Watershed Management Plan

2014

Otisco Lake

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NYS Department of State

Local Waterfront

Revitalization Grant

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John H. Mulroy Civic Center
4231 Montgomery Street
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Grant Partners

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Onondaga County Soil and Water Conservation District

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Central New York Regional Planning and Development Board

Otisco Lake Watershed Intermunicipal Committee

Others

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The Otisco Lake Watershed Management Plan grant partners would like to extend their appreciation to the following individuals for sharing their time and effort:

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EXECUTIVE SUMMARY

Otisco Lake
Watershed Management Plan

The Otisco Lake Watershed Management Plan provides a comprehensive review of the state of Otisco Lake and its watershed. The purpose of the plan is to identify issues affecting the water quality and ecology of Otisco Lake and to provide specific recommendations to protect the lake's future.

Otisco Lake is located in southwestern Onondaga County and is one of New York State's Finger Lakes. Slightly over 6 miles long with a maximum width of .8 miles, Otisco Lake is bordered by three townships (Marcellus, Otisco and Spafford) with small portions of three other towns (Onondaga and Tully in Onondaga County; Preble in Cortland County) comprising the rest of the watershed.

As a major drinking water supply source for Onondaga County, Otisco Lake is protected by the Otisco Lake Watershed Rules and Regulations implemented by the Onondaga County Water Authority (OCWA). The lake also serves as an important recreational and environmental resource. The Otisco Lake outlet dam is operated by OCWA, but water levels are largely weather dependent since OCWA has limited abilities to control lake elevations. Except for a narrow connection, Otisco Lake is divided by a causeway separating the smaller and much shallower southern end from the rest of the lake. The two sections are effectively distinct lakes.
There are two private boat launching access points at Otisco Lake with shoreline access located along the extreme northeastern portion of the lake, the southwestern corner near the lake causeway, and at the County Park near Turtle Bay on the east shore which operates as a "carry in / carry out" facility. Otisco Lake does not have a public boat launch facility.

The OCWA monitoring program is focused on treatment needs for water supply purposes and provides a comprehensive long-term water quality data base for Otisco Lake. Data collection with a more lake water quality focus was done remotely from 2002 to 2007 by the Upstate Freshwater Institute under a grant program known as Our Lake. Since 2008, Hobart William Smith College-Finger Lakes Institute has also sampled Otisco Lake as a part of its current Finger Lakes monitoring program.

Otisco Lake does not meet dissolved oxygen standards, but there is no conclusive evidence that conditions (such as nutrient levels and oxygen depletion) have changed appreciably over the period of record dating back to the early 1900s.

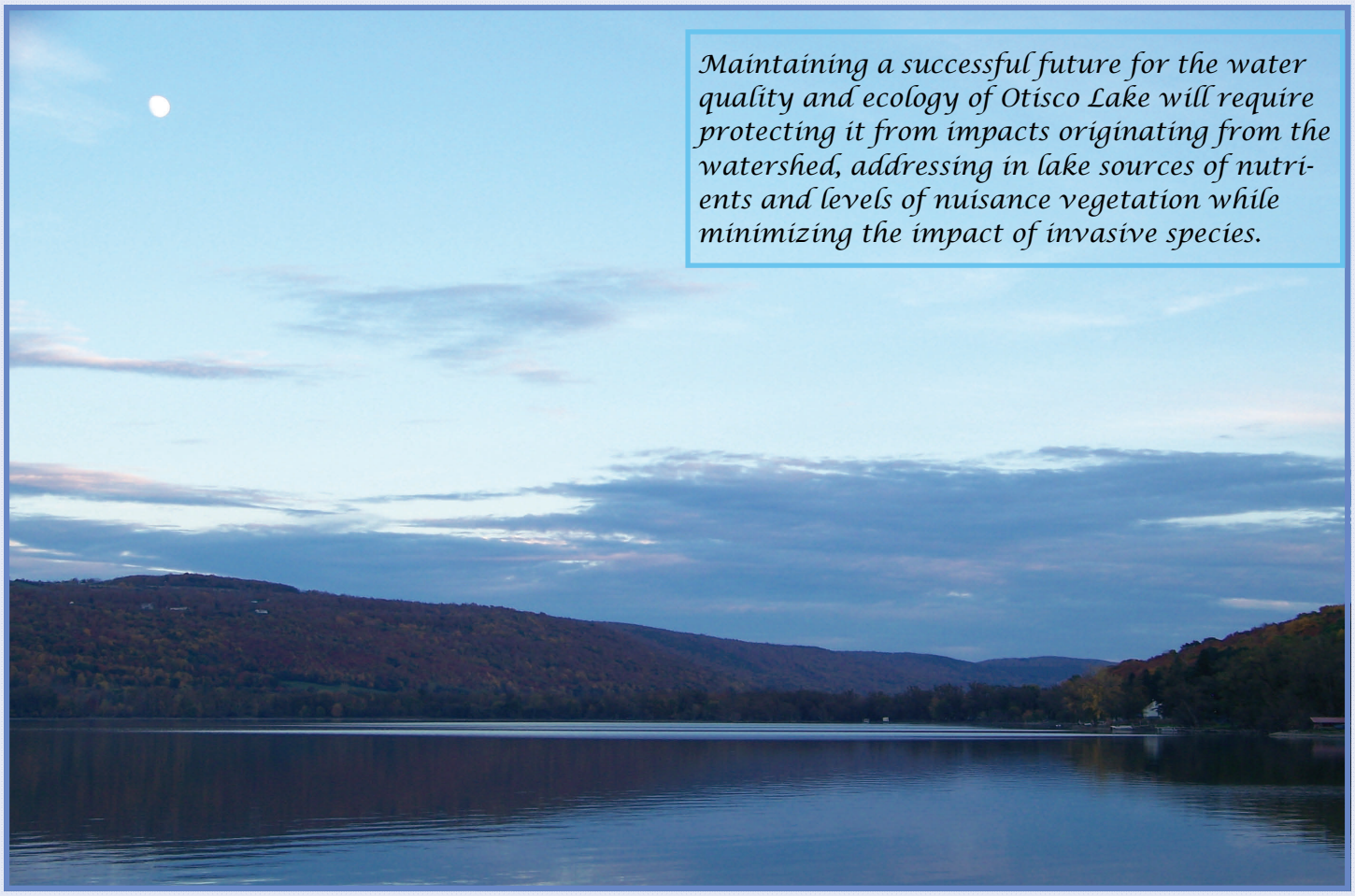
Otisco Lake has a diverse aquatic plant community with native coontail and the non-native Eurasian watermilfoil predominant. There is evidence aquatic vegetation expansion has been most apparent at

the north end of the lake in the area immediately south of the Narrows. Extensive areas of shallow water throughout the lake are impacted by an abundance of Eurasian watermilfoil and by nuisance levels of other species. Mechanical harvesting, benthic barrier placement and suction removal control efforts have provided a minimal measure of relief. Early detection and hand-pulling control efforts by the Otisco Lake Preservation Association (OLPA) have nearly eradicated the invasive water chestnut. Diverse populations of game fish including walleye, tiger muskellunge, smallmouth bass, largemouth bass, white perch, yellow perch and brown trout are found in Otisco Lake

The Otisco Lake watershed is 38.7 mi^2 (24,777 acres) and is large enough relative to the lake's size and volume to flush fairly rapidly. The watershed is approximately 42% agricultural, 33% forested lands and 9% shrub/scrub. Wetlands and open water comprise almost 13% of the watershed. Approximately 50% of the occupied dwellings in the watershed are lakefront residences with the majority of residential development along the east shore and northern third of the western shoreline.

Otisco Lake faces challenges in maintaining and improving its water quality in the coming years. These include the control of internal sources of nutrients (primarily phosphorus) as well as stormwater runoff containing nutrients, sediments, pesticides, and other pollutants from agricultural and non-agricultural watershed sources. Sediment inputs from three major tributaries were shown to have increases from 100 to 400 percent over an approximate 25-year period (1981-83 compared to 2005-08).

This plan evaluated and identified changes needed in priority area Tier V Agricultural Environmental Management (AEM) plans. Recommendations were made to implement these changes and to inventory and remediate other sources of contamination.



Maintaining a successful future for the water quality and ecology of Otisco Lake will require protecting it from impacts originating from the watershed, addressing in lake sources of nutrients and levels of nuisance vegetation while minimizing the impact of invasive species.

A review of land use regulations and policies in the primary watershed towns indicate they provide an adequate level of resource protection.

Rural communities often struggle to evaluate the potential impacts of development. This management plan recommends an evaluation of ecosystem services to better understand the value of the services provided by forested and agricultural environments to facilitate better decision making.

Watershed resident and stakeholder surveys were conducted to better understand public perception of Otisco Lake and the problems it faces. The resident survey with 177 responses identified dense aquatic weed growth interfering with boating and public access to the lake as major concerns. A stakeholder opinion survey identified invasive species prevention/education, high nutrient levels, septic effluent, and fishing as high priority issues of concern to lake quality.

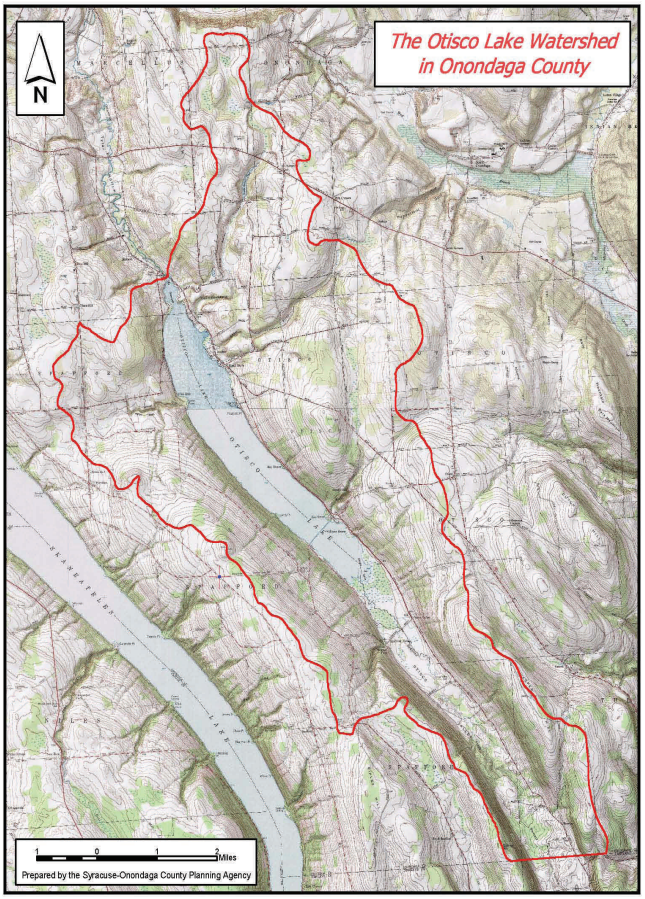
Watershed issues identified as of highest priority included: hydrofracking, chemical fertilizer application, affects of runoff, hazardous household waste disposal, and watershed inspection and maintenance of onsite septic systems.

Maintaining a successful future for the water quality and ecology of Otisco Lake will require protecting it from impacts originating from the watershed, addressing in lake sources of nutrients and levels of nuisance vegetation while minimizing the impact of invasive species. The recommendations outlined in the management plan provide a first step in this direction. Long term success can be achieved through continued and expanding cooperative working relationships among municipalities, public entities, the lake and other private resource oriented associations and local landowners. Otisco Lake and watershed issues and concerns are summarized below:

Summary of
Otisco Lake and Watershed Issues and Concerns

Area	Category	Issues
Lake	Monitoring	Need to assess on-going lake water quality.
	Aquatic vegetation	Excessive growth and effective methods of control.
	Invasive species	Control of current species, prevention of future introductions, on-going education of lake users.
	Water quality	Elevated levels of nutrients and sediments.
Watershed	Monitoring	Need to assess on-going tributary inputs.
	Fishing	No public boat launching facility available.
	Agriculture	Sediment, nutrient, pesticide and pathogen runoff.
	Commercial and industrial influences	Surface and groundwater pollution.
	Shoreline residences	Household hazardous waste disposal; onsite septic maintenance.

OTISCO LAKE



- Lake Length: 6 miles
- Maximum Width: .8 miles
- Lake Surface Elevation: 787 feet
- Lake Surface Area: 2048 acres
- Average Depth: 33 feet
- Maximum Depth: 66 feet
- Volume: 21 billion gallons
- Hydraulic Retention Time: 1.7 years
- DEC Water Quality Classification: AA
- Water Level Control: Some – Otisco Lake Outlet Dam
- Shoreline Length: 15.5 miles
- Watershed Area: 24,777 acres
- Primary Watershed Land Use: Agriculture (42%)
- Highest Point in Watershed: 1986 ft (Ripley Hill)
- Number of Towns in Watershed: 7
- Lake Associations: Otisco Lake Preservation Association (www. otiscolakepreservation.org)

CHAPTER 1

INTRODUCTION

1.1 Project Introduction and Background

Otisco Lake is the easternmost of New York State's Finger Lakes. It serves as a public drinking water supply source for Onondaga County residents and provides an important recreational and environmental resource for permanent and seasonal residents as well as visitors from other parts of central New York and beyond. Being such a valuable resource, it is incumbent upon residents, lake users, and stakeholders to protect and manage Otisco Lake to the best of their ability.

