICAL BULK STORAGE

The Hazardous Substances Bulk Storage Act of 1986 Environmental Conservation Law requires NYSDEC to develop and enforce State regulations governing the sale, storage, and handling of hazardous substances in order to prevent leaks and spills in New York State. Controls established by law include: registration and inspection of storage and handling facilities; standards for the design, construction and operation of the facilities; and requirements for proper facility closure. The regulations apply to both underground and above ground tanks and prohibit sales of hazardous substances to unregistered facilities.

Hazardous substances subject to regulation are listed in Part 597 of the Chemical Bulk Storage (CBS) regulations. Over 1000 solids, liquids, and gases that are toxic, known or suspected carcinogens, explosive or otherwise dangerous when improperly handled or stored are included on the list. Under Part 596 of the CBS regulations, hazardous substance storage tanks (or bins if solids are stored) must be registered with NYSDEC. Tank registration is valid for two years, after which renewal is required. Only stationary tanks are registered at this time. Owners must register all underground tanks regardless of size, and above ground tanks with a capacity of 185 gallons or more. If a tank is temporarily out of service, it must be registered until it is permanently closed.

There are sixteen CBS facility permits throughout the Seneca Lake Watershed. (See Figure 7B.1)

FORESTRY AND FOREST PRACTICES

Early forestry activities consisted primarily of clearing land for agriculture. Today, however, approximately half of the land once used for farming has been replanted with softwoods or is in the early stages of natural succession. Much forested land is also situated on the steep slopes where the potential for erosion is high.

As forests mature, timber harvesting is occurring throughout the watershed. Private landowners, who control the bulk of forest lands in the watershed, may or may not employ Best Management Practices (BMPs) to stop erosion and sedimentation from reaching Seneca Lake.

Because forests are natural filters, forest cover plays a major role in preserving lake water. Tree roots lessen erosion by holding soils in place and purify shallow groundwater by removing dissolved nutrients. Tree-tops and leaf litter intercept precipitation and lessen its erosive impact on the ground below. The layer of organic matter on the forest floor traps runoff and increases the infiltration of surface water into the ground. Even when trees fall during ice or wind storms, water quality benefits; the "pockets" left by root masses trap surface water and promote infiltration to groundwater.

Limited information is available to assess the impact of forest harvest activities on water quality in the watershed. Studies of other watersheds in the Northeast suggest that harvest activities, particularly logging road construction, have dramatic short-term impacts on water quality through the introduction of nutrients and sediments to surface water. Timber harvest areas are usually not of sufficient magnitude to affect long-term water quality, though only preliminary studies have been made of the cumulative impacts of numerous harvests on privately-owned wooded parcels.

Most forested land in the Seneca Lake watershed is privately owned in parcels of less than two hundred acres, most located in Schuyler and Chemung Counties.

About half of the 16,036 acre **Finger Lakes National Forest** (FLNF) lies in the Seneca Lake watershed. State Forests include the **Texas Hollow State Forest, Sugar Hill State Forest** (SHSF), and **Catlin State Forest.** There are also forested lands within the **Connecticut Hill Wildlife Management Area and Catharine Creek Wildlife Management Area,** both New York State Wildlife Management Areas. **State Parks include Watkins Glen State Park, Havana Glen State Park, Seneca Lake State Park, Lodi Point State** and **Sampson State Park** located in the Seneca Lake Watershed.

A number of sources of information on forestry practices are available to private property owners. An excellent publication, Best Management Practices During Timber Harvest Operations, is available from the Chemung County Soil and Water District. Forest landowners may participate in the Master Forest Owners Program and the New York Forest Owners Association. Forest owners may also receive harvesting advice from the NYS DEC and Soil and Water Conservation Districts in each county. The NYS DEC also can provide information about the Cooperating Consulting Forester and Cooperating Timber Harvesters programs, which assures property owners that foresters and harvesters have received and follow some training. Public Law 480A provides for property tax benefits to forest owners who follow a DEC approved management plan.

Few municipalities have timber harvest registration or regulation in place. Hardwood lumber is a major product from private forests of the Seneca Lake watershed. Hardwoods harvested from the watershed include sugar and red maple, ash, red and white oak, and hickory. Some softwoods such as hemlock and white pine are also harvested.

Forest Management Options & Conclusions

Seneca Lake watershed has less forest (41%) than many other Finger Lakes. Problems associated with lack of forest cover include increased intensity of stream flow, increased erosion rates, increased stream bank instability, prolonged periods of no-flow, and decreased infiltration of groundwater.

Publicly owned forested land is managed by professionals from the USDA Forest Service and the NYSDEC, who enforce the application of Best Management Practices on timber harvests. These harvests and practices can be used as models and teaching tools. Only a small portion of forested land in the watershed, however, is in public ownership. Therefore, decisions about whether and how to harvest are largely made by private property owners.

Decisions about when and how to harvest timber are based on many factors. Market factors are extremely important. Timber may be liquidated when other income sources, such as farm prices, are low. When timber prices are high, loggers actively recruit. Actual timber harvest probably involves 1-2% of the forest lands per year, depending on market conditions. In terms of water quality, the most significant problem with timber harvesting is failure to use best management practices.

(See Figure 7C.2)

LANDFILLS, DUMPS, AND INACTIVE HAZARDOUS WASTE SITES

Known Landfills, Dumps, and Hazardous Waste Sites

Of the 20 landfills in the watershed, two in Yates County remain active. One continues to receive dumping despite the fact that it is considered closed. The active sites are the NYSEG Ash landfill and the Hopeton Road landfill, both located in the Town of Torrey. There are a number of older, inactive non-engineered landfills and dumps in the watershed which have the potential to contaminate water quality. One municipality spreads municipal sludge on a regular basis in the watershed. This process is closely regulated by the NYSDEC.

Twelve inactive hazardous waste sites are all considered closed, either with complete remediation or with some level of monitoring and remediation taking place. There are 12 inactive hazardous waste disposal sites within the watershed. Eight of these sites are classified in the NYSDEC as *Class 2* (Posing a significant threat to public health or the environment) or *Class 2A* (A temporary classification for sites that have insufficient data for any other classification). Four sites have been de-listed because the site has been cleaned and no longer requires monitoring by the DEC.

Since concentrated waste areas can pose a potential human health risk and threaten water quality, landfills and inactive hazardous waste sites in the watershed were ranked for risk to surface and groundwater. Five landfills were identified with a high potential to threaten water quality, six landfills have a medium potential and eight landfills pose a low risk to water quality. Nine inactive hazardous waste sites were identified as having a high potential and three sites were ranked with a medium potential.

Old (fifteen or more years), inactive landfills pose a potential human health risk from exposure to toxic and pathogenic contaminants. These contaminants include heavy metals, pathogens, nutrients and a wide variety of organic chemicals.

The information found in this research should be considered qualitative and only used to provide information for prioritizing additional studies. The ranking analysis suggests that further study is needed to refine the pollution potential of the landfills not currently under remediation.

A low-cost, logical step is to physically observe the sites by a volunteer geologist who is familiar with the hydrogeology of the area. More detailed information on land cover, depth to bedrock, private well locations, historical waste disposal practices, coupled with water quality monitoring and physical investigation, is needed to accurately assess the status of landfills throughout the watershed.

(See Figure 7D.2 and 7D.4)

MINED LANDS

Permitted Mines

Mined lands have the potential to impact water quality primarily through increased erosion and sedimentation. Some types of mining can also impact adjacent wells by drawing upon large quantities of water from the same aquifer.

The NYS DEC lists 36 mined land and reclamation permits in the Seneca Lake watershed. Sand and gravel mines are the most common type of mine in the watershed. Others include shale, clay, glacial till, and salt.

Only in the last twenty-five years has the NYSDEC required permits for mining operations and reclamation. New York holds over $60 million bonding to make sure that mined land is reclaimed to a beneficial use. Reclamation bonds serve as a guarantee that funds will be available to reclaim affected land. Many gravel pits in the watersheds were worked and abandoned before the Mining Law was activated in 1975 and are not subject to the Mining Law and its reclamation requirements. All other mines that have continued to operate, have been re-activated since 1975, or have been newly permitted, are subject to reclamation requirements. A reclamation bond cannot be canceled or released unless the Department authorizes its termination.

(See Figure 7E.1)

PETROLEUM BULK STORAGE FACILITIES

New York's 1985 Petroleum Bulk Storage Law requires the NYS Department of Environmental Conservation to develop and enforce a state code for the storage and handling of petroleum products to protect public health, welfare and the lands and waters of the state. The resulting regulations are found in Title 6, Parts 612, 613 and 614 of the New York State Code of Rules and Regulations.

Regulated substances include refined non-waste petroleum-based products such as gasoline, heating oil, heavy residual fuel oils, kerosene or reprocessed waste oil used as fuel or lubricant.

Any facility with a combined capacity between 1,100 and 400,000 gallons must be registered. As of 1996, heating oil tanks under 1,100 gallons have been deregulated. This includes any stand-alone heating oil tank used for consumption at the same site. Sites with more than 400,000 gallons are considered major oil facilities and are licensed under the Major Oil Storage Facility (MOSF) Program.