Since a watershed can be defined as the total area that eventually drains into a lake, all surface and groundwater generated from precipitation and snowmelt in the area defined as the "Otisco Lake watershed" will makes its way into Otisco Lake. Thus, it is imperative that a plan for Otisco Lake includes its watershed since decisions regarding land use within the watershed have a direct influence on the water quality, aquatic biology, and recreational opportunities in the lake.

As a public drinking water supply source, Otisco Lake is provided a level of enhanced protection thorough the Otisco Lake Watershed Rules and Regulations. However, while applicable to lake resource management, these rules and regulation focus on drinking water quality needs. There is some state and federal agency authority over lake resource management and land use, but it is limited. As a result, actions and activities having the greatest impact upon land use and ultimately the lake are conducted at the local level. Therefore, municipal decisions play a much larger role in how well a lake is protected form development activities.

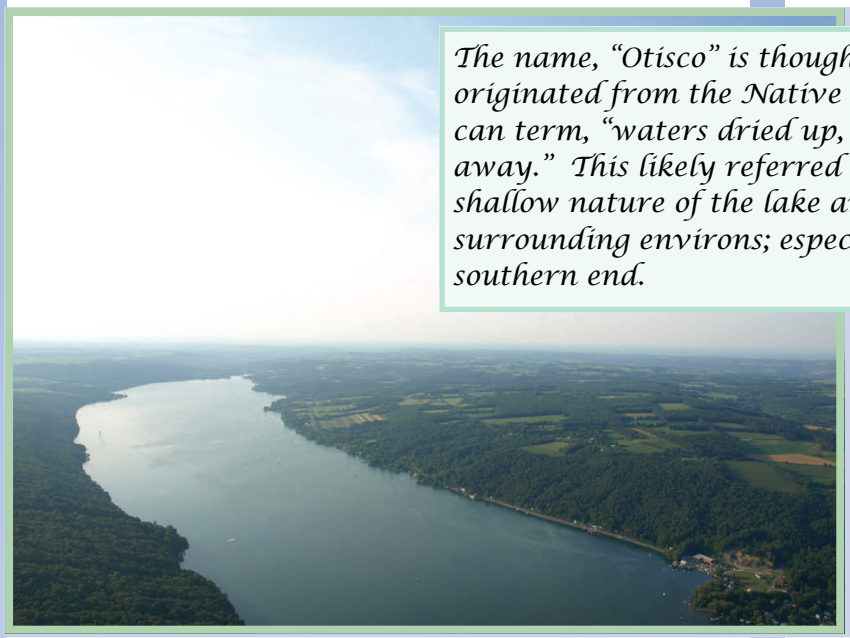
There is a long history of lake and watershed stewardship conducted cooperatively by the Onondaga County Water Authority (OCWA) as the drinking water supply purveyor, Onondaga County agencies as well as a number of federal and state agencies. A more recent addition has been a local non-profit lake association (Otisco Lake Preservation Association) as a primary impetus for lake management activities (e.g., aquatic vegetation management, invasive species control, land use policy) and public outreach activities.

A view of Otisco Lake, north of the narrows. Primary roadways adjacent to the lake are Otisco Valleey Road (left) and Route 174 (right). Otisco Lake outlet dam also visible (center left)

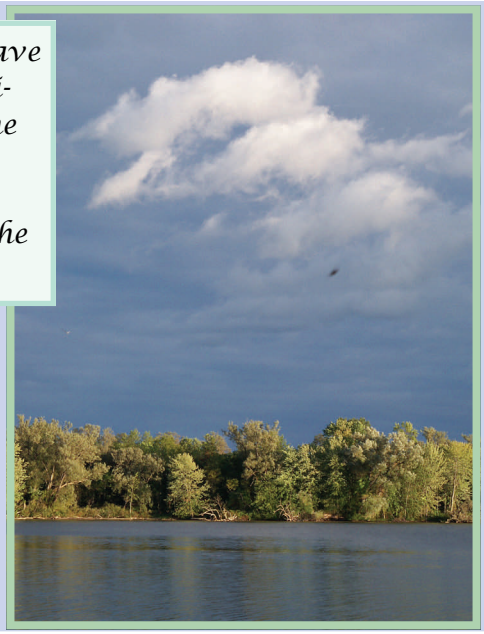
Otisco Lake is provided a level of enhanced protection through the Otisco Lake Watershed Rules and Regulations.

1.2 Cultural History of the Otisco Lake Region

The Finger Lakes region has been occupied by Native Americans since about 9,000 years with the retreat of the Pleistocene glaciers. The Iroquois were one of the first tribes to permanently inhabit the area and thought to have arrived during the thirteenth or fourteenth century. Three of the five Iroquois Nation tribes (the Onondagas, the Senecas, and the Cayugas) lived in the Finger Lakes region. They held dominion over the area until the 1700s when Europeans arrived.



The name, "Otisco" is thought to have originated from the Native American term, "waters dried up, or gone away." This likely referred to the shallow nature of the lake and its surrounding environs; especially the southern end.



Although it is known that the Onondagas had a trail leading to Otisco and other lakes in the area for fishing and hunting, there are no recorded permanent Native American settlements in the Otisco Lake watershed. However, there are stories and signs indicating their camps were near the lake.

Permanent European settlement began after the Revolutionary War when lands were given by the United States Government to soldiers as payment for their services. In 1804, the first house by a white settler (Oliver Tuttle) was erected at the head of the lake in the present day Town of Otisco, which was formed two years later in 1806.

The name, "Otisco" is thought to have originated from the Native American term, "waters dried up, or gone away." This likely referred to the shallow nature of the lake and its surrounding environs; especially the southern end. The watershed landscape changed permanently with the construction in 1869 of a dam at the north end to impound water for use in maintaining water levels in the Erie Canal. The dam raised the lake's water level by approximately 9 feet. It also submerged a road that existed at the southern end linking residents in the town of Otisco and Spafford. In addition to expanding the lake's surface, the wetlands at the southern end were submerged. The road was rebuilt with hemlock logs in 1908. A storm in 1929 washed out portions of the causeway and the structure continued to deteriorate until it was reconstructed in 1983 (Deyle 1985).

In the early part of the last century, Syracuse residents would take come to the lake by way of the Marcellus-Otisco Railway for boat excursions. Heath's Grove contained a Pavilion that was used for parties and town picnics, and rental cottages available. Over the ensuing decades, most of the lake's shoreline (except for areas with steep slopes along the western shore) was developed.

In 1908 the Suburban Water Company obtained the right to use Otisco Lake for a public water supply. The Company raised the dam in 1909 which increased the water level another 4 feet. In 1926, the Federal Water Company bought Syracuse Suburban and changed its name to the Onondaga Water Service. From the 1920s on, demand for Otisco Lake water grew with the expanding economy and housing boom. After a series of changes and ownership, the Water Service became known in 1955 under its present name, the Onondaga County Water Authority.

CHAPTER 2

STATE OF OTISCO LAKE

2.1 Overview and Summary

Otisco Lake is a valued water body serving as a major source of drinking water for approximately 340,000 customers in Onondaga County and provides recreational, aesthetic and ecologically benefits to residents and visitors alike. These uses are intrinsically bound by the quality of the lake.

In order to protect, preserve or enhance a resource, it is important to understand how it functions. To that end, monitoring and investigations over several decades have helped determine whether conditions in Otisco Lake have changed, what factors are responsible for the lake's present condition, and what are the threats to its future well-being.

The existing database provides no conclusive evidence lake conditions, including nutrient levels and oxygen depletion, have changed appreciably.

Long-term management is dependent upon the physical characteristics of the lake and its watershed, water quality data, information on biological communities living in the lake, and how people use both the lake and surrounding watershed. Obtaining such information can be time-consuming, costly and at times inconclusive. Nevertheless, these steps are necessary to make sound decisions and commitments for the future of Otisco Lake. Fortunately, the existing data base provides more than an adequate amount of information to help formulate a number of management decisions.

Focused on drinking water supply treatment needs, the OCWA lake monitoring program provides the lake's longest-standing water quality data set. Lake and tributary data has been collected during the last decade mostly notably through the Central New York's Near-Real-Time Surface Water Quality Network, Hobart-William Smith College-Finger Lakes Institute, and the United States Geological Survey (USGS). There is also an historical data base of special studies and investigations.

Otisco Lake is usually described as mesotrophic or moderately nutrient - enriched. While the watershed contributes phosphorus, nitrogen, sediment and other contaminants, the lake bottom sediments are a major source of phosphorus which is the nutrient most responsible for algal growth.

However, the "open water" or mid-lake area normally exhibits very good water clarity which is thought to have increased since zebra mussels established themselves in the late 1990s. Aquatic vegetation expansion in parts of the lake, most notably the area immediately south of the Narrows, may also be a result of the increased water clarity.

Oxygen loss from the deeper waters and warm temperatures in the water column limit Otisco Lake's ability to support trout thorough late summer. Nevertheless, Otisco Lake supports a healthy aquatic system providing a diversity of game fish including walleye, tiger muskellunge, smallmouth bass, largemouth bass, white perch, yellow perch and brown trout. While walleye are the most sought after game species, Otisco Lake has developed a region wide reputation for tiger muskie.

The existing database provides no conclusive evidence lake conditions, including nutrient levels and oxygen depletion, have changed appreciably over the period of record which dates back to limited data collection and narrative accounts from the early decades of the 1900s.

Data indicate overall water quality condition in Otisco Lake are similar to Honeoye, Cayuga, and Owasco lakes rather than its more pristine neighbors such as Skaneateles and Canandaigua lakes.

2.2Lake Characteristics and Hydrology

Otisco Lake is the most easterly of the eleven Finger Lakes. It is 6.01 miles long and contains 15.53 miles of shoreline. The average width is .59 miles with a maximum width of .80 miles. It is a shallow lake compared to most of the other Finger Lakes with an average depth of 33 feet and a maximum depth of 66 feet. Thirty-five percent of the lake's volume is found at depths greater than 33 feet.

With a surface area of 3.2 mi^2 and a volume of 21 billion gallons, Otisco Lake has the fourth smallest surface area and third smallest volume of the Finger Lakes. Net flow direction is south to north. On average, Otisco Lake flushes approximately once every two years which is the third fastest rate of all the Finger Lakes.

A notable feature of Otisco Lake is its division by a causeway separating the smaller and much shallower southern end from the rest of the lake. Average depth in the southern section of the lake is about 3 feet and the maximum depth around 9 feet. A narrow channel through the causeway serves as the only connection and means for water exchange between the two lake sections.

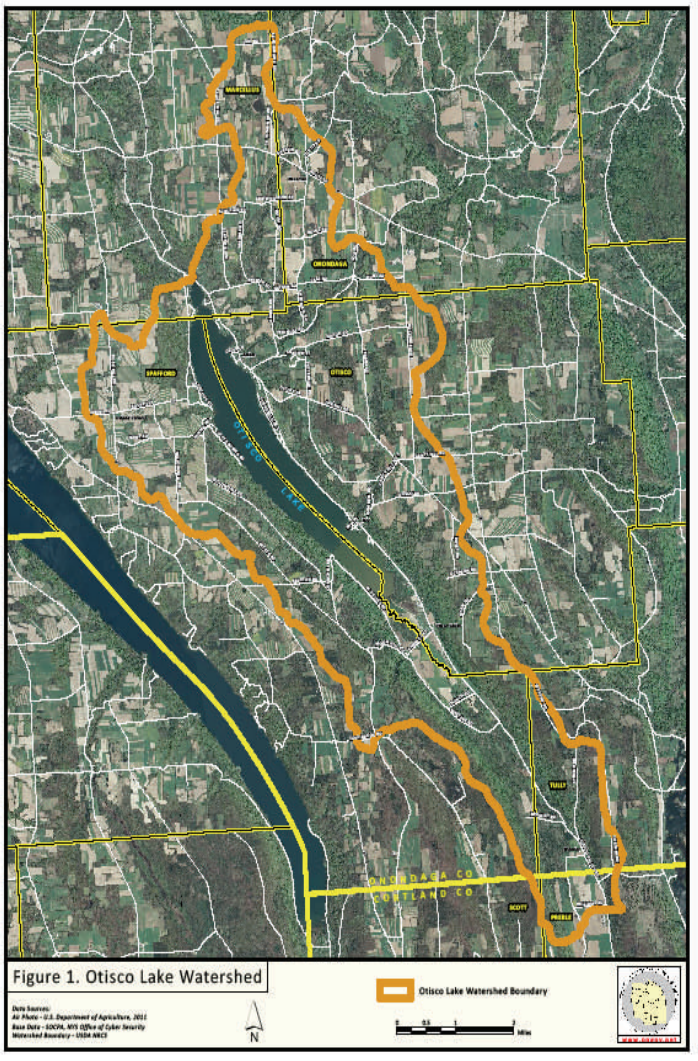
The southern basin normally has a brown turbid appearance attributed to sediment resuspension. While there is deposition from Spafford Creek, bottom sediments in the southern basin are organic soils derived from the former wetland area flooded when the elevation of Otisco Lake was first raised in 1869 by the original outlet dam to impound additional water for use in maintaining water levels in the Erie Canal.

The causeway was constructed in 1895 to replace a road built through the Spafford Creek swamp that had been submerged when the first dam was built in 1869. The causeway elevation was also raised following the increase in dam height in 1909.

Winkley (1989) included Otisco Lake in the hydrogeological setting known as the northward-draining troughs. The glacial troughs of Onondaga County are unusually deep valleys and oriented in the same direction (parallel) to the regional topographical trend. Groundwater from the east and west sides of the lake generally flows toward the lake. Longitudinal flows move along the axes of the valley which is generally in a northward direction.

Otisco Lake has the fourth smallest surface area and third smallest volume of the Finger Lakes.

Turbid conditions characterize Otisco Lake south (top of photo) of the causeway.



2.3 Water Quality and Clarity

Chemical Characteristics

Otisco Lake is classified as mesotrophic meaning it supports a moderate level of biological productivity. Lakes of this trophic status are generally described as being moderately clear with an increasing probability of the hypolimnion (bottom waters) becoming depleted of dissolved oxygen (i.e., anoxic) during the summer. In a mesotrophic system, numerical ranges for average summer values for the following parameters include: total phosphorus: 12-24 ppb, secchi disc transparencies: 2-4m and chlorophyll a: 2.6- 7.3 ppb. This also translates into a Carlson Trophic State Index (TSI) value of 30-50 (Carlson and Simpson 1996).

Data collection and calculated TSI values for Otisco Lake support mesotrophic classification. Mean values for secchi disc transparencies, total phosphate (TP) and chlorophyll-a for the 2008-2011 data set are indicative of a mesotrophic lake.

Otisco Lake Mean Values 2008-2011 for Trophic Indicators

Secchi Disc	Total Phosphate (TP)	Chlorophyll-a
3.2m (10.5 ft)	**18.4 ppb**	**2.0 ppb**

Likewise, TSI values computed over the past two decades (**Table 2 Appendix I)** exhibiting some variability, but also are all in the mesotrophic range.

Otisco Lake was one of several local waterbodies where water quality data was collected from 2002 to 2007 by the Upstate Freshwater Institute thorough a multi-organizational effort (www.ourlake.org 2009). Hobart William Smith College-Finger Lakes Institute has been sampling Otisco Lake as a part of its Finger Lakes monitoring program since 2008. Surface and lake bottom values for several parameters in 2008, 2009, 2010, and 2011 are summarized in **Table 1** (See Appendix I)**.**

An interesting anomaly is seen in the high mean total phosphorus and large standard deviation reported for the 2009 data in Table 1**.** Both the high mean value and large standard deviation reflect a single sample taken on July 22, 2009 showing an elevation spike in a surface water sample for total phosphorus (TP >150 ppb). Explanations include: i) the sample being taken soon after a strong precipitation or wind event, ii) an event induced by carnivorous zooplankton predation upon herbaceous zooplankton, or iii) bottom water mixing due to wind events inducing blue green algae blooms. The latter phenomenon has been reported to occur in Honeoye Lake (J. Halfman pers. comm. 2010). This explanation is also an indication of the role bottom sediments likely play in supplying phosphorus (called internal cycling) for phytoplankton (algae) growth.

A notable characteristic of Otisco Lake is the strong temperature stratification exhibited during the summer months. Average depth of the thermocline in the July through August time period is typically around 26-33 feet (8-10 meters, www.ourlake.org 2009, Halfman, pers. comm 2012). At the same time, dissolved oxygen is depleted rapidly from the lower waters resulting in close to or the complete loss of oxygen (anoxia) from virtually the entire hypolimnion.

The widespread depletion of dissolved oxygen, has lead some investigators to consider Otisco Lake as being eutrophic (Halfman and O'Neill 2009).

The precipitation of calcium carbonate known as "whiting" is another interesting, recurring phenomenon in Otisco Lake that varies with respect to timing and magnitude. It is a distinct component of lake turbidity in the upper waters and arises abruptly. Whiting events can easily be mistaken for phytoplankton blooms due to the green, turbid appearance of the lake water.

From a limnological standpoint, Otisco Lake south of the causeway can be considered a separate lake. Total phosphorus, phytoplankton biomass, and turbidity levels are much greater than those found in the main lake while transparencies are much lower (Callinan, 2001).

Chemical Characteristics- Historical

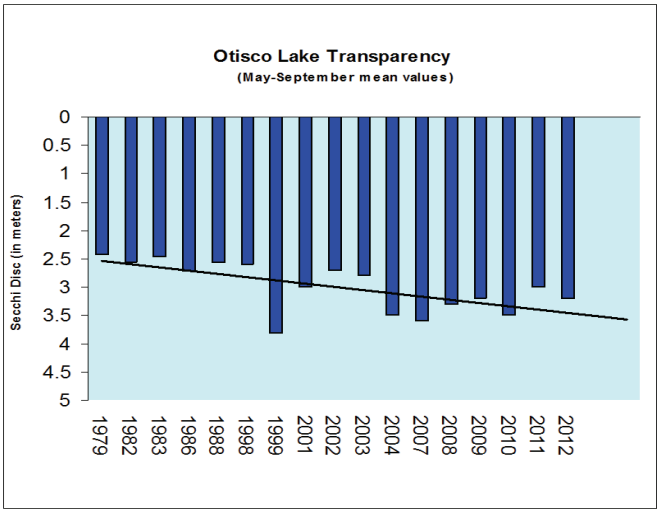
Not unexpectedly, secchi disc transparencies, which are a measure of visibility or water clarity,

show seasonal and annual variability. A general increase in mean values for May-September is seen since zebera mussels became established in the lake in 1997.

Of historical interest is a single August secchi disc reading of 3.0 meters (9.8 feet) from Birge and Juday (1910) and a mean of two readings in 1973 of 5.7 meters (10.8 feet) reported by Oglesby (1974).

The release of phosphorus from bottom sediments due to anoxia in the hypolimnion has long been thought to play a role in Otisco Lake nutrient dynamics.

Further indication of the lake's historic low levels of dissolved oxygen in the deeper lower waters is seen in an assessment of the lake fishery by Eaton (1928) who described Otisco as the shallowest, warmest and weediest of the lakes he surveyed. The author added the deeper waters were not suited for fish during the summer



The pattern of seasonal dissolved oxygen loss has shown no substantive change.

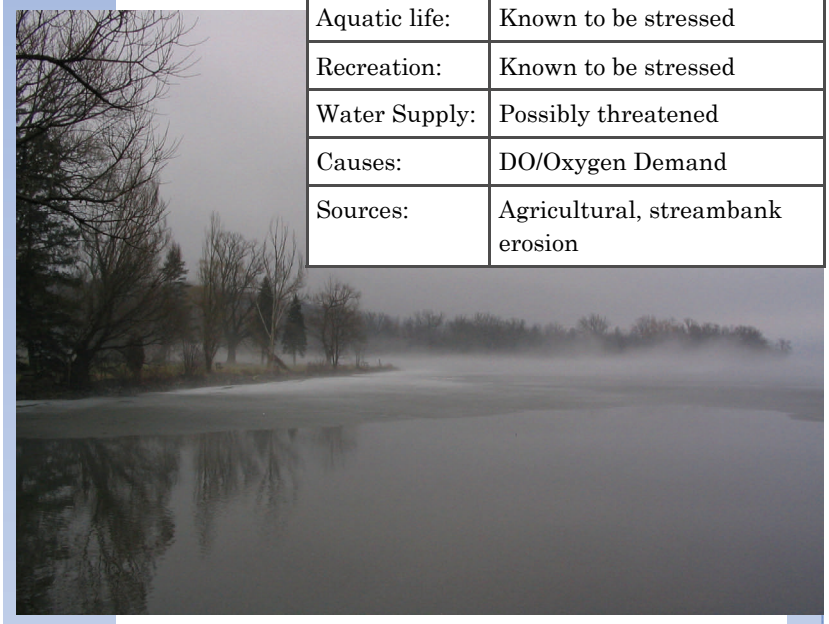
due to low dissolved oxygen levels.

Internal cycling or the release of phosphorus from bottom sediments due to anoxia in the hypolimnion has long been thought to play a role in Otisco Lake's nutrient dynamics. Concentrations up to 80 mg/l of total phosphorus were reported from the hypolimnion by Effler et.al, (1989).

Major ion trends over several past decades indicate declines in calcium, magnesium and alkalinity, but increases in sodium, chloride, and sulfate. Sediment accumulation rates of 0.74 cm/year have been calculated for Otisco Lake, one of the highest rates measured for the Finger Lakes (Callinan, 2001).

Water Quality Classification

Otisco Lake is classified as AA (best usage classification-drinking water) and serves as a public and private drinking water supply source. It also provides multi-recreational uses including fishing, boating and swimming.



Aquatic life:	Known to be stressed
Recreation:	Known to be stressed
Water Supply:	Possibly threatened
Causes:	DO/Oxygen Demand
Sources:	Agricultural, streambank erosion

Otisco Lake is on the New York State Department of Environmental Conservation (NYSDEC) Waterbody Inventory/Priority Waterbodies List (WI/PWL) with the following use impairments, causes and sources:

Otisco Lake does not meet current dissolved oxygen standards due to undetermined natural or unnatural causes. As a result, Otisco Lake is on the Federal Clean Water Act Section 303 (d) list as a "Listed Waterbody Not Meeting Dissolved Oxygen Standards, Pending Verification of Impairments/Pollutants/Sources." The NYSDEC is conducting an evaluation of 45 waters, including Otisco Lake, identified by the USEPA to determine whether these waters are impaired in any significant manner by pollutant loadings from other than natural conditions.

2.4 Lake Water Level

OCWA is responsible for the operation and maintenance of the dam. There is an ongoing program of monitoring and inspection of the dam to meet NYSDEC regulations as well as a schedule for future needs of the dam (Anthony Geiss, pers. Comm. 2013). OCWA is required to maintain a minimum flow release into Nine Mile Creek of 1million gallons per day (mgd) or 1.5 cubic feet per second (cfs). As a target level, OCWA tries to maintain a daily lake level average computed from a 50-year record. The lake level is based upon the spillway crest elevation of 786.60 feet (Mark Murphy, pers. comm. 2013). However, lake levels throughout the year are largely weather dependent since OCWA has limited ability to control lake elevations. The average minimum level over the past 52 years has been 28.5 inches below the spillway crest and the average maximum 4.4 inches above it (Mark Murphy, pers. comm. 2013).

Map showing historical lake water levels.

Lake levels throughout the year are largely weather dependent since OCWA has limited ability to control lake elevations.

Otisco Lake outlet dam

Phytoplankton and Zooplankton

There are no known recent studies of phytoplankton and zooplankton population dynamics for Otisco Lake. The most comprehensive phytoplankton data set comes from OCWA's weekly analyses on water samples drawn from their water supply intake (depth 20 feet) and samples that historically were taken at several locations and depths in the lake. OCWA sampling is primarily conducted for drinking water supply monitoring purposes. Identification is done to the genus level. In recent years, *Fragilaria* sp., have typically been dominant during bloom periods. The cyanobacteria (blue-green algae), *Anacystis sp.* is dominant through most of the growing season (OCWA 2011).

Studies of diatom species presence in bottom sediment cores have been used to infer historical changes in total phosphorus concentrations in lakes. Such an investigation has included a number of New York lakes, including Otisco Lake. Findings indicated *Fragellaria crotonensis*, a well known eutrophic and a mesotrophic indicator, increased significantly in top sections of core samples (more recently deposited) when compared to the bottom sections (older deposition) which are estimated to be from approximately 1940.

Some mesotrophic species were also found in the lower sections (older) of the Otisco Lake core suggesting moderate nutrient concentrations have been present for some time or that the core sample was not deep enough to represent conditions prior to the lake's human-induced nutrient enrichment (Enache et al. 2012).

Otisco Lake provides a diversity of game fish and has developed a reputation for tiger muskie and ice fishing for this species which is particularly popular.

Fisheries

Walleye are the most sought after species and Otisco Lake is rated "very good" as a walleye fisheries.

Otisco Lake provides a diversity of game fish including walleye, tiger muskellunge, smallmouth bass, largemouth bass, white perch, yellow perch and brown trout. White perch are the most abundant sport fish caught. Stocking includes walleye, tiger muskellunge and brown trout.

Otisco Lake has developed a reputation for tiger muskie and ice fishing for this species is especially popular. An ice fishing world record fish was caught in February 2009. Otisco Lake provides an excellent environment for tiger muskie growth (NYSDEC, 2009).

Otisco Lake has a limited ability to support trout

thorough late summer Because the water temperatures throughout much of the water column are too warm (>20 degrees C or 68 F) and not oxygenated sufficiently (≥5 mg/l). This more than likely affects the number of stocked brown trout surviving into the fall (NYSDEC, 2009).

In July 2008, the NYSDEC conducted its first comprehensive fisheries survey in Otisco Lake since the 1990s. White perch were by far the most abundant species caught which was also the case in the previous survey. Smallmouth bass were more abundant than in past surveys with walleye more abundant than in previous sampling, but below what was considered peak populations levels in the 1998-2001 time period.

Alewife were common as were bluegill and pumpkinseed. Relatively few yellow perch were caught, but this was similar to past surveys. Infrequent or incidental collections were made of brown trout, rock bass, carp, white sucker, black crappie brown bullhead and spottail shiner (D. Lemon, pers. comm. 2010).