Stationary tanks and associated pipes and equipment are also regulated under these rules and regulations. All new underground storage tanks must have a secondary containment system and existing tanks scheduled for replacement must be treated as a new storage tank installation.

There are 166 active, regulated and unregulated petroleum bulk storage facility permits listed with NYSDEC in the Seneca Lake watershed. Of these, 25 sites have volumes under 1100 gallons and are unregulated by the NYSDEC.

(See Figure 7F.2)

ROADBANK EROSION

A survey of public roads in the Seneca Lake watershed was undertaken during the summer of 1997 with a grant from the New York State Soil & Water Conservation Committee. This road ditch survey found that the Seneca Lake watershed has a total of 1,279 miles of public roads. Of these, 4.18 miles of roads were identified as having very severe bank erosion, 42.4 miles indicate severe bank erosion and 68.01 miles show moderate bank erosion. The erosive potential of an area is based on factors that include hydrology, soil erosion potential, land use, ditch slope and fall, vegetative cover and precipitation. How water is managed near roads may exacerbate several of these factors.

Highway departments are in the difficult situation of having to maintain roadways to prevent flooding and unsafe driving conditions while simultaneously satisfying water quality concerns. The report listed a number of remedial actions. While not all these recommendations are equally feasible or economical, many can be quickly and easily implemented.

The primary purpose of this critical roadbank study was to provide information identifying problematic erosion areas in the Seneca Lake watershed. This study supplies highway departments and organizations with the data necessary both to correct these areas and to identify other potential bank erosion problems to minimize sediment transport into the lake. It will also allow targeting high load areas for specialized treatment to lower road maintenance costs while increasing water quality benefits in the watershed.

(See Figure 7G.1)

SALT STORAGE AND DEICING MATERIALS

Deicing salt, commonly known as road salt, is used to help deice road surfaces during the colder months of the year, usually from November through April. There are several environmental concerns regarding the use of deicing salts. Salts are water soluble and easily wash off pavement into surface waters and may leach into soil and eventually groundwater. High concentrations of salt can damage and kill vegetation, disrupt fish spawning in streams, reduce oxygen solubility in surface water, interfere with the chemical and physical characteristics of a lake, pollute groundwater making well water undrinkable, disintegrate pavement, and cause metal corrosion of bridges, cars and plumbing. This cause/effect relationship is increased when salt is stored in exposed piles.

Counties, municipalities, the New York State Department of Transportation (NYSDOT), the Seneca Army Depot and other private organizations in the Seneca Lake watershed were asked to complete a survey about salt practices during the 1997-1998 season. Municipalities were asked to provide information on total mileage maintained during the winter and total amount of salt in tons used for the 1997-98 season. This survey did not address salt application on private roads.

The survey identified 18 storage piles in the watershed and based on survey results, 6,985 tons of salt were applied to 1,271 road miles in the watershed during the 1997-1998 season. This averages to 5.5 tons per road mile.

(See Figure 7H.4)

STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES) PERMITS

The SPDES permit is a contract between the New York State Department of Environmental Conservation (NYSDEC) and any facility discharging wastewater directly into surface or groundwater. SPDES permit data for this report was obtained from the NYSDEC Region 8 and state office.

SPDES permits are divided into two categories: significant and non-significant. Significant discharges are those facilities with large amounts of wastewater discharge or wastewater that contains toxic substances. Permits are issued for five years and during issuance and/or permit renewal, the public can examine and comment on the permit's condition and limits prior to granting of the permit. Significant SPDES permits require the holders to sample, analyze and report regularly to NYSDEC the amount of controlled pollutants they discharge. (These are also the only pollutants they may discharge.) State certified laboratories must be used for all wastewater analysis. Owners or operators of these facilities must treat wastewater so it does not exceed the limits in their permit. Significant SPDES facilities are inspected yearly by the DEC, which also conducts spot checking and independent sampling.

Non-significant SPDES permits are administratively extended and/or renewed without review and without a site visit by NYSDEC. Pubic comment is still permitted prior to issuing a permit. Non-significant SPDES permits also require the permit holder to sample and analyze pollutant discharges, but they are not obligated to report to the DEC. Sampling data must be kept on the facility site. As a result, actual sampling results from non-significant facilities are not available for review.

There are 80 significant SPDES permits within the Seneca Lake watershed. Of these, 29 discharge to groundwater (i.e. leach field system) and 51 discharge into surface waters. Twenty-one discharge directly into Seneca Lake. (See Figure 7J.1)

SPILLS

Information about the frequency and quantity of spills reported within the Seneca Lake watershed reveals that there have been 990 hazardous material spills within the Seneca Lake Watershed reported to the NYS DEC from 1974 to 1998. (The actual number may be higher since not all spills may be reported. 1999 data was not yet available for the completion of the State of the Watershed Report.) Using information from the NYSDEC database, an attempt was made to locate and assign each spill to a specific subwatershed. Due to the nature of spill reports, however, data are not always linked to a specific address, so some spill locations were estimated.

Petroleum based products were the most common material reported spilled, accounting for 37% of the total number of spills reported in the watershed. Of special note were the large numbers of gasoline spills (185) and #2 fuel oil spills (172). The number and character of spills are outlined in detail in the report.

STREAMBANK EROSION

Streambank erosion is a primary source of sediment loading into Seneca Lake. A study was conducted to estimate sediment yield from each subwatershed and prioritize those having the highest "potential" sediment yield. The Seneca Lake watershed was divided into 17 subwatersheds and 12 direct drainage areas which include 175 tributaries with a total of 917 miles of waterways entering the Lake.

Between summer 1997 and spring 1998, 221 sites throughout the watershed were visited to collect data on stream bottom material, vegetation, the side slope condition and cross-sectional information. The result is an Erosion Potential Index for each of the 17 subwatersheds and 12 direct drainages with a higher Potential Index Number indicating the greater potential of sediment loading from that portion of the watershed.

(See Figure 7L.1)

GENERAL FINDINGS

Seneca Lake's water quality is generally very good. The lake supports its designated best use as a public drinking water supply and recreational resource. The fish community is diverse and productive. However, Seneca Lake has not been well studied and there is even less information available about its tributaries since only a few long-term tributary monitoring programs are in place.

General findings for the Seneca Lake Watershed include the following:

- **Water Quality:** Seneca Lake provides Class AA drinking water to 70,000 residents within its watershed. The water is chloride rich and hard but is not acidic and is believed pollutant free. This assessment, however, is based on limited data.

- **Trophic Status**: Seneca Lake is borderline oligotrophic/mesotrophic. Very low nutrient concentrations prevent algae blooms.

- **Home*A*Syst Survey:** More than half of respondents felt water quality had a major impact on property values; saw deterioration in the lake's water quality; believed there is an aquatic weed problem: felt that current land use regulation "very adequately" protected the water quality of the lake, felt regulations were "adequate," and felt they were "not adequate."

- **Demographics:** Population in the watershed has remained essentially stable. Most cities and villages have had small increases or have lost population, while some towns have shown significant increases.

Despite the conclusion that water quality is very good, a number of specific areas of concern remain for which additional research will be required:

- **Limnological changes over time:** Evidence suggests that zebra mussels decreased algal concentrations in Seneca Lake and increased water clarity from the early 1990's to 1998.. These trends reversed in 1998, while nitrate and phosphate concentrations increased. Decomposition of dead zebra mussels during this unusually warm year may have triggered these changes.

- **Nutrient concentrations** in monitored streams are larger than in the lake, suggesting that nutrient runoff significantly impacts the water quality of the streams in the watershed.

- **Tributaries:** Bedrock and agriculture seem to control the water quality of the streams within the watershed and calcium and atrazine concentrations appear to reflect nonpoint sources respectively.

- **Chloride concentrations** in the lake do not pose an immediate health risk but concentrations are 2 to 10 times higher than in other Finger Lakes.

- **Agriculture:** Several subwatersheds ranked high for agricultural loading potential.

- **Forests:** Seneca Lake Watershed has less forest (41%) than many other Finger Lakes. Lack of forest cover tends to increase intensity of stream flow, erosion rates and streambank instability while prolonging no-flow periods and decreased infiltration to groundwater. Water quality problems associated with timber harvesting often reflect a lack of best management practices.

- **Bulk Storage:** Some subwatersheds have large numbers of chemical and petroleum bulk storage, and therefore a higher potential for leaks.

- **Roadbank Erosion:** Of public roads in the watershed, 4.18 miles of road were identified with very severe bank erosion, 42.40 miles had severe erosion, and 67.92 had moderate erosion.

- **Road Deicing:** Application rates vary by municipality, but average 5.50 tons/mile/year in the watershed.

- **Lakeshore residences:** The Home*A*Syst survey indicated that some water supplies have not been tested, some septic systems show no visible sign of failure, and few residents are taking measures to combat zebra mussels.

- **On-site Septic Systems:** Systems that are poorly maintained, improperly sited, overloaded and/or have exceeded their design life expectancy can cause both surface and groundwater contamination and transport of nutrients and pathogens from failed systems beyond the treatment site. Failed septic tanks, leach fields or cesspools present an immediate water quality threat through the introduction of nutrients that support increased aquatic plant populations and disease transmission from untreated effluent.