Fish Advisories

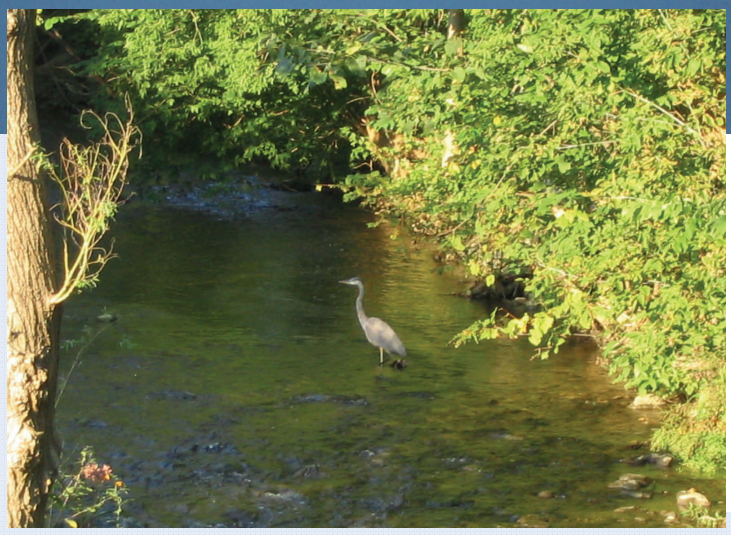
There are no special advisories for eating sport fish in Otisco Lake. Only the general health advisory for freshwater systems applies which is eating no more than one meal (one-half pound) per week of fish from the state's freshwaters.

Wildlife

No site-specific investigations on water-dependent wildlife were identified, but anecdotal evidence provides some information on reptile and amphibian abundance. In the 1960s, Turtle Bay, as the name implies, was the home to turtle populations, but since then, the population of turtles has been decimated and turtles are no longer observed in the bay. Based on conversations with a local resident, turtle harvesting during the 1990s resulted in the loss of the turtles. Likewise, incidental reconnaissance of tributaries to the lake indicate amphibians may be absent from some of these streams.

Similar to observations reported for other Finger Lakes, Canada geese over the past decade have begun to inhabit areas of the lake throughout the summer months as opposed to their previous inhabiting the area only during migration seasons. The extended presence of Canada geese is a new source of nutrients to the lake.

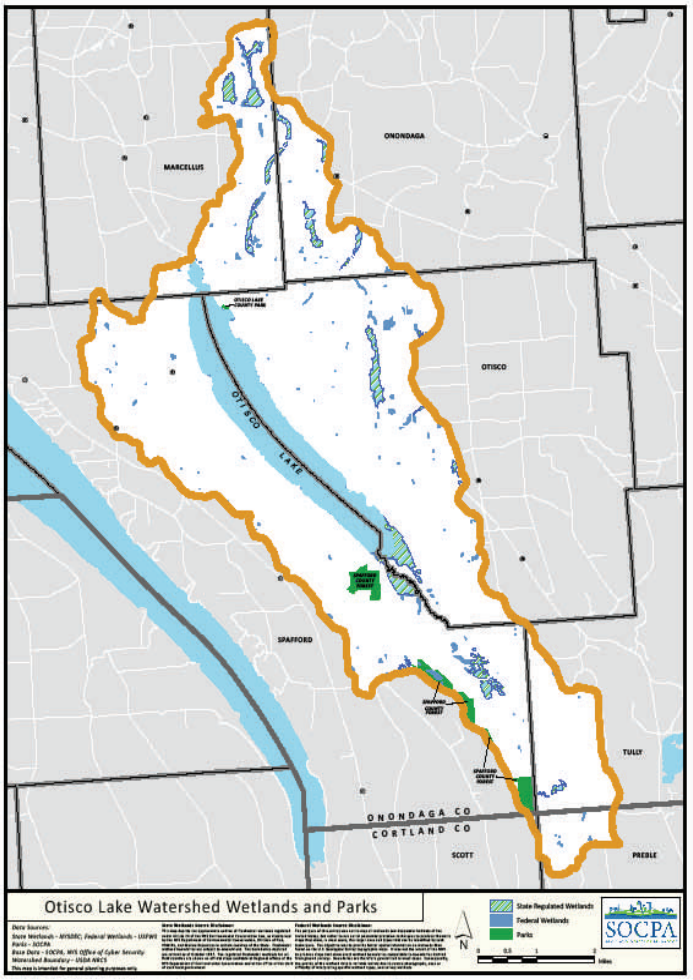
The many wildlife species that inhabit Otisco Lake and surrounding area.

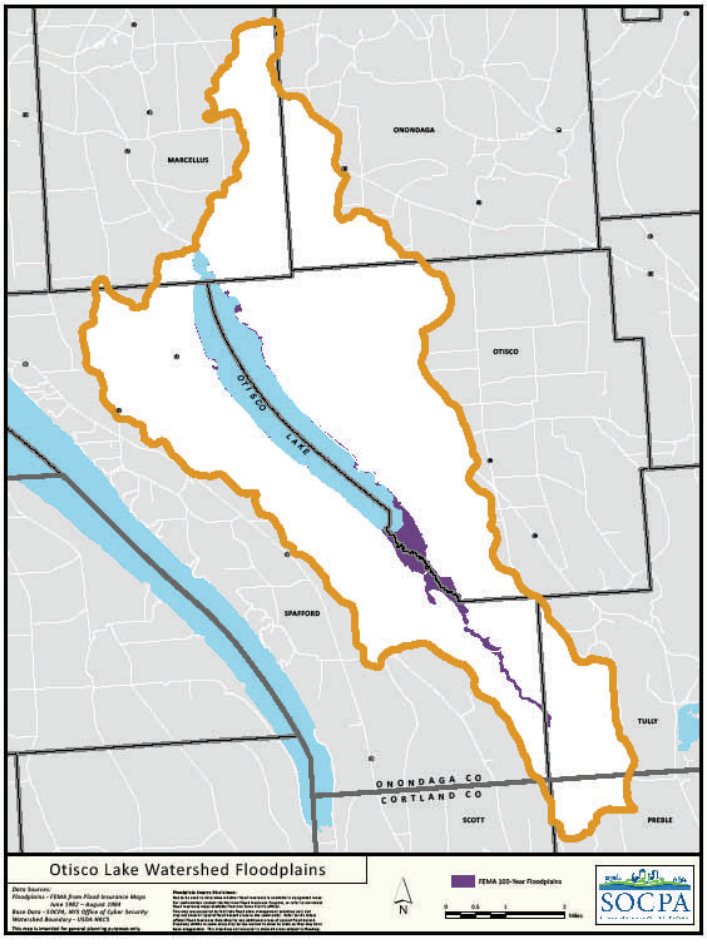


2.6 Floodplains and Important Habitats

Along the lake, the current 100-year floodplain is restricted to the extreme southeast corner adjacent to and just north of the Causeway. The areas adjacent to the lower and middle reaches of Spafford Creek are the primary flood plain areas in the watershed (Federal Emergency Management Agency 2012, **Figure 4- Floodplains).**

Regulated wetlands are found in the upper reaches of Van Benthuysen Creek, Amber Brook, Rice Brook, and in areas adjacent to Spafford Creek. Portions of the Spafford County Forest are located within the extreme southern and southwestern portions of the watershed. Spafford Forest contains 701 acres of wilderness available for hiking and outdoor exploration. The 3-acre Onondaga County Otisco Lake Park on the lake's eastern shore provides shoreline fishing access and leisure opportunities (**Figure 5- Wetlands, Parks).**





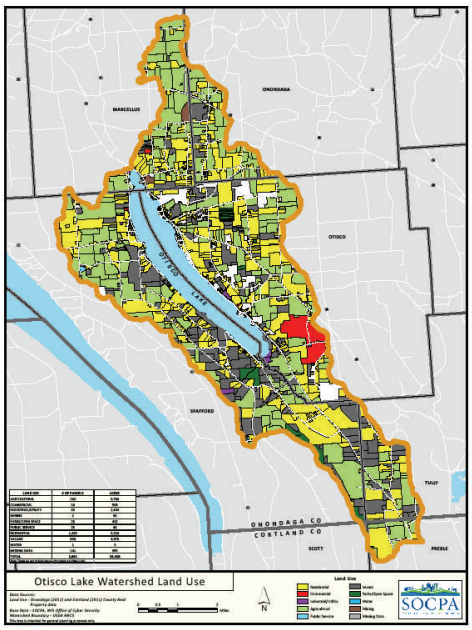
2.7 Aquatic Plants

Present Conditions

The most recent comprehensive work on submerged aquatic vegetation was conducted in 2003-2004 by Hairston, Johnson and Lord (2005) as part of an investigation to assess the use of biological control for Eurasian watermilfoil in Otisco Lake. In this investigation the littoral zone or area where rooted or attached plants grow was defined as 5.6 meters (18.4 feet) or less.

Twenty aquatic plant species were identified from Otisco Lake with native coontail (*Ceratophyllum demersum*) and the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) as codominants. Other abundant species included: water stargrass (*Zosterella dubia*), water celery (*Vallisneria americana*). elodea *(Elodea canadensis*), southern naiad (*Najas guadalupensis*) and curly leaf pondweed (*Potamogeton crispus*).

Greatest macrophyte abundance was found in the extreme northern end of the lake to roughly one mile south of the narrows. Densities were greater in the eastern half of the lake than on the western side. On the western side of the lake, the Lader Point area had the highest densities of aquatic vegetation while the rest of the western shore had densities characterized as sparse or non-existent. This is largely due to the steep drop off in water depth which provides a very narrow littoral zone. The only area along the Causeway where medium to dense vegetation densities were found was in the extreme southeast corner. Most of the eastern near shore was found to have moderate or high densities. The lake south of the Causeway had little vegetation present (Hairston, Johnson and Lord 2005).

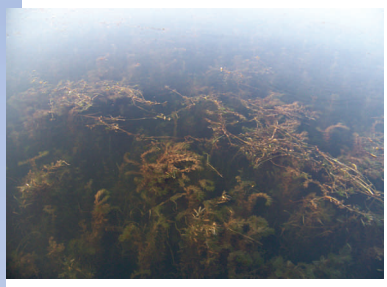


Locations of dense vegetation from the study are shown in **Figure 6**.

Historical Conditions

A less comprehensive study using a different methodology was conducted in 1987 (Auer and Effler 1987). The objective was to assess areas where mechanical harvesting would be beneficial. *Myriophyllum* species (likely all or predominately *M. spicatum* - Eurasian water milfoil) and *Potamogeton crispus* dominated in heavily vegetated areas.

As with the most recent survey, much of the area north of the Narrows was found to have dense vegetation growth as was the Lader Point area and near shore areas north of where Amber Brook enters the lake (eastern shoreline).



Dense areas of aquatic vegetation include the invasive Eurasian water milfoil.

Algae growth and shoreline buildup of aquatic vegetation.

However, several changes in conditions can also be inferred. With the exception of only a few inshore areas of medium or moderate growth, the area immediately south of the Narrows in the lake's northern end had generally sparse growth. This contrasts greatly with the dense growth reported by Hairston et al. (2005). Auer and Effler (1987) also identified much of the near shore area south of the Causeway as having moderate to dense aquatic vegetation growth while this area was found to be generally void of rooted vegetation by Hairston et al (2005).

Along with other lake parameters, Shaffner and Ogelsby (1979) reviewed macrophyte conditions. Perhaps of greatest present day interest was reference by the authors to the general absence of macrophyte coverage reported in the lake by Baston and Ross (1975) in the mid-1970s and the possible role played by low lake levels due to a drought in 1965 about a decade earlier Water levels did not return to normal until 1967.

2.8 Invasive Species

Several non-native or invasive species are of particular concern for Otisco Lake and the watershed. Both the zebra mussel (*Dreissena polymorpha*) and rooted aquatic Eurasian water milfoil (*Myriophyllum spicatum*) are well-established in Otisco Lake. Zebra mussels were first sighted in Otisco Lake in 1997. While the closely related quagga mussel (*Dreissena bugensis*) has not been reported in the lake, this may be due more to the absence of any concerted effort to identify it from Otisco Lake as opposed to its true absence. Eurasian watermilfoil is a co-dominant along with native coontail, *Ceratophyllum demersum* (Hairston et. al, 2005). Water chestnut (*Trapa natans)* has been present in the northeastern section of the lake north of Turtle Bay since at least 2006, but is nearly eradicated.

Asian clams (*Corbicula fluminea*) were found in the southwest corner of the lake by the Causeway and off the County Park near Turtle Bay in September 2012. Based upon size, it is estimated Asian clams have been in Otisco Lake since about 2010.

A mat of the highly invasive species, Hydrilla verticillata. (Photo by David J. Moorhead, University of Georgia, Bugwood.org and taken from the Cornell Cooperative Extension, Invasive Species Program, and the New York Invasive Species Clearinghouse publication: Hydrilla verticillata: What Marians Need to Know-March 2012.)

The 2011 discovery of Hydrilla (Hydrilla verticillata) in the Cayuga Lake outlet raises the threat of this highly aggressive macrophyte spreading to Otisco Lake and other nearby water bodies.

Volunteer hand pulling water chestnut removal from Otisco Lake.

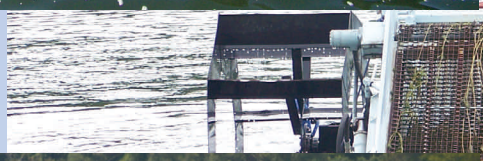
Buildup of Eurasian watermilfoil.

The Asian clam, Corbicula sp. is found in Otisco Lake.

2.9 Invasive Species Management

Invasive species management in Otisco Lake has focused on the aquatic plants, Eurasian watermilfoil and water chestnut. Mechanical harvesting and limited "suction dredging" has been used to help control an overabundance of Eurasian watermilfoil as we well as other aquatic macrophytes. These efforts have been funded privately and through New York State Finger-Lake-Lake Ontario Watershed Protection Alliance (FLLOWPA) funds made available to Onondaga County. A pilot one-acre benthic matting project was conducted in 2012. In 2013, matting was made available for seasonal use by lake residents through the Otisco Lake Preservation Association (OLPA). This popular program was expected to continue in 2014.

An approximate one-acre area of water chestnut has been the target of hand-pulling efforts for successive years with the plant nearly eradicated from Otisco Lake. Public education and awareness efforts have been used separately and in conjunction with the Watercraft Steward Program thorough the Finger Lakes Institute to inform lake users about invasive invertebrate and plant species of concern or of imminent threat to Otisco Lake. Over the past several years, Cornell Cooperative Extension of Onondaga County has conducted workshops and other information sessions on invasive species for lake and watershed residents.



Three methods of aquatic plant management (clockwise from top); suction removal, mechanical harvesting and benthic matting.

CHAPTER 3
OTISCO LAKE WATERSHED AND LAND USE

3.1 Introduction

The water quality of a lake is a direct reflection of present and past land uses in the watershed. Numerous studies show a direct relationship between the amount of development and corresponding decreases in lake water quality. Thus, it is no surprise that lakes with the poorest water quality are usually in highly developed settings.

However, it is inevitable that land development and changes in existing land use will take place since much of our economy hinges upon new residential, commercial and industrial growth. On the other hand, it is not a foregone conclusion that new development or changing land uses must negatively impact a natural resource such as Otisco Lake.

This chapter provides a physical description of the Otisco Lake watershed and its land use patterns. Information has been collected on land uses, highway infrastructure, drinking water supplies/infrastructure, wastewater treatment, population, stream systems, local regulations and other issues that affect Otisco Lake.

These issues are discussed in greater detail in this document with recommendations for long-term improvement presented in Chapter 5. Information needs were also identified during this process with respect to delineating stormwater runoff patterns and more specific locations of sediments and other upland generated contaminants. As a result, a number of recommendations have been made to help acquire this information.

PLACE PRETTY PICS OF LAKE/ SUNSETS—see chapter 1.1 and put watershed map here from page 15 watershed map. ?????

The Otisco Lake Watershed Rules and Regulations provide an added measure of protection not afforded to non-drinking water supply watersheds.

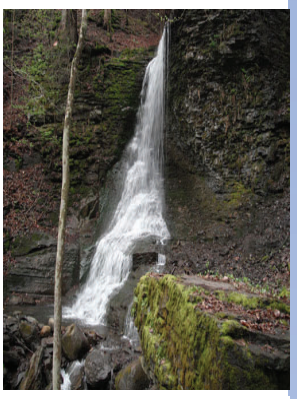
3.2 Characteristics

The Otisco Lake watershed is 38.7 mi² (24,777 acres) and includes portions of five Onondaga County towns (Marcellus, Onondaga, Otisco, Spafford and Tully) plus a small portion (646 acres) of the town of Preble in Cortland County (**Figure 7- Watershed Map**).

Bedrock and Surficial Geology

The bedrock of the Otisco Lake watershed consists largely of sandstones, siltstones and shales of Ludlowville Formation, West River Shale, Moscow Formation, Skaneateles Formation, and Tully Limestone. On a percentage basis, the Ludlowville Formation is predominant (39%) and comprises much of the bedrock at elevation just above lake level. Skaneateles Formation is found immediately surrounding the lake and along the major tributaries (**Figure 3- Otisco Lake Watershed Bedrock**). (**Photo- Example Bedrock /Falls**)

Formation of all the Finger Lakes was due to both glacial and interglacial periods over approximately the last two million years. It was not simply "ice in/ice out" that created the region, but a complex "dance" of multiple ice advances and retreats that created the Finger Lakes valleys. The Pre-Illionian glacier flowed over the region about 1 million years ago with the glacier's southern edge stabilized just south of the present day Finger Lakes. The last period of ice advances/retreats was during the Wisconsonian age which occurred about 25,000 to 11,000 years ago and created the current landscape, end moraines (Valley Head Moraine) and the Finger Lakes as we know them today.



Bedrock formation nearby feeding the lake.

Lodgemont till is predominant on the eastern side of the lake watershed and on the western side at lower elevations. It is a generally poorly-sorted mixture of rounded to subrounded cobbles and boulders embedded within a silt/clay matrix locally referred to as "hardpan."

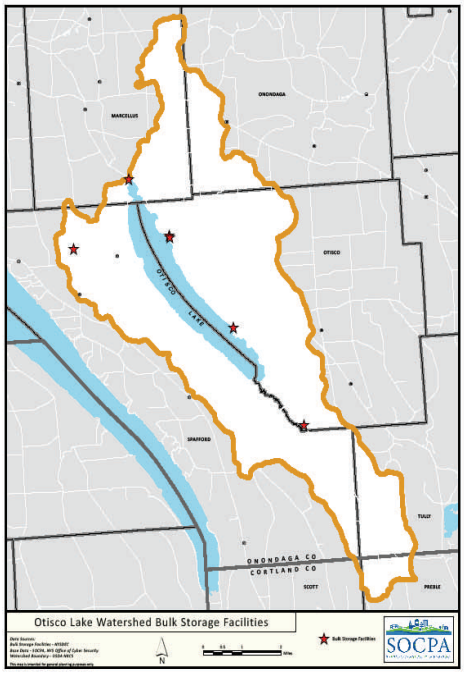
At higher elevations, especially on the western side of the watershed, thin layers of till or exposed Paleozoic sedimentary rocks prevail. However, in the tributary drainages on the eastern side of the lake (Van Benthuysen, Amber and Rice Brooks) along with the Spafford Creek drainage at the lake's southern end, outwash sand and gravel deposits along with ice contact sand and gravel deposits dominant (Winkley 1989).

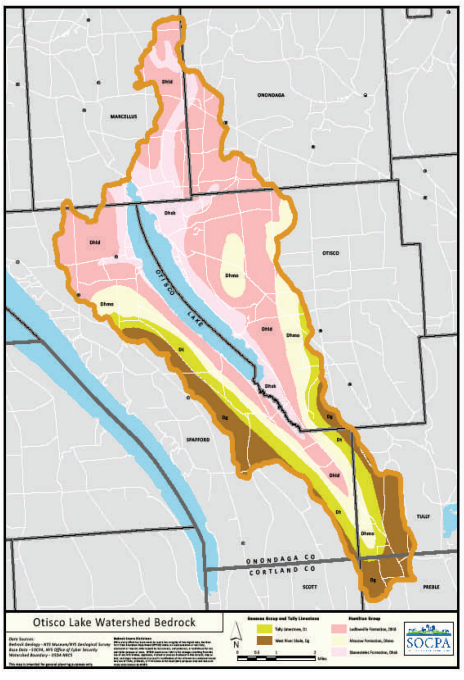
Soils

The eastern lakeshore area is dominated by Honeoye and Howard series soils. Honeoye soils are classified as deep, well drained, medium-texture soils formed in calcareous glacial till. Howard series soils are deep, well drained and somewhat excessively drained medium-textured and moderately coarse textured soils formed in stratified sand and gravel outwash material. Seasonal high water table (groundwater) is 2-3 feet below the soil surface. Schoharie soils, which are slow to dry out and where runoff can be rapid after a storm event, are found along the northeastern shoreline of the lake.

Aurora-Farmington-Rock outcrop association is found along much of the central western shoreline between Lader Point and Lundy Point. Soils from this association are mainly found on valley sides with steep slopes, very steep gorges and ledges of bedrock outcrops the prominent features of the landscape.

Other predominant soil types include





the Wayland soils found along the tributary streams and in flood plains and Teel silt loams found around the northeastern or "Narrows" area of the lake. Both soil types frequently flood in the spring (Soil Survey of Onondaga County, New York 1973).

Topography

The region is characterized by broad U-shaped valleys with steep slopes projecting upwards for several hundred feet and capped by rounded or gently rolling hilltops.

Otisco Lake and its watershed lie within the glaciated portion of the Appalachian Plateau Physiographic Province. The region is characterized by broad U-shaped valleys with steep slopes projecting upwards for several hundred feet and capped by rounded or gently rolling hilltops. The northern and southern ends of the lake are low-lying areas representing a continuation of the lake valley in both directions.

In general, steeper slopes or rises in elevation are found along the western side of the lake's mid-portion. The highest elevations in the watershed exceed 1700 feet and are found in its extreme southern, southeastern and southwestern portions.

Climate

Variations in month-to-month precipitation or for the same month year-to-year can vary considerably with fluctuations of 6 inches or more.

New York State's climate is generally representative of the humid, continental type found in the northeastern United States. Two different air mass types are responsible for the dominant continental characteristics of the state's climate. Masses of cold, dry air frequently arrive from the continent's northern interior with prevailing south and southwesterly winds transporting warm, humid air from the Gulf of Mexico and adjacent subtropical waters. Having less of an influence especially away from southeastern New York is a third type of air mass that flows inland from the North Atlantic Ocean producing cool, cloudy and damp weather conditions.

During most winter seasons, temperatures of -15˚F or colder can be expected in the east-central highlands of the Southern Plateau which includes the Otisco Lake region. The summer climate is cool in the higher elevations of the Southern Plateau with daytime temperatures usually in the upper 70s to mid-80s range and infrequently exceeding 90˚F. The region's average freeze-free season is 120-150 days.

New York State has a fairly uniform precipitation distribution pattern during the year with no distinctly dry or wet season repeated on a regular basis. In the Otisco Lake region, minimum precipitation occurs in the winter and maximum amounts in summer. However, variations in month-to-month precipitation or for the same month year-to-year can vary considerably with fluctuations of 1-6 inches or more. (Average annual precipitation recorded at Syracuse, New York 30 year record-Regional Climate Center) data is 40.1 inches. For comparative purposes, annual precipitation at the Otisco Lake outlet for 2005-09 recorded by the Onondaga County Water Authority (OCWA) was 44.2 inches (Mark Murphy, pers. comm. December 2010).

Topography, elevation and proximity to large water bodies such as Lake Ontario result in considerable variation in snowfall amounts in the state's interior even within relatively short distances. Average annual snowfall for Syracuse, New York (59 year record) is 118.6 inches (Regional Climate Center data). Similarly, annual snowfall recorded at the Otisco Lake outlet by OCWA was 119.1 inches for the 2005-09 time period (Mark Murphy, pers. comm. December 2010).

Despite a rather long-term record characterizing stable climatic conditions, the region is presently experiencing greater climate variability which is affecting water levels and water quality of all the Finger Lakes.

3.3 Land Use and Development in the Watershed

Agricultural-General

The OCWA 2011 annual census enumerated 42 farms in the Otisco Lake watershed. This is in close agreement with the 38 farms listed on the Onondaga County 911 record (SOCPA, pers. comm. February 2013). Farm counts can vary depending upon the definition used to describe an active farm. Many of the farms are not being farmed by the owners, but are rented out to other watershed farmers. Agriculture in the Otisco Lake watershed is following the general countywide trend with a reduction in the number of farms, but an increase in their size. Agriculture activity is seen in the map of Agricultural District parcels present in the watershed **(Figure 10).** The Otisco Lake watershed served as a model for the New York State Agricultural Environmental Management (AEM) program. About 80% of the watershed farms are in some stage of the AEM program (D. Fisher, pers. comm. August 2013).

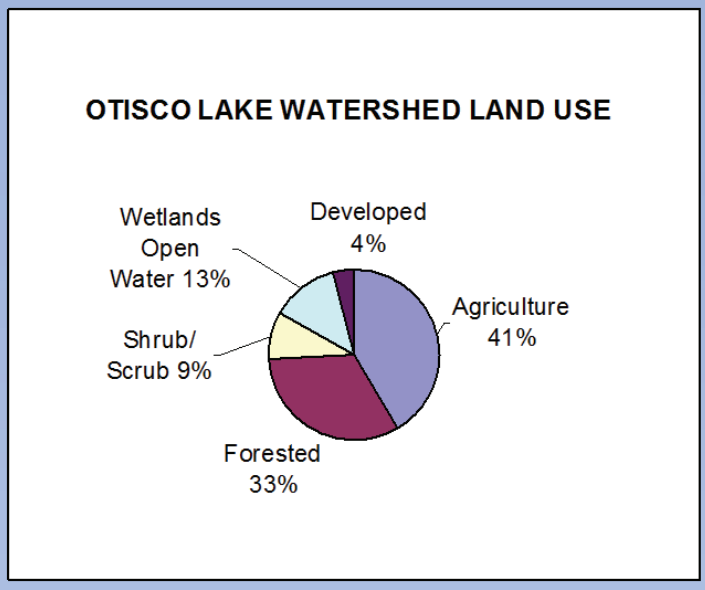
The OCWA 2012 census classified 11,508 acres as active meaning devoted to cropland and pasture. Corn was the major crop constituting 4,858 acres. Other crops and acreages were as follows: hay (4,781), soybeans (716); wheat (300), oats (275); rye (226) and barley (6). The total number of livestock counted was 6,656.