INFORMATION GAPS:

In order to better understand these areas of concern, more data and information are needed, including:

- **Sampling and Monitoring** of the water quality of Seneca Lake, especially in regards to chloride, hardness and selected pollutants;

- **Exotic Species:** continued research is essential to completely understand the extent of zebra mussel impact on the ecology of the lake.

- **Pesticides:** Research on neighboring lakes indicates that data needs to be collected on organic compounds (including pesticides) in the lake.

- **Tributaries:** Only limited data is available on some water quality parameters, including calcium, chloride, atrazine, nutrients, dissolved oxygen, turbidity, and conductivity. Information on additional parameters, like heavy metals, polychlorinated organics and other pollutants – is needed.

- **Forestry:** Limited information is available to assess the impact of forest harvest activities on water quality. Studies of other watersheds suggest that harvesting can have dramatic short-term impacts on water quality through the introduction of nutrients and sediments to surface water.

- **Landfills, Dumps, Junkyards, Hazardous Waste Sites:** There are no complete records for the opening and closure of local municipal dumps. Data is needed on all public and private dumps not listed in the NYSDEC database.

- **Mines:** In the last 20 years NYS DEC has required permits for mining operations and reclamation. Mines abandoned prior to 1975 are not subject to the Law and its reclamation requirements. Additional work is needed to identify these mines.

- **Bulk Storage:** NYSDEC databases do not identify unpermitted sites or sites that were in operation prior to current permitting practices. Additional work is needed to identify these sites.

- **On-site Septic Systems:** More data and information on septic systems in the watershed is needed to assess potential environmental and water quality impacts.

- **Well Drilling Operations:** Data are needed on gas, oil, brine and solution wells.

- **Recreation Data** needs to be generated through a recreation inventory and survey of the watershed.

- **Biosolids Inventory:** Include data on use and content.

- **Regulatory Environment:** Inventory and description of federal, state and local laws affecting land use regulation and control, nonpoint source pollution and water quality are needed.

- **Effectiveness of remedial measures for reducing sediment and nutrient runoff:** monitoring is lacking on tributaries where remedial measures such as streambank stabilization, agricultural best management practices, or stormwater controls have been implemented. Monitoring should occur over a range of hydrologic conditions, particularly high flow events.

SOME POSSIBLE NEXT STEPS

- **Municipal Ordinances:** review current municipal ordinances and Suggested SLPWA Minimum Municipal Ordinances.

- **Increased sampling and monitoring** in the lake and its tributaries with a focused effort on each of the 29 subwatersheds to assess their contribution to nutrient, pollution and other loads to the lake. Since the lake changes in significant ways over longer time scales, continual monitoring of the lake and its watershed is imperative to preserve this vital resource and completely understand its ecology.

- **Agriculture:** Farm planning (agricultural Best Management Practices) and implementation activities should target areas considered high for agricultural loading potential.

- **Forestry:** Develop a watershed-wide forest management policy that includes providing property owners and loggers with better information about timber harvest practices; offering incentives to encourage the use of Best Management Practices; and regulating timber harvesting.

- **Roads:** Institute best management practices for control of pollutants originating on roads and in roadside ditches. Management practices could include items listed under Roadbank Erosion.

- **On-site Septic Systems:** Explore a watershed-wide on-site septic inspection program.

- **Streambank Stabilization:** A streambank stabilization program should be designed using the Seneca Lake Watershed Streambank Inventory to prioritize areas of implementation.

- **Access and Open Space:** Designate lake frontage for permanent natural habitat and wildlife; maintain open space and acquire public access; and control and manage shoreline building and development.

- **Education:** More people need to be educated and involved, including school age children. Some suggestions include holding workshops for highway superintendents and people interested in land use regulation and control, developing school curriculum and developing a web site.

Contact Seneca Lake Pure Waters Association/ Seneca Lake Area Partners in Five Counties (SLAP-5) at 207 Franklin Square, P.O. Box 247, Geneva New York 14456 (315) 789-3052 or slpwa@eznet.net for further information and data regarding this report.

The State of the Watershed Report, "Setting A Course for Seneca Lake" is on file at all Soil & Water Conservation Districts, Cornell Cooperative Extensions, County and Regional Planning Departments and Municipal Government offices within the five county watershed.

(Technical editing and writing completed by consultant, Eric Havill and Marion E. Balyszak, Executive Director, Seneca Lake Pure Waters Association.)