Liquid manure systems were noted at 5 of the 12 dairy operations while the remaining operators handled manure in a solid form (OCWA Report on Otisco Lake Reservoir Watershed Inspections 2012).

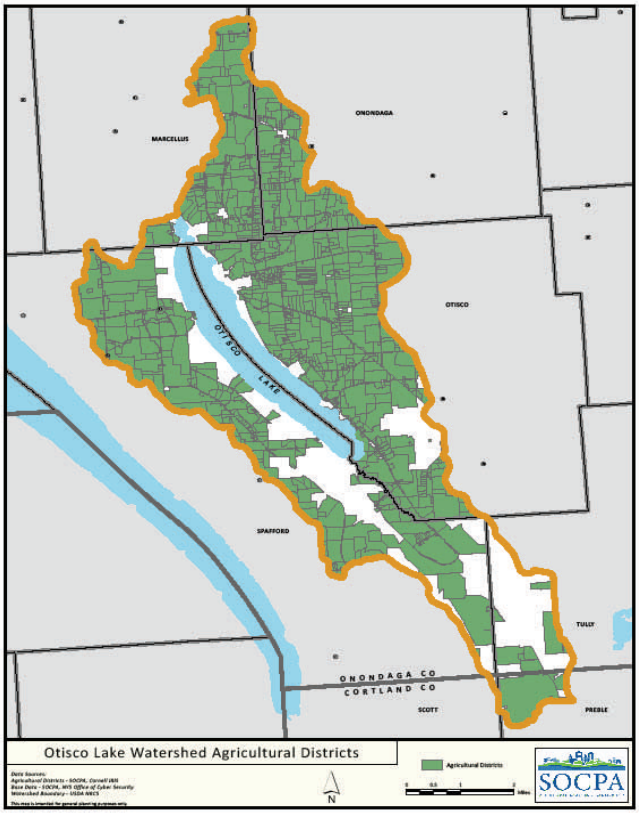
Minor fluctuations in crop types and pastured acreages are seen on a year-to-year basis, but the predominant crops planted (i.e., corn, hay, soybeans) have not changed.

Agricultural-Tier V Assessment

In 2013, the Onondaga County Soil and Water Conservation District mailed out a Tier 1/Tier 5 questionnaire to all farms in the watershed to update District records regarding animal numbers, acres, and land use patterns in the watershed. Farms that did not respond were given a follow up call to fill out the data, or the data was updated during



The watershed is approximately 42% agricultural, 33% forested lands and 9% shrub/scrub. Wetlands and open water comprise almost 13% of the watershed. Only a little over 4% of the watershed is categorized as "developed" with the majority of development along the eastern shoreline and on the western shore about as far southward as Lader Point. Most of the forested lands are along the steep-sloped western side of the lake and south of the lake, proper. Watershed land cover is shown in pie chart.



the farm site visit. At this date, 20 Tier 1/Tier 5 questionnaires out of 33 are completed. Five farms had been sold, and 8 farms had not completed the questionnaire. The sold farms have been added to other farms and the District has updated this information accordingly. At least one of these farms did not previously work land in the Otisco Lake watershed.

District staff interviewed producers regarding changes in operation that may warrant new Best Management Practices (BMPs), operation and maintenance concerns, lifespan issues.

Soil sampling as part of Tier V assessment.

Meetings were arranged with multiple farms that had participated with the District in the past. District staff interviewed producers regarding changes in operation that may warrant new Best Management Practices (BMPs), operation and maintenance concerns, and lifespan issues. BMPs installed were reviewed with producers, and they were given the opportunity to discuss what problems, if any, they had with the BMPs. Potential new projects were identified for some farms. Farms that lacked information on the original Tier1/ Tier 5 questionnaire were asked to furnish that information. Fourteen farms were met with plus two new farms were identified for the District's AEM program and follow up meetings were held.

A buffer is designed and installed to capture and filter barnyard runoff.

BMP visual inspections were conducted on two farms to identify problems discussed during the farm visit and to observe operation and maintenance of BMPs. New projects were identified by the District. At least one of these projects (repair of manure storage) was completed. Inspections of BMPs on other watershed farms and identification of projects that can be implemented will continue as resources allow. The District has provided technical assistance to one startup farm regarding drainage concerns and continues to work with the landowners. Table ___ provides a summation of recommended BMPs for watershed farms.

Best Management Practices applied on farms in the Otisco Lake watershed

Additionally, the District has provided assistance through OCWA funding to implement cover crops on 700+ acres of land in the watershed. Farms that implement and document the cover crops will receive a reimbursement at a per acre price.

Public Access

There are two private boat launching access points on Otisco Lake with shoreline access found along the extreme northeastern portion of the lake, the southwestern corner near the lake causeway, and from the County park near Turtle Bay on the east shore. The Otisco Lake County Park operates as a "carry in / carry out" facility. At present, Otisco Lake does not have a public boat launch, but discussions as to a location and size (auto/trailer capacity) of such a facility have been held.

The majority of watershed residents rely on private wells for their water supply needs with smaller numbers utilizing springs or water taken directly from Otisco Lake.

Roads

The Otisco Lake outlet is located approximately 2½ miles south of U.S. Route 20, the major east-west roadway through southern Onondaga County. New York State Route 174 runs north-south from U.S. Route 20 and along the west shore of Otisco Lake for about 1.5 miles before turning to a predominant east-west orientation. The only other road adjacent to the lake's west shore is West Valley Road which runs north-south between the lake's southern extreme and the causeway. Otisco Valley Road runs adjacent or in close proximity to the lake's east side.

Public access at Otisco Lake County Park.

Drinking Water Supply and Infrastructure

Otisco Lake is a major drinking water supply source. OCWA provides drinking water for Onondaga County outside of the City of Syracuse and to a small portion of Madison County. While OCWA is licensed to withdraw 20 mgd on an annual basis and up to 25 mgd on a daily basis from Otisco Lake, withdrawals currently average around 17.5 mgd.

Water is withdrawn by two intake pipes and is immediately disinfected with either sodium hypochlorite or chlorine dioxide to discourage the growth of zebra mussels. The water then travels, by gravity, approximately 5 miles to OCWA's Water Treatment Plant located in Marcellus, NY for further treatment before transport through the distribution system.

Mountain Glen, a spring water supply source, previously serviced 80 customers in the Otisco Lake area. This supply has been replaced by the Southern Onondaga Area Water District which allows for construction of infrastructure facilities to provide area customers with Otisco Lake public water from OCWA.

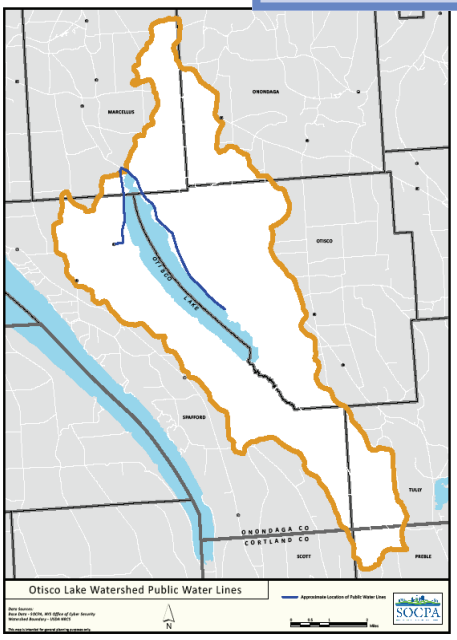
This public water supply service extends on the lake western shore south to the Glen Cove area and to an additional 1600 feet from where County Route 174 turns westward. On the east side of Otisco Lake, service extends southward on Otisco Valley Road to 300 feet north of the Otisco Lake Marina which is in close proximity to the Otisco Road (County Route 246)/ Otisco Valley Road intersection. Almost 200 customers (196) are serviced on this side of the lakeshore.

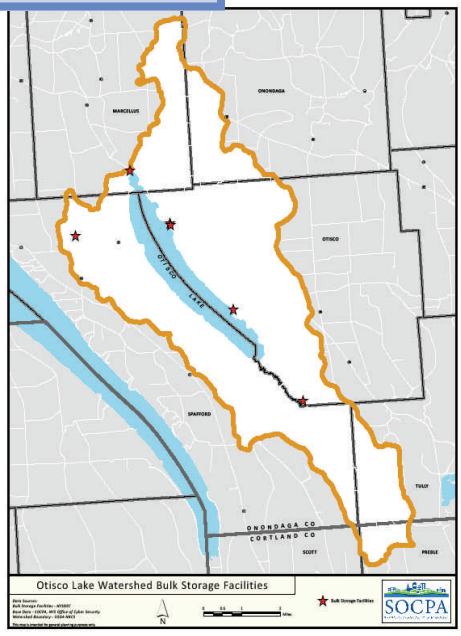
Wastewater Management/Bulk Storage Facilities

There are no publically owned wastewater treatment facilities discharging to Otisco Lake or to tributaries located within the watershed. Wastewater treatment is handled almost exclusively by septic systems with very few holding tanks, chemical toilets and privies in service. For example, of 1,011 residences inspected, 978 used septic systems, 27 had holding tanks, 4 used chemical toilets, and 2 utilized privies (OCWA 2011).

There are no regulated point sources discharging either directly into Otisco Lake or any of its tributaries. There are seven bulk storage facilities listed in the NYSDEC Bulk Storage Database.

Wastewater treatment is handled almost exclusively by septic systems ...





3.4 Watershed Socio-economic Characteristics

The estimated watershed population shows the following breakdown by town:

Otisco Lake Watershed Population by Town

Town	2012 Watershed Population
Marcellus	305
Onondaga	174
Otisco	1289*
Tully	84
Preble	0
Spafford	585
Total	2437

*From OCWA 2012 watershed census. Total includes 8 residents listed only as from Marietta and included in the town of Otisco total.

Since median household income is reported by township, only data for the two towns (Otisco and Spafford) comprising most of the land area and population in the Otisco Lake watershed are presented.

Comparing the 2000 and 2010 census data, the town of Otisco had a decrease of 0.8% and the town of Spafford showed a 1.5% increase. Population density in the town of Otisco is 86 persons per square mile and 51.6 persons per square mile in the town of Spafford. Median ages are 42.2 years for Otisco and 48.1 for Spafford. American Community Survey data for the period 2005-2010 shows the median household income in the town of Otisco as $61,898 and $71,908 in the town of Spafford.

Reflecting the above population totals and trends, the Otisco Lake watershed has not experienced developmental pressure. New septic system approvals provide a fairly accurate measure of development. In the years 2010 through 2012, there were 16 approvals by the Onondaga County Health Department within the watershed: five in 2010, five in 2011 and six in 2012. While these numbers may have been depressed by recent economic conditions, they do not differ significantly from years prior to 2010.

OCWA conducts an annual watershed population survey as part of its Annual Report made to the New York State Department of Health. Based upon population counts plus an estimate for residences that could not be surveyed, the breakdown for the watershed population of 2,437 in 2012 was 1,829 permanent and 608 seasonal residents (M. Murphy, pers. comm. 2013).

The 2011 survey found the number of occupied dwellings in the watershed was 1,275 with an additional 76 vacant. Of the 1,011 occupied dwellings OCWA inspectors were able to survey in 2011, a total of 515 or just over 50% were lakefront residences (OCWA 2011). In 2012, the percentage of lakeshore residences defined as seasonal was 57% and 43% permanent. (M. Murphy, pers. comm. 2013). Percentages are based upon the number of occupied dwellings at the time of the survey and accounts for most, if not all, of the slight annual variations seen in the percentages.

These percentages have remained largely unchanged over the past 25 years. For example, 280 of an estimated 500 lakeshore residences (56%) were classified as seasonal and 44% permanent from OCWA census data in the mid-1980s (Onondaga County Water Quality Management Agency 1986). However, the type of dwellings has changed with summer or seasonal dwellings being upgraded to year round homes.

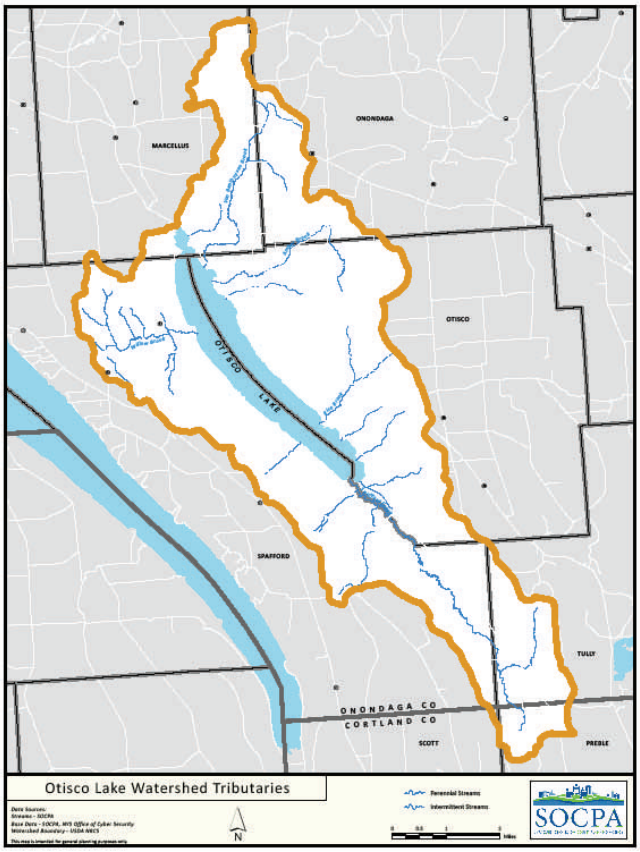
An improving economy and corresponding increase in development of the Onondaga Hill area could lead to expansion of infrastructure services (i.e., water, sewer, roads, etc.) and also make the nearby eastern portion of the Otisco lake watershed (towns of Marcellus, Onondaga and Otisco) more desirable for development.

3.5 Streams of the Otisco Lake Watershed

Otisco Lake has five major tributaries: Amber Brook, Van Benthuysen Brook, Rice Brook, Spafford Creek and Willow Brook (**Figure 13).** Spafford Creek, the largest tributary, enters Otisco Lake at its southern end and contributes about 33% of the annual inflow. The ungaged portion of the watershed contributes about the same percentage (34%). Other tributaries and their contributions are: Van Benthuysen Brook (11%), Amber Brook (9%), Willow Brook (8%) and Rice Brook (6%) (Paschal and Sherwood 1987).

Spafford Creek and Rice Brook are classified as C (T) (best usage-fishing /suitable for trout) with the remaining tributaries (Amber Brook, Van Benthuysen Brook, and Willow Brook) classified as C (best usage-fishing).

The sub-basin drainage areas are as follows: Spafford Creek (12 mi^2), Willow Brook (3.7 mi^2), Amber Brook (3.7 mi^2), Van Benthuysen Brook (3.5 mi^2), Rice Brook (2.4 mi^2) and drainage directly into the lake or by minor watercourse (11.0 mi^2).



Delta build-up at the mouth of Rice Creek.

Trout in lake tributary.

3.6 Watershed Pollutant Inputs

Sampling of the major lake tributaries has been sporadic with the exception of two sampling periods which are over twenty years apart: 1981-83 and 2005-08. The yields (quantities per acre) of selected nutrients and suspended sediment transported in three tributaries: Spafford Creek, Rice Brook, and Willow Brook were reported by Coon et. al (2009) for 2005-08 and compared to 1981-83.

The 2005–08 precipitation-weighted yields (tributary contributions) of TKN **(**Ammonia-plus organic nitrogen**),** PO4 (orthophosphate**),** and TP (Total Phosphorus**)** were comparable to those from 1981–83. Yields of NOx (nitrate-plus nitrite) in Rice Brook and Willow Brook and those of suspended sediments in all three sub-basins increased. The largest yield increases were shown for suspended sediments with yields during 2005–08 being 100 to 400 percent greater than during 1981–83. Although Spafford Creek, the largest of the Otisco Lake tributaries, had the highest precipitation-weighted yield of suspended sediments among the three sites, the 2005–08 yields in Rice Brook and Willow Brook increased by a greater percentage compared to their 1981–83 yields, as well as relative to Spafford Creek's increase in yield (**Table 4**).

Beyond the studies discussed above, no investigations have been conducted to ascertain principle pollutant sources on a sub-watershed basis. While Otisco Lake is subject to a generic list of watershed-derived contaminants that impact many area lakes, several inferences can be made.

The installation of public water system has provided unlimited water to residents of the water district along Otisco Lake

For example, Rice Brook's high sediment loadings can be largely attributed to erodible cliffs and stream banks. Spafford Creek's large sediment loads are due to its flows thorough lacustrine silt and clay deposits. Comprising nearly half of the watershed land use on a percentage basis, it stands to reason that agricultural activity is a source of nutrients (phosphorus/ nitrogen).

The installation of public water system has provided unlimited water to residents of the water district along Otisco Lake (see Section 3.3 Drinking Water Supply and Infrastructure). Previously, the use of ground water provided a constraint on water uses. Since residents generally rely on on-site septic systems, increased discharge of waste water from the public system could result in an increase of the volume of wastewater in shallow ground water and recharge to the lake. The extent, if any, of groundwater

Otisco Valley Road adjacent to the lake's eastern shore.

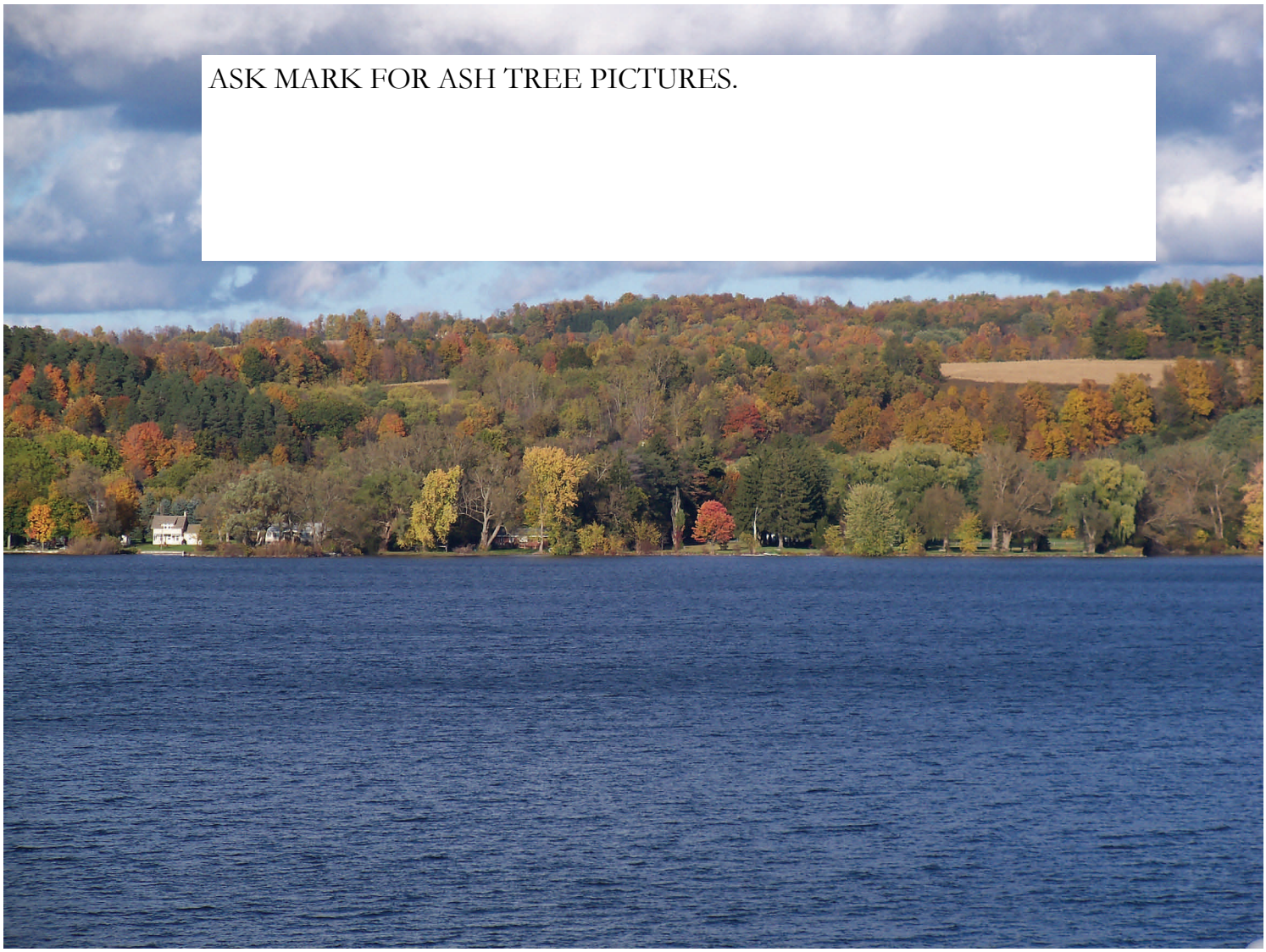
Tributary inputs from eroding streambanks such as from Rice Brook.

Best Management Practices are needed for agricultural pollution in the Otisco Lake watershed. GET BEFORE & AFTER BMP PICS

3.7 Upland Invasive Species Management

The Emerald Ash Borer (EAB) presents the most significant threat to the watershed's upland landscape. With its presence in Onondaga County documented in 2013, the elimination of native ash species from the area landscape is highly likely. Onondaga County, through the Onondaga County Soil and Water Conservation District (SWCD) is completing an inventory of ash trees along county roads.

This will help prioritize trees to be scheduled for removal based upon hazard potential. Cornell Cooperative Extension of Onondaga County is conducting educational programs to help landowners identify ash trees and provide alternatives for addressing EAB impacts. It is estimated that roughly 15% of the Otisco Lake watershed forest consists of ash species.



ASK MARK FOR ASH TREE PICTURES.

3.8 Lake and Watershed Stewardship

Onondaga County Water Authority
By Anthony J. Geiss, Jr., PE, Deputy Executive Director

The Onondaga County Water Authority (OCWA) supplies drinking water to a four county area in Central New York. OCWA delivers water from Otisco Lake and Lake Ontario to accomplish this mission. OCWA supplies and treats Otisco Lake water at its own facilities. The Lake Ontario water supply is a wholesale purchase from the Metropolitan Water Board (MWB).

The Otisco Lake supply consists of water intakes, dam, and treatment plant and transmission lines. OCWA inspects the Otisco Lake watershed as part of its monitoring the water quality in the Lake. The Watershed Inspection includes dye tests of existing septic systems, survey of farms for animal, manure systems and crops planted, and monitoring new construction.

The raw water quality is monitored for temperature, turbidity, pH, alkalinity and algae. The lake level is measured each day as well. The treated water is also monitored for water quality according to drinking water regulations.

Otisco Lake Protection Association
By Anita Williams, President

The Otisco Lake Preservation Association (OLPA) was formed in 2008 as a grassroots organization with a mission to preserve the health and welfare of Otisco Lake with a primary focus on invasive weeds. Since then we have expanded our focus to ensure not only the health and integrity of the lake but the entire watershed. We became a 501(c)(3) organization in 2009. Our goal has expanded to maintain and protect the quality of the lake not only for recreational purposes but as a primary drinking water source for CNY residents. OLPA works towards promoting the common interests of preserving, maintaining and assuring the integrity of Otisco Lake, its shores and watershed so as to achieve optimum quality of the lake for its surrounding communities through education, materials and programs. We actively seek advice and assistance from experts in government, universities and private companies, donate our time, solicit volunteers and seek funding through grants, fund raising events and individual donations.

Past Activities:

*Annually fund mechanical harvesting to control/ maintain weed growth and remove biomass bogs in heavily trafficked areas of the lake (with additional assistance from FLLOWPA funds through the Onondaga County Health Department- Division of Environmental Health).

*With grant monies through FLLOWPA (from the Onondaga County Health Department- Division of Environmental Health) an area matting project was conducted in 2012. Using the same materials in 2013, matting was provided to lake residents to assist in weed control near shorelines for improved recreational use.

*Annually partner with the NYS DEC and Onondaga County Cornell Cooperative
Extension (CCE) in efforts (hand pulling) to eradicate the Water Chestnut weed in Turtle Bay.

*Created and provided "Responsible Boating" brochures, posters, signage and place mats through a grant from the BoatUS Foundation.

*Formed a Lake Weed Committee to patrol the lake; track weed growth and provide feedback and direction.

*Annually work with CCE to provide educational programs/materials to the Otisco Lake communities regarding invasive weed identification and control, maintaining septic systems, and importance of using non-phosphorus products (in 2009 assisted CCE with disbursement of over 100 bags of no phosphorus fertilizer to watershed residents).

*Provide strong advocacy against currently unsafe drilling practices (hydrofracking) to ensure strict established regulations to protect the lake, its watershed and communities.

* Helped to secure bans in 4 of the 5 Otisco Lake Towns (5th has a moratorium).

*Member of NYFOLA (Federation of Lakes Association) and Finger Lakes Regional
Watershed Alliance (FLRWA).

CHAPTER 4
OPINION SURVEY RESULTS

4.1 Watershed Resident Survey

A survey was conducted in 2010 to gauge permanent and seasonal resident opinion on water quality conditions in Otisco Lake. While modified, survey questions closely resembled those provided in the NYSFOLA's *Diet for a Small Lake: A New Yorker's Guide to Lake Management*. The Onondaga County Council on Environmental Health finalized the number and wording of questions to be asked so they could be easily answered as part of the Onondaga County Water Authority's (OCWA) annual watershed survey. The Otisco Lake Preservation Association (OLPA) assisted by publicizing the survey on its website. The survey and tabulated responses are included in the **Appendices.**

A total of 177 responses were received. Eighty percent of those identified themselves as permanent watershed residents. Over 60% said they engaged at least occasionally in at least one of the water-based recreational activity categories listed: boating, fishing, or swimming.

Although the responses were based on perception, those responding to the question whether they thought water quality had changed in the lake over the past 1,5, or 10 years indicated overwhelmingly (one year- 69%, five years- 56%, five to ten years-60%) there had been no change during those time frames.

Though a limited response pool, residents residing in the watershed for over 10 years to 40 or more years were split equally between those that felt the lake had improved (12) versus those feeling it has gotten worse (11).Slightly more than those two groups combined (24) thought there had been no change. Seven respondents were not sure if there had been any change.

Residents were asked to assess 12 potential lake and watershed issues. While every problem was identified by the surveyed residents, aquatic weeds and algae blooms were the most frequently cited as being a problem to some degree.