Figure 3.5

Seneca Lake Sub-Watershed and Direct Drainage Reference Map

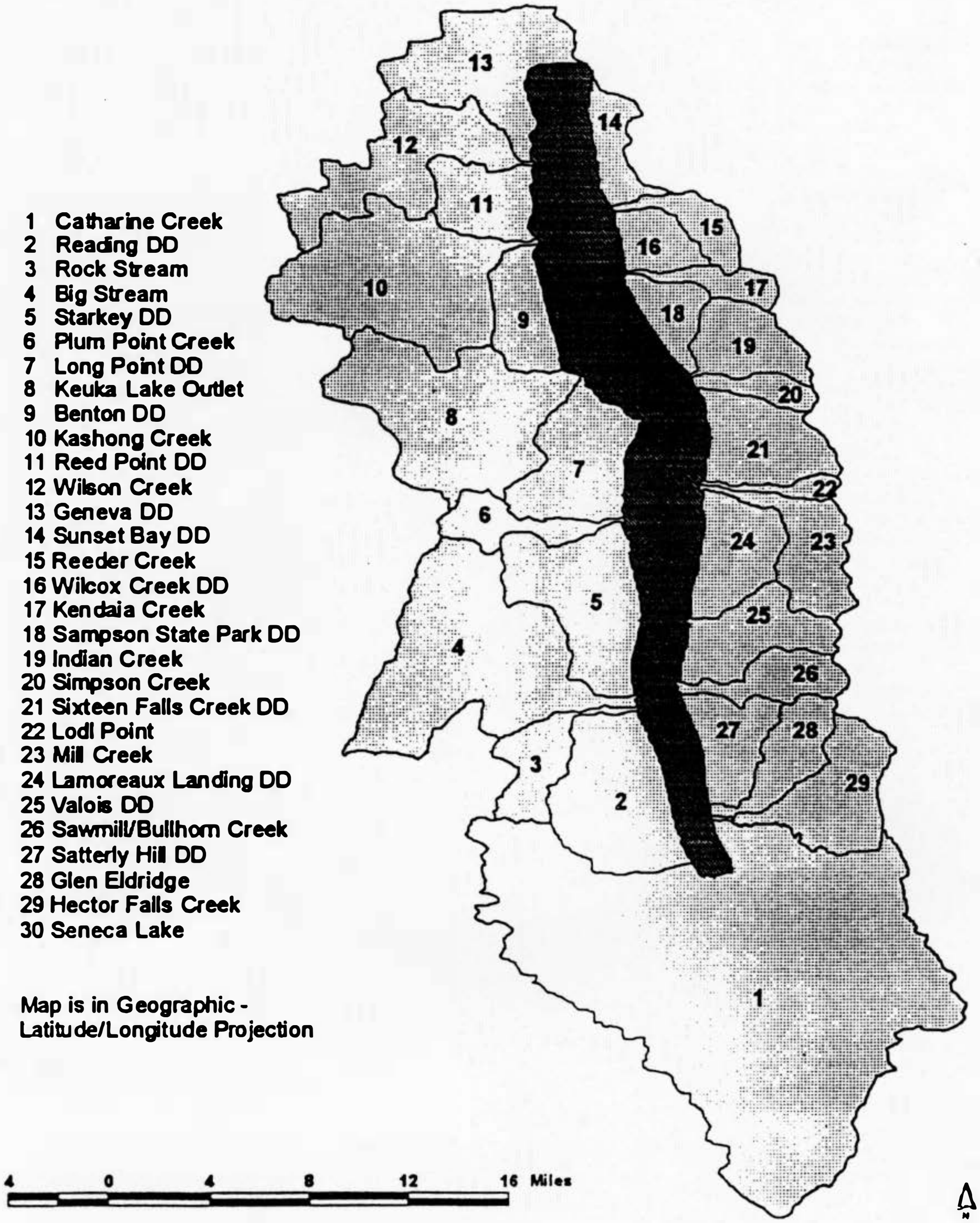

Figure 3.6

Seneca Lake Watershed
Municipalities Reference Map

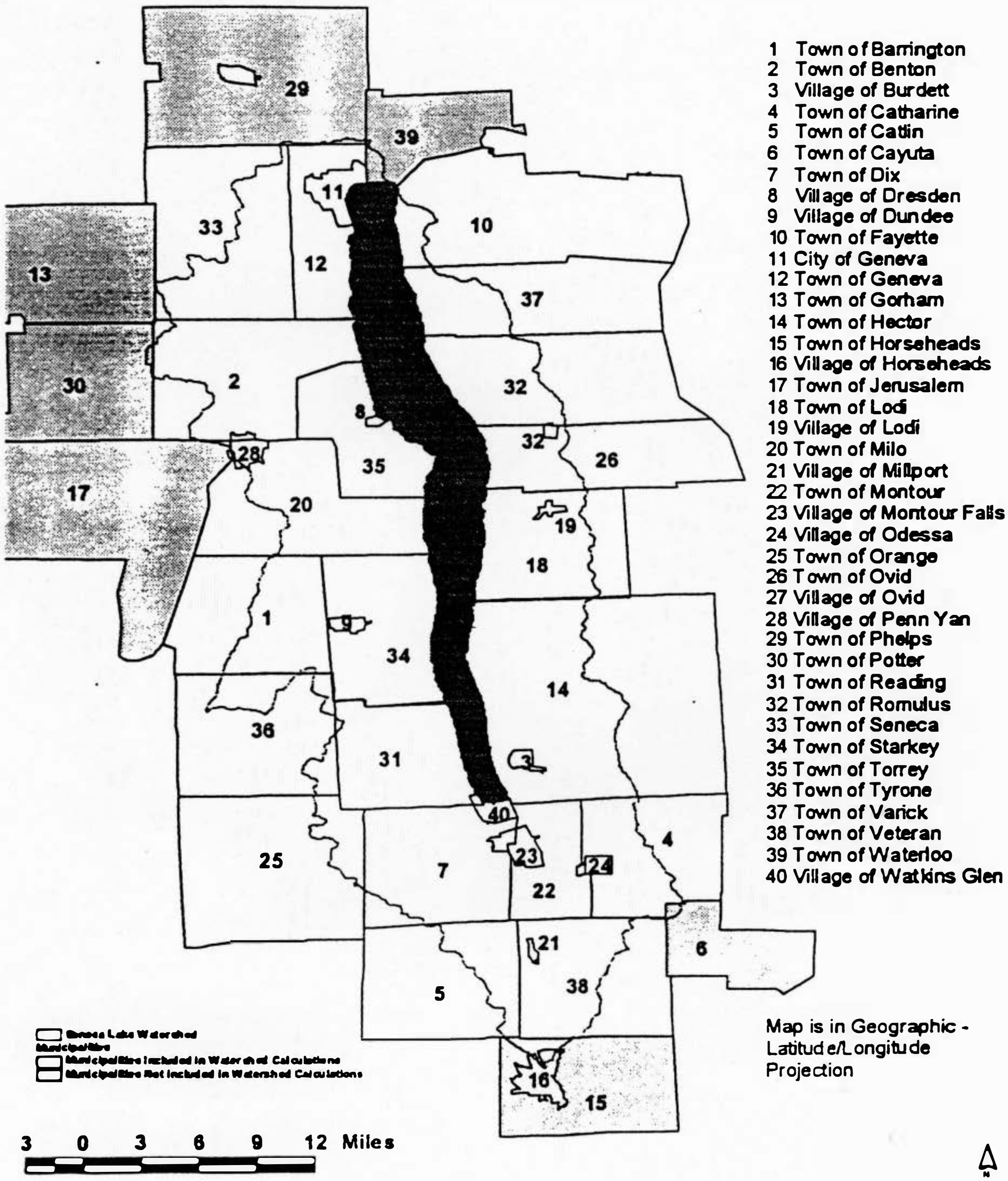

Figure 4.1

Seneca Lake Sub-Watersheds
Idle Land Percentages

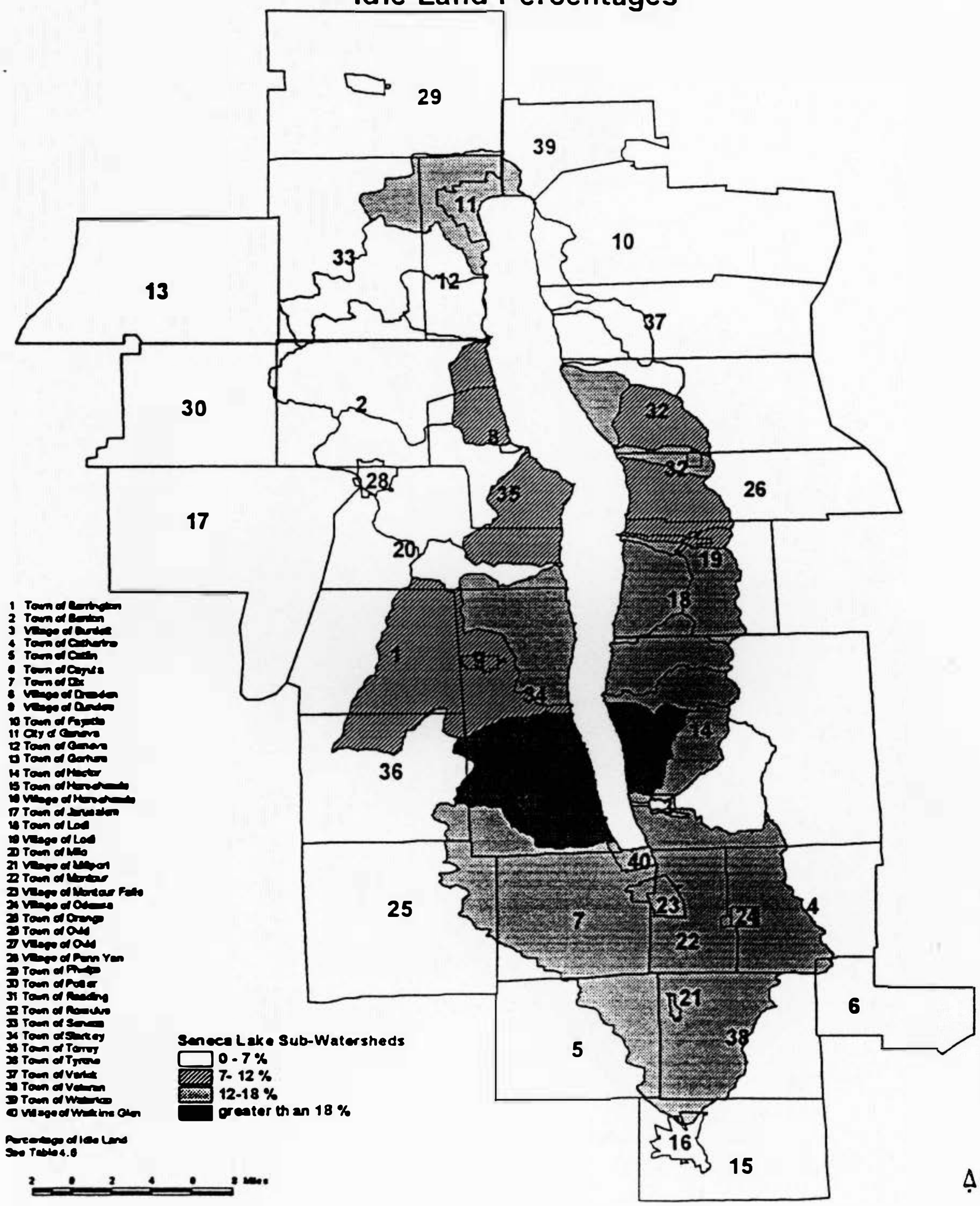

Figure 7A.5.

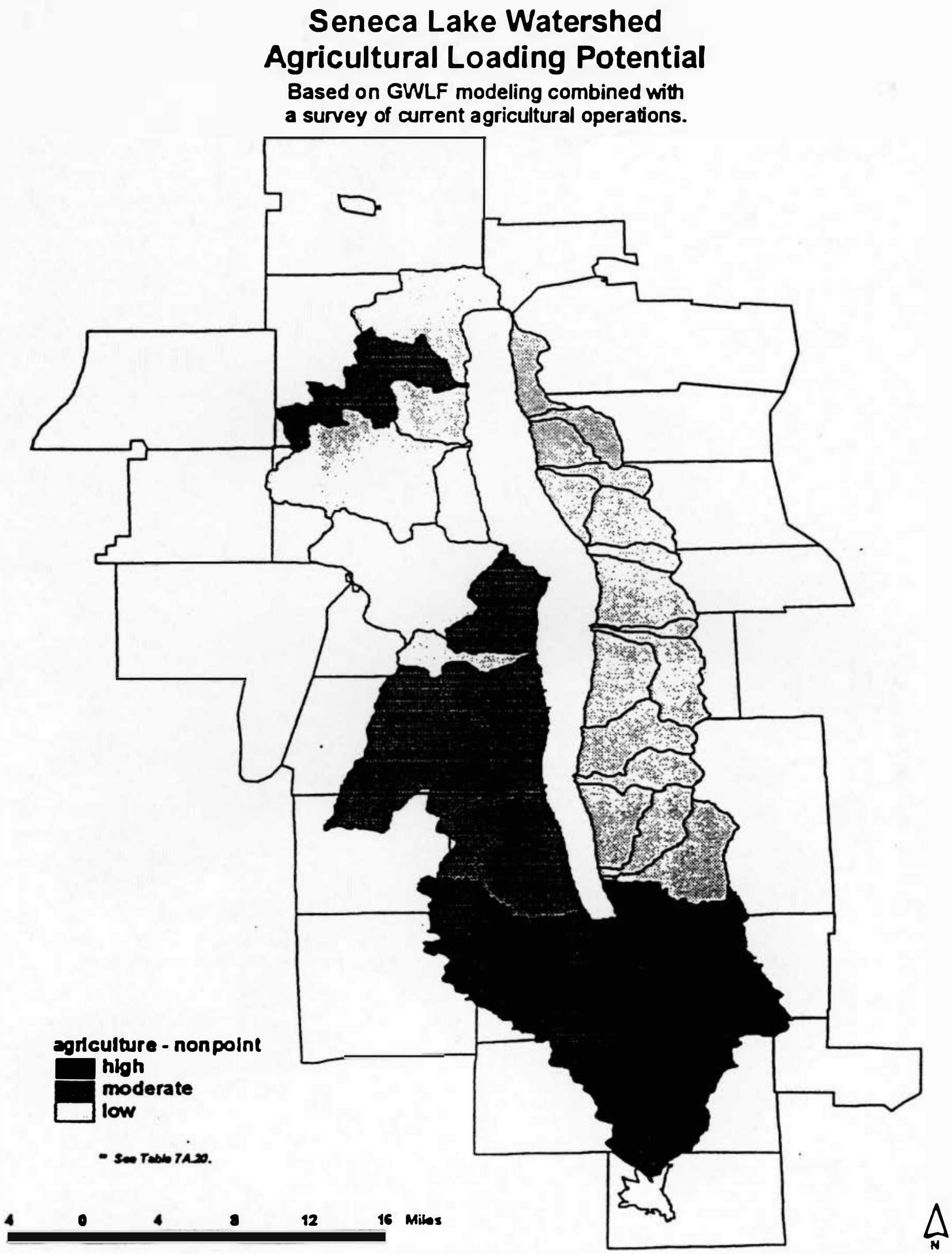
Seneca Lake Watershed
Agricultural Loading Potential
Based on GWLF modeling combined with
a survey of current agricultural operations.
agriculture - nonpoint
high
moderate
low
* See Table 7A.20.
4 0 4 8 12 16 Miles
N

Figure 7B.1

Potential Pollution Problems By Sub-Watershed
Chemical Bulk Storage Facilities

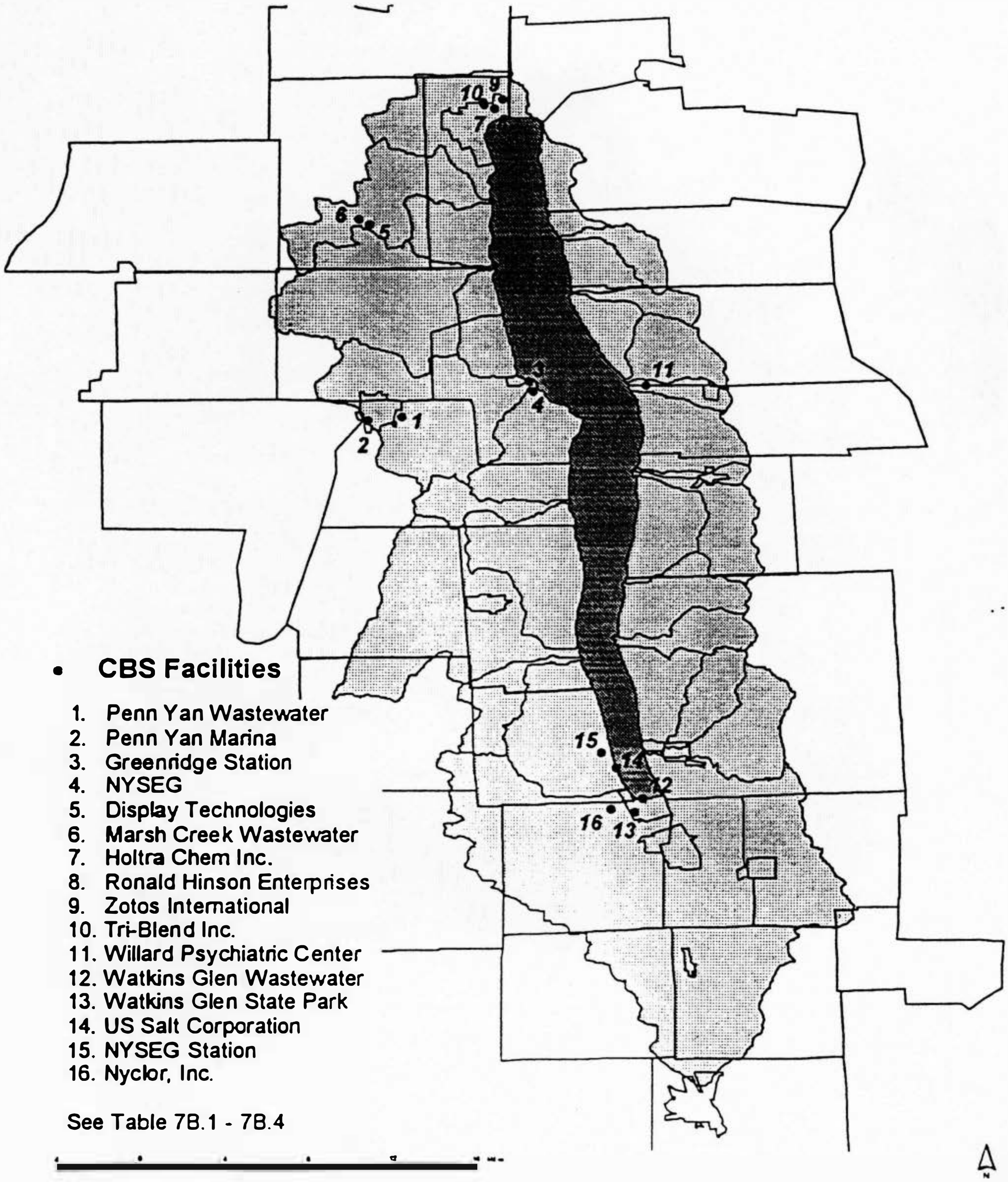

Figure 7.C.2 Percentages of Forest Cover in Subwatersheds of the Seneca Lake Watershed