Aquatic weeds and algae blooms were the most frequently cited as being a problem to some degree.

4.2 Stakeholder Survey

In the spring of 2012, a water quality survey was taken of watershed stakeholders (27 respondents) that had been invited to serve on the Otisco Lake Watershed Advisory Committee. The primary role of the Advisory Committee is to facilitate communication and cooperation of the involved local governments, state agencies, and other stakeholders essential to the preparation and implementation of the watershed plan.

A main objective of the survey was to identify priority lake and watershed issues to be addressed in the lake management plan. Monitoring tributaries and the lake was selected as a high priority by 84% of those responding, with long-term regional planning selected as a high priority by 74% and open space planning by 67%. The in-lake issues selected as highest priorities were: invasive species prevention/ education (82%), nutrient levels being too high (81%), septic effluent (81%), and fishing (71%).

Stakeholders were asked to rank watershed issues of concern for five specific categories. Those issues noted as of "high priority" by 70% or more of the respondents were as follows:

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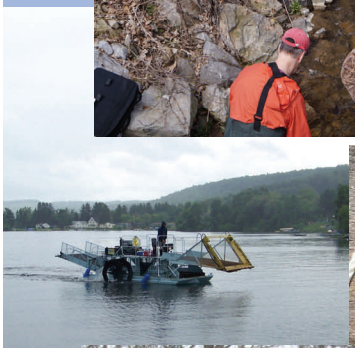

Category/Issue	Selected as High Priority
I. Development:	
• Hydrofracking	75%
II. Affects of agriculture to surface and groundwater	86%
• Chemical fertilizers	
III. Commercial and /industrial affects to surface/groundwater:	70%
• Affects of runoff	
IV. Residential affects to surface and groundwater	71%
• Stormwater runoff	71%
• Hazardous household waste disposal	
V. Onsite septic systems	70%
• Lack of watershed inspection& maintenance schedule	

TABLES, FIGURES, APPENDICES

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Table 3. Annual Mean Otisco Lake Data (Annual Mean ± 1σ)

(from Halfman and O'Neill, 2009 and Halfman, pers. comm. 2012)

Parameter	2008	2009	2010	2011
Total Suspended Solids (mg/l)	2.3 ± 1.9	2.2 ± 0.8	1.5 ±0.7	2.3 ±0.7
Total Suspended Solids (mg/l)	2.1± 0.7	1.8 ±0.6	1.6 ±0.9	1.8 ±0.6
Dissolved Phosphate (µg/l SRP)	0.8±1.2	0.5±0.4	0.4±0.3	1.2± 2.3
Dissolved Phosphate (µg/l SRP)	4.8 ±9.7	1.9±2.1	2.0±3.9	2.0 ±1.7
Total Phosphate (µg/l TP) Surface	12.8±3.21	36.1±60.3	8.6±2.2	16.6 ± 7.6
Total Phosphate (µg/l TP) Bottom	14.2±9.6	10.6±11.1	11.4±10.3	16.9± 7.4
Nitrate as N (mg/l) Surface	0.3±0.1	0.2 ±0.1	0.3 ±0.2	0.3 ±0.3
Nitrate as N (mg/l) Bottom	0.3±0.2	0.3±0.1	0.3 ±0.1	0.4 ± 0.2
Silica (SR, µg/l) Surface	334±413	321±297	467 ±206	1106± 598
Silica (SR, µg/l Bottom	1298 ±890	854±444	935 ±241	1124 ± 534
Chlorophyll a (µg/l) Surface	3.7±0.6	5.7±4.1	3.0 ±1.7	2.8± 1.3
Chlorophyll a (µg/l) Bottom	3.0 ±1.7	2.8±2.1	2.2 ± 0.7	1.8± 1.7

Table 5. Trophic Status Index and Parameter Values for Otisco Lake (Effler et. al 1989 and Halfman and O'Neill, 2009, Halfman, pers. comm. 2012)

Year	Total Phosphorus		Chlorophyll a		Secchi Disc	
	mg/m3)	TSI	(mg/m3)	TSI	(m)	TSI
1979	---	---	5.1	46.5	2.4	47.3
1982	---	---	---	---	2.6	46.2
1983	---	---	2.8	40.6	2.5	46.7
1986	13.7	41.8	2.6	39.9	2.8	45.1
1988	17.0	45.0	1.8	36.3	2.55	46.5
2008	13.5	41.6*	3.4	42.6*	3.1	43.7*
2011	16.8	44.8*	2.3	38.7*	2.9	44.7*

* TSI calculated separately using the data from Halfman and O'Neill, 2009 and Halfman, 2012)

Table 6. Comparison of Secchi Disc Transparencies: May-September (modified from Effler et al. (1989)

Year	Ave (m)	Std. Dev	Min (m)	Max (m)	n	Original Data Source
1979	2.43	0.36	1.0	4.6	17	Litten et al. (1980)
1982	2.55	0.23	1.75	3.95	16	Effler (unpublished)
1983	2.46	0.27	1.25	3.7	19	Effler et al. (1985)
1986	2.72	0.22	1.65	4.0	23	Effler et al. (1987)
1988	2.55	0.25	1.3	3.5	29	Effler et al. (1989)
2001	3.0	0.8	1.2	3.7	11	OCWA (unpublished)
2002	2.7	1.0	1.5	4.6	8	OCWA (unpublished)
2003	2.8	0.7	1.8	4.6	12	OCWA (unpublished)
2004	3.5	0.9	2.1	5.2	14	OCWA (unpublished)
2007	3.6	1.7	2.4	5.5	17	OCWA (unpublished)
2008	3.1	0.9	**----**	**----**	**---**	Halfman and O'Neill (2009)
2008	3.5.	1.7	2.3	4.9	15	OCWA (unpublished)
2009	3.5	0.96	2.4	5.0	17	OCWA (unpublished)
2009	2.8	0.8	---	---	---	Halfman (unpublished)
2010	3.8	0.6	----	---	----	Halfman et. al (unpublished)
2011	2.8	1.6	2.0	5.0	12	OCWA (unpublished)
2012	3.2	0.17	2.3	6.1	16	OCWA (unpublished)

Table 7. Concentrations and yields of nutrient and suspended sediment in Otisco Lake tributaries water years 2006-2008 and comparisons to 1982-83 (from Coon et. al 2009)[1]

	Spafford Creek	Rice Brook	Willow Brook[2]
Mean Annual Precipitation 43.4 in			
Ammonia-plus organic nitrogen, unfiltered (TKN)			
Max. conc. (mg/l)	3.3	14.0	12.0
Water weighted mean conc. (mg/l)	.73	.71	.95
Min. conc. (mg/l)	.14	.15	.19
Yield (lbs per acre)	4.48	4.31	6.73
Yield percent difference from 1982-83	-2.82	-16.1	5.98
Nitrate-plus-nitrite, filtered			
Max. conc.(mg/l)	2.03	4.60	7.88
Water weighted mean conc. (mg/l)	1.20	3.07	2.66
Min. conc. (mg/l)	.39	.84	.35
Yield (lbs per acre per year)	7.30	18.6	18.9
Yield percent difference from 1982-83	55	136	52.5
Orthophosphate. Filtered			
Max. conc. (mg/l)	.049	.464	.217
Water weighted mean conc. (mg/l)	0.14	.030	.039
Min. conc. (mg/l)	.003	.003	.003
Yield (lbs per acre per year)	.08	.18	.28
Yield percent difference from 1982-83	-33.3	38.5	-6.7
Phosphorus, unfiltered			
Max. conc. (mg/l)	.80	3.31	1.81
Water weighted mean conc. (mg/l)	.18	.13	.18
Min. conc. (mg/l)	.010	.008	.010
Yield (lbs per acre per year)	1.08	.76	1.26
Yield percent difference from 1982-83	+25.6	+55.1	+77.5
Suspended sediment			
Max. conc. (mg/l)	1,870	5,600	1,960
Water weighted mean conc. (mg/l)	347	202	175
Min. conc. (mg/l)	19	1	16
Yield (tons per acre per year)	1.06	.61	.62
Yield percent difference from 1982-83	+121	+454	+210

1 USGS water year defined as October 1st to September 30th of the following year. For example, water year 2006 includes the time period October 1, 2005 through September 30, 2006.

2.Data for Willow Brook during 1982-83 water years collected at a site near the mouth of the stream (USGS station number 0424016205); whereas those for water years 2006-2008 water years were from a site about 1.1 miles upstream (number 04240158).

APPENDIX A
2010 Otisco Lake Watershed Survey Questions

Property Location_____

1. Are you a year-round resident? Yes or No If Yes, How Long?_____

2. Are you a seasonal resident? Yes or No If Yes, How Long?_____

3. Does your property contain lakeshore frontage? Yes or No

4. How often do you participate in these activities on Otisco Lake?

	1----------2----------3		
	Never	**Occasionally**	**Frequently**
Swimming	1	2	3
Boating	1	2	3
Fishing	1	2	3
Other_____	1	2	3

Have you noticed any change in the water quality of Otisco Lake? (Check as appropriate)

	No change	**Better**	**Worse**	**Not sure**
In the last year	_____	_____	_____	_____
In the last five years	_____	_____	_____	_____
In the last 5-10 years	_____	_____	_____	_____
In the last 10-25 years	_____	_____	_____	_____
In the last 25-40 years	_____	_____	_____	_____
In the last 40+ years	_____	_____	_____	_____

Which of the following conditions are problems in Otisco Lake?

	no problem	minor problem	serious problem	don't know
	1----------2----------3----------4			
Aquatic weeds	1	2	3	4
Algae blooms (green scum)	1	2	3	4
Turbid/colored water	1	2	3	4
Undesirable taste or odors	1	2	3	4
Lake level too high or low	1	2	3	
Poor bottom conditions for swimming	1	2	3	4
Swimmers itch or bacteria problems	1	2	3	4
Poor fishing	1	2	3	4
Fish kills	1	2	3	4
Boating: Too many boats	1	2	3	4
Excessive boat speed	1	2	3	4
Intoxicated boaters	1	2	3	4

2010 Otisco Lake Watershed Resident Survey Results

Resident Type	**#**	**% of responding**	**% of total**
Permanent Resident	134	80%	76%
Temporary	34	20%	18%
No response	9	---	6%

Years of Residence	**#**
(147 responses)	
1yr or less	13
2-5 yrs	24
6-10yrs	17
11-25yrs	51
26-40yrs	25
40+yrs	18

Property	**#**	**% of responding**	**% of total**
Lakefront Property	72	56%	41%
Non-Lakefront	57	44%	32%
No response	47	---	27%

Lake Use

Over 60% of the total 177 engage in boating fishing, swimming occasionally or frequently

Have you noticed any change in the water quality of Otisco Lake in the last

	1yr	**5yrs**	**5-10yrs**	**10-25yrs**	**25-40 yrs**	**40+yrs**
No Change	77	34	35	11	8	5
Better	12	13	8	7	4	1
Worse	13	9	11	6	3	2
Not Sure	9	5	4	2	2	3
No Response	66	116	119	151	160	166

Which of the following conditions are problems on Otisco Lake?

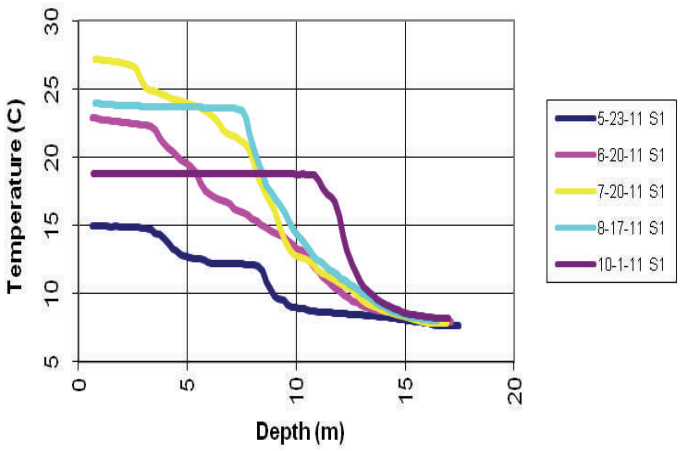
(Number of Responses)

	No problem	Minor Problem	Serious Problem	Don't Know	No Response
Aquatic Weeds	39	**31**	**64**	15	28
Algae Blooms	44	**35**	**42**	16	40
Turbid/Colored Water	52	14	8	15	88
Undesirable Taste/Odors	86	12	0	15	64
Lake Levels too high or low	48	17	3	11	98
Poor bottom conditions for swimming	43	13	3	11	107
Swimmers itch or bacteria problems	50	4	1	11	111
Poor Fishing	49	4	0	12	112
Fish kills	48	6	2	13	108
Too many boats	66	10	4	15	82
Excessive boat speed	61	9	5	14	87
Intoxicated boaters	57	6	1	17	96

Other Comments

- "Aquatic Weed" problem. Mostly that it is bad; a commenter said it was not a problem
- by their residence.
- Algae creating odor.
- Comments about trash; especially at causeway
- Several comments about zebra mussels. .
- Sediment erosion control needed
- Septic system maintenance
- Clarity/turbidity-some saying lake clearer
- Lake level too low
- "Mess" around Marina
- Jet skis
- Several offers to "help"

Otisco Lake Temperature Profiles 2011
(John Halfman, pers. comm. 2012)



Otisco Lake Dissolved Oxygen Profiles 2011
(John Halfman, pers. comm. 2012)