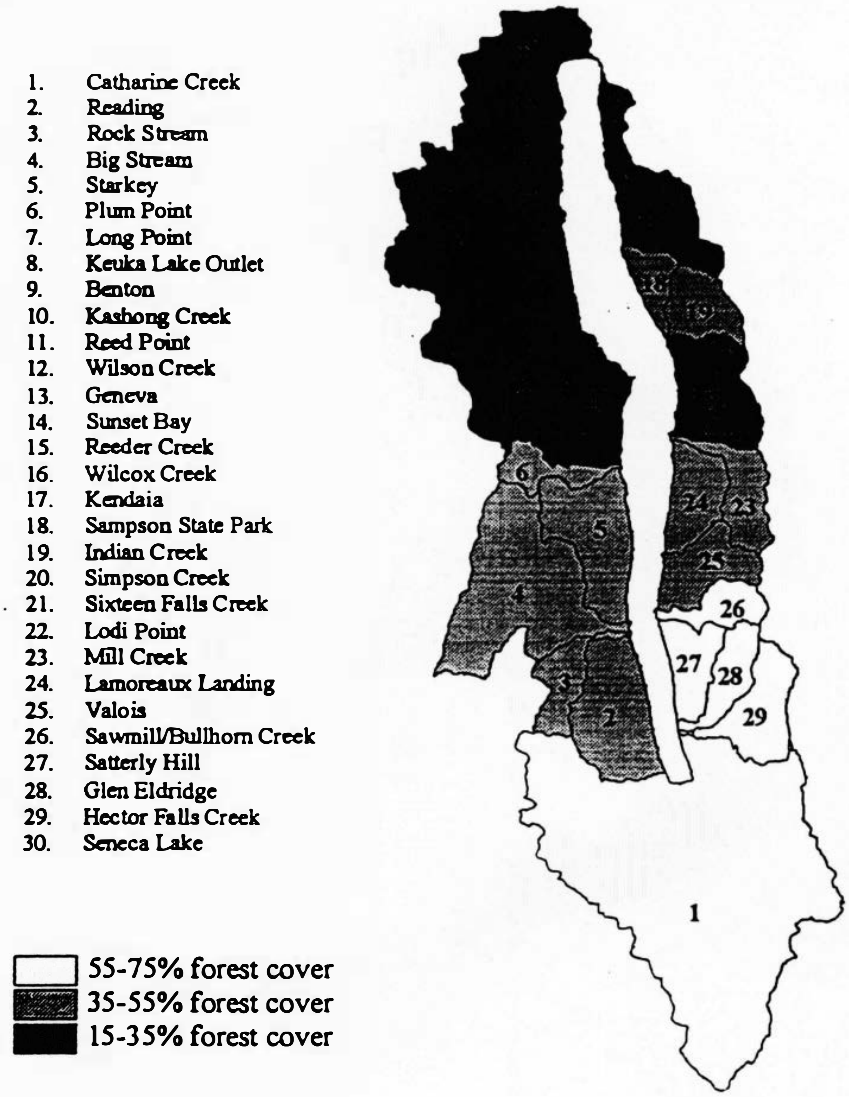

Figure 7D.2

Potential Pollution Problems By Sub-Watershed
Landfills and Dumps

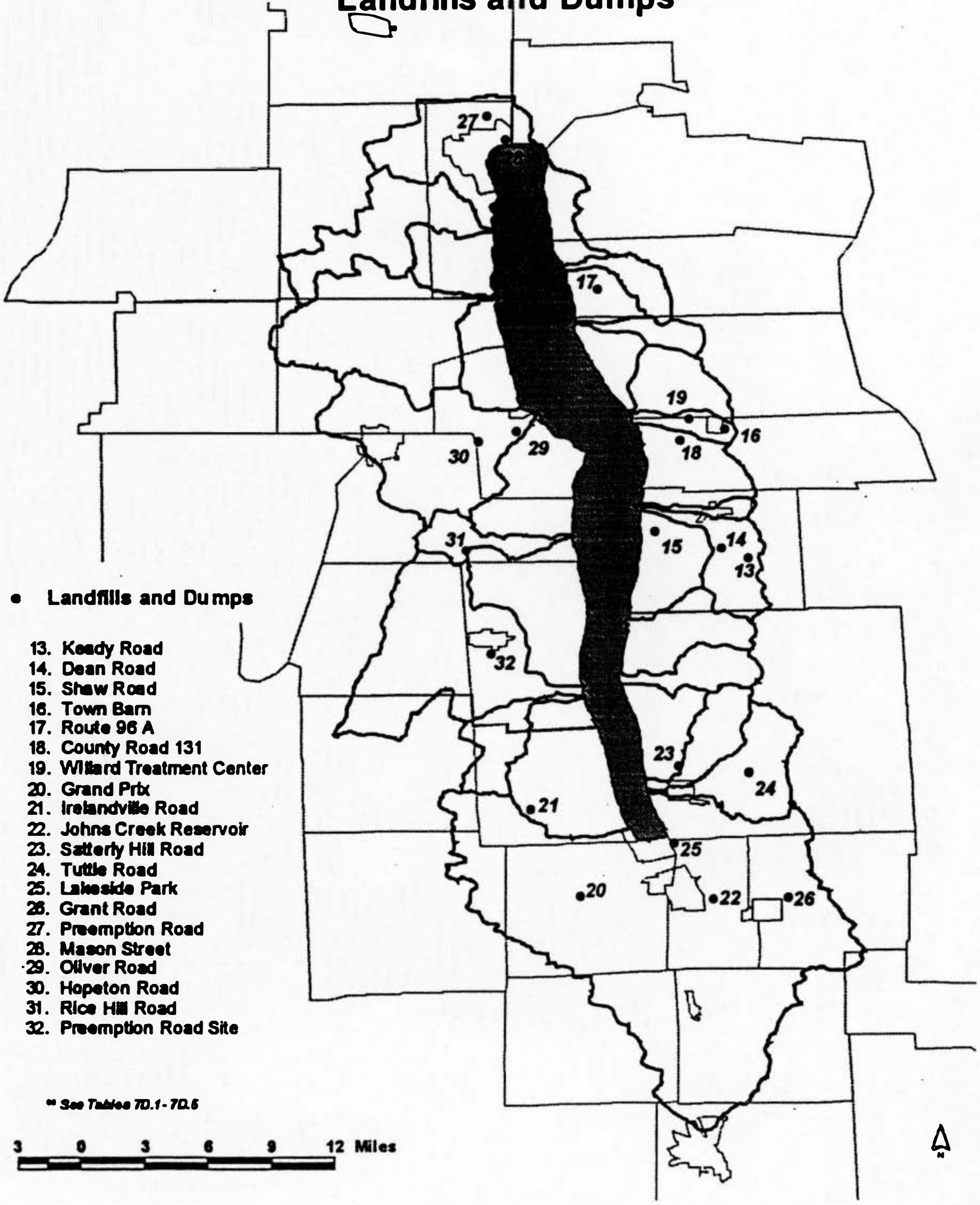

Figure 7D.4

Potential Pollution Problems By Sub-Watershed
Inactive Hazardous Waste Sites
Ranking By Site

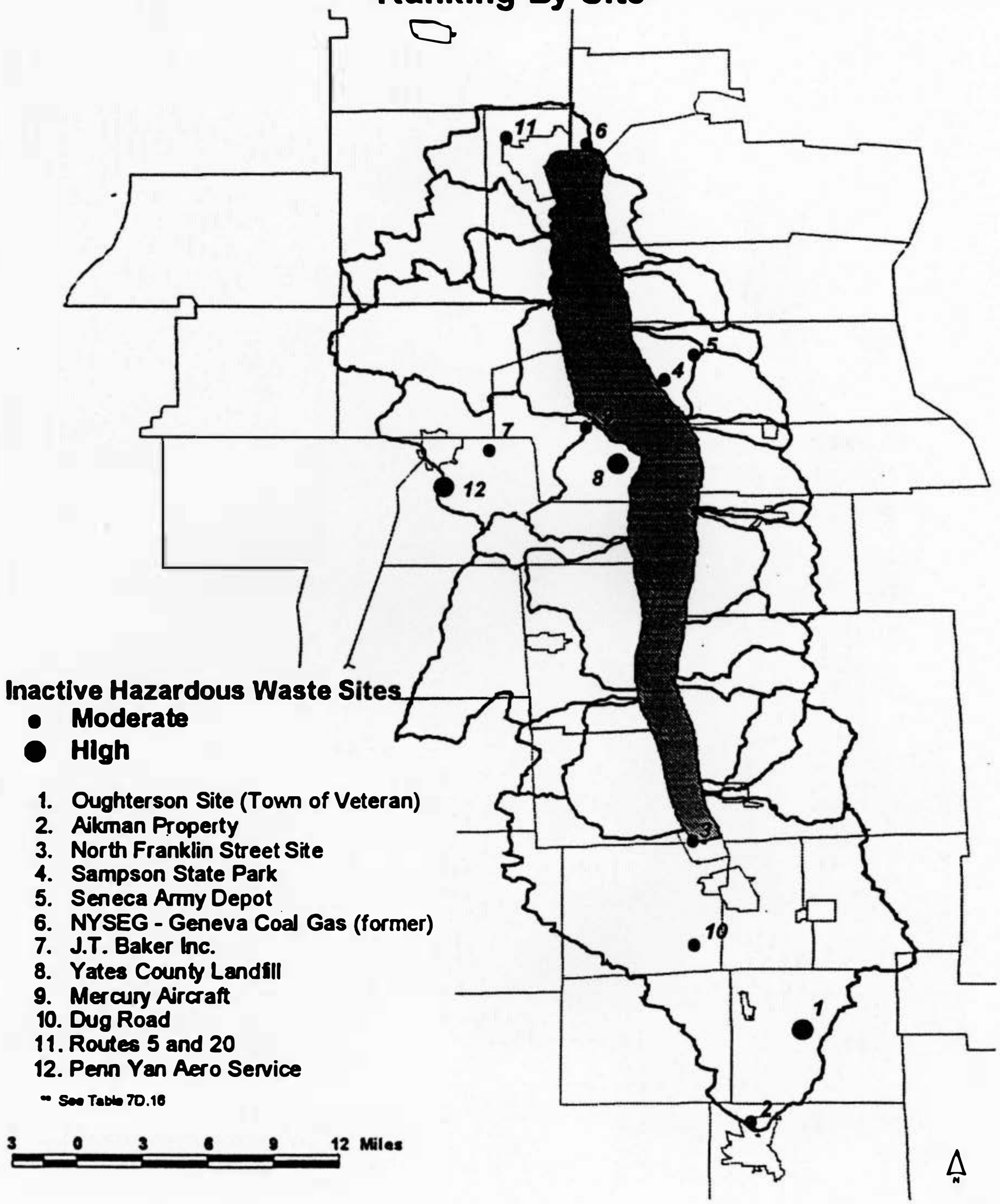

Figure 7E.1

Seneca Lake Watershed Mined Land

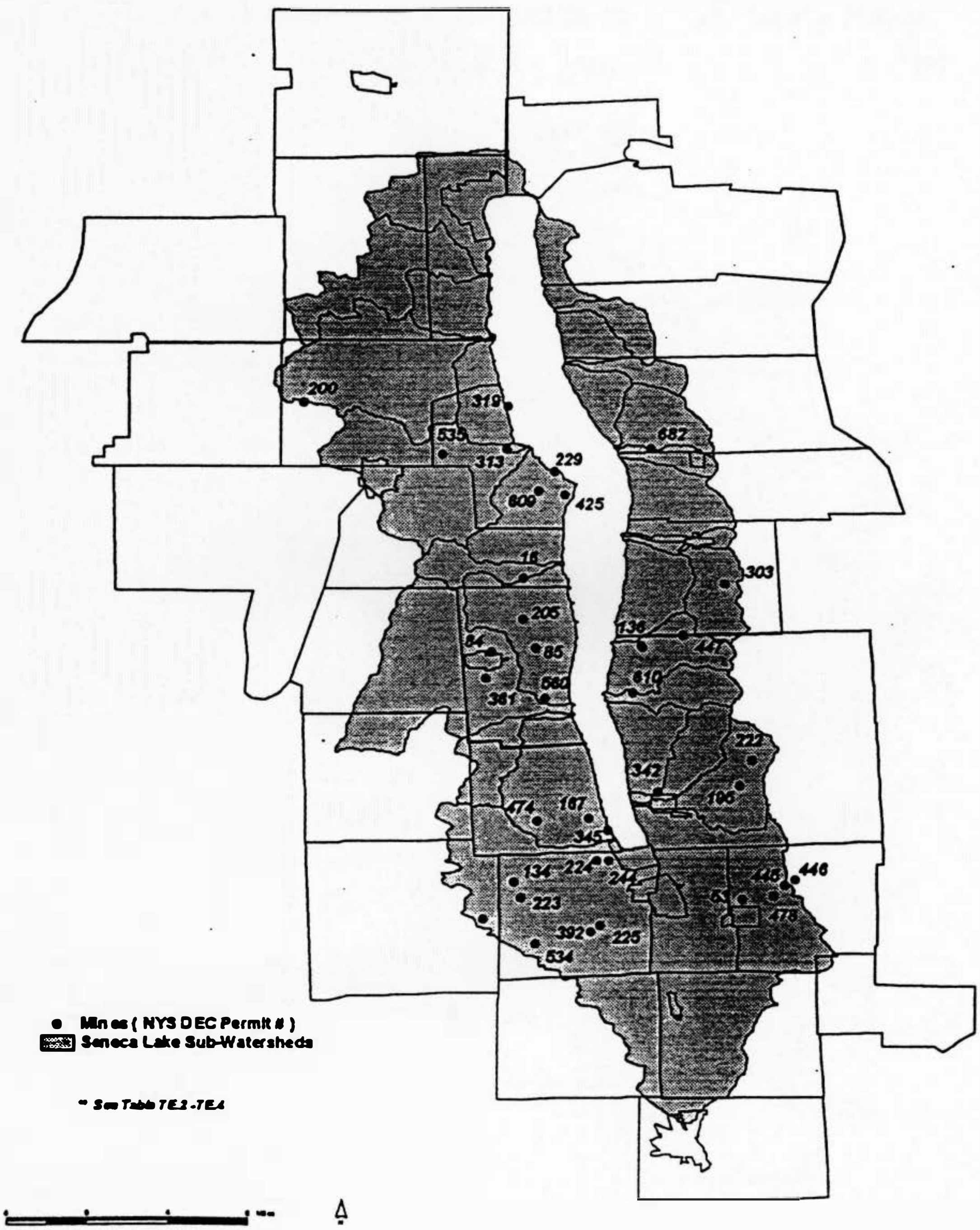

Figure 7F.2

Potential Pollution Problems By Sub-Watershed
Petroleum Bulk Storage Facilities - Overall Ranking

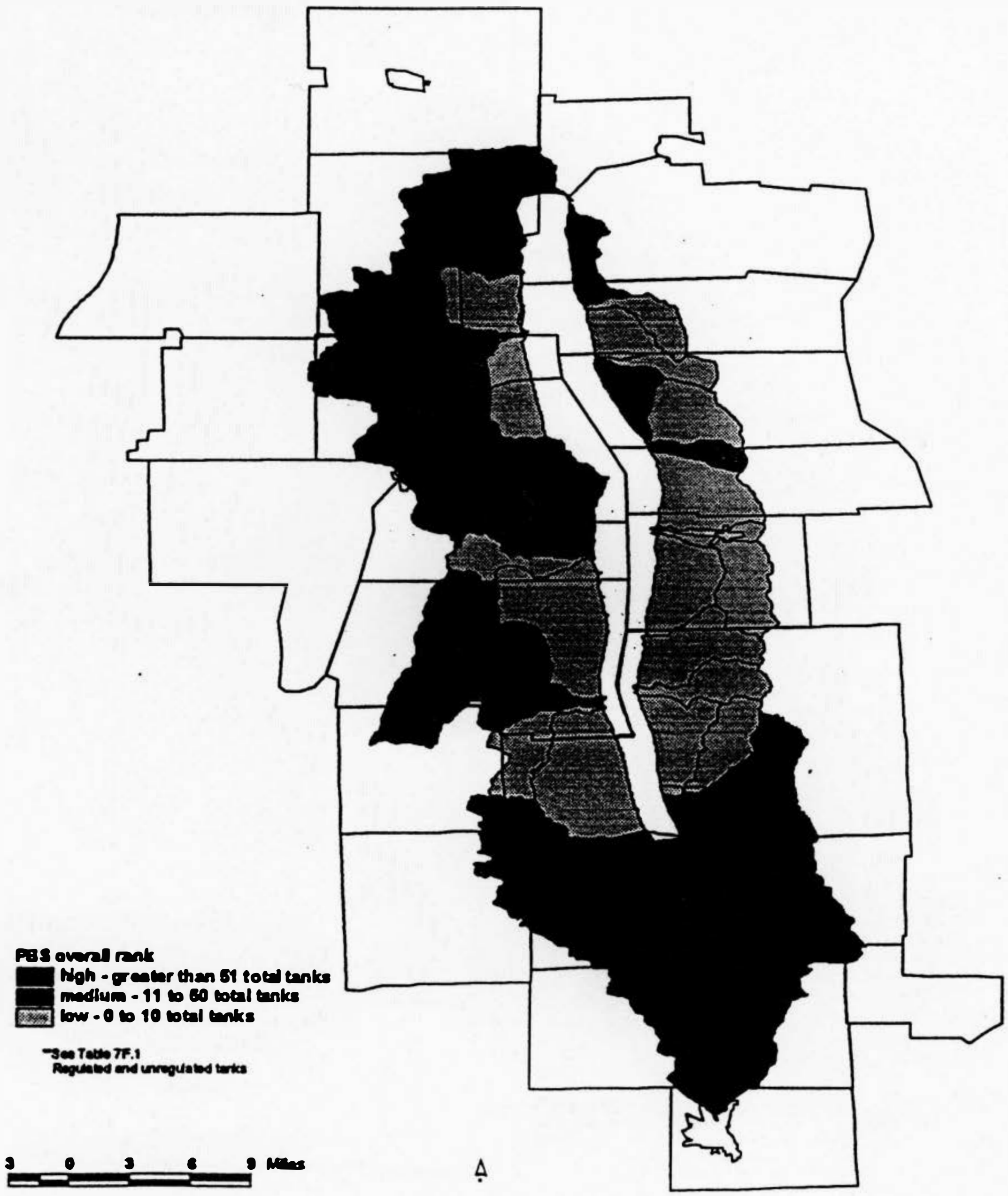

Figure 7G.1

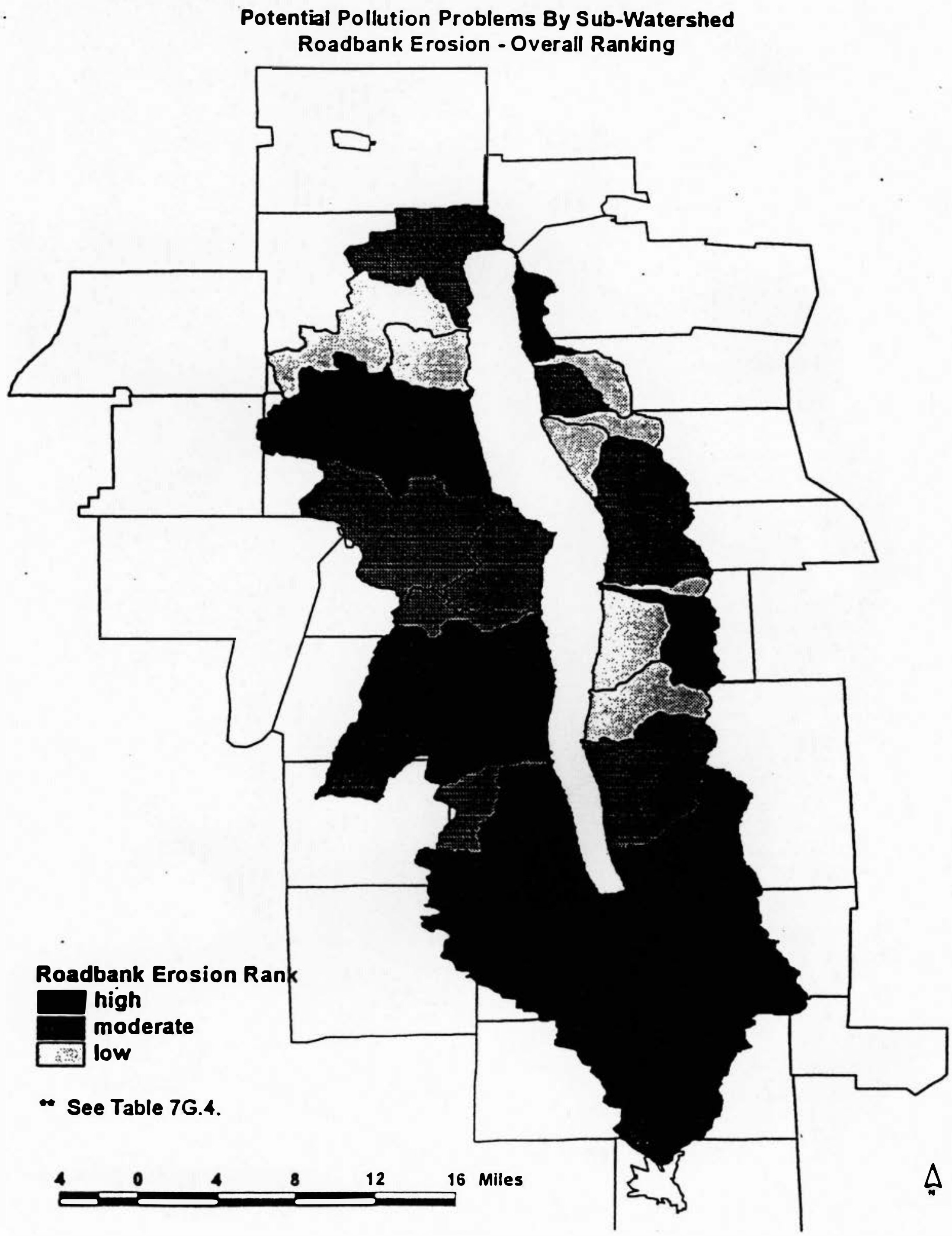
Potential Pollution Problems By Sub-Watershed
Roadbank Erosion - Overall Ranking
Roadbank Erosion Rank
high
moderate
low
** See Table 7G.4.
4 0 4 8 12 16 Miles

Figure 7H.4

Potential Pollution Problems By Sub-Watershed
'Deicing Salt - Overall Rank

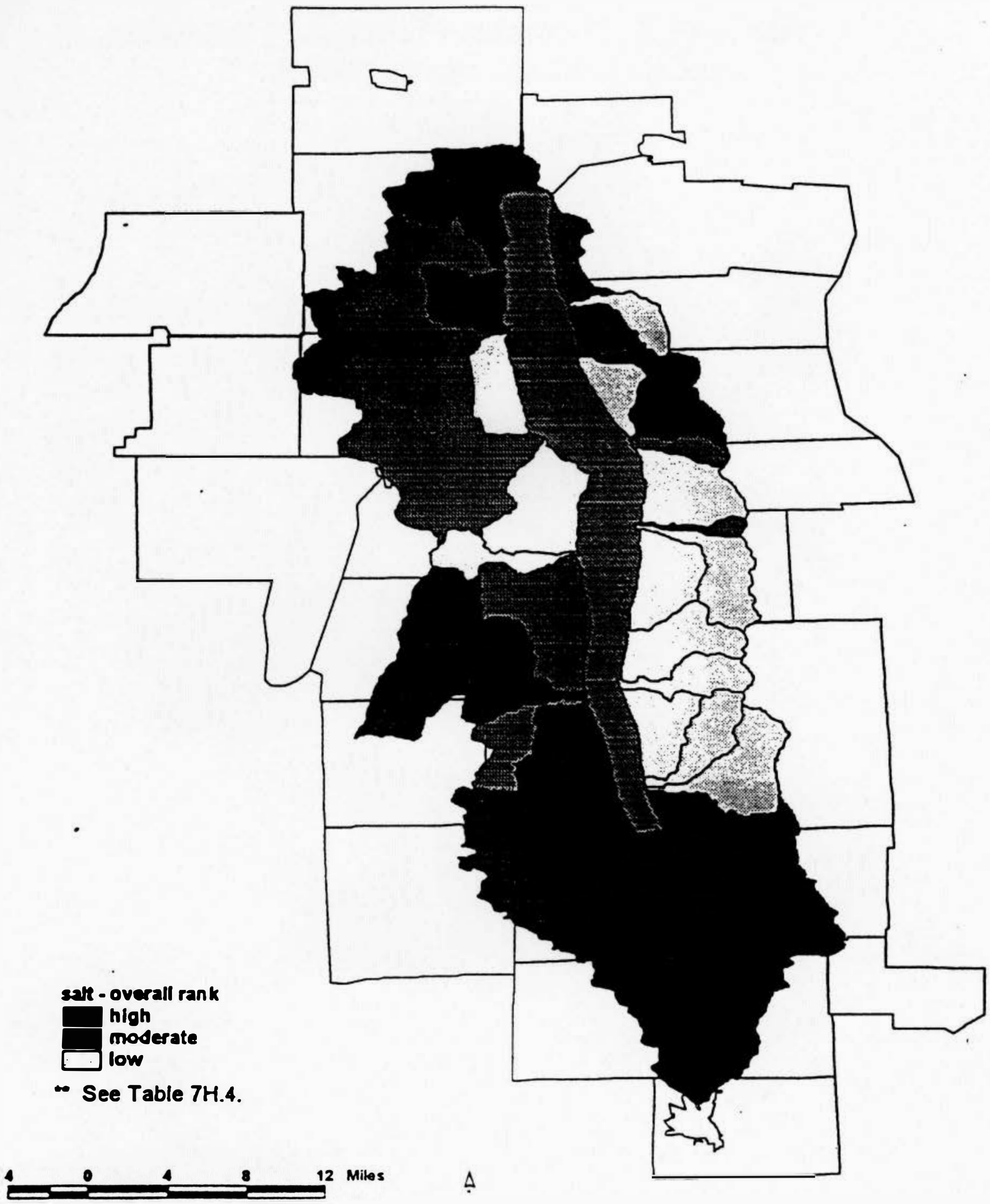

Figure 7J.1

Potential Pollution Problems By Sub-Watershed
SPDES Permitted Facilities

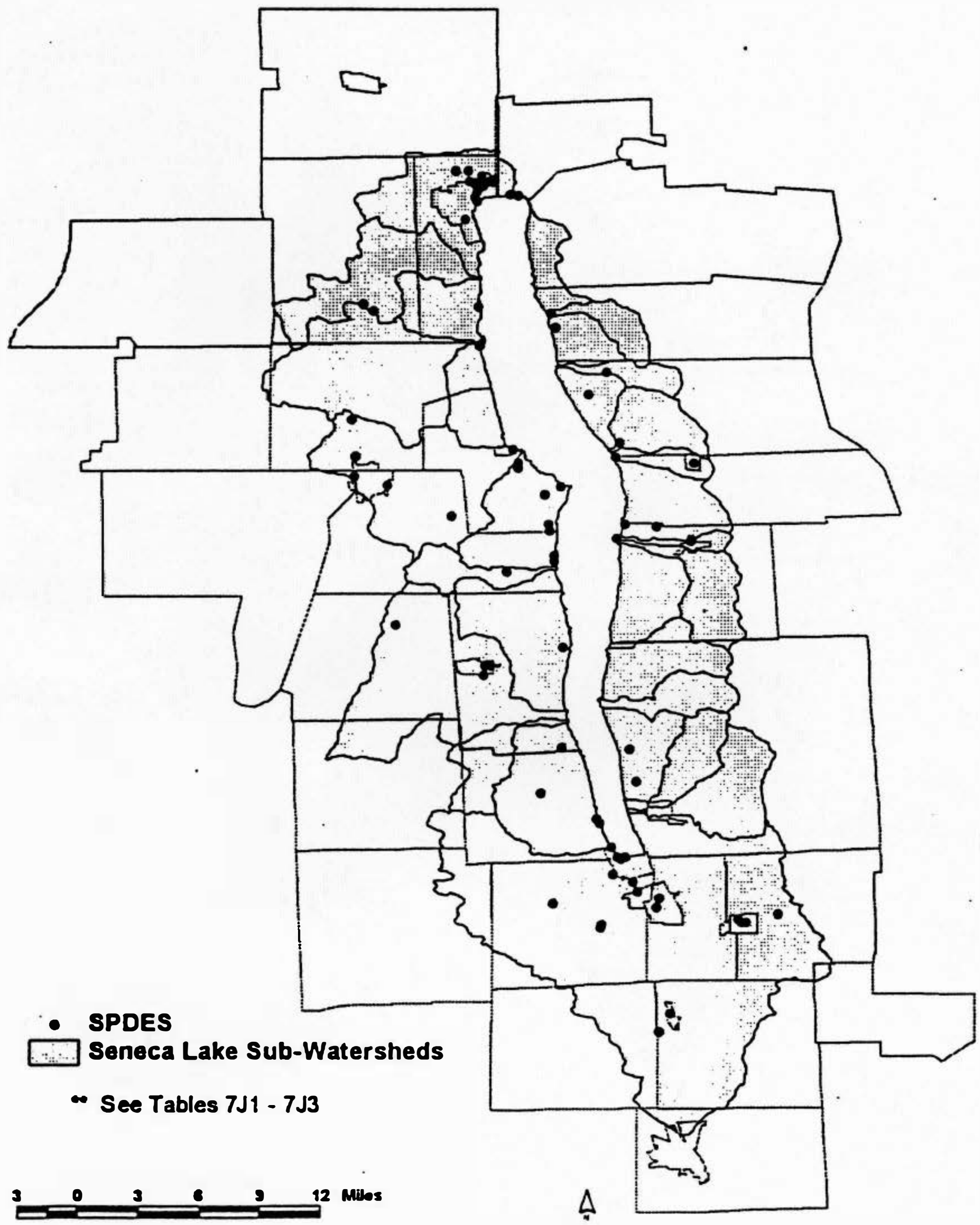

Figure 7L.1

Potential Pollution Problems By Sub-Watershed
Streambank Erosion Potential